NVIDIA DOCA RegEx

Programming Guide

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Chapter 1. Introduction

DOCA RegEx is a library that provides RegEx pattern matching to DOCA applications. It provides access to the regular expression processor (RXP) , a high-performance, hardware-accelerated RegEx engine available on the NVIDIA® BlueField® DPUs, and can utilize software-based engines when required.

Using DOCA RegEx, developers can easily execute complex regular expression operations in an optimized, hardware-accelerated way.

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

Chapter 2. Prerequisites

DOCA RegEx-based applications can run either on the host machine or on the DPU target.

The RegEx engine is enabled by default on the DPU. However, to enable RegEx offloading on the host, run:

```
host> sudo /etc/init.d/openibd stop
host> sudo echo 1024 > /sys/kernel/mm/hugepages/hugepages-2048kB/nr_hugepages
```

Then enable host access to the RegEx engine on the DPU:

```
dpu> echo 1 > /sys/bus/pci/devices/0000\:03\:00.0/regex/pf/regex_en
```

Chapter 3. Architecture

DOCA RegEx provides a flexible API for programming regular expression databases, enqueuing jobs and dequeuing results. The API operates asynchronously allowing many pattern matching operations to be executed in parallel.

3.1. Rule Compilation

Regular expressions can be provided as:

- A "compiled" rule files, where an external compiler can be used to generate a compiled data file; or
- An "uncompiled" where the library will compile the supplied regular expressions when initialized

For hardware acceleration, the external compiler is termed " rxpc" (RXP compiler) and generates RXP object format (ROF) binary files that represent the compiled regular expressions.

When uncompiled rules are provided, the library utilizes a set of default options during compilation. For complete control and optimization, it is recommend you use compile rules with custom compiler options.

3.2. RegEx Implementations

The library itself is designed to support multiple RegEx engine implementations. Currently, only hardware devices are supported. Software devices will be introduced in the future.

3.3. Huge Job Emulation

The library includes a facility to accept job lengths that are greater than the maximum size supported by an engine. The library fragments incoming jobs into smaller fragments and processes them sequentially looking for potential matches. The "huge job emulation" mechanism takes data from the end of the previous fragment and appends it to the start of the next fragment (the "size" of the overlap) to find additional matches. See the `doca_regex_property_huge_job_emulation_overlap_set` API call for more information.

Chapter 4. API

This section details the specific enumerated types, structures, and API operations related to the DOCA RegEx library.

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

4.1. Enumerated Types

4.1.1. doca_regex_job_types

This enumerated type provides the available job types for RegEx operations.

```
enum doca_regex_job_types {
        /** Default RegEx search mode */
        DOCA_REGEX_JOB_SEARCH = DOCA_ACTION_REGEX_FIRST + 1,
};
```

4.1.2. doca_regex_search_job_flags

This enumerated type provides the flags which are applicable to RegEx jobs.

```
enum doca_regex_search_job_flags {
        DOCA_REGEX_SEARCH_JOB_FLAG_HIGHEST_PRIORITY_MATCH = 1 << 1,
        DOCA_REGEX_SEARCH_JOB_FLAG_STOP_ON_ANY_MATCH = 1 << 2,
};
```

DOCA_REGEX_SEARCH_JOB_FLAG_HIGHEST_PRIORITY_MATCH
When a RegEx job is submitted for searching, a number of regular expressions can be tested for in parallel. This flag results in only the match with the lowest rule ID being returned.

DOCA_REGEX_SEARCH_JOB_FLAG_STOP_ON_ANY_MATCH
BlueField-3 only. If this option is set on a RegEx job, the engine stops and returns the first RegEx match detected in the input data.

4.1.3. doca_regex_status_flag

This enumerated type provides flags that indicate the status of a job response.

```
enum doca_regex_status_flag {
 DOCA_REGEX_STATUS_SEARCH_FAILED = 1,
};
```

DOCA_REGEX_STATUS_SEARCH_FAILED
This is a general failure indication for any RegEx job.

4.2. Structures

4.2.1. doca_regex_job_search

This structure contains information required when sending a job to the RegEx engine.

```
struct doca_regex_job_search {
 struct doca_job base;
 uint16_t rule_group_ids[4];
 struct doca_buf const *buffer;
 struct doca_regex_search_result *result;
 uint8_t allow_batching;
};
```

base
Common DOCA job data.

rule_group_ids
An array of IDs which can be used to select which groups of rules are used to process this job. Set each value to a non-zero value to enable group selection, or to 0 to ignore it.

buffer
A `doca_buf` representing the data to be scanned for RegEx matches.

result
Pointer to where the job response is stored. The caller must ensure this pointer is valid when submitting a job and it must remain valid until a response for the job has been retrieved from the engine.

allow_batching
Setting this field to 1 allows the RegEx device to aggregate jobs into batches if this is the optimal method for the supplied data. Batching can improve throughput at the cost of latency. Set this field to 0 to force this job to begin executing immediately. This also forces any previously enqueued jobs that have been batched and not yet dispatched to begin processing.

