Data Management System for SPD Online Filter

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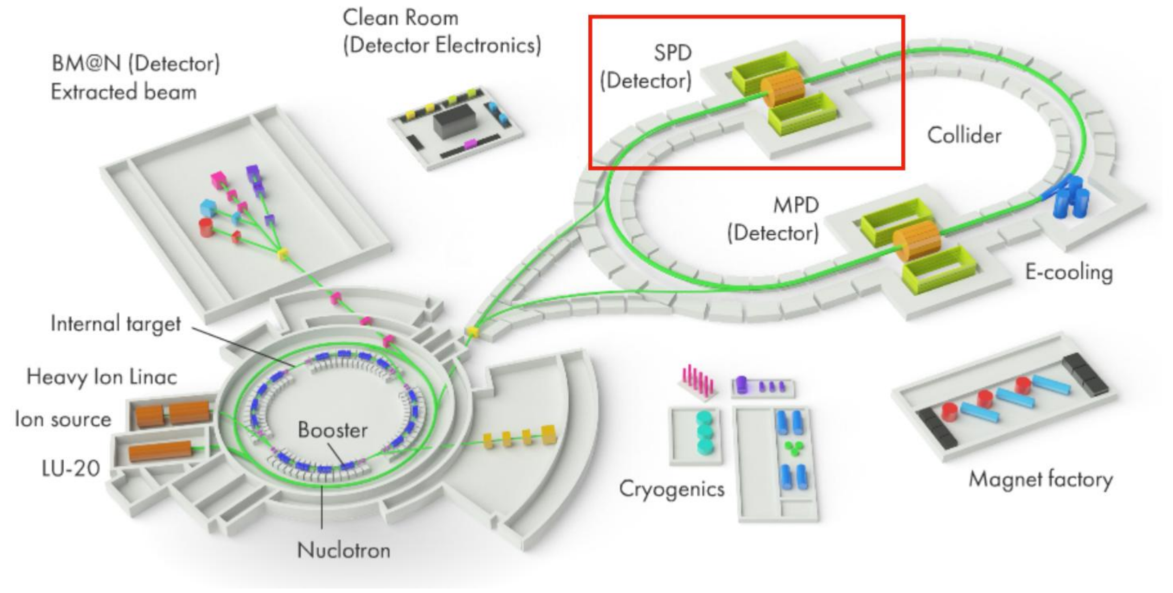
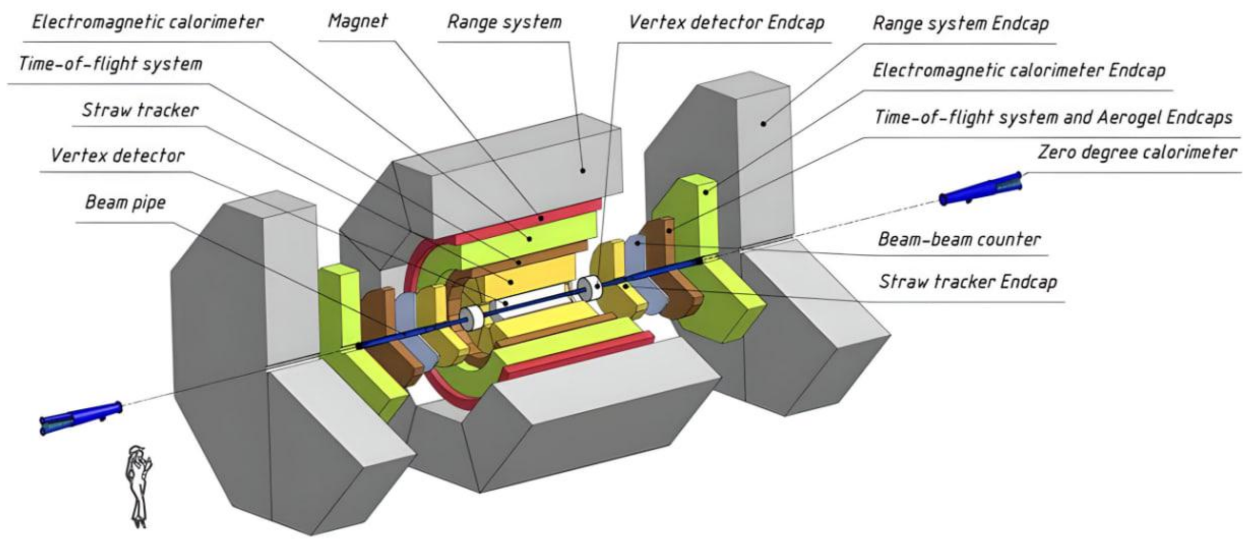
2025 GRID

Spin Physics Detector

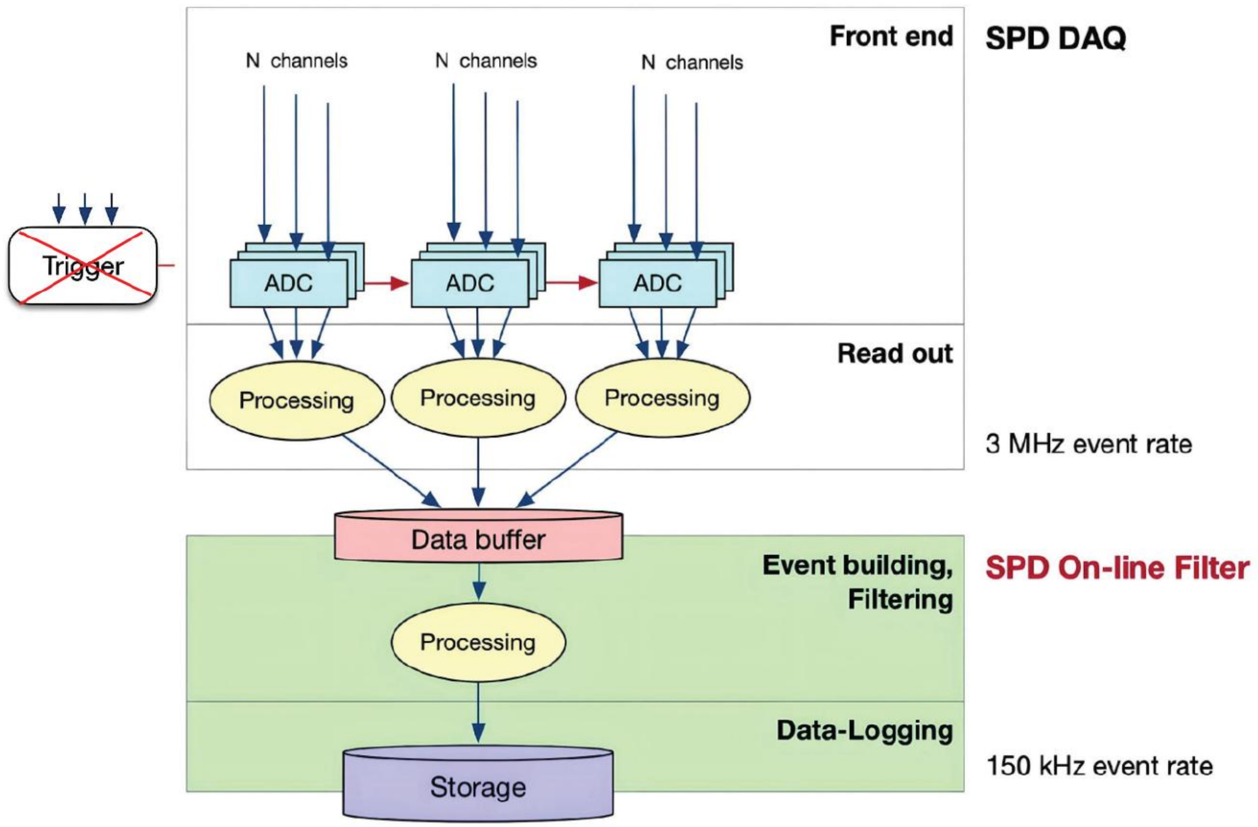


The SPD detector will be used to study the spin structure of the proton and deuteron and other spin-related phenomena

The main purpose of the SPD experiment is a comprehensive study of the unpolarized and polarized gluon component of the nucleon



