NVIDIA DOCA Erasure Coding Programming Guide

Programming Guide

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Chapter 1. Introduction

Note: This library is currently supported at alpha version only.

The DOCA Erasure Coding (known also as forward error correction or FEC) library provides an API to encode and decode data using hardware acceleration, supporting both host and NVIDIA® BlueField®-3 (and higher) DPU memory regions.

DOCA Erasure Coding recovers lost data fragments by creating generic redundancy fragment (backup). Each redundancy block that the library creates can help recover any block in the original data should a total loss of fragment occur. This increases data redundancy and reduces data overhead.

The library provides an API for executing erasure coding (EC) operations on DOCA buffers residing in either the DPU or host memory.

This document is intended for software developers wishing to accelerate their application's EC memory operations.

1.1. Glossary

Familiarize yourself with the following terms to better understand the information in this document:

Term	Definition
Data	Original data, original blocks, blocks of original data to be protected/preserved
Coding matrix	Coefficients, the matrix used to generate the redundancy blocks and recovery
Redundancy blocks	Codes; encoded data; the extra blocks that help recover data loss
Encoding	The process of creating the redundancy blocks. Encoded data is referred to as the original blocks or redundancy blocks.
Decoding	The process of recovering the data. Decoded data is referred to as the original blocks alone.

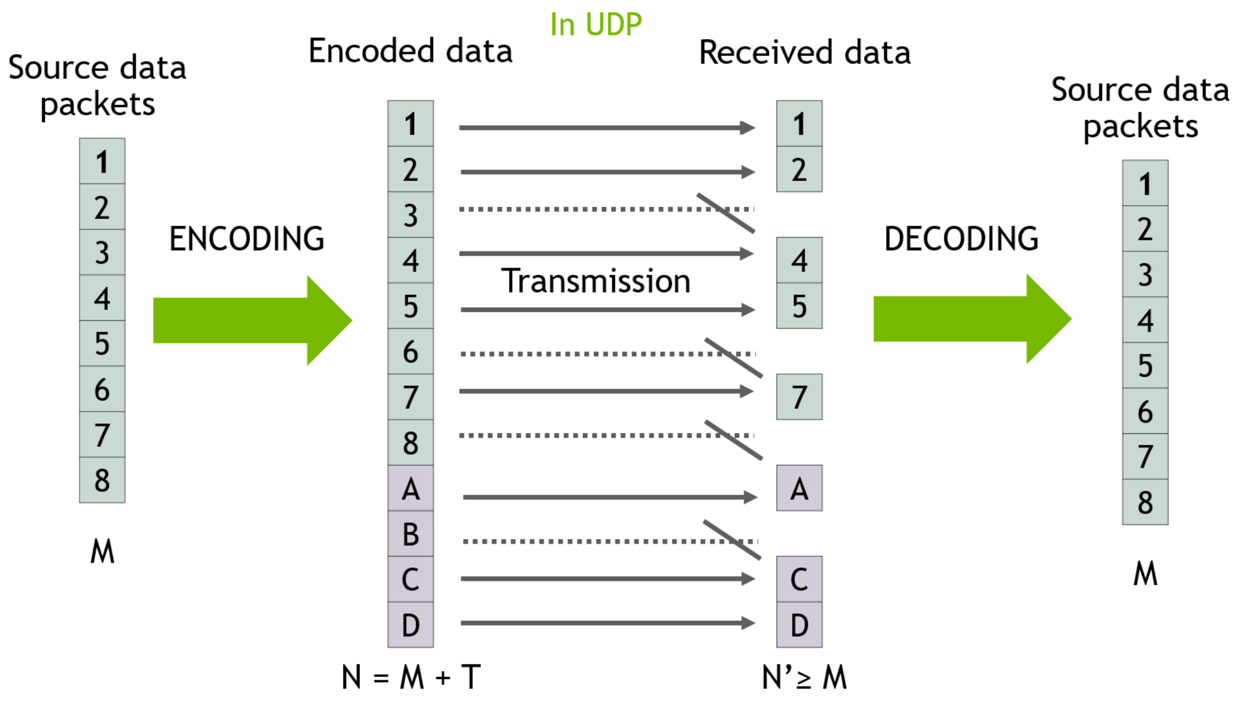
Chapter 2. Prerequisites

DOCA Erasure Coding-based applications can run either on the host machine or on the DPU target (BlueField-3 devices and above).

