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Chapter 1. Difference between the driver and runtime APIs

The driver and runtime APIs are very similar and can for the most part be used interchangeably. However, there are some key differences worth noting between the two.

Complexity vs. control

The runtime API eases device code management by providing implicit initialization, context management, and module management. This leads to simpler code, but it also lacks the level of control that the driver API has.

In comparison, the driver API offers more fine-grained control, especially over contexts and module loading. Kernel launches are much more complex to implement, as the execution configuration and kernel parameters must be specified with explicit function calls. However, unlike the runtime, where all the kernels are automatically loaded during initialization and stay loaded for as long as the program runs, with the driver API it is possible to only keep the modules that are currently needed loaded, or even dynamically reload modules. The driver API is also language-independent as it only deals with cubin objects.

Context management

Context management can be done through the driver API, but is not exposed in the runtime API. Instead, the runtime API decides itself which context to use for a thread: if a context has been made current to the calling thread through the driver API, the runtime will use that, but if there is no such context, it uses a "primary context." Primary contexts are created as needed, one per device per process, are reference-counted, and are then destroyed when there are no more references to them. Within one process, all users of the runtime API will share the primary context, unless a context has been made current to each thread. The context that the runtime uses, i.e, either the current context or primary context, can be synchronized with cudaDeviceSynchronize(), and destroyed with cudaDeviceReset().

Using the runtime API with primary contexts has its tradeoffs, however. It can cause trouble for users writing plug-ins for larger software packages, for example, because if all plug-ins run in the same process, they will all share a context but will likely have no way to communicate with each other. So, if one of them calls cudaDeviceReset() after finishing all its CUDA work, the other plug-ins will fail because the context they were using was destroyed without their knowledge. To avoid this issue,
CUDA clients can use the driver API to create and set the current context, and then use the runtime API to work with it. However, contexts may consume significant resources, such as device memory, extra host threads, and performance costs of context switching on the device. This runtime-driver context sharing is important when using the driver API in conjunction with libraries built on the runtime API, such as cuBLAS or cuFFT.
Chapter 2. API synchronization behavior

The API provides memcpy/memset functions in both synchronous and asynchronous forms, the latter having an "Async" suffix. This is a misnomer as each function may exhibit synchronous or asynchronous behavior depending on the arguments passed to the function. The synchronous forms of these APIs issue these copies through the default stream.

Any CUDA API call may block or synchronize for various reasons such as contention for or unavailability of internal resources. Such behavior is subject to change and undocumented behavior should not be relied upon.

Memcpy

In the reference documentation, each memcpy function is categorized as synchronous or asynchronous, corresponding to the definitions below.

Synchronous

1. For transfers from pageable host memory to device memory, a stream sync is performed before the copy is initiated. The function will return once the pageable buffer has been copied to the staging memory for DMA transfer to device memory, but the DMA to final destination may not have completed.

2. For transfers from pinned host memory to device memory, the function is synchronous with respect to the host.

3. For transfers from device to either pageable or pinned host memory, the function returns only once the copy has completed.

4. For transfers from device memory to device memory, no host-side synchronization is performed.

5. For transfers from any host memory to any host memory, the function is fully synchronous with respect to the host.

Asynchronous

1. For transfers between device memory and pageable host memory, the function might be synchronous with respect to host.

2. For transfers from any host memory to any host memory, the function is fully synchronous with respect to the host.
3. If pageable memory must first be staged to pinned memory, the driver may synchronize with the stream and stage the copy into pinned memory.

4. For all other transfers, the function should be fully asynchronous.

**Memset**

The cudaMemset functions are asynchronous with respect to the host except when the target memory is pinned host memory. The Async versions are always asynchronous with respect to the host.

**Kernel Launches**

Kernel launches are asynchronous with respect to the host. Details of concurrent kernel execution and data transfers can be found in the CUDA Programmers Guide.
Chapter 3. Stream synchronization behavior

Default stream

The default stream, used when 0 is passed as a cudaStream_t or by APIs that operate on a stream implicitly, can be configured to have either legacy or per-thread synchronization behavior as described below.

The behavior can be controlled per compilation unit with the --default-stream nvcc option. Alternatively, per-thread behavior can be enabled by defining the CUDA_API_PER_THREAD_DEFAULT_STREAM macro before including any CUDA headers. Either way, the CUDA_API_PER_THREAD_DEFAULT_STREAM macro will be defined in compilation units using per-thread synchronization behavior.

Legacy default stream

The legacy default stream is an implicit stream which synchronizes with all other streams in the same CUcontext except for non-blocking streams, described below. (For applications using the runtime APIs only, there will be one context per device.) When an action is taken in the legacy stream such as a kernel launch or cudaStreamWaitEvent(), the legacy stream first waits on all blocking streams, the action is queued in the legacy stream, and then all blocking streams wait on the legacy stream.

For example, the following code launches a kernel k_1 in stream s, then k_2 in the legacy stream, then k_3 in stream s:

```c
k_1<<<1, 1, 0, s>>>()
k_2<<<1, 1>>>()
k_3<<<1, 1, 0, s>>>()
```

The resulting behavior is that k_2 will block on k_1 and k_3 will block on k_2.

Non-blocking streams which do not synchronize with the legacy stream can be created using the cudaStreamNonBlocking flag with the stream creation APIs.

The legacy default stream can be used explicitly with the CUstream(cudaStream_t) handle CU_STREAM_LEGACY(cudaStreamLegacy).
**Per-thread default stream**

The per-thread default stream is an implicit stream local to both the thread and the CUcontext, and which does not synchronize with other streams (just like explicitly created streams). The per-thread default stream is not a non-blocking stream and will synchronize with the legacy default stream if both are used in a program.

The per-thread default stream can be used explicitly with the `CUstream(cuStream_t) handle CU_STREAM_PER_THREAD(cuStreamPerThread)`.
Chapter 4. Graph object thread safety

Graph objects (cudaGraph_t, CUgraph) are not internally synchronized and must not be accessed concurrently from multiple threads. API calls accessing the same graph object must be serialized externally.

Note that this includes APIs which may appear to be read-only, such as cudaGraphClone() (cuGraphClone()) and cudaGraphInstantiate() (cuGraphInstantiate()). No API or pair of APIs is guaranteed to be safe to call on the same graph object from two different threads without serialization.
Chapter 5. Rules for version mixing

1. Starting with CUDA 11.0, the ABI version for the CUDA runtime is bumped every major release. CUDA-defined types, whether opaque handles or structures like `cudaDeviceProp`, have their ABI tied to the major release of the CUDA runtime. It is unsafe to pass them from function A to function B if those functions have been compiled with different major versions of the toolkit and linked together into the same device executable.

2. The CUDA Driver API has a per-function ABI denoted with a `_v*` extension. CUDA-defined types (e.g structs) should not be passed across different ABI versions. For example, an application calling `cuMemcpy2D_v2(const CUDA_MEMCPY2D_v2 *pCopy)` and using the older version of the struct `CUDA_MEMCPY2D_v1` instead of `CUDA_MEMCPY2D_v2`.

3. Users should not arbitrarily mix different API versions during the lifetime of a resource. These resources include IPC handles, memory, streams, contexts, events, etc. For example, a user who wants to allocate CUDA memory using `cuMemAlloc_v2` should free the memory using `cuMemFree_v2` and not `cuMemFree`. 
Chapter 6. Modules

Here is a list of all modules:

- **Device Management**
- **Device Management [DEPRECATED]**
- **Thread Management [DEPRECATED]**
- **Error Handling**
- **Stream Management**
- **Event Management**
- **External Resource Interoperability**
- **Execution Control**
- **Execution Control [DEPRECATED]**
- **Occupancy**
- **Memory Management**
- **Memory Management [DEPRECATED]**
- **Stream Ordered Memory Allocator**
- **Unified Addressing**
- **Peer Device Memory Access**
- **OpenGL Interoperability**
- **OpenGL Interoperability [DEPRECATED]**
- **Direct3D 9 Interoperability**
- **Direct3D 9 Interoperability [DEPRECATED]**
- **Direct3D 10 Interoperability**
- **Direct3D 10 Interoperability [DEPRECATED]**
- **Direct3D 11 Interoperability**
- **Direct3D 11 Interoperability [DEPRECATED]**
- **VDPAU Interoperability**
- **EGL Interoperability**
- **Graphics Interoperability**
6.1. Device Management

This section describes the device management functions of the CUDA runtime application programming interface.

```c
__host__ cudaError_t cudaChooseDevice (int *device, const cudaDeviceProp *prop)
```

Select compute-device which best matches criteria.

**Parameters**

- **device**
  - Device with best match
- **prop**
  - Desired device properties

**Returns**

- cudaSuccess, cudaErrorInvalidValue

**Description**

Returns in *device the device which has properties that best match *prop.

**Note:**

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
See also:

cudaGetDeviceCount, cudaGetDevice, cudaSetDevice, cudaGetDeviceProperties, cudaInitDevice

__host__ cudaError_t

cudaDeviceFlushGPUDirectRDMAWrites
(cudaFlushGPUDirectRDMAWritesTarget target, cudaFlushGPUDirectRDMAWritesScope scope)

Blocks until remote writes are visible to the specified scope.

Parameters

target
- The target of the operation, see cudaFlushGPUDirectRDMAWritesTarget

scope
- The scope of the operation, see cudaFlushGPUDirectRDMAWritesScope

Returns

cudaSuccess, cudaErrorNotSupported.

Description

Blocks until remote writes to the target context via mappings created through GPUDirect RDMA APIs, like nvidia_p2p_get_pages (see https://docs.nvidia.com/cuda/gpudirect-rdma for more information), are visible to the specified scope.

If the scope equals or lies within the scope indicated by cudaDevAttrGPUDirectRDMAWritesOrdering, the call will be a no-op and can be safely omitted for performance. This can be determined by comparing the numerical values between the two enums, with smaller scopes having smaller values.

Users may query support for this API via cudaDevAttrGPUDirectRDMAFlushWritesOptions.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
__host__ __device__ cudaError_t cudaDeviceGetAttribute (int *value, cudaDeviceAttr attr, int device)

Returns information about the device.

Parameters

value
- Returned device attribute value

attr
- Device attribute to query

device
- Device number to query

Returns

cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidValue

Description

Returns in *value the integer value of the attribute attr on device device. The supported attributes are:

- `cudaDevAttrMaxThreadsPerBlock`: Maximum number of threads per block
- `cudaDevAttrMaxBlockSize`: Maximum x-dimension of a block
- `cudaDevAttrMaxBlockDimY`: Maximum y-dimension of a block
- `cudaDevAttrMaxBlockDimZ`: Maximum z-dimension of a block
- `cudaDevAttrMaxGridDimX`: Maximum x-dimension of a grid
- `cudaDevAttrMaxGridDimY`: Maximum y-dimension of a grid
- `cudaDevAttrMaxGridDimZ`: Maximum z-dimension of a grid
- `cudaDevAttrMaxSharedMemoryPerBlock`: Maximum amount of shared memory available to a thread block in bytes
- `cudaDevAttrTotalConstantMemory`: Memory available on device for __constant__ variables in a CUDA C kernel in bytes
- `cudaDevAttrWarpSize`: Warp size in threads
- `cudaDevAttrMaxPitch`: Maximum pitch in bytes allowed by the memory copy functions that involve memory regions allocated through cudaMallocPitch()
- `cudaDevAttrMaxTexture1DWidth`: Maximum 1D texture width
- `cudaDevAttrMaxTexture1DLinearWidth`: Maximum width for a 1D texture bound to linear memory
- `cudaDevAttrMaxTexture1DNonMipmappedWidth`: Maximum non-mipmapped 1D texture width
- `cudaDevAttrMaxTexture2DWidth`: Maximum 2D texture width
- `cudaDevAttrMaxTexture2DHeight`: Maximum 2D texture height
- `cudaDevAttrMaxTexture2DLinearWidth`: Maximum width for a 2D texture bound to linear memory
- `cudaDevAttrMaxTexture2DLinearHeight`: Maximum height for a 2D texture bound to linear memory
- `cudaDevAttrMaxTexture2DLinearPitch`: Maximum pitch in bytes for a 2D texture bound to linear memory
- `cudaDevAttrMaxTexture2DMipmappedWidth`: Maximum mipmapped 2D texture width
- `cudaDevAttrMaxTexture2DMipmappedHeight`: Maximum mipmapped 2D texture height
- `cudaDevAttrMaxTexture3DWidth`: Maximum 3D texture width
- `cudaDevAttrMaxTexture3DHeight`: Maximum 3D texture height
- `cudaDevAttrMaxTexture3DDepth`: Maximum 3D texture depth
- `cudaDevAttrMaxTexture3DWidthAlt`: Alternate maximum 3D texture width, 0 if no alternate maximum 3D texture size is supported
- `cudaDevAttrMaxTexture3DHeightAlt`: Alternate maximum 3D texture height, 0 if no alternate maximum 3D texture size is supported
- `cudaDevAttrMaxTexture3DDepthAlt`: Alternate maximum 3D texture depth, 0 if no alternate maximum 3D texture size is supported
- `cudaDevAttrMaxTextureCubemapWidth`: Maximum cubemap texture width or height
- `cudaDevAttrMaxTexture1DLayeredWidth`: Maximum 1D layered texture width
- `cudaDevAttrMaxTexture1DLayeredLayers`: Maximum layers in a 1D layered texture
- `cudaDevAttrMaxTexture2DLayeredWidth`: Maximum 2D layered texture width
- `cudaDevAttrMaxTexture2DLayeredHeight`: Maximum 2D layered texture height
- `cudaDevAttrMaxTexture2DLayeredLayers`: Maximum layers in a 2D layered texture
- `cudaDevAttrMaxTextureCubemapLayeredWidth`: Maximum cubemap layered texture width or height
- `cudaDevAttrMaxTextureCubemapLayeredLayers`: Maximum layers in a cubemap layered texture
- `cudaDevAttrMaxSurface1DWidth`: Maximum 1D surface width
- `cudaDevAttrMaxSurface2DWidth`: Maximum 2D surface width
- `cudaDevAttrMaxSurface2DHeight`: Maximum 2D surface height
- `cudaDevAttrMaxSurface3DWidth`: Maximum 3D surface width
- `cudaDevAttrMaxSurface3DHeight`: Maximum 3D surface height
- `cudaDevAttrMaxSurface3DDepth`: Maximum 3D surface depth
- `cudaDevAttrMaxSurface1DLayeredWidth`: Maximum 1D layered surface width
- `cudaDevAttrMaxSurface1DLayeredLayers`: Maximum layers in a 1D layered surface
- `cudaDevAttrMaxSurface2DLayeredWidth`: Maximum 2D layered surface width
- cudaAttrMaxSurface2DLayeredHeight: Maximum 2D layered surface height
- cudaAttrMaxSurface2DLayeredLayers: Maximum layers in a 2D layered surface
- cudaAttrMaxSurfaceCubemapWidth: Maximum cubemap surface width
- cudaAttrMaxSurfaceCubemapLayeredWidth: Maximum cubemap layered surface width
- cudaAttrMaxSurfaceCubemapLayeredLayers: Maximum layers in a cubemap layered surface
- cudaAttrMaxRegistersPerBlock: Maximum number of 32-bit registers available to a thread block
- cudaAttrClockRate: Peak clock frequency in kilohertz
- cudaAttrTextureAlignment: Alignment requirement; texture base addresses aligned to textureAlign bytes do not need an offset applied to texture fetches
- cudaAttrTexturePitchAlignment: Pitch alignment requirement for 2D texture references bound to pitched memory
- cudaAttrGpuOverlap: 1 if the device can concurrently copy memory between host and device while executing a kernel, or 0 if not
- cudaAttrMultiProcessorCount: Number of multiprocessors on the device
- cudaAttrKernelExecTimeout: 1 if there is a run time limit for kernels executed on the device, or 0 if not
- cudaAttrIntegrated: 1 if the device is integrated with the memory subsystem, or 0 if not
- cudaAttrCanMapHostMemory: 1 if the device can map host memory into the CUDA address space, or 0 if not
- cudaAttrComputeMode: Compute mode is the compute mode that the device is currently in. Available modes are as follows:
  - cudaComputeModeDefault: Default mode - Device is not restricted and multiple threads can use cudaSetDevice() with this device.
  - cudaComputeModeProhibited: Compute-prohibited mode - No threads can use cudaSetDevice() with this device.
  - cudaComputeModeExclusiveProcess: Compute-exclusive-process mode - Many threads in one process will be able to use cudaSetDevice() with this device.
- cudaAttrConcurrentKernels: 1 if the device supports executing multiple kernels within the same context simultaneously, or 0 if not. It is not guaranteed that multiple kernels will be resident on the device concurrently so this feature should not be relied upon for correctness.
- cudaAttrEccEnabled: 1 if error correction is enabled on the device, 0 if error correction is disabled or not supported by the device
- cudaAttrPciBusId: PCI bus identifier of the device
- cudaAttrPciDeviceId: PCI device (also known as slot) identifier of the device
- cudaAttrTccDriver: 1 if the device is using a TCC driver. TCC is only available on Tesla hardware running Windows Vista or later.
- cudaAttrMemoryClockRate: Peak memory clock frequency in kilohertz
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- `cudaDevAttrGlobalMemoryBusWidth`: Global memory bus width in bits
- `cudaDevAttrL2CacheSize`: Size of L2 cache in bytes. 0 if the device doesn't have L2 cache.
- `cudaDevAttrMaxThreadsPerMultiProcessor`: Maximum resident threads per multiprocessor
- `cudaDevAttrUnifiedAddressing`: 1 if the device shares a unified address space with the host, or 0 if not
- `cudaDevAttrComputeCapabilityMajor`: Major compute capability version number
- `cudaDevAttrComputeCapabilityMinor`: Minor compute capability version number
- `cudaDevAttrStreamPrioritiesSupported`: 1 if the device supports stream priorities, or 0 if not
- `cudaDevAttrGlobalL1CacheSupported`: 1 if device supports caching globals in L1 cache, 0 if not
- `cudaDevAttrLocalL1CacheSupported`: 1 if device supports caching locals in L1 cache, 0 if not
- `cudaDevAttrMaxSharedMemoryPerMultiprocessor`: Maximum amount of shared memory available to a multiprocessor in bytes; this amount is shared by all thread blocks simultaneously resident on a multiprocessor
- `cudaDevAttrMaxRegistersPerMultiprocessor`: Maximum number of 32-bit registers available to a multiprocessor; this number is shared by all thread blocks simultaneously resident on a multiprocessor
- `cudaDevAttrManagedMemory`: 1 if device supports allocating managed memory, 0 if not
- `cudaDevAttrIsMultiGpuBoard`: 1 if device is on a multi-GPU board, 0 if not
- `cudaDevAttrMultiGpuBoardGroupID`: Unique identifier for a group of devices on the same multi-GPU board
- `cudaDevAttrHostNativeAtomicSupported`: 1 if the link between the device and the host supports native atomic operations
- `cudaDevAttrSingleToDoublePrecisionPerfRatio`: Ratio of single precision performance (in floating-point operations per second) to double precision performance
- `cudaDevAttrPageableMemoryAccess`: 1 if the device supports coherently accessing pageable memory without calling cudaHostRegister on it, and 0 otherwise
- `cudaDevAttrConcurrentManagedAccess`: 1 if the device can coherently access managed memory concurrently with the CPU, and 0 otherwise
- `cudaDevAttrCanUseHostPointerForRegisteredMem`: 1 if the device can access host registered memory at the same virtual address as the CPU, and 0 otherwise
- `cudaDevAttrCooperativeLaunch`: 1 if the device supports launching cooperative kernels via `cudaLaunchCooperativeKernel`, and 0 otherwise
- `cudaDevAttrCooperativeMultiDeviceLaunch`: 1 if the device supports launching cooperative kernels via `cudaLaunchCooperativeKernelMultiDevice`, and 0 otherwise
- `cudaDevAttrCanFlushRemoteWrites`: 1 if the device supports flushing of outstanding remote writes, and 0 otherwise
- `cudaDevAttrHostRegisterSupported`: 1 if the device supports host memory registration via `cudaHostRegister`, and 0 otherwise
- **cudaDevAttrPageableMemoryAccessUsesHostPageTables**: 1 if the device accesses pageable memory via the host's page tables, and 0 otherwise
- **cudaDevAttrDirectManagedMemAccessFromHost**: 1 if the host can directly access managed memory on the device without migration, and 0 otherwise
- **cudaDevAttrMaxSharedMemoryPerBlockOptin**: Maximum per block shared memory size on the device. This value can be opted into when using `cudaFuncSetAttribute`
- **cudaDevAttrMaxBlocksPerMultiprocessor**: Maximum number of thread blocks that can reside on a multiprocessor
- **cudaDevAttrMaxPersistingL2CacheSize**: Maximum L2 persisting lines capacity setting in bytes
- **cudaDevAttrMaxAccessPolicyWindowSize**: Maximum value of `cudaAccessPolicyWindow::num_bytes`
- **cudaDevAttrReservedSharedMemoryPerBlock**: Shared memory reserved by CUDA driver per block in bytes
- **cudaDevAttrSparseCudaArraySupported**: 1 if the device supports sparse CUDA arrays and sparse CUDA mipmapped arrays.
- **cudaDevAttrHostRegisterReadOnlySupported**: Device supports using the `cudaHostRegister` flag `cudaHostRegisterReadOnly` to register memory that must be mapped as read-only to the GPU
- **cudaDevAttrMemoryPoolsSupported**: 1 if the device supports using the `cudaMallocAsync` and `cudaMemPool` family of APIs, and 0 otherwise
- **cudaDevAttrGPUDirectRDMA_supported**: 1 if the device supports GPUDirect RDMA APIs, and 0 otherwise
- **cudaDevAttrGPUDirectRDMAFlushWritesOptions**: bitmask to be interpreted according to the `cudaFlushGPUDirectRDMAWritesOptions` enum
- **cudaDevAttrGPUDirectRDMAWritesOrdering**: see the `cudaGPUDirectRDMAWritesOrdering` enum for numerical values
- **cudaDevAttrMemoryPoolSupportedHandleTypes**: Bitmask of handle types supported with mempool based IPC
- **cudaDevAttrDeferredMappingCudaArraySupported**: 1 if the device supports deferred mapping CUDA arrays and CUDA mipmapped arrays.
- **cudaDevAttrIpcEventSupport**: 1 if the device supports IPC Events.
- **cudaDevAttrNumaConfig**: NUMA configuration of a device: value is of type `cudaDeviceNumaConfig` enum
- **cudaDevAttrNumaId**: NUMA node ID of the GPU memory

**Note:**
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
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Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
`cudaGetDeviceCount`, `cudaGetDevice`, `cudaSetDevice`, `cudaChooseDevice`, `cudaGetDeviceProperties`, `cudaInitDevice`, `cuDeviceGetAttribute`

```__host__ cudaError_t cudaDeviceGetByPCIBusId (int *device, const char *pciBusId)```

Returns a handle to a compute device.

**Parameters**

- **device**
  - Returned device ordinal

- **pciBusId**
  - String in one of the following forms: `[domain]:[bus]:[device].[function]` `[domain]:[bus]:[device]` `[bus]:[device].[function]` where `domain`, `bus`, `device`, and `function` are all hexadecimal values

**Returns**

- `cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorInvalidDevice`

**Description**

Returns in `*device` a device ordinal given a PCI bus ID string.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cudaDeviceGetPCIBusId`, `cuDeviceGetByPCIBusId`
__host__ __device__ cudaError_t
cudaDeviceGetCacheConfig (cudaFuncCache *pCacheConfig)

Returns the preferred cache configuration for the current device.

Parameters

pCacheConfig
- Returned cache configuration

Returns
cudaSuccess

Description

On devices where the L1 cache and shared memory use the same hardware resources, this returns through pCacheConfig the preferred cache configuration for the current device. This is only a preference. The runtime will use the requested configuration if possible, but it is free to choose a different configuration if required to execute functions.

This will return a pCacheConfig of cudaFuncCachePreferNone on devices where the size of the L1 cache and shared memory are fixed.

The supported cache configurations are:

- cudaFuncCachePreferNone: no preference for shared memory or L1 (default)
- cudaFuncCachePreferShared: prefer larger shared memory and smaller L1 cache
- cudaFuncCachePreferL1: prefer larger L1 cache and smaller shared memory
- cudaFuncCachePreferEqual: prefer equal size L1 cache and shared memory

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaDeviceSetCacheConfig, cudaFuncSetCacheConfig (C API), cudaFuncSetCacheConfig (C++ API), cuCtxGetCacheConfig
__host__ cudaError_t cudaDeviceGetDefaultMemPool
(cudaMemPool_t *memPool, int device)

Returns the default mempool of a device.

Returns

cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidValue
cudaErrorNotSupported

Description

The default mempool of a device contains device memory from that device.

Note:

‣ Note that this function may also return error codes from previous, asynchronous launches.
‣ Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or
cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
‣ Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback.
cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cuDeviceGetDefaultMemPool, cudaMallocAsync, cudaMemPoolTrimTo, cudaMemPoolGetAttribute,
cudaDeviceSetMemPool, cudaMemPoolSetAttribute, cudaMemPoolSetAccess

__host__ device__cudaError_t cudaDeviceGetLimit
(size_t *pValue, cudaLimit limit)

Return resource limits.

Parameters

pValue
  - Returned size of the limit
limit
  - Limit to query

Returns

cudaSuccess, cudaErrorUnsupportedLimit, cudaErrorInvalidValue

Description

Returns in *pValue the current size of limit. The following cudaLimit values are supported.
- `cudaLimitStackSize` is the stack size in bytes of each GPU thread.
- `cudaLimitPrintFifoSize` is the size in bytes of the shared FIFO used by the printf() device system call.
- `cudaLimitMallocHeapSize` is the size in bytes of the heap used by the malloc() and free() device system calls.
- `cudaLimitDevRuntimeSyncDepth` is the maximum grid depth at which a thread can issue the device runtime call `cudaDeviceSynchronize()` to wait on child grid launches to complete. This functionality is removed for devices of compute capability \( \geq 9.0 \), and hence will return error `cudaErrorUnsupportedLimit` on such devices.
- `cudaLimitDevRuntimePendingLaunchCount` is the maximum number of outstanding device runtime launches.
- `cudaLimitMaxL2FetchGranularity` is the L2 cache fetch granularity.
- `cudaLimitPersistingL2CacheSize` is the persisting L2 cache size in bytes.

**Note:**
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
- `cudaDeviceSetLimit`, `cuCtxGetLimit`

```c
__host__ cudaError_t cudaDeviceGetMemPool(
cudaMemPool_t *memPool, int device)
```

Gets the current mempool for a device.

**Returns**
- `cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorNotSupported`

**Description**

Returns the last pool provided to `cudaDeviceSetMemPool` for this device or the device's default memory pool if `cudaDeviceSetMemPool` has never been called. By default the current mempool is the default mempool for a device, otherwise the returned pool must have been set with `cuDeviceSetMemPool` or `cudaDeviceSetMemPool`. 
Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cuDeviceGetMemPool`, `cudaDeviceGetDefaultMemPool`, `cudaDeviceSetMemPool`

```c
__host__ cudaError_t cudaDeviceGetNvSciSyncAttributes (void *nvSciSyncAttrList, int device, int flags)
```

Return NvSciSync attributes that this device can support.

**Parameters**

- **nvSciSyncAttrList**
  - Return NvSciSync attributes supported.
- **device**
  - Valid Cuda Device to get NvSciSync attributes for.
- **flags**
  - flags describing NvSciSync usage.

**Description**

Returns in `nvSciSyncAttrList`, the properties of NvSciSync that this CUDA device, `dev` can support. The returned `nvSciSyncAttrList` can be used to create an NvSciSync that matches this device's capabilities.

If NvSciSyncAttrKey_RequiredPerm field in `nvSciSyncAttrList` is already set this API will return `cudaErrorInvalidValue`.

The applications should set `nvSciSyncAttrList` to a valid `nvSciSyncAttrList` failing which this API will return `cudaErrorInvalidHandle`.

The `flags` controls how applications intends to use the NvSciSync created from the `nvSciSyncAttrList`. The valid flags are:

- `cudaNvSciSyncAttrSignal`, specifies that the applications intends to signal an NvSciSync on this CUDA device.
- `cudaNvSciSyncAttrWait`, specifies that the applications intends to wait on an NvSciSync on this CUDA device.
At least one of these flags must be set, failing which the API returns cudaErrorInvalidValue. Both the flags are orthogonal to one another: a developer may set both these flags that allows to set both wait and signal specific attributes in the same nvSciSyncAttrList.

Note that this API updates the input nvSciSyncAttrList with values equivalent to the following public attribute key-values: NvSciSyncAttrKey_RequiredPerm is set to


- NvSciSyncAttrValPrimitiveType_SysmemSemaphore on any valid device.
- NvSciSyncAttrValPrimitiveType_Syncpoint if device is a Tegra device.
- NvSciSyncAttrValPrimitiveType_SysmemSemaphorePayload64b if device is GA10X. NvSciSyncAttrKey_GpuId is set to the same UUID that is returned in cudaDeviceProp.uuid from cudaDeviceGetProperties for this device.

 cudaSuccess, cudaErrorDeviceUninitialized, cudaErrorInvalidValue, cudaErrorInvalidHandle, cudaErrorInvalidDevice, cudaErrorNotSupported, cudaErrorMemoryAllocation

See also:
cudaImportExternalSemaphore, cudaDestroyExternalSemaphore, cudaSignalExternalSemaphoresAsync, cudaWaitExternalSemaphoresAsync

__host__ cudaError_t cudaDeviceGetP2PAttribute (int *value, cudaDeviceP2PAttr attr, int srcDevice, int dstDevice)

Queries attributes of the link between two devices.

Parameters
value
- Returned value of the requested attribute
attr
srcDevice
- The source device of the target link.
dstDevice
- The destination device of the target link.

Returns
cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidValue
Description

Returns in *value the value of the requested attribute attrib of the link between srcDevice and dstDevice. The supported attributes are:

- **cudaDevP2PAttrPerformanceRank**: A relative value indicating the performance of the link between two devices. Lower value means better performance (0 being the value used for most performant link).
- **cudaDevP2PAttrAccessSupported**: 1 if peer access is enabled.
- **cudaDevP2PAttrNativeAtomicSupported**: 1 if native atomic operations over the link are supported.
- **cudaDevP2PAttrCudaArrayAccessSupported**: 1 if accessing CUDA arrays over the link is supported.

Returns cudaErrorInvalidDevice if srcDevice or dstDevice are not valid or if they represent the same device.

Returns cudaErrorInvalidValue if attrib is not valid or if value is a null pointer.

---

**Note:**

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaDeviceEnablePeerAccess, cudaDeviceDisablePeerAccess, cudaDeviceCanAccessPeer, cuDeviceGetP2PAttribute

__host__ cudaError_t cudaDeviceGetPCIBusId (char *pciBusId, int len, int device)

Returns a PCI Bus Id string for the device.

Parameters

- **pciBusId**
  - Returned identifier string for the device in the following format [domain]:[bus]:[device].[function] where domain, bus, device, and function are all hexadecimal values. pciBusId should be large enough to store 13 characters including the NULL-terminator.

- **len**
  - Maximum length of string to store in name
device
- Device to get identifier string for

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidDevice

Description
Returns an ASCII string identifying the device dev in the NULL-terminated string pointed to by pciBusId.len specifies the maximum length of the string that may be returned.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaDeviceGetByPCIBusId, cuDeviceGetPCIBusId

__host__ cudaError_t cudaDeviceGetStreamPriorityRange(int *leastPriority, int *greatestPriority)
Returns numerical values that correspond to the least and greatest stream priorities.

Parameters
leastPriority
- Pointer to an int in which the numerical value for least stream priority is returned
greatestPriority
- Pointer to an int in which the numerical value for greatest stream priority is returned

Returns
cudaSuccess

Description
Returns in *leastPriority and *greatestPriority the numerical values that correspond to the least and greatest stream priorities respectively. Stream priorities follow a convention where lower numbers imply greater priorities. The range of meaningful stream priorities is given by [*greatestPriority,*leastPriority]. If the user attempts to create a stream with a priority
value that is outside the meaningful range as specified by this API, the priority is automatically clamped down or up to either *leastPriority or *greatestPriority respectively. See cudaStreamCreateWithPriority for details on creating a priority stream. A NULL may be passed in for *leastPriority or *greatestPriority if the value is not desired.

This function will return '0' in both *leastPriority and *greatestPriority if the current context's device does not support stream priorities (see cudaDeviceGetAttribute).

See also:

cudaStreamCreateWithPriority, cudaStreamGetPriority, cuCtxGetStreamPriorityRange

__host__ cudaError_t
cudaDeviceGetTexture1DLinearMaxWidth (size_t *maxWidthInElements, const cudaChannelFormatDesc *fmtDesc, int device)

Returns the maximum number of elements allocatable in a 1D linear texture for a given element size.

Parameters

maxWidthInElements
- Returns maximum number of texture elements allocatable for given fmtDesc.

fmtDesc
- Texture format description.

device

Returns
cudaSuccess, cudaErrorUnsupportedLimit, cudaErrorInvalidValue

Description

Returns in maxWidthInElements the maximum number of elements allocatable in a 1D linear texture for given format descriptor fmtDesc.
Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback`, no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
`cuDeviceGetTexture1DLinearMaxWidth`

```c
__host__ cudaError_t
cudaDeviceRegisterAsyncNotification (int device, cudaAsyncCallback callbackFunc, void *userData, cudaAsyncCallbackHandle_t *callback)
```

Registers a callback function to receive async notifications.

**Parameters**

- **device**
  - The device on which to register the callback
- **callbackFunc**
  - The function to register as a callback
- **userData**
  - A generic pointer to user data. This is passed into the callback function.
- **callback**
  - A handle representing the registered callback instance

**Returns**

- `cudaSuccess`
- `cudaErrorNotSupported`
- `cudaErrorInvalidDevice`
- `cudaErrorInvalidValue`
- `cudaErrorNotPermitted`
- `cudaErrorUnknown`

**Description**

Registers `callbackFunc` to receive async notifications.

The `userData` parameter is passed to the callback function at async notification time. Likewise, `callback` is also passed to the callback function to distinguish between multiple registered callbacks.

The callback function being registered should be designed to return quickly (~10ms). Any long running tasks should be queued for execution on an application thread.
Callbacks may not call cudaDeviceRegisterAsyncNotification or cudaDeviceUnregisterAsyncNotification. Doing so will result in cudaErrorNotPermitted. Async notification callbacks execute in an undefined order and may be serialized.

Returns in *callback a handle representing the registered callback instance.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaDeviceUnregisterAsyncNotification

__host__ cudaError_t cudaDeviceReset (void)
Destroy all allocations and reset all state on the current device in the current process.

Returns
cudaSuccess

Description
Explicitly destroys and cleans up all resources associated with the current device in the current process. It is the caller's responsibility to ensure that the resources are not accessed or passed in subsequent API calls and doing so will result in undefined behavior. These resources include CUDA types cudaStream_t, cudaEvent_t, cudaArray_t, cudaMipmappedArray_t, cudaPitchedPtr, cudaTextureObject_t, cudaSurfaceObject_t, textureReference, surfaceReference, cudaExternalMemory_t, cudaExternalSemaphore_t and cudaGraphicsResource_t. These resources also include memory allocations by cudaMalloc, cudaMallocHost, cudaMallocManaged and cudaMallocPitch. Any subsequent API call to this device will reinitialize the device.

Note that this function will reset the device immediately. It is the caller's responsibility to ensure that the device is not being accessed by any other host threads from the process when this function is called.

Note:
- cudaDeviceReset() will not destroy memory allocations by cudaMallocAsync() and cudaMallocFromPoolAsync(). These memory allocations need to be destroyed explicitly.
- If a non-primary CUcontext is current to the thread, cudaDeviceReset() will destroy only the internal CUDA RT state for that CUcontext.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.

Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cudaDeviceSynchronize`

```c
__host__ cudaError_t cudaDeviceSetCacheConfig(cuFuncCache cacheConfig)
```

Sets the preferred cache configuration for the current device.

**Parameters**

*cacheConfig*  
- Requested cache configuration

**Returns**

`cudaSuccess`

**Description**

On devices where the L1 cache and shared memory use the same hardware resources, this sets through `cacheConfig` the preferred cache configuration for the current device. This is only a preference. The runtime will use the requested configuration if possible, but it is free to choose a different configuration if required to execute the function. Any function preference set via `cudaFuncSetCacheConfig (C API)` or `cudaFuncSetCacheConfig (C++ API)` will be preferred over this device-wide setting. Setting the device-wide cache configuration to `cudaFuncCachePreferNone` will cause subsequent kernel launches to prefer to not change the cache configuration unless required to launch the kernel.

This setting does nothing on devices where the size of the L1 cache and shared memory are fixed.

Launching a kernel with a different preference than the most recent preference setting may insert a device-side synchronization point.

The supported cache configurations are:

- `cudaFuncCachePreferNone`: no preference for shared memory or L1 (default)
- `cudaFuncCachePreferShared`: prefer larger shared memory and smaller L1 cache
- `cudaFuncCachePreferL1`: prefer larger L1 cache and smaller shared memory
- `cudaFuncCachePreferEqual`: prefer equal size L1 cache and shared memory
Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cudaDeviceGetCacheConfig`, `cudaFuncSetCacheConfig (C API)`, `cudaFuncSetCacheConfig (C++ API)`, `cuCtxSetCacheConfig`

__host__ cudaError_t cudaDeviceSetLimit (cudaLimit limit, size_t value)

Set resource limits.

Parameters

- **limit** - Limit to set
- **value** - Size of limit

Returns

`cudaSuccess`, `cudaErrorUnsupportedLimit`, `cudaErrorInvalidValue`, `cudaErrorMemoryAllocation`

Description

Setting `limit` to `value` is a request by the application to update the current limit maintained by the device. The driver is free to modify the requested value to meet h/w requirements (this could be clamping to minimum or maximum values, rounding up to nearest element size, etc). The application can use `cudaDeviceGetLimit()` to find out exactly what the limit has been set to.

Setting each `cudaLimit` has its own specific restrictions, so each is discussed here.

- **cudaLimitStackSize** controls the stack size in bytes of each GPU thread.
- **cudaLimitPrintFifoSize** controls the size in bytes of the shared FIFO used by the printf() device system call. Setting `cudaLimitPrintFifoSize` must not be performed after launching any kernel that uses the printf() device system call - in such case `cudaErrorInvalidValue` will be returned.
- **cudaLimitMallocHeapSize** controls the size in bytes of the heap used by the malloc() and free() device system calls. Setting `cudaLimitMallocHeapSize` must not be performed after launching any
kernel that uses the malloc() or free() device system calls - in such case

\texttt{cudaErrorInvalidValue} will be returned.

- \texttt{cudaLimitDevRuntimeSyncDepth} controls the maximum nesting depth of a grid at which a thread can safely call \texttt{cudaDeviceSynchronize()}. Setting this limit must be performed before any launch of a kernel that uses the device runtime and calls \texttt{cudaDeviceSynchronize()} above the default sync depth, two levels of grids. Calls to \texttt{cudaDeviceSynchronize()} will fail with error code \texttt{cudaErrorSyncDepthExceeded} if the limitation is violated. This limit can be set smaller than the default or up to the maximum launch depth of 24. When setting this limit, keep in mind that additional levels of sync depth require the runtime to reserve large amounts of device memory which can no longer be used for user allocations. If these reservations of device memory fail, \texttt{cudaDeviceSetLimit} will return \texttt{cudaErrorMemoryAllocation}, and the limit can be reset to a lower value. This limit is only applicable to devices of compute capability < 9.0. Attempting to set this limit on devices of other compute capability will result in error \texttt{cudaErrorUnsupportedLimit} being returned.

- \texttt{cudaLimitDevRuntimePendingLaunchCount} controls the maximum number of outstanding device runtime launches that can be made from the current device. A grid is outstanding from the point of launch up until the grid is known to have been completed. Device runtime launches which violate this limitation fail and return \texttt{cudaErrorLaunchPendingCountExceeded} when \texttt{cudaGetLastError()} is called after launch. If more pending launches than the default (2048 launches) are needed for a module using the device runtime, this limit can be increased. Keep in mind that being able to sustain additional pending launches will require the runtime to reserve larger amounts of device memory upfront which can no longer be used for allocations. If these reservations fail, \texttt{cudaDeviceSetLimit} will return \texttt{cudaErrorMemoryAllocation}, and the limit can be reset to a lower value. This limit is only applicable to devices of compute capability 3.5 and higher. Attempting to set this limit on devices of compute capability less than 3.5 will result in the error \texttt{cudaErrorUnsupportedLimit} being returned.

- \texttt{cudaLimitMaxL2FetchGranularity} controls the L2 cache fetch granularity. Values can range from 0B to 128B. This is purely a performance hint and it can be ignored or clamped depending on the platform.

- \texttt{cudaLimitPersistingL2CacheSize} controls size in bytes available for persisting L2 cache. This is purely a performance hint and it can be ignored or clamped depending on the platform.

\begin{itemize}
  \item Note that this function may also return error codes from previous, asynchronous launches.
  \item Note that this function may also return \texttt{cudaErrorInitializationError}, \texttt{cudaErrorInsufficientDriver} or \texttt{cudaErrorNoDevice} if this call tries to initialize internal CUDA RT state.
  \item Note that as specified by \texttt{cudaStreamAddCallback} no CUDA function may be called from callback. \texttt{cudaErrorNotPermitted} may, but is not guaranteed to, be returned as a diagnostic in such case.
\end{itemize}
See also:

cudaDeviceGetLimit, cuCtxSetLimit

__host__ cudaError_t cudaDeviceSetMemPool (int device, cudaMemPool_t memPool)
Sets the current memory pool of a device.

Returns

cudaSuccess, cudaErrorInvalidValue cudaErrorInvalidDevice cudaErrorNotSupported

Description

The memory pool must be local to the specified device. Unless a mempool is specified in the cudaMallocAsync call, cudaMallocAsync allocates from the current mempool of the provided stream's device. By default, a device's current memory pool is its default memory pool.

Note:

Use cudaMemcpyFromPoolAsync to specify asynchronous allocations from a device different than the one the stream runs on.

Note:

‣ Note that this function may also return error codes from previous, asynchronous launches.
‣ Note that as specified by cudaMemcpyAsync, no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:


__host__ device__cudaError_t cudaDeviceSynchronize (void)
Wait for compute device to finish.

Returns

cudaSuccess
Description

Blocks until the device has completed all preceding requested tasks. `cudaDeviceSynchronize()` returns an error if one of the preceding tasks has failed. If the `cudaDeviceScheduleBlockingSync` flag was set for this device, the host thread will block until the device has finished its work.

Note:
- Use of `cudaDeviceSynchronize` in device code was deprecated in CUDA 11.6 and removed for compute_90+ compilation. For compute capability < 9.0, compile-time opt-in by specifying `-DCUDA_FORCE_CDP1_IF_SUPPORTED` is required to continue using `cudaDeviceSynchronize()` in device code for now. Note that this is different from host-side `cudaDeviceSynchronize`, which is still supported.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
`cudaDeviceReset`, `cuCtxSynchronize`

```c
__host__ cudaError_t cudaDeviceUnregisterAsyncNotification (int device, cudaAsyncCallbackHandle_t callback)
```

Unregisters an async notification callback.

Parameters

- **device**
  - The device from which to remove `callback`.

- **callback**
  - The callback instance to unregister from receiving async notifications.

Returns

- `cudaSuccess`
- `cudaErrorNotSupported`
- `cudaErrorInvalidDevice`
- `cudaErrorInvalidValue`
- `cudaErrorNotPermitted`
- `cudaErrorUnknown`
Description

Unregisters `callback` so that the corresponding callback function will stop receiving async notifications.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:

cudaDeviceRegisterAsyncNotification

```c
__host__ __device__ cudaError_t cudaGetDevice (int *device)
```

Returns which device is currently being used.

Parameters

`device`

- Returns the device on which the active host thread executes the device code.

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorDeviceUnavailable, cudaErrorDeviceUnspecified,

description

Returns in *device the current device for the calling host thread.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaGetDeviceCount, cudaSetDevice, cudaGetDeviceProperties, cudaChooseDevice, cuCtxGetCurrent
__host__ __device__ cudaError_t cudaGetDeviceCount (int *count)

Returns the number of compute-capable devices.

Parameters

count
- Returns the number of devices with compute capability greater or equal to 2.0

Returns
cudaSuccess

Description

Returns in *count the number of devices with compute capability greater or equal to 2.0 that are available for execution.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpyOndevice no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGetDevice, cudaSetDevice, cudaGetDeviceProperties, cudaChooseDevice, cudaInitDevice, cuDeviceGetCount

__host____device__cudaError_t cudaGetDeviceFlags (unsigned int *flags)

Gets the flags for the current device.

Parameters

flags
- Pointer to store the device flags

Returns
cudaSuccess, cudaErrorInvalidDevice
Description

Returns in `flags` the flags for the current device. If there is a current device for the calling thread, the flags for the device are returned. If there is no current device, the flags for the first device are returned, which may be the default flags. Compare to the behavior of `cudaSetDeviceFlags`.

Typically, the flags returned should match the behavior that will be seen if the calling thread uses a device after this call, without any change to the flags or current device inbetween by this or another thread. Note that if the device is not initialized, it is possible for another thread to change the flags for the current device before it is initialized. Additionally, when using exclusive mode, if this thread has not requested a specific device, it may use a device other than the first device, contrary to the assumption made by this function.

If a context has been created via the driver API and is current to the calling thread, the flags for that context are always returned.

Flags returned by this function may specifically include `cudaDeviceMapHost` even though it is not accepted by `cudaSetDeviceFlags` because it is implicit in runtime API flags. The reason for this is that the current context may have been created via the driver API in which case the flag is not implicit and may be unset.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

- `cudaGetDevice`
- `cudaGetDeviceProperties`
- `cudaSetDevice`
- `cudaSetDeviceFlags`
- `cudaInitDevice`
- `cuCtxGetFlags`
- `cuDevicePrimaryCtxGetState`

__host__ `cudaError_t cudaGetDeviceProperties` *(cudaDeviceProp *prop, int device)*

Returns information about the compute-device.

Parameters

**prop**

- Properties for the specified device

**device**

- Device number to get properties for
Returns

cudaSuccess, cudaErrorInvalidDevice

Description

Returns in *prop the properties of device dev. The cudaDeviceProp structure is defined as:

```c
struct cudaDeviceProp {
    char name[256];
    cudaUUID_t uuid;
    size_t totalGlobalMem;
    size_t sharedMemPerBlock;
    int regPerBlock;
    int warpSize;
    size_t memPitch;
    int maxThreadsPerBlock;
    int maxThreadsDim[3];
    int maxGridSize[3];
    int clockRate;
    size_t totalConstMem;
    int major;
    int minor;
    size_t textureAlignment;
    size_t texturePitchAlignment;
    int deviceOverlap;
    int multiprocessorCount;
    int kernelExecTimeoutEnabled;
    int integrated;
    int canMapHostMemory;
    int computeMode;
    int maxTexture1D;
    int maxTexture1DMap;
    int maxTexture1DLinear;
    int maxTexture2D[2];
    int maxTexture2DMipmap[2];
    int maxTexture2DLinear[3];
    int maxTexture2DGather[2];
    int maxTexture3D[3];
    int maxTexture3DAlt[3];
    int maxTextureCubemap;
    int maxTexture1DLayered[2];
    int maxTexture2DLayered[3];
    int maxTextureCubemapLayered[2];
    int maxSurface1D;
    int maxSurface2D[2];
    int maxSurface3D[3];
    int maxSurface1DLayered[2];
    int maxSurface2DLayered[3];
    int maxSurfaceCubemap;
    int maxSurfaceCubemapLayered[2];
    size_t surfaceAlignment;
    int concurrentKernels;
    int ECCEnabled;
    int pciBusID;
    int pciDeviceID;
    int pciDomainID;
    int tccDriver;
    int asyncEngineCount;
    int unifiedAddressing;
    int memoryClockRate;
    int memoryBusWidth;
    int l2CacheSize;
    int persistingL2CacheMaxSize;
    int maxThreadsPerMultiProcessor;
};
```
int streamPrioritiesSupported;
int globalL1CacheSupported;
int localL1CacheSupported;
size_t sharedMemPerMultiprocessor;
int regsPerMultiprocessor;
int managedMemory;
int isMultiGpuBoard;
int multiGpuBoardGroupID;
int singleToDoublePrecisionPerfRatio;
int pageableMemoryAccess;
int concurrentManagedAccess;
int computePreemptionSupported;
int canUseHostPointerForRegisteredMem;
int cooperativeLaunch;
int cooperativeMultiDeviceLaunch;
int pageableMemoryAccessUsesHostPageTables;
int directManagedMemAccessFromHost;
int accessPolicyMaxWindowSize;
}

where:

- name[256] is an ASCII string identifying the device.
- uuid is a 16-byte unique identifier.
- totalGlobalMem is the total amount of global memory available on the device in bytes.
- sharedMemPerBlock is the maximum amount of shared memory available to a thread block in bytes.
- regsPerBlock is the maximum number of 32-bit registers available to a thread block.
- warpSize is the warp size in threads.
- memPitch is the maximum pitch in bytes allowed by the memory copy functions that involve memory regions allocated through cudaMallocPitch().
- maxThreadsPerBlock is the maximum number of threads per block.
- maxThreadsDim[3] contains the maximum size of each dimension of a block.
- clockRate is the clock frequency in kilohertz.
- totalConstMem is the total amount of constant memory available on the device in bytes.
- major, minor are the major and minor revision numbers defining the device's compute capability.
- textureAlignment is the alignment requirement; texture base addresses that are aligned to textureAlignment bytes do not need an offset applied to texture fetches.
- texturePitchAlignment is the pitch alignment requirement for 2D texture references that are bound to pitched memory.
- deviceOverlap is 1 if the device can concurrently copy memory between host and device while executing a kernel, or 0 if not. Deprecated, use instead asyncEngineCount.
- multiProcessorCount is the number of multiprocessors on the device.
- kernelExecTimeoutEnabled is 1 if there is a run time limit for kernels executed on the device, or 0 if not.
- integrated is 1 if the device is an integrated (motherboard) GPU and 0 if it is a discrete (card) component.
- **canMapHostMemory** is 1 if the device can map host memory into the CUDA address space for use with `cudahostAlloc()`/`cudahostGetDevicePointer()`, or 0 if not.

- **computeMode** is the compute mode that the device is currently in. Available modes are as follows:
  - `cudaComputeModeDefault`: Default mode - Device is not restricted and multiple threads can use `cudaSetDevice()` with this device.
  - `cudaComputeModeProhibited`: Compute-prohibited mode - No threads can use `cudaSetDevice()` with this device.
  - `cudaComputeModeExclusiveProcess`: Compute-exclusive-process mode - Many threads in one process will be able to use `cudaSetDevice()` with this device.

  When an occupied exclusive mode device is chosen with `cudaSetDevice()`, all subsequent non-device management runtime functions will return `cudahostErrorDeviceUnavailable`.

- **maxTexture1D** is the maximum 1D texture size.

- **maxTexture1DMipmap** is the maximum 1D mipmapped texture size.

- **maxTexture1DLinear** is the maximum 1D texture size for textures bound to linear memory.

- **maxTexture2D[2]** contains the maximum 2D texture dimensions.

- **maxTexture2DMipmap[2]** contains the maximum 2D mipmapped texture dimensions.

- **maxTexture2DLinear[3]** contains the maximum 2D texture dimensions for 2D textures bound to pitch linear memory.

- **maxTexture2DGather[2]** contains the maximum 2D texture dimensions if texture gather operations have to be performed.

- **maxTexture3D[3]** contains the maximum 3D texture dimensions.

- **maxTexture3DAlt[3]** contains the maximum alternate 3D texture dimensions.

- **maxTextureCubemap** is the maximum cubemap texture width or height.

- **maxTexture1DLayered[2]** contains the maximum 1D layered texture dimensions.

- **maxTexture2DLayered[3]** contains the maximum 2D layered texture dimensions.

- **maxTextureCubemapLayered[2]** contains the maximum cubemap layered texture dimensions.

- **maxSurface1D** is the maximum 1D surface size.

- **maxSurface2D[2]** contains the maximum 2D surface dimensions.

- **maxSurface3D[3]** contains the maximum 3D surface dimensions.

- **maxSurface1DLayered[2]** contains the maximum 1D layered surface dimensions.

- **maxSurface2DLayered[3]** contains the maximum 2D layered surface dimensions.

- **maxSurfaceCubemap** is the maximum cubemap surface width or height.

- **maxSurfaceCubemapLayered[2]** contains the maximum cubemap layered surface dimensions.

- **surfaceAlignment** specifies the alignment requirements for surfaces.

- **concurrentKernels** is 1 if the device supports executing multiple kernels within the same context simultaneously, or 0 if not. It is not guaranteed that multiple kernels will be resident on the device concurrently so this feature should not be relied upon for correctness.
**ECCEnabled** is 1 if the device has ECC support turned on, or 0 if not.

**pciBusID** is the PCI bus identifier of the device.

**pciDeviceID** is the PCI device (sometimes called slot) identifier of the device.

**pciDomainID** is the PCI domain identifier of the device.

**tccDriver** is 1 if the device is using a TCC driver or 0 if not.

**asyncEngineCount** is 1 when the device can concurrently copy memory between host and device while executing a kernel. It is 2 when the device can concurrently copy memory between host and device in both directions and execute a kernel at the same time. It is 0 if neither of these is supported.

**unifiedAddressing** is 1 if the device shares a unified address space with the host and 0 otherwise.

**memoryClockRate** is the peak memory clock frequency in kilohertz.

**memoryBusWidth** is the memory bus width in bits.

**l2CacheSize** is L2 cache size in bytes.

**persistingL2CacheMaxSize** is L2 cache's maximum persisting lines size in bytes.

**maxThreadsPerMultiProcessor** is the number of maximum resident threads per multiprocessor.

**streamPrioritiesSupported** is 1 if the device supports stream priorities, or 0 if it is not supported.

**globalL1CacheSupported** is 1 if the device supports caching of globals in L1 cache, or 0 if it is not supported.

**localL1CacheSupported** is 1 if the device supports caching of locals in L1 cache, or 0 if it is not supported.

**sharedMemPerMultiprocessor** is the maximum amount of shared memory available to a multiprocessor in bytes; this amount is shared by all thread blocks simultaneously resident on a multiprocessor.

**regsPerMultiprocessor** is the maximum number of 32-bit registers available to a multiprocessor; this number is shared by all thread blocks simultaneously resident on a multiprocessor.

**managedMemory** is 1 if the device supports allocating managed memory on this system, or 0 if it is not supported.

**isMultiGpuBoard** is 1 if the device is on a multi-GPU board (e.g. Gemini cards), and 0 if not;

**multiGpuBoardGroupID** is a unique identifier for a group of devices associated with the same board. Devices on the same multi-GPU board will share the same identifier.

**hostNativeAtomicSupported** is 1 if the link between the device and the host supports native atomic operations, or 0 if it is not supported.

**singleToDoublePrecisionPerfRatio** is the ratio of single precision performance (in floating-point operations per second) to double precision performance.

** pageableMemoryAccess** is 1 if the device supports coherently accessing pageable memory without calling cudaHostRegister on it, and 0 otherwise.

**concurrentManagedAccess** is 1 if the device can coherently access managed memory concurrently with the CPU, and 0 otherwise.

**computePreemptionSupported** is 1 if the device supports Compute Preemption, and 0 otherwise.
- `canUseHostPointerForRegisteredMem` is 1 if the device can access host registered memory at the same virtual address as the CPU, and 0 otherwise.
- `cooperativeLaunch` is 1 if the device supports launching cooperative kernels via `cudaLaunchCooperativeKernel`, and 0 otherwise.
- `cooperativeMultiDeviceLaunch` is 1 if the device supports launching cooperative kernels via `cudaLaunchCooperativeKernelMultiDevice`, and 0 otherwise.
- `sharedMemPerBlockOptin` is the per device maximum shared memory per block usable by special opt in
- `pageableMemoryAccessUsesHostPageTables` is 1 if the device accesses pageable memory via the host's page tables, and 0 otherwise.
- `directManagedMemAccessFromHost` is 1 if the host can directly access managed memory on the device without migration, and 0 otherwise.
- `maxBlocksPerMultiProcessor` is the maximum number of thread blocks that can reside on a multiprocessor.
- `accessPolicyMaxWindowSize` is the maximum value of `cudaAccessPolicyWindow::num_bytes`.
- `reservedSharedMemPerBlock` is the shared memory reserved by CUDA driver per block in bytes
- `hostRegisterSupported` is 1 if the device supports host memory registration via `cudaHostRegister`, and 0 otherwise.
- `sparseCudaArraySupported` is 1 if the device supports sparse CUDA arrays and sparse CUDA mipmapmed arrays, 0 otherwise
- `hostRegisterReadOnlySupported` is 1 if the device supports using the `cudaHostRegister` flag `cudaHostRegisterReadOnly` to register memory that must be mapped as read-only to the GPU
- `timelineSemaphoreInteropSupported` is 1 if external timeline semaphore interop is supported on the device, 0 otherwise
- `memoryPoolsSupported` is 1 if the device supports using the `cudaMallocAsync` and `cudaMemPool` family of APIs, 0 otherwise
- `gpuDirectRDMASupported` is 1 if the device supports GPUDirect RDMA APIs, 0 otherwise
- `gpuDirectRDMAFlushWritesOptions` is a bitmask to be interpreted according to the `cudaFlushGPUDirectRDMAWritesOptions` enum
- `gpuDirectRDMAWritesOrdering` See the `cudaGPUDirectRDMAWritesOrdering` enum for numerical values
- `memoryPoolSupportedHandleTypes` is a bitmask of handle types supported with mempool-based IPC
- `deferredMappingCudaArraySupported` is 1 if the device supports deferred mapping CUDA arrays and CUDA mipmapmed arrays
- `ipcEventSupported` is 1 if the device supports IPC Events, and 0 otherwise
- `unifiedFunctionPointers` is 1 if the device support unified pointers, and 0 otherwise
Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cudaGetDeviceCount`, `cudaGetDevice`, `cudaSetDevice`, `cudaChooseDevice`, `cudaDeviceGetAttribute`, `cudaInitDevice`, `cuDeviceGetAttribute`, `cuDeviceGetName`

```c
__host__ cudaError_t cudaInitDevice (int device, unsigned int deviceFlags, unsigned int flags)
```

Initialize device to be used for GPU executions.

**Parameters**

- **device**
  - Device on which the runtime will initialize itself.
- **deviceFlags**
  - Parameters for device operation.
- **flags**
  - Flags for controlling the device initialization.

**Returns**

`cudaSuccess`, `cudaErrorInvalidDevice`.

**Description**

This function will initialize the CUDA Runtime structures and primary context on `device` when called, but the context will not be made current to `device`.

When `cudaInitDeviceFlagsAreValid` is set in `flags`, `deviceFlags` are applied to the requested device. The values of `deviceFlags` match those of the flags parameters in `cudaSetDeviceFlags`. The effect may be verified by `cudaGetDeviceFlags`.

This function will return an error if the device is in `cudaComputeModeExclusiveProcess` and is occupied by another process or if the device is in `cudaComputeModeProhibited`.

Note:
__host__ cudaError_t cudaIpcCloseMemHandle (void *devPtr)

Attempts to close memory mapped with cudaIpcOpenMemHandle.

Parameters

devPtr
- Device pointer returned by cudaIpcOpenMemHandle

Returns

cudaSuccess, cudaErrorMapBufferObjectFailed, cudaErrorNotSupported, cudaErrorInvalidValue

Description

Decrements the reference count of the memory returned by cudaIpcOpenMemHandle by 1. When the reference count reaches 0, this API unmaps the memory. The original allocation in the exporting process as well as imported mappings in other processes will be unaffected.

Any resources used to enable peer access will be freed if this is the last mapping using them.

IPC functionality is restricted to devices with support for unified addressing on Linux and Windows operating systems. IPC functionality on Windows is supported for compatibility purposes but not recommended as it comes with performance cost. Users can test their device for IPC functionality by calling cudaDeviceGetAttribute with cudaDevAttrIpcEventSupport.

See also:

cudaGetDeviceCount, cudaGetDevice, cudaGetDeviceProperties, cudaChooseDevice, cudaSetDevice, cuCtxSetCurrent
CUDA Runtime API

cudaMalloc, cudaFree, cudaIpcGetEventHandle, cudaIpcOpenEventHandle, cudaIpcGetMemHandle, cudaIpcOpenMemHandle, cuIpcCloseMemHandle

__host__ cudaError_t cudaIpcGetEventHandle (cudaIpcEventHandle_t *handle, cudaEvent_t event)

Gets an interprocess handle for a previously allocated event.

Parameters

handle
- Pointer to a user allocated cudaIpcEventHandle in which to return the opaque event handle

event
- Event allocated with cudaEventInterprocess and cudaEventDisableTiming flags.

Returns
cudaSuccess, cudaErrorInvalidResourceHandle, cudaErrorMemoryAllocation, cudaErrorMapBufferObjectFailed, cudaErrorNotSupported, cudaErrorInvalidValue

Description

Takes as input a previously allocated event. This event must have been created with the cudaEventInterprocess and cudaEventDisableTiming flags set. This opaque handle may be copied into other processes and opened with cudaIpcOpenEventHandle to allow efficient hardware synchronization between GPU work in different processes.

After the event has been been opened in the importing process, cudaEventRecord, cudaEventSynchronize, cudaStreamWaitEvent and cudaEventQuery may be used in either process. Performing operations on the imported event after the exported event has been freed with cudaEventDestroy will result in undefined behavior.

IPC functionality is restricted to devices with support for unified addressing on Linux and Windows operating systems. IPC functionality on Windows is supported for compatibility purposes but not recommended as it comes with performance cost. Users can test their device for IPC functionality by calling cudaDeviceGetAttribute with cudaDevAttrIpcEventSupport

Note:

- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpyAsync, no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
__host__ cudaError_t cudaIpcGetMemHandle (cudaIpcMemHandle_t *handle, void *devPtr)

Gets an interprocess memory handle for an existing device memory allocation.

**Parameters**

**handle**
- Pointer to user allocated cudaIpcMemHandle to return the handle in.

**devPtr**
- Base pointer to previously allocated device memory

**Returns**

cudaSuccess, cudaErrorMemoryAllocation, cudaErrorMapBufferObjectFailed, cudaErrorNotSupported, cudaErrorInvalidValue

**Description**

Takes a pointer to the base of an existing device memory allocation created with cudaMalloc and exports it for use in another process. This is a lightweight operation and may be called multiple times on an allocation without adverse effects.

If a region of memory is freed with cudaFree and a subsequent call to cudaMalloc returns memory with the same device address, cudaIpcGetMemHandle will return a unique handle for the new memory.

IPC functionality is restricted to devices with support for unified addressing on Linux and Windows operating systems. IPC functionality on Windows is supported for compatibility purposes but not recommended as it comes with performance cost. Users can test their device for IPC functionality by calling cudaDeviceGetAttribute with cudaDevAttrIpcEventSupport

**Note:**

- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

**See also:**
cudaMalloc, cudaFree, cudaIpcGetEventHandle, cudaIpcOpenEventHandle, cudaIpcOpenMemHandle, cudaIpcCloseMemHandle, cuIpcGetMemHandle
__host__ cudaError_t cudaIpcOpenEventHandle (cudaEvent_t *event, cudaIpcEventHandle_t handle)

Opens an interprocess event handle for use in the current process.

Parameters

- event
  - Returns the imported event

- handle
  - Interprocess handle to open

Returns

- cudaSuccess, cudaErrorMapBufferObjectFailed, cudaErrorNotSupported, cudaErrorInvalidValue, cudaErrorDeviceUninitialized

Description

Opens an interprocess event handle exported from another process with cudaIpcGetEventHandle. This function returns a cudaEvent_t that behaves like a locally created event with the cudaEventDisableTiming flag specified. This event must be freed with cudaEventDestroy.

Performing operations on the imported event after the exported event has been freed with cudaEventDestroy will result in undefined behavior.

IPC functionality is restricted to devices with support for unified addressing on Linux and Windows operating systems. IPC functionality on Windows is supported for compatibility purposes but not recommended as it comes with performance cost. Users can test their device for IPC functionality by calling cudaDeviceGetAttribute with cudaDevAttrIpcEventSupport.

Note:

- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaEventCreate, cudaEventDestroy, cudaEventSynchronize, cudaEventQuery, cudaStreamWaitEvent, cudaIpcGetEventHandle, cudaIpcGetMemHandle, cudaIpcOpenMemHandle, cudaIpcCloseMemHandle, cuIpcOpenEventHandle
__host__ cudaError_t cudaIpcOpenMemHandle (void **devPtr, cudaIpcMemHandle_t handle, unsigned int flags)

Opens an interprocess memory handle exported from another process and returns a device pointer usable in the local process.

Parameters

devPtr
- Returned device pointer
handle
- cudaIpcMemHandle to open
flags
- Flags for this operation. Must be specified as cudaIpcMemLazyEnablePeerAccess

Returns
cudaSuccess, cudaErrorMapBufferObjectFailed, cudaErrorInvalidResourceHandle, cudaErrorDeviceUninitialized, cudaErrorTooManyPeers, cudaErrorNotSupported, cudaErrorInvalidValue

Description

Maps memory exported from another process with cudaIpcGetMemHandle into the current device address space. For contexts on different devices cudaIpcOpenMemHandle can attempt to enable peer access between the devices as if the user called cudaDeviceEnablePeerAccess. This behavior is controlled by the cudaIpcMemLazyEnablePeerAccess flag. cudaDeviceCanAccessPeer can determine if a mapping is possible.

cudaIpcOpenMemHandle can open handles to devices that may not be visible in the process calling the API.

Contexts that may open cudaIpcMemHandles are restricted in the following way. cudaIpcMemHandles from each device in a given process may only be opened by one context per device per other process.

If the memory handle has already been opened by the current context, the reference count on the handle is incremented by 1 and the existing device pointer is returned.

Memory returned from cudaIpcOpenMemHandle must be freed with cudaIpcCloseMemHandle.

Calling cudaMemcpy on an exported memory region before calling cudaIpcCloseMemHandle in the importing context will result in undefined behavior.

IPC functionality is restricted to devices with support for unified addressing on Linux and Windows operating systems. IPC functionality on Windows is supported for compatibility purposes but not recommended as it comes with performance cost. Users can test their device for IPC functionality by calling cudaDeviceGetAttribute with cudaDevAttrIpcEventSupport.
__host__ cudaError_t cudaSetDevice (int device)
Set device to be used for GPU executions.

Parameters

device
- Device on which the active host thread should execute the device code.

Returns
cudaSuccess, cudaErrorInvalidDevice, cudaErrorDeviceUnavailable,

description
Sets device as the current device for the calling host thread. Valid device id's are 0 to (cudaGetDeviceCount() - 1).

Any device memory subsequently allocated from this host thread using cudaMalloc(), cudaMallocPitch() or cudaMallocArray() will be physically resident on device. Any host memory allocated from this host thread using cudaMallocHost() or cudaHostAlloc() or cudaHostRegister() will have its lifetime associated with device. Any streams or events created from this host thread will be associated with device. Any kernels launched from this host thread using the <<<>>> operator or cudaLaunchKernel() will be executed on device.

This call may be made from any host thread, to any device, and at any time. This function will do no synchronization with the previous or new device, and should only take significant time when it initializes the runtime's context state. This call will bind the primary context of the specified device to the calling thread and all the subsequent memory allocations, stream and event creations, and kernel launches will be associated with the primary context. This function will also immediately initialize the runtime state on the primary context, and the context will be current on device immediately. This

Note:
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpyAsync no CUDA function may be called from callback. cudaMemcpyAsync may, but is not guaranteed to, be returned as a diagnostic in such case.
- No guarantees are made about the address returned in *devPtr. In particular, multiple processes may not receive the same address for the same handle.

See also:
cudaMalloc, cudaMemcpyAsync, cudaMemcpy, cudaMemcpy3D, cudaMemcpy2D, cudaMemcpy

function will return an error if the device is in `cudaComputeModeExclusiveProcess` and is occupied by another process or if the device is in `cudaComputeModeProhibited`.

It is not required to call `cudaInitDevice` before using this function.

### cudaSetDeviceFlags

```c
__host__ cudaError_t cudaSetDeviceFlags (unsigned int flags)
```

Sets flags to be used for device executions.

#### Parameters

- **flags**
  - Parameters for device operation

#### Returns

- `cudaSuccess`
- `cudaErrorInvalidValue`

#### Description

Records `flags` as the flags for the current device. If the current device has been set and that device has already been initialized, the previous flags are overwritten. If the current device has not been initialized, it is initialized with the provided flags. If no device has been made current to the calling thread, a default device is selected and initialized with the provided flags.

The three LSBs of the `flags` parameter can be used to control how the CPU thread interacts with the OS scheduler when waiting for results from the device.

- **cudaDeviceScheduleAuto**: The default value if the `flags` parameter is zero, uses a heuristic based on the number of active CUDA contexts in the process $C$ and the number of logical processors in the system $P$. If $C > P$, then CUDA will yield to other OS threads when waiting for the device, otherwise CUDA will not yield while waiting for results and actively spin on the processor. Additionally, on Tegra devices, `cudaDeviceScheduleAuto` uses a heuristic based on the power.
profile of the platform and may choose `cudaDeviceScheduleBlockingSync` for low-powered devices.

- **cudaDeviceScheduleSpin**: Instruct CUDA to actively spin when waiting for results from the device. This can decrease latency when waiting for the device, but may lower the performance of CPU threads if they are performing work in parallel with the CUDA thread.

- **cudaDeviceScheduleYield**: Instruct CUDA to yield its thread when waiting for results from the device. This can increase latency when waiting for the device, but can increase the performance of CPU threads performing work in parallel with the device.

- **cudaDeviceScheduleBlockingSync**: Instruct CUDA to block the CPU thread on a synchronization primitive when waiting for the device to finish work.

- **cudaDeviceBlockingSync**: Instruct CUDA to block the CPU thread on a synchronization primitive when waiting for the device to finish work.

  **Deprecated**: This flag was deprecated as of CUDA 4.0 and replaced with `cudaDeviceScheduleBlockingSync`.

- **cudaDeviceMapHost**: This flag enables allocating pinned host memory that is accessible to the device. It is implicit for the runtime but may be absent if a context is created using the driver API. If this flag is not set, `cudaHostGetDevicePointer()` will always return a failure code.

- **cudaDeviceLmemResizeToMax**: Instruct CUDA to not reduce local memory after resizing local memory for a kernel. This can prevent thrashing by local memory allocations when launching many kernels with high local memory usage at the cost of potentially increased memory usage.

  **Deprecated**: This flag is deprecated and the behavior enabled by this flag is now the default and cannot be disabled.

- **cudaDeviceSyncMemops**: Ensures that synchronous memory operations initiated on this context will always synchronize. See further documentation in the section titled "API Synchronization behavior" to learn more about cases when synchronous memory operations can exhibit asynchronous behavior.

---

**Note:**

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

---

See also:

- `cudaGetDeviceFlags`, `cudaGetDeviceCount`, `cudaGetDevice`, `cudaGetDeviceProperties`, `cudaSetDevice`, `cudaSetValidDevices`, `cudaInitDevice`, `cudaChooseDevice`, `cuDevicePrimaryCtxSetFlags`
__host__ cudaError_t cudaSetValidDevices (int *device_arr, int len)
Set a list of devices that can be used for CUDA.

Parameters

device_arr
- List of devices to try

len
- Number of devices in specified list

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidDevice

Description
Sets a list of devices for CUDA execution in priority order using device_arr. The parameter len specifies the number of elements in the list. CUDA will try devices from the list sequentially until it finds one that works. If this function is not called, or if it is called with a len of 0, then CUDA will go back to its default behavior of trying devices sequentially from a default list containing all of the available CUDA devices in the system. If a specified device ID in the list does not exist, this function will return cudaErrorInvalidDevice. If len is not 0 and device_arr is NULL or if len exceeds the number of devices in the system, then cudaErrorInvalidValue is returned.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGetDeviceCount, cudaSetDevice, cudaGetDeviceProperties, cudaSetDeviceFlags, cudaChooseDevice

6.2. Device Management [DEPRECATED]

This section describes the deprecated device management functions of the CUDA runtime application programming interface.
`__host__ __device__ cudaError_t cudaMemcpy (cudaMemcpyHandle handle, const void *dst, void *src, size_t size, cudaMemcpyKind kind)`

Copies data from `src` to `dst`.

Parameters

handle - cudaMemcpyHandle of a previously created cudaMemcpyHandle.

dst - A pointer to the destination memory object.

src - A pointer to the source memory object.

size - The size of the data to transfer.

kind - The cudaMemcpyKind of the transfer.

Returns

cudaMemcpySuccess, cudaMemcpyError

Description

This function copies data from one memory location to another. The kind parameter specifies the type of transfer.

See also:

cudaMemcpy, cudaMemcpyAsync, cudaMemcpy2d

---

`__host__ __device__ cudaError_t cudaMemcpyAsync (cudaMemcpyHandle handle, const void *dst, void *src, size_t size, cudaMemcpyKind kind)`

Asynchronously copies data from `src` to `dst`.

Parameters

handle - cudaMemcpyHandle of a previously created cudaMemcpyHandle.

dst - A pointer to the destination memory object.

src - A pointer to the source memory object.

size - The size of the data to transfer.

kind - The cudaMemcpyKind of the transfer.

Returns

cudaMemcpySuccess, cudaMemcpyError

Description

This function is an asynchronous version of cudaMemcpy. It copies data from one memory location to another without blocking the calling thread.

See also:

cudaMemcpy, cudaMemcpyAsync, cudaMemcpy2d

---

`__host__ __device__ cudaError_t cudaMemcpy2d (cudaMemcpyHandle handle, const void *dstRow, void *srcRow, size_t RowPitch, size_t Width, cudaMemcpyKind kind)`

Copies 2D data from `srcRow` to `dstRow`.

Parameters

handle - cudaMemcpyHandle of a previously created cudaMemcpyHandle.

dstRow - A pointer to the destination memory object.

srcRow - A pointer to the source memory object.

RowPitch - The pitch of the row of data.

Width - The width of the data.

kind - The cudaMemcpyKind of the transfer.

Returns

cudaMemcpySuccess, cudaMemcpyError

Description

This function copies 2D data from one memory location to another. The kind parameter specifies the type of transfer.

See also:

cudaMemcpy, cudaMemcpyAsync, cudaMemcpy2d

---

`__host__ __device__ cudaError_t cudaMemcpy2dAsync (cudaMemcpyHandle handle, const void *dstRow, void *srcRow, size_t RowPitch, size_t Width, cudaMemcpyKind kind)`

Asynchronously copies 2D data from `srcRow` to `dstRow`.

Parameters

handle - cudaMemcpyHandle of a previously created cudaMemcpyHandle.

dstRow - A pointer to the destination memory object.

srcRow - A pointer to the source memory object.

RowPitch - The pitch of the row of data.

Width - The width of the data.

kind - The cudaMemcpyKind of the transfer.

Returns

cudaMemcpySuccess, cudaMemcpyError

Description

This function is an asynchronous version of cudaMemcpy2d. It copies 2D data from one memory location to another without blocking the calling thread.
__host__ cudaError_t cudaDeviceSetSharedMemConfig (cudaSharedMemConfig config)

Sets the shared memory configuration for the current device.

Parameters
config
- Requested cache configuration

Returns
cudaSuccess, cudaErrorInvalidValue

Description
Deprecated

On devices with configurable shared memory banks, this function will set the shared memory bank size which is used for all subsequent kernel launches. Any per-function setting of shared memory set via cudaFuncSetSharedMemConfig will override the device wide setting.

Changing the shared memory configuration between launches may introduce a device side synchronization point.

Changing the shared memory bank size will not increase shared memory usage or affect occupancy of kernels, but may have major effects on performance. Larger bank sizes will allow for greater potential bandwidth to shared memory, but will change what kinds of accesses to shared memory will result in bank conflicts.

This function will do nothing on devices with fixed shared memory bank size.

The supported bank configurations are:

- cudaSharedMemBankSizeDefault: set bank width the device default (currently, four bytes)
- cudaSharedMemBankSizeFourByte: set shared memory bank width to be four bytes natively.
- cudaSharedMemBankSizeEightByte: set shared memory bank width to be eight bytes natively.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
### 6.3. Thread Management [DEPRECATED]

This section describes deprecated thread management functions of the CUDA runtime application programming interface.

___host__ cudaError_t cudaThreadExit (void)

Exit and clean up from CUDA launches.

**Returns**

cudaSuccess

**Description**

**Deprecated**

Note that this function is deprecated because its name does not reflect its behavior. Its functionality is identical to the non-deprecated function `cudaDeviceReset()`, which should be used instead.

Explicitly destroys all cleans up all resources associated with the current device in the current process. Any subsequent API call to this device will reinitialize the device.

Note that this function will reset the device immediately. It is the caller's responsibility to ensure that the device is not being accessed by any other host threads from the process when this function is called.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaDeviceReset
__host__ cudaError_t cudaThreadGetCacheConfig (cudaFuncCache *pCacheConfig)

Returns the preferred cache configuration for the current device.

Parameters

pCacheConfig
- Returned cache configuration

Returns

cudaSuccess

Description

Deprecated

Note that this function is deprecated because its name does not reflect its behavior. Its functionality is identical to the non-deprecated function cudaDeviceGetCacheConfig(), which should be used instead.

On devices where the L1 cache and shared memory use the same hardware resources, this returns through pCacheConfig the preferred cache configuration for the current device. This is only a preference. The runtime will use the requested configuration if possible, but it is free to choose a different configuration if required to execute functions.

This will return a pCacheConfig of cudaFuncCachePreferNone on devices where the size of the L1 cache and shared memory are fixed.

The supported cache configurations are:

- cudaFuncCachePreferNone: no preference for shared memory or L1 (default)
- cudaFuncCachePreferShared: prefer larger shared memory and smaller L1 cache
- cudaFuncCachePreferL1: prefer larger L1 cache and smaller shared memory

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaDeviceGetCacheConfig
__host__ cudaError_t cudaThreadGetLimit (size_t *pValue, cudaLimit limit)

Returns resource limits.

Parameters

pValue
- Returned size in bytes of limit

limit
- Limit to query

Returns

cudaSuccess, cudaErrorUnsupportedLimit, cudaErrorInvalidValue

Description

Deprecated

Note that this function is deprecated because its name does not reflect its behavior. Its functionality is identical to the non-deprecated function cudaDeviceGetLimit(), which should be used instead.

Returns in *pValue the current size of limit. The supported cudaLimit values are:

- cudaLimitStackSize: stack size of each GPU thread;
- cudaLimitPrintFifoSize: size of the shared FIFO used by the printf() device system call.
- cudaLimitMallocHeapSize: size of the heap used by the malloc() and free() device system calls;

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback, no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaDeviceGetLimit
__host__ cudaError_t cudaThreadSetCacheConfig (cudaFuncCache cacheConfig)
Sets the preferred cache configuration for the current device.

Parameters

- **cacheConfig**
  - Requested cache configuration

Returns

cudaSuccess

Description

**Deprecated**

Note that this function is deprecated because its name does not reflect its behavior. Its functionality is identical to the non-deprecated function **cudaDeviceSetCacheConfig()**, which should be used instead.

On devices where the L1 cache and shared memory use the same hardware resources, this sets through **cacheConfig** the preferred cache configuration for the current device. This is only a preference. The runtime will use the requested configuration if possible, but it is free to choose a different configuration if required to execute the function. Any function preference set via **cudaFuncSetCacheConfig (C API)** or **cudaFuncSetCacheConfig (C++ API)** will be preferred over this device-wide setting. Setting the device-wide cache configuration to **cudaFuncCachePreferNone** will cause subsequent kernel launches to prefer not to change the cache configuration unless required to launch the kernel.

This setting does nothing on devices where the size of the L1 cache and shared memory are fixed.

Launching a kernel with a different preference than the most recent preference setting may insert a device-side synchronization point.

The supported cache configurations are:

- **cudaFuncCachePreferNone**: no preference for shared memory or L1 (default)
- **cudaFuncCachePreferShared**: prefer larger shared memory and smaller L1 cache
- **cudaFuncCachePreferL1**: prefer larger L1 cache and smaller shared memory

**Note:**

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return **cudaErrorInitializationError**, **cudaErrorInsufficientDriver** or **cudaErrorNoDevice** if this call tries to initialize internal CUDA RT state.
- Note that as specified by **cudaStreamAddCallback** no CUDA function may be called from callback. **cudaErrorNotPermitted** may, but is not guaranteed to, be returned as a diagnostic in such case.
__host__ cudaError_t cudaThreadSetLimit (cudaLimit limit, size_t value)
Set resource limits.

Parameters

limit
- Limit to set

value
- Size in bytes of limit

Returns
cudaSuccess, cudaErrorUnsupportedLimit, cudaErrorInvalidValue

Description

Deprecated

Note that this function is deprecated because its name does not reflect its behavior. Its functionality is identical to the non-deprecated function cudaDeviceSetLimit(), which should be used instead.

Setting limit to value is a request by the application to update the current limit maintained by the device. The driver is free to modify the requested value to meet h/w requirements (this could be clamping to minimum or maximum values, rounding up to nearest element size, etc). The application can use cudaThreadGetLimit() to find out exactly what the limit has been set to.

Setting each cudaLimit has its own specific restrictions, so each is discussed here.

- cudaLimitStackSize controls the stack size of each GPU thread.

- cudaLimitPrintFifoSize controls the size of the shared FIFO used by the printf() device system call. Setting cudaLimitPrintFifoSize must be performed before launching any kernel that uses the printf() device system call, otherwise cudaErrorInvalidValue will be returned.

- cudaLimitMallocHeapSize controls the size of the heap used by the malloc() and free() device system calls. Setting cudaLimitMallocHeapSize must be performed before launching any kernel that uses the malloc() or free() device system calls, otherwise cudaErrorInvalidValue will be returned.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
See also:
cudaDeviceSetLimit

__host__ cudaError_t cudaThreadSynchronize (void)
Wait for compute device to finish.

Returns
cudaSuccess

Description
Deprecated
Note that this function is deprecated because its name does not reflect its behavior. Its functionality is similar to the non-deprecated function cudaDeviceSynchronize(), which should be used instead.

Blocks until the device has completed all preceding requested tasks. cudaThreadSynchronize() returns an error if one of the preceding tasks has failed. If the cudaDeviceScheduleBlockingSync flag was set for this device, the host thread will block until the device has finished its work.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaDeviceSynchronize

6.4. Error Handling
This section describes the error handling functions of the CUDA runtime application programming interface.
__host__ __device__ __const char *cudaGetErrorName (cudaError_t error)

Returns the string representation of an error code enum name.

Parameters
error
- Error code to convert to string

Returns
char* pointer to a NULL-terminated string

Description
Returns a string containing the name of an error code in the enum. If the error code is not recognized, "unrecognized error code" is returned.

See also:
cudaGetErrorString, cudaGetLastError, cudaPeekAtLastError, cudaError, cuGetErrorName

__host__ __device__ __const char *cudaGetErrorString (cudaError_t error)

Returns the description string for an error code.

Parameters
error
- Error code to convert to string

Returns
char* pointer to a NULL-terminated string

Description
Returns the description string for an error code. If the error code is not recognized, "unrecognized error code" is returned.

See also:
cudaGetErrorName, cudaGetLastError, cudaPeekAtLastError, cudaError, cuGetErrorString
__host__ __device__ cudaError_t cudaGetLastError (void)

Returns the last error from a runtime call.

Returns


Description

Returns the last error that has been produced by any of the runtime calls in the same instance of the CUDA Runtime library in the host thread and resets it to cudaSuccess.

Note: Multiple instances of the CUDA Runtime library can be present in an application when using a library that statically links the CUDA Runtime.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaPeekAtLastError, cudaGetErrorName, cudaGetErrorString, cudaError
__host__ __device__ cudaError_t cudaPeekAtLastError (void)

Returns the last error from a runtime call.

Returns

cudaSuccess, cudaErrorMissingConfiguration, cudaErrorMemoryAllocation,
cudaErrorInitializationError, cudaErrorLaunchFailure, cudaErrorLaunchTimeout,
cudaErrorLaunchOutOfResources, cudaErrorInvalidDeviceFunction, cudaErrorInvalidConfiguration,
cudaErrorInvalidDevice, cudaErrorInvalidValue, cudaErrorInvalidPitchValue,
cudaErrorInvalidSymbol, cudaErrorUnmapBufferObjectFailed, cudaErrorInvalidDevicePointer,
cudaErrorInvalidTexture, cudaErrorInvalidTextureBinding, cudaErrorInvalidChannelDescriptor,
cudaErrorInvalidMemcpyDirection, cudaErrorInvalidFilterSetting, cudaErrorInvalidNormSetting,
cudaErrorUnknown, cudaErrorInvalidResourceHandle, cudaErrorInsufficientDriver,
cudaErrorNoDevice, cudaErrorSetOnActiveProcess, cudaErrorStartupFailure,
cudaErrorInvalidPtx, cudaErrorUnsupportedPtxVersion, cudaErrorNoKernelImageForDevice,
cudaErrorJitCompilerNotFound, cudaErrorJitCompilationDisabled

Description

Returns the last error that has been produced by any of the runtime calls in the same instance of
the CUDA Runtime library in the host thread. This call does not reset the error to cudaSuccess like
cudaGetLastError().

Note: Multiple instances of the CUDA Runtime library can be present in an application when using a
library that statically links the CUDA Runtime.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or
cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback.
cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGetLastError, cudaGetErrorName, cudaGetErrorString, cudaError
6.5. Stream Management

This section describes the stream management functions of the CUDA runtime application programming interface.

typedef void (CUDART_CB *cudaStreamCallback_t) (cudaStream_t stream, cudaError_t status, void* userData)

Type of stream callback functions.

__host__ cudaError_t cudaCtxResetPersistingL2Cache (void)

Resets all persisting lines in cache to normal status.

Returns

cudaSuccess.

Description

Resets all persisting lines in cache to normal status. Takes effect on function return.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:

cudaAccessPolicyWindow

__host__ cudaError_t cudaStreamAddCallback (cudaStream_t stream, cudaStreamCallback_t callback, void *userData, unsigned int flags)

Add a callback to a compute stream.

Parameters

stream
- Stream to add callback to

callback
- The function to call once preceding stream operations are complete
**userData**
- User specified data to be passed to the callback function

**flags**
- Reserved for future use, must be 0

**Returns**
cudaSuccess, cudaErrorInvalidResourceHandle, cudaErrorInvalidValue, cudaErrorNotSupported

**Description**

Add a callback to be called on the host after all currently enqueued items in the stream have completed. For each cudaStreamAddCallback call, a callback will be executed exactly once. The callback will block later work in the stream until it is finished.

The callback may be passed cudaSuccess or an error code. In the event of a device error, all subsequently executed callbacks will receive an appropriate cudaError_t.

Callbacks must not make any CUDA API calls. Attempting to use CUDA APIs may result in cudaErrorNotPermitted. Callbacks must not perform any synchronization that may depend on outstanding device work or other callbacks that are not mandated to run earlier. Callbacks without a mandated order (in independent streams) execute in undefined order and may be serialized.

For the purposes of Unified Memory, callback execution makes a number of guarantees:

- The callback stream is considered idle for the duration of the callback. Thus, for example, a callback may always use memory attached to the callback stream.
- The start of execution of a callback has the same effect as synchronizing an event recorded in the same stream immediately prior to the callback. It thus synchronizes streams which have been "joined" prior to the callback.
- Adding device work to any stream does not have the effect of making the stream active until all preceding callbacks have executed. Thus, for example, a callback might use global attached memory even if work has been added to another stream, if it has been properly ordered with an event.
- Completion of a callback does not cause a stream to become active except as described above. The callback stream will remain idle if no device work follows the callback, and will remain idle across consecutive callbacks without device work in between. Thus, for example, stream synchronization can be done by signaling from a callback at the end of the stream.
Note:

‣ This function uses standard default stream semantics.
‣ Note that this function may also return error codes from previous, asynchronous launches.
‣ Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
‣ Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaStreamCreate, cudaStreamCreateWithFlags, cudaStreamQuery, cudaStreamSynchronize, cudaStreamWaitEvent, cudaStreamDestroy, cudaMallocManaged, cudaStreamAttachMemAsync, cudaLaunchHostFunc, cuStreamAddCallback

__host__ cudaError_t cudaStreamAttachMemAsync (cudaStream_t stream, void *devPtr, size_t length, unsigned int flags)

Attach memory to a stream asynchronously.

Parameters

stream

- Stream in which to enqueue the attach operation
devPtr

- Pointer to memory (must be a pointer to managed memory or to a valid host-accessible region of system-allocated memory)
length

- Length of memory (defaults to zero)
flags

- Must be one of cudaMemAttachGlobal, cudaMemAttachHost or cudaMemAttachSingle (defaults to cudaMemAttachSingle)

Returns
cudaSuccess, cudaErrorNotReady, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle

Description

Enqueues an operation in stream to specify stream association of length bytes of memory starting from devPtr. This function is a stream-ordered operation, meaning that it is dependent on, and will only take effect when, previous work in stream has completed. Any previous association is automatically replaced.
devPtr must point to one of the following types of memories:

- managed memory declared using the __managed__ keyword or allocated with \texttt{cudaMallocManaged}.
- a valid host-accessible region of system-allocated pageable memory. This type of memory may only be specified if the device associated with the stream reports a non-zero value for the device attribute \texttt{cudaDevAttrPageableMemoryAccess}.

For managed allocations, \texttt{length} must be either zero or the entire allocation's size. Both indicate that the entire allocation's stream association is being changed. Currently, it is not possible to change stream association for a portion of a managed allocation.

For pageable allocations, \texttt{length} must be non-zero.

The stream association is specified using \texttt{flags} which must be one of \texttt{cudaMemAttachGlobal}, \texttt{cudaMemAttachHost} or \texttt{cudaMemAttachSingle}. The default value for \texttt{flags} is \texttt{cudaMemAttachSingle}. If the \texttt{cudaMemAttachGlobal} flag is specified, the memory can be accessed by any stream on any device. If the \texttt{cudaMemAttachHost} flag is specified, the program makes a guarantee that it won't access the memory on the device from any stream on a device that has a zero value for the device attribute \texttt{cudaDevAttrConcurrentManagedAccess}. If the \texttt{cudaMemAttachSingle} flag is specified and \texttt{stream} is associated with a device that has a zero value for the device attribute \texttt{cudaDevAttrConcurrentManagedAccess}, the program makes a guarantee that it will only access the memory on the device from \texttt{stream}. It is illegal to attach singly to the NULL stream, because the NULL stream is a virtual global stream and not a specific stream. An error will be returned in this case.

When memory is associated with a single stream, the Unified Memory system will allow CPU access to this memory region so long as all operations in \texttt{stream} have completed, regardless of whether other streams are active. In effect, this constrains exclusive ownership of the managed memory region by an active GPU to per-stream activity instead of whole-GPU activity.

Accessing memory on the device from streams that are not associated with it will produce undefined results. No error checking is performed by the Unified Memory system to ensure that kernels launched into other streams do not access this region.

It is a program's responsibility to order calls to \texttt{cudaStreamAttachMemAsync} via events, synchronization or other means to ensure legal access to memory at all times. Data visibility and coherency will be changed appropriately for all kernels which follow a stream-association change.

If \texttt{stream} is destroyed while data is associated with it, the association is removed and the association reverts to the default visibility of the allocation as specified at \texttt{cudaMallocManaged}. For __managed__ variables, the default association is always \texttt{cudaMemAttachGlobal}. Note that destroying a stream is an asynchronous operation, and as a result, the change to default association won't happen until all work in the stream has completed.

\textbf{Note:}
- Note that this function may also return error codes from previous, asynchronous launches.
Module

**CUDA Runtime API**

### cudasErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice

Note that this function may also return **cudasErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice** if this call tries to initialize internal CUDA RT state.

### cudaErrorInsufficientDriver or cudaErrorNoDevice

Note that as specified by **cudaStreamAddCallback** no CUDA function may be called from callback. **cudaErrorNotPermitted** may, but is not guaranteed to, be returned as a diagnostic in such case.

---

See also:


---

**__host__ cudaError_t cudaStreamBeginCapture**

_Begins graph capture on a stream._

**cudaStream_t stream, cudaStreamCaptureMode mode**

**Parameters**

- _stream_ - Stream in which to initiate capture
- _mode_ - Controls the interaction of this capture sequence with other API calls that are potentially unsafe.
  
  For more details see **cudaThreadExchangeStreamCaptureMode**.

**Returns**

- _cudaSuccess_, _cudaErrorInvalidValue_

**Description**

Begin graph capture on _stream_. When a stream is in capture mode, all operations pushed into the stream will not be executed, but will instead be captured into a graph, which will be returned via **cudaStreamEndCapture**. Capture may not be initiated if _stream_ is **cudaStreamLegacy**. Capture must be ended on the same stream in which it was initiated, and it may only be initiated if the stream is not already in capture mode. The capture mode may be queried via **cudaStreamIsCapturing**. A unique id representing the capture sequence may be queried via **cudaStreamGetCaptureInfo**.

If _mode_ is not cudaStreamCaptureModeRelaxed, **cudaStreamEndCapture** must be called on this stream from the same thread.

---

**Note:**

Kernels captured using this API must not use texture and surface references. Reading or writing through any texture or surface reference is undefined behavior. This restriction does not apply to texture and surface objects.
__host__ cudaError_t cudaStreamBeginCaptureToGraph(
    cudaStream_t stream, cudaGraph_t graph,
    const cudaGraphNode_t *dependencies, const
cudaGraphEdgeData *dependencyData, size_t
numDependencies, cudaStreamCaptureMode mode)

Begins graph capture on a stream to an existing graph.

Parameters

stream
    - Stream in which to initiate capture.

graph
    - Graph to capture into.

dependencies
    - Dependencies of the first node captured in the stream. Can be NULL if numDependencies is 0.

dependencyData
    - Optional array of data associated with each dependency.

numDependencies
    - Number of dependencies.

mode
    - Controls the interaction of this capture sequence with other API calls that are potentially unsafe.
    For more details see cudaThreadExchangeStreamCaptureMode.

Returns

cudaSuccess, cudaErrorInvalidValue

Description

Begin graph capture on stream. When a stream is in capture mode, all operations pushed into the
stream will not be executed, but will instead be captured into graph, which will be returned via
cudaStreamEndCapture.
Capture may not be initiated if `stream` is `cudaStreamLegacy`. Capture must be ended on the same stream in which it was initiated, and it may only be initiated if the stream is not already in capture mode. The capture mode may be queried via `cudaStreamIsCapturing`. A unique id representing the capture sequence may be queried via `cudaStreamGetCaptureInfo`.

If `mode` is not `cudaStreamCaptureModeRelaxed`, `cudaStreamEndCapture` must be called on this stream from the same thread.

---

**Note:**

Kernels captured using this API must not use texture and surface references. Reading or writing through any texture or surface reference is undefined behavior. This restriction does not apply to texture and surface objects.

---

**Note:**

Note that this function may also return error codes from previous, asynchronous launches.

See also:

`cudaStreamCreate`, `cudaStreamIsCapturing`, `cudaStreamEndCapture`, `cudaThreadExchangeStreamCaptureMode`

**__host__ cudaError_t cudaStreamCopyAttributes (cudaStream_t dst, cudaStream_t src)**

Copies attributes from source stream to destination stream.

**Parameters**

- **dst**
  - Destination stream
- **src**
  - Source stream For attributes see cudaStreamAttrID

**Returns**

- cudaSuccess, cudaErrorNotSupported

**Description**

Copies attributes from source stream `src` to destination stream `dst`. Both streams must have the same context.
**Note:**

Note that this function may also return error codes from previous, asynchronous launches.

See also:

`cudaAccessPolicyWindow`

```
__host__ cudaError_t cudaStreamCreate (cudaStream_t *pStream)
```

Create an asynchronous stream.

**Parameters**

**pStream**
- Pointer to new stream identifier

**Returns**

`cudaSuccess`, `cudaErrorInvalidValue`

**Description**

Creates a new asynchronous stream on the context that is current to the calling host thread. If no context is current to the calling host thread, then the primary context for a device is selected, made current to the calling thread, and initialized before creating a stream on it.

**Note:**

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

__host__ __device__ cudaError_t
cudaStreamCreateWithFlags (cudaStream_t *pStream, unsigned int flags)
Create an asynchronous stream.

Parameters

pStream
- Pointer to new stream identifier

flags
- Parameters for stream creation

Returns
cudaSuccess, cudaErrorInvalidValue

Description

Creates a new asynchronous stream on the context that is current to the calling host thread. If no context is current to the calling host thread, then the primary context for a device is selected, made current to the calling thread, and initialized before creating a stream on it. The flags argument determines the behaviors of the stream. Valid values for flags are

- cudaStreamDefault: Default stream creation flag.
- cudaStreamNonBlocking: Specifies that work running in the created stream may run concurrently with work in stream 0 (the NULL stream), and that the created stream should perform no implicit synchronization with stream 0.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
__host__ cudaError_t cudaStreamCreateWithPriority (cudaStream_t *pStream, unsigned int flags, int priority)

Create an asynchronous stream with the specified priority.

Parameters

pStream
- Pointer to new stream identifier

flags
- Flags for stream creation. See cudaStreamCreateWithFlags for a list of valid flags that can be passed

priority
- Priority of the stream. Lower numbers represent higher priorities. See cudaDeviceGetStreamPriorityRange for more information about the meaningful stream priorities that can be passed.

Returns

cudaSuccess, cudaErrorInvalidValue

Description

Creates a stream with the specified priority and returns a handle in pStream. The stream is created on the context that is current to the calling host thread. If no context is current to the calling host thread, then the primary context for a device is selected, made current to the calling thread, and initialized before creating a stream on it. This affects the scheduling priority of work in the stream. Priorities provide a hint to preferentially run work with higher priority when possible, but do not preempt already-running work or provide any other functional guarantee on execution order.

priority follows a convention where lower numbers represent higher priorities. '0' represents default priority. The range of meaningful numerical priorities can be queried using cudaDeviceGetStreamPriorityRange. If the specified priority is outside the numerical range returned by cudaDeviceGetStreamPriorityRange, it will automatically be clamped to the lowest or the highest number in the range.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
- Stream priorities are supported only on GPUs with compute capability 3.5 or higher.
In the current implementation, only compute kernels launched in priority streams are affected by the stream's priority. Stream priorities have no effect on host-to-device and device-to-host memory operations.

See also:

__host__ __device__ cudaError_t cudaStreamDestroy (cudaStream_t stream)
Destroys and cleans up an asynchronous stream.

Parameters
stream
- Stream identifier

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle

Description
Destroys and cleans up the asynchronous stream specified by stream.

In case the device is still doing work in the stream stream when cudaStreamDestroy() is called, the function will return immediately and the resources associated with stream will be released automatically once the device has completed all work in stream.

Note:
- This function uses standard default stream semantics.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
- Use of the handle after this call is undefined behavior.

See also:
cudaStreamCreate, cudaStreamCreateWithFlags, cudaStreamQuery, cudaStreamWaitEvent, cudaStreamSynchronize, cudaStreamAddCallback, cuStreamDestroy

__host__ cudaError_t cudaStreamEndCapture (cudaStream_t stream, cudaGraph_t *pGraph)

Ends capture on a stream, returning the captured graph.

Parameters
stream
   - Stream to query
pGraph
   - The captured graph

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorStreamCaptureWrongThread

Description
End capture on stream, returning the captured graph via pGraph. Capture must have been initiated on stream via a call to cudaStreamBeginCapture. If capture was invalidated, due to a violation of the rules of stream capture, then a NULL graph will be returned.

If the mode argument to cudaStreamBeginCapture was not cudaStreamCaptureModeRelaxed, this call must be from the same thread as cudaStreamBeginCapture.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaStreamCreate, cudaStreamBeginCapture, cudaStreamIsCapturing, cudaGraphDestroy

__host__ cudaError_t cudaStreamGetAttribute (cudaStream_t hStream, cudaStreamAttrID attr, cudaStreamAttrValue *value_out)

Queries stream attribute.

Parameters
hStream
attr
value_out

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle

Description
Queries attribute attr from hStream and stores it in corresponding member of value_out.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaAccessPolicyWindow

__host__ cudaError_t cudaStreamGetCaptureInfo
(cudaStream_t stream, cudaStreamCaptureStatus *captureStatus_out, unsigned long long *id_out,
cudaGraph_t *graph_out, const cudaGraphNode_t **dependencies_out, size_t *numDependencies_out)
Query a stream's capture state.

Parameters
stream
- The stream to query
captureStatus_out
- Location to return the capture status of the stream; required
id_out
- Optional location to return an id for the capture sequence, which is unique over the lifetime of the process
graph_out
- Optional location to return the graph being captured into. All operations other than destroy and node removal are permitted on the graph while the capture sequence is in progress. This API does not transfer ownership of the graph, which is transferred or destroyed at cudaStreamEndCapture. Note that the graph handle may be invalidated before end of capture for certain errors. Nodes that are or become unreachable from the original stream at cudaStreamEndCapture due to direct actions on the graph do not trigger cudaErrorStreamCaptureUnjoined.
**dependencies_out**
- Optional location to store a pointer to an array of nodes. The next node to be captured in the stream will depend on this set of nodes, absent operations such as event wait which modify this set. The array pointer is valid until the next API call which operates on the stream or until the capture is terminated. The node handles may be copied out and are valid until they or the graph is destroyed. The driver-owned array may also be passed directly to APIs that operate on the graph (not the stream) without copying.

**numDependencies_out**
- Optional location to store the size of the array returned in dependencies_out.

**Returns**
- cudaSuccess, cudaErrorInvalidValue, cudaErrorStreamCaptureImplicit

**Description**
Query stream state related to stream capture.

If called on cudaStreamLegacy (the "null stream") while a stream not created with cudaStreamNonBlocking is capturing, returns cudaErrorStreamCaptureImplicit.

Valid data (other than capture status) is returned only if both of the following are true:

- the call returns cudaSuccess
- the returned capture status is cudaStreamCaptureStatusActive

**Note:**
- Graph objects are not threadsafe. [More here](#).
- Note that this function may also return error codes from previous, asynchronous launches.

**See also:**
cudaStreamGetCaptureInfo_v3, cudaStreamBeginCapture, cudaStreamIsCapturing, cudaStreamUpdateCaptureDependencies
_cudaError_t cudaStreamGetCaptureInfo_v3
(cudaStream_t stream, cudaStreamCaptureStatus
*captureStatus_out, unsigned long long *id_out,
cudaGraph_t *graph_out, const cudaGraphNode_t
**dependencies_out, const cudaGraphEdgeData
**edgeData_out, size_t *numDependencies_out)

Query a stream's capture state (12.3+).

Parameters

stream
- The stream to query

captureStatus_out
- Location to return the capture status of the stream; required

id_out
- Optional location to return an id for the capture sequence, which is unique over the lifetime of the process

graph_out
- Optional location to return the graph being captured into. All operations other than destroy and node removal are permitted on the graph while the capture sequence is in progress. This API does not transfer ownership of the graph, which is transferred or destroyed at cudaStreamEndCapture. Note that the graph handle may be invalidated before end of capture for certain errors. Nodes that are or become unreachable from the original stream at cudaStreamEndCapture due to direct actions on the graph do not trigger cudaErrorStreamCaptureUnjoined.

dependencies_out
- Optional location to store a pointer to an array of nodes. The next node to be captured in the stream will depend on this set of nodes, absent operations such as event wait which modify this set. The array pointer is valid until the next API call which operates on the stream or until the capture is terminated. The node handles may be copied out and are valid until they or the graph is destroyed. The driver-owned array may also be passed directly to APIs that operate on the graph (not the stream) without copying.

dependencies_out
- Optional location to store a pointer to an array of graph edge data. This array parallels dependencies_out; the next node to be added has an edge to dependencies_out[i] with annotation edgeData_out[i] for each i. The array pointer is valid until the next API call which operates on the stream or until the capture is terminated.

numDependencies_out
- Optional location to store the size of the array returned in dependencies_out.
Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorStreamCaptureImplicit, cudaErrorLossyQuery

Description

Query stream state related to stream capture.

If called on cudaStreamLegacy (the "null stream") while a stream not created with cudaStreamNonBlocking is capturing, returns cudaErrorStreamCaptureImplicit.

Valid data (other than capture status) is returned only if both of the following are true:

- the call returns cudaSuccess
- the returned capture status is cudaStreamCaptureStatusActive

If edgeData_out is non-NULL then dependencies_out must be as well. If dependencies_out is non-NULL and edgeData_out is NULL, but there is non-zero edge data for one or more of the current stream dependencies, the call will return cudaErrorLossyQuery.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.

See also:

cudaStreamBeginCapture, cudaStreamIsCapturing, cudaStreamUpdateCaptureDependencies

__host__ cudaError_t cudaStreamGetFlags (cudaStream_t hStream, unsigned int *flags)

Query the flags of a stream.

Parameters

hStream
  - Handle to the stream to be queried

flags
  - Pointer to an unsigned integer in which the stream's flags are returned

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle
Description

Query the flags of a stream. The flags are returned in `flags`. See `cudaStreamCreateWithFlags` for a list of valid flags.

**Note:**
- This function uses standard `default stream` semantics.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cudaStreamCreateWithPriority`, `cudaStreamCreateWithFlags`, `cudaStreamGetPriority`, `cuStreamGetFlags`

```c
__host__ cudaError_t cudaStreamGetId (cudaStream_t hStream, unsigned long long *streamId)
```

Query the Id of a stream.

**Parameters**

- **hStream** - Handle to the stream to be queried
- **streamId** - Pointer to an unsigned long long in which the stream Id is returned

**Returns**

`cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorInvalidResourceHandle`

**Description**

Query the Id of a stream. The Id is returned in `streamId`. The Id is unique for the life of the program. The stream handle `hStream` can refer to any of the following:

- a stream created via any of the CUDA runtime APIs such as `cudaStreamCreate`, `cudaStreamCreateWithFlags` and `cudaStreamCreateWithPriority`, or their driver API equivalents such as `cuStreamCreate` or `cuStreamCreateWithPriority`. Passing an invalid handle will result in undefined behavior.
any of the special streams such as the NULL stream, `cudaStreamLegacy` and `cudaStreamPerThread` respectively. The driver API equivalents of these are also accepted which are NULL, `CU_STREAM_LEGACY` and `CU_STREAM_PER_THREAD`.

**Note:**
- This function uses standard default stream semantics.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
`cudaStreamCreateWithPriority`, `cudaStreamCreateWithFlags`, `cudaStreamGetPriority`, `cudaStreamGetFlags`, `cuStreamGetId`

```c
__host__ cudaError_t cudaStreamGetPriority (cudaStream_t hStream, int *priority)
```

Query the priority of a stream.

**Parameters**

- **hStream**
  - Handle to the stream to be queried
- **priority**
  - Pointer to a signed integer in which the stream's priority is returned

**Returns**

- `cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorInvalidResourceHandle`

**Description**

Query the priority of a stream. The priority is returned in `priority`. Note that if the stream was created with a priority outside the meaningful numerical range returned by `cudaDeviceGetStreamPriorityRange`, this function returns the clamped priority. See `cudaStreamCreateWithPriority` for details about priority clamping.

**Note:**
- Note that this function may also return error codes from previous, asynchronous launches.
Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.

Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaStreamCreateWithPriority, cudaDeviceGetStreamPriorityRange, cudaStreamGetFlags, cuStreamGetPriority

__host__ cudaError_t cudaStreamIsCapturing (cudaStream_t stream, cudaStreamCaptureStatus *pCaptureStatus)

Returns a stream's capture status.

Parameters
stream
- Stream to query
pCaptureStatus
- Returns the stream's capture status

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorStreamCaptureImplicit

Description
Return the capture status of stream via pCaptureStatus. After a successful call, *pCaptureStatus will contain one of the following:

- cudaStreamCaptureStatusNone: The stream is not capturing.
- cudaStreamCaptureStatusActive: The stream is capturing.
- cudaStreamCaptureStatusInvalidated: The stream was capturing but an error has invalidated the capture sequence. The capture sequence must be terminated with cudaStreamEndCapture on the stream where it was initiated in order to continue using stream.

Note that, if this is called on cudaStreamLegacy (the "null stream") while a blocking stream on the same device is capturing, it will return cudaErrorStreamCaptureImplicit and *pCaptureStatus is unspecified after the call. The blocking stream capture is not invalidated.

When a blocking stream is capturing, the legacy stream is in an unusable state until the blocking stream capture is terminated. The legacy stream is not supported for stream capture, but attempted use would have an implicit dependency on the capturing stream(s).
__host__ cudaError_t cudaStreamQuery (cudaStream_t stream)

Queries an asynchronous stream for completion status.

Parameters

- stream - Stream identifier

Returns

cudaSuccess, cudaErrorNotReady, cudaErrorInvalidResourceHandle

Description

Returns cudaSuccess if all operations in stream have completed, or cudaErrorNotReady if not.

For the purposes of Unified Memory, a return value of cudaSuccess is equivalent to having called cudaStreamSynchronize().
__host__ cudaError_t cudaStreamSetAttribute
(cudaStream_t hStream, cudaStreamAttrID attr, const cudaStreamAttrValue *value)
Sets stream attribute.

Parameters

hStream
attr
value

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle

Description
Sets attribute attr on hStream from corresponding attribute of value. The updated attribute will be applied to subsequent work submitted to the stream. It will not affect previously submitted work.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaAccessPolicyWindow

__host__ cudaError_t cudaStreamSynchronize
(cudaStream_t stream)
Waits for stream tasks to complete.

Parameters

stream

- Stream identifier

Returns
cudaSuccess, cudaErrorInvalidResourceHandle
Description

Blocks until stream has completed all operations. If the cudaDeviceScheduleBlockingSync flag was set for this device, the host thread will block until the stream is finished with all of its tasks.

Note:

- This function uses standard default stream semantics.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaStreamCreate, cudaStreamCreateWithFlags, cudaStreamQuery, cudaStreamWaitEvent, cudaStreamAddCallback, cudaStreamDestroy, cuStreamSynchronize

__host__ cudaError_t

cudaStreamUpdateCaptureDependencies (cudaStream_t stream, cudaGraphNode_t *dependencies, size_t numDependencies, unsigned int flags)

Update the set of dependencies in a capturing stream (11.3+).

Parameters

stream
  - The stream to update

dependencies
  - The set of dependencies to add

numDependencies
  - The size of the dependencies array

flags
  - See above

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorIllegalState
Description

Modifies the dependency set of a capturing stream. The dependency set is the set of nodes that the next captured node in the stream will depend on.

Valid flags are `cudaStreamAddCaptureDependencies` and `cudaStreamSetCaptureDependencies`. These control whether the set passed to the API is added to the existing set or replaces it. A flags value of 0 defaults to `cudaStreamAddCaptureDependencies`.

Nodes that are removed from the dependency set via this API do not result in `cudaErrorStreamCaptureUnjoined` if they are unreachable from the stream at `cudaStreamEndCapture`.

Returns `cudaErrorIllegalState` if the stream is not capturing.

This API is new in CUDA 11.3. Developers requiring compatibility across minor versions of the CUDA driver to 11.0 should not use this API or provide a fallback.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:

`cudaStreamBeginCapture`, `cudaStreamGetCaptureInfo`.

