MAFw: Modular Analysis Framework

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CHAPTER 1

FIRST STEPS

1.1 Installation

MAFw can be installed using pip in a separated virtual environment.

Windows

```
c:\> python -m venv mafw-env
c:\> cd mafw-env
c:\mafw-env> Scripts\activate
(mafw-env)c:\mafw-env> pip install mafw
```

linux & MacOS

```
$ python -m venv mafw-env
$ cd mafw-env
$ source bin/activate
(mafw-env) $ pip install mafw
```

1.1.1 Requirements

MAFw has been developed using python version 3.11 and tested with newer versions up to the current stable release (3. 13). Apart from some *typing* issues, we do not expect problems when running it with older releases. It is our intention to follow the future advancement of python and possibly use the NO-GIL option starting from version 3.14 to improve the overall performances.

Concerning dependencies, all packages required by MAFw are specified in the pyproject file and will be automatically installed by pip. Nevertheless, if you are curious to know what comes with MAFw, here is a list of direct dependencies with the indication of what their role is inside the library.

- **pluggy** (>=1.5): to implement the plugin mechanism and let the users develop their own processors;
- **click** (>=8.1): to implement the command line interface for the mafw execution engine;
- **tomlkit** (>0.13): to implement the reading and writing of steering files;
- **peewee** (>3.17): to implement the ORM database interface;
- **Deprecated** (>1.2): to inform the user about deprecated usages;
- **typing-extensions** (>4.13 only for python <=3.11) to have access to typing annotations.

If mafw is installed with the additional features provided with by **seaborn**, then those packages will also be installed.

- **seaborn** (>=0.13): to implement the generation of high level graphical outputs;
- **matplotlib** (>=3.1): the low level graphics interface;
- **pandas[hdf5]** (>=2.2): to allow the use of dataframes for data manipulations.

By default mafw comes with an abstract plotting interface. If you want to use seaborn, then just install the optional dependency *pip install mafw[seaborn]*

All MAFw dependencies will be automatically installed by pip.

1.2 Contributing

Contributions to the software development are very much welcome. A more detailed guide on how to contribute or to get help for the development of your processors can be found in CONTRIBUTING.md.

If you want to join the developer efforts, the best way is to clone/fork this repository on your system and start working.

The development team has adopted hatch for basic tasks. So, once you have downloaded the git repository to your system, open a shell there and type:

Windows

```
D:\mafw> hatch env create dev
D:\mafw> hatch env find dev
C:\path\to\.venv\mafw\KVhWIDtq\dev.py3.11
C:\path\to\.venv\mafw\KVhWIDtq\dev.py3.12
C:\path\to\.venv\mafw\KVhWIDtq\dev.py3.13
```

linux & MacOS

```
$ hatch env create dev
$ hatch env find dev
/path/to/venv/dev.py3.11
/path/to/venv/dev.py3.12
/path/to/venv/dev.py3.13
```

to generate the python environments for the development. This command will actually create the whole environment matrix, that means one environment for each supported python version. If you intend to work primarily with one single python version, simply specify it in the create command, for example:

Windows

```
D:\mafw> hatch env create dev.py3.13
D:\mafw> hatch env find dev.py3.13
C:\path\to\.venv\mafw\KVhWIDtq\dev.py3.13
```

linux & MacOS

```
$ hatch env create dev.py3.13
$ hatch env find dev.py3.13
/path/to/venv/dev.py3.13
```

hatch will take care of installing MAFw in development mode with all the required dependencies. Use the output of the find command, if you want to add the same virtual environment to your favorite IDE. Once done, you can spawn a shell in the development environment just by typing:

Windows

```
D:\mafw> hatch shell dev.py3.13
(dev.py3.13) D:\mafw>
```

linux & MacOS

```
$ hatch shell dev.py3.13
(dev.py3.13) $
```

and from there you can simply run mafw and all other scripts.

> **Note**
>
> If you are not familiar **hatch**, we strongly encorage to have a look at their website. This powerful tool, similar to poetry and uv, it is simplifying the creation of a matrix of virtual environments for developing and testing your code with different combination of requirements.
>
> We strongly recommend to install hatch via pipx, so to have the executable available systemwide, but nevertheless running in a separate environment.

MAFw uses pre-commit to assure a high quality code style. The pre-commit package will be automatically installed into your environment, but it must be initialised before its first use. To do this, simply run the following command:

Windows

```
(dev.py3.13) D:\mafw> pre-commit install
```

linux & MacOS

```
(dev.py3.13) $ pre-commit install
```

And now you are really ready to go with your coding!

Before pushing all your commits to the remote branch, we encourage you to run the pre-push tests to be sure that everything still works as expected. You can do this by typing:

Windows

```
D:\mafw> hatch run dev.py3.13:pre-push
```

linux & MacOS

```
$ hatch run dev.py3.13:pre-push
```

if you are not in an activated development shell, or

Windows

```
(dev.py3.13) D:\mafw> hatch run pre-push
```

linux & MacOS

```
(dev.py3.13) $ hatch run pre-push
```

if you are already in the dev environment.

These pre-push checks will include some cosmetic aspects (ruff check and format) and more relevant points like static type checking with mypy, documentation generation with sphinx and functionality tests with pytest.

1.3 Testing

MAFw comes with an extensive unit test suite of more than 1000 test cases for an overall code coverage of 99%.

Tests have been coded using pytest best practice and are aiming to prove the functionality of each unit of code taken individually. Given the high level of interoperability of MAFw with other libraries (toml, peewee and seaborn just to name a few), unit tests rely heavily on patched objects to assure reproducibility.

Nevertheless full integration tests are also included in the test suite. These tests will cover all relevant aspects of MAFw, including:

1. Installation of MAFw and of a Plugin project in a isolated environment
2. Use of MAFw executable to create some data files and analyse them to create a graphical output.
3. Use of a database to store the collected data.
4. Check the database trigger functionalities to avoid repeating useless analysis steps, for example when a new file is added, removed or changed.

If you plan to collaborate in the development of MAFw, you must include unit tests for your contributions.

As already mentioned, MAFw is using hatch as project management. In the pyproject.toml file, hatch is configured to have a matrix of test environment in order to run the whole test suite with the supported versions of python (3.11, 3.12 and 3.13).

Running the suite is very easy. Navigate to the folder where you have your local copy of MAFw and type `hatch test`. Hatch will take care of installing the proper environment and run the tests. Should one or more test(s) fail, then the slow integration tests will be skipped to spare some time.

Have a look at the hatch test options, in particular the *-a*, to test over all the environments in the matrix and the *-c* to generate coverage data for the production of a coverage report.

1.4 Citing MAFw

If you used MAFw in your research and you would like to acknoledge the project in your academic publication we suggest citing the following paper:

- Bulgheroni et al., (2025). MAFw: A Modular Analysis Framework for Streamlining and Optimizing Data Analysis Workflows. Journal of Open Source Software, 10(114), 8449, https://doi.org/10.21105/joss.08449

or as BibTeX format:

```
@article{Bulgheroni2025,
    doi = {10.21105/joss.08449},
    url = {https://doi.org/10.21105/joss.08449},
    year = {2025},
    publisher = {The Open Journal},
    volume = {10},
    number = {114},
    pages = {8449},
    author = {Bulgheroni, Antonio and Krachler, Michael},
    title = {MAFw: A Modular Analysis Framework for Streamlining and Optimizing Data␣
↪Analysis Workflows},
    journal = {Journal of Open Source Software}
}
```

Tip

Reading Path Recommendation: This documentation follows a systematic approach, describing all the elements composing MAFw and their interactions before presenting a comprehensive practical example. However, we recognize that different users have varying learning preferences. If you prefer to begin with a concrete implementation to understand the library's capabilities before diving into theoretical foundations, you may jump directly to the *tutorial section*. After reviewing the practical application, you can return to this detailed documentation for a thorough understanding of the underlying concepts and architectural design.

CHAPTER 2

INTRODUCTION

2.1 Statement of need

MAFw addresses the need for a flexible and modular framework that enables data scientists to implement complex analytical tasks in a well-defined environment. Currently, data analysis workflows often require scientists to handle multiple tasks, such as data ingestion, processing, and visualization, which can be time-consuming and prone to errors. Moreover, the lack of standardization in data analysis pipelines can lead to difficulties in reproducing and sharing results.

MAFw aims to fill this gap by providing a Python-based tool that allows data scientists to focus on the analysis itself, rather than on the ancillary tasks. The framework is designed to be highly customizable, enabling users to create their own processors and integrate them into the workflow. A key feature of MAFw is its strong collaboration with a relational database structure, which simplifies the analysis workflow by providing a centralized location for storing and retrieving data. This database integration enables seamless data exchange between different processors, making it easier to manage complex data pipelines.

2.2 MAFw conceptual design

The concept behind MAFw is certainly not novel. Its functionality is so prevalent in data analysis that numerous developers, particularly data scientists, have attempted to create libraries with similar capabilities. MAFw's developers got inspired by MARLIN: this object C++ oriented application framework, no longer being maintained, was offering a modular environment where particle physicists were developing their code in the form of shared libraries that could be loaded at run time in a plugin-like manner[1]. One of MARLIN strengths was the strong connection with the serial I/O persistency data model offered by LCIO.

Starting from those solid foundations, MAFw moved from C++ to python in order to facilitate the on-boarding of data scientists and to profit from the vast availability of analytical tools, replacing the obsolete LCIO backend with a more flexible database supported input/output able to deal with large amount of data with categorical variables without severely impacting on I/O performance.

The general concept behind MAFw has been developed by the authors to perform image analysis on autoradiography images, featuring an ultra simplified database interface (sqlite only) along with some dedicated processors targeting autoradiography specific tasks.

Having understood the potentiality of this scheme, the authors decided to extract the core functionalities of the framework itself, expand the database interface making use of an ORM approach (peewee), include a plugin system to simplify the integration of processors developed for different purposes in external projects and supply an extensive general and API documentation, before releasing the code to the public domain as open source.

[1] One of MAFw developer was in charge of the original coding of EUTelescope, a set of MARLIN processors for the reconstruction of particle trajectories recorded with beam telescopes.

2.3 The way ahead

The future development of MAFw is driven by code usability. The authors are trying their best to make the framework as functional as possible offering colleague scientists a platform where to perform their analyses. At the time of writing there are already three targets envisaged: improved user-friendliness via a GUI or at least a TUI, improved performance via parallel processing and improved interactivity.

2.3.1 A G- / T- UI for MAFw

For the time being, the authors focused their efforts in coding a functional framework leaving usability aspects for a later development stage. MAFw is able to *execute* one or more processors one after the other from the command line following the instructions given in a human- and machine- readable (toml) steering file. While users can generate examples of steering files to serve as a starting point, implementing a graphical or at least a textual user interface would significantly simplify the process of creating and executing these files.

Following the plugin approach already used elsewhere in the library, the authors are considering to implement a TUI based on textual where the user is guided in the creation of steering files.

2.3.2 Parallel processing

Python is often recognized for its slower performance compared to some other programming languages available today. Analytical tasks are often I/O and/or CPU demanding, making the performance of a single threaded single processor program somehow limited.

MAFw uses pandas and numpy when dealing with data and those libraries are already capable to perform concurrent operations under some specific circumstances.

The well-known python GIL is actually preventing multi-threaded applications to improve overall performance for CPU-bound tasks. In this respect, an important revolution is taking place with the release of the experimental Free-threaded CPython implementation of python (added in version 3.13) and MAFw authors are closely observing those developments to identify the more convenient approach to improve computational performance.

2.3.3 Introduce interactivity

Even though in the original implementation of MAFw precursor, interactive processors were already existing, they were temporary removed from the current implementation. The authors recognize that many data scientists prefer to conduct interactive analysis using jupyter or marimo notebooks. Therefore, they are actively exploring ways to seamlessly integrate interactivity into the processor workflow through these notebook environments.

CHAPTER 3

PROCESSOR: THE CORE OF MAFW

The Processor is responsible to carry out a specific analytical task, in other simple words, it takes some input data, it does some calculations or manipulations, and it produces some output data.

The input and output data can be of any type: a simple list of numbers, a structured data frame, a path to a file where data are stored, an output graph or a link to a web resource, a database table, and so on.

In ultra simplified words, a Processor does three sequential actions:

1. Prepare the conditions to operate (`start()`)
2. Process the data (`process()`)
3. Clean up what is left (`finish()`).

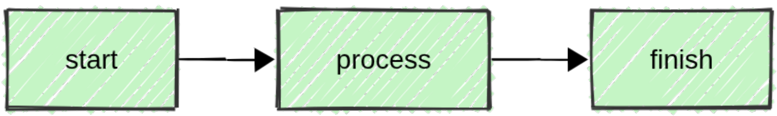
3.1 Execution workflow

There are instances where tasks can be executed in a single operation across your entire dataset, such as generating a graph from the data. However, there are also situations where you need to iterate over a list of similar items, applying the same process repeatedly. Additionally, you may need to continue a process until a specific condition is met. The `Processor` can actually accomplish all those different execution workflows just by changing a variable: `the loop type`.

You will be presented a more detailed description of the different workflows in the following sections.

3.1.1 The single loop execution

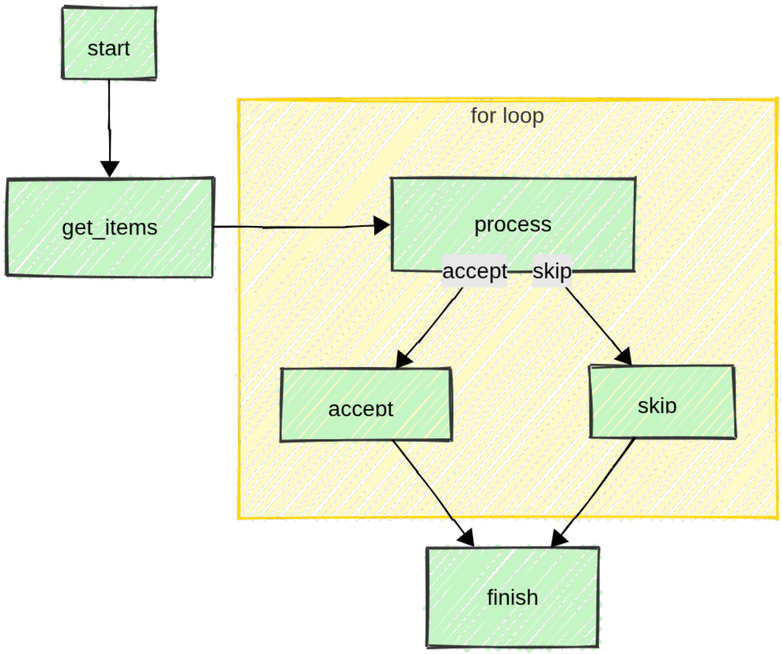
The first family has a simplified execution workflow schematically shown here below:



The distinction of roles between the three methods is purely academic, one could implement all the preparation, the real calculation and the clean up in one method and the processor will work in the same way. The methods are anyhow preserved to offer a similar execution scheme also for the other looping scheme.

3.1.2 The for loop execution

In python a for loop is generally performed on a list of items and MAFw is actually following the same strategy. Here below is the schematic workflow.

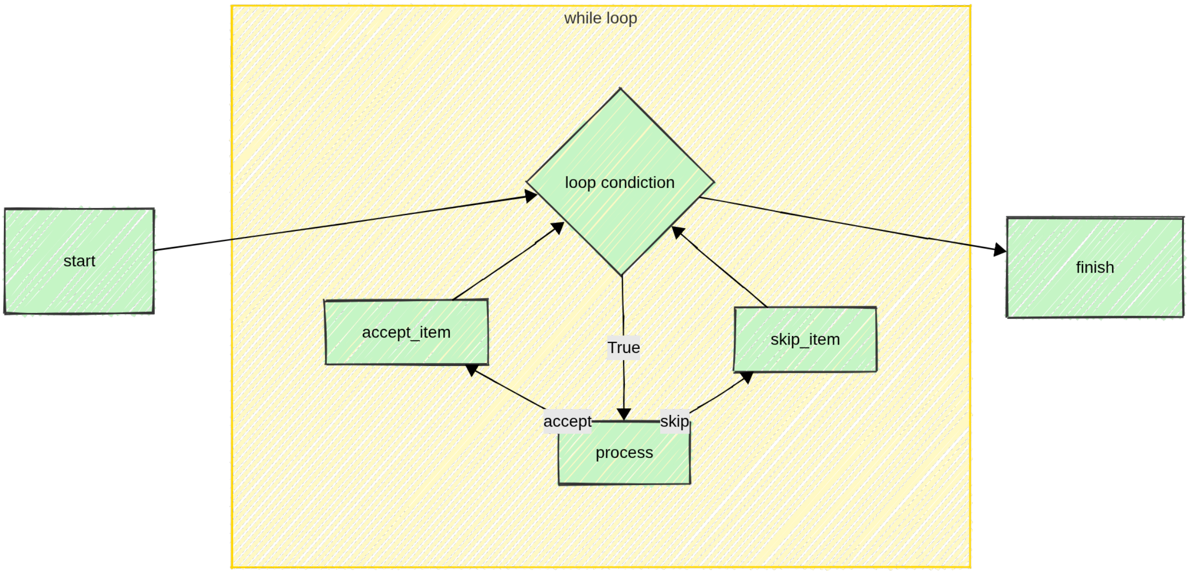


As you can see, after having called the *start()*, the user must provide a list of items to be processed implementing the *get_items()*. This can be the list of files in a directory, or the rows in a DB table or even a list of simple numbers; whatever best suit the user's needs. You will soon learn how to deal with *database* entries and how to *filter* them.

Now everything is ready to start the loop and call the *process()* as many times as the items in the input list. In the process implementation, the user can realize that something went wrong with a particular item and can modify what is executed next (*accept_item()* or *skip_item()*). See an example of such a possibility *here*. At the end of the loop it is time to clean up everything, saving files, updating DBs and so one. This is again the task of the *finish()* method.

3.1.3 The while loop execution

From a programming point of view, the for loop and the while loop execution are rather similar. Between the execution of the start and the finish method, the process is repeated for a certain number of times until a certain condition is met.



In this case, there is no list of items to loop over, but a condition that should be checked. Thus the user has to overload the `while_condition()` method to return a boolean value: True if the loop has to continue or False if it has to stop and go to the finish.

3.1.4 How to switch from one loop type to another

It is extremely simple to switch from one execution scheme to another. The `Processor` class takes the argument `loop_type`, just change this value in the processor init and the rest will come automatically.

Remember that, by default a processor is set to work with a *for loop* workflow, and thus you have to implement the `get_items()`. If you switch to *while loop*, then you need to implement `while_condition()` for the system to work.

The last thing, you need to know is how to run a processor. First you create an instance of your processor, then you call the `execute()` method. There are other more practical ways, not involving any coding that we will discuss *later on*.

A comparison between the **for loop** and the **while loop** execution workflow is described in the *example page*.

3.2 Subclassing

The basic processor provided in the library does nothing specifically, it is only used as a skeleton for the execution. In order to perform some real analysis, the user has to subclass it and overload some methods. Having gained a clear understanding of the role of each steps in the execution workflow, read the list of methods that can be overloaded here below and then you are ready to see some simple *Processor Examples*.

3.2.1 List of methods to be overloaded

The `process()` method.

> This is the central part of the processor, and it must contain all the calculations. If the processor is looping on a list of input items, the user can access the current item via the `item` attribute.

The `start()` method.

> This is useful to prepare the condition to operate. For example, it is a good idea to open files and do all the preparatory work. In a looping processor, this method is called just before the cycle starts.

The `finish()` method.

> This is useful to clean up after the work. For example, to save files, update DB tables and so on. In a looping processor this is performed just after the last iteration. Here is also the place where you

can set the value of the `ProcessorExitStatus`. This attribute is particularly relevant when several processors are executed in a daisy-chained manner. See more about this *here* and *here*.

Specifically for processors with a looping workflow, these methods need to be subclassed.

The `get_items()` method.

This is where the input collection of items is generated. Very likely this can be a list of files resulting from a glob or the rows of an input table or similar. This is required only for **for_loop** processors and must return an iterable object.

The `while_condition()` method.

This is the point at which the decision is made to either continue or terminate the loop. This is required only for **while_loop** processors and must return a boolean value.

The `accept_item()` and `skip_item()` methods (optional).

The execution of the for loop can be slightly modified using the `LoopingStatus` (see this *example*). If the current iteration was successful, then the user can decide to perform some actions, otherwise if the current iteration was failing, then some other actions can be taken.

The `format_progress_message()` (optional).

During the process execution, your console may look frozen because your CPU is working out your analysis, thus it may be relevant to have every now and then an update on the progress. The `Processor` will automatically display regular messages via the logging system about the progress (more or less every 10% of the total number of items), but the message it is using is rather generic and does not contain any information about the current item.

By overloading this method, you can include information about the current item and customize the content of the message. You can use `item` to refer to the current item being processed. Here below is an example:

```
def format_progress_message(self):
    self.progress_message = f'{self.name} is processing {self.item}'
```

Be aware that if your items are objects without a good __repr__ or string conversion, the output may be a little messy.

The `validate_configuration()` (optional).

If your processor has several parameters, it might be a good idea that the configuration provided by the user via `ActiveParameter` is validated. For this purpose the user can subclass the `validate_configuration()` method, where the validation of the configuration should silently take place. If the configuration is invalid, then the method should raise a `InvalidConfigurationError`. You will read more on processor parameters and how to use it in one of the next *section*.

3.2.2 Customize and document you processor

You are a scientist, we know, the only text you like to write is the manuscript with your last research results. Nevertheless, documenting your code, in particular your processor is a very helpful approach. We strongly recommend to use *docstring* to give a description of what a processor does. If you do so, you will get a surprise when you will *generate your first steering file*.

It is also a very good practice to provide help/doc information to your parameters using the help_doc argument of the `ActiveParameter`. If you do so, your *first steering file* will be much more readable.

One more point, each `Processor` has a class attribute named `description`, this is a short string that is used by some user interfaces (like `RichInterface`) to make the progress bars more meaningful.

3.3 Processor parameters

One super power of MAFw is its capability to re-use code, that means less work, less bugs and more efficiency.

In order to boost code re-usability, one should implement Processor accomplishing one single task and possibly doing it with a lot of general freedom. If you have a processor to calculate the Threshold of B/W images and you have hard coded the threshold algorithm and tomorrow you decide to give a try to another algorithm, then you have to recode a processor that actually already exists.

The solution is to have processor parameters, kind of variables that can be changed in order to make your processor more general and more useful. A note of caution, if you opt for too many parameters, then it may become too difficult to configure your processor. As always, the optimal solution often lies in finding a balance.

You can have parameters implemented in the processor subclass as normal attributes, but then you would need to modify the code in order to change them and this is far from being practical. You can have them as specific variables passed to the processor init, but then you would need to code the command line script to pass this value or to implement a way to read a configuration file.

MAFw has already done all this for you as long as you use the right way to declare processor parameters.

Let us start with a bit of code.

```
class MyProcessor(Processor):
    """
    This is my wonderful processor.

    It needs to know the folder where the input files are stored.
    Let us put this in a processor parameter.

    :param input_folder: The input folder.
    """
    input_folder = ActiveParameter(name='input_folder', default=Path.cwd(),
                                   help_doc='This is the input folder for the file')

    def __init__(self, *args, **kwargs):
        super().__init(*args, **kwargs)

        # change the input folder to something else
        self.input_folder = Path(r'D:\data')

        # get the value of the parameter
        print(self.input_folder)
```

Some important notes: input_folder is defined as a class attribute rather then as an instance attribute, it is to say it is outside the init method. **This must always be the case for processor parameters**. The fact that the variable and the parameter names are the same is not compulsory, but why do you want to make your life more complicated!

We have declared *input_folder* as an `ActiveParameter`, but if you put a break point in the code execution and you inspect the type of *self.input_folder* you will see that it is a Path object. This is because `ActiveParameter` is a descriptor, a very pythonic way to have a double interface for one single variable.

If your processor is subclassing the *__init__* method, then never forget to include right at the beginning a call to its super, this is ensuring that the processor, and its parameters, are properly initialized and ready to be used.

3.3.1 What's behind an `ActiveParameter`

Note

This is a very technical paragraph, you can skip it if you are not interested in the *behind the scene* of processor parameters.

Have a look at the code in the previous snippet. When you define *input_folder*, you use up to four parameters in the ActiveParameter init, but if you try to access those attributes from input_folder you will get an error message, because class Path does not have the attributes you are looking for. Where are then those values gone?

When you create an ActiveParameter, there is a lot of work behind the scene: each processor instance has a dictionary (Processor._processor_parameters) where the parameter name is used as a key and the corresponding value is an instance of PassiveParameter. This helper class has a very similar structure as the active counter part and it is used to store the current value of the parameter and all its metadata (default value and help string) defined when the active parameter was created.

The set and get dunder methods of the input_file are overloaded to operate directly on the private interface, more or less in the same way like when you define *property* setter and getter, but here it is done all automatically.

If you want to access the private interface, you can still do it. You can always use the processor get_parameter() using the parameter name as a key, to retrieve the PassiveParameter instance. Theoretically you can even set the value of the parameter using the private interface (set_parameter_value()), but this is equivalent to set it via the public interface directly.

Let us summarize all this with an example:

```
from mafw.processor import Processor, ActiveParameter

class MyFavProcessor(Processor):
    useful_param = ActiveParameter('useful_param', default=0, help_doc='Important␣
↪parameter')

# create your processor, initialize the parameter with a keyword argument.
my_fav = MyFavProcessor(useful_param=10)

# print the value of useful_param in all possible ways
print(my_fav.useful_param)
print(my_fav.get_parameter('useful_param').value)

# change the value of useful_param in all possible ways
my_fav.useful_param += 1
my_fav.get_parameter('useful_param').value += 1

print(my_fav.useful_param)

# access other fields of the parameter
print(my_fav.get_parameter('useful_param').doc)
```

This is the output that will be generated:

```
10
10
12
Important parameter
```

3.3.2 Parameter configuration

We have seen how to add flexibility to a processor including parameters, but how do you configure the parameters?

You have probably noticed that ActiveParameter has the possibility to pass a default value, that is a very good practice, especially for very advanced parameters that will remain untouched most of the time.

If you want to set a value for a parameter, the easiest way is via the processor *__init__* method. The basic Processor accepts any number of keyword arguments that can be used exactly for this purpose. Just add a keyword argument named after the parameter and the processor will take care of the rest.

Have a look at the example below covering both the case of Active and Passive parameters:

Listing 3.1: Parameter setting via kwargs

```
class MyProcessor(Processor):
    active_param = ActiveParameter('value', default=0, help_doc='An active parameter')
    active_string = ActiveParameter('string', default=0, help_doc='An active parameter')

my_p = MyProcessor(value=100, string='a better string', looper='single')

print(my_p.active_param)  # we get 100
assert my_p.active_param == 100

print(my_p.active_string)  # we get 'a better string'
assert my_p.active_string == 'a better string'
```

Note that the best way is to avoid to explicitly include the parameter names in the init signature. They will be collected anyhow through keyword arguments and registered automatically.

The second approach is to use a configuration object, it is to say a dictionary containing all the parameters key and value pairs. This is particularly handy when using a configuration file. Exactly for this reason, the configuration object can have one of the two following structures. In both cases the configuration object has to be passed to the class using the keyword *config*

Listing 3.2: Parameter setting via configuration object

```
@single_loop
class ConfigProcessor(Processor):
    p1 = ActiveParameter('param1', default='value')
    p2 = ActiveParameter('param2', default='value')


cp = ConfigProcessor(config=dict(param1='new_value', param2='better_value', param3='do not exists'))
assert cp.p1 == 'new_value'
assert cp.p2 == 'better_value'
dumped_config = cp.dump_parameter_configuration(option=2)
assert dumped_config == dict(param1='new_value', param2='better_value')

config = {'ConfigProcessor': {'param1': '1st', 'param2': '2nd'}}
cp = ConfigProcessor(config=config)
assert cp.p1 == '1st'
assert cp.p2 == '2nd'
dumped_config = cp.dump_parameter_configuration()
assert config == dumped_config
```

Note

Migration from MAFw v1 to v2

If you were using MAFw already in its early day of version 1, you might remember that users could also use `PassiveParameter` directly as processor parameters. They had the disadvantage of requiring the dot notation (*.value*) to access the data member, but everything else was identical to an `ActiveParameter`. This was a consequence of the implementation of the old parameter initialisation. This procedure has been totally reviewed in version 2 and now there is no need anymore to use `PassiveParameter`. On the contrary, the user is recommended not to use `PassiveParameter`, but only their active counterpart.

3.3.3 Saving parameter configuration

We have seen that we can configure processor using a dictionary with parameter / value pairs. This is very handy, because we can load toml file with the configuration to be used for all the processors we want to execute.

We don't want you to write toml file by hand, for this we have a function *dump_processor_parameters_to_toml()* that will generate an output file with all the parameter values.

But which value is stored? The default or the actual one? Good question! The actual answer is: *it depends*!

Let us have a look at the following example.

Listing 3.3: Processors definition

```
from mafw.processor import ActiveParameter, PassiveParameter

class ActiveParameterProcessor(Processor):
    """A processor with one active parameter."""

    active_param = ActiveParameter('active_param', default=-1,
                                   help_doc='An active parameter with default value -1
↪')


class AnotherActiveParameterProcessor(Processor):
    """Another processor with one active parameter."""

    active_param = ActiveParameter('active_param', default=-1,
                                   help_doc='An active parameter with default value -1
↪')
```

We have defined two different processors with one parameter each.

Now let us have a look at what happens when we attempt to dump the configuration of these processors.

Listing 3.4: Case 1: all processor types

```
processor_list = [ActiveParameterProcessor, AnotherActiveParameterProcessor]

dump_processor_parameters_to_toml(processor_list, 'test1.toml')
```

We have not created any instances of the two processors, and the processor_list consists of two classes. When passed to the *dump_processor_parameters_to_toml()* function, an instance of each class type is created and the parameter dictionary is retrieved. The creation of an instance is required because only after __init__ all parameters are registered.

Inside the function, the instances are created without passing any parameters, so it means that for all parameters the dumped value will be the initial value of the parameter, if specified, or the default value if a value is not given in the parameter definition.

The output of the *first example* will show the two processors with their parameters listed and connected to their default values.

Listing 3.5: Output of case 1: test1.toml

```
[ActiveParameterProcessor] # A processor with one active parameter.
active_param = -1 # An active parameter with default value -1

[AnotherActiveParameterProcessor] # Another processor with one active parameter.
active_param = -1 # An active parameter with default value -1
```

Now, let us take a step forward and add a bit more complexity to the situation. See the next snippet:

Listing 3.6: Case 2: mixed instances and classes

```
# create an instance of ActiveParameterProcessor with a specific value of the␣
↪parameter
# but we will include the class in the processor list.
active_processor_instance = ActiveParameterProcessor(active_param=100)

# create an instance of AnotherActiveParameterProcessor with a specific value of the␣
↪parameter
# and we will submit the instance
another_active_processor_instance = AnotherActiveParameterProcessor(active_param=101)


processor_list = [
    ActiveParameterProcessor,  # a class
    another_active_processor_instance,  # an instance
]
dump_processor_parameters_to_toml(processor_list, 'test2.toml')
```

This time we have a mixed list, the first item is a class, so the function will have to create an instance of this. The new instance created inside the dumping function will not have any parameter initial value specified in the constructor, so it will dump the default value -1. For the second one, since we are passing a living instance, the dumping function will use the actual value of the parameter, in this case 101.

Here is the produced configuration file:

Listing 3.7: Output of case 2: test2.toml

```
[ActiveParameterProcessor] # A processor with one active parameter.
active_param = -1 # An active parameter with default value -1

[AnotherActiveParameterProcessor] # Another processor with one active parameter.
active_param = 101 # An active parameter with default value -1
```

Ultimately, the values that will be output depends on the fact if you pass an instance of the processor or its class. But in the end, this is not really important because the user should dump TOML configuration files as a sort of template to be checked, modified and adapted by the user for a specific run.

3.3.4 Parameter and processor inheritance

Parameters, like any other class attributes and methods, can be inherited via subclassing and this can turn out to be very useful. Imagine to have a full class of processors having some parameters in common (the most simple example is the base path for the produced output), then the user might consider to have an intermediate subclass between MAFw Processor and their final Processors defining all these common parameters.