Chapter 3. Architecture

DOCA Erasure Coding relies on DOCA Core architecture, utilizing the existing memory map and buffer objects. After initialization, an EC operation is requested by submitting an EC job on the relevant work queue (workq). The DOCA Erasure Coding library then executes that operation asynchronously before posting a completion event on the workq.

The following diagram presents a high-level view of the EC transmission flow:

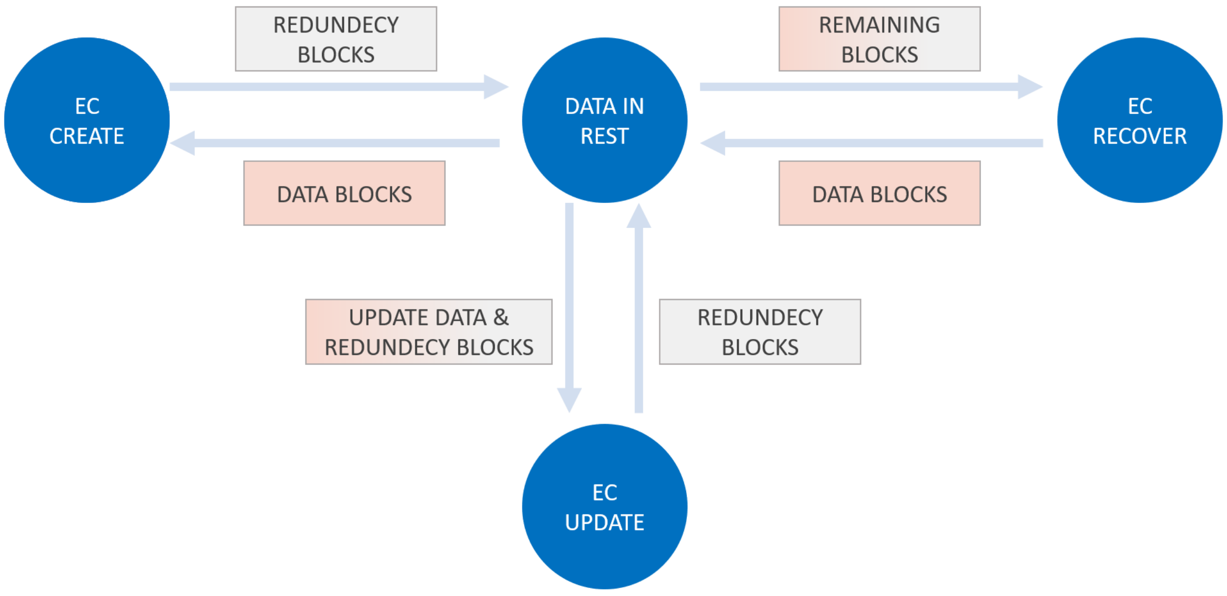


1. M packets are sent from the source (8 in this case).
2. Before the source send them, the source encode the data by adding to it T redundancy packets (4 in this case).
3. The packets are transmitted to the destination in UDP protocol. Some packets are lost and N packets are received (in this case 4 packets are lost and 8 are received).
4. The destination decodes the data using all the packets available (both original data in green and redundancy data in red) and gets back the M original data packets.

Chapter 4. Flows

Regular EC flow consists of the following elements:

1. Creating redundancy blocks from data (EC create).
2. Updating redundancy blocks from updated data (EC update).
3. Recovering data blocks from redundancy blocks (EC recover).



The following sections examine an M:K (where M is the original data and K is redundancy) EC.