```c
__host__ cudaError_t
cudaStreamUpdateCaptureDependencies_v2 (cudaStream_t stream, cudaGraphNode_t *dependencies, const
cudaGraphEdgeData *dependencyData, size_t numDependencies, unsigned int flags)
```

Update the set of dependencies in a capturing stream (12.3+).

Parameters

**stream**
- The stream to update

**dependencies**
- The set of dependencies to add

**dependencyData**
- Optional array of data associated with each dependency.

**numDependencies**
- The size of the dependencies array
flags
- See above

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorIllegalState

Description
Modifies the dependency set of a capturing stream. The dependency set is the set of nodes that the next captured node in the stream will depend on.

Valid flags are cudaStreamAddCaptureDependencies and cudaStreamSetCaptureDependencies. These control whether the set passed to the API is added to the existing set or replaces it. A flags value of 0 defaults to cudaStreamAddCaptureDependencies.

Nodes that are removed from the dependency set via this API do not result in cudaErrorStreamCaptureUnjoined if they are unreachable from the stream at cudaStreamEndCapture.

Returns cudaErrorIllegalState if the stream is not capturing.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaStreamBeginCapture, cudaStreamGetCaptureInfo.

__host__ __device__ cudaError_t cudaStreamWaitEvent
(cudaStream_t stream, cudaEvent_t event, unsigned int flags)
Make a compute stream wait on an event.

Parameters
stream
- Stream to wait
event
- Event to wait on
flags
- Parameters for the operation(See above)

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle
Description

Makes all future work submitted to `stream` wait for all work captured in `event`. See `cudaEventRecord()` for details on what is captured by an event. The synchronization will be performed efficiently on the device when applicable. `event` may be from a different device than `stream`. Flags include:

- `cudaEventWaitDefault`: Default event creation flag.
- `cudaEventWaitExternal`: Event is captured in the graph as an external event node when performing stream capture.

Note:

- This function uses standard default stream semantics.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cudaStreamCreate`, `cudaStreamCreateWithFlags`, `cudaStreamQuery`, `cudaStreamSynchronize`, `cudaStreamAddCallback`, `cudaStreamDestroy`, `cuStreamWaitEvent`

__host__ `cudaError_t` cudaThreadExchangeStreamCaptureMode (`cudaStreamCaptureMode *mode`)

Swaps the stream capture interaction mode for a thread.

Parameters

- `mode` - Pointer to mode value to swap with the current mode

Returns

`cudaSuccess`, `cudaErrorInvalidValue`
Description

Sets the calling thread’s stream capture interaction mode to the value contained in *mode, and overwrites *mode with the previous mode for the thread. To facilitate deterministic behavior across function or module boundaries, callers are encouraged to use this API in a push-pop fashion:

```c
 cudaStreamCaptureMode mode = desiredMode;
 cudaThreadExchangeStreamCaptureMode(&mode);
 ... cudaThreadExchangeStreamCaptureMode(&mode); // restore previous mode
```

During stream capture (see `cudaStreamBeginCapture`), some actions, such as a call to `cudaMalloc`, may be unsafe. In the case of `cudaMalloc`, the operation is not enqueued asynchronously to a stream, and is not observed by stream capture. Therefore, if the sequence of operations captured via `cudaStreamBeginCapture` depended on the allocation being replayed whenever the graph is launched, the captured graph would be invalid.

Therefore, stream capture places restrictions on API calls that can be made within or concurrently to a `cudaStreamBeginCapture-cudaStreamEndCapture` sequence. This behavior can be controlled via this API and flags to `cudaStreamBeginCapture`.

A thread's mode is one of the following:

- **cudaStreamCaptureModeGlobal**: This is the default mode. If the local thread has an ongoing capture sequence that was not initiated with `cudaStreamCaptureModeRelaxed` at `cudaStreamBeginCapture`, or if any other thread has a concurrent capture sequence initiated with `cudaStreamCaptureModeGlobal`, this thread is prohibited from potentially unsafe API calls.

- **cudaStreamCaptureModeThreadLocal**: If the local thread has an ongoing capture sequence not initiated with `cudaStreamCaptureModeRelaxed`, it is prohibited from potentially unsafe API calls. Concurrent capture sequences in other threads are ignored.

- **cudaStreamCaptureModeRelaxed**: The local thread is not prohibited from potentially unsafe API calls. Note that the thread is still prohibited from API calls which necessarily conflict with stream capture, for example, attempting `cudaEventQuery` on an event that was last recorded inside a capture sequence.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:

`cudaStreamBeginCapture`
6.6. Event Management

This section describes the event management functions of the CUDA runtime application programming interface.

__host__ cudaError_t cudaEventCreate (cudaEvent_t *event)

Creates an event object.

Parameters

event
- Newly created event

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorLaunchFailure, cudaErrorMemoryAllocation

Description

Creates an event object for the current device using cudaEventDefault.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaEventCreate (C++ API), cudaEventCreateWithFlags, cudaEventRecord, cudaEventQuery, cudaEventSynchronize, cudaEventDestroy, cudaEventElapsedTime, cudaStreamWaitEvent, cuEventCreate
__host__ __device__ cudaError_t

cudaEventCreateWithFlags (cudaEvent_t *event, unsigned int flags)

Creates an event object with the specified flags.

Parameters

event
  - Newly created event
flags
  - Flags for new event

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorLaunchFailure, cudaErrorMemoryAllocation

Description

Creates an event object for the current device with the specified flags. Valid flags include:

- **cudaEventDefault**: Default event creation flag.
- **cudaEventBlockingSync**: Specifies that event should use blocking synchronization. A host thread that uses `cudaEventSynchronize()` to wait on an event created with this flag will block until the event actually completes.
- **cudaEventDisableTiming**: Specifies that the created event does not need to record timing data. Events created with this flag specified and the `cudaEventBlockingSync` flag not specified will provide the best performance when used with `cudaStreamWaitEvent()` and `cudaEventQuery()`.
- **cudaEventInterprocess**: Specifies that the created event may be used as an interprocess event by `cudaIpcGetEventHandle()`. `cudaEventInterprocess` must be specified along with `cudaEventDisableTiming`.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaEventCreate (C API), cudaEventSynchronize, cudaEventDestroy, cudaEventElapsedTime, cudaStreamWaitEvent, cuEventCreate

__host__ __device__ cudaError_t cudaEventDestroy (cudaEvent_t event)

Destroys an event object.

Parameters

event
- Event to destroy

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorLaunchFailure

Description

Destroys the event specified by event.

An event may be destroyed before it is complete (i.e., while cudaEventQuery() would return cudaErrorNotReady). In this case, the call does not block on completion of the event, and any associated resources will automatically be released asynchronously at completion.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
- Use of the handle after this call is undefined behavior.
- Returns cudaErrorInvalidResourceHandle in the event of being passed NULL as the input event.

See also:

cudaEventCreate (C API), cudaEventCreateWithFlags, cudaEventQuery, cudaEventSynchronize, cudaEventRecord, cudaEventElapsedTime, cuEventDestroy
__host__ cudaError_t cudaEventElapsedTime (float *ms, cudaEvent_t start, cudaEvent_t end)
Computes the elapsed time between events.

Parameters
ms
- Time between start and end in ms

start
- Starting event

end
- Ending event

Returns
cudaSuccess, cudaErrorNotReady, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorLaunchFailure, cudaErrorUnknown

Description
Computes the elapsed time between two events (in milliseconds with a resolution of around 0.5 microseconds).

If either event was last recorded in a non-NULL stream, the resulting time may be greater than expected (even if both used the same stream handle). This happens because the cudaEventRecord() operation takes place asynchronously and there is no guarantee that the measured latency is actually just between the two events. Any number of other different stream operations could execute in between the two measured events, thus altering the timing in a significant way.

If cudaEventRecord() has not been called on either event, then cudaErrorInvalidResourceHandle is returned. If cudaEventRecord() has been called on both events but one or both of them has not yet been completed (that is, cudaEventQuery() would return cudaErrorNotReady on at least one of the events), cudaErrorNotReady is returned. If either event was created with the cudaEventDisableTiming flag, then this function will return cudaErrorInvalidResourceHandle.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
- Returns cudaErrorInvalidResourceHandle in the event of being passed NULL as the input event.
See also:

cudaEventCreate ( C API), cudaEventCreateWithFlags, cudaEventQuery, cudaEventSynchronize, cudaEventDestroy, cudaEventRecord, cuEventElapsedTime

__host__ cudaError_t cudaEventQuery (cudaEvent_t event)
Queries an event's status.

Parameters

event
- Event to query

Returns

cudaSuccess, cudaErrorNotReady, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorLaunchFailure

Description
Queries the status of all work currently captured by event. See cudaEventRecord() for details on what is captured by an event.

Returns cudaSuccess if all captured work has been completed, or cudaErrorNotReady if any captured work is incomplete.

For the purposes of Unified Memory, a return value of cudaSuccess is equivalent to having called cudaEventSynchronize().

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
- Returns cudaErrorInvalidResourceHandle in the event of being passed NULL as the input event.

See also:

cudaEventCreate ( C API), cudaEventCreateWithFlags, cudaEventRecord, cudaEventSynchronize, cudaEventDestroy, cudaEventElapsedTime, cuEventQuery
__host__ __device__ cudaError_t cudaEventRecord (cudaEvent_t event, cudaStream_t stream)

Records an event.

Parameters

- **event** - Event to record
- **stream** - Stream in which to record event

Returns

- cudaSuccess
- cudaErrorInvalidValue
- cudaErrorInvalidResourceHandle
- cudaErrorLaunchFailure

Description

Captures in `event` the contents of `stream` at the time of this call. `event` and `stream` must be on the same CUDA context. Calls such as `cudaEventQuery()` or `cudaStreamWaitEvent()` will then examine or wait for completion of the work that was captured. Uses of `stream` after this call do not modify `event`. See note on default stream behavior for what is captured in the default case.

`cudaEventRecord()` can be called multiple times on the same event and will overwrite the previously captured state. Other APIs such as `cudaStreamWaitEvent()` use the most recently captured state at the time of the API call, and are not affected by later calls to `cudaEventRecord()`. Before the first call to `cudaEventRecord()`, an event represents an empty set of work, so for example `cudaEventQuery()` would return cudaSuccess.

Note:

- This function uses standard default stream semantics.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
- Returns cudaErrorInvalidResourceHandle in the event of being passed NULL as the input event.

See also:

cudaEventCreate (C API), cudaEventCreateWithFlags, cudaEventQuery, cudaEventSynchronize, cudaEventDestroy, cudaEventElapsedTime, cudaStreamWaitEvent, cudaEventRecordWithFlags, cuEventRecord
__host__ cudaError_t cudaEventRecordWithFlags
cudaEvent_t event, cudaStream_t stream, unsigned int flags)
Records an event.

Parameters

- **event**
  - Event to record

- **stream**
  - Stream in which to record event

- **flags**
  - Parameters for the operation (See above)

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorLaunchFailure

Description

Captures in **event** the contents of **stream** at the time of this call. **event** and **stream** must be on the same CUDA context. Calls such as cudaEventQuery() or cudaStreamWaitEvent() will then examine or wait for completion of the work that was captured. Uses of **stream** after this call do not modify **event**. See note on default stream behavior for what is captured in the default case.

cudaEventRecordWithFlags() can be called multiple times on the same event and will overwrite the previously captured state. Other APIs such as cudaStreamWaitEvent() use the most recently captured state at the time of the API call, and are not affected by later calls to cudaEventRecordWithFlags(). Before the first call to cudaEventRecordWithFlags(), an event represents an empty set of work, so for example cudaEventQuery() would return cudaSuccess.

flags include:

- **cudaEventRecordDefault**: Default event creation flag.
- **cudaEventRecordExternal**: Event is captured in the graph as an external event node when performing stream capture.

Note:

- This function uses standard default stream semantics.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
See also:

cudaEventCreate (C API), cudaEventCreateWithFlags, cudaEventQuery, cudaEventSynchronize, cudaEventDestroy, cudaEventElapsedTime, cudaStreamWaitEvent, cudaEventRecord, cuEventRecord,

__host__ cudaError_t cudaEventSynchronize (cudaEvent_t event)

Waits for an event to complete.

Parameters

event
- Event to wait for

Returns

cudaSuccess, cudaMemcpyError, cudaMemcpyInvalidResourceHandle, cudaMemcpyLaunchFailure

Description

Waits until the completion of all work currently captured in event. See cudaEventRecord() for details on what is captured by an event.

Waiting for an event that was created with the cudaMemcpyBlockingSync flag will cause the calling CPU thread to block until the event has been completed by the device. If the cudaMemcpyBlockingSync flag has not been set, then the CPU thread will busy-wait until the event has been completed by the device.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaMemcpyInitializationError, cudaMemcpyInsufficientDriver or cudaMemcpyNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpyStreamAddCallback no CUDA function may be called from callback. cudaMemcpyNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
- Returns cudaMemcpyInvalidResourceHandle in the event of being passed NULL as the input event.

See also:

cudaEventCreate (C API), cudaMemcpyCreateWithFlags, cudaMemcpyRecord, cudaMemcpyQuery, cudaMemcpyDestroy, cudaMemcpyElapsedTime, cudaMemcpySynchronize
6.7. External Resource Interoperability

This section describes the external resource interoperability functions of the CUDA runtime application programming interface.

__host__ cudaError_t cudaDestroyExternalMemory (cudaExternalMemory_t extMem)

Destroys an external memory object.

Parameters

extMem
- External memory object to be destroyed

Returns

cudaSuccess, cudaErrorInvalidResourceHandle

Description

Destroys the specified external memory object. Any existing buffers and CUDA mipmapped arrays mapped onto this object must no longer be used and must be explicitly freed using cudaFree and cudaFreeMipmappedArray respectively.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
- Use of the handle after this call is undefined behavior.

See also:

cudaImportExternalMemory, cudaExternalMemoryGetMappedBuffer, cudaExternalMemoryGetMappedMipmappedArray
__host__ cudaError_t cudaDestroyExternalSemaphore (cudaExternalSemaphore_t extSem)

Destroys an external semaphore.

Parameters

extSem
- External semaphore to be destroyed

Returns

cudaSuccess, cudaErrorInvalidResourceHandle

Description

Destroys an external semaphore object and releases any references to the underlying resource. Any outstanding signals or waits must have completed before the semaphore is destroyed.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaMemcpyInitializationError, cudaMemcpyInsufficientDriver or cudaMemcpyNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpyStreamAddCallback no CUDA function may be called from callback. cudaMemcpyNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
- Use of the handle after this call is undefined behavior.

See also:

cudaImportExternalSemaphore, cudaMemcpyExternalSemaphoresAsync, cudaMemcpyWaitExternalSemaphoresAsync
```c
__host__ cudaError_t
cudaExternalMemoryGetMappedBuffer (void **devPtr, cudaExternalMemory_t extMem, const cudaExternalMemoryBufferDesc *bufferDesc)
```
Maps a buffer onto an imported memory object.

**Parameters**

**devPtr**
- Returned device pointer to buffer

**extMem**
- Handle to external memory object

**bufferDesc**
- Buffer descriptor

**Returns**

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle

**Description**
Maps a buffer onto an imported memory object and returns a device pointer in `devPtr`. The properties of the buffer being mapped must be described in `bufferDesc`. The `cudaExternalMemoryBufferDesc` structure is defined as follows:

```c
typedef struct cudaExternalMemoryBufferDesc_st {
    unsigned long long offset;
    unsigned long long size;
    unsigned int flags;
} cudaExternalMemoryBufferDesc;
```

where `cudaExternalMemoryBufferDesc::offset` is the offset in the memory object where the buffer's base address is. `cudaExternalMemoryBufferDesc::size` is the size of the buffer. `cudaExternalMemoryBufferDesc::flags` must be zero.

The offset and size have to be suitably aligned to match the requirements of the external API. Mapping two buffers whose ranges overlap may or may not result in the same virtual address being returned for the overlapped portion. In such cases, the application must ensure that all accesses to that region from the GPU are volatile. Otherwise writes made via one address are not guaranteed to be visible via the other address, even if they're issued by the same thread. It is recommended that applications map the combined range instead of mapping separate buffers and then apply the appropriate offsets to the returned pointer to derive the individual buffers.

The returned pointer `devPtr` must be freed using `cudaFree`.
Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cudaImportExternalMemory`, `cudaDestroyExternalMemory`,
`cudaExternalMemoryGetMappedMipmappedArray`

```c
__host__ cudaError_t
cudaExternalMemoryGetMappedMipmappedArray
(cudaMipmappedArray_t *mipmap,
cudaExternalMemory_t extMem, const
cudaExternalMemoryMipmappedArrayDesc
*mipmapDesc)
```

Maps a CUDA mipmapped array onto an external memory object.

**Parameters**

- **mipmap**
  - Returned CUDA mipmapped array
- **extMem**
  - Handle to external memory object
- **mipmapDesc**
  - CUDA array descriptor

**Returns**

`cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorInvalidResourceHandle`

**Description**

Maps a CUDA mipmapped array onto an external object and returns a handle to it in `mipmap`.

The properties of the CUDA mipmapped array being mapped must be described in `mipmapDesc`. The structure `cudaExternalMemoryMipmappedArrayDesc` is defined as follows:

```c
typedef struct cudaExternalMemoryMipmappedArrayDesc_st {
    unsigned long long offset;
    cudaChannelFormatDesc formatDesc;
} cudaExternalMemoryMipmappedArrayDesc;
```
where `cudaExternalMemoryMipmappedArrayDesc::offset` is the offset in the memory object where the base level of the mipmap chain is. `cudaExternalMemoryMipmappedArrayDesc::formatDesc` describes the format of the data. `cudaExternalMemoryMipmappedArrayDesc::extent` specifies the dimensions of the base level of the mipmap chain. `cudaExternalMemoryMipmappedArrayDesc::flags` are flags associated with CUDA mipmapped arrays. For further details, please refer to the documentation for `cudaMalloc3DArray`. Note that if the mipmapped array is bound as a color target in the graphics API, then the flag `cudaArrayColorAttachment` must be specified in `cudaExternalMemoryMipmappedArrayDesc::flags`. `cudaExternalMemoryMipmappedArrayDesc::numLevels` specifies the total number of levels in the mipmap chain.

The returned CUDA mipmapped array must be freed using `cudaFreeMipmappedArray`.

---

**Note:**

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cudaImportExternalMemory`, `cudaDestroyExternalMemory`, `cudaExternalMemoryGetMappedBuffer`

---

If `cudaExternalMemoryHandleDesc::type` is `cudaExternalMemoryHandleTypeNvSciBuf`, then `cudaExternalMemoryMipmappedArrayDesc::numLevels` must not be greater than 1.

```c
__host__ cudaError_t cudaImportExternalMemory
(cudaExternalMemory_t *extMem_out, const cudaExternalMemoryHandleDesc *memHandleDesc)
```

Imports an external memory object.

**Parameters**

*extMem_out*

- Returned handle to an external memory object
**memHandleDesc**
- Memory import handle descriptor

**Returns**
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorOperatingSystem

**Description**
Imports an externally allocated memory object and returns a handle to that in `extMem_out`.
The properties of the handle being imported must be described in `memHandleDesc`. The `cudaExternalMemoryHandleDesc` structure is defined as follows:

```c
typedef struct cudaExternalMemoryHandleDesc_st {
cudaExternalMemoryHandleType type;
union {
    int fd;
    struct {
        void *handle;
        const void *name;
    } win32;
    const void *nvSciBufObject;
} handle;
unsigned long long size;
unsigned int flags;
} cudaExternalMemoryHandleDesc;
```

where `cudaExternalMemoryHandleDesc::type` specifies the type of handle being imported.
`cudaExternalMemoryHandleType` is defined as:

```c
typedef enum cudaExternalMemoryHandleType_enum {
cudaExternalMemoryHandleTypeOpaqueFd = 1,
cudaExternalMemoryHandleTypeOpaqueWin32 = 2,
cudaExternalMemoryHandleTypeOpaqueWin32Kmt = 3,
cudaExternalMemoryHandleTypeD3D12Heap = 4,
cudaExternalMemoryHandleTypeD3D12Resource = 5,
cudaExternalMemoryHandleTypeD3D11Resource = 6,
cudaExternalMemoryHandleTypeD3D11ResourceKmt = 7,
cudaExternalMemoryHandleTypeNvSciBuf = 8
} cudaExternalMemoryHandleType;
```

If `cudaExternalMemoryHandleDesc::type` is `cudaExternalMemoryHandleTypeOpaqueFd`, then
`cudaExternalMemoryHandleDesc::handle::fd` must be a valid file descriptor referencing a memory
object. Ownership of the file descriptor is transferred to the CUDA driver when the handle is imported
successfully. Performing any operations on the file descriptor after it is imported results in undefined
behavior.

If `cudaExternalMemoryHandleDesc::type` is `cudaExternalMemoryHandleTypeOpaqueWin32`,
then exactly one of `cudaExternalMemoryHandleDesc::handle::win32::handle` and
`cudaExternalMemoryHandleDesc::handle::win32::name` must not be NULL. If
`cudaExternalMemoryHandleDesc::handle::win32::handle` is not NULL, then it must represent a valid
shared NT handle that references a memory object. Ownership of this handle is not transferred to
CUDA after the import operation, so the application must release the handle using the appropriate
system call. If `cudaExternalMemoryHandleDesc::handle::win32::name` is not NULL, then it must point
to a NULL-terminated array of UTF-16 characters that refers to a memory object.
If `cudaExternalMemoryHandleDesc::type` is `cudaExternalMemoryHandleTypeOpaqueWin32Kmt`, then `cudaExternalMemoryHandleDesc::handle` must be non-NULL and `cudaExternalMemoryHandleDesc::handle::win32::name` must be NULL. The handle specified must be a globally shared KMT handle. This handle does not hold a reference to the underlying object, and thus will be invalid when all references to the memory object are destroyed.

If `cudaExternalMemoryHandleDesc::type` is `cudaExternalMemoryHandleTypeD3D12Heap`, then exactly one of `cudaExternalMemoryHandleDesc::handle::win32::handle` and `cudaExternalMemoryHandleDesc::handle::win32::name` must not be NULL. If `cudaExternalMemoryHandleDesc::handle::win32::handle` is not NULL, then it must represent a valid shared NT handle that is returned by `ID3D12Device::CreateSharedHandle` when referring to a ID3D12Heap object. This handle holds a reference to the underlying object. If `cudaExternalMemoryHandleDesc::handle::win32::name` is not NULL, then it must point to a NULL-terminated array of UTF-16 characters that refers to a ID3D12Heap object.

If `cudaExternalMemoryHandleDesc::type` is `cudaExternalMemoryHandleTypeD3D12Resource`, then exactly one of `cudaExternalMemoryHandleDesc::handle::win32::handle` and `cudaExternalMemoryHandleDesc::handle::win32::name` must not be NULL. If `cudaExternalMemoryHandleDesc::handle::win32::handle` is not NULL, then it must represent a valid shared NT handle that is returned by `ID3D12Device::CreateSharedHandle` when referring to a ID3D12Resource object. This handle holds a reference to the underlying object. If `cudaExternalMemoryHandleDesc::handle::win32::name` is not NULL, then it must point to a NULL-terminated array of UTF-16 characters that refers to a ID3D12Resource object.

If `cudaExternalMemoryHandleDesc::type` is `cudaExternalMemoryHandleTypeD3D11Resource`, then exactly one of `cudaExternalMemoryHandleDesc::handle::win32::handle` and `cudaExternalMemoryHandleDesc::handle::win32::name` must not be NULL. If `cudaExternalMemoryHandleDesc::handle::win32::handle` is not NULL, then it must represent a valid shared NT handle that is returned by `IDXGIResource1::CreateSharedHandle` when referring to a ID3D11Resource object. If `cudaExternalMemoryHandleDesc::handle::win32::name` is not NULL, then it must point to a NULL-terminated array of UTF-16 characters that refers to a ID3D11Resource object.

If `cudaExternalMemoryHandleDesc::type` is `cudaExternalMemoryHandleTypeD3D11ResourceKmt`, then `cudaExternalMemoryHandleDesc::handle::win32::handle` must be non-NULL and `cudaExternalMemoryHandleDesc::handle::win32::name` must be NULL. The handle specified must be a valid shared KMT handle that is returned by `IDXGIResource::GetSharedHandle` when referring to a ID3D11Resource object.

If `cudaExternalMemoryHandleDesc::type` is `cudaExternalMemoryHandleTypeNvSciBuf`, then `cudaExternalMemoryHandleDesc::handle::nvSciBufObject` must be NON-NULL and reference a valid NvSciBuf object. If the NvSciBuf object imported into CUDA is also mapped by other drivers, then the application must use `cudaWaitExternalSemaphoresAsync` or `cudaSignalExternalSemaphoresAsync` as appropriate barriers to maintain coherence between CUDA and the other drivers. See `cudaExternalSemaphoreWaitSkipNvSciBufMemSync` and `cudaExternalSemaphoreSignalSkipNvSciBufMemSync` for memory synchronization.
The size of the memory object must be specified in `cudaExternalMemoryHandleDesc::size`. Specifying the flag `cudaExternalMemoryDedicated` in `cudaExternalMemoryHandleDesc::flags` indicates that the resource is a dedicated resource. The definition of what a dedicated resource is outside the scope of this extension. This flag must be set if `cudaExternalMemoryHandleDesc::type` is one of the following: `cudaExternalMemoryHandleTypeD3D12Resource`, `cudaExternalMemoryHandleTypeD3D11ResourceKmt`, and `cudaExternalMemoryHandleTypeD3D11Resource`

**Note:**
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.
- If the Vulkan memory imported into CUDA is mapped on the CPU then the application must use `vkInvalidateMappedMemoryRanges/vkFlushMappedMemoryRanges` as well as appropriate Vulkan pipeline barriers to maintain coherence between CPU and GPU. For more information on these APIs, please refer to "Synchronization and Cache Control" chapter from Vulkan specification.

See also:
- `cudaDestroyExternalMemory`, `cudaExternalMemoryGetMappedBuffer`, `cudaExternalMemoryGetMappedMipmappedArray`

```c
__host__ cudaError_t cudaImportExternalSemaphore (cudaExternalSemaphore_t *extSem_out, const cudaExternalSemaphoreHandleDesc *semHandleDesc)
```

Imports an external semaphore.

**Parameters**

- `extSem_out` - Returned handle to an external semaphore
- `semHandleDesc` - Semaphore import handle descriptor

**Returns**

- `cudaSuccess`, `cudaErrorInvalidResourceHandle`, `cudaErrorOperatingSystem`
## Description

Imports an externally allocated synchronization object and returns a handle to that in `extSem_out`. The properties of the handle being imported must be described in `semHandleDesc`. The `cudaExternalSemaphoreHandleDesc` is defined as follows:

```c
typedef struct cudaExternalSemaphoreHandleDesc_st {
    cudaExternalSemaphoreHandleType type;
    union {
        int fd;
        struct {
            void *handle;
            const void *name;
        } win32;
        const void* NvSciSyncObj;
    } handle;
    unsigned int flags;
} cudaExternalSemaphoreHandleDesc;
```

where `cudaExternalSemaphoreHandleDesc::type` specifies the type of handle being imported. `cudaExternalSemaphoreHandleType` is defined as:

```c
typedef enum cudaExternalSemaphoreHandleType_enum {
    cudaExternalSemaphoreHandleTypeOpaqueFd = 1,
    cudaExternalSemaphoreHandleTypeOpaqueWin32 = 2,
    cudaExternalSemaphoreHandleTypeOpaqueWin32Kmt = 3,
    cudaExternalSemaphoreHandleTypeD3D12Fence = 4,
    cudaExternalSemaphoreHandleTypeD3D11Fence = 5,
    cudaExternalSemaphoreHandleTypeNvSciSync = 6,
    cudaExternalSemaphoreHandleTypeKeyedMutex = 7,
    cudaExternalSemaphoreHandleTypeKeyedMutexKmt = 8,
    cudaExternalSemaphoreHandleTypeTimelineSemaphoreFd = 9,
    cudaExternalSemaphoreHandleTypeTimelineSemaphoreWin32 = 10
} cudaExternalSemaphoreHandleType;
```

If `cudaExternalSemaphoreHandleDesc::type` is `cudaExternalSemaphoreHandleTypeOpaqueFd`, then `cudaExternalSemaphoreHandleDesc::handle::fd` must be a valid file descriptor referencing a synchronization object. Ownership of the file descriptor is transferred to the CUDA driver when the handle is imported successfully. Performing any operations on the file descriptor after it is imported results in undefined behavior.

If `cudaExternalSemaphoreHandleDesc::type` is `cudaExternalSemaphoreHandleTypeOpaqueWin32`, then exactly one of `cudaExternalSemaphoreHandleDesc::handle::win32::handle` and `cudaExternalSemaphoreHandleDesc::handle::win32::name` must not be NULL. If `cudaExternalSemaphoreHandleDesc::handle::win32::handle` is not NULL, then it must represent a valid shared NT handle that references a synchronization object. Ownership of this handle is not transferred to CUDA after the import operation, so the application must release the handle using the appropriate system call. If `cudaExternalSemaphoreHandleDesc::handle::win32::name` is not NULL, then it must name a valid synchronization object.

If `cudaExternalSemaphoreHandleDesc::type` is `cudaExternalSemaphoreHandleTypeOpaqueWin32Kmt`, then `cudaExternalSemaphoreHandleDesc::handle::win32::name` must not be NULL and `cudaExternalSemaphoreHandleDesc::handle::win32::handle` must be non-NULL.
be a globally shared KMT handle. This handle does not hold a reference to the underlying object, and thus will be invalid when all references to the synchronization object are destroyed.

If `cudaExternalSemaphoreHandleDesc::type` is `cudaExternalSemaphoreHandleTypeD3D12Fence`, then exactly one of `cudaExternalSemaphoreHandleDesc::handle::win32::handle` and `cudaExternalSemaphoreHandleDesc::handle::win32::name` must not be NULL. If `cudaExternalSemaphoreHandleDesc::handle::win32::handle` is not NULL, then it must represent a valid shared NT handle that is returned by `ID3D12Device::CreateSharedHandle` when referring to a `ID3D12Fence` object. This handle holds a reference to the underlying object. If `cudaExternalSemaphoreHandleDesc::handle::win32::name` is not NULL, then it must name a valid synchronization object that refers to a valid `ID3D12Fence` object.

If `cudaExternalSemaphoreHandleDesc::type` is `cudaExternalSemaphoreHandleTypeD3D11Fence`, then exactly one of `cudaExternalSemaphoreHandleDesc::handle::win32::handle` and `cudaExternalSemaphoreHandleDesc::handle::win32::name` must not be NULL. If `cudaExternalSemaphoreHandleDesc::handle::win32::handle` is not NULL, then it must represent a valid shared NT handle that is returned by `ID3D11Fence::CreateSharedHandle`. If `cudaExternalSemaphoreHandleDesc::handle::win32::name` is not NULL, then it must name a valid synchronization object that refers to a valid `ID3D11Fence` object.

If `cudaExternalSemaphoreHandleDesc::type` is `cudaExternalSemaphoreHandleTypeNvSciSync`, then `cudaExternalSemaphoreHandleDesc::handle::nvSciSyncObj` represents a valid `NvSciSyncObj`.

If `cudaExternalSemaphoreHandleDesc::type` is `cudaExternalSemaphoreHandleTypeKeyedMutex`, then exactly one of `cudaExternalSemaphoreHandleDesc::handle::win32::handle` and `cudaExternalSemaphoreHandleDesc::handle::win32::name` must not be NULL. If `cudaExternalSemaphoreHandleDesc::handle::win32::handle` is not NULL, then it represents a valid shared NT handle that is returned by `IDXGIResource1::CreateSharedHandle` when referring to a `IDXGIKeyedMutex` object.

If `cudaExternalSemaphoreHandleDesc::type` is `cudaExternalSemaphoreHandleTypeKeyedMutexKmt`, then `cudaExternalSemaphoreHandleDesc::handle::fd` must be non-NULL and must represent a valid KMT handle that is returned by `IDXGIResource::GetSharedHandle` when referring to a `IDXGIKeyedMutex` object.

If `cudaExternalSemaphoreHandleDesc::type` is `cudaExternalSemaphoreHandleTypeTimelineSemaphoreFd`, then `cudaExternalSemaphoreHandleDesc::handle::fd` must be a valid file descriptor referencing a synchronization object. Ownership of the file descriptor is transferred to the CUDA driver when the handle is imported successfully. Performing any operations on the file descriptor after it is imported results in undefined behavior.

If `cudaExternalSemaphoreHandleDesc::type` is `cudaExternalSemaphoreHandleTypeTimelineSemaphoreWin32`, then exactly one of `cudaExternalSemaphoreHandleDesc::handle::win32::handle` and `cudaExternalSemaphoreHandleDesc::handle::win32::name` must not be NULL. If `cudaExternalSemaphoreHandleDesc::handle::win32::handle` is not NULL, then it must represent
a valid shared NT handle that references a synchronization object. Ownership of this handle is not transferred to CUDA after the import operation, so the application must release the handle using the appropriate system call. If cudaExternalSemaphoreHandleDesc::handle::win32::name is not NULL, then it must name a valid synchronization object.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaDestroyExternalSemaphore, cudaSignalExternalSemaphoresAsync, cudaWaitExternalSemaphoresAsync

__host__ cudaError_t cudaSignalExternalSemaphoresAsync(const cudaExternalSemaphore_t *extSemArray, const cudaExternalSemaphoreSignalParams *paramsArray, unsigned int numExtSems, cudaStream_t stream)

Signals a set of external semaphore objects.

Parameters

- **extSemArray**: Set of external semaphores to be signaled
- **paramsArray**: Array of semaphore parameters
- **numExtSems**: Number of semaphores to signal
- **stream**: Stream to enqueue the signal operations in

Returns

cudaSuccess, cudaErrorInvalidResourceHandle

Description

Enqueues a signal operation on a set of externally allocated semaphore object in the specified stream. The operations will be executed when all prior operations in the stream complete.
The exact semantics of signaling a semaphore depends on the type of the object.

If the semaphore object is any one of the following types:

- `cudaExternalSemaphoreHandleTypeOpaqueFd`, `cudaExternalSemaphoreHandleTypeOpaqueWin32`,
- `cudaExternalSemaphoreHandleTypeOpaqueWin32Kmt`
then signaling the semaphore will set it to the signaled state.

If the semaphore object is any one of the following types:

- `cudaExternalSemaphoreHandleTypeD3D12Fence`, `cudaExternalSemaphoreHandleTypeD3D11Fence`,
- `cudaExternalSemaphoreHandleTypeTimelineSemaphoreFd`,
- `cudaExternalSemaphoreHandleTypeTimelineSemaphoreWin32`
then the semaphore will be set to the value specified in `cudaExternalSemaphoreSignalParams::params::fence::value`.

If the semaphore object is of the type `cudaExternalSemaphoreHandleTypeNvSciSync` this API sets `cudaExternalSemaphoreSignalParams::params::nvSciSync::fence` to a value that can be used by subsequent waiters of the same NvSciSync object to order operations with those currently submitted in stream. Such an update will overwrite previous contents of `cudaExternalSemaphoreSignalParams::params::nvSciSync::fence`. By default, signaling such an external semaphore object causes appropriate memory synchronization operations to be performed over all the external memory objects that are imported as `cudaExternalMemoryHandleTypeNvSciBuf`. This ensures that any subsequent accesses made by other importers of the same set of NvSciBuf memory object(s) are coherent. These operations can be skipped by specifying the flag `cudaExternalSemaphoreSignalSkipNvSciBufMemSync`, which can be used as a performance optimization when data coherency is not required. But specifying this flag in scenarios where data coherency is required results in undefined behavior. Also, for semaphore object of the type `cudaExternalSemaphoreHandleTypeNvSciSync`, if the NvSciSyncAttrList used to create the NvSciSyncObj had not set the flags in `cudaDeviceGetNvSciSyncAttributes` to `cudaNvSciSyncAttrSignal`, this API will return `cudaErrorNotSupported`.

For this the `NvSciSyncAttrKey_RequireDeterministicFences` key set to true. Deterministic fences allow users to enqueue a wait over the semaphore object even before corresponding signal is enqueued. For such a semaphore object, CUDA guarantees that each signal operation will increment the fence value by '1'. Users are expected to track count of signals enqueued on the semaphore object and insert waits accordingly. When such a semaphore object is signaled from multiple streams, due to concurrent stream execution, it is possible that the order in which the semaphore gets signaled is indeterministic. This could lead to waiters of the semaphore getting unblocked incorrectly. Users are expected to handle such situations, either by not using the same semaphore object with deterministic fence support enabled in different streams or by adding explicit dependency amongst such streams so that the semaphore is signaled in order.

If the semaphore object is any one of the following types:

- `cudaExternalSemaphoreHandleTypeKeyedMutex`,

CUDA Runtime API
cudaExternalSemaphoreHandleTypeKeyedMutexKmt, then the keyed mutex will be released with the key specified in cudaExternalSemaphoreSignalParams::params::keyedmutex::key.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaImportExternalSemaphore, cudaDestroyExternalSemaphore, cudaWaitExternalSemaphoresAsync

__host__ cudaError_t cudaWaitExternalSemaphoresAsync
(const cudaExternalSemaphore_t *extSemArray, const cudaExternalSemaphoreWaitParams *paramsArray,
unsigned int numExtSems, cudaStream_t stream)
Waits on a set of external semaphore objects.

Parameters
extSemArray
- External semaphores to be waited on
paramsArray
- Array of semaphore parameters
numExtSems
- Number of semaphores to wait on
stream
- Stream to enqueue the wait operations in

Returns
cudaSuccess, cudaErrorInvalidResourceHandle cudaErrorTimeout

Description
Enqueues a wait operation on a set of externally allocated semaphore object in the specified stream. The operations will be executed when all prior operations in the stream complete.
The exact semantics of waiting on a semaphore depends on the type of the object.
If the semaphore object is any one of the following types:

- `cudaExternalSemaphoreHandleTypeOpaqueFd`
- `cudaExternalSemaphoreHandleTypeOpaqueWin32`
- `cudaExternalSemaphoreHandleTypeOpaqueWin32Kmt`

then waiting on the semaphore will wait until the semaphore reaches the signaled state. The semaphore will then be reset to the unsignaled state. Therefore for every signal operation, there can only be one wait operation.

If the semaphore object is any one of the following types:

- `cudaExternalSemaphoreHandleTypeD3D12Fence`
- `cudaExternalSemaphoreHandleTypeD3D11Fence`
- `cudaExternalSemaphoreHandleTypeTimelineSemaphoreFd`
- `cudaExternalSemaphoreHandleTypeTimelineSemaphoreWin32`

then waiting on the semaphore will wait until the value of the semaphore is greater than or equal to `cudaExternalSemaphoreWaitParams::params::fence::value`.

If the semaphore object is of the type `cudaExternalSemaphoreHandleTypeNvSciSync` then, waiting on the semaphore will wait until the `cudaExternalSemaphoreSignalParams::params::nvSciSync::fence` is signaled by the signaler of the NvSciSyncObj that was associated with this semaphore object. By default, waiting on such an external semaphore object causes appropriate memory synchronization operations to be performed over all external memory objects that are imported as `cudaExternalMemoryHandleTypeNvSciBuf`. This ensures that any subsequent accesses made by other importers of the same set of NvSciBuf memory object(s) are coherent. These operations can be skipped by specifying the flag `cudaExternalSemaphoreWaitSkipNvSciBufMemSync`, which can be used as a performance optimization when data coherency is not required. But specifying this flag in scenarios where data coherency is required results in undefined behavior. Also, for semaphore object of the type `cudaExternalSemaphoreHandleTypeNvSciSync`, if the `NvSciSyncAttrList` used to create the NvSciSyncObj had not set the flags in `cudaDeviceGetNvSciSyncAttributes` to `cudaNvSciSyncAttrWait`, this API will return `cudaErrorNotSupported`.

If the semaphore object is any one of the following types:

- `cudaExternalSemaphoreHandleTypeKeyedMutex`
- `cudaExternalSemaphoreHandleTypeKeyedMutexKmt`

then the keyed mutex will be acquired when it is released with the key specified in `cudaExternalSemaphoreSignalParams::params::keyedmutex::key` or until the timeout specified by `cudaExternalSemaphoreSignalParams::params::keyedmutex::timeoutMs` has lapsed. The timeout interval can either be a finite value specified in milliseconds or an infinite value. In case an infinite value is specified the timeout never elapses. The windows INFINITE macro must be used to specify infinite timeout.

**Note:**

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.
See also:
cudaImportExternalSemaphore, cudaDestroyExternalSemaphore,
cudaSignalExternalSemaphoresAsync

6.8. Execution Control

This section describes the execution control functions of the CUDA runtime application programming interface.

Some functions have overloaded C++ API template versions documented separately in the C++ API Routines module.

__host__ __device__ cudaError_t cudaFuncGetAttributes (cudaFuncAttributes *attr, const void *func)

Find out attributes for a given function.

Parameters

attr
- Return pointer to function's attributes

func
- Device function symbol

Returns
cudaSuccess, cudaErrorInvalidDeviceFunction

Description

This function obtains the attributes of a function specified via func. func is a device function symbol and must be declared as a __global__ function. The fetched attributes are placed in attr. If the specified function does not exist, then cudaErrorInvalidDeviceFunction is returned. For templated functions, pass the function symbol as follows: func_name<template_arg_0,...,template_arg_N>

Note that some function attributes such as maxThreadsPerBlock may vary based on the device that is currently being used.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Use of a string naming a function as the func parameter was deprecated in CUDA 4.1 and removed in CUDA 5.0.
__host__ cudaError_t cudaFuncGetName (const char **name, const void *func)

Returns the function name for a device entry function pointer.

Parameters

name
- The returned name of the function

func
- The function pointer to retrieve name for

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidDeviceFunction

Description

Returns in **name the function name associated with the symbol func. The function name is returned as a null-terminated string. This API may return a mangled name if the function is not declared as having C linkage. If **name is NULL, cudaErrorInvalidValue is returned. If func is not a device entry function, cudaErrorInvalidDeviceFunction is returned.

Note:

- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
__host__ cudaError_t cudaFuncGetParamInfo (const void *func, size_t paramIndex, size_t *paramOffset, size_t *paramSize)

Returns the offset and size of a kernel parameter in the device-side parameter layout.

Parameters

func
  - The function to query
paramIndex
  - The parameter index to query
paramOffset
  - The offset into the device-side parameter layout at which the parameter resides
paramSize
  - The size of the parameter in the device-side parameter layout

Returns

CUDA_SUCCESS, CUDA_ERROR_INVALID_VALUE.

Description

Queries the kernel parameter at paramIndex in func's list of parameters and returns parameter information via paramOffset and paramSize. paramOffset returns the offset of the parameter in the device-side parameter layout. paramSize returns the size in bytes of the parameter. This information can be used to update kernel node parameters from the device via cudaGraphKernelNodeSetParam() and cudaGraphKernelNodeUpdatesApply(). paramIndex must be less than the number of parameters that func takes.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

__host__ cudaError_t cudaFuncSetAttribute (const void *func, cudaFuncAttribute attr, int value)

Set attributes for a given function.

Parameters

func
  - Function to get attributes of
attr
- Attribute to set

value
- Value to set

Returns
cudaSuccess, cudaErrorInvalidDeviceFunction, cudaErrorInvalidValue

Description
This function sets the attributes of a function specified via `func`. The parameter `func` must be a pointer to a function that executes on the device. The parameter specified by `func` must be declared as a `__global__` function. The enumeration defined by `attr` is set to the value defined by `value`. If the specified function does not exist, then `cudaErrorInvalidDeviceFunction` is returned. If the specified attribute cannot be written, or if the value is incorrect, then `cudaErrorInvalidValue` is returned.

Valid values for `attr` are:

- `cudaFuncAttributeMaxDynamicSharedMemorySize` - The requested maximum size in bytes of dynamically-allocated shared memory. The sum of this value and the function attribute `sharedSizeBytes` cannot exceed the device attribute `cudaDevAttrMaxSharedMemoryPerBlockOptin`. The maximal size of requestable dynamic shared memory may differ by GPU architecture.

- `cudaFuncAttributePreferredSharedMemoryCarveout` - On devices where the L1 cache and shared memory use the same hardware resources, this sets the shared memory carveout preference, in percent of the total shared memory. See `cudaDevAttrMaxSharedMemoryPerMultiprocessor`. This is only a hint, and the driver can choose a different ratio if required to execute the function.

- `cudaFuncAttributeRequiredClusterWidth`: The required cluster width in blocks. The width, height, and depth values must either all be 0 or all be positive. The validity of the cluster dimensions is checked at launch time. If the value is set during compile time, it cannot be set at runtime. Setting it at runtime will return `cudaErrorNotPermitted`.

- `cudaFuncAttributeRequiredClusterHeight`: The required cluster height in blocks. The width, height, and depth values must either all be 0 or all be positive. The validity of the cluster dimensions is checked at launch time. If the value is set during compile time, it cannot be set at runtime. Setting it at runtime will return `cudaErrorNotPermitted`.

- `cudaFuncAttributeRequiredClusterDepth`: The required cluster depth in blocks. The width, height, and depth values must either all be 0 or all be positive. The validity of the cluster dimensions is checked at launch time. If the value is set during compile time, it cannot be set at runtime. Setting it at runtime will return `cudaErrorNotPermitted`.

- `cudaFuncAttributeNonPortableClusterSizeAllowed`: Indicates whether the function can be launched with non-portable cluster size. 1 is allowed, 0 is disallowed.

cudaLaunchKernel (C++ API), cudaFuncSetCacheConfig (C++ API), cudaFuncGetAttributes (C API).

__host__ cudaError_t cudaFuncSetCacheConfig (const void *func, cudaFuncCache cacheConfig)

Sets the preferred cache configuration for a device function.

Parameters

func
- Device function symbol

cacheConfig
- Requested cache configuration

Returns

cudaSuccess, cudaErrorInvalidDeviceFunction

Description

On devices where the L1 cache and shared memory use the same hardware resources, this sets through cacheConfig the preferred cache configuration for the function specified via func. This is only a preference. The runtime will use the requested configuration if possible, but it is free to choose a different configuration if required to execute func.

func is a device function symbol and must be declared as a __global__ function. If the specified function does not exist, then cudaErrorInvalidDeviceFunction is returned. For templated functions, pass the function symbol as follows: func_name<template_arg_0,...,template_arg_N>

This setting does nothing on devices where the size of the L1 cache and shared memory are fixed.

Launching a kernel with a different preference than the most recent preference setting may insert a device-side synchronization point.

The supported cache configurations are:

- cudaFuncCachePreferNone: no preference for shared memory or L1 (default)
- cudaFuncCachePreferShared: prefer larger shared memory and smaller L1 cache
- `cudaFuncCachePreferL1`: prefer larger L1 cache and smaller shared memory
- `cudaFuncCachePreferEqual`: prefer equal size L1 cache and shared memory

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Use of a string naming a function as the `func` parameter was deprecated in CUDA 4.1 and removed in CUDA 5.0.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
- `cudaFuncSetCacheConfig (C++ API)`, `cudaFuncGetAttributes (C API)`, `cudaLaunchKernel (C API)`, `cuFuncSetCacheConfig`

```c
__device__ void *cudaGetParameterBuffer (size_t alignment, size_t size)
```

Obtains a parameter buffer.

Parameters
- **alignment**
  - Specifies alignment requirement of the parameter buffer
- **size**
  - Specifies size requirement in bytes

Returns
- Returns pointer to the allocated parameterBuffer

Description
- Obtains a parameter buffer which can be filled with parameters for a kernel launch. Parameters passed to `cudaLaunchDevice` must be allocated via this function.
- This is a low level API and can only be accessed from Parallel Thread Execution (PTX). CUDA user code should use `<<< >>>` to launch kernels.
See also:
cudaLaunchDevice

__device__ void cudaGridDependencySynchronize (void)
Programmatic grid dependency synchronization.

Description
This device function will block the thread until all direct grid dependencies have completed.
This API is intended to use in conjuncture with programmatic / launch event / dependency.
See cudaLaunchAttributeID::cudaLaunchAttributeProgrammaticStreamSerialization and
cudaLaunchAttributeID::cudaLaunchAttributeProgrammaticEvent for more information.

__host__ cudaError_t cudaLaunchCooperativeKernel (const void *func, dim3 gridDim, dim3 blockDim, void **args, size_t sharedMem, cudaStream_t stream)
Launches a device function where thread blocks can cooperate and synchronize as they execute.

Parameters
func
- Device function symbol
gridDim
- Grid dimensions
blockDim
- Block dimensions
args
- Arguments
sharedMem
- Shared memory
stream
- Stream identifier

Returns
cudaSuccess, cudaErrorInvalidDeviceFunction, cudaErrorInvalidConfiguration,
cudaErrorLaunchFailure, cudaErrorLaunchTimeout, cudaErrorLaunchOutOfResources,
cudaErrorCooperativeLaunchTooLarge, cudaErrorSharedObjectInitFailed
### Description

The function invokes kernel `func` on `gridDim(gridDim.x gridDim.y gridDim.z)` grid of blocks. Each block contains `blockDim(blockDim.x blockDim.y blockDim.z)` threads.

The device on which this kernel is invoked must have a non-zero value for the device attribute `cudaDevAttrCooperativeLaunch`.

The total number of blocks launched cannot exceed the maximum number of blocks per multiprocessor as returned by `cudaOccupancyMaxActiveBlocksPerMultiprocessor` (or `cudaOccupancyMaxActiveBlocksPerMultiprocessorWithFlags`) times the number of multiprocessors as specified by the device attribute `cudaDevAttrMultiProcessorCount`.

The kernel cannot make use of CUDA dynamic parallelism.

If the kernel has N parameters the `args` should point to array of N pointers. Each pointer, from `args[0]` to `args[N - 1]`, point to the region of memory from which the actual parameter will be copied.

For templated functions, pass the function symbol as follows: `func_name<template_arg_0,...,template_arg_N>`

`sharedMem` sets the amount of dynamic shared memory that will be available to each thread block. `stream` specifies a stream the invocation is associated to.

---

**Note:**

- This function uses standard default stream semantics.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

---

See also:

- `cudaLaunchCooperativeKernel` (C++ API), `cudaLaunchCooperativeKernelMultiDevice`.
- `cuLaunchCooperativeKernel`
__host__ cudaError_t
cudaLaunchCooperativeKernelMultiDevice
(cudaLaunchParams *launchParamsList, unsigned int
numDevices, unsigned int flags)

Launches device functions on multiple devices where thread blocks can cooperate and synchronize as they execute.

Parameters

launchParamsList
- List of launch parameters, one per device

numDevices
- Size of the launchParamsList array

flags
- Flags to control launch behavior

Returns

cudaSuccess, cudaErrorInvalidDeviceFunction, cudaErrorInvalidConfiguration,
cudaErrorLaunchFailure, cudaErrorLaunchTimeout, cudaErrorLaunchOutOfResources,
cudaErrorCooperativeLaunchTooLarge, cudaErrorSharedObjectInitFailed

Description

Deprecated This function is deprecated as of CUDA 11.3.

Invokes kernels as specified in the launchParamsList array where each element of the array specifies all the parameters required to perform a single kernel launch. These kernels can cooperate and synchronize as they execute. The size of the array is specified by numDevices.

No two kernels can be launched on the same device. All the devices targeted by this multi-device launch must be identical. All devices must have a non-zero value for the device attribute cudaDevAttrCooperativeMultiDeviceLaunch.

The same kernel must be launched on all devices. Note that any __device__ or __constant__ variables are independently instantiated on every device. It is the application's responsibility to ensure these variables are initialized and used appropriately.

The size of the grids as specified in blocks, the size of the blocks themselves and the amount of shared memory used by each thread block must also match across all launched kernels.

The streams used to launch these kernels must have been created via either cudaStreamCreate or cudaStreamCreateWithPriority or cudaStreamCreateWithPriority. The NULL stream or cudaStreamLegacy or cudaStreamPerThread cannot be used.

The total number of blocks launched per kernel cannot exceed the maximum number of blocks per multiprocessor as returned by cudaOccupancyMaxActiveBlocksPerMultiprocessor (or
cudaOccupancyMaxActiveBlocksPerMultiprocessorWithFlags) times the number of multiprocessors as specified by the device attribute cudaDevAttrMultiProcessorCount. Since the total number of blocks launched per device has to match across all devices, the maximum number of blocks that can be launched per device will be limited by the device with the least number of multiprocessors.

The kernel cannot make use of CUDA dynamic parallelism. The cudaLaunchParams structure is defined as:

```c
struct cudaLaunchParams {
    void *func;
    dim3 gridDim;
    dim3 blockDim;
    void **args;
    size_t sharedMem;
    cudaStream_t stream;
};
```

where:

- **cudaLaunchParams::func** specifies the kernel to be launched. This same function must be launched on all devices. For templated functions, pass the function symbol as follows: func_name<template_arg_0,...,template_arg_N>
- **cudaLaunchParams::gridDim** specifies the width, height and depth of the grid in blocks. This must match across all kernels launched.
- **cudaLaunchParams::blockDim** is the width, height and depth of each thread block. This must match across all kernels launched.
- **cudaLaunchParams::args** specifies the arguments to the kernel. If the kernel has N parameters then cudaLaunchParams::args should point to an array of N pointers. Each pointer, from cudaLaunchParams::args[0] to cudaLaunchParams::args[N - 1], point to the region of memory from which the actual parameter will be copied.
- **cudaLaunchParams::sharedMem** is the dynamic shared-memory size per thread block in bytes. This must match across all kernels launched.
- **cudaLaunchParams::stream** is the handle to the stream to perform the launch in. This cannot be the NULL stream or cudaStreamLegacy or cudaStreamPerThread.

By default, the kernel won’t begin execution on any GPU until all prior work in all the specified streams has completed. This behavior can be overridden by specifying the flag cudaCooperativeLaunchMultiDeviceNoPreSync. When this flag is specified, each kernel will only wait for prior work in the stream corresponding to that GPU to complete before it begins execution.

Similarly, by default, any subsequent work pushed in any of the specified streams will not begin execution until the kernels on all GPUs have completed. This behavior can be overridden by specifying the flag cudaCooperativeLaunchMultiDeviceNoPostSync. When this flag is specified, any subsequent work pushed in any of the specified streams will only wait for the kernel launched on the GPU corresponding to that stream to complete before it begins execution.
See also:
cudaLaunchCooperativeKernel (C++ API), cudaLaunchCooperativeKernelMultiDevice

__device__ cudaError_t cudaLaunchDevice (void *func, void *parameterBuffer, dim3 gridDimension, dim3 blockDimension, unsigned int sharedMemSize, cudaStream_t stream)
Launches a specified kernel.

Parameters

func
- Pointer to the kernel to be launched

parameterBuffer
- Holds the parameters to the launched kernel. parameterBuffer can be NULL. (Optional)

gridDimension
- Specifies grid dimensions

blockDimension
- Specifies block dimensions

sharedMemSize
- Specifies size of shared memory

stream
- Specifies the stream to be used

Returns
cudaSuccess, cudaErrorInvalidDevice, cudaErrorLaunchMaxDepthExceeded, cudaErrorInvalidConfiguration, cudaErrorStartupFailure, cudaErrorLaunchPendingCountExceeded, cudaErrorLaunchOutOfResources
Description

Launches a specified kernel with the specified parameter buffer. A parameter buffer can be obtained by calling `cudaGetParameterBuffer()`.

This is a low level API and can only be accessed from Parallel Thread Execution (PTX). CUDA user code should use `<<< >>>` to launch the kernels.

- **Note:**
  Note that this function may also return error codes from previous, asynchronous launches.

  Please refer to Execution Configuration and Parameter Buffer Layout from the CUDA Programming Guide for the detailed descriptions of launch configuration and parameter layout respectively.

See also:
`cudaGetParameterBuffer`

```c
__host__ cudaError_t cudaLaunchHostFunc (cudaStream_t stream, cudaHostFn_t fn, void *userData)
```

Enqueues a host function call in a stream.

- **Parameters**
  - **stream**
  - **fn** - The function to call once preceding stream operations are complete
  - **userData** - User-specified data to be passed to the function

- **Returns**
  - `cudaSuccess`, `cudaErrorInvalidResourceHandle`, `cudaErrorInvalidValue`, `cudaErrorNotSupported`

- **Description**

  Enqueues a host function to run in a stream. The function will be called after currently enqueued work and will block work added after it.

  The host function must not make any CUDA API calls. Attempting to use a CUDA API may result in `cudaErrorNotPermitted`, but this is not required. The host function must not perform any synchronization that may depend on outstanding CUDA work not mandated to run earlier. Host functions without a mandated order (such as in independent streams) execute in undefined order and may be serialized.
For the purposes of Unified Memory, execution makes a number of guarantees:

- The stream is considered idle for the duration of the function's execution. Thus, for example, the function may always use memory attached to the stream it was enqueued in.

- The start of execution of the function has the same effect as synchronizing an event recorded in the same stream immediately prior to the function. It thus synchronizes streams which have been "joined" prior to the function.

- Adding device work to any stream does not have the effect of making the stream active until all preceding host functions and stream callbacks have executed. Thus, for example, a function might use global attached memory even if work has been added to another stream, if the work has been ordered behind the function call with an event.

- Completion of the function does not cause a stream to become active except as described above. The stream will remain idle if no device work follows the function, and will remain idle across consecutive host functions or stream callbacks without device work in between. Thus, for example, stream synchronization can be done by signaling from a host function at the end of the stream.

Note that, in constrast to cuStreamAddCallback, the function will not be called in the event of an error in the CUDA context.

Note:

- This function uses standard default stream semantics.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cuStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaStreamCreate, cudaStreamQuery, cudaStreamSynchronize, cudaStreamWaitEvent, cudaStreamDestroy, cudaMallocManaged, cudaStreamAttachMemAsync, cudaStreamAddCallback, cuLaunchHostFunc
__host__ cudaError_t cudaLaunchKernel (const void *func, dim3 gridDim, dim3 blockDim, void **args, size_t sharedMem, cudaStream_t stream)

Launches a device function.

Parameters

func
  - Device function symbol

gridDim
  - Grid dimensions

blockDim
  - Block dimensions

args
  - Arguments

sharedMem
  - Shared memory

stream
  - Stream identifier

Returns

cudaSuccess, cudaErrorInvalidDeviceFunction, cudaErrorInvalidConfiguration,
cudaErrorLaunchFailure, cudaErrorLaunchTimeout, cudaErrorLaunchOutOfResources,
cudaErrorSharedObjectInitFailed, cudaErrorInvalidPtx, cudaErrorUnsupportedPtxVersion,
cudaErrorNoKernelImageForDevice, cudaErrorJitCompilerNotFound,
cudaErrorJitCompilationDisabled

Description

The function invokes kernel func on gridDim (gridDim.x gridDim.y gridDim.z) grid of blocks. Each block contains blockDim (blockDim.x blockDim.y blockDim.z) threads.

If the kernel has N parameters the args should point to array of N pointers. Each pointer, from args[0] to args[N - 1], point to the region of memory from which the actual parameter will be copied.

For templated functions, pass the function symbol as follows:
func_name<template_arg_0,...,template_arg_N>

sharedMem sets the amount of dynamic shared memory that will be available to each thread block.

stream specifies a stream the invocation is associated to.
Note:

- This function uses standard default stream semantics.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaLaunchKernel (C++ API), cuLaunchKernel

__host__ cudaError_t cudaLaunchKernelExC (const cudaLaunchConfig_t *config, const void *func, void **args)

Launches a CUDA function with launch-time configuration.

Parameters

config
  - Launch configuration

func
  - Kernel to launch

args
  - Array of pointers to kernel parameters

Returns
cudaSuccess, cudaErrorInvalidDeviceFunction, cudaErrorInvalidConfiguration,
cudaErrorLaunchFailure, cudaErrorLaunchTimeout, cudaErrorLaunchOutOfResources,
cudaErrorSharedObjectInitFailed, cudaErrorInvalidPtx, cudaErrorUnsupportedPtxVersion,
cudaErrorNoKernelImageForDevice, cudaErrorJitCompilerNotFound,
cudaErrorJitCompilationDisabled

Description

Note that the functionally equivalent variadic template cudaLaunchKernelEx is available for C++11 and newer.

Invokes the kernel func on config->gridDim (config->gridDim.x config->gridDim.y config->gridDim.z) grid of blocks. Each block contains config->blockDim (config->blockDim.x config->blockDim.y config->blockDim.z) threads.
config->dynamicSmemBytes sets the amount of dynamic shared memory that will be available to each thread block.

config->stream specifies a stream the invocation is associated to.

Configuration beyond grid and block dimensions, dynamic shared memory size, and stream can be provided with the following two fields of config:

config->attrs is an array of config->numAttrs contiguous cudaLaunchAttribute elements. The value of this pointer is not considered if config->numAttrs is zero. However, in that case, it is recommended to set the pointer to NULL. config->numAttrs is the number of attributes populating the first config->numAttrs positions of the config->attrs array.

If the kernel has N parameters the args should point to array of N pointers. Each pointer, from args[0] to args[N - 1], point to the region of memory from which the actual parameter will be copied.

N.B. This function is so named to avoid unintentionally invoking the templated version, cudaLaunchKernelEx, for kernels taking a single void** or void* parameter.

Note:

- This function uses standard default stream semantics.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaLaunchKernelEx(const cudaLaunchConfig_t *config, void (*kernel)(ExpTypes...), ActTypes &&... args) "cudaLaunchKernelEx (C++ API)”, cuLaunchKernelEx

__host__ cudaError_t cudaSetDoubleForDevice (double *d)

Converts a double argument to be executed on a device.

Parameters

d
  - Double to convert

Returns

cudaSuccess
Description

**Deprecated** This function is deprecated as of CUDA 7.5

Converts the double value of \( d \) to an internal float representation if the device does not support double arithmetic. If the device does natively support doubles, then this function does nothing.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

- `cudaFuncSetCacheConfig (C API)`, `cudaFuncGetAttributes (C API)`, `cudaSetDoubleForHost`

```__host__ cudaError_t cudaSetDoubleForHost (double *d)```

Converts a double argument after execution on a device.

**Parameters**

- **d**
  - Double to convert

**Returns**

- `cudaSuccess`

**Description**

**Deprecated** This function is deprecated as of CUDA 7.5

Converts the double value of \( d \) from a potentially internal float representation if the device does not support double arithmetic. If the device does natively support doubles, then this function does nothing.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.
Programmatic dependency trigger.

Description

This device function ensures the programmatic launch completion edges / events are fulfilled. See `cudaLaunchAttributeID::cudaLaunchAttributeProgrammaticStreamSerialization` and `cudaLaunchAttributeID::cudaLaunchAttributeProgrammaticEvent` for more information. The event / edge kick off only happens when every CTAs in the grid has either exited or called this function at least once, otherwise the kick off happens automatically after all warps finishes execution but before the grid completes. The kick off only enables scheduling of the secondary kernel. It provides no memory visibility guarantee itself. The user could enforce memory visibility by inserting a memory fence of the correct scope.

### 6.9. Execution Control [DEPRECATED]

This section describes the deprecated execution control functions of the CUDA runtime application programming interface.

Some functions have overloaded C++ API template versions documented separately in the C++ API Routines module.

__host__`cudaError_t cudaFuncSetSharedMemConfig` (const void *func, cudaSharedMemConfig config)

Sets the shared memory configuration for a device function.

**Parameters**

*func*  
- Device function symbol

*config*  
- Requested shared memory configuration

**Returns**

`cudaSuccess`, `cudaErrorInvalidDeviceFunction`, `cudaErrorInvalidValue`,
Description

Deprecated

On devices with configurable shared memory banks, this function will force all subsequent launches of the specified device function to have the given shared memory bank size configuration. On any given launch of the function, the shared memory configuration of the device will be temporarily changed if needed to suit the function's preferred configuration. Changes in shared memory configuration between subsequent launches of functions, may introduce a device side synchronization point.

Any per-function setting of shared memory bank size set via `cudaFuncSetSharedMemConfig` will override the device wide setting set by `cudaDeviceSetSharedMemConfig`.

Changing the shared memory bank size will not increase shared memory usage or affect occupancy of kernels, but may have major effects on performance. Larger bank sizes will allow for greater potential bandwidth to shared memory, but will change what kinds of accesses to shared memory will result in bank conflicts.

This function will do nothing on devices with fixed shared memory bank size.

For templated functions, pass the function symbol as follows:

`func_name<template_arg_0,...,template_arg_N>`

The supported bank configurations are:

- `cudaSharedMemBankSizeDefault`: use the device's shared memory configuration when launching this function.
- `cudaSharedMemBankSizeFourByte`: set shared memory bank width to be four bytes natively when launching this function.
- `cudaSharedMemBankSizeEightByte`: set shared memory bank width to be eight bytes natively when launching this function.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Use of a string naming a function as the `func` parameter was deprecated in CUDA 4.1 and removed in CUDA 5.0.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cudaDeviceSetSharedMemConfig`, `cudaDeviceGetSharedMemConfig`, `cudaDeviceSetCacheConfig`, `cudaDeviceGetCacheConfig`, `cudaFuncSetCacheConfig`, `cuFuncSetSharedMemConfig`
6.10. Occupancy

This section describes the occupancy calculation functions of the CUDA runtime application programming interface.

Besides the occupancy calculator functions (cudaOccupancyMaxActiveBlocksPerMultiprocessor and cudaOccupancyMaxActiveBlocksPerMultiprocessorWithFlags), there are also C++ only occupancy-based launch configuration functions documented in C++ API Routines module.

See cudaOccupancyMaxPotentialBlockSize (C++ API), cudaOccupancyMaxPotentialBlockSize (C++ API), cudaOccupancyMaxPotentialBlockSizeVariableSMem (C++ API), cudaOccupancyMaxPotentialBlockSizeVariableSMem (C++ API), cudaOccupancyAvailableDynamicSMemPerBlock (C++ API),

```c
__host__ cudaError_t
cudaOccupancyAvailableDynamicSMemPerBlock (size_t *dynamicSmemSize, const void *func, int numBlocks, int blockSize)
```

Returns dynamic shared memory available per block when launching numBlocks blocks on SM.

**Parameters**

- **dynamicSmemSize**
  - Returned maximum dynamic shared memory
- **func**
  - Kernel function for which occupancy is calculated
- **numBlocks**
  - Number of blocks to fit on SM
- **blockSize**
  - Size of the block

**Returns**

cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidDeviceFunction, cudaErrorInvalidValue, cudaErrorUnknown.

**Description**

Returns in *dynamicSmemSize the maximum size of dynamic shared memory to allow numBlocks blocks per SM.
Note:

‣ Note that this function may also return error codes from previous, asynchronous launches.
‣ Note that this function may also return `cudErrorInitializationError`, `cudErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
‣ Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

- `cudaOccupancyMaxActiveBlocksPerMultiprocessorWithFlags`
- `cudaOccupancyMaxPotentialBlockSize (C++ API)`, `cudaOccupancyMaxPotentialBlockSizeWithFlags (C++ API)`, `cudaOccupancyMaxPotentialBlockSizeVariableSMem (C++ API)`, `cudaOccupancyMaxPotentialBlockSizeVariableSMemWithFlags (C++ API)`, `cudaOccupancyAvailableDynamicSMemPerBlock`

```c
__host__ __device__ cudaError_t
cudaOccupancyMaxActiveBlocksPerMultiprocessor
(int *numBlocks, const void *func, int blockSize, size_t dynamicSMemSize)
```

Returns occupancy for a device function.

**Parameters**

- `numBlocks`
  - Returned occupancy
- `func`
  - Kernel function for which occupancy is calculated
- `blockSize`
  - Block size the kernel is intended to be launched with
- `dynamicSMemSize`
  - Per-block dynamic shared memory usage intended, in bytes

**Returns**

- `cudaSuccess`, `cudaErrorInvalidDevice`, `cudaErrorInvalidDeviceFunction`, `cudaErrorInvalidValue`, `cudaErrorUnknown`

**Description**

Returns in `*numBlocks` the maximum number of active blocks per streaming multiprocessor for the device function.
Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaOccupancyMaxActiveBlocksPerMultiprocessorWithFlags, cudaOccupancyMaxPotentialBlockSize (C++ API), cudaOccupancyMaxPotentialBlockSizeWithFlags (C++ API), cudaOccupancyMaxPotentialBlockSizeVariableSMem (C++ API), cudaOccupancyMaxPotentialBlockSizeVariableSMemWithFlags (C++ API), cudaOccupancyAvailableDynamicSMemPerBlock (C++ API), cuOccupancyMaxActiveBlocksPerMultiprocessor

__host__ cudaError_t
cudaOccupancyMaxActiveBlocksPerMultiprocessorWithFlags (int *numBlocks, const void *func, int blockSize, size_t dynamicSMemSize, unsigned int flags)

Returns occupancy for a device function with the specified int flags.

Parameters

numBlocks
  - Returned occupancy
func
  - Kernel function for which occupancy is calculated
blockSize
  - Block size the kernel is intended to be launched with
dynamicSMemSize
  - Per-block dynamic shared memory usage intended, in bytes
flags
  - Requested behavior for the occupancy calculator

Returns
cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidDeviceFunction, cudaErrorInvalidValue, cudaErrorUnknown,
Description

Returns in *numBlocks* the maximum number of active blocks per streaming multiprocessor for the device function.

The *flags* parameter controls how special cases are handled. Valid flags include:

- **cudaOccupancyDefault**: keeps the default behavior as
  cudaOccupancyMaxActiveBlocksPerMultiprocessor

- **cudaOccupancyDisableCachingOverride**: This flag suppresses the default behavior on platform where global caching affects occupancy. On such platforms, if caching is enabled, but per-block SM resource usage would result in zero occupancy, the occupancy calculator will calculate the occupancy as if caching is disabled. Setting this flag makes the occupancy calculator to return 0 in such cases. More information can be found about this feature in the "Unified L1/Texture Cache" section of the Maxwell tuning guide.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaOccupancyMaxActiveBlocksPerMultiprocessor, cudaOccupancyMaxPotentialBlockSize (C++ API), cudaOccupancyMaxPotentialBlockSizeWithFlags (C++ API), cudaOccupancyMaxPotentialBlockSizeVariableSMem (C++ API), cudaOccupancyMaxPotentialBlockSizeVariableSMemWithFlags (C++ API), cudaOccupancyAvailableDynamicSMemPerBlock (C++ API), cuOccupancyMaxActiveBlocksPerMultiprocessorWithFlags
__host__ cudaError_t cudaOccupancyMaxActiveClusters
(int *numClusters, const void *func, const
cudaLaunchConfig_t *launchConfig)

Given the kernel function (func) and launch configuration (config), return the maximum number of
clusters that could co-exist on the target device in *numClusters.

Parameters

numClusters
- Returned maximum number of clusters that could co-exist on the target device

func
- Kernel function for which maximum number of clusters are calculated

launchConfig

Returns
cudaSuccess, cudaErrorInvalidDeviceFunction, cudaErrorInvalidValue, cudaErrorInvalidClusterSize,
cudaErrorUnknown.

Description

If the function has required cluster size already set (see cudaFuncGetAttributes), the cluster size from
config must either be unspecified or match the required size. Without required sizes, the cluster size
must be specified in config, else the function will return an error.

Note that various attributes of the kernel function may affect occupancy calculation. Runtime
environment may affect how the hardware schedules the clusters, so the calculated occupancy is not
guaranteed to be achievable.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or
cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback.
cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaFuncGetAttributes cudaOccupancyMaxActiveClusters (C++ API),
cuOccupancyMaxActiveClusters
__host__ cudaError_t
cudaOccupancyMaxPotentialClusterSize (int *clusterSize, const void *func, const cudaLaunchConfig_t *launchConfig)

Given the kernel function (func) and launch configuration (config), return the maximum cluster size in *clusterSize.

Parameters

clusterSize
  - Returned maximum cluster size that can be launched for the given kernel function and launch configuration

func
  - Kernel function for which maximum cluster size is calculated

launchConfig

Returns
cudaSuccess, cudaErrorInvalidDeviceFunction, cudaErrorInvalidValue, cudaErrorUnknown,

Description

The cluster dimensions in config are ignored. If func has a required cluster size set (see cudaFuncGetAttributes), *clusterSize will reflect the required cluster size.

By default this function will always return a value that's portable on future hardware. A higher value may be returned if the kernel function allows non-portable cluster sizes.

This function will respect the compile time launch bounds.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaFuncGetAttributes, cudaOccupancyMaxPotentialClusterSize (C++ API),
cuOccupancyMaxPotentialClusterSize
6.11. Memory Management

This section describes the memory management functions of the CUDA runtime application programming interface.

Some functions have overloaded C++ API template versions documented separately in the C++ API Routines module.

```c
__host__ cudaError_t cudaArrayGetInfo
(cudaChannelFormatDesc *desc, cudaExtent *extent,
unsigned int *flags, cudaArray_t array)
```

Gets info about the specified cudaArray.

**Parameters**

- **desc**
  - Returned array type
- **extent**
  - Returned array shape. 2D arrays will have depth of zero
- **flags**
  - Returned array flags
- **array**
  - The cudaArray to get info for

**Returns**

- `cudaSuccess`
- `cudaErrorInvalidValue`

**Description**

Returns in `*desc`, `*extent` and `*flags` respectively, the type, shape and flags of `array`.

Any of `*desc`, `*extent` and `*flags` may be specified as NULL.

---

**Note:**

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.
See also:

`cuArrayGetDescriptor`, `cuArray3DGetDescriptor`

__host__ cudaError_t cudaArrayGetMemoryRequirements (cudaArrayMemoryRequirements *memoryRequirements, cudaArray_t array, int device)

Returns the memory requirements of a CUDA array.

Parameters

memoryRequirements
  - Pointer to `cudaArrayMemoryRequirements`
array
  - CUDA array to get the memory requirements of
device
  - Device to get the memory requirements for

Returns

`cudaSuccess` `cudaErrorInvalidValue`

Description

Returns the memory requirements of a CUDA array in `memoryRequirements`. If the CUDA array is not allocated with flag `cudaArrayDeferredMapping` `cudaErrorInvalidValue` will be returned.

The returned value in `cudaArrayMemoryRequirements::size` represents the total size of the CUDA array. The returned value in `cudaArrayMemoryRequirements::alignment` represents the alignment necessary for mapping the CUDA array.

See also:

`cudaMipmappedArrayGetMemoryRequirements`

__host__ cudaError_t cudaArrayGetPlane (cudaArray_t *pPlaneArray, cudaArray_t hArray, unsigned int planeIdx)

Gets a CUDA array plane from a CUDA array.

Parameters

pPlaneArray
  - Returned CUDA array referenced by the planeIdx
hArray
  - CUDA array
planeIdx
- Plane index

Returns
cudaSuccess, cudaErrorInvalidValue cudaErrorInvalidResourceHandle

Description
Returns in pPlaneArray a CUDA array that represents a single format plane of the CUDA array hArray.

If planeIdx is greater than the maximum number of planes in this array or if the array does not have a multi-planar format e.g: cudaChannelFormatKindNV12, then cudaErrorInvalidValue is returned.

Note that if the hArray has format cudaChannelFormatKindNV12, then passing in 0 for planeIdx returns a CUDA array of the same size as hArray but with one 8-bit channel and cudaChannelFormatKindUnsigned as its format kind. If 1 is passed for planeIdx, then the returned CUDA array has half the height and width of hArray with two 8-bit channels and cudaChannelFormatKindUnsigned as its format kind.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cuArrayGetPlane

__host__ cudaError_t cudaArrayGetSparseProperties (cudaArraySparseProperties *sparseProperties, cudaArray_t array)
Returns the layout properties of a sparse CUDA array.

Parameters
sparseProperties
- Pointer to return the cudaArraySparseProperties
array
- The CUDA array to get the sparse properties of

Returns
cudaSuccess cudaErrorInvalidValue
Description

Returns the layout properties of a sparse CUDA array in `sparseProperties`. If the CUDA array is not allocated with flag `cudaArraySparse`, `cudaErrorInvalidValue` will be returned.

If the returned value in `cudaArraySparseProperties::flags` contains `cudaArraySparsePropertiesSingleMipTail`, then `cudaArraySparseProperties::miptailSize` represents the total size of the array. Otherwise, it will be zero. Also, the returned value in `cudaArraySparseProperties::miptailFirstLevel` is always zero. Note that the array must have been allocated using `cudaMallocArray` or `cudaMalloc3DArray`. For CUDA arrays obtained using `cudaMipmappedArrayGetLevel`, `cudaErrorInvalidValue` will be returned. Instead, `cudaMipmappedArrayGetSparseProperties` must be used to obtain the sparse properties of the entire CUDA mipmapped array to which `array` belongs to.

See also:
`cudaMipmappedArrayGetSparseProperties`, `cuMemMapArrayAsync`

```c
__host__ __device__ cudaError_t cudaFree (void *devPtr)
```

Frees memory on the device.

Parameters

- `devPtr` - Device pointer to memory to free

Returns

`cudaSuccess`, `cudaErrorInvalidValue`

Description

Frees the memory space pointed to by `devPtr`, which must have been returned by a previous call to one of the following memory allocation APIs - `cudaMalloc()`, `cudaMallocPitch()`, `cudaMallocManaged()`, `cudaMallocAsync()`, `cudaMallocFromPoolAsync()`. Note - This API will not perform any implicit synchronization when the pointer was allocated with `cudaMallocAsync` or `cudaMallocFromPoolAsync`. Callers must ensure that all accesses to these pointer have completed before invoking `cudaFree`. For best performance and memory reuse, users should use `cudaFreeAsync` to free memory allocated via the stream ordered memory allocator. For all other pointers, this API may perform implicit synchronization.

If `cudaFree(devPtr)` has already been called before, an error is returned. If `devPtr` is 0, no operation is performed. `cudaFree()` returns `cudaErrorValue` in case of failure.

The device version of `cudaFree` cannot be used with a `*devPtr` allocated using the host API, and vice versa.
Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaMalloc, cudaMallocPitch, cudaMallocManaged, cudaMallocArray, cudaFreeArray, cudaMallocAsync, cudaMallocFromPoolAsync, cudaMallocHost (C API), cudaFreeHost, cudaMalloc3D, cudaMalloc3DArray, cudaFreeAsync, cudaHostAlloc, cuMemFree

__host__ cudaError_t cudaFreeArray (cudaArray_t array)
Frees an array on the device.

Parameters
array
- Pointer to array to free

Returns

cudaSuccess, cudaErrorInvalidValue

Description
Frees the CUDA array array, which must have been returned by a previous call to cudaMallocArray(). If devPtr is 0, no operation is performed.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaMalloc, cudaMallocPitch, cudaFree, cudaMallocArray, cudaMallocHost (C API), cudaFreeHost, cudaHostAlloc, cuArrayDestroy
__host__ cudaError_t cudaFreeHost (void *ptr)
Frees page-locked memory.

Parameters
ptr
- Pointer to memory to free

Returns
cudaSuccess, cudaErrorInvalidValue

Description
Frees the memory space pointed to by hostPtr, which must have been returned by a previous call to cudaMallocHost() or cudaHostAlloc().

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaMalloc, cudaMallocPitch, cudaFree, cudaMallocArray, cudaFreeArray, cudaMallocHost (C API), cudaMalloc3D, cudaMalloc3DArray, cudaHostAlloc, cuMemFreeHost

__host__ cudaError_t cudaFreeMipmappedArray (cudaMipmappedArray_t mipmappedArray)
Frees a mipmapped array on the device.

Parameters
mipmappedArray
- Pointer to mipmapped array to free

Returns
cudaSuccess, cudaErrorInvalidValue
Description

Frees the CUDA mipmapped array `mipmappedArray`, which must have been returned by a previous call to `cudaMallocMipmappedArray()`. If `devPtr` is 0, no operation is performed.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
- `cudaMalloc`, `cudaMallocPitch`, `cudaFree`, `cudaMallocArray`, `cudaMallocHost (C API)`, `cudaFreeHost`, `cudaHostAlloc`, `cuMipmappedArrayDestroy`

```c
__host__ cudaError_t cudaGetMipmappedArrayLevel (cudaArray_t *levelArray, cudaMipmappedArray_const_t mipmappedArray, unsigned int level)
```

Gets a mipmap level of a CUDA mipmapped array.

Parameters

- `levelArray` - Returned mipmap level CUDA array
- `mipmappedArray` - CUDA mipmapped array
- `level` - Mipmap level

Returns

- `cudaSuccess`
- `cudaErrorInvalidValue`
- `cudaErrorInvalidResourceHandle`

Description

Returns in `*levelArray` a CUDA array that represents a single mipmap level of the CUDA mipmapped array `mipmappedArray`.

If `level` is greater than the maximum number of levels in this mipmapped array, `cudaErrorInvalidValue` is returned.
If `mipmappedArray` is NULL, `cudaErrorInvalidResourceHandle` is returned.

**Note:**
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
- `cudaMalloc3D`, `cudaMalloc`, `cudaMallocPitch`, `cudaFree`, `cudaFreeArray`, `cudaMallocHost (C API)`, `cudaFreeHost`, `cudaHostAlloc`, `make_cudaExtent`, `cuMipmappedArrayGetLevel`

```c
__host__ cudaError_t cudaGetSymbolAddress (void **devPtr, const void *symbol)
```

Finds the address associated with a CUDA symbol.

**Parameters**

- **devPtr**
  - Return device pointer associated with symbol
- **symbol**
  - Device symbol address

**Returns**

- `cudaSuccess`
- `cudaErrorInvalidSymbol`
- `cudaErrorNoKernelImageForDevice`

**Description**

Returns in `*devPtr` the address of symbol `symbol` on the device. `symbol` is a variable that resides in global or constant memory space. If `symbol` cannot be found, or if `symbol` is not declared in the global or constant memory space, `*devPtr` is unchanged and the error `cudaErrorInvalidSymbol` is returned.

**Note:**
- Note that this function may also return error codes from previous, asynchronous launches.
- Use of a string naming a variable as the `symbol` parameter was deprecated in CUDA 4.1 and removed in CUDA 5.0.
Note that this function may also return(cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice) if this call tries to initialize internal CUDA RT state.

Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGetSymbolAddress (C++ API), cudaGetSymbolSize (C API), cuModuleGetGlobal

__host__ cudaError_t cudaGetSymbolSize (size_t *size, const void *symbol)
Finds the size of the object associated with a CUDA symbol.

Parameters
size
- Size of object associated with symbol
symbol
- Device symbol address

Returns
cudaSuccess, cudaErrorInvalidSymbol, cudaErrorNoKernelImageForDevice

Description
Returns in *size the size of symbol symbol. symbol is a variable that resides in global or constant memory space. If symbol cannot be found, or if symbol is not declared in global or constant memory space, *size is unchanged and the error cudaErrorInvalidSymbol is returned.

Note:
- Use of a string naming a variable as the symbol parameter was deprecated in CUDA 4.1 and removed in CUDA 5.0.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGetSymbolAddress (C API), cudaGetSymbolSize (C++ API), cuModuleGetGlobal
__host__ cudaError_t cudaHostAlloc (void **pHost, size_t size, unsigned int flags)
Allocates page-locked memory on the host.

Parameters
pHost
- Device pointer to allocated memory
size
- Requested allocation size in bytes
flags
- Requested properties of allocated memory

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorMemoryAllocation

Description
Allocates size bytes of host memory that is page-locked and accessible to the device. The driver tracks the virtual memory ranges allocated with this function and automatically accelerates calls to functions such as cudaMemcpy(). Since the memory can be accessed directly by the device, it can be read or written with much higher bandwidth than pageable memory obtained with functions such as malloc(). Allocating excessive amounts of pinned memory may degrade system performance, since it reduces the amount of memory available to the system for paging. As a result, this function is best used sparingly to allocate staging areas for data exchange between host and device.

The flags parameter enables different options to be specified that affect the allocation, as follows.

- cudaHostAllocDefault: This flag's value is defined to be 0 and causes cudaHostAlloc() to emulate cudaMallocHost().
- cudaHostAllocPortable: The memory returned by this call will be considered as pinned memory by all CUDA contexts, not just the one that performed the allocation.
- cudaHostAllocMapped: Maps the allocation into the CUDA address space. The device pointer to the memory may be obtained by calling cudaHostGetDevicePointer().
- cudaHostAllocWriteCombined: Allocates the memory as write-combined (WC). WC memory can be transferred across the PCI Express bus more quickly on some system configurations, but cannot be read efficiently by most CPUs. WC memory is a good option for buffers that will be written by the CPU and read by the device via mapped pinned memory or host->device transfers.

All of these flags are orthogonal to one another: a developer may allocate memory that is portable, mapped and/or write-combined with no restrictions.
In order for the `cudaHostAllocMapped` flag to have any effect, the CUDA context must support the `cudaDeviceMapHost` flag, which can be checked via `cudaGetDeviceFlags()`. The `cudaDeviceMapHost` flag is implicitly set for contexts created via the runtime API.

The `cudaHostAllocMapped` flag may be specified on CUDA contexts for devices that do not support mapped pinned memory. The failure is deferred to `cudaHostGetDevicePointer()` because the memory may be mapped into other CUDA contexts via the `cudaHostAllocPortable` flag.

Memory allocated by this function must be freed with `cudaFreeHost()`.

---

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cudaSetDeviceFlags`, `cudamallocHost (C API)`, `cudaFreeHost`, `cudaGetDeviceFlags`, `cuMemHostAlloc`

---

```c
__host__ cudaError_t cudaHostGetDevicePointer (void **pDevice, void *pHost, unsigned int flags)
```

Passes back device pointer of mapped host memory allocated by `cudaHostAlloc` or registered by `cudaHostRegister`.

**Parameters**

- **pDevice**
  - Returned device pointer for mapped memory
- **pHost**
  - Requested host pointer mapping
- **flags**
  - Flags for extensions (must be 0 for now)

**Returns**

`cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorMemoryAllocation`

**Description**

Passes back the device pointer corresponding to the mapped, pinned host buffer allocated by `cudaHostAlloc()` or registered by `cudaHostRegister()`.  

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`cudaHostGetDevicePointer()` will fail if the `cudaDeviceMapHost` flag was not specified before deferred context creation occurred, or if called on a device that does not support mapped, pinned memory.

For devices that have a non-zero value for the device attribute `cudaDevAttrCanUseHostPointerForRegisteredMem`, the memory can also be accessed from the device using the host pointer `pHost`. The device pointer returned by `cudaHostGetDevicePointer()` may or may not match the original host pointer `pHost` and depends on the devices visible to the application. If all devices visible to the application have a non-zero value for the device attribute, the device pointer returned by `cudaHostGetDevicePointer()` will match the original pointer `pHost`. If any device visible to the application has a zero value for the device attribute, the device pointer returned by `cudaHostGetDevicePointer()` will not match the original host pointer `pHost`, but it will be suitable for use on all devices provided Unified Virtual Addressing is enabled. In such systems, it is valid to access the memory using either pointer on devices that have a non-zero value for the device attribute. Note however that such devices should access the memory using only of the two pointers and not both.