Have a look at the example below:

```
@single_loop
class BaseProcessor(Processor):
    my_param = ActiveParameter('my_param', default=5, help_doc='An integer value')

class SameDefaultProcessor(BaseProcessor):
    pass

class OtherDefaultProcessor(BaseProcessor):
    new_defaults = {'my_param': 885}

dump_processor_parameters_to_toml([BaseProcessor, SameDefaultProcessor,␣
↪OtherDefaultProcessor], 'test.toml')
```

All processors have a parameter names *my_param*. Since the parameter has been defined only once (in the base processor), it is born with the same default value for all subclasses. But this can be changed setting the processor instance variable *new_defaults* as done in the OtherDefaultProcessor. In fact, the TOML configuration file is exactly showing this situation:

```
[BaseProcessor]
my_param = 5 # An integer value

[SameDefaultProcessor]
my_param = 5 # An integer value

[OtherDefaultProcessor]
my_param = 885 # An integer value
```

3.3.5 Parameter typing

When creating an Active parameter, you have the option to directly specify the parameter's type using the typing template, but you can also do it, and probably in a simpler way assigning a reasonable default value. While this is not really important for numbers, it is extremely important if you want to interpret string as Path object.

If you declare the default value as a Path, for example Path.cwd(), then the string read from the configuration file will be automatically converted in a Path.

> **Note**
>
> If you intend to have a float parameter, use a decimal number, for example 0., as default, otherwise the interpreter will assume it is an integer and convert to int the parameter being read from the configuration file.

One more note about parameters. Theoretically speaking you could also have custom objects / classes as parameters, but this will become a problem when you will be loading the parameters from a TOML file. Actually two problems:

1. The TOML writer is not necessarily able to convert your custom type to a valid TOML type (number, string…). If your custom type has a relatively easy string representation then you can add an encoder to the TOML writer and teach it how to write your object. See for example the encoder for the Path object.

```python
def path_encoder(obj: Any) -> Item:
    """Encoder for PathItem."""
    if isinstance(obj, PosixPath):
        return PathItem.from_raw(str(obj), type_=StringType.SLB, escape=False)
    elif isinstance(obj, WindowsPath):
        return PathItem.from_raw(str(obj), type_=StringType.SLL, escape=False)
    else:
        raise ConvertError
```

2. Even though you managed to write your class to the TOML steering file, you have now the problem of reading back the steering file information and build your custom type with that.

One way to overcome this limitation might be to write to the steering file the `__repr__` of your custom class and at read back time to use eval to transform it back to your class. This below would be a more concrete implementation:

python

```python
import tomlkit
from tomlkit.items import  String, Item, ConvertError
from tomlkit.toml_file import TOMLFile
```

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```python

class MyClass:
    """A custom class to be used as a processor parameter"""
    def __init__(self, a, b):
        self.a = a
        self.b = b

    def __repr__(self):
        """IT MUST BE IMPLEMENTED"""
        return f"{self.__class__.__name__}({self.a}, {self.b})"

class MyClassItem(String):
    """TOML item representing a MyClass"""
    def unwrap(self) -> MyClass:
        return MyClass(*super().unwrap())

def my_class_encoder(obj: MyClassItem) -> Item:
    """Encoder for MyClassItem."""
    if isinstance(obj, MyClass):
        # we write the class as a string using the class repr.
        return MyClassItem.from_raw(repr(obj))
    else:
        raise ConvertError

# register the encoder
tomlkit.register_encoder(my_class_encoder)

# ------------------
# write to TOML file
# ------------------

my_class = MyClass(10,24)
doc = tomlkit.document()
doc.add('my_class', my_class)
doc.add('simple_i', 15)

with open('test.toml', 'w') as fd:
    tomlkit.dump(doc, fd)

# ------------------------
# read back from TOML file
# ------------------------

doc = TOMLFile('test.toml').read()
read_back_class = eval(doc['my_class'])
try:
    simple_i = eval(doc['simple_i'])
except TypeError:
    simple_i = doc['simple_i']

assert isinstance(read_back_class, MyClass)
assert read_back_class.a == my_class.a

assert isinstance(simple_i, int)
assert simple_i == 15
```

TOML

```
my_class = "MyClass(10, 24)"
simple_i = 15
```

This approach, even though possible, is rather risky, we all know how dangerous `eval` can be especially when using it directly with information coming from external files. Furthermore, it is worth considering whether having a custom class as a parameter in a processor is truly necessary. Often, there are simpler and safer alternatives available.

3.4 What's next

You reached the end of the first part. It means that by now you have understood what a processor is and how you can subclass the basic class to implement your analytical tasks, both with looping or single shot workflow. You learned a lot about parameters and how you can configure it.

The next section will be about chaining more processors one after the other using the *ProcessorList*.

CHAPTER 4

PROCESSOR EXAMPLES

From this page, you can see a few example of processors in order to simplify the creation of your first processor sub class.

4.1 Simple and looping processors

The first two examples of this library are demonstrating how you can implement a simple processor that execute all calculations in one go and a looping processor where you need to loop over a list of items to get either a cumulative results.

`AccumulatorProcessor` is calculating the sum of the first N integer numbers in a loop. The processor takes the *last_number* as an input to include and put the output in the *accumulated_value* parameter. This process is very inefficient, but it is here to demonstrate how to subclass a looping processor.

```
class AccumulatorProcessor(Processor):
    r"""
    A processor to calculate the sum of the first n values via a looping approach.

    In mathematical terms, this processor solves this easy equation:

    .. math::

        N = \sum_{i=0}^{n}{i}

    by looping. It is a terribly inefficient approach, but it works as a␣
↪demonstration of the looping structure.

    The user can get the results by retrieving the `accumulated_value` parameter at␣
↪the end of the processor
    execution.
    """

    last_value = ActiveParameter('last_value', default=100, help_doc='Last value of␣
↪the series')

    def __init__(self, *args, **kwargs):
        """Constructor parameters:

        :param last_value: The `n` in the equation above. Defaults to 100
        :type last_value: int
```

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```
        :param accumulated_value: The `N` in the equation above at the end of the process.
        :type accumulated_value: int
        """
        super().__init__(*args, **kwargs)
        self.accumulated_value: int = 0

    def start(self):
        """Resets the accumulated value to 0 before starting."""
        super().start()
        self.accumulated_value = 0

    def get_items(self) -> list[int]:
        """Returns the list of the first `last_value` integers."""
        return list(range(self.last_value))

    def process(self):
        """Increase the accumulated value by the current item."""
        self.accumulated_value += self.item
```

GaussAdder is calculating exactly the same result using the Gauss formula, eliminating the need for any looping. Indeed the looping is disabled and the output is the same.

```
class GaussAdder(Processor):
    r"""
    A processor to calculate the sum of the first n values via the so called *Gauss formula*.

    In mathematical terms, this processor solves this easy equation:

    .. math::

        N = \frac{n * (n - 1)}{2}

    without any looping

    The user can get the results by retrieving the `sum_value` parameter at the end of the processor
    execution.
    """

    last_value = ActiveParameter('last_value', default=100, help_doc='Last value of the series.')

    def __init__(self, *args, **kwargs):
        """
        Constructor parameters:

        :param last_value: The `n` in the equation above. Defaults to 100
        :type last_value: int
        :param sum_value: The `N` in the equation above.
        :type sum_value: int
        """
        super().__init__(looper=LoopType.SingleLoop, *args, **kwargs)
        self.sum_value: int = 0

```

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```
31     def start(self):
32         """Sets the sum value to 0."""
33         super().start()
34         self.sum_value = 0
35 
36     def process(self):
37         """Compute the sum using the Gauss formula."""
38         self.sum_value = int(self.last_value * (self.last_value - 1) / 2)
```

If you carefully look at line 28, you will notice that in the GaussAdder constructor, the looper option is set to SingleLoop and as we have *seen*, it means that that the processor will follow the single loop execution workflow.

The definition of the looper parameter in the init method can be sometimes hard to remember and unpractical especially if you have to overload the init method just to set the value of the looper. In such circumstances the use of a class decorator can be very handy. MAFw makes you available three class decorators for this purpose, to transform a processor in a `single loop`, a `for loop` or a `while loop`.

Using the decorator approach the GaussAdder above can be re-written in this way:

```
@single_loop
class GaussAdder(Processor):
    # the rest of the implementation remains the same
```

And here below is an example of execution of the two.

```
from mafw.examples.sum_processor import GaussAdder, AccumulatorProcessor

n = 35

# create the two processors
accumulator = AccumulatorProcessor(last_value=n)
gauss = GaussAdder(last_value=n)

# execute them
accumulator.execute()
gauss.execute()

# print the calculated results
print(accumulator.accumulated_value)
print(gauss.sum_value)
```

This will generate the following output:

```
595
595
```

4.2 Modify the *for loop* cycle using the `LoopingStatus`

In a looping processor, the `process()` method is invoked inside a loop, but the user can decide to skip a certain item and even to interrupt the (abort or quit) the loop.

The tool to achieve this is the `LoopingStatus`. This is set to Continue at the beginning of each iteration, but the user can turn it Skip, Abort or Quit inside the implementation of `process()`.

When set to Skip, a special callback is invoked `skip_item()` where the user can do actions accordingly. When set to Abort or Quit, the loop is broken and the user can decide what to do in the `finish()` method. Those two statuses seams to be redundant, but this gives the user the freedom to decide if everything was wasted (Abort) or if what done so far was still acceptable (Quit).

Here below is the implementation of a simple processor demonstrating such a functionality.

```python
class ModifyLoopProcessor(Processor):
    """
    Example processor demonstrating how it is possible to change the looping structure.

    It is a looping processor where some events will be skipped, and at some point one event will trigger an abort.
    """

    total_item: ActiveParameter[int] = ActiveParameter('total_item', default=100, help_doc='Total item in the loop.')
    items_to_skip: ActiveParameter[list[int]] = ActiveParameter(
        'items_to_skip', default=[12, 16, 25], help_doc='List of items to be skipped.'
    )
    item_to_abort: ActiveParameter[int] = ActiveParameter('item_to_abort', default=65, help_doc='Item to abort')

    def __init__(self, *args, **kwargs):
        """
        Processor Parameters:

        :param total_item: The total number of items
        :type total_item: int
        :param items_to_skip: A list of items to skip.
        :type items_to_skip: list[int]
        :param item_to_abort: The item where to trigger an abort.
        :type item_to_abort: int

        """
        super().__init__(*args, **kwargs)
        self.skipped_items: [list[int]] = []
        """A list with the skipped items."""

    def start(self):
        """Resets the skipped item container."""
        super().start()
        self.skipped_items = []

    def get_items(self) -> list[int]:
        """Returns the list of items, the range from 0 to total_item."""
        return list(range(self.total_item))

    def process(self):
        """Processes the item"""
        if self.item in self.items_to_skip:
            self.looping_status = LoopingStatus.Skip
            return
        if self.item == self.item_to_abort:
            self.looping_status = LoopingStatus.Abort
            return

    def skip_item(self):
        """Add skipped item to the skipped item list."""
        self.skipped_items.append(self.item)
```

And here below is how the processor can be used.

```python
import random
from mafw.examples.loop_modifier import ModifyLoopProcessor

# generate a random number corresponding to the last item
last_value = random.randint(10, 1000)

# get a sample with event to be skipped
skip_items = random.sample(range(last_value), k=4)

# find an event to abort after the last skipped one
max_skip = max(skip_items)
if max_skip + 1 < last_value:
    abort_item = max_skip + 1
else:
    abort_item = last_value - 1

# create the processor and execute it
mlp = ModifyLoopProcessor(total_item=last_value, items_to_skip=skip_items, item_to_abort=abort_item)
mlp.execute()

# compare the recorded skipped items with the list we provided.
assert mlp.skipped_items == list(sorted(skip_items))

# check that the last item was the abort item.
assert mlp.item == abort_item
```

4.3 For and while loop execution workflow

We have seen in the previous chapter that there are different type of loopers and in the previous section we have seen in practice the execution workflow of a single loop and a while loop processor.

In this example, we will explore the difference between the **for loop** and the **while loop** execution workflow. Both processors will run the `Processor.process()` method inside a loop, but for the former we will loop over a pre-established list of items, while for the latter we will continue repeating the process until a certain condition is valid.

Both processors will work with prime number and we will use this `helper function` to check if an integer number is prime or not.

```python
def is_prime(n: int) -> bool:
    """
    Check if n is a prime number.

    :param n: The integer number to be checked.
    :type n: int
    :return: True if n is a prime number. False, otherwise.
    :rtype: bool
    """
    prime = True
    if n < 2:
        prime = False
    elif n == 2:
        prime = True
    elif n % 2 == 0:
        prime = False
    else:
```

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```python
        sqrt_n = int(math.floor(math.sqrt(n)))
        for i in range(3, sqrt_n + 1, 2):
            if n % i == 0:
                prime = False

    return prime
```

The task of the **for loop** processor is to find all prime numbers included in a given user defined range of integer numbers. In other words, we want to find all prime numbers between 1000 and 2000, for example. The brute force approach is to start a loop on 1000, check if it is prime and if not check the next one until you get to 2000. If a number is actually prime, then store it in a list for further use.

For the sake of clarity, along with the *API documentation*, we are copying here also the processor source code.

```python
@for_loop
class FindPrimeNumberInRange(Processor):
    """
    An example processor to find prime numbers in the defined interval from ``start_from`` to ``stop_at``.

    This processor is meant to demonstrate the use of a for_loop execution workflow.

    Let us say we want to select only the prime numbers in a user defined range. One possible brute force approach is
    to generate the list of integers between the range extremes and check if it is prime or not. If yes,
    then add it to the list of prime numbers, if not continue with the next element.

    This is a perfect application for a loop execution workflow.
    """

    start_from = ActiveParameter('start_from', default=50, help_doc='From which number to start the search')
    stop_at = ActiveParameter('stop_at', default=100, help_doc='At which number to stop the search')

    def __init__(self, *args: Any, **kwargs: Any):
        """
        Processor parameters:

        :param start_from: First element of the range under investigation.
        :type start_from: int
        :param stop_at: Last element of the range under investigation.
        :type stop_at: int
        """
        super().__init__(*args, **kwargs)
        self.prime_num_found: list[int] = []
        """The list with the found prime numbers"""
```

This is the class definition with its constructor. As you can see, we have decorated the class with the *for loop decorator* even though it is not strictly required because the for loop is the default execution workflow.

We have added two processor parameters, the `start_from` and the `stop_at` to allow the user to specify a range on interest where to look for prime numbers.

In the init method, we create a list of integer to store all the prime numbers that we will finding during the process.

Now let us overload all compulsory methods for a **for loop** processor.

```python
def get_items(self) -> Collection[Any]:
    """
    Overload of the get_items method.

    This method must be overloaded when you select a for loop workflow.

    Here we generate the list of odd numbers between the start and stop that we need to check.
    We also check that the stop is actually larger than the start, otherwise we print an error message, and we
    return an empty list of items.

    :return: A list of odd integer numbers between start_from and stop_at.
    :rtype: list[int]
    """
    if self.start_from >= self.stop_at:
        log.critical('%s must be smaller than %s' % (self.start_from, self.stop_at))
        return []

    if self.start_from != 2 and self.start_from % 2 == 0:
        self.start_from += 1

    if self.stop_at != 2 and self.stop_at % 2 == 0:
        self.stop_at -= 1

    return list(range(self.start_from, self.stop_at, 2))
```

The get items method is expected to return a list of items, that will be processed by the *Processor.process()* method. It is absolutely compulsory to overload this method, otherwise the whole loop structure will not have a list to loop over.

And now, let us have a look at the three stages: start, process and finish.

```python
def start(self) -> None:
    """
    Overload of the start method.

    **Remember:** to call the super method when you overload the start.

    In this specific case, we just make sure that the list of found prime numbers is empty.
    """
    super().start()
    self.prime_num_found = []

def process(self) -> None:
    """
    The process method.

    In this case, it is very simple. We check if :attr:`.Processor.item` is a prime number, if so we added to the list,
    otherwise we let the loop continue.
    """
    if is_prime(self.item):
        self.prime_num_found.append(self.item)

def finish(self) -> None:
```

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```
    """
    Overload of the finish method.

    **Remember:** to call the super method when you overload the finish method.

    In this case, we just print out some information about the prime number found in the range.
    """
    super().finish()
    log.info(
        'Found %s prime numbers in the range from %s to %s'
        % (len(self.prime_num_found), self.start_from, self.stop_at)
    )
    if len(self.prime_num_found):
        log.info('The smallest is %s', self.prime_num_found[0])
        log.info('The largest is %s', self.prime_num_found[-1])
```

These three methods are the core of the execution workflow, so it is obvious that you have to overload them. Keep in mind to always include a call to the super method when you overload the start and finish because they perform some tasks also in the basic processor implementation. The code is written in a straightforward manner and includes clear, thorough explanations in the docstring.

The looping parameters: *Processor.i_item*, *Processor.n_item* and *Processor.item* can be used while implementing the *process()* and *finish()*. The *n_item* is calculated soon after the list of items is returned, while *item*, *i_item* are assigned in the for loop as the current item and its enumeration.

Optionally, one can overload the *format_progress_message()* in order to generate a nice progress message informing the user that something is happening. This is an example:

```
def format_progress_message(self) -> None:
    self.progress_message = (
        f'Checking integer number: {self.item}, already found {len(self.prime_num_found)} prime numbers'
    )
```

The task for the **while loop** processor is again about prime number finding but different. We want to find a certain number of prime numbers starting from an initial value. We cannot generate a list of integer number and loop over that in the *FindPrimeNumberInRange*, but we need to reorganize our workflow in order to loop until the number of found primes is equal to the requested one.

This is how such a task can be implemented using the while loop execution framework. You can find the example in the *API documentation* and an explanation of the here below.

Let us start again from the class definition.

```
@while_loop
class FindNPrimeNumber(Processor):
    """
    An example of Processor to search for N prime numbers starting from a given starting integer.

    This processor is meant to demonstrate the use of a while_loop execution workflow.

    Let us say we need to find 1000 prime numbers starting from 12347. One possible brute force approach to solve this
    problem is to start checking if the initial value is a prime number. If this is not the case, then check the next
    odd number. If it is the case, then add the current number to the list of found prime numbers and continue until
```

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```python
    the size of this list is 1000.

    This is a perfect application for a while loop execution workflow.
    """

    prime_num_to_find = ActiveParameter(
        'prime_num_to_find', default=100, help_doc='How many prime number we have to find'
    )
    start_from = ActiveParameter('start_from', default=50, help_doc='From which number to start the search')

    def __init__(self, *args: Any, **kwargs: Any):
        """
        Processor parameters:

        :param prime_num_to_find: The number of prime numbers to be found.
        :type prime_num_to_find: int
        :param start_from: The initial integer number from where to start the search.
        :type start_from: int
        """
        super().__init__(*args, **kwargs)
        self.prime_num_found: list[int] = []
        """The list with the found prime numbers"""
```

The first difference compared to the previous case is the use of the *while_loop()* decorator, this time it is really necessary to specify the processor *LoopType* because the while loop is not the default strategy.

The processor has two parameters, the number of prime number to find and from where to start. Similarly as before, in the init method, we define a list of integer to store all the prime numbers that we have found.

For while loop processor, we don't have a list of items, but we need to have a condition either to continue or to stop the loop. For this reason we need to overload the *while_condition()* method, keeping in mind that we return True if we want the cycle to continue for another iteration and False otherwise.

Here is the implementation of the *while_condition()* for the *FindNPrimeNumber*.

```python
def while_condition(self) -> bool:
    """
    Define the while condition.

    First, it checks if the prime_num_to_find is positive. Otherwise, it does not make sense to start.
    Then it will check if the length of the list with the already found prime numbers is enough. If so, then we can
    stop the loop return False, otherwise, it will return True and continue the loop.

    Differently from the for_loop execution, we are responsible to assign the value to the looping variables
    :attr:`.Processor.i_item`, :attr:`.Processor.item` and :attr:`.Processor.n_item`.

    In this case, we will use the :attr:`.Processor.i_item` to count how many prime numbers we have found and :attr:`.Processor.n_item`
    will be our target. In this way, the progress bar will work as expected.

    In the while condition, we set the :attr:`.Processor.i_item` to the current length of the found prime number list.

```

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```
    :return: True if the loop has to continue, False otherwise
    """
    if self.prime_num_to_find <= 0:
        log.warning('You requested to find a negative number of prime numbers. It makes no sense.')
        return False

    self.i_item = len(self.prime_num_found)
    return self.i_item < self.prime_num_to_find
```

For a while loop, it is not easy to define an enumeration parameter and also the total number of items might be misleading. It is left to the user to decide if they want to use them or not. If yes, their definition and incrementation is under their responsability. For this processor, it was natural to consider the requested number of primes as the *n_item* and consequently the value of *i_item* can be utilized to keep track of the quantity of prime numbers that have already been discovered. This choice is very convenient because then progress bar that uses *i_item* and *n_item* to calculate the progress will show the actual progress. In case, you do not have any way to assign a value to *n_item*, do not do it, or set it to None. In this way, the progress bar will display an indeterminate progress . You can set the value of *n_item* either in the *start()* or in the *while_condition()*, with a performance preference with the first option because it is executed only once before the start of the loop.

Here below is the implementation of the three stages.

```
def start(self) -> None:
    """
    The overload of the start method.

    **Remember:** The start method is called just before the while loop is started. So all instructions in this
    method will be executed only once at the beginning of the process execution. Always put a call to its `super`
    when you overload start.

    First, we empty the list of found prime numbers. It should not be necessary, but it makes the code more readable.
    Then set the :attr:`.Processor.n_item` to the total number of prime numbers we need to find. In this way, the progress bar
    will display useful progress.

    If the start value is smaller than 2, then let's add 2 to the list of found prime number and set our first
    item to check at 3. In principle, we could already add 3 as well, but maybe the user wanted to find only 1
    prime number, and we are returning a list with two, that is not what he was expecting.

    Since prime numbers different from 2 can only be odd, if the starting number is even, increment it already by
    1 unit.
    """
    super().start()
    self.prime_num_found = []
    self.n_item = self.prime_num_to_find
    if self.start_from < 2:
        self.prime_num_found.append(2)
        self.start_from = 3

    if self.start_from % 2 == 0:
```

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```python
        self.item = self.start_from + 1
    else:
        self.item = self.start_from

def process(self) -> None:
    """
    The overload of the process method.

    **Remember:** The process method is called inside the while loop. It has access to the looping parameters:
    :attr:`.Processor.i_item`, :attr:`.Processor.item` and :attr:`.Processor.n_item`.

    In our specific case, the process contains another while loop. We start by checking if the current
    :attr:`.Processor.item` is a prime number or not. If so, then we have found the next prime number, we add it to the list,
    we increment by two units the value of :attr:`.Processor.item` and we leave the process method ready for the next iteration.

    If :attr:`.Processor.item` is not prime, then increment it by 2 and check it again.
    """
    while not is_prime(self.item):
        self.item += 2
    self.prime_num_found.append(self.item)
    self.item += 2

def finish(self) -> None:
    """
    Overload of the finish method.

    **Remember:** The finish method is called only once just after the last loop interaction.
    Always put a call to its `super` when you overload finish.

    The loop is over, it means that the while condition was returning false, and now we can do something with our
    list of prime numbers.
    """
    super().finish()
    log.info('Found the requested %s prime numbers' % len(self.prime_num_found))
    log.info('The smallest is %s', self.prime_num_found[0])
    log.info('The largest is %s', self.prime_num_found[-1])
```

Let us have a look at the `FindNPrimeNumber.start()`. First of all we set the value of `Processor.n_item` to our target value of primes. We use the `Processor.item` to store the current integer number being tested, so we initialize it to start_from or the first not prime odd number following it. In the `FindNPrimeNumber.process()` we need to include another while loop, this time we need to check the current value of `Processor.item` if it is a prime number. If yes, then we add it to the storage list, we increment it by two units (*remember that for while loop processors it is your responsibility to increment the loop parameters*) and we get ready for the next loop iteration. As for the other processor, we `FindNPrimeNumber.finish()` printing some statistics.

4.4 Importing elements to the database

> **Note**
>
> This example is using concepts that have not yet been introduced, in particular the database. So in a first instance, you can simply skip it and come back later.

Importing elements in the database is a very common task, that is required in all analytical projects. To accomplish this task, mafw is providing a dedicated base class (the *Importer*) that heavily relies on the use of the *FilenameParser* to extract parameters from the filenames.

The *ImporterExample* is a concrete implementation of the base Importer that can be used by the user to get inspiration in the development of their importer subclass.

Before diving into the *ImporterExample* code analysis, we should understand the role and the functionality of other two helper classes: the *FilenameElement* and the *FilenameParser*.

4.4.1 Retrieving information from filenames

When setting up an experimental plan involving the acquisition of several data files, there are different approaches.

1. The **descriptive** approach, where the filename is used to store information about the measurement itself,
2. the **metadata** approach, where the same information are stored inside the file in a metadata section,
3. or the **logbook** approach, where the filename is just a unique identifier and the measurement information are stored in a logbook (another file, database, piece of paper…) using the same unique identifier.

The **descriptive** approach, despite being sometime a bit messy because it may end up with very long filenames, it is actually very practical. You do not need to be a hacker including the metadata in the file itself and you do not risk to forget to add the parameters to the logbook.

The tricky part is to include those information to the database containing all your experiments, and you do not want to do this by hand to avoid errors.

The best way is to use regular expression that is a subject in which python is performing excellently and MAFw is helping you with two helpers.

The first helper is the *FilenameElement*. This represents one single piece of information that is stored in the filename.

Let us assuming that you have a file named as `sample_12_energy_10_repetition_2.dat`. You can immediately spot that there are three different pieces of information stored in the filename. The sample name, the value of the energy in some unit that you should known, and the value of the repetition. Very likely there is also a repetition_1 file saved on disc.

In order to properly interpret the information stored in the filename, we need to define three *FilenameElement* s, one for each of them!

If you look at the documentation of the *FilenameElement*, you will see that you need four arguments to build it:

- its **name**, this is easy. Take one, and use it to name a named group in the regular expression.
- its **regular expression**, this is tricky. This is the pattern that python is using to read and parse the actual element.
- its **type**, this is the expected type for the element. It can be a string, an integer or a floating point number.
- its **default** value, this is used to make the element optional. It means that if the element is not found, then the default value is returned. If no default value is provided and the element is not found then an error is raised.

Let us see how you could use *FilenameElement* class to parse the example filename.

```
filename = 'sample_12_energy_10_repetition_2.dat'

sample = FilenameElement('sample', r'[_]*(?P<sample>sample_\d+)[_]*', value_type=str)
energy = FilenameElement('energy', r'[_]*energy_(?P<energy>\d+\.*\d*)[_]*', value_
↪type=float)
repetition = FilenameElement(
    'repetition', r'[_]*repetition_(?P<repetition>\d+)[_]*', value_type=int, default_
↪value=1
)

sample.search(filename)
assert sample.value == 'sample_12'

energy.search(filename)
assert energy.value == 10

repetition.search(filename)
assert repetition.value == 2
```

The interesting thing is that you can swap the position of the elements in the filename, for example starting with the energy, and it will still be working absolutely fine.

Just open a python interpreter, import the FilenameElement class and give it a try yourself to familiarize with the regular expression. Be careful, when you write the regular expression pattern, since it usually contains a lot of '\', it may be useful to prefix the string with a r, in order to inform python that what is coming must be interpreted as a raw string.

If you want to gain confidence with regular expressions, make some tests and understand their power, we recommend to play around with one of the many online tools available on the web, like pythex.

The *FilenameElement* is already very helpful, but if you have several elements in the filename, the readability of your code will quickly degrade. To help you further, you can enjoy the *FilenameParser*.

This is actually a combination of filename elements and when you will try to interpret the filename by invoking *interpret()* all of the filename elements will be parsed and thus you can retrieve all parameters in a much easier way.

If you look at the *FilenameParser* documentation, you will see that you need a configuration file to build an instance of it. This configuration file is actually containing the information to build all the filename element.

In the two tabs here below you can see the configuration file and the python code.

Parser configuration

```
# FilenameParser configuration file
#
# General idea:
#
# The file contains the information required to build all the FilenameElement␣
↪requested by the importer.
#
# Prepare a table for each element and in each table add the regexp, the type and␣
↪optionally the default.
# Adding the default field, will make the element optional.
#
# Add the table name in the elements array. The order is irrelevant. The division in␣
↪compulsory and optional elements
# is also irrelevant. It is provided here just for the sake of clarity.
#
# You can have as many element tables as you like, but only the one listed in the␣
```

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```
↪elements array will be used to
# configure the Importer.
#
elements = [
    # compulsory elements:
    'sample', 'energy',
    # optional elements:
    'repetition'
]


[sample]
regexp = '[_]*(?P<sample>sample_\d+)[_]*'
type='str'

[energy]
regexp = '[_]*energy_(?P<energy>\d+\.*\d*)[_]*'
type='float'

[repetition]
regexp = '[_]*repetition_(?P<repetition>\d+)[_]*'
type='int'
default = 1
```

Python test code

```
filename = 'energy_10.3_sample_12.dat'

parser = FilenameParser('example_conf.toml')
parser.interpret(filename)

assert parser.get_element_value('sample') == 'sample_12'
assert parser.get_element_value('energy') == 10.3
assert parser.get_element_value('repetition') == 1
```

The configuration file must contain a top level `elements` array with the name of all the filename elements that are included into the filename. For each value in `elements`, there must be a dedicated table with the same name containing the definition of the regular expression, the type and optionally the default value.

Important

In TOML configuration files, the use of single quotation marks allows to treat a string as a raw string, that is very important when passing expression containing backslashes. If you prefer to use double quotation marks, then you have to escape all backslashes.

The order of the elements in the `elements` array is irrelevant and also the fact we have divided them in compulsory and optional is just for the sake of clarity.

In the python tab, you can see how the use of *FilenameParser* makes your code looking much tidier and easier to read. In this second example, we have removed the optional specification of the `repetition` element and you can see that the parser is returning the default value of 1 for such element and we have swapped the energy field with the sample name. Moreover, now the energy field is actually a floating number with a decimal figure.

4.4.2 The basic importer

With the power of these two helper classes, building a processor for parsing all our measurement filenames is a piece of a cake. In the *processor_library* package, you can find a basic implementation of a generic *Importer* processor, that you can use as a base class for your specific importer.

The idea behind this importer is that you are interested in files inside an `input_folder` and possibly all its subfolders. You can force the processor to look recursively in all subfolder by turning the processor parameter `recursive` to True. The last parameter of this processor is the `parser_configuration` that is the path to the *FilenameParser* configuration file.

This configuration file is used during the *start()* method of *Importer* (or any of its subclasses) to configure its *FilenameParser*, so that you do not have to worry of this step. In your subclass process method, the filename parser will be straight away ready to use.

Let us have a loop and the *ImporterExample* processor (available in the *examples* package) for a concrete implementation of an importer processor.

4.4.3 The ImportExample processor

We will build a subclass of the *Importer* processor following the *for_loop* execution workflow.

In the *start()* method, we will assure that the target table in the database is existing. The definition of the target database Model (*InputElement* in this example) should be done in a separate database model module to facilitate import statements from other modules as well.

```
class InputElement(MAFwBaseModel):
    """A model to store the input elements"""

    element_id = AutoField(primary_key=True, help_text='Primary key for the input␣
↪element table')
    filename = FileNameField(unique=True, checksum_field='checksum', help_text='The␣
↪filename of the element')
    checksum = FileChecksumField(help_text='The checksum of the element file')
    sample = TextField(help_text='The sample name')
    exposure = FloatField(help_text='The exposure time in hours')
    resolution = IntegerField(default=25, help_text='The readout resolution in µm')
```

```
def start(self) -> None:
    """
    The start method.