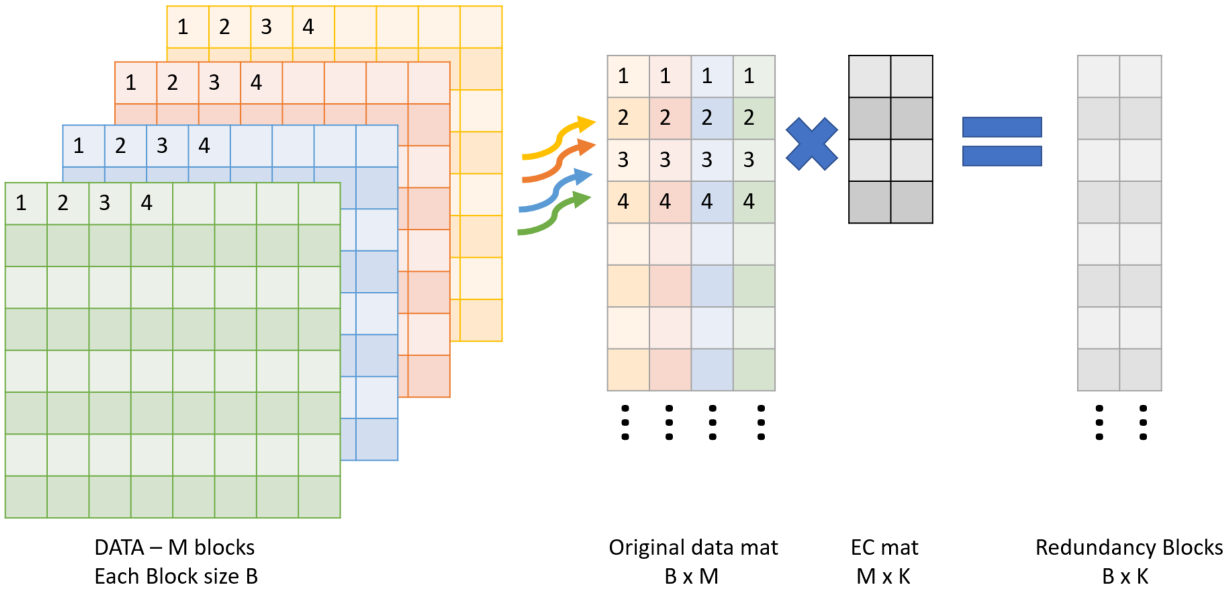
4.1. Create Redundancy Blocks

The user must perform the following:

1. Input M data blocks via `doca_buf` (filled with data, each block size B)
2. Output K empty blocks via `doca_buf` (each block size B)
3. Use DOCA Erasure Coding to "create coding matrix" of M by K via `doca_buf`.

4. Create an EC job and get in return the K output redundancy blocks.

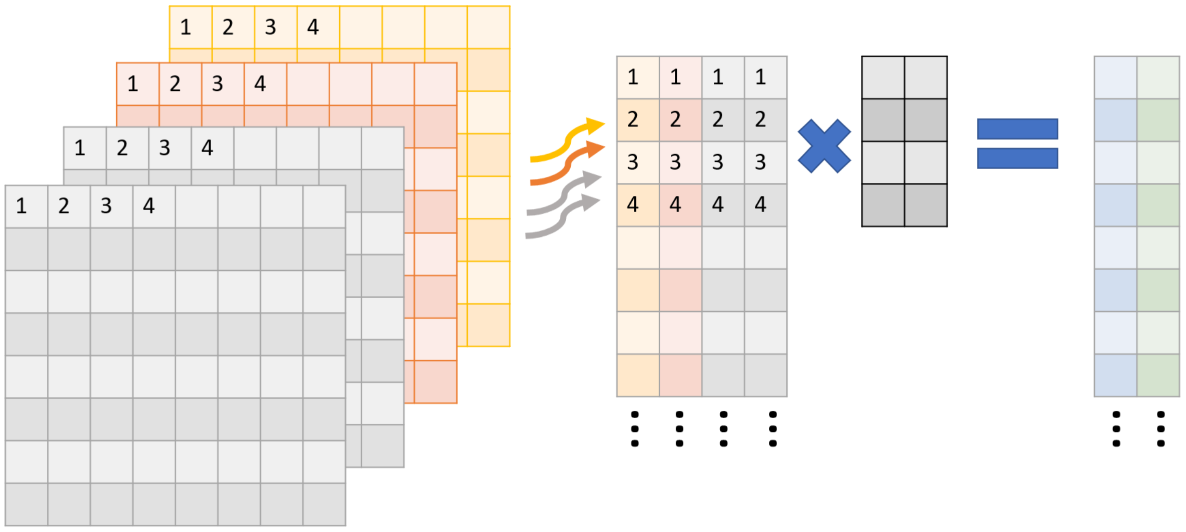
> Note: This step can be repeated in a stream use case, as the DPU would not be the recovery or update point.



4.2. Recover Block

The user must perform the following:

1. Input M-L original blocks via `doca_buf` (not harmed blocks).
2. Input L≤K (any) redundancy blocks via `doca_buf` (from create or last update).
3. Input bitmask or array, indicating which blocks to recover.
4. Output L empty blocks via `doca_buf` (same size of data block).
5. Use DOCA EC to create a "recovery coding matrix" of M by L via `doca_buf` (unique per bitmask).
6. Use EC job and get in return the L output recovered data blocks.