Flags provides for future releases. For now, it must be set to 0.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotAllowed` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
- `cudaSetDeviceFlags`, `cudaHostAlloc`, `cuMemHostGetDevicePointer`

```__host__ cudaError_t cudaHostGetFlags (unsigned int *pFlags, void *pHost)```

Passes back flags used to allocate pinned host memory allocated by `cudaHostAlloc`.

**Parameters**

- **pFlags**
  - Returned flags word

- **pHost**
  - Host pointer

**Returns**

- `cudaSuccess`, `cudaErrorInvalidValue`
Description

cudaHostGetFlags() will fail if the input pointer does not reside in an address range allocated by cudaHostAlloc.

Note:

‣ Note that this function may also return error codes from previous, asynchronous launches.
‣ Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
‣ Note that as specified by cudaMemcpy no CUDA function may be called from callback.
   cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaHostAlloc, cuMemHostGetFlags

__host__ cudaError_t cudaHostRegister (void *ptr, size_t size, unsigned int flags)
Registrates an existing host memory range for use by CUDA.

Parameters

ptr
  - Host pointer to memory to page-lock
size
  - Size in bytes of the address range to page-lock in bytes
flags
  - Flags for allocation request

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorMemoryAllocation, cudaErrorHostMemoryAlreadyRegistered, cudaErrorNotSupported

Description

Page-locks the memory range specified by ptr and size and maps it for the device(s) as specified by flags. This memory range also is added to the same tracking mechanism as cudaHostAlloc() to automatically accelerate calls to functions such as cudaMemcpy(). Since the memory can be accessed directly by the device, it can be read or written with much higher bandwidth than pageable memory that has not been registered. Page-locking excessive amounts of memory may degrade system performance,
since it reduces the amount of memory available to the system for paging. As a result, this function is best used sparingly to register staging areas for data exchange between host and device.

On systems where pageableMemoryAccessUsesHostPageTables is true, *cudaHostRegister* will not page-lock the memory range specified by *ptr* but only populate unpopulated pages.

*cudaHostRegister* is supported only on I/O coherent devices that have a non-zero value for the device attribute *cudaDevAttrHostRegisterSupported*.

The *flags* parameter enables different options to be specified that affect the allocation, as follows.

- **cudaHostRegisterDefault**: On a system with unified virtual addressing, the memory will be both mapped and portable. On a system with no unified virtual addressing, the memory will be neither mapped nor portable.

- **cudaHostRegisterPortable**: The memory returned by this call will be considered as pinned memory by all CUDA contexts, not just the one that performed the allocation.

- **cudaHostRegisterMapped**: Maps the allocation into the CUDA address space. The device pointer to the memory may be obtained by calling *cudaHostGetDevicePointer()*.

- **cudaHostRegisterIoMemory**: The passed memory pointer is treated as pointing to some memory-mapped I/O space, e.g. belonging to a third-party PCIe device, and it will marked as non cache-coherent and contiguous.

- **cudaHostRegisterReadOnly**: The passed memory pointer is treated as pointing to memory that is considered read-only by the device. On platforms without *cudaDevAttrPageableMemoryAccessUsesHostPageTables*, this flag is required in order to register memory mapped to the CPU as read-only. Support for the use of this flag can be queried from the device attribute *cudaDeviceAttrReadOnlyHostRegisterSupported*. Using this flag with a current context associated with a device that does not have this attribute set will cause *cudaHostRegister* to error with cudaErrorNotSupported.

All of these flags are orthogonal to one another: a developer may page-lock memory that is portable or mapped with no restrictions.

The CUDA context must have been created with the cudaMapHost flag in order for the *cudaHostRegisterMapped* flag to have any effect.

The *cudaHostRegisterMapped* flag may be specified on CUDA contexts for devices that do not support mapped pinned memory. The failure is deferred to *cudaHostGetDevicePointer()* because the memory may be mapped into other CUDA contexts via the *cudaHostRegisterPortable* flag.

For devices that have a non-zero value for the device attribute *cudaDevAttrCanUseHostPointerForRegisteredMem*, the memory can also be accessed from the device using the host pointer *ptr*. The device pointer returned by *cudaHostGetDevicePointer()* may or may not match the original host pointer *ptr* and depends on the devices visible to the application. If all devices visible to the application have a non-zero value for the device attribute, the device pointer returned by *cudaHostGetDevicePointer()* will match the original pointer *ptr*. If any device visible to the application has a zero value for the device attribute, the device pointer returned by...
cudaHostGetDevicePointer() will not match the original host pointer ptr, but it will be suitable for use on all devices provided Unified Virtual Addressing is enabled. In such systems, it is valid to access the memory using either pointer on devices that have a non-zero value for the device attribute. Note however that such devices should access the memory using only of the two pointers and not both. The memory page-locked by this function must be unregistered with cudaHostUnregister().

See also:
cudaHostUnregister, cudaHostGetFlags, cudaHostGetDevicePointer, cuMemHostRegister

__host__ cudaError_t cudaHostUnregister (void *ptr)

Unregisters a memory range that was registered with cudaHostRegister.

Parameters

ptr
- Host pointer to memory to unregister

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorHostMemoryNotRegistered

Description

Unmaps the memory range whose base address is specified by ptr, and makes it pageable again. The base address must be the same one specified to cudaHostRegister().

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
See also:

`cudaHostUnregister`, `cuMemHostUnregister`

```c
__host__ __device__ cudaError_t cudaMalloc (void **devPtr, size_t size)
```

Allocate memory on the device.

**Parameters**

`devPtr`
- Pointer to allocated device memory

`size`
- Requested allocation size in bytes

**Returns**

`cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorMemoryAllocation`

**Description**

Allocates `size` bytes of linear memory on the device and returns in `*devPtr` a pointer to the allocated memory. The allocated memory is suitably aligned for any kind of variable. The memory is not cleared. `cudaMalloc()` returns `cudaErrorMemoryAllocation` in case of failure.

The device version of `cudaFree` cannot be used with a `*devPtr` allocated using the host API, and vice versa.

**Note:**

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cudaMallocPitch`, `cudaFree`, `cudaMallocArray`, `cudaFreeArray`, `cudaMalloc3D`, `cudaMalloc3DArray`, `cudaMallocHost (C API)`, `cudaFreeHost`, `cudaHostAlloc`, `cuMemAlloc`
__host__ cudaError_t cudaMalloc3D (cudaPitchedPtr *pitchedDevPtr, cudaExtent extent)

Allocates logical 1D, 2D, or 3D memory objects on the device.

Parameters

**pitchedDevPtr**
- Pointer to allocated pitched device memory

**extent**
- Requested allocation size (width field in bytes)

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorMemoryAllocation

Description

Allocates at least width * height * depth bytes of linear memory on the device and returns a cudaPitchedPtr in which ptr is a pointer to the allocated memory. The function may pad the allocation to ensure hardware alignment requirements are met. The pitch returned in the pitch field of pitchedDevPtr is the width in bytes of the allocation.

The returned cudaPitchedPtr contains additional fields xsize and ysize, the logical width and height of the allocation, which are equivalent to the width and height extent parameters provided by the programmer during allocation.

For allocations of 2D and 3D objects, it is highly recommended that programmers perform allocations using cudaMalloc3D() or cudaMallocPitch(). Due to alignment restrictions in the hardware, this is especially true if the application will be performing memory copies involving 2D or 3D objects (whether linear memory or CUDA arrays).

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaMallocPitch, cudaMemcpy3D, cudaMemcpy3DAsync, cudaMemcpy3DType, cudaHostAlloc, make_cudaPitchedPtr, make_cudaExtent, cuMemAllocPitch
__host__ cudaError_t cudaMalloc3DArray (cudaArray_t *array, const cudaChannelFormatDesc *desc, cudaExtent extent, unsigned int flags)
Allocate an array on the device.

Parameters
array
- Pointer to allocated array in device memory
desc
- Requested channel format
extent
- Requested allocation size (width field in elements)
flags
- Flags for extensions

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorMemoryAllocation

Description
Allocates a CUDA array according to the cudaChannelFormatDesc structure desc and returns a handle to the new CUDA array in *array.

The cudaChannelFormatDesc is defined as:

```
struct cudaChannelFormatDesc {
  int x, y, z, w;
  enum cudaChannelFormatKind f;
};
```

where cudaChannelFormatKind is one of cudaChannelFormatKindSigned, cudaChannelFormatKindUnsigned, or cudaChannelFormatKindFloat.

cudaMalloc3DArray() can allocate the following:

- A 1D array is allocated if the height and depth extents are both zero.
- A 2D array is allocated if only the depth extent is zero.
- A 3D array is allocated if all three extents are non-zero.
- A 1D layered CUDA array is allocated if only the height extent is zero and the cudaArrayLayered flag is set. Each layer is a 1D array. The number of layers is determined by the depth extent.
- A 2D layered CUDA array is allocated if all three extents are non-zero and the cudaArrayLayered flag is set. Each layer is a 2D array. The number of layers is determined by the depth extent.
- A cubemap CUDA array is allocated if all three extents are non-zero and the cudaArrayCubemap flag is set. Width must be equal to height, and depth must be six. A cubemap is a special type of
2D layered CUDA array, where the six layers represent the six faces of a cube. The order of the six layers in memory is the same as that listed in cudaGraphicsCubeFace.

- A cubemap layered CUDA array is allocated if all three extents are non-zero, and both, cudaArrayCubemap and cudaArrayLayered flags are set. Width must be equal to height, and depth must be a multiple of six. A cubemap layered CUDA array is a special type of 2D layered CUDA array that consists of a collection of cubemaps. The first six layers represent the first cubemap, the next six layers form the second cubemap, and so on.

The flags parameter enables different options to be specified that affect the allocation, as follows.

- cudaArrayDefault: This flag's value is defined to be 0 and provides default array allocation
- cudaArrayLayered: Allocates a layered CUDA array, with the depth extent indicating the number of layers
- cudaArrayCubemap: Allocates a cubemap CUDA array. Width must be equal to height, and depth must be six. If the cudaArrayLayered flag is also set, depth must be a multiple of six.
- cudaArraySurfaceLoadStore: Allocates a CUDA array that could be read from or written to using a surface reference.
- cudaArrayTextureGather: This flag indicates that texture gather operations will be performed on the CUDA array. Texture gather can only be performed on 2D CUDA arrays.
- cudaArraySparse: Allocates a CUDA array without physical backing memory. The subregions within this sparse array can later be mapped onto a physical memory allocation by calling cuMemMapArrayAsync. This flag can only be used for creating 2D, 3D or 2D layered sparse CUDA arrays. The physical backing memory must be allocated via cuMemCreate.
- cudaArrayDeferredMapping: Allocates a CUDA array without physical backing memory. The entire array can later be mapped onto a physical memory allocation by calling cuMemMapArrayAsync. The physical backing memory must be allocated via cuMemCreate.

The width, height and depth extents must meet certain size requirements as listed in the following table. All values are specified in elements.

<table>
<thead>
<tr>
<th>CUDA array type</th>
<th>Valid extents that must always be met</th>
<th>Valid extents with cudaArraySurfaceLoadStore set</th>
</tr>
</thead>
<tbody>
<tr>
<td>1D</td>
<td>{ (1,maxTexture1D), 0, 0 }</td>
<td>{ (1,maxSurface1D), 0, 0 }</td>
</tr>
<tr>
<td>2D</td>
<td>{ (1,maxTexture2D[0]), (1,maxTexture2D[1]), 0 }</td>
<td>{ (1,maxSurface2D[0]), (1,maxSurface2D[1]), 0 }</td>
</tr>
<tr>
<td>3D</td>
<td>{ (1,maxTexture3D[0]), (1,maxTexture3D[1]), (1,maxTexture3D[2]) } OR { (1,maxTexture3DAlt[0]), (1,maxSurface3D[2]) }</td>
<td>{ (1,maxSurface3D[0]), (1,maxSurface3D[1]), (1,maxSurface3D[2]) }</td>
</tr>
<tr>
<td>CUDA array type</td>
<td>Valid extents that must always be met {(width range in elements), (height range), (depth range)}</td>
<td>Valid extents with cudaArraySurfaceLoadStore set {(width range in elements), (height range), (depth range)}</td>
</tr>
<tr>
<td>----------------------</td>
<td>------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>(1,maxTexture3DAlt[1]), (1,maxTexture3DAlt[2])</td>
<td></td>
</tr>
<tr>
<td>1D Layered</td>
<td>{ (1,maxTexture1DLayered[0]), 0, (1,maxTexture1DLayered[1]) }</td>
<td>{ (1,maxSurface1DLayered[0]), 0, (1,maxSurface1DLayered[1]) }</td>
</tr>
<tr>
<td>2D Layered</td>
<td>{ (1,maxTexture2DLayered[0]), (1,maxTexture2DLayered[1]), (1,maxTexture2DLayered[2]) }</td>
<td>{ (1,maxSurface2DLayered[0]), (1,maxSurface2DLayered[1]), (1,maxSurface2DLayered[2]) }</td>
</tr>
<tr>
<td>Cubemap</td>
<td>{ (1,maxTextureCubemap), (1,maxTextureCubemap), 6 }</td>
<td>{ (1,maxSurfaceCubemap), (1,maxSurfaceCubemap), 6 }</td>
</tr>
<tr>
<td>Cubemap Layered</td>
<td>{ (1,maxTextureCubemapLayered[0]), (1,maxTextureCubemapLayered[1]), (1,maxTextureCubemapLayered[2]) }</td>
<td>{ (1,maxSurfaceCubemapLayered[0]), (1,maxSurfaceCubemapLayered[1]) }</td>
</tr>
</tbody>
</table>

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaMalloc3D, cudaMalloc, cudaMallocPitch, cudaFree, cudaFreeArray, cudaMallocHost (C API), cudaFreeHost, cudaHostAlloc, make_cudaExtent, cuArray3DCreate

__host__ cudaError_t cudaMallocArray (cudaArray_t *array, const cudaChannelFormatDesc *desc, size_t width, size_t height, unsigned int flags)

Allocate an array on the device.

Parameters

array
- Pointer to allocated array in device memory
desc
  - Requested channel format
width
  - Requested array allocation width
height
  - Requested array allocation height
flags
  - Requested properties of allocated array

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorMemoryAllocation

Description
Allocates a CUDA array according to the cudaChannelFormatDesc structure desc and returns a handle to the new CUDA array in *array.

The cudaChannelFormatDesc is defined as:

```c
struct cudaChannelFormatDesc {
    int x, y, z, w;
    enum cudaChannelFormatKind f;
};
```

where cudaChannelFormatKind is one of cudaChannelFormatKindSigned, cudaChannelFormatKindUnsigned, or cudaChannelFormatKindFloat.

The flags parameter enables different options to be specified that affect the allocation, as follows.

- **cudaArrayDefault:** This flag's value is defined to be 0 and provides default array allocation
- **cudaArraySurfaceLoadStore:** Allocates an array that can be read from or written to using a surface reference
- **cudaArrayTextureGather:** This flag indicates that texture gather operations will be performed on the array.
- **cudaArraySparse:** Allocates a CUDA array without physical backing memory. The subregions within this sparse array can later be mapped onto a physical memory allocation by calling cuMemMapArrayAsync. The physical backing memory must be allocated via cuMemCreate.
- **cudaArrayDeferredMapping:** Allocates a CUDA array without physical backing memory. The entire array can later be mapped onto a physical memory allocation by calling cuMemMapArrayAsync. The physical backing memory must be allocated via cuMemCreate.

width and height must meet certain size requirements. See cudaMalloc3DArray() for more details.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
**cudaMallocHost** (void **ptr, size_t size)

Allocates page-locked memory on the host.

**Parameters**

- **ptr**
  - Pointer to allocated host memory

- **size**
  - Requested allocation size in bytes

**Returns**

- **cudaSuccess**
- **cudaErrorInvalidValue**
- **cudaErrorMemoryAllocation**

**Description**

Allocates `size` bytes of host memory that is page-locked and accessible to the device. The driver tracks the virtual memory ranges allocated with this function and automatically accelerates calls to functions such as `cudaMemcpy`(). Since the memory can be accessed directly by the device, it can be read or written with much higher bandwidth than pageable memory obtained with functions such as `malloc()`.

On systems where `pageableMemoryAccessUsesHostPageTables` is true, `cudaMallocHost` may not page-lock the allocated memory.

Page-locking excessive amounts of memory with `cudaMallocHost()` may degrade system performance, since it reduces the amount of memory available to the system for paging. As a result, this function is best used sparingly to allocate staging areas for data exchange between host and device.

**Note:**

- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
See also:
cudaMalloc, cudaMallocPitch, cudaMallocArray, cudaMalloc3D, cudaMalloc3DArray, cudaHostAlloc, cudaFree, cudaFreeArray, cudaMallocHost (C++ API), cudaFreeHost, cudaHostAlloc, cuMemAllocHost

__host__ cudaError_t cudaMallocManaged (void **devPtr, size_t size, unsigned int flags)

Allocates memory that will be automatically managed by the Unified Memory system.

Parameters

devPtr
  - Pointer to allocated device memory
size
  - Requested allocation size in bytes
flags
  - Must be either cudaMemAttachGlobal or cudaMemAttachHost (defaults to cudaMemAttachGlobal)

Returns
cudaSuccess, cudaErrorMemoryAllocation, cudaErrorNotSupported, cudaErrorInvalidValue

Description

Allocates size bytes of managed memory on the device and returns in *devPtr a pointer to the allocated memory. If the device doesn't support allocating managed memory, cudaErrorNotSupported is returned. Support for managed memory can be queried using the device attribute cudaDevAttrManagedMemory. The allocated memory is suitably aligned for any kind of variable. The memory is not cleared. If size is 0, cudaMallocManaged returns cudaErrorInvalidValue. The pointer is valid on the CPU and on all GPUs in the system that support managed memory. All accesses to this pointer must obey the Unified Memory programming model.

flags specifies the default stream association for this allocation. flags must be one of cudaMemAttachGlobal or cudaMemAttachHost. The default value for flags is cudaMemAttachGlobal. If cudaMemAttachGlobal is specified, then this memory is accessible from any stream on any device. If cudaMemAttachHost is specified, then the allocation should not be accessed from devices that have a zero value for the device attribute cudaDevAttrConcurrentManagedAccess; an explicit call to cudaStreamAttachMemAsync will be required to enable access on such devices.
If the association is later changed via `cudaStreamAttachMemAsync` to a single stream, the default association, as specified during `cudaMallocManaged`, is restored when that stream is destroyed. For __managed__ variables, the default association is always `cudaMemAttachGlobal`. Note that destroying a stream is an asynchronous operation, and as a result, the change to default association won't happen until all work in the stream has completed.

Memory allocated with `cudaMallocManaged` should be released with `cudaFree`.

Device memory oversubscription is possible for GPUs that have a non-zero value for the device attribute `cudaDevAttrConcurrentManagedAccess`. Managed memory on such GPUs may be evicted from device memory to host memory at any time by the Unified Memory driver in order to make room for other allocations.

In a system where all GPUs have a non-zero value for the device attribute `cudaDevAttrConcurrentManagedAccess`, managed memory may not be populated when this API returns and instead may be populated on access. In such systems, managed memory can migrate to any processor's memory at any time. The Unified Memory driver will employ heuristics to maintain data locality and prevent excessive page faults to the extent possible. The application can also guide the driver about memory usage patterns via `cudaMemAdvise`. The application can also explicitly migrate memory to a desired processor's memory via `cudaMemPrefetchAsync`.

In a multi-GPU system where all of the GPUs have a zero value for the device attribute `cudaDevAttrConcurrentManagedAccess` and all the GPUs have peer-to-peer support with each other, the physical storage for managed memory is created on the GPU which is active at the time `cudaMallocManaged` is called. All other GPUs will reference the data at reduced bandwidth via peer mappings over the PCIe bus. The Unified Memory driver does not migrate memory among such GPUs.

In a multi-GPU system where not all GPUs have peer-to-peer support with each other and where the value of the device attribute `cudaDevAttrConcurrentManagedAccess` is zero for at least one of those GPUs, the location chosen for physical storage of managed memory is system-dependent.

- **On Linux**, the location chosen will be device memory as long as the current set of active contexts are on devices that either have peer-to-peer support with each other or have a non-zero value for the device attribute `cudaDevAttrConcurrentManagedAccess`. If there is an active context on a GPU that does not have a non-zero value for that device attribute and it does not have peer-to-peer support with the other devices that have active contexts on them, then the location for physical storage will be 'zero-copy' or host memory. Note that this means that managed memory that is located in device memory is migrated to host memory if a new context is created on a GPU that doesn’t have a non-zero value for the device attribute and does not support peer-to-peer with at least one of the other devices that has an active context. This in turn implies that context creation may fail if there is insufficient host memory to migrate all managed allocations.

- **On Windows**, the physical storage is always created in 'zero-copy' or host memory. All GPUs will reference the data at reduced bandwidth over the PCIe bus. In these circumstances, use of the environment variable `CUDA_VISIBLE_DEVICES` is recommended to restrict CUDA to only use those GPUs that have peer-to-peer support. Alternatively, users can also set `CUDA_MANAGED_FORCE_DEVICE_ALLOC` to a non-zero value to force the driver to always use device memory for physical storage. When this environment variable is set to a non-
zero value, all devices used in that process that support managed memory have to be peer-to-peer compatible with each other. The error `cudaErrorInvalidDevice` will be returned if a device that supports managed memory is used and it is not peer-to-peer compatible with any of the other managed memory supporting devices that were previously used in that process, even if `cudaDeviceReset` has been called on those devices. These environment variables are described in the CUDA programming guide under the "CUDA environment variables" section.

---

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

- `cudaMallocPitch`, `cudaFree`, `cudaMallocArray`, `cudaFreeArray`, `cudaMalloc3D`, `cudaMalloc3DArray`, `cudaMallocHost (C API)`, `cudaFreeHost`, `cudaHostAlloc`, `cudaDeviceGetAttribute`, `cudaStreamAttachMemAsync`, `cuMemAllocManaged`

```c
__host__ cudaError_t cudaMallocMipmappedArray(
    cudaMipmappedArray_t *mipmappedArray, const cudaChannelFormatDesc *desc, cudaExtent extent,
    unsigned int numLevels, unsigned int flags)
```

Allocate a mipmapped array on the device.

**Parameters**

- `mipmappedArray` - Pointer to allocated mipmapped array in device memory
- `desc` - Requested channel format
- `extent` - Requested allocation size (width field in elements)
- `numLevels` - Number of mipmap levels to allocate
- `flags` - Flags for extensions
Returns

`cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorMemoryAllocation`

Description

Allocates a CUDA mipmapped array according to the `cudaChannelFormatDesc` structure `desc` and returns a handle to the new CUDA mipmapped array in `*mipmappedArray`. `numLevels` specifies the number of mipmap levels to be allocated. This value is clamped to the range \([1, 1 + \text{floor}(\log_2(\max(\text{width, height, depth}))))\].

The `cudaChannelFormatDesc` is defined as:

```c
struct cudaChannelFormatDesc {
    int x, y, z, w;
    enum cudaChannelFormatKind f;
};
```

where `cudaChannelFormatKind` is one of `cudaChannelFormatKindSigned`, `cudaChannelFormatKindUnsigned`, or `cudaChannelFormatKindFloat`.

`cudaMallocMipmappedArray()` can allocate the following:

- A 1D mipmapped array is allocated if the height and depth extents are both zero.
- A 2D mipmapped array is allocated if only the depth extent is zero.
- A 3D mipmapped array is allocated if all three extents are non-zero.
- A 1D layered CUDA mipmapped array is allocated if only the height extent is zero and the `cudaArrayLayered` flag is set. Each layer is a 1D mipmapped array. The number of layers is determined by the depth extent.
- A 2D layered CUDA mipmapped array is allocated if all three extents are non-zero and the `cudaArrayLayered` flag is set. Each layer is a 2D mipmapped array. The number of layers is determined by the depth extent.
- A cubemap CUDA mipmapped array is allocated if all three extents are non-zero and the `cudaArrayCubemap` flag is set. Width must be equal to height, and depth must be six. The order of the six layers in memory is the same as that listed in `cudaGraphicsCubeFace`.
- A cubemap layered CUDA mipmapped array is allocated if all three extents are non-zero, and both, `cudaArrayCubemap` and `cudaArrayLayered` flags are set. Width must be equal to height, and depth must be a multiple of six. A cubemap layered CUDA mipmapped array is a special type of 2D layered CUDA mipmapped array that consists of a collection of cubemap mipmapped arrays. The first six layers represent the first cubemap mipmapped array, the next six layers form the second cubemap mipmapped array, and so on.

The `flags` parameter enables different options to be specified that affect the allocation, as follows.

- `cudaArrayDefault`: This flag's value is defined to be 0 and provides default mipmapped array allocation
- `cudaArrayLayered`: Allocates a layered CUDA mipmapped array, with the depth extent indicating the number of layers
- **cudaArrayCubemap**: Allocates a cubemap CUDA mipmapped array. Width must be equal to height, and depth must be six. If the cudaArrayLayered flag is also set, depth must be a multiple of six.

- **cudaArraySurfaceLoadStore**: This flag indicates that individual mipmap levels of the CUDA mipmapped array will be read from or written to using a surface reference.

- **cudaArrayTextureGather**: This flag indicates that texture gather operations will be performed on the CUDA array. Texture gather can only be performed on 2D CUDA mipmapped arrays, and the gather operations are performed only on the most detailed mipmap level.

- **cudaArraySparse**: Allocates a CUDA mipmapped array without physical backing memory. The subregions within this sparse array can later be mapped onto a physical memory allocation by calling `cuMemMapArrayAsync`. This flag can only be used for creating 2D, 3D or 2D layered sparse CUDA mipmapped arrays. The physical backing memory must be allocated via `cuMemCreate`.

- **cudaArrayDeferredMapping**: Allocates a CUDA mipmapped array without physical backing memory. The entire array can later be mapped onto a physical memory allocation by calling `cuMemMapArrayAsync`. The physical backing memory must be allocated via `cuMemCreate`.

The width, height and depth extents must meet certain size requirements as listed in the following table. All values are specified in elements.

<table>
<thead>
<tr>
<th>CUDA array type</th>
<th>Valid extents that must always be met</th>
<th>Valid extents with cudaArraySurfaceLoadStore set</th>
</tr>
</thead>
<tbody>
<tr>
<td>1D</td>
<td>{(1,maxTexture1DMipmap), 0, 0}</td>
<td>{(1,maxSurface1D), 0, 0}</td>
</tr>
<tr>
<td>2D</td>
<td>{(1,maxTexture2DMipmap[0]), (1,maxTexture2DMipmap[1]), 0}</td>
<td>{(1,maxSurface2D[0], (1,maxSurface2D[1]), 0}</td>
</tr>
<tr>
<td>3D</td>
<td>{(1,maxTexture3D[0]), (1,maxTexture3D[1]), (1,maxTexture3D[2]) \ OR {(1,maxTexture3DAlt[0]), (1,maxTexture3DAlt[1]), (1,maxTexture3DAlt[2]) }</td>
<td>{(1,maxSurface3D[0], (1,maxSurface3D[1]), (1,maxSurface3D[2]) }</td>
</tr>
<tr>
<td>1D Layered</td>
<td>{(1,maxTexture1DLayered[0]), 0, (1,maxTexture1DLayered[1]) }</td>
<td>{(1,maxSurface1DLayered[0]), 0, (1,maxSurface1DLayered[1]) }</td>
</tr>
<tr>
<td>2D Layered</td>
<td>{(1,maxTexture2DLayered[0]), (1,maxTexture2DLayered[1]), (1,maxTexture2DLayered[2]) }</td>
<td>{(1,maxSurface2DLayered[0]), (1,maxSurface2DLayered[1]), (1,maxSurface2DLayered[2]) }</td>
</tr>
<tr>
<td>Cubemap</td>
<td>{(1,maxTextureCubemap), (1,maxTextureCubemap), 6}</td>
<td>{(1,maxSurfaceCubemap), (1,maxSurfaceCubemap), 6}</td>
</tr>
<tr>
<td>CUDA array type</td>
<td>Valid extents that must always be met</td>
<td>Valid extents with cudaArraySurfaceLoadStore set</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Cubemap Layered</td>
<td>{ (1,maxTextureCubemapLayered[0]), (1,maxTextureCubemapLayered[0]), (1,maxTextureCubemapLayered[1]) }</td>
<td>{ (1,maxSurfaceCubemapLayered[0]), (1,maxSurfaceCubemapLayered[0]), (1,maxSurfaceCubemapLayered[1]) }</td>
</tr>
</tbody>
</table>

**Note:**
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
- `cudaMalloc3D`, `cudaMalloc`, `cudaMallocPitch`, `cudaFree`, `cudaFreeArray`, `cudaMallocHost (C API)`, `cudaFreeHost`, `cudaHostAlloc`, `make_cudaExtent`, `cuMipmappedArrayCreate`

__host__ cudaError_t cudaMallocPitch (void **devPtr, size_t *pitch, size_t width, size_t height)

Allocates pitched memory on the device.

**Parameters**

- **devPtr**: Pointer to allocated pitched device memory
- **pitch**: Pitch for allocation
- **width**: Requested pitched allocation width (in bytes)
- **height**: Requested pitched allocation height

**Returns**
- `cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorMemoryAllocation`
Description

Allocates at least width (in bytes) * height bytes of linear memory on the device and returns in *devPtr a pointer to the allocated memory. The function may pad the allocation to ensure that corresponding pointers in any given row will continue to meet the alignment requirements for coalescing as the address is updated from row to row. The pitch returned in *pitch by cudaMallocPitch() is the width in bytes of the allocation. The intended usage of pitch is as a separate parameter of the allocation, used to compute addresses within the 2D array. Given the row and column of an array element of type T, the address is computed as:

\[
T* pElement = (T*)((char*)BaseAddress + Row * pitch) + Column;
\]

For allocations of 2D arrays, it is recommended that programmers consider performing pitch allocations using cudaMallocPitch(). Due to pitch alignment restrictions in the hardware, this is especially true if the application will be performing 2D memory copies between different regions of device memory (whether linear memory or CUDA arrays).

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaMalloc, cudaFree, cudaMallocArray, cudaFreeArray, cudaMallocHost (C API), cudaFreeHost, cudaMalloc3D, cudaMalloc3DArray, cudaHostAlloc, cuMemAllocPitch

__host__ cudaError_t cudaMemAdvise (const void *devPtr, size_t count, cudaMemoryAdvise advice, int device)

Advise about the usage of a given memory range.

Parameters

devPtr
- Pointer to memory to set the advice for

count
- Size in bytes of the memory range

advice
- Advice to be applied for the specified memory range

device
- Device to apply the advice for
Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidDevice

Description

Advise the Unified Memory subsystem about the usage pattern for the memory range starting at devPtr with a size of count bytes. The start address and end address of the memory range will be rounded down and rounded up respectively to be aligned to CPU page size before the advice is applied. The memory range must refer to managed memory allocated via cudaMallocManaged or declared via __managed__ variables. The memory range could also refer to system-allocated pageable memory provided it represents a valid, host-accessible region of memory and all additional constraints imposed by advice as outlined below are also satisfied. Specifying an invalid system-allocated pageable memory range results in an error being returned.

The advice parameter can take the following values:

- **cudaMemAdviseSetReadMostly**: This implies that the data is mostly going to be read from and only occasionally written to. Any read accesses from any processor to this region will create a read-only copy of at least the accessed pages in that processor's memory. Additionally, if cudaMemPrefetchAsync is called on this region, it will create a read-only copy of the data on the destination processor. If any processor writes to this region, all copies of the corresponding page will be invalidated except for the one where the write occurred. The device argument is ignored for this advice. Note that for a page to be read-duplicated, the accessing processor must either be the CPU or a GPU that has a non-zero value for the device attribute cudaDevAttrConcurrentManagedAccess. Also, if a context is created on a device that does not have the device attribute cudaDevAttrConcurrentManagedAccess set, then read-duplication will not occur until all such contexts are destroyed. If the memory region refers to valid system-allocated pageable memory, then the accessing device must have a non-zero value for the device attribute cudaDevAttrPageableMemoryAccess for a read-only copy to be created on that device. Note however that if the accessing device also has a non-zero value for the device attribute cudaDevAttrPageableMemoryAccessUsesHostPageTables, then setting this advice will not create a read-only copy when that device accesses this memory region.

- **cudaMemAdviceUnsetReadMostly**: Undoes the effect of cudaMemAdviceReadMostly and also prevents the Unified Memory driver from attempting heuristic read-duplication on the memory range. Any read-duplicated copies of the data will be collapsed into a single copy. The location for the collapsed copy will be the preferred location if the page has a preferred location and one of the read-duplicated copies was resident at that location. Otherwise, the location chosen is arbitrary.

- **cudaMemAdviseSetPreferredLocation**: This advice sets the preferred location for the data to be the memory belonging to device. Passing in cudaCpuDeviceId for device sets the preferred location as host memory. If device is a GPU, then it must have a non-zero value for the device attribute cudaDevAttrConcurrentManagedAccess. Setting the preferred location does not cause data to migrate to that location immediately. Instead, it guides the migration policy when a fault occurs on that memory region. If the data is already in its preferred location and the
faulting processor can establish a mapping without requiring the data to be migrated, then data migration will be avoided. On the other hand, if the data is not in its preferred location or if a direct mapping cannot be established, then it will be migrated to the processor accessing it. It is important to note that setting the preferred location does not prevent data prefetching done using \texttt{cudaMemPrefetchAsync}. Having a preferred location can override the page thrash detection and resolution logic in the Unified Memory driver. Normally, if a page is detected to be constantly thrashing between for example host and device memory, the page may eventually be pinned to host memory by the Unified Memory driver. But if the preferred location is set as device memory, then the page will continue to thrash indefinitely. If \texttt{cudaMemAdviseSetReadMostly} is also set on this memory region or any subset of it, then the policies associated with that advice will override the policies of this advice, unless read accesses from device will not result in a read-only copy being created on that device as outlined in description for the advice \texttt{cudaMemAdviseSetReadMostly}. If the memory region refers to valid system-allocated pageable memory, then device must have a non-zero value for the device attribute \texttt{cudaDevAttrPageableMemoryAccess}.

\begin{itemize}
  \item \texttt{cudaMemAdviseUnsetPreferredLocation}: Undoes the effect of \texttt{cudaMemAdviseSetPreferredLocation} and changes the preferred location to none.
  \item \texttt{cudaMemAdviseSetAccessedBy}: This advice implies that the data will be accessed by device. Passing in \texttt{cudaCpuDeviceId} for device will set the advice for the CPU. If device is a GPU, then the device attribute \texttt{cudaDevAttrConcurrentManagedAccess} must be non-zero. This advice does not cause data migration and has no impact on the location of the data per se. Instead, it causes the data to always be mapped in the specified processor's page tables, as long as the location of the data permits a mapping to be established. If the data gets migrated for any reason, the mappings are updated accordingly. This advice is recommended in scenarios where data locality is not important, but avoiding faults is. Consider for example a system containing multiple GPUs with peer-to-peer access enabled, where the data located on one GPU is occasionally accessed by peer GPUs. In such scenarios, migrating data over to the other GPUs is not as important because the accesses are infrequent and the overhead of migration may be too high. But preventing faults can still help improve performance, and so having a mapping set up in advance is useful. Note that on CPU access of this data, the data may be migrated to host memory because the CPU typically cannot access device memory directly. Any GPU that had the \texttt{cudaMemAdviceSetAccessedBy} flag set for this data will now have its mapping updated to point to the page in host memory. If \texttt{cudaMemAdviseSetReadMostly} is also set on this memory region or any subset of it, then the policies associated with that advice will override the policies of this advice. Additionally, if the preferred location of this memory region or any subset of it is also device, then the policies associated with \texttt{cudaMemAdviseSetPreferredLocation} will override the policies of this advice. If the memory region refers to valid system-allocated pageable memory, then device must have a non-zero value for the device attribute \texttt{cudaDevAttrPageableMemoryAccess}. Additionally, if device has a non-zero value for the device attribute \texttt{cudaDevAttrPageableMemoryAccessUsesHostPageTables}, then this call has no effect.
  \item \texttt{cudaMemAdviseUnsetAccessedBy}: Undoes the effect of \texttt{cudaMemAdviseSetAccessedBy}. Any mappings to the data from device may be removed at any time causing accesses
\end{itemize}
to result in non-fatal page faults. If the memory region refers to valid system-allocated pageable memory, then device must have a non-zero value for the device attribute cudaDevAttrPageableMemoryAccess. Additionally, if device has a non-zero value for the device attribute cudaDevAttrPageableMemoryAccessUsesHostPageTables, then this call has no effect.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits asynchronous behavior for most use cases.
- This function uses standard default stream semantics.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaMemcpy, cudaMemcpyPeer, cudaMemcpyAsync, cudaMemcpy3DPeerAsync, cudaMemcpyAsync, cuMemAdvise

__host__ cudaError_t cudaMemAdvise_v2 (const void *devPtr, size_t count, cudaMemoryAdvise advice, cudaMemLocation location)

Advise about the usage of a given memory range.

Parameters

devPtr
- Pointer to memory to set the advice for
count
- Size in bytes of the memory range
advice
- Advice to be applied for the specified memory range
location
- location to apply the advice for

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidDevice
Description

Advise the Unified Memory subsystem about the usage pattern for the memory range starting at devPtr with a size of count bytes. The start address and end address of the memory range will be rounded down and rounded up respectively to be aligned to CPU page size before the advice is applied. The memory range must refer to managed memory allocated via cudaMallocManaged or declared via __managed__ variables. The memory range could also refer to system-allocated pageable memory provided it represents a valid, host-accessible region of memory and all additional constraints imposed by advice as outlined below are also satisfied. Specifying an invalid system-allocated pageable memory range results in an error being returned.

The advice parameter can take the following values:

- **cudaMemAdviseSetReadMostly**: This implies that the data is mostly going to be read from and only occasionally written to. Any read accesses from any processor to this region will create a read-only copy of at least the accessed pages in that processor's memory. Additionally, if cudaMemPrefetchAsync or cudaMemPrefetchAsync_v2 is called on this region, it will create a read-only copy of the data on the destination processor. If the target location for cudaMemPrefetchAsync_v2 is a host NUMA node and a read-only copy already exists on another host NUMA node, that copy will be migrated to the targeted host NUMA node. If any processor writes to this region, all copies of the corresponding page will be invalidated except for the one where the write occurred. If the writing processor is the CPU and the preferred location of the page is a host NUMA node, then the page will also be migrated to that host NUMA node. The location argument is ignored for this advice. Note that for a page to be read-duplicated, the accessing processor must either be the CPU or a GPU that has a non-zero value for the device attribute cudaDevAttrConcurrentManagedAccess. Also, if a context is created on a device that does not have the device attribute cudaDevAttrConcurrentManagedAccess set, then read-duplication will not occur until all such contexts are destroyed. If the memory region refers to valid system-allocated pageable memory, then the accessing device must have a non-zero value for the device attribute cudaDevAttrPageableMemoryAccess for a read-only copy to be created on that device. Note however that if the accessing device also has a non-zero value for the device attribute cudaDevAttrPageableMemoryAccessUsesHostPageTables, then setting this advice will not create a read-only copy when that device accesses this memory region.

- **cudaMemAdviceUnsetReadMostly**: Undoes the effect of cudaMemAdviseSetReadMostly and also prevents the Unified Memory driver from attempting heuristic read-duplication on the memory range. Any read-duplicated copies of the data will be collapsed into a single copy. The location for the collapsed copy will be the preferred location if the page has a preferred location and one of the read-duplicated copies was resident at that location. Otherwise, the location chosen is arbitrary. Note: The location argument is ignored for this advice.

- **cudaMemAdviseSetPreferredLocation**: This advice sets the preferred location for the data to be the memory belonging to location. When cudaMemLocation::type is cudaMemLocationTypeHost, cudaMemLocation::id is ignored and the preferred location is set to be host memory. To set the preferred location to a specific host NUMA node, applications must set cudaMemLocation::type to...
`cudaMemLocationTypeHostNuma` and `cudaMemLocation::id` must specify the NUMA ID of the host NUMA node. If `cudaMemLocation::type` is set to `cudaMemLocationTypeHostNumaCurrent`, `cudaMemLocation::id` will be ignored and the host NUMA node closest to the calling thread's CPU will be used as the preferred location. If `cudaMemLocation::type` is a `cudaMemLocationTypeDevice`, then `cudaMemLocation::id` must be a valid device ordinal and the device must have a non-zero value for the device attribute `cudaDevAttrConcurrentManagedAccess`. Setting the preferred location does not cause data to migrate to that location immediately. Instead, it guides the migration policy when a fault occurs on that memory region. If the data is already in its preferred location and the faulting processor can establish a mapping without requiring the data to be migrated, then data migration will be avoided. On the other hand, if the data is not in its preferred location or if a direct mapping cannot be established, then it will be migrated to the processor accessing it. It is important to note that setting the preferred location does not prevent data prefetching done using `cudaMemPrefetchAsync`. Having a preferred location can override the page thrash detection and resolution logic in the Unified Memory driver. Normally, if a page is detected to be constantly thrashing between for example host and device memory, the page may eventually be pinned to host memory by the Unified Memory driver. But if the preferred location is set as device memory, then the page will continue to thrash indefinitely. If `cudaMemAdviseSetReadMostly` is also set on this memory region or any subset of it, then the policies associated with that advice will override the policies of this advice, unless read accesses from location will not result in a read-only copy being created on that processor as outlined in description for the advice `cudaMemAdviseSetReadMostly`. If the memory region refers to valid system-allocated pageable memory, and `cudaMemLocation::type` is `cudaMemLocationTypeDevice` then `cudaMemLocation::id` must be a valid device that has a non-zero value for the device attribute `cudaDevAttrPageableMemoryAccess`.

- **`cudaMemAdviseUnsetPreferredLocation`**: Undoes the effect of `cudaMemAdviseSetPreferredLocation` and changes the preferred location to none. The location argument is ignored for this advice.

- **`cudaMemAdviseSetAccessedBy`**: This advice implies that the data will be accessed by processor location. The `cudaMemLocation::type` must be either `cudaMemLocationTypeDevice` with `cudaMemLocation::id` representing a valid device ordinal or `cudaMemLocationTypeHost` and `cudaMemLocation::id` will be ignored. All other location types are invalid. If `cudaMemLocation::id` is a GPU, then the device attribute `cudaDevAttrConcurrentManagedAccess` must be non-zero. This advice does not cause data migration and has no impact on the location of the data per se. Instead, it causes the data to always be mapped in the specified processor's page tables, as long as the location of the data permits a mapping to be established. If the data gets migrated for any reason, the mappings are updated accordingly. This advice is recommended in scenarios where data locality is not important, but avoiding faults is. Consider for example a system containing multiple GPUs with peer-to-peer access enabled, where the data located on one GPU is occasionally accessed by peer GPUs. In such scenarios, migrating data over to the other GPUs is not as important because the accesses are infrequent and the overhead of migration may be too high. But preventing faults can still help improve performance, and so having a mapping set up in advance is useful. Note that on CPU access of this data, the data may be
migrated to host memory because the CPU typically cannot access device memory directly. Any GPU that had the `cudaMemAdviseSetAccessedBy` flag set for this data will now have its mapping updated to point to the page in host memory. If `cudaMemAdviseSetReadMostly` is also set on this memory region or any subset of it, then the policies associated with that advice will override the policies of this advice. Additionally, if the preferred location of this memory region or any subset of it is also location, then the policies associated with `CU_MEM_ADVISE_SET_PREFERRED_LOCATION` will override the policies of this advice. If the memory region refers to valid system-allocated pageable memory, and `cudaMemLocation::type` is `cudaMemLocationTypeDevice` then device in `cudaMemLocation::id` must have a non-zero value for the device attribute `cudaDevAttrPageableMemoryAccess`. Additionally, if `cudaMemLocation::id` has a non-zero value for the device attribute `cudaDevAttrPageableMemoryAccessUsesHostPageTables`, then this call has no effect.

- **CU_MEM_ADVISE_UNSET_ACCESSED_BY**: Undoes the effect of `cudaMemAdviseSetAccessedBy`. Any mappings to the data from location may be removed at any time causing accesses to result in non-fatal page faults. If the memory region refers to valid system-allocated pageable memory, and `cudaMemLocation::type` is `cudaMemLocationTypeDevice` then device in `cudaMemLocation::id` must have a non-zero value for the device attribute `cudaDevAttrPageableMemoryAccess`. Additionally, if `cudaMemLocation::id` has a non-zero value for the device attribute `cudaDevAttrPageableMemoryAccessUsesHostPageTables`, then this call has no effect.

### Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits asynchronous behavior for most use cases.
- This function uses standard default stream semantics.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback`, no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
- `cudaMemcpy`, `cudaMemcpypPeer`, `cudaMemcpypAsync`, `cudaMemcpyp3DPeerAsync`, `cudaMemPrefetchAsync`, `cuMemAdvise`, `cuMemAdvise_v2`
__host__ cudaError_t cudaMemcpy (void *dst, const void *src, size_t count, cudaMemcpyKind kind)

Copies data between host and device.

Parameters

dst  
- Destination memory address

src  
- Source memory address

count  
- Size in bytes to copy

kind  
- Type of transfer

Returns

cudaSuccess, cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, cudaMemcpyHostToDevice, cudaMemcpyInvalidDirection, cudaMemcpyInvalidValue

Description

Copies count bytes from the memory area pointed to by src to the memory area pointed to by dst, where kind specifies the direction of the copy, and must be one of cudaMemcpyHostToHost, cudaMemcpyHostToDevice, cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing. Calling cudaMemcpy() with dst and src pointers that do not match the direction of the copy results in an undefined behavior.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaMemcpyNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpyAddCallback no CUDA function may be called from callback. cudaMemcpyNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
- This function exhibits synchronous behavior for most use cases.
- Memory regions requested must be either entirely registered with CUDA, or in the case of host pageable transfers, not registered at all. Memory regions spanning over allocations that are both registered and not registered with CUDA are not supported and will return CUDA_ERROR_INVALID_VALUE.
__host__ cudaError_t cudaMemcpy2D (void *dst, size_t dpitch, const void *src, size_t spitch, size_t width, size_t height, cudaMemcpyKind kind)

Copies data between host and device.

Parameters

dst
- Destination memory address
dpitch
- Pitch of destination memory
src
- Source memory address
spitch
- Pitch of source memory
width
- Width of matrix transfer (columns in bytes)
height
- Height of matrix transfer (rows)
kind
- Type of transfer

Returns

cudaSuccess, cudaErrorInvalidValue, cudaMemcpyErrorInvalidPitchValue, cudaMemcpyErrorInvalidMemcpyKind

Description

Copies a matrix (height rows of width bytes each) from the memory area pointed to by src to the memory area pointed to by dst, where kind specifies the direction of the copy, and must be one of cudaMemcpyHostToHost, cudaMemcpyHostToDevice, cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing. dpitch and spitch are the widths in memory in bytes of the 2D arrays pointed to by dst and src, including any padding added to the end of each row. The memory areas may not overlap. width must not
 exceed either dpitch or spitch. Calling cudaMemcpy2D() with dst and src pointers that do not match the direction of the copy results in an undefined behavior. cudaMemcpy2D() returns an error if dpitch or spitch exceeds the maximum allowed.

See also:
 cudaMemcpy, cudaMemcpy2DTo Array, cudaMemcpy2DFromArray, cudaMemcpy2DArrayToArray, cudaMemcpyToSymbol, cudaMemcpyFromSymbol, cudaMemcpyAsync, cudaMemcpy2DAsync, cudaMemcpy2DToArrayAsync, cudaMemcpy2DFromArrayAsync, cudaMemcpyToSymbolAsync, cudaMemcpyFromSymbolAsync, cuMemcpy2D, cuMemcpy2DUnaligned

__host__ cudaError_t cudaMemcpy2DArrayToArray (cudaArray_t dst, size_t wOffsetDst, size_t hOffsetDst, cudaArray_const_t src, size_t wOffsetSrc, size_t hOffsetSrc, size_t width, size_t height, cudaMemcpyKind kind)
 Copies data between host and device.

Parameters

dst
  - Destination memory address
wOffsetDst
  - Destination starting X offset (columns in bytes)
hOffsetDst
  - Destination starting Y offset (rows)
src
  - Source memory address
wOffsetSrc
  - Source starting X offset (columns in bytes)

hOffsetSrc
  - Source starting Y offset (rows)

width
  - Width of matrix transfer (columns in bytes)

height
  - Height of matrix transfer (rows)

kind
  - Type of transfer

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidMemcpyDirection

Description

Copies a matrix (height rows of width bytes each) from the CUDA array src starting at hOffsetSrc rows and wOffsetSrc bytes from the upper left corner to the CUDA array dst starting at hOffsetDst rows and wOffsetDst bytes from the upper left corner, where kind specifies the direction of the copy, and must be one of cudaMemcpyHostToHost, cudaMemcpyHostToDevice, cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing. wOffsetDst + width must not exceed the width of the CUDA array dst. wOffsetSrc + width must not exceed the width of the CUDA array src.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits synchronous behavior for most use cases.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaMemcpy, cudaMemcpy2D, cudaMemcpy2DToArray, cudaMemcpy2DFromArray, cudaMemcpyToSymbol, cudaMemcpyFromSymbol, cudaMemcpyAsync, cudaMemcpy2DAsync, cudaMemcpy2DToArrayAsync, cudaMemcpy2DFromArrayAsync, cudaMemcpyToSymbolAsync, cudaMemcpyFromSymbolAsync, cuMemcpy2D, cuMemcpy2DUnaligned
__host__ __device__ cudaError_t cudaMemcpy2DAsync (void *dst, size_t dpitch, const void *src, size_t spitch, size_t width, size_t height, cudaMemcpyKind kind, cudaStream_t stream)

Copies data between host and device.

Parameters

dst
- Destination memory address
dpitch
- Pitch of destination memory
src
- Source memory address
spitch
- Pitch of source memory
width
- Width of matrix transfer (columns in bytes)
height
- Height of matrix transfer (rows)
kind
- Type of transfer
stream
- Stream identifier

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidPitchValue, cudaErrorInvalidMemcpyDirection

Description

Copies a matrix (height rows of width bytes each) from the memory area pointed to by src to the memory area pointed to by dst, where kind specifies the direction of the copy, and must be one of cudaMemcpyHostToDevice, cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing. dpitch and spitch are the widths in memory in bytes of the 2D arrays pointed to by dst and src, including any padding added to the end of each row. The memory areas may not overlap. width must not exceed either dpitch or spitch.
Calling `cudaMemcpy2DAsync()` with `dst` and `src` pointers that do not match the direction of the copy results in an undefined behavior. `cudaMemcpy2DAsync()` returns an error if `dpitch` or `spitch` is greater than the maximum allowed.

`cudaMemcpy2DAsync()` is asynchronous with respect to the host, so the call may return before the copy is complete. The copy can optionally be associated to a stream by passing a non-zero `stream` argument. If `kind` is `cudaMemcpyHostToDevice` or `cudaMemcpyDeviceToHost` and `stream` is non-zero, the copy may overlap with operations in other streams.

The device version of this function only handles device to device copies and cannot be given local or shared pointers.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits asynchronous behavior for most use cases.
- This function uses standard default stream semantics.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.
- Memory regions requested must be either entirely registered with CUDA, or in the case of host pageable transfers, not registered at all. Memory regions spanning over allocations that are both registered and not registered with CUDA are not supported and will return `CUDA_ERROR_INVALID_VALUE`.

See also:

- `cudaMemcpy`, `cudaMemcpy2D`, `cudaMemcpy2DToArray`, `cudaMemcpy2DFromArray`, `cudaMemcpy2DArrayToArray`, `cudaMemcpy2DToArrayAsync`, `cudaMemcpy2DFromArrayAsync`, `cudaMemcpyAsync`, `cudaMemcpyToSymbol`, `cudaMemcpyFromSymbol`, `cudaMemcpyAsync`, `cudaMemcpyToSymbolAsync`, `cudaMemcpyFromSymbolAsync`, `cuMemcpy2DAsync`
__host__ cudaError_t cudaMemcpy2DFromArray
(void *dst, size_t dpitch, cudaArray_const_t src, size_t wOffset, size_t hOffset, size_t width, size_t height, cudaMemcpyKind kind)

Copies data between host and device.

Parameters

dst
- Destination memory address
dpitch
- Pitch of destination memory
src
- Source memory address
wOffset
- Source starting X offset (columns in bytes)
hOffset
- Source starting Y offset (rows)
width
- Width of matrix transfer (columns in bytes)
height
- Height of matrix transfer (rows)
kind
- Type of transfer

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidPitchValue, cudaErrorInvalidMemcpyDirection

Description
Copies a matrix (height rows of width bytes each) from the CUDA array src starting at hOffset rows and wOffset bytes from the upper left corner to the memory area pointed to by dst, where kind specifies the direction of the copy, and must be one of cudaMemcpyHostToHost, cudaMemcpyHostToDevice, cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing. dpitch is the width in memory in bytes of the 2D array pointed to by dst, including any padding added to the end of each row. wOffset + width must not exceed the width of the CUDA array src.width must not exceed dpitch. cudaMemcpy2DFromArray() returns an error if dpitch exceeds the maximum allowed.
Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits synchronous behavior for most use cases.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
- Memory regions requested must be either entirely registered with CUDA, or in the case of host pageable transfers, not registered at all. Memory regions spanning over allocations that are both registered and not registered with CUDA are not supported and will return CUDA_ERROR_INVALID_VALUE.

See also:
cudaMemcpy, cudaMemcpy2D, cudaMemcpy2DToArray, cudaMemcpy2DArrayToArray, cudaMemcpyToSymbol, cudaMemcpyFromSymbol, cudaMemcpyAsync, cudaMemcpy2DAsync, cudaMemcpy2DFromArrayAsyncAsync, cudaMemcpy2DFromArrayAsyncAsync, cudaMemcpyToSymbolAsync, cudaMemcpyFromSymbolAsync, cuMemcpy2D, cuMemcpy2DUnaligned

__host__ cudaError_t cudaMemcpy2DFromArrayAsync
(void *dst, size_t dpitch, cudaArray_const_t src, size_t wOffset, size_t hOffset, size_t width, size_t height, cudaMemcpyKind kind, cudaStream_t stream)

Copies data between host and device.

Parameters

dst
- Destination memory address
dpitch
- Pitch of destination memory
src
- Source memory address
wOffset
- Source starting X offset (columns in bytes)
hOffset
- Source starting Y offset (rows)
width
- Width of matrix transfer (columns in bytes)
height
- Height of matrix transfer (rows)

kind
- Type of transfer

stream
- Stream identifier

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidPitchValue, cudaErrorInvalidMemcpyDirection

Description
Copies a matrix (height rows of width bytes each) from the CUDA array src starting at hOffset rows and wOffset bytes from the upper left corner to the memory area pointed to by dst, where kind specifies the direction of the copy, and must be one of cudaMemcpyHostToHost, cudaMemcpyHostToDevice, cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing. dpitch is the width in memory in bytes of the 2D array pointed to by dst, including any padding added to the end of each row. wOffset + width must not exceed the width of the CUDA array src. width must not exceed dpitch. cudaMemcpy2DFromArrayAsync returns an error if dpitch exceeds the maximum allowed.

cudaMemcpy2DFromArrayAsync is asynchronous with respect to the host, so the call may return before the copy is complete. The copy can optionally be associated to a stream by passing a non-zero stream argument. If kind is cudaMemcpyHostToDevice or cudaMemcpyDeviceToHost and stream is non-zero, the copy may overlap with operations in other streams.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits asynchronous behavior for most use cases.
- This function uses standard default stream semantics.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
- Memory regions requested must be either entirely registered with CUDA, or in the case of host pageable transfers, not registered at all. Memory regions spanning over allocations that are both registered and not registered with CUDA are not supported and will return CUDA_ERROR_INVALID_VALUE.

See also:
__host__ cudaError_t cudaMemcpy2DToArray (cudaArray_t dst, size_t wOffset, size_t hOffset, const void *src, size_t spitch, size_t width, size_t height, cudaMemcpyKind kind)

Copies data between host and device.

Parameters

dst
- Destination memory address

wOffset
- Destination starting X offset (columns in bytes)

hOffset
- Destination starting Y offset (rows)

src
- Source memory address

spitch
- Pitch of source memory

width
- Width of matrix transfer (columns in bytes)

height
- Height of matrix transfer (rows)

kind
- Type of transfer

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidPitchValue, cudaErrorInvalidMemcpyDirection

Description

Copies a matrix (height rows of width bytes each) from the memory area pointed to by src to the CUDA array dst starting at hOffset rows and wOffset bytes from the upper left corner, where kind specifies the direction of the copy, and must be one of cudaMemcpyHostToDevice, cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing. spitch is the width in memory in bytes of the 2D array pointed to.
by src, including any padding added to the end of each row. \( w_{\text{Offset}} + \text{width} \) must not exceed the width of the CUDA array dst. width must not exceed \( \text{spitch} \). cudaMemcpy2DToArray() returns an error if \( \text{spitch} \) exceeds the maximum allowed.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits synchronous behavior for most use cases.
- Note that this function may also return cudaMemcpyErrorInitializationError, cudaMemcpyErrorInsufficientDriver or cudaMemcpyErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpyAddCallback no CUDA function may be called from callback. cudaMemcpyNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
- Memory regions requested must be either entirely registered with CUDA, or in the case of host pageable transfers, not registered at all. Memory regions spanning over allocations that are both registered and not registered with CUDA are not supported and will return CUDA_ERROR_INVALID_VALUE.

See also:
cudaMemcpy, cudaMemcpy2D, cudaMemcpy2DFromArray, cudaMemcpy2DToArray, cudaMemcpyToSymbol, cudaMemcpyFromSymbol, cudaMemcpyAsync, cudaMemcpy2DAsync, cudaMemcpy2DToArrayAsync, cudaMemcpy2DFromArrayAsync, cudaMemcpyToSymbolAsync, cudaMemcpyFromSymbolAsync, cuMemcpy2D, cuMemcpy2DUnaligned

```
__host__ cudaError_t cudaMemcpy2DToArrayAsync(cuArray_t dst, size_t wOffset, size_t hOffset, const void *src, size_t spitch, size_t width, size_t height, cudaMemcpyKind kind, cudaStream_t stream)
```

Copies data between host and device.

Parameters

dst
- Destination memory address

wOffset
- Destination starting X offset (columns in bytes)

hOffset
- Destination starting Y offset (rows)

src
- Source memory address
spitch
  - Pitch of source memory
width
  - Width of matrix transfer (columns in bytes)
height
  - Height of matrix transfer (rows)
kind
  - Type of transfer
stream
  - Stream identifier

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidPitchValue, cudaErrorInvalidMemcpyDirection

Description
Copies a matrix (height rows of width bytes each) from the memory area pointed to by src to the CUDA array dst starting at hOffset rows and wOffset bytes from the upper left corner, where kind specifies the direction of the copy, and must be one of cudaMemcpyHostToDevice, cudaMemcpyHostToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing. spitch is the width in memory in bytes of the 2D array pointed to by src, including any padding added to the end of each row. wOffset + width must not exceed the width of the CUDA array dst.width must not exceed spitch. cudaMemcpy2DToArrayAsync() returns an error if spitch exceeds the maximum allowed.

cudaMemcpy2DToArrayAsync() is asynchronous with respect to the host, so the call may return before the copy is complete. The copy can optionally be associated to a stream by passing a non-zero stream argument. If kind is cudaMemcpyHostToDevice or cudaMemcpyDeviceToHost and stream is non-zero, the copy may overlap with operations in other streams.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits asynchronous behavior for most use cases.
- This function uses standard default stream semantics.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
- Memory regions requested must be either entirely registered with CUDA, or in the case of host pageable transfers, not registered at all. Memory regions spanning over allocations...
that are both registered and not registered with CUDA are not supported and will return CUDA_ERROR_INVALID_VALUE.

See also:
cudaMemcpy, cudaMemcpy2D, cudaMemcpy2DToArray, cudaMemcpy2DFromArray, cudaMemcpy2DArrayToArrary, cudaMemcpyToSymbol, cudaMemcpyFromSymbol, cudaMemcpyAsync, cudaMemcpy2DAsync, cudaMemcpy2DFromArrayAsync, cudaMemcpyToSymbolAsync, cudaMemcpyFromSymbolAsync, cudaMemcpy2DAsync

cudaMemcpy2DFromArrayAsync, cudaMemcpyToSymbolAsync, cudaMemcpyFromSymbolAsync, cudaMemcpy2DAsync

__host__ cudaError_t cudaMemcpy3D (const cudaMemcpy3DParms *p)
Copies data between 3D objects.

Parameters

p
- 3D memory copy parameters

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidPitchValue, cudaErrorInvalidMemcpyDirection

Description

```c
typedef struct cudaMemcpy3DParms {
    cudaMemcpy3DParms srcArray;
    cudaMemcpy3DParms dstArray;
} cudaMemcpy3DParms;
```
struct cudaExtent
{
    extent;
}
enum cudaMemcpyKind
{
    kind;
};

`cudaMemcpy3D()` copies data between two 3D objects. The source and destination objects may be in either host memory, device memory, or a CUDA array. The source, destination, extent, and kind of copy performed is specified by the `cudaMemcpy3DParms` struct which should be initialized to zero before use:

```
cudaMemcpy3DParms myParms = {0};
```

The struct passed to `cudaMemcpy3D()` must specify one of `srcArray` or `srcPtr` and one of `dstArray` or `dstPtr`. Passing more than one non-zero source or destination will cause `cudaMemcpy3D()` to return an error.

The `srcPos` and `dstPos` fields are optional offsets into the source and destination objects and are defined in units of each object's elements. The element for a host or device pointer is assumed to be unsigned char.

The `extent` field defines the dimensions of the transferred area in elements. If a CUDA array is participating in the copy, the extent is defined in terms of that array's elements. If no CUDA array is participating in the copy then the extents are defined in elements of unsigned char.

The `kind` field defines the direction of the copy. It must be one of `cudaMemcpyHostToHost`, `cudaMemcpyHostToDevice`, `cudaMemcpyDeviceToHost`, `cudaMemcpyDeviceToDevice`, or `cudaMemcpyDefault`. Passing `cudaMemcpyDefault` is recommended, in which case the type of transfer is inferred from the pointer values. However, `cudaMemcpyDefault` is only allowed on systems that support unified virtual addressing. For `cudaMemcpyHostToHost` or `cudaMemcpyHostToDevice` or `cudaMemcpyDeviceToDevice` passed as kind and cudaArray type passed as source or destination, if the kind implies cudaArray type to be present on the host, `cudaMemcpy3D()` will disregard that implication and silently correct the kind based on the fact that cudaArray type can only be present on the device.

If the source and destination are both arrays, `cudaMemcpy3D()` will return an error if they do not have the same element size.

The source and destination object may not overlap. If overlapping source and destination objects are specified, undefined behavior will result.

The source object must entirely contain the region defined by `srcPos` and `extent`. The destination object must entirely contain the region defined by `dstPos` and `extent`.

`cudaMemcpy3D()` returns an error if the pitch of `srcPtr` or `dstPtr` exceeds the maximum allowed. The pitch of a `cudaPitchedPtr` allocated with `cudaMalloc3D()` will always be valid.

**Note:**
- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits synchronous behavior for most use cases.
Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.

Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cudaMalloc3D`, `cudaMalloc3DArray`, `cudaMemset3D`, `cudaMemcpy3DAsync`, `cudaMemcpy`, `cudaMemcpy2D`, `cudaMemcpy2DtoArray`, `cudaMemcpy2DFromArray`, `cudaMemcpy2DToArray`, `cudaMemcpyToSymbol`, `cudaMemcpyFromSymbol`, `cudaMemcpyAsync`, `cudaMemcpy2DAsync`, `cudaMemcpy2DtoArrayAsync`, `cudaMemcpy2DFromArrayAsync`, `cudaMemcpyToSymbolAsync`, `cudaMemcpyFromSymbolAsync`, `make_cudaExtent`, `make_cudaPos`, `cuMemcpy3D`

```c
__host__ __device__ cudaError_t cudaMemcpy3DAsync(const cudaMemcpy3DParms *p, cudaStream_t stream)
```

Copies data between 3D objects.

**Parameters**

- `p` - 3D memory copy parameters
- `stream` - Stream identifier

**Returns**

`cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorInvalidPitchValue`, `cudaErrorInvalidMemcpyDirection`

**Description**

```c
struct cudaExtent {
    size_t width;
    size_t height;
    size_t depth;
};
struct cudaMemcpy3DParms {
    cudaArray_t srcArray;
    struct cudaPos srcPos;
};

struct cudaMemcpy3DParms {
    srcArray;
    struct cudaMemcpy3DParms {
        srcPos;
    }
};

struct cudaMemcpy3DParms {
    cudaMemcpy3DParms {
        srcPos;
    }
};
```
cudaMemcpy3DAsync() copies data between two 3D objects. The source and destination objects may be in either host memory, device memory, or a CUDA array. The source, destination, extent, and kind of copy performed is specified by the cudaMemcpy3DParms struct which should be initialized to zero before use:

```c
cudaMemcpy3DParms myParms = {0};
```

The struct passed to cudaMemcpy3DAsync() must specify one of srcArray or srcPtr and one of dstArray or dstPtr. Passing more than one non-zero source or destination will cause cudaMemcpy3DAsync() to return an error.

The srcPos and dstPos fields are optional offsets into the source and destination objects and are defined in units of each object's elements. The element for a host or device pointer is assumed to be unsigned char. For CUDA arrays, positions must be in the range [0, 2048) for any dimension.

The extent field defines the dimensions of the transferred area in elements. If a CUDA array is participating in the copy, the extent is defined in terms of that array's elements. If no CUDA array is participating in the copy then the extents are defined in elements of unsigned char.

The kind field defines the direction of the copy. It must be one of cudaMemcpyHostToHost, cudaMemcpyHostToDevice, cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing. For cudaMemcpyHostToHost or cudaMemcpyHostToDevice or cudaMemcpyDeviceToDeviceToHost passed as kind and cudaMemcpy type passed as source or destination, if the kind implies cudaMemcpy type to be present on the host, cudaMemcpy3DAsync() will disregard that implication and silently correct the kind based on the fact that cudaMemcpy type can only be present on the device.

If the source and destination are both arrays, cudaMemcpy3DAsync() will return an error if they do not have the same element size.

The source and destination object may not overlap. If overlapping source and destination objects are specified, undefined behavior will result.

The source object must lie entirely within the region defined by srcPos and extent. The destination object must lie entirely within the region defined by dstPos and extent.

cudaMemcpy3DAsync() returns an error if the pitch of srcPtr or dstPtr exceeds the maximum allowed. The pitch of a cudaPitchedPtr allocated with cudaMemcpy3D() will always be valid.
cudaMemcpy3DAsync() is asynchronous with respect to the host, so the call may return before the copy is complete. The copy can optionally be associated to a stream by passing a non-zero stream argument. If kind is cudaMemcpyHostToDevice or cudaMemcpyDeviceToHost and stream is non-zero, the copy may overlap with operations in other streams.

The device version of this function only handles device to device copies and cannot be given local or shared pointers.

```c
__host__ cudaError_t cudaMemcpy3DPeer (const cudaMemcpy3DPeerParms *p)
```

Copies memory between devices.

**Parameters**

- `p` - Parameters for the memory copy

**Returns**

cudaSuccess, cudaMemcpyInvalidValue, cudaMemcpyInvalidDevice, cudaMemcpyInvalidPitchValue

**Description**

Perform a 3D memory copy according to the parameters specified in p. See the definition of the cudaMemcpy3DPeerParms structure for documentation of its parameters.
Note that this function is synchronous with respect to the host only if the source or destination of the transfer is host memory. Note also that this copy is serialized with respect to all pending and future asynchronous work in to the current device, the copy's source device, and the copy's destination device (use cudaMemcpy3DPeerAsync to avoid this synchronization).

See also:

cudaMemcpy, cudaMemcpyPeer, cudaMemcpyAsync, cudaMemcpyPeerAsync, cudaMemcpy3DPeerAsync, cuMemcpy3DPeer

__host__ cudaError_t cudaMemcpy3DPeerAsync (const cudaMemcpy3DPeerParms *p, cudaStream_t stream)

Copies memory between devices asynchronously.

Parameters

p
- Parameters for the memory copy

stream
- Stream identifier

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidDevice, cudaErrorInvalidPitchValue

Description

Perform a 3D memory copy according to the parameters specified in p. See the definition of the cudaMemcpy3DPeerParms structure for documentation of its parameters.
This function uses standard default stream semantics.

Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.

Note that as specified by cudaMemcpyAsync, no CUDA function may be called from callback. cudaMemcpyAsync may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudamemcpy, cudaMemcpyPeer, cudaMemcpyAsync, cudaMemcpyPeerAsync, cudaMemcpy3DPeerAsync, cuMemcpy3DPeerAsync

__host__ __device__ cudaError_t cudaMemcpyAsync (void *dst, const void *src, size_t count, cudaMemcpyKind kind, cudaStream_t stream)

Copies data between host and device.

Parameters

dst
  - Destination memory address

src
  - Source memory address

count
  - Size in bytes to copy

kind
  - Type of transfer

stream
  - Stream identifier

Returns

cudaSuccess, cudaMemcpyInvalidValue, cudaMemcpyInvalidMemcpyDirection

Description

Copies count bytes from the memory area pointed to by src to the memory area pointed to by dst, where kind specifies the direction of the copy, and must be one of cudaMemcpyHostToDevice, cudaMemcpyDeviceToDevice, cudaMemcpyHostToDevice, cudaMemcpyDeviceToHost, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing.

The memory areas may not overlap. Calling cudaMemcpyAsync() with dst and src pointers that do not match the direction of the copy results in an undefined behavior.
cudaMemcpyAsync() is asynchronous with respect to the host, so the call may return before the copy is complete. The copy can optionally be associated to a stream by passing a non-zero stream argument. If kind is cudaMemcpyHostToDevice or cudaMemcpyDeviceToHost and the stream is non-zero, the copy may overlap with operations in other streams.

The device version of this function only handles device to device copies and cannot be given local or shared pointers.

---

**Note:**

- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits asynchronous behavior for most use cases.
- This function uses standard default stream semantics.
- Note that this function may also return cudaMemcpyInitializationError, cudaMemcpyInsufficientDriver or cudaMemcpyNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaMemcpyNotAllowed may, but is not guaranteed to, be returned as a diagnostic in such case.
- Memory regions requested must be either entirely registered with CUDA, or in the case of host pageable transfers, not registered at all. Memory regions spanning over allocations that are both registered and not registered with CUDA are not supported and will return CUDA_ERROR_INVALID_VALUE.

---

See also:
cudaMemcpy, cudaMemcpy2D, cudaMemcpy2DToArray, cudaMemcpy2DFromArray, cudaMemcpy2DToArrayAsync, cudaMemcpy2DFromArrayAsync, cudaMemcpy2DAsync, cudaMemcpy2DToArrayAsync, cudaMemcpy2DFromArrayAsync, cudaMemcpyToSymbol, cudaMemcpyFromSymbol, cudaMemcpyToSymbolAsync, cudaMemcpyFromSymbolAsync, cuMemcpyAsync, cuMemcpyDtoHAsync, cuMemcpyHtoDAsync, cuMemcpyDtoDAsync

__host__ cudaMemcpy_t cudaMemcpyFromSymbol (void *dst, const void *symbol, size_t count, size_t offset, cudaMemcpyKind kind)

Copies data from the given symbol on the device.

**Parameters**

dst
  - Destination memory address

symbol
  - Device symbol address
count
   - Size in bytes to copy
offset
   - Offset from start of symbol in bytes
kind
   - Type of transfer

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidSymbol, cudaErrorInvalidMemcpyDirection, cudaErrorNoKernelImageForDevice

Description
Copies count bytes from the memory area pointed to by offset bytes from the start of symbol to the memory area pointed to by dst. The memory areas may not overlap. symbol is a variable that resides in global or constant memory space. kind can be either cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits synchronous behavior for most use cases.
- Use of a string naming a variable as the symbol parameter was deprecated in CUDA 4.1 and removed in CUDA 5.0.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cupyMemcpy, cupyMemcpy2D, cupyMemcpy2DtoArray, cupyMemcpy2DFromArray, cupyMemcpy2DToArray, cupyMemcpyToArray, cupyMemcpyAsync, cupyMemcpyAsync, cupyMemcpyAsync, cupyMemcpyAsync, cuMemcpy, cuMemcpyDtoH, cuMemcpyDtoD
__host__ cudaError_t cudaMemcpyFromSymbolAsync
(void *dst, const void *symbol, size_t count, size_t offset,
cudaMemcpyKind kind, cudaStream_t stream)

Copies data from the given symbol on the device.

Parameters

dst
- Destination memory address

symbol
- Device symbol address

count
- Size in bytes to copy

offset
- Offset from start of symbol in bytes

kind
- Type of transfer

stream
- Stream identifier

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidSymbol, cudaErrorInvalidMemcpyDirection, cudaErrorNoKernelImageForDevice

Description

Copies count bytes from the memory area pointed to by offset bytes from the start of symbol symbol to the memory area pointed to by dst. The memory areas may not overlap. symbol is a variable that resides in global or constant memory space. kind can be either cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing.

cudaMemcpyFromSymbolAsync() is asynchronous with respect to the host, so the call may return before the copy is complete. The copy can optionally be associated to a stream by passing a non-zero stream argument. If kind is cudaMemcpyDeviceToHost and stream is non-zero, the copy may overlap with operations in other streams.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
This function exhibits asynchronous behavior for most use cases.

- This function uses standard default stream semantics.
- Use of a string naming a variable as the symbol parameter was deprecated in CUDA 4.1 and removed in CUDA 5.0.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaMemcpy, cudaMemcpy2D, cudaMemcpy2DToArray, cudaMemcpy2DFromArray, cudaMemcpy2DArrayToArray, cudaMemcpy2DFromArrayAsync, cudaMemcpyToSymbol, cudaMemcpyFromSymbol, cudaMemcpyAsync, cudaMemcpy2DAsync, cudaMemcpy2DToArrayAsync, cudaMemcpy2DFromArrayAsync, cudaMemcpyToSymbolAsync, cuMemcpyAsync, cuMemcpyDtoHAsync, cuMemcpyDtoDAsync

__host__ cudaError_t cudaMemcpyPeer (void *dst, int dstDevice, const void *src, int srcDevice, size_t count)

Copies memory between two devices.

Parameters

dst
- Destination device pointer
dstDevice
- Destination device
src
- Source device pointer
srcDevice
- Source device
count
- Size of memory copy in bytes

Returns
cudaSuccess, cudaMemcpyInvalidValue, cudaMemcpyInvalidDevice

Description

Copies memory from one device to memory on another device. dst is the base device pointer of the destination memory and dstDevice is the destination device. src is the base device pointer of the source memory and srcDevice is the source device. count specifies the number of bytes to copy.
Note that this function is asynchronous with respect to the host, but serialized with respect all pending and future asynchronous work in to the current device, srcDevice, and dstDevice (use cudaMemcpyPeerAsync to avoid this synchronization).

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits synchronous behavior for most use cases.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaMemcpy, cudaMemcpyAsync, cudaMemcpyPeerAsync, cudaMemcpy3DPeerAsync, cuMemcpyPeer

__host__ cudaError_t cudaMemcpyPeerAsync (void *dst, int dstDevice, const void *src, int srcDevice, size_t count, cudaStream_t stream)
Copies memory between two devices asynchronously.

Parameters

dst
- Destination device pointer
dstDevice
- Destination device
src
- Source device pointer
srcDevice
- Source device
count
- Size of memory copy in bytes
stream
- Stream identifier

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidDevice
Description

Copies memory from one device to memory on another device. \texttt{dst} is the base device pointer of the destination memory and \texttt{dstDevice} is the destination device. \texttt{src} is the base device pointer of the source memory and \texttt{srcDevice} is the source device. \texttt{count} specifies the number of bytes to copy. Note that this function is asynchronous with respect to the host and all work on other devices.

See also:
\begin{verbatim}
cudaMemcpy, cudaMemcpyPeer, cudaMemcpyAsync, cudaMemcpy3DPeerAsync, cuMemcpyPeerAsync
\end{verbatim}

\begin{verbatim}
__host__ cudaError_t cudaMemcpyToSymbol (const void *symbol, const void *src, size_t count, size_t offset, cudaMemcpyKind kind)
\end{verbatim}

Copies data to the given symbol on the device.

Parameters

\begin{verbatim}
symbol
  - Device symbol address
src
  - Source memory address
count
  - Size in bytes to copy
offset
  - Offset from start of symbol in bytes
kind
  - Type of transfer
\end{verbatim}
Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidSymbol, cudaErrorInvalidMemcpyDirection, cudaErrorNoKernelImageForDevice

Description

Copies count bytes from the memory area pointed to by src to the memory area pointed to by offset bytes from the start of symbol symbol. The memory areas may not overlap. symbol is a variable that resides in global or constant memory space. kind can be either cudaMemcpyHostToDevice, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits synchronous behavior for most use cases.
- Use of a string naming a variable as the symbol parameter was deprecated in CUDA 4.1 and removed in CUDA 5.0.
- Note that this function may also return cudaMemcpyInitializationError, cudaMemcpyInsufficientDriver or cudaMemcpyNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpyAsync no CUDA function may be called from callback. cudaMemcpyNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudAMemcpy, cudaMemcpy2D, cudaMemcpy2DToArray, cudaMemcpy2DFromArray, cudaMemcpy2DArrayToArray, cudaMemcpyFromSymbol, cudaMemcpyAsync, cudaMemcpy2DAsync, cudaMemcpy2DToArrayAsync, cudaMemcpy2DFromArrayAsync, cudaMemcpyToSymbolAsync, cudaMemcpyFromSymbolAsync, cudaMemcpyAsync, cudaMemcpyHtoD, cudaMemcpyDtoD
`__host__ cudaError_t cudaMemcpyToSymbolAsync (const void *symbol, const void *src, size_t count, size_t offset, cudaMemcpyKind kind, cudaStream_t stream)`

Copies data to the given symbol on the device.

**Parameters**

- **symbol**
  - Device symbol address
- **src**
  - Source memory address
- **count**
  - Size in bytes to copy
- **offset**
  - Offset from start of symbol in bytes
- **kind**
  - Type of transfer
- **stream**
  - Stream identifier

**Returns**

- `cudaSuccess`
- `cudaErrorInvalidValue`
- `cudaErrorInvalidSymbol`
- `cudaErrorInvalidMemcpyDirection`
- `cudaErrorNoKernelImageForDevice`

**Description**

Copies `count` bytes from the memory area pointed to by `src` to the memory area pointed to by `offset` bytes from the start of symbol `symbol`. The memory areas may not overlap. `symbol` is a variable that resides in global or constant memory space. `kind` can be either `cudaMemcpyHostToDevice`, `cudaMemcpyDeviceToDevice`, or `cudaMemcpyDefault`. Passing `cudaMemcpyDefault` is recommended, in which case the type of transfer is inferred from the pointer values. However, `cudaMemcpyDefault` is only allowed on systems that support unified virtual addressing.

`cudaMemcpyToSymbolAsync()` is asynchronous with respect to the host, so the call may return before the copy is complete. The copy can optionally be associated to a stream by passing a non-zero `stream` argument. If `kind` is `cudaMemcpyHostToDevice` and `stream` is non-zero, the copy may overlap with operations in other streams.

**Note:**

- Note that this function may also return error codes from previous, asynchronous launches.
This function exhibits **asynchronous** behavior for most use cases.

This function uses standard **default stream** semantics.

Use of a string naming a variable as the `symbol` parameter was deprecated in CUDA 4.1 and removed in CUDA 5.0.

Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.

Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

- `cudaMemcpy`
- `cudaMemcpy2D`
- `cudaMemcpy2DToArray`
- `cudaMemcpy2DFromArray`
- `cudaMemcpy2DArrayToArray`
- `cudaMemcpyToSymbol`
- `cudaMemcpyFromSymbol`
- `cudaMemcpyAsync`
- `cudaMemcpy2DAsync`
- `cudaMemcpy2DToArrayAsync`
- `cudaMemcpy2DFromArrayAsync`
- `cudaMemcpyFromSymbolAsync`
- `cuMemcpyAsync`
- `cuMemcpyHtoDAsync`
- `cuMemcpyDtoDAsync`

---

**__host__ cudaError_t cudaMemGetInfo (size_t *free, size_t *total)**

Gets free and total device memory.

**Parameters**

- **free**
  - Returned free memory in bytes

- **total**
  - Returned total memory in bytes

**Returns**

- `cudaSuccess`
- `cudaErrorInvalidValue`
- `cudaErrorLaunchFailure`

**Description**

Returns in `*total` the total amount of memory available to the the current context. Returns in `*free` the amount of memory on the device that is free according to the OS. CUDA is not guaranteed to be able to allocate all of the memory that the OS reports as free. In a multi-tenant situation, free estimate returned is prone to race condition where a new allocation/free done by a different process or a different thread in the same process between the time when free memory was estimated and reported, will result in deviation in free value reported and actual free memory.

The integrated GPU on Tegra shares memory with CPU and other component of the SoC. The free and total values returned by the API excludes the SWAP memory space maintained by the OS on some
platforms. The OS may move some of the memory pages into swap area as the GPU or CPU allocate or access memory. See Tegra app note on how to calculate total and free memory on Tegra.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cuMemGetInfo`

```__host__ cudaError_t cudaMemcpyAsync (const void *devPtr, size_t count, int dstDevice, cudaStream_t stream)`
Prefetches memory to the specified destination device.

Parameters

devPtr
- Pointer to be prefetched

count
- Size in bytes

dstDevice
- Destination device to prefetch to

stream
- Stream to enqueue prefetch operation

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidDevice

Description

Prefetches memory to the specified destination device. devPtr is the base device pointer of the memory to be prefetched and dstDevice is the destination device. count specifies the number of bytes to copy. stream is the stream in which the operation is enqueued. The memory range must refer to managed memory allocated via `cudaMallocManaged` or declared via `__managed__` variables, or it may also refer to system-allocated memory on systems with non-zero `cudaDevAttrPageableMemoryAccess`.```
Passing in cudaCpuDeviceId for dstDevice will prefetch the data to host memory. If dstDevice is a GPU, then the device attribute cudaDevAttrConcurrentManagedAccess must be non-zero. Additionally, stream must be associated with a device that has a non-zero value for the device attribute cudaDevAttrConcurrentManagedAccess.

The start address and end address of the memory range will be rounded down and rounded up respectively to be aligned to CPU page size before the prefetch operation is enqueued in the stream.

If no physical memory has been allocated for this region, then this memory region will be populated and mapped on the destination device. If there's insufficient memory to prefetch the desired region, the Unified Memory driver may evict pages from other cudaMallocManaged allocations to host memory in order to make room. Device memory allocated using cudaMalloc or cudaMallocArray will not be evicted.

By default, any mappings to the previous location of the migrated pages are removed and mappings for the new location are only setup on dstDevice. The exact behavior however also depends on the settings applied to this memory range via cudaMemAdvise as described below:

If cudaMemAdviseSetReadMostly was set on any subset of this memory range, then that subset will create a read-only copy of the pages on dstDevice.

If cudaMemAdviseSetPreferredLocation was called on any subset of this memory range, then the pages will be migrated to dstDevice even if dstDevice is not the preferred location of any pages in the memory range.

If cudaMemAdviseSetAccessedBy was called on any subset of this memory range, then mappings to those pages from all the appropriate processors are updated to refer to the new location if establishing such a mapping is possible. Otherwise, those mappings are cleared.

Note that this API is not required for functionality and only serves to improve performance by allowing the application to migrate data to a suitable location before it is accessed. Memory accesses to this range are always coherent and are allowed even when the data is actively being migrated.

Note that this function is asynchronous with respect to the host and all work on other devices.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits asynchronous behavior for most use cases.
- This function uses standard default stream semantics.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaMemcpy, cudaMemcpyPeer, cudaMemcpyAsync, cudaMemcpy3DPeerAsync, cudaMemcpyAsync_v2, cudaMemcpy, cudaMemcpyAsync_v2

__host__ cudaError_t cudaMemPrefetchAsync_v2 (const void *devPtr, size_t count, cudaMemLocation location, unsigned int flags, cudaStream_t stream)

Prefetches memory to the specified destination location.

Parameters

devPtr
- Pointer to be prefetched

count
- Size in bytes

devPtr
- Pointer to be prefetched

location
- location to prefetch to

flags
- flags for future use, must be zero now.

stream
- Stream to enqueue prefetch operation

Returns

cudaSuccess, cudaMemcpyInvalidValue, cudaMemcpyInvalidDevice

Description

Prefetches memory to the specified destination location. devPtr is the base device pointer of the memory to be prefetched and location specifies the destination location. count specifies the number of bytes to copy. stream is the stream in which the operation is enqueued. The memory range must refer to managed memory allocated via cudaMallocManaged or declared via __managed__ variables, or it may also refer to system-allocated memory on systems with non-zero cudaDevAttrPageableMemoryAccess.

Specifying cudaMemcpyLocationTypeDevice for cudaMemcpyLocation::type will prefetch memory to GPU specified by device ordinal cudaMemcpyLocation::id which must have non-zero value for the device attribute concurrentManagedAccess. Additionally, stream must be associated with a device that has a non-zero value for the device attribute concurrentManagedAccess. Specifying cudaMemcpyLocationTypeHost as cudaMemcpyLocation::type will prefetch data to host memory.

Applications can request prefetching memory to a specific host NUMA node by specifying cudaMemcpyLocationTypeHostNuma for cudaMemcpyLocation::type and a valid host NUMA node id in cudaMemcpyLocation::id Users can also request prefetching memory to the host NUMA node closest to the current thread's CPU by specifying cudaMemcpyLocationTypeHostNumaCurrent for
cudaMemLocation::type. Note when cudaMemLocation::type is either cudaMemLocationTypeHost OR cudaMemLocationTypeHostNumaCurrent, cudaMemLocation::id will be ignored.

The start address and end address of the memory range will be rounded down and rounded up respectively to be aligned to CPU page size before the prefetch operation is enqueued in the stream.

If no physical memory has been allocated for this region, then this memory region will be populated and mapped on the destination device. If there's insufficient memory to prefetch the desired region, the Unified Memory driver may evict pages from other cudaMallocManaged allocations to host memory in order to make room. Device memory allocated using cudaMalloc or cudaMallocArray will not be evicted.

By default, any mappings to the previous location of the migrated pages are removed and mappings for the new location are only setup on the destination location. The exact behavior however also depends on the settings applied to this memory range via cuMemAdvise as described below:

If cudaMemAdviseSetReadMostly was set on any subset of this memory range, then that subset will create a read-only copy of the pages on destination location. If however the destination location is a host NUMA node, then any pages of that subset that are already in another host NUMA node will be transferred to the destination.

If cudaMemAdviseSetPreferredLocation was called on any subset of this memory range, then the pages will be migrated to location even if location is not the preferred location of any pages in the memory range.

If cudaMemAdviseSetAccessedBy was called on any subset of this memory range, then mappings to those pages from all the appropriate processors are updated to refer to the new location if establishing such a mapping is possible. Otherwise, those mappings are cleared.

Note that this API is not required for functionality and only serves to improve performance by allowing the application to migrate data to a suitable location before it is accessed. Memory accesses to this range are always coherent and are allowed even when the data is actively being migrated.

Note that this function is asynchronous with respect to the host and all work on other devices.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits asynchronous behavior for most use cases.
- This function uses standard default stream semantics.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaMemcpy, cudaMemcpyPeer, cudaMemcpyAsync, cudaMemcpy3DPeerAsync, cudaMemcpy, cudaMemcpy_v2, cuMemPrefetchAsync

__host__ cudaError_t cudaMemcpy (void *data, size_t dataSize, cudaMemRangeAttribute attribute, const void *devPtr, size_t count)

Query an attribute of a given memory range.

Parameters

data
- A pointer to a memory location where the result of each attribute query will be written to.

dataSize
- Array containing the size of data

attribute
- The attribute to query

devPtr
- Start of the range to query

count
- Size of the range to query

Returns

cudaSuccess, cudaErrorInvalidValue

Description

Query an attribute about the memory range starting at devPtr with a size of count bytes. The memory range must refer to managed memory allocated via cudaMemcpyManaged or declared via __managed__ variables.

The attribute parameter can take the following values:

- cudaMemcpyRangeAttributeReadMostly: If this attribute is specified, data will be interpreted as a 32-bit integer, and dataSize must be 4. The result returned will be 1 if all pages in the given memory range have read-duplication enabled, or 0 otherwise.

- cudaMemcpyRangeAttributePreferredLocation: If this attribute is specified, data will be interpreted as a 32-bit integer, and dataSize must be 4. The result returned will be a GPU device id if all pages in the memory range have that GPU as their preferred location, or it will be cudaCpuDeviceId if all pages in the memory range have the CPU as their preferred location, or it will be cudaInvalidDeviceId if either all the pages don't have the same preferred location or some of the pages don't have a preferred location at all. Note that the actual location of the pages in the memory range at the time of the query may be different from the preferred location.
- **cudaMemRangeAttributeAccessedBy**: If this attribute is specified, `data` will be interpreted as an array of 32-bit integers, and `dataSize` must be a non-zero multiple of 4. The result returned will be a list of device ids that had `cudaMemAdviceSetAccessedBy` set for that entire memory range. If any device does not have that advice set for the entire memory range, that device will not be included. If `data` is larger than the number of devices that have that advice set for that memory range, `cudaInvalidDeviceId` will be returned in all the extra space provided. For ex., if `dataSize` is 12 (i.e. `data` has 3 elements) and only device 0 has the advice set, then the result returned will be `{ 0, cudaInvalidDeviceId, cudaInvalidDeviceId }`. If `data` is smaller than the number of devices that have that advice set, then only as many devices will be returned as can fit in the array. There is no guarantee on which specific devices will be returned, however.

- **cudaMemRangeAttributeLastPrefetchLocation**: If this attribute is specified, `data` will be interpreted as a 32-bit integer, and `dataSize` must be 4. The result returned will be the last location to which all pages in the memory range were prefetched explicitly via `cudaMemPrefetchAsync`. This will either be a GPU id or `cudaCpuDeviceId` depending on whether the last location for prefetch was a GPU or the CPU respectively. If any page in the memory range was never explicitly prefetched or if all pages were not prefetched to the same location, `cudaInvalidDeviceId` will be returned. Note that this simply returns the last location that the application requested to prefetch the memory range to. It gives no indication as to whether the prefetch operation to that location has completed or even begun.

- **cudaMemRangeAttributePreferredLocationType**: If this attribute is specified, `data` will be interpreted as a `cudaMemLocationType`, and `dataSize` must be `sizeof(cudaMemLocationType)`. The `cudaMemLocationType` returned will be `cudaMemLocationTypeDevice` if all pages in the memory range have the same GPU as their preferred location, or `cudaMemLocationTypeHost` if all pages in the memory range have the CPU as their preferred location, or it will be `cudaMemLocationTypeHostNuma` if all the pages in the memory range have the same host NUMA node ID as their preferred location or it will be `cudaMemLocationTypeInvalid` if either all the pages don't have the same preferred location or some of the pages don't have a preferred location at all. Note that the actual location type of the pages in the memory range at the time of the query may be different from the preferred location type.

- **cudaMemRangeAttributePreferredLocationId**: If this attribute is specified, `data` will be interpreted as a 32-bit integer, and `dataSize` must be 4. If the `cudaMemRangeAttributePreferredLocationType` query for the same address range returns `cudaMemLocationTypeDevice`, it will be a valid device ordinal or if it returns `cudaMemLocationTypeHostNuma`, it will be a valid host NUMA node ID or if it returns any other location type, the id should be ignored.

- **cudaMemRangeAttributeLastPrefetchLocationType**: If this attribute is specified, `data` will be interpreted as a `cudaMemLocationType`, and `dataSize` must be `sizeof(cudaMemLocationType)`. The result returned will be the last location type to which all pages in the memory range were prefetched explicitly via `cuMemPrefetchAsync`. The `cudaMemLocationType` returned will be `cudaMemLocationTypeDevice` if the last prefetch location was the GPU or `cudaMemLocationTypeHost` if it was the CPU or `cudaMemLocationTypeHostNuma` if
the last prefetch location was a specific host NUMA node. If any page in the memory range was never explicitly prefetched or if all pages were not prefetched to the same location, `CUmemLocationType` will be `cudaMemLocationTypeInvalid`. Note that this simply returns the last location type that the application requested to prefetch the memory range to. It gives no indication as to whether the prefetch operation to that location has completed or even begun.

- **cudaMemRangeAttributeLastPrefetchLocationId**: If this attribute is specified, `data` will be interpreted as a 32-bit integer, and `dataSize` must be 4. If the `cudaMemRangeAttributeLastPrefetchLocationType` query for the same address range returns `cudaMemLocationTypeDevice`, it will be a valid device ordinal or if it returns `cudaMemLocationTypeHostNuma`, it will be a valid host NUMA node ID or if it returns any other location type, the id should be ignored.

### Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits asynchronous behavior for most use cases.
- This function uses standard default stream semantics.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver`, or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

- `cudaMemRangeGetAttributes`, `cudaMemPrefetchAsync`, `cudaMemAdvise`, `cuMemRangeGetAttribute`

```c
__host__ cudaError_t cudaMemRangeGetAttributes(
    void **data, size_t *dataSizes, cudaMemRangeAttribute
    *attributes, size_t numAttributes, const void *devPtr, size_t count)
```

Query attributes of a given memory range.

**Parameters**

- **data**
  - A two-dimensional array containing pointers to memory locations where the result of each attribute query will be written to.

- **dataSizes**
  - Array containing the sizes of each result
attributes
- An array of attributes to query (numAttributes and the number of attributes in this array should
  match)
numAttributes
- Number of attributes to query
devPtr
- Start of the range to query
count
- Size of the range to query

Returns
cudaSuccess, cudaErrorInvalidValue

Description
Query attributes of the memory range starting at devPtr with a size of count bytes. The memory
range must refer to managed memory allocated via cudaMallocManaged or declared via __managed__
variables. The attributes array will be interpreted to have numAttributes entries. The
dataSizes array will also be interpreted to have numAttributes entries. The results of the query
will be stored in data.

The list of supported attributes are given below. Please refer to cudaMemRangeGetAttribute for
attribute descriptions and restrictions.

- cudaMemRangeAttributeReadMostly
- cudaMemRangeAttributePreferredLocation
- cudaMemRangeAttributeAccessedBy
- cudaMemRangeAttributeLastPrefetchLocation
- :: cudaMemRangeAttributePreferredLocationType
- :: cudaMemRangeAttributePreferredLocationId
- :: cudaMemRangeAttributeLastPrefetchLocationType
- :: cudaMemRangeAttributeLastPrefetchLocationId

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or
cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpyAsync no CUDA function may be called from callback.
cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaMemRangeGetAttribute, cudaMemAdvise, cudaMemPrefetchAsync, cuMemRangeGetAttributes

__host__ cudaError_t cudaMemcpy (void *devPtr, int value, size_t count)
Initializes or sets device memory to a value.

Parameters

devPtr
  - Pointer to device memory
value
  - Value to set for each byte of specified memory
count
  - Size in bytes to set

Returns
cudaSuccess, cudaErrorInvalidValue.

Description
Fills the first count bytes of the memory area pointed to by devPtr with the constant byte value value.

Note that this function is asynchronous with respect to the host unless devPtr refers to pinned host memory.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- See also memset synchronization details.
- Note that this function may also return cudaMemcpyInitializationError, cudaMemcpyInsufficientDriver or cudaMemcpyNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpyAddCallback no CUDA function may be called from callback. cudaMemcpyNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cuMemsetD8, cuMemsetD16, cuMemsetD32
__host__ cudaError_t cudaMemcpy(void *devPtr, size_t pitch, int value, size_t width, size_t height)

Initializes or sets device memory to a value.

Parameters

**devPtr**
- Pointer to 2D device memory

**pitch**
- Pitch in bytes of 2D device memory (Unused if **height** is 1)

**value**
- Value to set for each byte of specified memory

**width**
- Width of matrix set (columns in bytes)

**height**
- Height of matrix set (rows)

Returns

cudaSuccess, cudaErrorInvalidValue.

Description

Sets to the specified value **value** a matrix (height rows of width bytes each) pointed to by **devPtr**. **pitch** is the width in bytes of the 2D array pointed to by **devPtr**, including any padding added to the end of each row. This function performs fastest when the pitch is one that has been passed back by cudaMallocPitch().

Note that this function is asynchronous with respect to the host unless **devPtr** refers to pinned host memory.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- See also [memset synchronization details](https://docs.nvidia.com/cuda/cuda-runtime-api/group__CUDA__Memset.html).
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaMemset, cudaMemcpy3D, cudaMemcpyAsync, cudaMemcpy2DAsync, cudaMemcpy3DAsync, cuMemsetD2D8, cuMemsetD2D16, cuMemsetD2D32
__host__ __device__ cudaError_t cudaMemcpy2DAsync  
(void *devPtr, size_t pitch, int value, size_t width, size_t height, cudaStream_t stream)

Initializes or sets device memory to a value.

**Parameters**

*devPtr*  
- Pointer to 2D device memory

*pitch*  
- Pitch in bytes of 2D device memory (Unused if *height* is 1)

*value*  
- Value to set for each byte of specified memory

*width*  
- Width of matrix set (columns in bytes)

*height*  
- Height of matrix set (rows)

*stream*  
- Stream identifier

**Returns**

cudaSuccess, cudaErrorInvalidValue.

**Description**

Sets to the specified *value* a matrix (*height* rows of *width* bytes each) pointed to by *devPtr*.  
*pitch* is the width in bytes of the 2D array pointed to by *devPtr*, including any padding added to the end of each row. This function performs fastest when the pitch is one that has been passed back by cudaMemcpy2DAsync().

cudaMemset2DAsync() is asynchronous with respect to the host, so the call may return before the memset is complete. The operation can optionally be associated to a stream by passing a non-zero *stream* argument. If *stream* is non-zero, the operation may overlap with operations in other streams.

The device version of this function only handles device to device copies and cannot be given local or shared pointers.

**Note:**
- Note that this function may also return error codes from previous, asynchronous launches.
- See also memset synchronization details.
This function uses standard default stream semantics.

Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.

Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaMemset, cudaMemset2D, cudaMemset3D, cudaMemsetAsync, cudaMemset3DAsync, cuMemsetD2D8Async, cuMemsetD2D16Async, cuMemsetD2D32Async

__host__ cudaError_t cudaMemset3D (cudaPitchedPtr pitchedDevPtr, int value, cudaExtent extent)

Initializes or sets device memory to a value.

Parameters

- pitchedDevPtr: Pointer to pitched device memory
- value: Value to set for each byte of specified memory
- extent: Size parameters for where to set device memory (width field in bytes)

Returns

cudaSuccess, cudaErrorInvalidValue,

Description

Initializes each element of a 3D array to the specified value value. The object to initialize is defined by pitchedDevPtr. The pitch field of pitchedDevPtr is the width in memory in bytes of the 3D array pointed to by pitchedDevPtr, including any padding added to the end of each row. The xsize field specifies the logical width of each row in bytes, while the ysize field specifies the height of each 2D slice in rows. The pitch field of pitchedDevPtr is ignored when height and depth are both equal to 1.

The extents of the initialized region are specified as a width in bytes, a height in rows, and a depth in slices.

Extents with width greater than or equal to the xsize of pitchedDevPtr may perform significantly faster than extents narrower than the xsize. Secondarily, extents with height equal to the ysize of pitchedDevPtr will perform faster than when the height is shorter than the ysize.

This function performs fastest when the pitchedDevPtr has been allocated by cudaMalloc3D().
Note that this function is asynchronous with respect to the host unless `pitchedDevPtr` refers to pinned host memory.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- See also `memset synchronization details`.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
`cudaMemset`, `cudaMemset2D`, `cudaMemsetAsync`, `cudaMemset2DAsync`, `cudaMemset3DAsync`, `cudaMalloc3D`, `make_cudaPitchedPtr`, `make_cudaExtent`

```c
__host__ __device__ cudaError_t cudaMemset3DAsync(
cudaPitchedPtr pitchedDevPtr, int value, cudaExtent
extent, cudaStream_t stream)
```

Initializes or sets device memory to a value.

Parameters

- `pitchedDevPtr` - Pointer to pitched device memory
- `value` - Value to set for each byte of specified memory
- `extent` - Size parameters for where to set device memory (width field in bytes)
- `stream` - Stream identifier

Returns

`cudaSuccess`, `cudaErrorInvalidValue`.

Description

Initializes each element of a 3D array to the specified value `value`. The object to initialize is defined by `pitchedDevPtr`. The pitch field of `pitchedDevPtr` is the width in memory in bytes of the 3D array pointed to by `pitchedDevPtr`, including any padding added to the end of each row. The xsize field specifies the logical width of each row in bytes, while the ysize field specifies the
height of each 2D slice in rows. The pitch field of pitchedDevPtr is ignored when height and depth are both equal to 1.

The extents of the initialized region are specified as a width in bytes, a height in rows, and a depth in slices.

Extents with width greater than or equal to the xsize of pitchedDevPtr may perform significantly faster than extents narrower than the xsize. Secondarily, extents with height equal to the ysize of pitchedDevPtr will perform faster than when the height is shorter than the ysize.

This function performs fastest when the pitchedDevPtr has been allocated by cudaMalloc3D().

cudaMemset3DAsync() is asynchronous with respect to the host, so the call may return before the memset is complete. The operation can optionally be associated to a stream by passing a non-zero stream argument. If stream is non-zero, the operation may overlap with operations in other streams.

The device version of this function only handles device to device copies and cannot be given local or shared pointers.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- See also memset synchronization details.
- This function uses standard default stream semantics.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaMemset, cudaMemset2D, cudaMemset3D, cudaMemsetAsync, cudaMemset2DAsync, cudaMalloc3D, make_cudaPitchedPtr, make_cudaExtent

__host__ __device__ cudaError_t cudaMemsetAsync (void *devPtr, int value, size_t count, cudaStream_t stream)

Initializes or sets device memory to a value.

Parameters

devPtr
  - Pointer to device memory
value
- Value to set for each byte of specified memory

count
- Size in bytes to set

stream
- Stream identifier

Returns
cudaSuccess, cudaErrorInvalidValue.

Description
Fills the first count bytes of the memory area pointed to by devPtr with the constant byte value value.

cudaMemsetAsync() is asynchronous with respect to the host, so the call may return before the memset is complete. The operation can optionally be associated to a stream by passing a non-zero stream argument. If stream is non-zero, the operation may overlap with operations in other streams.

The device version of this function only handles device to device copies and cannot be given local or shared pointers.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- See also memset synchronization details.
- This function uses standard default stream semantics.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaMemset, cudaMemset2D, cudaMemset3D, cudaMemset2DAsync, cudaMemset3DAsync, cuMemsetD8Async, cuMemsetD16Async, cuMemsetD32Async
__host__ cudaError_t
cudaMipmappedArrayGetMemoryRequirements
(cudaArrayMemoryRequirements *memoryRequirements,
cudaMipmappedArray_t mipmap, int device)

Returns the memory requirements of a CUDA mipmapped array.

Parameters
memoryRequirements
- Pointer to cudaArrayMemoryRequirements
mipmap
- CUDA mipmapped array to get the memory requirements of
device
- Device to get the memory requirements for

Returns
cudaSuccess cudaErrorInvalidValue

Description
Returns the memory requirements of a CUDA mipmapped array in memoryRequirements If the
CUDA mipmapped array is not allocated with flag cudaArrayDeferredMapping cudaErrorInvalidValue
will be returned.

The returned value in cudaArrayMemoryRequirements::size represents the total size of the CUDA
mipmapped array. The returned value in cudaArrayMemoryRequirements::alignment represents the
alignment necessary for mapping the CUDA mipmapped array.

See also:
cudaArrayGetMemoryRequirements
cudaMipmappedArrayGetSparseProperties (cudaArraySparseProperties *sparseProperties, cudaMipmappedArray_t mipmap)

Returns the layout properties of a sparse CUDA mipmapped array.

**Parameters**

- **sparseProperties**
  - Pointer to return cudaArraySparseProperties
- **mipmap**
  - The CUDA mipmapped array to get the sparse properties of

**Returns**

cudaSuccess cudaErrorInvalidValue

**Description**

Returns the sparse array layout properties in sparseProperties. If the CUDA mipmapped array is not allocated with flag cudaArraySparse cudaErrorInvalidValue will be returned.