    The filename parser is ready to use because it has been already configured in the␣
↪super method.
    We need to be sure that the input table exists, otherwise we create it from␣
↪scratch.
    """
    super().start()
    self.database.create_tables([InputElement])
```

In the *get_items()*, we create a list of all files, in this case matching the fact that the extension is *.tif*, included in the `input_folder`. We use the `recursive` flag to decide if we want to include also all subfolders.

The *steering* file may contain a GlobalFilter section (see *the Filter section*) and we use the new_only flag of the filter_register, to further filter the input list from all files that have been already included in the database. It is also important to check that the table is update because you may have an entry pointing to the same filename that in the mean time has been modified. For this purpose the *verify_checksum()* can be very useful. A more detailed explanation of this function will be presented in a *subsequent section*.

```
def get_items(self) -> Collection[Any]:
    r"""Retrieves the list of element to be imported.
```

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```
    The base folder is provided in the configuration file, along with the recursive␣
↪flags and all the filter options.

    :return: The list of items full file names to be processed.
    :rtype: list[Path]
    """
    pattern = '**/*tif' if self.recursive else '*tif'
    input_folder_path = Path(self.input_folder)

    file_list = [file for file in input_folder_path.glob(pattern) if file.is_file()]

    # verify the checksum of the elements in the input table. if they are not up to␣
↪date, then remove the row.
    verify_checksum(InputElement)

    if self.filter_register.new_only:
        # get the filenames that are already present in the input table
        existing_rows = InputElement.select(InputElement.filename).namedtuples()
        # create a set with the filenames
        existing_files = {row.filename for row in existing_rows}
        # filter out the file list from filenames that are already in the database.
        file_list = [file for file in file_list if file not in existing_files]

    return file_list
```

The *ImporterExample* follows an implementation approach that tries to maximise the efficiency of the database transaction. It means that instead of making one transaction for each element to be added to the database, all elements are collected inside a list and then transferred to the database with a cumulative transaction at the end of the process itself. This approach, as said, is very efficient from the database point of view, but it can be a bit more demanding from the memory point of view. The best approach depends on the typical number of items to be added for each run and the size of each element.

The implementation of the *process()* is rather simple and as you can see from the source code it is retrieving the parameter values encoded in the filename via the *FilenameParser*. If you are wondering why we have assigned the filename to the filename and to the checksum field, have a look at the section about *custom fields*.

```
def process(self):
    """
    The process method overload.

    This is where the whole list of files is scanned.

    The current item is a filename, so we can feed it directly to the FilenameParser␣
↪interpret command, to have it
    parsed. To maximise the efficiency of the database transaction, instead of␣
↪inserting each file
    singularly, we are collecting them all in a list and then insert all of them in␣
↪the :meth:`~.finish` method.

    In case the parsing is failing, then the element is skipped and an error message␣
↪is printed.
    """
    try:
        new_element = {}
        self._filename_parser.interpret(self.item.name)
        new_element['sample'] = self._filename_parser.get_element_value('sample_name')
```

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```
        new_element['exposure'] = self._filename_parser.get_element_value('exposure')
        new_element['resolution'] = self._filename_parser.get_element_value(
↪'resolution')
        new_element['filename'] = self.item
        new_element['checksum'] = self.item
        self._data_list.append(new_element)
    except ParsingError:
        log.critical('Problem parsing %s' % self.item.name)
        self.looping_status = LoopingStatus.Skip
```

The *finish()* is where the real database transaction is occurring. All the elements have been collected into a list, so we can use an insert_many statement to transfer them all to the corresponding model in the database. Since we have declared the filename field as unique (this was our implementation decision, but the user is free to relax this requirement), we have added a `on_conflict` clause to deal with the case the user is updating an entry with the same filename.

Since the *super method* is printing the execution statistics, we are leaving its call at the end of the implementation.

```
def finish(self) -> None:
    """
    The finish method overload.

    Here is where we do the database insert with a on_conflict_replace to cope with␣
↪the unique constraint.
    """
    # we are ready to insert the lines in the database
    InputElement.insert_many(self._data_list).on_conflict_replace(replace=True).
↪execute()

    # the super is printing the statistics, so we call it after the implementation
    super().finish()
```

CHAPTER 5

PROCESSORLIST: COMBINE YOUR PROCESSORS IN ONE GO

So far we have seen how a *Processor* can be coded to perform a simple task with a certain degree of generality offered by the configurable parameters. But analytical tasks are normally rather complex and coding the whole task in a single processor will actually go against the mantra of simplicity and code reusability of MAFw.

To tackle your complex analytical task, MAFw proposes a solution that involves chaining multiple processors together. The following processors can start where the previous one stopped so that like in a building game, scientists can put together their analytical solution with simple blocks.

From a practical point of view, this is achieved via the *ProcessorList* that is an evolution of the basic python list, which can contain only instances of processor subclasses or other ProcessorLists.

Once you have appended the processors in the order you want them to be executed, just call the *execute()* method of the list and it will take care of running all the processors.

As simple as that:

```python
def run_simple_processor_list():
    """Simplest way to run several processors in a go."""
    from mafw.examples.sum_processor import AccumulatorProcessor, GaussAdder
    from mafw.processor import ProcessorList

    # create the list. name and description are optional
    new_list = ProcessorList(name='AddingProcessor', description='Summing up numbers')

    # append the processors. you can pass parameters to the processors in the standard way
    max_value = 120
    new_list.append(AccumulatorProcessor(last_value=max_value))
    new_list.append(GaussAdder(last_value=max_value))

    # execute the list. This will execute all the processors in the list
    new_list.execute()

    # you can access single processors in the list, in the standard way.
    # remember that the ProcessorList is actually a list!
    assert new_list[0].accumulated_value == new_list[1].sum_value
```

5.1 The `ProcessorExitStatus`

We have seen in a *previous section* that the user can modify the looping behavior of a processor by using the `LoopingStatus` enumerator. In a similar manner, the execution loop of a processor list can be modified looking at the `ProcessorExitStatus` of each processors.

When one processor in the list is finishing its task, the `ProcessorList` is checking for its exit status before moving to the next item. If a processor is finishing with an Abort status, then the processor list will raise a `AbortProcessorException` that will cause the loop to be interrupted.

Let us have a look at the snippet here below:

```python
def run_processor_list_with_loop_modifier():
    """Example on deal with processors inside a processor list changing the loop structure.

    In this example there are two processors, one that will run until the end and the other that will set the looping
    status to abort half way. The user can see what happens when the :class:`~mafw.processor.ProcessorList` is executed.
    """
    import time

    from mafw.enumerators import LoopingStatus, ProcessorExitStatus, ProcessorStatus
    from mafw.mafw_errors import AbortProcessorException
    from mafw.processor import ActiveParameter, Processor, ProcessorList

    class GoodProcessor(Processor):
        n_loop = ActiveParameter('n_loop', default=100, help_doc='The n of the loop')
        sleep_time = ActiveParameter('sleep_time', default=0.01, help_doc='So much work')

        def get_items(self) -> list[int]:
            return list(range(self.n_loop))

        def process(self):
            # pretend to do something, but actually sleep
            time.sleep(self.sleep_time)

        def finish(self):
            super().finish()
            print(f'{self.name} just finished with status: {self.processor_exit_status.name}')

    class BadProcessor(Processor):
        n_loop = ActiveParameter('n_loop', default=100, help_doc='The n of the loop')
        sleep_time = ActiveParameter('sleep_time', default=0.01, help_doc='So much work')
        im_bad = ActiveParameter('im_bad', default=50, help_doc='I will crash it!')

        def get_items(self) -> list[int]:
            return list(range(self.n_loop))

        def process(self):
            if self.item == self.im_bad:
                self.looping_status = LoopingStatus.Abort
                return
            # let me do my job
```

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```
41            time.sleep(self.sleep_time)
42
43        def finish(self):
44            super().finish()
45            print(f'{self.name} just finished with status: {self.processor_exit_status.name}')
46
47    proc_list = ProcessorList(name='with exception')
48    proc_list.extend([GoodProcessor(), BadProcessor(), GoodProcessor()])
49    try:
50        proc_list.execute()
51    except AbortProcessorException:
52        print('I know you were a bad guy')
53    assert proc_list.processor_exit_status == ProcessorExitStatus.Aborted
54    assert proc_list[0].processor_exit_status == ProcessorExitStatus.Successful
55    assert proc_list[1].processor_exit_status == ProcessorExitStatus.Aborted
56    assert proc_list[2].processor_status == ProcessorStatus.Init
```

We created two processors, a good and a bad one. The good one is doing nothing, but getting till the end of its job. The bad one is also doing nothing but giving up before the end of the item list. In the process method, the bad processor is setting the looping status to abort, causing the for loop to break immediately and to call finish right away. In the processor finish method, we check if the status was aborted and in such a case we set the exit status of the processor to Aborted.

At line 47, we create a list and we populate it with three elements, a good, a bad and another good processor and we execute it inside a try/except block. The execution of the first good processor finished properly as you can see from the print out and also from the fact that its status (line 54) is Successful. The second processor did not behave, the exception was caught by the except clause and this is confirmed at line 55 by its exit status. The third processor was not even started because the whole processor list got stopped in the middle of processor 2.

5.2 Resources acquisition and distribution

While it may seems somewhat technical for this for this tutorial, it is worth highlighting an intriguing implementation detail. If you look at the constructor of the *Processor* class, you will notice that you can provide some resources, like the Timer and UserInterface even though we have never done this so far. The idea is that when you execute a single processor, it is fully responsible of creating the required resources by itself, using them during the execution and then closing them when finishing.

Just as an example, consider the case of the use of a database interface. The processor is opening the connection, doing all the needed transactions and finally closing the connection. This approach is also very practical because it is much easier to keep expectations under control.

If you run a *ProcessorList*, you may want to move the responsibility of handling the resources from the single Processor to the output ProcessorList. This approach allows all processors to share the same resources efficiently, eliminating the need to repeatedly open and close the database connection each time the ProcessorList advances to the next item.

You do not have to care about this shift in responsibility, it is automatically done behind the scene when you add a processor to the processor lists.

5.3 What's next

In this part we have seen how we can chain the execution of any number of processors all sharing the same resources. Moreover, we have seen how we can change the looping among different processors using the exit status.

Now it is time to move forward and see how you can add your own processor library!

CHAPTER 6

PLUGINS: IMPORT YOUR PROCESSORS

We are almost half-way through our tutorial on MAFw. We have learned what a *Processor* is and how we can create our own processors just by subclassing the base class. With the *ProcessorList* we have seen an easy way to chain the execution of many processors. So by now, you might be tempted to open your IDE and start coding stuff… But please hold on your horses for another minute, MAFw has much more to offer.

In the previous pages of this tutorial, we always coded our *processors* and then executed them manually, either from the python console or via an ad-hoc script. This is already helpful, but not really practical, because everytime you want to change which *processors* are executed or one of their parameters, we need to change the script code. This seems very likely the job for a configuration file, doesn't it?

MAFw is providing you with exactly this capability, a generic script that will read your configuration file (**steering file** in the MAFw language) and execute it. Here comes the problem, *how can the execution framework load your processors since they are not living in the same library*?

To this problem there are two solutions: a quick and dirty and a clean and effective! Of course you will have the tendency to prefer the first one, but really consider the benefits of the second one before giving up reading!

6.1 The quick and dirty: code inside MAFw

When you install MAFw on your system, you can always do it in development mode (for `pip` this corresponds to the *-e* option). In this way, you will be allowed to code your *processors* library directly inside your locally installed MAFw.

It is very quick, because you can start coding right away, but it is also rather dirty, because it will be much harder to install MAFw updates and after a while the project will become too big and messy.

For these and many other reasons, we are convinced that this is not the right way to go.

6.2 The clean and effective: turn your library into a plugin

It may seem more challenging than it actually is, but in reality, it is quite simple. MAFw uses the plugin system developed by pluggy, that is very powerful and at the same time relatively easy to deploy.

After you have installed MAFw in your system (you can do it in development mode if you want to contribute!), create a new project to store your processor. How to create a project is well described in details here with a step by step guide. You don't need to upload your package tp PyPI, you can stop as soon as you are able to build a wheel of your package and install it in a virtual environment.

To achieve this, you would need to have a *pyproject.toml* file, with the project metadata, the list of dependencies and other things. Here below is an example of what you should have:

Listing 6.1: An example of pyproject.toml for a plugin

```
1 [build-system]
2 requires = ["hatchling"]
3 build-backend = "hatchling.build"
4
5 [project]
6 name = "fantastic_analysis"
7 dynamic = ["version"]
8 description = 'My processor library'
9 readme = "README.md"
10 requires-python = ">=3.8"
11 license = "MIT"
12 keywords = []
13 authors = [
14   { name = "Surname Name", email = "this.is.me@my.domain.com" },
15 ]
16 classifiers = [
17   "Development Status :: 4 - Beta",
18   "Programming Language :: Python",
19   "Programming Language :: Python :: 3.8",
20   "Programming Language :: Python :: 3.9",
21   "Programming Language :: Python :: 3.10",
22   "Programming Language :: Python :: 3.11",
23   "Programming Language :: Python :: 3.12",
24   "Programming Language :: Python :: Implementation :: CPython",
25   "Programming Language :: Python :: Implementation :: PyPy",
26 ]
27
28 dependencies = ['mafw'] # plus all your other dependencies
29
30 [project.urls]
31 Documentation = "https://github.com/..."
32 Issues = "https://github.com/..."
33 Source = "https://github.com/."
34
35 ## THIS IS THE KEY PART
36 ## --------------------
37 # you can add as many lines you want to the table.
38 # always use unique names for the entry.
39
40 [project.entry-points.'mafw']
41 fantastic_analysis_plugin = 'fantastic_analysis.plugins'
42
43 [tool.hatch.version]
44 path = "src/fantastic_analysis/__about__.py"
```

Particularly important are lines 40 and 41. There you declare that when installed in an environment, your package is providing a plugin for MAFw, in particular this plugin that you named *fantastic_analysis_plugin* is located inside your package in a file named plugins.py.

So now, let us have a look at what do you have to have inside this file:

Listing 6.2: Example of plugins.py

```
"""
This is the module that will be exposed via the entry point declaration.

```

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```
Make sure to have all processors that you need to export in the list.
"""

import mafw
from mafw.processor import Processor
from fantastic_analysis import my_processor_lib

@mafw.mafw_hookimpl
def register_processors() -> list[mafw.processor.Processor]:
    return [my_processor_lib.Processor1, my_processor_lib.Processor2]
```

In this python file you need to import mafw in order to have access to the `mafw_hookimpl` decorator. This is a marker for pluggy so that it knows that this function should return something for the host application. The second import statement is needed only for the typing of the return value. The third one is to import your library with the processors. It can be one or as many as you have.

Inside the returned list, just put all the processors you want to export and the trick is done!

Now install in development mode your package and MAFw will be able to access all your processor library, without you having to do anything else!

6.2.1 Using a proxy instead of a real processor

Exporting all your processor is as easy as listing them in the *register_processors* hook. There is a limitation with this approach and it becomes clear as soon as you have many processors. Imagine to have a dozen of processors, each of them importing large modules (pandas, matplotlib, TensorFlow…). When MAFw will retrieve the processor list from your plugin, it will have to import your modules triggering the import of all other dependency. In other words, your calculation have not started yet and all the modules are imported, including the ones that are needed by processors that will not be executed!

The solution is to use a so-called *lazy proxy*, it is to say an object that will behave like the real processor class during the plugin discovery, but it will reify in the real processor when it is needed! If you are interested in the implementation, have a look at the proxy `API`.

The performance gain following this approach is really impressive and it cost you nothing. The code below is totally equivalent to the *previous one*, but faster!

Listing 6.3: Example of plugins.py with proxy

```
"""
This is the module that will be exposed via the entry point declaration.

Make sure to have all processors that you need to export in the list.
"""
import mafw
from mafw.lazy_import import LazyImportProcessor, ProcessorClassProtocol

@mafw.mafw_hookimpl
def register_processors() -> list[ProcessorClassProtocol]:
    return [
        LazyImportProcessor('fantastic_analysis.my_processor_lib', 'Processor1'),
        LazyImportProcessor('fantastic_analysis.my_processor_lib', 'Processor2')
    ]
```

Migration from MAFw v1.4

If you are migrating from v1.4 to v2, then you may have noticed that the plugin hook to export the standard tables has disappeared.

If fact, the standard table plugin became useless with the introduction of the `ModelRegister`, where all database Models are stored automatically. The same applies to models inheriting to `StandardTable`, so you can easily retrieve them via the `model register`.

Refer to these two other paragraphs: *Automatic model registration* and *Standard tables*.

6.3 What's next

If you are still reading this tutorial, it means that you are aware of the benefits that MAFw can bring to your daily analysis task. And the best part is, there is even more to discover! On the following section, you will discover how to efficiently manage your complex analytical process by simply listing all the sequential steps in a steering file.

CHAPTER 7

RUN YOUR PROCESSORS FROM THE COMMAND LINE

Now that you have a wonderful library of `processors` that are exported as plugins to MAFw, you can benefit from an additional *bonus*, the possibility to execute them without having to code any other line!

When you have installed *MAFw* in your environment, an executable file mafw has been put in your path, so that if you open a console and you activate the python environment, you can run it.

Just try something like this!

```
(env) C:\>mafw -v
mafw, version 0.0.5
```

If you get this message (the version number may vary), you are good to go. Otherwise, check that everything was installed correctly and try again.

This executable is rather powerful and can launch several commands (see the full documentation *here*), but for the time we will focus on three.

7.1 List the processors

Before doing anything else, it is important to check that your processor library has been properly loaded in MAFw. To check that, run the following command from the console.

```
(env) C:\>mafw list


                  Available processors (External Plugins = True)
        ┏━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━┓
        ┃ Processor Name        ┃ Package Name     ┃ Module                 ┃
        ┡━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━┩
        │ AccumulatorProcessor  │ mafw             │ examples.sum_processor │
        │ GaussAdder            │ mafw             │ examples.sum_processor │
        │ ModifyLoopProcessor   │ mafw             │ examples.loop_modifier │
        │ PrimeFinder           │ mafw_plugin_test │ prime_finder           │
        └───────────────────────┴──────────────────┴────────────────────────┘
                  Total processors = 4, internal = 3, external = 1
```

The output should be a table similar to the one above, containing a list of known processors in the first column, the package where they come from in the second and the module in the third one.

If you have exported your processors correctly the total external processors should be different from zero.

7.2 Prepare a generic steering file

The next step is to prepare a steering file. We do not want you to open your text editor and start preparing the TOML file from scratch. MAFw can prepare a generic template for you that you have to adapt to your needs before running.

```
(env) C:\>mafw steering steering-file.toml
A generic steering file has been saved in steering-file.toml.
Open it in your favourite text editor, change the processors_to_run list and save it.

To execute it launch: mafw run steering-file.toml.
```

This command is generating a generic steering file with a list of all processors available (internal to MAFw and imported from your library) with all their configurable parameters. You can pass the option *–show* to display the generated file on the console, or even more practical the *–open-editor* to open the steering file in your default editor so that you can immediately customize it.

Here below is an example of what you will get. The content may vary, but the ideas are the same.

Listing 7.1: An example of steering file.

```
1  # MAFw steering file generated on 2024-11-21 16:54:22.455297
2
3  # uncomment the line below and insert the processors you want to run from the available processor list
4  # processors_to_run = []
5
6  # customise the name of the analysis
7  analysis_name = "mafw analysis"
8  analysis_description = "Summing up numbers"
9  available_processors = ["AccumulatorProcessor", "GaussAdder", "ModifyLoopProcessor"]
10
11 [AccumulatorProcessor] # A processor to calculate the sum of the first n values via a looping approach.
12 last_value = 100 # Last value of the series
13
14 [GaussAdder] # A processor to calculate the sum of the first n values via the so called *Gauss formula*.
15 last_value = 100 # Last value of the series.
16
17 [ModifyLoopProcessor] # Example processor demonstrating how it is possible to change the looping structure.
18 item_to_abort = 65 # Item to abort
19 items_to_skip = [12, 16, 25] # List of items to be skipped.
20 total_item = 100 # Total item in the loop.
21
22 [UserInterface] # Specify UI options
23 interface = "rich" # Default "rich", backup "console"
```

The TOML file contains some tables and arrays that should be rather easy to understand. There is an important array at line 4 that you need to uncomment and to fill in with the `processors` that you want to run. For all known processors, there is table with all the configurable parameters, you can change them to your wishes. You do not need to remove the configuration information of the processors that you do not intend to use. They will be simply ignored.

If you have commented your `Processor` classes properly, the short description will appear next to the table.

You can customize the analysis name and short description to make the execution of the steering file a bit nicer. In the UserInterface section, you can change the way the processor will interact with you. If you are running the steering file on a headless HPC, then you do not need to have any fancy output. If you like to see progress bars and spinners moving, then select rich as your interface.

7.3 Run the steering file

Here we are, finally! Now we can run our analysis and enjoy the first results.

From the console type the following command:

```
(env) C:\>mafw run steering-file.toml
```

and enjoy the thrill of seeing your data being processed. From now on, you have a new buddy helping you with the analysis of your data, giving you more time to generate nice and interesting plots because MAFw will do all the boring stuff for you!

7.4 Debugging your processors

When you execute your processors from the command line using *mafw* and something does not work as expected, you may want to debug your processors to fix the problem. Normally you would turn back to your IDE and click on the debug run button to follow your code line by line and see where it fails.

The problem here is that the module where you have coded your processor is not *running*, it just contains the definition of the processor! You would need to create an instance of your processor and to execute it in a standalone way, but then you would have to set the parameters manually. In other words, it is going to be slow and problematic and MAFw wants to alleviate your problems, not to create new ones!

The best way is to run the mafw executable in debug mode from your IDE inserting a breakpoint in your processor code.

In PyCharm, you would create a new python configuration launching a module instead of a script. See the screenshot below.

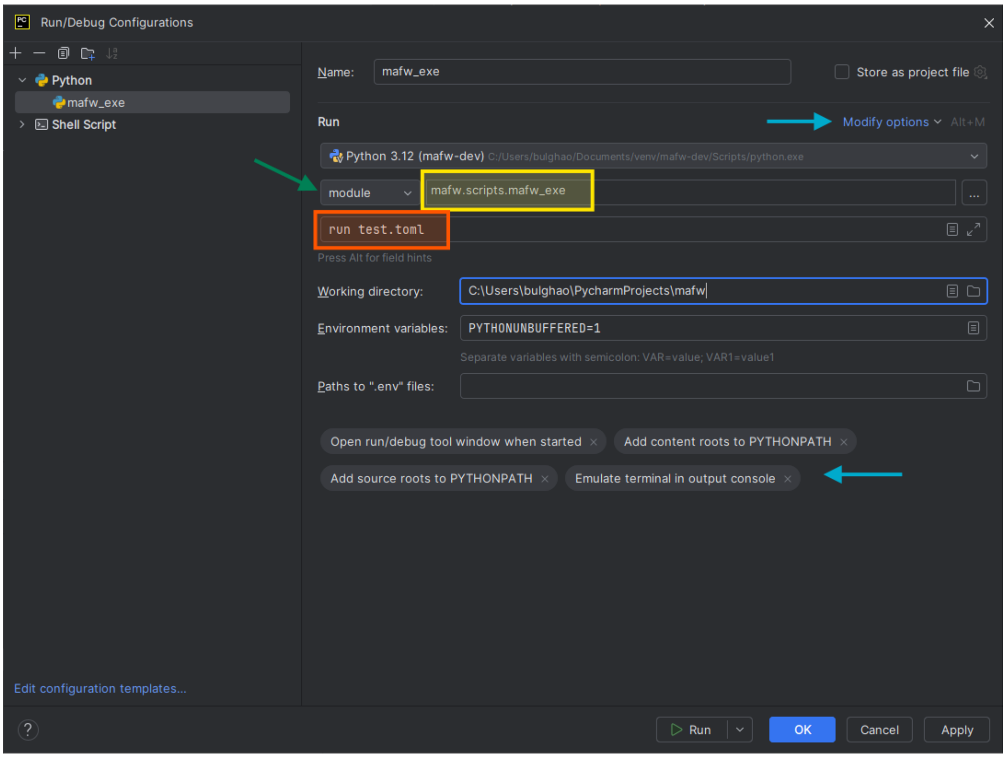

Fig. 7.1: The PyCharm configuration for running mafw_exe from your plugin module. It can be particularly helpful to execute your processor in debug mode.

The three most important points have been highlighted. First of all, you need to select module and not script from the drop down menu indicated by the green arrow. In the text field next to it (yellow in the screenshot), write *mafw.scripts.mafw_exe*. MAFw is installed in the environment where your plugins are living, so PyCharm will complete the module name while writing. In the text field below (orange in the screenshot) write the command line options as you were doing from the console. Optionally, if you want to enjoy the colorful output of the `RichInterface`, click on the *Modify options* (top blue arrow) and add *Emulate terminal in output console*. The corresponding label will appear in the bottom part as indicated by the blue arrow.

7.5 Running more instances of the same processor

Can I run the same processor twice? Of course, you can. MAFw is here to facilitate your life, not to make it even more difficult. In the steering file, you set the list of processor to be executed in the array *processors_to_run*. The execution workflow will follow exactly the order you enter the processor in the list. If you want to run the same processor twice, or multiple times, just put its name in the list in the position you want to run it.

If you want your multiple instances to use different processor parameter values, then have a look at the steering file below:

```
processors_to_run = ['MyProcessor', 'MyProcessor#1', 'MyProcessor#2']

[MyProcessor]
param1 = 'base_value'
param2 = 10

["MyProcessor#1"] # note the quotation around the name
param1 = 'value_1'
```

The processors_to_run array contains three elements, the first is our processor, while the other two are still our processors but we have added a # followed by a number (actually it could have been any other string, not necessarily a number). In MAFw terminology, the string after the # is called the `replica id` and it is used to identify uniquely a processor inside the steering file.

When *mafw* is executing the steering file, it will parse the elements in the processor_to_run array and instantiate each processors using the base name (the part on the left of the # sign). During the parameter configuration, each processor will look for a section with either its base name (MyProcessor in this case) or its *so-called* `replica aware name` (MyProcessor#1 and MyProcessor#2 in this example). By default, the parameter configuration follows a kind of *inheritance scheme*. It means that when a processor is listed with its replica_name, take 'MyProcessor#1' for example, the processor configuration will first load the base configuration and then update it with the replica specific one. In the case of MyProcessor#1, this will result in the value of param1 being set to 'value_1', while param2 will be 10. The last processor, 'MyProcessor#2' does not have a replica specific section, so it will use the parameter settings as defined in the base section.

Warning

TOML allows to have only alphanumeric digit plus dashes and underscores in a bare key. This means that section for replicas aware processors must be quoted otherwise the # will trigger a parsing error.

If you do not want to have this inheritance between the replica and the base configuration, you can switch it off for a single replica setting the keyword *__inheritance__* to false in its table like this:

```
["MyProcessor#2"]
__inheritance__ = false
```

In this case, the processor configuration will only use the parameters defined in the replica specific table. For all missing parameters, the default value defined in the code with of the `ActiveParameter` definition.

7.6 Grouping processors together

Another interesting features of the MAFw steering file is the possibility to join processors in groups, so that they will be added to the main *ProcessorList* as a nested *ProcessorList*. Imagine, for example, that in your pipeline you have several processors (or processor replicas) all dedicated to generate simulated data, and another group focused on the analysis of real data. You can then prepare a steering file like this:

```
processors_to_run = [ 'Simulation', 'RealData']
analysis_name = 'full-pipeline'
analysis_description = """Full pipeline"""

[Simulation]
name = 'simulation-pipeline' # optional
description = 'Simulation pipeline' # optional
processors_to_run = ['SimulProc#123', 'SimulProc1', 'PlotProcessor#Simul'] #
↪compulsory

[RealData]
name = 'real-data-pipeline'
description = 'Real data pipeline'
processors_to_run = ['RealDataProc', 'AnotherProcessor', 'PlotProcessor#Real']

# do not forget to add a section for each of the processors
```

This steering file will run the main processor list containing two other processor lists. The advantage is that if you decide to skip the simulation, you just have to remove one single item from the main processors_to_run variable. For each processor group you can optionally add a name and a description, while the processors_to_run list must be present all the time. You can even add groups to groups, the only thing you cannot do is do add a cyclic recursion; in such a case, MAFw will detect it and raise an error.

7.7 The exit code

The MAFw executable is always releasing an exit code when its execution is terminated. This exit code follows the standard convention of being 0 if the process was successful. Any other number is a symptom that something went wrong during the execution.

You will get an exit code different from 0 whenever, for example, you have not provided all the required parameters or they are invalid. You can also get an exit code different from 0 if your processor failed its execution.

Keep in mind that the *MAFwApplication* is actually dynamically generating and processing a *ProcessorList* according to the information stored in the `steering file`. The exit code for the whole app is linked to the output of the last executed processor in the list.

The reason for this is clearly explained. We have seen in a previous *section* that the execution of a *ProcessorList* can be modified using the *ProcessorExitStatus*. This parameter can assume three different values: **Successful**, **Failed** and **Aborted**. In MAFw convention, when a processor is aborted, then the execution of the processor list is immediately interrupted, thus resulting in the MAFw executable to return a no zero exit code.

On the contrary, when a processor exit status is Failed, the execution of the processor list is continued until the end of the list or the first processor terminating with an Abort status. The MAFw executable exit code is affected by the the processor exit status of the last executed processor, so it might be zero even if there were several processors with Failed exit status in the middle of the list.

The use of the exit code is particularly relevant if you want to execute MAFw on a headless cluster. You can, for example, trigger retry or logging actions when the execution fails.

7.8 Commands abbreviation

The MAFw executable is based on the very powerful click and allows the execution of complex nested commands with options and arguments.

You can get the list of available commands (for each level) using the `-h` option and keep in mind that MAFw allows you to shorten the command as long as the command selection will be unique, so actually `mafw list` and `mafw l` are both accepted and produce the same effect.

7.9 What's next

You believed we were done? Not really. We have just started, this was just the appetizer! Get ready for the next course, when we will enjoy the power of relational databases!

CHAPTER 8

DATABASE: YOUR NEW BUDDY!

As a scientist you are used to work with many software tools and often you need to write your own programs because the ones available do not really match your needs. Databases are not so common among scientists, we do not really understand why, but nevertheless their strength is beyond question.

The demonstration of the power and usefulness of a database assisted analysis framework will become clear and evident during our *tutorial* where we will build a small analytical experiment from scratch one step at the time.

For the time being, let us concentrate a bit on the technical aspect without delving too deeply into the specifics.

8.1 Database: one name, many implementations

Database is really a generic term and, from a technical point of view, one should try to be more specific and define better what kind of database we are talking about. We are not just referring to the brand or the producing software house: there are indeed different database architectures, but the one best suited for our application is the **relational database**, where each entity can be related directly to one or more other entities. You can read about relational databases on wikipedia for example, and if you find it too complicated, have a look at this shorter and easier version.

The software market is full of relational databases, from the very common MySQL to the very famous ORACLE, passing through the open source PostgreSQL to finish with SQLite the simplest and most used database in the world. As you may have guessed from their names, they are all sharing the same query language (*SQL*: structured query language), making it rather simple to have an abstract interface, that is to say a layer in between the user and the actual database that allows your code to work in the same way irrespectively of the specific implementation.

8.2 Peewee: a simple and small ORM

Of course there are also lots of different abstract interfaces, some more performing than the others. We have selected peewee, because it is lightweight, easy to understand and to use, and it works with several different implementations.

peewee is a ORM (promised this is the last acronym for this page!), it is to say an object relational mappers, or in simpler words a smart way to connect the tables in your database with python classes in your code. Have a look at this interesting article for a more detailed explanation.

peewee offers at least three different backends: SQLite, MySQL and PostgreSQL. If the size of your project is small to medium and the analysis is mainly performed on a single computer, then we recommend SQLite: the entire database will be living in a single file on your disc, eliminating the need for IT experts to set up a database server. If you are aiming for a much bigger project with distributed computing power, then the other two choices are probably equally good and your local IT helpdesk may suggest you what is best for your configuration and the available IT infrastructure. As you see, MAFw is always offering you a tailored solution!

Now, take a short break from this page, move to the peewee documentation and read the *Quickstart* section before coming back here.

8.2.1 Database drivers

If you have installed MAFw via pip without specifying the *all-db* optional features, then your python environment is very likely missing the python drivers to connect to MySQL and PostgreSQL. This is not a bug, but more a feature, because MAFw gives you the freedom to select the database implementation that fits your needs. Sqlite is natively supported by python, so you do not need to install anything extra, but if you want to use MySQL, PostgreSQL or any other DB supported by peewee than it is your responsibility to install in your environment the proper driver. Here you can find a list of DB driver compatible with peewee.

If you want, you can install MAFw adding the *all-db* optional feature and in this way the standard MySQL and PostgreSQL drivers will also be installed.

8.3 One class for each table

As mentioned before, the goal of an ORM is to establish a link between a database table and a python class. You can use the class to retrieve existing rows or to add new ones, and as always, you do not need take care of the boring parts, like establishing the connection, creating the table and so on, because this is the task of MAFw and we do it gladly for you!

Let us have a look together to the following example. We want a processor that lists recursively all files starting from a given directory and adds the filenames and the file hash digests to a table in the database.

Let us start with some imports

```
1  import datetime
2  from pathlib import Path
3
4  from peewee import DateTimeField, IntegerField, TextField
5
6  import mafw.processor
7  from mafw.db.db_configurations import db_scheme, default_conf
8  from mafw.db.db_model import MAFwBaseModel
9  from mafw.decorators import database_required
10 from mafw.tools.file_tools import file_checksum
```

The crucial one is at line 8, where we import `MAFwBaseModel` that is the base model for all the tables we want to handle with MAFw. Your tables **must inherit** from that one, if you want the `Processor` to take care of handling the link between the class and the table in the database. At line 4, we import some classes from peewee, that will define the columns in our model class and consequently in our DB table.

Now let us create the model class for our table of files.