Data collection from the detector

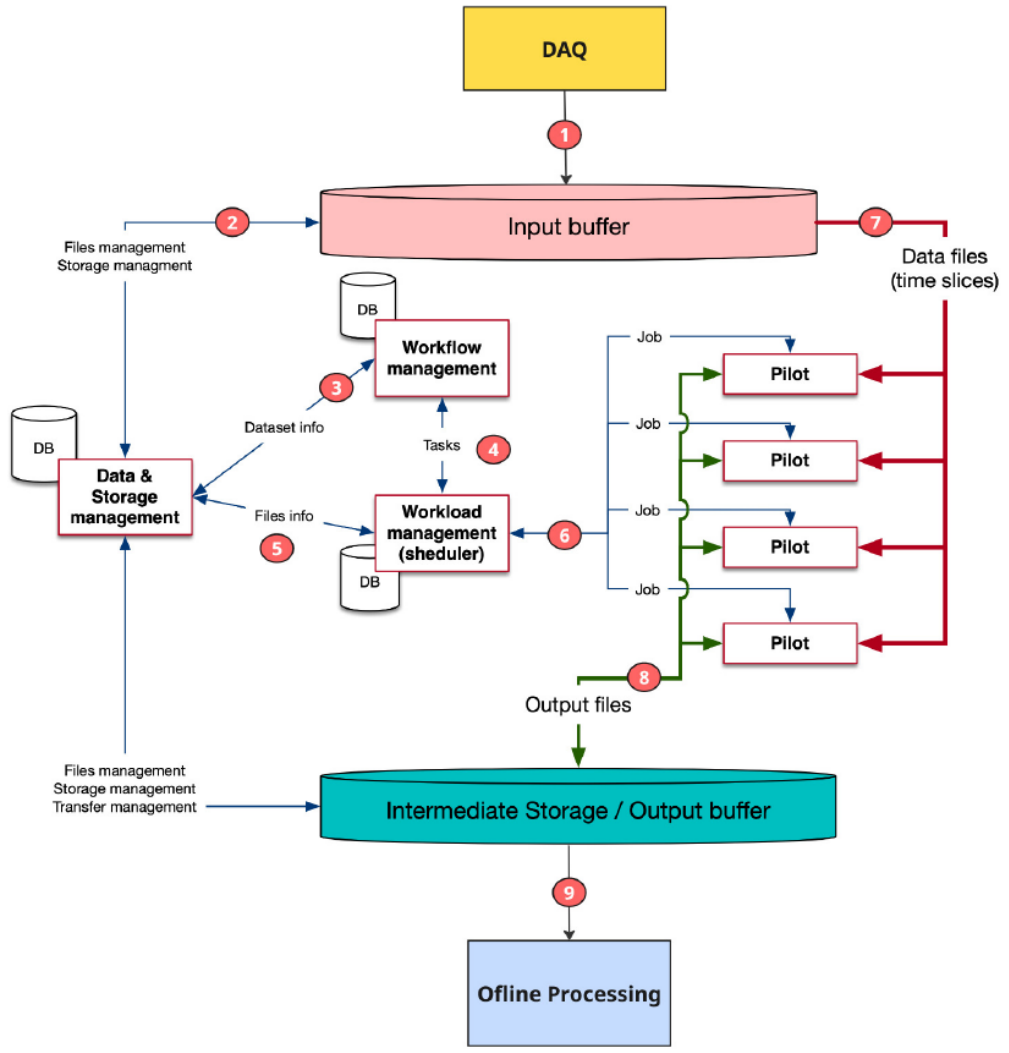


- A simple selection of physical events at the hardware level is not possible
- The need to collect the entire set of generated signals from subsystems combined in time blocks
- Large data flow up to 20 GB/s (~200 PB/year)
- The need to reduce the amount of data for subsequent analysis
- Software Trigger Development – SPD Online filter

Online Filter

SPD Online Filter is a high-performance computing system for high-throughput data processing

A special feature of **high-throughput data processing** is the large amount of data, both primary that needs to be processed and intermediate that occurs during processing



Middleware software

Data management system

- data lifecycle support (data catalog, consistency check, cleanup, storage)

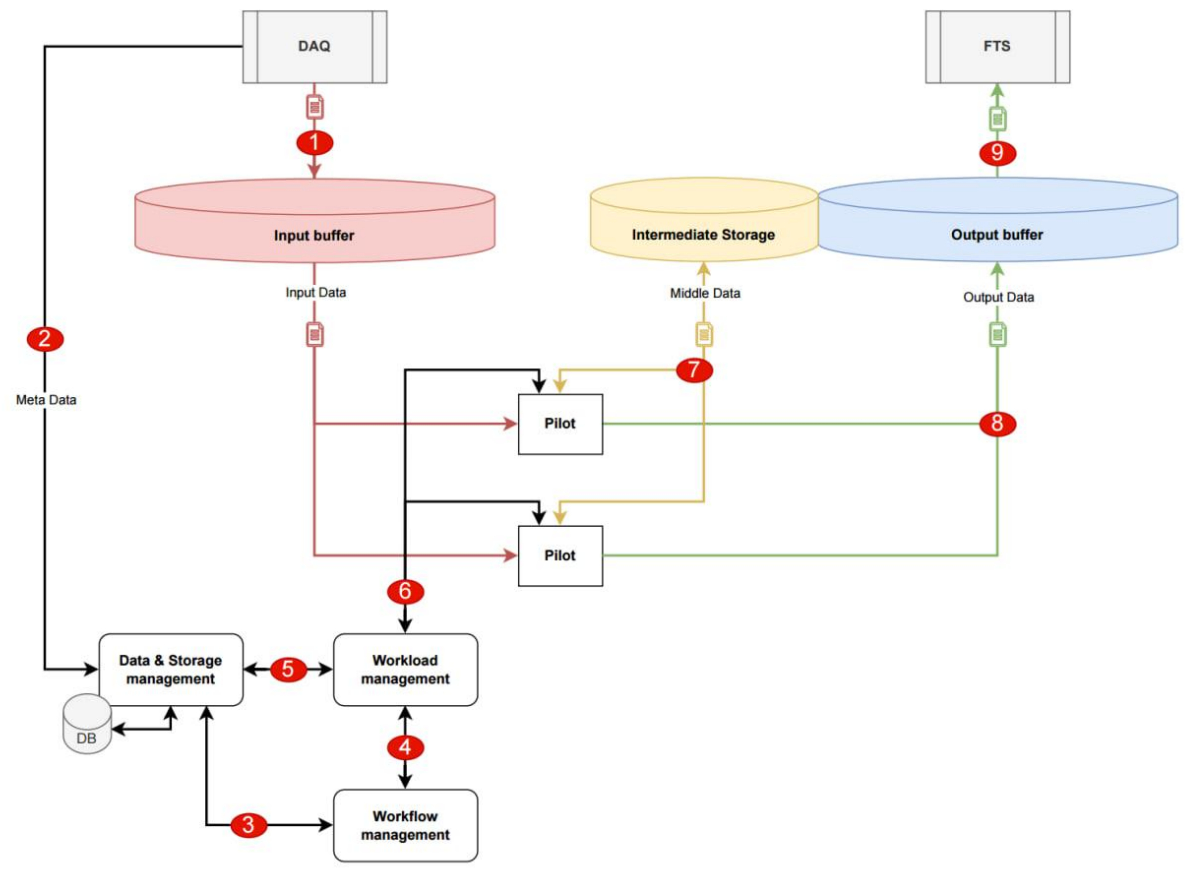
Workflow Management System

- define and execute processing chains by generating the required number of computational tasks

Workload management system

- implementation of processing stages (task generation, sending tasks to pilots)

Pilot – an application running on a computing node and performing tasks

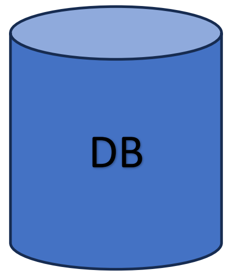


Data management system: tasks

- ✓ Registration of new data
- ✓ Cataloging
- ✓ File integrity and upload control, file deletion on storages, storage monitoring