M original blocks & L Redundancy blocks
Each Block size B

Original data & Redundancy mat
B x M

EC mat
M x L

Recovered Blocks
B x L

Chapter 5. API

This chapter details the specific structures and operations related to the DOCA Erasure Coding library for general initialization, setup, and clean-up. See later sections for local and remote DOCA Erasure Coding operations.

5.1. Jobs

The API for DOCA Erasure Coding consists of two job structures:

- `struct doca_ec_job_create` for encoding:

```
struct doca_ec_job_create {
 struct doca_job base;                            /**< Common job data. */
 struct doca_matrix *create_matrix;               /**< create matrix (see below
 doca_ec_matrix_create) */
 struct doca_buf const *src_original_data_buff;   /**< Source original data buffer
 - sequence containing all original blocks - block_1, block_2 ,.... (order does
 matter) */
 struct doca_buf *dst_rdnc_buff;                  /**< Destination redundancy
 data buffer - sequence containing all redundancy blocks - rdnc_block_1,
 rdnc_block_2 ,.... */
};
```

> Note: `src_original_data_buff` and `dst_rdnc_buff` must be in multiplication of the block size. For example, if a create job matrix is 10x4 (i.e., 10 original blocks, 4 redundancy blocks):
>
> - `src_original_data_buff` size is 10x64KB = 640KB
> - `dst_rdnc_buff` size is 4x64KB = 256KB

- `struct doca_ec_job_recover` for decoding:

```
struct doca_ec_job_recover {
 struct doca_job base;                            /**< Common job data. */
 struct doca_matrix *recover_matrix;              /**< recover matrix (see below
 doca_ec_recover_matrix_create) */
 struct doca_buf const *src_remaining_data_buff; /**< Source remaining
 blocks buffer - sequence containing all remaining original blocks and pad
 them with redundancy blocks at size of original data - block_1, block_2,
 block_4 ,.... ,rdnc_block_1, rdnc_block_2 ,.... */
 struct doca_buf *dst_recovered_data_buff;       /**< Destination data buffer -
 sequence containing all missing/recovered blocks - block_3, block_5 ,....  */
};
```

Note: `src_remaining_data_buff` and `dst_recovered_data_buff` must be in multiplication of the block size. For example, if a recover job matrix is 10x4 (i.e., 10 original and redundancy blocks, 4 expected original recovered blocks):

- `src_remaining_data_buff` size is 10x64KB = 640KB
- `dst_recovered_data_buff` size is 4x64KB = 256KB

These structures are passed to the workq to instruct the library on the source, destination, and output.

The source and destination buffers must not overlap with the destination buffer. The `data_len` field of the source `doca_buf` defines the number of bytes to erasure code/decode, and the `data` field of the source `doca_buf` defines the location in the source buffer to erasure code/decode coding from.

Note: Buffer size should be at 64B padded. For example: a 500B buffer should be padded to be 512B. Buffer size minimum is 64B.

As with other libraries, the EC job contains the standard `doca_job` base field which must be set as follows:

- For an encoding job:
  ```
  /* Construct encoding job */
  doca_job.type = DOCA_EC_JOB_CREATE;
  doca_job.flags = DOCA_JOB_FLAGS_NONE;
  doca_job.ctx = doca_ec_as_ctx(doca_ec_inst);
  ```
- For a decoding job:
  ```
  /* Construct decoding job */
  doca_job.type = DOCA_EC_JOB_RECOVER;
  doca_job.flags = DOCA_JOB_FLAGS_NONE;
  doca_job.ctx = doca_ec_as_ctx(doca_ec_inst);
  ```

EC job-specific fields must be set based on the required source and destination buffers:

- For an encoding job:
  ```
  ec_job_create.base = doca_job;
  ec_job_create.create_matrix = create_matrix;
  ec_job_create.src_original_data_buff = src_original_data_buff;
  ec_job_create.dst_rdnc_buff = dst_rdnc_buff;
  ```
- For a decoding job:
  ```
  ec_job_recover.base = doca_job;
  ec_job_recover.recover_matrix = create_matrix;
  ec_job_recover.src_remaining_data_buff = src_remaining_data_buff;
  ec_job_recover.dst_recovered_data_buff = dst_recovered_data_buff;
  ```

To get the job result from the workq, depending on the workq's working mode, the application can either periodically poll the workq or wait for an event on the workq using the `doca_workq_progress_retrieve` API call.

When the call returns `DOCA_SUCCESS` (to indicate the workq event is valid), you may then test that received event for success:

```
event.result.u64 == DOCA_SUCCESS
```

5.2. Matrix Generate

5.2.1. Create

There are two options for creating matrices as detailed in the following subsections.