4.2.2. doca_regex_search_result

This structure contains result information from a previous RegEx search.

```
struct doca_regex_search_result {
 uint64_t status_flags;
 uint32_t detected_matches;
 uint32_t num_matches;
 struct doca_regex_match *matches;
 struct doca_regex_mempool *matches_mempool;
};
```

status_flags
This field indicates any status flags that have been set as a result of the RegEx operation. See doca_regex_status_flag enumerated type for more information.

detected_matches
The total matches that have been detected by the RegEx operation.

num_matches
The actual number of matches returned.

matches
A linked list of doca_regex_match elements. The linked list is num_matches long.
matches_mempool
The memory pool that owns the matches.

4.2.3. doca-regex

This is an opaque structure used to represent a RegEx instance and is used with API calls.

```
struct doca_regex ;
```

4.3. Instance Construction/Destruction

This section details API calls related to the creation and destruction of DOCA RegEx instances.

4.3.1. doca_regex_create

Creates a DOCA RegEx instance.

```
doca_error_t doca_regex_create(struct doca_regex **regex);
```

regex [out]
A pointer to be populated with the address of the newly created RegEx context.
Returns

- doca_error_t return code with DOCA_SUCCESS if successful
- DOCA_ERROR_INVALID_VALUE – indicates an invalid input to the API call
- DOCA_ERROR_NO_MEMORY – indicates a failure to allocate memory for the instance

4.3.2. doca_regex_destroy

Destroys a previously created DOCA RegEx instance.

```
doca_error_t doca_regex_destroy(struct doca_regex *regex);
```

regex [out]
A pointer to be populated with the address of the newly created RegEx context.
Returns

- doca_error_t return code with DOCA_SUCCESS if successful
- DOCA_ERROR_INVALID_VALUE – indicates an invalid input to the API call

4.3.3. doca_regex_destroy

Converts a RegEx instance into a generic doca_ctx. See the NVIDIA DOCA Core Programming Guide for more information on DOCA contexts.

```
struct doca_ctx *doca_regex_as_ctx(struct doca_regex *regex);
```

regex [in]
The RegEx instance to convert.

Note: Must remain valid until after the context is no longer required.

Returns

`doca_ctx` object on success; otherwise `NULL`.

4.4. Device Query API

This section details API calls that can be used to query a DOCA device regarding its RegEx functionality.

4.4.1. doca_regex_is_supported

Validates whether a DOCA device supports RegEx.

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

devinfo [in]

The device to check.

Returns

- `DOCA_SUCCESS` – device can be used with `doca_regex`
- `DOCA_ERROR_INVALID_VALUE` – received invalid input; the `devinfo` is not correct
- `DOCA_ERROR_NOT_SUPPORTED` – device cannot be used with `doca_regex`

4.4.2. doca_regex_get_hardware_supported

Validates whether a DOCA device supports hardware accelerated RegEx operations.

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

devinfo [in]

The device to check.

Returns

- `DOCA_SUCCESS` – hardware accelerated RegEx offloading is supported
- `DOCA_ERROR_INVALID_VALUE` – received invalid input; the `devinfo` is not correct
- `DOCA_ERROR_NOT_SUPPORTED` – device cannot hardware accelerate RegEx

4.4.3. doca_regex_get_maximum_job_size

Returns the maximum accepted job size for the selected device.

```
doca_error_t doca_regex_get_maximum_job_size(struct doca_devinfo const *devinfo,
 uint64_t *max_job_len);
```

devinfo [in]

The device to check.

max_job_len [out]

The maximum job size in bytes.

Returns

- `DOCA_SUCCESS` – `max_job_len` is populated correctly
- `DOCA_ERROR_INVALID_VALUE` – received invalid input; the `devinfo` is not correct
- `DOCA_ERROR_NOT_SUPPORTED` – device does not support RegEx

4.4.4. doca_regex_get_maximum_non_huge_job_size

Determines the maximum job size supported by this device without requiring the huge job emulation feature.

```
doca_error_t doca_regex_get_maximum_non_huge_job_size(struct doca_devinfo const
 *devinfo, uint64_t *max_job_len);
```

devinfo [in]
The device to check.

max_job_len [out]
The maximum job size in bytes.