```
class File(MAFwBaseModel):
    """The Model class representing the table in the database"""

    filename = TextField(primary_key=True)
    digest = TextField()
    creation_date = DateTimeField()
    file_size = IntegerField()
```

> **Note**
>
> A much better implementation of a similar class will be given *later on* demonstrating the power of custom defined fields.

As you can see the class definition is extremely simple. We define a class attribute for each of the columns we want to have in the table and we can choose the field type from a long list of available ones or we can even easily implement our owns. The role of a field is to adapt the type of the column from the native python type to the native database type and vice versa.

Our table will have just four columns, but you can have as many as you like. We will have one text field with the full filename, another text containing the hexadecimal hashlib digest of the file, the creation date for which we will use a datetime field, and finally a file_size field of integer type. We will be using the filename column as a primary key, because there cannot be two files with the same filename. On the contrary, there might be two identical files having the same hash but different filenames. According to many good database experts, using a not numeric primary key is not a good practice, but for our small example it is very practical.

If you do not specify any primary key, the ORM will add an additional number auto-incrementing column for this purpose. If you want to specify multiple primary keys, this is what you should do. If you want to create a model without a primary key, here is what you need to do.

The ORM will define the actual name of the table in the database and the column names. You do not need to worry about this!

And now comes the processor that will be doing the real work, it is to say, filling the File table.

```python
@database_required
class FillFileTableProcessor(mafw.processor.Processor):
    """Processor to fill a table with the content of a directory"""

    root_folder: Path = mafw.processor.ActiveParameter(
        'root_folder', default=Path.cwd(), help_doc='The root folder for the file listing'
    )

    def __init__(self, *args, **kwargs):
        """
        Constructor parameter:

        :param root_folder: ActiveParameter corresponding to the directory from
            where to start the recursive search
        :type root_folder: Path, Optional
        """
        super().__init__(*args, **kwargs)
        self.data: list[dict] = []

    def format_progress_message(self):
        self.progress_message = f'Upserting {self.item.name}'

    def start(self):
        """Starts the execution.

        Be sure that the table corresponding to the File model exists.
        It it does already exists, it is not a problem.
        """
        super().start()
        self.database.create_tables((File,))

    def get_items(self) -> list[Path]:
        """Retrieves the list of files.

        Insert or update the files from the root folder to the database

        :return: The list of full filename
        :rtype: list[Path]
        """
        file_list = []
        if self.root_folder.is_file():
            return [self.root_folder]
```

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```
43         elif self.root_folder.is_dir():
44             for f in self.root_folder.glob('**/*'):
45                 if f.is_file():
46                     file_list.append(f)
47         else:  # root_file is a glob
48             for f in self.root_folder.parent.glob(self.root_folder.name):
49                 file_list.append(f)
50         return file_list
51 
52     def process(self):
53         """Add all information to the data list"""
54         self.data.append(
55             dict(
56                 filename=str(self.item),
57                 digest=file_checksum(self.item),
58                 file_size=self.item.stat().st_size,
59                 creation_date=datetime.datetime.fromtimestamp(self.item.stat().st_
↪mtime),
60             )
61         )
62 
63     def finish(self):
64         """Transfers all the data to the File table via an atomic transaction."""
65         with self.database.atomic():
66             File.insert_many(self.data).on_conflict_replace().execute()
67         super().finish()
```

The first thing to notice is at line 1, where we used the decorator *database_required()*. The use of this decorator is actually not compulsory, its goal is to raise an exception if the user tries to execute the processor without having a properly initialized database.

At line 30, in the *start* method we ask the database to create the table corresponding to our *File* model. If the table already exists, then nothing will happen.

In the *process* method we will store all the information we have collected from the files into a list and we interact with the database only in the *finish* method. At line 65, we use a context manager to create an atomic transaction and then, at line 66, we insert in the *File* all our entries and in case a row with the same primary key exists, then it is replaced.

We could have used several different insert approaches, here below are few examples:

```
# create an instance of File with all fields initialized
new_file = File(filename=str(self.item),
              digest=file_checksum(self.item),
              file_size=self.item.stat().st_size,
              creation_date=datetime.datetime.fromtimestamp(self.item.stat().st_
↪mtime))
new_file.save() # new_file is now stored in the database

# create an instance of File and add the fields later
new_file = File()
new_file.filename = str(self.item)
new_file.digest = file_checksum(self.item)
new_file.file_size = self.item.stat().st_size
new_file.creation_data = datetime.datetime.fromtimestamp(self.item.stat().st_mtime)
new_file.save()

# create and insert directly
```

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```
new_file = File.create(filename=str(self.item),
              digest=file_checksum(self.item),
              file_size=self.item.stat().st_size,
              creation_date=datetime.datetime.fromtimestamp(self.item.stat().st_
↪mtime))
```

The approach to follow depends on various factor. Keep in mind that peewee operates by default in auto commit mode, meaning that for each database interaction, it creates a transaction to do the operation and it closes afterwards.

To be more performant from the database point of view, especially when you have several operations that can be grouped together, you can create an atomic transaction where the ORM will open one transaction only to perform all the required operations.

What we have done in the *finish* method is actually known as an upsert. It means that we will be inserting new items or updating them if they exist already.

8.4 Ready, go!

We have prepared the code, now we can try to run it. We can do it directly from a script

```
if __name__ == '__main__':
    database_conf = default_conf['sqlite']
    database_conf['URL'] = db_scheme['sqlite'] + str( Path.cwd() / Path('test.db'))

    db_proc = FillFileTableProcessor(root_folder =r'C:\Users\bulghao\Documents\
↪autorad-analysis\EdgeTrimming',
                                     database_conf=database_conf)

    db_proc.execute()
```

or in a more elegant way we can use the mafw app to run, but first we need to generate the proper steering file.

Console

```
c:\> mafw steering db-processor.toml
A generic steering file has been saved in db-processor.toml.
Open it in your favourite text editor, change the processors_to_run list and save it.

To execute it launch: mafw run db-processor.toml.
```

TOML

```
# MAFw steering file generated on 2024-11-24 22:13:38.248423

# uncomment the line below and insert the processors you want to run from the␣
↪available processor list
processors_to_run = ["FillFileTableProcessor"]

# customise the name of the analysis
analysis_name = "mafw analysis"
analysis_description = "Using the DB"
available_processors = ["AccumulatorProcessor", "GaussAdder", "ModifyLoopProcessor",
↪"FillFileTableProcessor", "PrimeFinder"]

[DBConfiguration]
URL = "sqlite:///file-db.db" # Change the protocol depending on the DB type. Update␣
```

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```
↪this file to the path of your DB.

[DBConfiguration.pragmas] # Leave these default values, unless you know what you are␣
↪doing!
journal_mode = "wal"
cache_size = -64000
foreign_keys = 1
synchronous = 0

[FillFileTableProcessor] # Processor to fill a table with the content of a directory
root_folder = 'C:\Users\bulghao\PycharmProjects\mafw' # The root folder for the file␣
↪listing

[UserInterface] # Specify UI options
interface = "rich" # Default "rich", backup "console"
```

If you look at the steering file, you will notice that there is a `DBConfiguration` section, where we define the most important variable, it is to say the DB URL. This is not only specifying where the database can be found, but also the actual implementation of the database. In this case, it will be a sqlite database located in the file `file-db.db` inside the current directory.

There is also an additional sub table, named pragmas, containing advanced options for the sqlite DB. Unless you really know what you are doing, otherwise, you should leave them as they are.

In the following *Configuring other types of databases*, we will cover the case you want to use another DB implementation different from SQLite.

In the `FillFileTableProcessor` you can find the standard configuration of its processor parameters.

Now we are really ready to run our first DB processor and with a bit of luck, you should get your DB created and filled.

How to check the content of a DB?

There are several tools serving this purpose. One of those is dbeaver that works with all kind of databases offering an open source community version that you can download and install.

8.4.1 Configuring other types of databases

In the previous example, we have seen how to configure a simple SQLite database. For this database, you just need to indicate in the URL field the path on the local disc where the database file is stored.

SQLite does not require any user name nor password and there are no other fields to be provided. Nevertheless, it is worth adding the previously mentioned pragmas section to assure the best functionality of peewee.

In the case of MySQL and PostgreSQL, the URL should point to the server where the database is running. This could be the localhost but also any other network destination. Along with the server destination, you need also to specify the port, the database name, the user name and the password to establish the connection.

Of course, it is not a good idea to write your database password as plain text in a steering file that might be shared among colleagues or even worse included in a Git repository. To avoid this security issue, it is recommended to follow some other authentication approach.

Both MySQL and PostgreSQL offers the possibility to store the password in a separate file, that, at least in linux, should have a very limited access right. Have a look at the exemplary steering files with the corresponding password files here below.

SQLite

```
[DBConfiguration]
URL = "sqlite:///file-db.db" # change the filename to the absolute path of the db

[DBConfiguration.pragmas] # Leave these default values, unless you know what you are␣
↪doing!
journal_mode = "wal"
cache_size = -64000
foreign_keys = 1
synchronous = 0
```

PostgreSQL

```
[DBConfiguration]
# Update the database server and the database name to reflect your configuration
URL = "postgresql://database-server:5432/database-name"

# change it to your username
user = 'username'

# if you want, you can leave the pragmas section from the SQLite default␣
↪configuration because it
# want be used.
```

Instruction on how to create a PostgreSQL password file are provided here. This is an example:

```
database-server:5432:database-name:username:password
```

MySQL

```
[DBConfiguration]
# Update the database server and the database name to reflect your configuration
URL = "mysql://database-server:3306/database-name"

# update to specify your username
user = 'username'

# update to specify the password file
read_default_file = '~/.my.cnf'

# if you want, you can leave the pragmas section from the SQLite default␣
↪configuration because it
# want be used.
```

Instruction on how to create a MySQL password file are provided here. This is an example:

```
[client]
user=username
password=password
host=database-server
```

8.5 The advantages of using MAFwBaseModel

In the previous code snippets we have implemented our Model classes as sub-class of *MAFwBaseModel*. This is not just a detail because *MAFwBaseModel* is offering some embedded advantages compared to the base model class of peewee. In the following subsections we will explicitly describe them all. For additional details, you can also read the API documentation of `MAFwBaseModel` and of `RegisteredMeta` the meta class where all this magic is taking place.

8.5.1 Automatic model registration

We will explain you the relevance of this point with an example.

Imagine that you have a processor that is performing some calculations; the processor can operate on real data or on simulated data following the same workflow, the only difference is that we will be taking input items from two different tables, one for real data and one for simulated data. Similarly we would like to save the output into two different tables.

The most convenient approach would be to set the input and output Models as processor parameters, but a Model is a python class and we could not provide this via our steering file. There we can imagine to provide a string representing the name of the corresponding DB table, but peewee is missing the capability to retrieve the Model class given the name of the corresponding DB table or the model name, the last possibility would be to build up a custom selection logic based on *if/else* blocks.

The automatic registration and the `mafw_model_register` are there exactly to fill this hole. When you define a new model class inheriting from `MAFwBaseModel`, this will be automatically added to model register and then you will be able to retrieve it using the `ModelRegister.get_model()` method[1].

Here is a little example to make it simpler.

db_model.py

```python
# file: db_model.py
# this is the module where all our models are defined

from peewee import IntegerField
from mafw.db_model import MAFwBaseModel

class MyRegisteredModel(MAFwBaseModel):
    integer_num = IntegerField(primary_key=True)
```

my_processor.py

```python
1  # file: my_processor.py
2  # this it the module where the processors are defined
3
4  from mafw.processor import Processor
5  from mafw.db.db_model import mafw_model_register
6
7  import db_model.py
8
9  class MyProcessor(Processor):
10     # put here all your definitions...
11     def get_items(self):
12         # we want to process all items in the input model.
13         input_model = mafw_model_register.get_model('my_registered_model')
14         return input_model.select()
```

In the my_processor.py file you can see how to retrieve a Model class from the register. You can use either the full table name or if you wish the Model name (MyRegisteredModel) as a key. It is important to notice line 7 where we import db_model with all our model definitions. This is necessary because the automatic registration occurs when the interpreter is processing the definition of a class inheriting from `MAFwBaseModel`. The imported module is actually not used in the processor, but we need to be sure that the interpreter has read the definition of the model. In a *following section*, you will see a smart method to avoid this useless import.

[1] The automatic registration of a class at his definition is a nice piece of syntactic sugar obtained via the use metaclasses. See the `API` for more.

Exclude from automatic registration

There might be cases, not many to be honest, in which you want a Model class not to be registered. A typical example is the case of a Model class used in your project as a base for all your models. It makes no sense to have this *abstract* model in the registry because you will never use it.

If you want to prevent the automatic registration then you simply have to specify it in the model definition as in the following example:

```
from mafw.db.db_model import MAFwBaseModel

class MyBaseModel(MAFwBaseModel, do_not_register=True):
    pass

class MyConcreteModel(MyBaseModel):
    pass
```

Have a look at the definition of MyBaseModel. Along with the specification of the base class, we provided as well the extra keyword argument *do_not_register*. In this example, MyBaseModel will not be registered in the `mafw_model_register`, while MyConcreteModel is.

Automatic import of db modules

Having the automatic registration is for sure a big step forward, something less for you to take care, but having to import the module with the model class definition is a bit annoying, in particular if your code is using a linter where unused_import (F401) are often automatically removed.

The idea is to use once again the plugin mechanism of MAFw to inform the runner (`mafw`), that the module including all the db models should be imported. This is how you can achieve this:

The *register_db_model_modules* is expected to return a list of module fully qualified module names. Those strings will be then automatically passed to the importlib.import_module function in order to be loaded. It is important that the string is properly formatted and the module is correctly spelled, otherwise MAFw will raise an ImportError.

8.5.2 Trigger support

The use of triggers and their advantages for an efficient and reliable data analysis will be discussed at length in the *following chapter*. Some special triggers can also be automatically generated as explained *here*.

8.5.3 Customizable table name

The default naming convention adopted by peewee is to transform the CamelCase model name is a snake_case table name. Unless you want to access the tables using low level SQL statements or from an external tool like dbeaver, then knowing the actual table name is not very important.

Peewee offers the possibility to customize the table names and MAFwBaseModel expand this even further, with the possibility to add a prefix, a suffix or both to the camel_case table name. This feature is very handy when you are handling a large database with several tens of tables. When browsing the database index from dbeaver, tables are normally sorted in alphabetical order and thus finding a specific table can be frustrating. You may want to prefix all the tables belonging to a specific part of your experiment with a given word, in order to have them all grouped together[2].

This is how:

```
from mafw.db.db_model import MAFwBaseModel

class SimulationModel(MAFwBaseModel, do_not_register=True):
    class Meta:
        prefix = 'simul'
```

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[2] MySQL does not directly support adding WHEN conditions to the trigger, but a similar behaviour is obtainable using an IF statement in the trigger SQL body. This adaptation is automatically implemented by the `MySQLDialect`.

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```
class SimulationResult(SimulationModel):
    # put here your fields
    pass

class DataModel(MAFwBaseModel, do_not_register=True):
    class Meta:
        prefix = 'data'

class DataResult(DataModel):
    # put here your fields
    pass
```

In this example we have defined two base models (that are not registered automatically), one for simulation and one for real data results. In the Meta class definition of the two base models we have assigned a value to the attribute `prefix`. This attribute will be inherited by all their subclasses, so that the table name corresponding to SimulationResult will be *simul_simulation_result*. A similar effect can be obtained setting the `suffix` parameter.

See also

See also `make_prefixed_suffixed_name()` for more details on the naming convention.

8.5.4 Automatic table creation

In our first *processor using the database*, we have created the table corresponding to the File model manually in the start method. This operation must be done before we try to access the content of the table, otherwise the database will generate an error. If a table is already existing, then the create_table command is actually ignored.

One of the biggest advantage of inheriting from `MAFwBaseModel` is that the creation of all models can be automatized by using a processor included in MAFw library: the `TableCreator`. You can simply include this processor in your TOML steering file, possibly as a first processor in the list and afterwards you can forget about creating tables.

This processor is customizable via two parameters:

1. *apply_only_to_prefix*: allows to restrict the creation of tables whose name is starting with a given prefix. More than one prefix can be provided.
2. *force_recreate*: will force the tables to be recreated in the case they are already existing. This is rather **dangerous** because, the processor will actually drop all tables before creating them causing the loss of all your data. Use it with extreme care!!!

You still have the freedom to disable this automatic feature by setting the *automatic_creation* flag in the Meta class to False, like in this example:

```
from mafw.db.db_model import MAFwBaseModel

class NoAutoModel(MAFwBaseModel):
    # put here your fields
    class Meta:
        automatic_creation = False
```

Remember: only registered models can have tables automatically created. If you decided not to register a model, then you will have to manually create the corresponding table before using it.

8.6 Triggers: when the database works on its own

In the next paragraphs we will spend a few minutes understanding the roles of Triggers. Those are database entities performing some actions in response of specific events. You can have, for example, a trigger that is inserting a row in TableB whenever a row is inserted in TableA. If you are not really familiar with triggers, this is a brief introduction.

Triggers are very handy for many applications, and in our *tutorial* we will see an interesting case, but they tend to struggle with ORM in general. In fact, no ORM system is natively supporting triggers. The reason is very simple. In an ORM, the application (the python code, if you wish) is the main actor and the database is just playing the role of the passive buddy. From the point of view of an ORM based application, if you want to have a trigger, then just write the needed lines of python code to have the actions performed in the other tables. It makes totally sense, you have only one active player and it simplifies the debugging because if something is going wrong, it can only be a fault of the application.

The standard implementation of trigger-like functions with ORM is to use signals, where you can have callbacks called before and after high level ORM APIs calls to the underlying database. Signals are good, but they are not free from disadvantages: at a first glance, they look like a neat solution, but as soon as the number of callbacks is growing, it may become difficult to follow a linear path in the application debugging. Second, if you do a change in the database from another application, like the dbeaver browser, then none of your codified triggers will be executed. Moreover in the case of Peewee, signals work only on Model instances, so all bulk inserts and updates are excluded.

Having triggers in the database would assure that irrespectively of the source of the change, they will always be executed, but as mentioned above, the user will have to be more careful in the debug because also the database is now playing an active role.

We let you decide what is the best solution. If you want to follow the pure ORM approach, then all models inheriting from `MAFwBaseModel` have the possibility to use signals. If you want to have triggers, you can also do so. An example for both approaches is shown here below.

8.6.1 The signal approach

As mentioned above, the signal approach is the favourite one if you plan to make all changes to the database only via your python code. If you are considering making changes also from other applications, then you should better use the trigger approach.

Another limitation is that only model instances emit signals. Everytime you use a *classmethod* of a Model, then no signals will be emitted.

The signal dispatching pattern functionality is achieved by linking the signal emitted by a sender in some specific circumstances to a handler that is receiving this signal and performing some additional operations (not necessarily database operations).

Every model class has five different signals:

1. **pre_save**: emitted just before that a model instance is saved;
2. **post_save**: emitted just after the saving of a model instance in the DB;
3. **pre_delete**: emitted just before deleting a model instance in the DB;
4. **post_delete**: emitted just after deleting a model instance from the DB;
5. **pre_init**: emitted just after the init method of the class is invoked. Note that the *pre* is actually a *post* in the case of init.

Let us try to understand how this works with the next example.

Listing 8.1: A test with signal

```python
class MyTable(MAFwBaseModel):
    id_ = AutoField(primary_key=True)
    integer = IntegerField()
    float_num = FloatField()
```

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```python

class TargetTable(MAFwBaseModel):
    id_ = ForeignKeyField(MyTable, on_delete='cascade', primary_key=True, backref='half')
    another_float_num = FloatField()

    @post_save(sender=MyTable, name='my_table_after_save_handler')
    def post_save_of_my_table(sender: type(MAFwBaseModel), instance: MAFwBaseModel, created: bool):
        """
        Handler for the post save signal.

        The post_save decorator is taking care of making the connection.
        The sender specified in the decorator argument is assuring that only signals generated from MyClass will be
        dispatched to this handler.

        The name in the decorator is optional and can be use if we want to disconnect the signal from the handler.

        :param sender: The Model class sending this signal.
        :type sender: type(Model)
        :param instance: The actual instance sending the signal.
        :type instance: Model
        :param created: Bool flag if the instance has been created.
        :type created: bool
        """
        TargetTable.insert({'id__id': instance.id, 'another_float_num': instance.float_num / 2}).execute()

database: Database = SqliteDatabase(':memory:', pragmas=default_conf['sqlite']['pragmas'])
database.connect()
database_proxy.initialize(database)
database.create_tables([MyTable, TargetTable], safe=True)

MyTable.delete().execute()
TargetTable.delete().execute()

# insert a single row in MyTable with the save method.
my_table = MyTable()
my_table.integer = 20
my_table.float_num = 32.16
my_table.save()
# after the save query is done, the signal mechanism will call the
# post_save_trigger_of_my_table and perform an insert on the target
# table as well.
assert MyTable.select().count() == 1
assert TargetTable.select().count() == 1

# add some bulk data to MyTable
data = []
for i in range(100):
    data.append(dict(integer=random.randint(i, 10 * i), float_num=random.gauss(i, 2 * i)))
MyTable.insert_many(data).execute()
```

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```
54 # this is done via the Model class and not via a concrete instance of the Model, so no signals will be emitted.
55
56 assert MyTable.select().count() == 101
57 assert TargetTable.select().count() == 1
```

We created two tables linked via a foreign key. The goal is that everytime we fill in a row in `MyTable`, a row is also added to TargetTable with the same id but where the value of another_float_num is just half of the original float_num. The example is stupid, but it is good enough for our demonstration.

The signal part is coded in the lines from 11 to 28 (mainly doc strings). We use the `post_save` decorator to connect MyTable to the `post_save_of_my_table` function where an insert in the TargetTable will be made.

The code is rather simple to follow. Just to be sure, we empty the two tables, then we create an instance of the MyTable model, to set the integer and the float_num column. When we save the new row, the post_save signal of MyTable is emitted and the handler is reacting by creating an entry in the TargetTable as well. In fact the number of rows of both tables are equal to 1.

What happens later is to demonstrate the weak point of signals. At line 53, we insert several rows via a `insert_many`. It must be noted that the insert_many is a classmethod applied directly to the model class. The consequence is that the signal handler will not be invoked and no extra rows will be added to the TargetTable.

8.6.2 The trigger approach

In order to use a trigger you need to create it. This is an entity that lives in the database, so you would need the database itself to create it.

MAFw is providing a *Trigger* class that helps you in creating the required SQL query that needed to be issued in order to create the trigger. Once it is created it will operate continuously.

If you have a look at the CREATE TRIGGER SQL command you will see that it starts with the definition of when the trigger is entering into play (BEFORE/AFTER) and which operation (INSERT/DELETE/UPDATE) of which table. Then there is a section enclosed by the BEGIN and END keywords, where you can have as many SQL queries as you like.

The same structure is reproduced in the *Trigger* class. In the constructor, we will pass the arguments related to the configuration of the trigger itself. Then you can add as many SQL statement as you wish.

Python

Listing 8.2: python Trigger class

```python
from mafw.db.db_model import Trigger

new_trigger = Trigger('trigger_after_update', (TriggerWhen.After,
        TriggerAction.Update), 'my_table', safe=False, for_each_row=False)
new_trigger.add_sql('INSERT INTO another_table (col1, col2) VALUES (1, 2)')
new_trigger.add_sql('INSERT INTO third_table (col1, col2) VALUES (2, 3)'))
new_trigger.create()
```

SQL

Listing 8.3: emitted SQL

```sql
CREATE TRIGGER trigger_after_update
AFTER UPDATE  ON my_table

BEGIN
    INSERT INTO another_table (col1, col2) VALUES (1, 2);
```

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```
    INSERT INTO third_table (col1, col2) VALUES (2, 3);
END;
```

Now let us have a look at how you can use this, following one of our test benches.

Standalone triggers

Listing 8.4: A test Trigger created manually

```
1  def test_manually_created_trigger():
2      class MyTable(MAFwBaseModel):
3          id_ = AutoField(primary_key=True)
4          integer = IntegerField()
5          float_num = FloatField()
6  
7      class TargetTable(MAFwBaseModel):
8          id_ = ForeignKeyField(MyTable, on_delete='cascade', primary_key=True, backref='half')
9          half_float_num = FloatField()
10 
11     database: Database = SqliteDatabase(':memory:', pragmas=default_conf['sqlite']['pragmas'])
12     database.connect()
13     database_proxy.initialize(database)
14     database.create_tables([MyTable, TargetTable], safe=True)
15 
16     MyTable.delete().execute()
17     TargetTable.delete().execute()
18 
19     # manually create a trigger
20     trig = Trigger('mytable_after_insert', (TriggerWhen.After, TriggerAction.Insert), MyTable, safe=True)
21     trig.add_sql('INSERT INTO target_table (id__id, half_float_num) VALUES (NEW.id_, NEW.float_num / 2)')
22     database.execute_sql(trig.create())
23 
24     # add some data for testing to the first table
25     data = []
26     for i in range(100):
27         data.append(dict(integer=random.randint(i, 10 * i), float_num=random.gauss(i, 2 * i)))
28     MyTable.insert_many(data).execute()
29 
30     # check that the target table got the right entries
31     for row in MyTable.select(MyTable.float_num, TargetTable.half_float_num).join(TargetTable).namedtuples():
32         assert row.float_num == 2 * row.half_float_num
33 
34     assert MyTable.select().count() == TargetTable.select().count()
```

In lines 20 - 22, we create a trigger and we ask the database to execute the generated SQL statement.

We insert 100 rows using the insert many class method and the trigger is doing its job in the background filling the other table. We can check that the values in the two tables are matching our expectations.

The drawback of this approach is that you may have triggers created all around your code, making your code a bit messy.

Model embedded triggers

An alternative approach is to define the trigger within the Model class, allowing it to be created simultaneously with model table. This is demonstrated in the code example below.

Listing 8.5: A test Trigger created within the Model

```
1  # the trigger is directly defined in the class.
2  class MyTable(MAFwBaseModel):
3      id_ = AutoField(primary_key=True)
4      integer = IntegerField()
5      float_num = FloatField()
6  
7      @classmethod
8      def triggers(cls):
9          return [
10             Trigger('mytable_after_insert', (TriggerWhen.After, TriggerAction.Insert),
   ↪ cls, safe=True).add_sql(
11                 'INSERT INTO target_table (id__id, half_float_num) VALUES (NEW.id_,␣
   ↪NEW.float_num / 2)'
12             )
13         ]
14 
15 class TargetTable(MAFwBaseModel):
16     id_ = ForeignKeyField(MyTable, on_delete='cascade', primary_key=True, backref=
   ↪'half')
17     half_float_num = FloatField()
18 
19 database: Database = SqliteDatabase(':memory:', pragmas=default_conf['sqlite'][
   ↪'pragmas'])
20 database.connect()
21 database_proxy.initialize(database)
22 database.create_tables([MyTable, TargetTable], safe=True)
```

This approach is much cleaner. The Trigger is stored directly in the Model (lines 8 - 13). In the specific case, the triggers method returned one trigger only, but you can return as many as you like. When the tables are created (line 22), all the triggers will also be created.

In the example above, you have written the SQL statement directly, but nobody is preventing you to use peewee queries for this purpose. See below, how exactly the same trigger might be re-written, using an insert statement:

Listing 8.6: A test Trigger created within the Model using an Insert statement

```
class MyTable(MAFwBaseModel):
    id_ = AutoField(primary_key=True)
    integer = IntegerField()
    float_num = FloatField()

    @classmethod
    def triggers(cls):
        trigger = Trigger('mytable_after_insert', (TriggerWhen.After, TriggerAction.
↪Insert), cls, safe=True)
        sql = TargetTable.insert(id_=SQL('NEW.id_'), half_float_num=SQL('NEW.float_
↪num/2'))
        trigger.add_sql(sql)
        return [trigger]

    class Meta:
```

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```
14        depends_on = [TargetTable]
```

The key point here is at line 9, where the actual insert statement is generated by peewee (just for your information, you have generated the statement, but you have not *execute it*) and added to the existing trigger.

In the last two highlighted lines, we are overloading the Meta class, specifying that MyTable, depends on TargetTable, so that when the create_tables is issued, they are built in the right order. This is not necessary if you follow the previous approach because the trigger will be very likely executed only after that the tables have been created.

> **Warning**
>
> Even though starting from MAFw release v1.1.0, triggers are now properly generated for the three main *database backends*, its use has been deeply tested only with SQLite. For this reason, we (MAFw developers) encourage the user community to work also with other DBs and, in case, submit bugs or feature request.

Disabling triggers

Not all database implementations provide the same option to temporarily disable one or more triggers. In order to cope with this limitation, MAFw is providing a general solution that is always working independently of the concrete implementation of the database.

The standard SQL trigger definition allows to have one or more WHEN clauses[3], meaning that the firing of a trigger script might be limited to the case in which some other external conditions are met.

In order to achieve that, we use one of our *standard tables*, that are automatically created in every MAFw database.

This is the TriggerStatus table as you can see it in the snippet below:

Listing 8.7: TriggerStatus model

```python
class TriggerStatus(StandardTable):
    """A Model for the trigger status"""

    trigger_type_id = AutoField(primary_key=True, help_text='Primary key')
    trigger_type = TextField(
        help_text='You can use it to specify the type (DELETE/INSERT/UPDATE) or the name of a specific trigger'
    )
    status = BooleanField(default=True, help_text='False (0) = disable / True (1) = enable')

    # noinspection PyProtectedMember
    @classmethod
    def init(cls) -> None:
        """Resets all triggers to enable when the database connection is opened."""
        data = [
            dict(trigger_type_id=1, trigger_type='DELETE', status=True),
            dict(trigger_type_id=2, trigger_type='INSERT', status=True),
            dict(trigger_type_id=3, trigger_type='UPDATE', status=True),
            dict(trigger_type_id=4, trigger_type='DELETE_FILES', status=True),
        ]

        # this is used just to make mypy happy
        # cls and meta_cls are exactly the same thing
        meta_cls = cast(PeeweeModelWithMeta, cls)
```

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[3] In some databases, like mysql, one can use the *schema* to group tables together.

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```
        db_proxy = meta_cls._meta.database
        if isinstance(db_proxy, peewee.DatabaseProxy):
            db = cast(peewee.Database, db_proxy.obj)
        else:
            db = cast(peewee.Database, db_proxy)

        if isinstance(db, peewee.PostgresqlDatabase):
            cls.insert_many(data).on_conflict(
                'update', conflict_target=[cls.trigger_type_id], update={cls.status:␣
↪True}
            ).execute()
        else:
            cls.insert_many(data).on_conflict_replace().execute()
```

You can use the `trigger_type` column to specify a generic family of triggers (DELETE/INSERT/UPDATE) or the name of a specific trigger. By default a trigger is active (status = 1), but you can easily disable it by changing its status to 0.