5.2.1.1. Generic

Generic creation (`doca_ec_matrix_gen`) is used for a simple setup with one of matrix types provided by the library.

```
/**
 * @param [in] ctx - ctx of doca EC
 * @param [in] type - provided in enum doca_ec_matrix_types, the type should be
 consistent in recovery/update process.
 * @param [in] data_block_count - original data block count
 * @param [in] rdnc_block_count - redundancy block count
 * @param [out] matrix - output object
 */
doca_error_t doca_ec_matrix_create(struct doca_ec *ctx, enum doca_ec_matrix_types
 type, size_t data_block_count, size_t rdnc_block_count, struct doca_matrix
 **matrix);
```

5.2.1.2. Custom

Custom creation is used if another type of matrix is needed not provided by the library.

```
/**
* @param [in] ctx - ctx of doca EC
* @param [in] data - coding matrix in size data_block_count * rdnc_block_count
* @param [in] data_block_count - original data block count
* @param [in] rdnc_block_count - redundancy block count
* @param [out] matrix - output object
*/
doca_error_t doca_ec_matrix_from_raw(struct doca_ec *ctx, uint8_t *data, size_t
 data_block_count, size_t rdnc_block_count, struct doca_matrix **matrix);
```

5.2.2. Recover

```
/**
 * @param [in] coding_matrix - matrix generated with gen function (see
 doca_ec_matrix_gen)
 * @param [in] ctx - ctx of doca EC
 * @param [in] missing_indices - array containing which data blocks are missing
 (note that the indexes should match to the create function data block
 * order)
 * @param [in] n_missing - missing_indices count
 * @param [out] matrix - output object
 */
doca_error_t doca_ec_recover_matrix_create(const struct doca_matrix *coding_matrix,
 struct doca_ec *ctx, uint32_t missing_indices[], size_t n_missing, struct
 doca_matrix **matrix);
```

Chapter 6. Local Memory Programming

The following subsections cover the usage of the DOCA Erasure Coding library in real-world situations. Most of this section utilizes code which is available in the DOCA Erasure Coding sample projects located under `/samples/doca_erasure_coding/`.

When memory is local to your DOCA application (i.e., you can directly access the memory space of both source and destination buffers) this is referred to as a local erasure coding/decoding operation.

The following step-by-step guide goes through the various stages necessary to initialize, execute, and clean-up a local memory erasure coding/decoding operation.

6.1. Initializing Operation

The DOCA Erasure Coding API uses the DOCA Core library to create the required objects (e.g., memory map, inventory, buffers, etc.) for its operations.

This section runs through this process in a logical order. If you already have some of these operations in your DOCA application, you may skip or modify them as needed.

6.1.1. Opening DOCA Device

The first requirement is to open a DOCA device, normally your BlueField device. You should iterate on all DOCA devices (via `doca_devinfo_list_create`) and select one using some criteria (e.g., PCIe address, etc). You may also use the function `doca_ec_job_get_supported` to check if the device is suitable for the EC job type you want to perform. After this, the device must be opened using `doca_dev_open`.

6.1.2. Creating DOCA Core Objects

DOCA Erasure Coding requires several DOCA objects to be created. This includes the memory map (`doca_mmap_create`), buffer inventory (`doca_buf_inventory_create`), and workq (`doca_workq_create`). DOCA Erasure Coding also requires the actual DOCA Erasure Coding context to be created (`doca_ec_create`).

Once a DOCA Erasure Coding instance has been created, it can be used as a context using the `doca_ctx` APIs. This can be achieved by getting a context representation using `doca_ec_as_ctx()`.

6.1.3. Initializing DOCA Core Objects

In this phase of initialization, the core objects are ready to be set up and started.

6.1.3.1. Memory Map Initialization

Prior to starting the mmap (`doca_mmap_start`), make sure that you set the memory range correctly (via `doca_mmap_set_memrange`). After starting mmap, add the DOCA device to the mmap (`doca_mmap_dev_add`).

6.1.3.2. Buffer Inventory Initialization

This can be started using the `doca_buf_inventory_start` call.

6.1.3.3. WorkQ Initialization

The workq can be set to one of two modes: Polling mode (default) or event-driven mode.

To set the workq to event-driven mode, use `doca_workq_set_event_driven_enable` and then `doca_workq_get_event_handle` to get the event handle of the workq so you can wait on events using epoll or other Linux wait for event interfaces.