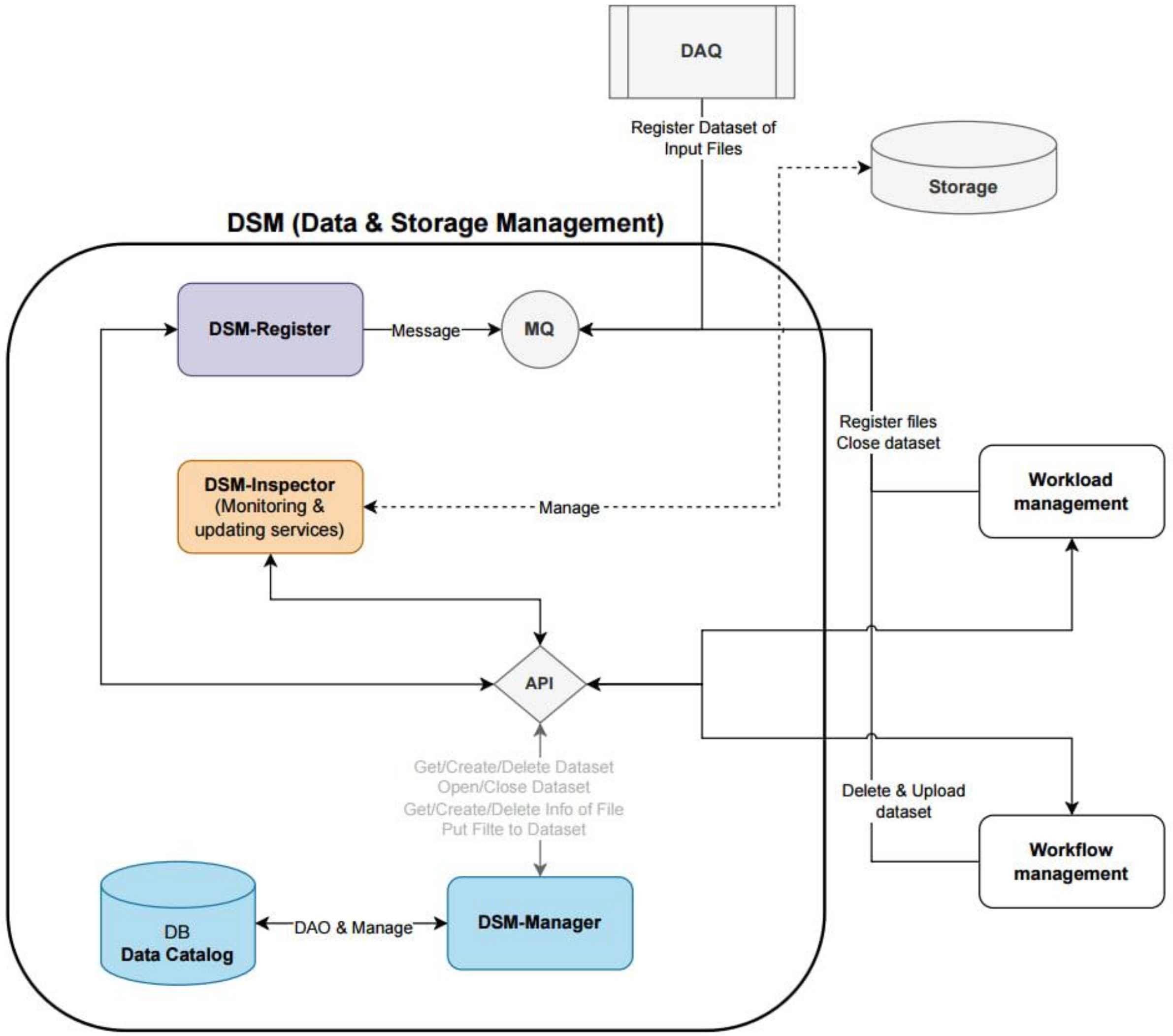
Interface for accepting requests for adding/deleting data in the system

Interface to the data catalog



A set of background tasks to ensure consistency between storage and database

Data management system



dsm-register (data registration)

- a service that receive requests for adding/deleting data in the system asynchronously (via MQ)

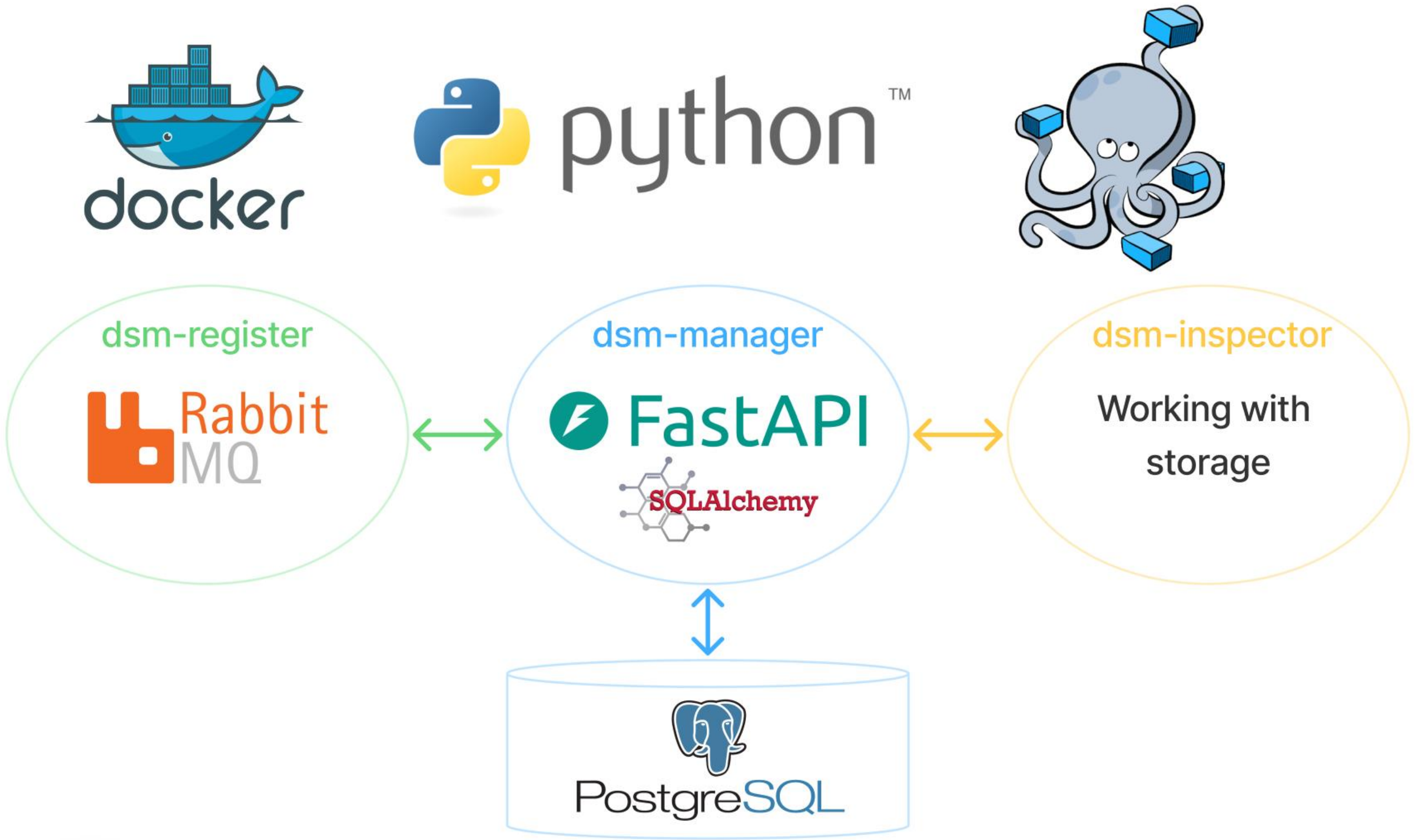
dsm-manager (REST API of data catalog)

- file and dataset management (adding data to a database, changing data, deleting data)

dsm-inspector (daemon tasks)

- delete files on storage, check consistency of files, monitoring the use of storage (for example, "dark" data)

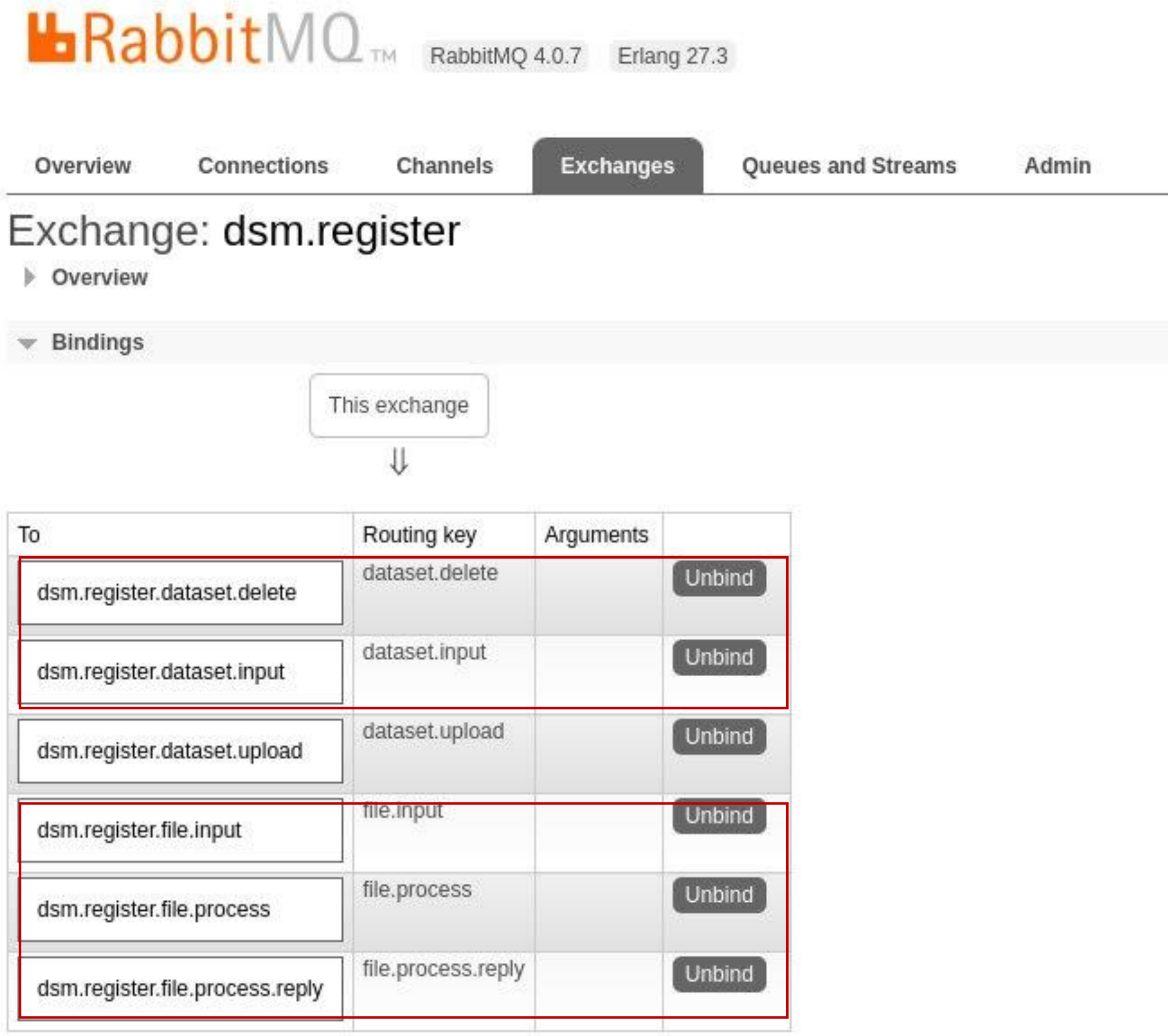
Technology stack



dsm-register: configured queues

The service should listen to the message queue and process requests for adding/deleting data in the system