To use this functionality, the Trigger definition should include a WHEN clause as described in this modified model definition.

Listing 8.8: Trigger definition with when conditions.

```
class MyTable(MAFwBaseModel):
    id_ = AutoField(primary_key=True)
    integer = IntegerField()
    float_num = FloatField()

    @classmethod
    def triggers(cls):
        return [
            Trigger('mytable_after_insert', (TriggerWhen.After, TriggerAction.Insert),
↪ cls, safe=True)
            .add_sql('INSERT INTO target_table (id__id, half_float_num) VALUES (NEW.
↪id_, NEW.float_num / 2)')
            .add_when('1 == (SELECT status FROM trigger_status WHERE trigger_type ==
↪"INSERT")')
        ]
```

To facilitate the temporary disabling of a specific trigger family, MAFw provides a special class *TriggerDisabler* that can be easily used as a context manager in your code. This is an ultra simplified snippet.

Listing 8.9: Use of a context manager to disable a trigger

```
with TriggerDisabler(trigger_type_id = 1):
    # do something without triggering the execution of any trigger of type 1
    # in case of exceptions thrown within the block, the context manager is restoring
    # the trigger status to 1.
```

8.6.3 Triggers on different databases

We have seen that Peewee provides an abstract interface that allows interaction with various SQL databases like MySQL, PostgreSQL, and SQLite.

This abstraction simplifies database operations by enabling the same codebase to work across different database backends, thanks to the common SQL language they all support. However, while these databases share SQL as their query language, they differ in how they handle certain features, such as triggers. Each database has its own peculiarities and syntax for defining and managing triggers, which can lead to inconsistencies when using a single approach across all databases.

To address this challenge, the MAFw introduced the `TriggerDialect` abstract class and three specific implementations for the main databases. Relying on the use of the TriggerDialect class, a syntactically correct SQL statement for the creation or removal of triggers is generated. But, MAFw cannot read the mind of the user (yet!) and given the very different behaviour of the databases, the operation of the triggers will be different.

Have a look at the table below for an illustrative comparison on how triggers are handled by the different databases.

Feature	MySQL	PostgreSQL	SQLite
Trigger Event	• INSERT • UPDATE • DELETE	• INSERT • UPDATE • DELETE • TRUNCATE	• INSERT • UPDATE • DELETE
Trigger Time	• BEFORE • AFTER	• BEFORE • AFTER • INSTEAD OF	• BEFORE • AFTER • INSTEAD OF
Activation	Row-level only	Row-level and statement-level	Row-level and statement-level
Implementation	BEGIN-END block with SQL statements (supports non-standard SQL like SET statements)	Functions written in PL/pgSQL, PL/Perl, PL/Python, etc.	BEGIN-END block with SQL statements
Trigger Per Event	Multiple triggers allowed ordered by creation time	Multiple triggers allowed ordered alphabetically by default, can be specified	Multiple triggers allowed but unspecified execution order
Privileges required	TRIGGER privilege on the table and SUPER or SYSTEM_VARIABLES_ADMIN for DEFINER	CREATE TRIGGER privilege on schema and TRIGGER privilege on table	No specific privilege model
Foreign Key Cascading	Cascaded foreign key actions do not activate triggers	Triggers are activated by cascaded foreign key actions	Triggers are activated by cascaded foreign key actions
Disabled/Enabled Trigger	Yes, using ALTER TABLE … DISABLE/ENABLE TRIGGER	Yes, using ALTER TABLE … DISABLE/ENABLE TRIGGER	No direct mechanism to disable

PostgreSQL offers the most comprehensive trigger functionality, with built-in support for both row-level and statement-level triggers, INSTEAD OF triggers for views, and the widest range of programming languages for implementation. Its trigger functions can be written in any supported procedural language, providing considerable flexibility.

MySQL implements triggers using SQL statements within BEGIN-END blocks and only supports row-level triggers. It allows non-standard SQL statements like SET within trigger bodies, making it somewhat more flexible for certain operations. A critical limitation is that MySQL triggers are not activated by cascaded foreign key actions, unlike the other databases. This is a strong limiting factor and the user should consider it when designing the database model to store their data. In this case, it might be convenient to not rely at all on the cascading operations, but to have dedicated triggers for this purpose.

SQLite provides more trigger capabilities than it might initially appear. While its implementation is simpler than PostgreSQL's, it supports both row-level and statement-level triggers (statement-level being the default if FOR EACH ROW is not specified). Like PostgreSQL, SQLite triggers are activated by cascaded foreign key actions, which creates an important behavioral difference compared to MySQL.

When designing database applications that may need to work across different database systems, these implementation differences can lead to subtle bugs, especially around foreign key cascading behavior. MySQL applications that rely on triggers not firing during cascaded operations might behave differently when migrated to PostgreSQL or SQLite. Similarly, applications that depend on statement-level triggers will need to be redesigned when moving from PostgreSQL or SQLite to MySQL.

All so said, even though MAFw provides a way to handle triggers creation and removal in the same way across all the databases, the user who wants to move from one DB implementation to the other should carefully review the content of the trigger body to ensure that the resulting behavior is what is expected.

8.6.4 Debugging triggers

The challenges connected to debugging triggers have been already mentioned several times. It is a block of code that is executed outside the application in full autonomy and you cannot put a breakpoint in the database. If you see that your code is not behaving as expected and you doubt that triggers can be behind the malfunctioning, then the general recommendation is to proceed one step at the time, trying to simplify as much as possible the trigger function.

In all these cases, you will need to drop the triggers from the database and recreate them with the simplified / corrected implementation. This is a bit annoying because it cannot be done directly from the application because very likely you have *embedded* your triggers in the target class, so you have no way to retrieve them.

The solution is to use the `TriggerRefresher` processor. It will take care of dropping all triggers in the database and recreate them from the corresponding model definition. The idea of dropping something is generally rather scary, because it is a undoable operation; but if you put all your trigger definitions inside the various models and they are all subclasses of `MAFwBaseModel`, then they will all recreated using their latest definition.

You can even leave the `TriggerRefresher` processor in your analysis pipelines all the times!

8.7 Standard tables

In the previous section, we discussed a workaround implemented by MAFw to address the limitations of database backends that cannot temporarily disable trigger execution. This is achieved querying a table where the status of a specific trigger or a family of triggers can be toggled from active to inactive and vice-versa.

This `TriggerStatus` model is one of the so-called MAFw standard tables,

The main differences between a Model inheriting from `MAFwBaseModel` and one inheriting from `StandardTable` are two:

1. A standard table has an additional `initialisation method`, that can be used to set or restore the default content of the table.
2. Automatic creation and initialisation performed by MAFw when the database connection is established. In other words, as soon as your processor connect to a database, it will retrieve from the `ModelRegister` all the standard tables, create them and initialise them.

Note

To avoid useless multiple creation and initialisation of standard tables, only the first `Processor` or `ProcessorList` that is establishing a connection to the database, is taking the responsibility to proceed with the standard table creation and initialisation task.

This means that if you manually connect to a database and you pass the database object to your `Processor`/`ProcessorList`, then the standard table creation and initialisation will be skipped, because your `Processor`/`ProcessorList` will think that it was already done when the database connection was established.

The automatic creation and initialisation can be disabled, either using the `Processor.create_standard_tables` argument in the `Processor` or `ProcessorList` constructor, or, if you run the pipelines via the mafw executables using the top level *create_standard_table* variable in your steering file.

The role of those tables is to support the functionality of the whole analysis pipeline, they are rarely the direct input / output of a specific processor. If you want to add your own, just create a model inheriting from `StandardTable` or make your own subclass, to customize for example the prefix, and the automatic registration in the model register will do the trick.

8.7.1 Default standard tables

Along with the TriggerStatus, there are two other relevant standard tables: the *OrphanFile* and the *PlotterOutput*.

OrphanFile: the house of files without a row

> This table can be profitably used in conjunction with Triggers. The user can define a trigger fired when a row in a table is deleted. The trigger will then insert all file references contained in the deleted row into the OrphanFile model.
>
> The next time a processor (it does not matter which one) having access to the database is executed, it will query the full list of files from the *OrphanFile* and remove them.
>
> This procedure is needed to avoid having files on your disc without a reference in the database. It is kind of a complementary cleaning up with respect to *another function* you will discover in a moment.
>
> Additional details about this function are provided directly in the *API*.

PlotterOutput: where all figures go.

> *Plotters* are special *Processor* subclasses with the goal of generating a graphical representation of some data you have produced in a previous step.
>
> The output of a plotter is in many cases one or more figure files and instead of having to define a specific table to store just one line, MAFw is providing a common table for all plotters where they can store the reference to their output files linked to the plotter name.
>
> It is very useful because it allows the user to skip the execution of a plotter if its output file already exists on disc.
>
> Triggers are again very relevant, because when a change is made in the data used to generate a plotter output, then the corresponding rows in this table should also be removed, in order to force the regeneration of the output figures with the updated data.

8.8 Custom fields

We have seen in a previous section that there are plenty of field types for you to build up your model classes and that it is also possible to add additional ones. We have made a few for you that are very useful from the point of view of MAFw. The full list is available *here*.

The role of the database in MAFw is to support the input / output operation. You do not need to worry about specifying filenames or paths. Simply instruct the database to retrieve a list of items, and it will automatically provide the various processors with the necessary file paths for analysis.

With this in mind, we have created a *FileNameField*, that is the evolution of a text field accepting a Path object as a python type and converting it into a string for database storage. On top of *FileNameField*, we have made *FileNameListField* that can contain a list of filenames. This second one is more appropriate when your processor is generating a group of files as output. The filenames are stored in the database as a ';' separated string, and they are seen by the python application as a list of Path objects.

Similarly, we have also a *FileChecksumField* to store the string of hexadecimal characters corresponding to the checksum of a file (or a list of files). From the python side, you can assign either the checksum directly, as generated for example by *file_checksum()* or the path to the file, and the field will calculate the checksum automatically.

The *FileNameField* and *FileNameListField* accept an additional argument in their constructor, called `checksum_field`. If you set it to the name of a *FileChecksumField* in the same table, then you do not even have to set the value of the checksum field because this will be automatically calculated when the row is saved.

With these custom fields in mind, our initial definition of a *File table*, can be re-factored as follows:

```python
from peewee import AutoField

from mafw.db.db_model import MAFwBaseModel
from mafw.db.fields import FileNameField, FileChecksumField

class File(MAFwBaseModel):
    file_id = AutoField(primary_key=True, help_text='The primary key')
    file_name = FileNameField(checksum_field='file_digest', help_text='The full filename')
    file_digest = FileChecksumField(help_text='The hex digest of the file')
```

Pay attention at the definition of the file_name field. The FileNameField constructor takes an optional parameter `checksum_field` that is actually pointing to the variable of the FileChecksumField.

You can use the two custom fields as normal, for example you can do:

```python
new_file = File()
# you can assign a Path object.
new_file.file_name = Path('/path/to/some/file')
# the real checksum will be calculated automatically.
# this next line is totally optional, you can leave it out and it will work in the same way.
new_file.file_digest = Path('/path/to/some/file')
```

The super power of these two custom fields is that you can remove useless rows from the database, just issuing one command.

8.8.1 Removing widow rows

Due to its I/O support, the database content should always remain aligned with the files on your disc. If you have a row in your database pointing to a missing file, this may cause troubles, because sooner or later, you will try to access this missing file causing an application crash.

In MAFw nomenclature, those rows are called *widows*, following a similar concept in typesetting, because they are a fully valid database entry, but their data counter part on disc disappeared.

To avoid any problem with widow rows, MAFw is supplying a `function` that the processor can invoke in the start method on the Model classes used as input:

```python
class MyProcessor(Processor):

    def start():
        super().start()
        remove_widow_db_rows(InputData)
```

The `remove_widow_db_rows()` will check that all the `FileNameField` fields in the table are pointing to existing files on disc. If not, then the row is removed from the database.

The function is not automatically called by any of the Processor super methods. It is up to the user to decide if and when to use it. Its recommended use is in the overload of the `start()` method or as a first action in the `get_items()` in the case of a *for loop* workflow, so that you are sure to re-generate the rows that have been removed.

8.8.2 Pruning orphan files

The opposite situation is when you have a file on disc that is not linked to an entry in the database anymore. This situation could be even more perilous than the previous one and may occur more frequently than you realize. The consequences of this mismatch can be severe, imagine that during the *testing / development phase* of your `Processor` you generate an output figure saved on disc. You then realize that the plot is wrong and you fix the bug and update the DB, but for some reasons you have forgotten to delete the figure file from the disc. Afterwards, while looking for the processor output, you find this file and believe it is a valid result and you use it for your publication. In order to prevent this to happen, you just have to follow some simple rules, and then the reliable machinery of MAFw will do the rest.

The key point is to use a specific trigger in every table that has a file name field. This trigger has to react before any delete query on such a table and inserting all FileNameFields or FileNameListFields in the OrphanFile table. You will see an example of such a trigger in the next paragraphs. This standard tables will be queried by the next processor being executed and during the start super method, all files in the Orphan table will be removed from the disc.

Let us try to understand this better with a step-by-step example. For simplicity, we have removed the import statements from the code snippet, but it should not be too difficult to understand the code anyway.

We begin with the declaration of our input model:

Listing 8.10: File model definition with trigger

```
class File(MAFwBaseModel):
    file_id = AutoField(primary_key=True, help_text='primary key')
    file_name = FileNameField(checksum_field='check_sum', help_text='the file name')
    check_sum = FileChecksumField(help_text='checksum')

    @classmethod
    def triggers(cls) -> list[Trigger]:
        file_delete_file = Trigger(
            'file_delete_file',
            (TriggerWhen.Before, TriggerAction.Delete),
            source_table=cls,
            safe=True,
            for_each_row=True,
        )
        file_delete_file.add_when('1 == (SELECT status FROM trigger_status WHERE␣
↪trigger_type = "DELETE_FILES")')
        file_delete_file.add_sql(OrphanFile.insert(filenames=SQL('OLD.file_name'),␣
↪checksum=SQL('OLD.file_name')))
        return [file_delete_file]

    class Meta:
        depends_on = [OrphanFile]
```

Here you see the trigger definition: it is a before delete type and when triggered it is adding the filename field to the OrphanFile table. It is important to notice that this trigger has a when condition and will only be executed when the trigger type DELETE_FILES is enabled. This is necessary for the pruning mechanism to work, just copy this line in your trigger definition.

And now let us define some fake processors. First we import some files into our model, then we remove some rows from the file table and finally other two processors, doing nothing but useful to demonstrate the effect of the orphan removal.

Listing 8.11: Some example processors

```
@database_required
class FileImporter(Processor):
    input_folder = ActiveParameter('input_folder', default=Path.cwd(), help_doc='From␣
↪where to import')

    def __init__(self, *args, **kwargs):
        super().__init__(*args, looper=LoopType.SingleLoop, **kwargs)
        self.n_files: int = -1

    def start(self):
```

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```
        super().start()
        self.database.create_tables([File])
        File.delete().execute()

    def process(self):
        data = [(f, f) for f in self.input_folder.glob('**/*dat')]
        File.insert_many(data, fields=['file_name', 'check_sum']).execute()
        self.n_files = len(data)

    def finish(self):
        super().finish()
        if File.select().count() != self.n_files:
            self.processor_exit_status = ProcessorExitStatus.Failed

@database_required
class RowRemover(Processor):
    n_rows = ActiveParameter('n_rows', default=0, help_doc='How many rows to be␣
↪removed')

    def __init__(self, *args, **kwargs):
        super().__init__(*args, looper=LoopType.SingleLoop, **kwargs)
        self.n_initial = 0

    def start(self):
        super().start()
        self.database.create_tables([File])

    def process(self):
        self.n_initial = File.select().count()
        query = File.select().order_by(fn.Random()).limit(self.n_rows).execute()
        ids = [q.file_id for q in query]
        File.delete().where(File.file_id.in_(ids)).execute()

    def finish(self):
        super().finish()
        if File.select().count() != self.n_initial - self.n_rows or OrphanFile.
↪select().count() != self.n_rows:
            self.processor_exit_status = ProcessorExitStatus.Failed

@orphan_protector
@database_required
class OrphanProtector(Processor):
    def __init__(self, *args, **kwargs):
        super().__init__(looper=LoopType.SingleLoop, *args, **kwargs)
        self.n_orphan = 0

    def start(self):
        self.n_orphan = OrphanFile.select().count()
        super().start()

    def finish(self):
        super().finish()
        if OrphanFile.select().count() != self.n_orphan:
            self.processor_exit_status = ProcessorExitStatus.Failed

@single_loop
```

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```
class LazyProcessor(Processor):
    def finish(self):
        super().finish()
        if OrphanFile.select().count() != 0:
            self.processor_exit_status = ProcessorExitStatus.Failed
```

The **FileImporter**[4] is very simple, it reads all dat files in a directory and loads them in the File model along with their checksum. Just to be sure we empty the File model in the start and in the finish we check that the number of rows in File is the same as the number of files in the folder.

The **RowRemover** is getting an integer number of rows to be removed. Even though the File model is already created, it is a good practice to repeat the statement again in the start method. Then we select some random rows from File and we delete them. At this point, we have created some orphan files on disc without related rows in the DB. Finally (in the finish method), we verify that the number of remaining rows in the database aligns with our expectations. Additionally, we ensure that the trigger functioned correctly, resulting in the appropriate rows being added to the OrphanFile model.

The **OrphanProtector** does even less than the others. But if you look carefully, you will see that along with the `database_required()` there is also the `orphan_protector()` decorator. This will prevent the processor to perform the check on the OrphanFile model and deleting the unrelated files. In the start method, we record the number of orphan files in the OrphanFile model and we confirm that they are still there in the finish. Since the actual removal of the orphan files happens in the processor start method, we need to count the number of orphans before calling the super start.

The **LazyProcessor** is responsible to check that there are no rows left in the OrphanFile, meaning that the removal was successful.

And now let us put everything together and run it.

Listing 8.12: ProcessorList execution

```
db_conf = default_conf['sqlite']
db_conf['URL'] = 'sqlite:///:memory:'
plist = ProcessorList(name='Orphan test', description='dealing with orphan files',␣
↪database_conf=db_conf)
importer = FileImporter(input_folder=tmp_path)
remover = RowRemover(n_rows=n_delete)
protector = OrphanProtector()
lazy = LazyProcessor()
plist.extend([importer, remover, protector, lazy])
plist.execute()

assert importer.processor_exit_status == ProcessorExitStatus.Successful
assert remover.processor_exit_status == ProcessorExitStatus.Successful
assert protector.processor_exit_status == ProcessorExitStatus.Successful
assert lazy.processor_exit_status == ProcessorExitStatus.Successful
```

In practice, the only thing you have to take care of is to add a dedicated trigger to each of your tables having at least a file field and then the rest will be automatically performed by MAFw.

> **Warning**
>
> You should be very careful if your processor is removing rows from the target table (where you should be storing the processor's results). This might be the case of a processor that wants to reset the status of your analysis to a previous step, for example. In this case, as soon as *ProcessorA* removes the rows from the model, the trigger will inserts all FileNameFields in the OrphanFile model in order to be deleted. This is a lazy operation and

[4] A much better implementation of an Importer could be achieved using a subclass of the `Importer`. See, for example, the `ImporterExample` class and its *documentation*.

will be performed by the following processor to be executed either in the same pipeline or in the next. When *ProcessorA* will have finished its work, the target table will be repopulated and the same will happen to the folders on the disc. Now the next processor will empty the orphan file model and possibly remove the freshly generated files.

You have two solutions for this problem: either you block the execution of the trigger when deleting the rows (you can use the `TriggerDisabler` for this purpose), in this way the rows in the model will be removed, but not the files from disc with the risks we have already mentioned. The second possibility is to force the processor to immediately take care of the orphan file pruning. This is the suggested procedure and you only need to include a call to the `_remove_orphan_files()` soon after the delete query.

Automatic creation of *file removal* trigger

In the definition of *File model* we have manually created a trigger that is fired every time a row is removed from the table. The action of this trigger is to insert in the `OrphanFile` model the content of the `FileNameField` that is actually the specifically designed Field type to store a path to a file.

This trigger creation part can be totally automatized, if you want to insert in the `OrphanFile` the content of all `FileNameField` and `FileNameListField` fields. The automatic creation is another advantage of using the `MAFwBaseModel`. This functionality can be activated very simply by setting a flag in the metadata class.

Listing 8.13: File model definition with automatic trigger

```
class File(MAFwBaseModel):
    file_id = AutoField(primary_key=True, help_text='primary key')
    file_name = FileNameField(checksum_field='check_sum', help_text='the file name')
    check_sum = FileChecksumField(help_text='checksum')

    class Meta:
        depends_on = [OrphanFile]
        file_trigger_auto_create = True
```

This model class is absolutely identical to the *previous one*; MAFw base model will take care of generating the necessary trigger.

It is worth remembering that *file_trigger_auto_create* is inherited by subclasses, so if you want all the models in your project to have this feature, you can simply set it to true in your base model.

Warning

We have already mentioned the main disadvantage of working with triggers, that is to say the difficult debugging. Triggers are pieces of code that are executed in full autonomy by the database, so when you are trying to understand why your analysis pipeline is not working as expected a part from looking at your python code, you should also keep in mind that triggers might be the source of the problem.

This effect is amplified, if you turn on the automatic trigger creation, because you don't even see the trigger definition in your python code and you may have forgotten about the auto trigger flag. As always with great power comes even greater responsibility!

8.8.3 Keeping the entries updated

One aspect is that the file exists; another is that the file content remains unchanged. You may have replaced an input file with a newer one and the database will not know it. If your processors are only executed on items for which there is still no output generated, then this replaced file may go unnoticed causing issues to your analysis.

For this reason, we are strongly recommending to always add a checksum field for each file field in your table. Calculating a checksum is just a matter of a split second on modern CPU while the time for the debugging your analysis code is for sure longer.

The function *verify_checksum()* takes a Model as argument and will verify that all checksums are still valid. In other words, for each FileNameField (or FileNameListField) with a link to a checksum field in the table, the function will compare the actual digest with the stored one. If it is different, then the DB row will be removed.

Also this function is not automatically called by any processor super methods. It is ultimately the user's responsibility to decide whether to proceed, bearing in mind that working with long tables and large files may result in delays in processor execution.

The implementation is very similar to the previous one, just change the function name. Keep in mind that the *verify_checksum()* will implicitly check for the existence of files and warn you if some items are missing, so you can avoid the *remove_widow_db_rows()*, if you perform the checksum verification.

```
class MyProcessor(Processor):

    def start():
        super().start()
        verify_checksum(InputData)
```

8.9 Multi-primary key columns

Special attention is required when you need to have a primary key that is spanning over two or more columns of your model. So far we have seen how we can identify one column in the model as the primary key and now we will see what to do if you want to use more than one column as primary key and, even more important, how you can use this composite primary key as a foreign key in another model.

To describe this topic, we will make use of an example that you can also find in the examples modules of MAFw named *multi_primary*.

Let us start with the model definition.

```
class Sample(MAFwBaseModel, do_not_register=True):
    sample_id = AutoField(primary_key=True, help_text='The sample id primary key')
    sample_name = TextField(help_text='The sample name')

class Resolution(MAFwBaseModel, do_not_register=True):
    resolution_id = AutoField(primary_key=True, help_text='The resolution id primary key')
    resolution_value = FloatField(help_text='The resolution in µm')

class Image(MAFwBaseModel, do_not_register=True):
    image_id = AutoField(primary_key=True, help_text='The image id primary key')
    filename = FileNameField(help_text='The filename of the image', checksum_field='checksum')
    checksum = FileChecksumField()
    sample = ForeignKeyField(Sample, on_delete='CASCADE', backref='+', lazy_load=False, column_name='sample_id')
    resolution = ForeignKeyField(
        Resolution, on_delete='CASCADE', backref='+', lazy_load=False, column_name='resolution_id'
    )

class ProcessedImage(MAFwBaseModel, do_not_register=True):
    image = ForeignKeyField(
        Image,
        primary_key=True,
        backref='+',
        help_text='The image id, foreign key and primary',
        on_delete='CASCADE',
        lazy_load=False,
```

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```python
        column_name='image_id',
    )
    value = FloatField(default=0)

class CalibrationMethod(MAFwBaseModel, do_not_register=True):
    method_id = AutoField(primary_key=True, help_text='The primary key for the calculation method')
    multiplier = FloatField(default=1.0, help_text='The multiplication factor of this method')

class CalibratedImage(MAFwBaseModel, do_not_register=True):
    image = ForeignKeyField(
        ProcessedImage,
        on_delete='CASCADE',
        help_text='The reference to the processed image',
        backref='+',
        lazy_load=False,
        column_name='image_id',
    )
    method = ForeignKeyField(
        CalibrationMethod,
        on_delete='CASCADE',
        help_text='The reference to the calibration method',
        backref='+',
        lazy_load=False,
        column_name='method_id',
    )
    calibrated_value = FloatField(default=0.0, help_text='The calibrated value')

    @property
    def primary_key(self) -> Iterable:
        return self.image_id, self.method_id

    class Meta:
        primary_key = CompositeKey('image', 'method')

class ColoredImage(MAFwBaseModel, do_not_register=True):
    image_id = IntegerField(help_text='The reference to the processed image. Combined FK with method_id')
    method_id = IntegerField(help_text='The reference to the calibration method. Combined FK with method_id')
    red = FloatField(default=0, help_text='Fake red. Only for testing')
    green = FloatField(default=0, help_text='Fake green. Only for testing')
    blue = FloatField(default=0, help_text='Fake blue. Only for testing')

    @property
    def primary_key(self) -> Iterable:
        return self.image_id, self.method_id

    class Meta:
        constraints = [
            SQL(
                'FOREIGN KEY (image_id, method_id) REFERENCES '
                'calibrated_image(image_id, method_id) ON DELETE CASCADE'
            )
        ]
```

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```
78          primary_key = CompositeKey('image_id', 'method_id')
79
```

As always, one single picture can convey more than a thousand lines of code. Here below the ERDs of Image and of CalibratedImage.

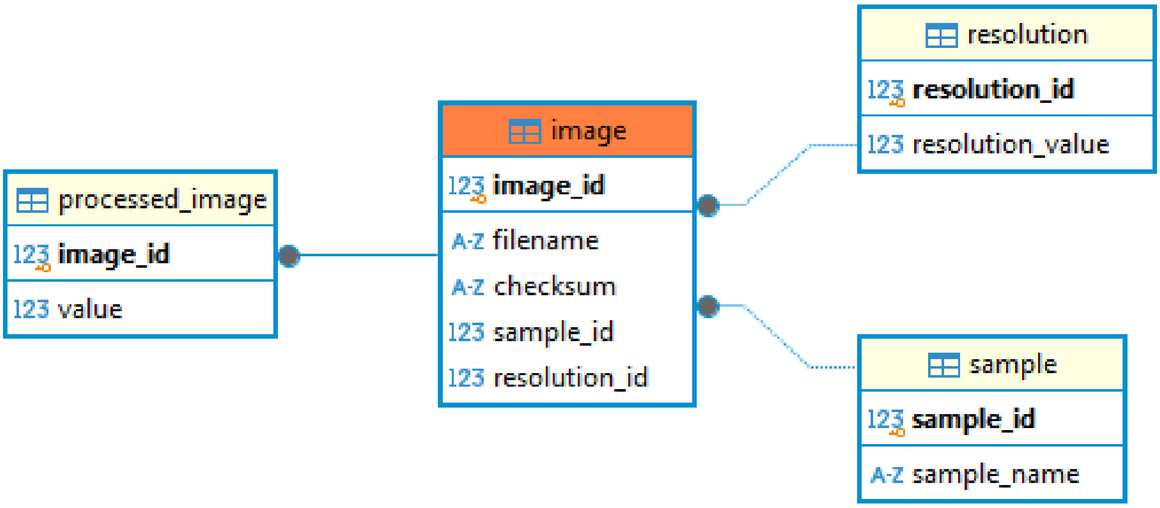


Fig. 8.1: The ERD of the Image Model

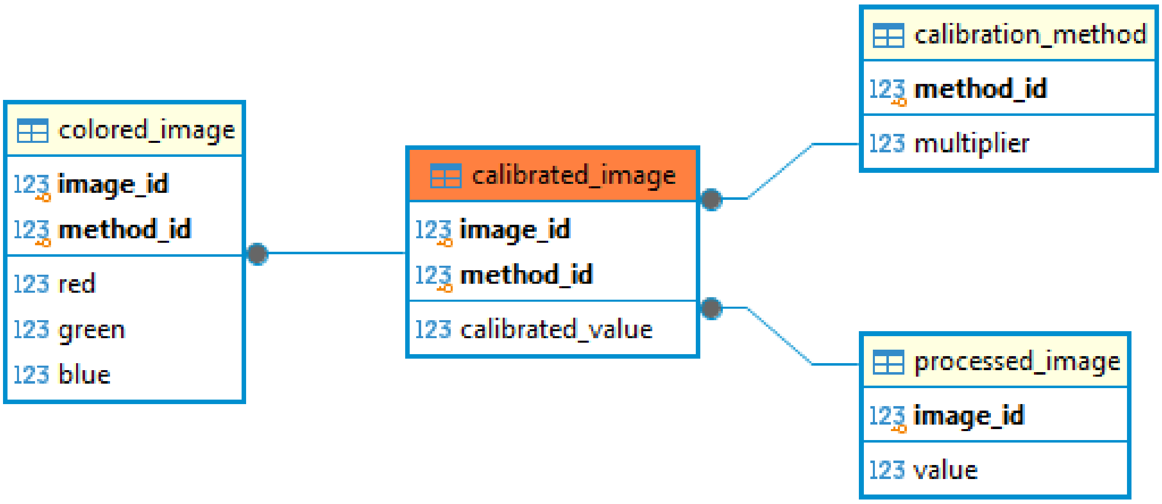


Fig. 8.2: The ERD of the CalibratedImage Model

In the diagrams, the fields with bold font represent primary keys, also highlighted by the separation line, while the arrow are the standard relation.

As in the examples above, we have images of different samples acquired with different resolutions entering the Image model. We use those lines to make some calculations and we obtain the rows in the ProcessedImage model. These two tables are in 1 to 1 relation and this relation is enforced with a delete cascade, meaning that if we delete an element in the Image model, the corresponding one in the ProcessedImage will also be deleted.

The CalibrationMethod model contains different sets of calibration constants to bring each row from the ProcessedImage model to the CalibratedImage one. It is natural to assume that the `image_id` and the `method_id` are the best candidates to be a combined primary key. To achieve this, in the CalibratedImage model, we need to add (line 57-58) an overload of the Meta class, where we specify our `CompositeKey`. Pay attention to an important detail:

the CompositeKey constructor takes the name of the fields and not the name of the columns, that in the case of foreign keys differ of '_id'. Optionally we can also define a primary_key property (line 53-55) to quickly retrieve the values of our keys.

From the application point of view, we want all the processed images to be calibrated with all possible calibration methods, that means we need to make a cross join as described below:

```
with database.atomic() as txn:
    cross_join = (
        ProcessedImage.select(ProcessedImage, CalibrationMethod).join(CalibrationMethod, JOIN.CROSS).execute()
    )
    for row in cross_join:
        calibrated_image = CalibratedImage()
        calibrated_image.image_id = row.image_id
        calibrated_image.method_id = row.method_id
        calibrated_image.calibrated_value = row.value * row.multiplier
        calibrated_image.save(force_insert=True)
```

Up to this point we have seen what we have to do to specify a composite primary key, we cannot use the AutoField or the primary_key parameter, but we need to go through the Meta class in the way shown in the example.

The next step is to have another table (ColoredImage in our imaginary case) that is in relation with CalibratedImage. We would need to have again a composite primary key that is also a composite foreign key. Peewee does not support composite foreign keys, but we can use the workaround shown at lines 72-77. Along with the CompositeKey definition, we need to add a Constraint as well using the SQL function to convert a string into a valid SQL statement. This time, since we are using low level SQL directives, we have to use the column names (additional '_id') instead of the field name.