For non-layered CUDA mipmapped arrays, cudaArraySparseProperties::miptailSize returns the size of the mip tail region. The mip tail region includes all mip levels whose width, height or depth is less than that of the tile. For layered CUDA mipmapped arrays, if cudaArraySparseProperties::flags contains cudaArraySparsePropertiesSingleMipTail, then cudaArraySparseProperties::miptailSize specifies the size of the mip tail of all layers combined. Otherwise, cudaArraySparseProperties::miptailSize specifies mip tail size per layer. The returned value of cudaArraySparseProperties::miptailFirstLevel is valid only if cudaArraySparseProperties::miptailSize is non-zero.

See also:

cudaArrayGetSparseProperties, cuMemMapArrayAsync

make_cudaExtent (size_t w, size_t h, size_t d)

Returns a cudaExtent based on input parameters.

**Parameters**

- **w**
  - Width in elements when referring to array memory, in bytes when referring to linear memory
- **h**
  - Height in elements
Returns `cudaExtent` specified by `w, h, and d`.

Description

Returns a `cudaExtent` based on the specified input parameters `w, h, and d`.

See also:

`make_cudaPitchedPtr`, `make_cudaPos`

```c
__host__ make_cudaPitchedPtr (void *d, size_t p, size_t xsz, size_t ysz)
```

Returns a cudaPitchedPtr based on input parameters.

Parameters

- `d` - Pointer to allocated memory
- `p` - Pitch of allocated memory in bytes
- `xsz` - Logical width of allocation in elements
- `ysz` - Logical height of allocation in elements

Returns `cudaPitchedPtr` specified by `d, p, xsz, and ysz`

Description

Returns a `cudaPitchedPtr` based on the specified input parameters `d, p, xsz, and ysz`.

See also:

`make_cudaExtent`, `make_cudaPos`
__host__ make_cudaPos (size_t x, size_t y, size_t z)

Returns a cudaPos based on input parameters.

Parameters

x
- X position

y
- Y position

z
- Z position

Returns
cudaPos specified by x, y, and z

Description

Returns a cudaPos based on the specified input parameters x, y, and z.

See also:
make_cudaExtent, make_cudaPitchedPtr

6.12. Memory Management [DEPRECATED]

This section describes deprecated memory management functions of the CUDA runtime application programming interface.

Some functions have overloaded C++ API template versions documented separately in the C++ API Routines module.

__host__ cudaError_t cudaMemcpyArrayToArray (cudaArray_t dst, size_t wOffsetDst, size_t hOffsetDst, cudaArray_const_t src, size_t wOffsetSrc, size_t hOffsetSrc, size_t count, cudaMemcpyKind kind)

Copies data between host and device.

Parameters
dst
- Destination memory address
wOffsetDst
- Destination starting X offset (columns in bytes)

hOffsetDst
- Destination starting Y offset (rows)

dst
- Source memory address

wOffsetSrc
- Source starting X offset (columns in bytes)

hOffsetSrc
- Source starting Y offset (rows)

count
- Size in bytes to copy

kind
- Type of transfer

Returns
cudaSuccess, cudaMemcpyInvalidValue, cudaMemcpyInvalidMemcpyDirection

Description
Deprecated
Copies count bytes from the CUDA array src starting at hOffsetSrc rows and wOffsetSrc bytes from the upper left corner to the CUDA array dst starting at hOffsetDst rows and wOffsetDst bytes from the upper left corner, where kind specifies the direction of the copy, and must be one of cudaMemcpyHostToHost, cudaMemcpyHostToDevice, cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaMemcpyInitializationError, cudaMemcpyInsufficientDriver or cudaMemcpyNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpyStreamAddCallback no CUDA function may be called from callback. cudaMemcpyNotPermitted may, but is not guaranteed to be returned as a diagnostic in such case.

See also:
cudMemcpy, cudaMemcpy2D, cudaMemcpyToArray, cudaMemcpy2DToArray, cudaMemcpyFromArray, cudaMemcpy2DFromArray, cudaMemcpy2DArrayToArray, cudaMemcpyToSymbol, cudaMemcpyFromSymbol, cudaMemcpyAsync, cudaMemcpy2DAsync, cudaMemcpyToArrayAsync, cudaMemcpy2DToarrayAsync, cudaMemcpyFromArrayAsync.
__host__ cudaError_t cudaMemcpyFromArray (void *dst, cudaArray_const_t src, size_t wOffset, size_t hOffset, size_t count, cudaMemcpyKind kind)

Copies data between host and device.

Parameters

dst
- Destination memory address

src
- Source memory address

wOffset
- Source starting X offset (columns in bytes)

hOffset
- Source starting Y offset (rows)

count
- Size in bytes to copy

kind
- Type of transfer

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidMemcpyDirection

Description

Deprecated

Copies count bytes from the CUDA array src starting at hOffset rows and wOffset bytes from the upper left corner to the memory area pointed to by dst, where kind specifies the direction of the copy, and must be one of cudaMemcpyHostToHost, cudaMemcpyHostToDevice, cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits synchronous behavior for most use cases.
Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.

Note that as specified by cudaMemcpyFromArrayAsync no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaMemcpy, cudaMemcpy2D, cudaMemcpyToArray, cudaMemcpy2DToArray, cudaMemcpy2DFromArray, cudaMemcpyToArrayAsync, cudaMemcpy2DToArrayAsync, cudaMemcpy2DFromArrayAsync, cudaMemcpyToArrayAsync, cudaMemcpyFromSymbol, cudaMemcpyFromSymbolAsync, cuMemcpypToH, cuMemcpypTod

__host__ cudaError_t cudaMemcpyFromArrayAsync (void *dst, cudaMemcpy_const_t src, size_t wOffset, size_t hOffset, size_t count, cudaMemcpyKind kind, cudaStream_t stream)

Copies data between host and device.

Parameters
dst
  - Destination memory address
src
  - Source memory address
wOffset
  - Source starting X offset (columns in bytes)
hOffset
  - Source starting Y offset (rows)
count
  - Size in bytes to copy
kind
  - Type of transfer
stream
  - Stream identifier

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidMemcpypDirection

Description
Deprecated
Copies `count` bytes from the CUDA array `src` starting at `hOffset` rows and `wOffset` bytes from the upper left corner to the memory area pointed to by `dst`, where `kind` specifies the direction of the copy, and must be one of `cudaMemcpyHostToDevice`, `cudaMemcpyDeviceToDevice`, or `cudaMemcpyDefault`. Passing `cudaMemcpyDefault` is recommended, in which case the type of transfer is inferred from the pointer values. However, `cudaMemcpyDefault` is only allowed on systems that support unified virtual addressing.

`cudaMemcpyFromArrayAsync()` is asynchronous with respect to the host, so the call may return before the copy is complete. The copy can optionally be associated to a stream by passing a non-zero `stream` argument. If `kind` is `cudaMemcpyHostToDevice` or `cudaMemcpyDeviceToHost` and `stream` is non-zero, the copy may overlap with operations in other streams.

**Note:**
- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits asynchronous behavior for most use cases.
- This function uses standard default stream semantics.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
- `cudaMemcpy`, `cudaMemcpy2D`, `cudaMemcpyToHost`, `cudaMemcpy2DToHost`, `cudaMemcpyToArray`, `cudaMemcpyToSymbol`, `cudaMemcpy2DFromArray`, `cudaMemcpy2DToArray`, `cudaMemcpyFromSymbolAsync`, `cudaMemcpy2DAsync`, `cuMemcpyAtoHAsync`, `cuMemcpy2DAsync`.

```c
__host__ cudaError_t cudaMemcpyToArray (cudaArray_t dst, size_t wOffset, size_t hOffset, const void *src, size_t count, cudaMemcpyKind kind)
```

Copies data between host and device.

**Parameters**

`dst`
- Destination memory address
wOffset
- Destination starting X offset (columns in bytes)

hOffset
- Destination starting Y offset (rows)

src
- Source memory address

count
- Size in bytes to copy

kind
- Type of transfer

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidMemcpyDirection

Description
Deprecated

Copies count bytes from the memory area pointed to by src to the CUDA array dst starting at hOffset rows and wOffset bytes from the upper left corner, where kind specifies the direction of the copy, and must be one of cudaMemcpyHostToHost, cudaMemcpyHostToDevice, cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits synchronous behavior for most use cases.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaMemcpyNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudamemcpy, cudamemcpy2D, cudamemcpy2DtoArray, cudamemcpyFromArray, cudamemcpy2DFromArray, cudamemcpyFromArrayToArray, cudamemcpy2DArrayToArray, cudamemcpyToSymbol, cudamemcpyFromSymbol, cudamemcpyAsync, cudamemcpy2DAsync, cudamemcpyToArrayAsync, cudamemcpy2DtoArrayAsync, cudamemcpyFromArrayAsync, cudamemcpy2DFromArrayAsync, cudamemcpyToSymbolAsync, cudamemcpyFromArraySymbolAsync, cudamemcpyHtoA, cudamemcpyDtoA
__host__ cudaError_t cudaMemcpyToArrayAsync (cudaArray_t dst, size_t wOffset, size_t hOffset, const void *src, size_t count, cudaMemcpyKind kind, cudaStream_t stream)

Copies data between host and device.

Parameters

dst
- Destination memory address

wOffset
- Destination starting X offset (columns in bytes)

hOffset
- Destination starting Y offset (rows)

src
- Source memory address

count
- Size in bytes to copy

kind
- Type of transfer

stream
- Stream identifier

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidMemcpyDirection

Description

Deprecated

Copies count bytes from the memory area pointed to by src to the CUDA array dst starting at hOffset rows and wOffset bytes from the upper left corner, where kind specifies the direction of the copy, and must be one of cudaMemcpyHostToHost, cudaMemcpyHostToDevice, cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing.

cudaMemcpyToArrayAsync() is asynchronous with respect to the host, so the call may return before the copy is complete. The copy can optionally be associated to a stream by passing a non-zero stream argument. If kind is cudaMemcpyHostToDevice or cudaMemcpyDeviceToHost and stream is non-zero, the copy may overlap with operations in other streams.
6.13. Stream Ordered Memory Allocator

overview

The asynchronous allocator allows the user to allocate and free in stream order. All asynchronous accesses of the allocation must happen between the stream executions of the allocation and the free. If the memory is accessed outside of the promised stream order, a use before allocation / use after free error will cause undefined behavior.

The allocator is free to reallocate the memory as long as it can guarantee that compliant memory accesses will not overlap temporally. The allocator may refer to internal stream ordering as well as inter-stream dependencies (such as CUDA events and null stream dependencies) when establishing the temporal guarantee. The allocator may also insert inter-stream dependencies to establish the temporal guarantee.

Supported Platforms

Whether or not a device supports the integrated stream ordered memory allocator may be queried by calling `cudaDeviceGetAttribute()` with the device attribute `cudaDevAttrMemoryPoolsSupported`.
__host__ cudaError_t cudaFreeAsync (void *devPtr, cudaStream_t hStream)
Frees memory with stream ordered semantics.

Parameters

- **devPtr**
- **hStream**
  - The stream establishing the stream ordering promise

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorNotSupported

Description

Inserts a free operation into hStream. The allocation must not be accessed after stream execution reaches the free. After this API returns, accessing the memory from any subsequent work launched on the GPU or querying its pointer attributes results in undefined behavior.

Note:

During stream capture, this function results in the creation of a free node and must therefore be passed the address of a graph allocation.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- This function uses standard default stream semantics.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cuMemFreeAsync, cudaMallocAsync
__host__ cudaError_t cudaMallocAsync (void **devPtr, size_t size, cudaStream_t hStream)

Allocates memory with stream ordered semantics.

Parameters

- **devPtr**: Returned device pointer
- **size**: Number of bytes to allocate
- **hStream**: The stream establishing the stream ordering contract and the memory pool to allocate from

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorNotSupported, cudaErrorOutOfMemory,

description

Inserts an allocation operation into hStream. A pointer to the allocated memory is returned immediately in *dptr. The allocation must not be accessed until the allocation operation completes. The allocation comes from the memory pool associated with the stream's device.

Note:

- The default memory pool of a device contains device memory from that device.
- Basic stream ordering allows future work submitted into the same stream to use the allocation. Stream query, stream synchronize, and CUDA events can be used to guarantee that the allocation operation completes before work submitted in a separate stream runs.
- During stream capture, this function results in the creation of an allocation node. In this case, the allocation is owned by the graph instead of the memory pool. The memory pool's properties are used to set the node's creation parameters.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- This function uses standard default stream semantics.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
__host__ cudaError_t cudaMallocFromPoolAsync (void **ptr, size_t size, cudaMemPool_t memPool, cudaStream_t stream)

Allocates memory from a specified pool with stream ordered semantics.

Parameters

ptr
  - Returned device pointer

size

memPool
  - The pool to allocate from

stream
  - The stream establishing the stream ordering semantic

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorNotSupported, cudaErrorOutOfMemory

Description

Inserts an allocation operation into hStream. A pointer to the allocated memory is returned immediately in *dptr. The allocation must not be accessed until the the allocation operation completes. The allocation comes from the specified memory pool.

Note:

- The specified memory pool may be from a device different than that of the specified hStream.

- Basic stream ordering allows future work submitted into the same stream to use the allocation. Stream query, stream synchronize, and CUDA events can be used to guarantee that the allocation operation completes before work submitted in a separate stream runs.

Note:

During stream capture, this function results in the creation of an allocation node. In this case, the allocation is owned by the graph instead of the memory pool. The memory pool’s properties are used to set the node’s creation parameters.
__host__ cudaError_t cudaMemPoolCreate
(cudaMemPool_t *memPool, const cudaMemPoolProps *poolProps)

Creates a memory pool.

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorNotSupported

Description

Creates a CUDA memory pool and returns the handle in `pool`. The `poolProps` determines the properties of the pool such as the backing device and IPC capabilities.

To create a memory pool targeting a specific host NUMA node, applications must set `cudaMemPoolProps::cudaMemLocation::type` to `cudaMemLocationTypeHostNuma` and `cudaMemPoolProps::cudaMemLocation::id` must specify the NUMA ID of the host memory node. Specifying `cudaMemLocationTypeHostNumaCurrent` or `cudaMemLocationTypeHost` as the `cudaMemPoolProps::cudaMemLocation::type` will result in `cudaErrorInvalidValue`. By default, the pool's memory will be accessible from the device it is allocated on. In the case of pools created with `cudaMemLocationTypeHostNuma`, their default accessibility will be from the host CPU. Applications can control the maximum size of the pool by specifying a non-zero value for `cudaMemPoolProps::maxSize`. If set to 0, the maximum size of the pool will default to a system dependent value.

Applications can set `cudaMemPoolProps::handleTypes` to `cudaMemHandleTypeFabric` in order to create `cudaMemPool_t` suitable for sharing within an IMEX domain. An IMEX domain is either an OS instance or a group of securely connected OS instances using the NVIDIA IMEX daemon. An IMEX channel is a global resource within the IMEX domain that represents a logical entity that aims to provide fine grained accessibility control for the participating processes. When exporter and importer CUDA processes have been granted access to the same IMEX channel, they can securely share memory. If the allocating process does not have access setup for an IMEX channel, attempting to export a `CUmemoryPool` with `cudaMemHandleTypeFabric` will result in `cudaErrorNotPermitted`. The nvidia-modprobe CLI provides more information regarding setting up of IMEX channels.

Note:

Specifying `cudaMemHandleTypeNone` creates a memory pool that will not support IPC.
__host__ cudaError_t cudaMemPoolDestroy (cudaMemPool_t memPool)

Destroys the specified memory pool.

Returns

cudaSuccess, cudaErrorInvalidValue

Description

If any pointers obtained from this pool haven't been freed or the pool has free operations that haven't completed when cudaMemPoolDestroy is invoked, the function will return immediately and the resources associated with the pool will be released automatically once there are no more outstanding allocations.

Destroying the current mempool of a device sets the default mempool of that device as the current mempool for that device.

Note:

A device's default memory pool cannot be destroyed.

See also:


__host__ cudaError_t cudaMemPoolExportPointer (cudaMemPoolPtrExportData *exportData, void *ptr)

Export data to share a memory pool allocation between processes.

Parameters

exportData

ptr

- pointer to memory being exported

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorOutOfMemory
Description

Constructs `shareData_out` for sharing a specific allocation from an already shared memory pool. The recipient process can import the allocation with the `cudaMemPoolImportPointer` api. The data is not a handle and may be shared through any IPC mechanism.

See also:


```
__host__ cudaError_t
cudaMemPoolExportToShareableHandle (void *
*shareableHandle, cudaMemPool_t memPool,
cudaMemAllocationHandleType handleType, unsigned int
flags)
```

Exports a memory pool to the requested handle type.

Parameters

`shareableHandle`
`memPool`
`handleType`
- the type of handle to create
`flags`
- must be 0

Returns

`cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorOutOfMemory`.

Description

Given an IPC capable mempool, create an OS handle to share the pool with another process. A recipient process can convert the shareable handle into a mempool with `cudaMemPoolImportFromShareableHandle`. Individual pointers can then be shared with the `cudaMemPoolExportPointer` and `cudaMemPoolImportPointer` APIs. The implementation of what the shareable handle is and how it can be transferred is defined by the requested handle type.

Note:

: To create an IPC capable mempool, create a mempool with a `CUmemAllocationHandleType` other than `cudaMemHandleTypeNone`. 
See also:

`cuMemPoolExportToShareableHandle`, `cudaMemPoolImportFromShareableHandle`,
`cudaMemPoolExportPointer`, `cudaMemPoolImportPointer`

```c
__host__ cudaError_t cudaMemPoolGetAccess
(cudaMemAccessFlags *flags, cudaMemPool_t memPool,
 cudaMemLocation *location)
```

Returns the accessibility of a pool from a device.

**Parameters**

- `flags`
  - the accessibility of the pool from the specified location
- `memPool`
  - the pool being queried
- `location`
  - the location accessing the pool

**Description**

Returns the accessibility of the pool's memory from the specified location.

See also:

`cuMemPoolGetAccess`, `cudaMemPoolSetAccess`

```c
__host__ cudaError_t cudaMemPoolGetAttribute
(cudaMemPool_t memPool, cudaMemPoolAttr attr, void *value)
```

Gets attributes of a memory pool.

**Parameters**

- `memPool`
- `attr`
  - The attribute to get
- `value`
  - Retrieved value

**Returns**

`cudaSuccess`, `cudaErrorInvalidValue`
Description

Supported attributes are:

- **cudaMemPoolAttrReleaseThreshold**: (value type = cuuint64_t) Amount of reserved memory in bytes to hold onto before trying to release memory back to the OS. When more than the release threshold bytes of memory are held by the memory pool, the allocator will try to release memory back to the OS on the next call to stream, event or context synchronize. (default 0)

- **cudaMemPoolReuseFollowEventDependencies**: (value type = int) Allow `cudaMallocAsync` to use memory asynchronously freed in another stream as long as a stream ordering dependency of the allocating stream on the free action exists. Cuda events and null stream interactions can create the required stream ordered dependencies. (default enabled)

- **cudaMemPoolReuseAllowOpportunistic**: (value type = int) Allow reuse of already completed frees when there is no dependency between the free and allocation. (default enabled)

- **cudaMemPoolReuseAllowInternalDependencies**: (value type = int) Allow `cudaMallocAsync` to insert new stream dependencies in order to establish the stream ordering required to reuse a piece of memory released by `cudaFreeAsync` (default enabled).

- **cudaMemPoolAttrReservedMemCurrent**: (value type = cuuint64_t) Amount of backing memory currently allocated for the mempool.

- **cudaMemPoolAttrReservedMemHigh**: (value type = cuuint64_t) High watermark of backing memory allocated for the mempool since the last time it was reset.

- **cudaMemPoolAttrUsedMemCurrent**: (value type = cuuint64_t) Amount of memory from the pool that is currently in use by the application.

- **cudaMemPoolAttrUsedMemHigh**: (value type = cuuint64_t) High watermark of the amount of memory from the pool that was in use by the application since the last time it was reset.

Note:

Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

- `cuMemPoolGetAttribute`, `cudaMallocAsync`, `cudaFreeAsync`, `cudaDeviceGetDefaultMemPool`, `cudaDeviceGetMemPool`, `cudaMemPoolCreate`
__host__ cudaError_t
cudaMemPoolImportFromShareableHandle
(cudaMemPool_t *memPool, void *shareableHandle,
cudaMemAllocationHandleType handleType, unsigned int flags)
imports a memory pool from a shared handle.

Parameters
  memPool
  shareableHandle
  handleType
    - The type of handle being imported
  flags
    - must be 0

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorOutOfMemory

Description
Specific allocations can be imported from the imported pool with cudaMemPoolImportPointer.

Note:
Imported memory pools do not support creating new allocations. As such imported memory pools may not be used in cudaDeviceSetMemPool or cudaMallocFromPoolAsync calls.

See also:
cuMemPoolImportFromShareableHandle, cudaMemPoolExportToShareableHandle,
cudaMemPoolExportPointer, cudaMemPoolImportPointer
__host__ cudaError_t cudaMemPoolImportPointer
(void **ptr, cudaMemPool_t memPool,
cudaMemPoolPtrExportData *exportData)

Import a memory pool allocation from another process.

Returns
CUDA_SUCCESS, CUDA_ERROR_INVALID_VALUE, CUDA_ERROR_NOT_INITIALIZED,
CUDA_ERROR_OUT_OF_MEMORY

Description
Returns in ptr_out a pointer to the imported memory. The imported memory must not be accessed
before the allocation operation completes in the exporting process. The imported memory must be
freed from all importing processes before being freed in the exporting process. The pointer may be
freed with cudaFree or cudaFreeAsync. If cudaFreeAsync is used, the free must be completed on the
importing process before the free operation on the exporting process.

Note:
The cudaFreeAsync api may be used in the exporting process before the cudaFreeAsync operation
completes in its stream as long as the cudaFreeAsync in the exporting process specifies a stream with a
stream dependency on the importing process's cudaFreeAsync.

See also:
cuMemPoolImportPointer, cudaMemPoolExportToShareableHandle,
cudaMemPoolImportFromShareableHandle, cudaMemPoolExportPointer

__host__ cudaError_t cudaMemPoolSetAccess
(cudaMemPool_t memPool, const cudaMemAccessDesc
*descList, size_t count)

Controls visibility of pools between devices.

Parameters

memPool
descList
count
- Number of descriptors in the map array.
__host__ cudaError_t cudaMemPoolSetAttribute (cudaMemPool_t memPool, cudaMemPoolAttr attr, void *value)

Sets attributes of a memory pool.

Parameters

memPool
attr
- The attribute to modify

value
- Pointer to the value to assign

Returns
cudaSuccess, cudaErrorInvalidValue

Description

Supported attributes are:

- **cudaMemPoolAttrReleaseThreshold**: (value type = cuuint64_t) Amount of reserved memory in bytes to hold onto before trying to release memory back to the OS. When more than the release threshold bytes of memory are held by the memory pool, the allocator will try to release memory back to the OS on the next call to stream, event or context synchronize. (default 0)

- **cudaMemPoolReuseFollowEventDependencies**: (value type = int) Allow cudaMallocAsync to use memory asynchronously freed in another stream as long as a stream ordering dependency of the allocating stream on the free action exists. Cuda events and null stream interactions can create the required stream ordered dependencies. (default enabled)

- **cudaMemPoolReuseAllowOpportunistic**: (value type = int) Allow reuse of already completed frees when there is no dependency between the free and allocation. (default enabled)

- **cudaMemPoolReuseAllowInternalDependencies**: (value type = int) Allow cudaMallocAsync to insert new stream dependencies in order to establish the stream ordering required to reuse a piece of memory released by cudaFreeAsync (default enabled).
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- **cudaMemPoolAttrReservedMemHigh**: (value type = cuuint64_t) Reset the high watermark that tracks the amount of backing memory that was allocated for the memory pool. It is illegal to set this attribute to a non-zero value.

- **cudaMemPoolAttrUsedMemHigh**: (value type = cuuint64_t) Reset the high watermark that tracks the amount of used memory that was allocated for the memory pool. It is illegal to set this attribute to a non-zero value.

**Note:**

Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:


### __host__ cudaError_t cudaMemPoolTrimTo
*(cudaMemPool_t memPool, size_t minBytesToKeep)*

Tries to release memory back to the OS.

**Parameters**

- **memPool**
- **minBytesToKeep**
  - If the pool has less than minBytesToKeep reserved, the TrimTo operation is a no-op. Otherwise the pool will be guaranteed to have at least minBytesToKeep bytes reserved after the operation.

**Returns**

- `cudaSuccess`
- `cudaErrorInvalidValue`

**Description**

Releases memory back to the OS until the pool contains fewer than minBytesToKeep reserved bytes, or there is no more memory that the allocator can safely release. The allocator cannot release OS allocations that back outstanding asynchronous allocations. The OS allocations may happen at different granularity from the user allocations.

**Note:**

- : Allocations that have not been freed count as outstanding.
- : Allocations that have been asynchronously freed but whose completion has not been observed on the host (eg. by a synchronize) can count as outstanding.

This section describes the unified addressing functions of the CUDA runtime application programming interface.

Overview

CUDA devices can share a unified address space with the host. For these devices there is no distinction between a device pointer and a host pointer -- the same pointer value may be used to access memory from the host program and from a kernel running on the device (with exceptions enumerated below).

Supported Platforms

Whether or not a device supports unified addressing may be queried by calling `cudaGetDeviceProperties()` with the device property `cudaDeviceProp::unifiedAddressing`. Unified addressing is automatically enabled in 64-bit processes.

Looking Up Information from Pointer Values

It is possible to look up information about the memory which backs a pointer value. For instance, one may want to know if a pointer points to host or device memory. As another example, in the case of device memory, one may want to know on which CUDA device the memory resides. These properties may be queried using the function `cudaPointerGetAttributes()`.

Since pointers are unique, it is not necessary to specify information about the pointers specified to `cudaMemcpy()` and other copy functions. The copy direction `cudaMemcpyDefault` may be used to specify that the CUDA runtime should infer the location of the pointer from its value.

Automatic Mapping of Host Allocated Host Memory

All host memory allocated through all devices using `cudaMallocHost()` and `cudaHostAlloc()` is always directly accessible from all devices that support unified addressing. This is the case regardless of whether or not the flags `cudaHostAllocPortable` and `cudaHostAllocMapped` are specified.

The pointer value through which allocated host memory may be accessed in kernels on all devices that support unified addressing is the same as the pointer value through which that memory is accessed.
on the host. It is not necessary to call \texttt{cudaHostGetDevicePointer()} to get the device pointer for these allocations.

Note that this is not the case for memory allocated using the flag \texttt{cudaHostAllocWriteCombined}, as discussed below.

Direct Access of Peer Memory

Upon enabling direct access from a device that supports unified addressing to another peer device that supports unified addressing using \texttt{cudaDeviceEnablePeerAccess()} all memory allocated in the peer device using \texttt{cudaMalloc()} and \texttt{cudaMallocPitch()} will immediately be accessible by the current device. The device pointer value through which any peer's memory may be accessed in the current device is the same pointer value through which that memory may be accessed from the peer device.

Exceptions, Disjoint Addressing

Not all memory may be accessed on devices through the same pointer value through which they are accessed on the host. These exceptions are host memory registered using \texttt{cudaHostRegister()} and host memory allocated using the flag \texttt{cudaHostAllocWriteCombined}. For these exceptions, there exists a distinct host and device address for the memory. The device address is guaranteed to not overlap any valid host pointer range and is guaranteed to have the same value across all devices that support unified addressing.

This device address may be queried using \texttt{cudaHostGetDevicePointer()} when a device using unified addressing is current. Either the host or the unified device pointer value may be used to refer to this memory in \texttt{cudaMemcpy()} and similar functions using the \texttt{cudaMemcpyDefault} memory direction.

\begin{verbatim}
__host__ cudaError_t cudaPointerGetAttributes 
(cudaPointerAttributes *attributes, const void *ptr)

Parameters
attributes
  - Attributes for the specified pointer
ptr
  - Pointer to get attributes for

Returns
cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidValue

Description
Returns in *attributes the attributes of the pointer ptr. If pointer was not allocated in, mapped by or registered with context supporting unified addressing cudaErrorInvalidValue is returned.

Note:
\end{verbatim}
In CUDA 11.0 forward passing host pointer will return `cudaMemoryTypeUnregistered` in `cudaPointerAttributes::type` and call will return `cudaSuccess`.

The `cudaPointerAttributes` structure is defined as:

```c
struct cudaPointerAttributes {
    enum cudaMemoryType
        type;
    int device;
    void * devicePointer;
    void * hostPointer;
};
```

In this structure, the individual fields mean

- `cudaPointerAttributes::type` identifies type of memory. It can be `cudaMemoryTypeUnregistered` for unregistered host memory, `cudaMemoryTypeHost` for registered host memory, `cudaMemoryTypeDevice` for device memory or `cudaMemoryTypeManaged` for managed memory.

- `device` is the device against which `ptr` was allocated. If `ptr` has memory type `cudaMemoryTypeDevice` then this identifies the device on which the memory referred to by `ptr` physically resides. If `ptr` has memory type `cudaMemoryTypeHost` then this identifies the device which was current when the allocation was made (and if that device is deinitialized then this allocation will vanish with that device's state).

- `devicePointer` is the device pointer alias through which the memory referred to by `ptr` may be accessed on the current device. If the memory referred to by `ptr` cannot be accessed directly by the current device then this is NULL.

- `hostPointer` is the host pointer alias through which the memory referred to by `ptr` may be accessed on the host. If the memory referred to by `ptr` cannot be accessed directly by the host then this is NULL.

**Note:**

- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.

- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

- `cudaGetDeviceCount`, `cudaGetDevice`, `cudaSetDevice`, `cudaChooseDevice`, `cudaInitDevice`, `cuPointerGetAttributes`
6.15. Peer Device Memory Access

This section describes the peer device memory access functions of the CUDA runtime application programming interface.

__host__ cudaError_t cudaDeviceCanAccessPeer (int *canAccessPeer, int device, int peerDevice)

Queries if a device may directly access a peer device's memory.

Parameters

canAccessPeer
- Returned access capability
device
- Device from which allocations on peerDevice are to be directly accessed.
peerDevice
- Device on which the allocations to be directly accessed by device reside.

Returns

cudaSuccess, cudaErrorInvalidDevice

Description

Returns in *canAccessPeer a value of 1 if device device is capable of directly accessing memory from peerDevice and 0 otherwise. If direct access of peerDevice from device is possible, then access may be enabled by calling cudaDeviceEnablePeerAccess().

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaDeviceEnablePeerAccess, cudaDeviceDisablePeerAccess, cuDeviceCanAccessPeer
__host__ cudaError_t cudaDeviceDisablePeerAccess (int peerDevice)
Disables direct access to memory allocations on a peer device.

Parameters
peerDevice
- Peer device to disable direct access to

Returns
cudaSuccess, cudaErrorPeerAccessNotEnabled, cudaErrorInvalidDevice

Description
Returns cudaErrorPeerAccessNotEnabled if direct access to memory on peerDevice has not yet been enabled from the current device.

Note:
▶ Note that this function may also return error codes from previous, asynchronous launches.
▶ Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
▶ Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaDeviceCanAccessPeer, cudaDeviceEnablePeerAccess, cuCtxDisablePeerAccess

__host__ cudaError_t cudaDeviceEnablePeerAccess (int peerDevice, unsigned int flags)
Enables direct access to memory allocations on a peer device.

Parameters
peerDevice
- Peer device to enable direct access to from the current device
flags
- Reserved for future use and must be set to 0
Returns

cudaSuccess, cudaErrorInvalidDevice, cudaErrorPeerAccessAlreadyEnabled, cudaErrorInvalidValue

Description

On success, all allocations from peerDevice will immediately be accessible by the current device. They will remain accessible until access is explicitly disabled using cudaDeviceDisablePeerAccess() or either device is reset using cudaDeviceReset().

Note that access granted by this call is unidirectional and that in order to access memory on the current device from peerDevice, a separate symmetric call to cudaDeviceEnablePeerAccess() is required.

Note that there are both device-wide and system-wide limitations per system configuration, as noted in the CUDA Programming Guide under the section "Peer-to-Peer Memory Access".

Returns cudaErrorInvalidDevice if cudaDeviceCanAccessPeer() indicates that the current device cannot directly access memory from peerDevice.

Returns cudaErrorPeerAccessAlreadyEnabled if direct access of peerDevice from the current device has already been enabled.

Returns cudaErrorInvalidValue if flags is not 0.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaDeviceCanAccessPeer, cudaDeviceDisablePeerAccess, cuCtxEnablePeerAccess

6.16. OpenGL Interoperability

This section describes the OpenGL interoperability functions of the CUDA runtime application programming interface. Note that mapping of OpenGL resources is performed with the graphics API agnostic, resource mapping interface described in Graphics Interopability.

enum cudaGLDeviceList

CUDA devices corresponding to the current OpenGL context
Values

`cudaGLDeviceListAll = 1`
- The CUDA devices for all GPUs used by the current OpenGL context

`cudaGLDeviceListCurrentFrame = 2`
- The CUDA devices for the GPUs used by the current OpenGL context in its currently rendering frame

`cudaGLDeviceListNextFrame = 3`
- The CUDA devices for the GPUs to be used by the current OpenGL context in the next frame

```c
__host__ cudaError_t cudaGLGetDevices (unsigned int *pCudaDeviceCount, int *pCudaDevices, unsigned int cudaDeviceCount, cudaGLDeviceList deviceList)
```

Gets the CUDA devices associated with the current OpenGL context.

Parameters

`pCudaDeviceCount`
- Returned number of CUDA devices corresponding to the current OpenGL context

`pCudaDevices`
- Returned CUDA devices corresponding to the current OpenGL context

`cudaDeviceCount`
- The size of the output device array `pCudaDevices`

`deviceList`
- The set of devices to return. This set may be `cudaGLDeviceListAll` for all devices, `cudaGLDeviceListCurrentFrame` for the devices used to render the current frame (in SLI), or `cudaGLDeviceListNextFrame` for the devices used to render the next frame (in SLI).

Returns

`cudaSuccess`, `cudaErrorNoDevice`, `cudaErrorInvalidGraphicsContext`, `cudaErrorOperatingSystem`, `cudaErrorUnknown`

Description

Returns in `*pCudaDeviceCount` the number of CUDA-compatible devices corresponding to the current OpenGL context. Also returns in `*pCudaDevices` at most `cudaDeviceCount` of the CUDA-compatible devices corresponding to the current OpenGL context. If any of the GPUs being used by the current OpenGL context are not CUDA capable then the call will return `cudaErrorNoDevice`.

Note:
This function is not supported on Mac OS X.
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaGraphicsUnregisterResource, cudaGraphicsMapResources,
cudaGraphicsSubResourceGetMappedArray, cudaGraphicsResourceGetMappedPointer,
cuGLGetDevices

__host__ cudaError_t cudaGraphicsGLRegisterBuffer
(cudaGraphicsResource **resource, GLuint buffer,
unsigned int flags)
Registers an OpenGL buffer object.

Parameters
resource
  - Pointer to the returned object handle
buffer
  - name of buffer object to be registered
flags
  - Register flags

Returns
cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle,
cudaErrorOperatingSystem, cudaErrorUnknown

Description
Registers the buffer object specified by buffer for access by CUDA. A handle to the registered
object is returned as resource. The register flags flags specify the intended usage, as follows:

- **cudaGraphicsRegisterFlagsNone**: Specifies no hints about how this resource will be used. It is
  therefore assumed that this resource will be read from and written to by CUDA. This is the default
  value.
- **cudaGraphicsRegisterFlagsReadOnly**: Specifies that CUDA will not write to this resource.
- **cudaGraphicsRegisterFlagsWriteDiscard**: Specifies that CUDA will not read from this resource
  and will write over the entire contents of the resource, so none of the data previously stored in the
  resource will be preserved.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaGraphicsUnregisterResource, cudaGraphicsMapResources,
cudaGraphicsResourceGetMappedPointer, cuGraphicsGLRegisterBuffer

__host__ cudaError_t cudaGraphicsGLRegisterImage
(cudaGraphicsResource **resource, GLuint image, GLenum target, unsigned int flags)
Register an OpenGL texture or renderbuffer object.

Parameters
resource
- Pointer to the returned object handle
image
- name of texture or renderbuffer object to be registered
target
- Identifies the type of object specified by image
flags
- Register flags

Returns
cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle,
cudaErrorOperatingSystem, cudaErrorUnknown

Description
 Registers the texture or renderbuffer object specified by image for access by CUDA. A handle to the
registered object is returned as resource.

target must match the type of the object, and must be one of GL_TEXTURE_2D,
GL_TEXTURE_RECTANGLE, GL_TEXTURE_CUBE_MAP, GL_TEXTURE_3D,
GL_TEXTURE_2D_ARRAY, or GL_RENDERBUFFER.

The register flags flags specify the intended usage, as follows:

- cudaGraphicsRegisterFlagsNone: Specifies no hints about how this resource will be used. It is
  therefore assumed that this resource will be read from and written to by CUDA. This is the default
  value.
- cudaGraphicsRegisterFlagsReadOnly: Specifies that CUDA will not write to this resource.
- `cudaGraphicsRegisterFlagsWriteDiscard`: Specifies that CUDA will not read from this resource and will write over the entire contents of the resource, so none of the data previously stored in the resource will be preserved.

- `cudaGraphicsRegisterFlagsSurfaceLoadStore`: Specifies that CUDA will bind this resource to a surface reference.

- `cudaGraphicsRegisterFlagsTextureGather`: Specifies that CUDA will perform texture gather operations on this resource.

The following image formats are supported. For brevity's sake, the list is abbreviated. For ex., `{GL_R, GL_RG} X {8, 16}` would expand to the following 4 formats `{GL_R8, GL_R16, GL_RG8, GL_RG16}`:

- GL_RED, GL_RG, GL_RGBA, GL_LUMINANCE, GL_ALPHA, GL_LUMINANCE_ALPHA, GL_INTENSITY
- `{GL_R, GL_RG, GL_RGBA} X {8, 16, 16F, 32F, 8UI, 16UI, 32UI, 8I, 16I, 32I}
- `{GL_LUMINANCE, GL_ALPHA, GL_LUMINANCE_ALPHA, GL_INTENSITY} X {8, 16, 16F_ARB, 32F_ARB, 8UI_EXT, 16UI_EXT, 32UI_EXT, 8I_EXT, 16I_EXT, 32I_EXT}

The following image classes are currently disallowed:

- Textures with borders
- Multisampled renderbuffers

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:

- `cudaGraphicsUnregisterResource`
- `cudaGraphicsMapResources`
- `cudaGraphicsSubResourceGetMappedArray`
- `cuGraphicsGLRegisterImage`

---

```c
__host__ cudaError_t cudaWGLGetDevice (int *device, HGPUNV hGpu)
```

Gets the CUDA device associated with hGpu.

**Parameters**

- `device` - Returns the device associated with hGpu, or -1 if hGpu is not a compute device.
- `hGpu` - Handle to a GPU, as queried via WGL_NV_gpu_affinity
Returns

`cudaSuccess`

Description

Returns the CUDA device associated with a hGpu, if applicable.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:

WGL_NV_gpu_affinity, cuWGLGetDevice

6.17. OpenGL Interoperability

[DEPRECATED]

This section describes deprecated OpenGL interoperability functionality.

`enum cudaGLMapFlags`

CUDA GL Map Flags

Values

`cudaGLMapFlagsNone` = 0

Default; Assume resource can be read/written

`cudaGLMapFlagsReadOnly` = 1

CUDA kernels will not write to this resource

`cudaGLMapFlagsWriteDiscard` = 2

CUDA kernels will only write to and will not read from this resource

`__host__ cudaError_t cudaGLMapBufferObject (void **devPtr, GLuint bufObj)`

Maps a buffer object for access by CUDA.

Parameters

`devPtr`

- Returned device pointer to CUDA object
bufObj
- Buffer object ID to map

Returns
cudaSuccess, cudaErrorMapBufferObjectFailed

Description
Deprecated This function is deprecated as of CUDA 3.0.
Maps the buffer object of ID bufObj into the address space of CUDA and returns in *devPtr the base pointer of the resulting mapping. The buffer must have previously been registered by calling cudaGLRegisterBufferObject(). While a buffer is mapped by CUDA, any OpenGL operation which references the buffer will result in undefined behavior. The OpenGL context used to create the buffer, or another context from the same share group, must be bound to the current thread when this is called.
All streams in the current thread are synchronized with the current GL context.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaGraphicsMapResources

__host__ cudaError_t cudaGLMapBufferObjectAsync (void **devPtr, GLuint bufObj, cudaStream_t stream)
Maps a buffer object for access by CUDA.

Parameters
devPtr
- Returned device pointer to CUDA object
bufObj
- Buffer object ID to map
stream
- Stream to synchronize

Returns
cudaSuccess, cudaErrorMapBufferObjectFailed

Description
Deprecated This function is deprecated as of CUDA 3.0.
Maps the buffer object of ID `bufObj` into the address space of CUDA and returns in `*devPtr` the base pointer of the resulting mapping. The buffer must have previously been registered by calling `cudaGLRegisterBufferObject()`. While a buffer is mapped by CUDA, any OpenGL operation which references the buffer will result in undefined behavior. The OpenGL context used to create the buffer, or another context from the same share group, must be bound to the current thread when this is called.

Stream /p stream is synchronized with the current GL context.

---

**Note:**

Note that this function may also return error codes from previous, asynchronous launches.

See also:

`cudaGraphicsMapResources`

```c
__host__ cudaError_t cudaGLRegisterBufferObject (GLuint bufObj)
```

Registers a buffer object for access by CUDA.

**Parameters**

- `bufObj` - Buffer object ID to register

**Returns**

- `cudaSuccess`, `cudaErrorInitializationError`

**Description**

`Deprecated` This function is deprecated as of CUDA 3.0.

Registers the buffer object of ID `bufObj` for access by CUDA. This function must be called before CUDA can map the buffer object. The OpenGL context used to create the buffer, or another context from the same share group, must be bound to the current thread when this is called.

---

**Note:**

Note that this function may also return error codes from previous, asynchronous launches.

See also:

`cudaGraphicsGLRegisterBuffer`
__host__ cudaError_t cudaGLSetBufferObjectMapFlags (GLuint bufObj, unsigned int flags)

Set usage flags for mapping an OpenGL buffer.

Parameters

bufObj
- Registered buffer object to set flags for
flags
- Parameters for buffer mapping

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

Deprecated This function is deprecated as of CUDA 3.0.

Set flags for mapping the OpenGL buffer bufObj

Changes to flags will take effect the next time bufObj is mapped. The flags argument may be any of the following:

- **cudaGLMapFlagsNone**: Specifies no hints about how this buffer will be used. It is therefore assumed that this buffer will be read from and written to by CUDA kernels. This is the default value.
- **cudaGLMapFlagsReadOnly**: Specifies that CUDA kernels which access this buffer will not write to the buffer.
- **cudaGLMapFlagsWriteDiscard**: Specifies that CUDA kernels which access this buffer will not read from the buffer and will write over the entire contents of the buffer, so none of the data previously stored in the buffer will be preserved.

If bufObj has not been registered for use with CUDA, then cudaErrorInvalidResourceHandle is returned. If bufObj is presently mapped for access by CUDA, then cudaErrorUnknown is returned.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaGraphicsResourceSetMapFlags
__host__ cudaError_t cudaGLSetGLDevice (int device)
Sets a CUDA device to use OpenGL interoperability.

Parameters
device
- Device to use for OpenGL interoperability

Returns
cudaSuccess, cudaErrorInvalidDevice, cudaErrorSetOnActiveProcess

Description
Deprecated This function is deprecated as of CUDA 5.0.
This function is deprecated and should no longer be used. It is no longer necessary to associate a
CUDA device with an OpenGL context in order to achieve maximum interoperability performance.
This function will immediately initialize the primary context on device if needed.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaGraphicsGLRegisterBuffer, cudaGraphicsGLRegisterImage

__host__ cudaError_t cudaGLUnmapBufferObject (GLuint bufObj)
Unmaps a buffer object for access by CUDA.

Parameters
bufObj
- Buffer object to unmap

Returns
cudaSuccess, cudaErrorUnmapBufferObjectFailed

Description
Deprecated This function is deprecated as of CUDA 3.0.
Unmaps the buffer object of ID `bufObj` for access by CUDA. When a buffer is unmapped, the base address returned by `cudaGLMapBufferObject()` is invalid and subsequent references to the address result in undefined behavior. The OpenGL context used to create the buffer, or another context from the same share group, must be bound to the current thread when this is called.

All streams in the current thread are synchronized with the current GL context.

---

**Note:**

Note that this function may also return error codes from previous, asynchronous launches.

---

**See also:**

`cudaGraphicsUnmapResources`

**__host__ cudaError_t cudaGLUnmapBufferObjectAsync (GLuint bufObj, cudaStream_t stream)**

Unmaps a buffer object for access by CUDA.

**Parameters**

- **bufObj**
  - Buffer object to unmap

- **stream**
  - Stream to synchronize

**Returns**

`cudaSuccess`, `cudaErrorUnmapBufferObjectFailed`

**Description**

**Deprecated** This function is deprecated as of CUDA 3.0.

Unmaps the buffer object of ID `bufObj` for access by CUDA. When a buffer is unmapped, the base address returned by `cudaGLMapBufferObject()` is invalid and subsequent references to the address result in undefined behavior. The OpenGL context used to create the buffer, or another context from the same share group, must be bound to the current thread when this is called.

Stream `/p stream` is synchronized with the current GL context.

---

**Note:**

Note that this function may also return error codes from previous, asynchronous launches.

---

**See also:**
cudaGraphicsUnmapResources

__host__ cudaError_t cudaGLUnregisterBufferObject(GLuint bufObj)

Unregisters a buffer object for access by CUDA.

Parameters

bufObj
- Buffer object to unregister

Returns

cudaSuccess

Description

Deprecated This function is deprecated as of CUDA 3.0.

Unregisters the buffer object of ID bufObj for access by CUDA and releases any CUDA resources associated with the buffer. Once a buffer is unregistered, it may no longer be mapped by CUDA. The GL context used to create the buffer, or another context from the same share group, must be bound to the current thread when this is called.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:

cudaGraphicsUnregisterResource

6.18. Direct3D 9 Interoperability

This section describes the Direct3D 9 interoperability functions of the CUDA runtime application programming interface. Note that mapping of Direct3D 9 resources is performed with the graphics API agnostic, resource mapping interface described in Graphics Interopability.

eenum cudaD3D9DeviceList

CUDA devices corresponding to a D3D9 device
Values

cudaD3D9DeviceListAll = 1
   The CUDA devices for all GPUs used by a D3D9 device

cudaD3D9DeviceListCurrentFrame = 2
   The CUDA devices for the GPUs used by a D3D9 device in its currently rendering frame

cudaD3D9DeviceListNextFrame = 3
   The CUDA devices for the GPUs to be used by a D3D9 device in the next frame

__host__ cudaError_t cudaD3D9GetDevice (int *device, const char *pszAdapterName)

Gets the device number for an adapter.

Parameters

device
   - Returns the device corresponding to pszAdapterName

pszAdapterName
   - D3D9 adapter to get device for

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorUnknown

Description

Returns in *device the CUDA-compatible device corresponding to the adapter name pszAdapterName obtained from EnumDisplayDevices or IDirect3D9::GetAdapterIdentifier(). If no device on the adapter with name pszAdapterName is CUDA-compatible then the call will fail.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:

cudaD3D9SetDirect3DDevice, cudaGraphicsD3D9RegisterResource, cuD3D9GetDevice
__host__ cudaError_t cudaD3D9GetDevices (unsigned int *pCudaDeviceCount, int *pCudaDevices, unsigned int cudaDeviceCount, IDirect3DDevice9 *pD3D9Device, cudaD3D9DeviceList deviceList)

Gets the CUDA devices corresponding to a Direct3D 9 device.

Parameters

pCudaDeviceCount
- Returned number of CUDA devices corresponding to pD3D9Device

pCudaDevices
- Returned CUDA devices corresponding to pD3D9Device

cudaDeviceCount
- The size of the output device array pCudaDevices

pD3D9Device
- Direct3D 9 device to query for CUDA devices

deviceList
- The set of devices to return. This set may be cudaD3D9DeviceListAll for all devices, cudaD3D9DeviceListCurrentFrame for the devices used to render the current frame (in SLI), or cudaD3D9DeviceListNextFrame for the devices used to render the next frame (in SLI).

Returns
cudaSuccess, cudaErrorNoDevice, cudaErrorUnknown

Description

Returns in *pCudaDeviceCount the number of CUDA-compatible devices corresponding to the Direct3D 9 device pD3D9Device. Also returns in *pCudaDevices at most cudaDeviceCount of the the CUDA-compatible devices corresponding to the Direct3D 9 device pD3D9Device.

If any of the GPUs being used to render pDevice are not CUDA capable then the call will return cudaErrorNoDevice.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:
**__host__ cudaError_t cudaD3D9GetDirect3DDevice (IDirect3DDevice9 **ppD3D9Device)**

Gets the Direct3D device against which the current CUDA context was created.

**Parameters**

**ppD3D9Device**

- Returns the Direct3D device for this thread

**Returns**

cudaSuccess, cudaErrorInvalidGraphicsContext, cudaErrorUnknown

**Description**

Returns in *ppD3D9Device* the Direct3D device against which this CUDA context was created in cudaD3D9SetDirect3DDevice().

**Note:**

Note that this function may also return error codes from previous, asynchronous launches.

See also:

cudaD3D9SetDirect3DDevice, cuD3D9GetDirect3DDevice

**__host__ cudaError_t cudaD3D9SetDirect3DDevice (IDirect3DDevice9 *pD3D9Device, int device)**

Sets the Direct3D 9 device to use for interoperability with a CUDA device.

**Parameters**

**pD3D9Device**

- Direct3D device to use for this thread

**device**

- The CUDA device to use. This device must be among the devices returned when querying cudaD3D9DeviceListAll from cudaD3D9GetDevices, may be set to -1 to automatically select an appropriate CUDA device.

**Returns**

cudaSuccess, cudaErrorInitializationError, cudaErrorInvalidValue, cudaErrorSetOnActiveProcess
Description

Records `pD3D9Device` as the Direct3D 9 device to use for Direct3D 9 interoperability with the CUDA device `device` and sets `device` as the current device for the calling host thread.

This function will immediately initialize the primary context on `device` if needed.

If `device` has already been initialized then this call will fail with the error `cudaErrorSetOnActiveProcess`. In this case it is necessary to reset `device` using `cudaDeviceReset()` before Direct3D 9 interoperability on `device` may be enabled.

Successfully initializing CUDA interoperability with `pD3D9Device` will increase the internal reference count on `pD3D9Device`. This reference count will be decremented when `device` is reset using `cudaDeviceReset()`.

Note that this function is never required for correct functionality. Use of this function will result in accelerated interoperability only when the operating system is Windows Vista or Windows 7, and the device `pD3DDdevice` is not an IDirect3DDevice9Ex. In all other circumstances, this function is not necessary.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:

`cudaD3D9GetDevice`, `cudaGraphicsD3D9RegisterResource`, `cudaDeviceReset`

```c
__host__ cudaError_t cudaGraphicsD3D9RegisterResource (cudaGraphicsResource **resource, IDirect3DResource9 *pD3DResource, unsigned int flags)
```

Register a Direct3D 9 resource for access by CUDA.

Parameters

- `resource`
  - Pointer to returned resource handle

- `pD3DResource`
  - Direct3D resource to register

- `flags`
  - Parameters for resource registration
Returns

cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

 Registers the Direct3D 9 resource pD3DResource for access by CUDA.

If this call is successful then the application will be able to map and unmap this resource until it is unregistered through cudaGraphicsUnregisterResource(). Also on success, this call will increase the internal reference count on pD3DResource. This reference count will be decremented when this resource is unregistered through cudaGraphicsUnregisterResource().

This call potentially has a high-overhead and should not be called every frame in interactive applications.

The type of pD3DResource must be one of the following.

- IDirect3DVertexBuffer9: may be accessed through a device pointer
- IDirect3DIndexBuffer9: may be accessed through a device pointer
- IDirect3DSurface9: may be accessed through an array. Only stand-alone objects of type IDirect3DSurface9 may be explicitly shared. In particular, individual mipmap levels and faces of cube maps may not be registered directly. To access individual surfaces associated with a texture, one must register the base texture object.
- IDirect3DBaseTexture9: individual surfaces on this texture may be accessed through an array.

The flags argument may be used to specify additional parameters at register time. The valid values for this parameter are

- cudaGraphicsRegisterFlagsNone: Specifies no hints about how this resource will be used.
- cudaGraphicsRegisterFlagsSurfaceLoadStore: Specifies that CUDA will bind this resource to a surface reference.
- cudaGraphicsRegisterFlagsTextureGather: Specifies that CUDA will perform texture gather operations on this resource.

Not all Direct3D resources of the above types may be used for interoperability with CUDA. The following are some limitations.

- The primary rendertarget may not be registered with CUDA.
- Resources allocated as shared may not be registered with CUDA.
- Textures which are not of a format which is 1, 2, or 4 channels of 8, 16, or 32-bit integer or floating-point data cannot be shared.
- Surfaces of depth or stencil formats cannot be shared.

A complete list of supported formats is as follows:

- D3DFMT_L8
D3DFMT_L16
D3DFMT_A8R8G8B8
D3DFMT_X8R8G8B8
D3DFMT_G16R16
D3DFMT_A8B8G8R8
D3DFMT_A8
D3DFMT_A8L8
D3DFMT_Q8W8V8U8
D3DFMT_V16U16
D3DFMT_A16B16G16R16F
D3DFMT_A16B16G16R16
D3DFMT_R32F
D3DFMT_G16R16F
D3DFMT_A32B32G32R32F
D3DFMT_G32R32F
D3DFMT_R16F

If `pD3DResource` is of incorrect type or is already registered, then `cudaErrorInvalidResourceHandle` is returned. If `pD3DResource` cannot be registered, then `cudaErrorUnknown` is returned.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:

6.19. Direct3D 9 Interoperability
[DEPRECATED]

This section describes deprecated Direct3D 9 interoperability functions.

enum cudaD3D9MapFlags

CUDA D3D9 Map Flags
Values

cudaD3D9MapFlagsNone = 0
  Default; Assume resource can be read/written

cudaD3D9MapFlagsReadOnly = 1
  CUDA kernels will not write to this resource

cudaD3D9MapFlagsWriteDiscard = 2
  CUDA kernels will only write to and will not read from this resource

enum cudaD3D9RegisterFlags
CUDA D3D9 Register Flags

Values

cudaD3D9RegisterFlagsNone = 0
  Default; Resource can be accessed through void*
cudaD3D9RegisterFlagsArray = 1
  Resource can be accessed through a CUArray*

__host__ cudaError_t cudaD3D9MapResources (int count, IDirect3DResource9 **ppResources)
Map Direct3D resources for access by CUDA.

Parameters

count
  - Number of resources to map for CUDA

ppResources
  - Resources to map for CUDA

Returns
cudaSuccess, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

Deprecated This function is deprecated as of CUDA 3.0.
Maps the count Direct3D resources in ppResources for access by CUDA.
The resources in ppResources may be accessed in CUDA kernels until they are unmapped.
Direct3D should not access any resources while they are mapped by CUDA. If an application does so, the results are undefined.
This function provides the synchronization guarantee that any Direct3D calls issued before `cudaD3D9MapResources()` will complete before any CUDA kernels issued after `cudaD3D9MapResources()` begin.

If any of `ppResources` have not been registered for use with CUDA or if `ppResources` contains any duplicate entries then `cudaErrorInvalidResourceHandle` is returned. If any of `ppResources` are presently mapped for access by CUDA then `cudaErrorUnknown` is returned.

**Note:**
Note that this function may also return error codes from previous, asynchronous launches.

See also:
`cudaGraphicsMapResources`

```c
__host__ cudaError_t cudaD3D9RegisterResource
(IDirect3DResource9 *pResource, unsigned int flags)
```
Registers a Direct3D resource for access by CUDA.

**Parameters**
- `pResource` - Resource to register
- `flags` - Parameters for resource registration

**Returns**
- `cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorInvalidResourceHandle`, `cudaErrorUnknown`

**Description**
- **Deprecated** This function is deprecated as of CUDA 3.0.

Registers the Direct3D resource `pResource` for access by CUDA.

If this call is successful, then the application will be able to map and unmap this resource until it is unregistered through `cudaD3D9UnregisterResource()`. Also on success, this call will increase the internal reference count on `pResource`. This reference count will be decremented when this resource is unregistered through `cudaD3D9UnregisterResource()`.

This call potentially has a high-overhead and should not be called every frame in interactive applications.

The type of `pResource` must be one of the following:

- `IDirect3DVertexBuffer9`: No notes.
- IDirect3DIndexBuffer9: No notes.
- IDirect3DSurface9: Only stand-alone objects of type IDirect3DSurface9 may be explicitly shared. In particular, individual mipmap levels and faces of cube maps may not be registered directly. To access individual surfaces associated with a texture, one must register the base texture object.
- IDirect3DBaseTexture9: When a texture is registered, all surfaces associated with all mipmap levels of all faces of the texture will be accessible to CUDA.

The `flags` argument specifies the mechanism through which CUDA will access the Direct3D resource. The following value is allowed:

- `cudaD3D9RegisterFlagsNone`: Specifies that CUDA will access this resource through a `void*`. The pointer, size, and pitch for each subresource of this resource may be queried through `cudaD3D9ResourceGetMappedPointer()`, `cudaD3D9ResourceGetMappedSize()`, and `cudaD3D9ResourceGetMappedPitch()` respectively. This option is valid for all resource types.

Not all Direct3D resources of the above types may be used for interoperability with CUDA. The following are some limitations:

- The primary rendertarget may not be registered with CUDA.
- Resources allocated as shared may not be registered with CUDA.
- Any resources allocated in `D3DPOOL_SYSTEMMEM` or `D3DPOOL_MANAGED` may not be registered with CUDA.
- Textures which are not of a format which is 1, 2, or 4 channels of 8, 16, or 32-bit integer or floating-point data cannot be shared.
- Surfaces of depth or stencil formats cannot be shared.

If Direct3D interoperability is not initialized on this context, then `cudaErrorInvalidDevice` is returned. If `pResource` is of incorrect type (e.g. is a non-stand-alone IDirect3DSurface9) or is already registered, then `cudaErrorInvalidResourceHandle` is returned. If `pResource` cannot be registered then `cudaErrorUnknown` is returned.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:

`cudaGraphicsD3D9RegisterResource`
__host__ cudaError_t cudaD3D9ResourceGetMappedArray
(cudaArray **ppArray, IDirect3DResource9 *pResource,
unsigned int face, unsigned int level)

Get an array through which to access a subresource of a Direct3D resource which has been mapped for
access by CUDA.

Parameters

ppArray
- Returned array corresponding to subresource
pResource
- Mapped resource to access
face
- Face of resource to access
level
- Level of resource to access

Returns

cudaSuccess, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

Deprecated This function is deprecated as of CUDA 3.0.

Returns in *pArray an array through which the subresource of the mapped Direct3D resource
pResource, which corresponds to face and level may be accessed. The value set in pArray
may change every time that pResource is mapped.

If pResource is not registered then cudaErrorInvalidResourceHandle is returned. If
pResource was not registered with usage flags cudaD3D9RegisterFlagsArray, then
cudaErrorInvalidResourceHandle is returned. If pResource is not mapped, then cudaErrorUnknown
is returned.

For usage requirements of face and level parameters, see cudaD3D9ResourceGetMappedPointer().

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaGraphicsSubResourceGetMappedArray
__host__ cudaError_t cudaD3D9ResourceGetMappedPitch(size_t *pPitch, size_t *pPitchSlice, IDirect3DResource9 *pResource, unsigned int face, unsigned int level)

Get the pitch of a subresource of a Direct3D resource which has been mapped for access by CUDA.

Parameters

pPitch
- Returned pitch of subresource

pPitchSlice
- Returned Z-slice pitch of subresource

pResource
- Mapped resource to access

face
- Face of resource to access

level
- Level of resource to access

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

Deprecated
This function is deprecated as of CUDA 3.0.

Returns in *pPitch and *pPitchSlice the pitch and Z-slice pitch of the subresource of the mapped Direct3D resource pResource, which corresponds to face and level. The values set in pPitch and pPitchSlice may change every time that pResource is mapped.

The pitch and Z-slice pitch values may be used to compute the location of a sample on a surface as follows.

For a 2D surface, the byte offset of the sample at position x, y from the base pointer of the surface is:

\[ y \times \text{pitch} + (\text{bytes per pixel}) \times x \]

For a 3D surface, the byte offset of the sample at position x, y, z from the base pointer of the surface is:

\[ z \times \text{slicePitch} + y \times \text{pitch} + (\text{bytes per pixel}) \times x \]

Both parameters pPitch and pPitchSlice are optional and may be set to NULL.

If pResource is not of type IDirect3DBaseTexture9 or one of its sub-types or if pResource has not been registered for use with CUDA, then cudaErrorInvalidResourceHandle is returned.

If pResource was not registered with usage flags cudaD3D9RegisterFlagsNone, then cudaErrorInvalidResourceHandle is returned. If pResource is not mapped for access by CUDA then cudaErrorUnknown is returned.
For usage requirements of face and level parameters, see `cudaD3D9ResourceGetMappedPointer()`.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:

`cudaGraphicsResourceGetMappedPointer`

```c
__host__ cudaError_t
cudaD3D9ResourceGetMappedPointer (void **pPointer, IDirect3DResource9 *pResource, unsigned int face, unsigned int level)
```

Get a pointer through which to access a subresource of a Direct3D resource which has been mapped for access by CUDA.

**Parameters**

- **pPointer** - Returned pointer corresponding to subresource
- **pResource** - Mapped resource to access
- **face** - Face of resource to access
- **level** - Level of resource to access

**Returns**

- `cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorInvalidResourceHandle`, `cudaErrorUnknown`

**Description**

**Deprecated** This function is deprecated as of CUDA 3.0.

Returns in `*pPointer` the base pointer of the subresource of the mapped Direct3D resource `pResource`, which corresponds to `face` and `level`. The value set in `pPointer` may change every time that `pResource` is mapped.

If `pResource` is not registered, then `cudaErrorInvalidResourceHandle` is returned. If `pResource` was not registered with usage flags `cudaD3D9RegisterFlagsNone`, then `cudaErrorInvalidResourceHandle` is returned. If `pResource` is not mapped, then `cudaErrorUnknown` is returned.
If pResource is of type IDirect3DCubeTexture9, then face must one of the values enumerated by type D3DCUBEMAP_FACES. For all other types, face must be 0. If face is invalid, then cudaErrorInvalidValue is returned.

If pResource is of type IDirect3DBaseTexture9, then level must correspond to a valid mipmap level. Only mipmap level 0 is supported for now. For all other types level must be 0. If level is invalid, then cudaErrorInvalidValue is returned.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaGraphicsResourceGetMappedPointer

```c
__host__ cudaError_t cudaD3D9ResourceGetMappedSize(
    size_t *pSize, IDirect3DResource9 *pResource, unsigned int face, unsigned int level)
```

Get the size of a subresource of a Direct3D resource which has been mapped for access by CUDA.

Parameters

pSize
- Returned size of subresource

pResource
- Mapped resource to access

face
- Face of resource to access

level
- Level of resource to access

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

Deprecated This function is deprecated as of CUDA 3.0.

Returns in *pSize the size of the subresource of the mapped Direct3D resource pResource, which corresponds to face and level. The value set in pSize may change every time that pResource is mapped.

If pResource has not been registered for use with CUDA then cudaErrorInvalidResourceHandle is returned. If pResource was not registered with usage flags cudaD3D9RegisterFlagsNone, then
cudaErrorInvalidResourceHandle is returned. If pResource is not mapped for access by CUDA then cudaErrorUnknown is returned.

For usage requirements of face and level parameters, see cudaD3D9ResourceGetMappedPointer().

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaGraphicsResourceGetMappedPointer

__host__ cudaError_t
cudaD3D9ResourceGetSurfaceDimensions(size_t *pWidth, size_t *pHeight, size_t *pDepth, IDirect3DResource9 *pResource, unsigned int face, unsigned int level)

Get the dimensions of a registered Direct3D surface.

Parameters
pWidth
- Returned width of surface
pHeight
- Returned height of surface
pDepth
- Returned depth of surface
pResource
- Registered resource to access
face
- Face of resource to access
level
- Level of resource to access

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle,

Description
Deprecated This function is deprecated as of CUDA 3.0.
Returns in *pWidth, *pHeight, and *pDepth the dimensions of the subresource of the mapped Direct3D resource pResource which corresponds to face and level.

Since anti-aliased surfaces may have multiple samples per pixel, it is possible that the dimensions of a resource will be an integer factor larger than the dimensions reported by the Direct3D runtime.

The parameters pWidth, pHeight, and pDepth are optional. For 2D surfaces, the value returned in *pDepth will be 0.

If pResource is not of type IDirect3DBaseTexture9 or IDirect3DSurface9 or if pResource has not been registered for use with CUDA, then cudaErrorInvalidResourceHandle is returned.

For usage requirements of face and level parameters, see cudaD3D9ResourceGetMappedPointer.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaGraphicsSubResourceGetMappedArray

__host__ cudaError_t cudaD3D9ResourceSetMapFlags
(IDirect3DResource9 *pResource, unsigned int flags)
Set usage flags for mapping a Direct3D resource.

Parameters

**pResource**
- Registered resource to set flags for

**flags**
- Parameters for resource mapping

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

**Deprecated** This function is deprecated as of CUDA 3.0.

Set flags for mapping the Direct3D resource pResource.

Changes to flags will take effect the next time pResource is mapped. The flags argument may be any of the following:

- **cudaD3D9MapFlagsNone**: Specifies no hints about how this resource will be used. It is therefore assumed that this resource will be read from and written to by CUDA kernels. This is the default value.
- **cudaD3D9MapFlagsReadOnly**: Specifies that CUDA kernels which access this resource will not write to this resource.
- **cudaD3D9MapFlagsWriteDiscard**: Specifies that CUDA kernels which access this resource will not read from this resource and will write over the entire contents of the resource, so none of the data previously stored in the resource will be preserved.

If `pResource` has not been registered for use with CUDA, then `cudaErrorInvalidResourceHandle` is returned. If `pResource` is presently mapped for access by CUDA, then `cudaErrorUnknown` is returned.

**Note:**

Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaInteropResourceSetMapFlags

```c
__host__ cudaError_t cudaD3D9UnmapResources (int count, IDirect3DResource9 **ppResources)
```

Unmap Direct3D resources for access by CUDA.

**Parameters**

- **count**
  - Number of resources to unmap for CUDA
- **ppResources**
  - Resources to unmap for CUDA

**Returns**

`cudaSuccess`, `cudaErrorInvalidResourceHandle`, `cudaErrorUnknown`

**Description**

**Deprecated** This function is deprecated as of CUDA 3.0.

Unmaps the `count` Direct3D resources in `ppResources`.

This function provides the synchronization guarantee that any CUDA kernels issued before `cudaD3D9UnmapResources()` will complete before any Direct3D calls issued after `cudaD3D9UnmapResources()` begin.

If any of `ppResources` have not been registered for use with CUDA or if `ppResources` contains any duplicate entries, then `cudaErrorInvalidResourceHandle` is returned. If any of `ppResources` are not presently mapped for access by CUDA then `cudaErrorUnknown` is returned.
__host__ cudaError_t cudaD3D9UnregisterResource (IDirect3DResource9 *pResource)

Unregisters a Direct3D resource for access by CUDA.

Parameters

pResource
- Resource to unregister

Returns

cudaSuccess, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

Deprecated This function is deprecated as of CUDA 3.0.

Unregisters the Direct3D resource pResource so it is not accessible by CUDA unless registered again.

If pResource is not registered, then cudaErrorInvalidResourceHandle is returned.

See also:

cudaGraphicsUnregisterResource

6.20. Direct3D 10 Interoperability

This section describes the Direct3D 10 interoperability functions of the CUDA runtime application programming interface. Note that mapping of Direct3D 10 resources is performed with the graphics API agnostic, resource mapping interface described in Graphics Interopability.
enum cudaD3D10DeviceList

CUDA devices corresponding to a D3D10 device

Values

cudaD3D10DeviceListAll = 1
   The CUDA devices for all GPUs used by a D3D10 device
cudaD3D10DeviceListCurrentFrame = 2
   The CUDA devices for the GPUs used by a D3D10 device in its currently rendering frame
cudaD3D10DeviceListNextFrame = 3
   The CUDA devices for the GPUs to be used by a D3D10 device in the next frame

__host__ cudaError_t cudaD3D10GetDevice (int *device, IDXGIAdapter *pAdapter)

Gets the device number for an adapter.

Parameters

device
   - Returns the device corresponding to pAdapter

pAdapter
   - D3D10 adapter to get device for

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorUnknown

Description

Returns in *device the CUDA-compatible device corresponding to the adapter pAdapter obtained from IDXGIFactory::EnumAdapters. This call will succeed only if a device on adapter pAdapter is CUDA-compatible.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:

cudaGraphicsD3D10RegisterResource, cuD3D10GetDevice
__host__ cudaError_t cudaD3D10GetDevices (unsigned int *pCudaDeviceCount, int *pCudaDevices, unsigned int cudaDeviceCount, ID3D10Device *pD3D10Device, cudaD3D10DeviceList deviceList)

Gets the CUDA devices corresponding to a Direct3D 10 device.

**Parameters**

- **pCudaDeviceCount**
  - Returned number of CUDA devices corresponding to `pD3D10Device`

- **pCudaDevices**
  - Returned CUDA devices corresponding to `pD3D10Device`

- **cudaDeviceCount**
  - The size of the output device array `pCudaDevices`

- **pD3D10Device**
  - Direct3D 10 device to query for CUDA devices

- **deviceList**
  - The set of devices to return. This set may be `cudaD3D10DeviceListAll` for all devices, `cudaD3D10DeviceListCurrentFrame` for the devices used to render the current frame (in SLI), or `cudaD3D10DeviceListNextFrame` for the devices used to render the next frame (in SLI).

**Returns**

- `cudaSuccess`
- `cudaErrorNoDevice`
- `cudaErrorUnknown`

**Description**

Returns in `*pCudaDeviceCount` the number of CUDA-compatible devices corresponding to the Direct3D 10 device `pD3D10Device`. Also returns in `*pCudaDevices` at most `cudaDeviceCount` of the CUDA-compatible devices corresponding to the Direct3D 10 device `pD3D10Device`.

If any of the GPUs being used to render `pDevice` are not CUDA capable then the call will return `cudaErrorNoDevice`.

**Note:**

Note that this function may also return error codes from previous, asynchronous launches.

See also:
__host__ cudaError_t

cudaGraphicsD3D10RegisterResource

(cudaGraphicsResource **resource, ID3D10Resource *pD3DResource, unsigned int flags)

Registers a Direct3D 10 resource for access by CUDA.

Parameters

resource
  - Pointer to returned resource handle

pD3DResource
  - Direct3D resource to register

flags
  - Parameters for resource registration

Returns

cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

Registers the Direct3D 10 resource pD3DResource for access by CUDA.

If this call is successful, then the application will be able to map and unmap this resource until it is unregistered through cudaGraphicsUnregisterResource(). Also on success, this call will increase the internal reference count on pD3DResource. This reference count will be decremented when this resource is unregistered through cudaGraphicsUnregisterResource().

This call potentially has a high-overhead and should not be called every frame in interactive applications.

The type of pD3DResource must be one of the following.

- ID3D10Buffer: may be accessed via a device pointer
- ID3D10Texture1D: individual subresources of the texture may be accessed via arrays
- ID3D10Texture2D: individual subresources of the texture may be accessed via arrays
- ID3D10Texture3D: individual subresources of the texture may be accessed via arrays

The flags argument may be used to specify additional parameters at register time. The valid values for this parameter are
- **cudaGraphicsRegisterFlagsNone**: Specifies no hints about how this resource will be used.
- **cudaGraphicsRegisterFlagsSurfaceLoadStore**: Specifies that CUDA will bind this resource to a surface reference.
- **cudaGraphicsRegisterFlagsTextureGather**: Specifies that CUDA will perform texture gather operations on this resource.

Not all Direct3D resources of the above types may be used for interoperability with CUDA. The following are some limitations.

- The primary rendertarget may not be registered with CUDA.
- Textures which are not of a format which is 1, 2, or 4 channels of 8, 16, or 32-bit integer or floating-point data cannot be shared.
- Surfaces of depth or stencil formats cannot be shared.

A complete list of supported DXGI formats is as follows. For compactness the notation A\_\{B,C,D\} represents A\_B, A\_C, and A\_D.

- DXGI_FORMAT_A8_UNORM
- DXGI_FORMAT_B8G8R8A8_UNORM
- DXGI_FORMAT_B8G8R8X8_UNORM
- DXGI_FORMAT_R16_FLOAT
- DXGI_FORMAT_R16G16B16A16\_\{FLOAT,SINT,SNORM,UINT,UNORM\}
- DXGI_FORMAT_R16G16\_\{FLOAT,SINT,SNORM,UINT,UNORM\}
- DXGI_FORMAT_R16\_\{SINT,SNORM,UINT,UNORM\}
- DXGI_FORMAT_R32_FLOAT
- DXGI_FORMAT_R32G32B32A32\_\{FLOAT,SINT,UINT\}
- DXGI_FORMAT_R32G32\_\{FLOAT,SINT,UINT\}
- DXGI_FORMAT_R32\_\{SINT,UINT\}
- DXGI_FORMAT_R8G8B8A8\_\{SINT,SNORM,UINT,UNORM,UNORM\_SRGB\}
- DXGI_FORMAT_R8G8\_\{SINT,SNORM,UINT,UNORM\}
- DXGI_FORMAT_R8\_\{SINT,SNORM,UINT,UNORM\}

If `pD3DResource` is of incorrect type or is already registered, then `cudaErrorInvalidResourceHandle` is returned. If `pD3DResource` cannot be registered, then `cudaErrorUnknown` is returned.

**Note:**

Note that this function may also return error codes from previous, asynchronous launches.

**See also:**

6.21. Direct3D 10 Interoperability
[DEPRECATED]

This section describes deprecated Direct3D 10 interoperability functions.

enum cudaD3D10MapFlags

CUDA D3D10 Map Flags

Values

cudaD3D10MapFlagsNone = 0
  Default; Assume resource can be read/written

cudaD3D10MapFlagsReadOnly = 1
  CUDA kernels will not write to this resource

cudaD3D10MapFlagsWriteDiscard = 2
  CUDA kernels will only write to and will not read from this resource

enum cudaD3D10RegisterFlags

CUDA D3D10 Register Flags

Values

cudaD3D10RegisterFlagsNone = 0
  Default; Resource can be accessed through a void*
cudaD3D10RegisterFlagsArray = 1
  Resource can be accessed through a CUarray*

__host__ cudaError_t cudaD3D10GetDirect3DDevice
(ID3D10Device **ppD3D10Device)

Gets the Direct3D device against which the current CUDA context was created.

Parameters

ppD3D10Device
  - Returns the Direct3D device for this thread
Returns

cudaSuccess, cudaErrorUnknown

Description

**Deprecated** This function is deprecated as of CUDA 5.0.

This function is deprecated and should no longer be used. It is no longer necessary to associate a CUDA device with a D3D10 device in order to achieve maximum interoperability performance.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:

cudaD3D10SetDirect3DDevice

__host__ cudaError_t cudaD3D10MapResources (int count, ID3D10Resource **ppResources)
Maps Direct3D Resources for access by CUDA.

Parameters

count
- Number of resources to map for CUDA

ppResources
- Resources to map for CUDA

Returns

cudaSuccess, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

**Deprecated** This function is deprecated as of CUDA 3.0.

Maps the count Direct3D resources in ppResources for access by CUDA.

The resources in ppResources may be accessed in CUDA kernels until they are unmapped. Direct3D should not access any resources while they are mapped by CUDA. If an application does so, the results are undefined.

This function provides the synchronization guarantee that any Direct3D calls issued before cudaD3D10MapResources() will complete before any CUDA kernels issued after cudaD3D10MapResources() begin.
If any of `ppResources` have not been registered for use with CUDA or if `ppResources` contains any duplicate entries then `cudaErrorInvalidResourceHandle` is returned. If any of `ppResources` are presently mapped for access by CUDA then `cudaErrorUnknown` is returned.

**Note:**

Note that this function may also return error codes from previous, asynchronous launches.

See also:

`cudaGraphicsMapResources`

```c
__host__ cudaError_t cudaD3D10RegisterResource(
    ID3D10Resource *pResource, unsigned int flags)
```

Registers a Direct3D 10 resource for access by CUDA.

**Parameters**

- **pResource**
  - Resource to register

- **flags**
  - Parameters for resource registration

**Returns**

`cudaSuccess`, `cudaErrorInvalidDevice`, `cudaErrorInvalidValue`, `cudaErrorInvalidResourceHandle`, `cudaErrorUnknown`

**Description**

**Deprecated** This function is deprecated as of CUDA 3.0.

Registers the Direct3D resource `pResource` for access by CUDA.

If this call is successful, then the application will be able to map and unmap this resource until it is unregistered through `cudaD3D10UnregisterResource()`. Also on success, this call will increase the internal reference count on `pResource`. This reference count will be decremented when this resource is unregistered through `cudaD3D10UnregisterResource()`.

This call potentially has a high-overhead and should not be called every frame in interactive applications.

The type of `pResource` must be one of the following:

- **ID3D10Buffer**: Cannot be used with `flags` set to `cudaD3D10RegisterFlagsArray`.
- **ID3D10Texture1D**: No restrictions.
- **ID3D10Texture2D**: No restrictions.
ID3D10Texture3D: No restrictions.

The flags argument specifies the mechanism through which CUDA will access the Direct3D resource. The following values are allowed.

- **cudaD3D10RegisterFlagsNone**: Specifies that CUDA will access this resource through a `void*`. The pointer, size, and pitch for each subresource of this resource may be queried through `cudaD3D10ResourceGetMappedPointer()`, `cudaD3D10ResourceGetMappedSize()`, and `cudaD3D10ResourceGetMappedPitch()` respectively. This option is valid for all resource types.

- **cudaD3D10RegisterFlagsArray**: Specifies that CUDA will access this resource through a `CUarray` queried on a sub-resource basis through `cudaD3D10ResourceGetMappedArray()`. This option is only valid for resources of type ID3D10Texture1D, ID3D10Texture2D, and ID3D10Texture3D.

Not all Direct3D resources of the above types may be used for interoperability with CUDA. The following are some limitations.

- The primary rendertarget may not be registered with CUDA.
- Resources allocated as shared may not be registered with CUDA.
- Textures which are not of a format which is 1, 2, or 4 channels of 8, 16, or 32-bit integer or floating-point data cannot be shared.
- Surfaces of depth or stencil formats cannot be shared.

If Direct3D interoperability is not initialized on this context then `cudaErrorInvalidDevice` is returned. If `pResource` is of incorrect type or is already registered then `cudaErrorInvalidResourceHandle` is returned. If `pResource` cannot be registered then `cudaErrorUnknown` is returned.

---

**Note:**

Note that this function may also return error codes from previous, asynchronous launches.

See also:

`cudaGraphicsD3D10RegisterResource`
cudaD3D10ResourceGetMappedArray (cudaArray **ppArray, ID3D10Resource *pResource, unsigned int subResource)

Gets an array through which to access a subresource of a Direct3D resource which has been mapped for access by CUDA.

Parameters

**ppArray**
- Returned array corresponding to subresource

**pResource**
- Mapped resource to access

**subResource**
- Subresource of pResource to access

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

**Deprecated** This function is deprecated as of CUDA 3.0.

Returns in *ppArray an array through which the subresource of the mapped Direct3D resource pResource which corresponds to subResource may be accessed. The value set in ppArray may change every time that pResource is mapped.

If pResource is not registered, then cudaErrorInvalidResourceHandle is returned. If pResource was not registered with usage flags cudaD3D10RegisterFlagsArray, then cudaErrorInvalidResourceHandle is returned. If pResource is not mapped then cudaErrorUnknown is returned.

For usage requirements of the subResource parameter, see cudaD3D10ResourceGetMappedPointer().

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:

cudaGraphicsSubResourceGetMappedArray
__host__ cudaError_t cudaD3D10ResourceGetMappedPitch
(size_t *pPitch, size_t *pPitchSlice, ID3D10Resource *pResource, unsigned int subResource)

Gets the pitch of a subresource of a Direct3D resource which has been mapped for access by CUDA.

Parameters

pPitch
- Returned pitch of subresource
pPitchSlice
- Returned Z-slice pitch of subresource
pResource
- Mapped resource to access
subResource
- Subresource of pResource to access

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

Deprecated This function is deprecated as of CUDA 3.0.

Returns in *pPitch and *pPitchSlice the pitch and Z-slice pitch of the subresource of the mapped Direct3D resource pResource, which corresponds to subResource. The values set in pPitch and pPitchSlice may change every time that pResource is mapped.

The pitch and Z-slice pitch values may be used to compute the location of a sample on a surface as follows.

For a 2D surface, the byte offset of the sample at position x, y from the base pointer of the surface is:
y * pitch + (bytes per pixel) * x

For a 3D surface, the byte offset of the sample at position x, y, z from the base pointer of the surface is:
z* slicePitch + y * pitch + (bytes per pixel) * x

Both parameters pPitch and pPitchSlice are optional and may be set to NULL.

If pResource is not of type ID3D10Texture1D, ID3D10Texture2D, or ID3D10Texture3D, or if pResource has not been registered for use with CUDA, then cudaErrorInvalidResourceHandle is returned. If pResource was not registered with usage flags cudaD3D10RegisterFlagsNone, then cudaErrorInvalidResourceHandle is returned. If pResource is not mapped for access by CUDA then cudaErrorUnknown is returned.

For usage requirements of the subResource parameter see cudaD3D10ResourceGetMappedPointer().
__host__ cudaError_t


Gets a pointer through which to access a subresource of a Direct3D resource which has been mapped for access by CUDA.

Parameters

 **pPointer**
- Returned pointer corresponding to subresource

 **pResource**
- Mapped resource to access

 **subResource**
- Subresource of pResource to access

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

**Deprecated** This function is deprecated as of CUDA 3.0.

Returns in *pPointer the base pointer of the subresource of the mapped Direct3D resource pResource which corresponds to subResource. The value set in pPointer may change every time that pResource is mapped.

If pResource is not registered, then cudaErrorInvalidResourceHandle is returned. If pResource was not registered with usage flags cudaD3D9RegisterFlagsNone, then cudaErrorInvalidResourceHandle is returned. If pResource is not mapped then cudaErrorUnknown is returned.

If pResource is of type ID3D10Buffer then subResource must be 0. If pResource is of any other type, then the value of subResource must come from the subresource calculation in D3D10CalcSubResource().

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:

cudaGraphicsSubResourceGetMappedArray
Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaGraphicsResourceGetMappedPointer

__host__ cudaError_t cudaD3D10ResourceGetMappedSize(size_t *pSize, ID3D10Resource *pResource, unsigned int subResource)

Gets the size of a subresource of a Direct3D resource which has been mapped for access by CUDA.

Parameters

pSize
- Returned size of subresource

pResource
- Mapped resource to access

subResource
- Subresource of pResource to access

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

Deprecated This function is deprecated as of CUDA 3.0.

Returns in *pSize the size of the subresource of the mapped Direct3D resource pResource which corresponds to subResource. The value set in pSize may change every time that pResource is mapped.

If pResource has not been registered for use with CUDA then cudaErrorInvalidHandle is returned. If pResource was not registered with usage flags cudaD3D10RegisterFlagsNone, then cudaErrorInvalidResourceHandle is returned. If pResource is not mapped for access by CUDA then cudaErrorUnknown is returned.

For usage requirements of the subResource parameter see cudaD3D10ResourceGetMappedPointer().

Note:
Note that this function may also return error codes from previous, asynchronous launches.
See also:

cudaGraphicsResourceGetMappedPointer

__host__ cudaError_t
cudaD3D10ResourceGetSurfaceDimensions
(size_t *pWidth, size_t *pHeight, size_t *pDepth, ID3D10Resource *pResource, unsigned int subResource)

Gets the dimensions of a registered Direct3D surface.

Parameters

pWidth
- Returned width of surface

pHeight
- Returned height of surface

pDepth
- Returned depth of surface

pResource
- Registered resource to access

subResource
- Subresource of pResource to access

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle.

Description

Deprecated This function is deprecated as of CUDA 3.0.

Returns in *pWidth, *pHeight, and *pDepth the dimensions of the subresource of the mapped Direct3D resource pResource which corresponds to subResource.

Since anti-aliased surfaces may have multiple samples per pixel, it is possible that the dimensions of a resource will be an integer factor larger than the dimensions reported by the Direct3D runtime.

The parameters pWidth, pHeight, and pDepth are optional. For 2D surfaces, the value returned in *pDepth will be 0.

If pResource is not of type ID3D10Texture1D, ID3D10Texture2D, or ID3D10Texture3D, or if pResource has not been registered for use with CUDA, then cudaErrorInvalidHandle is returned.

For usage requirements of subResource parameters see cudaD3D10ResourceGetMappedPointer().
Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaGraphicsSubResourceGetMappedArray

__host__ cudaError_t cudaD3D10ResourceSetMapFlags
(ID3D10Resource *pResource, unsigned int flags)
Set usage flags for mapping a Direct3D resource.

Parameters
pResource
- Registered resource to set flags for
flags
- Parameters for resource mapping

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorUnknown.

Description
Deprecated This function is deprecated as of CUDA 3.0.
Set usage flags for mapping the Direct3D resource pResource.
Changes to flags will take effect the next time pResource is mapped. The flags argument may be any of the following:

- cudaD3D10MapFlagsNone: Specifies no hints about how this resource will be used. It is therefore assumed that this resource will be read from and written to by CUDA kernels. This is the default value.
- cudaD3D10MapFlagsReadOnly: Specifies that CUDA kernels which access this resource will not write to this resource.
- cudaD3D10MapFlagsWriteDiscard: Specifies that CUDA kernels which access this resource will not read from this resource and will write over the entire contents of the resource, so none of the data previously stored in the resource will be preserved.

If pResource has not been registered for use with CUDA then cudaErrorInvalidHandle is returned. If pResource is presently mapped for access by CUDA then cudaErrorUnknown is returned.
Note that this function may also return error codes from previous, asynchronous launches.

See also:

cudaGraphicsResourceSetMapFlags

__host__ cudaError_t cudaD3D10SetDirect3DDevice

(ID3D10Device *pD3D10Device, int device)

Sets the Direct3D 10 device to use for interoperability with a CUDA device.

Parameters

pD3D10Device

- Direct3D device to use for interoperability

device

- The CUDA device to use. This device must be among the devices returned when querying
cudaD3D10DeviceListAll from cudaD3D10GetDevices, may be set to -1 to automatically select an
appropriate CUDA device.

Returns

cudaSuccess, cudaErrorInitializationError, cudaErrorInvalidValue, cudaErrorSetOnActiveProcess

Description

Deprecated This function is deprecated as of CUDA 5.0.

This function is deprecated and should no longer be used. It is no longer necessary to associate a
CUDA device with a D3D10 device in order to achieve maximum interoperability performance.

This function will immediately initialize the primary context on device if needed.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:

cudaD3D10GetDevice, cudaGraphicsD3D10RegisterResource, cudaDeviceReset
__host__ cudaError_t cudaD3D10UnmapResources (int count, ID3D10Resource **ppResources)

Unmaps Direct3D resources.

Parameters

**count**
- Number of resources to unmap for CUDA

**ppResources**
- Resources to unmap for CUDA

Returns

cudaSuccess, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

Deprecated This function is deprecated as of CUDA 3.0.

Unmaps the **count** Direct3D resource in **ppResources**.

This function provides the synchronization guarantee that any CUDA kernels issued before **cudaD3D10UnmapResources**() will complete before any Direct3D calls issued after **cudaD3D10UnmapResources**() begin.

If any of **ppResources** have not been registered for use with CUDA or if **ppResources** contains any duplicate entries, then **cudaErrorInvalidResourceHandle** is returned. If any of **ppResources** are not presently mapped for access by CUDA then **cudaErrorUnknown** is returned.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:

cudaGraphicsUnmapResources

__host__ cudaError_t cudaD3D10UnregisterResource (ID3D10Resource *pResource)

Unregisters a Direct3D resource.

Parameters

**pResource**
- Resource to unregister
Returns
cudaSuccess, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description
Deprecated This function is deprecated as of CUDA 3.0.

Unregisters the Direct3D resource resource so it is not accessible by CUDA unless registered again. If pResource is not registered, then cudaErrorInvalidResourceHandle is returned.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaGraphicsUnregisterResource

6.22. Direct3D 11 Interoperability

This section describes the Direct3D 11 interoperability functions of the CUDA runtime application programming interface. Note that mapping of Direct3D 11 resources is performed with the graphics API agnostic, resource mapping interface described in Graphics Interopability.

class cudaD3D11DeviceList

CUDA devices corresponding to a D3D11 device

Values
cudaD3D11DeviceListAll = 1
   The CUDA devices for all GPUs used by a D3D11 device
cudaD3D11DeviceListCurrentFrame = 2
   The CUDA devices for the GPUs used by a D3D11 device in its currently rendering frame
cudaD3D11DeviceListNextFrame = 3
   The CUDA devices for the GPUs to be used by a D3D11 device in the next frame
__host__ cudaError_t cudaD3D11GetDevice (int *device, IDXGIAppAdapter *pAdapter)

Gets the device number for an adapter.

Parameters

device
- Returns the device corresponding to pAdapter

pAdapter
- D3D11 adapter to get device for

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorUnknown

Description

Returns in *device the CUDA-compatible device corresponding to the adapter pAdapter obtained from IDXGIFactory::EnumAdapters. This call will succeed only if a device on adapter pAdapter is CUDA-compatible.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaGraphicsUnregisterResource, cudaGraphicsMapResources,
cudaGraphicsSubResourceGetMappedArray, cudaGraphicsResourceGetMappedPointer,
cuD3D11GetDevice

__host__ cudaError_t cudaD3D11GetDevices (unsigned int *pCudaDeviceCount, int *pCudaDevices, unsigned int cudaDeviceCount, ID3D11Device *pD3D11Device, cudaD3D11DeviceList deviceList)

Gets the CUDA devices corresponding to a Direct3D 11 device.

Parameters

pCudaDeviceCount
- Returned number of CUDA devices corresponding to pD3D11Device
**pCudaDevices**
- Returned CUDA devices corresponding to `pD3D11Device`

**cudaDeviceCount**
- The size of the output device array `pCudaDevices`

**pD3D11Device**
- Direct3D 11 device to query for CUDA devices

**deviceList**
- The set of devices to return. This set may be `cudaD3D11DeviceListAll` for all devices, `cudaD3D11DeviceListCurrentFrame` for the devices used to render the current frame (in SLI), or `cudaD3D11DeviceListNextFrame` for the devices used to render the next frame (in SLI).

**Returns**
- `cudaSuccess`, `cudaErrorNoDevice`, `cudaErrorUnknown`

**Description**
Returns in `*pCudaDeviceCount` the number of CUDA-compatible devices corresponding to the Direct3D 11 device `pD3D11Device`. Also returns in `*pCudaDevices` at most `cudaDeviceCount` of the CUDA-compatible devices corresponding to the Direct3D 11 device `pD3D11Device`.

If any of the GPUs being used to render `pDevice` are not CUDA capable then the call will return `cudaErrorNoDevice`.

**Note:**
- Note that this function may also return error codes from previous, asynchronous launches.

See also:
__host__ cudaError_t
cudaGraphicsD3D11RegisterResource
(cudaGraphicsResource **resource, ID3D11Resource *
pD3DResource, unsigned int flags)

Register a Direct3D 11 resource for access by CUDA.

Parameters

resource
- Pointer to returned resource handle

pD3DResource
- Direct3D resource to register

flags
- Parameters for resource registration

Returns

cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

Registers the Direct3D 11 resource pD3DResource for access by CUDA.

If this call is successful, then the application will be able to map and unmap this resource until it is unregistered through cudaGraphicsUnregisterResource(). Also on success, this call will increase the internal reference count on pD3DResource. This reference count will be decremented when this resource is unregistered through cudaGraphicsUnregisterResource().

This call potentially has a high-overhead and should not be called every frame in interactive applications.

The type of pD3DResource must be one of the following.

- ID3D11Buffer: may be accessed via a device pointer
- ID3D11Texture1D: individual subresources of the texture may be accessed via arrays
- ID3D11Texture2D: individual subresources of the texture may be accessed via arrays
- ID3D11Texture3D: individual subresources of the texture may be accessed via arrays

The flags argument may be used to specify additional parameters at register time. The valid values for this parameter are

- cudaGraphicsRegisterFlagsNone: Specifies no hints about how this resource will be used.
- cudaGraphicsRegisterFlagsSurfaceLoadStore: Specifies that CUDA will bind this resource to a surface reference.
CUDA Runtime API

- **cudaGraphicsRegisterFlagsTextureGather**: Specifies that CUDA will perform texture gather operations on this resource.

Not all Direct3D resources of the above types may be used for interoperability with CUDA. The following are some limitations.

- The primary rendertarget may not be registered with CUDA.
- Textures which are not of a format which is 1, 2, or 4 channels of 8, 16, or 32-bit integer or floating-point data cannot be shared.
- Surfaces of depth or stencil formats cannot be shared.

A complete list of supported DXGI formats is as follows. For compactness the notation A_{B,C,D} represents A_B, A_C, and A_D.

- DXGI_FORMAT_A8_UNORM
- DXGI_FORMAT_B8G8R8A8_UNORM
- DXGI_FORMAT_B8G8R8X8_UNORM
- DXGI_FORMAT_R16_FLOAT
- DXGI_FORMAT_R16G16B16A16_{FLOAT,SINT,SNORM,UINT,UNORM}
- DXGI_FORMAT_R16G16_{FLOAT,SINT,SNORM,UINT,UNORM}
- DXGI_FORMAT_R16_{SINT,SNORM,UINT,UNORM}
- DXGI_FORMAT_R32_FLOAT
- DXGI_FORMAT_R32G32B32A32_{FLOAT,SINT,UINT}
- DXGI_FORMAT_R32G32_{FLOAT,SINT,UINT}
- DXGI_FORMAT_R32_{SINT,UINT}
- DXGI_FORMAT_R8G8B8A8_{SINT,SNORM,UINT,UNORM,UNORM_SRGB}
- DXGI_FORMAT_R8G8_{SINT,SNORM,UINT,UNORM}
- DXGI_FORMAT_R8_{SINT,SNORM,UINT,UNORM}

If `pD3DResource` is of incorrect type or is already registered, then `cudaErrorInvalidResourceHandle` is returned. If `pD3DResource` cannot be registered, then `cudaErrorUnknown` is returned.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
- cudaGraphicsUnregisterResource, cudaGraphicsMapResources,
- cudaGraphicsSubResourceGetMappedArray, cudaGraphicsResourceGetMappedPointer,
- cuGraphicsD3D11RegisterResource
### 6.23. Direct3D 11 Interoperability [DEPRECATED]

This section describes deprecated Direct3D 11 interoperability functions.

```c
__host__ cudaError_t cudaD3D11GetDirect3DDevice (ID3D11Device **ppD3D11Device)
```

Gets the Direct3D device against which the current CUDA context was created.

**Parameters**

- `ppD3D11Device`: Returns the Direct3D device for this thread

**Returns**

- `cudaSuccess`, `cudaErrorUnknown`

**Description**

**Deprecated**

This function is deprecated as of CUDA 5.0.

This function is deprecated and should no longer be used. It is no longer necessary to associate a CUDA device with a D3D11 device in order to achieve maximum interoperability performance.

---

**Note:**

Note that this function may also return error codes from previous, asynchronous launches.

**See also:**

- `cudaD3D11SetDirect3DDevice`

```c
__host__ cudaError_t cudaD3D11SetDirect3DDevice (ID3D11Device *pD3D11Device, int device)
```

Sets the Direct3D 11 device to use for interoperability with a CUDA device.

**Parameters**

- `pD3D11Device`: Direct3D device to use for interoperability
device
- The CUDA device to use. This device must be among the devices returned when querying `cudaD3D11DeviceListAll` from `cudaD3D11GetDevices`. may be set to -1 to automatically select an appropriate CUDA device.

Returns
`cudaSuccess`, `cudaErrorInitializationError`, `cudaErrorInvalidValue`, `cudaErrorSetOnActiveProcess`

Description
Deprecated
This function is deprecated as of CUDA 5.0.
This function is deprecated and should no longer be used. It is no longer necessary to associate a CUDA device with a D3D11 device in order to achieve maximum interoperability performance.
This function will immediately initialize the primary context on `device` if needed.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:

6.24. VDPAU Interoperability

This section describes the VDPAU interoperability functions of the CUDA runtime application programming interface.

`__host__ cudaError_t cudaGraphicsVDPAURegisterOutputSurface`
`cudaGraphicsResource **resource, VdpOutputSurface vdpSurface, unsigned int flags)`
Register a VdpOutputSurface object.

Parameters
resource
- Pointer to the returned object handle
vdpSurface
- VDPAU object to be registered
flags
- Map flags

Returns
cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description
Registers the VdpOutputSurface specified by vdpSurface for access by CUDA. A handle to the registered object is returned as resource. The surface's intended usage is specified using flags, as follows:

- cudaGraphicsMapFlagsNone: Specifies no hints about how this resource will be used. It is therefore assumed that this resource will be read from and written to by CUDA. This is the default value.
- cudaGraphicsMapFlagsReadOnly: Specifies that CUDA will not write to this resource.
- cudaGraphicsMapFlagsWriteDiscard: Specifies that CUDA will not read from this resource and will write over the entire contents of the resource, so none of the data previously stored in the resource will be preserved.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:

__host__ cudaError_t
cudaGraphicsVDPAURegisterVideoSurface
cudaGraphicsResource **resource, VdpVideoSurface vdpSurface, unsigned int flags)

Register a VdpVideoSurface object.

Parameters

resource
- Pointer to the returned object handle

vdpSurface
- VDPAU object to be registered
**flags**
- Map flags

**Returns**
cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorUnknown

**Description**
Registers the VdpVideoSurface specified by vdpSurface for access by CUDA. A handle to the registered object is returned as resource. The surface's intended usage is specified using flags, as follows:

- **cudaGraphicsMapFlagsNone**: Specifies no hints about how this resource will be used. It is therefore assumed that this resource will be read from and written to by CUDA. This is the default value.
- **cudaGraphicsMapFlagsReadOnly**: Specifies that CUDA will not write to this resource.
- **cudaGraphicsMapFlagsWriteDiscard**: Specifies that CUDA will not read from this resource and will write over the entire contents of the resource, so none of the data previously stored in the resource will be preserved.

**Note:**
Note that this function may also return error codes from previous, asynchronous launches.

See also:

```c
__host__ cudaError_t cudaVDPAUGetDevice (int *device, VdpDevice vdpDevice, VdpGetProcAddress *vdpGetProcAddress)
```

Gets the CUDA device associated with a VdpDevice.

**Parameters**

- **device**
  - Returns the device associated with vdpDevice, or -1 if the device associated with vdpDevice is not a compute device.

- **vdpDevice**
  - A VdpDevice handle
**vdpGetProcAddress**
- VDPAU's VdpGetProcAddress function pointer

**Returns**
cudaSuccess

**Description**
Returns the CUDA device associated with a VdpDevice, if applicable.

**Note:**
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaVDPAUSetVDPAUDevice, cuVDPAUGetDevice

**__host__ cudaError_t cudaVDPAUSetVDPAUDevice**
(int device, VdpDevice vdpDevice, VdpGetProcAddress *vdpGetProcAddress)
Sets a CUDA device to use VDPAU interoperability.

**Parameters**
**device**
- Device to use for VDPAU interoperability

**vdpDevice**
- The VdpDevice to interoperate with

**vdpGetProcAddress**
- VDPAU's VdpGetProcAddress function pointer

**Returns**
cudaSuccess, cudaErrorInvalidDevice, cudaErrorSetOnActiveProcess

**Description**
Records vdpDevice as the VdpDevice for VDPAU interoperability with the CUDA device device and sets device as the current device for the calling host thread.
This function will immediately initialize the primary context on device if needed.
If \texttt{device} has already been initialized then this call will fail with the error \texttt{cudaErrorSetOnActiveProcess}. In this case it is necessary to reset \texttt{device} using \texttt{cudaDeviceReset()} before VDPAU interoperability on \texttt{device} may be enabled.

\begin{center}
\begin{tabular}{|l|}
\hline
\textbf{Note:} \\
Note that this function may also return error codes from previous, asynchronous launches. \\ 
\hline
\end{tabular}
\end{center}

See also:
\texttt{cudaGraphicsVDPAURegisterVideoSurface}, \texttt{cudaGraphicsVDPAURegisterOutputSurface}, \texttt{cudaDeviceReset}

\section*{6.25. EGL Interoperability}
This section describes the EGL interoperability functions of the CUDA runtime application programming interface.

\begin{verbatim}
__host__ cudaError_t
cudaEGLStreamConsumerAcquireFrame
cudaEglStreamConnection *conn, 
cudaGraphicsResource_t *pCudaResource, cudaStream_t *pStream, unsigned int timeout)
\end{verbatim}

Acquire an image frame from the EGLStream with CUDA as a consumer.