6.1.3.4. DOCA Erasure Coding Context Initialization

The context created previously via `doca_ec_create()` and acquired using `doca_ec_as_ctx()` can have the device added (`doca_ctx_dev_add`), started (`doca_ctx_start`), and workq added (`doca_ctx_workq_add`). It is also possible to add multiple workqs to the same context.

6.1.4. Populating Memory Map

Provide the memory regions to use for EC operations to the memory map using the `doca_mmap_set_memrange` call. These regions may be one large region or many smaller regions.

6.1.5. Constructing DOCA Buffers

Prior to building and submitting an EC operation, construct two source DOCA buffers for the source and destination addresses (the addresses used must exist within the memory region registered with the memory map). The `doca_buf_inventory_buf_by_addr` returns a `doca_buffer` when provided with a memory address.

Finally, set the data address and length of the DOCA buffers using the function `doca_buf_set_data`. This field determines the data address and the data length to perform the erasure code/decode operation on.

To know the maximum `data_len` of a `doca_buffer` that can be used to perform an EC operation on, call the function `doca_ec_get_max_buffer_size`.

6.2. Executing Erasure Coding

The DOCA Erasure Coding operation is asynchronous. Therefore, you must enqueue the operation and poll for completion later.

To begin the EC operation, enqueue an EC job on the previously created work queue object. This involves creating the DOCA Erasure Coding job (`struct doca_ec_job`) which is a composite of specific EC fields.

Within the EC job structure, the context field must point to the DOCA Erasure Coding context and the `type` field must be set to:

- `DOCA_EC_JOB_CREATE` for an encoding EC operation
- `DOCA_EC_JOB_RECOVER` for a decoding EC operation

The DOCA Erasure Coding specific elements of the job point to your DOCA buffers for the source and destination.

Finally, the `doca_workq_submit` API call is used to submit the EC operation to the hardware.

6.3. Waiting for Completion

It is possible to detect when the Erasure Coding operation has completed (via `doca_workq_progress_retrieve`) depending on the workq mode:

- Polling mode – periodically poll the work queue until the API call indicates that a valid event has been received
- Event mode – while `doca_workq_progress_retrieve` does not return a success result, perform the following loop:
  1. Arm the workq using `doca_workq_event_handle_arm`.
  2. Wait for an event using the event handle (e.g., `epoll_wait()`).
  3. Once the thread wakes up, call `doca_workq_event_handle_clear`.

Regardless of the operating mode, you are able to detect the success of the EC operation if the `event.result.u64` field is equal to `DOCA_SUCCESS`.

Note: Other workq operations (i.e., non-EC operations) present their events differently. Refer to their respective guides for more information.

If there is data inside the destination buffer already, the DOCA Erasure Coding library appends the EC operation result after the existing data. If not, it stores the new data in the data address of the destination buffer. Either way, the library keeps the data address unchanged and increases the `data_len` field of the destination buffer by the number of bytes produced by the erasure codes/decodes operation.

6.4. Clean-up

To clean up the `doca_buffers`, deference them using the `doca_buf_refcount_rm` call. This call must be made on all buffers after finishing with them (regardless of whether the operation is successful or not).

The main cleanup process is to remove the workq from the context (`doca_ctx_workq_rm`), stop the context itself (`doca_ctx_stop`), remove the device from the context (`doca_ctx_dev_rm`), and remove the device from the memory map (`doca_mmap_dev_rm`).

The final destruction of the objects can now occur. This can happen in any order, but destruction must occur on the workq (`doca_workq_destroy`), EC context (`doca_ec_destroy`), buf inventory (`doca_buf_inventory_destroy`), mmap (`doca_mmap_destroy`), and device closure (`doca_dev_close`).

Chapter 7. Remote Memory Programming

This section covers the creation of a remote memory DOCA Erasure Coding operation. This operation allows memory from the host, accessible by DOCA Erasure Coding on the DPU, to be used as a source or destination.

7.1. Sender

The sender holds the source memory to perform the EC operation on and sends it to the DPU. The developer decides the method of how the source memory address is transmitted to the DPU (e.g., it can be a socket that is connected from a "local" host sender to a "remote" BlueField DPU receiver). The address is passed using this method.

The sender application should open the device, as per a normal local memory operation, but initialize only a memory map (`doca_mmap_create`, `doca_mmap_start`, `doca_mmap_dev_add`). It should then populate the mmap with exactly one memory regions (`doca_mmap_set_memrange`) and call a special mmap function (`doca_mmap_export`).