And in a similar way we can insert items in the ColoredImage model.

```
with database.atomic() as txn:
    full_list = CalibratedImage.select().execute()

    for row in full_list:
        colored_image = ColoredImage(image_id=row.image_id, method_id=row.method_id)
        colored_image.red = row.calibrated_value / 3
        colored_image.green = row.calibrated_value / 3
        colored_image.blue = row.calibrated_value / 3
        colored_image.save(force_insert=True)
```

Now, with all the tables linked to each other, try to delete one from a table, and guess what will happen to all other tables.

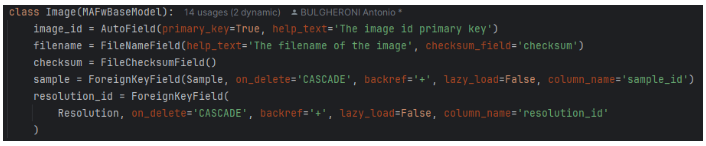
This tutorial might be a bit more complex than the examples we have seen so far, but we believed you have appreciated the power of such a relational tool.

8.10 Importing an existing DB

The last section of this long chapter on database will show you how to deal with an existing DB. It is possible that before you have adopted MAFw for your analysis tasks, you were already employing a relational database to store your dataset and results. So far we have seen how to create tables in a database starting from an object oriented description (a model) in a python library. But what do we have to do if the database already exists? Can we create the classes starting from a database? This process goes under the name of **reflection** and it is the subject of this section.

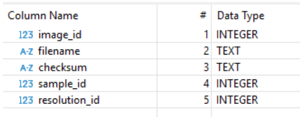
The reflection of tables in python classes cannot be performed automatically at 100% by definition. A typical case is the use of application specific fields. Consider, for example, the FileNameField that we have discussed earlier. This field corresponds to a Path object when you look at it from the application point of view, but the actual path is saved as a text field in the concrete database implementation. If you now read the metadata of this table from the database point of view, you will see that the field will contain a text variable and thus the reflected class will not have any FileNameField.

Let us try to understand the process looking at the picture below. If we create the model in python, then we can assign special field descriptors to the table columns, but their concrete implementation in the database must be done using types that are available in the database itself. So when we perform the reverse process, we get only a good approximation of the initial definition.



```
class Image(MAFwBaseModel):  14 usages (2 dynamic)  BULGHERONI Antonio *
    image_id = AutoField(primary_key=True, help_text='The image id primary key')
    filename = FileNameField(help_text='The filename of the image', checksum_field='checksum')
    checksum = FileChecksumField()
    sample = ForeignKeyField(Sample, on_delete='CASCADE', backref='+', lazy_load=False, column_name='sample_id')
    resolution_id = ForeignKeyField(
        Resolution, on_delete='CASCADE', backref='+', lazy_load=False, column_name='resolution_id'
    )
```

Fig. 8.3: This is the model implementation as you would code it making use of the specific field definitions.



Column Name	#	Data Type
123 image_id	1	INTEGER
A-Z filename	2	TEXT
A-Z checksum	3	TEXT
123 sample_id	4	INTEGER
123 resolution_id	5	INTEGER

Fig. 8.4: During the actual implementation of the model as a database table, python column definitions will be translated into database types.

```
class Image(MAFwBaseModel):  3 usages (2 dynamic)
    image_id = AutoField()
    filename = TextField()
    checksum = TextField()
    sample = ForeignKeyField(column_name='sample_id', field='sample_id', model=Sample)
    resolution = ForeignKeyField(column_name='resolution_id', field='resolution_id', model=Resolution)

    class Meta:
        table_name = 'image'
```

Fig. 8.5: The reflection process will translate the database implementation in a generic model implementation, not necessarily including all the specific field definition.

Nevertheless the process is rather efficient and can generate an excellent starting point that we can use to customize the model classes to make them more useful in our application.

From a practical point of view, you just have to open a console and type the command `mafw db wizard --help` to get some help on the tool and also read its documentation. You need to provide the name of the database and how to connect to it, in the case of Sqlite DB, it is enough to provide the filename, and you have to specify the name of the output python file that will contain all the model classes. This module is ready to go, you could theoretically import it into your project and use it, but it is strongly recommended to accurately check that everything is really the way you want it to be.

The reflection process is absolutely safe for your existing database, so it is worth to give it a try!

8.11 Execute SQL scripts

If you are not new to databases, you might have some SQL script files hanging around. Something link initialisation or optimisation procedure. If this is the case, you can include those in your analysis pipelines.

The *SQLScriptRunner* processor provides a convenient way to execute SQL scripts against your database. This is particularly useful when you need to perform database operations that are not easily expressed through the ORM or when you want to leverage database-specific features.

To use the SQLScriptRunner, you need to configure it in your steering file by specifying a list of SQL files to be processed. Here's an example configuration:

```
[SQLScriptRunner]
sql_files = ["./scripts/init_schema.sql", "./scripts/populate_data.sql"]
```

The processor will:

1. Validate that all specified SQL files exist and are regular files
2. Read each SQL file content
3. Remove multi-line block comments (/* ... */) from the SQL content
4. Split the content into individual SQL statements
5. Execute all statements within a single atomic transaction

This ensures that either all statements are executed successfully, or none are applied if an error occurs, maintaining database integrity.

Each SQL file should contain one or more valid SQL statements separated by semicolons. The processor automatically handles the transaction boundaries, so you don't need to include explicit BEGIN/COMMIT statements in your SQL files.

> ⚠ **Warning**
>
> Since all statements are executed within a single transaction, very large SQL files or operations that take a long time to complete might impact database performance. Consider breaking large scripts into smaller chunks if needed.

8.12 What's next

Congratulations! You reached the end of the most difficult chapter in this tutorial. It is difficult because as a scientist you might not be used to deal with databases everyday, but their power is incredible, isn't it?

The next chapter is about efficiency! You will learn how to process only the data you want and that need to be analysed. Get ready to understand database filters!

CHAPTER 9

FILTERS: DO ONLY WHAT IS NEEDED TO BE DONE!

As mentioned already several times, the main role of the database is to support the processor execution in providing the input items and in storing the output products. Not everything can be efficiently stored in a database, for example large chunk of binary data are better saved to the disc, in this case, the database will know the path where these data are stored.

One advantage of the database is that you can apply selection rules and you do not have to process the whole dataset if you do not need it. To help you in this, MAFw is offering you a ready-to-use solution, the *db_filter*.

This module is providing a filtering system that allows users to precisely control which data is processed by each processor. This system offers several key benefits:

- **Precision Control**: Users can define exactly which records should be included or excluded from processing
- **Performance Optimization**: By filtering early in the pipeline, unnecessary computations are avoided
- **Flexibility**: Supports various filtering operations including simple conditions, logical combinations, and conditional logic
- **Configuration-Driven**: Filters can be easily configured through the steering files without code changes
- **Scalability**: Complex filtering scenarios can be expressed through logical expressions and nested conditions

The filtering system is built around three main components plus an extra one:

- *ProcessorFilter* - For managing multiple model filters in a processor
- *ModelFilter* - For defining filters at the model level
- *ConditionNode* - For defining filters at the field level
- *ConditionalFilterCondition* - For conditional filtering logic (this is the extra)

and they implement the following hierarchical structure:

9.1 How to use a filter

The filter native playground is in the implementation of the *get_items()* method and of course it can only work if the list of items is retrieved from the database.

Let us assume that our *Processor*, named AdvProcessor, is using three models to obtain the item lists. Everything is nicely described in the ERD below. The three models are interconnected via foreign key relations. There is a fourth model, that is where the output data will be saved.

The real core of our database is the image table, where our data are first introduced, the other two on the right, are kind of helper tables storing references to the samples and to the resolution of our images. The processed_image table is where the output of our AdvProcessor will be stored.

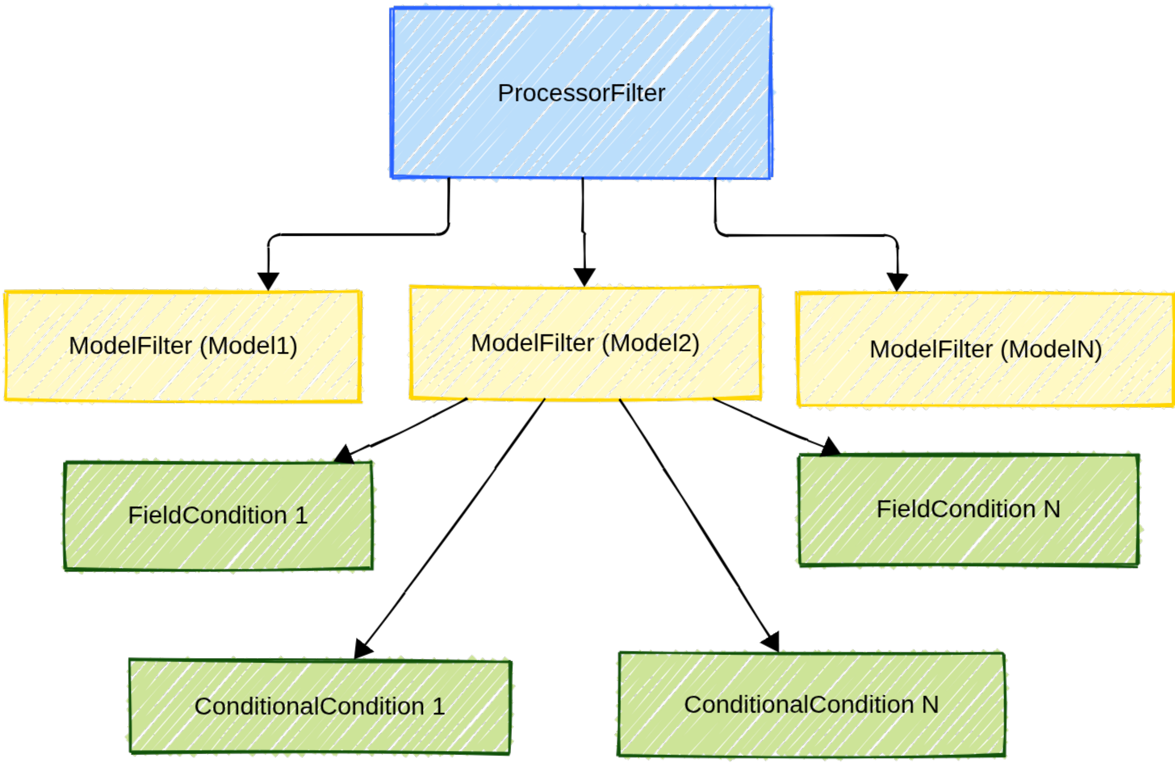


Fig. 9.1: The description of the filtering hierarchical structure.

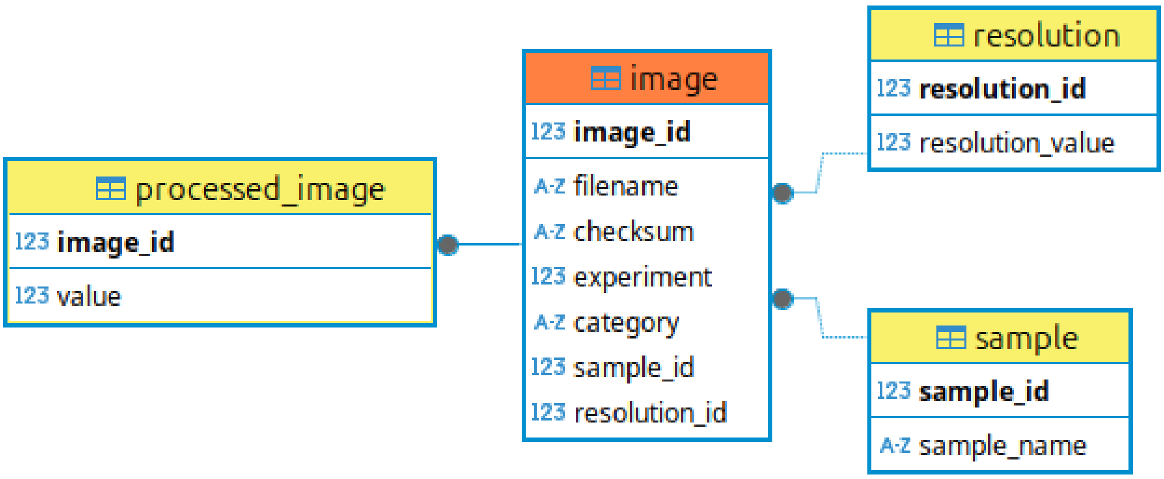


Fig. 9.2: The ERD of the AdvProcessor.

To realize this database with our ORM we need to code the corresponding model classes as follows:

```python
class Sample(MAFwBaseModel):
    sample_id = AutoField(primary_key=True, help_text='The sample id primary key')
    sample_name = TextField(help_text='The sample name')

class Resolution(MAFwBaseModel):
    resolution_id = AutoField(primary_key=True, help_text='The resolution id primary key')
    resolution_value = FloatField(help_text='The resolution in µm')

class Image(MAFwBaseModel):
    image_id = AutoField(primary_key=True, help_text='The image id primary key')
    filename = FileNameField(help_text='The filename of the image', checksum_field='checksum')
    checksum = FileChecksumField(help_text='The checksum of the input file')
    experiment = IntegerField(default=1,
                              help_text='A flag for selection of the experiment. Flags are bitwise combinable')
    category = TextField(
        help_text='A text string to describe the image category. Accepted values are:"STANDARD", "SUT", "REFERENCE"')
    sample = ForeignKeyField(
        Sample, Sample.sample_id, on_delete='CASCADE', backref='sample', column_name='sample_id'
    )
    resolution = ForeignKeyField(
        Resolution, Resolution.resolution_id, on_delete='CASCADE', backref='resolution', column_name='resolution_id'
    )

class ProcessedImage(MAFwBaseModel):
    image = ForeignKeyField(
        Image,
        Image.image_id,
        primary_key=True,
        column_name='image_id',
        backref='raw',
        help_text='The image id, foreign key and primary',
        on_delete='CASCADE',
    )
    value = FloatField(default=0)
```

By now, you should be an expert in ORM and everything there should be absolutely clear, otherwise, take your chance now to go back to the previous sections or to the peewee documentation to find an explanation. Note how the Image class is making use of our *FileNameField* and *FileChecksumField*. We added also a bit of help text to each field, in order to make even more evident what they are.

Particularly interesting is the experiment field in the Image model. This is a binary flag and can be very useful to assign one file (an image in this case) to one or more experiments. For example, imagine you have three different experiments in your data analysis; you assign to the first experiment the label 1 (binary: 0b1), to the second the label 2 (0b10) and to the third the label 4 (0b100). Now, if you want an image to be used only for experiment 1, you set the experiment column to 1; similarly if you want an image to be part of experiment 1 and 3, then you set its experiment column to 1 + 4 = 5 (b101). In fact, if you bit-wise AND, this image with the label of the experiments (5 BIT_AND 1 = 5 BIT_AND 4 = True) you will get a True value.

For each foreign key field, we have specified a backref field, so that you could get access to the related models. Pay attention also at the highlighted lines, where we define foreign key fields to other tables. Peewee follows Django style references, so actually the field object is named with the noun of the object you are referring to. This will allow the following:

```
image.sample # Resolve the related object returning a Sample instance, it costs an additional query
image.sample_id # Return the corresponding Sample's id number
```

The primary source of input is the Image; however, you may wish to process only images that meet specific criteria, such as belonging to a particular sample or being captured at a certain resolution. Unfortunately, this information is not explicitly included in the Image model. Only the resolution_id and the sample_id are included in the image table: those primary keys are excellent for a computer, but for a human being it is better to use sample names and resolution values. The solution is to use a join query in order to have all fields available and then we will be able to apply the configurable filters from the TOML steering file to limit the selection to what we want.

Since we have three input models for our processor we can have up to three different Model level filters defined in the steering files. The processor is storing all the filters configured in the steering files in a container class *filter register* that will be the main actor of our *get_items()* implementation that follows:

```
def get_items(self):

    # first of all, let us be sure that the tables exist
    # the order is irrelevant, the ORM will find the best creation strategy.
    # if the table already exists, nothing will happen.
    self.database.create_tables([Sample, Resolution, Image, ProcessedImage])

    # if you want to remove widow rows from the output table or verify the checksum do it now!
    remove_widow_rows([Image, ProcessedImage])

    # did we select new_only in the global filter?
    # if yes, prepare an additional condition in which we specify that the
    # Image.image_id should not be among the image_id of the ProcessedImage.
    # if no, then just accept everything.
    if self.filter_register.new_only:
        # let us get a list of all already processed items.
        # since the item in the output table are stored using the same primary key,
        # this will simplify the discrimination between new and already processed items.
        existing_entries = ProcessedImage.select(ProcessedImage.image_id).execute()

        # build the condition
        existing = ~Image.image_id.in_([i.image_id for i in existing_entries])
    else:
        existing = True

    # finally let us make the query.
    query = (Image.select(Image, Sample, Resolution)
                .join(Sample, on=(Image.sample_id == Sample.sample_id), attr='s')
                .switch(Image)
                .join(Resolution, on=(Image.resolution_id == Resolution.resolution_id), attr='r')
                .where(self.filter_register.filter_all())
                .where(existing)
            )
    return query
```

The processor filter register comes up in two points (highlighted in the code), when can retrieve a boolean flag representing whether we want to process input data for which an output record already exists or not.

The second usage is in the query, where we generate a peewee combined expression representing the whole combination of all user defined (and configured) filters. Let's move on and see how we configure a filter!

9.2 How to configure a filter

In a steering file, there is a table for each processor where you can set the configurable active parameters. To this table, you can add a sub-table named *__filter__*, containing other tables, one for each input Model. The reason for the underscores is to avoid to pollute the processor parameter namespace. This is how it will look like:

```
[AdvProcessor]
param1 = 15

[AdvProcessor.__filter__.Resolution]
resolution_value = 25

[AdvProcessor.__filter__.Sample]
sample_name = 'sample_00*'
```

In the example above, AdvProcessor has two *.__filter__.* tables, one for Resolution and one for Sample. When the steering file will be parsed, the processor constructor will automatically generate two filters: for Resolution it will put a condition that the resolution field must be 25 and for Sample, the sample_name column should be 'sample_1'. You could add a third table for the Image model, if you wish.

In this way, the processor initialization machinery will create the necessary filters and add them to the processor filter register from where we can retrieve it.

The *new_only* parameter of the register can also be configured in the steering file. By default, you can find in the steering file in the general section a parameter *new_only = true*. This flag will be applied to all processors in the pipeline, but you can change it for each processor in this way:

```
[AdvProcessor]
__new_only__ = false
param1 = 15

# The rest as before...
```

In this way, for the AdvProcessor the new only flag will be False[1], while the rest is left to the default value.

If we use this configuration the AdvProcessor will obtain an input item list with only the input images having a resolution_value of 25 **AND** a sample_name matching the glob style string sample_00*.

It is important to underline that the filters on the models are joined (by default) using an AND. In this simple example we had one field for each model being the subject of the filter, but you could have as many as you like. Inside a model, the default joining logic is again **AND**.

The configuration of these filters is done using the so called *single value* approach, even if for the sample_name we specified an * in the name. The reason is that we have assigned with the = symbol one single value to the model field.

The filter will interpret the meaning of = differently depending on the type of the right hand side value, following this table:

Filter field type	Logical operation	Example
Numeric, boolean	==	Field == 3.14
String	GLOB	Field GLOB '*ree'
List	IN	Field IN [1, 2, 3]

[1] Remember that in TOML, the two booleans are **NOT** capitalized as in Python. Moreover, you can specify new_only also in Processor/Model but it will not be taken into account unless that model has a column named new_only.

9.3 Explicit operation configuration

In the previous example we have seen how to select one specific field to be exactly equal to a given value, but maybe our goal is to select an interval, or performing a bitwise logical operation. The filter system also supports explicit operation specification, allowing you to define the exact logical operation to be applied. Here is an example:

```
[AdvProcessor]
param1 = 15

[AdvProcessor.__filter__.Resolution]
resolution_value = {op = ">=", value = "25"}

[AdvProcessor.__filter__.Image]
experiment = { op = "BIT_AND", value = 5 }
```

In this configuration example, you can see to practical usage of the so-called explicit operation configuration. It is called explicit, because this time you clear specify which operation you want to apply. So, in this case we will be getting all images with a resolution value greater or equal to 25 and an experimental flag returning true when bitwise AND'ed to 5. If you remember, in our introduction, this is equivalent to select experiment labelled with 1 and with 4.

The supported operations include[2]:

Operation	Description	Example
==	Equal	Field == 42
!=	Not equal	Field != 42
<	Less than	Field < 100
<=	Less than/equal	Field <= 100
>	Greater than	Field > 0
>	Greater than/equal	Field >= 10
GLOB	Pattern matching	Field GLOB 'test*'
LIKE	SQL LIKE	Field LIKE 'test%'
REGEXP	Regular expression	Field REGEXP '^[A-Z]'
IN	Value in list	Field IN [1, 2, 3]
NOT_IN	Value not in list	Field NOT_IN [1, 2]
BETWEEN	Value between	Field BETWEEN [1, 10]
BIT_AND	Bitwise AND	Field & 5 != 0
BIT_OR	Bitwise OR	Field | 7 != 0
IS_NULL	Field is NULL	Field IS NULL
IS_NOT_NULL	Field is not NULL	Field IS NOT NULL

Note

The default sqlite library provides only an abstract definition of the regular expression matching. In simple words, it means that the user needs to implement the user function *regexp()*, or using any sqlite extensions that implements it.

In summary, if you are using the vanilla sqlite, you **cannot use the REGEXP operator** in your filter and you need to reformulate your filtering condition using a combination of other string matching tools.

[2] The list of all overloaded operator and special method is available in the peewee doc.

9.4 Logical Composition

In the examples seen so far, the field conditions inside of a `ModelFilter` were logically AND'ed to generate the condition for that specific model. If more model filters are present, then the overall processor filter was generated logically AND'ing all model filters. Always keep in mind this hierarchical structure: Field Condition < Model Condition < Processor Condition described in Fig. 9.1.

You may want to have a different logical composition, defining how field conditions inside a model or model filters inside a processor are combined. To do so use the *__logic__* keyword to define the logical composition. See the example below.

Listing 9.1: Logical composition filtering

```
[AdvProcessor]
param1 = 15
__logic__ = "(Resolution OR Sample) AND Image"

[AdvProcessor.__filter__.Resolution]
resolution_value = {op = ">=", value = "25"}

[AdvProcessor.__filter__.Image]
__logic__ = "category OR image_id"
experiment = { op = "BIT_AND", value = 5 }
category = "beautiful_images"

[AdvProcessor.__filter__.Image.image_id]
__logic__ = "good_images AND NOT bad_images"
good_images = {op = "BETWEEN", value = [100, 145]}
bad_images = {op = "IN", value=[105, 109]}

[AdvProcessor.__filter__.Sample]
sample_name = "sample_00*"
sample_id = [1,2]
```

This is a very advanced configuration and I hope you will appreciate how easy is to obtain.

First of all there is a logic sentence in the AdvProcess table. It says that we want to combine the expressions for the Resolution and the Sample models using OR. The result of this should be combined with AND with the expression for the Image model.

The resolution filter is an explicit condition as seen in the previous paragraph. There is only one condition for this model, so nothing to combine. For the Sample model, we have two field conditions and no __logic__ keyword, so the two conditions will be combined with the default AND.

The filter on Image is a bit more complicated. First of all, it has a logic statement that will be used to combine the field condition. The statement is mentioning *category* and *image_id*, but nothing about *experiment*, as a consequence the condition on the experiment will be simply ignored. The category condition is a simple value one while the one over *image_id* is a nested. In fact for *image_id*, we have an additional table describing what we want. This is a combination governed by a logic statement where we have defined two sub-conditions, a range of good images to be combined with some bad images.

This whole configuration is equivalent to this SQL statement:

```
SELECT
    *
FROM
    image
    join resolution using(resolution_id)
    join sample using(sample_id)
WHERE
```

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```
    ( resolution.resolution_value >= 25 OR
      (sample.sample_name GLOB "sample_00*"
        AND sample.sample_id IN (1, 1) ) AND
    ( image.image_id BETWEEN 100 and 145 AND NOT image.image_id IN (105, 109))
```

> **Summary**
>
> There are three different filtering levels: Field, Model, Processor.
>
> For each level, you can define as many conditions as you wish. Those conditions are by default combined using **AND**, but more advanced logical composition can be achieved using the *__logic__* keyword via a simplify grammar.
>
> The logical grammar uses only three logical operators: **AND**, **OR** and **NOT**. The variable names are the model names at the processor level, the field name at the model level and the condition name at the field level.
>
> Be aware that the grammar is **case sensitive**: the operators must always be written in capitol letters, while the variable names should respect the original case. Use parenthesis to specify the order. When a logic statement is provided, variables that are not mentioned in the statement will not be included in the filter generation.
>
> Each condition lives in its own scope and cannot be directly linked to conditions in other scope. So for example, field conditions of defined in Resolution cannot be included in the logic statement of the Image model.

9.5 Conditional filters

In the introduction, we mention the three pillars on which the filtering system is based plus one extra. This extra one is the conditional filter! They allow expressing logic where one field's criteria depend on another field's value.

They live inside the model scope since they relate different fields of the same table. For each model, you can have as many as you like and you can also include them in the model level logic statement.

Listing 9.2: Conditional filtering

```
[AdvProcessor]
param1 = 15

[AdvProcessor.__filter__.Image]
__logic__ = "resolution_id AND conditional_1"
resolution_id = 1 # this is the foreign key value

[[AdvProcessor.__filter__.Image.__conditional__]] # this is a list, note the double␣
↪[]
name = 'conditional_1'
condition_field = 'category'
condition_op = 'GLOB'
condition_value = 'beautiful'
then_field = 'raw_image_id'
then_op = 'BETWEEN'
then_value = [100, 140]
else_field = 'raw_image_id' # OPTIONAL
else_op = '>' # OPTIONAL
else_value = 200 # OPTIONAL
```

The conditional filter translates as follow: if the category is matching 'beautiful', then select raw_image_id between 100 and 140, otherwise (if not matching 'beautiful') select raw_image_id greater than 200.

The SQL equivalent is:

```
WHERE resolution_id = 1 AND
     (( category GLOB "beautiful" AND raw_image_id BETWEEN 100 AND 140 )
     OR ( category NOT GLOB "beautiful" AND raw_image_id > 200 ))
```

Summary

Conditional filters allows to select one field based on the value of another fields.

You can add as many as you like, just repeat the same table header (with the double set of []).

9.6 How to use the *new_only* filter

9.6.1 Basic usage example

The basic usage of the new only filter is based on the relation between input and output table. Going back to our previous *example*, we have an Image model containing our input data and a ProcessedImage model containing the output of the processor. The two models are in a 1-to-1 relation via a foreign key constrain linking the primary keys of both models. In this case the selection of the *so-called* new_only elements, it is to say the items in the input list for which an output is not yet existing is very easy to obtain. You get the whole list of primary keys in the output table (this is the existing list) and you compare with the list of primary keys in the input table. If the two lists are different, then run the processor only on the difference!

Note

The output primary key list is at most equal to the input primary key. It cannot contain elements that are not in the input table by definition of 1-to-1 relation.

Programmatically you can obtain this in the implementation of the `Processor.get_items()` method as shown in *this code snippet* at lines 19 and 22.

9.6.2 New only flag and processor parameters

Let's now consider another common scenario where the 1-to-1 relation between two tables are not enough. You have implemented a `Processor` that is responsible to perform a gaussian filtering of your data and for this you have defined *gauss_sigma* as an `ActiveParameter`. You run the pipeline for the first time and your *GaussFilter* is doing its job using *gauss_sigma* = 3, but then you realize that 3 is probably too much and you want to lower it down to say 2. You change the steering file and you re-run it and very likely nothing will happen. The reason is that if you have implemented the *new_only* filter in the `get_items()` as shown before, the output table is already containing all the filtered items from the input table.

A trick to force the re-processing is to delete the items manually from the database or one of its output files (if any and if you have included the `remove_widow_db_rows()` or `verify_checksum()`) but this is not really comfortable. The most elegant solution is to include a column in the output table to store the value of *gauss_sigma* and then adding a where condition in the query looking for the existing items.

Look at this query snippet example:

```python
def get_items(self):

    # add here all your checks, table creations, filter bindings

    if self.filter_register.new_only:
        query = (
            Image.select(OutputTable.input_id)
            .where(OutputTable.gauss_sigma == self.gauss_sigma)
            )
```

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```
        existing = ~InputTable.input_id.in_([row.input_id for row in query])
    else:
        existing = True

    items = (InputTable.select(InputTable)
                .where(self.filter_register.filter_all())
                .where(existing)
                )

    return items
```

This approach is very handy, because it allows to link the entries in the database with the parameters set in the steering file, but it must be used with care, because changing a parameter will trigger the reprocessing of all entries while you might be thinking that this will only apply to the added items only.

9.6.3 Advanced *new_only* filtering with multiple column primary keys

Before moving on to the next section, we would like to show you another implementation tip where multiple column primary keys and *new_only* filtering work nice together. In the *basic usage* the new only flag the input and output tables were linked by a foreign key based on a single column primary key. Now let's see how we can handle the situation where the input table is the cross join of two tables with different primary keys (*image_id* from ProcessedImage and *method_id* from CalibrationMethod) and the output table CalibratedImage has the combined primary key (*image_id*, *method_id*). The models described here refers to the ones described *here*.

The idea is to use field combinations and for this you can rely on some helper functions defined in the `db_tools` module. Let's have a look at a possible implementation.

```
def get_items(self):

    # check if we want to process only new items
    if self.filter_register.new_only:
        # get a combined primary key because the output table (CalibratedImage) has
        # a multicolumn primary key
        existing_combo = combine_pk(CalibratedImage,
                                    alias_name = 'combo',
                                    join_str = ' x ')

        # execute a select on the output table for the combined field
        existing_entries = CalibratedImage.select(existing_combo).execute()

        # to find the existing entries in the input model, we need to combine the fields
        # and compare them to the list of combined pks from the target model.
        # Pay attention to two things:
        #   1. In the where conditions you cannot have an alias, so the
        #       combine_fields is not aliased.
        #   2. The argument of the in_ must be a python list and not the pure select.
        existing = ~combine_fields(
            [ProcessedImage.image_id,
            CalibrationMethod.method_id],
            join_str = ' x '
            ).in_([entry.combo for entry in existing_entries])
    else:
        existing = True

    query = (
        ProcessedImage.select(ProcessedImage, Image, Sample,
```

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```
30                                              Resolution, CalibrationMethod)
31          .join_from(ProcessedImage, Image, attr='_image')
32          .join_from(Image, Sample, on=(Image.sample_id == Sample.sample_id), attr='_sample')
33          .join_from(Image, Resolution, on=(Image.resolution_id == Resolution.resolution_id), attr='_resolution')
34          .join_from(ProcessedImage, CalibrationMethod, on=True, attr='_calibration_method')
35          .where(existing)
36          .where(self.filter_register.filter_all())
37      )
38      return query
```

The code snippet is rather self-explanatory and well commented. The most important parts are the lines 7-9: they are the SQL equivalent of:

```sql
SELECT image_id | ' x ' | method_id FROM calibrated_image
```

so it will return one single column of text where each row is something like *1 x 1*, *2 x 1*. . . .. You can change the joining string to whatever you like most, the only requirement is that it must be the same as the one used at line 23.

The next step is to build a query of all possible combinations of the two fields *ProcessedImage.image_id* and *CalibrationMethod.method_id*. This is obtained using the `combine_fields()` function. Pay attention to two small details:

1. The output of `combine_fields()` is meant to be used in the where condition and peewee does not supported aliased expression in where conditions.
2. The *in_* operator is expecting a python list as argument, so you need to transform the existing_entries query is a list with the combinations.

9.7 Why do I get an error about model binging?

It is possible that when using filters in your project, you will get an error at runtime mentioning that it was not possible to perform autobinding of the model or that the `ModelFilter` was no bound before it is use.

The reason for this error is very simple and the solution also straightforward. But let me fist explain what model binding means and how it is done. When you write your steering file and configure the filters, you identify the model class with a string in the TOML dictionary. The model is a class and the interpreter needs to connect (bind) the name you provide with the steering file with a Model class in order to perform the actual filters generation.

The current implementation of peewee does not provide a list or a dictionary of all the existing models in a database, but MAFw has a solution for this, the `ModelRegister` already introduced in the previous section *Automatic model registration*. If your Model inherits from `MAFwBaseModel`, then you are safe: the `processor filter` will ask the `model register` to provide the link between the model name and the actual class and your are good to go.

If your Models are not inheriting from `MAFwBaseModel` then you have to do the binding manually. It is not difficult, it is just a line of code to be added to the implementation of the get_items method just before preparing the query, Here is an example:

Listing 9.3: Manual filter - model binding

```python
def get_items(self):

    # create your tables, if they still do not exist
    self.database.create_tables([Model1, Model2])

    # now bind the filters with the models
    self.filter_register.bind([Model1, Model2])
```

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```
    # now continue the code as in the previous examples.
```

9.8 Filter migration from MAFw v1.4.0

If you were using MAFw in its early version v1.4, you might be find interesting reading this paragraph. Otherwise, skip it and go to the next chapter.