\textbf{Parameters}
\begin{itemize}
    \item \texttt{conn} - Connection on which to acquire
    \item \texttt{pCudaResource} - CUDA resource on which the EGLStream frame will be mapped for use.
    \item \texttt{pStream} - CUDA stream for synchronization and any data migrations implied by \texttt{cudaEglResourceLocationFlags}.
    \item \texttt{timeout} - Desired timeout in usec.
\end{itemize}

\textbf{Returns}
\texttt{cudaSuccess}, \texttt{cudaErrorInvalidValue}, \texttt{cudaErrorUnknown}, \texttt{cudaErrorLaunchTimeout}
Description

Acquire an image frame from EGLStreamKHR. `cudaGraphicsResourceGetMappedEglFrame` can be called on `pCudaResource` to get `cudaEglFrame`.

See also:

`cudaEGLStreamConsumerConnect`, `cudaEGLStreamConsumerDisconnect`,
`cudaEGLStreamConsumerReleaseFrame`, `cuEGLStreamConsumerAcquireFrame`

```c
__host__ cudaError_t cudaEGLStreamConsumerConnect(cudaEglStreamConnection *conn, EGLStreamKHR eglStream)
```

Connect CUDA to EGLStream as a consumer.

Parameters

`conn`
- Pointer to the returned connection handle

`eglStream`
- EGLStreamKHR handle

Returns

`cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorUnknown`

Description

Connect CUDA as a consumer to EGLStreamKHR specified by `eglStream`.

The EGLStreamKHR is an EGL object that transfers a sequence of image frames from one API to another.

See also:

`cudaEGLStreamConsumerDisconnect`, `cudaEGLStreamConsumerAcquireFrame`,
`cudaEGLStreamConsumerReleaseFrame`, `cuEGLStreamConsumerConnect`
cudaEGLStreamConsumerConnectWithFlags
(cudaEglStreamConnection *conn, EGLStreamKHR eglStream, unsigned int flags)
Connect CUDA to EGLStream as a consumer with given flags.

Parameters
conn
- Pointer to the returned connection handle
eglStream
- EGLStreamKHR handle
flags
- Flags denote intended location - system or video.

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorUnknown

Description
Connect CUDA as a consumer to EGLStreamKHR specified by stream with specified flags defined by cudaEglResourceLocationFlags.
The flags specify whether the consumer wants to access frames from system memory or video memory. Default is cudaEglResourceLocationVidmem.

See also:
cudaEGLStreamConsumerDisconnect, cudaEGLStreamConsumerAcquireFrame, cudaEGLStreamConsumerReleaseFrame, cuEGLStreamConsumerConnectWithFlags

cudaEGLStreamConsumerDisconnect
(cudaEglStreamConnection *conn)
Disconnect CUDA as a consumer to EGLStream.

Parameters
conn
- Connection to disconnect.

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorUnknown
Description

Disconnect CUDA as a consumer to EGLStreamKHR.

See also:
cudaEGLStreamConsumerConnect, cudaEGLStreamConsumerAcquireFrame,
cudaEGLStreamConsumerReleaseFrame, cuEGLStreamConsumerDisconnect

__host__ cudaError_t
cudaEGLStreamConsumerReleaseFrame
(cudaEglStreamConnection *conn,
cudaGraphicsResource_t pCudaResource, cudaStream_t *pStream)

Releases the last frame acquired from the EGLStream.

Parameters

conn
  - Connection on which to release

pCudaResource
  - CUDA resource whose corresponding frame is to be released

pStream
  - CUDA stream on which release will be done.

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorUnknown

Description

Release the acquired image frame specified by pCudaResource to EGLStreamKHR.

See also:
cudaEGLStreamConsumerConnect, cudaEGLStreamConsumerDisconnect,
cudaEGLStreamConsumerAcquireFrame, cuEGLStreamConsumerReleaseFrame
__host__ cudaError_t cudaEGLStreamProducerConnect (cudaEglStreamConnection *conn, EGLStreamKHR eglStream, EGLint width, EGLint height)

Connect CUDA to EGLStream as a producer.

Parameters

conn
- Pointer to the returned connection handle

eglStream
- EGLStreamKHR handle

width
- width of the image to be submitted to the stream

height
- height of the image to be submitted to the stream

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorUnknown

Description

Connect CUDA as a producer to EGLStreamKHR specified by stream.

The EGLStreamKHR is an EGL object that transfers a sequence of image frames from one API to another.

See also:
cudaEGLStreamProducerDisconnect, cudaEGLStreamProducerPresentFrame, cudaEGLStreamProducerReturnFrame, cuEGLStreamProducerConnect

__host__ cudaError_t cudaEGLStreamProducerDisconnect (cudaEglStreamConnection *conn)

Disconnect CUDA as a producer to EGLStream.

Parameters

conn
- Connection to disconnect.

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorUnknown
Description

Disconnect CUDA as a producer to EGLStreamKHR.

See also:

cudaEGLStreamProducerConnect, cudaEGLStreamProducerPresentFrame, cudaEGLStreamProducerReturnFrame, cuEGLStreamProducerDisconnect

__host__ cudaError_t
cudaEGLStreamProducerPresentFrame
(cudaEglStreamConnection *conn, cudaEglFrame eglframe, cudaStream_t *pStream)

Present a CUDA eglFrame to the EGLStream with CUDA as a producer.

Parameters

conn
  - Connection on which to present the CUDA array
eglframe
  - CUDA Eglstream Proucer Frame handle to be sent to the consumer over EglStream.
pStream
  - CUDA stream on which to present the frame.

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorUnknown

Description

The cudaEglFrame is defined as:

```c
typedef struct cudaEglFrame_st {
    union {
        cudaArray_t pArray[CUDA_EGL_MAX_PLANES];
        struct cudaPitchedPtr pPitch[CUDA_EGL_MAX_PLANES];
    } frame;
    cudaEglPlaneDesc planeDesc[CUDA_EGL_MAX_PLANES];
    unsigned int planeCount;
    cudaEglFrameType frameType;
    cudaEglColorFormat eglColorFormat;
} cudaEglFrame;
```

For cudaEglFrame of type cudaEglFrameTypePitch, the application may present sub-region of a memory allocation. In that case, cudaPitchedPtr::ptr will specify the start address of the sub-region in the allocation and cudaEglPlaneDesc will specify the dimensions of the sub-region.

See also:
__host__ cudaError_t
cudaEGLStreamProducerReturnFrame
(cudaEglStreamConnection *conn, cudaEglFrame *eglframe, cudaStream_t *pStream)

Return the CUDA eglFrame to the EGLStream last released by the consumer.

Parameters

conn
- Connection on which to present the CUDA array

eglFrame
- CUDA Eglstream Proucer Frame handle returned from the consumer over EglStream.

pStream
- CUDA stream on which to return the frame.

Returns

cudaSuccess, cudaErrorLaunchTimeout, cudaErrorInvalidValue, cudaErrorUnknown

Description

This API can potentially return cudaErrorLaunchTimeout if the consumer has not returned a frame to
EGL stream. If timeout is returned the application can retry.

See also:

cudaEGLStreamProducerConnect, cudaEGLStreamProducerDisconnect, cudaEGLStreamProducerPresentFrame, cuEGLStreamProducerReturnFrame

__host__ cudaError_t cudaEventCreateFromEGLSync
(cudaEvent_t *phEvent, EGLSyncKHR eglSync, unsigned int flags)

Creates an event from EGLSync object.

Parameters

phEvent
- Returns newly created event
eglSync
- Opaque handle to EGLSync object

flags
- Event creation flags

Returns
cudaSuccess, cudaErrorInitializationError, cudaErrorInvalidValue, cudaErrorLaunchFailure, cudaErrorMemoryAllocation

Description
Creates an event *phEvent from an EGLSyncKHR eglSync with the flags specified via flags. Valid flags include:

- **cudaEventDefault**: Default event creation flag.
- **cudaEventBlockingSync**: Specifies that the created event should use blocking synchronization. A CPU thread that uses cudaEventSynchronize() to wait on an event created with this flag will block until the event has actually been completed.

cudaEventRecord and TimingData are not supported for events created from EGLSync.

The EGLSyncKHR is an opaque handle to an EGL sync object. typedef void* EGLSyncKHR

See also:
cudaEventQuery, cudaEventSynchronize, cudaEventDestroy

__host__ cudaError_t.cudaGraphicsEGLRegisterImage (cudaGraphicsResource **pCudaResource, EGLImageKHR image, unsigned int flags)

Registers an EGL image.

Parameters

pCudaResource
- Pointer to the returned object handle

image
- An EGLImageKHR image which can be used to create target resource.

flags
- Map flags

Returns
cudaSuccess, cudaErrorInvalidResourceHandle, cudaErrorInvalidValue, cudaErrorUnknown
Description

Registers the EGLImageKHR specified by `image` for access by CUDA. A handle to the registered object is returned as `pCudaResource`. Additional Mapping/Unmapping is not required for the registered resource and `cudaGraphicsResourceGetMappedEglFrame` can be directly called on the `pCudaResource`.

The application will be responsible for synchronizing access to shared objects. The application must ensure that any pending operation which access the objects have completed before passing control to CUDA. This may be accomplished by issuing and waiting for `glFinish` command on all `GL` contexts (for OpenGL and likewise for other APIs). The application will be also responsible for ensuring that any pending operation on the registered CUDA resource has completed prior to executing subsequent commands in other APIs accessing the same memory objects. This can be accomplished by calling `cuCtxSynchronize` or `cuEventSynchronize` (preferably).

The surface's intended usage is specified using flags, as follows:

- `cudaGraphicsRegisterFlagsNone`: Specifies no hints about how this resource will be used. It is therefore assumed that this resource will be read from and written to by CUDA. This is the default value.
- `cudaGraphicsRegisterFlagsReadOnly`: Specifies that CUDA will not write to this resource.
- `cudaGraphicsRegisterFlagsWriteDiscard`: Specifies that CUDA will not read from this resource and will write over the entire contents of the resource, so none of the data previously stored in the resource will be preserved.

The EGLImageKHR is an object which can be used to create EGLImage target resource. It is defined as a void pointer. `typedef void* EGLImageKHR`

See also:

- `cudaGraphicsUnregisterResource`
- `cudaGraphicsResourceGetMappedEglFrame`
- `cuGraphicsEGLRegisterImage`

```c
__host__ cudaError_t
cudaGraphicsResourceGetMappedEglFrame
(cudaEglFrame *eglFrame, cudaGraphicsResource_t resource, unsigned int index, unsigned int mipLevel)
```

Get an `eglFrame` through which to access a registered EGL graphics resource.

**Parameters**

- `eglFrame` - Returned `eglFrame`. 
resource
- Registered resource to access.

index
- Index for cubemap surfaces.

mipLevel
- Mipmap level for the subresource to access.

Returns
\texttt{cudaSuccess}, \texttt{cudaErrorInvalidValue}, \texttt{cudaErrorUnknown}

Description

Returns in \texttt{*eglFrame} an eglFrame pointer through which the registered graphics resource may be accessed. This API can only be called for EGL graphics resources.

The \texttt{cudaEglFrame} is defined as

\begin{verbatim}
typedef struct cudaEglFrame_st {
    union {
        cudaArray_t pArray[CUDA_EGL_MAX_PLANES];
        struct cudaPitchedPtr pPitch[CUDA_EGL_MAX_PLANES];
    } frame;
    cudaEglPlaneDesc planeDesc[CUDA_EGL_MAX_PLANES];
    unsigned int planeCount;
    cudaEglFrameType frameType;
    cudaEglColorFormat eglColorFormat;
} cudaEglFrame;
\end{verbatim}

Note:

Note that in case of multiplanar \texttt{*eglFrame}, pitch of only first plane (unsigned int \texttt{cudaEglPlaneDesc::pitch}) is to be considered by the application.

See also:


This section describes the graphics interoperability functions of the CUDA runtime application programming interface.
__host__ cudaError_t cudaGraphicsMapResources (int count, cudaGraphicsResource_t *resources, cudaStream_t stream)
Map graphics resources for access by CUDA.

Parameters

- **count**
  - Number of resources to map

- **resources**
  - Resources to map for CUDA

- **stream**
  - Stream for synchronization

Returns
cudaSuccess, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description
Maps the `count` graphics resources in `resources` for access by CUDA.

The resources in `resources` may be accessed by CUDA until they are unmapped. The graphics API from which `resources` were registered should not access any resources while they are mapped by CUDA. If an application does so, the results are undefined.

This function provides the synchronization guarantee that any graphics calls issued before `cudaGraphicsMapResources()` will complete before any subsequent CUDA work issued in `stream` begins.

If `resources` contains any duplicate entries then `cudaErrorInvalidResourceHandle` is returned. If any of `resources` are presently mapped for access by CUDA then `cudaErrorUnknown` is returned.

Note:
- This function uses standard default stream semantics.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
__host__ cudaError_t
cudaGraphicsResourceGetMappedMipmappedArray
cudaMipmappedArray_t *mipmappedArray,
cudaGraphicsResource_t resource)
Get a mipmapped array through which to access a mapped graphics resource.

Parameters
mipmappedArray
- Returned mipmapped array through which resource may be accessed
resource
- Mapped resource to access

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description
Returns in *mipmappedArray a mipmapped array through which the mapped graphics resource resource may be accessed. The value set in mipmappedArray may change every time that resource is mapped.

If resource is not a texture then it cannot be accessed via an array and cudaErrorUnknown is returned. If resource is not mapped then cudaErrorUnknown is returned.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
__host__ cudaError_t
cudaGraphicsResourceGetMappedPointer (void **devPtr, size_t *size, cudaGraphicsResource_t resource)
Get an device pointer through which to access a mapped graphics resource.

Parameters

**devPtr**
- Returned pointer through which resource may be accessed

**size**
- Returned size of the buffer accessible starting at *devPtr

**resource**
- Mapped resource to access

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

Returns in *devPtr a pointer through which the mapped graphics resource resource may be accessed. Returns in *size the size of the memory in bytes which may be accessed from that pointer. The value set in devPtr may change every time that resource is mapped.

If resource is not a buffer then it cannot be accessed via a pointer and cudaErrorUnknown is returned. If resource is not mapped then cudaErrorUnknown is returned. *

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
__host__ cudaError_t cudaGraphicsResourceSetMapFlags
(cudaGraphicsResource_t resource, unsigned int flags)

Set usage flags for mapping a graphics resource.

Parameters

resource - Registered resource to set flags for
flags - Parameters for resource mapping

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorUnknown.

Description

Set flags for mapping the graphics resource resource.

Changes to flags will take effect the next time resource is mapped. The flags argument may be any of the following:

- cudaGraphicsMapFlagsNone: Specifies no hints about how resource will be used. It is therefore assumed that CUDA may read from or write to resource.
- cudaGraphicsMapFlagsReadOnly: Specifies that CUDA will not write to resource.
- cudaGraphicsMapFlagsWriteDiscard: Specifies CUDA will not read from resource and will write over the entire contents of resource, so none of the data previously stored in resource will be preserved.

If resource is presently mapped for access by CUDA then cudaErrorUnknown is returned. If flags is not one of the above values then cudaErrorInvalidValue is returned.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaGraphicsMapResources, cuGraphicsResourceSetMapFlags
cudaGraphicsSubResourceGetMappedArray (cudaArray_t *array, cudaGraphicsResource_t resource, unsigned int arrayIndex, unsigned int mipLevel)

Get an array through which to access a subresource of a mapped graphics resource.

Parameters

array
- Returned array through which a subresource of resource may be accessed

resource
- Mapped resource to access

arrayIndex
- Array index for array textures or cubemap face index as defined by cudaGraphicsCubeFace for cubemap textures for the subresource to access

mipLevel
- Mipmap level for the subresource to access

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

Returns in *array an array through which the subresource of the mapped graphics resource resource which corresponds to array index arrayIndex and mipmap level mipLevel may be accessed. The value set in array may change every time that resource is mapped.

If resource is not a texture then it cannot be accessed via an array and cudaErrorUnknown is returned. If arrayIndex is not a valid array index for resource then cudaErrorInvalidValue is returned. If mipLevel is not a valid mipmap level for resource then cudaErrorInvalidValue is returned. If resource is not mapped then cudaErrorUnknown is returned.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

__host__ cudaError_t cudaGraphicsUnmapResources (int count, cudaGraphicsResource_t *resources, cudaStream_t stream)

Unmap graphics resources.

Parameters

count
  - Number of resources to unmap
resources
  - Resources to unmap
stream
  - Stream for synchronization

Returns

cudaSuccess, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

Unmaps the count graphics resources in resources.

Once unmapped, the resources in resources may not be accessed by CUDA until they are mapped again.

This function provides the synchronization guarantee that any CUDA work issued in stream before cudaGraphicsUnmapResources() will complete before any subsequently issued graphics work begins.

If resources contains any duplicate entries then cudaErrorInvalidResourceHandle is returned. If any of resources are not presently mapped for access by CUDA then cudaErrorUnknown is returned.

Note:

- This function uses standard default stream semantics.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaGraphicsMapResources, cuGraphicsUnmapResources
__host__ cudaError_t cudaGraphicsUnregisterResource (cudaGraphicsResource_t resource)

Unregisters a graphics resource for access by CUDA.

Parameters

resource

- Resource to unregister

Returns
cudaSuccess, cudaErrorInvalidResourceHandle, cudaErrorUnknown

Description

Unregisters the graphics resource resource so it is not accessible by CUDA unless registered again. If resource is invalid then cudaErrorInvalidResourceHandle is returned.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
- Use of the handle after this call is undefined behavior.

See also:
cudaGraphicsD3D9RegisterResource, cudaGraphicsD3D10RegisterResource,
cudaGraphicsD3D11RegisterResource, cudaGraphicsGLRegisterBuffer,
cudaGraphicsGLRegisterImage, cuGraphicsUnregisterResource

6.27. Texture Object Management

This section describes the low level texture object management functions of the CUDA runtime application programming interface. The texture object API is only supported on devices of compute capability 3.0 or higher.
__host__ cudaCreateChannelDesc (int x, int y, int z, int w, cudaChannelFormatKind f)

Returns a channel descriptor using the specified format.

Parameters

x
- X component

y
- Y component

z
- Z component

w
- W component

f
- Channel format

Returns

Channel descriptor with format f

Description

Returns a channel descriptor with format f and number of bits of each component x, y, z, and w. The cudaChannelFormatDesc is defined as:

```c
struct cudaChannelFormatDesc {
    int x, y, z, w;
    enum cudaChannelFormatKind f;
};
```

where cudaChannelFormatKind is one of cudaChannelFormatKindSigned, cudaChannelFormatKindUnsigned, or cudaChannelFormatKindFloat.

See also:

cudaCreateChannelDesc (C++ API), cudaGetChannelDesc, cudaCreateTextureObject, cudaCreateSurfaceObject
__host__ cudaError_t cudaCreateTextureObject
(cudaTextureObject_t *pTexObject, const
cudaResourceDesc *pResDesc, const cudaTextureDesc
*pTexDesc, const cudaResourceViewDesc
*pResViewDesc)

Creates a texture object.

Parameters

pTexObject
- Texture object to create

pResDesc
- Resource descriptor

pTexDesc
- Texture descriptor

pResViewDesc
- Resource view descriptor

Returns

cudaSuccess, cudaErrorInvalidValue

Description

Creates a texture object and returns it in pTexObject. pResDesc describes the data to texture from. pTexDesc describes how the data should be sampled. pResViewDesc is an optional argument that specifies an alternate format for the data described by pResDesc, and also describes the subresource region to restrict access to when texturing. pResViewDesc can only be specified if the type of resource is a CUDA array or a CUDA mipmapmed array not in a block compressed format.

Texture objects are only supported on devices of compute capability 3.0 or higher. Additionally, a texture object is an opaque value, and, as such, should only be accessed through CUDA API calls.

The cudaResourceDesc structure is defined as:

```c
struct cudaResourceDesc {
    enum cudaResourceType
    resType;

    union {
        struct {
            cudaArray_t
            array;
        } array;
        struct {
            cudaMipmappedArray_t
            mipmap;
        } mipmap;
    } storage;
}
```
void *devPtr;

struct cudaChannelFormatDesc
    desc;
    size_t sizeInBytes;
} linear;

struct {
    void *devPtr;
    struct cudaChannelFormatDesc
        desc;
    size_t width;
    size_t height;
    size_t pitchInBytes;
} pitch2D;
}
res;

where:

- **cudaResourceDesc::resType** specifies the type of resource to texture from. CUresourceType is defined as:

  ```
  enum cudaResourceType {
      cudaResourceTypeArray = 0x00,
      cudaResourceTypeMipmappedArray = 0x01,
      cudaResourceTypeLinear = 0x02,
      cudaResourceTypePitch2D = 0x03
  };
  ```

  If **cudaResourceDesc::resType** is set to **cudaResourceTypeArray**, **cudaResourceDesc::res::array::array** must be set to a valid CUDA array handle.

  If **cudaResourceDesc::resType** is set to **cudaResourceTypeMipmappedArray**, **cudaResourceDesc::res::mipmap::mipmap** must be set to a valid CUDA mipmapped array handle and **cudaTextureDesc::normalizedCoords** must be set to true.

  If **cudaResourceDesc::resType** is set to **cudaResourceTypeLinear**, **cudaResourceDesc::res::linear::devPtr** must be set to a valid device pointer, that is aligned to **cudaDeviceProp::textureAlignment**. **cudaResourceDesc::res::linear::desc** describes the format and the number of components per array element. **cudaResourceDesc::res::linear::sizeInBytes** specifies the size of the array in bytes. The total number of elements in the linear address range cannot exceed **cudaDeviceProp::maxTexture1DLinear**. The number of elements is computed as (sizeInBytes / sizeof(desc)).

  If **cudaResourceDesc::resType** is set to **cudaResourceTypePitch2D**, **cudaResourceDesc::res::pitch2D::devPtr** must be set to a valid device pointer, that is aligned to **cudaDeviceProp::textureAlignment**. **cudaResourceDesc::res::pitch2D::desc** describes the format and the number of components per array element. **cudaResourceDesc::res::pitch2D::width** and **cudaResourceDesc::res::pitch2D::height** specify the width and height of the array in elements, and cannot exceed **cudaDeviceProp::maxTexture2DLinear[0]** and **cudaDeviceProp::maxTexture2DLinear[1]** respectively. **cudaResourceDesc::res::pitch2D::pitchInBytes** specifies the pitch between two rows in bytes and has to be aligned to **cudaDeviceProp::texturePitchAlignment**. Pitch cannot exceed **cudaDeviceProp::maxTexture2DLinear[2]**.
The `cudaTextureDesc` struct is defined as

```c
struct cudaTextureDesc {
    enum cudaTextureAddressMode
        addressMode[3];
    enum cudaTextureFilterMode
        filterMode;
    enum cudaTextureReadMode
        readMode;
    int sRGB;
    float borderColor[4];
    int normalizedCoords;
    unsigned int maxAnisotropy;
    enum cudaTextureFilterMode
       .mipmapFilterMode;
    float.mipmapLevelBias;
    float.minMipmapLevelClamp;
    float.maxMipmapLevelClamp;
    int disableTrilinearOptimization;
    int seamlessCubemap;
};
```

where

- `cudaTextureDesc::addressMode` specifies the addressing mode for each dimension of the texture data. `cudaTextureAddressMode` is defined as:

```c
enum cudaTextureAddressMode {
    cudaAddressModeWrap = 0,
    cudaAddressModeClamp = 1,
    cudaAddressModeMirror = 2,
    cudaAddressModeBorder = 3
};
```

This is ignored if `cudaResourceDesc::resType` is `cudaResourceTypeLinear`. Also, if `cudaTextureDesc::normalizedCoords` is set to zero, `cudaAddressModeWrap` and `cudaAddressModeMirror` won't be supported and will be switched to `cudaAddressModeClamp`.

- `cudaTextureDesc::filterMode` specifies the filtering mode to be used when fetching from the texture. `cudaTextureFilterMode` is defined as:

```c
enum cudaTextureFilterMode {
    cudaFilterModePoint = 0,
    cudaFilterModeLinear = 1
};
```

This is ignored if `cudaResourceDesc::resType` is `cudaResourceTypeLinear`.

- `cudaTextureDesc::readMode` specifies whether integer data should be converted to floating point or not. `cudaTextureReadMode` is defined as:

```c
enum cudaTextureReadMode {
    cudaReadModeElementType = 0,
    cudaReadModeNormalizedFloat = 1
};
```

Note that this applies only to 8-bit and 16-bit integer formats. 32-bit integer format would not be promoted, regardless of whether or not this `cudaTextureDesc::readMode` is set `cudaReadModeNormalizedFloat` is specified.

- `cudaTextureDesc::sRGB` specifies whether sRGB to linear conversion should be performed during texture fetch.

- `cudaTextureDesc::borderColor` specifies the float values of color. where:
  - `cudaTextureDesc::borderColor[0]` contains value of 'R', `cudaTextureDesc::borderColor[1]`
cudaTextureDesc::borderColor[3] contains value of ‘A’ Note that application using integer border 
color values will need to <reinterpret_cast> these values to float. The values are set only when the 
addressing mode specified by cudaTextureDesc::addressMode is cudaAddressModeBorder.

- cudaTextureDesc::normalizedCoords specifies whether the texture coordinates will be normalized 
or not.
- cudaTextureDesc::maxAnisotropy specifies the maximum anistropy ratio to be used when doing 
anisotropic filtering. This value will be clamped to the range [1,16].
- cudaTextureDesc::mipmapFilterMode specifies the filter mode when the calculated mipmap level 
lies between two defined mipmap levels.
- cudaTextureDesc::mipmapLevelBias specifies the offset to be applied to the calculated mipmap 
level.
- cudaTextureDesc::minMipmapLevelClamp specifies the lower end of the mipmap level range to 
clamp access to.
- cudaTextureDesc::maxMipmapLevelClamp specifies the upper end of the mipmap level range to 
clamp access to.
- cudaTextureDesc::disableTrilinearOptimization specifies whether the trilinear filtering 
optimizations will be disabled.
- cudaTextureDesc::seamlessCubemap specifies whether seamless cube map filtering is enabled. 
This flag can only be specified if the underlying resource is a CUDA array or a CUDA 
mipmapped array that was created with the flag cudaArrayCubemap. When seamless cube map filtering 
is enabled, texture address modes specified by cudaTextureDesc::addressMode are ignored. 
Instead, if the cudaTextureDesc::filterMode is set to cudaFilterModePoint the address mode 
cudaAddressModeClamp will be applied for all dimensions. If the cudaTextureDesc::filterMode is 
set to cudaFilterModeLinear seamless cube map filtering will be performed when sampling along 
the cube face borders.

The cudaResourceViewDesc struct is defined as

```
struct cudaResourceViewDesc {
  enum cudaResourceViewFormat
    format;
  size_t      width;
  size_t      height;
  size_t      depth;
  unsigned int firstMipmapLevel;
  unsigned int lastMipmapLevel;
  unsigned int firstLayer;
  unsigned int lastLayer;
};
```

where:

- cudaResourceViewDesc::format specifies how the data contained in the CUDA array or CUDA 
mipmapped array should be interpreted. Note that this can incur a change in size of the texture 
data. If the resource view format is a block compressed format, then the underlying CUDA array
or CUDA mipmapped array has to have a 32-bit unsigned integer format with 2 or 4 channels, depending on the block compressed format. For ex., BC1 and BC4 require the underlying CUDA array to have a 32-bit unsigned int with 2 channels. The other BC formats require the underlying resource to have the same 32-bit unsigned int format but with 4 channels.

- `cudaResourceViewDesc::width` specifies the new width of the texture data. If the resource view format is a block compressed format, this value has to be 4 times the original width of the resource. For non block compressed formats, this value has to be equal to that of the original resource.

- `cudaResourceViewDesc::height` specifies the new height of the texture data. If the resource view format is a block compressed format, this value has to be 4 times the original height of the resource. For non block compressed formats, this value has to be equal to that of the original resource.

- `cudaResourceViewDesc::depth` specifies the new depth of the texture data. This value has to be equal to that of the original resource.

- `cudaResourceViewDesc::firstMipmapLevel` specifies the most detailed mipmap level. This will be the new mipmap level zero. For non-mipmapped resources, this value has to be zero. `cudaTextureDesc::minMipmapLevelClamp` and `cudaTextureDesc::maxMipmapLevelClamp` will be relative to this value. For ex., if the firstMipmapLevel is set to 2, and a `minMipmapLevelClamp` of 1.2 is specified, then the actual minimum mipmap level clamp will be 3.2.

- `cudaResourceViewDesc::lastMipmapLevel` specifies the least detailed mipmap level. For non-mipmapped resources, this value has to be zero.

- `cudaResourceViewDesc::firstLayer` specifies the first layer index for layered textures. This will be the new layer zero. For non-layered resources, this value has to be zero.

- `cudaResourceViewDesc::lastLayer` specifies the last layer index for layered textures. For non-layered resources, this value has to be zero.

---

**Note:**

- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaDestroyTextureObject, cuTexObjectCreate
__host__ cudaError_t cudaDestroyTextureObject(cudaTextureObject_t texObject)
Destroys a texture object.

Parameters

texObject
- Texture object to destroy

Returns

cudaSuccess, cudaErrorInvalidValue

Description
Destroys the texture object specified by texObject.

Note:
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpyAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
- Use of the handle after this call is undefined behavior.

See also:
cudaCreateTextureObject, cuTexObjectDestroy

__host__ cudaError_t cudaGetChannelDesc(cudaChannelFormatDesc *desc, cudaArray_const_t array)
Get the channel descriptor of an array.

Parameters

desc
- Channel format
array
- Memory array on device

Returns
cudaSuccess, cudaErrorInvalidValue
Description

Returns in *desc the channel descriptor of the CUDA array array.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaCreateChannelDesc (C API), cudaCreateTextureObject, cudaCreateSurfaceObject

__host__ cudaError_t cudaGetTextureObjectResourceDesc (cudaResourceDesc *pResDesc, cudaTextureObject_t texObject)

Returns a texture object’s resource descriptor.

Parameters

pResDesc
- Resource descriptor
texObject
- Texture object

Returns

cudaSuccess, cudaErrorInvalidValue

Description

Returns the resource descriptor for the texture object specified by texObject.

Note:

- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
See also:

`cudaCreateTextureObject`, `cuTexObjectGetResourceDesc`

```c
__host__ cudaError_t
cudaGetTextureObjectResourceViewDesc
(cudaResourceViewDesc *pResViewDesc, cudaTextureObject_t texObject)
```

Returns a texture object's resource view descriptor.

**Parameters**

- `pResViewDesc` - Resource view descriptor
- `texObject` - Texture object

**Returns**

`cudaSuccess`, `cudaErrorInvalidValue`

**Description**

Returns the resource view descriptor for the texture object specified by `texObject`. If no resource view was specified, `cudaErrorInvalidValue` is returned.

**Note:**

- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cudaCreateTextureObject`, `cuTexObjectGetResourceViewDesc`
__host__ cudaError_t cudaGetTextureObjectTextureDesc (cudaTextureDesc *pTexDesc, cudaTextureObject_t texObject)

Returns a texture object's texture descriptor.

Parameters

pTexDesc
- Texture descriptor
texObject
- Texture object

Returns
cudaSuccess, cudaErrorInvalidValue

Description

Returns the texture descriptor for the texture object specified by texObject.

Note:

- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaCreateTextureObject, cuTexObjectGetTextureDesc

6.28. Surface Object Management

This section describes the low level texture object management functions of the CUDA runtime application programming interface. The surface object API is only supported on devices of compute capability 3.0 or higher.
__host__ cudaError_t cudaCreateSurfaceObject
(cuSurfaceObject_t *pSurfObject, const
cudaResourceDesc *pResDesc)

Creates a surface object.

Parameters

pSurfObject
- Surface object to create

pResDesc
- Resource descriptor

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidChannelDescriptor,
cudaErrorInvalidResourceHandle

Description

Creates a surface object and returns it in pSurfObject. pResDesc describes the data to
perform surface load/stores on. cudaResourceDesc::resType must be cudaResourceTypeArray and
cudaResourceDesc::res::array::array must be set to a valid CUDA array handle.

Surface objects are only supported on devices of compute capability 3.0 or higher. Additionally, a
surface object is an opaque value, and, as such, should only be accessed through CUDA API calls.

Note:

- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or
cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.

- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback.
cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaDestroySurfaceObject, cuSurfObjectCreate
__host__ cudaError_t cudaDestroySurfaceObject (cudaSurfaceObject_t surfObject)
Destroys a surface object.

Parameters

surfObject
- Surface object to destroy

Returns
cudaSuccess, cudaErrorInvalidValue

Description
Destroys the surface object specified by surfObject.

Note:
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotAllowed may, but is not guaranteed to, be returned as a diagnostic in such case.
- Use of the handle after this call is undefined behavior.

See also:
cudaCreateSurfaceObject, cuSurfObjectDestroy

__host__ cudaError_t cudaGetSurfaceObjectResourceDesc (cudaResourceDesc *pResDesc, cudaSurfaceObject_t surfObject)
Returns a surface object's resource descriptor Returns the resource descriptor for the surface object specified by surfObject.

Parameters

pResDesc
- Resource descriptor

surfObject
- Surface object
Returns

cudaSuccess, cudaErrorInvalidValue

Description

Note:

- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaCreateSurfaceObject, cuSurfObjectGetResourceDesc

6.29. Version Management

__host__ cudaError_t cudaMemcpyVersion (int *driverVersion)

Returns the latest version of CUDA supported by the driver.

Parameters

driverVersion
  - Returns the CUDA driver version.

Returns

cudaSuccess, cudaErrorInvalidValue

Description

Returns in *driverVersion the latest version of CUDA supported by the driver. The version is returned as (1000 major + 10 minor). For example, CUDA 9.2 would be represented by 9020. If no driver is installed, then 0 is returned as the driver version.

This function automatically returns cudaErrorInvalidValue if driverVersion is NULL.
Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.

Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
```
cudaRuntimeGetVersion, cuDriverGetVersion
```

```__host__ __device__ cudaError_t cudaRuntimeGetVersion(int *runtimeVersion)`
```
Returns the CUDA Runtime version.

Parameters
`runtimeVersion`
- Returns the CUDA Runtime version.

Returns
`cudaSuccess, cudaErrorInvalidValue`

Description
Returns in `*runtimeVersion` the version number of the current CUDA Runtime instance. The version is returned as (1000 major + 10 minor). For example, CUDA 9.2 would be represented by 9020.

As of CUDA 12.0, this function no longer initializes CUDA. The purpose of this API is solely to return a compile-time constant stating the CUDA Toolkit version in the above format.

This function automatically returns `cudaErrorInvalidValue` if the `runtimeVersion` argument is NULL.

Note:
```
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.
```

See also:
```
cudaDriverGetVersion, cuDriverGetVersion
```
6.30.  Graph Management

This section describes the graph management functions of CUDA runtime application programming interface.

__host__ cudaError_t cudaDeviceGetGraphMemAttribute (int device, cudaGraphMemAttributeType attr, void *value)

Query asynchronous allocation attributes related to graphs.

Parameters

- **device**
  - Specifies the scope of the query

- **attr**
  - attribute to get

- **value**
  - retrieved value

Returns

- cudaSuccess
- cudaErrorInvalidDevice

Description

Valid attributes are:

- **cudaGraphMemAttrUsedMemCurrent**: Amount of memory, in bytes, currently associated with graphs
- **cudaGraphMemAttrUsedMemHigh**: High watermark of memory, in bytes, associated with graphs since the last time it was reset. High watermark can only be reset to zero.
- **cudaGraphMemAttrReservedMemCurrent**: Amount of memory, in bytes, currently allocated for use by the CUDA graphs asynchronous allocator.
- **cudaGraphMemAttrReservedMemHigh**: High watermark of memory, in bytes, currently allocated for use by the CUDA graphs asynchronous allocator.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
`cudaDeviceSetGraphMemAttribute`, `cudaGraphAddMemAllocNode`, `cudaGraphAddMemFreeNode`, `cudaDeviceGraphMemTrim`, `cudaMallocAsync`, `cudaFreeAsync`

```c
__host__ cudaError_t cudaDeviceGraphMemTrim (int device)
```

Free unused memory that was cached on the specified device for use with graphs back to the OS.

**Parameters**

`device`
- The device for which cached memory should be freed.

**Returns**

`cudaSuccess`, `cudaErrorInvalidValue`

**Description**

Blocks which are not in use by a graph that is either currently executing or scheduled to execute are freed back to the operating system.

```c
 cudaError_t cudaDeviceGraphMemTrim (int device)
```

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
`cudaGraphAddMemAllocNode`, `cudaGraphAddMemFreeNode`, `cudaDeviceGetGraphMemAttribute`, `cudaDeviceSetGraphMemAttribute`, `cudaMallocAsync`, `cudaFreeAsync`
__host__ cudaError_t cudaDeviceSetGraphMemAttribute
(int device, cudaGraphMemAttributeType attr, void *value)

Set asynchronous allocation attributes related to graphs.

Parameters

device
- Specifies the scope of the query

attr
- attribute to get

value
- pointer to value to set

Returns

cudaSuccess, cudaErrorInvalidDevice

Description

Valid attributes are:

- **cudaGraphMemAttrUsedMemHigh**: High watermark of memory, in bytes, associated with graphs since the last time it was reset. High watermark can only be reset to zero.

- **cudaGraphMemAttrReservedMemHigh**: High watermark of memory, in bytes, currently allocated for use by the CUDA graphs asynchronous allocator.

Note:

- Graph objects are not threadsafe. More here.

- Note that this function may also return error codes from previous, asynchronous launches.

- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.

- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaDeviceGetGraphMemAttribute, cudaGraphAddMemAllocNode, cudaGraphAddMemFreeNode, cudaDeviceGraphMemTrim, cudaMallocAsync, cudaFreeAsync
__device__ cudaGraphExec_t cudaGetCurrentGraphExec (void)
Get the currently running device graph id.

Returns
Returns the current device graph id, 0 if the call is outside of a device graph.

Description
Get the currently running device graph id.

See also:
cudaGraphLaunch

__host__ cudaError_t cudaGraphAddChildGraphNode (cudaGraphNode_t *pGraphNode, cudaGraph_t graph, const cudaGraphNode_t *pDependencies, size_t numDependencies, cudaGraph_t childGraph)
Creates a child graph node and adds it to a graph.

Parameters
pGraphNode
- Returns newly created node
graph
- Graph to which to add the node
pDependencies
- Dependencies of the node
numDependencies
- Number of dependencies
childGraph
- The graph to clone into this node

Returns
cudaSuccess, cudaErrorInvalidValue

Description
Creates a new node which executes an embedded graph, and adds it to graph with numDependencies dependencies specified via pDependencies. It is possible for
numDependencies to be 0, in which case the node will be placed at the root of the graph.
pDependencies may not have any duplicate entries. A handle to the new node will be returned in pGraphNode.

If hGraph contains allocation or free nodes, this call will return an error.

The node executes an embedded child graph. The child graph is cloned in this call.

### Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphAddNode, cudaGraphChildGraphNodeGetGraph, cudaGraphCreate, cudaGraphDestroyNode, cudaGraphAddEmptyNode, cudaGraphAddKernelNode, cudaGraphAddHostNode, cudaGraphAddMemcpyNode, cudaGraphAddMemsetNode, cudaGraphClone

```c
__host__ cudaError_t cudaGraphAddDependencies
(cudaGraph_t graph, const cudaGraphNode_t *from, const cudaGraphNode_t *to, size_t numDependencies)
```

Adds dependency edges to a graph.

### Parameters
- **graph**
  - Graph to which dependencies are added
- **from**
  - Array of nodes that provide the dependencies
- **to**
  - Array of dependent nodes
- **numDependencies**
  - Number of dependencies to be added

### Returns
cudaSuccess, cudaErrorInvalidValue
Description

The number of dependencies to be added is defined by `numDependencies`. Elements in `pFrom` and `pTo` at corresponding indices define a dependency. Each node in `pFrom` and `pTo` must belong to `graph`.

If `numDependencies` is 0, elements in `pFrom` and `pTo` will be ignored. Specifying an existing dependency will return an error.

Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
- `cudaGraphRemoveDependencies`, `cudaGraphGetEdges`, `cudaGraphNodeGetDependencies`, `cudaGraphNodeGetDependentNodes`

__host__ cudaError_t cudaGraphAddDependencies_v2 (cudaGraph_t graph, const cudaGraphNode_t *from, const cudaGraphNode_t *to, const cudaGraphEdgeData *edgeData, size_t numDependencies)

Adds dependency edges to a graph. (12.3+).

Parameters

- **graph**
  - Graph to which dependencies are added
- **from**
  - Array of nodes that provide the dependencies
- **to**
  - Array of dependent nodes
- **edgeData**
  - Optional array of edge data. If NULL, default (zeroed) edge data is assumed.
- **numDependencies**
  - Number of dependencies to be added
Returns

\text{cudaSuccess}, \text{cudaErrorInvalidValue}

Description

The number of dependencies to be added is defined by \text{numDependencies}. Elements in \text{pFrom} and \text{pTo} at corresponding indices define a dependency. Each node in \text{pFrom} and \text{pTo} must belong to \text{graph}.

If \text{numDependencies} is 0, elements in \text{pFrom} and \text{pTo} will be ignored. Specifying an existing dependency will return an error.

\begin{itemize}
  \item Graph objects are not threadsafe. \text{More here}.
  \item Note that this function may also return error codes from previous, asynchronous launches.
  \item Note that this function may also return \text{cudaErrorInitializationError}, \text{cudaErrorInsufficientDriver} or \text{cudaErrorNoDevice} if this call tries to initialize internal CUDA RT state.
  \item Note that as specified by \text{cudaStreamAddCallback} no CUDA function may be called from callback. \text{cudaErrorNotPermitted} may, but is not guaranteed to, be returned as a diagnostic in such case.
\end{itemize}

See also:

\text{cudaGraphRemoveDependencies}, \text{cudaGraphGetEdges}, \text{cudaGraphNodeGetDependencies}, \text{cudaGraphNodeGetDependentNodes}

\begin{verbatim}
__host__ cudaError_t cudaGraphAddEmptyNode (cudaGraphNode_t *pGraphNode, cudaGraph_t graph, const cudaGraphNode_t *pDependencies, size_t numDependencies)
\end{verbatim}

Creates an empty node and adds it to a graph.

Parameters

\text{pGraphNode}
  - Returns newly created node

\text{graph}
  - Graph to which to add the node

\text{pDependencies}
  - Dependencies of the node
**numDependencies**
- Number of dependencies

**Returns**
cudaSuccess, cudaErrorInvalidValue

**Description**
Creates a new node which performs no operation, and adds it to graph with numDependencies dependencies specified via pDependencies. It is possible for numDependencies to be 0, in which case the node will be placed at the root of the graph. pDependencies may not have any duplicate entries. A handle to the new node will be returned in pGraphNode.

An empty node performs no operation during execution, but can be used for transitive ordering. For example, a phased execution graph with 2 groups of n nodes with a barrier between them can be represented using an empty node and 2*n dependency edges, rather than no empty node and n^2 dependency edges.

**Note:**
- Graph objects are not threadsafe. [More here.](#)
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphAddNode, cudaGraphCreate, cudaGraphDestroyNode, cudaGraphAddChildGraphNode, cudaGraphAddKernelNode, cudaGraphAddHostNode, cudaGraphAddMemcpyNode, cudaGraphAddMemsetNode
__host__ cudaError_t cudaGraphAddEventRecordNode (cudaGraphNode_t *pGraphNode, cudaGraph_t graph, const cudaGraphNode_t *pDependencies, size_t numDependencies, cudaEvent_t event)

Creates an event record node and adds it to a graph.

Parameters

- **pGraphNode**
- **graph**
- **pDependencies**
- **numDependencies**
  - Number of dependencies
- **event**
  - Event for the node

Returns

- cudaSuccess, cudaErrorInvalidValue

Description

Creates a new event record node and adds it to hGraph with numDependencies dependencies specified via dependencies and event specified in event. It is possible for numDependencies to be 0, in which case the node will be placed at the root of the graph. dependencies may not have any duplicate entries. A handle to the new node will be returned in phGraphNode.

Each launch of the graph will record event to capture execution of the node's dependencies.

These nodes may not be used in loops or conditionals.

Note:

- Graph objects are not threadsafe. [More here](#).
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphAddNode, cudaGraphAddEventWaitNode, cudaEventRecordWithFlags, cudaStreamWaitEvent, cudaGraphCreate, cudaGraphDestroyNode, cudaGraphAddChildGraphNode, cudaGraphAddEmptyNode, cudaGraphAddKernelNode, cudaGraphAddMemcpyNode, cudaGraphAddMemsetNode

__host__ cudaError_t cudaGraphAddEventWaitNode (cudaGraphNode_t *pGraphNode, cudaGraph_t graph, const cudaGraphNode_t *pDependencies, size_t numDependencies, cudaEvent_t event)

Creates an event wait node and adds it to a graph.

Parameters

pGraphNode
graph
pDependencies
numDependencies
- Number of dependencies
event
- Event for the node

Returns

cudaSuccess, cudaErrorInvalidValue

Description

Creates a new event wait node and adds it to hGraph with numDependencies dependencies specified via dependencies and event specified in event. It is possible for numDependencies to be 0, in which case the node will be placed at the root of the graph. dependencies may not have any duplicate entries. A handle to the new node will be returned in pGraphNode.

The graph node will wait for all work captured in event. See cuEventRecord() for details on what is captured by an event. The synchronization will be performed efficiently on the device when applicable. event may be from a different context or device than the launch stream.

These nodes may not be used in loops or conditionals.

Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.

Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaGraphAddNode, cudaGraphAddEventRecordNode, cudaEventRecordWithFlags, cudaStreamWaitEvent, cudaGraphCreate, cudaGraphDestroyNode, cudaGraphAddChildGraphNode, cudaGraphAddEmptyNode, cudaGraphAddKernelNode, cudaGraphAddMemcpyNode, cudaGraphAddMemsetNode

__host__ cudaError_t

cudaGraphAddExternalSemaphoresSignalNode

cudaGraphNode_t *pGraphNode, cudaGraph_t graph, const cudaGraphNode_t *pDependencies, size_t numDependencies, const cudaExternalSemaphoreSignalNodeParams *nodeParams)

Creates an external semaphore signal node and adds it to a graph.

Parameters

pGraphNode
- Returns newly created node

graph
- Graph to which to add the node

pDependencies
- Dependencies of the node

numDependencies
- Number of dependencies

nodeParams
- Parameters for the node

Returns

cudaSuccess, cudaErrorInvalidValue

Description

Creates a new external semaphore signal node and adds it to graph with numDependencies dependencies specified via dependencies and arguments specified in nodeParams. It is possible for numDependencies to be 0, in which case the node will be placed at the root of the graph.
dependencies may not have any duplicate entries. A handle to the new node will be returned in pGraphNode.

Performs a signal operation on a set of externally allocated semaphore objects when the node is launched. The operation(s) will occur after all of the node's dependencies have completed.

---

**Note:**

- Graph objects are not threadsafe. [More here](#).
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

- `cudaGraphAddNode`, `cudaGraphExternalSemaphoresSignalNodeGetParams`
- `cudaGraphExternalSemaphoresSignalNodeSetParams`
- `cudaGraphExecExternalSemaphoresSignalNodeSetParams`
- `cudaGraphAddExternalSemaphoresWaitNode`, `cudaImportExternalSemaphore`
- `cudaSignalExternalSemaphoresAsync`, `cudaWaitExternalSemaphoresAsync`, `cudaGraphCreate`, `cudaGraphDestroyNode`, `cudaGraphAddEventRecordNode`, `cudaGraphAddEventWaitNode`, `cudaGraphAddChildGraphNode`, `cudaGraphAddEmptyNode`, `cudaGraphAddKernelNode`, `cudaGraphAddMemcpyNode`, `cudaGraphAddMemsetNode`

```c
__host__ cudaError_t
cudaGraphAddExternalSemaphoresWaitNode
cudaGraphNode_t *pGraphNode,
cudaGraph_t graph, const cudaGraphNode_t *
pDependencies, size_t numDependencies, const
cudaExternalSemaphoreWaitNodeParams *nodeParams)
```

Creates an external semaphore wait node and adds it to a graph.

**Parameters**

- **pGraphNode**
  - Returns newly created node
- **graph**
  - Graph to which to add the node
**pDependencies**
- Dependencies of the node

**numDependencies**
- Number of dependencies

**nodeParams**
- Parameters for the node

**Returns**
cudaSuccess, cudaErrorInvalidValue

**Description**

Creates a new external semaphore wait node and adds it to graph with `numDependencies` dependencies specified via `dependencies` and arguments specified in `nodeParams`. It is possible for `numDependencies` to be 0, in which case the node will be placed at the root of the graph. `dependencies` may not have any duplicate entries. A handle to the new node will be returned in `pGraphNode`.

Performs a wait operation on a set of externally allocated semaphore objects when the node is launched. The node's dependencies will not be launched until the wait operation has completed.

**Note:**
- Graph objects are not threadsafe. [More here.](#)
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

**See also:**
cudaGraphAddNode, cudaGraphExternalSemaphoresWaitNodeGetParams, cudaGraphExternalSemaphoresWaitNodeSetParams, cudaGraphExecExternalSemaphoresWaitNodeSetParams, cudaGraphAddExternalSemaphoresSignalNode, cudaImportExternalSemaphore, cudaSignalExternalSemaphoresAsync, cudaWaitExternalSemaphoresAsync, cudaGraphCreate, cudaGraphDestroyNode, cudaGraphAddEventRecordNode, cudaGraphAddEventWaitNode, cudaGraphAddChildGraphNode, cudaGraphAddEmptyNode, cudaGraphAddKernelNode, cudaGraphAddMemcpyNode, cudaGraphAddMemsetNode
__host__ cudaError_t cudaGraphAddHostNode (cudaGraphNode_t *pGraphNode, cudaGraph_t graph, const cudaGraphNode_t *pDependencies, size_t numDependencies, const cudaHostNodeParams *pNodeParams)

Creates a host execution node and adds it to a graph.

Parameters

pGraphNode
  - Returns newly created node

graph
  - Graph to which to add the node

pDependencies
  - Dependencies of the node

numDependencies
  - Number of dependencies

pNodeParams
  - Parameters for the host node

Returns

cudaSuccess, cudaErrorNotSupported, cudaErrorInvalidValue

Description

Creates a new CPU execution node and adds it to graph with numDependencies dependencies specified via pDependencies and arguments specified in pNodeParams. It is possible for numDependencies to be 0, in which case the node will be placed at the root of the graph. pDependencies may not have any duplicate entries. A handle to the new node will be returned in pGraphNode.

When the graph is launched, the node will invoke the specified CPU function. Host nodes are not supported under MPS with pre-Volta GPUs.

Note:

- Graph objects are not thread-safe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
`cudaGraphAddNode`, `cudaLaunchHostFunc`, `cudaGraphHostNodeGetParams`, `cudaGraphHostNodeSetParams`, `cudaGraphCreate`, `cudaGraphDestroyNode`, `cudaGraphAddChildGraphNode`, `cudaGraphAddEmptyNode`, `cudaGraphAddKernelNode`, `cudaGraphAddMemcpyNode`, `cudaGraphAddMemsetNode`

```c
__host__ cudaError_t cudaGraphAddKernelNode(
    cudaGraphNode_t *pGraphNode, cudaGraph_t graph,
    const cudaGraphNode_t *pDependencies, size_t numDependencies,
    const cudaKernelNodeParams *pNodeParams)
```

Creates a kernel execution node and adds it to a graph.

**Parameters**
- **pGraphNode**
  - Returns newly created node
- **graph**
  - Graph to which to add the node
- **pDependencies**
  - Dependencies of the node
- **numDependencies**
  - Number of dependencies
- **pNodeParams**
  - Parameters for the GPU execution node

**Returns**
- `cudaSuccess`
- `cudaErrorInvalidValue`
- `cudaErrorInvalidDeviceFunction`

**Description**

Creates a new kernel execution node and adds it to `graph` with `numDependencies` dependencies specified via `pDependencies` and arguments specified in `pNodeParams`. It is possible for `numDependencies` to be 0, in which case the node will be placed at the root of the graph. `pDependencies` may not have any duplicate entries. A handle to the new node will be returned in `pGraphNode`.

The `cudaKernelNodeParams` structure is defined as:

```c
typedef struct cudaKernelNodeParams {
    // structure fields...
} cudaKernelNodeParams;
```
When the graph is launched, the node will invoke kernel `func` on a \((gridDim.x \times gridDim.y \times gridDim.z)\) grid of blocks. Each block contains \((blockDim.x \times blockDim.y \times blockDim.z)\) threads.

`sharedMem` sets the amount of dynamic shared memory that will be available to each thread block.

**Kernel parameters to `func` can be specified in one of two ways:**

1) Kernel parameters can be specified via `kernelParams`. If the kernel has \(N\) parameters, then `kernelParams` needs to be an array of \(N\) pointers. Each pointer, from `kernelParams[0]` to `kernelParams[N-1]`, points to the region of memory from which the actual parameter will be copied. The number of kernel parameters and their offsets and sizes do not need to be specified as that information is retrieved directly from the kernel's image.

2) Kernel parameters can also be packaged by the application into a single buffer that is passed in via `extra`. This places the burden on the application of knowing each kernel parameter's size and alignment/padding within the buffer. The `extra` parameter exists to allow this function to take additional less commonly used arguments. `extra` specifies a list of names of extra settings and their corresponding values. Each extra setting name is immediately followed by the corresponding value. The list must be terminated with either `NULL` or `CU_LAUNCH_PARAM_END`.

- `CU_LAUNCH_PARAM_END`, which indicates the end of the `extra` array;
- `CU_LAUNCH_PARAM_BUFFER_POINTER`, which specifies that the next value in `extra` will be a pointer to a buffer containing all the kernel parameters for launching kernel `func`;
- `CU_LAUNCH_PARAM_BUFFER_SIZE`, which specifies that the next value in `extra` will be a pointer to a `size_t` containing the size of the buffer specified with `CU_LAUNCH_PARAM_BUFFER_POINTER`;

The error `cudaErrorInvalidValue` will be returned if kernel parameters are specified with both `kernelParams` and `extra` (i.e. both `kernelParams` and `extra` are non-NULL).

The `kernelParams` or `extra` array, as well as the argument values it points to, are copied during this call.

---

**Note:**

Kernels launched using graphs must not use texture and surface references. Reading or writing through any texture or surface reference is undefined behavior. This restriction does not apply to texture and surface objects.
Note:

- Graph objects are not thread-safe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback.

See also:

`cudaGraphAddNode`, `cudaLaunchKernel`, `cudaGraphKernelNodeGetParams`,
`cudaGraphKernelNodeSetParams`, `cudaGraphCreate`, `cudaGraphDestroyNode`,
`cudaGraphAddChildGraphNode`, `cudaGraphAddEmptyNode`, `cudaGraphAddHostNode`,
`cudaGraphAddMemcpyNode`, `cudaGraphAddMemsetNode`

```c
__host__ cudaError_t cudaGraphAddMemAllocNode(
    cudaGraphNode_t *pGraphNode, cudaGraph_t graph,
    const cudaGraphNode_t *pDependencies,
    size_t numDependencies, cudaMemAllocNodeParams *nodeParams)
```

Creates an allocation node and adds it to a graph.

Parameters

- **pGraphNode**
  - Returns newly created node
- **graph**
  - Graph to which to add the node
- **pDependencies**
  - Dependencies of the node
- **numDependencies**
  - Number of dependencies
- **nodeParams**
  - Parameters for the node

Returns

`cudaSuccess`, `cudaErrorCudartUnloading`, `cudaErrorInitializationError`, `cudaErrorNotSupported`,
`cudaErrorInvalidValue`, `cudaErrorOutOfMemory`
Description

Creates a new allocation node and adds it to graph with `numDependencies` dependencies specified via `pDependencies` and arguments specified in `nodeParams`. It is possible for `numDependencies` to be 0, in which case the node will be placed at the root of the graph. `pDependencies` may not have any duplicate entries. A handle to the new node will be returned in `pGraphNode`.

When `cudaGraphAddMemAllocNode` creates an allocation node, it returns the address of the allocation in `nodeParams.dptr`. The allocation's address remains fixed across instantiations and launches.

If the allocation is freed in the same graph, by creating a free node using `cudaGraphAddMemFreeNode`, the allocation can be accessed by nodes ordered after the allocation node but before the free node. These allocations cannot be freed outside the owning graph, and they can only be freed once in the owning graph.

If the allocation is not freed in the same graph, then it can be accessed not only by nodes in the graph which are ordered after the allocation node, but also by stream operations ordered after the graph's execution but before the allocation is freed.

Allocations which are not freed in the same graph can be freed by:

- passing the allocation to `cudaMemFreeAsync` or `cudaMemFree`;
- launching a graph with a free node for that allocation; or
- specifying `cudaGraphInstantiateFlagAutoFreeOnLaunch` during instantiation, which makes each launch behave as though it called `cudaMemFreeAsync` for every unfreed allocation.

It is not possible to free an allocation in both the owning graph and another graph. If the allocation is freed in the same graph, a free node cannot be added to another graph. If the allocation is freed in another graph, a free node can no longer be added to the owning graph.

The following restrictions apply to graphs which contain allocation and/or memory free nodes:

- Nodes and edges of the graph cannot be deleted.
- The graph cannot be used in a child node.
- Only one instantiation of the graph may exist at any point in time.
- The graph cannot be cloned.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.

See also:

`cudaGraphAddNode`, `cudaGraphAddMemFreeNode`, `cudaGraphMemAllocNodeGetParams`, `cudaDeviceGraphMemTrim`, `cudaDeviceGetGraphMemAttribute`, `cudaDeviceSetGraphMemAttribute`. 
__host__ cudaError_t cudaGraphAddMemcpyNode (cudaGraphNode_t *pGraphNode, cudaGraph_t graph, const cudaGraphNode_t *pDependencies, size_t numDependencies, const cudaMemcpy3DParms *pCopyParams)

Creates a memcpy node and adds it to a graph.

Parameters

pGraphNode
- Returns newly created node

graph
- Graph to which to add the node

pDependencies
- Dependencies of the node

numDependencies
- Number of dependencies

pCopyParams
- Parameters for the memory copy

Returns

cudaSuccess, cudaErrorInvalidValue

Description

Creates a new memcpy node and adds it to graph with numDependencies dependencies specified via pDependencies. It is possible for numDependencies to be 0, in which case the node will be placed at the root of the graph. pDependencies may not have any duplicate entries. A handle to the new node will be returned in pGraphNode.

When the graph is launched, the node will perform the memcpy described by pCopyParams. See cudaMemcpy3D() for a description of the structure and its restrictions.

Memcpy nodes have some additional restrictions with regards to managed memory, if the system contains at least one device which has a zero value for the device attribute cudaDevAttrConcurrentManagedAccess.
__host__ cudaError_t cudaGraphAddMemcpyNode1D (cudaGraphNode_t *pGraphNode, cudaGraph_t graph, const cudaGraphNode_t *pDependencies, size_t numDependencies, void *dst, const void *src, size_t count, cudaMemcpyKind kind)

Creates a 1D memcpy node and adds it to a graph.

**Parameters**

**pGraphNode**
- Returns newly created node

**graph**
- Graph to which to add the node

**pDependencies**
- Dependencies of the node

**numDependencies**
- Number of dependencies

**dst**
- Destination memory address

**src**
- Source memory address

**count**
- Size in bytes to copy
kind
- Type of transfer

Returns
cudaSuccess, cudaErrorInvalidValue

Description
Creates a new 1D memcpy node and adds it to graph with numDependencies dependencies specified via pDependencies. It is possible for numDependencies to be 0, in which case the node will be placed at the root of the graph. pDependencies may not have any duplicate entries. A handle to the new node will be returned in pGraphNode.

When the graph is launched, the node will copy count bytes from the memory area pointed to by src to the memory area pointed to by dst, where kind specifies the direction of the copy, and must be one of cudaMemcpyHostToHost, cudaMemcpyHostToDevice, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing. Launching a memcpy node with dst and src pointers that do not match the direction of the copy results in an undefined behavior.

Memcpy nodes have some additional restrictions with regards to managed memory, if the system contains at least one device which has a zero value for the device attribute cudaDevAttrConcurrentManagedAccess.

Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpyDefault no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaMemcpy, cudaGraphAddMemcpyNode, cudaGraphMemcpyNodeGetParams, cudaGraphMemcpyNodeSetParams, cudaGraphMemcpyNodeSetParams1D, cudaGraphCreate, cudaGraphDestroyNode, cudaGraphAddChildGraphNode, cudaGraphAddEmptyNode, cudaGraphAddKernelNode, cudaGraphAddHostNode, cudaGraphAddMemsetNode
__host__ cudaError_t

cudaGraphAddMemcpyNodeFromSymbol
(cudaGraphNode_t *pGraphNode, cudaGraph_t graph,
const cudaGraphNode_t *pDependencies, size_t
numDependencies, void *dst, const void *symbol, size_t
count, size_t offset, cudaMemcpyKind kind)

Creates a memcpy node to copy from a symbol on the device and adds it to a graph.

Parameters

pGraphNode
  - Returns newly created node

graph
  - Graph to which to add the node

pDependencies
  - Dependencies of the node

numDependencies
  - Number of dependencies

dst
  - Destination memory address

symbol
  - Device symbol address

count
  - Size in bytes to copy

offset
  - Offset from start of symbol in bytes

kind
  - Type of transfer

Returns

cudaSuccess, cudaErrorInvalidValue

Description

Creates a new memcpy node to copy from symbol and adds it to graph with numDependencies dependencies specified via pDependencies. It is possible for numDependencies to be 0, in which case the node will be placed at the root of the graph. pDependencies may not have any duplicate entries. A handle to the new node will be returned in pGraphNode.

When the graph is launched, the node will copy count bytes from the memory area pointed to by offset bytes from the start of symbol symbol to the memory area pointed to by dst. The memory
areas may not overlap. symbol is a variable that resides in global or constant memory space. kind can be either cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing.

Memcpy nodes have some additional restrictions with regards to managed memory, if the system contains at least one device which has a zero value for the device attribute cudaDevAttrConcurrentManagedAccess.

Note:

‣ Graph objects are not threadsafe. More here.
‣ Note that this function may also return error codes from previous, asynchronous launches.
‣ Note that this function may also return cudaMemcpyInitializationError, cudaMemcpyInsufficientDriver or cudaMemcpyNoDevice if this call tries to initialize internal CUDA RT state.
‣ Note that as specified by cudaMemcpyDefault no CUDA function may be called from callback. cudaMemcpyNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

c__host__ cudaError_t
cudaGraphAddMemcpyNodeToSymbol (cudaGraphNode_t *pGraphNode, cudaGraph_t graph, const cudaGraphNode_t *pDependencies, size_t numDependencies, const void *symbol, const void *src, size_t count, size_t offset, cudaMemcpyKind kind)

Creates a memcpy node to copy to a symbol on the device and adds it to a graph.

Parameters

pGraphNode
  - Returns newly created node
graph
  - Graph to which to add the node
pDependencies
  - Dependencies of the node
numDependencies
  - Number of dependencies
symbol
  - Device symbol address
src
  - Source memory address
count
  - Size in bytes to copy
offset
  - Offset from start of symbol in bytes
kind
  - Type of transfer

Returns
  cudaSuccess, cudaErrorInvalidValue

Description

Creates a new memcpy node to copy to symbol and adds it to graph with numDependencies dependencies specified via pDependencies. It is possible for numDependencies to be 0, in which case the node will be placed at the root of the graph. pDependencies may not have any duplicate entries. A handle to the new node will be returned in pGraphNode.

When the graph is launched, the node will copy count bytes from the memory area pointed to by src to the memory area pointed to by offset bytes from the start of symbol symbol. The memory areas may not overlap. symbol is a variable that resides in global or constant memory space. kind can be either cudaMemcpyHostToDevice, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing.

Memcpy nodes have some additional restrictions with regards to managed memory, if the system contains at least one device which has a zero value for the device attribute cudaDevAttrConcurrentManagedAccess.

Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.

Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
`cudaMemcpyToSymbol`, `cudaGraphAddMemcpyNode`, `cudaGraphAddMemcpyNodeFromSymbol`,
`cudaGraphMemcpyNodeGetParams`, `cudaGraphMemcpyNodeSetParams`,
`cudaGraphMemcpyNodeSetParamsToSymbol`, `cudaGraphMemcpyNodeSetParamsFromSymbol`,
`cudaGraphCreate`, `cudaGraphDestroyNode`, `cudaGraphAddChildGraphNode`,
`cudaGraphAddEmptyNode`, `cudaGraphAddKernelNode`, `cudaGraphAddHostNode`,
`cudaGraphAddMemsetNode`

```c
__host__ cudaError_t cudaGraphAddMemFreeNode(cudaGraphNode_t *pGraphNode, cudaGraph_t graph, const cudaGraphNode_t *pDependencies, size_t numDependencies, void *dptr)
```

Creates a memory free node and adds it to a graph.

**Parameters**

- **pGraphNode**
  - Returns newly created node
- **graph**
  - Graph to which to add the node
- **pDependencies**
  - Dependencies of the node
- **numDependencies**
  - Number of dependencies
- **dptr**
  - Address of memory to free

**Returns**

`cudaSuccess`, `cudaErrorCudartUnloading`, `cudaErrorInitializationError`, `cudaErrorNotSupported`,
`cudaErrorInvalidValue`, `cudaErrorOutOfMemory`

**Description**

Creates a new memory free node and adds it to `graph` with `numDependencies` dependencies specified via `pDependencies` and address specified in `dptr`. It is possible for `numDependencies` to be 0, in which case the node will be placed at the root of the graph.
pDependencies may not have any duplicate entries. A handle to the new node will be returned in pGraphNode.

cudaGraphAddMemFreeNode will return cudaErrorInvalidValue if the user attempts to free:

- an allocation twice in the same graph.
- an address that was not returned by an allocation node.
- an invalid address.

The following restrictions apply to graphs which contain allocation and/or memory free nodes:

- Nodes and edges of the graph cannot be deleted.
- The graph cannot be used in a child node.
- Only one instantiation of the graph may exist at any point in time.
- The graph cannot be cloned.

**Note:**

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.

See also:

cudaGraphAddNode, cudaGraphAddMemAllocNode, cudaGraphMemFreeNodeGetParams, cudaDeviceGraphMemTrim, cudaDeviceGetGraphMemAttribute, cudaDeviceSetGraphMemAttribute, cudaMallocAsync, cudaFreeAsync, cudaGraphCreate, cudaGraphDestroyNode, cudaGraphAddChildGraphNode, cudaGraphAddEmptyNode, cudaGraphAddEventRecordNode, cudaGraphAddEventWaitNode, cudaGraphAddExternalSemaphoresSignalNode, cudaGraphAddExternalSemaphoresWaitNode, cudaGraphAddKernelNode, cudaGraphAddMemcpyNode, cudaGraphAddMemsetNode

__host__ cudaError_t cudaGraphAddMemsetNode (cudaGraphNode_t *pGraphNode, cudaGraph_t graph, const cudaGraphNode_t *pDependencies, size_t numDependencies, const cudaMemsetParams *pMemsetParams)

Creates a memset node and adds it to a graph.

**Parameters**

**pGraphNode**

- Returns newly created node
**graph**
- Graph to which to add the node

**pDependencies**
- Dependencies of the node

**numDependencies**
- Number of dependencies

**pMemsetParams**
- Parameters for the memory set

**Returns**
- `cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorInvalidDevice`

**Description**

Creates a new memset node and adds it to `graph` with `numDependencies` dependencies specified via `pDependencies`. It is possible for `numDependencies` to be 0, in which case the node will be placed at the root of the `graph`. `pDependencies` may not have any duplicate entries. A handle to the new node will be returned in `pGraphNode`.

The element size must be 1, 2, or 4 bytes. When the graph is launched, the node will perform the memset described by `pMemsetParams`.

**Note:**
- Graph objects are not threadsafe. [More here.](#)
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
- `cudaGraphAddNode`, `cudaMemset2D`, `cudaGraphMemsetNodeGetParams`, `cudaGraphMemsetNodeSetParams`, `cudaGraphCreate`, `cudaGraphDestroyNode`, `cudaGraphAddChildGraphNode`, `cudaGraphAddEmptyNode`, `cudaGraphAddKernelNode`, `cudaGraphAddHostNode`, `cudaGraphAddMemcpyNode`
__host__ cudaError_t cudaGraphAddNode
cudaGraphNode_t *pGraphNode, cudaGraph_t graph,
const cudaGraphNode_t *pDependencies, size_t
numDependencies, cudaGraphNodeParams *nodeParams)

Adds a node of arbitrary type to a graph.

Parameters

pGraphNode
- Returns newly created node

graph
- Graph to which to add the node

pDependencies
- Dependencies of the node

numDependencies
- Number of dependencies

nodeParams
- Specification of the node

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidDeviceFunction, cudaErrorNotSupported

Description

Creates a new node in graph described by nodeParams with numDependencies dependencies
specified via pDependencies. numDependencies may be 0. pDependencies may be null if
numDependencies is 0. pDependencies may not have any duplicate entries.

nodeParams is a tagged union. The node type should be specified in the type field, and type-
specific parameters in the corresponding union member. All unused bytes - that is, reserved0
and all bytes past the utilized union member - must be set to zero. It is recommended to use brace
initialization or memset to ensure all bytes are initialized.

Note that for some node types, nodeParams may contain "out parameters" which are modified during
the call, such as nodeParams->alloc.dptr.

A handle to the new node will be returned in pGraphNode.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.

Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
`cudaGraphCreate`, `cudaGraphNodeSetParams`, `cudaGraphExecNodeSetParams`

```c
__host__ cudaError_t cudaGraphAddNode_v2
(cudaGraphNode_t *pGraphNode, cudaGraph_t graph, const cudaGraphNode_t *pDependencies,
 const cudaGraphEdgeData *dependencyData, size_t numDependencies, cudaGraphNodeParams *nodeParams)
```

Adds a node of arbitrary type to a graph (12.3+).

**Parameters**

- `pGraphNode` - Returns newly created node
- `graph` - Graph to which to add the node
- `pDependencies` - Dependencies of the node
- `dependencyData` - Optional edge data for the dependencies. If NULL, the data is assumed to be default (zeroed) for all dependencies.
- `numDependencies` - Number of dependencies
- `nodeParams` - Specification of the node

**Returns**

`cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorInvalidDeviceFunction`, `cudaErrorNotSupported`

**Description**

Creates a new node in `graph` described by `nodeParams` with `numDependencies` dependencies specified via `pDependencies`. `numDependencies` may be 0, `pDependencies` may be null if `numDependencies` is 0. `pDependencies` may not have any duplicate entries.
nodeParams is a tagged union. The node type should be specified in the type field, and type-specific parameters in the corresponding union member. All unused bytes - that is, reserved0 and all bytes past the utilized union member - must be set to zero. It is recommended to use brace initialization or memset to ensure all bytes are initialized.

Note that for some node types, nodeParams may contain "out parameters" which are modified during the call, such as nodeParams->alloc.dptr.

A handle to the new node will be returned in phGraphNode.

See also:
cudaGraphCreate, cudaGraphNodeSetParams, cudaGraphExecNodeSetParams

__host__ cudaError_t cudaGraphChildGraphNodeGetGraph (cudaGraphNode_t node, cudaGraph_t *pGraph)

Gets a handle to the embedded graph of a child graph node.

Parameters
node - Node to get the embedded graph for
pGraph - Location to store a handle to the graph

Returns
cudaSuccess, cudaErrorInvalidValue

Description
Gets a handle to the embedded graph in a child graph node. This call does not clone the graph. Changes to the graph will be reflected in the node, and the node retains ownership of the graph.

Allocation and free nodes cannot be added to the returned graph. Attempting to do so will return an error.
Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cuErrorInitializationError, cuErrorInsufficientDriver or cuErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cuErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaGraphAddChildGraphNode, cudaGraphNodeFindInClone

```c
__host__ cudaError_t cudaGraphClone (cudaGraph_t *pGraphClone, cudaGraph_t originalGraph)
```

Clones a graph.

Parameters

- **pGraphClone**
  - Returns newly created cloned graph
- **originalGraph**
  - Graph to clone

Returns

- cudaSuccess, cuErrorInvalidValue, cuErrorMemoryAllocation

Description

This function creates a copy of originalGraph and returns it in pGraphClone. All parameters are copied into the cloned graph. The original graph may be modified after this call without affecting the clone.

Child graph nodes in the original graph are recursively copied into the clone.
Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cudaGraphCreate`, `cudaGraphNodeFindInClone`

```c
__host__ cudaError_t cudaGraphConditionalHandleCreate (cudaGraphConditionalHandle *pHandle_out, cudaGraph_t graph, unsigned int defaultLaunchValue, unsigned int flags)
```

Create a conditional handle.

**Parameters**

- **pHandle_out**
  - Pointer used to return the handle to the caller.
- **graph**
- **defaultLaunchValue**
  - Optional initial value for the conditional variable.
- **flags**
  - Currently must be `cudaGraphCondAssignDefault` or 0.

**Returns**

`CUDA_SUCCESS`, `CUDA_ERROR_INVALID_VALUE`, `CUDA_ERROR_NOT_SUPPORTED`

**Description**

Creates a conditional handle associated with `hGraph`.

The conditional handle must be associated with a conditional node in this graph or one of its children. Handles not associated with a conditional node may cause graph instantiation to fail.

**Note:**

- Graph objects are not threadsafe. [More here.](#)
- Note that this function may also return error codes from previous, asynchronous launches.

See also:

`cuGraphAddNode`. 
__host__ cudaError_t cudaGraphCreate (cudaGraph_t *pGraph, unsigned int flags)

Creates a graph.

Parameters

pGraph
- Returns newly created graph

flags
- Graph creation flags, must be 0

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorMemoryAllocation

Description

Creates an empty graph, which is returned via pGraph.

Note:
- Graph objects are not threadsafe. [More here.](#)
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphAddChildGraphNode, cudaGraphAddEmptyNode, cudaGraphAddKernelNode,
cudaGraphAddHostNode, cudaGraphAddMemcpyNode, cudaGraphAddMemsetNode,
cudaGraphInstantiate, cudaGraphDestroy, cudaGraphGetNodes, cudaGraphGetRootNodes,
cudaGraphGetEdges, cudaGraphClone
__host__ cudaError_t cudaGraphDebugDotPrint (cudaGraph_t graph, const char *path, unsigned int flags)
Write a DOT file describing graph structure.

Parameters

graph
- The graph to create a DOT file from

path
- The path to write the DOT file to

flags
- Flags from cudaGraphDebugDotFlags for specifying which additional node information to write

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorOperatingSystem

Description

Using the provided graph, write to path a DOT formatted description of the graph. By default this includes the graph topology, node types, node id, kernel names and memcpy direction. flags can be specified to write more detailed information about each node type such as parameter values, kernel attributes, node and function handles.

__host__ cudaError_t cudaGraphDestroy (cudaGraph_t graph)
Destroys a graph.

Parameters

graph
- Graph to destroy

Returns

cudaSuccess, cudaErrorInvalidValue

Description

Destroys the graph specified by graph, as well as all of its nodes.

Note:
- Graph objects are not threadsafe. More here.
__host__ cudaError_t cudaGraphDestroyNode (cudaGraphNode_t node)

Remove a node from the graph.

Parameters

node
  - Node to remove

Returns

cudaSuccess, cudaErrorInvalidValue

Description

Removes node from its graph. This operation also severs any dependencies of other nodes on node and vice versa.

Dependencies cannot be removed from graphs which contain allocation or free nodes. Any attempt to do so will return an error.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
- Use of the handle after this call is undefined behavior.

See also:

cudaGraphCreate

cudaErrorInitializationError, cudaErrorInsufficientDriver, cudaErrorNoDevice
cudaGraphAddChildGraphNode, cudaGraphAddEmptyNode, cudaGraphAddKernelNode, cudaGraphAddHostNode, cudaGraphAddMemcpyNode, cudaGraphAddMemsetNode

__host__ cudaError_t
cudaGraphEventRecordNodeGetEvent (cudaGraphNode_t node, cudaEvent_t *event_out)

Returns the event associated with an event record node.

Parameters

node
event_out
  - Pointer to return the event

Returns
cudaSuccess, cudaErrorInvalidValue

Description

Returns the event of event record node hNode in event_out.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphAddEventRecordNode, cudaGraphEventRecordNodeGetEvent, cudaGraphEventWaitNodeGetEvent, cudaEventRecordWithFlags, cudaStreamWaitEvent
__host__ cudaError_t

`cudaGraphEventRecordNodeSetEvent (cudaGraphNode_t node, cudaEvent_t event)`

Sets an event record node's event.

**Parameters**

- `node`
- `event`
  - Event to use

**Returns**

- `cudaSuccess`
- `cudaErrorInvalidValue`

**Description**

Sets the event of event record node `hNode` to `event`.

**Note:**

- Graph objects are not threadsafe. [More here](#).
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

- `cudaGraphNodeSetParams`, `cudaGraphAddEventRecordNode`, `cudaGraphEventRecordNodeGetEvent`, `cudaGraphEventWaitNodeSetEvent`, `cudaEventRecordWithFlags`, `cudaStreamWaitEvent`

__host__ cudaError_t

`cudaGraphEventWaitNodeGetEvent (cudaGraphNode_t node, cudaEvent_t *event_out)`

Returns the event associated with an event wait node.

**Parameters**

- `node`
- `event_out`
  - Pointer to return the event
Returns
cudaSuccess, cudaErrorInvalidValue

Description
Returns the event of event wait node hNode in event_out.

Note:
- Graph objects are not thread safe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphAddEventWaitNode, cudaGraphEventWaitNodeSetEvent,
cudaGraphEventRecordNodeGetEvent, cudaEventRecordWithFlags, cudaStreamWaitEvent

__host__ cudaError_t cudaGraphEventWaitNodeSetEvent (cudaGraphNode_t node, cudaEvent_t event)
Sets an event wait node's event.

Parameters
node
event
- Event to use

Returns
cudaSuccess, cudaErrorInvalidValue

Description
Sets the event of event wait node hNode to event.
Note that this function may also return error codes from previous, asynchronous launches.

Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.

Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphNodeSetParams, cudaGraphAddEventWaitNode, cudaGraphEventWaitNodeGetEvent, cudaGraphEventRecordNodeSetEvent, cudaEventRecordWithFlags, cudaStreamWaitEvent

__host__ cudaError_t
cudaGraphExecChildGraphGraphNodeSetParams
(cudaGraphExec_t hGraphExec, cudaGraphNode_t node, cudaGraph_t childGraph)
Updates node parameters in the child graph node in the given graphExec.

Parameters

hGraphExec
- The executable graph in which to set the specified node

node
- Host node from the graph which was used to instantiate graphExec

childGraph
- The graph supplying the updated parameters

Returns
cudaSuccess, cudaErrorInvalidValue.

Description

Updates the work represented by node in hGraphExec as though the nodes contained in node's graph had the parameters contained in childGraph's nodes at instantiation. node must remain in the graph which was used to instantiate hGraphExec. Changed edges to and from node are ignored.

The modifications only affect future launches of hGraphExec. Already enqueued or running launches of hGraphExec are not affected by this call. node is also not modified by this call.

The topology of childGraph, as well as the node insertion order, must match that of the graph contained in node. See cudaGraphExecUpdate() for a list of restrictions on what can be updated in an instantiated graph. The update is recursive, so child graph nodes contained within the top level child graph will also be updated.
Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
- `cudaGraphExecNodeSetParams`, `cudaGraphAddChildGraphNode`
- `cudaGraphChildGraphNodeGetGraph`, `cudaGraphExecKernelNodeSetParams`
- `cudaGraphExecMemcpyNodeSetParams`, `cudaGraphExecMemsetNodeSetParams`
- `cudaGraphExecHostNodeSetParams`, `cudaGraphExecEventRecordNodeSetEvent`
- `cudaGraphExecEventWaitNodeSetEvent`, `cudaGraphExecExternalSemaphoresSignalNodeSetParams`
- `cudaGraphExecExternalSemaphoresWaitNodeSetParams`, `cudaGraphExecUpdate`, `cudaGraphInstantiate`

```c
__host__ cudaError_t cudaGraphExecDestroy(cudaGraphExec_t graphExec)
```

Destroys an executable graph.

**Parameters**

- `graphExec` - Executable graph to destroy

**Returns**

- `cudaSuccess`, `cudaErrorInvalidValue`

**Description**

Destroys the executable graph specified by `graphExec`.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

Use of the handle after this call is undefined behavior.

See also:
`cudaGraphInstantiate`, `cudaGraphUpload`, `cudaGraphLaunch`

```c
__host__ cudaError_t
cudaGraphExecEventRecordNodeSetEvent
  (cudaGraphExec_t hGraphExec, cudaGraphNode_t hNode, cudaEvent_t event)
```

Sets the event for an event record node in the given graphExec.

**Parameters**

- **hGraphExec**
  - The executable graph in which to set the specified node
- **hNode**
  - Event record node from the graph from which graphExec was instantiated
- **event**
  - Updated event to use

**Returns**

`cudaSuccess`, `cudaErrorInvalidValue`.

**Description**

Sets the event of an event record node in an executable graph `hGraphExec`. The node is identified by the corresponding node `hNode` in the non-executable graph, from which the executable graph was instantiated.

The modifications only affect future launches of `hGraphExec`. Already enqueued or running launches of `hGraphExec` are not affected by this call. `hNode` is also not modified by this call.

**Note:**

- Graph objects are not threadsafe. [More here.](#)
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

- `cudaGraphExecNodeSetParams`
- `cudaGraphAddEventRecordNode`
- `cudaGraphEventRecordNodeGetEvent`
- `cudaGraphEventWaitNodeSetEvent`
- `cudaEventRecordWithFlags`
- `cudaStreamWaitEvent`
- `cudaGraphExecKernelNodeSetParams`
- `cudaGraphExecMemcpyNodeSetParams`
- `cudaGraphExecMemsetNodeSetParams`
- `cudaGraphExecHostNodeSetParams`
- `cudaGraphExecChildGraphNodeSetParams`
- `cudaGraphExecMemcpyNodeSetParams`
- `cudaGraphExecMemsetNodeSetParams`
- `cudaGraphExecHostNodeSetParams`
- `cudaGraphEventWaitNodeSetEvent`
- `cudaGraphExecMemcpyNodeSetParams`
- `cudaGraphExecMemsetNodeSetParams`
- `cudaGraphExecHostNodeSetParams`
- `cudaGraphExecChildGraphNodeSetParams`
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- `cudaGraphExecMemsetNodeSetParams`
Graph objects are not threadsafe. More here.
Note that this function may also return error codes from previous, asynchronous launches.
Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphExecNodeSetParams, cudaGraphAddEventWaitNode, cudaGraphEventWaitNodeGetEvent, cudaGraphEventRecordNodeSetEvent, cudaEventRecordWithFlags, cudaStreamWaitEvent, cudaGraphExecKernelNodeSetParams, cudaGraphExecMemcpyNodeSetParams, cudaGraphExecMemsetNodeSetParams, cudaGraphExecHostNodeSetParams, cudaGraphExecChildGraphNodeSetParams, cudaGraphExecEventRecordNodeSetEvent, cudaGraphExecExternalSemaphoresSignalNodeSetParams, cudaGraphExecExternalSemaphoresWaitNodeSetParams, cudaGraphExecUpdate, cudaGraphInstantiate

__host__ cudaError_t cudaGraphExecExternalSemaphoresSignalNodeSetParams (cudaGraphExec_t hGraphExec, cudaGraphNode_t hNode, const cudaExternalSemaphoreSignalNodeParams *nodeParams)
Sets the parameters for an external semaphore signal node in the given graphExec.

Parameters

hGraphExec
- The executable graph in which to set the specified node

hNode
- semaphore signal node from the graph from which graphExec was instantiated

nodeParams
- Updated Parameters to set

Returns
cudaSuccess, cudaErrorInvalidValue.
Description

Sets the parameters of an external semaphore signal node in an executable graph `hGraphExec`. The node is identified by the corresponding node `hNode` in the non-executable graph, from which the executable graph was instantiated.

`hNode` must not have been removed from the original graph.

The modifications only affect future launches of `hGraphExec`. Already enqueued or running launches of `hGraphExec` are not affected by this call. `hNode` is also not modified by this call. Changing `nodeParams->numExtSems` is not supported.

Note:
- Graph objects are not threadsafe. [More here.](#)
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
- `cudaGraphExecNodeSetParams`, `cudaGraphAddExternalSemaphoresSignalNode`,
- `cudaImportExternalSemaphore`, `cudaSignalExternalSemaphoresAsync`,
- `cudaWaitExternalSemaphoresAsync`, `cudaGraphExecKernelNodeSetParams`,
- `cudaGraphExecMemcpyNodeSetParams`, `cudaGraphExecMemsetNodeSetParams`,
- `cudaGraphExecHostNodeSetParams`, `cudaGraphExecChildGraphNodeSetParams`,
- `cudaGraphExecEventRecordNodeSetEvent`, `cudaGraphExecEventWaitNodeSetEvent`,
- `cudaGraphExecExternalSemaphoresWaitNodeSetParams`, `cudaGraphExecUpdate`,
- `cudaGraphInstantiate`
__host__ cudaError_t

cudaGraphExecExternalSemaphoresWaitNodeSetParams
(cudaGraphExec_t hGraphExec, cudaGraphNode_t hNode, const cudaExternalSemaphoreWaitNodeParams *nodeParams)

Sets the parameters for an external semaphore wait node in the given graphExec.

Parameters

hGraphExec
- The executable graph in which to set the specified node

hNode
- semaphore wait node from the graph from which graphExec was instantiated

nodeParams
- Updated Parameters to set

Returns
cudaSuccess, cudaErrorInvalidValue.

Description

Sets the parameters of an external semaphore wait node in an executable graph hGraphExec. The node is identified by the corresponding node hNode in the non-executable graph, from which the executable graph was instantiated.

hNode must not have been removed from the original graph.

The modifications only affect future launches of hGraphExec. Already enqueued or running launches of hGraphExec are not affected by this call. hNode is also not modified by this call.

Changing nodeParams->numExtSems is not supported.

Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
See also:

cudaGraphExecNodeSetParams, cudaGraphAddExternalSemaphoresWaitNode,
cudaImportExternalSemaphore, cudaSignalExternalSemaphoresAsync,
cudaWaitExternalSemaphoresAsync, cudaGraphExecKernelNodeSetParams,
cudaGraphExecMemcpyNodeSetParams, cudaGraphExecMemsetNodeSetParams,
cudaGraphExecHostNodeSetParams, cudaGraphExecChildGraphNodeSetParams,
cudaGraphExecEventRecordNodeSetEvent, cudaGraphExecEventWaitNodeSetEvent,
cudaGraphExecExternalSemaphoresSignalNodeSetParams, cudaGraphExecUpdate,
cudaGraphInstantiate

__host__ cudaError_t cudaGraphExecGetFlags
(cudaGraphExec_t graphExec, unsigned long long *flags)

Query the instantiation flags of an executable graph.

**Parameters**

*graphExec*
- The executable graph to query

*flags*
- Returns the instantiation flags

**Returns**

cudaSuccess, cudaErrorInvalidValue

**Description**

Returns the flags that were passed to instantiation for the given executable graph.
 cudaGraphInstantiateFlagUpload will not be returned by this API as it does not affect the resulting executable graph.

**Note:**

- Graph objects are not threadsafe. [More here](#).
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
__host__ cudaError_t cudaGraphExecHostNodeSetParams (cudaGraphExec_t hGraphExec, cudaGraphNode_t node, const cudaHostNodeParams *pNodeParams)

Sets the parameters for a host node in the given graphExec.

Parameters

**hGraphExec**
- The executable graph in which to set the specified node

**node**
- Host node from the graph which was used to instantiate graphExec

**pNodeParams**
- Updated Parameters to set

Returns

cudaSuccess, cudaErrorInvalidValue.

Description

Updates the work represented by node in hGraphExec as though node had contained pNodeParams at instantiation. node must remain in the graph which was used to instantiate hGraphExec. Changed edges to and from node are ignored.

The modifications only affect future launches of hGraphExec. Already enqueued or running launches of hGraphExec are not affected by this call. node is also not modified by this call.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpy, no CUDA function may be called from callback. cudaErrorNotAllowed may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphExecNodeSetParams, cudaGraphAddHostNode, cudaGraphHostNodeSetParams, cudaGraphExecKernelNodeSetParams, cudaGraphExecMemcpyNodeSetParams, cudaGraphExecMemsetNodeSetParams, cudaGraphExecChildGraphNodeSetParams, cudaGraphExecEventRecordNodeSetEvent, cudaGraphExecEventWaitNodeSetEvent, cudaGraphExecExternalSemaphoresSignalNodeSetParams,
__host__ cudaError_t cudaGraphExecKernelNodeSetParams (cudaGraphExec_t hGraphExec, cudaGraphNode_t node, const cudaKernelNodeParams *pNodeParams)
Sets the parameters for a kernel node in the given graphExec.

Parameters

hGraphExec
- The executable graph in which to set the specified node

node
- kernel node from the graph from which graphExec was instantiated

pNodeParams
- Updated Parameters to set

Returns
cudaSuccess, cudaErrorInvalidValue.

Description

Sets the parameters of a kernel node in an executable graph hGraphExec. The node is identified by the corresponding node node in the non-executable graph, from which the executable graph was instantiated.

node must not have been removed from the original graph. All nodeParams fields may change, but the following restrictions apply to func updates:

- The owning device of the function cannot change.
- A node whose function originally did not use CUDA dynamic parallelism cannot be updated to a function which uses CDP
- A node whose function originally did not make device-side update calls cannot be updated to a function which makes device-side update calls.
- If hGraphExec was not instantiated for device launch, a node whose function originally did not use device-side cudaGraphLaunch() cannot be updated to a function which uses device-side cudaGraphLaunch() unless the node resides on the same device as nodes which contained such calls at instantiate-time. If no such calls were present at instantiation, these updates cannot be performed at all.

The modifications only affect future launches of hGraphExec. Already enqueued or running launches of hGraphExec are not affected by this call. node is also not modified by this call.
If node is a device-updatable kernel node, the next upload/launch of hGraphExec will overwrite any previous device-side updates. Additionally, applying host updates to a device-updatable kernel node while it is being updated from the device will result in undefined behavior.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpy3D the function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaGraphExecNodeSetParams, cudaGraphAddKernelNode,
cudaGraphKernelNodeSetParams, cudaGraphExecMemcpyNodeSetParams,
cudaGraphExecMemsetNodeSetParams, cudaGraphExecHostNodeSetParams,
cudaGraphExecChildGraphNodeSetParams, cudaGraphExecEventRecordNodeSetEvent,
cudaGraphExecEventWaitNodeSetEvent, cudaGraphExecExternalSemaphoresSignalNodeSetParams,
cudaGraphExecExternalSemaphoresWaitNodeSetParams, cudaGraphExecUpdate,
cudaGraphInstantiate

__host__ cudaError_t
cudaGraphExecMemcpyNodeSetParams
(cudaGraphExec_t hGraphExec, cudaGraphNode_t node,
const cudaMemcpy3DParms *pNodeParams)

Sets the parameters for a memcpy node in the given graphExec.

Parameters

hGraphExec
- The executable graph in which to set the specified node
node
- Mempcy node from the graph which was used to instantiate graphExec
pNodeParams
- Updated Parameters to set

Returns

cudaSuccess, cudaErrorInvalidValue,
Description

Updates the work represented by `node` in `hGraphExec` as though `node` had contained `pNodeParams` at instantiation. `node` must remain in the graph which was used to instantiate `hGraphExec`. Changed edges to and from `node` are ignored.

The source and destination memory in `pNodeParams` must be allocated from the same contexts as the original source and destination memory. Both the instantiation-time memory operands and the memory operands in `pNodeParams` must be 1-dimensional. Zero-length operations are not supported.

The modifications only affect future launches of `hGraphExec`. Already enqueued or running launches of `hGraphExec` are not affected by this call. `node` is also not modified by this call.

Returns `cudaErrorInvalidValue` if the memory operands' mappings changed or either the original or new memory operands are multidimensional.

Note:

- Graph objects are not threadsafe. [More here](#).
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cudaGraphExecNodeSetParams`, `cudaGraphAddMemcpyNode`, `cudaGraphMemcpyNodeSetParams`, `cudaGraphExecMemcpyNodeSetParamsToSymbol`, `cudaGraphExecMemcpyNodeSetParamsFromSymbol`, `cudaGraphExecMemcpyNodeSetParams1D`, `cudaGraphExecKernelNodeSetParams`, `cudaGraphExecMemsetNodeSetParams`, `cudaGraphExecHostNodeSetParams`, `cudaGraphExecChildGraphNodeSetParams`, `cudaGraphExecEventRecordNodeSetEvent`, `cudaGraphExecEventWaitNodeSetEvent`, `cudaGraphExecExternalSemaphoresSignalNodeSetParams`, `cudaGraphExecExternalSemaphoresWaitNodeSetParams`, `cudaGraphExecUpdate`, `cudaGraphInstantiate`
__host__ cudaError_t
CUDA_RUNTIME_API
cudaGraphExecMemcpyNodeSetParams1D
(cudaGraphExec_t hGraphExec, cudaGraphNode_t node,
void *dst, const void *src, size_t count, cudaMemcpyKind kind)

Sets the parameters for a memcpy node in the given graphExec to perform a 1-dimensional copy.

Parameters

hGraphExec
- The executable graph in which to set the specified node

node
- Memcpy node from the graph which was used to instantiate graphExec

dst
- Destination memory address

src
- Source memory address

count
- Size in bytes to copy

kind
- Type of transfer

Returns
cudaSuccess, cudaErrorInvalidValue

Description

Updates the work represented by node in hGraphExec as though node had contained the given
params at instantiation. node must remain in the graph which was used to instantiate hGraphExec.
Changed edges to and from node are ignored.

src and dst must be allocated from the same contexts as the original source and destination memory.
The instantiation-time memory operands must be 1-dimensional. Zero-length operations are not
supported.

The modifications only affect future launches of hGraphExec. Already enqueued or running
launches of hGraphExec are not affected by this call. node is also not modified by this call.

Returns cudaErrorInvalidValue if the memory operands’ mappings changed or the original memory
operands are multidimensional.
__host__ cudaError_t
cudaGraphExecMemcpyNodeSetParamsFromSymbol
cudaGraphExec_t hGraphExec, cudaGraphNode_t node, 
void *dst, const void *symbol, size_t count, size_t offset, 
cudaMemcpyKind kind)
Sets the parameters for a memcpy node in the given graphExec to copy from a symbol on the device.

Parameters

**hGraphExec**
- The executable graph in which to set the specified node

**node**
- Memcpy node from the graph which was used to instantiate graphExec

**dst**
- Destination memory address

**symbol**
- Device symbol address

**count**
- Size in bytes to copy
offset
- Offset from start of symbol in bytes

kind
- Type of transfer

Returns
cudaSuccess, cudaErrorInvalidValue

Description
Updates the work represented by node in hGraphExec as though node had contained the given params at instantiation. node must remain in the graph which was used to instantiate hGraphExec. Changed edges to and from node are ignored.
symbol and dst must be allocated from the same contexts as the original source and destination memory. The instantiation-time memory operands must be 1-dimensional. Zero-length operations are not supported.
The modifications only affect future launches of hGraphExec. Already enqueued or running launches of hGraphExec are not affected by this call. node is also not modified by this call.
Returns cudaErrorInvalidValue if the memory operands' mappings changed or the original memory operands are multidimensional.

Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphAddMemcpyNode, cudaGraphAddMemcpyNodeFromSymbol, cudaGraphMemcpyNodeSetParams, cudaGraphMemcpyNodeSetParamsFromSymbol, cudaGraphExecMemcpyNodeSetParams, cudaGraphExecMemcpyNodeSetParamsToSymbol, cudaGraphExecKernelNodeSetParams, cudaGraphExecMemsetNodeSetParams, cudaGraphExecHostNodeSetParams, cudaGraphExecChildGraphNodeSetParams, cudaGraphExecEventRecordNodeSetEvent, cudaGraphExecEventWaitNodeSetEvent, cudaGraphExecExternalSemaphoresSignalNodeSetParams, cudaGraphExecExternalSemaphoresWaitNodeSetParams, cudaGraphExecUpdate, cudaGraphInstantiate
__host__ cudaError_t

cudaGraphExecMemcpyNodeSetParamsToSymbol

(cudaGraphExec_t hGraphExec, cudaGraphNode_t node,
const void *symbol, const void *src, size_t count, size_t
offset, cudaMemcpyKind kind)

Sets the parameters for a memcpy node in the given graphExec to copy to a symbol on the device.

Parameters

hGraphExec
- The executable graph in which to set the specified node
node
- Memcpy node from the graph which was used to instantiate graphExec
symbol
- Device symbol address
src
- Source memory address
count
- Size in bytes to copy
offset
- Offset from start of symbol in bytes
kind
- Type of transfer

Returns

cudaSuccess, cudaErrorInvalidValue

Description

Updates the work represented by node in hGraphExec as though node had contained the given
params at instantiation. node must remain in the graph which was used to instantiate hGraphExec.
Changed edges to and from node are ignored.

src and symbol must be allocated from the same contexts as the original source and destination
memory. The instantiation-time memory operands must be 1-dimensional. Zero-length operations are
not supported.

The modifications only affect future launches of hGraphExec. Already enqueued or running
launches of hGraphExec are not affected by this call. node is also not modified by this call.

Returns cudaErrorInvalidValue if the memory operands' mappings changed or the original memory
operands are multidimensional.
__host__ cudaError_t
cudaGraphExecMemsetNodeSetParams (cudaGraphExec_t hGraphExec, cudaGraphNode_t node, const cudaMemsetParams *pNodeParams)

Sets the parameters for a memset node in the given graphExec.

Parameters

hGraphExec
- The executable graph in which to set the specified node
node
- Memset node from the graph which was used to instantiate graphExec
pNodeParams
- Updated Parameters to set

Returns

cudaSuccess, cudaErrorInvalidValue,
Description

Updates the work represented by `node` in `hGraphExec` as though `node` had contained `pNodeParams` at instantiation. `node` must remain in the graph which was used to instantiate `hGraphExec`. Changed edges to and from `node` are ignored.

Zero sized operations are not supported.

The new destination pointer in `pNodeParams` must be to the same kind of allocation as the original destination pointer and have the same context association and device mapping as the original destination pointer.

Both the value and pointer address may be updated. Changing other aspects of the memset (width, height, element size or pitch) may cause the update to be rejected. Specifically, for 2d memsets, all dimension changes are rejected. For 1d memsets, changes in height are explicitly rejected and other changes are opportunistically allowed if the resulting work maps onto the work resources already allocated for the node.

The modifications only affect future launches of `hGraphExec`. Already enqueued or running launches of `hGraphExec` are not affected by this call. `node` is also not modified by this call.

Note:

- Graph objects are not threadsafe. [More here](#).
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

- `cudaGraphExecNodeSetParams`, `cudaGraphAddMemsetNode`,
- `cudaGraphMemsetNodeSetParams`, `cudaGraphExecKernelNodeSetParams`,
- `cudaGraphExecMemcpyNodeSetParams`, `cudaGraphExecHostNodeSetParams`,
- `cudaGraphExecChildGraphNodeSetParams`, `cudaGraphExecEventRecordNodeSetEvent`,
- `cudaGraphExecEventWaitNodeSetEvent`, `cudaGraphExecExternalSemaphoresSignalNodeSetParams`,
- `cudaGraphExecExternalSemaphoresWaitNodeSetParams`, `cudaGraphExecUpdate`,
- `cudaGraphInstantiate`
__host__ cudaError_t cudaGraphExecNodeSetParams
(cudaGraphExec_t graphExec, cudaGraphNode_t node, 
cudaGraphNodeParams *nodeParams)

Update's a graph node's parameters in an instantiated graph.

Parameters

graphExec
- The executable graph in which to update the specified node

node
- Corresponding node from the graph from which graphExec was instantiated

nodeParams
- Updated Parameters to set

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidDeviceFunction, cudaErrorNotSupported

Description

Sets the parameters of a node in an executable graph graphExec. The node is identified by
the corresponding node node in the non-executable graph from which the executable graph was
instantiated. node must not have been removed from the original graph.

The modifications only affect future launches of graphExec. Already enqueued or running launches
of graphExec are not affected by this call. node is also not modified by this call.