This function generates a descriptor object that can be transmitted to the DPU. The information in the descriptor object refers to the exported "remote" host memory (from the perspective of the receiver).

7.2. Receiver

For reception, the initiation process described for local memory must be followed.

Prior to constructing the DOCA buffer (via `doca_buf_inventory_buf_by_addr`) to represent the host memory, call the special mmap function that retrieves the remote mmap from the host (`doca_mmap_create_from_export`). The DOCA buffer can then be created using this remote mmap and used as source/destination buffer in the DOCA Erasure Coding job structures.

All other aspects of the application (i.e., executing, waiting on results, and clean-up) must follow the same process described for local memory.

Chapter 8. DOCA Erasure Coding SG Support

The DOCA Erasure Coding library supports scatter-gather (SG) DOCA buffers. A `doca_buf` may be used with a linked list extension as the source buffer in the `doca_ec` job. The library then codes and decodes all the content of the DOCA buffers to a single destination buffer.

Note: The length of the linked list for the source buffer must not exceed the returned value from the function `doca_ec_get_max_list_buf_num_elem`.

Chapter 9. DOCA Erasure Coding Pseudo Code Examples

9.1. Erasure Coding Job: Polling WorkQ Mode

```
/* Create doca_ec object */
struct doca_ec *ec_ctx;
struct doca_ctx *ctx;

doca_ec_create(&ec_ctx);
ctx = doca_ec_as_ctx(ec_ctx);

/* Open a suitable device */
struct doca_devinfo **dev_list;
struct doca_dev *dev;
uint32_t nb_devs;

doca_devinfo_list_create(&dev_list, &nb_devs);
for (i = 0; i < nb_devs; i++) {
    if (doca_ec_job_get_supported(dev_list[i], DOCA_EC_JOB_CREATE) == DOCA_SUCCESS)
 {
        doca_dev_open(dev_list[i], &dev);
        break;
    }
}
doca_devinfo_list_destroy(dev_list);

/* Add device and WorkQ to ctx */
uint32_t workq_depth = 32;
struct doca_workq *workq;

doca_ctx_dev_add(ctx, dev);
doca_ctx_start(ctx);
doca_workq_create(workq_depth, &workq);
doca_ctx_workq_add(ctx, workq);

/* Alloc DOCA buffers */
struct doca_mmap *mmap;
struct doca_buf_inventory *buf_inv;
size_t file_size;
char *file_to_ec = read_file(&file_size);
void *dst_buf_memory_range = malloc(REQUIRED_SIZE);

doca_mmap_create(NULL, &mmap);
doca_buf_inventory_create(NULL, 2, DOCA_BUF_EXTENSION_NONE, &buf_inv);
```

```
doca_mmap_set_memrange(mmap, memory_range, REQUIRED_SIZE));
doca_mmap_start(mmap);
doca_mmap_dev_add(mmap, dev);
doca_buf_inventory_start(buf_inv);
doca_buf_inventory_buf_by_data(buf_inv, mmap, file_to_ec, file_size, &src_doca_buf);
doca_buf_inventory_buf_by_addr(buf_inv, mmap, dst_buf_memory_range, dst_buf_len,
 &dst_doca_buf);

/* prepare matrix */
struct doca_matrix *create_matrix;
uint32_t data_block_count = 10;
uint32_t rdnc_block_count = 2;
doca_ec_matrix_create(ec_ctx, DOCA_CODING_MATRIX_CAUCHY, data_block_count,
 rdnc_block_count, &create_matrix)

/* Construct coding job */
const struct doca_ec_create_job ec_job = {
    .base = (struct doca_job) {
        .type = DOCA_EC_JOB_CREATE,
        .flags = DOCA_JOB_FLAGS_NONE,
        .ctx = state.ctx,
        },
    .create_matrix = create_matrix,
    .src_original_data_buff = src_doca_buf,
    .dst_rdnc_buff = dst_doca_buf,
};

/* Submit & Retrieve ec job */
struct doca_event event = {0};

doca_workq_submit(workq, &ec_create_job.base);
while ((doca_workq_progress_retrieve(state.workq, event,
 DOCA_WORKQ_RETRIEVE_FLAGS_NONE)) ==
    DOCA_ERROR_AGAIN) {
    usleep(10);
}

/* Clean and destroy */
doca_buf_refcount_rm(src_doca_buf, NULL));
doca_buf_refcount_rm(dst_doca_buf, NULL));
free(file_to_ec);
free(dst_buf_memory_range);
doca_ctx_workq_rm(ctx, workq);
doca_workq_destroy(workq);
doca_buf_inventory_destroy(buf_inv);
doca_mmap_destroy(mmap);
doca_dev_close(dev);
doca_ec_destroy(ec_ctx);
```

Chapter 10. DOCA Erasure Coding Samples

This section provides DOCA Erasure Coding sample implementation on top of the BlueField-3 DPU (and higher).

