NVIDIA DOCA Rivermax

Programming Guide

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Chapter 1. Introduction

DOCA Rivermax (RMAX) is a DOCA API for NVIDIA Rivermax, an optimized networking SDK for media and data streaming applications. Rivermax leverages NVIDIA® BlueField® DPU hardware streaming acceleration technology which enables direct data transfers to and from the GPU, delivering best-in-class throughput and latency with minimal CPU utilization for streaming workloads.

This document is intended for software developers wishing to accelerate their networking operations.

Chapter 2. Prerequisites

DOCA Rivermax-based applications can run on the target DPU.

It is recommended to have at least 800 huge pages enabled to achieve maximum performance:

```
dpu> echo 1000000000 > /proc/sys/kernel/shmmax
dpu> echo 800 > /proc/sys/vm/nr_hugepages
```

Chapter 3. Architecture

DOCA Rivermax (RMAX) library contains two objects:

- `doca_rmax_flow` – is a flow object that represents an IP/port tuple
- `doca_rmax_in_stream` – represents the input stream and can be thought of as a receive queue which scatters the received data into memory. Each stream can receive one or more flows.

Chapter 4. API

For the library API reference, refer to DOCA Rivermax (RMAX) API documentation in NVIDIA DOCA Libraries API Reference Manual.

Note: The pkg-config (`*.pc` file) for the Rivermax library is named `doca-rmax`.

The following sections provide additional details about the library API.

4.1. Objects

4.1.1. struct doca_rmax_in_stream

Represents Rivermax's input stream. This is a main object in the RX part.

4.1.2. struct doca_rmax_flow

Represents the steering flow for the input stream to filter incoming data flow by match criteria.

4.2. Library Initialization

Users must explicitly call library initialization and deinitialization functions. Global parameters such as internal thread affinity mask must be set before initialization.

4.2.1. doca_rmax_set_cpu_affinity_mask()

Set the CPU affinity mask for the Rivermax (RMAX) internal thread. This must be called before library initialization.

The function `doca_rmax_get_cpu_affinity_mask()` can be used to query the CPU affinity mask for the Rivermax internal thread at any time.

```
doca_error_t doca_rmax_set_cpu_affinity_mask(const struct
 doca_rmax_cpu_affinity_mask * mask);
```

mask [in]
Affinity mask. The CPU is included in the affinity mask if the corresponding bit is set. By default, affinity mask is not set so the internal thread can run on any CPU core.

Returns
`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.2.2. doca_rmax_init()

This function initializes the DOCA Rivermax (RMAX) global resources. This function must be called after `doca_rmax_set_cpu_affinity_mask()` and before any other DOCA RMAX library call.

```
doca_error_t doca_rmax_init(void);
```

Returns
`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.2.3. doca_rmax_release()

This function cleans up the DOCA Rivermax (RMAX) resources. No DOCA Rivermax function may be called after calling this function.

```
doca_error_t doca_rmax_release(void);
```

Returns
`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.3. Checking Device Capability

DOCA Rivermax (RMAX) can query additional device capabilities related to the library.

4.3.1. doca_rmax_get_ptp_clock_supported()

Query PTP clock capability for device.

```
doca_error_t doca_rmax_get_ptp_clock_supported(const struct doca_devinfo * devinfo);
```

devinfo [in]
Device to query

Returns
`doca_error_t` value

- `DOCA_SUCCESS`– PTP clock is supported
- `DOCA_ERROR_NOT_SUPPORTED` – PTP clock is not supported
- Other possible error values are documented in the header file

4.4. Stream Life Cycle

The following sections detail the stages of the stream life cycle from creation to teardown.

4.4.1. Create and Configure Input Stream

4.4.1.1. doca_rmax_in_stream_create()

Create a DOCA Rivermax (RMAX) input stream context. The stream can be downcasted to the DOCA context using the function `doca_rmax_in_stream_as_ctx()`.

```
doca_error_t doca_rmax_in_stream_create(struct doca_rmax_in_stream ** stream);
```

stream [out]
The input stream context created for DOCA Rivermax. Non-NULL upon success, NULL otherwise.

Returns
`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.4.1.2. doca_rmax_in_stream_set_*() and doca_rmax_in_stream_get_*()

Use `doca_rmax_in_stream_set_*()` functions to set the properties of the input stream and the corresponding `doca_rmax_in_stream_get_*()` functions to retrieve the current properties of the input stream.

4.4.1.2.1. Header-data Split Mode

By default, the DOCA Rivermax (RMAX) input stream places the whole packet data into a buffer (`memblk_count = 1`).