RabbitMQ is used as an AMQP broker that performs routing and subscribing to the necessary queues



Exchange: dsm.register

Overview

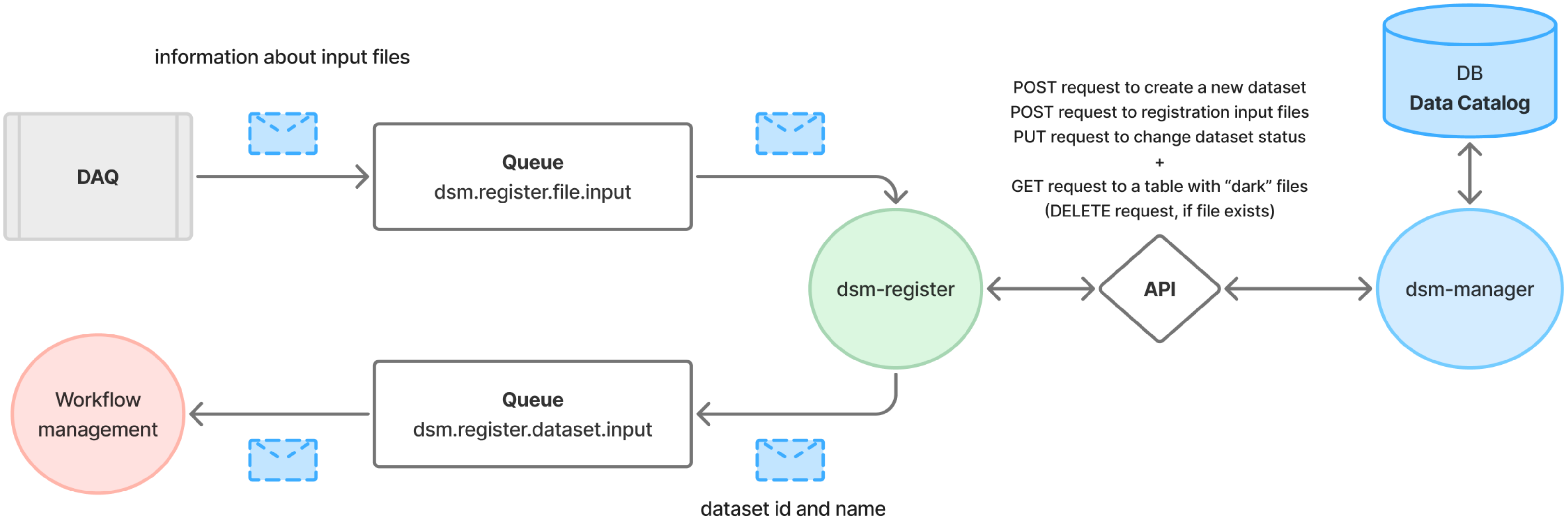
Bindings

This exchange

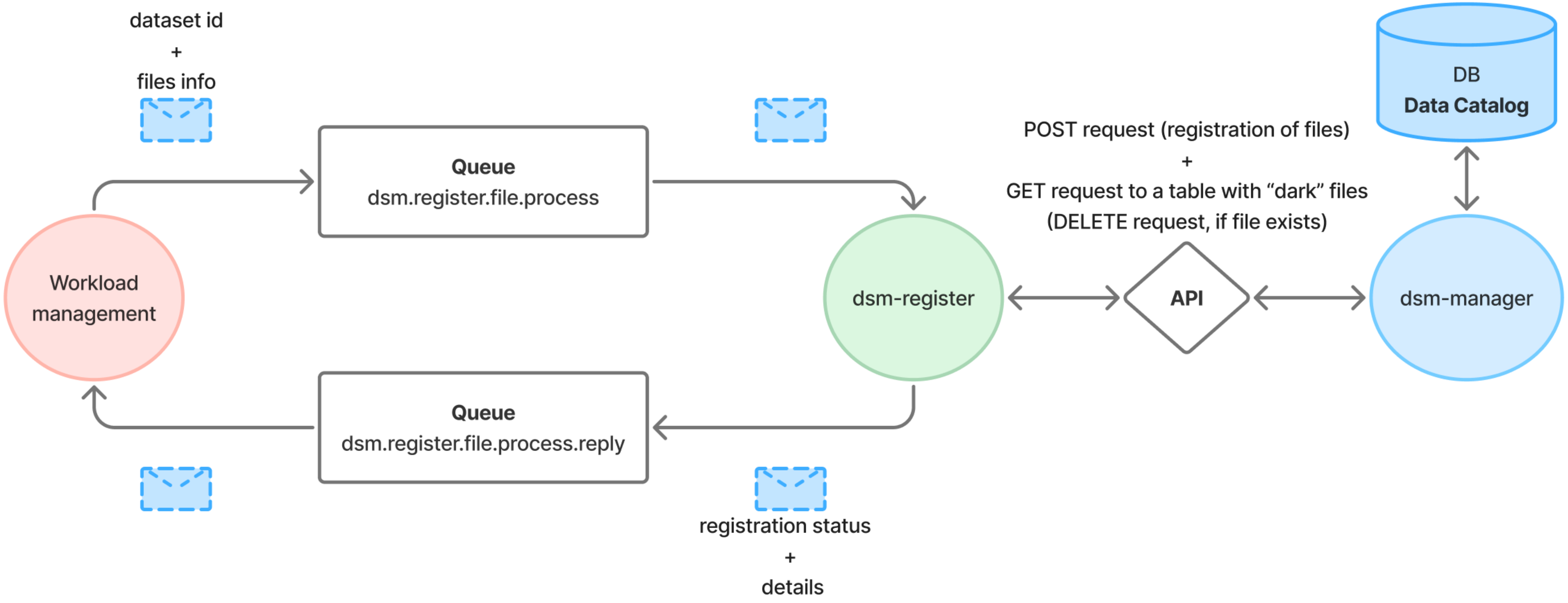
⇓

To	Routing key	Arguments	
dsm.register.dataset.delete	dataset.delete		Unbind
dsm.register.dataset.input	dataset.input		Unbind
dsm.register.dataset.upload	dataset.upload		Unbind
dsm.register.file.input	file.input		Unbind
dsm.register.file.process	file.process		Unbind
dsm.register.file.process.reply	file.process.reply		Unbind