Returns

- DOCA_SUCCESS – max_job_len is populated correctly
- DOCA_ERROR_INVALID_VALUE – received invalid input; the devinfo is not correct
- DOCA_ERROR_NOT_SUPPORTED – device does not support RegEx

4.4.5. doca_regex_job_get_supported

Determines if a given job type is supported for a given device.

```
doca_error_t doca_regex_job_get_supported(struct doca_devinfo const *devinfo, enum
 doca_regex_job_types job_type);
```

devinfo [in]
The device to check.

job_type [in]
Job type to validate.

Returns

- DOCA_SUCCESS – job type is supported by device
- DOCA_ERROR_INVALID_VALUE – received invalid input; the devinfo is not correct
- DOCA_ERROR_NOT_SUPPORTED – job type is not supported by device

4.4.6. doca_regex_search_job_flag_get_highest_priority_ma

Determines if highest priority match is supported for a given device when submitting doca_regex_job_search jobs.

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

devinfo [in]
The device to check.

Returns

- DOCA_SUCCESS – job type is supported by device
- DOCA_ERROR_INVALID_VALUE – received invalid input; the devinfo is not correct
- DOCA_ERROR_NOT_SUPPORTED – job type is not supported by device

4.4.7. doca_regex_search_job_flag_get_stop_on_any_match

Determines if "stop on any" match is supported for a given device when submitting `doca_regex_job_search` jobs.

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

devinfo [in]
The device to check.

Returns

- `DOCA_SUCCESS` – job type is supported by device
- `DOCA_ERROR_INVALID_VALUE` – received invalid input; the `devinfo` is not correct
- `DOCA_ERROR_NOT_SUPPORTED` – job type is not supported by device

4.5. Programming RegEx

As part of initialization, the RegEx device must be progsrammed with compiled regular expressions. This compilation process takes place offline and generates a compiled file that can be given to a selected device.

4.5.1. doca_regex_set_hardware_compiled_rules

This function specifies the compiled rules data to be used by the RegEx engine.

```
doca_error_t doca_regex_set_hardware_compiled_rules(struct doca_regex
 *regex, void const *rules_data, size_t rules_data_size);
```

regex [in]
The DOCA RegEx instance.

rules_data [in]
A pointer to a buffer of pre-compiled binary rules data.

rules_data_size [in]
The size of the binary rules data in bytes.

Returns

- `DOCA_SUCCESS` – the RegEx instance accepted the supplied rules data
- `DOCA_ERROR_INVALID_VALUE` – one or more input fields are invalid
- `DOCA_ERROR_NO_LOCK` – unable to gain exclusive control of RegEx instance
- `DOCA_ERROR_IN_USE` – RegEx instance is currently started and in-use

- DOCA_ERROR_NO_MEMORY – unable to allocate memory to store a copy of the rules

Note: The caller retains ownership of the data pointed to by rules_data and is responsible for freeing it when they no longer require it. The engine will make a copy of this data for its own purposes.

Note: This API call is mutually exclusive with the uncompiled rules API call (doca_regex_set_hardware_uncompiled_rules).

4.5.2. doca_regex_get_hardware_compiled_rules

This function gets the compiled rules data that is currently in use by the RegEx engine.

```
doca_error_t doca_regex_get_hardware_compiled_rules(struct doca_regex
 *regex, void const *rules_data, size_t rules_data_size);
```

regex [in]
The DOCA RegEx instance.

rules_data [out]
Values to populate with a pointer to an array of bytes containing the compiled rules in used by the RegEx engine.

rules_data_size [out]
The size, in bytes, of the memory pointed to by the rules_data field (assuming data != NULL).

Returns

- DOCA_SUCCESS – the RegEx instance accepted the supplied rules data
- DOCA_ERROR_INVALID_VALUE – one or more input fields are invalid
- DOCA_ERROR_NO_MEMORY – unable to allocate memory to store a copy of the rules

Note: The caller is responsible for the memory pointed to by rules_data field and therefore must free it when they no longer require it.

4.5.3. doca_regex_set_hardware_uncompiled_rules

This function specifies the compiled rules data to be used by the RegEx engine.

```
doca_error_t doca_regex_set_hardware_uncompiled_rules(struct doca_regex
 *regex, void const *rules_data, size_t rules_data_size);
```

regex [in]
The DOCA RegEx instance.

rules_data [out]
Values to populate with a pointer to an array of bytes containing the compiled rules in used by the RegEx engine.

rules_data_size [out]
The size, in bytes, of the memory pointed to by the rules_data field (assuming data != NULL).

Returns

- DOCA_SUCCESS – the RegEx instance accepted the supplied rules data

- DOCA_ERROR_INVALID_VALUE – one or more input fields are invalid
- DOCA_ERROR_NO_MEMORY – unable to allocate memory to store a copy of the rules

Note: The caller is responsible for the memory pointed to by rules_data field and therefore must free it when they no longer require it.