To enable header-data split mode when the headers and payload are placed to a different buffers, set the property `memblk_count` (`doca_rmax_in_stream_set_memblks_count`) to 2. In this case you must also set a non-zero value for the `min_size`/`max_size` property of memory descriptor (`doca_rmax_in_stream_memblk_desc_set_min_size`/`doca_rmax_in_stream_memblk_desc_set_max_siz`

4.4.1.2.1.1. doca_rmax_in_stream_set_memblks_count()

Set the number of configured memory blocks.

```
doca_error_t doca_rmax_in_stream_set_memblks_count(struct doca_rmax_in_stream *
 stream, uint32_t value);
```

stream [in]
The input stream to write the property.

value [in]
Property value.

Returns

`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.4.1.2.2. Mandatory Properties

4.4.1.2.2.1. doca_rmax_in_stream_set_elements_count()

Set number of elements in the stream buffer. The actual number of elements in a buffer can be increased by the library, so the actual value can be queried using `doca_rmax_in_stream_get_elements_count()`.

```
doca_error_t doca_rmax_in_stream_set_elements_count(struct doca_rmax_in_stream *
 stream, uint32_t value);
```

stream [in]

The input stream to write the property.

value [in]

Property value.

Returns

`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.4.1.2.2.2. doca_rmax_in_stream_memblk_desc_set_min_size()

Set minimal packet segment size(s). The value is an array of the minimal packet segment sizes received by the input stream.

```
doca_error_t doca_rmax_in_stream_memblk_desc_set_min_size(struct doca_rmax_in_stream
 * stream, uint16_t * value);
```

stream [in]

The input stream to write the property.

value [in]

- When `memblk_count`=1, pointer to a variable that contains the packet size
- When `memblk_count`>1, pointer to an array of packet sizes

Returns

`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.4.1.2.2.3. doca_rmax_in_stream_memblk_desc_set_max_size()

Set maximal packet segment size(s). The value is an array of the maximal packet segment sizes received by the input stream.

```
doca_error_t doca_rmax_in_stream_memblk_desc_set_min_size(struct doca_rmax_in_stream
 * stream, uint16_t * value);
```

stream [in]

The input stream to write the property.

value [in]

- When `memblk_count`=1, pointer to a variable that contains the packet size
- When `memblk_count`>1, pointer to an array of packet sizes

Returns

doca_error_t value. DOCA_SUCCESS if successful, or an error value upon failure. Possible error values are documented in the header file.

4.4.1.2.3. Optional Properties

The following properties have a default value and may be set as long as the input stream is not yet active.

4.4.1.2.3.1. doca_rmax_in_stream_set_type()

Set the input stream type.

```
doca_error_t doca_rmax_in_stream_set_type(struct doca_rmax_in_stream * stream, enum
 doca_rmax_in_stream_type value);
```

stream [in]

The input stream to write the property.

value [in]

Property value.

Returns

doca_error_t value. DOCA_SUCCESS if successful, or an error value upon failure. Possible error values are documented in the header file.

4.4.1.2.3.2. doca_rmax_in_stream_set_scatter_type()

Set the type of packet's data scatter:

- All packet data including network headers
- Only User-Level Protocol data (discard network header up to L4)
- Payload data only (all headers will be discarded)

```
doca_error_t doca_rmax_in_stream_set_scatter_type(struct doca_rmax_in_stream *
 stream, enum doca_rmax_in_stream_scatter_type value);
```

stream [in]

The input stream to write the property.

value [in]

Property value.

Returns

doca_error_t value. DOCA_SUCCESS if successful, or an error value upon failure. Possible error values are documented in the header file.

4.4.1.2.3.3. doca_rmax_in_stream_set_timestamp_format()

Set stream timestamp format.

```
doca_error_t doca_rmax_in_stream_set_scatter_type(struct doca_rmax_in_stream *
 stream, enum doca_rmax_in_stream_scatter_type value);
```

stream [in]

The input stream to write the property.

value [in]

Property value.

Returns

doca_error_t value. DOCA_SUCCESS if successful, or an error value upon failure. Possible error values are documented in the header file.

4.4.1.2.4. Run-time Properties

The following properties have a default value and may be set at any time.

4.4.1.2.4.1. doca_rmax_in_stream_set_min_packets()

Set minimal number of packets that the input stream must return in a read event.

```
doca_error_t doca_rmax_in_stream_set_min_packets(struct doca_rmax_in_stream *
 stream, uint32_t value);
```

stream [in]
The input stream to write the property.

value [in]
Property value.