There were a lot of changes to the filter module going from v1.4 to v2.0, mainly in the implementation side but some also in the interface. So if you had steering files generated with version v1.4, they probably won't work directly with the newest version.

Here is a list of the important changes that you need to take care of:

1. **The GlobalFilter** is removed. In the old version, this was used to store the global new_only flag and, if implemented, some default filters to be applied to all processors in the pipeline. This functionality has become incompatible with the new system and has been removed. If you want to set the value of the new_only flag at the pipeline level, just use the new_only variable at the top level of the steering file and you can change it at Processor level using the *__new_only__* keyword.
2. **Filter replaced by __filter__**. In the old steering files, the TOML table containing the definition of the filters for each model was identified by the word *Filter* (with capitol F). This has now been replaced by the keyword *__filter__*, with double underscores at the beginning and at the end. This is to allow you to have a processor parameter named Filter and also it is more in line with the keyword style used for the logic statement, the new only tag and the conditional filters.
3. **Automatic binding**. In version v1.4, the filter binding with the model was under the responsibility of the user, meaning that it was your task to do the binding of each filter with its model before being able to generate the filtering expression. In version v2.0, thanks to the `ModelRegister` the binding process is happening automatically if your models inherit from `MAFwBaseModel`.
4. **Missing fields in a ModelFilter**. In version v1.4, if you had a field condition in a ModelFilter that was not matching any field in the bound model, the condition was silently ignored. If for example, you wanted to create a condition on a field named *my_image_id* and you wrote a condition line *image_id = 5*, the filter was not able to find the image_id field in the model and it was ignoring this statement. This behavior is incompatible with the new implementation. Now all conditions in a ModelFilter should match a field in the corresponding model. If the user provided a logic statement, not mentioning one or more conditions, they will silently ignored, otherwise the default behavior of AND'ing all of them will be applied.

9.9 What's next

The power of filters is incredible and you can control them via the steering file without having to change a single line in your code!

The next chapter is about the library of advanced processors that MAFw is sharing to simplify your job even further. In particular, we are sure you will like a lot our plotting processors!

CHAPTER 10

DISPLAY YOUR RESULTS

Scientists love to present their results graphically, because like a picture is worth a thousand words, a good plot can replace a lot of tables. The python scene is full of libraries for data visualization, from the most basic like matplotlib offering a low level interface to higher level tools like seaborn where the user can profit from predefined classes to display complex relationships among different variables in the dataset.

In a spirit of complete freedom, MAFw is not deciding for you what plotting or data frame library you should use for your analysis. For this reason, we have prepared a skeleton of the *generic plotter processor* that you can use as a template and implement it with your favorite libraries.

Nevertheless, if you are ok with the use of seaborn as a data visualization platform (using matplotlib under the hood for the low level plotting routines) and pandas and numpy for data handling, then MAFw can offer you a pre-cooked solution implemented in the *SNSPlotter*.

If you want to use *SNSPlotter*, then you need to install mafw including the *seaborn* optional feature, in this way:

```
c:\> pip install mafw[seaborn]
```

In the next section of this unit, we will assume that you are using the seaborn functionalities.

10.1 Add diagnostic information to your processors

Processors are responsible for performing simple analysis tasks; however, it is essential to verify and assess the accuracy of their output. We strongly recommend to include the generation of some diagnostic plots or storing some key results in a database table while implementing the *process()* method in order to verify the correct execution of the analysis task.

This aspect is totally in your hand and MAFw has little to offer; you will have to code your *Processor* so that it can create meaningful figures.

> **Warning**
>
> For this diagnostic output you can use the graphical library of your choice, but many of you will opt for *matplotlib* given its widespread use in the field. This library allows you to decide which backend to use from a long list of options including interactive and not interactive choices. If you let matplotlib decide, it will use one of the available backends according to a precedence list. In many cases, this will be *TkAgg* that is known to have issues when used in a non interactive way with frequently opening and closure of figure windows. Those issues will appear as randomly occurring RuntimeError involving TclAsync or main thread not in main loop. In such a case, the solution is to switch to a non-interactive backend that is normally absolutely ok because usually diagnostic output is simply saved on files and not directly displayed to you. The simplest non interactive backend is *Agg* and it is built-in in *matplotlib* so no need to install anything else.

You can force *matplotlib* to select a specific backend via the environment variable MPLBACKEND simply setting it to agg. This decision will affect all scripts (including mafw execution engine). If you want something that is specific for one or many processors of yours, you can add the following lines of code to your processor start method.

```
try:
    my_backend == 'agg'
    if plt.get_backend() != my_backend:
        plt.switch_backend(my_backend)
except ModuleNotFoundError:
    log.critical('%s is not a valid plt backend' % my_backend)
    raise
```

You can even have a processor whose only task is to turn on and off interactivity. The reason why this is not an option available in the base Processor class is that MAFw is graphics agnostic and unless you install the optional feature `seaborn` otherwise matplotlib is not automatically installed.

10.2 Generate high level graphs

Along with graphs aimed to verify that your processor was actually behaving as expected, you might have the need to have processors whose main task is indeed the generation of high level figures to be used for your publications or presentations starting from a data frame.

In this case, MAFw is providing you a powerful tool: the *generic plotter processor*.

The *SNSPlotter* is a member of the *processor_library* package and represents a specialized subclass of a *Processor*[1] with a predefined *process()* method.

When you are subclassing a *Processor*, you are normally required to implement some methods and the most important of all is clearly the *process()* one, where your analytical task is actually coded.

For a *SNSPlotter*, the *process method* is already implemented and it looks like the following code snipped:

```
def process(self) -> None:
    """
    Process method overload.

    In the case of a plotter subclass, the process method is already implemented and␣
↪the user should not overload
    it. On the contrary, the user must overload the other implementation methods␣
↪described in the general
    :class:`class description <.SNSPlotter>`.
    """
    if self.filter_register.new_only:
        if self.is_output_existing():
            return

    self.in_loop_customization()
    self.get_data_frame()
    self.patch_data_frame()
    self.slice_data_frame()
    self.group_and_aggregate_data_frame()
    if not self.is_data_frame_empty():
        self.plot()
        self.customize_plot()
        self.save()
        self.update_db()
```

[1] Actually *SNSPlotter* parent class is *GenericPlotter* that is a subclass of *Processor*. This intermediate inheritance step is needed to allow the user to define their preferred interface to graphical and data frame library.

In its basic form, all the methods included in the process have an empty implementation, and it is your task to make them doing something.

We can divide these methods into two blocks:

- **The data handling methods: where the data frame is acquired and prepared for the plotting step.**
  1. *get_data_frame()*
  2. *patch_data_frame()*
  3. *slice_data_frame()*
  4. *group_and_aggregate_data_frame()*
- **The plotting methods: where you will have to generate the figures from the data frame and save them.**
  1. *plot()*
  2. *customize_plot()*
  3. *save()*
  4. *update_db()*

10.2.1 Getting the data

The first thing to do when you want to plot some data is to have the data! The *SNSPlotter* has a *data_frame* attribute to store a pandas data frame exactly for this purpose. The data frame can be read in from a file or retrieved from a database table or even built directly in the processor itself. The *get_data_frame()* is the place where this is happening. It is important that you assign the data frame to *self.data_frame* attribute so that the following methods can operate on it.

The following three methods are giving you the possibility to add new columns based on the existing ones (*patch_data_frame()*), selecting a sub set of rows (*slice_data_frame()*) and grouping / aggregating the rows (*group_and_aggregate_data_frame()*).

Data frame patching

Use this method to add or modify data frame columns. One typical example is the application of unit of measurement conversion: you may want to store the data using the SI unit, but it is more convenient to display them using another more practical unit. Another interesting application is to replace numerical categorical values with textual one: for example you may want to add a column with the sample name to replace the column with the sample identification number. You can implement all these operations overloading the *patch_data_frame()* method. Below is an example of how to add an additional column that represents the exposure time of an image acquisition in hours, converted from the stored value in seconds.

```
self.data_frame['ExposureTimeH'] = self.data_frame['ExposureTime'] / 3600.
```

Slicing the data frame

Use this method to select a specific group of rows, corresponding to a certain value for a variable. You do not need to overload the *slice_data_frame()*, but just define the *slicing_dict* attribute and the basic implementation will do the magic. Have a look also at the documentation of the function *slice_data_frame()* from the *pandas_tools* module. In a few words, if you have a data frame with four columns named A, B, C and D and you want to select only the rows where column A is equal to 10, then set `self.slicing_dict = { 'A' :  10 }` and the *slice_data_frame()* method will do the job for you.

Group and aggregate the data frame

In a similar manner, you can group and aggregate the columns of the data frame by defining the *grouping columns* and *aggregation functions* attributes. Also for this method, have a look at the *group_and_aggregate_data_frame()* function from the *pandas_tools*. If, for example, you have a data frame containing two columns named SampleName and Signal and you want to get the average and standard deviation of the signal column for each of the different samples, then you can do:

```
self.grouping_columns = ['SampleName']
self.aggregation_functions = ['mean', 'std']
```

The *group_and_aggregate_data_frame()* will perform the grouping and aggregation and assign to the *self.data_frame* a modified data frame with three columns named SampleName, Signal_mean and Signal_std.

Per cycle customization

You may wonder, when and where in your code you should be setting the slicing and grouping / aggregating parameters. Those values can be 'statically' provided directly in the constructor of the generic plotter processor subclass, but you can also have them dynamically assigned at run time overloading the *in_loop_customization()* method.

In the implementation of this method you can also set other parameters relevant for your plotting.

10.2.2 Plotting the data

Now that you have retrieved and prepared your data frame, you can start the real plotting. First of all, just be sure that after all your modifications, the data frame is still containing some rows, otherwise, just move on to the next iteration.

The generation of the real plot is done in the implementation of the *plot()*. The *SNSPlotter* is meant to operate with seaborn so it is quite reasonable to anticipate that the results of the plotting will be assigned to a *facet grid attribute*, in order to allow the following methods to refer to the plotting output.

If your *plot()* implementation is not actually generating a facet grid, but something else, it is still ok. If you want to pass a static typing, then define a attribute in your *SNSPlotter* subclass with the proper typing; if you are not doing any static typing you can still use the facet grid attribute for storing your object.

Customising the plot

When producing high quality graphs, you want to have everything looking perfect. You can implement this method to set the figure and plot titles, the axis labels and to add specific annotations. If your *SNSPlotter* implementation is following a looping execution workflow, you can use the looping parameters if you need them. Theoretically speaking you could code this customisation directly in the plot method, but the reason for this split will become clear later on when explaining the *mixin approach*.

Save the plot

This is where your figure must be saved to a file. The very typical implementation of this method is the following:

```
def save(self) -> None:
    self.facet_grid.figure.savefig(self.output_filename)
    self.output_filename_list.append(self.output_filename)
```

This is assuming that your *SNSPlotter* subclass has an attribute (it can also be a processor parameter) named output_filename. The second statement is also very common: the *SNSPlotter* has a list type attribute to store the names of all generated files. This list, along with the cumulative checksum will be stored in the dedicated *PlotterOutput* standard table, to avoid the regeneration of identical plots. You do not have to worry about updating this standard table, this operation will be performed automatically by the private method *_update_plotter_db()*.

Update the db

Along with the *PlotterOutput* standard table, you may want to update also other objects in the database. For this purpose, you can implement the *update_db()* method.

10.2.3 Mixin approach

You might have noticed that the structure of the `process()` is a bit *over-granular*. The reason behind this fine distinction is due to the fact that the code can potentially be reused to a large extent thanks to a clever use of mixin classes.

Explanation

If you are not a seasoned programmer, you might not be familiar with the concept of mixins. Those are small classes implementing a specific subtask of a bigger class, finding extensive usage in developing interfaces. If you wish, you can have a general explanation following this webpage.

If you are aware of what a mixin is and how to use it, then just go to the *next section*.

In the case of the `SNSPlotter`, we have seen that its methods can be divided into two categories: the data retriever and the actual plotter. You can have several different data retriever options and also different plotting strategies, thus making the creation of a matrix of subclasses of the `SNSPlotter` covering all possible cases really unpractical.

The mixin approach allows to have a flexible subclass scheme and at the same time an optimal reuse of code units.

To make things even more evident, here is a logical scheme of what happens when you mix a `DataRetriever` mixin with a `SNSPlotter`.

Let us start from the definition of the subclass itself:

```
class MyPlotterSNS(MyDataRetrieverMixin, MyPlotMixin, SNSPlotter):
```

MyPlotterSNS is mixing two mixins, one `DataRetriever` and one `FigurePlotter`, with the `SNSPlotter`. The order **matters**: always put mixins before the base class, because this is affecting the method resolution order (MRO) that follows a depth-first left-to-right traversal.

`MyDataRetrieverMixin` being a subclass of `DataRetriever` is implementing these two methods `get_data_frame()` and `patch_data_frame()` that are also defined in the `SNSPlotter`.

During the execution of the `process()`, the `get_data_frame` method will be called and, thanks to the MRO, the MyDataRetrieverMixin will provide its implementation of such method. The same will apply for the `plot`, where the MyPlotMixin will kick in and provide its implementation of the method.

Mixins can come with other class parameters along with the ones shared with the base class. Those can be accessed and assigned using the standard dot notation on the instances of the mixed class, or they can also be defined in the mixed class constructor directly.

Data-retriever mixins

Let us start considering the data retrieval part. Very likely, you will get those data either from a database table or from a HDF5 file. If this is the case, then you do not need to code the get_data_frame method everytime, but you can use one of the available mixin to grab the data.

For the moment, the following data retriever mixins exist[2]:

- `HDFPdDataRetriever`.

  This data retriever is opening the provided HDF5 file name and obtaining the data frame identified by the provided key.

- `SQLPdDataRetriever`.

  This data retriever is performing a SQL query on a table (*table_name*) using as columns the provided *required_columns* list and fulfilling the *where_clause*. A valid database connection must exist for this retriever to work, it means that the processor with which this class is mixed must have a working database instance.

- `FromDatasetDataRetriever`.

[2] The extra *Pd* in the name of these classes stands for Pandas. In fact the user is free to select any other data frame library and define their own data retriever mixin.

This data retriever is provided mainly for test and debug purposes. It allows to obtain a data frame from the standard data set library of seaborn.

If you plan to retrieve data several times from a common source, you may consider to add your own mixin class. Just make it inheriting from the `DataRetriever` (or `PdDataRetriever` if you are using Pandas) class and follow one of the provided case as an example.

Here below is an example of a Plotter retrieving the data from a HDF file:

```
@single_loop
class HDFPlotterSNS(HDFDataRetriever, SNSPlotter):
    pass

hdf = HDFPlotterSNS(hdf_filename=your_input_file, key=your_key)
hdf.execute()
```

The hdf_filename and the key can be provided directly in the class constructor, but this might not doable if you are planning to execute the processor using the *mafw steering file* approach.

In this case, you can add two parameters to your processor that can be read from the steering file and follow this approach:

```
@single_loop
class HDFPlotterSNS(HDFDataRetriever, SNSPlotter):
    hdf_filename_from_steering = ActiveParameter('hdf_filename_from_steering',␣
↪default='my_datafile.h5')
    hdf_key_from_steering = ActiveParameter('hdf_key_from_steering', default='my_key')

    def start(self):
        super().start()
        # you can assign the parameter values to the mixin attributes in the start␣
↪method
        # but also in the in_loop_customization method if this is better suiting your␣
↪needs
        self.hdf_filename = self.hdf_filename_from_steering
        self.key = self.hdf_key_from_steering

# let us execute the processor from within the mafw runner.
```

Figure plot mixins

In a similar way, if what you want is to generate a seaborn figure level plot, then you do not need to define the plot method every time. Just mix the SNSPlotter with one of the four figure plotter mixins available:

- *`RelPlot`*: to plot relational plots.
- *`DisPlot`*: to plot distribution graphs.
- *`CatPlot`*: to produce categorical figures.
- *`LMPlot`*: to produce linear regression model figures.

From the coding point of it, the approach is identical to the one shown before for the data retrieving mixin.

```
@single_loop
@processor_depends_on_optional(module_name='pandas;seaborn')
class DataSetRelPlotPlotterSNS(FromDatasetDataRetriever, RelPlot, SNSPlotter):
    def __init__(self, output_png: str | Path | None = None, *args: Any, **kwargs:␣
↪Any) -> None:
        super().__init__(*args, **kwargs)
        self.output_png = Path(output_png) if output_png is not None else Path()
```

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```
    def save(self) -> None:
        self.facet_grid.figure.savefig(self.output_png)
        self.output_filename_list.append(self.output_png)

output_file = tmp_path / Path('relplot_from_dataset.png')

dsrp = DataSetRelPlotPlotterSNS(
    output_file, dataset_name='penguins', x='flipper_length_mm', y='bill_length_mm',␣
↪col='sex', hue='species'
)
dsrp.execute()
```

The code above will generate this plot:

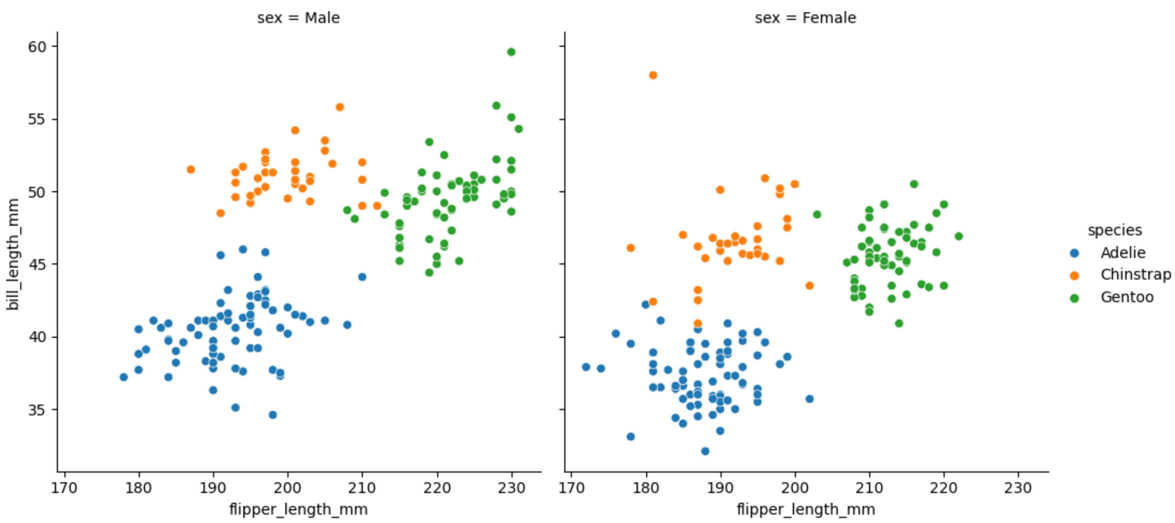

Fig. 10.1: This is the exemplary output of a SNSPlotter mixed with a data retriever and a relational plot mixin.

As you can see, the plot method is taken from the RelPlot mixin and the output can be further customized (axis labels and similar things) implementing the customize_plot method.

A large fraction of the parameters that can be passed to the seaborn figure level functions corresponds to attributes in the mixin class, but not all of them. For the missing ones, you can use the dictionary like parameter plot_kws, to have them passed to the underlying plotting function. See the documentation of the mixins for more details (*RelPlot*, *DisPlot* and *CatPlot*).

Note

Note for direct readers: If you have navigated directly to this practical example without reading the preceding documentation, please be aware that this implementation demonstrates advanced concepts and methodologies that are thoroughly explained in the earlier sections. While this example is designed to be self-contained, some technical details, and design decisions may not be immediately clear without the foundational knowledge provided in the main documentation. Should you encounter unfamiliar concepts or require deeper understanding of the library's architecture and principles, we recommend referring back to the relevant sections of the complete documentation.

CHAPTER 11

A STEP BY STEP TUTORIAL FOR A REAL EXPERIMENTAL CASE STUDY

Congratulations! You have decided to give a try to MAFw for your next analysis, you have read all the documentation provided, but you got overwhelmed by information and now you do not know from where to start.

Do not worry, we have a simple, but nevertheless complete example that will guide you through each and every steps of your analysis.

Before start typing code, let's introduce the experimental scenario.

11.1 The experimental scenario

Let's imagine, that we have a measurement setup integrating the amount of UV radiation reaching a sensor in a give amount of time.

The experimental data acquisition (DAQ) system is saving one file for each exposure containing the value read by the sensor. The DAQ is encoding the duration of the acquisition in the file name and let's assume we acquired 25 different exposures, starting from 0 up to 24 hours. The experimental procedure is repeated for three different detectors having different type of response and the final goal of our experiment is to compare their performance.

It is an ultra simplified experimental case and you can easily make it as complex as you wish, just by adding other variables (different UV lamps, detector operating conditions, background illumination…). Nevertheless this simple scenario can be straightforward expanded to any real experimental campaign.

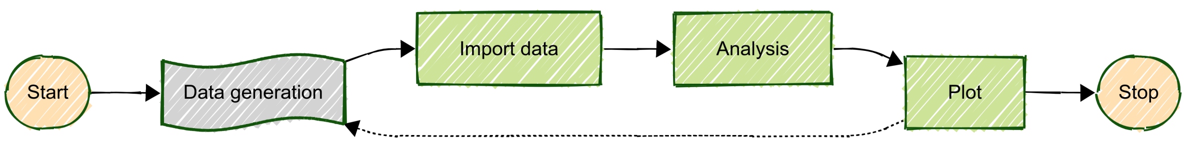

Fig. 11.1: The simplified pipeline for the tutorial example.

11.1.1 Task 0. Generating the data

This is not really an analysis task, rather the real acquisition of the data, that's why it is represented with a different color in schema above. Nevertheless it is important to include that in our planning, because new data might be generated during or after some data have been already analyzed. In this case, it is important that our analysis pipelines will be able to process only the new (or modified) data, without wasting time and resources re-doing what has been done already. This is the reason why there is a dashed line looping back from the plot step to the data generation. Since this is a simulated experiment, instead of collecting real data, we will use a *Processor* to generate some synthetic data.

11.1.2 Task 1. Building your data bank

From a conceptual point of view, the first thing you should do when using MAFw is to import all your data (in this case the raw data files) into a relational database. You do not need to store the content of the file in the database, otherwise it will soon explode in size, you can simply insert the full path from where the file can be retrieved and its checksum, so that we can keep an eye on possible modifications.

11.1.3 Task 2. Do the analysis

In the specific scenario the analysis is very easy. Each file contains only one number, so there is very little to be done, but your case can be as complicated as needed. We will open each file, read the content and then put it in a second database table containing the results of the analysis of each file. In your real life experiment, this stage can contain several processors generating intermediate results stored as well in the database.

11.1.4 Task 3. Prepare a relation plot

Using the data stored in the database, we can generate a plot representing the integral flux versus the exposure time for the three different detectors using a relation plot.

11.2 The 'code'

In the previous section, we have defined what we want to achieve with our analysis (it is always a good idea to have a plan before start coding!). Now we are ready to start with setting up the project containing the required processors to achieve the analytical goal described above.

If you want to use MAFw plugin mechanism, then you need to build your project as a proper python package. Let's start then with the project specification contained in the `pyproject.toml` file.

```toml
[build-system]
requires = ["hatchling"]
build-backend = "hatchling.build"

[project]
name = "plug_test"
dynamic = ["version"]
description = 'A MAFw processor library plugin'
readme = "README.md"
requires-python = ">=3.11"
license = "EUPL-1.2"
authors = [
  { name = "Antonio Bulgheroni", email = "antonio.bulgheroni@ec.europa.eu" },
]
classifiers = [
  "Development Status :: 4 - Beta",
  "Programming Language :: Python",
  "Programming Language :: Python :: 3.11",
  "Programming Language :: Python :: 3.12",
  "Programming Language :: Python :: 3.13",
  "Programming Language :: Python :: Implementation :: CPython",
  "Programming Language :: Python :: Implementation :: PyPy",
]

dependencies = ['mafw', 'pluggy']

[project.urls]
Documentation = "https://github.com/..."
Issues = "https://github.com/..."
Source = "https://github.com/."
```

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```

[project.entry-points.mafw]
plug_test = 'plug.plugins'

[tool.hatch.version]
path = "src/plug/__about__.py"

[tool.hatch.build.targets.wheel]
packages = ['src/plug']
```

The specificity of this configuration file is in the highlighted lines: we define an entry point where your processors are made available to MAFw.

Now before start creating the rest of the project, prepare the directory structure according to the python packaging specification. Here below is the expected directory structure.

```
plug
├── README.md
├── pyproject.toml
└── src
    └── plug
        ├── __about__.py
        ├── db_model.py
        ├── plug_processor.py
        └── plugins.py
```

You can divide the code of your analysis in as many python modules as you wish, but for this simple project we will keep all processors in one single module *plug_processor.py*. We will use a second module for the definition of the database model classes (*db_model.py*). Additionally we will have to include a *plugins.py* module (this is the one declared in the pyproject.toml entry point definition) where we will list the processors to be exported along with our additional standard tables.

11.2.1 The database definition

Let's move to the database definition.

Our database will contain tables corresponding to the three model classes: InputFile and Data, and one helper table for the detectors along with all the *standard tables* that are automatically created by MAFw.

Before analysing the code let's visualize the database with the ERD.

The InputFile is the model where we will be storing all the data files that are generated in our experiment while the Data model is where we will be storing the results of the analysis processor, in our specific case, the value contained in the input file.

The rows of these two models are linked by a 1-to-1 relation defined by the primary key.

Remember that is always a good idea to add a checksum field every time you have a filename field, so that we can check if the file has changed or not.

The InputFile model is also linked with the Detector model to be sure that only known detectors are added to the analysis.

Let's have a look at the way we have defined the three models.

```
class Detector(StandardTable):
    detector_id = AutoField(primary_key=True, help_text='Primary key for the detector␣
↪table')
    name = TextField(help_text='The name of the detector')
    description = TextField(help_text='A longer description for the detector')

```

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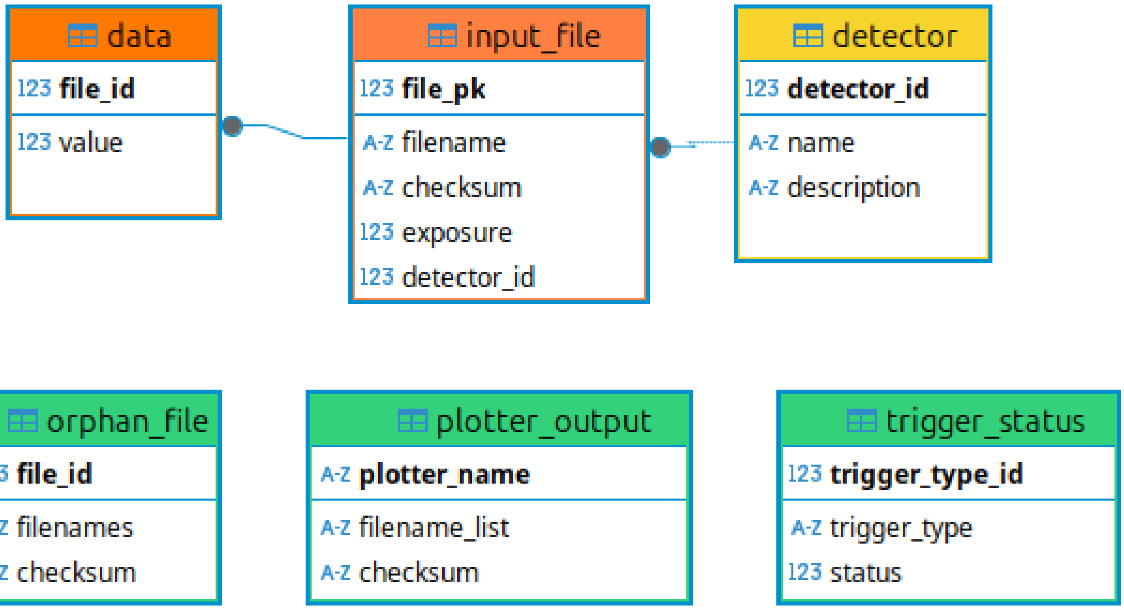

Fig. 11.2: The schematic representation of our database. The standard tables, automatically created are in green. The detector table (yellow) is exported as a standard table and its content is automatically restored every time mafw is executed.

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```
    @classmethod
    def init(cls) -> None:
        data = [
            dict(detector_id=1, name='Normal', description='Standard detector'),
            dict(detector_id=2, name='HighGain', description='High gain detector'),
            dict(detector_id=3, name='NoDark', description='Low dark current detector'),
        ]

        cls.insert_many(data).on_conflict(
            conflict_target=[cls.detector_id],
            update={'name': SQL('EXCLUDED.name'), 'description': SQL('EXCLUDED.description')},
        ).execute()
```

The detector table is derived from the StandardTable, because we want the possibility to initialize the content of this table every time the application is executed. This is obtained in the init method. The use of the on_conflict clause assure that the three detectors are for sure present in the table with the value given in the data object. This means that if the user manually changes the name of one of these three detectors, the next time the application is executed, the original name will be restored.

```
class InputFile(MAFwBaseModel):
    @classmethod
    def triggers(cls) -> list[Trigger]:
        update_file_trigger = Trigger(
            trigger_name='input_file_after_update',
            trigger_type=(TriggerWhen.After, TriggerAction.Update),
            source_table=cls,
            safe=True,
            for_each_row=True,
        )
```

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```python
        update_file_trigger.add_when(or_('NEW.exposure != OLD.exposure', 'NEW.checksum != OLD.checksum'))
        update_file_trigger.add_sql('DELETE FROM data WHERE file_pk = OLD.file_pk;')

        return [update_file_trigger]

    file_pk = AutoField(primary_key=True, help_text='Primary key for the input file table')
    filename = FileNameField(unique=True, checksum_field='checksum', help_text='The filename of the element')
    checksum = FileChecksumField(help_text='The checksum of the element file')
    exposure = FloatField(help_text='The duration of the exposure in h')
    detector = ForeignKeyField(
        Detector, Detector.detector_id, on_delete='CASCADE', backref='detector', column_name='detector_id'
    )
```

The InputFile has five columns, one of which is a foreign key linking it to the Detector model. Note that we have used the FileNameField and FileChecksumField to take advantage of the *verify_checksum()* function. InputFile has a trigger that is executed after each update that is changing either the exposure or the file content (checksum). When one of these conditions is verified, then the corresponding row in the Data file will be removed, because we want to force the reprocessing of this file since it has changed. A similar trigger on delete is actually not needed because the Data model is linked to this model with an on_delete cascade option.

```python
class Data(MAFwBaseModel):
    @classmethod
    def triggers(cls) -> list[Trigger]:
        delete_plotter_sql = 'DELETE FROM plotter_output WHERE plotter_name = "PlugPlotter";'

        insert_data_trigger = Trigger(
            trigger_name='data_after_insert',
            trigger_type=(TriggerWhen.After, TriggerAction.Insert),
            source_table=cls,
            safe=True,
            for_each_row=False,
        )
        insert_data_trigger.add_sql(delete_plotter_sql)

        update_data_trigger = Trigger(
            trigger_name='data_after_update',
            trigger_type=(TriggerWhen.After, TriggerAction.Update),
            source_table=cls,
            safe=True,
            for_each_row=False,
        )
        update_data_trigger.add_when('NEW.value != OLD.value')
        update_data_trigger.add_sql(delete_plotter_sql)

        delete_data_trigger = Trigger(
            trigger_name='data_after_delete',
            trigger_type=(TriggerWhen.After, TriggerAction.Delete),
            source_table=cls,
            safe=True,
            for_each_row=False,
        )
```

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```
        delete_data_trigger.add_sql(delete_plotter_sql)

        return [insert_data_trigger, delete_data_trigger, update_data_trigger]

    file_pk = ForeignKeyField(InputFile, on_delete='cascade', backref='file', primary_
↪key=True, column_name='file_id')
    value = FloatField(help_text='The result of the measurement')
```

The Data model has only two columns, one foreign key linking to the InputFile and one with the value calculated by the Analysis processor. It is featuring three triggers executed on INSERT, UPDATE and DELETE. In all these cases, we want to be sure that the output of the PlugPlotter is removed so that a new one is generated. Keep in mind that when a row is removed from the PlotterOutput model, the corresponding files are automatically added to the OrphanFile model for removal from the filesystem the next time a processor is executed.

Via the use of the foreign key, it is possible to associate a detector and the exposure for this specific value.

11.2.2 The processor library

Let's now prepare one processor for each of the tasks that we have identified in our planning. We will create a processor also for the data generation.

GenerateDataFiles

This processor will accomplish Task 0 and it is very simple. It will generate a given number of files containing one single number calculated given the exposure, the slope and the intercept. The detector parameter is used to differentiate the output file name. As you see here below, the code is very simple.