Note: This API call is mutually exclusive with the compiled rules API call (doca_regex_set_hardware_compiled_rules).

Note: The compilation of the RegEx rules takes place during context start.

4.5.4. doca_regex_get_hardware_uncompiled_rules

This function gets the uncompiled rules data that is currently in use by the RegEx engine.

```
doca_error_t doca_regex_get_hardware_uncompiled_rules(struct doca_regex
 *regex, void const *rules_data, size_t rules_data_size);
```

regex [in]
The DOCA RegEx instance.

rules_data [out]
Values to populate with a pointer to an array of bytes containing the compiled rules in used by the RegEx engine.

rules_data_size [out]
The size, in bytes, of the memory pointed to by the rules_data field (assuming data != NULL).

Returns

- DOCA_SUCCESS – the RegEx instance accepted the supplied rules data
- DOCA_ERROR_INVALID_VALUE – one or more input fields are invalid
- DOCA_ERROR_NO_MEMORY – unable to allocate memory to store a copy of the rules

Note: The caller is responsible for the memory pointed to by rules_data field and therefore must free it when they no longer require it.

4.6. DOCA RegEx Setup

This section details the API calls required to setup DOCA RegEx with memory to store received matches, adjust the number of queue pairs, etc.

4.6.1. doca_regex_set_workq_matches_memory_pool_size

Each work queue attached to the RegEx instance gets a pool allocator for matches. Set this value to set the maximum number of matches that can be stored for a given work queue.

```
doca_error_t doca_regex_set_workq_matches_memory_pool_size(struct doca_regex *regex,
 uint32_t pool_size);
```

regex [in]
The DOCA RegEx instance.

pool_size [in]
The number of items to have available to each work queue.

Returns

- DOCA_SUCCESS – the RegEx instance accepted the supplied rules data
- DOCA_ERROR_INVALID_VALUE – one or more input fields are invalid
- DOCA_ERROR_NO_MEMORY – unable to allocate memory to store a copy of the rules
- DOCA_ERROR_IN_USE – RegEx instance is currently started and in-use

Note: The range of valid values for this property depend upon the device in use. This means that acceptance of a value through this API does not ensure the value is acceptable. This is validated as part of starting the context.

4.6.2. doca_regex_get_workq_matches_memory_pool_size

This function gets the uncompiled rules data that is currently in use by the RegEx engine.

```
doca_error_t doca_regex_set_workq_matches_memory_pool_size(struct doca_regex *regex,
 uint32_t pool_size);
```

regex [in]
The DOCA RegEx instance.

pool_size [out]
The number of items to have available in each work queue.

Returns

- DOCA_SUCCESS – the RegEx instance accepted the supplied rules data
- DOCA_ERROR_INVALID_VALUE – one or more input fields are invalid

4.7. Configuration Options

DOCA RegEx has options that alter its mode of operation and control certain features. This section details those API calls and their related impact.

4.7.1. doca_regex_set_huge_job_emulation_overlap_size

This API call enables the Huge Job Emulation functionality of the DOCA RegEx instance, allowing it to find matches in data that exceeds the maximum job length of a particular RegEx device. For example, the BlueField RXP hardware device has a maximum job size of 16KB.

This function is provided with a size parameter that indicates the size of overlap to use in the Huge Job Emulation algorithm. This algorithm breaks up the incoming job data into fragments. Therefore, the overlap size causes data from the previous fragment to be prepended to the start of the next fragment.

As this overlap impacts performance (job data may get searched multiple times) the overlap size should be kept to a minimum value that still guarantees that matches are found.

```
doca_error_t doca_regex_set_huge_job_emulation_overlap_size(struct doca_regex
 *regex, uint16_t nb_overlap_bytes);
```

regex [in]
The DOCA RegEx instance.

nb_overlap_bytes [in]
The number of items to have available to each work queue.

Returns

- DOCA_SUCCESS – the RegEx instance accepted the supplied rules data
- DOCA_ERROR_INVALID_VALUE – one or more input fields were invalid
- DOCA_ERROR_NO_LOCK – unable to gain exclusive control of RegEx instance
- DOCA_ERROR_IN_USE – RegEx instance is currently started and in-use

4.7.2. doca_regex_get_huge_job_emulation_overlap_size

Gets the size of overlap to use when a job exceeds a devices maximum search size.

```
doca_error_t doca_regex_get_huge_job_emulation_overlap_size(struct doca_regex const
 *regex, uint16_t *nb_overlap_bytes);
```

regex [in]
The DOCA RegEx instance.

nb_overlap_bytes [out]
The number of bytes to overlap.

Returns

- DOCA_SUCCESS – the RegEx instance accepted the supplied rules data
- DOCA_ERROR_INVALID_VALUE – one or more input fields were invalid

Chapter 5. Samples

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

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