Returns
`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.4.1.2.4.2. doca_rmax_in_stream_set_max_packets()

Set the maximal number of packets that the input stream must return in read event.

```
doca_error_t doca_rmax_in_stream_set_max_packets(struct doca_rmax_in_stream *
 stream, uint32_t value);
```

stream [in]
The input stream to write the property.

value [in]
Property value.

Returns
`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.4.1.2.4.3. doca_rmax_in_stream_set_timeout_us()

Set receive timeout. The number of µsecs that library would do busy wait (polling) for reception of at least `min_packets` number of packets.

```
doca_error_t doca_rmax_in_stream_set_timeout_us(struct doca_rmax_in_stream * stream,
 int value);
```

stream [in]
The input stream to write the property.

value [in]
Property value.

Returns
`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.4.2. Attach Network Device

Attach a network device to the stream context using the `doca_ctx_dev_add()` function. Only one device per stream is supported.

4.4.3. Query Buffer and Stride Size

Query the memory block size to determine the required size of the memory buffers.

4.4.3.1. doca_rmax_in_stream_get_memblk_size()

Get the size of the memory blocks.

```
doca_error_t doca_rmax_in_stream_get_memblk_size(struct doca_rmax_in_stream *
 stream, size_t * value);
```

stream [in]
The input stream to write the property.

value [out]
Size of the memory block (array of sizes for multiple memblks, the number of memory blocks in stream is more than one).

Returns
`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.4.3.2. doca_rmax_in_stream_get_memblk_stride_size()

Get stride sizes.

```
doca_error_t doca_rmax_in_stream_get_memblk_stride_size(struct doca_rmax_in_stream *
 stream, uint16_t * value);
```

stream [in]
The input stream to write the property.

value [out]
Stride size of the memory block (array of stride sizes for multiple memory blocks)

Returns
`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.4.4. Create and Set Memory Buffer (doca_buf)

Allocate the memory of at least one previously queried size and then configure the input stream to use this buffer.

For header-data split mode, users must use two buffers and the buffers for the header and the payload data must be chained. See `doca_buf_list_chain()` for more information.

4.4.4.1. doca_rmax_in_stream_set_memblk()

Set memory buffer(s) to be used as received data storage.

Note: Must be set before starting the stream context.

```
doca_error_t doca_rmax_in_stream_set_memblk(struct doca_rmax_in_stream * stream,
 struct doca_buf * buf);
```

stream [in]
The input stream to write the property.

buf [in]
Memory buffer (or head of linked list of memory buffers) to store received data. The length of the linked list must be the same as the number of memory blocks configured.

Returns

`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.4.5. Start Stream Context

Cast a stream object to the DOCA context and start the context.

4.4.6. Attach to WorkQ

Use the `doca_ctx_workq_add()` function.

4.4.7. Attach Flows

You can attach one or more flows to a stream after start.

4.4.7.1. doca_rmax_flow_attach()

Attach a flow to a stream.

```
doca_error_t doca_rmax_flow_attach (const struct doca_rmax_flow * flow, const struct
 doca_rmax_in_stream * stream);
```

`flow [in]`

Flow to operate on.

`buf [in]`

The context for attaching a flow.

Returns

`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.4.8. Receive Data

DOCA Rivermax (RMAX) does not accept jobs posted to the WorkQ. Instead, you can retrieve available input packets by polling WorkQ progress. Use `doca_workq_progress_retrieve()` to query available data.

Note: Event-driven mode is not yet supported.

If progress status is `DOCA_SUCCESS`, then event of type `DOCA_RMAX_ACTION_TYPE_RX_DATA` contains a pointer to the `doca_rmax_in_stream_completion` structure in the field of the `result.ptr` event.

4.4.8.1. doca_rmax_in_stream_completion

Completion is returned by the input stream describing the incoming packets.

```
struct doca_rmax_in_stream_completion {
        uint32_t elements_count;
        uint64_t ts_first;
        uint64_t ts_last;
        uint32_t seqn_first;
        uint32_t memblk_ptr_arr_len;
```

```
        void **memblk_ptr_arr;
};
```

elements_count
Number of packets received.

ts_first
Time of arrival of the first packet.

ts_last
Time of arrival of the last packet.

seqn_first
Sequence number of the first packet.

memblk_ptr_arr_len
Number of memory blocks placed in `memblk_ptr_arr`.

memblk_ptr_arr
Array of pointers to the beginning of the memory block as configured by the input stream create step. The offset between packets inside the memory block is a stride size that can be queried using `doca_rmax_in_stream_get_memblk_stride_size`.