Allowed changes to parameters on executable graphs are as follows:

<table>
<thead>
<tr>
<th>Node type</th>
<th>Allowed changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>kernel</td>
<td>See cudaGraphExecKernelNodeSetParams</td>
</tr>
<tr>
<td>memcpy</td>
<td>Addresses for 1-dimensional copies if allocated in same context; see cudaGraphExecMemcpyNodeSetParams</td>
</tr>
<tr>
<td>memset</td>
<td>Addresses for 1-dimensional memsets if allocated in same context; see cudaGraphExecMemsetNodeSetParams</td>
</tr>
<tr>
<td>host</td>
<td>Unrestricted</td>
</tr>
<tr>
<td>child graph</td>
<td>Topology must match and restrictions apply recursively; see cudaGraphExecUpdate</td>
</tr>
<tr>
<td>event wait</td>
<td>Unrestricted</td>
</tr>
</tbody>
</table>
### Node type | Allowed changes
--- | ---
event record | Unrestricted
external semaphore signal | Number of semaphore operations cannot change
external semaphore wait | Number of semaphore operations cannot change
memory allocation | API unsupported
memory free | API unsupported

**Note:**
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
- `cudaGraphAddNode`, `cudaGraphNodeSetParams` `cudaGraphExecUpdate`, `cudaGraphInstantiate`

```__host__ cudaError_t cudaGraphExecUpdate```
```(cudaGraphExec_t hGraphExec, cudaGraph_t hGraph, cudaGraphExecUpdateResultInfo *resultInfo)```
Check whether an executable graph can be updated with a graph and perform the update if possible.

**Parameters**

- **hGraphExec**
  The instantiated graph to be updated

- **hGraph**
  The graph containing the updated parameters

- **resultInfo**
  the error info structure

**Returns**
- `cudaSuccess`, `cudaErrorGraphExecUpdateFailure`,

---

**Notes:**
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.
Description

Updates the node parameters in the instantiated graph specified by hGraphExec with the node parameters in a topologically identical graph specified by hGraph.

Limitations:

- **Kernel nodes:**
  - The owning context of the function cannot change.
  - A node whose function originally did not use CUDA dynamic parallelism cannot be updated to a function which uses CDP.
  - A node whose function originally did not make device-side update calls cannot be updated to a function which makes device-side update calls.
  - A cooperative node cannot be updated to a non-cooperative node, and vice-versa.
  - If the graph was instantiated with cudaGraphInstantiateFlagUseNodePriority, the priority attribute cannot change. Equality is checked on the originally requested priority values, before they are clamped to the device's supported range.
  - If hGraphExec was not instantiated for device launch, a node whose function originally did not use device-side cudaGraphLaunch() cannot be updated to a function which uses device-side cudaGraphLaunch() unless the node resides on the same device as nodes which contained such calls at instantiate-time. If no such calls were present at instantiation, these updates cannot be performed at all.
  - Neither hGraph nor hGraphExec may contain device-updatable kernel nodes.

- **Memset and memcpy nodes:**
  - The CUDA device(s) to which the operand(s) was allocated/mapped cannot change.
  - The source/destination memory must be allocated from the same contexts as the original source/destination memory.
  - For 2d memsets, only address and assigned value may be updated.
  - For 1d memsets, updating dimensions is also allowed, but may fail if the resulting operation doesn't map onto the work resources already allocated for the node.

- **Additional memcpy node restrictions:**
  - Changing either the source or destination memory type (i.e. CU_MEMORYTYPE_DEVICE, CU_MEMORYTYPE_ARRAY, etc.) is not supported.

- **Conditional nodes:**
  - Changing node parameters is not supported.
  - Changeing parameters of nodes within the conditional body graph is subject to the rules above.
  - Conditional handle flags and default values are updated as part of the graph update.

Note: The API may add further restrictions in future releases. The return code should always be checked.
cudaGraphExecUpdate sets the result member of resultInfo to:
cudaGraphExecUpdateError if passed an invalid value.
cudaGraphExecUpdateErrorTopologyChanged if the graph topology changed
cudaGraphExecUpdateErrorNodeTypeChanged if the type of a node changed, in which case hErrorNode_out is set to the node from hGraph.
cudaGraphExecUpdateErrorFunctionChanged if the function of a kernel node changed (CUDA driver < 11.2)
cudaGraphExecUpdateErrorUnsupportedFunctionChange if the func field of a kernel changed in an unsupported way (see note above), in which case hErrorNode_out is set to the node from hGraph.
cudaGraphExecUpdateErrorParametersChanged if any parameters to a node changed in a way that is not supported, in which case hErrorNode_out is set to the node from hGraph.
cudaGraphExecUpdateErrorAttributesChanged if any attributes of a node changed in a way that is not supported, in which case hErrorNode_out is set to the node from hGraph.
cudaGraphExecUpdateErrorNotSupported if something about a node is unsupported, like the node's type or configuration, in which case hErrorNode_out is set to the node from hGraph.

If the update fails for a reason not listed above, the result member of resultInfo will be set to cudaGraphExecUpdateError. If the update succeeds, the result member will be set to cudaGraphExecUpdateSuccess.

cudaGraphExecUpdate returns cudaSuccess when the updated was performed successfully. It returns cudaErrorGraphExecUpdateFailure if the graph update was not performed because it included changes which violated constraints specific to instantiated graph update.

Note:
- Graph objects are not threadsafe. More here.
cudaGraphExternalSemaphoresSignalNodeGetParams

__host__ cudaError_t

cudaGraphExternalSemaphoresSignalNodeGetParams
(cudaGraphNode_t hNode,
cudaExternalSemaphoreSignalNodeParams *params_out)

Returns an external semaphore signal node's parameters.

Parameters

hNode
  - Node to get the parameters for

params_out
  - Pointer to return the parameters

Returns

cudaSuccess, cudaErrorInvalidValue

Description

Returns the parameters of an external semaphore signal node hNode in params_out. The extSemArray and paramsArray returned in params_out, are owned by the node. This memory remains valid until the node is destroyed or its parameters are modified, and should not be modified directly. Use cudaGraphExternalSemaphoresSignalNodeSetParams to update the parameters of this node.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
`cudaLaunchKernel`, `cudaGraphAddExternalSemaphoresSignalNode`, `cudaGraphExternalSemaphoresSignalNodeSetParams`, `cudaGraphAddExternalSemaphoresWaitNode`, `cudaSignalExternalSemaphoresAsync`, `cudaWaitExternalSemaphoresAsync`

```c
__host__ cudaError_t
cudaGraphExternalSemaphoresSignalNodeSetParams
(const cudaGraphNode_t hNode, const
cudaExternalSemaphoreSignalNodeParams *nodeParams)
```

Sets an external semaphore signal node's parameters.

**Parameters**

- **hNode**
  - Node to set the parameters for
- **nodeParams**
  - Parameters to copy

**Returns**

`cudaSuccess`, `cudaErrorInvalidValue`

**Description**

Sets the parameters of an external semaphore signal node `hNode` to `nodeParams`.

**Note:**

- Graph objects are not threadsafe. [More here.](#)
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphNodeSetParams, cudaGraphAddExternalSemaphoresSignalNode, cudaGraphExternalSemaphoresSignalNodeSetParams, cudaGraphAddExternalSemaphoresWaitNode, cudaSignalExternalSemaphoresAsync, cudaWaitExternalSemaphoresAsync

__host__ cudaError_t
cudaGraphExternalSemaphoresWaitNodeGetParams (cudaGraphNode_t hNode, cudaExternalSemaphoreWaitNodeParams *params_out)

Returns an external semaphore wait node's parameters.

Parameters

hNode
- Node to get the parameters for

params_out
- Pointer to return the parameters

Returns

cudaSuccess, cudaErrorInvalidValue

Description

Returns the parameters of an external semaphore wait node hNode in params_out. The extSemArray and paramsArray returned in params_out, are owned by the node. This memory remains valid until the node is destroyed or its parameters are modified, and should not be modified directly. Use cudaGraphExternalSemaphoresSignalNodeSetParams to update the parameters of this node.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphNodeSetParams, cudaGraphAddExternalSemaphoresWaitNode,
cudaGraphAddExternalSemaphoresWaitNodeSetParams, cudaGraphAddExternalSemaphoresWaitNode,
cudaSignalExternalSemaphoresAsync, cudaWaitExternalSemaphoresAsync

__host__ cudaError_t
cudaGraphExternalSemaphoresWaitNodeSetParams
(cudaGraphNode_t hNode, const
cudaExternalSemaphoreWaitNodeParams *nodeParams)
Sets an external semaphore wait node's parameters.

Parameters

hNode
  - Node to set the parameters for

nodeParams
  - Parameters to copy

Returns
cudaSuccess, cudaErrorInvalidValue

Description

Sets the parameters of an external semaphore wait node hNode to nodeParams.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphNodeSetParams, cudaGraphAddExternalSemaphoresWaitNode,
cudaGraphAddExternalSemaphoresWaitNodeSetParams, cudaGraphAddExternalSemaphoresWaitNode,
cudaSignalExternalSemaphoresAsync, cudaWaitExternalSemaphoresAsync
__host__ cudaError_t cudaGraphGetEdges (cudaGraph_t graph, cudaGraphNode_t *from, cudaGraphNode_t *to, size_t *numEdges)

Returns a graph's dependency edges.

Parameters

graph
  - Graph to get the edges from
from
  - Location to return edge endpoints
to
  - Location to return edge endpoints
numEdges
  - See description

Returns
cudaSuccess, cudaErrorInvalidValue

Description

Returns a list of graph's dependency edges. Edges are returned via corresponding indices in from and to; that is, the node in to[i] has a dependency on the node in from[i]. from and to may both be NULL, in which case this function only returns the number of edges in numEdges. Otherwise, numEdges entries will be filled in. If numEdges is higher than the actual number of edges, the remaining entries in from and to will be set to NULL, and the number of edges actually returned will be written to numEdges.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
__host__ cudaError_t cudaGraphGetEdges_v2 (cudaGraph_t graph, cudaGraphNode_t *from, cudaGraphNode_t *to, cudaGraphEdgeData *edgeData, size_t *numEdges)

Returns a graph's dependency edges (12.3+).

Parameters

- graph
  - Graph to get the edges from
- from
  - Location to return edge endpoints
- to
  - Location to return edge endpoints
- edgeData
  - Optional location to return edge data
- numEdges
  - See description

Returns

cudaSuccess, cudaErrorLossyQuery, cudaErrorInvalidValue

Description

Returns a list of graph's dependency edges. Edges are returned via corresponding indices in from, to and edgeData; that is, the node in to[i] has a dependency on the node in from[i] with data edgeData[i]. from and to may both be NULL, in which case this function only returns the number of edges in numEdges. Otherwise, numEdges entries will be filled in. If numEdges is higher than the actual number of edges, the remaining entries in from and to will be set to NULL, and the number of edges actually returned will be written to numEdges. edgeData may alone be NULL, in which case the edges must all have default (zeroed) edge data. Attempting a losst query via NULL edgeData will result in cudaErrorLossyQuery. If edgeData is non-NULL then from and to must be as well.

Note:

- Graph objects are not threadsafe. More here.
See also:
cudaGraphGetNodes, cudaGraphGetRootNodes, cudaGraphAddDependencies,
cudaGraphRemoveDependencies, cudaGraphNodeGetDependencies,
cudaGraphNodeGetDependentNodes

__host__ cudaError_t cudaGraphGetNodes (cudaGraph_t graph, cudaGraphNode_t *nodes, size_t *numNodes)
Returns a graph's nodes.

Parameters

- **graph**
  - Graph to query
- **nodes**
  - Pointer to return the nodes
- **numNodes**
  - See description

Returns

- cudaSuccess
- cudaErrorInvalidValue

Description

Returns a list of graph's nodes. nodes may be NULL, in which case this function will return the number of nodes in numNodes. Otherwise, numNodes entries will be filled in. If numNodes is higher than the actual number of nodes, the remaining entries in nodes will be set to NULL, and the number of nodes actually obtained will be returned in numNodes.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphCreate, cudaGraphGetRootNodes, cudaGraphGetEdges, cudaGraphNodeGetType,
cudaGraphNodeGetDependencies, cudaGraphNodeGetDependentNodes

__host__ cudaError_t cudaGraphGetRootNodes
(cudaGraph_t graph, cudaGraphNode_t *pRootNodes,
size_t *pNumRootNodes)
Returns a graph's root nodes.

Parameters
graph
  - Graph to query
pRootNodes
  - Pointer to return the root nodes
pNumRootNodes
  - See description

Returns
cudaSuccess, cudaErrorInvalidValue

Description
Returns a list of graph's root nodes. pRootNodes may be NULL, in which case this function will return the number of root nodes in pNumRootNodes. Otherwise, pNumRootNodes entries will be filled in. If pNumRootNodes is higher than the actual number of root nodes, the remaining entries in pRootNodes will be set to NULL, and the number of nodes actually obtained will be returned in pNumRootNodes.

Note:
  - Graph objects are not threadsafe. [More here]
  - Note that this function may also return error codes from previous, asynchronous launches.
  - Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
  - Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
See also:

cudaGraphCreate, cudaGraphGetNodes, cudaGraphGetEdges, cudaGraphNodeGetType, cudaGraphNodeGetDependencies, cudaGraphNodeGetDependentNodes

__host__ cudaError_t cudaGraphHostNodeGetParams (cudaGraphNode_t node, cudaHostNodeParams *pNodeParams)

Returns a host node's parameters.

Parameters

node
- Node to get the parameters for

pNodeParams
- Pointer to return the parameters

Returns
cudaSuccess, cudaErrorInvalidValue

Description

Returns the parameters of host node node in pNodeParams.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaLaunchHostFunc, cudaGraphAddHostNode, cudaGraphHostNodeSetParams
__host__ cudaError_t cudaGraphHostNodeSetParams (cudaGraphNode_t node, const cudaHostNodeParams *pNodeParams)

Sets a host node's parameters.

Parameters

node
  - Node to set the parameters for

pNodeParams
  - Parameters to copy

Returns
cudaSuccess, cudaErrorInvalidValue

Description

Sets the parameters of host node node to nodeParams.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphNodeSetParams, cudaLaunchHostFunc, cudaGraphAddHostNode, cudaGraphHostNodeGetParams
__host__ cudaError_t cudaGraphInstantiate (cudaGraphExec_t *pGraphExec, cudaGraph_t graph, unsigned long long flags)

Creates an executable graph from a graph.

Parameters

pGraphExec
- Returns instantiated graph

graph
- Graph to instantiate

flags
- Flags to control instantiation. See CUgraphInstantiate_flags.

Returns
cudaSuccess, cudaErrorInvalidValue

Description

Instantiates graph as an executable graph. The graph is validated for any structural constraints or intra-node constraints which were not previously validated. If instantiation is successful, a handle to the instantiated graph is returned in pGraphExec.

The flags parameter controls the behavior of instantiation and subsequent graph launches. Valid flags are:

- cudaGraphInstantiateFlagAutoFreeOnLaunch, which configures a graph containing memory allocation nodes to automatically free any unfreed memory allocations before the graph is relaunched.

- cudaGraphInstantiateFlagDeviceLaunch, which configures the graph for launch from the device. If this flag is passed, the executable graph handle returned can be used to launch the graph from both the host and device. This flag cannot be used in conjunction with cudaGraphInstantiateFlagAutoFreeOnLaunch.

- cudaGraphInstantiateFlagUseNodePriority, which causes the graph to use the priorities from the per-node attributes rather than the priority of the launch stream during execution. Note that priorities are only available on kernel nodes, and are copied from stream priority during stream capture.

If graph contains any allocation or free nodes, there can be at most one executable graph in existence for that graph at a time. An attempt to instantiate a second executable graph before destroying the first with cudaGraphExecDestroy will result in an error. The same also applies if graph contains any device-updatable kernel nodes.
Graphs instantiated for launch on the device have additional restrictions which do not apply to host graphs:

- The graph's nodes must reside on a single device.
- The graph can only contain kernel nodes, memcpy nodes, memset nodes, and child graph nodes.
- The graph cannot be empty and must contain at least one kernel, memcpy, or memset node.

Operation-specific restrictions are outlined below.

Kernel nodes:

- Use of CUDA Dynamic Parallelism is not permitted.
- Cooperative launches are permitted as long as MPS is not in use.

Memcpy nodes:

- Only copies involving device memory and/or pinned device-mapped host memory are permitted.
- Copies involving CUDA arrays are not permitted.
- Both operands must be accessible from the current device, and the current device must match the device of other nodes in the graph.

If graph is not instantiated for launch on the device but contains kernels which call device-side cudaGraphLaunch() from multiple devices, this will result in an error.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaGraphInstantiateWithFlags, cudaGraphCreate, cudaGraphUpload, cudaGraphLaunch, cudaGraphExecDestroy
cudaGraphInstantiateWithFlags

 cudaGraphExec_t *pGraphExec, cudaGraph_t graph, unsigned long long flags)

Creates an executable graph from a graph.

**Parameters**

- **pGraphExec**
  - Returns instantiated graph
- **graph**
  - Graph to instantiate
- **flags**
  - Flags to control instantiation. See **CUgraphInstantiate_flags**.

**Returns**

cudaSuccess, cudaErrorInvalidValue

**Description**

Instantiates `graph` as an executable graph. The graph is validated for any structural constraints or intra-node constraints which were not previously validated. If instantiation is successful, a handle to the instantiated graph is returned in `pGraphExec`.

The `flags` parameter controls the behavior of instantiation and subsequent graph launches. Valid flags are:

- `cudaGraphInstantiateFlagAutoFreeOnLaunch`, which configures a graph containing memory allocation nodes to automatically free any unfreed memory allocations before the graph is relaunched.
- `cudaGraphInstantiateFlagDeviceLaunch`, which configures the graph for launch from the device. If this flag is passed, the executable graph handle returned can be used to launch the graph from both the host and device. This flag can only be used on platforms which support unified addressing. This flag cannot be used in conjunction with `cudaGraphInstantiateFlagAutoFreeOnLaunch`.
- `cudaGraphInstantiateFlagUseNodePriority`, which causes the graph to use the priorities from the per-node attributes rather than the priority of the launch stream during execution. Note that priorities are only available on kernel nodes, and are copied from stream priority during stream capture.

If `graph` contains any allocation or free nodes, there can be at most one executable graph in existence for that graph at a time. An attempt to instantiate a second executable graph before destroying the first with `cudaGraphExecDestroy` will result in an error. The same also applies if `graph` contains any device-updatable kernel nodes.
If graph contains kernels which call device-side `cudaGraphLaunch()` from multiple devices, this will result in an error.

Graphs instantiated for launch on the device have additional restrictions which do not apply to host graphs:

- The graph's nodes must reside on a single device.
- The graph can only contain kernel nodes, memcpy nodes, memset nodes, and child graph nodes.
- The graph cannot be empty and must contain at least one kernel, memcpy, or memset node.

Operation-specific restrictions are outlined below.

**Kernel nodes:**

- Use of CUDA Dynamic Parallelism is not permitted.
- Cooperative launches are permitted as long as MPS is not in use.

**Memcpy nodes:**

- Only copies involving device memory and/or pinned device-mapped host memory are permitted.
- Copies involving CUDA arrays are not permitted.
- Both operands must be accessible from the current device, and the current device must match the device of other nodes in the graph.

**Note:**

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cudaGraphInstantiate`, `cudaGraphCreate`, `cudaGraphUpload`, `cudaGraphLaunch`, `cudaGraphExecDestroy`
__host__ cudaError_t cudaGraphInstantiateWithParams (cudaGraphExec_t *pGraphExec, cudaGraph_t graph, cudaGraphInstantiateParams *instantiateParams)

Creates an executable graph from a graph.

Parameters

pGraphExec
- Returns instantiated graph

graph
- Graph to instantiate

instantiateParams
- Instantiation parameters

Returns
cudaSuccess, cudaErrorInvalidValue

Description

Instantiates graph as an executable graph according to the instantiateParams structure. The graph is validated for any structural constraints or intra-node constraints which were not previously validated. If instantiation is successful, a handle to the instantiated graph is returned in pGraphExec.

instantiateParams controls the behavior of instantiation and subsequent graph launches, as well as returning more detailed information in the event of an error. cudaGraphInstantiateParams is defined as:

```
typedef struct {
  unsigned long long flags;
  cudaStream_t uploadStream;
  cudaGraphNode_t errNode_out;
  cudaGraphInstantiateResult result_out;
} cudaGraphInstantiateParams;
```

The flags field controls the behavior of instantiation and subsequent graph launches. Valid flags are:

- **cudaGraphInstantiateFlagAutoFreeOnLaunch**, which configures a graph containing memory allocation nodes to automatically free any unfreed memory allocations before the graph is relaunched.

- **cudaGraphInstantiateFlagUpload**, which will perform an upload of the graph into uploadStream once the graph has been instantiated.

- **cudaGraphInstantiateFlagDeviceLaunch**, which configures the graph for launch from the device. If this flag is passed, the executable graph handle returned can be used to launch the graph from both the host and device. This flag can only be used on platforms which support unified addressing. This flag cannot be used in conjunction with cudaGraphInstantiateFlagAutoFreeOnLaunch.
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- **cudaGraphInstantiateFlagUseNodePriority**, which causes the graph to use the priorities from the per-node attributes rather than the priority of the launch stream during execution. Note that priorities are only available on kernel nodes, and are copied from stream priority during stream capture.

If `graph` contains any allocation or free nodes, there can be at most one executable graph in existence for that graph at a time. An attempt to instantiate a second executable graph before destroying the first with `cudaGraphExecDestroy` will result in an error. The same also applies if `graph` contains any device-updatable kernel nodes.

If `graph` contains kernels which call device-side `cudaGraphLaunch()` from multiple devices, this will result in an error.

Graphs instantiated for launch on the device have additional restrictions which do not apply to host graphs:

- The graph's nodes must reside on a single device.
- The graph can only contain kernel nodes, memcpy nodes, memset nodes, and child graph nodes.
- The graph cannot be empty and must contain at least one kernel, memcpy, or memset node.

Operation-specific restrictions are outlined below.

- **Kernel nodes**:
  - Use of CUDA Dynamic Parallelism is not permitted.
  - Cooperative launches are permitted as long as MPS is not in use.

- **Memcpy nodes**:
  - Only copies involving device memory and/or pinned device-mapped host memory are permitted.
  - Copies involving CUDA arrays are not permitted.
  - Both operands must be accessible from the current device, and the current device must match the device of other nodes in the graph.

In the event of an error, the `result_out` and `errNode_out` fields will contain more information about the nature of the error. Possible error reporting includes:

- **cudaGraphInstantiateError**, if passed an invalid value or if an unexpected error occurred which is described by the return value of the function. `errNode_out` will be set to NULL.
- **cudaGraphInstantiateInvalidStructure**, if the graph structure is invalid. `errNode_out` will be set to one of the offending nodes.
- **cudaGraphInstantiateNodeOperationNotSupported**, if the graph is instantiated for device launch but contains a node of an unsupported node type, or a node which performs unsupported operations, such as use of CUDA dynamic parallelism within a kernel node. `errNode_out` will be set to this node.
- **cudaGraphInstantiateMultipleDevicesNotSupported**, if the graph is instantiated for device launch but a node’s device differs from that of another node. This error can also be returned.
if a graph is not instantiated for device launch and it contains kernels which call device-side
`cudaGraphLaunch()` from multiple devices. `errNode_out` will be set to this node.

If instantiation is successful, `result_out` will be set to `cudaGraphInstantiateSuccess`, and
`hErrNode_out` will be set to NULL.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or
  `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback.
  `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

`cudaGraphCreate`, `cudaGraphInstantiate`, `cudaGraphInstantiateWithFlags`, `cudaGraphExecDestroy`

```c
__host__ cudaError_t
cudaGraphKernelNodeCopyAttributes (cudaGraphNode_t hSrc, cudaGraphNode_t hDst)
```

Copies attributes from source node to destination node.

Returns

`cudaSuccess`, `cudaErrorInvalidContext`

Description

Copies attributes from source node `src` to destination node `dst`. Both node must have the same
context.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.

See also:

`cudaAccessPolicyWindow`
__host__ cudaError_t cudaGraphKernelNodeGetAttribute
(cudaGraphNode_t hNode, cudaKernelNodeAttrID attr, cudaKernelNodeAttrValue *value_out)
Queries node attribute.

Parameters

hNode
attr
value_out

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle

Description
Queries attribute attr from node hNode and stores it in corresponding member of value_out.

Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaAccessPolicyWindow

__host__ cudaError_t cudaGraphKernelNodeGetParams
(cudaGraphNode_t node, cudaKernelNodeParams *pNodeParams)
Returns a kernel node's parameters.

Parameters

node
- Node to get the parameters for

pNodeParams
- Pointer to return the parameters

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidDeviceFunction
Description

Returns the parameters of kernel node node in pNodeParams. The kernelParams or extra array returned in pNodeParams, as well as the argument values it points to, are owned by the node. This memory remains valid until the node is destroyed or its parameters are modified, and should not be modified directly. Use cudaGraphKernelNodeSetParams to update the parameters of this node.

The params will contain either kernelParams or extra, according to which of these was most recently set on the node.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaLaunchKernel, cudaGraphAddKernelNode, cudaGraphKernelNodeSetParams

__host__ cudaError_t cudaGraphKernelNodeSetAttribute (cudaGraphNode_t hNode, cudaKernelNodeAttrID attr, const cudaKernelNodeAttrValue *value)

Sets node attribute.

Parameters

hNode
attr
value

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle

Description

Sets attribute attr on node hNode from corresponding attribute of value.
**__device__ cudaError_t cudaGraphKernelNodeSetEnabled (cudaGraphDeviceNode_t node, bool enable)**

Enables or disables the given kernel node.

### Parameters

- **node**
  - The node to update

- **enable**
  - Whether to enable or disable the node

### Returns

cudaSuccess, cudaErrorInvalidValue

### Description

Enables or disables `node` based upon `enable`. If `enable` is true, the node will be enabled; if it is false, the node will be disabled. Disabled nodes will act as a NOP during execution. `node` must be device-updatable, and must reside upon the same device as the calling kernel.

If this function is called for the node's immediate dependent and that dependent is configured for programmatic dependent launch, then a memory fence must be invoked via `__threadfence()` before kickoff of the dependent is triggered via `cudaTriggerProgrammaticLaunchCompletion()` to ensure that the update is visible to that dependent node before it is launched.

---

**Note:**

Note that this function may also return error codes from previous, asynchronous launches.

---

See also:

cudaGraphKernelNodeSetParam, cudaGraphKernelNodeSetGridDim, cudaGraphKernelNodeUpdatesApply
__device__ cudaError_t cudaGraphKernelNodeSetGridDim (cudaGraphDeviceNode_t node, dim3 gridDim)
Updates the grid dimensions of the given kernel node.

Parameters

node
- The node to update

gridDim
- The grid dimensions to set

Returns
cudaSuccess, cudaErrorInvalidValue

Description

Sets the grid dimensions of `node` to `gridDim`. `node` must be device-updatable, and must reside upon the same device as the calling kernel.

If this function is called for the node's immediate dependent and that dependent is configured for programmatic dependent launch, then a memory fence must be invoked via `__threadfence()` before kickoff of the dependent is triggered via `cudaTriggerProgrammaticLaunchCompletion()` to ensure that the update is visible to that dependent node before it is launched.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaGraphKernelNodeSetParam, cudaGraphKernelNodeSetEnabled, cudaGraphKernelNodeUpdatesApply

template < typename T > __device__ cudaError_t cudaGraphKernelNodeSetParam (cudaGraphDeviceNode_t node, size_t offset, const T value)
Updates the kernel parameters of the given kernel node.

Parameters

node
- The node to update
offset

- The offset into the params at which to make the update

value

- Parameter value to write

Returns

cudaSuccess, cudaErrorInvalidValue

Description

Updates the kernel parameters of node at offset to value. node must be device-updatable, and must reside upon the same device as the calling kernel.

If this function is called for the node's immediate dependent and that dependent is configured for programmatic dependent launch, then a memory fence must be invoked via __threadfence() before kickoff of the dependent is triggered via cudaTriggerProgrammaticLaunchCompletion() to ensure that the update is visible to that dependent node before it is launched.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:
etblGraphKernelNodeSetEnabled, etblGraphKernelNodeSetGridDim, etblGraphKernelNodeUpdatesApply

__global__ cudaError_t cudaGraphKernelNodeSetParam
cudaGraphDeviceNode_t node, size_t offset, const void *value, size_t size

Updates the kernel parameters of the given kernel node.

Parameters

node

- The node to update

offset

- The offset into the params at which to make the update

value

- Buffer containing the params to write

size

- Size in bytes to update
Returns

cudaSuccess, cudaErrorInvalidValue

Description

Updates size bytes in the kernel parameters of node at offset to the contents of value. node must be device-updatable, and must reside upon the same device as the calling kernel.

If this function is called for the node's immediate dependent and that dependent is configured for programmatic dependent launch, then a memory fence must be invoked via __threadfence() before kickoff of the dependent is triggered via cudaTriggerProgrammaticLaunchCompletion() to ensure that the update is visible to that dependent node before it is launched.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:

cudaGraphKernelNodeSetEnabled, cudaGraphKernelNodeSetGridDim,
cudaGraphKernelNodeUpdatesApply

__host__ cudaError_t cudaGraphKernelNodeSetParams
(cudaGraphNode_t node, const cudaKernelNodeParams *pNodeParams)
Sets a kernel node's parameters.

Parameters

node
  - Node to set the parameters for
pNodeParams
  - Parameters to copy

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidResourceHandle, cudaErrorMemoryAllocation

Description

Sets the parameters of kernel node node to pNodeParams.
__device__ cudaError_t cudaGraphKernelNodeUpdatesApply (const cudaGraphKernelNodeUpdate *updates, size_t updateCount)
Batch applies multiple kernel node updates.

Parameters
updates
  - The updates to apply
updateCount
  - The number of updates to apply

Returns
cudaSucces, cudaErrorInvalidValue

Description
Batch applies one or more kernel node updates based on the information provided in updates. updateCount specifies the number of updates to apply. Each entry in updates must specify a node to update, the type of update to apply, and the parameters for that type of update. See the documentation for cudaGraphKernelNodeUpdate for more detail.

If this function is called for the node's immediate dependent and that dependent is configured for programmatic dependent launch, then a memory fence must be invoked via __threadfence() before kickoff of the dependent is triggered via cudaTriggerProgrammaticLaunchCompletion() to ensure that the update is visible to that dependent node before it is launched.
**Note:**

Note that this function may also return error codes from previous, asynchronous launches.

See also:

cudaGraphKernelNodeSetParam, cudaGraphKernelNodeSetEnabled, cudaGraphKernelNodeSetGridDim

```c
__host__ __device__ cudaError_t cudaGraphLaunch(cuGraphExec_t graphExec, cuStream_t stream)
```

Launches an executable graph in a stream.

**Parameters**

- `graphExec` - Executable graph to launch
- `stream` - Stream in which to launch the graph

**Returns**

cudaSuccess, cudaErrorInvalidValue

**Description**

Executes `graphExec` in `stream`. Only one instance of `graphExec` may be executing at a time. Each launch is ordered behind both any previous work in `stream` and any previous launches of `graphExec`. To execute a graph concurrently, it must be instantiated multiple times into multiple executable graphs.

If any allocations created by `graphExec` remain unfreed (from a previous launch) and `graphExec` was not instantiated with `cudaGraphInstantiateFlagAutoFreeOnLaunch`, the launch will fail with cudaErrorInvalidValue.

**Note:**

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.
See also:
cudaGraphInstantiate, cudaGraphUpload, cudaGraphExecDestroy

__host__ cudaError_t cudaGraphMemAllocNodeGetParams (cudaGraphNode_t node, cudaMemAllocNodeParams *params_out)
Returns a memory alloc node's parameters.

Parameters
node
  - Node to get the parameters for
params_out
  - Pointer to return the parameters

Returns
cudaSuccess, cudaErrorInvalidValue

Description
Returns the parameters of a memory alloc node hNode in params_out. The poolProps and accessDescs returned in params_out, are owned by the node. This memory remains valid until the node is destroyed. The returned parameters must not be modified.

Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphAddMemAllocNode, cudaGraphMemFreeNodeGetParams
__host__ cudaError_t cudaMemcpyNodeGetParams (cudaGraphNode_t node, cudaMemcpy3DParms *pNodeParams)

Returns a memcpy node's parameters.

Parameters

node
- Node to get the parameters for

pNodeParams
- Pointer to return the parameters

Returns
cudaSuccess, cudaErrorInvalidValue

Description

Returns the parameters of memcpy node node in pNodeParams.

See also:
cudaMemcpy3D, cudaGraphAddMemcpyNode, cudaGraphMemcpyNodeSetParams

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpyNodeGetParams no CUDA function may be called from callback. cudaMemcpyNodeGetParams may, but is not guaranteed to, be returned as a diagnostic in such case.
__host__ cudaError_t cudaMemcpyNodeSetParams (cudaGraphNode_t node, const cudaMemcpy3DParms *pNodeParams)
Sets a memcpy node's parameters.

Parameters
node
- Node to set the parameters for
pNodeParams
- Parameters to copy

Returns
cudaSuccess, cudaErrorInvalidValue.

Description
Sets the parameters of memcpy node node to pNodeParams.

Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpyNodeSetParamsToSymbol, cudaMemcpyNodeSetParamsFromSymbol, cudaMemcpyNodeSetParams1D, cudaMemcpyNodeGetParams, cudaMemcpyNodeSetParams may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
__host__ cudaError_t

cudaGraphMemcpyNodeSetParams1D (cudaGraphNode_t node, void *dst, const void *src, size_t count, cudaMemcpyKind kind)

Sets a memcpy node's parameters to perform a 1-dimensional copy.

Parameters

node
- Node to set the parameters for
dst
- Destination memory address
src
- Source memory address
count
- Size in bytes to copy
kind
- Type of transfer

Returns
cudaSuccess, cudaErrorInvalidValue

Description

Sets the parameters of memcpy node node to the copy described by the provided parameters.

When the graph is launched, the node will copy count bytes from the memory area pointed to by src to the memory area pointed to by dst, where kind specifies the direction of the copy, and must be one of cudaMemcpyHostToHost, cudaMemcpyHostToDevice, cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing. Launching a memcpy node with dst and src pointers that do not match the direction of the copy results in an undefined behavior.

Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaMemcpyInitializationError, cudaMemcpyInsufficientDriver or cudaMemcpyNoDevice if this call tries to initialize internal CUDA RT state.
Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
`cudaMemcpy`, `cudaGraphMemcpyNodeSetParams`, `cudaGraphAddMemcpyNode`, `cudaGraphMemcpyNodeGetParams`

```c
__host__ cudaError_t
cudaGraphMemcpyNodeSetParamsFromSymbol(
cudaGraphNode_t node, void *dst, const void *symbol,
size_t count, size_t offset, cudaMemcpyKind kind)
```

Sets a memcpy node's parameters to copy from a symbol on the device.

**Parameters**
- **node** - Node to set the parameters for
- **dst** - Destination memory address
- **symbol** - Device symbol address
- **count** - Size in bytes to copy
- **offset** - Offset from start of symbol in bytes
- **kind** - Type of transfer

**Returns**
`cudaSuccess`, `cudaErrorInvalidValue`

**Description**
Sets the parameters of memcpy node `node` to the copy described by the provided parameters.

When the graph is launched, the node will copy `count` bytes from the memory area pointed to by `offset` bytes from the start of symbol `symbol` to the memory area pointed to by `dst`. The memory areas may not overlap. `symbol` is a variable that resides in global or constant memory space. `kind` can be either `cudaMemcpyDeviceToHost`, `cudaMemcpyDeviceToDevice`, or `cudaMemcpyDefault`. Passing `cudaMemcpyDefault` is recommended, in which case the type of transfer is inferred from the pointer values. However, `cudaMemcpyDefault` is only allowed on systems that support unified virtual addressing.
Note:

- Graph objects are not threadsafe. [More here.](#)
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

- `cudaMemcpyFromSymbol`, `cudaGraphMemcpyNodeSetParams`,
- `cudaGraphMemcpyNodeSetParamsToSymbol`, `cudaGraphAddMemcpyNode`,
- `cudaGraphMemcpyNodeGetParams`

```c
__host__ cudaError_t
cudaGraphMemcpyNodeSetParamsToSymbol
(cudaGraphNode_t node, const void *symbol, const void *src, size_t count, size_t offset, cudaMemcpyKind kind)
```

Sets a memcpy node's parameters to copy to a symbol on the device.

**Parameters**

- **node**
  - Node to set the parameters for
- **symbol**
  - Device symbol address
- **src**
  - Source memory address
- **count**
  - Size in bytes to copy
- **offset**
  - Offset from start of symbol in bytes
- **kind**
  - Type of transfer

**Returns**

- `cudaSuccess`, `cudaErrorInvalidValue`
Description

Sets the parameters of memcpy node `node` to the copy described by the provided parameters. When the graph is launched, the node will copy `count` bytes from the memory area pointed to by `src` to the memory area pointed to by `offset` bytes from the start of `symbol`. The memory areas may not overlap. `symbol` is a variable that resides in global or constant memory space. `kind` can be either `cudaMemcpyHostToDevice`, `cudaMemcpyDeviceToDevice`, or `cudaMemcpyDefault`. Passing `cudaMemcpyDefault` is recommended, in which case the type of transfer is inferred from the pointer values. However, `cudaMemcpyDefault` is only allowed on systems that support unified virtual addressing.

Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaMemcpyToSymbol, cudaMemcpyNodeSetParams, cudaMemcpyNodeSetParamsFromSymbol, cudaMemcpyNodeGetParams

__host__ cudaError_t cudaMemcpyNodeGetParams (cudaGraphNode_t node, void *dptr_out)

Returns a memory free node's parameters.

Parameters

node
- Node to get the parameters for
dptr_out
- Pointer to return the device address

Returns
cudaSuccess, cudaErrorInvalidValue
Description

Returns the address of a memory free node `hNode` in `dptr_out`.

Note:
- Graph objects are not threadsafe. [More here.](#)
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
`cudaGraphAddMemFreeNode`, `cudaGraphMemFreeNodeGetParams`

```c
__host__ cudaError_t cudaMemcpyNodeGetParams (cudaGraphNode_t node, cudaMemcpyParams *pNodeParams)
```

Returns a cudaMemcpy node's parameters.

Parameters

- `node` - Node to get the parameters for
- `pNodeParams` - Pointer to return the parameters

Returns

`cudaSuccess`, `cudaErrorInvalidValue`

Description

Returns the parameters of cudaMemcpy node `node` in `pNodeParams`.

Note:
- Graph objects are not threadsafe. [More here.](#)
- Note that this function may also return error codes from previous, asynchronous launches.
__host__ cudaError_t cudaGraphMemsetNodeSetParams (cudaGraphNode_t node, const cudaMemsetParams *pNodeParams)
Sets a memset node's parameters.

Parameters

node
- Node to set the parameters for

pNodeParams
- Parameters to copy

Returns
cudaSuccess, cudaErrorInvalidValue

Description
Sets the parameters of memset node node to pNodeParams.

See also:
cudaGraphNodeSetParams, cudaMemset2D, cudaGraphAddMemsetNode, cudaGraphMemsetNodeGetParams
`__host__ cudaError_t cudaGraphNodeFindInClone (cudaGraphNode_t *pNode, cudaGraphNode_t originalNode, cudaGraph_t clonedGraph)`

Finds a cloned version of a node.

**Parameters**

- **pNode**
  - Returns handle to the cloned node
- **originalNode**
  - Handle to the original node
- **clonedGraph**
  - Cloned graph to query

**Returns**

- `cudaSuccess`, `cudaErrorInvalidValue`

**Description**

This function returns the node in `clonedGraph` corresponding to `originalNode` in the original graph.

`clonedGraph` must have been cloned from `originalGraph` via `cudaGraphClone`. `originalNode` must have been in `originalGraph` at the time of the call to `cudaGraphClone`, and the corresponding cloned node in `clonedGraph` must not have been removed. The cloned node is then returned via `pClonedNode`.

---

**Note:**

- Graph objects are not threadsafe. [More here](#).
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

**See also:**

- `cudaGraphClone`
__host__ cudaError_t cudaGraphNodeGetDependencies (cudaGraphNode_t node, cudaGraphNode_t *pDependencies, size_t *pNumDependencies)

Returns a node's dependencies.

Parameters

node
- Node to query

pDependencies
- Pointer to return the dependencies

pNumDependencies
- See description

Returns

cudaSuccess, cudaErrorInvalidValue

Description

Returns a list of node's dependencies. pDependencies may be NULL, in which case this function will return the number of dependencies in pNumDependencies. Otherwise, pNumDependencies entries will be filled in. If pNumDependencies is higher than the actual number of dependencies, the remaining entries in pDependencies will be set to NULL, and the number of nodes actually obtained will be returned in pNumDependencies.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphNodeGetDependentNodes, cudaGraphNodeGetNodes, cudaGraphNodeGetRootNodes, cudaGraphNodeGetEdges, cudaGraphNodeAddDependencies, cudaGraphNodeRemoveDependencies
__host__ cudaError_t cudaGraphNodeGetDependencies_v2 (cudaGraphNode_t node, cudaGraphNode_t *pDependencies, cudaGraphEdgeData *edgeData, size_t *pNumDependencies)

Returns a node's dependencies (12.3+).

Parameters

node
- Node to query
pDependencies
- Pointer to return the dependencies
edgeData
- Optional array to return edge data for each dependency
pNumDependencies
- See description

Returns
cudaSuccess, cudaErrorLossyQuery, cudaErrorInvalidValue

Description

Returns a list of node's dependencies. pDependencies may be NULL, in which case this function will return the number of dependencies in pNumDependencies. Otherwise, pNumDependencies entries will be filled in. If pNumDependencies is higher than the actual number of dependencies, the remaining entries in pDependencies will be set to NULL, and the number of nodes actually obtained will be returned in pNumDependencies.

Note that if an edge has non-zero (non-default) edge data and edgeData is NULL, this API will return cudaErrorLossyQuery. If edgeData is non-NULL, then pDependencies must be as well.

Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpyAsync no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphNodeGetDependentNodes, cudaGraphGetNodes, cudaGraphGetRootNodes, cudaGraphGetEdges, cudaGraphAddDependencies, cudaGraphRemoveDependencies

__host__ cudaError_t cudaGraphNodeGetDependentNodes (cudaGraphNode_t node, cudaGraphNode_t *pDependentNodes, size_t *pNumDependentNodes)
Returns a node's dependent nodes.

Parameters

node
- Node to query

pDependentNodes
- Pointer to return the dependent nodes

pNumDependentNodes
- See description

Returns

cudaSuccess, cudaErrorInvalidValue

Description

Returns a list of node's dependent nodes. pDependentNodes may be NULL, in which case this function will return the number of dependent nodes in pNumDependentNodes. Otherwise, pNumDependentNodes entries will be filled in. If pNumDependentNodes is higher than the actual number of dependent nodes, the remaining entries in pDependentNodes will be set to NULL, and the number of nodes actually obtained will be returned in pNumDependentNodes.

Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphNodeGetDependencies, cudaGraphGetNodes, cudaGraphGetRootNodes, cudaGraphGetEdges, cudaGraphAddDependencies, cudaGraphRemoveDependencies

`__host__ cudaError_t cudaGraphNodeGetDependentNodes_v2(cudaGraphNode_t node, cudaGraphNode_t *pDependentNodes, cudaGraphEdgeData *edgeData, size_t *pNumDependentNodes)`

Returns a node's dependent nodes (12.3+).

Parameters

- **node**
  - Node to query
- **pDependentNodes**
  - Pointer to return the dependent nodes
- **edgeData**
  - Optional pointer to return edge data for dependent nodes
- **pNumDependentNodes**
  - See description

Returns

- `cudaSuccess`
- `cudaErrorLossyQuery`
- `cudaErrorInvalidValue`

Description

Returns a list of node's dependent nodes. `pDependentNodes` may be NULL, in which case this function will return the number of dependent nodes in `pNumDependentNodes`. Otherwise, `pNumDependentNodes` entries will be filled in. If `pNumDependentNodes` is higher than the actual number of dependent nodes, the remaining entries in `pDependentNodes` will be set to NULL, and the number of nodes actually obtained will be returned in `pNumDependentNodes`.

Note that if an edge has non-zero (non-default) edge data and `edgeData` is NULL, this API will return `cudaErrorLossyQuery`. If `edgeData` is non-NULL, then `pDependentNodes` must be as well.

Note:

- Graph objects are not threadsafe. [More here.](#)
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
`cudaGraphNodeGetDependencies`, `cudaGraphGetNodes`, `cudaGraphGetRootNodes`, `cudaGraphGetEdges`, `cudaGraphAddDependencies`, `cudaGraphRemoveDependencies`.

```
__host__ cudaError_t cudaGraphNodeGetEnabled
(cudaGraphExec_t hGraphExec, cudaGraphNode_t hNode,
unsigned int *isEnabled)
```

Query whether a node in the given graphExec is enabled.

**Parameters**

- **hGraphExec**
  - The executable graph in which to set the specified node
- **hNode**
  - Node from the graph from which graphExec was instantiated
- **isEnabled**
  - Location to return the enabled status of the node

**Returns**

`cudaSuccess`, `cudaErrorInvalidValue`.

**Description**

Sets `isEnabled` to 1 if `hNode` is enabled, or 0 if `hNode` is disabled.

The node is identified by the corresponding node `hNode` in the non-executable graph, from which the executable graph was instantiated.

`hNode` must not have been removed from the original graph.

**Note:**

Currently only kernel, memset and memcpy nodes are supported.

**Note:**

- Graph objects are not threadsafe. [More here.](#)
- Note that this function may also return error codes from previous, asynchronous launches.
__host__ cudaError_t cudaGraphNodeGetType (cudaGraphNode_t node, cudaGraphNodeType *pType)

Returns a node's type.

**Parameters**

- **node**
  - Node to query

- **pType**
  - Pointer to return the node type

**Returns**

cudaSuccess, cudaErrorInvalidValue

**Description**

Returns the node type of `node` in `pType`.

**Note:**

- Graph objects are not threadsafe. [More here.](#)
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaGraphGetNodes, cudaGraphGetRootNodes, cudaGraphChildGraphNodeGetGraph, cudaGraphKernelNodeGetParams, cudaGraphKernelNodeSetParams, cudaGraphHostNodeGetParams, cudaGraphHostNodeSetParams, cudaGraphMemcpyNodeGetParams, cudaGraphMemcpyNodeSetParams, cudaGraphMemsetNodeGetParams, cudaGraphMemsetNodeSetParams
__host__ cudaError_t cudaGraphNodeSetEnabled
(cudaGraphExec_t hGraphExec, cudaGraphNode_t hNode, unsigned int isEnabled)

Enables or disables the specified node in the given graphExec.

Parameters

hGraphExec
- The executable graph in which to set the specified node

hNode
- Node from the graph from which graphExec was instantiated

isEnabled
- Node is enabled if != 0, otherwise the node is disabled

Returns

cudaSuccess, cudaErrorInvalidValue,

Description

Sets hNode to be either enabled or disabled. Disabled nodes are functionally equivalent to empty
nodes until they are reenabled. Existing node parameters are not affected by disabling/enabling the
node.

The node is identified by the corresponding node hNode in the non-executable graph, from which the
executable graph was instantiated.

hNode must not have been removed from the original graph.

The modifications only affect future launches of hGraphExec. Already enqueued or running
launches of hGraphExec are not affected by this call. hNode is also not modified by this call.

Note:
Currently only kernel, memset and memcpy nodes are supported.

Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or
cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
Note that as specified by \texttt{cudaStreamAddCallback} no CUDA function may be called from callback. \texttt{cudaErrorNotPermitted} may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
\texttt{cudaGraphNodeGetEnabled}, \texttt{cudaGraphExecUpdate}, \texttt{cudaGraphInstantiate} \texttt{cudaGraphLaunch}

\textbf{\_host\_\_cudaError\_t cudaGraphNodeSetParams (cudaGraphNode\_t node, cudaGraphNodeParams *nodeParams)}

Update's a graph node's parameters.

\textbf{Parameters}

\textbf{node}
- Node to set the parameters for

\textbf{nodeParams}
- Parameters to copy

\textbf{Returns}
\texttt{cudaSuccess}, \texttt{cudaErrorInvalidValue}, \texttt{cudaErrorInvalidDeviceFunction}, \texttt{cudaErrorNotSupported}

\textbf{Description}

Sets the parameters of graph node \texttt{node} to \texttt{nodeParams}. The node type specified by \texttt{nodeParams->type} must match the type of \texttt{node}. \texttt{nodeParams} must be fully initialized and all unused bytes (reserved, padding) zeroed.

Modifying parameters is not supported for node types \texttt{cudaGraphNodeTypeMemAlloc} and \texttt{cudaGraphNodeTypeMemFree}.

Note:
- Graph objects are not threadsafe. \texttt{More here}.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return \texttt{cudaErrorInitializationError}, \texttt{cudaErrorInsufficientDriver} or \texttt{cudaErrorNoDevice} if this call tries to initialize internal CUDA RT state.
- Note that as specified by \texttt{cudaStreamAddCallback} no CUDA function may be called from callback. \texttt{cudaErrorNotPermitted} may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
\texttt{cudaGraphAddNode}, \texttt{cudaGraphExecNodeSetParams}
__host__ cudaError_t cudaGraphReleaseUserObject
(cudaGraph_t graph, cudaUserObject_t object, unsigned int count)

Release a user object reference from a graph.

Parameters

graph
  - The graph that will release the reference

object
  - The user object to release a reference for

count
  - The number of references to release, typically 1. Must be nonzero and not larger than INT_MAX.

Returns
cudaSuccess, cudaErrorInvalidValue

Description

Releases user object references owned by a graph.

See CUDA User Objects in the CUDA C++ Programming Guide for more information on user objects.

See also:
cudaUserObjectCreate, cudaUserObjectRetain, cudaUserObjectRelease, cudaGraphRetainUserObject, cudaGraphCreate

__host__ cudaError_t cudaGraphRemoveDependencies
(cudaGraph_t graph, const cudaGraphNode_t *from, const cudaGraphNode_t *to, size_t numDependencies)

Removes dependency edges from a graph.

Parameters

graph
  - Graph from which to remove dependencies

from
  - Array of nodes that provide the dependencies

to
  - Array of dependent nodes
numDependencies
   - Number of dependencies to be removed

Returns
cudaSuccess, cudaErrorInvalidValue

Description
The number of dependencies to be removed is defined by numDependencies. Elements in pFrom and pTo at corresponding indices define a dependency. Each node in pFrom and pTo must belong to graph.

If numDependencies is 0, elements in pFrom and pTo will be ignored. Specifying a non-existing dependency will return an error.

Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphAddDependencies, cudaGraphGetEdges, cudaGraphNodeGetDependencies, cudaGraphNodeGetDependentNodes

__host__ cudaError_t cudaGraphRemoveDependencies_v2 (cudaGraph_t graph, const cudaGraphNode_t *from, const cudaGraphNode_t *to, const cudaGraphEdgeData *edgeData, size_t numDependencies)
Removes dependency edges from a graph. (12.3+).

Parameters
graph
   - Graph from which to remove dependencies
from
   - Array of nodes that provide the dependencies
to
- Array of dependent nodes

edgeData
- Optional array of edge data. If NULL, edge data is assumed to be default (zeroed).

numDependencies
- Number of dependencies to be removed

Returns
cudaSuccess, cudaErrorInvalidValue

Description
The number of pDependencies to be removed is defined by numDependencies. Elements in pFrom and pTo at corresponding indices define a dependency. Each node in pFrom and pTo must belong to graph.

If numDependencies is 0, elements in pFrom and pTo will be ignored. Specifying an edge that does not exist in the graph, with data matching edgeData, results in an error. edgeData is nullable, which is equivalent to passing default (zeroed) data for each edge.

Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphAddDependencies, cudaGraphGetEdges, cudaGraphNodeGetDependencies, cudaGraphNodeGetDependentNodes

__host__ cudaError_t cudaGraphRetainUserObject (cudaGraph_t graph, cudaUserObject_t object, unsigned int count, unsigned int flags)
Retain a reference to a user object from a graph.

Parameters
graph
- The graph to associate the reference with
object
- The user object to retain a reference for

count
- The number of references to add to the graph, typically 1. Must be nonzero and not larger than INT_MAX.

flags
- The optional flag cudaGraphUserObjectMove transfers references from the calling thread, rather than create new references. Pass 0 to create new references.

Returns
cudaSuccess, cudaErrorInvalidValue

Description
Creates or moves user object references that will be owned by a CUDA graph.
See CUDA User Objects in the CUDA C++ Programming Guide for more information on user objects.

See also:
cudaUserObjectCreate, cudaUserObjectRetain, cudaUserObjectRelease, cudaGraphReleaseUserObject, cudaGraphCreate

__device__ void cudaGraphSetConditional
(cudaGraphConditionalHandle handle, unsigned int value)
Sets the condition value associated with a conditional node.

Description
Sets the condition value associated with a conditional node.
See also:
cudaGraphConditionalHandleCreate

__host__ cudaError_t cudaGraphUpload (cudaGraphExec_t graphExec, cudaStream_t stream)
Uploads an executable graph in a stream.

Returns
cudaSuccess, cudaErrorInvalidValue.
Description

Uploads `hGraphExec` to the device in `hStream` without executing it. Uploads of the same `hGraphExec` will be serialized. Each upload is ordered behind both any previous work in `hStream` and any previous launches of `hGraphExec`. Uses memory cached by `stream` to back the allocations owned by `graphExec`.

Note:

‣ Note that this function may also return error codes from previous, asynchronous launches.
‣ Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.

See also:

cudaGraphInstantiate, cudaGraphLaunch, cudaGraphExecDestroy

```c
__host__ cudaError_t cudaUserObjectCreate(
    cudaUserObject_t *object_out, void *ptr, cudaHostFn_t destroy, unsigned int initialRefcount, unsigned int flags)
```

Create a user object.

Parameters

- `object_out` - Location to return the user object handle
- `ptr` - The pointer to pass to the destroy function
- `destroy` - Callback to free the user object when it is no longer in use
- `initialRefcount` - The initial refcount to create the object with, typically 1. The initial references are owned by the calling thread.
- `flags` - Currently it is required to pass `cudaUserObjectNoDestructorSync`, which is the only defined flag. This indicates that the destroy callback cannot be waited on by any CUDA API. Users requiring synchronization of the callback should signal its completion manually.

Returns

`cudaSuccess`, `cudaErrorInvalidValue`
Description
Create a user object with the specified destructor callback and initial reference count. The initial references are owned by the caller.

Destructor callbacks cannot make CUDA API calls and should avoid blocking behavior, as they are executed by a shared internal thread. Another thread may be signaled to perform such actions, if it does not block forward progress of tasks scheduled through CUDA.

See CUDA User Objects in the CUDA C++ Programming Guide for more information on user objects.

See also:
cudaUserObjectCreate, cudaUserObjectRetain, cudaGraphRetainUserObject, cudaGraphReleaseUserObject, cudaGraphCreate

`__host__ cudaError_t cudaUserObjectRelease(cudaUserObject_t object, unsigned int count)`
Release a reference to a user object.

Parameters
- **object**
  - The object to release
- **count**
  - The number of references to release, typically 1. Must be nonzero and not larger than INT_MAX.

Returns
cudaSuccess, cudaErrorInvalidValue

Description
Releases user object references owned by the caller. The object's destructor is invoked if the reference count reaches zero.

It is undefined behavior to release references not owned by the caller, or to use a user object handle after all references are released.

See CUDA User Objects in the CUDA C++ Programming Guide for more information on user objects.

See also:
cudaUserObjectCreate, cudaUserObjectRetain, cudaGraphRetainUserObject, cudaGraphReleaseUserObject, cudaGraphCreate
__host__ cudaError_t cudaUserObjectRetain (cudaUserObject_t object, unsigned int count)
Retain a reference to a user object.

Parameters

object
- The object to retain

count
- The number of references to retain, typically 1. Must be nonzero and not larger than INT_MAX.

Returns
cudaSuccess, cudaErrorInvalidValue

Description
Retains new references to a user object. The new references are owned by the caller.
See CUDA User Objects in the CUDA C++ Programming Guide for more information on user objects.

See also:
cudaUserObjectCreate, cudaUserObjectRelease, cudaGraphRetainUserObject, cudaGraphReleaseUserObject, cudaGraphCreate

6.31.   Driver Entry Point Access
This section describes the driver entry point access functions of CUDA runtime application programming interface.

__host__ cudaError_t cudaGetDriverEntryPoint (const char *symbol, void **funcPtr, unsigned long long flags, cudaDriverEntryPointQueryResult *driverStatus)
Returns the requested driver API function pointer.

Parameters

symbol
- The base name of the driver API function to look for. As an example, for the driver API cuMemAlloc_v2, symbol would be cuMemAlloc. Note that the API will use the CUDA runtime
version to return the address to the most recent ABI compatible driver symbol, cuMemAlloc or cuMemAlloc_v2.

**funcPtr**
- Location to return the function pointer to the requested driver function

**flags**
- Flags to specify search options.

**driverStatus**
- Optional location to store the status of finding the symbol from the driver. See cudaDriverEntryPointQueryResult for possible values.

**Returns**
cudaSuccess, cudaErrorInvalidValue, cudaErrorNotSupported

**Description**

Returns in **funcPtr** the address of the CUDA driver function for the requested flags.

For a requested driver symbol, if the CUDA version in which the driver symbol was introduced is less than or equal to the CUDA runtime version, the API will return the function pointer to the corresponding versioned driver function.

The pointer returned by the API should be cast to a function pointer matching the requested driver function's definition in the API header file. The function pointer typedef can be picked up from the corresponding typedefs header file. For example, cudaTypedefs.h consists of function pointer typedefs for driver APIs defined in cuda.h.

The API will return cudaSuccess and set the returned funcPtr if the requested driver function is valid and supported on the platform.

The API will return cudaSuccess and set the returned funcPtr to NULL if the requested driver function is not supported on the platform, no ABI compatible driver function exists for the CUDA runtime version or if the driver symbol is invalid.

It will also set the optional driverStatus to one of the values in cudaDriverEntryPointQueryResult with the following meanings:

- **cudaDriverEntryPointSuccess** - The requested symbol was successfully found based on input arguments and pf is valid
- **cudaDriverEntryPointSymbolNotFound** - The requested symbol was not found
- **cudaDriverEntryPointVersionNotSufficient** - The requested symbol was found but is not supported by the current runtime version (CUDART_VERSION)

The requested flags can be:

- **cudaEnableDefault**: This is the default mode. This is equivalent to cudaEnablePerThreadDefaultStream if the code is compiled with --default-stream per-thread compilation flag or the macro CUDA_API_PER_THREAD_DEFAULT_STREAM is defined; cudaEnableLegacyStream otherwise.
- **cudaEnableLegacyStream**: This will enable the search for all driver symbols that match the requested driver symbol name except the corresponding per-thread versions.

- **cudaEnablePerThreadDefaultStream**: This will enable the search for all driver symbols that match the requested driver symbol name including the per-thread versions. If a per-thread version is not found, the API will return the legacy version of the driver function.

---

**Note:**

- Version mixing among CUDA-defined types and driver API versions is strongly discouraged and doing so can result in an undefined behavior. [More here.](#)

- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.

- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

- [cuGetProcAddress](#)

---

```c
__host__ cudaError_t cudaGetDriverEntryPointByVersion(const char *symbol, void **funcPtr, unsigned int cudaVersion, unsigned long long flags, cudaDriverEntryPointQueryResult *driverStatus)
```

Returns the requested driver API function pointer by CUDA version.

**Parameters**

- **symbol**
  - The base name of the driver API function to look for. As an example, for the driver API `cuMemAlloc_v2`, `symbol` would be `cuMemAlloc`.

- **funcPtr**
  - Location to return the function pointer to the requested driver function

- **cudaVersion**
  - The CUDA version to look for the requested driver symbol

- **flags**
  - Flags to specify search options.

- **driverStatus**
  - Optional location to store the status of finding the symbol from the driver. See [cudaDriverEntryPointQueryResult](#) for possible values.
Returns

`cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorNotSupported`

Description

Returns in `**funcPtr` the address of the CUDA driver function for the requested flags and CUDA driver version.

The CUDA version is specified as (1000 * major + 10 * minor), so CUDA 11.2 should be specified as 11020. For a requested driver symbol, if the specified CUDA version is greater than or equal to the CUDA version in which the driver symbol was introduced, this API will return the function pointer to the corresponding versioned function.

The pointer returned by the API should be cast to a function pointer matching the requested driver function's definition in the API header file. The function pointer typedef can be picked up from the corresponding typedefs header file. For example, `cudaTypedefs.h` consists of function pointer typedefs for driver APIs defined in `cuda.h`.

For the case where the CUDA version requested is greater than the CUDA Toolkit installed, there may not be an appropriate function pointer typedef in the corresponding header file and may need a custom typedef to match the driver function signature returned. This can be done by getting the typedefs from a later toolkit or creating appropriately matching custom function typedefs.

The API will return `cudaSuccess` and set the returned `funcPtr` if the requested driver function is valid and supported on the platform.

The API will return `cudaSuccess` and set the returned `funcPtr` to NULL if the requested driver function is not supported on the platform, no ABI compatible driver function exists for the requested version or if the driver symbol is invalid.

It will also set the optional `driverStatus` to one of the values in `cudaDriverEntryPointQueryResult` with the following meanings:

- `cudaDriverEntryPointSuccess` - The requested symbol was successfully found based on input arguments and `pfn` is valid
- `cudaDriverEntryPointSymbolNotFound` - The requested symbol was not found
- `cudaDriverEntryPointVersionNotSufficient` - The requested symbol was found but is not supported by the specified version `cudaVersion`

The requested flags can be:

- `cudaEnableDefault`: This is the default mode. This is equivalent to `cudaEnablePerThreadDefaultStream` if the code is compiled with --default-stream per-thread compilation flag or the macro CUDA_API_PER_THREAD_DEFAULT_STREAM is defined; `cudaEnableLegacyStream` otherwise.
- `cudaEnableLegacyStream`: This will enable the search for all driver symbols that match the requested driver symbol name except the corresponding per-thread versions.
cudaEnablePerThreadDefaultStream: This will enable the search for all driver symbols that match
the requested driver symbol name including the per-thread versions. If a per-thread version is not
found, the API will return the legacy version of the driver function.

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‣ cudaEnablePerThreadDefaultStream: This will enable the search for all driver symbols that match
the requested driver symbol name including the per-thread versions. If a per-thread version is not
found, the API will return the legacy version of the driver function.

Note:
‣ Version mixing among CUDA-defined types and driver API versions is strongly discouraged and
doing so can result in an undefined behavior. More here.
‣ Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or
cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
‣ Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback.
cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

See also:
cuGetProcAddress

6.32. C++ API Routines

C++-style interface built on top of CUDA runtime API.
This section describes the C++ high level API functions of the CUDA runtime application
programming interface. To use these functions, your application needs to be compiled with the
nvcc compiler.

__cudaOccupancyB2DHelper
cppClassifierVisibility: visibility=public
template < class T > __host__ cudaCreateChannelDesc
( void )
[C++ API] Returns a channel descriptor using the specified format

Returns
Channel descriptor with format f

Description
Returns a channel descriptor with format f and number of bits of each component x, y, z, and w. The
cudaChannelFormatDesc is defined as:

```cpp
struct cudaChannelFormatDesc {
  int x, y, z, w;
  enum cudaChannelFormatKind f;
};
```
where `cudaChannelFormatKind` is one of `cudaChannelFormatKindSigned`, `cudaChannelFormatKindUnsigned`, `cudaChannelFormatKindFloat`, `cudaChannelFormatKindSignedNormalized8X1`, `cudaChannelFormatKindSignedNormalized8X2`, `cudaChannelFormatKindSignedNormalized8X4`, `cudaChannelFormatKindUnsignedNormalized8X1`, `cudaChannelFormatKindUnsignedNormalized8X2`, `cudaChannelFormatKindUnsignedNormalized8X4`, `cudaChannelFormatKindSignedNormalized16X1`, `cudaChannelFormatKindSignedNormalized16X2`, `cudaChannelFormatKindSignedNormalized16X4`, `cudaChannelFormatKindUnsignedNormalized16X1`, `cudaChannelFormatKindUnsignedNormalized16X2`, `cudaChannelFormatKindUnsignedNormalized16X4` or `cudaChannelFormatKindNV12`.

The format is specified by the template specialization.

The template function specializes for the following scalar types: char, signed char, unsigned char, short, unsigned short, int, unsigned int, long, unsigned long, and float. The template function specializes for the following vector types: char{1|2|4}, uchar{1|2|4}, short{1|2|4}, ushort{1|2|4}, int{1|2|4}, uint{1|2|4}, long{1|2|4}, ulong{1|2|4}, float{1|2|4}. The template function specializes for following `cudaChannelFormatKind` enum values: `cudaChannelFormatKind`{SignedNormalized{8|16}X{1|2|4}, and `cudaChannelFormatKindNV12`.

Invoking the function on a type without a specialization defaults to creating a channel format of kind `cudaChannelFormatKindNone`.

See also:
`cudaCreateChannelDesc` (Low level), `cudaGetChannelDesc`.

```cpp
__host__ cudaError_t cudaEventCreate (cudaEvent_t *event, unsigned int flags)

[C++ API] Creates an event object with the specified flags

Parameters

- **event**
  - Newly created event

- **flags**
  - Flags for new event

Returns

- `cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorLaunchFailure`, `cudaErrorMemoryAllocation`

Description

Creates an event object with the specified flags. Valid flags include:

- **cudaEventDefault**: Default event creation flag.
- **cudaEventBlockingSync**: Specifies that event should use blocking synchronization. A host thread that uses `cudaEventSynchronize()` to wait on an event created with this flag will block until the event actually completes.

- **cudaEventDisableTiming**: Specifies that the created event does not need to record timing data. Events created with this flag specified and the `cudaEventBlockingSync` flag not specified will provide the best performance when used with `cudaStreamWaitEvent()` and `cudaEventQuery()`.

**Note:**

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

- `cudaEventCreate (C API)`, `cudaEventCreateWithFlags`, `cudaEventRecord`, `cudaEventQuery`, `cudaEventSynchronize`, `cudaEventDestroy`, `cudaEventElapsedTime`, `cudaStreamWaitEvent`

**template <class T> __host__ cudaError_t cudaFuncGetAttributes (cudaFuncAttributes *attr, T *entry)**

[C++ API] Find out attributes for a given function

**Parameters**

- **attr**
  - Return pointer to function's attributes
- **entry**
  - Function to get attributes of

**Returns**

- `cudaSuccess`, `cudaErrorInvalidDeviceFunction`

**Description**

This function obtains the attributes of a function specified via `entry`. The parameter `entry` must be a pointer to a function that executes on the device. The parameter specified by `entry` must be declared as a `_global_` function. The fetched attributes are placed in `attr`. If the specified function does not exist, then `cudaErrorInvalidDeviceFunction` is returned.
Note that some function attributes such as `maxThreadsPerBlock` may vary based on the device that is currently being used.

```
 cudaLaunchKernel (C++ API), cudaFuncSetCacheConfig (C++ API), cudaFuncGetAttributes (C API), cudaMemcpyDoubleForDevice, cudaMemcpyDoubleForHost
```

template <class T> __host__ cudaError_t

cudaFuncGetName (const char **name, T *func)

Returns the function name for a device entry function pointer.

**Parameters**

- **name**
  - The returned name of the function

- **func**
  - The function pointer to retrieve name for

**Returns**

- `cudaSuccess`
- `cudaErrorInvalidValue`
- `cudaErrorInvalidDeviceFunction`

**Description**

Returns in **name** the function name associated with the symbol **func**. The function name is returned as a null-terminated string. This API may return a mangled name if the function is not declared as having C linkage. If **name** is NULL, `cudaErrorInvalidValue` is returned. If **func** is not a device entry function, `cudaErrorInvalidDeviceFunction` is returned.
**cudaFuncGetName ( C API)**

```cpp
template < class T > __host__ cudaError_t
cudaFuncSetAttribute (T *func, cudaFuncAttribute attr, int value)
```

[C++ API] Set attributes for a given function

**Parameters**
- `func`
- `attr`
  - Attribute to set
- `value`
  - Value to set

**Returns**
- `cudaSuccess`, `cudaErrorInvalidDeviceFunction`, `cudaErrorInvalidValue`

**Description**
This function sets the attributes of a function specified via `entry`. The parameter `entry` must be a pointer to a function that executes on the device. The parameter specified by `entry` must be declared as a `__global__` function. The enumeration defined by `attr` is set to the value defined by `value`. If the specified function does not exist, then `cudaErrorInvalidDeviceFunction` is returned. If the specified attribute cannot be written, or if the value is incorrect, then `cudaErrorInvalidValue` is returned.

Valid values for `attr` are:

- `cudaFuncAttributeMaxDynamicSharedMemorySize` - The requested maximum size in bytes of dynamically-allocated shared memory. The sum of this value and the function attribute `sharedSizeBytes` cannot exceed the device attribute `cudaDevAttrMaxSharedMemoryPerBlockOptin`. The maximal size of requestable dynamic shared memory may differ by GPU architecture.

- `cudaFuncAttributePreferredSharedMemoryCarveout` - On devices where the L1 cache and shared memory use the same hardware resources, this sets the shared memory carveout preference, in percent of the total shared memory. See `cudaDevAttrMaxSharedMemoryPerMultiprocessor`. This is only a hint, and the driver can choose a different ratio if required to execute the function.

- `cudaFuncAttributeRequiredClusterWidth`: The required cluster width in blocks. The width, height, and depth values must either all be 0 or all be positive. The validity of the cluster dimensions is checked at launch time. If the value is set during compile time, it cannot be set at runtime. Setting it at runtime will return `cudaErrorNotPermitted`.

- `cudaFuncAttributeRequiredClusterHeight`: The required cluster height in blocks. The width, height, and depth values must either all be 0 or all be positive. The validity of the cluster dimensions is
checked at launch time. If the value is set during compile time, it cannot be set at runtime. Setting it at runtime will return cudaErrorNotPermitted.

- **cudaFuncAttributeRequiredClusterDepth**: The required cluster depth in blocks. The width, height, and depth values must either all be 0 or all be positive. The validity of the cluster dimensions is checked at launch time. If the value is set during compile time, it cannot be set at runtime. Setting it at runtime will return cudaErrorNotPermitted.

- **cudaFuncAttributeNonPortableClusterSizeAllowed**: Indicates whether the function can be launched with non-portable cluster size. 1 is allowed, 0 is disallowed.

- **cudaFuncAttributeClusterSchedulingPolicyPreference**: The block scheduling policy of a function. The value type is cudaClusterSchedulingPolicy.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

**cudaLaunchKernel (C++ API)**, **cudaFuncSetCacheConfig (C++ API)**, **cudaFuncGetAttributes (C API)**, **cudaSetDoubleForDevice**, **cudaSetDoubleForHost**

```cpp
template <class T> __host__ cudaError_t cudaFuncSetCacheConfig (T *func, cudaFuncCache cacheConfig)

[C++ API] Sets the preferred cache configuration for a device function
```

**Parameters**

- **func**
  - device function pointer

- **cacheConfig**
  - Requested cache configuration

**Returns**

- **cudaSuccess**, **cudaErrorInvalidDeviceFunction**

**Description**

On devices where the L1 cache and shared memory use the same hardware resources, this sets through cacheConfig the preferred cache configuration for the function specified via func. This is only
a preference. The runtime will use the requested configuration if possible, but it is free to choose a different configuration if required to execute `func`.

`func` must be a pointer to a function that executes on the device. The parameter specified by `func` must be declared as a `__global__` function. If the specified function does not exist, then `cudaErrorInvalidDeviceFunction` is returned.

This setting does nothing on devices where the size of the L1 cache and shared memory are fixed.

Launching a kernel with a different preference than the most recent preference setting may insert a device-side synchronization point.

The supported cache configurations are:

- `cudaFuncCachePreferNone`: no preference for shared memory or L1 (default)
- `cudaFuncCachePreferShared`: prefer larger shared memory and smaller L1 cache
- `cudaFuncCachePreferL1`: prefer larger L1 cache and smaller shared memory

---

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

---

`cudaLaunchKernel`, `cudaFuncSetCacheConfig`, `cudaFuncGetAttributes`, `cudaSetDoubleForDevice`, `cudaSetDoubleForHost`, `cudaThreadGetCacheConfig`, `cudaThreadSetCacheConfig`:

```cpp
template < class T > __host__ cudaError_t cudaGetKernel (cudaKernel_t *kernelPtr, T *func)
```

Get pointer to device kernel that matches entry function `entryFuncAddr`.

**Parameters**

- `kernelPtr` - Returns the device kernel
- `func`

**Returns**

- `cudaSuccess`
Description
Returns in `kernelPtr` the device kernel corresponding to the entry function `entryFuncAddr`.

See also:
cudaGetKernel (C API)

template < class T > __host__ cudaError_t
cudaGetSymbolAddress (void **devPtr, const T symbol)
[C++ API] Finds the address associated with a CUDA symbol

Parameters
- **devPtr**
  - Return device pointer associated with symbol
- **symbol**
  - Device symbol reference

Returns
- `cudaSuccess`
- `cudaErrorInvalidSymbol`
- `cudaErrorNoKernelImageForDevice`

Description
Returns in `*devPtr` the address of symbol `symbol` on the device. `symbol` can either be a variable that resides in global or constant memory space. If `symbol` cannot be found, or if `symbol` is not declared in the global or constant memory space, `*devPtr` is unchanged and the error `cudaErrorInvalidSymbol` is returned.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGetSymbolAddress (C API), cudaGetSymbolSize (C++ API)
template < class T > __host__ cudaError_t
cudaGetSymbolSize (size_t *size, const T symbol)

[C++ API] Finds the size of the object associated with a CUDA symbol

Parameters

size
- Size of object associated with symbol

symbol
- Device symbol reference

Returns

cudaSuccess, cudaErrorInvalidSymbol, cudaErrorNoKernelImageForDevice

Description

Returns in *size the size of symbol symbol. symbol must be a variable that resides in global
or constant memory space. If symbol cannot be found, or if symbol is not declared in global
or constant memory space, *size is unchanged and the error cudaErrorInvalidSymbol is returned.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or
cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback.
cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaGetSymbolAddress ( C++ API), cudaGetSymbolSize ( C API)
template < class T > __host__ cudaError_t
cudaGraphAddMemcpyNodeFromSymbol
(cudaGraphNode_t *pGraphNode, cudaGraph_t graph,
const cudaGraphNode_t *pDependencies, size_t
numDependencies, void *dst, const T symbol, size_t count,
size_t offset, cudaMemcpyKind kind)

Creates a memcpy node to copy from a symbol on the device and adds it to a graph.

Parameters

pGraphNode
- Returns newly created node

graph
- Graph to which to add the node

pDependencies
- Dependencies of the node

numDependencies
- Number of dependencies

dst
- Destination memory address

symbol
- Device symbol address

count
- Size in bytes to copy

offset
- Offset from start of symbol in bytes

kind
- Type of transfer

Returns
cudaSuccess, cudaErrorInvalidValue

Description

Creates a new memcpy node to copy from symbol and adds it to graph with numDependencies dependencies specified via pDependencies. It is possible for numDependencies to be 0, in which case the node will be placed at the root of the graph. pDependencies may not have any duplicate entries. A handle to the new node will be returned in pGraphNode.

When the graph is launched, the node will copy count bytes from the memory area pointed to by offset bytes from the start of symbol symbol to the memory area pointed to by dst. The memory
areas may not overlap. symbol is a variable that resides in global or constant memory space. kind can be either cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing.

Memcpy nodes have some additional restrictions with regards to managed memory, if the system contains at least one device which has a zero value for the device attribute cudaDevAttrConcurrentManagedAccess.

Note:

‣ Graph objects are not threadsafe. More here.
‣ Note that this function may also return error codes from previous, asynchronous launches.
‣ Note that this function may also return cudaMemcpyInitializationError, cudaMemcpyInsufficientDriver or cudaMemcpyNoDevice if this call tries to initialize internal CUDA RT state.
‣ Note that as specified by cudaMemcpyDefault no CUDA function may be called from callback. cudaMemcpyNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaMemcpyFromSymbol, cudaMemcpyNodeToSymbol, cudaMemcpyNodeGetParams, cudaMemcpyNodeSetParams,
cudaMemcpyNodeSetParamsFromSymbol, cudaMemcpyNodeSetParamsToSymbol,
cudaGraphCreate, cudaGraphDestroyNode, cudaMemcpyDeviceToSymbol,
cudaGraphAddEmptyNode, cudaMemcpyHostNode, cudaMemcpyKernelNode,
cudaGraphAddMemsetNode

template < class T > __host__ cudaError_t
cudaGraphAddMemcpyNodeToSymbol (cudaGraphNode_t *pGraphNode, cudaGraph_t graph, const cudaGraphNode_t *pDependencies, size_t numDependencies, const T symbol, const void *src, size_t count, size_t offset, cudaMemcpyKind kind)

Creates a memcpy node to copy to a symbol on the device and adds it to a graph.

Parameters
pGraphNode
- Returns newly created node
graph
- Graph to which to add the node

pDependencies
- Dependencies of the node

numDependencies
- Number of dependencies

symbol
- Device symbol address

src
- Source memory address

count
- Size in bytes to copy

offset
- Offset from start of symbol in bytes

kind
- Type of transfer

Returns
cudaSuccess, cudaErrorInvalidValue

Description

Creates a new memcpy node to copy to symbol and adds it to graph with numDependencies dependencies specified via pDependencies. It is possible for numDependencies to be 0, in which case the node will be placed at the root of the graph. pDependencies may not have any duplicate entries. A handle to the new node will be returned in pGraphNode.

When the graph is launched, the node will copy count bytes from the memory area pointed to by src to the memory area pointed to by offset bytes from the start of symbol symbol. The memory areas may not overlap. symbol is a variable that resides in global or constant memory space. kind can be either cudaMemcpyHostToDevice, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing.

Memcpy nodes have some additional restrictions with regards to managed memory, if the system contains at least one device which has a zero value for the device attribute cudaDevAttrConcurrentManagedAccess.

Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.

Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaMemcpyToSymbol, cudaGraphAddMemcpyNode, cudaGraphAddMemcpyNodeFromSymbol,
cudaGraphMemcpyNodeGetParams, cudaGraphMemcpyNodeSetParams,
cudaGraphMemcpyNodeSetParamsToSymbol, cudaGraphMemcpyNodeSetParamsFromSymbol,
cudaGraphCreate, cudaGraphDestroyNode, cudaGraphAddChildGraphNode,
cudaGraphAddEmptyNode, cudaGraphAddKernelNode, cudaGraphAddHostNode,
cudaGraphAddMemsetNode

template < class T > __host__ cudaError_t
cudaGraphExecMemcpyNodeSetParamsFromSymbol
(cudaGraphExec_t hGraphExec, cudaGraphNode_t node,
void *dst, const T symbol, size_t count, size_t offset,
cudaMemcpyKind kind)

Sets the parameters for a memcpy node in the given graphExec to copy from a symbol on the device.

Parameters

**hGraphExec**
- The executable graph in which to set the specified node

**node**
- Memcpy node from the graph which was used to instantiate graphExec

**dst**
- Destination memory address

**symbol**
- Device symbol address

**count**
- Size in bytes to copy

**offset**
- Offset from start of symbol in bytes

**kind**
- Type of transfer

Returns

cudaSuccess, cudaErrorInvalidValue
Description

Updates the work represented by node in hGraphExec as though node had contained the given params at instantiation. node must remain in the graph which was used to instantiate hGraphExec. Changed edges to and from node are ignored.

symbol and dst must be allocated from the same contexts as the original source and destination memory. The instantiation-time memory operands must be 1-dimensional. Zero-length operations are not supported.

The modifications only affect future launches of hGraphExec. Already enqueued or running launches of hGraphExec are not affected by this call. node is also not modified by this call.

Returns cudaErrorInvalidValue if the memory operands' mappings changed or the original memory operands are multidimensional.

Note:

- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphAddMemcpyNode, cudaGraphAddMemcpyNodeFromSymbol, cudaGraphMemcpyNodeSetParams, cudaGraphMemcpyNodeSetParamsFromSymbol, cudaGraphInstantiate, cudaGraphExecMemcpyNodeSetParams, cudaGraphExecMemcpyNodeSetParamsToSymbol, cudaGraphExecKernelNodeSetParams, cudaGraphExecMemsetNodeSetParams, cudaGraphExecHostNodeSetParams
template < class T > __host__ cudaError_t
cudaGraphExecMemcpyNodeSetParamsToSymbol
(cudaGraphExec_t hGraphExec, cudaGraphNode_t node,
const T symbol, const void *src, size_t count, size_t offset,
cudaMemcpyKind kind)

Sets the parameters for a memcpy node in the given graphExec to copy to a symbol on the device.

Parameters

hGraphExec
- The executable graph in which to set the specified node

node
- Memcpy node from the graph which was used to instantiate graphExec

symbol
- Device symbol address

src
- Source memory address

count
- Size in bytes to copy

offset
- Offset from start of symbol in bytes

kind
- Type of transfer

Returns
cudaSuccess, cudaErrorInvalidValue

Description

Updates the work represented by node in hGraphExec as though node had contained the given
params at instantiation. node must remain in the graph which was used to instantiate hGraphExec.
Changed edges to and from node are ignored.

src and symbol must be allocated from the same contexts as the original source and destination
memory. The instantiation-time memory operands must be 1-dimensional. Zero-length operations are
not supported.

The modifications only affect future launches of hGraphExec. Already enqueued or running
launches of hGraphExec are not affected by this call. node is also not modified by this call.

Returns cudaErrorInvalidValue if the memory operands' mappings changed or the original memory
operands are multidimensional.
Note:

- Graph objects are not threadsafe. [More here](#).
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

- `cudaGraphAddMemcpyNode`, `cudaGraphAddMemcpyNodeToSymbol`,
- `cudaGraphMemcpyNodeSetParams`, `cudaGraphMemcpyNodeSetParamsToSymbol`,
- `cudaGraphInstantiate`, `cudaGraphExecMemcpyNodeSetParams`,
- `cudaGraphExecMemcpyNodeSetParamsFromSymbol`, `cudaGraphExecKernelNodeSetParams`,
- `cudaGraphExecMemsetNodeSetParams`, `cudaGraphExecHostNodeSetParams`

```c
__host__ cudaError_t cudaGraphInstantiate
cudaGraphExec_t *pGraphExec, cudaGraph_t graph, cudaGraphNode_t *pErrorNode, char *pLogBuffer, size_t bufferSize)
```

Creates an executable graph from a graph.

**Parameters**

- `pGraphExec`
  - Returns instantiated graph
- `graph`
  - Graph to instantiate
- `pErrorNode`
  - In case of an instantiation error, this may be modified to indicate a node contributing to the error
- `pLogBuffer`
  - A character buffer to store diagnostic messages
- `bufferSize`
  - Size of the log buffer in bytes

**Returns**

- `cudaSuccess`, `cudaErrorInvalidValue`
Description

Instantiates graph as an executable graph. The graph is validated for any structural constraints or intra-node constraints which were not previously validated. If instantiation is successful, a handle to the instantiated graph is returned in pGraphExec.

If there are any errors, diagnostic information may be returned in pErrorNode and pLogBuffer. This is the primary way to inspect instantiation errors. The output will be null terminated unless the diagnostics overflow the buffer. In this case, they will be truncated, and the last byte can be inspected to determine if truncation occurred.

Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaGraphInstantiateWithFlags, cudaGraphCreate, cudaGraphUpload, cudaGraphLaunch, cudaGraphExecDestroy

template < class T > __host__ cudaError_t
cudaGraphMemcpyNodeSetParamsFromSymbol
(cudaGraphNode_t node, void *dst, const T symbol, size_t count, size_t offset, cudaMemcpyKind kind)

Sets a memcpy node's parameters to copy from a symbol on the device.

Parameters
node
- Node to set the parameters for
dst
- Destination memory address
symbol
- Device symbol address
count
- Size in bytes to copy
offset
- Offset from start of symbol in bytes

kind
- Type of transfer

Returns
cudaSuccess, cudaErrorInvalidValue

Description
Sets the parameters of memcpy node node to the copy described by the provided parameters.

When the graph is launched, the node will copy `count` bytes from the memory area pointed to by `offset` bytes from the start of symbol `symbol` to the memory area pointed to by `dst`. The memory areas may not overlap. `symbol` is a variable that resides in global or constant memory space. `kind` can be either cudaMemcpyDeviceToHost, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing.

Note:
- Graph objects are not threadsafe. More here.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaMemcpyInitializationError, cudaMemcpyInsufficientDriver or cudaMemcpyNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpyDefault no CUDA function may be called from callback. cudaMemcpyNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
ccudaMemcpyFromSymbol, cudaMemcpyNodeSetParams,
cgraphMemcpyNodeSetParamsToSymbol, cudaMemcpyNodeGetParams
template < class T > __host__ cudaError_t cudaGraphMemcpyNodeSetParamsToSymbol (cudaGraphNode_t node, const T symbol, const void *src, size_t count, size_t offset, cudaMemcpyKind kind)

Sets a memcpy node's parameters to copy to a symbol on the device.

**Parameters**

- **node**
  - Node to set the parameters for
- **symbol**
  - Device symbol address
- **src**
  - Source memory address
- **count**
  - Size in bytes to copy
- **offset**
  - Offset from start of symbol in bytes
- **kind**
  - Type of transfer

**Returns**

cudaSuccess, cudaErrorInvalidValue

**Description**

Sets the parameters of memcpy node `node` to the copy described by the provided parameters.

When the graph is launched, the node will copy `count` bytes from the memory area pointed to by `src` to the memory area pointed to by `offset` bytes from the start of symbol `symbol`. The memory areas may not overlap. `symbol` is a variable that resides in global or constant memory space. `kind` can be either cudaMemcpyHostToDevice, cudaMemcpyDeviceToDevice, or cudaMemcpyDefault. Passing cudaMemcpyDefault is recommended, in which case the type of transfer is inferred from the pointer values. However, cudaMemcpyDefault is only allowed on systems that support unified virtual addressing.

**Note:**

- Graph objects are not threadsafe. [More here.](#)
- Note that this function may also return error codes from previous, asynchronous launches.
template < class T > __host__ cudaError_t 
cudaLaunchCooperativeKernel (T *func, dim3 gridDim, 
dim3 blockDim, void **args, size_t sharedMem, 
cudaStream_t stream)

Launches a device function.

Parameters

func
  - Device function symbol

gridDim
  - Grid dimensions

blockDim
  - Block dimensions

args
  - Arguments

sharedMem
  - Shared memory (defaults to 0)

stream
  - Stream identifier (defaults to NULL)

Returns

cudaSuccess, cudaErrorInvalidDeviceFunction, cudaErrorInvalidConfiguration, 
cudaErrorLaunchFailure, cudaErrorLaunchTimeout, cudaErrorLaunchOutOfResources, 
cudaErrorSharedObjectInitFailed

Description

The function invokes kernel func on grid Dim (gridDim.x gridDim.y gridDim.z) grid of 
blocks. Each block contains blockDim(blockDim.x blockDim.y blockDim.z) threads.
The device on which this kernel is invoked must have a non-zero value for the device attribute `cudaDevAttrCooperativeLaunch`.

The total number of blocks launched cannot exceed the maximum number of blocks per multiprocessor as returned by `cudaOccupancyMaxActiveBlocksPerMultiprocessor` (or `cudaOccupancyMaxActiveBlocksPerMultiprocessorWithFlags`) times the number of multiprocessors as specified by the device attribute `cudaDevAttrMultiProcessorCount`.

The kernel cannot make use of CUDA dynamic parallelism.

If the kernel has N parameters the `args` should point to array of N pointers. Each pointer, from `args[0]` to `args[N - 1]`, point to the region of memory from which the actual parameter will be copied.

`sharedMem` sets the amount of dynamic shared memory that will be available to each thread block.

`stream` specifies a stream the invocation is associated to.

---

**Note:**

- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits asynchronous behavior for most use cases.
- This function uses standard default stream semantics.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

### `cudaLaunchCooperativeKernel` (C API)

```c
template < class T > __host__ cudaError_t
cudaLaunchKernel (T *func, dim3 blockDim, void **args, size_t sharedMem, cudaStream_t stream)
```

Launches a device function.

**Parameters**

- `func` - Device function symbol
- `gridDim` - Grid dimensions
- `blockDim` - Block dimensions
args
- Arguments

sharedMem
- Shared memory (defaults to 0)

stream
- Stream identifier (defaults to NULL)

Returns

Description

The function invokes kernel func on gridDim (gridDim.x gridDim.y gridDim.z) grid of blocks. Each block contains blockDim (blockDim.x blockDim.y blockDim.z) threads.

If the kernel has N parameters the args should point to array of N pointers. Each pointer, from args[0] to args[N – 1], point to the region of memory from which the actual parameter will be copied.

sharedMem sets the amount of dynamic shared memory that will be available to each thread block.

stream specifies a stream the invocation is associated to.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits asynchronous behavior for most use cases.
- This function uses standard default stream semantics.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

cudaLaunchKernel (C API)
template < typename... ExpTypes, typename... ActTypes > __host__ cudaError_t cudaLaunchKernelEx (const cudaLaunchConfig_t *config, void(*)(ExpTypes...) kernel, ActTypes &&... args)
Launches a CUDA function with launch-time configuration.

Parameters

config
- Launch configuration

kernel
- Kernel to launch

args
- Parameter pack of kernel parameters

Returns
cudaSuccess, cudaErrorInvalidDeviceFunction, cudaErrorInvalidConfiguration,
cudaErrorLaunchFailure, cudaErrorLaunchTimeout, cudaErrorLaunchOutOfResources,
cudaErrorSharedObjectInitFailed, cudaErrorInvalidPtx, cudaErrorUnsupportedPtxVersion,
cudaErrorNoKernelImageForDevice, cudaErrorJitCompilerNotFound,
cudaErrorJitCompilationDisabled

Description

Invokes the kernel kernel on config->gridDim (config->gridDim.x config->gridDim.y config->gridDim.z) grid of blocks. Each block contains config->blockDim (config->blockDim.x config->blockDim.y config->blockDim.z) threads.

config->dynamicSmemBytes sets the amount of dynamic shared memory that will be available to each thread block.

config->stream specifies a stream the invocation is associated to.

Configuration beyond grid and block dimensions, dynamic shared memory size, and stream can be provided with the following two fields of config:

config->attrs is an array of config->numAttrs contiguous cudaLaunchAttribute elements. The value of this pointer is not considered if config->numAttrs is zero. However, in that case, it is recommended to set the pointer to NULL. config->numAttrs is the number of attributes populating the first config->numAttrs positions of the config->attrs array.

The kernel arguments should be passed as arguments to this function via the args parameter pack.

The C API version of this function, cudaLaunchKernelExC, is also available for pre-C++11 compilers and for use cases where the ability to pass kernel parameters via void* array is preferable.
**__host__ cudaError_t cudaMallocAsync (void **ptr, size_t size, cudaMemPool_t memPool, cudaStream_t stream)**

Allocate from a pool.

**Description**

This is an alternate spelling for cudaMallocFromPoolAsync made available through operator overloading.

See also:

cudaMallocFromPoolAsync, cudaMallocAsync (C API)

**__host__ cudaError_t cudaMallocHost (void **ptr, size_t size, unsigned int flags)**

[C++ API] Allocates page-locked memory on the host

**Parameters**

- **ptr**
  - Device pointer to allocated memory
- **size**
  - Requested allocation size in bytes
- **flags**
  - Requested properties of allocated memory

**Returns**

cudaSuccess, cudaErrorMemoryAllocation

---

**Note:**

- This function uses standard default stream semantics.
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaLaunchKernelEx (C API), cuLaunchKernelEx
Description

Allocates size bytes of host memory that is page-locked and accessible to the device. The driver tracks the virtual memory ranges allocated with this function and automatically accelerates calls to functions such as \texttt{cudaMemcpyv()}. Since the memory can be accessed directly by the device, it can be read or written with much higher bandwidth than pageable memory obtained with functions such as malloc(). Allocating excessive amounts of pinned memory may degrade system performance, since it reduces the amount of memory available to the system for paging. As a result, this function is best used sparingly to allocate staging areas for data exchange between host and device.

The flags parameter enables different options to be specified that affect the allocation, as follows.

- \texttt{cudaHostAllocDefault}: This flag's value is defined to be 0.
- \texttt{cudaHostAllocPortable}: The memory returned by this call will be considered as pinned memory by all CUDA contexts, not just the one that performed the allocation.
- \texttt{cudaHostAllocMapped}: Maps the allocation into the CUDA address space. The device pointer to the memory may be obtained by calling \texttt{cudaHostGetDevicePointer()}. 
- \texttt{cudaHostAllocWriteCombined}: Allocates the memory as write-combined (WC). WC memory can be transferred across the PCI Express bus more quickly on some system configurations, but cannot be read efficiently by most CPUs. WC memory is a good option for buffers that will be written by the CPU and read by the device via mapped pinned memory or host->device transfers.

All of these flags are orthogonal to one another: a developer may allocate memory that is portable, mapped and/or write-combined with no restrictions. \texttt{cudaSetDeviceFlags()} must have been called with the \texttt{cudaDeviceMapHost} flag in order for the \texttt{cudaHostAllocMapped} flag to have any effect.

The \texttt{cudaHostAllocMapped} flag may be specified on CUDA contexts for devices that do not support mapped pinned memory. The failure is deferred to \texttt{cudaHostGetDevicePointer()} because the memory may be mapped into other CUDA contexts via the \texttt{cudaHostAllocPortable} flag.

Memory allocated by this function must be freed with \texttt{cudaFreeHost()}.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return \texttt{cudaErrorInitializationError}, \texttt{cudaErrorInsufficientDriver} or \texttt{cudaErrorNoDevice} if this call tries to initialize internal CUDA RT state.
- Note that as specified by \texttt{cudaStreamAddCallback} no CUDA function may be called from callback. \texttt{cudaErrorNotPermitted} may, but is not guaranteed to, be returned as a diagnostic in such case.

See also: \texttt{cudaSetDeviceFlags, cudaMemcpy (C API), cudaFreeHost, cudaHostAlloc}
template < class T > __host__ cudaError_t 
cudaMallocManaged (T **devPtr, size_t size, unsigned int flags)

Allocates memory that will be automatically managed by the Unified Memory system.

Parameters

devPtr
- Pointer to allocated device memory

size
- Requested allocation size in bytes

flags
- Must be either cudaMemAttachGlobal or cudaMemAttachHost (defaults to cudaMemAttachGlobal)

Returns
cudaSuccess, cudaErrorMemoryAllocation, cudaErrorNotSupported, cudaErrorInvalidValue

Description

Allocates size bytes of managed memory on the device and returns in *devPtr a pointer to the allocated memory. If the device doesn't support allocating managed memory, cudaErrorNotSupported is returned. Support for managed memory can be queried using the device attribute cudaDevAttrManagedMemory. The allocated memory is suitably aligned for any kind of variable. The memory is not cleared. If size is 0, cudaMallocManaged returns cudaErrorInvalidValue. The pointer is valid on the CPU and on all GPUs in the system that support managed memory. All accesses to this pointer must obey the Unified Memory programming model.

flags specifies the default stream association for this allocation. flags must be one of cudaMemAttachGlobal or cudaMemAttachHost. The default value for flags is cudaMemAttachGlobal. If cudaMemAttachGlobal is specified, then this memory is accessible from any stream on any device. If cudaMemAttachHost is specified, then the allocation should not be accessed from devices that have a zero value for the device attribute cudaDevAttrConcurrentManagedAccess; an explicit call to cudaStreamAttachMemAsync will be required to enable access on such devices.

If the association is later changed via cudaStreamAttachMemAsync to a single stream, the default association, as specified during cudaMallocManaged, is restored when that stream is destroyed. For __managed__ variables, the default association is always cudaMemAttachGlobal. Note that destroying a stream is an asynchronous operation, and as a result, the change to default association won't happen until all work in the stream has completed.

Memory allocated with cudaMallocManaged should be released with cudaFree.
Device memory oversubscription is possible for GPUs that have a non-zero value for the device attribute \texttt{cudaDevAttrConcurrentManagedAccess}. Managed memory on such GPUs may be evicted from device memory to host memory at any time by the Unified Memory driver in order to make room for other allocations.

In a multi-GPU system where all GPUs have a non-zero value for the device attribute \texttt{cudaDevAttrConcurrentManagedAccess}, managed memory may not be populated when this API returns and instead may be populated on access. In such systems, managed memory can migrate to any processor's memory at any time. The Unified Memory driver will employ heuristics to maintain data locality and prevent excessive page faults to the extent possible. The application can also guide the driver about memory usage patterns via \texttt{cudaMemAdvise}. The application can also explicitly migrate memory to a desired processor's memory via \texttt{cudaMemPrefetchAsync}.

In a multi-GPU system where all of the GPUs have a zero value for the device attribute \texttt{cudaDevAttrConcurrentManagedAccess} and all the GPUs have peer-to-peer support with each other, the physical storage for managed memory is created on the GPU which is active at the time \texttt{cudaMallocManaged} is called. All other GPUs will reference the data at reduced bandwidth via peer mappings over the PCIe bus. The Unified Memory driver does not migrate memory among such GPUs.

In a multi-GPU system where not all GPUs have peer-to-peer support with each other and where the value of the device attribute \texttt{cudaDevAttrConcurrentManagedAccess} is zero for at least one of those GPUs, the location chosen for physical storage of managed memory is system-dependent.

- On Linux, the location chosen will be device memory as long as the current set of active contexts are on devices that either have peer-to-peer support with each other or have a non-zero value for the device attribute \texttt{cudaDevAttrConcurrentManagedAccess}. If there is an active context on a GPU that does not have a non-zero value for that device attribute and it does not have peer-to-peer support with the other devices that have active contexts on them, then the location for physical storage will be 'zero-copy' or host memory. Note that this means that managed memory that is located in device memory is migrated to host memory if a new context is created on a GPU that doesn't have a non-zero value for the device attribute and does not support peer-to-peer with at least one of the other devices that has an active context. This in turn implies that context creation may fail if there is insufficient host memory to migrate all managed allocations.

- On Windows, the physical storage is always created in 'zero-copy' or host memory. All GPUs will reference the data at reduced bandwidth over the PCIe bus. In these circumstances, use of the environment variable CUDA\_VISIBLE\_DEVICES is recommended to restrict CUDA to only use those GPUs that have peer-to-peer support. Alternatively, users can also set CUDA\_MANAGED\_FORCE\_DEVICE\_ALLOC to a non-zero value to force the driver to always use device memory for physical storage. When this environment variable is set to a non-zero value, all devices used in that process that support managed memory have to be peer-to-peer compatible with each other. The error \texttt{cudaErrorInvalidDevice} will be returned if a device that supports managed memory is used and it is not peer-to-peer compatible with any of the other managed memory supporting devices that were previously used in that process, even if \texttt{cudaDeviceReset} has been called on those devices. These environment variables are described in the CUDA programming guide under the "CUDA environment variables" section.
Note:

- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
`cudaMallocPitch`, `cudaFree`, `cudaMallocArray`, `cudaFreeArray`, `cudaMalloc3D`, `cudaMalloc3DArray`, `cudaMallocHost (C API)`, `cudaFreeHost`, `cudaHostAlloc`, `cudaDeviceGetAttribute`, `cudaStreamAttachMemAsync`

```cpp
template < class T > cudaError_t cudaMemAdvise
(T *devPtr, size_t count, cudaMemoryAdvise advice, cudaMemLocation location)
```

Advise about the usage of a given memory range.

**Description**

This is an alternate spelling for `cudaMemAdvise` made available through operator overloading.

See also:
`cudaMemAdvise`, `cudaMemAdvise (C API)`

```cpp
template < class T > __host__ cudaError_t
cudamemcpyFromSymbol (void *dst, const T symbol, size_t count, size_t offset, cudaMemcpyKind kind)
```

[C++ API] Copies data from the given symbol on the device

**Parameters**

- `dst` - Destination memory address
- `symbol` - Device symbol reference
- `count` - Size in bytes to copy
offset
  - Offset from start of symbol in bytes

kind
  - Type of transfer

Returns
cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidSymbol, cudaErrorInvalidMemcpyDirection, cudaErrorNoKernelImageForDevice

Description
Copies count bytes from the memory area offset bytes from the start of symbol symbol to the memory area pointed to by dst. The memory areas may not overlap. symbol is a variable that resides in global or constant memory space. kind can be either cudaMemcpyDeviceToHost or cudaMemcpyDeviceToDevice.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits synchronous behavior for most use cases.
- Use of a string naming a variable as the symbol parameter was deprecated in CUDA 4.1 and removed in CUDA 5.0.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudamemcpy, cudamemcpy2D, cudamemcpy2DtoArray, cudamemcpy2DFromArray, cudamemcpy2DArrayToArray, cudamemcpyToSymbol, cudamemcpyAsync, cudamemcpy2DAsync, cudamemcpy2DtoArrayAsync, cudamemcpy2DFromArrayAsync, cudamemcpyToSymbolAsync, cudamemcpyFromSymbolAsync
template < class T > __host__ cudaError_t

cudaMemcpyFromSymbolAsync (void *dst, const T

symbol, size_t count, size_t offset, cudaMemcpyKind kind, cudaStream_t stream)

[C++ API] Copies data from the given symbol on the device

Parameters

dst
  - Destination memory address

symbol
  - Device symbol reference

count
  - Size in bytes to copy

offset
  - Offset from start of symbol in bytes

kind
  - Type of transfer

stream
  - Stream identifier

Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidSymbol, cudaErrorInvalidMemcpyDirection,
cudaErrorNoKernelImageForDevice

Description

Copies count bytes from the memory area offset bytes from the start of symbol symbol to
the memory area pointed to by dst. The memory areas may not overlap. symbol is a variable
that resides in global or constant memory space. kind can be either cudaMemcpyDeviceToHost or
cudaMemcpyDeviceToDevice.

cudaMemcpyFromSymbolAsync() is asynchronous with respect to the host, so the call may return
before the copy is complete. The copy can optionally be associated to a stream by passing a non-zero
stream argument. If kind is cudaMemcpyDeviceToHost and stream is non-zero, the copy may
overlap with operations in other streams.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits asynchronous behavior for most use cases.
Use of a string naming a variable as the `symbol` parameter was deprecated in CUDA 4.1 and removed in CUDA 5.0.

Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.

Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
`
cudamemcpy, cudamemcpy2D, cudamemcpy2DtoArray, cudamemcpy2DFromArray, cudamemcpy2DArrayToArray, cudamemcpyToSymbol, cudamemcpyFromSymbol, cudamemcpyAsync, cudamemcpy2DAsync, cudamemcpy2DtoArrayAsync, cudamemcpy2DFromArrayAsync, cudamemcpyToSymbolAsync
`