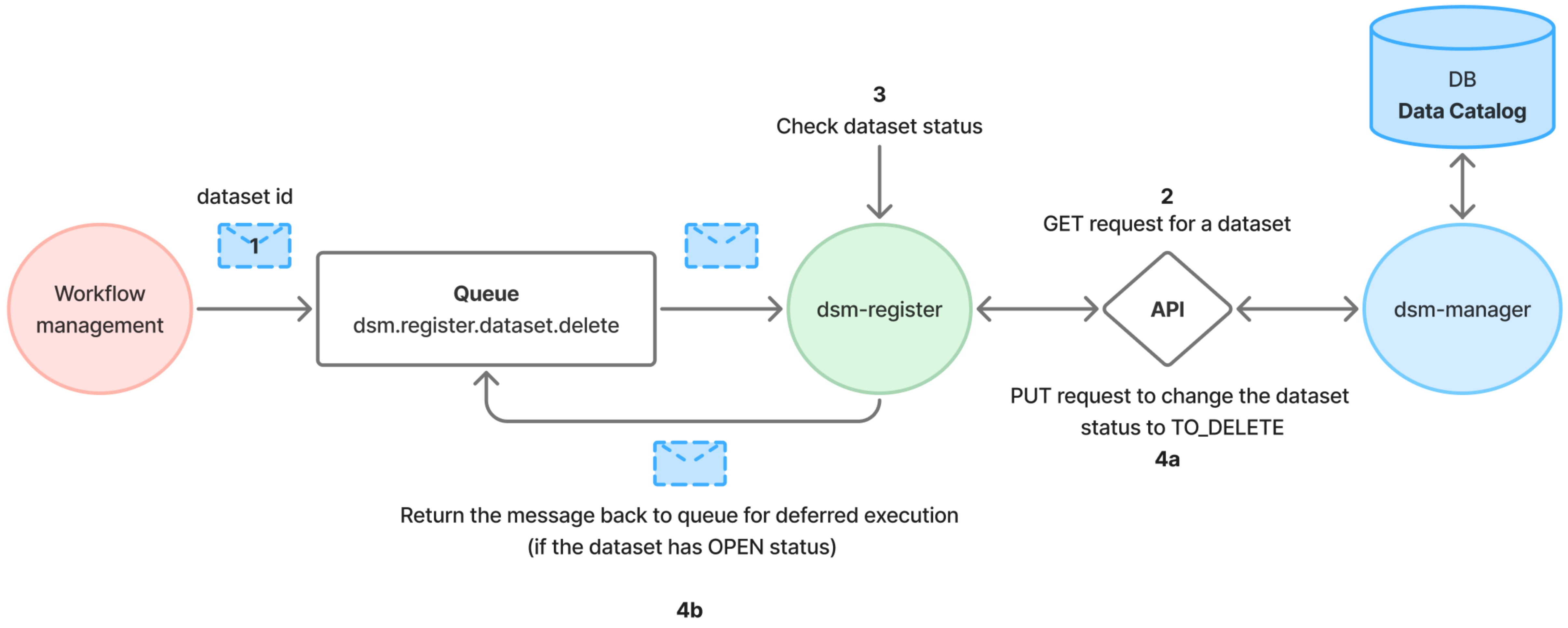
dsm.register.file.input и dsm.register.dataset.input


information about input files
DAQ
Queue
dsm.register.file.input
dsm-register
POST request to create a new dataset
POST request to registration input files
PUT request to change dataset status
+
GET request to a table with "dark" files
(DELETE request, if file exists)
API
DB
Data Catalog
dsm-manager
Workflow management
Queue
dsm.register.dataset.input
dataset id and name

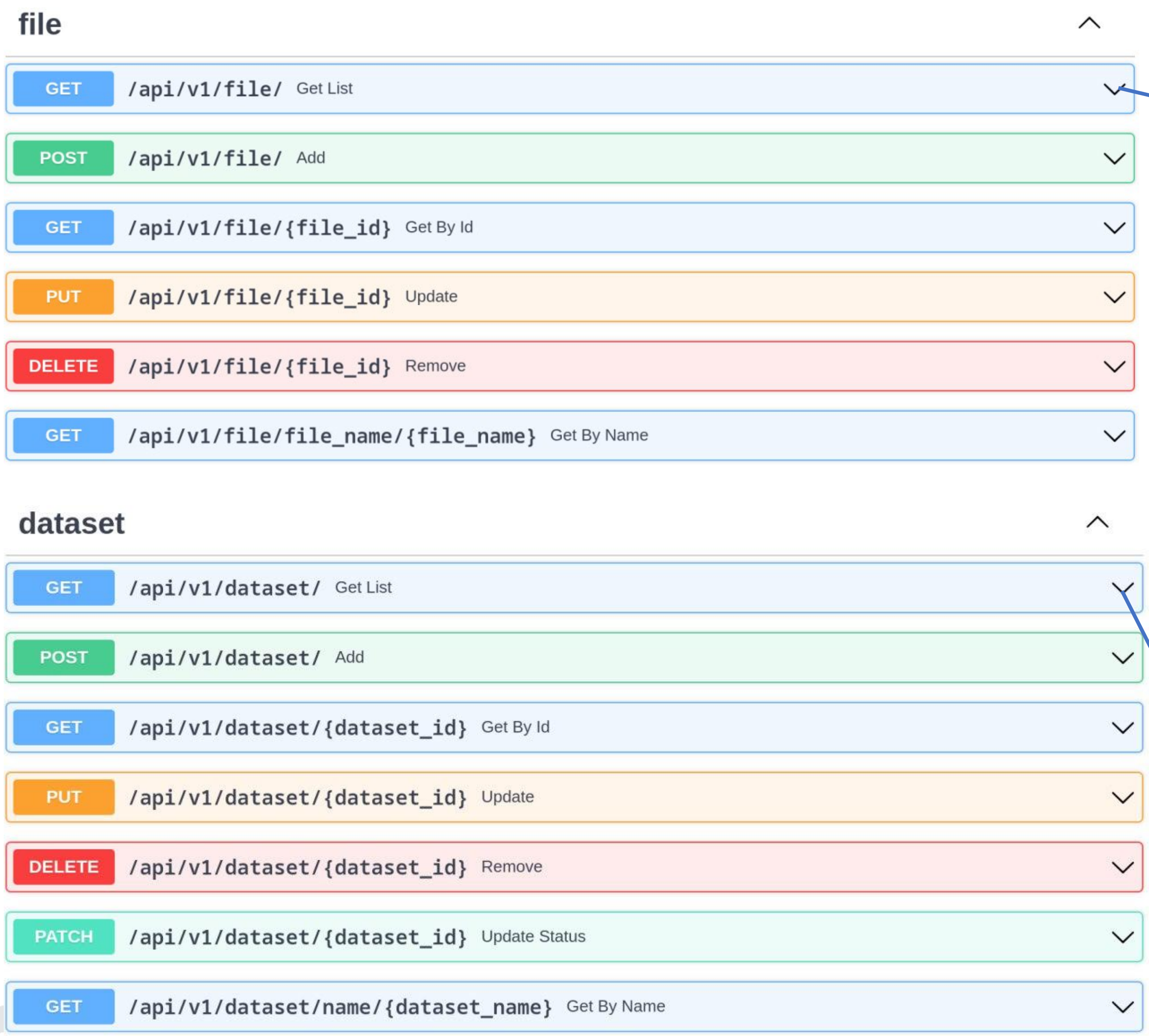
dsm.register.file.process and dsm.register.file.process.reply


dataset id
+
files info
Queue
dsm.register.file.process
DB
Data Catalog
POST request (registration of files)
+
GET request to a table with “dark” files
(DELETE request, if file exists)
Workload management
dsm-register
API
dsm-manager
Queue
dsm.register.file.process.reply
registration status
+
details

dsm.register.dataset.delete


3
Check dataset status
DB
Data Catalog
dataset id
1
2
GET request for a dataset
Workflow management
Queue
dsm.register.dataset.delete
dsm-register
API
dsm-manager
PUT request to change the dataset status to TO_DELETE
4a
Return the message back to queue for deferred execution (if the dataset has OPEN status)
4b

dsm-manager: API to the DB



file

GET /api/v1/file/ Get List

POST /api/v1/file/ Add

GET /api/v1/file/{file_id} Get By Id

PUT /api/v1/file/{file_id} Update

DELETE /api/v1/file/{file_id} Remove

GET /api/v1/file/file_name/{file_name} Get By Name

dataset

GET /api/v1/dataset/ Get List

POST /api/v1/dataset/ Add

GET /api/v1/dataset/{dataset_id} Get By Id

PUT /api/v1/dataset/{dataset_id} Update

DELETE /api/v1/dataset/{dataset_id} Remove

PATCH /api/v1/dataset/{dataset_id} Update Status

GET /api/v1/dataset/name/{dataset_name} Get By Name

- ✓ Getting a list of files in a dataset
- ✓ Getting a list of files with a specific status