If the progress status is `DOCA_ERROR_IO_FAILED`, then the event of type `DOCA_RMAX_ACTION_TYPE_RX_DATA` would contain a pointer to `the doca_rmax_stream_error` structure in the event's `result.ptr` field.

4.4.8.2. doca_rmax_stream_error

Detailed completion error information.

```
struct doca_rmax_stream_error {
        int code;
        const char *message;
};
```

code
Raw Rivermax error code.

message
Human-readable error message.

Progress status `DOCA_ERROR_AGAIN` signifies that no data is available yet. All other codes should be handled as a DOCA error.

4.4.9. Teardown

4.4.9.1. Detach Flows

All flows must be detached from an input stream before stopping it.

4.4.9.1.1. doca_rmax_flow_detach()

Detach a flow from a stream.

```
doca_error_t doca_rmax_flow_detach (const struct doca_rmax_flow * flow, const struct
 doca_rmax_in_stream * stream);
```

flow [in]
Flow to operate on.

buf [in]
The context for detaching a flow.

Returns

`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.4.9.2. Detach from WorkQ

Use the `doca_ctx_workq_rm()` function.

4.4.9.3. Stop Stream Context

Cast the stream object to the DOCA context and stop the context.

4.4.9.4. Detach Network Device

Use the `doca_ctx_dev_rm()` function.

4.4.9.5. Destroy Stream

4.4.9.5.1. doca_rmax_in_stream_destroy()

Destroy a DOCA input stream context. Free all allocated resources associated with a DOCA Rivermax (RMAX) input stream.

```
doca_error_t doca_rmax_in_stream_destroy(struct doca_rmax_in_stream * stream);
```

`stream [in]`

The context to be destroyed.

Returns

`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.5. Flow Functions

4.5.1. Create Flow

4.5.1.1. doca_rmax_flow_create()

Create a steering flow for the input stream to filter the incoming data flow by match criteria.

```
doca_error_t doca_rmax_flow_create(struct doca_rmax_flow ** flow);
```

`flow [out]`

The context to be destroyed.

Returns

`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.5.2. Configure Flow Properties

4.5.2.1. doca_rmax_flow_set_src_ip()

Set the source IP filter for the flow.

```
doca_error_t doca_rmax_flow_set_src_ip(struct doca_rmax_flow * flow, const struct
 in_addr * ip);
```

flow [in]
Flow to operate on.

ip [in]
Source IPv4 address.

Returns
`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.5.2.2. doca_rmax_flow_set_dst_ip()

Set the destination IP filter for the flow.

```
doca_error_t doca_rmax_flow_set_dst_ip(struct doca_rmax_flow * flow, const struct
 in_addr * ip);
```

flow [in]
Flow to operate on.

ip [in]
Destination IPv4 address.

Returns
`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.5.2.3. doca_rmax_flow_set_src_port()

Set the source port filter for the flow.

```
doca_error_t doca_rmax_flow_set_src_port(struct doca_rmax_flow * flow, uint16_t
 port);
```

flow [in]
Flow to operate on.

port [in]
Source port number. If zero, then any source port is accepted.

Returns
`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.5.2.4. doca_rmax_flow_set_dst_port()

Set the destination port filter for the flow.

```
doca_error_t doca_rmax_flow_set_dst_port(struct doca_rmax_flow * flow, uint16_t
 port);
```

flow [in]
Flow to operate on.

port [in]
Destination port number (non-zero)

Returns

`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.5.2.5. doca_rmax_flow_set_tag()

Set the tag for the flow.

```
doca_error_t doca_rmax_flow_set_tag(struct doca_rmax_flow * flow, uint32_t tag);
```

flow [in]

Flow to operate on.

tag [in]

Non-zero tag

Returns

`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

4.5.3. Destroy Flow

4.5.3.1. doca_rmax_flow_destroy()

Set the tag for the flow.

```
doca_error_t doca_rmax_flow_destroy(struct doca_rmax_flow * flow);
```

flow [in]

Flow to destroy.

Returns

`doca_error_t` value. `DOCA_SUCCESS` if successful, or an error value upon failure. Possible error values are documented in the header file.

Chapter 5. Packaging

DOCA Rivermax (RMAX) is distributed separately from other DOCA libraries:

- `doca-rmax-libs` – library binary
- `libdoca-rmax-libs-dev` – header files and samples

DOCA Rivermax binaries depend on:

- `doca-runtime`
- `rivermax`

DOCA Rivermax headers and samples:

- `doca-sdk`
- `rivermax`
- `rivermax-ext`

Chapter 6. Samples

Please refer to the NVIDIA DOCA Rivermax Sample Guide for more information about the API of this DOCA library.

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