10.1. Sample Prerequisites

N/A

10.2. Running the Sample

1. Refer to the following documents:
    - NVIDIA DOCA Installation Guide for Linux for details on how to install BlueField-related software.
    - NVIDIA DOCA Troubleshooting Guide for any issue you may encounter with the installation, compilation, or execution of DOCA samples.
2. To build a given sample:

```
cd /opt/mellanox/doca/samples/doca_dma/<sample_name>
meson build
ninja -C build
```

Note: The binary `doca_<sample_name>` is created under `./build/`.

3. Sample (e.g., `doca_erasure_coding_recover`) usage:

```
Usage: doca_erasure_coding_recover [DOCA Flags] [Program Flags]

DOCA Flags:
  -h, --help                        Print a help synopsis
  -v, --version                     Print program version information
  -l, --log-level                   Set the log level for the program
 <CRITICAL=20, ERROR=30, WARNING=40, INFO=50, DEBUG=60>

Program Flags:
  -p, --pci-addr                    DOCA device PCI device address - default:
 03:00.0
  -i, --input                       Input file/folder to ec - default: self
  -o, --output                      Output file/folder to ec - default: /tmp
  -b, --both                        Do both (encode & decode) - default: false
  -x, --matrix                      Matrix - {cauchy, vandermonde} - default:
 cauchy
  -t, --data                        Data block count - default: 2
  -r, --rdnc                        Redundancy block count - default: 2
  -d, --delete_index                Indices of data blocks to delete comma
 seperated i.e. 0,3,4 - default: 0
```

Note: Current BlueField-3 limitations:

- Data block count range: 1-128
- Redundancy block count: 1-32
- Block size: 64B-128MB

4. For additional information per sample, use the `-h` option:

```
./build/doca_<sample_name> -h
```

10.3. Samples

10.3.1. Erasure Coding Recover

This sample illustrates how to use DOCA Erasure Coding library to encode and decode a file block (and entire file).

The sample logic includes 3 steps:

1. Encode – create redundancy.
2. Delete – simulate disaster.
3. Decode – recover data.

The encode logic includes:

1. Locating a DOCA device.
2. Initializing the required DOCA Core structures.
3. Reading source original data file and splitting it to a specified number of blocks, `<data block count>`, specified for the sample to the output directory.
4. Populating DOCA memory map with two relevant buffers: one for the source data and one for the result.
5. Allocating elements in DOCA buffer inventory for each buffer.
6. Initializing EC job object.
7. Create EC encoding matrix by the matrix type specified to the sample.
8. Submitting an EC create job into the workq.
9. Retrieving the job from the workq once it is done.
10. Writing the resulting redundancy blocks to the output directory (count is specified by `<redundancy block count>`).
11. Destroying all DOCA Erasure Coding and DOCA Core structures.

The delete logic includes:

1. Deleting the block files specified with `<indices of data blocks to delete>`.

The decode logic includes:

1. Locating a DOCA device.
2. Initializing the required DOCA Core structures.
3. Reading the output directory (source remaining data) and determining the block size and which blocks are missing (needing recovery).
4. Populating DOCA memory map with two relevant buffers: one for the source data and one for the result.
5. Allocating elements in DOCA buffer inventory for each buffer.
6. Initializing EC job object.
7. Creating EC encoding matrix by the matrix type specified to the sample.
8. Creating EC decoding matrix using the encoding matrix.
9. Submitting an EC recover job into the workq.
10. Retrieving the job from the workq once it is done.
11. Writing the resulting recovered blocks to the output directory.
12. Writing the recovered file to the output path.
13. Destroying all DOCA Erasure Coding and DOCA Core structures.

References:

- `/opt/mellanox/doca/samples/doca_erasure_coding/doca_erasure_coding_recover/erasure_coding_recover_sample.c`
- `/opt/mellanox/doca/samples/doca_erasure_coding/doca_erasure_coding_recover/erasure_coding_recover_main.c`
- `/opt/mellanox/doca/samples/doca_erasure_coding/doca_erasure_coding_recover/meson.build`