FastAPI

The service must provide a REST API to the database

The asynchronous **FastAPI** framework is used as a web framework

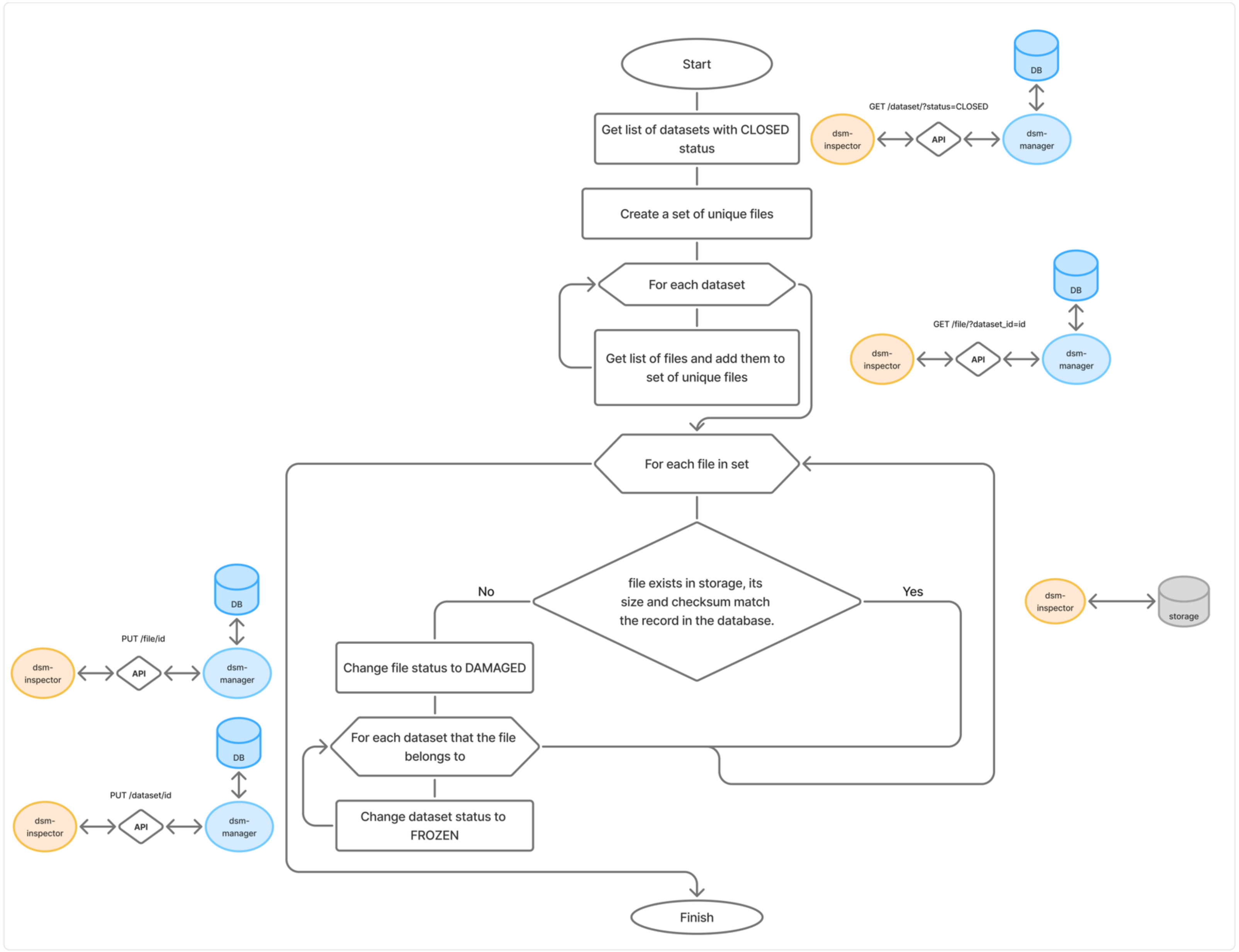
- ✓ Getting a list of datasets that contain a specific file
- ✓ Getting a list of datasets with a specific status

dsm-inspector

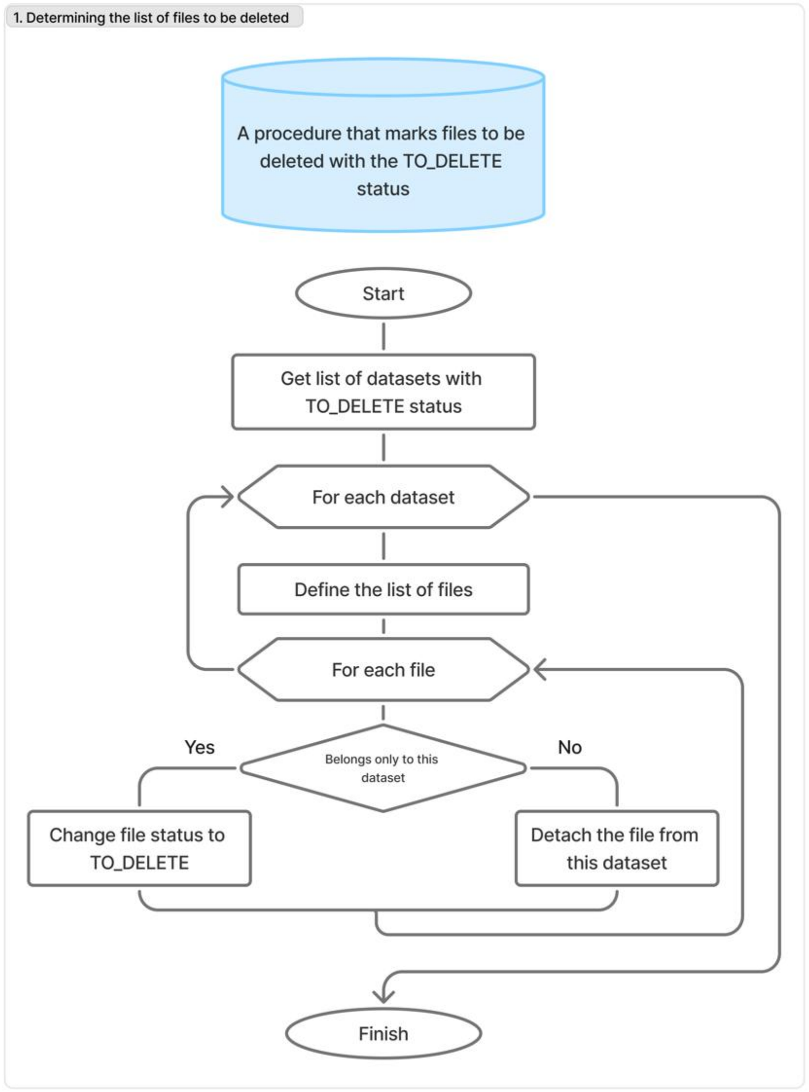
The service consists of a set of **background** tasks:

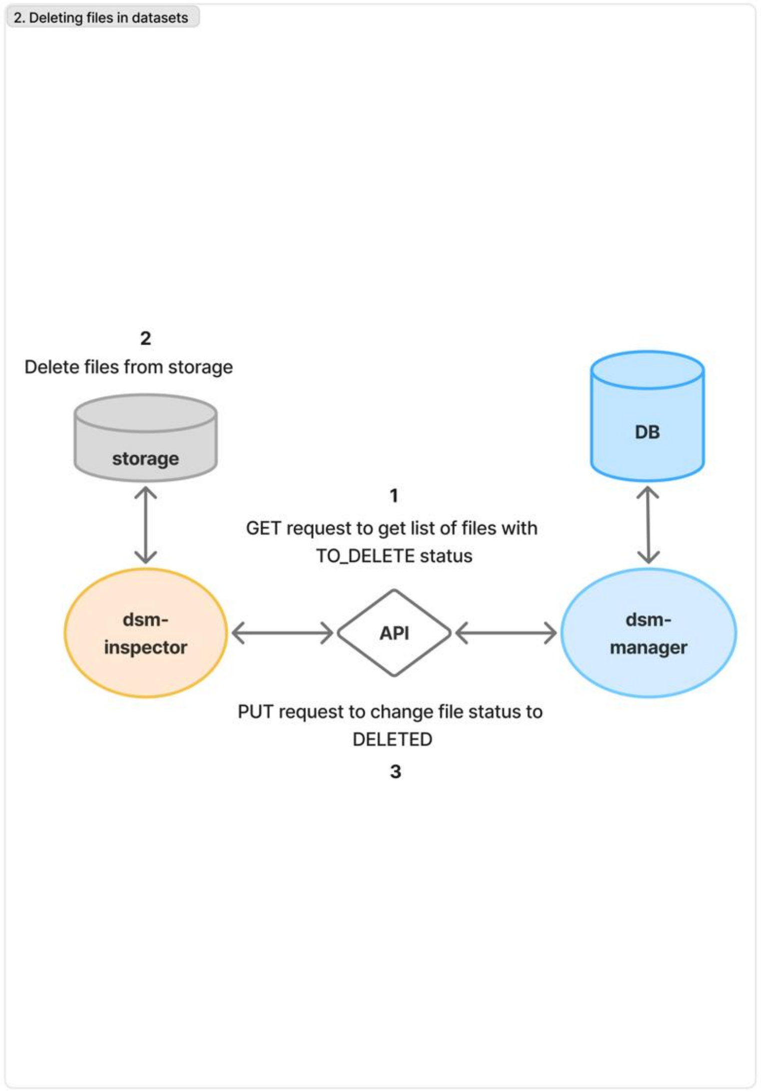
- Deleting files on storages
- File upload control
- File integrity check
- Monitoring storage usage