```cpp
template < class T > __host__ cudaError_t cudamemcpyToSymbol (const T symbol, const void *src, size_t count, size_t offset, cudaMemcpyKind kind)

[C++ API] Copies data to the given symbol on the device
```

**Parameters**

- `symbol` - Device symbol reference
- `src` - Source memory address
- `count` - Size in bytes to copy
- `offset` - Offset from start of symbol in bytes
- `kind` - Type of transfer

**Returns**

- `cudaSuccess`, `cudaErrorInvalidValue`, `cudaErrorInvalidSymbol`, `cudaErrorInvalidMemcpyDirection`, `cudaErrorNoKernelImageForDevice`

**Description**

Copies `count` bytes from the memory area pointed to by `src` to the memory area `offset` bytes from the start of symbol `symbol`. The memory areas may not overlap. `symbol` is a variable that resides in global or constant memory space. `kind` can be either `cudaMemcpyHostToDevice` or `cudaMemcpyDeviceToDevice`. 
Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits synchronous behavior for most use cases.
- Use of a string naming a variable as the symbol parameter was deprecated in CUDA 4.1 and removed in CUDA 5.0.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaMemcpyAsync no CUDA function may be called from callback. cudaMemcpyNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
cudaMemcpy, cudaMemcpy2D, cudaMemcpy2DToArray, cudaMemcpy2DFromArray, cudaMemcpy2DArrayToArray, cudaMemcpyFromSymbol, cudaMemcpyAsync, cudaMemcpy2DAsync, cudaMemcpy2DToArrayAsync, cudaMemcpy2DFromArrayAsync, cudaMemcpyToSymbolAsync, cudaMemcpyFromSymbolAsync

template < class T > __host__ cudaError_t cudaMemcpyToSymbolAsync (const T symbol, const void *src, size_t count, size_t offset, cudaMemcpyKind kind, cudaStream_t stream)

[C++ API] Copies data to the given symbol on the device

Parameters

symbol
- Device symbol reference
src
- Source memory address
count
- Size in bytes to copy
offset
- Offset from start of symbol in bytes
kind
- Type of transfer
stream
- Stream identifier
Returns

cudaSuccess, cudaErrorInvalidValue, cudaErrorInvalidSymbol, cudaErrorInvalidMemcpyDirection, cudaErrorNoKernelImageForDevice

Description

Copies `count` bytes from the memory area pointed to by `src` to the memory area `offset` bytes from the start of `symbol`. The memory areas may not overlap. `symbol` is a variable that resides in global or constant memory space. `kind` can be either `cudaMemcpyHostToDevice` or `cudaMemcpyDeviceToDevice`.

`cudaMemcpyToSymbolAsync()` is asynchronous with respect to the host, so the call may return before the copy is complete. The copy can optionally be associated to a stream by passing a non-zero `stream` argument. If `kind` is `cudaMemcpyHostToDevice` and `stream` is non-zero, the copy may overlap with operations in other streams.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- This function exhibits asynchronous behavior for most use cases.
- Use of a string naming a variable as the `symbol` parameter was deprecated in CUDA 4.1 and removed in CUDA 5.0.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaMemcpy, cudaMemcpy2D, cudaMemcpy2DToArray, cudaMemcpy2DFromArray, cudaMemcpy2DArrayToArray, cudaMemcpy2DFromArrayAsync, cudaMemcpyFromSymbol, cudaMemcpyAsync, cudaMemcpy2DAsync, cudaMemcpy2DFromArrayAsync, cudaMemcpyFromSymbolAsync
template < class T > __host__ cudaError_t
cudaOccupancyAvailableDynamicSMemPerBlock
(size_t *dynamicSmemSize, T *func, int numBlocks, int blockSize)

Returns dynamic shared memory available per block when launching numBlocks blocks on SM.

Parameters

dynamicSmemSize
  - Returned maximum dynamic shared memory
func
  - Kernel function for which occupancy is calculated
numBlocks
  - Number of blocks to fit on SM
blockSize
  - Size of the block

Returns

cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidDeviceFunction, cudaErrorInvalidValue, cudaErrorUnknown.

Description

Returns in *dynamicSmemSize the maximum size of dynamic shared memory to allow numBlocks blocks per SM.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaOccupancyMaxPotentialBlockSize

cudaOccupancyMaxPotentialBlockSizeWithFlags

cudaOccupancyMaxActiveBlocksPerMultiprocessor

cudaOccupancyMaxActiveBlocksPerMultiprocessorWithFlags
```
template < class T > __host__ cudaError_t
cudaOccupancyMaxActiveBlocksPerMultiprocessor
(int *numBlocks, T func, int blockSize, size_t
dynamicSMemSize)
```

Returns occupancy for a device function.

**Parameters**

**numBlocks**
- Returned occupancy

**func**
- Kernel function for which occupancy is calculated

**blockSize**
- Block size the kernel is intended to be launched with

**dynamicSMemSize**
- Per-block dynamic shared memory usage intended, in bytes

**Returns**

*cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidDeviceFunction, cudaErrorInvalidValue, cudaErrorUnknown.*

**Description**

Returns in *numBlocks* the maximum number of active blocks per streaming multiprocessor for the device function.

---

**Note:**

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return *cudaErrorInitializationError, cudaErrorInsufficientDriver* or *cudaErrorNoDevice* if this call tries to initialize internal CUDA RT state.
- Note that as specified by *cudaStreamAddCallback* no CUDA function may be called from callback. *cudaErrorNotPermitted* may, but is not guaranteed to, be returned as a diagnostic in such case.

**See also:**

- *cudaOccupancyMaxActiveBlocksPerMultiprocessorWithFlags*
- *cudaOccupancyMaxPotentialBlockSize*
cudaOccupancyMaxPotentialBlockSizeWithFlags

cudaOccupancyMaxPotentialBlockSizeVariableSMem

cudaOccupancyMaxPotentialBlockSizeVariableSMemWithFlags

cudaOccupancyAvailableDynamicSMemPerBlock

template < class T > __host__ cudaError_t
cudaOccupancyMaxActiveBlocksPerMultiprocessorWithFlags
(int *numBlocks, T func, int blockSize, size_t
dynamicSMemSize, unsigned int flags)
Returns occupancy for a device function with the specified flags.

Parameters

numBlocks
- Returned occupancy
func
- Kernel function for which occupancy is calculated
blockSize
- Block size the kernel is intended to be launched with
dynamicSMemSize
- Per-block dynamic shared memory usage intended, in bytes
flags
- Requested behavior for the occupancy calculator

Returns
cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidDeviceFunction, cudaErrorInvalidValue,
cudaErrorUnknown.

Description

Returns in *numBlocks the maximum number of active blocks per streaming multiprocessor for the device function.

The flags parameter controls how special cases are handled. Valid flags include:

- cudaOccupancyDefault: keeps the default behavior as
cudaOccupancyMaxActiveBlocksPerMultiprocessor

- cudaOccupancyDisableCachingOverride: suppresses the default behavior on platform where global caching affects occupancy. On such platforms, if caching is enabled, but per-block SM resource usage would result in zero occupancy, the occupancy calculator will calculate the occupancy as if caching is disabled. Setting this flag makes the occupancy calculator to return 0 in such cases.
More information can be found about this feature in the "Unified L1/Texture Cache" section of the Maxwell tuning guide.

**Note:**
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
- `cudaOccupancyMaxActiveBlocksPerMultiprocessor`
- `cudaOccupancyMaxPotentialBlockSize`
- `cudaOccupancyMaxPotentialBlockSizeWithFlags`
- `cudaOccupancyMaxPotentialBlockSizeVariableSMem`
- `cudaOccupancyMaxPotentialBlockSizeVariableSMemWithFlags`
- `cudaOccupancyAvailableDynamicSMemPerBlock`

```cpp
template < class T > __host__ cudaError_t
cudaOccupancyMaxActiveClusters (int *numClusters, T *func, const cudaLaunchConfig_t *config)
```

Given the kernel function (`func`) and launch configuration (`config`), return the maximum number of clusters that could co-exist on the target device in `*numClusters`.

**Parameters**

- `numClusters`
  - Returned maximum number of clusters that could co-exist on the target device
- `func`
  - Kernel function for which maximum number of clusters are calculated
- `config`
  - Launch configuration for the given kernel function

**Returns**

- `cudaSuccess`, `cudaErrorInvalidDeviceFunction`, `cudaErrorInvalidValue`, `cudaErrorInvalidClusterSize`, `cudaErrorUnknown`,
**Description**

If the function has required cluster size already set (see `cudaFuncGetAttributes`), the cluster size from `config` must either be unspecified or match the required size. Without required sizes, the cluster size must be specified in `config`, else the function will return an error.

Note that various attributes of the kernel function may affect occupancy calculation. Runtime environment may affect how the hardware schedules the clusters, so the calculated occupancy is not guaranteed to be achievable.

**Note:**
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
`cudaFuncGetAttributes`

```c
template < class T > __host__ cudaError_t
cudaOccupancyMaxPotentialBlockSize (int *minGridSize, int *blockSize, T func, size_t dynamicSMemSize, int blockSizeLimit)
```

Returns grid and block size that achieves maximum potential occupancy for a device function.

**Parameters**

- **minGridSize**
  - Returned minimum grid size needed to achieve the best potential occupancy
- **blockSize**
  - Returned block size
- **func**
  - Device function symbol
- **dynamicSMemSize**
  - Per-block dynamic shared memory usage intended, in bytes
- **blockSizeLimit**
  - The maximum block size `func` is designed to work with. 0 means no limit.
Returns

cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidDeviceFunction, cudaErrorInvalidValue, cudaErrorUnknown.

Description

Returns in *minGridSize and *blocksize a suggested grid / block size pair that achieves the best potential occupancy (i.e. the maximum number of active warps with the smallest number of blocks).

Use

See also:

cudaOccupancyMaxPotentialBlockSizeVariableSMem if the amount of per-block dynamic shared memory changes with different block sizes.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaOccupancyMaxPotentialBlockSizeWithFlags
cudaOccupancyMaxActiveBlocksPerMultiprocessor
cudaOccupancyMaxActiveBlocksPerMultiprocessorWithFlags
cudaOccupancyMaxPotentialBlockSizeVariableSMem
cudaOccupancyMaxPotentialBlockSizeVariableSMemWithFlags
cudaOccupancyAvailableDynamicSMemPerBlock
template < typename UnaryFunction, class T >
__host__ cudaError_t
cudaOccupancyMaxPotentialBlockSizeVariableSMem(
  int *minGridSize, int *blockSize, T func,
  UnaryFunction blockSizeToDynamicSMemSize, int blockSizeLimit)

Returns grid and block size that achieves maximum potential occupancy for a device function.

Parameters

*minGridSize
- Returned minimum grid size needed to achieve the best potential occupancy

*blockSize
- Returned block size

*func
- Device function symbol

*blockSizeToDynamicSMemSize
- A unary function / functor that takes block size, and returns the size, in bytes, of dynamic shared
  memory needed for a block

*blockSizeLimit
- The maximum block size *func is designed to work with. 0 means no limit.

Returns

cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidDeviceFunction, cudaErrorInvalidValue,
cudaErrorUnknown.

Description

Returns in *minGridSize and *blocksize a suggested grid / block size pair that achieves the best potential occupancy (i.e. the maximum number of active warps with the smallest number of blocks).

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or
cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback.
cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
template < typename UnaryFunction, class T >
__host__ cudaError_t
cudaOccupancyMaxPotentialBlockSizeVariableSMemWithFlags
(int *minGridSize, int *blockSize, T func, UnaryFunction
blockSizeToDynamicSMemSize, int blockSizeLimit,
unsigned int flags)

Returns grid and block size that achieves maximum potential occupancy for a device function.

Parameters

minGridSize
- Returned minimum grid size needed to achieve the best potential occupancy

blockSize
- Returned block size

func
- Device function symbol

blockSizeToDynamicSMemSize
- A unary function / functor that takes block size, and returns the size, in bytes, of dynamic shared
  memory needed for a block

blockSizeLimit
- The maximum block size func is designed to work with. 0 means no limit.

flags
- Requested behavior for the occupancy calculator

Returns

cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidDeviceFunction, cudaErrorInvalidValue,
cudaErrorUnknown.

CUDA Runtime API
Description

Returns in *minGridSize and *blocksize a suggested grid / block size pair that achieves the best potential occupancy (i.e. the maximum number of active warps with the smallest number of blocks).

The flags parameter controls how special cases are handled. Valid flags include:

- **cudaOccupancyDefault**: keeps the default behavior as cudaOccupancyMaxPotentialBlockSizeVariableSMemWithFlags
- **cudaOccupancyDisableCachingOverride**: This flag suppresses the default behavior on platform where global caching affects occupancy. On such platforms, if caching is enabled, but per-block SM resource usage would result in zero occupancy, the occupancy calculator will calculate the occupancy as if caching is disabled. Setting this flag makes the occupancy calculator to return 0 in such cases. More information can be found about this feature in the "Unified L1/Texture Cache" section of the Maxwell tuning guide.

**Note:**

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaOccupancyMaxPotentialBlockSizeVariableSMem

cudaOccupancyMaxActiveBlocksPerMultiprocessor

cudaOccupancyMaxActiveBlocksPerMultiprocessorWithFlags

cudaOccupancyMaxPotentialBlockSize

cudaOccupancyMaxPotentialBlockSizeWithFlags

cudaOccupancyAvailableDynamicSMemPerBlock
template < class T > __host__ cudaError_t
cudaOccupancyMaxPotentialBlockSizeWithFlags
(int *minGridSize, int *blockSize, T func, size_t
dynamicSMemSize, int blockSizeLimit, unsigned int flags)

Returns grid and block size that achieved maximum potential occupancy for a device function with the specified flags.

Parameters

minGridSize
- Returned minimum grid size needed to achieve the best potential occupancy

blockSize
- Returned block size

func
- Device function symbol

dynamicSMemSize
- Per-block dynamic shared memory usage intended, in bytes

blockSizeLimit
- The maximum block size \texttt{func} is designed to work with. 0 means no limit.

flags
- Requested behavior for the occupancy calculator

Returns

cudaSuccess, cudaErrorInvalidDevice, cudaErrorInvalidDeviceFunction, cudaErrorInvalidValue, cudaErrorUnknown.

Description

Returns in *minGridSize and *blockSize a suggested grid / block size pair that achieves the best potential occupancy (i.e. the maximum number of active warps with the smallest number of blocks).

The flags parameter controls how special cases are handle. Valid flags include:

- cudaOccupancyDefault: keeps the default behavior as cudaOccupancyMaxPotentialBlockSize

- cudaOccupancyDisableCachingOverride: This flag suppresses the default behavior on platform where global caching affects occupancy. On such platforms, if caching is enabled, but per-block SM resource usage would result in zero occupancy, the occupancy calculator will calculate the occupancy as if caching is disabled. Setting this flag makes the occupancy calculator to return 0 in such cases. More information can be found about this feature in the “Unified L1/Texture Cache” section of the Maxwell tuning guide.

Use
See also:

cudaOccupancyMaxPotentialBlockSizeVariableSMem if the amount of per-block dynamic shared memory changes with different block sizes.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return cudaErrorInitializationError, cudaErrorInsufficientDriver or cudaErrorNoDevice if this call tries to initialize internal CUDA RT state.
- Note that as specified by cudaStreamAddCallback no CUDA function may be called from callback. cudaErrorNotPermitted may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:

cudaOccupancyMaxPotentialBlockSize
cudaOccupancyMaxActiveBlocksPerMultiprocessor
cudaOccupancyMaxActiveBlocksPerMultiprocessorWithFlags
cudaOccupancyMaxPotentialBlockSizeVariableSMem
cudaOccupancyMaxPotentialBlockSizeVariableSMemWithFlags
cudaOccupancyAvailableDynamicSMemPerBlock

template < class T > __host__ cudaError_t
cudaOccupancyMaxPotentialClusterSize (int *clusterSize, T *func, const cudaLaunchConfig_t *config)

Given the kernel function (func) and launch configuration (config), return the maximum cluster size in *clusterSize.

Parameters

- clusterSize
  - Returned maximum cluster size that can be launched for the given kernel function and launch configuration
- func
  - Kernel function for which maximum cluster size is calculated
- config
  - Launch configuration for the given kernel function

Returns

cudaSuccess, cudaErrorInvalidDeviceFunction, cudaErrorInvalidValue, cudaErrorUnknown,
Description

The cluster dimensions in `config` are ignored. If `func` has a required cluster size set (see `cudaFuncGetAttributes`), `*clusterSize` will reflect the required cluster size.

By default this function will always return a value that's portable on future hardware. A higher value may be returned if the kernel function allows non-portable cluster sizes.

This function will respect the compile time launch bounds.

Note:
- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
- `cudaFuncGetAttributes`

```
template < class T > __host__ cudaError_t cudaStreamAttachMemAsync (cudaStream_t stream, T *devPtr, size_t length, unsigned int flags)
```

Attach memory to a stream asynchronously.

Parameters
- `stream` - Stream in which to enqueue the attach operation
- `devPtr` - Pointer to memory (must be a pointer to managed memory or to a valid host-accessible region of system-allocated memory)
- `length` - Length of memory (defaults to zero)
- `flags` - Must be one of `cudaMemAttachGlobal`, `cudaMemAttachHost` or `cudaMemAttachSingle` (defaults to `cudaMemAttachSingle`)

Returns
- `cudaSuccess`, `cudaErrorNotReady`, `cudaErrorInvalidValue`, `cudaErrorInvalidResourceHandle`
Description

Enqueues an operation in stream to specify stream association of length bytes of memory starting from devPtr. This function is a stream-ordered operation, meaning that it is dependent on, and will only take effect when, previous work in stream has completed. Any previous association is automatically replaced.

devPtr must point to an one of the following types of memories:

- managed memory declared using the __managed__ keyword or allocated with cudaMallocManaged.
- a valid host-accessible region of system-allocated pageable memory. This type of memory may only be specified if the device associated with the stream reports a non-zero value for the device attribute cudaDevAttrPageableMemoryAccess.

For managed allocations, length must be either zero or the entire allocation's size. Both indicate that the entire allocation's stream association is being changed. Currently, it is not possible to change stream association for a portion of a managed allocation.

For pageable allocations, length must be non-zero.

The stream association is specified using flags which must be one of cudaMemAttachGlobal, cudaMemAttachHost or cudaMemAttachSingle. The default value for flags is cudaMemAttachSingle. If the cudaMemAttachGlobal flag is specified, the memory can be accessed by any stream on any device. If the cudaMemAttachHost flag is specified, the program makes a guarantee that it won't access the memory on the device from any stream on a device that has a zero value for the device attribute cudaDevAttrConcurrentManagedAccess. If the cudaMemAttachSingle flag is specified and stream is associated with a device that has a zero value for the device attribute cudaDevAttrConcurrentManagedAccess, the program makes a guarantee that it will only access the memory on the device from stream. It is illegal to attach singly to the NULL stream, because the NULL stream is a virtual global stream and not a specific stream. An error will be returned in this case.

When memory is associated with a single stream, the Unified Memory system will allow CPU access to this memory region so long as all operations in stream have completed, regardless of whether other streams are active. In effect, this constrain exclusive ownership of the managed memory region by an active GPU to per-stream activity instead of whole-GPU activity.

Accessing memory on the device from streams that are not associated with it will produce undefined results. No error checking is performed by the Unified Memory system to ensure that kernels launched into other streams do not access this region.

It is a program's responsibility to order calls to cudaStreamAttachMemAsync via events, synchronization or other means to ensure legal access to memory at all times. Data visibility and coherence will be changed appropriately for all kernels which follow a stream-association change.

If stream is destroyed while data is associated with it, the association is removed and the association reverts to the default visibility of the allocation as specified at cudaMallocManaged. For __managed__ variables, the default association is always cudaMemAttachGlobal. Note that destroying a stream is an
asynchronous operation, and as a result, the change to default association won't happen until all work in the stream has completed.

Note:

- Note that this function may also return error codes from previous, asynchronous launches.
- Note that this function may also return `cudaErrorInitializationError`, `cudaErrorInsufficientDriver` or `cudaErrorNoDevice` if this call tries to initialize internal CUDA RT state.
- Note that as specified by `cudaStreamAddCallback` no CUDA function may be called from callback. `cudaErrorNotPermitted` may, but is not guaranteed to, be returned as a diagnostic in such case.

See also:
`cudaStreamCreate`, `cudaStreamCreateWithFlags`, `cudaStreamWaitEvent`, `cudaStreamSynchronize`, `cudaStreamAddCallback`, `cudaStreamDestroy`, `cudaMallocManaged`

### 6.33. Interactions with the CUDA Driver API

This section describes the interactions between the CUDA Driver API and the CUDA Runtime API

**Primary Contexts**

There exists a one to one relationship between CUDA devices in the CUDA Runtime API and `CUcontext`s in the CUDA Driver API within a process. The specific context which the CUDA Runtime API uses for a device is called the device's primary context. From the perspective of the CUDA Runtime API, a device and its primary context are synonymous.

**Initialization and Tear-Down**

CUDA Runtime API calls operate on the CUDA Driver API `CUcontext` which is current to the calling host thread.

The function `cudaInitDevice()` ensures that the primary context is initialized for the requested device but does not make it current to the calling thread.

The function `cudaSetDevice()` initializes the primary context for the specified device and makes it current to the calling thread by calling `cuCtxSetCurrent()`.

The CUDA Runtime API will automatically initialize the primary context for a device at the first CUDA Runtime API call which requires an active context. If no `CUcontext` is current to the calling thread when a CUDA Runtime API call which requires an active context is made, then the primary context for a device will be selected, made current to the calling thread, and initialized.

The context which the CUDA Runtime API initializes will be initialized using the parameters specified by the CUDA Runtime API functions `cudaSetDeviceFlags()`, `cudaD3D9SetDirect3DDevice()`, `cudaD3D10SetDirect3DDevice()`, `cudaD3D11SetDirect3DDevice()`. 
cudaGLSetGLDevice(), and cudaVDPAUSetVDPAUDevice(). Note that these functions will fail with cudaErrorSetOnActiveProcess if they are called when the primary context for the specified device has already been initialized. (or if the current device has already been initialized, in the case of cudaSetDeviceFlags()).

Primary contexts will remain active until they are explicitly deinitialized using cudaDeviceReset(). The function cudaDeviceReset() will deinitialize the primary context for the calling thread's current device immediately. The context will remain current to all of the threads that it was current to. The next CUDA Runtime API call on any thread which requires an active context will trigger the reinitialization of that device's primary context.

Note that primary contexts are shared resources. It is recommended that the primary context not be reset except just before exit or to recover from an unspecified launch failure.

Context Interoperability

Note that the use of multiple CUcontext s per device within a single process will substantially degrade performance and is strongly discouraged. Instead, it is highly recommended that the implicit one-to-one device-to-context mapping for the process provided by the CUDA Runtime API be used.

If a non-primary CUcontext created by the CUDA Driver API is current to a thread then the CUDA Runtime API calls to that thread will operate on that CUcontext, with some exceptions listed below. Interoperability between data types is discussed in the following sections.

The function cudaPointerGetAttributes() will return the error cudaErrorIncompatibleDriverContext if the pointer being queried was allocated by a non-primary context. The function cudaDeviceEnablePeerAccess() and the rest of the peer access API may not be called when a non-primary CUcontext is current. To use the pointer query and peer access APIs with a context created using the CUDA Driver API, it is necessary that the CUDA Driver API be used to access these features.

All CUDA Runtime API state (e.g. global variables' addresses and values) travels with its underlying CUcontext. In particular, if a CUcontext is moved from one thread to another then all CUDA Runtime API state will move to that thread as well.

Please note that attaching to legacy contexts (those with a version of 3010 as returned by cuCtxGetApiVersion()) is not possible. The CUDA Runtime will return cudaErrorIncompatibleDriverContext in such cases.

Interactions between CUstream and cudaStream_t

The types CUstream and cudaStream_t are identical and may be used interchangeably.

Interactions between CUevent and cudaEvent_t

The types CUevent and cudaEvent_t are identical and may be used interchangeably.

Interactions between CUarray and cudaArray_t

The types CUarray and struct cudaArray * represent the same data type and may be used interchangeably by casting the two types between each other.
In order to use a `CUarray` in a CUDA Runtime API function which takes a struct `cudaArray *`, it is necessary to explicitly cast the `CUarray` to a struct `cudaArray *`.

In order to use a struct `cudaArray *` in a CUDA Driver API function which takes a `CUarray`, it is necessary to explicitly cast the struct `cudaArray *` to a `CUarray`.

Interactions between `CUgraphicsResource` and `cudaGraphicsResource_t`

The types `CUgraphicsResource` and `cudaGraphicsResource_t` represent the same data type and may be used interchangeably by casting the two types between each other.

In order to use a `CUgraphicsResource` in a CUDA Runtime API function which takes a `cudaGraphicsResource_t`, it is necessary to explicitly cast the `CUgraphicsResource` to a `cudaGraphicsResource_t`.

In order to use a `cudaGraphicsResource_t` in a CUDA Driver API function which takes a `CUgraphicsResource`, it is necessary to explicitly cast the `cudaGraphicsResource_t` to a `CUgraphicsResource`.

Interactions between `CUtexObject` and `cudaTextureObject_t`

The types `CUtexObject` and `cudaTextureObject_t` represent the same data type and may be used interchangeably by casting the two types between each other.

In order to use a `CUtexObject` in a CUDA Runtime API function which takes a `cudaTextureObject_t`, it is necessary to explicitly cast the `CUtexObject` to a `cudaTextureObject_t`.

In order to use a `cudaTextureObject_t` in a CUDA Driver API function which takes a `CUtexObject`, it is necessary to explicitly cast the `cudaTextureObject_t` to a `CUtexObject`.

Interactions between `CUsurfObject` and `cudaSurfaceObject_t`

The types `CUsurfObject` and `cudaSurfaceObject_t` represent the same data type and may be used interchangeably by casting the two types between each other.

In order to use a `CUsurfObject` in a CUDA Runtime API function which takes a `cudaSurfaceObject_t`, it is necessary to explicitly cast the `CUsurfObject` to a `cudaSurfaceObject_t`.

In order to use a `cudaSurfaceObject_t` in a CUDA Driver API function which takes a `CUsurfObject`, it is necessary to explicitly cast the `cudaSurfaceObject_t` to a `CUsurfObject`.

Interactions between `CUfunction` and `cudaFunction_t`

The types `CUfunction` and `cudaFunction_t` represent the same data type and may be used interchangeably by casting the two types between each other.

In order to use a `cudaFunction_t` in a CUDA Driver API function which takes a `CUfunction`, it is necessary to explicitly cast the `cudaFunction_t` to a `CUfunction`.
__host__ cudaError_t cudaGetFuncBySymbol (cudaFunction_t *functionPtr, const void *symbolPtr)
Get pointer to device entry function that matches entry function symbolPtr.

Parameters

functionPtr
- Returns the device entry function

symbolPtr
- Pointer to device entry function to search for

Returns
cudaSuccess

Description

Returns in functionPtr the device entry function corresponding to the symbol symbolPtr.

__host__ cudaError_t cudaGetKernel (cudaKernel_t *kernelPtr, const void *entryFuncAddr)
Get pointer to device kernel that matches entry function entryFuncAddr.

Parameters

kernelPtr
- Returns the device kernel

entryFuncAddr
- Address of device entry function to search kernel for

Returns
cudaSuccess

Description

Returns in kernelPtr the device kernel corresponding to the entry function entryFuncAddr.

See also:
cudaGetKernel (C++ API)
6.34. Profiler Control

This section describes the profiler control functions of the CUDA runtime application programming interface.

__host__ cudaError_t cudaProfilerStart (void)

Enable profiling.

Returns

cudaSuccess

Description

Enables profile collection by the active profiling tool for the current context. If profiling is already enabled, then cudaProfilerStart() has no effect.

cudaProfilerStart and cudaProfilerStop APIs are used to programmatically control the profiling granularity by allowing profiling to be done only on selective pieces of code.

Note:

Note that this function may also return error codes from previous, asynchronous launches.

See also:

cudaProfilerStop, cuProfilerStart

__host__ cudaError_t cudaProfilerStop (void)

Disable profiling.

Returns

cudaSuccess

Description

Disables profile collection by the active profiling tool for the current context. If profiling is already disabled, then cudaProfilerStop() has no effect.

cudaProfilerStart and cudaProfilerStop APIs are used to programmatically control the profiling granularity by allowing profiling to be done only on selective pieces of code.
Note:
Note that this function may also return error codes from previous, asynchronous launches.

See also:
cudaProfilerStart, cuProfilerStop

6.35. Data types used by CUDA Runtime
struct cudaAccessPolicyWindow
struct cudaArrayMemoryRequirements
struct cudaArraySparseProperties
struct cudaAsyncNotificationInfo_t
struct cudaChannelFormatDesc
struct cudaChildGraphNodeParams
struct cudaConditionalNodeParams
struct cudaDeviceProp
struct cudaEglFrame
struct cudaEglPlaneDesc
struct cudaEventRecordNodeParams
struct cudaEventWaitNodeParams
struct cudaExtent
struct cudaExternalMemoryBufferDesc
struct cudaExternalMemoryHandleDesc
struct cudaExternalMemoryMipmappedArrayDesc
struct cudaExternalSemaphoreHandleDesc
struct cudaExternalSemaphoreSignalNodeParams
struct cudaExternalSemaphoreSignalNodeParamsV2
struct cudaExternalSemaphoreSignalParams
struct cudaExternalSemaphoreSignalParams_v1
struct cudaExternalSemaphoreWaitNodeParams
struct cudaExternalSemaphoreWaitNodeParamsV2
struct cudaExternalSemaphoreWaitParams
struct cudaExternalSemaphoreWaitParams_v1
struct cudaFuncAttributes
struct cudaGraphEdgeData
struct cudaGraphExecUpdateResultInfo
struct cudaGraphInstantiateParams
struct cudaGraphKernelNodeUpdate
struct cudaGraphNodeParams
struct cudaHostNodeParams
struct cudaHostNodeParamsV2
struct cudaIpcEventHandle_t
struct cudaIpcMemHandle_t
struct cudaMemcpyNodeParams
struct cudaMemcpyNodeParamsV2
struct cudaLaunchAttribute
union cudaLaunchAttributeValue
struct cudaLaunchConfig_t
struct cudaMemcpy3DParms
struct cudaMemcpy3DPeerParms
struct cudaMemcpyNodeParams
struct cudaMemcpyNodeParamsV2
struct cudaMemcpyNodePoolProps
struct cudaMemPoolPtrExportData
struct cudaMemsetParams
struct cudaMemsetParamsV2
struct cudaPitchedPtr
struct cudaMemcpyAttributes
struct cudaPos
struct cudaResourceDesc
struct cudaResourceViewDesc
struct cudaTextureDesc
struct CUuuid_st
enum cudaAccessProperty

Specifies performance hint with cudaAccessPolicyWindow for hitProp and missProp members.

Values

<table>
<thead>
<tr>
<th>Enum</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cudaAccessPropertyNormal</td>
<td>0 Normal cache persistence.</td>
</tr>
<tr>
<td>cudaAccessPropertyStreaming</td>
<td>1 Streaming access is less likely to persist from cache.</td>
</tr>
<tr>
<td>cudaAccessPropertyPersisting</td>
<td>2 Persisting access is more likely to persist in cache.</td>
</tr>
</tbody>
</table>

enum cudaAsyncNotificationType

Types of async notification that can occur
Values
cudaAsyncNotificationTypeOverBudget = 0x1

enum cudaCGScope
CUDA cooperative group scope

Values
cudaCGScopeInvalid = 0
   Invalid cooperative group scope
cudaCGScopeGrid = 1
   Scope represented by a grid_group
cudaCGScopeMultiGrid = 2
   Scope represented by a multi_grid_group

enum cudaChannelFormatKind
Channel format kind

Values
cudaChannelFormatKindSigned = 0
   Signed channel format
cudaChannelFormatKindUnsigned = 1
   Unsigned channel format
cudaChannelFormatKindFloat = 2
   Float channel format
cudaChannelFormatKindNone = 3
   No channel format
cudaChannelFormatKindNV12 = 4
   Unsigned 8-bit integers, planar 4:2:0 YUV format
cudaChannelFormatKindUnsignedNormalized8X1 = 5
   1 channel unsigned 8-bit normalized integer
cudaChannelFormatKindUnsignedNormalized8X2 = 6
   2 channel unsigned 8-bit normalized integer
cudaChannelFormatKindUnsignedNormalized8X4 = 7
   4 channel unsigned 8-bit normalized integer
cudaChannelFormatKindUnsignedNormalized16X1 = 8
   1 channel unsigned 16-bit normalized integer
cudaChannelFormatKindUnsignedNormalized16X2 = 9
   2 channel unsigned 16-bit normalized integer
cudaChannelFormatKindUnsignedNormalized16X4 = 10
   4 channel unsigned 16-bit normalized integer
cudaChannelFormatKindSignedNormalized8X1 = 11
  1 channel signed 8-bit normalized integer

cudaChannelFormatKindSignedNormalized8X2 = 12
  2 channel signed 8-bit normalized integer

cudaChannelFormatKindSignedNormalized8X4 = 13
  4 channel signed 8-bit normalized integer

cudaChannelFormatKindSignedNormalized16X1 = 14
  1 channel signed 16-bit normalized integer

cudaChannelFormatKindSignedNormalized16X2 = 15
  2 channel signed 16-bit normalized integer

cudaChannelFormatKindSignedNormalized16X4 = 16
  4 channel signed 16-bit normalized integer

cudaChannelFormatKindUnsignedBlockCompressed1 = 17
  4 channel unsigned normalized block-compressed (BC1 compression) format

cudaChannelFormatKindUnsignedBlockCompressed1SRGB = 18
  4 channel unsigned normalized block-compressed (BC1 compression) format with sRGB encoding

cudaChannelFormatKindUnsignedBlockCompressed2 = 19
  4 channel unsigned normalized block-compressed (BC2 compression) format

cudaChannelFormatKindUnsignedBlockCompressed2SRGB = 20
  4 channel unsigned normalized block-compressed (BC2 compression) format with sRGB encoding

cudaChannelFormatKindUnsignedBlockCompressed3 = 21
  4 channel unsigned normalized block-compressed (BC3 compression) format

cudaChannelFormatKindUnsignedBlockCompressed3SRGB = 22
  4 channel unsigned normalized block-compressed (BC3 compression) format with sRGB encoding

cudaChannelFormatKindUnsignedBlockCompressed4 = 23
  1 channel unsigned normalized block-compressed (BC4 compression) format

cudaChannelFormatKindSignedBlockCompressed4 = 24
  1 channel signed normalized block-compressed (BC4 compression) format

cudaChannelFormatKindUnsignedBlockCompressed5 = 25
  2 channel unsigned normalized block-compressed (BC5 compression) format

cudaChannelFormatKindSignedBlockCompressed5 = 26
  2 channel signed normalized block-compressed (BC5 compression) format

cudaChannelFormatKindUnsignedBlockCompressed6H = 27
  3 channel unsigned half-float block-compressed (BC6H compression) format

cudaChannelFormatKindSignedBlockCompressed6H = 28
  3 channel signed half-float block-compressed (BC6H compression) format

cudaChannelFormatKindUnsignedBlockCompressed7 = 29
  4 channel unsigned normalized block-compressed (BC7 compression) format

cudaChannelFormatKindUnsignedBlockCompressed7SRGB = 30
  4 channel unsigned normalized block-compressed (BC7 compression) format with sRGB encoding

enum cudaClusterSchedulingPolicy

Cluster scheduling policies. These may be passed to cudaFuncSetAttribute
Values

- `cudaClusterSchedulingPolicyDefault = 0`  
  the default policy
- `cudaClusterSchedulingPolicySpread = 1`  
  spread the blocks within a cluster to the SMs
- `cudaClusterSchedulingPolicyLoadBalancing = 2`  
  allow the hardware to load-balance the blocks in a cluster to the SMs

**enum cudaComputeMode**

CUDA device compute modes

Values

- `cudaComputeModeDefault = 0`  
  Default compute mode (Multiple threads can use `cudaSetDevice()` with this device)
- `cudaComputeModeExclusive = 1`  
  Compute-exclusive-thread mode (Only one thread in one process will be able to use `cudaSetDevice()` with this device)
- `cudaComputeModeProhibited = 2`  
  Compute-prohibited mode (No threads can use `cudaSetDevice()` with this device)
- `cudaComputeModeExclusiveProcess = 3`  
  Compute-exclusive-process mode (Many threads in one process will be able to use `cudaSetDevice()` with this device)

**enum cudaDeviceAttr**

CUDA device attributes

Values

- `cudaDevAttrMaxThreadsPerBlock = 1`  
  Maximum number of threads per block
- `cudaDevAttrMaxBlockDimX = 2`  
  Maximum block dimension X
- `cudaDevAttrMaxBlockDimY = 3`  
  Maximum block dimension Y
- `cudaDevAttrMaxBlockDimZ = 4`  
  Maximum block dimension Z
- `cudaDevAttrMaxGridDimX = 5`  
  Maximum grid dimension X
- `cudaDevAttrMaxGridDimY = 6`  
  Maximum grid dimension Y
- `cudaDevAttrMaxGridDimZ = 7`
Maximum grid dimension Z

cudaDevAttrMaxSharedMemoryPerBlock = 8
  Maximum shared memory available per block in bytes

cudaDevAttrTotalConstantMemory = 9
  Memory available on device for __constant__ variables in a CUDA C kernel in bytes

cudaDevAttrWarpSize = 10
  Warp size in threads

cudaDevAttrMaxPitch = 11
  Maximum pitch in bytes allowed by memory copies

cudaDevAttrMaxRegistersPerBlock = 12
  Maximum number of 32-bit registers available per block

cudaDevAttrClockRate = 13
  Peak clock frequency in kilohertz

cudaDevAttrTextureAlignment = 14
  Alignment requirement for textures

cudaDevAttrGpuOverlap = 15
  Device can possibly copy memory and execute a kernel concurrently

cudaDevAttrMultiProcessorCount = 16
  Number of multiprocessors on device

cudaDevAttrKernelExecTimeout = 17
  Specifies whether there is a run time limit on kernels

cudaDevAttrIntegrated = 18
  Device is integrated with host memory

cudaDevAttrCanMapHostMemory = 19
  Device can map host memory into CUDA address space

cudaDevAttrComputeMode = 20
  Compute mode (See cudaComputeMode for details)

cudaDevAttrMaxTexture1DWidth = 21
  Maximum 1D texture width

cudaDevAttrMaxTexture2DWidth = 22
  Maximum 2D texture width

cudaDevAttrMaxTexture2DHeight = 23
  Maximum 2D texture height

cudaDevAttrMaxTexture3DWidth = 24
  Maximum 3D texture width

cudaDevAttrMaxTexture3DHeight = 25
  Maximum 3D texture height

cudaDevAttrMaxTexture3DDepth = 26
  Maximum 3D texture depth

cudaDevAttrMaxTexture2DLayeredWidth = 27
  Maximum 2D layered texture width

cudaDevAttrMaxTexture2DLayeredHeight = 28
  Maximum 2D layered texture height
cudaDevAttrMaxTexture2DLayeredLayers = 29
   Maximum layers in a 2D layered texture

cudaDevAttrSurfaceAlignment = 30
   Alignment requirement for surfaces

cudaDevAttrConcurrentKernels = 31
   Device can possibly execute multiple kernels concurrently

cudaDevAttrEccEnabled = 32
   Device has ECC support enabled

cudaDevAttrPciBusId = 33
   PCI bus ID of the device

cudaDevAttrPciDeviceId = 34
   PCI device ID of the device

cudaDevAttrTccDriver = 35
   Device is using TCC driver model

cudaDevAttrMemoryClockRate = 36
   Peak memory clock frequency in kilohertz

cudaDevAttrGlobalMemoryBusWidth = 37
   Global memory bus width in bits

cudaDevAttrL2CacheSize = 38
   Size of L2 cache in bytes

cudaDevAttrMaxThreadsPerMultiProcessor = 39
   Maximum resident threads per multiprocessor

cudaDevAttrAsyncEngineCount = 40
   Number of asynchronous engines

cudaDevAttrUnifiedAddressing = 41
   Device shares a unified address space with the host

cudaDevAttrMaxTexture1DLayeredWidth = 42
   Maximum 1D layered texture width

cudaDevAttrMaxTexture1DLayeredLayers = 43
   Maximum layers in a 1D layered texture

cudaDevAttrMaxTexture2DGatherWidth = 45
   Maximum 2D texture width if cudaArrayTextureGather is set

cudaDevAttrMaxTexture2DHeight = 46
   Maximum 2D texture height if cudaArrayTextureGather is set

cudaDevAttrMaxTexture3DWidthAlt = 47
   Alternate maximum 3D texture width

cudaDevAttrMaxTexture3DHeightAlt = 48
   Alternate maximum 3D texture height

cudaDevAttrMaxTexture3DDepthAlt = 49
   Alternate maximum 3D texture depth

cudaDevAttrPciDomainId = 50
   PCI domain ID of the device

cudaDevAttrTexturePitchAlignment = 51
Pitch alignment requirement for textures

\textbf{cudaDevAttrMaxTextureCubemapWidth} = 52
Maximum cubemap texture width/height

\textbf{cudaDevAttrMaxTextureCubemapLayeredWidth} = 53
Maximum cubemap layered texture width/height

\textbf{cudaDevAttrMaxTextureCubemapLayeredLayers} = 54
Maximum layers in a cubemap layered texture

\textbf{cudaDevAttrMaxSurface1DWidth} = 55
Maximum 1D surface width

\textbf{cudaDevAttrMaxSurface2DWidth} = 56
Maximum 2D surface width

\textbf{cudaDevAttrMaxSurface2DHeight} = 57
Maximum 2D surface height

\textbf{cudaDevAttrMaxSurface3DWidth} = 58
Maximum 3D surface width

\textbf{cudaDevAttrMaxSurface3DHeight} = 59
Maximum 3D surface height

\textbf{cudaDevAttrMaxSurface3DDepth} = 60
Maximum 3D surface depth

\textbf{cudaDevAttrMaxSurface1DLayeredWidth} = 61
Maximum 1D layered surface width

\textbf{cudaDevAttrMaxSurface1DLayeredLayers} = 62
Maximum layers in a 1D layered surface

\textbf{cudaDevAttrMaxSurface2DLayeredWidth} = 63
Maximum 2D layered surface width

\textbf{cudaDevAttrMaxSurface2DLayeredHeight} = 64
Maximum 2D layered surface height

\textbf{cudaDevAttrMaxSurface2DLayeredLayers} = 65
Maximum layers in a 2D layered surface

\textbf{cudaDevAttrMaxSurfaceCubemapWidth} = 66
Maximum cubemap surface width

\textbf{cudaDevAttrMaxSurfaceCubemapLayeredWidth} = 67
Maximum cubemap layered surface width

\textbf{cudaDevAttrMaxSurfaceCubemapLayeredLayers} = 68
Maximum layers in a cubemap layered surface

\textbf{cudaDevAttrMaxTexture1DLinearWidth} = 69
Maximum 1D linear texture width

\textbf{cudaDevAttrMaxTexture2DLinearWidth} = 70
Maximum 2D linear texture width

\textbf{cudaDevAttrMaxTexture2DLinearHeight} = 71
Maximum 2D linear texture height

\textbf{cudaDevAttrMaxTexture2DLinearPitch} = 72
Maximum 2D linear texture pitch in bytes
cudaDevAttrMaxTexture2DMipmappedWidth = 73
  Maximum mipmapped 2D texture width
cudaDevAttrMaxTexture2DMipmappedHeight = 74
  Maximum mipmapped 2D texture height
cudaDevAttrComputeCapabilityMajor = 75
  Major compute capability version number
cudaDevAttrComputeCapabilityMinor = 76
  Minor compute capability version number
cudaDevAttrMaxTexture1DMipmappedWidth = 77
  Maximum mipmapped 1D texture width
cudaDevAttrStreamPrioritiesSupported = 78
  Device supports stream priorities
cudaDevAttrGlobalL1CacheSupported = 79
  Device supports caching globals in L1
cudaDevAttrLocalL1CacheSupported = 80
  Device supports caching locals in L1
cudaDevAttrMaxSharedMemoryPerMultiprocessor = 81
  Maximum shared memory available per multiprocessor in bytes
cudaDevAttrMaxRegistersPerMultiprocessor = 82
  Maximum number of 32-bit registers available per multiprocessor
cudaDevAttrManagedMemory = 83
  Device can allocate managed memory on this system
cudaDevAttrIsMultiGpuBoard = 84
  Device is on a multi-GPU board
cudaDevAttrMultiGpuBoardGroupID = 85
  Unique identifier for a group of devices on the same multi-GPU board
cudaDevAttrHostNativeAtomicSupported = 86
  Link between the device and the host supports native atomic operations
cudaDevAttrSingleToDoublePrecisionPerfRatio = 87
  Ratio of single precision performance (in floating-point operations per second) to double precision performance
cudaDevAttrPageableMemoryAccess = 88
  Device supports coherently accessing pageable memory without calling cudaHostRegister on it
cudaDevAttrConcurrentManagedAccess = 89
  Device can coherently access managed memory concurrently with the CPU
cudaDevAttrComputePreemptionSupported = 90
  Device supports Compute Preemption
cudaDevAttrCanUseHostPointerForRegisteredMem = 91
  Device can access host registered memory at the same virtual address as the CPU
cudaDevAttrReserved92 = 92
cudaDevAttrReserved93 = 93
cudaDevAttrReserved94 = 94
cudaDevAttrCooperativeLaunch = 95
Device supports launching cooperative kernels via `cudaLaunchCooperativeKernel`.

`cudaDevAttrCooperativeMultiDeviceLaunch = 96`
- Deprecated, `cudaLaunchCooperativeKernelMultiDevice` is deprecated.

`cudaDevAttrMaxSharedMemoryPerBlockOptin = 97`
- The maximum optin shared memory per block. This value may vary by chip. See `cudaFuncSetAttribute`.

`cudaDevAttrCanFlushRemoteWrites = 98`
- Device supports flushing of outstanding remote writes.

`cudaDevAttrHostRegisterSupported = 99`
- Device supports host memory registration via `cudaHostRegister`.

`cudaDevAttrPageableMemoryAccessUsesHostPageTables = 100`
- Device accesses pageable memory via the host's page tables.

`cudaDevAttrDirectManagedMemAccessFromHost = 101`
- Host can directly access managed memory on the device without migration.

`cudaDevAttrMaxBlocksPerMultiprocessor = 106`
- Maximum number of blocks per multiprocessor.

`cudaDevAttrMaxPersistingL2CacheSize = 108`
- Maximum L2 persisting lines capacity setting in bytes.

`cudaDevAttrMaxAccessPolicyWindowSize = 109`
- Maximum value of `cudaAccessPolicyWindow::num_bytes`.

`cudaDevAttrReservedSharedMemoryPerBlock = 111`
- Shared memory reserved by CUDA driver per block in bytes.

`cudaDevAttrSparseCudaArraySupported = 112`
- Device supports sparse CUDA arrays and sparse CUDA mipmapped arrays.

`cudaDevAttrHostRegisterReadOnlySupported = 113`
- Device supports using the `cudaHostRegister` flag `cudaHostRegisterReadOnly` to register memory that must be mapped as read-only to the GPU.

`cudaDevAttrTimelineSemaphoreInteropSupported = 114`
- External timeline semaphore interop is supported on the device.

`cudaDevAttrMaxTimelineSemaphoreInteropSupported = 114`
- Deprecated, External timeline semaphore interop is supported on the device.

`cudaDevAttrMemoryPoolsSupported = 115`
- Device supports using the `cudaMallocAsync` and `cudaMemPool` family of APIs.

`cudaDevAttrGPUDirectRDMASupported = 116`
- Device supports GPUDirect RDMA APIs, like `nvidia_p2p_get_pages` (see https://docs.nvidia.com/cuda/gpudirect-rdma for more information).

`cudaDevAttrGPUDirectRDMAFlushWritesOptions = 117`
- The returned attribute shall be interpreted as a bitmask, where the individual bits are listed in the `cudaFlushGPUDirectRDMAFlushWriteOptions` enum.

`cudaDevAttrGPUDirectRDMAWritesOrdering = 118`
- GPUDirect RDMA writes to the device do not need to be flushed for consumers within the scope indicated by the returned attribute. See `cudaGPUDirectRDMAFlushWriteOptions` for the numerical values returned here.
cudaDevAttrMemoryPoolSupportedHandleTypes = 119
    Handle types supported with mempool based IPC

cudaDevAttrClusterLaunch = 120
    Indicates device supports cluster launch

cudaDevAttrDeferredMappingCudaArraySupported = 121
    Device supports deferred mapping CUDA arrays and CUDA mipmapped arrays

cudaDevAttrReserved122 = 122

cudaDevAttrReserved123 = 123

cudaDevAttrReserved124 = 124

cudaDevAttrIpcEventSupport = 125
    Device supports IPC Events.

cudaDevAttrMemSyncDomainCount = 126
    Number of memory synchronization domains the device supports.

cudaDevAttrReserved127 = 127

cudaDevAttrReserved128 = 128

cudaDevAttrReserved129 = 129

cudaDevAttrNumaConfig = 130
    NUMA configuration of a device: value is of type cudaDeviceNumaConfig enum

cudaDevAttrNumaId = 131
    NUMA node ID of the GPU memory

cudaDevAttrReserved132 = 132

cudaDevAttrMpsEnabled = 133
    Contexts created on this device will be shared via MPS

cudaDevAttrHostNumaId = 134
    NUMA ID of the host node closest to the device. Returns -1 when system does not support NUMA.

cudaDevAttrD3D12CigSupported = 135
    Device supports CIG with D3D12.

cudaDevAttrMax

enum cudaDeviceNumaConfig

CUDA device NUMA config

Values

cudaDeviceNumaConfigNone = 0
    The GPU is not a NUMA node

cudaDeviceNumaConfigNumaNode
    The GPU is a NUMA node, cudaDevAttrNumaId contains its NUMA ID

enum cudaDeviceP2PAttr

CUDA device P2P attributes
Values

\textbf{cudaDevP2PAttrPerformanceRank} = 1
A relative value indicating the performance of the link between two devices

\textbf{cudaDevP2PAttrAccessSupported} = 2
Peer access is enabled

\textbf{cudaDevP2PAttrNativeAtomicSupported} = 3
Native atomic operation over the link supported

\textbf{cudaDevP2PAttrCudaArrayAccessSupported} = 4
Accessing CUDA arrays over the link supported

\textbf{enum cudaDriverEntryPointQueryResult}
Enum for status from obtaining driver entry points, used with cudaApiGetDriverEntryPoint

Values

\textbf{cudaDriverEntryPointSuccess} = 0
Search for symbol found a match

\textbf{cudaDriverEntryPointSymbolNotFound} = 1
Search for symbol was not found

\textbf{cudaDriverEntryPointVersionNotSufficient} = 2
Search for symbol was found but version wasn't great enough

\textbf{enum cudaEglColorFormat}
CUDA EGL Color Format - The different planar and multiplanar formats currently supported for CUDA_EGL interops.

Values

\textbf{cudaEglColorFormatYUV420Planar} = 0
Y, U, V in three surfaces, each in a separate surface, U/V width = 1/2 Y width, U/V height = 1/2 Y height.

\textbf{cudaEglColorFormatYUV420SemiPlanar} = 1
Y, UV in two surfaces (UV as one surface) with VU byte ordering, width, height ratio same as YUV420Planar.

\textbf{cudaEglColorFormatYUV422Planar} = 2
Y, U, V each in a separate surface, U/V width = 1/2 Y width, U/V height = Y height.

\textbf{cudaEglColorFormatYUV422SemiPlanar} = 3
Y, UV in two surfaces with VU byte ordering, width, height ratio same as YUV422Planar.

\textbf{cudaEglColorFormatARGB} = 6
R/G/B/A four channels in one surface with BGRA byte ordering.

\textbf{cudaEglColorFormatRGBA} = 7
R/G/B/A four channels in one surface with ABGR byte ordering.
cudaEglColorFormatL = 8
    single luminance channel in one surface.

cudaEglColorFormatR = 9
    single color channel in one surface.

cudaEglColorFormatYUV444Planar = 10
    Y, U, V in three surfaces, each in a separate surface, U/V width = Y width, U/V height = Y height.

cudaEglColorFormatYUV444SemiPlanar = 11
    Y, UV in two surfaces (UV as one surface) with VU byte ordering, width, height ratio same as YUV444Planar.

cudaEglColorFormatYUYV422 = 12
    Y, U, V in one surface, interleaved as UYYV in one channel.

cudaEglColorFormatUYVY422 = 13
    Y, U, V in one surface, interleaved as YUYV in one channel.

cudaEglColorFormatABGR = 14
    R/G/B/A four channels in one surface with RGBA byte ordering.

cudaEglColorFormatBGRA = 15
    R/G/B/A four channels in one surface with ARGB byte ordering.

cudaEglColorFormatA = 16
    Alpha color format - one channel in one surface.

cudaEglColorFormatRG = 17
    R/G color format - two channels in one surface with GR byte ordering.

cudaEglColorFormatAYUV = 18
    Y, U, V, A four channels in one surface, interleaved as VUYA.

cudaEglColorFormatYVU444SemiPlanar = 19
    Y, VU in two surfaces (VU as one surface) with UV byte ordering, U/V width = Y width, U/V height = Y height.

cudaEglColorFormatYVU422SemiPlanar = 20
    Y, VU in two surfaces (VU as one surface) with UV byte ordering, U/V width = 1/2 Y width, U/V height = Y height.

cudaEglColorFormatYVU420SemiPlanar = 21
    Y, VU in two surfaces (VU as one surface) with UV byte ordering, U/V width = 1/2 Y width, U/V height = 1/2 Y height.

cudaEglColorFormatY10V10U10_444SemiPlanar = 22
    Y10, V10U10 in two surfaces (VU as one surface) with UV byte ordering, U/V width = Y width, U/V height = Y height.

cudaEglColorFormatY10V10U10_420SemiPlanar = 23
    Y10, V10U10 in two surfaces (VU as one surface) with UV byte ordering, U/V width = 1/2 Y width, U/V height = 1/2 Y height.

cudaEglColorFormatY12V12U12_444SemiPlanar = 24
    Y12, V12U12 in two surfaces (VU as one surface) with UV byte ordering, U/V width = Y width, U/V height = Y height.

cudaEglColorFormatY12V12U12_420SemiPlanar = 25
Y12, V12U12 in two surfaces (VU as one surface) with UV byte ordering, U/V width = 1/2 Y width, U/V height = 1/2 Y height.

cudaEglColorFormatVYUY_ER = 26
   Extended Range Y, U, V in one surface, interleaved as VYU in one channel.

cudaEglColorFormatUYVY_ER = 27
   Extended Range Y, U, V in one surface, interleaved as YUYV in one channel.

cudaEglColorFormatYUYV_ER = 28
   Extended Range Y, U, V in one surface, interleaved as UYVY in one channel.

cudaEglColorFormatVYVYU_ER = 29
   Extended Range Y, U, V in one surface, interleaved as VYUY in one channel.

cudaEglColorFormatYUVA_ER = 31
   Extended Range Y, U, V, A four channels in one surface, interleaved as AVUY.

cudaEglColorFormatAYUV_ER = 32
   Extended Range Y, U, V, A four channels in one surface, interleaved as VUYA.

cudaEglColorFormatYUV444Planar_ER = 33
   Extended Range Y, U, V in three surfaces, U/V width = Y width, U/V height = Y height.

cudaEglColorFormatYUV422Planar_ER = 34
   Extended Range Y, U, V in three surfaces, U/V width = 1/2 Y width, U/V height = Y height.

cudaEglColorFormatYUV420Planar_ER = 35
   Extended Range Y, U, V in three surfaces, U/V width = 1/2 Y width, U/V height = 1/2 Y height.

cudaEglColorFormatYUV444SemiPlanar_ER = 36
   Extended Range Y, UV in two surfaces (UV as one surface) with VU byte ordering, U/V width = Y width, U/V height = Y height.

cudaEglColorFormatYUV422SemiPlanar_ER = 37
   Extended Range Y, UV in two surfaces (UV as one surface) with VU byte ordering, U/V width = 1/2 Y width, U/V height = Y height.

cudaEglColorFormatYUV420SemiPlanar_ER = 38
   Extended Range Y, UV in two surfaces (UV as one surface) with VU byte ordering, U/V width = 1/2 Y width, U/V height = 1/2 Y height.

cudaEglColorFormatYVU444Planar_ER = 39
   Extended Range Y, V, U in three surfaces, U/V width = Y width, U/V height = Y height.

cudaEglColorFormatYVU422Planar_ER = 40
   Extended Range Y, V, U in three surfaces, U/V width = 1/2 Y width, U/V height = Y height.

cudaEglColorFormatYVU420Planar_ER = 41
   Extended Range Y, V, U in three surfaces, U/V width = 1/2 Y width, U/V height = 1/2 Y height.

cudaEglColorFormatYVU444SemiPlanar_ER = 42
   Extended Range Y, VU in two surfaces (VU as one surface) with UV byte ordering, U/V width = Y width, U/V height = Y height.

cudaEglColorFormatYVU422SemiPlanar_ER = 43
   Extended Range Y, VU in two surfaces (VU as one surface) with UV byte ordering, U/V width = 1/2 Y width, U/V height = Y height.

cudaEglColorFormatYVU420SemiPlanar_ER = 44
Extended Range Y, VU in two surfaces (VU as one surface) with UV byte ordering, U/V width = 1/2 Y width, U/V height = 1/2 Y height.

**cudaEglColorFormatBayerRGGB = 45**
Bayer format - one channel in one surface with interleaved RGGB ordering.

**cudaEglColorFormatBayerBGGR = 46**
Bayer format - one channel in one surface with interleaved BGGR ordering.

**cudaEglColorFormatBayerGRBG = 47**
Bayer format - one channel in one surface with interleaved GRBG ordering.

**cudaEglColorFormatBayerGBRG = 48**
Bayer format - one channel in one surface with interleaved GBRG ordering.

**cudaEglColorFormatBayer10RGGB = 49**
Bayer10 format - one channel in one surface with interleaved RGGB ordering. Out of 16 bits, 10 bits used 6 bits No-op.

**cudaEglColorFormatBayer10BGGR = 50**
Bayer10 format - one channel in one surface with interleaved BGGR ordering. Out of 16 bits, 10 bits used 6 bits No-op.

**cudaEglColorFormatBayer10GRBG = 51**
Bayer10 format - one channel in one surface with interleaved GRBG ordering. Out of 16 bits, 10 bits used 6 bits No-op.

**cudaEglColorFormatBayer10GBRG = 52**
Bayer10 format - one channel in one surface with interleaved GBRG ordering. Out of 16 bits, 10 bits used 6 bits No-op.

**cudaEglColorFormatBayer12RGGB = 53**
Bayer12 format - one channel in one surface with interleaved RGGB ordering. Out of 16 bits, 12 bits used 4 bits No-op.

**cudaEglColorFormatBayer12BGGR = 54**
Bayer12 format - one channel in one surface with interleaved BGGR ordering. Out of 16 bits, 12 bits used 4 bits No-op.

**cudaEglColorFormatBayer12GRBG = 55**
Bayer12 format - one channel in one surface with interleaved GRBG ordering. Out of 16 bits, 12 bits used 4 bits No-op.

**cudaEglColorFormatBayer12GBRG = 56**
Bayer12 format - one channel in one surface with interleaved GBRG ordering. Out of 16 bits, 12 bits used 4 bits No-op.

**cudaEglColorFormatBayer14RGGB = 57**
Bayer14 format - one channel in one surface with interleaved RGGB ordering. Out of 16 bits, 14 bits used 2 bits No-op.

**cudaEglColorFormatBayer14BGGR = 58**
Bayer14 format - one channel in one surface with interleaved BGGR ordering. Out of 16 bits, 14 bits used 2 bits No-op.

**cudaEglColorFormatBayer14GRBG = 59**
Bayer14 format - one channel in one surface with interleaved GRBG ordering. Out of 16 bits, 14 bits used 2 bits No-op.
cudaEglColorFormatBayer14GBRG = 60
Bayer14 format - one channel in one surface with interleaved GBRG ordering. Out of 16 bits, 14
bits used 2 bits No-op.

cudaEglColorFormatBayer20RGGB = 61
Bayer20 format - one channel in one surface with interleaved RGGB ordering. Out of 32 bits, 20
bits used 12 bits No-op.

cudaEglColorFormatBayer20BGGR = 62
Bayer20 format - one channel in one surface with interleaved BGGR ordering. Out of 32 bits, 20
bits used 12 bits No-op.

cudaEglColorFormatBayer20GRBG = 63
Bayer20 format - one channel in one surface with interleaved GRBG ordering. Out of 32 bits, 20
bits used 12 bits No-op.

cudaEglColorFormatBayer20GBRG = 64
Bayer20 format - one channel in one surface with interleaved GBRG ordering. Out of 32 bits, 20
bits used 12 bits No-op.

cudaEglColorFormatYVU444Planar = 65
Y, V, U in three surfaces, each in a separate surface, U/V width = Y width, U/V height = Y height.

cudaEglColorFormatYVU422Planar = 66
Y, V, U in three surfaces, each in a separate surface, U/V width = 1/2 Y width, U/V height = Y
height.

cudaEglColorFormatYVU420Planar = 67
Y, V, U in three surfaces, each in a separate surface, U/V width = 1/2 Y width, U/V height = 1/2 Y
height.

cudaEglColorFormatBayerIspRGGB = 68
Nvidia proprietary Bayer ISP format - one channel in one surface with interleaved RGGB ordering
and mapped to opaque integer datatype.

cudaEglColorFormatBayerIspBGGR = 69
Nvidia proprietary Bayer ISP format - one channel in one surface with interleaved BGGR ordering
and mapped to opaque integer datatype.

cudaEglColorFormatBayerIspGRBG = 70
Nvidia proprietary Bayer ISP format - one channel in one surface with interleaved GRBG ordering
and mapped to opaque integer datatype.

cudaEglColorFormatBayerIspGBRG = 71
Nvidia proprietary Bayer ISP format - one channel in one surface with interleaved GBRG ordering
and mapped to opaque integer datatype.

cudaEglColorFormatBayerBCCR = 72
Bayer format - one channel in one surface with interleaved BCCR ordering.

cudaEglColorFormatBayerRCCB = 73
Bayer format - one channel in one surface with interleaved RCCB ordering.

cudaEglColorFormatBayerCRBC = 74
Bayer format - one channel in one surface with interleaved CRBC ordering.

cudaEglColorFormatBayerCBRC = 75
Bayer format - one channel in one surface with interleaved CBRC ordering.
cudaEglColorFormatBayer10CCCC = 76
  Bayer10 format - one channel in one surface with interleaved CCCC ordering. Out of 16 bits, 10
  bits used 6 bits No-op.

cudaEglColorFormatBayer12BCCR = 77
  Bayer12 format - one channel in one surface with interleaved BCCR ordering. Out of 16 bits, 12
  bits used 4 bits No-op.

cudaEglColorFormatBayer12RCCB = 78
  Bayer12 format - one channel in one surface with interleaved RCCB ordering. Out of 16 bits, 12
  bits used 4 bits No-op.

cudaEglColorFormatBayer12CRBC = 79
  Bayer12 format - one channel in one surface with interleaved CRBC ordering. Out of 16 bits, 12
  bits used 4 bits No-op.

cudaEglColorFormatBayer12CBRC = 80
  Bayer12 format - one channel in one surface with interleaved CBRC ordering. Out of 16 bits, 12
  bits used 4 bits No-op.

cudaEglColorFormatBayer12CCCC = 81
  Bayer12 format - one channel in one surface with interleaved CCCC ordering. Out of 16 bits, 12
  bits used 4 bits No-op.

cudaEglColorFormatY = 82
  Color format for single Y plane.

cudaEglColorFormatYUV420SemiPlanar_2020 = 83
  Y, UV in two surfaces (UV as one surface) U/V width = 1/2 Y width, U/V height = 1/2 Y height.

cudaEglColorFormatYVU420SemiPlanar_2020 = 84
  Y, VU in two surfaces (VU as one surface) U/V width = 1/2 Y width, U/V height = 1/2 Y height.

cudaEglColorFormatYUV420Planar_2020 = 85
  Y, U, V in three surfaces, each in a separate surface, U/V width = 1/2 Y width, U/V height = 1/2 Y
  height.

cudaEglColorFormatYVU420Planar_2020 = 86
  Y, V, U in three surfaces, each in a separate surface, U/V width = 1/2 Y width, U/V height = 1/2 Y
  height.

cudaEglColorFormatYUV420SemiPlanar_709 = 87
  Y, UV in two surfaces (UV as one surface) U/V width = 1/2 Y width, U/V height = 1/2 Y height.

cudaEglColorFormatYVU420SemiPlanar_709 = 88
  Y, VU in two surfaces (VU as one surface) U/V width = 1/2 Y width, U/V height = 1/2 Y height.

cudaEglColorFormatYUV420Planar_709 = 89
  Y, U, V in three surfaces, each in a separate surface, U/V width = 1/2 Y width, U/V height = 1/2 Y
  height.

cudaEglColorFormatYVU420Planar_709 = 90
  Y, V, U in three surfaces, each in a separate surface, U/V width = 1/2 Y width, U/V height = 1/2 Y
  height.

cudaEglColorFormatY10V10U10_420SemiPlanar_709 = 91
  Y10, V10U10 in two surfaces (VU as one surface) U/V width = 1/2 Y width, U/V height = 1/2 Y
  height.
cudaEglColorFormatY10V10U10_420SemiPlanar_2020 = 92
Y10, V10U10 in two surfaces (VU as one surface) U/V width = 1/2 Y width, U/V height = 1/2 Y height.

cudaEglColorFormatY10V10U10_422SemiPlanar_2020 = 93
Y10, V10U10 in two surfaces (VU as one surface) U/V width = 1/2 Y width, U/V height = Y height.

cudaEglColorFormatY10V10U10_422SemiPlanar = 94
Y10, V10U10 in two surfaces (VU as one surface) U/V width = 1/2 Y width, U/V height = Y height.

cudaEglColorFormatY10V10U10_422SemiPlanar_709 = 95
Y10, V10U10 in two surfaces (VU as one surface) U/V width = 1/2 Y width, U/V height = Y height.

cudaEglColorFormatY_ER = 96
Extended Range Color format for single Y plane.

cudaEglColorFormatY_709_ER = 97
Extended Range Color format for single Y plane.

cudaEglColorFormatY10_ER = 98
Extended Range Color format for single Y10 plane.

cudaEglColorFormatY10_709_ER = 99
Extended Range Color format for single Y10 plane.

cudaEglColorFormatY12_ER = 100
Extended Range Color format for single Y12 plane.

cudaEglColorFormatY12_709_ER = 101
Extended Range Color format for single Y12 plane.

cudaEglColorFormatYUVA = 102
Y, U, V, A four channels in one surface, interleaved as AVUY.

cudaEglColorFormatYVYU = 104
Y, U, V in one surface, interleaved as YVYU in one channel.

cudaEglColorFormatVVYU = 105
Y, U, V in one surface, interleaved as VYUY in one channel.

cudaEglColorFormatY10V10U10_420SemiPlanar_ER = 106
Extended Range Y10, V10U10 in two surfaces (VU as one surface) U/V width = 1/2 Y width, U/V height = 1/2 Y height.

cudaEglColorFormatY10V10U10_420SemiPlanar_709_ER = 107
Extended Range Y10, V10U10 in two surfaces (VU as one surface) U/V width = 1/2 Y width, U/V height = 1/2 Y height.

cudaEglColorFormatY10V10U10_444SemiPlanar_ER = 108
Extended Range Y10, V10U10 in two surfaces (VU as one surface) U/V width = Y width, U/V height = Y height.

cudaEglColorFormatY10V10U10_444SemiPlanar_709_ER = 109
Extended Range Y10, V10U10 in two surfaces (VU as one surface) U/V width = Y width, U/V height = Y height.

cudaEglColorFormatY12V12U12_420SemiPlanar_ER = 110
Extended Range Y12, V12U12 in two surfaces (VU as one surface) U/V width = 1/2 Y width, U/V height = 1/2 Y height.

cudaEglColorFormatY12V12U12_420SemiPlanar_709_ER = 111
Extended Range Y12, V12U12 in two surfaces (VU as one surface) U/V width = 1/2 Y width, U/V height = 1/2 Y height.

cudaEglColorFormatY12V12U12_444SemiPlanar_ER = 112
Extended Range Y12, V12U12 in two surfaces (VU as one surface) U/V width = Y width, U/V height = Y height.

cudaEglColorFormatY12V12U12_444SemiPlanar_709_ER = 113
Extended Range Y12, V12U12 in two surfaces (VU as one surface) U/V width = Y width, U/V height = Y height.

**enum cudaEglFrameType**

CUDA EglFrame type - array or pointer

**Values**

cudaEglFrameTypeArray = 0
Frame type CUDA array

cudaEglFrameTypePitch = 1
Frame type CUDA pointer

**enum cudaEglResourceLocationFlags**

Resource location flags- sysmem or vidmem

For CUDA context on iGPU, since video and system memory are equivalent - these flags will not have an effect on the execution.

For CUDA context on dGPU, applications can use the flag `cudaEglResourceLocationFlags` to give a hint about the desired location.

cudaEglResourceLocationSysmem - the frame data is made resident on the system memory to be accessed by CUDA.

cudaEglResourceLocationVidmem - the frame data is made resident on the dedicated video memory to be accessed by CUDA.

There may be an additional latency due to new allocation and data migration, if the frame is produced on a different memory.

**Values**

cudaEglResourceLocationSysmem = 0x00
Resource location sysmem

cudaEglResourceLocationVidmem = 0x01
Resource location vidmem
enum cudaError

CUDA error types

Values

cudaSuccess = 0
    The API call returned with no errors. In the case of query calls, this also means that the operation
    being queried is complete (see cudaEventQuery() and cudaStreamQuery()).
cudaErrorInvalidValue = 1
    This indicates that one or more of the parameters passed to the API call is not within an acceptable
    range of values.
cudaErrorMemoryAllocation = 2
    The API call failed because it was unable to allocate enough memory or other resources to perform
    the requested operation.
cudaErrorInitializationError = 3
    The API call failed because the CUDA driver and runtime could not be initialized.
cudaErrorCudartUnloading = 4
    This indicates that a CUDA Runtime API call cannot be executed because it is being called during
    process shut down, at a point in time after CUDA driver has been unloaded.
cudaErrorProfilerDisabled = 5
    This indicates profiler is not initialized for this run. This can happen when the application is running
    with external profiling tools like visual profiler.
cudaErrorProfilerNotInitialized = 6
    Deprecated This error return is deprecated as of CUDA 5.0. It is no longer an error to attempt to
    enable/disable the profiling via cudaProfilerStart or cudaProfilerStop without initialization.
cudaErrorProfilerAlreadyStarted = 7
    Deprecated This error return is deprecated as of CUDA 5.0. It is no longer an error to call
    cudaProfilerStart() when profiling is already enabled.
cudaErrorProfilerAlreadyStopped = 8
    Deprecated This error return is deprecated as of CUDA 5.0. It is no longer an error to call
    cudaProfilerStop() when profiling is already disabled.
cudaErrorInvalidConfiguration = 9
    This indicates that a kernel launch is requesting resources that can never be satisfied by the current
    device. Requesting more shared memory per block than the device supports will trigger this error, as
    will requesting too many threads or blocks. See cudaDeviceProp for more device limitations.
cudaErrorInvalidPitchValue = 12
    This indicates that one or more of the pitch-related parameters passed to the API call is not within
    the acceptable range for pitch.
cudaErrorInvalidSymbol = 13
    This indicates that the symbol name/identifier passed to the API call is not a valid name or
    identifier.
cudaErrorInvalidHostPointer = 16
This indicates that at least one host pointer passed to the API call is not a valid host pointer.  

**Deprecated** This error return is deprecated as of CUDA 10.1.

**cudaErrorInvalidDevicePointer = 17**
This indicates that at least one device pointer passed to the API call is not a valid device pointer.  

**Deprecated** This error return is deprecated as of CUDA 10.1.

**cudaErrorInvalidTexture = 18**
This indicates that the texture passed to the API call is not a valid texture.

**Deprecated** This error return is deprecated as of CUDA 10.1.

**cudaErrorInvalidTextureBinding = 19**
This indicates that the texture binding is not valid. This occurs if you call 
cudaGetTextureAlignmentOffset() with an unbound texture.

**cudaErrorInvalidChannelDescriptor = 20**
This indicates that the channel descriptor passed to the API call is not valid. This occurs if the 
format is not one of the formats specified by cudaChannelFormatKind, or if one of the dimensions 
is invalid.

**cudaErrorInvalidMemcpyDirection = 21**
This indicates that the direction of the memcpy passed to the API call is not one of the types 
specified by cudaMemcpyKind.

**cudaErrorAddressOfConstant = 22**
This indicated that the user has taken the address of a constant variable, which was forbidden up 
until the CUDA 3.1 release. **Deprecated** This error return is deprecated as of CUDA 3.1. Variables in constant memory may now have their address taken by the runtime via cudaGetSymbolAddress().

**cudaErrorTextureFetchFailed = 23**
This indicated that a texture fetch was not able to be performed. This was previously used for device 
emulation of texture operations. **Deprecated** This error return is deprecated as of CUDA 3.1. Device 
emulation mode was removed with the CUDA 3.1 release.

**cudaErrorTextureNotBound = 24**
This indicated that a texture was not bound for access. This was previously used for device 
emulation of texture operations. **Deprecated** This error return is deprecated as of CUDA 3.1. Device 
emulation mode was removed with the CUDA 3.1 release.

**cudaErrorSynchronizationError = 25**
This indicated that a synchronization operation had failed. This was previously used for some 
device emulation functions. **Deprecated** This error return is deprecated as of CUDA 3.1. Device 
emulation mode was removed with the CUDA 3.1 release.

**cudaErrorInvalidFilterSetting = 26**
This indicates that a non-float texture was being accessed with linear filtering. This is not supported 
by CUDA.

**cudaErrorInvalidNormSetting = 27**
This indicates that an attempt was made to read a non-float texture as a normalized float. This is not supported 
by CUDA.

**cudaErrorMixedDeviceExecution = 28**
Mixing of device and device emulation code was not allowed. **Deprecated** This error return is 
deprecated as of CUDA 3.1. Device emulation mode was removed with the CUDA 3.1 release.

**cudaErrorNotYetImplemented = 31**
This indicates that the API call is not yet implemented. Production releases of CUDA will never return this error.  

- **cudaErrorMemoryValueTooLarge = 32**
  This indicated that an emulated device pointer exceeded the 32-bit address range.  Deprecated This error return is deprecated as of CUDA 3.1. Device emulation mode was removed with the CUDA 3.1 release.

- **cudaErrorStubLibrary = 34**
  This indicates that the CUDA driver that the application has loaded is a stub library. Applications that run with the stub rather than a real driver loaded will result in CUDA API returning this error.

- **cudaErrorInsufficientDriver = 35**
  This indicates that the installed NVIDIA CUDA driver is older than the CUDA runtime library. This is not a supported configuration. Users should install an updated NVIDIA display driver to allow the application to run.

- **cudaErrorCallRequiresNewerDriver = 36**
  This indicates that the API call requires a newer CUDA driver than the one currently installed. Users should install an updated NVIDIA CUDA driver to allow the API call to succeed.

- **cudaErrorInvalidSurface = 37**
  This indicates that the surface passed to the API call is not a valid surface.

- **cudaErrorDuplicateVariableName = 43**
  This indicates that multiple global or constant variables (across separate CUDA source files in the application) share the same string name.

- **cudaErrorDuplicateTextureName = 44**
  This indicates that multiple textures (across separate CUDA source files in the application) share the same string name.

- **cudaErrorDuplicateSurfaceName = 45**
  This indicates that multiple surfaces (across separate CUDA source files in the application) share the same string name.

- **cudaErrorDevicesUnavailable = 46**
  This indicates that all CUDA devices are busy or unavailable at the current time. Devices are often busy/unavailable due to use of `cudaComputeModeProhibited`, `cudaComputeModeExclusiveProcess`, or when long running CUDA kernels have filled up the GPU and are blocking new work from starting. They can also be unavailable due to memory constraints on a device that already has active CUDA work being performed.

- **cudaErrorIncompatibleDriverContext = 49**
  This indicates that the current context is not compatible with this the CUDA Runtime. This can only occur if you are using CUDA Runtime/Driver interoperability and have created an existing Driver context using the driver API. The Driver context may be incompatible either because the Driver context was created using an older version of the API, because the Runtime API call expects a primary driver context and the Driver context is not primary, or because the Driver context has been destroyed. Please see `Interactions` with the CUDA Driver API" for more information.

- **cudaErrorMissingConfiguration = 52**
  The device function being invoked (usually via `cudaLaunchKernel()`) was not previously configured via the cudaConfigureCall() function.
cudaErrorPriorLaunchFailure = 53
This indicated that a previous kernel launch failed. This was previously used for device emulation of kernel launches. Deprecated This error return is deprecated as of CUDA 3.1. Device emulation mode was removed with the CUDA 3.1 release.

cudaErrorLaunchMaxDepthExceeded = 65
This error indicates that a device runtime grid launch did not occur because the depth of the child grid would exceed the maximum supported number of nested grid launches.

cudaErrorLaunchFileScopedTex = 66
This error indicates that a grid launch did not occur because the kernel uses file-scoped textures which are unsupported by the device runtime. Kernels launched via the device runtime only support textures created with the Texture Object API's.

cudaErrorLaunchFileScopedSurf = 67
This error indicates that a grid launch did not occur because the kernel uses file-scoped surfaces which are unsupported by the device runtime. Kernels launched via the device runtime only support surfaces created with the Surface Object API's.

cudaErrorSyncDepthExceeded = 68
This error indicates that a call to cudaDeviceSynchronize made from the device runtime failed because the call was made at grid depth greater than than either the default (2 levels of grids) or user specified device limit cudaLimitDevRuntimeSyncDepth. To be able to synchronize on launched grids at a greater depth successfully, the maximum nested depth at which cudaDeviceSynchronize will be called must be specified with the cudaLimitDevRuntimeSyncDepth limit to the cudaDeviceSetLimit api before the host-side launch of a kernel using the device runtime. Keep in mind that additional levels of sync depth require the runtime to reserve large amounts of device memory that cannot be used for user allocations. Note that cudaDeviceSynchronize made from device runtime is only supported on devices of compute capability < 9.0.

cudaErrorLaunchPendingCountExceeded = 69
This error indicates that a device runtime grid launch failed because the launch would exceed the limit cudaLimitDevRuntimePendingLaunchCount. For this launch to proceed successfully, cudaDeviceSetLimit must be called to set the cudaLimitDevRuntimePendingLaunchCount to be higher than the upper bound of outstanding launches that can be issued to the device runtime. Keep in mind that raising the limit of pending device runtime launches will require the runtime to reserve device memory that cannot be used for user allocations.

cudaErrorInvalidDeviceFunction = 98
The requested device function does not exist or is not compiled for the proper device architecture.

cudaErrorNoDevice = 100
This indicates that no CUDA-capable devices were detected by the installed CUDA driver.

cudaErrorInvalidDevice = 101
This indicates that the device ordinal supplied by the user does not correspond to a valid CUDA device or that the action requested is invalid for the specified device.

cudaErrorDeviceNotLicensed = 102
This indicates that the device doesn't have a valid Grid License.

cudaErrorSoftwareValidityNotEstablished = 103
By default, the CUDA runtime may perform a minimal set of self-tests, as well as CUDA driver tests, to establish the validity of both. Introduced in CUDA 11.2, this error return indicates that at least one of these tests has failed and the validity of either the runtime or the driver could not be established.

cudaErrorStartupFailure = 127
This indicates an internal startup failure in the CUDA runtime.

cudaErrorInvalidKernelImage = 200
This indicates that the device kernel image is invalid.

cudaErrorDeviceUninitialized = 201
This most frequently indicates that there is no context bound to the current thread. This can also be returned if the context passed to an API call is not a valid handle (such as a context that has had cuCtxDestroy() invoked on it). This can also be returned if a user mixes different API versions (i.e. 3010 context with 3020 API calls). See cuCtxGetApiVersion() for more details.

cudaErrorMapBufferObjectFailed = 205
This indicates that the buffer object could not be mapped.

cudaErrorUnmapBufferObjectFailed = 206
This indicates that the buffer object could not be unmapped.

cudaErrorArrayIsMapped = 207
This indicates that the specified array is currently mapped and thus cannot be destroyed.

cudaErrorAlreadyMapped = 208
This indicates that the resource is already mapped.

cudaErrorNoKernelImageForDevice = 209
This indicates that there is no kernel image available that is suitable for the device. This can occur when a user specifies code generation options for a particular CUDA source file that do not include the corresponding device configuration.

cudaErrorAlreadyAcquired = 210
This indicates that a resource has already been acquired.

cudaErrorNotMapped = 211
This indicates that a resource is not mapped.

cudaErrorNotMappedAsArray = 212
This indicates that a mapped resource is not available for access as an array.

cudaErrorNotMappedAsPointer = 213
This indicates that a mapped resource is not available for access as a pointer.

cudaErrorECCUncorrectable = 214
This indicates that an uncorrectable ECC error was detected during execution.

cudaErrorUnsupportedLimit = 215
This indicates that the cudaLimit passed to the API call is not supported by the active device.

cudaErrorDeviceAlreadyInUse = 216
This indicates that a call tried to access an exclusive-thread device that is already in use by a different thread.

cudaErrorPeerAccessUnsupported = 217
This error indicates that P2P access is not supported across the given devices.

cudaErrorInvalidPtx = 218
A PTX compilation failed. The runtime may fall back to compiling PTX if an application does not contain a suitable binary for the current device.

cudaErrorInvalidGraphicsContext = 219
This indicates an error with the OpenGL or DirectX context.

cudaErrorNvlinkUncorrectable = 220
This indicates that an uncorrectable NVLink error was detected during the execution.

cudaErrorJitCompilerNotFound = 221
This indicates that the PTX JIT compiler library was not found. The JIT Compiler library is used for PTX compilation. The runtime may fall back to compiling PTX if an application does not contain a suitable binary for the current device.

cudaErrorUnsupportedPtxVersion = 222
This indicates that the provided PTX was compiled with an unsupported toolchain. The most common reason for this, is the PTX was generated by a compiler newer than what is supported by the CUDA driver and PTX JIT compiler.

cudaErrorJitCompilationDisabled = 223
This indicates that the JIT compilation was disabled. The JIT compilation compiles PTX. The runtime may fall back to compiling PTX if an application does not contain a suitable binary for the current device.

cudaErrorUnsupportedExecAffinity = 224
This indicates that the provided execution affinity is not supported by the device.

cudaErrorUnsupportedDevSideSync = 225
This indicates that the code to be compiled by the PTX JIT contains unsupported call to cudaDeviceSynchronize.

cudaErrorInvalidSource = 300
This indicates that the device kernel source is invalid.

cudaErrorFileNotFound = 301
This indicates that the file specified was not found.

cudaErrorSharedObjectSymbolNotFound = 302
This indicates that a link to a shared object failed to resolve.

cudaErrorSharedObjectInitFailed = 303
This indicates that initialization of a shared object failed.

cudaErrorOperatingSystem = 304
This error indicates that an OS call failed.

cudaErrorInvalidResourceHandle = 400
This indicates that a resource handle passed to the API call was not valid. Resource handles are opaque types like cudaMemcpy_t and cudaMemcpy_t.

cudaErrorIllegalState = 401
This indicates that a resource required by the API call is not in a valid state to perform the requested operation.

cudaErrorLossyQuery = 402
This indicates an attempt was made to introspect an object in a way that would discard semantically important information. This is either due to the object using functionality newer than the API version used to introspect it or omission of optional return arguments.
cudaErrorSymbolNotFound = 500
This indicates that a named symbol was not found. Examples of symbols are global/constant variable names, driver function names, texture names, and surface names.

cudaErrorNotReady = 600
This indicates that asynchronous operations issued previously have not completed yet. This result is not actually an error, but must be indicated differently than cudaSuccess (which indicates completion). Calls that may return this value include cudaEventQuery() and cudaStreamQuery().

cudaErrorIllegalAddress = 700
The device encountered a load or store instruction on an invalid memory address. This leaves the process in an inconsistent state and any further CUDA work will return the same error. To continue using CUDA, the process must be terminated and relaunched.

cudaErrorLaunchOutOfResources = 701
This indicates that a launch did not occur because it did not have appropriate resources. Although this error is similar to cudaErrorInvalidConfiguration, this error usually indicates that the user has attempted to pass too many arguments to the device kernel, or the kernel launch specifies too many threads for the kernel's register count.

cudaErrorLaunchTimeout = 702
This indicates that the device kernel took too long to execute. This can only occur if timeouts are enabled - see the device property kernelExecTimeoutEnabled for more information. This leaves the process in an inconsistent state and any further CUDA work will return the same error. To continue using CUDA, the process must be terminated and relaunched.

cudaErrorLaunchIncompatibleTexturing = 703
This error indicates a kernel launch that uses an incompatible texturing mode.

cudaErrorPeerAccessAlreadyEnabled = 704
This error indicates that a call to cudaDeviceEnablePeerAccess() is trying to re-enable peer addressing on from a context which has already had peer addressing enabled.

cudaErrorPeerAccessNotEnabled = 705
This error indicates that cudaDeviceDisablePeerAccess() is trying to disable peer addressing which has not been enabled yet via cudaDeviceEnablePeerAccess().

cudaErrorSetOnActiveProcess = 708
This indicates that the user has called cudaSetValidDevices(), cudaSetDeviceFlags(), cudaD3D9SetDirect3DDevice(), cudaD3D10SetDirect3DDevice, cudaD3D11SetDirect3DDevice(), or cudaVDPAUSetVDPAUDevice() after initializing the CUDA runtime by calling non-device management operations (allocating memory and launching kernels are examples of non-device management operations). This error can also be returned if using runtime/driver interoperability and there is an existing CuContext active on the host thread.

cudaErrorContextIsDestroyed = 709
This indicates that the context current to the calling thread has been destroyed using cuCtxDestroy, or is a primary context which has not yet been initialized.

cudaErrorAssert = 710
An assert triggered in device code during kernel execution. The device cannot be used again. All existing allocations are invalid. To continue using CUDA, the process must be terminated and relaunched.
cudaErrorTooManyPeers = 711
This error indicates that the hardware resources required to enable peer access have been exhausted for one or more of the devices passed to cudaEnablePeerAccess().

cudaErrorHostMemoryAlreadyRegistered = 712
This error indicates that the memory range passed to cudaMemcpy() has already been registered.

cudaErrorHostMemoryNotRegistered = 713
This error indicates that the pointer passed to cudaMemcpy() does not correspond to any currently registered memory region.

cudaErrorHardwareStackError = 714
Device encountered an error in the call stack during kernel execution, possibly due to stack corruption or exceeding the stack size limit. This leaves the process in an inconsistent state and any further CUDA work will return the same error. To continue using CUDA, the process must be terminated and relaunched.

cudaErrorIllegalInstruction = 715
The device encountered an illegal instruction during kernel execution. This leaves the process in an inconsistent state and any further CUDA work will return the same error. To continue using CUDA, the process must be terminated and relaunched.

cudaErrorMisalignedAddress = 716
The device encountered a load or store instruction on a memory address which is not aligned. This leaves the process in an inconsistent state and any further CUDA work will return the same error. To continue using CUDA, the process must be terminated and relaunched.

cudaErrorInvalidAddressSpace = 717
While executing a kernel, the device encountered an instruction which can only operate on memory locations in certain address spaces (global, shared, or local), but was supplied a memory address not belonging to an allowed address space. This leaves the process in an inconsistent state and any further CUDA work will return the same error. To continue using CUDA, the process must be terminated and relaunched.

cudaErrorInvalidPc = 718
The device encountered an invalid program counter. This leaves the process in an inconsistent state and any further CUDA work will return the same error. To continue using CUDA, the process must be terminated and relaunched.

cudaErrorLaunchFailure = 719
An exception occurred on the device while executing a kernel. Common causes include dereferencing an invalid device pointer and accessing out of bounds shared memory. Less common cases can be system specific - more information about these cases can be found in the system specific user guide. This leaves the process in an inconsistent state and any further CUDA work will return the same error. To continue using CUDA, the process must be terminated and relaunched.

cudaErrorCooperativeLaunchTooLarge = 720
This error indicates that the number of blocks launched per grid for a kernel that was launched via either cudaLaunchCooperativeKernel or cudaLaunchCooperativeKernelMultiDevice exceeds the maximum number of blocks as allowed by cudaOccupancyMaxActiveBlocksPerMultiprocessor or
cudaOccupancyMaxActiveBlocksPerMultiprocessorWithFlags times the number of multiprocessors as specified by the device attribute cudaDevAttrMultiProcessorCount.

cudaErrorNotPermitted = 800
This error indicates the attempted operation is not permitted.

cudaErrorNotSupported = 801
This error indicates the attempted operation is not supported on the current system or device.

cudaErrorSystemNotReady = 802
This error indicates that the system is not yet ready to start any CUDA work. To continue using CUDA, verify the system configuration is in a valid state and all required driver daemons are actively running. More information about this error can be found in the system specific user guide.

cudaErrorSystemDriverMismatch = 803
This error indicates that there is a mismatch between the versions of the display driver and the CUDA driver. Refer to the compatibility documentation for supported versions.

cudaErrorCompatNotSupportedOnDevice = 804
This error indicates that the system was upgraded to run with forward compatibility but the visible hardware detected by CUDA does not support this configuration. Refer to the compatibility documentation for the supported hardware matrix or ensure that only supported hardware is visible during initialization via the CUDA_VISIBLE_DEVICES environment variable.

cudaErrorMpsConnectionFailed = 805
This error indicates that the MPS client failed to connect to the MPS control daemon or the MPS server.

cudaErrorMpsRpcFailure = 806
This error indicates that the remote procedural call between the MPS server and the MPS client failed.

cudaErrorMpsServerNotReady = 807
This error indicates that the MPS server is not ready to accept new MPS client requests. This error can be returned when the MPS server is in the process of recovering from a fatal failure.

cudaErrorMpsMaxClientsReached = 808
This error indicates that the hardware resources required to create MPS client have been exhausted.

cudaErrorMpsMaxConnectionsReached = 809
This error indicates the the hardware resources required to device connections have been exhausted.

cudaErrorMpsClientTerminated = 810
This error indicates that the MPS client has been terminated by the server. To continue using CUDA, the process must be terminated and relaunched.

cudaErrorCdpNotSupported = 811
This error indicates, that the program is using CUDA Dynamic Parallelism, but the current configuration, like MPS, does not support it.

cudaErrorCdpVersionMismatch = 812
This error indicates, that the program contains an unsupported interaction between different versions of CUDA Dynamic Parallelism.

cudaErrorStreamCaptureUnsupport = 900
The operation is not permitted when the stream is capturing.

cudaErrorStreamCaptureInvalidated = 901
The current capture sequence on the stream has been invalidated due to a previous error.

cudaErrorStreamCaptureMerge = 902
The operation would have resulted in a merge of two independent capture sequences.

cudaErrorStreamCaptureUnmatched = 903
The capture was not initiated in this stream.

cudaErrorStreamCaptureUnjoined = 904
The capture sequence contains a fork that was not joined to the primary stream.

cudaErrorStreamCaptureIsolation = 905
A dependency would have been created which crosses the capture sequence boundary. Only implicit in-stream ordering dependencies are allowed to cross the boundary.

cudaErrorStreamCaptureImplicit = 906
The operation would have resulted in a disallowed implicit dependency on a current capture sequence from cudaStreamLegacy.

cudaErrorCapturedEvent = 907
The operation is not permitted on an event which was last recorded in a capturing stream.

cudaErrorStreamCaptureWrongThread = 908
A stream capture sequence not initiated with the cudaStreamCaptureModeRelaxed argument to cudaStreamBeginCapture was passed to cudaStreamEndCapture in a different thread.

cudaErrorTimeout = 909
This indicates that the wait operation has timed out.

cudaErrorGraphExecUpdateFailure = 910
This error indicates that the graph update was not performed because it included changes which violated constraints specific to instantiated graph update.

cudaErrorExternalDevice = 911
This indicates that an async error has occurred in a device outside of CUDA. If CUDA was waiting for an external device's signal before consuming shared data, the external device signaled an error indicating that the data is not valid for consumption. This leaves the process in an inconsistent state and any further CUDA work will return the same error. To continue using CUDA, the process must be terminated and relaunched.

cudaErrorInvalidClusterSize = 912
This indicates that a kernel launch error has occurred due to cluster misconfiguration.

cudaErrorFunctionNotLoaded = 913
Indicates a function handle is not loaded when calling an API that requires a loaded function.

cudaErrorInvalidResourceType = 914
This error indicates one or more resources passed in are not valid resource types for the operation.

cudaErrorInvalidResourceConfiguration = 915
This error indicates one or more resources are insufficient or non-applicable for the operation.

cudaErrorUnknown = 999
This indicates that an unknown internal error has occurred.

cudaErrorApiFailureBase = 10000

eenum cudaExternalMemoryHandleType

External memory handle types
Values

cudaExternalMemoryHandleTypeOpaqueFd = 1
    Handle is an opaque file descriptor

cudaExternalMemoryHandleTypeOpaqueWin32 = 2
    Handle is an opaque shared NT handle

cudaExternalMemoryHandleTypeOpaqueWin32Kmt = 3
    Handle is an opaque, globally shared handle

cudaExternalMemoryHandleTypeD3D12Heap = 4
    Handle is a D3D12 heap object

cudaExternalMemoryHandleTypeD3D12Resource = 5
    Handle is a D3D12 committed resource

cudaExternalMemoryHandleTypeD3D11Resource = 6
    Handle is a shared NT handle to a D3D11 resource

cudaExternalMemoryHandleTypeD3D11ResourceKmt = 7
    Handle is a globally shared handle to a D3D11 resource

cudaExternalMemoryHandleTypeNvSciBuf = 8
    Handle is an NvSciBuf object

enum cudaExternalSemaphoreHandleType

External semaphore handle types

Values

cudaExternalSemaphoreHandleTypeOpaqueFd = 1
    Handle is an opaque file descriptor

cudaExternalSemaphoreHandleTypeOpaqueWin32 = 2
    Handle is an opaque shared NT handle

cudaExternalSemaphoreHandleTypeOpaqueWin32Kmt = 3
    Handle is an opaque, globally shared handle

cudaExternalSemaphoreHandleTypeD3D12Fence = 4
    Handle is a shared NT handle referencing a D3D12 fence object

cudaExternalSemaphoreHandleTypeD3D11Fence = 5
    Handle is a shared NT handle referencing a D3D11 fence object

cudaExternalSemaphoreHandleTypeNvSciSync = 6
    Opaque handle to NvSciSync Object

cudaExternalSemaphoreHandleTypeKeyedMutex = 7
    Handle is a shared NT handle referencing a D3D11 keyed mutex object

cudaExternalSemaphoreHandleTypeKeyedMutexKmt = 8
    Handle is a shared KMT handle referencing a D3D11 keyed mutex object

cudaExternalSemaphoreHandleTypeTimelineSemaphoreFd = 9
    Handle is an opaque handle file descriptor referencing a timeline semaphore

cudaExternalSemaphoreHandleTypeTimelineSemaphoreWin32 = 10
enum cudaFlushGPUDirectRDMAWritesOptions

CUDA GPUDirect RDMA flush writes APIs supported on the device

Values

cudaFlushGPUDirectRDMAWritesOptionHost = 1<<0

cudaDeviceFlushGPUDirectRDMAWrites() and its CUDA Driver API counterpart are supported on the device.

cudaFlushGPUDirectRDMAWritesOptionMemOps = 1<<1

The CU_STREAM_WAIT_VALUE_FLUSH flag and the CU_STREAM_MEM_OP_FLUSH_REMOTE_WRITES MemOp are supported on the CUDA device.

enum cudaFlushGPUDirectRDMAWritesScope

CUDA GPUDirect RDMA flush writes scopes

Values

cudaFlushGPUDirectRDMAWritesToOwner = 100

Blocks until remote writes are visible to the CUDA device context owning the data.

cudaFlushGPUDirectRDMAWritesToAllDevices = 200

Blocks until remote writes are visible to all CUDA device contexts.

enum cudaFlushGPUDirectRDMAWritesTarget

CUDA GPUDirect RDMA flush writes targets

Values

cudaFlushGPUDirectRDMAWritesTargetCurrentDevice

Sets the target for cudaDeviceFlushGPUDirectRDMAWrites() to the currently active CUDA device context.

enum cudaFuncAttribute

CUDA function attributes that can be set using cudaFuncSetAttribute

Values

cudaFuncAttributeMaxDynamicSharedMemorySize = 8

Maximum dynamic shared memory size

cudaFuncAttributePreferredSharedMemoryCarveout = 9

Preferred shared memory-L1 cache split
cudaFuncAttributeClusterDimMustBeSet = 10
   Indicator to enforce valid cluster dimension specification on kernel launch

cudaFuncAttributeRequiredClusterWidth = 11
   Required cluster width

cudaFuncAttributeRequiredClusterHeight = 12
   Required cluster height

cudaFuncAttributeRequiredClusterDepth = 13
   Required cluster depth

cudaFuncAttributeNonPortableClusterSizeAllowed = 14
   Whether non-portable cluster scheduling policy is supported

cudaFuncAttributeClusterSchedulingPolicyPreference = 15
   Required cluster scheduling policy preference

cudaFuncAttributeMax

enum cudaFuncCache
   CUDA function cache configurations

Values

cudaFuncCachePreferNone = 0
   Default function cache configuration, no preference

cudaFuncCachePreferShared = 1
   Prefer larger shared memory and smaller L1 cache

cudaFuncCachePreferL1 = 2
   Prefer larger L1 cache and smaller shared memory

cudaFuncCachePreferEqual = 3
   Prefer equal size L1 cache and shared memory

enum cudaGetDriverEntryPointFlags
   Flags to specify search options to be used with cudaGetDriverEntryPoint
   For more details see cuGetProcAddress

Values

cudaEnableDefault = 0x0
   Default search mode for driver symbols.

cudaEnableLegacyStream = 0x1
   Search for legacy versions of driver symbols.

cudaEnablePerThreadDefaultStream = 0x2
   Search for per-thread versions of driver symbols.
enum cudaGPUDirectRDMAWritesOrdering

CUDA GPUDirect RDMA flush writes ordering features of the device

Values

cudaGPUDirectRDMAWritesOrderingNone = 0
  The device does not natively support ordering of GPUDirect RDMA writes.
cudaFlushGPUDirectRDMAWrites() can be leveraged if supported.
cudaGPUDirectRDMAWritesOrderingOwner = 100
  Natively, the device can consistently consume GPUDirect RDMA writes, although other CUDA
devices may not.
cudaGPUDirectRDMAWritesOrderingAllDevices = 200
  Any CUDA device in the system can consistently consume GPUDirect RDMA writes to this device.

enum cudaGraphConditionalNodeType

CUDA conditional node types

Values

cudaGraphCondTypeIf = 0
  Conditional 'if' Node. Body executed once if condition value is non-zero.
cudaGraphCondTypeWhile = 1
  Conditional 'while' Node. Body executed repeatedly while condition value is non-zero.

enum cudaGraphDebugDotFlags

CUDA Graph debug write options

Values

cudaGraphDebugDotFlagsVerbose = 1<<0
  Output all debug data as if every debug flag is enabled

cudaGraphDebugDotFlagsKernelNodeParams = 1<<2
  Adds cudaKernelNodeParams to output

cudaGraphDebugDotFlagsMemcpyNodeParams = 1<<3
  Adds cudaMemcpy3DParms to output

cudaGraphDebugDotFlagsMemsetNodeParams = 1<<4
  Adds cudaMemsetParams to output

cudaGraphDebugDotFlagsHostNodeParams = 1<<5
  Adds cudaHostNodeParams to output

cudaGraphDebugDotFlagsEventNodeParams = 1<<6
  Adds cudaEvent_t handle from record and wait nodes to output

cudaGraphDebugDotFlagsExtSemasSignalNodeParams = 1<<7
Adds `cudaExternalSemaphoreSignalNodeParams` values to output

`cudaGraphDebugDotFlagsExtSemasWaitNodeParams = 1<<8`

Adds `cudaExternalSemaphoreWaitNodeParams` to output

`cudaGraphDebugDotFlagsKernelNodeAttributes = 1<<9`

Adds `cudaKernelNodeAttrID` values to output

`cudaGraphDebugDotFlagsHandles = 1<<10`

Adds node handles and every kernel function handle to output

`cudaGraphDebugDotFlagsConditionalNodeParams = 1<<15`

Adds `cudaConditionalNodeParams` to output

**enum cudaGraphDependencyType**

Type annotations that can be applied to graph edges as part of `cudaGraphEdgeData`.

**Values**

`cudaGraphDependencyTypeDefault = 0`

This is an ordinary dependency.

`cudaGraphDependencyTypeProgrammatic = 1`

This dependency type allows the downstream node to use `cudaGridDependencySynchronize()` . It may only be used between kernel nodes, and must be used with either the `cudaGraphKernelNodePortProgrammatic` or `cudaGraphKernelNodePortLaunchCompletion` outgoing port.

**enum cudaGraphExecUpdateResult**

CUDA Graph Update error types

**Values**

`cudaGraphExecUpdateSuccess = 0x0`

The update succeeded

`cudaGraphExecUpdateError = 0x1`

The update failed for an unexpected reason which is described in the return value of the function

`cudaGraphExecUpdateErrorTopologyChanged = 0x2`

The update failed because the topology changed

`cudaGraphExecUpdateErrorNodeTypeChanged = 0x3`

The update failed because a node type changed

`cudaGraphExecUpdateErrorFunctionChanged = 0x4`

The update failed because the function of a kernel node changed (CUDA driver < 11.2)

`cudaGraphExecUpdateErrorParametersChanged = 0x5`

The update failed because the parameters changed in a way that is not supported

`cudaGraphExecUpdateErrorNotSupported = 0x6`

The update failed because something about the node is not supported

`cudaGraphExecUpdateErrorUnsupportedFunctionChange = 0x7`
The update failed because the function of a kernel node changed in an unsupported way

cudaGraphExecUpdateErrorAttributesChanged = 0x8
The update failed because the node attributes changed in a way that is not supported

**enum cudaGraphicsCubeFace**

CUDA graphics interop array indices for cube maps

**Values**

- `cudaGraphicsCubeFacePositiveX = 0x00`
  - Positive X face of cubemap
- `cudaGraphicsCubeFaceNegativeX = 0x01`
  - Negative X face of cubemap
- `cudaGraphicsCubeFacePositiveY = 0x02`
  - Positive Y face of cubemap
- `cudaGraphicsCubeFaceNegativeY = 0x03`
  - Negative Y face of cubemap
- `cudaGraphicsCubeFacePositiveZ = 0x04`
  - Positive Z face of cubemap
- `cudaGraphicsCubeFaceNegativeZ = 0x05`
  - Negative Z face of cubemap

**enum cudaGraphicsMapFlags**

CUDA graphics interop map flags

**Values**

- `cudaGraphicsMapFlagsNone = 0`
  - Default; Assume resource can be read/written
- `cudaGraphicsMapFlagsReadOnly = 1`
  - CUDA will not write to this resource
- `cudaGraphicsMapFlagsWriteDiscard = 2`
  - CUDA will only write to and will not read from this resource

**enum cudaGraphicsRegisterFlags**

CUDA graphics interop register flags

**Values**

- `cudaGraphicsRegisterFlagsNone = 0`
  - Default
- `cudaGraphicsRegisterFlagsReadOnly = 1`
  - CUDA will not write to this resource
cudaGraphicsRegisterFlagsWriteDiscard = 2
  CUDA will only write to and will not read from this resource

cudaGraphicsRegisterFlagsSurfaceLoadStore = 4
  CUDA will bind this resource to a surface reference

cudaGraphicsRegisterFlagsTextureGather = 8
  CUDA will perform texture gather operations on this resource

enum cudaGraphInstantiateFlags

Flags for instantiating a graph

Values

cudaGraphInstantiateFlagAutoFreeOnLaunch = 1
  Automatically free memory allocated in a graph before relaunching.

cudaGraphInstantiateFlagUpload = 2
  Automatically upload the graph after instantiation. Only supported by
  cudaGraphInstantiateWithParams. The upload will be performed using the stream provided in
  instantiateParams.

cudaGraphInstantiateFlagDeviceLaunch = 4
  Instantiate the graph to be launchable from the device. This flag can only be used on
  platforms which support unified addressing. This flag cannot be used in conjunction with
  cudaGraphInstantiateFlagAutoFreeOnLaunch.

cudaGraphInstantiateFlagUseNodePriority = 8
  Run the graph using the per-node priority attributes rather than the priority of the stream it is
  launched into.

enum cudaGraphInstantiateResult

Graph instantiation results

Values

cudaGraphInstantiateSuccess = 0
  Instantiation succeeded

cudaGraphInstantiateError = 1
  Instantiation failed for an unexpected reason which is described in the return value of the function

cudaGraphInstantiateInvalidStructure = 2
  Instantiation failed due to invalid structure, such as cycles

cudaGraphInstantiateNodeOperationNotSupported = 3
  Instantiation for device launch failed because the graph contained an unsupported operation

cudaGraphInstantiateMultipleDevicesNotSupported = 4
  Instantiation for device launch failed due to the nodes belonging to different contexts
enum cudaGraphKernelNodeField

Specifies the field to update when performing multiple node updates from the device

Values

cudaGraphKernelNodeFieldInvalid = 0
    Invalid field

cudaGraphKernelNodeFieldGridDim
    Grid dimension update

cudaGraphKernelNodeFieldParam
    Kernel parameter update

cudaGraphKernelNodeFieldEnabled
    Node enable/disable

enum cudaGraphMemAttributeType

Graph memory attributes

Values

cudaGraphMemAttrUsedMemCurrent = 0x0
    (value type = cuuint64_t) Amount of memory, in bytes, currently associated with graphs.

cudaGraphMemAttrUsedMemHigh = 0x1
    (value type = cuuint64_t) High watermark of memory, in bytes, associated with graphs since the last time it was reset. High watermark can only be reset to zero.

cudaGraphMemAttrReservedMemCurrent = 0x2
    (value type = cuuint64_t) Amount of memory, in bytes, currently allocated for use by the CUDA graphs asynchronous allocator.

cudaGraphMemAttrReservedMemHigh = 0x3
    (value type = cuuint64_t) High watermark of memory, in bytes, currently allocated for use by the CUDA graphs asynchronous allocator.

enum cudaGraphNodeType

CUDA Graph node types

Values

cudaGraphNodeTypeKernel = 0x00
    GPU kernel node

cudaGraphNodeTypeMemcpy = 0x01
   Memcpy node

cudaGraphNodeTypeMemset = 0x02
    Memset node
cudaGraphNodeTypeHost = 0x03
Host (executable) node

cudaGraphNodeTypeGraph = 0x04
Node which executes an embedded graph

cudaGraphNodeTypeEmpty = 0x05
Empty (no-op) node

cudaGraphNodeTypeWaitEvent = 0x06
External event wait node

cudaGraphNodeTypeEventRecord = 0x07
External event record node

cudaGraphNodeTypeExtSemaphoreSignal = 0x08
External semaphore signal node

cudaGraphNodeTypeExtSemaphoreWait = 0x09
External semaphore wait node

cudaGraphNodeTypeMemAlloc = 0x0a
Memory allocation node

cudaGraphNodeTypeMemFree = 0x0b
Memory free node

cudaGraphNodeTypeConditional = 0x0d
Conditional node
May be used to implement a conditional execution path or loop inside of a graph.
The graph(s) contained within the body of the conditional node can be selectively executed or
iterated upon based on the value of a conditional variable. Handles must be created in advance
of creating the node using cudaGraphConditionalHandleCreate. The following restrictions apply
to graphs which contain conditional nodes: The graph cannot be used in a child node. Only one
instantiation of the graph may exist at any point in time. The graph cannot be cloned. To set the
control value, supply a default value when creating the handle and/or call cudaGraphSetConditional
from device code.

cudaGraphNodeTypeCount

enum cudaLaunchAttributeID
Launch attributes enum; used as id field of cudaLaunchAttribute

Values

cudaLaunchAttributeIgnore = 0
Ignored entry, for convenient composition

cudaLaunchAttributeAccessPolicyWindow = 1
Valid for streams, graph nodes, launches. See cudaLaunchAttributeValue::accessPolicyWindow.

cudaLaunchAttributeCooperative = 2
Valid for graph nodes, launches. See cudaLaunchAttributeValue::cooperative.

cudaLaunchAttributeSynchronizationPolicy = 3
Valid for streams. See cudaLaunchAttributeValue::syncPolicy.

cudaLaunchAttributeClusterDimension = 4
Valid for graph nodes, launches. See `cudaLaunchAttributeValue::clusterDim`.

**cudaLaunchAttributeClusterSchedulingPolicyPreference = 5**
Valid for graph nodes, launches. See `cudaLaunchAttributeValue::clusterSchedulingPolicyPreference`.

**cudaLaunchAttributeProgrammaticStreamSerialization = 6**
Valid for launches. Setting `cudaLaunchAttributeValue::programmaticStreamSerializationAllowed` to non-0 signals that the kernel will use programmatic means to resolve its stream dependency, so that the CUDA runtime should opportunistically allow the grid's execution to overlap with the previous kernel in the stream, if that kernel requests the overlap. The dependent launches can choose to wait on the dependency using the programmatic sync (`cudaGridDependencySynchronize()` or equivalent PTX instructions).

**cudaLaunchAttributeProgrammaticEvent = 7**
Valid for launches. Set `cudaLaunchAttributeValue::programmaticEvent` to record the event. Event recorded through this launch attribute is guaranteed to only trigger after all block in the associated kernel trigger the event. A block can trigger the event programmatically in a future CUDA release. A trigger can also be inserted at the beginning of each block's execution if `triggerAtBlockStart` is set to non-0. The dependent launches can choose to wait on the dependency using the programmatic sync (`cudaGridDependencySynchronize()` or equivalent PTX instructions). Note that dependents (including the CPU thread calling `cudaEventSynchronize()`) are not guaranteed to observe the release precisely when it is released. For example, `cudaEventSynchronize()` may only observe the event trigger long after the associated kernel has completed. This recording type is primarily meant for establishing programmatic dependency between device tasks. Note also this type of dependency allows, but does not guarantee, concurrent execution of tasks. The event supplied must not be an interprocess or interop event. The event must disable timing (i.e. must be created with the `cudaEventDisableTiming` flag set).

**cudaLaunchAttributePriority = 8**
Valid for streams, graph nodes, launches. See `cudaLaunchAttributeValue::priority`.

**cudaLaunchAttributeMemSyncDomainMap = 9**
Valid for streams, graph nodes, launches. See `cudaLaunchAttributeValue::memSyncDomainMap`.

**cudaLaunchAttributeMemSyncDomain = 10**
Valid for streams, graph nodes, launches. See `cudaLaunchAttributeValue::memSyncDomain`.

**cudaLaunchAttributeLaunchCompletionEvent = 12**
Valid for launches. Set `cudaLaunchAttributeValue::launchCompletionEvent` to record the event. Nominally, the event is triggered once all blocks of the kernel have begun execution. Currently this is a best effort. If a kernel B has a launch completion dependency on a kernel A, B may wait until A is complete. Alternatively, blocks of B may begin before all blocks of A have begun, for example if B can claim execution resources unavailable to A (e.g. they run on different GPUs) or if B is a higher priority than A. Exercise caution if such an ordering inversion could lead to deadlock. A launch completion event is nominally similar to a programmatic event with `triggerAtBlockStart` set except that it is not visible to `cudaGridDependencySynchronize()` and can be used with compute capability less than 9.0. The event supplied must not be an interprocess or interop event. The event must disable timing (i.e. must be created with the `cudaEventDisableTiming` flag set).
cudaLaunchAttributeDeviceUpdatableKernelNode = 13
Valid for graph nodes, launches. This attribute is graphs-only, and
passing it to a launch in a non-capturing stream will result in an
error. :cudaLaunchAttributeValue::deviceUpdatableKernelNode::deviceUpdatable
can only be set to 0 or 1. Setting the field to 1 indicates that the corresponding
kernel node should be device-updatable. On success, a handle will be returned via
cudaLaunchAttributeValue::deviceUpdatableKernelNode::devNode which can be passed to the
various device-side update functions to update the node's kernel parameters from within another
kernel. For more information on the types of device updates that can be made, as well as the
relevant limitations thereof, see cudaGraphKernelNodeUpdatesApply. Nodes which are device-
updatable have additional restrictions compared to regular kernel nodes. Firstly, device-updatable
nodes cannot be removed from their graph via cudaGraphDestroyNode. Additionally, once opted-in
to this functionality, a node cannot opt out, and any attempt to set the deviceUpdatable attribute
to 0 will result in an error. Device-updatable kernel nodes also cannot have their attributes copied
to/from another kernel node via cudaGraphKernelNodeCopyAttributes. Graphs containing one or
more device-updatable nodes also do not allow multiple instantiation, and neither the graph nor its
instantiated version can be passed to cudaGraphExecUpdate. If a graph contains device-updatable
nodes and updates those nodes from the device from within the graph, the graph must be uploaded
with cuGraphUpload before it is launched. For such a graph, if host-side executable graph updates
are made to the device-updatable nodes, the graph must be uploaded before it is launched again.

cudaLaunchAttributePreferredSharedMemoryCarveout = 14
Valid for launches. On devices where the L1 cache and shared memory use the same
hardware resources, setting cudaLaunchAttributeValue::sharedMemCarveout to a
percentage between 0-100 signals sets the shared memory carveout preference in percent
of the total shared memory for that kernel launch. This attribute takes precedence over
cudaFuncAttributePreferredSharedMemoryCarveout. This is only a hint, and the driver can choose a
different configuration if required for the launch.

enum cudaLaunchMemSyncDomain
Memory Synchronization Domain
A kernel can be launched in a specified memory synchronization domain that affects all memory
operations issued by that kernel. A memory barrier issued in one domain will only order memory
operations in that domain, thus eliminating latency increase from memory barriers ordering unrelated
traffic.

By default, kernels are launched in domain 0. Kernel launched with
cudaLaunchMemSyncDomainRemote will have a different domain ID. User may also alter the
domain ID with cudaLaunchMemSyncDomainMap for a specific stream / graph node / kernel
launch. See cudaLaunchAttributeMemSyncDomain, cudaStreamSetAttribute, cudaLaunchKernelEx,
cudaGraphKernelNodeSetAttribute.
Memory operations done in kernels launched in different domains are considered system-scope distanced. In other words, a GPU scoped memory synchronization is not sufficient for memory order to be observed by kernels in another memory synchronization domain even if they are on the same GPU.

**Values**

- `cudaLaunchMemSyncDomainDefault = 0`
  - Launch kernels in the default domain
- `cudaLaunchMemSyncDomainRemote = 1`
  - Launch kernels in the remote domain

**enum cudaLimit**

CUDA Limits

**Values**

- `cudaLimitStackSize = 0x00`
  - GPU thread stack size
- `cudaLimitPrintfFifoSize = 0x01`
  - GPU printf FIFO size
- `cudaLimitMallocHeapSize = 0x02`
  - GPU malloc heap size
- `cudaLimitDevRuntimeSyncDepth = 0x03`
  - GPU device runtime synchronize depth
- `cudaLimitDevRuntimePendingLaunchCount = 0x04`
  - GPU device runtime pending launch count
- `cudaLimitMaxL2FetchGranularity = 0x05`
  - A value between 0 and 128 that indicates the maximum fetch granularity of L2 (in Bytes). This is a hint
- `cudaLimitPersistingL2CacheSize = 0x06`
  - A size in bytes for L2 persisting lines cache size

**enum cudaMemAccessFlags**

Specifies the memory protection flags for mapping.

**Values**

- `cudaMemAccessFlagsProtNone = 0`
  - Default, make the address range not accessible
- `cudaMemAccessFlagsProtRead = 1`
  - Make the address range read accessible
- `cudaMemAccessFlagsProtReadWrite = 3`
  - Make the address range read-write accessible
enum cudaMemAllocationHandleType

Flags for specifying particular handle types

Values

cudaMemHandleTypeNone = 0x0
   Does not allow any export mechanism.
cudaMemHandleTypePosixFileDescriptor = 0x1
   Allows a file descriptor to be used for exporting. Permitted only on POSIX systems. (int)
cudaMemHandleTypeWin32 = 0x2
   Allows a Win32 NT handle to be used for exporting. (HANDLE)
cudaMemHandleTypeWin32Kmt = 0x4
   Allows a Win32 KMT handle to be used for exporting. (D3DKMT_HANDLE)
cudaMemHandleTypeFabric = 0x8
   Allows a fabric handle to be used for exporting. (cudaMemFabricHandle_t)

enum cudaMemAllocationType

Defines the allocation types available

Values

cudaMemAllocationTypeInvalid = 0x0

cudaMemAllocationTypePinned = 0x1
   This allocation type is 'pinned', i.e. cannot migrate from its current location while the application is actively using it

cudaMemAllocationTypeMax = 0x7FFFFFFF

enum cudaMemcpyKind

CUDA memory copy types

Values

cudaMemcpyHostToHost = 0
   Host -> Host

cudaMemcpyHostToDevice = 1
   Host -> Device

cudaMemcpyDeviceToHost = 2
   Device -> Host

cudaMemcpyDeviceToDevice = 3
   Device -> Device

cudaMemcpyDefault = 4
   Direction of the transfer is inferred from the pointer values. Requires unified virtual addressing
enum cudaMemcpyLocationType

Specifies the type of location

Values

cudaMemcpyLocationTypeInvalid = 0

cudaMemcpyLocationTypeDevice = 1
   Location is a device location, thus id is a device ordinal

cudaMemcpyLocationTypeHost = 2
   Location is host, id is ignored

cudaMemcpyLocationTypeHostNuma = 3
   Location is a host NUMA node, thus id is a host NUMA node id

cudaMemcpyLocationTypeHostNumaCurrent = 4
   Location is the host NUMA node closest to the current thread's CPU, id is ignored

enum cudaMemcpyAdvise

CUDA Memory Advise values

Values

cudaMemcpyAdviseSetReadMostly = 1
   Data will mostly be read and only occasionally be written to

cudaMemcpyAdviseUnsetReadMostly = 2
   Undo the effect of cudaMemcpyAdviseSetReadMostly

cudaMemcpyAdviseSetPreferredLocation = 3
   Set the preferred location for the data as the specified device

cudaMemcpyAdviseUnsetPreferredLocation = 4
   Clear the preferred location for the data

cudaMemcpyAdviseSetAccessedBy = 5
   Data will be accessed by the specified device, so prevent page faults as much as possible

cudaMemcpyAdviseUnsetAccessedBy = 6
   Let the Unified Memory subsystem decide on the page faulting policy for the specified device

enum cudaMemcpyType

CUDA memory types

Values

cudaMemoryTypeUnregistered = 0
   Unregistered memory

cudaMemoryTypeHost = 1
   Host memory
cudaMemoryTypeDevice = 2
  Device memory
cudaMemoryTypeManaged = 3
  Managed memory

desc cudaMemPoolAttr
CUDA memory pool attributes

Values

cudaMemPoolReuseFollowEventDependencies = 0x1
(value type = int) Allow cuMemAllocAsync to use memory asynchronously freed in another
stream as long as a stream ordering dependency of the allocating stream on the free action exists.
Cuda events and null stream interactions can create the required stream ordered dependencies.
(default enabled)
cudaMemPoolReuseAllowOpportunistic = 0x2
(value type = int) Allow reuse of already completed frees when there is no dependency between the
free and allocation. (default enabled)
cudaMemPoolReuseAllowInternalDependencies = 0x3
(value type = int) Allow cuMemAllocAsync to insert new stream dependencies in order to establish
the stream ordering required to reuse a piece of memory released by cuFreeAsync (default enabled).
cudaMemPoolAttrReleaseThreshold = 0x4
(value type = cuuint64_t) Amount of reserved memory in bytes to hold onto before trying to release
memory back to the OS. When more than the release threshold bytes of memory are held by
the memory pool, the allocator will try to release memory back to the OS on the next call to stream,
evnet or context synchronize. (default 0)
cudaMemPoolAttrReservedMemCurrent = 0x5
(value type = cuuint64_t) Amount of backing memory currently allocated for the mempool.
cudaMemPoolAttrReservedMemHigh = 0x6
(value type = cuuint64_t) High watermark of backing memory allocated for the mempool since the
last time it was reset. High watermark can only be reset to zero.
cudaMemPoolAttrUsedMemCurrent = 0x7
(value type = cuuint64_t) Amount of memory from the pool that is currently in use by the
application.
cudaMemPoolAttrUsedMemHigh = 0x8
(value type = cuuint64_t) High watermark of the amount of memory from the pool that was in use
by the application since the last time it was reset. High watermark can only be reset to zero.

enum cudaMemRangeAttribute
CUDA range attributes
Values

cudaMemRangeAttributeReadMostly = 1
    Whether the range will mostly be read and only occasionally be written to

cudaMemRangeAttributePreferredLocation = 2
    The preferred location of the range

cudaMemRangeAttributeAccessedBy = 3
    Memory range has cudaMemAdviseSetAccessedBy set for specified device

cudaMemRangeAttributeLastPrefetchLocation = 4
    The last location to which the range was prefetched

cudaMemRangeAttributePreferredLocationType = 5
    The preferred location type of the range

cudaMemRangeAttributePreferredLocationId = 6
    The preferred location id of the range

cudaMemRangeAttributeLastPrefetchLocationType = 7
    The last location type to which the range was prefetched

cudaMemRangeAttributeLastPrefetchLocationId = 8
    The last location id to which the range was prefetched

enum cudaResourceType

CUDA resource types

Values

cudaResourceTypeArray = 0x00
    Array resource

cudaResourceTypeMipmappedArray = 0x01
    Mipmapped array resource

cudaResourceTypeLinear = 0x02
    Linear resource

cudaResourceTypePitch2D = 0x03
    Pitch 2D resource

enum cudaResourceViewFormat

CUDA texture resource view formats

Values

cudaResViewFormatNone = 0x00
    No resource view format (use underlying resource format)

cudaResViewFormatUnsignedChar1 = 0x01
    1 channel unsigned 8-bit integers

cudaResViewFormatUnsignedChar2 = 0x02
2 channel unsigned 8-bit integers
\[ \text{cudaResViewFormatUnsignedChar4} = 0x03 \]

4 channel unsigned 8-bit integers
\[ \text{cudaResViewFormatUnsignedChar1} = 0x04 \]

1 channel signed 8-bit integers
\[ \text{cudaResViewFormatSignedChar2} = 0x05 \]

2 channel signed 8-bit integers
\[ \text{cudaResViewFormatSignedChar4} = 0x06 \]

4 channel signed 8-bit integers
\[ \text{cudaResViewFormatUnsignedShort1} = 0x07 \]

1 channel unsigned 16-bit integers
\[ \text{cudaResViewFormatUnsignedShort2} = 0x08 \]

2 channel unsigned 16-bit integers
\[ \text{cudaResViewFormatUnsignedShort4} = 0x09 \]

4 channel unsigned 16-bit integers
\[ \text{cudaResViewFormatSignedShort1} = 0x0a \]

1 channel signed 16-bit integers
\[ \text{cudaResViewFormatSignedShort2} = 0x0b \]

2 channel signed 16-bit integers
\[ \text{cudaResViewFormatSignedShort4} = 0x0c \]

4 channel signed 16-bit integers
\[ \text{cudaResViewFormatUnsignedInt1} = 0x0d \]

1 channel unsigned 32-bit integers
\[ \text{cudaResViewFormatUnsignedInt2} = 0x0e \]

2 channel unsigned 32-bit integers
\[ \text{cudaResViewFormatUnsignedInt4} = 0x0f \]

4 channel unsigned 32-bit integers
\[ \text{cudaResViewFormatSignedInt1} = 0x10 \]

1 channel signed 32-bit integers
\[ \text{cudaResViewFormatSignedInt2} = 0x11 \]

2 channel signed 32-bit integers
\[ \text{cudaResViewFormatSignedInt4} = 0x12 \]

4 channel signed 32-bit integers
\[ \text{cudaResViewFormatHalf1} = 0x13 \]

1 channel 16-bit floating point
\[ \text{cudaResViewFormatHalf2} = 0x14 \]

2 channel 16-bit floating point
\[ \text{cudaResViewFormatHalf4} = 0x15 \]

4 channel 16-bit floating point
\[ \text{cudaResViewFormatFloat1} = 0x16 \]

1 channel 32-bit floating point
\[ \text{cudaResViewFormatFloat2} = 0x17 \]

2 channel 32-bit floating point
cudaResViewFormatFloat4 = 0x18
    4 channel 32-bit floating point
cudaResViewFormatUnsignedBlockCompressed1 = 0x19
    Block compressed 1
cudaResViewFormatUnsignedBlockCompressed2 = 0x1a
    Block compressed 2
cudaResViewFormatUnsignedBlockCompressed3 = 0x1b
    Block compressed 3
cudaResViewFormatUnsignedBlockCompressed4 = 0x1c
    Block compressed 4 unsigned
cudaResViewFormatSignedBlockCompressed4 = 0x1d
    Block compressed 4 signed
cudaResViewFormatUnsignedBlockCompressed5 = 0x1e
    Block compressed 5 unsigned
cudaResViewFormatSignedBlockCompressed5 = 0x1f
    Block compressed 5 signed
cudaResViewFormatUnsignedBlockCompressed6H = 0x20
    Block compressed 6 unsigned half-float
cudaResViewFormatSignedBlockCompressed6H = 0x21
    Block compressed 6 signed half-float
cudaResViewFormatUnsignedBlockCompressed7 = 0x22
    Block compressed 7

enum cudaSharedCarveout

Shared memory carveout configurations. These may be passed to cudaFuncSetAttribute

Values

cudaSharedmemCarveoutDefault = -1
    No preference for shared memory or L1 (default)
cudaSharedmemCarveoutMaxShared = 100
    Prefer maximum available shared memory, minimum L1 cache
cudaSharedmemCarveoutMaxL1 = 0
    Prefer maximum available L1 cache, minimum shared memory

enum cudaSharedMemConfig

Deprecated

CUDA shared memory configuration

Values

cudaSharedMemBankSizeDefault = 0
cudaSharedMemBankSizeFourByte = 1
cudaSharedMemBankSizeEightByte = 2

enum cudaStreamCaptureMode
Possible modes for stream capture thread interactions. For more details see cudaStreamBeginCapture and cudaThreadExchangeStreamCaptureMode

Values

cudaStreamCaptureModeGlobal = 0

cudaStreamCaptureModeThreadLocal = 1

cudaStreamCaptureModeRelaxed = 2

enum cudaStreamCaptureStatus
Possible stream capture statuses returned by cudaStreamIsCapturing

Values

cudaStreamCaptureStatusNone = 0
Stream is not capturing

cudaStreamCaptureStatusActive = 1
Stream is actively capturing

cudaStreamCaptureStatusInvalidated = 2
Stream is part of a capture sequence that has been invalidated, but not terminated

enum cudaStreamUpdateCaptureDependenciesFlags
Flags for cudaStreamUpdateCaptureDependencies

Values

cudaStreamAddCaptureDependencies = 0x0
Add new nodes to the dependency set

cudaStreamSetCaptureDependencies = 0x1
Replace the dependency set with the new nodes

enum cudaSurfaceBoundaryMode
CUDA Surface boundary modes

Values

cudaBoundaryModeZero = 0
Zero boundary mode

cudaBoundaryModeClamp = 1
Clamp boundary mode
cudaBoundaryModeTrap = 2
    Trap boundary mode

enum cudaSurfaceFormatMode

CUDA Surface format modes

Values

cudaFormatModeForced = 0
    Forced format mode
cudaFormatModeAuto = 1
    Auto format mode

enum cudaTextureAddressMode

CUDA texture address modes

Values

cudaAddressModeWrap = 0
    Wrapping address mode
cudaAddressModeClamp = 1
    Clamp to edge address mode
cudaAddressModeMirror = 2
    Mirror address mode
cudaAddressModeBorder = 3
    Border address mode

enum cudaTextureFilterMode

CUDA texture filter modes

Values

cudaFilterModePoint = 0
    Point filter mode
cudaFilterModeLinear = 1
    Linear filter mode

enum cudaTextureReadMode

CUDA texture read modes

Values

cudaReadModeElementType = 0
Read texture as specified element type
\texttt{cudaReadModeNormalizedFloat = 1}
Read texture as normalized float

\textbf{enum cudaUserObjectFlags}

Flags for user objects for graphs

\textbf{Values}
\texttt{cudaUserObjectNoDestructorSync = 0x1}
Indicates the destructor execution is not synchronized by any CUDA handle.

\textbf{enum cudaUserObjectRetainFlags}

Flags for retaining user object references for graphs

\textbf{Values}
\texttt{cudaGraphUserObjectMove = 0x1}
Transfer references from the caller rather than creating new references.

\textbf{typedef cudaArray *cudaArray\_const\_t}

CUDA array (as source copy argument)

\textbf{typedef cudaArray *cudaArray\_t}

CUDA array

\textbf{typedef cudaAsyncCallbackEntry *cudaAsyncCallbackHandle\_t}

CUDA async callback handle

\textbf{typedef struct CUeglStreamConnection\_st *cudaEglStreamConnection}

CUDA EGLStream Connection

\textbf{typedef cudaError\_t}

CUDA Error types
typedef struct CUevent_st *cudaEvent_t
CUDA event types

typedef struct CUexternalMemory_st *cudaExternalMemory_t
CUDA external memory

typedef struct CUexternalSemaphore_st *cudaExternalSemaphore_t
CUDA external semaphore

typedef struct CUfunc_st *cudaFunction_t
CUDA function

typedef struct CUgraph_st *cudaGraph_t
CUDA graph

typedef unsigned long long cudaGraphConditionalHandle
CUDA handle for conditional graph nodes

typedef struct CUgraphDeviceUpdatableNode_st *cudaGraphDeviceNode_t
CUDA device node handle for device-side node update

typedef struct CUgraphExec_st *cudaGraphExec_t
CUDA executable (launchable) graph

typedef cudaGraphicsResource *cudaGraphicsResource_t
CUDA graphics resource types

typedef struct CUgraphNode_st *cudaGraphNode_t
CUDA graph node.
typedef void (CUDART_CB *cudaHostFn_t) (void*userData)

CUDA host function

typedef struct CUkern_st *cudaKernel_t

CUDA kernel

typedef struct CUMemPoolHandle_st *cudaMemPool_t

CUDA memory pool

typedef cudaMipmappedArray *cudaMipmappedArray_const_t

CUDA mipmapped array (as source argument)

typedef cudaMipmappedArray *cudaMipmappedArray_t

CUDA mipmapped array

typedef struct CUstream_st *cudaStream_t

CUDA stream

typedef unsigned long long cudaSurfaceObject_t

An opaque value that represents a CUDA Surface object

typedef unsigned long long cudaTextureObject_t

An opaque value that represents a CUDA texture object

typedef struct CUuserObject_st *cudaUserObject_t

CUDA user object for graphs

#define CUDA_EGL_MAX_PLANES 3

Maximum number of planes per frame
#define CUDA_IPC_HANDLE_SIZE 64
CUDA IPC Handle Size

#define cudaArrayColorAttachment 0x20
Must be set in cudaExternalMemoryGetMappedMipmappedArray if the mipmapped array is used as a
color target in a graphics API

#define cudaArrayCubemap 0x04
Must be set in cudaMalloc3DArray to create a cubemap CUDA array

#define cudaArrayDefault 0x00
Default CUDA array allocation flag

#define cudaArrayDeferredMapping 0x80
Must be set in cudaMallocArray, cudaMalloc3DArray or cudaMallocMipmappedArray in order to
create a deferred mapping CUDA array or CUDA mipmapped array

#define cudaArrayLayered 0x01
Must be set in cudaMalloc3DArray to create a layered CUDA array

#define cudaArraySparse 0x40
Must be set in cudaMallocArray, cudaMalloc3DArray or cudaMallocMipmappedArray in order to
create a sparse CUDA array or CUDA mipmapped array

#define cudaArraySparsePropertiesSingleMipTail 0x1
Indicates that the layered sparse CUDA array or CUDA mipmapped array has a single mip tail region
for all layers

#define cudaArraySurfaceLoadStore 0x02
Must be set in cudaMallocArray or cudaMalloc3DArray in order to bind surfaces to the CUDA array
#define cudaArrayTextureGather 0x08
Must be set in cudaMallocArray or cudaMalloc3DArray in order to perform texture gather operations on the CUDA array.

#define cudaCooperativeLaunchMultiDeviceNoPostSync 0x02
If set, any subsequent work pushed in a stream that participated in a call to cudaLaunchCooperativeKernelMultiDevice will only wait for the kernel launched on the GPU corresponding to that stream to complete before it begins execution.

#define cudaCooperativeLaunchMultiDeviceNoPreSync 0x01
If set, each kernel launched as part of cudaLaunchCooperativeKernelMultiDevice only waits for prior work in the stream corresponding to that GPU to complete before the kernel begins execution.

#define cudaCpuDeviceId ((int)-1)
Device id that represents the CPU

#define cudaDeviceBlockingSync 0x04
Deprecated This flag was deprecated as of CUDA 4.0 and replaced with cudaDeviceScheduleBlockingSync.
Device flag - Use blocking synchronization

#define cudaDeviceLmemResizeToMax 0x10
Device flag - Keep local memory allocation after launch

#define cudaDeviceMapHost 0x08
Device flag - Support mapped pinned allocations

#define cudaDeviceMask 0xff
Device flags mask
#define cudaDeviceScheduleAuto 0x00
Device flag - Automatic scheduling

#define cudaDeviceScheduleBlockingSync 0x04
Device flag - Use blocking synchronization

#define cudaDeviceScheduleMask 0x07
Device schedule flags mask

#define cudaDeviceScheduleSpin 0x01
Device flag - Spin default scheduling

#define cudaDeviceScheduleYield 0x02
Device flag - Yield default scheduling

#define cudaDeviceSyncMemops 0x80
Device flag - Ensure synchronous memory operations on this context will synchronize

#define cudaEventBlockingSync 0x01
Event uses blocking synchronization

#define cudaEventDefault 0x00
Default event flag

#define cudaEventDisableTiming 0x02
Event will not record timing data

#define cudaEventInterprocess 0x04
Event is suitable for interprocess use. cudaEventDisableTiming must be set

#define cudaEventRecordDefault 0x00
Default event record flag
#define cudaEventRecordExternal 0x01
Event is captured in the graph as an external event node when performing stream capture

#define cudaEventWaitDefault 0x00
Default event wait flag

#define cudaEventWaitExternal 0x01
Event is captured in the graph as an external event node when performing stream capture

#define cudaExternalMemoryDedicated 0x1
Indicates that the external memory object is a dedicated resource

#define cudaExternalSemaphoreSignalSkipNvSciBufMemSync 0x01
When the /p flags parameter of cudaExternalSemaphoreSignalParams contains this flag, it indicates that signaling an external semaphore object should skip performing appropriate memory synchronization operations over all the external memory objects that are imported as cudaExternalMemoryHandleTypeNvSciBuf, which otherwise are performed by default to ensure data coherency with other importers of the same NvSciBuf memory objects.

#define cudaExternalSemaphoreWaitSkipNvSciBufMemSync 0x02
When the /p flags parameter of cudaExternalSemaphoreWaitParams contains this flag, it indicates that waiting an external semaphore object should skip performing appropriate memory synchronization operations over all the external memory objects that are imported as cudaExternalMemoryHandleTypeNvSciBuf, which otherwise are performed by default to ensure data coherency with other importers of the same NvSciBuf memory objects.

#define cudaGraphKernelNodePortDefault 0
This port activates when the kernel has finished executing.
#define cudaGraphKernelNodePortLaunchCompletion 2
This port activates when all blocks of the kernel have begun execution. See also
cudaLaunchAttributeLaunchCompletionEvent.

#define cudaGraphKernelNodePortProgrammatic 1
This port activates when all blocks of the kernel have performed
cudaTriggerProgrammaticLaunchCompletion() or have terminated. It must be used with edge type
cudaGraphDependencyTypeProgrammatic. See also cudaLaunchAttributeProgrammaticEvent.

#define cudaHostAllocDefault 0x00
Default page-locked allocation flag

#define cudaHostAllocMapped 0x02
Map allocation into device space

#define cudaHostAllocPortable 0x01
Pinned memory accessible by all CUDA contexts

#define cudaHostAllocWriteCombined 0x04
Write-combined memory

#define cudaHostRegisterDefault 0x00
Default host memory registration flag

#define cudaHostRegisterIoMemory 0x04
Memory-mapped I/O space

#define cudaHostRegisterMapped 0x02
Map registered memory into device space

#define cudaHostRegisterPortable 0x01
Pinned memory accessible by all CUDA contexts
#define cudaMemcpyHostRegisterReadOnly 0x08
Memory-mapped read-only

#define cudaMemcpyDeviceFlagsAreValid 0x01
Tell the CUDA runtime that DeviceFlags is being set in cudaMemcpyDevice call

#define cudaInvalidDeviceId ((int)-2)
Device id that represents an invalid device

#define cudaIpcMemLazyEnablePeerAccess 0x01
Automatically enable peer access between remote devices as needed

#define cudaMemcpyGlobal 0x01
Memory can be accessed by any stream on any device

#define cudaMemcpyHost 0x02
Memory cannot be accessed by any stream on any device

#define cudaMemcpySingle 0x04
Memory can only be accessed by a single stream on the associated device

#define cudaMemcpyNvSciSyncAttrSignal 0x1
When /p flags of cudaMemcpyNvSciSyncAttributes is set to this, it indicates that application need
generator specific NvSciSyncAttr to be filled by cudaMemcpyNvSciSyncAttributes.

#define cudaMemcpyNvSciSyncAttrWait 0x2
When /p flags of cudaMemcpyNvSciSyncAttributes is set to this, it indicates that application need
waiter specific NvSciSyncAttr to be filled by cudaMemcpyNvSciSyncAttributes.

#define cudaMemcpyOccupancyDefault 0x00
Default behavior
#define cudaOccupancyDisableCachingOverride 0x01
Assume global caching is enabled and cannot be automatically turned off

#define cudaPeerAccessDefault 0x00
Default peer addressing enable flag

#define cudaStreamDefault 0x00
Default stream flag

#define cudaStreamLegacy ((cudaStream_t)0x1)
Legacy stream handle
Stream handle that can be passed as a cudaStream_t to use an implicit stream with legacy
synchronization behavior.
See details of the synchronization behavior.

#define cudaStreamNonBlocking 0x01
Stream does not synchronize with stream 0 (the NULL stream)

#define cudaStreamPerThread ((cudaStream_t)0x2)
Per-thread stream handle
Stream handle that can be passed as a cudaStream_t to use an implicit stream with per-thread
synchronization behavior.
See details of the synchronization behavior.
Chapter 7. Data Structures

Here are the data structures with brief descriptions:

- __cudaOccupancyB2DHelper
- cudaAccessPolicyWindow
- cudaArrayMemoryRequirements
- cudaArraySparseProperties
- cudaAsyncNotificationInfo_t
- cudaChannelFormatDesc
- cudaChildGraphNodeParams
- cudaConditionalGraphNodeParams
- cudaDeviceProp
- cudaEglFrame
- cudaEglPlaneDesc
- cudaEventRecordNodeParams
- cudaEventWaitNodeParams
- cudaExtent
- cudaExternalMemoryBufferDesc
- cudaExternalMemoryHandleDesc
- cudaExternalMemoryMipmappedArrayDesc
- cudaExternalSemaphoreHandleDesc
- cudaExternalSemaphoreSignalNodeParams
- cudaExternalSemaphoreSignalNodeParamsV2
- cudaExternalSemaphoreSignalParams
- cudaExternalSemaphoreSignalParams_v1
- cudaExternalSemaphoreWaitNodeParams
- cudaExternalSemaphoreWaitNodeParamsV2
- cudaExternalSemaphoreWaitParams
- cudaExternalSemaphoreWaitParams_v1
- cudaFuncAttributes
- cudaGraphEdgeData
- cudaGraphExecUpdateResultInfo
- cudaGraphInstantiateParams
- cudaGraphKernelNodeUpdate
- cudaGraphNodeParams
cudaHostNodeParams
cudaHostNodeParamsV2
cudalpcEventHandle_t
cudalpcMemHandle_t
cudaKernelNodeParams
cudaKernelNodeParamsV2
cudaLaunchAttribute
cudaLaunchAttributeValue
cudaLaunchConfig_t
cudaLaunchMemSyncDomainMap
cudaLaunchParams
cudaMemAccessDesc
cudaMemAllocNodeParams
cudaMemAllocNodeParamsV2
cudamemcpy3DParms
cudamemcpy3DPeerParms
cudamemcpyNodeParams
cudamemFreeNodeParams
cudamemLocation
cudamemPoolProps
cudamemPoolPtrExportData
cudamemsetParams
cudamemsetParamsV2
cudapitchedPtr
cudapointerAttributes
cudapos
cudaresourcDesc
cudaresourcViewDesc
cudatextureDesc
cudauuid_t

7.1.  __cudaOccupancyB2DHelper

C++ API Routines cppClassifierVisibility: visibility=public  cppClassifierTemplateModel: =

Helper functor for cudaOccupancyMaxPotentialBlockSize
7.2. cudaAccessPolicyWindow Struct Reference

Specifies an access policy for a window, a contiguous extent of memory beginning at base_ptr and ending at base_ptr + num_bytes. Partition into many segments and assign segments such that. sum of "hit segments" / window == approx. ratio. sum of "miss segments" / window == approx 1-ratio. Segments and ratio specifications are fitted to the capabilities of the architecture. Accesses in a hit segment apply the hitProp access policy. Accesses in a miss segment apply the missProp access policy.