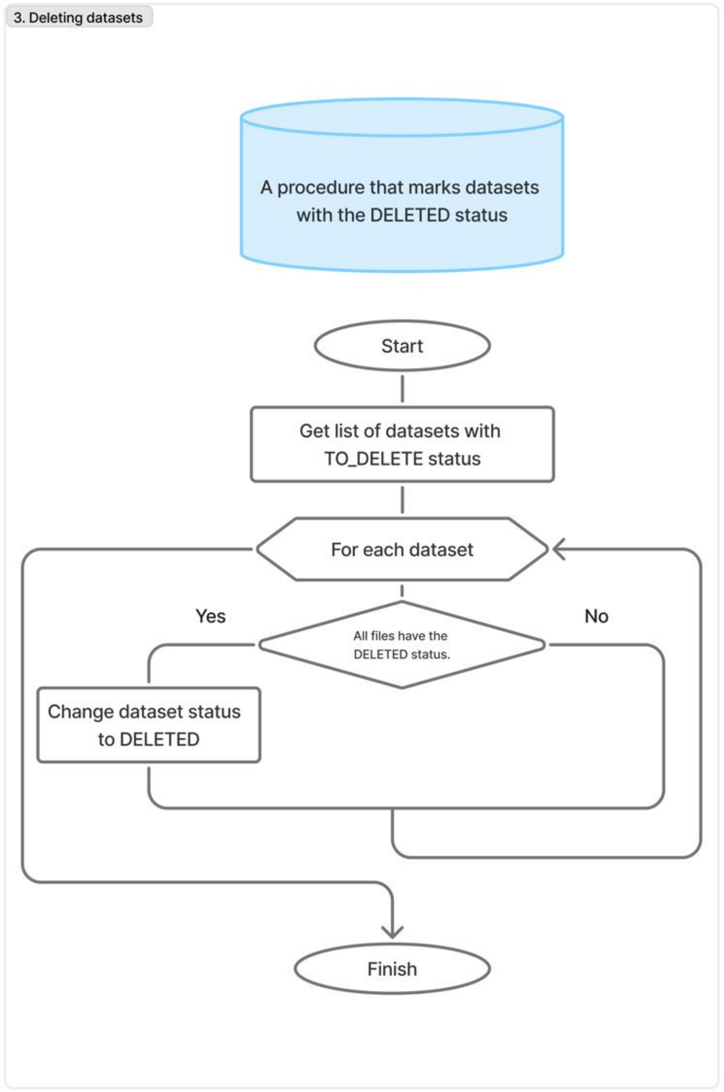
File Integrity Check


Start
Get list of datasets with CLOSED status
GET /dataset/?status=CLOSED
DB
dsm-inspector
API
dsm-manager
Create a set of unique files
For each dataset
Get list of files and add them to set of unique files
GET /file/?dataset_id=id
DB
dsm-inspector
API
dsm-manager
For each file in set
file exists in storage, its size and checksum match the record in the database.
No
Yes
dsm-inspector
storage
Change file status to DAMAGED
PUT /file/id
DB
dsm-inspector
API
dsm-manager
For each dataset that the file belongs to
Change dataset status to FROZEN
PUT /dataset/id
DB
dsm-inspector
API
dsm-manager
Finish

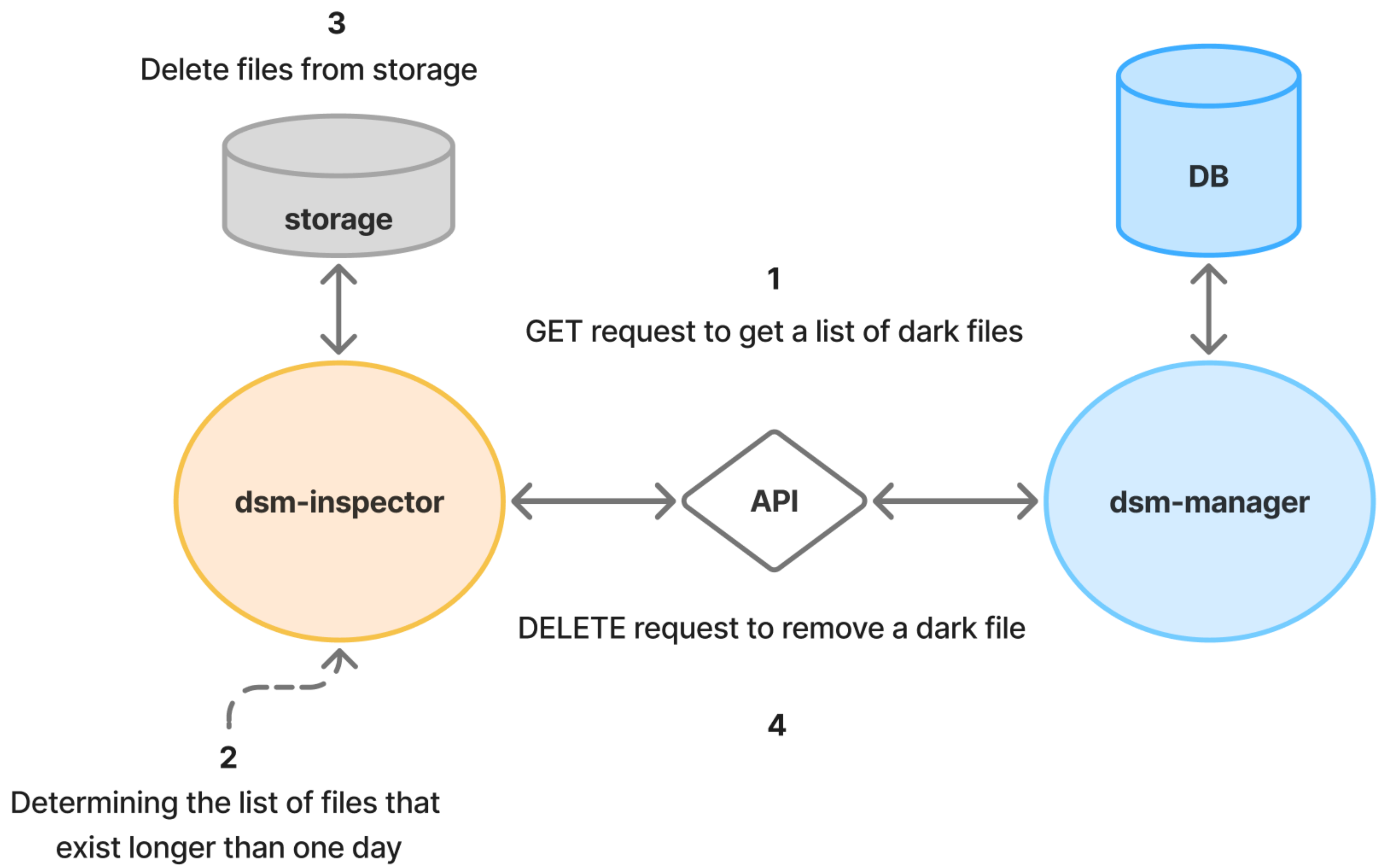
Deleting datasets and files


1. Determining the list of files to be deleted
A procedure that marks files to be deleted with the TO_DELETE status
Start
Get list of datasets with TO_DELETE status
For each dataset
Define the list of files
For each file
Belongs only to this dataset
Yes
No
Change file status to TO_DELETE
Detach the file from this dataset
Finish