```cpp
void *cudaAccessPolicyWindow::base_ptr
```

Starting address of the access policy window. CUDA driver may align it.

```cpp
enum cudaAccessProperty
cudaAccessPolicyWindow::hitProp
```

CUaccessProperty set for hit.

```cpp
float cudaAccessPolicyWindow::hitRatio
```

hitRatio specifies percentage of lines assigned hitProp, rest are assigned missProp.

```cpp
enum cudaAccessProperty
cudaAccessPolicyWindow::missProp
```

CUaccessProperty set for miss. Must be either NORMAL or STREAMING.

```cpp
size_t cudaAccessPolicyWindow::num_bytes
```

Size in bytes of the window policy. CUDA driver may restrict the maximum size and alignment.

7.3. cudaArrayMemoryRequirements Struct Reference

CUDA array and CUDA mipmapped array memory requirements
size_t cudaArrayMemoryRequirements::alignment
Alignment necessary for mapping the array.

size_t cudaArrayMemoryRequirements::size
Total size of the array.

7.4. cudaArraySparseProperties Struct
Reference
Sparse CUDA array and CUDA mipmapped array properties

unsigned int cudaArraySparseProperties::depth
Tile depth in elements

unsigned int cudaArraySparseProperties::flags
Flags will either be zero or cudaArraySparsePropertiesSingleMipTail

unsigned int cudaArraySparseProperties::height
Tile height in elements

unsigned int cudaArraySparseProperties::miptailFirstLevel
First mip level at which the mip tail begins

unsigned long long cudaArraySparseProperties::miptailSize
Total size of the mip tail.

unsigned int cudaArraySparseProperties::width
Tile width in elements
7.5. **cudaAsyncNotificationInfo_t Struct Reference**

Information describing an async notification event

7.6. **cudaChannelFormatDesc Struct Reference**

CUDA Channel format descriptor

```c
enum cudaChannelFormatKind cudaChannelFormatDesc::f

Channel format kind
```

```c
int cudaChannelFormatDesc::w

w
```

```c
int cudaChannelFormatDesc::x

x
```

```c
int cudaChannelFormatDesc::y

y
```

```c
int cudaChannelFormatDesc::z

z
```

7.7. **cudaChildGraphNodeParams Struct Reference**

Child graph node parameters
cudaGraph_t cudaChildGraphNodeParams::graph
The child graph to clone into the node for node creation, or a handle to the graph owned by the node for node query

7.8. cudaConditionalNodeParams Struct

CUDA conditional node parameters

cudaGraphConditionalHandle
cudaConditionalNodeParams::handle
Conditional node handle. Handles must be created in advance of creating the node using cudaGraphConditionalHandleCreate.

cudaGraph_t *cudaConditionalNodeParams::phGraph_out
CUDA-owned array populated with conditional node child graphs during creation of the node. Valid for the lifetime of the conditional node. The contents of the graph(s) are subject to the following constraints:

- Allowed node types are kernel nodes, empty nodes, child graphs, memsets, memcopies, and conditionals. This applies recursively to child graphs and conditional bodies.
- All kernels, including kernels in nested conditionals or child graphs at any level, must belong to the same CUDA context.

These graphs may be populated using graph node creation APIs or cudaStreamBeginCaptureToGraph.

unsigned int cudaConditionalNodeParams::size
Size of graph output array. Must be 1.

cenumcudaGraphConditionalNodeType
cudaConditionalNodeParams::type
Type of conditional node.
7.9. cudaDeviceProp Struct Reference

CUDA device properties

int cudaDeviceProp::accessPolicyMaxWindowSize
The maximum value of cudaAccessPolicyWindow::num_bytes.

int cudaDeviceProp::asyncEngineCount
Number of asynchronous engines

int cudaDeviceProp::canMapHostMemory
Device can map host memory with cudaHostAlloc/cudaHostGetDevicePointer

int cudaDeviceProp::canUseHostPointerForRegisteredMem
Device can access host registered memory at the same virtual address as the CPU

int cudaDeviceProp::clockRate
Deprecated, Clock frequency in kilohertz

int cudaDeviceProp::clusterLaunch
Indicates device supports cluster launch

int cudaDeviceProp::computeMode
Deprecated, Compute mode (See cudaComputeMode)

int cudaDeviceProp::computePreemptionSupported
Device supports Compute Preemption

int cudaDeviceProp::concurrentKernels
Device can possibly execute multiple kernels concurrently
int cudaDeviceProp::concurrentManagedAccess
Device can coherently access managed memory concurrently with the CPU

int cudaDeviceProp::cooperativeLaunch
Device supports launching cooperative kernels via cudaLaunchCooperativeKernel

int cudaDeviceProp::cooperativeMultiDeviceLaunch
Deprecated, cudaLaunchCooperativeKernelMultiDevice is deprecated.

int cudaDeviceProp::deferredMappingCudaArraySupported
1 if the device supports deferred mapping CUDA arrays and CUDA mipmapped arrays

int cudaDeviceProp::deviceOverlap
Device can concurrently copy memory and execute a kernel. Deprecated. Use instead asyncEngineCount.

int cudaDeviceProp::directManagedMemAccessFromHost
Host can directly access managed memory on the device without migration.

int cudaDeviceProp::ECCEnabled
Device has ECC support enabled

int cudaDeviceProp::globalL1CacheSupported
Device supports caching globals in L1

unsigned int cudaDeviceProp::gpuDirectRDMAFlushWritesOptions
Bitmask to be interpreted according to the cudaFlushGPUDirectRDMAWritesOptions enum

int cudaDeviceProp::gpuDirectRDMASupported
1 if the device supports GPUDirect RDMA APIs, 0 otherwise
int cudaDeviceProp::gpuDirectRDMAWritesOrdering
See the cudaGPUDirectRDMAWritesOrdering enum for numerical values

int cudaDeviceProp::hostNativeAtomicSupported
Link between the device and the host supports native atomic operations

int cudaDeviceProp::hostRegisterReadOnlySupported
Device supports using the cudaHostRegister flag cudaHostRegisterReadOnly to register memory that must be mapped as read-only to the GPU

int cudaDeviceProp::hostRegisterSupported
Device supports host memory registration via cudaHostRegister.

int cudaDeviceProp::integrated
Device is integrated as opposed to discrete

int cudaDeviceProp::ipcEventSupported
Device supports IPC Events.

int cudaDeviceProp::isMultiGpuBoard
Device is on a multi-GPU board

int cudaDeviceProp::kernelExecTimeoutEnabled
Deprecated, Specified whether there is a run time limit on kernels

int cudaDeviceProp::l2CacheSize
Size of L2 cache in bytes

int cudaDeviceProp::localL1CacheSupported
Device supports caching locals in L1
char cudaDeviceProp::luid

8-byte locally unique identifier. Value is undefined on TCC and non-Windows platforms

unsigned int cudaDeviceProp::luidDeviceNodeMask

LUID device node mask. Value is undefined on TCC and non-Windows platforms

int cudaDeviceProp::major

Major compute capability

int cudaDeviceProp::managedMemory

Device supports allocating managed memory on this system

int cudaDeviceProp::maxBlocksPerMultiProcessor

Maximum number of resident blocks per multiprocessor

int cudaDeviceProp::maxGridSize

Maximum size of each dimension of a grid

int cudaDeviceProp::maxSurface1D

Maximum 1D surface size

int cudaDeviceProp::maxSurface1DLayered

Maximum 1D layered surface dimensions

int cudaDeviceProp::maxSurface2D

Maximum 2D surface dimensions

int cudaDeviceProp::maxSurface2DLayered

Maximum 2D layered surface dimensions

int cudaDeviceProp::maxSurface3D

Maximum 3D surface dimensions
int cudaDeviceProp::maxSurfaceCubemap
Maximum Cubemap surface dimensions

int cudaDeviceProp::maxSurfaceCubemapLayered
Maximum Cubemap layered surface dimensions

int cudaDeviceProp::maxTexture1D
Maximum 1D texture size

int cudaDeviceProp::maxTexture1DLayered
Maximum 1D layered texture dimensions

int cudaDeviceProp::maxTexture1DLinear
Deprecated, do not use. Use cudaDeviceGetTexture1DLinearMaxWidth() or cuDeviceGetTexture1DLinearMaxWidth() instead.

int cudaDeviceProp::maxTexture1DMipmap
Maximum 1D mipmapped texture size

int cudaDeviceProp::maxTexture2D
Maximum 2D texture dimensions

int cudaDeviceProp::maxTexture2DGather
Maximum 2D texture dimensions if texture gather operations have to be performed

int cudaDeviceProp::maxTexture2DLayered
Maximum 2D layered texture dimensions

int cudaDeviceProp::maxTexture2DLinear
Maximum dimensions (width, height, pitch) for 2D textures bound to pitched memory
int cudaDeviceProp::maxTexture2DMipmap
Maximum 2D mipmapped texture dimensions

int cudaDeviceProp::maxTexture3D
Maximum 3D texture dimensions

int cudaDeviceProp::maxTexture3DAlt
Maximum alternate 3D texture dimensions

int cudaDeviceProp::maxTextureCubemap
Maximum Cubemap texture dimensions

int cudaDeviceProp::maxTextureCubemapLayered
Maximum Cubemap layered texture dimensions

int cudaDeviceProp::maxThreadsDim
Maximum size of each dimension of a block

int cudaDeviceProp::maxThreadsPerBlock
Maximum number of threads per block

int cudaDeviceProp::maxThreadsPerMultiProcessor
Maximum resident threads per multiprocessor

int cudaDeviceProp::memoryBusWidth
Global memory bus width in bits

int cudaDeviceProp::memoryClockRate
Deprecated, Peak memory clock frequency in kilohertz

int cudaDeviceProp::memoryPoolsSupported
1 if the device supports using the cudaMallocAsync and cudaMemPool family of APIs, 0 otherwise
unsigned int cudaDeviceProp::memoryPoolSupportedHandleTypes
Bitmask of handle types supported with mempool-based IPC

size_t cudaDeviceProp::memPitch
Maximum pitch in bytes allowed by memory copies

int cudaDeviceProp::minor
Minor compute capability

int cudaDeviceProp::multiGpuBoardGroupID
Unique identifier for a group of devices on the same multi-GPU board

int cudaDeviceProp::multiProcessorCount
Number of multiprocessors on device

char cudaDeviceProp::name
ASCII string identifying device

int cudaDeviceProp::pageableMemoryAccess
Device supports coherently accessing pageable memory without calling cudaHostRegister on it

int cudaDeviceProp::pageableMemoryAccessUsesHostPageTables
Device accesses pageable memory via the host's page tables

int cudaDeviceProp::pciBusID
PCI bus ID of the device

int cudaDeviceProp::pciDeviceID
PCI device ID of the device
int cudaDeviceProp::pciDomainID

PCI domain ID of the device

int cudaDeviceProp::persistingL2CacheMaxSize

Device's maximum l2 persisting lines capacity setting in bytes

int cudaDeviceProp::regsPerBlock

32-bit registers available per block

int cudaDeviceProp::regsPerMultiprocessor

32-bit registers available per multiprocessor

int cudaDeviceProp::reserved

Reserved for future use

int cudaDeviceProp::reserved1

Reserved for future use

size_t cudaDeviceProp::reservedSharedMemPerBlock

Shared memory reserved by CUDA driver per block in bytes

size_t cudaDeviceProp::sharedMemPerBlock

Shared memory available per block in bytes

size_t cudaDeviceProp::sharedMemPerBlockOptin

Per device maximum shared memory per block usable by special opt in

size_t cudaDeviceProp::sharedMemPerMultiprocessor

Shared memory available per multiprocessor in bytes
int cudaMemcpyProp::singleToDoublePrecisionPerfRatio

Deprecated, Ratio of single precision performance (in floating-point operations per second) to double precision performance

int cudaMemcpyProp::sparseCudaArraySupported

1 if the device supports sparse CUDA arrays and sparse CUDA mipmapped arrays, 0 otherwise

int cudaMemcpyProp::streamPrioritiesSupported

Device supports stream priorities

size_t cudaMemcpyProp::surfaceAlignment

Alignment requirements for surfaces

int cudaMemcpyProp::tccDriver

1 if device is a Tesla device using TCC driver, 0 otherwise

size_t cudaMemcpyProp::textureAlignment

Alignment requirement for textures

size_t cudaMemcpyProp::texturePitchAlignment

Pitch alignment requirement for texture references bound to pitched memory

int cudaMemcpyProp::timelineSemaphoreInteropSupported

External timeline semaphore interop is supported on the device

size_t cudaMemcpyProp::totalConstMem

Constant memory available on device in bytes

size_t cudaMemcpyProp::totalGlobalMem

Global memory available on device in bytes
int cudaDeviceProp::unifiedAddressing
Device shares a unified address space with the host

int cudaDeviceProp::unifiedFunctionPointers
Indicates device supports unified pointers

cudaUUID_t cudaDeviceProp::uuid
16-byte unique identifier

int cudaDeviceProp::warpSize
Warp size in threads

7.10. cudaEglFrame Struct Reference

CUDA EGLFrame Descriptor - structure defining one frame of EGL.

Each frame may contain one or more planes depending on whether the surface is Multiplanar or not.
Each plane of EGLFrame is represented by cudaEglPlaneDesc which is defined as:

```c
typedef struct cudaEglPlaneDesc_st {
    unsigned int width;
    unsigned int height;
    unsigned int depth;
    unsigned int pitch;
    unsigned int numChannels;
    struct cudaChannelFormatDesc channelDesc;
    unsigned int reserved[4];
} cudaEglPlaneDesc;
```

cudaEglColorFormat cudaEglFrame::eglColorFormat
CUDA EGL Color Format

cudaEglFrameType cudaEglFrame::frameType
Array or Pitch

cudaArray_t cudaEglFrame::pArray
Array of CUDA arrays corresponding to each plane
unsigned int cudaEglFrame::planeCount
Number of planes

struct cudaEglPlaneDesc cudaEglFrame::planeDesc
CUDA EGL Plane Descriptor cudaEglPlaneDesc

struct cudaPitchedPtr cudaEglFrame::pPitch
Array of Pointers corresponding to each plane

7.11. cudaEglPlaneDesc Struct Reference
CUDA EGL Plane Descriptor - structure defining each plane of a CUDA EGLFrame

struct cudaChannelFormatDesc
cudaEglPlaneDesc::channelDesc
Channel Format Descriptor

unsigned int cudaEglPlaneDesc::depth
Depth of plane

unsigned int cudaEglPlaneDesc::height
Height of plane

unsigned int cudaEglPlaneDesc::numChannels
Number of channels for the plane

unsigned int cudaEglPlaneDesc::pitch
Pitch of plane

unsigned int cudaEglPlaneDesc::reserved
Reserved for future use
unsigned int cudaEglPlaneDesc::width
Width of plane

7.12. cudaEventRecordNodeParams Struct Reference
Event record node parameters

cudaEvent_t cudaEventRecordNodeParams::event
The event to record when the node executes

7.13. cudaEventWaitNodeParams Struct Reference
Event wait node parameters

cudaEvent_t cudaEventWaitNodeParams::event
The event to wait on from the node

7.14. cudaExtent Struct Reference
CUDA extent
See also:
make_cudaExtent

size_t cudaExtent::depth
Depth in elements

size_t cudaExtent::height
Height in elements
size_t cudaExtent::width
Width in elements when referring to array memory, in bytes when referring to linear memory

7.15. cudaExternalMemoryBufferDesc Struct
Reference
External memory buffer descriptor

unsigned int cudaExternalMemoryBufferDesc::flags
Flags reserved for future use. Must be zero.

unsigned long long cudaExternalMemoryBufferDesc::offset
Offset into the memory object where the buffer's base is

unsigned long long cudaExternalMemoryBufferDesc::size
Size of the buffer

7.16. cudaExternalMemoryHandleDesc Struct
Reference
External memory handle descriptor

int cudaExternalMemoryHandleDesc::fd
File descriptor referencing the memory object. Valid when type is cudaExternalMemoryHandleTypeOpaqueFd

unsigned int cudaExternalMemoryHandleDesc::flags
Flags must either be zero or cudaExternalMemoryDedicated

void *cudaExternalMemoryHandleDesc::handle
Valid NT handle. Must be NULL if 'name' is non-NULL
const void *cudaExternalMemoryHandleDesc::name

Name of a valid memory object. Must be NULL if 'handle' is non-NULL.

const void
*cudaExternalMemoryHandleDesc::nvSciBufObject

A handle representing NvSciBuf Object. Valid when type is cudaExternalMemoryHandleTypeNvSciBuf

unsigned long long cudaExternalMemoryHandleDesc::size

Size of the memory allocation

denum cudaExternalMemoryHandleType

cudaExternalMemoryHandleDesc::type

Type of the handle

cudaExternalMemoryHandleDesc::@7::@8

cudaExternalMemoryHandleDesc::win32

Win32 handle referencing the semaphore object. Valid when type is one of the following:

- cudaExternalMemoryHandleTypeOpaqueWin32
- cudaExternalMemoryHandleTypeOpaqueWin32Kmt
- cudaExternalMemoryHandleTypeD3D12Heap
- cudaExternalMemoryHandleTypeD3D12Resource
- cudaExternalMemoryHandleTypeD3D11Resource
- cudaExternalMemoryHandleTypeD3D11ResourceKmt

Exactly one of 'handle' and 'name' must be non-NULL. If type is one of the following: cudaExternalMemoryHandleTypeOpaqueWin32Kmt cudaExternalMemoryHandleTypeD3D11ResourceKmt then 'name' must be NULL.

7.17. cudaExternalMemoryMipmappedArrayDesc

Struct Reference

External memory mipmap descriptor
struct cudaExtent

cudaExternalMemoryMipmappedArrayDesc::extent

Dimensions of base level of the mipmap chain

unsigned int

cudaExternalMemoryMipmappedArrayDesc::flags

Flags associated with CUDA mipmapped arrays. See cudaMallocMipmappedArray

struct cudaChannelFormatDesc

cudaExternalMemoryMipmappedArrayDesc::formatDesc

Format of base level of the mipmap chain

unsigned int

cudaExternalMemoryMipmappedArrayDesc::numLevels

Total number of levels in the mipmap chain

unsigned long long

cudaExternalMemoryMipmappedArrayDesc::offset

Offset into the memory object where the base level of the mipmap chain is.

7.18. cudaExternalSemaphoreHandleDesc

Struct Reference

External semaphore handle descriptor

int cudaExternalSemaphoreHandleDesc::fd

File descriptor referencing the semaphore object. Valid when type is one of the following:

- cudaExternalSemaphoreHandleTypeOpaqueFd
- cudaExternalSemaphoreHandleTypeTimelineSemaphoreFd
unsigned int cudaExternalSemaphoreHandleDesc::flags
Flags reserved for the future. Must be zero.

void *cudaExternalSemaphoreHandleDesc::handle
Valid NT handle. Must be NULL if 'name' is non-NULL.

const void *cudaExternalSemaphoreHandleDesc::name
Name of a valid synchronization primitive. Must be NULL if 'handle' is non-NULL.

const void *cudaExternalSemaphoreHandleDesc::nvSciSyncObj
Valid NvSciSyncObj. Must be non NULL.

e num cudaExternalSemaphoreHandleType
cudaExternalSemaphoreHandleDesc::type
Type of the handle

cudaExternalSemaphoreHandleDesc::@9::@10
cudaExternalSemaphoreHandleDesc::win32
Win32 handle referencing the semaphore object. Valid when type is one of the following:
- cudaExternalSemaphoreHandleTypeOpaqueWin32
- cudaExternalSemaphoreHandleTypeOpaqueWin32Kmt
- cudaExternalSemaphoreHandleTypeD3D12Fence
- cudaExternalSemaphoreHandleTypeD3D11Fence
- cudaExternalSemaphoreHandleTypeKeyedMutex
- cudaExternalSemaphoreHandleTypeTimelineSemaphoreWin32

Exactly one of 'handle' and 'name' must be non-NULL. If type is one of the following: cudaExternalSemaphoreHandleTypeOpaqueWin32Kmt
cudaExternalSemaphoreHandleTypeKeyedMutexKmt then 'name' must be NULL.
7.19. **cudaExternalSemaphoreSignalNodeParams**

Struct Reference

External semaphore signal node parameters

cudaExternalSemaphore_t
*cudaExternalSemaphoreSignalNodeParams::extSemArray

Array of external semaphore handles.

unsigned int
cudaExternalSemaphoreSignalNodeParams::numExtSems

Number of handles and parameters supplied in extSemArray and paramsArray.

cudaExternalSemaphoreSignalParams
*cudaExternalSemaphoreSignalNodeParams::paramsArray

Array of external semaphore signal parameters.

7.20. **cudaExternalSemaphoreSignalNodeParamsV2**

Struct Reference

External semaphore signal node parameters

cudaExternalSemaphore_t
*cudaExternalSemaphoreSignalNodeParamsV2::extSemArray

Array of external semaphore handles.

unsigned int
cudaExternalSemaphoreSignalNodeParamsV2::numExtSems

Number of handles and parameters supplied in extSemArray and paramsArray.
cudaExternalSemaphoreSignalParams
*cudaExternalSemaphoreSignalNodeParamsV2::paramsArray

Array of external semaphore signal parameters.

7.21. cudaExternalSemaphoreSignalParams
Struct Reference

External semaphore signal parameters, compatible with driver type

void *cudaExternalSemaphoreSignalParams::fence

Pointer to NvSciSyncFence. Valid if cudaExternalSemaphoreHandleType is of type
cudaExternalSemaphoreHandleTypeNvSciSync.

cudaExternalSemaphoreSignalParams::@19::@20
cudaExternalSemaphoreSignalParams::fence

Parameters for fence objects

unsigned int cudaExternalSemaphoreSignalParams::flags

Only when cudaExternalSemaphoreSignalParams is used to signal a cudaExternalSemaphore_t of type cudaExternalSemaphoreHandleTypeNvSciSync, the valid flag is
cudaExternalSemaphoreSignalSkipNvSciBufMemSync: which indicates that while signaling the
cudaExternalSemaphore_t, no memory synchronization operations should be performed for any
external memory object imported as cudaExternalMemoryHandleTypeNvSciBuf. For all other types of
cudaExternalSemaphore_t, flags must be zero.

cudaExternalSemaphoreSignalParams::@19::@22
cudaExternalSemaphoreSignalParams::keyedMutex

Parameters for keyed mutex objects

unsigned long long
cudaExternalSemaphoreSignalParams::value

Value of fence to be signaled
7.22.  cudaExternalSemaphoreSignalParams_v1 Struct Reference

External semaphore signal parameters (deprecated)

void *cudaExternalSemaphoreSignalParams_v1::fence

Pointer to NvSciSyncFence. Valid if cudaExternalSemaphoreHandleType is of type cudaExternalSemaphoreHandleTypeNvSciSync.

cudaExternalSemaphoreSignalParams_v1::@11::@12

cudaExternalSemaphoreSignalParams_v1::fence

Parameters for fence objects

unsigned int
cudaExternalSemaphoreSignalParams_v1::flags

Only when cudaExternalSemaphoreSignalParams is used to signal a cudaExternalSemaphore_t of type cudaExternalSemaphoreHandleTypeNvSciSync, the valid flag is cudaExternalSemaphoreSignalSkipNvSciBufMemSync: which indicates that while signaling the cudaExternalSemaphore_t, no memory synchronization operations should be performed for any external memory object imported as cudaExternalMemoryHandleTypeNvSciBuf. For all other types of cudaExternalSemaphore_t, flags must be zero.

cudaExternalSemaphoreSignalParams_v1::@11::@14
cudaExternalSemaphoreSignalParams_v1::keyedMutex

Parameters for keyed mutex objects

unsigned long long
cudaExternalSemaphoreSignalParams_v1::value

Value of fence to be signaled
7.23. cudaExternalSemaphoreWaitNodeParams
Struct Reference

External semaphore wait node parameters

cudaExternalSemaphore_t
*cudaExternalSemaphoreWaitNodeParams::extSemArray

Array of external semaphore handles.

unsigned int
cudaExternalSemaphoreWaitNodeParams::numExtSems

Number of handles and parameters supplied in extSemArray and paramsArray.

cudaExternalSemaphoreWaitParams
*cudaExternalSemaphoreWaitNodeParams::paramsArray

Array of external semaphore wait parameters.

7.24. cudaExternalSemaphoreWaitNodeParamsV2
Struct Reference

External semaphore wait node parameters

cudaExternalSemaphore_t
*cudaExternalSemaphoreWaitNodeParamsV2::extSemArray

Array of external semaphore handles.

unsigned int
cudaExternalSemaphoreWaitNodeParamsV2::numExtSems

Number of handles and parameters supplied in extSemArray and paramsArray.
cudaExternalSemaphoreWaitParams
*cudaExternalSemaphoreWaitNodeParamsV2::paramsArray

Array of external semaphore wait parameters.

7.25.  cudaExternalSemaphoreWaitParams
Struct Reference

External semaphore wait parameters, compatible with driver type

void *cudaExternalSemaphoreWaitParams::fence

Pointer to NvSciSyncFence. Valid if cudaExternalSemaphoreHandleType is of type cudaExternalSemaphoreHandleTypeNvSciSync.

cudaExternalSemaphoreWaitParams::@23::@24
cudaExternalSemaphoreWaitParams::fence

Parameters for fence objects

unsigned int cudaExternalSemaphoreWaitParams::flags

Only when cudaExternalSemaphoreSignalParams is used to signal a cudaExternalSemaphore_t of type cudaExternalSemaphoreHandleTypeNvSciSync, the valid flag is cudaExternalSemaphoreSignalSkipNvSciBufMemSync: which indicates that while waiting for the cudaExternalSemaphore_t, no memory synchronization operations should be performed for any external memory object imported as cudaExternalMemoryHandleTypeNvSciBuf. For all other types of cudaExternalSemaphore_t, flags must be zero.

unsigned long long
cudaExternalSemaphoreWaitParams::key

Value of key to acquire the mutex with

cudaExternalSemaphoreWaitParams::@23::@26
cudaExternalSemaphoreWaitParams::keyedMutex

Parameters for keyed mutex objects
unsigned int
cudaExternalSemaphoreWaitParams::timeoutMs

Timeout in milliseconds to wait to acquire the mutex

unsigned long long
cudaExternalSemaphoreWaitParams::value

Value of fence to be waited on

7.26.  cudaExternalSemaphoreWaitParams_v1

Struct Reference

External semaphore wait parameters (deprecated)

void *cudaExternalSemaphoreWaitParams_v1::fence

Pointer to NvSciSyncFence. Valid if cudaExternalSemaphoreHandleType is of type
cudaExternalSemaphoreHandleTypeNvSciSync.

cudaExternalSemaphoreWaitParams_v1::@15::@16
cudaExternalSemaphoreWaitParams_v1::fence

Parameters for fence objects

unsigned int cudaExternalSemaphoreWaitParams_v1::flags

Only when cudaExternalSemaphoreSignalParams is used to signal a cudaExternalSemaphore_t
of type cudaExternalSemaphoreHandleTypeNvSciSync, the valid flag is
cudaExternalSemaphoreSignalSkipNvSciBufMemSync: which indicates that while waiting for the
cudaExternalSemaphore_t, no memory synchronization operations should be performed for any
external memory object imported as cudaExternalMemoryHandleTypeNvSciBuf. For all other types of
cudaExternalSemaphore_t, flags must be zero.

unsigned long long
cudaExternalSemaphoreWaitParams_v1::key

Value of key to acquire the mutex with
cudaExternalSemaphoreWaitParams_v1::timeoutMs

Timeout in milliseconds to wait to acquire the mutex

cudaExternalSemaphoreWaitParams_v1::value

Value of fence to be waited on

7.27. cudaFuncAttributes Struct Reference

CUDA function attributes

int cudaFuncAttributes::binaryVersion

The binary architecture version for which the function was compiled. This value is the major binary version * 10 + the minor binary version, so a binary version 1.3 function would return the value 13.

int cudaFuncAttributes::cacheModeCA

The attribute to indicate whether the function has been compiled with user specified option "-Xptxas --dlcm=ca" set.

int cudaFuncAttributes::clusterDimMustBeSet

If this attribute is set, the kernel must launch with a valid cluster dimension specified.

int cudaFuncAttributes::clusterSchedulingPolicyPreference

The block scheduling policy of a function. See cudaFuncSetAttribute

size_t cudaFuncAttributes::constSizeBytes

The size in bytes of user-allocated constant memory required by this function.
size_t cudaFuncAttributes::localSizeBytes
The size in bytes of local memory used by each thread of this function.

int cudaFuncAttributes::maxDynamicSharedSizeBytes
The maximum size in bytes of dynamic shared memory per block for this function. Any launch must have a dynamic shared memory size smaller than this value.

int cudaFuncAttributes::maxThreadsPerBlock
The maximum number of threads per block, beyond which a launch of the function would fail. This number depends on both the function and the device on which the function is currently loaded.

int cudaFuncAttributes::nonPortableClusterSizeAllowed
Whether the function can be launched with non-portable cluster size. 1 is allowed, 0 is disallowed. A non-portable cluster size may only function on the specific SKUs the program is tested on. The launch might fail if the program is run on a different hardware platform.

CUDA API provides cudaOccupancyMaxActiveClusters to assist with checking whether the desired size can be launched on the current device.

Portable Cluster Size
A portable cluster size is guaranteed to be functional on all compute capabilities higher than the target compute capability. The portable cluster size for sm_90 is 8 blocks per cluster. This value may increase for future compute capabilities.

The specific hardware unit may support higher cluster sizes that’s not guaranteed to be portable. See cudaFuncSetAttribute

int cudaFuncAttributes::numRegs
The number of registers used by each thread of this function.

int cudaFuncAttributes::preferredShmemCarveout
On devices where the L1 cache and shared memory use the same hardware resources, this sets the shared memory carveout preference, in percent of the maximum shared memory. Refer to cudaDevAttrMaxSharedMemoryPerMultiprocessor. This is only a hint, and the driver can choose a different ratio if required to execute the function. See cudaFuncSetAttribute
int cudaFuncAttributes::ptxVersion

The PTX virtual architecture version for which the function was compiled. This value is the major PTX version * 10 + the minor PTX version, so a PTX version 1.3 function would return the value 13.

int cudaFuncAttributes::requiredClusterWidth

The required cluster width/height/depth in blocks. The values must either all be 0 or all be positive. The validity of the cluster dimensions is otherwise checked at launch time.

If the value is set during compile time, it cannot be set at runtime. Setting it at runtime should return cudaErrorNotPermitted. See cudaFuncSetAttribute

int cudaFuncAttributes::reserved

Reserved for future use.

size_t cudaFuncAttributes::sharedSizeBytes

The size in bytes of statically-allocated shared memory per block required by this function. This does not include dynamically-allocated shared memory requested by the user at runtime.

7.28. cudaGraphEdgeData Struct Reference

Optional annotation for edges in a CUDA graph. Note, all edges implicitly have annotations and default to a zero-initialized value if not specified. A zero-initialized struct indicates a standard full serialization of two nodes with memory visibility.

unsigned char cudaGraphEdgeData::from_port

This indicates when the dependency is triggered from the upstream node on the edge. The meaning is specific to the node type. A value of 0 in all cases means full completion of the upstream node, with memory visibility to the downstream node or portion thereof (indicated by to_port). Only kernel nodes define non-zero ports. A kernel node can use the following output port types: cudaGraphKernelNodePortDefault, cudaGraphKernelNodePortProgrammatic, or cudaGraphKernelNodePortLaunchCompletion.

unsigned char cudaGraphEdgeData::reserved

These bytes are unused and must be zeroed. This ensures compatibility if additional fields are added in the future.
unsigned char cudaGraphEdgeData::to_port

This indicates what portion of the downstream node is dependent on the upstream node or portion thereof (indicated by from_port). The meaning is specific to the node type. A value of 0 in all cases means the entirety of the downstream node is dependent on the upstream work. Currently no node types define non-zero ports. Accordingly, this field must be set to zero.

unsigned char cudaGraphEdgeData::type

This should be populated with a value from cudaGraphDependencyType. (It is typed as char due to compiler-specific layout of bitfields.) See cudaGraphDependencyType.

7.29. cudaGraphExecUpdateResultInfo Struct

Result information returned by cudaGraphExecUpdate

cudaGraphNode_t
cudaGraphExecUpdateResultInfo::errorFromNode

The from node of error edge when the topologies do not match. Otherwise NULL.

cudaGraphNode_t
cudaGraphExecUpdateResultInfo::errorNode

The "to node" of the error edge when the topologies do not match. The error node when the error is associated with a specific node. NULL when the error is generic.

enumcudaGraphExecUpdateResult
cudaGraphExecUpdateResultInfo::result

Gives more specific detail when a cuda graph update fails.

7.30. cudaGraphInstantiateParams Struct

Graph instantiation parameters
cudaGraphNode_t
cudaGraphInstantiateParams::errNode_out
The node which caused instantiation to fail, if any

unsigned long long cudaGraphInstantiateParams::flags
Instantiation flags

cudaGraphInstantiateResult
cudaGraphInstantiateParams::result_out
Whether instantiation was successful. If it failed, the reason why

cudaStream_t cudaGraphInstantiateParams::uploadStream
Upload stream

7.31. cudaGraphKernelNodeUpdate Struct

Struct to specify a single node update to pass as part of a larger array to cudaGraphKernelNodeUpdatesApply

enum cudaGraphKernelNodeField
cudaGraphKernelNodeUpdate::field
Which type of update to apply. Determines how updateData is interpreted

uint3 cudaGraphKernelNodeUpdate::gridDim
Grid dimensions

unsigned int cudaGraphKernelNodeUpdate::isEnabled
Node enable/disable data. Nonzero if the node should be enabled, 0 if it should be disabled
cudaGraphNodeParams Struct Reference

Graph node parameters. See `cudaGraphAddNode`.

```cpp
struct cudaMemAllocNodeParamsV2
```

Memory allocation node parameters.
struct cudaConditionalNodeParams
cudaGraphNodeParams::conditional

Conditional node parameters.

struct cudaEventRecordNodeParams
cudaGraphNodeParams::eventRecord

Event record node parameters.

struct cudaEventWaitNodeParams
cudaGraphNodeParams::eventWait

Event wait node parameters.

struct cudaExternalSemaphoreSignalNodeParamsV2
cudaGraphNodeParams::extSemSignal

External semaphore signal node parameters.

struct cudaExternalSemaphoreWaitNodeParamsV2
cudaGraphNodeParams::extSemWait

External semaphore wait node parameters.

struct cudaMemFreeNodeParams
cudaGraphNodeParams::free

Memory free node parameters.

struct cudaChildGraphNodeParams
cudaGraphNodeParams::graph

Child graph node parameters.

struct cudaHostNodeParamsV2
cudaGraphNodeParams::host

Host node parameters.
struct cudaKernelNodeParamsV2
cudaGraphNodeParams::kernel
Kernel node parameters.

struct cudaMemcpyNodeParams
cudaGraphNodeParams::memcpy
Memcpy node parameters.

struct cudaMemcpyNodeParams
cudaGraphNodeParams::memcpy
Memcpy node parameters.

int cudaGraphNodeParams::reserved0
Reserved. Must be zero.

long long cudaGraphNodeParams::reserved1
Padding. Unused bytes must be zero.

long long cudaGraphNodeParams::reserved2
Reserved bytes. Must be zero.

enum cudaGraphNodeType cudaGraphNodeParams::type
Type of the node

7.33. cudaHostNodeParams Struct Reference
CUDA host node parameters

cudaHostFn_t cudaHostNodeParams::fn
The function to call when the node executes
void *cudaHostNodeParams::userData
Argument to pass to the function

7.34. cudaHostNodeParamsV2 Struct Reference
CUDA host node parameters

cudaHostFn_t cudaHostNodeParamsV2::fn
The function to call when the node executes

void *cudaHostNodeParamsV2::userData
Argument to pass to the function

7.35. cudaIpcEventHandle_t Struct Reference
CUDA IPC event handle

7.36. cudaIpcMemHandle_t Struct Reference
CUDA IPC memory handle

7.37. cudaKernelNodeParams Struct Reference
CUDA GPU kernel node parameters

dim3 cudaKernelNodeParams::blockDim
Block dimensions

**cudaKernelNodeParams::extra
 Pointer to kernel arguments in the "extra" format
void *cudaKernelNodeParams::func

Kernel to launch

dim3 cudaKernelNodeParams::gridDim

Grid dimensions

**cudaKernelNodeParams::kernelParams

Array of pointers to individual kernel arguments

unsigned int cudaKernelNodeParams::sharedMemBytes

Dynamic shared-memory size per thread block in bytes

7.38. cudaKernelNodeParamsV2 Struct

Reference

CUDA GPU kernel node parameters

uint3 cudaKernelNodeParamsV2::blockDim

Block dimensions

**cudaKernelNodeParamsV2::extra

Pointer to kernel arguments in the "extra" format

void *cudaKernelNodeParamsV2::func

Kernel to launch

uint3 cudaKernelNodeParamsV2::gridDim

Grid dimensions

**cudaKernelNodeParamsV2::kernelParams

Array of pointers to individual kernel arguments
unsigned int cudaKernelNodeParamsV2::sharedMemBytes
Dynamic shared-memory size per thread block in bytes

7.39.  cudaLaunchAttribute Struct Reference
Launch attribute

cudaLaunchAttributeID cudaLaunchAttribute::id
Attribute to set

cudaLaunchAttribute::val
Value of the attribute

7.40.  cudaLaunchAttributeValue Union Reference
Launch attributes union; used as value field of cudaLaunchAttribute

struct cudaAccessPolicyWindow
cudaLaunchAttributeValue::accessPolicyWindow
Value of launch attribute cudaLaunchAttributeAccessPolicyWindow.

cudaLaunchAttributeValue::@31
cudaLaunchAttributeValue::clusterDim
Value of launch attribute cudaLaunchAttributeClusterDimension that represents the desired cluster dimensions for the kernel. Opaque type with the following fields:

- **x** - The X dimension of the cluster, in blocks. Must be a divisor of the grid X dimension.
- **y** - The Y dimension of the cluster, in blocks. Must be a divisor of the grid Y dimension.
- **z** - The Z dimension of the cluster, in blocks. Must be a divisor of the grid Z dimension.
enum cudaClusterSchedulingPolicy
cudaLaunchAttributeValue::clusterSchedulingPolicyPreference


int cudaLaunchAttributeValue::cooperative

Value of launch attribute cudaLaunchAttributeCooperative. Nonzero indicates a cooperative kernel (see cudaLaunchCooperativeKernel).

cudaLaunchAttributeValue::@34
cudaLaunchAttributeValue::deviceUpdatableKernelNode

Value of launch attribute cudaLaunchAttributeDeviceUpdatableKernelNode with the following fields:

- int deviceUpdatable - Whether or not the resulting kernel node should be device-updatable.
- cudaGraphDeviceNode_t devNode - Returns a handle to pass to the various device-side update functions.

cudaLaunchAttributeValue::@33
cudaLaunchAttributeValue::launchCompletionEvent

Value of launch attribute cudaLaunchAttributeLaunchCompletionEvent with the following fields:

- cudaEvent_t event - Event to fire when the last block launches.
- int flags - Event record flags, see cudaEventRecordWithFlags. Does not accept cudaEventRecordExternal.

cudaLaunchMemSyncDomain

cudaLaunchAttributeValue::memSyncDomain

Value of launch attribute cudaLaunchAttributeMemSyncDomain. See cudaLaunchMemSyncDomain.

struct cudaLaunchMemSyncDomainMap
cudaLaunchAttributeValue::memSyncDomainMap

Value of launch attribute cudaLaunchAttributeMemSyncDomainMap. See cudaLaunchMemSyncDomainMap.
int cudaLaunchAttributeValue::priority

Value of launch attribute cudaLaunchAttributePriority. Execution priority of the kernel.

cudaLaunchAttributeValue::@32

cudaLaunchAttributeValue::programmaticEvent

Value of launch attribute cudaLaunchAttributeProgrammaticEvent with the following fields:

- cudaEvent_t event - Event to fire when all blocks trigger it.
- int flags; - Event record flags, see cudaEventRecordWithFlags. Does not accept cudaEventRecordExternal.
- int triggerAtBlockStart - If this is set to non-0, each block launch will automatically trigger the event.

int cudaLaunchAttributeValue::programmaticStreamSerializationAllowed

Value of launch attribute cudaLaunchAttributeProgrammaticStreamSerialization.

unsigned int cudaLaunchAttributeValue::sharedMemCarveout

Value of launch attribute cudaLaunchAttributePreferredSharedMemoryCarveout.

enum cudaSynchronizationPolicy

cudaLaunchAttributeValue::syncPolicy

Value of launch attribute cudaLaunchAttributeSynchronizationPolicy. cudaSynchronizationPolicy for work queued up in this stream.

7.41. cudaLaunchConfig_t Struct Reference

CUDA extensible launch configuration

cudaLaunchAttribute *cudaLaunchConfig_t::attrs

List of attributes; nullable if cudaLaunchConfig_t::numAttrs == 0
\textbf{dim3 cudaLaunchConfig\_t::blockDim}

Block dimensions

\textbf{size\_t cudaLaunchConfig\_t::dynamicSmemBytes}

Dynamic shared-memory size per thread block in bytes

\textbf{dim3 cudaLaunchConfig\_t::gridDim}

Grid dimensions

\textbf{unsigned int cudaLaunchConfig\_t::numAttrs}

Number of attributes populated in \texttt{cudaLaunchConfig\_t::attrs}

\textbf{cudaStream\_t cudaLaunchConfig\_t::stream}

Stream identifier

\section*{7.42. \texttt{cudaLaunchMemSyncDomainMap} Struct Reference}

Memory Synchronization Domain map

See \texttt{cudaLaunchMemSyncDomain}.

By default, kernels are launched in domain 0. Kernel launched with \texttt{cudaLaunchMemSyncDomainRemote} will have a different domain ID. User may also alter the domain ID with \texttt{cudaLaunchMemSyncDomainMap} for a specific stream / graph node / kernel launch. See \texttt{cudaLaunchAttributeMemSyncDomainMap}.

Domain ID range is available through \texttt{cudaDevAttrMemSyncDomainCount}.

\textbf{unsigned char cudaLaunchMemSyncDomainMap::default\_}

The default domain ID to use for designated kernels

\textbf{unsigned char cudaLaunchMemSyncDomainMap::remote}

The remote domain ID to use for designated kernels
7.43. **cudaLaunchParams Struct Reference**

CUDA launch parameters

**cudaLaunchParams::args**

Arguments

*dim3* *cudaLaunchParams::blockDim*

Block dimensions

*void* *func* *(*cudaLaunchParams::func*)

Device function symbol

*dim3* *cudaLaunchParams::gridDim*

Grid dimensions

*size_t* *cudaLaunchParams::sharedMem*

Shared memory

cudaStream_t *cudaLaunchParams::stream*

Stream identifier

7.44. **cudaMemAccessDesc Struct Reference**

Memory access descriptor

enum cudaMemAccessFlags *cudaMemAccessDesc::flags*

CUmemProt accessibility flags to set on the request

struct cudaMemLocation *cudaMemAccessDesc::location*

Location on which the request is to change it's accessibility
7.45. cudaMemAllocNodeParams Struct Reference

Memory allocation node parameters

size_t cudaMemAllocNodeParams::accessDescCount
in: Number of `accessDescs`'s

cudaMemAccessDesc
*cudaMemAllocNodeParams::accessDescs
in: number of memory access descriptors. Must not exceed the number of GPUs.

size_t cudaMemAllocNodeParams::bytesize
in: size in bytes of the requested allocation

void *cudaMemAllocNodeParams::dptr
out: address of the allocation returned by CUDA

struct cudaMemPoolProps
cudaMemAllocNodeParams::poolProps
in: location where the allocation should reside (specified in location). handleTypes must be cudaMemHandleTypeNone. IPC is not supported. in: array of memory access descriptors. Used to describe peer GPU access

7.46. cudaMemAllocNodeParamsV2 Struct Reference

Memory allocation node parameters

size_t cudaMemAllocNodeParamsV2::accessDescCount
in: Number of `accessDescs`'s
cudaMemAccessDesc
*cudaMemAllocNodeParamsV2::accessDescs
in: number of memory access descriptors. Must not exceed the number of GPUs.

size_t cudaMemAllocNodeParamsV2::bytesize
in: size in bytes of the requested allocation

void *cudaMemAllocNodeParamsV2::dptr
out: address of the allocation returned by CUDA

struct cudaMemPoolProps
cudaMemAllocNodeParamsV2::poolProps
in: location where the allocation should reside (specified in location). handleTypes must be cudaMemHandleTypeNone. IPC is not supported. in: array of memory access descriptors. Used to describe peer GPU access

7.47. cudaMemcpy3DParms Struct Reference
CUDA 3D memory copying parameters

cudaArray_t cudaMemcpy3DParms::dstArray
Destination memory address

struct cudaPos cudaMemcpy3DParms::dstPos
Destination position offset

struct cudaPitchedPtr cudaMemcpy3DParms::dstPtr
Pitched destination memory address

struct cudaExtent cudaMemcpy3DParms::extent
Requested memory copy size
enum cudaMemcpyKind cudaMemcpy3DParms::kind
Type of transfer

cudaArray_t cudaMemcpy3DParms::srcArray
Source memory address

struct cudaMemcpy3DParms::srcPos
Source position offset

struct cudaMemcpy3DParms::srcPtr
Pitched source memory address

7.48. cudaMemcpy3DPeerParms Struct Reference
CUDA 3D cross-device memory copying parameters

cudaArray_t cudaMemcpy3DPeerParms::dstArray
Destination memory address

int cudaMemcpy3DPeerParms::dstDevice
Destination device

struct cudaMemcpy3DPeerParms::dstPos
Destination position offset

struct cudaMemcpy3DPeerParms::dstPtr
Pitched destination memory address

struct cudaMemcpy3DPeerParms::extent
Requested memory copy size
`cudaArray_t cudaMemcpy3DPeerParms::srcArray`
Source memory address

`int cudaMemcpy3DPeerParms::srcDevice`
Source device

`struct cudaPos cudaMemcpy3DPeerParms::srcPos`
Source position offset

`struct cudaPitchedPtr cudaMemcpy3DPeerParms::srcPtr`
Pitched source memory address

### 7.49. cudaMemcpyNodeParams Struct Reference

Memcpy node parameters

`struct cudaMemcpy3DParms cudaMemcpyNodeParams::copyParams`
Parameters for the memory copy

`int cudaMemcpyNodeParams::flags`
Must be zero

`int cudaMemcpyNodeParams::reserved`
Must be zero

### 7.50. cudaMemcpyFreeNodeParams Struct Reference

Memory free node parameters
void *cudaMemFreeNodeParams::dptr

in: the pointer to free

7.51. cudaMemLocation Struct Reference

Specifies a memory location.

To specify a gpu, set type = cudaMemLocationTypeDevice and set id = the gpu's device ordinal. To specify a cpu NUMA node, set type = cudaMemLocationTypeHostNuma and set id = host NUMA node id.

int cudaMemLocation::id

identifier for a given this location's CUmemLocationType.

denum cudaMemLocationType cudaMemLocation::type

Specifies the location type, which modifies the meaning of id.

7.52. cudaMemPoolProps Struct Reference

Specifies the properties of allocations made from the pool.

denum cudaMemAllocationType cudaMemPoolProps::allocType

Allocation type. Currently must be specified as cudaMemAllocationTypePinned

enum cudaMemAllocationHandleType cudaMemPoolProps::handleTypes

Handle types that will be supported by allocations from the pool.

struct cudaMemLocation cudaMemPoolProps::location

Location allocations should reside.
size_t cudaMemPoolProps::maxSize
Maximum pool size. When set to 0, defaults to a system dependent value.

unsigned char cudaMemPoolProps::reserved
reserved for future use, must be 0

unsigned short cudaMemPoolProps::usage
Bitmask indicating intended usage for the pool.

void *cudaMemPoolProps::win32SecurityAttributes
Windows-specific LPSECURITYATTRIBUTES required when cudaMemHandleTypeWin32 is specified. This security attribute defines the scope of which exported allocations may be transferred to other processes. In all other cases, this field is required to be zero.

7.53. cudaMemPoolPtrExportData Struct Reference
Opaque data for exporting a pool allocation

7.54. cudaMemsetParams Struct Reference
CUDA Memset node parameters

void *cudaMemsetParams::dst
Destination device pointer

unsigned int cudaMemsetParams::elementSize
Size of each element in bytes. Must be 1, 2, or 4.

size_t cudaMemsetParams::height
Number of rows
size_t cudaMemsetParams::pitch
Pitch of destination device pointer. Unused if height is 1

unsigned int cudaMemsetParams::value
Value to be set

size_t cudaMemsetParams::width
Width of the row in elements

7.55. cudaMemsetParamsV2 Struct Reference
CUDA Memset node parameters

void *cudaMemsetParamsV2::dst
Destination device pointer

unsigned int cudaMemsetParamsV2::elementSize
Size of each element in bytes. Must be 1, 2, or 4.

size_t cudaMemsetParamsV2::height
Number of rows

size_t cudaMemsetParamsV2::pitch
Pitch of destination device pointer. Unused if height is 1

unsigned int cudaMemsetParamsV2::value
Value to be set

size_t cudaMemsetParamsV2::width
Width of the row in elements
7.56. cudaPitchedPtr Struct Reference

CUDA Pitched memory pointer

See also:

make_cudaPitchedPtr

size_t cudaPitchedPtr::pitch

Pitch of allocated memory in bytes

void *cudaPitchedPtr::ptr

Pointer to allocated memory

size_t cudaPitchedPtr::xsize

Logical width of allocation in elements

size_t cudaPitchedPtr::ysize

Logical height of allocation in elements

7.57. cudaPointerAttributes Struct Reference

CUDA pointer attributes

int cudaPointerAttributes::device

The device against which the memory was allocated or registered. If the memory type is
CUDA Memory Type Device then this identifies the device on which the memory referred physically
resides. If the memory type is CUDA Memory Type Host or CUDA Memory Type Managed then this
identifies the device which was current when the memory was allocated or registered (and if that device
is deinitialized then this allocation will vanish with that device's state).

void *cudaPointerAttributes::devicePointer

The address which may be dereferenced on the current device to access the memory or NULL if no
such address exists.
void *cudaPointerAttributes::hostPointer

The address which may be dereferenced on the host to access the memory or NULL if no such address exists.

Note:
CUDA doesn't check if unregistered memory is allocated so this field may contain invalid pointer if an invalid pointer has been passed to CUDA.

enum cudaMemoryType cudaPointerAttributes::type

The type of memory - cudaMemoryTypeUnregistered, cudaMemoryTypeHost, cudaMemoryTypeDevice or cudaMemoryTypeManaged.

7.58. cudaPos Struct Reference

CUDA 3D position
See also:
make_cudaPos

size_t cudaPos::x
x

size_t cudaPos::y
y

size_t cudaPos::z
z

7.59. cudaResourceDesc Struct Reference

CUDA resource descriptor
cudaArray_t cudaResourceDesc::array
CUDA array

struct cudaChannelFormatDesc cudaResourceDesc::desc
Channel descriptor

void *cudaResourceDesc::devPtr
Device pointer

size_t cudaResourceDesc::height
Height of the array in elements

cudaMipmappedArray_t cudaResourceDesc::mipmap
CUDA mipmapped array

size_t cudaResourceDesc::pitchInBytes
Pitch between two rows in bytes

enum cudaResourceType cudaResourceDesc::resType
Resource type

size_t cudaResourceDesc::sizeInBytes
Size in bytes

size_t cudaResourceDesc::width
Width of the array in elements

7.60. cudaResourceViewDesc Struct Reference
CUDA resource view descriptor
size_t cudaResourceViewDesc::depth
Depth of the resource view

unsigned int cudaResourceViewDesc::firstLayer
First layer index

unsigned int cudaResourceViewDesc::firstMipmapLevel
First defined mipmap level

cudaResourceViewFormat
cudaResourceViewDesc::format
Resource view format

size_t cudaResourceViewDesc::height
Height of the resource view

unsigned int cudaResourceViewDesc::lastLayer
Last layer index

unsigned int cudaResourceViewDesc::lastMipmapLevel
Last defined mipmap level

size_t cudaResourceViewDesc::width
Width of the resource view

7.61. cudaTextureDesc Struct Reference

CUDA texture descriptor

cudaTextureDesc::addressMode
Texture address mode for up to 3 dimensions
float cudaTextureDesc::borderColor
Texture Border Color

int cudaTextureDesc::disableTrilinearOptimization
Disable any trilinear filtering optimizations.

enum cudaTextureFilterMode cudaTextureDesc::filterMode
Texture filter mode

unsigned int cudaTextureDesc::maxAnisotropy
Limit to the anisotropy ratio

float cudaTextureDesc::maxMipmapLevelClamp
Upper end of the mipmap level range to clamp access to

float cudaTextureDesc::minMipmapLevelClamp
Lower end of the mipmap level range to clamp access to

enum cudaTextureFilterMode cudaTextureDesc::mipmapFilterMode
Mipmap filter mode

float cudaTextureDesc::mipmapLevelBias
Offset applied to the supplied mipmap level

int cudaTextureDesc::normalizedCoords
Indicates whether texture reads are normalized or not

enum cudaTextureReadMode cudaTextureDesc::readMode
Texture read mode
**int cudaTextureDesc::seamlessCubemap**
Enable seamless cube map filtering.

**int cudaTextureDesc::sRGB**
Perform sRGB->linear conversion during texture read

### 7.62. CUuuid_st Struct Reference
CUDA UUID types

**char CUuuid_st::bytes**
< CUDA definition of UUID
Chapter 8. Data Fields

Here is a list of all documented struct and union fields with links to the struct/union documentation for each field:

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cudaMemAllocNodeParamsV2
accessDescs  
cudaMemAllocNodeParamsV2  
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- **dstPos**
  - cudaMemcpy3DPeerParms

- **dstPtr**
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- **dynamicSmemBytes**
  - cudaMemcpy3DPeerParms

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  - cudaLaunchConfig_t

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- **elementSize**
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- **errNode_out**
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Global cudaThreadExit

Global cudaThreadGetCacheConfig

Global cudaThreadGetLimit

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Global cudaThreadSetLimit

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Global cudaLaunchCooperativeKernelMultiDevice

This function is deprecated as of CUDA 11.3.

Global cudaSetDoubleForDevice

This function is deprecated as of CUDA 7.5
Global cudaMemcpyFromArrayAsync
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Global cudaMemcpyToHostFromArray
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Global cudaMemcpyToHostToArray
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Global cudaMemcpyToHostToArrayAsync
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Global cudaMemcpyToArrayAsync
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Global cudaMemcpyFromHostToArrayAsync
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Global cudaGLSetGLDevice
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Global cudaGLUnmapBufferObject
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Global cudaGLUnregisterBufferObject
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Global `cudaD3D9ResourceSetMapFlags`
   This function is deprecated as of CUDA 3.0.

Global `cudaD3D9UnmapResources`
   This function is deprecated as of CUDA 3.0.

Global `cudaD3D9UnregisterResource`
   This function is deprecated as of CUDA 3.0.

Global `cudaD3D10GetDirect3DDevice`
   This function is deprecated as of CUDA 5.0.

Global `cudaD3D10MapResources`
   This function is deprecated as of CUDA 3.0.

Global `cudaD3D10RegisterResource`
   This function is deprecated as of CUDA 3.0.

Global `cudaD3D10ResourceGetMappedArray`
   This function is deprecated as of CUDA 3.0.

Global `cudaD3D10ResourceGetMappedPitch`
   This function is deprecated as of CUDA 3.0.

Global `cudaD3D10ResourceGetMappedPointer`
   This function is deprecated as of CUDA 3.0.
Global `cudaD3D10ResourceGetMappedSize`
   This function is deprecated as of CUDA 3.0.

Global `cudaD3D10ResourceGetSurfaceDimensions`
   This function is deprecated as of CUDA 3.0.

Global `cudaD3D10ResourceSetMapFlags`
   This function is deprecated as of CUDA 3.0.

Global `cudaD3D10SetDirect3DDevice`
   This function is deprecated as of CUDA 5.0.

Global `cudaD3D10UnmapResources`
   This function is deprecated as of CUDA 3.0.

Global `cudaD3D10UnregisterResource`
   This function is deprecated as of CUDA 3.0.

Global `cudaD3D11GetDirect3DDevice`
   This function is deprecated as of CUDA 5.0.

Global `cudaD3D11SetDirect3DDevice`
   This function is deprecated as of CUDA 5.0.

Global `cudaErrorProfilerNotInitialized`
   This error return is deprecated as of CUDA 5.0. It is no longer an error to attempt to enable/disable the profiling via `cudaProfilerStart` or `cudaProfilerStop` without initialization.

Global `cudaErrorProfilerAlreadyStarted`
   This error return is deprecated as of CUDA 5.0. It is no longer an error to call `cudaProfilerStart()` when profiling is already enabled.
Global `cudaErrorProfilerAlreadyStopped`  
This error return is deprecated as of CUDA 5.0. It is no longer an error to call `cudaProfilerStop()` when profiling is already disabled.

Global `cudaErrorInvalidHostPointer`  
This error return is deprecated as of CUDA 10.1.

Global `cudaErrorInvalidDevicePointer`  
This error return is deprecated as of CUDA 10.1.

Global `cudaErrorAddressOfConstant`  
This error return is deprecated as of CUDA 3.1. Variables in constant memory may now have their address taken by the runtime via `cudaGetSymbolAddress()`.

Global `cudaErrorTextureFetchFailed`  
This error return is deprecated as of CUDA 3.1. Device emulation mode was removed with the CUDA 3.1 release.

Global `cudaErrorTextureNotBound`  
This error return is deprecated as of CUDA 3.1. Device emulation mode was removed with the CUDA 3.1 release.

Global `cudaErrorSynchronizationError`  
This error return is deprecated as of CUDA 3.1. Device emulation mode was removed with the CUDA 3.1 release.

Global `cudaErrorMixedDeviceExecution`  
This error return is deprecated as of CUDA 3.1. Device emulation mode was removed with the CUDA 3.1 release.

Global `cudaErrorNotYetImplemented`  
This error return is deprecated as of CUDA 4.1.

Global `cudaErrorMemoryValueTooLarge`  
This error return is deprecated as of CUDA 3.1. Device emulation mode was removed with the CUDA 3.1 release.
Global `cudaErrorPriorLaunchFailure`

This error return is deprecated as of CUDA 3.1. Device emulation mode was removed with the CUDA 3.1 release.

Global `cudaSharedMemConfig`

Global `cudaDeviceBlockingSync`

This flag was deprecated as of CUDA 4.0 and replaced with `cudaDeviceScheduleBlockingSync`. 
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