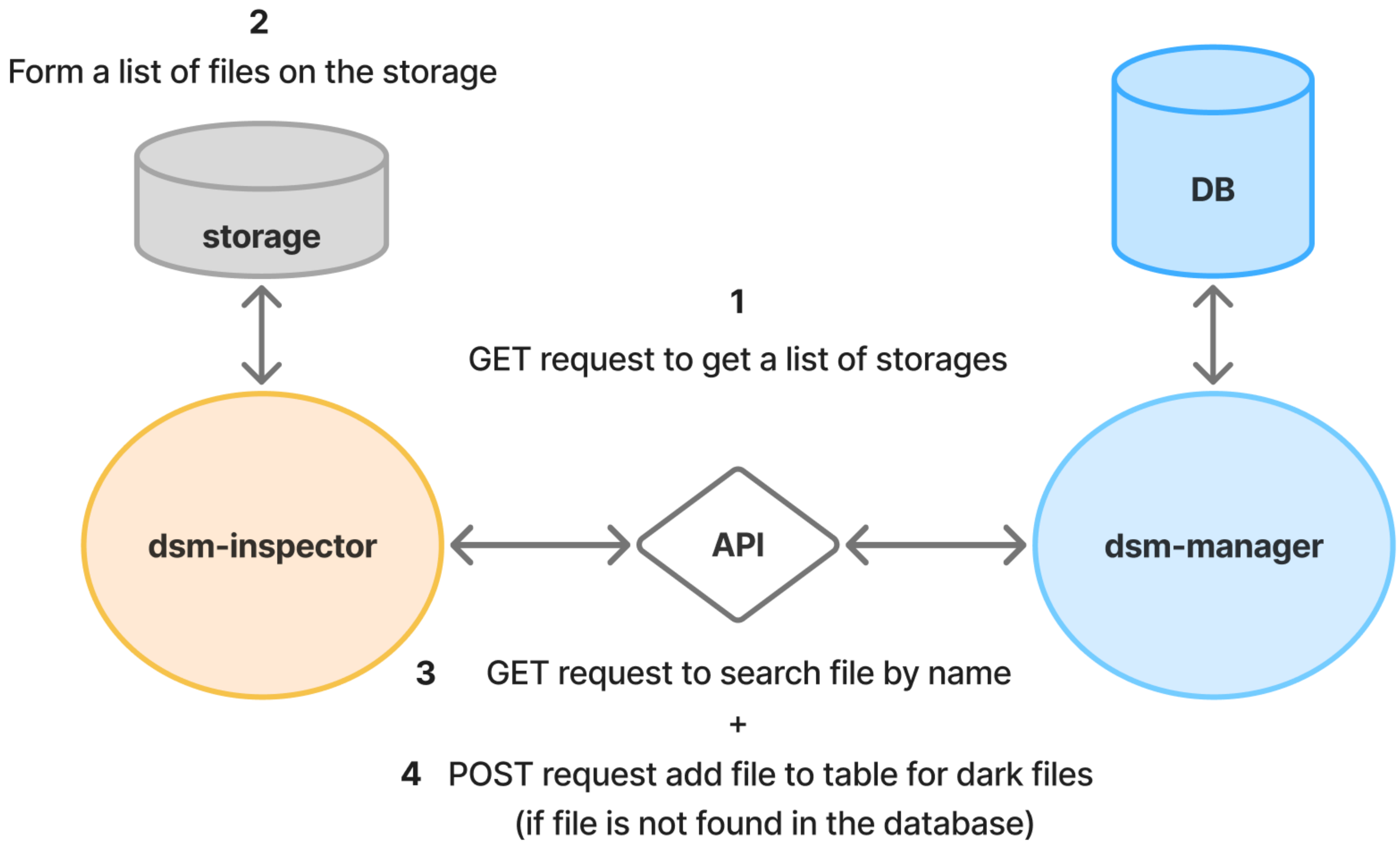

2. Deleting files in datasets
2
Delete files from storage
storage
DB
1
GET request to get list of files with TO_DELETE status
dsm-inspector
API
dsm-manager
PUT request to change file status to DELETED
3


3. Deleting datasets
A procedure that marks datasets with the DELETED status
Start
Get list of datasets with TO_DELETE status
For each dataset
Yes
No
All files have the DELETED status.
Change dataset status to DELETED
Finish

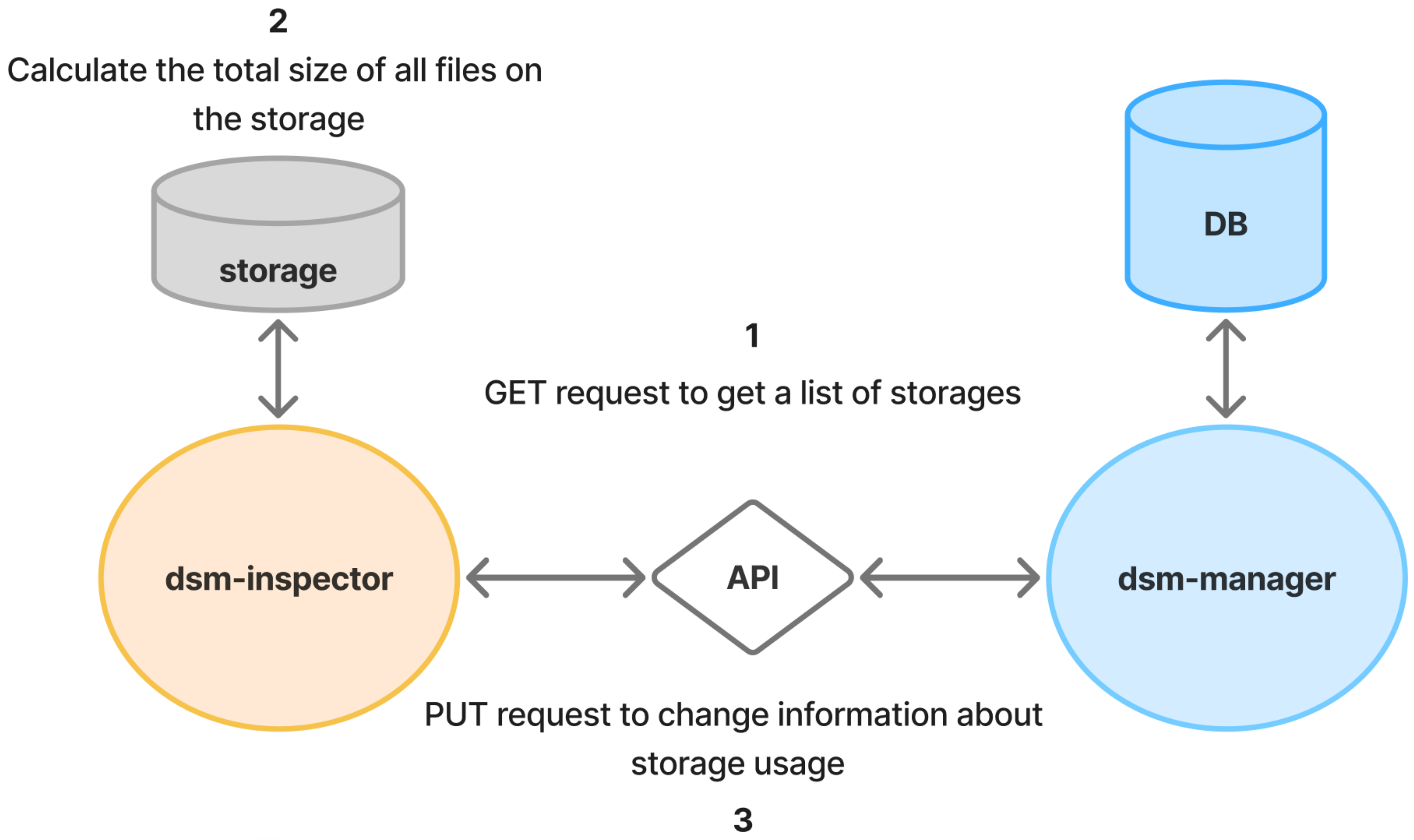
Deleting dark files


3
Delete files from storage
storage
DB
1
GET request to get a list of dark files
dsm-inspector
API
dsm-manager
DELETE request to remove a dark file
4
2
Determining the list of files that exist longer than one day

Storage usage monitoring: monitoring of dark files


2
Form a list of files on the storage
storage
DB
1
GET request to get a list of storages
dsm-inspector
API
dsm-manager
3 GET request to search file by name
+
4 POST request add file to table for dark files
(if file is not found in the database)

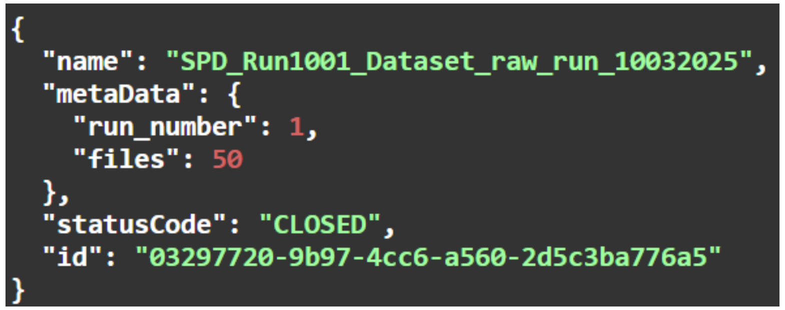
Storage usage monitoring


2
Calculate the total size of all files on the storage
storage
DB
1
GET request to get a list of storages
dsm-inspector
API
dsm-manager
PUT request to change information about storage usage
3

SPD DAQ generator

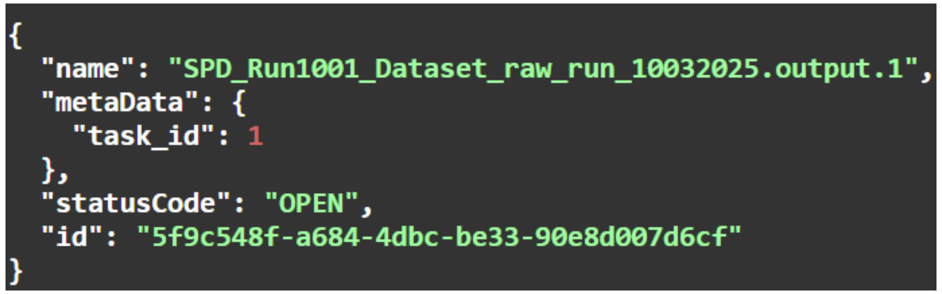
- Using SPD DAQ data generator, 50 2 GB files were generated (~ 7 minutes per file)

- An input dataset with these files has been created



```
{
  "name": "SPD_Run1001_Dataset_raw_run_10032025",
  "metaData": {
    "run_number": 1,
    "files": 50
  },
  "statusCode": "CLOSED",
  "id": "03297720-9b97-4cc6-a560-2d5c3ba776a5"
}
```

- A task has been generated and an output dataset has been created



```
{
  "name": "SPD_Run1001_Dataset_raw_run_10032025.output.1",
  "metaData": {
    "task_id": 1
  },
  "statusCode": "OPEN",
  "id": "5f9c548f-a684-4dbc-be33-90e8d007d6cf"
}
```

- The files were successfully processed by the pilots

Conclusion

Current results:

- ✓ **dsm-manager** fully functional for this stage of implementation
- ✓ **dsm-register** implemented for this stage
- ✓ **dsm-inspector** is implemented by 75%

Further plans:

dsm-inspector:

Implement background services for

- ➢ File upload control

dsm-register:

Realize processing of messages from queues:

- ➢ dsm.register.dataset.upload