```
class GenerateDataFiles(Processor):
    n_files = ActiveParameter('n_files', default=25, help_doc='The number of 1-h␣
↪increasing exposure')
    output_path = ActiveParameter(
        'output_path', default=Path.cwd(), help_doc='The path where the data files␣
↪are stored.'
    )
    slope = ActiveParameter(
        'slope', default=1.0, help_doc='The multiplication constant for the data␣
↪stored in the files.'
    )
    intercept = ActiveParameter(
        'intercept', default=5.0, help_doc='The additive constant for the data stored␣
↪in the files.'
    )
    detector = ActiveParameter(
        'detector', default=1, help_doc='The detector id being used. See the detector␣
↪table for more info.'
    )

    def __init__(self, *args, **kwargs):
        super().__init__(*args, **kwargs)
        self.n_digits = len(str(self.n_files))

    def start(self) -> None:
        super().start()
        self.output_path.mkdir(parents=True, exist_ok=True)

    def get_items(self) -> Collection[Any]:
        return list(range(self.n_files))
```

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```python

    def process(self) -> None:
        current_filename = self.output_path / f'rawfile_exp{self.i_item:0{self.n_digits}}_det{self.detector}.dat'
        value = self.i_item * self.slope + self.intercept
        with open(current_filename, 'wt') as f:
            f.write(str(value))

    def format_progress_message(self) -> None:
        self.progress_message = f'Generating exposure {self.i_item} for detector {self.detector}'
```

In order to generate the different detectors, you run the same processor with different values for the parameters.

PlugImporter

This processor will accomplish Task 1, i.e. import the raw data file into our database. This processor is inheriting from the basic *Importer* so that we can use the functionalities of the *FilenameParser*.

```python
@database_required
class PlugImporter(Importer):
    def __init__(self, *args: Any, **kwargs: Any) -> None:
        super().__init__(*args, **kwargs)
        self._data_list: list[dict[str, Any]] = []

    def get_items(self) -> Collection[Any]:
        pattern = '**/*dat' if self.recursive else '*dat'
        input_folder_path = Path(self.input_folder)

        file_list = [file for file in input_folder_path.glob(pattern) if file.is_file()]

        # verify the checksum of the elements in the input table. if they are not up to date, then remove the row.
        verify_checksum(InputFile)

        if self.filter_register.new_only:
            # get the filenames that are already present in the input table
            existing_rows = InputFile.select(InputFile.filename).namedtuples()
            # create a set with the filenames
            existing_files = {row.filename for row in existing_rows}
            # filter out the file list from filenames that are already in the database.
            file_list = [file for file in file_list if file not in existing_files]

        return file_list

    def process(self) -> None:
        try:
            new_file = {}
            self._filename_parser.interpret(self.item.name)
            new_file['filename'] = self.item
            new_file['checksum'] = self.item
            new_file['exposure'] = self._filename_parser.get_element_value('exposure')
            new_file['detector'] = self._filename_parser.get_element_value('detector')
            self._data_list.append(new_file)
        except ParsingError:
```

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```
            log.critical('Problem parsing %s' % self.item.name)
            self.looping_status = LoopingStatus.Skip

    def finish(self) -> None:
        InputFile.insert_many(self._data_list).on_conflict_replace(replace=True).
↪execute()
        super().finish()
```

The get_items is using the *verify_checksum()* to verify that the table is still actual and we apply the filter to be sure to process only new or modified files. The process and finish are very standard. In this specific case, we preferred to add all the relevant information in a list and insert them all in one single call to the database. But also the opposite approach (no storing, multiple insert) is possible.

Analyser

This processor will accomplish Task 2, i.e. the analysis of the files. In our case, we just need to open the file, read the value and put it in the database.

```
@database_required
class Analyser(Processor):
    def get_items(self) -> Collection[Any]:
        self.filter_register.bind_all([InputFile])

        if self.filter_register.new_only:
            existing_entries = Data.select(Data.file_pk).execute()
            existing = ~InputFile.file_pk.in_([i.file_pk for i in existing_entries])
        else:
            existing = True

        query = (
            InputFile.select(InputFile, Detector)
            .join(Detector, attr='_detector')
            .where(self.filter_register.filter_all())
            .where(existing)
        )

        return query

    def process(self) -> None:
        with open(self.item.filename, 'rt') as fp:
            value = float(fp.read())

        Data.create(file_pk=self.item.file_pk, value=value)

    def format_progress_message(self) -> None:
        self.progress_message = f'Analysing {self.item.filename.name}'
```

Also in this case, the generation of the item list is done keeping in mind the possible *filters* the user is applying in the steering file. In the process, we are inserting the data directly to the database, so we will have one query for each item.

PlugPlotter

This processor will accomplish the last task, i.e. the generation of a relation plot where the performance of the three detectors is compared.

```python
@database_required
@processor_depends_on_optional(module_name='seaborn')
@single_loop
class PlugPlotter(SQLPdDataRetriever, RelPlot, SNSPlotter):
    new_defaults = {
        'output_folder': Path.cwd(),
    }

    def __init__(self, *args, **kwargs):
        super().__init__(
            *args,
            table_name='data_view',
            required_cols=['exposure', 'value', 'detector_name'],
            x='exposure',
            y='value',
            hue='detector_name',
            facet_kws=dict(legend_out=False, despine=False),
            **kwargs,
        )

    def start(self) -> None:
        super().start()

        sql = """
        CREATE TEMP VIEW IF NOT EXISTS data_view AS
        SELECT
            file_id, detector.detector_id, detector.name as detector_name, exposure, value
        FROM
            data
            JOIN input_file ON data.file_id = input_file.file_pk
            JOIN detector USING (detector_id)
        ORDER BY
            detector.detector_id ASC,
            input_file.exposure ASC
            ;
        """
        self.database.execute_sql(sql)

    def customize_plot(self):
        self.facet_grid.set_axis_labels('Exposure', 'Value')
        self.facet_grid.figure.subplots_adjust(top=0.9)
        self.facet_grid.figure.suptitle('Data analysis results')
        self.facet_grid._legend.set_title('Detector type')

    def save(self) -> None:
        output_plot_path = self.output_folder / 'output.png'

        self.facet_grid.figure.savefig(output_plot_path)
        self.output_filename_list.append(output_plot_path)
```

This processor is a mixture of `SQLPdDataRetriever`, `RelPlot` and `SNSPlotter`. The `SNSPlotter` has already some parameters and with the *new_defaults* dictionary we *over ride* value of the output_folder to point to the current folder.

Looking at the init method, you might notice a strange thing, the table_name variable is set to *data_view*, that does not corresponding to any of our tables. The reason for this strangeness is quickly explained.

The *SQLPdDataRetriever* is generating a pandas Dataframe from a SQL query. In our database the data table contains only two columns: the file reference and the measured value, so we have no direct access to the exposure nor to the detector. To get these other fields we need to join the data table with the input_file and the detector ones. The solution for this problem is the creation of a temporary view containing this join query. Have a look at the start method. This view will be deleted as soon as the connection will be closed.

11.2.3 The plugin module

Everything is ready, we just have to make MAFw aware of our processors and our standard tables. We are missing just a few lines of code in the plugins module

```python
import mafw
from mafw.lazy_import import LazyImportProcessor, ProcessorClassProtocol


@mafw.mafw_hookimpl
def register_processors() -> list[ProcessorClassProtocol]:
    return [
        LazyImportProcessor('plug.plug_processor', 'GenerateDataFiles'),
        LazyImportProcessor('plug.plug_processor', 'PlugImporter'),
        LazyImportProcessor('plug.plug_processor', 'Analyser'),
        LazyImportProcessor('plug.plug_processor', 'PlugPlotter'),
    ]


@mafw.mafw_hookimpl
def register_db_model_modules() -> list[str]:
    return ['plug.db_model']
```

The code is self-explaining. We need to invoke the processor hooks and return the list of processors. Instead of passing the real processor, we will use the *processors proxies*, so that we can defer the import of the processor modules when and if needed.

11.3 Run the code!

We are done with coding and we are ready to run our analysis.

First thing, we need to install our package in a separated python environment.

Windows

```
c:\> python -m venv my_venv
c:\> cd my_venv
c:\my_venv> bin\activate
(my_venv) c:\my_venv> pip install -e c:\path\to\plug
```

linux & MacOS

```
$ python -m venv my_venv
$ source my_venv/bin/activate
(my_venv) $ pip install -e /path/to/plug
```

Now verify that the installation was successful. If you run mafw list command you should get the list of all available processors including the three that you have created.

Windows

```
(my_venv) c:\my_venv> mafw list
```

linux & MacOS

```
(my_venv) $ mafw list
```

One last step, before running the analysis. We need to make the two steering files, one for the generation of the synthetic data and one for the real analysis and also the configuration file for the importer.

File generation

```
# file: generate-file.toml
processors_to_run = ["GenerateDataFiles#1", "GenerateDataFiles#2", "GenerateDataFiles
↪#3"]

# customise the name of the analysis
analysis_name = "integration-test-p1"
analysis_description = """Generating data files"""
available_processors = ["GenerateDataFiles"]

[GenerateDataFiles]
n_files = 25 # The number of files being generated.
output_path = "/tmp/full-int/data" # The path where the data files are stored.
slope = 1.0 # The multiplication constant for the data stored in the files.
detector = 1 # The detector id being used. See the detector table for more info.

["GenerateDataFiles#1"]
intercept = 5.0 # The additive constant for the data stored in the files.
slope = 1.0 # The multiplication constant for the data stored in the files.
detector = 1 # The detector id being used. See the detector table for more info.

["GenerateDataFiles#2"]
intercept = 15.0 # The additive constant for the data stored in the files.
slope = 5.0 # The multiplication constant for the data stored in the files.
detector = 2 # The detector id being used. See the detector table for more info.

["GenerateDataFiles#3"]
intercept = 0.1 # The additive constant for the data stored in the files.
slope = 0.2 # The multiplication constant for the data stored in the files.
detector = 3 # The detector id being used. See the detector table for more info.

[UserInterface] # Specify UI options
interface = "rich" # Default "rich", backup "console"
```

Analysis

```
# file: analysis.toml
processors_to_run = ["TableCreator","PlugImporter","Analyser", "PlugPlotter"]

# customise the name of the analysis
analysis_name = "integration-test-p2"
analysis_description = """Analysing data"""
available_processors = ["PlugImporter", "Analyser", "PlugPlotter"]
new_only = true

```

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```toml
[DBConfiguration]
URL = "sqlite:////tmp/full-int/plug.db" # Change the protocol depending on the DB type. Update this file to the path of your DB.

[DBConfiguration.pragmas] # Leave these default values, unless you know what you are doing!
journal_mode = "wal"
cache_size = -64000
foreign_keys = 1
synchronous = 0

[TableCreator] # Processor to create all tables in the database.
apply_only_to_prefix = [] # Create only tables whose name start with the provided prefixes.
force_recreate = false

[PlugImporter]
input_folder = "/tmp/full-int/raw_data" # The input folder from where the images have to be imported.
parser_configuration = "/tmp/full-int/importer_config.toml" # The path to the TOML file with the filename parser configuration
recursive = true

[Analyser]

[PlugPlotter]
output_plot_path = "/tmp/full-int/output.png" # The filename of the output plot

[UserInterface] # Specify UI options
interface = "rich" # Default "rich", backup "console"
```

Importer configuration

```toml
# file: importer_config.toml
elements = ['exposure', 'detector']

[exposure]
regexp = '[_-]*exp(?P<exposure>\d+\.*\d*)[_-]*'
type='float'

[detector]
regexp = '[_-]*det(?P<detector>\d+)[_-]*'
type='int'
```

Adapt the steering files, in particular the paths and you are ready to run! In the analysis TOML file, you will also find the section concerning the database; for this simple case we used a SQLite single file DB, but whatever *other DB* would work exactly in the same way.

Windows

```
(my_venv) c:\my_venv> mafw run generate-file.toml
```

linux & MacOS

```
(my_venv) $ mafw run generate-file.toml
```

This will run the GenerateDataFiles processor three times, as specified in the three replicas, one for each detector. In the steering file, you can see that there are base settings specified in the base GenerateDataFiles table, plus some specific values for the three replicas. If you need are refresh on processor replicas, go back *here*. The three processor replicas will generate all our input data and we are ready to start the data analysis.

Windows

```
(my_venv) c:\my_venv> mafw run analysis.toml
```

linux & MacOS

```
(my_venv) $ mafw run analysis.toml
```

And here comes the magic! The three processors will be executed one after the other, the database is created and filled with all the provided data and the comparison plot is generated (default file name output.png).

This is just the beginning, now you can try all the benefits to use a clever database to drive your analysis pipeline. Try, for example, to remove one file and re-run the analysis, you will see a warning message informing you that a file was not found and that the corresponding row in the database has been removed as well. The rest of the analysis will remain the same, but the output plot will be regenerated with a missing point.

Try to manually modify the content of a file and re-run the analysis. The `verify_checksum()` will immediately detect the change and force the re-analysis of that file and the generation of the output plot.

Try to rename one file changing the exposure value. You will see that mafw will detect that one file is gone missing in action, but a new one has been found. The output file will be update.

Try to repeat the analysis without any change and mafw won't do anything! Try to delete the output plot and during the next run mafw will regenerate it.

You can also play with the database. Open it in DBeaver (be sure that the foreign_check is enforced) and remove one line from the input_file table. Run the analysis and you will see that the output plot file is immediately removed because it is no more actual and a new one is generated at the end of chain.

It's not magic even if it really looks like so, it's just a powerful library for scientists written by scientists!

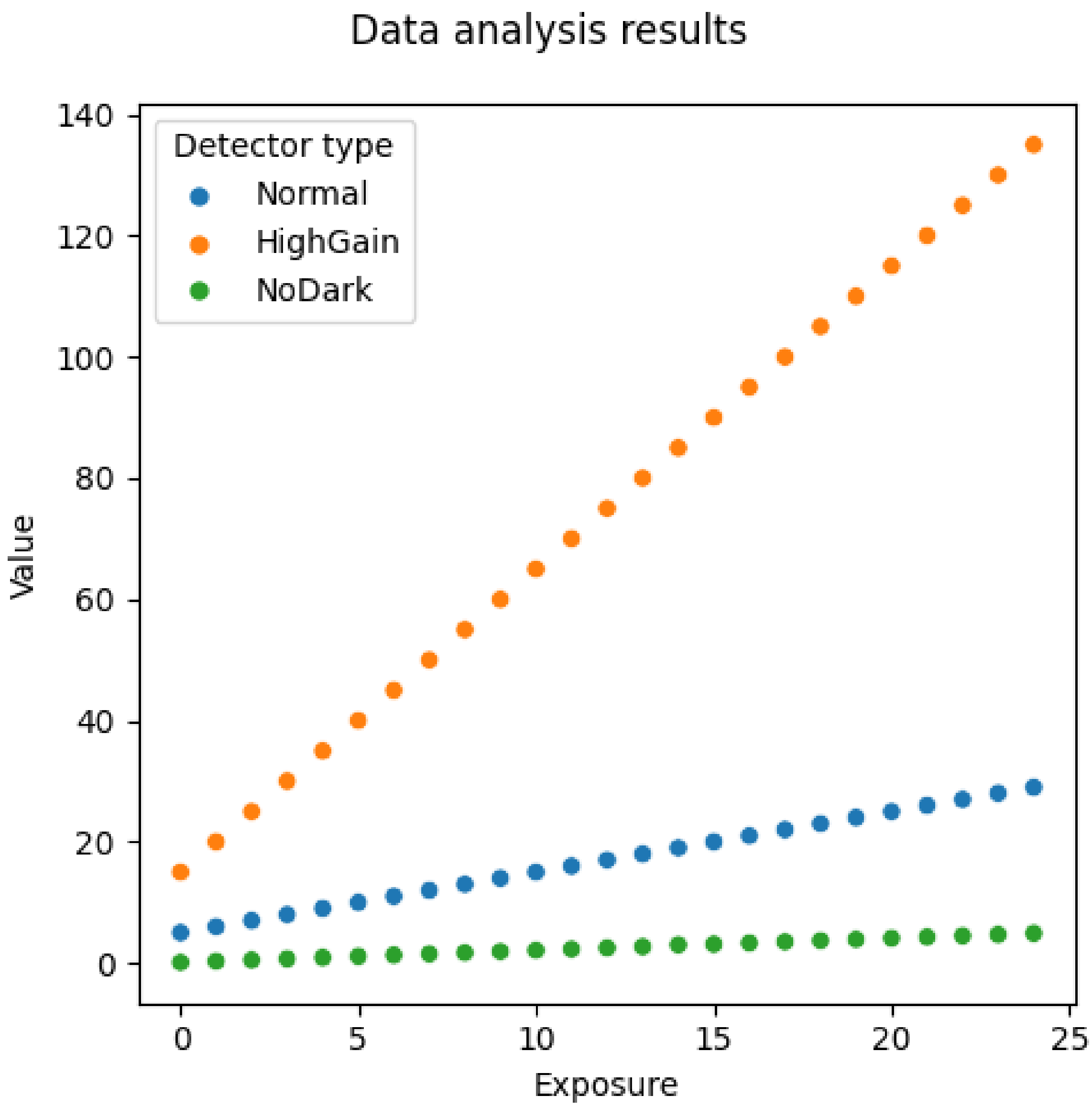

Fig. 11.3: The comparison plot of the three detectors.

CHAPTER 12

API

This page is particularly useful for the developers because it offers a quick view at the implemented API.

mafw	The Modular Analysis Framework

12.1 mafw

The Modular Analysis Framework

A software tool for scientists written by scientists!

Module Attributes

mafw_hookimpl	Marker to be imported and used in plugins loading

```
mafw.mafw_hookimpl = <pluggy._hooks.HookimplMarker object>
```

Marker to be imported and used in plugins loading

Modules

active	Module implements active variable for classes.
db	Defines the DB interface
decorators	The module provides some general decorator utilities that are used in several parts of the code, and that can be reused by the user community.
enumerators	Module provides a set of enumerators for dealing with standard tasks.
examples	A library of examples.
hookspecs	Defines the hook specification decorator bound the MAFw library.
lazy_import	This module provides classes for lazy importing of plugins, ensuring thread-safe access and transparent usage.
mafw_errors	Module defines MAFw exceptions
plugin_manager	Plugin management system for MAFw framework.
plugins	Exports Processor classes to the execution script.

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processor	Module implements the basic Processor class, the ProcessorList and all helper classes to achieve the core functionality of the MAFw.
processor_library	Library of generic processors.
runner	Provides a container to run configurable and modular analytical tasks.
scripts	Executables.
timer	Module implements a simple timer to measure the execution duration.
tools	The package provides a set of tools for different range of applications.
ui	User interface modules.

12.1.1 mafw.active

Module implements active variable for classes.

Module Attributes

ActiveType	A type for templating the Active class.
ActivableType	A type for all classes that can include an Active.

Classes

Active([default])	A descriptor class to make class variable **active**.

`class mafw.active.ActivableType`

A type for all classes that can include an Active.

alias of TypeVar('ActivableType')

`class mafw.active.Active`(*default:* ActiveType | *None* = *None*)

Bases: `Generic[ActiveType]`

A descriptor class to make class variable **active**.

When assigned to a class variable, any change of this value will trigger a call back to a specific function.

Here is a clarifying example.

```
class Person:
    age = Active()

    def __init__(self, age):
        self.age = age

    def on_age_change(self, old_value, new_value):
        # callback invoked every time the value of age is changed
        # do something with the old and the new age
        pass

    def on_age_set(self, value):
        # callback invoked every time the value on age is set to the same
        # value as before.
        pass

```

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```
    def on_age_get(self, value):
        # callback invoked every time the value of age is asked.
        # not really useful, but...
        pass
```

Once you have assigned an Active to a class member, you need to implement the callback in your class. If you do not implement them, the code will run without problems.

The three callbacks have the signature described in the example.

- on_[var_name]_change(self, old, new)
- on_[var_name]_set(self, value)
- on_[var_name]_get(self, value)

Constructor parameter:

Parameters
`default` (`ActiveType`) – Initial value of the Active value. Defaults to None.

class `mafw.active.ActiveType`

A type for templating the Active class.

alias of TypeVar('ActiveType')

12.1.2 mafw.db

Defines the DB interface

Modules

db_configurations	Module provides default configurations for different database engines.
db_filter	Database filter module for MAFW.
db_model	The module provides functionality to MAFw to interface to a DB.
db_types	Database Type Definitions
db_wizard	The module allows to generate a DB model structure starting from an existing DB.
fields	Module provides customised model fields specific for MAFw.
model_register	Module for registering and retrieving database models.
std_tables	Module provides standard tables that are included in all database created by MAFw processor.
trigger	Module provides a Trigger class and related tools to create triggers in the database via the ORM.

mafw.db.db_configurations

Module provides default configurations for different database engines.

Module Attributes

default_conf	default configuration dictionary used to generate steering files
db_scheme	default database scheme

mafw.db.db_configurations.**db_scheme = {'mysql': 'mysql://', 'postgresql': 'postgresql://', 'sqlite': 'sqlite:///'}**

default database scheme

mafw.db.db_configurations.**default_conf = {'mysql': {'URL': 'mysql://user:passwd@ip:port/my_db'}, 'postgresql': {'URL': 'postgresql://postgres:my_password@localhost:5432/my_database'}, 'sqlite': {'URL': 'sqlite:///my_database.db', 'pragmas': {'cache_size': -64000, 'foreign_keys': 1, 'journal_mode': 'wal', 'synchronous': 0}}}**

default configuration dictionary used to generate steering files

mafw.db.db_filter

Database filter module for MAFW.

This module provides classes and utilities for creating and managing database filters using Peewee ORM. It supports various filtering operations including simple conditions, logical combinations, and conditional filters where one field's criteria depend on another.

The module implements a flexible filter system that can handle:

- Simple field comparisons (equality, inequality, greater/less than, etc.)
- Complex logical operations (AND, OR, NOT)
- Conditional filters with dependent criteria
- Nested logical expressions
- Support for various data types and operations

Key components include:

- *FilterNode*: Abstract base class for filter nodes
- *ConditionNode*: Represents individual field conditions
- *LogicalNode*: Combines filter nodes with logical operators
- *ConditionalNode*: Wraps conditional filter conditions
- *ModelFilter*: Main class for building and applying filters to models
- *ProcessorFilter*: Container for multiple model filters in a processor

The module uses a hierarchical approach to build filter expressions that can be converted into Peewee expressions for database queries. It supports both simple and complex filtering scenarios through a combination of direct field conditions and logical expressions.

Changed in version v2.0.0: Major overhaul introducing conditional filters and logical expression support.

Example usage:

```
from mafw.db.db_filter import ModelFilter

# Create a simple filter
flt = ModelFilter(
    'Processor.__filter__.Model',
    field1='value1',
    field2={'op': 'IN', 'value': [1, 2, 3]},
)

# Bind to a model and generate query
flt.bind(MyModel)
query = MyModel.select().where(flt.filter())
```

See also

peewee - The underlying ORM library used for database operations

LogicalOp - Logical operation enumerations used in filters

Module Attributes

Token	Type definition for a logical expression token
NameNode	An atom is a tuple of the literal string 'NAME' and the value
NotNode	A NOT node is a tuple of 'NOT' and a recursive node
BinaryNode	AND/OR nodes are tuples of the operator and two recursive nodes
ExprNode	The main recursive type combining all options
TOKEN_SPECIFICATION	Token specifications
MASTER_RE	Compiled regular expression to interpret the logical expression grammar

Functions

tokenize(text)	Tokenize a logical expression string into a list of tokens.

Classes

ConditionNode(field, operation, value[, name])	Represents a single condition node in a filter expression.
ConditionalFilterCondition(condition_field, ...)	Represents a conditional filter where one field's criteria depends on another.
ConditionalNode(conditional[, name])	Wraps *ConditionalFilterCondition* behaviour as a *FilterNode*.
ExprParser(text)	Recursive descent parser producing a simple Abstract Syntax Tree (AST).
FilterNode()	Abstract base for nodes.
LogicalNode(op, *children)	Logical combination of child nodes.
ModelFilter(name_, **kwargs)	Class to filter rows from a model.
ProcessorFilter([data])	A special dictionary to store all *Filters* in a processors.

Exceptions

ParseError	Exception raised when parsing a logical expression fails.

exception `mafw.db.db_filter.`**`ParseError`**

Bases: `ValueError`

Exception raised when parsing a logical expression fails.

This exception is raised when the parser encounters invalid syntax in a logical expression string.

class `mafw.db.db_filter.`**`ConditionNode`**(*field: str | None*, *operation: LogicalOp | str*, *value: Any*, *name: str | None = None*)

Bases: *FilterNode*

Represents a single condition node in a filter expression.

This class encapsulates a single filtering condition that can be applied to a model field. It supports various logical operations through the *LogicalOp* enumerator or string representations of operations.

Added in version v2.0.0.

Initialize a condition node.

Parameters

- **field** (*str | None*) – The name of the field to apply the condition to.
- **operation** (LogicalOp *| str*) – The logical operation to perform.
- **value** (*Any*) – The value to compare against.
- **name** (*str | None, Optional*) – Optional name for this condition node.

to_expression(*model: type[Model]*) → Expression

Convert this condition node to a Peewee expression.

This method translates the condition represented by this node into a Peewee expression that can be used in database queries.

Parameters
model (*type[Model]*) – The model class containing the field to filter.

Returns
A Peewee expression representing this condition.

Return type
peewee.Expression

Raises

- **RuntimeError** – If the node has no field to evaluate.
- **ValueError** – If an unsupported operation is specified.
- **TypeError** – If operation requirements are not met (e.g., IN operation requires list/tuple).

class mafw.db.db_filter.**ConditionalFilterCondition**(*condition_field: str*, *condition_op: str |* LogicalOp, *condition_value: Any*, *then_field: str*, *then_op: str |* LogicalOp, *then_value: Any*, *else_field: str | None = None*, *else_op: str |* LogicalOp *| None = None*, *else_value: Any | None = None*, *name: str | None = None*)

Bases: object

Represents a conditional filter where one field's criteria depends on another.

This allows expressing logic like: "IF field_a IN [x, y] THEN field_b IN [1, 2] ELSE no constraint on field_b"

Example usage:

```
# Filter: sample_id in [1,2] if composite_image_id in [100,101]
condition = ConditionalFilterCondition(
    condition_field='composite_image_id',
    condition_op='IN',
    condition_value=[100, 101],
    then_field='sample_id',
    then_op='IN',
```

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```
    then_value=[1, 2],
)

# This generates:
# WHERE (composite_image_id IN (100, 101) AND sample_id IN (1, 2))
#    OR (composite_image_id NOT IN (100, 101))
```

Initialise a conditional filter condition.

Parameters

- **condition_field** (*str*) – The field to check for the condition
- **condition_op** (*str | LogicalOp*) – The operation for the condition (e.g., 'IN', '==')
- **condition_value** (*Any*) – The value(s) for the condition
- **then_field** (*str*) – The field to filter when condition is true
- **then_op** (*str | LogicalOp*) – The operation to apply when condition is true
- **then_value** (*Any*) – The value(s) for the then clause
- **else_field** (*str | None*) – Optional field to filter when condition is false
- **else_op** (*str | LogicalOp | None*) – Optional operation when condition is false
- **else_value** (*Any | None*) – Optional value(s) for the else clause
- **name** (*str | None, Optional*) – The name of this condition. Avoid name clashing with model fields. Defaults to None

to_expression(*model: type[Model]*) → Expression

Convert this conditional filter to a Peewee expression.

The resulting expression is: (condition AND then_constraint) OR (NOT condition AND else_constraint)

Which logically means:

- When condition is true, apply then_constraint
- When condition is false, apply else_constraint (or no constraint)

Parameters
model (*type[Model]*) – The model class containing the fields

Returns
A Peewee expression

Return type
peewee.Expression

class mafw.db.db_filter.**ConditionalNode**(*conditional: ConditionalFilterCondition*, *name: str | None = None*)

Bases: *FilterNode*

Wraps *ConditionalFilterCondition* behaviour as a *FilterNode*.

This class serves as an adapter to integrate conditional filter conditions into the filter node hierarchy, allowing them to be treated uniformly with other filter nodes during expression evaluation.

Added in version v2.0.0.

Initialize a conditional node.

Parameters

- **conditional** (`ConditionalFilterCondition`) – The conditional filter condition to wrap
- **name** (*str | None, Optional*) – Optional name for this conditional node

to_expression(*model: type[Model]*) → Expression

Convert this conditional node to a Peewee expression.

This method delegates the conversion to the wrapped conditional filter condition's *to_expression()* method.

Parameters
model (*type[Model]*) – The model class to generate the expression for

Returns
A Peewee expression representing this conditional node

Return type
peewee.Expression

class mafw.db.db_filter.**ExprParser**(*text: str*)

Bases: `object`

Recursive descent parser producing a simple Abstract Syntax Tree (AST).

The parser handles logical expressions with the following grammar:

```
expr    := or_expr
or_expr := and_expr ("OR" and_expr)*
and_expr:= not_expr ("AND" not_expr)*
not_expr:= "NOT" not_expr | atom
atom    := NAME | "(" expr ")"
```

AST nodes are tuples representing different constructs:

- ("NAME", "token"): A named element (field name or filter name)
- ("NOT", node): A negation operation
- ("AND", left, right): An AND operation between two nodes
- ("OR", left, right): An OR operation between two nodes

Added in version v2.0.0.

Initialize the expression parser with a logical expression string.

Parameters
text (*str*) – The logical expression to parse

accept(**kinds: str*) → tuple[str, str] | None

Accept and consume the next token if it matches one of the given types.

Parameters
kinds (*str*) – Token types to accept

Returns
The consumed token if matched, otherwise None

Return type
Token | None

expect(*kind: str*) → tuple[str, str]

Expect and consume a specific token type.

Parameters
kind (*str*) – The expected token type

Returns
The consumed token

Return type
Token

Raises
ParseError – If the expected token is not found

parse() → tuple[Literal['NAME'], str] | tuple[Literal['NOT'], ExprNode] | tuple[Literal['AND', 'OR'], ExprNode, ExprNode]

Parse the entire logical expression and return the resulting AST.

Returns
The abstract syntax tree representation of the expression

Return type
ExprNode

Raises
ParseError – If the expression is malformed

parse_and() → tuple[Literal['NAME'], str] | tuple[Literal['NOT'], ExprNode] | tuple[Literal['AND', 'OR'], ExprNode, ExprNode]

Parse an AND expression.

Returns
The parsed AND expression AST node

Return type
ExprNode

parse_atom() → tuple[Literal['NAME'], str] | tuple[Literal['NOT'], ExprNode] | tuple[Literal['AND', 'OR'], ExprNode, ExprNode]

Parse an atomic expression (NAME or parenthesised expression).

Returns
The parsed atomic expression AST node

Return type
ExprNode

Raises
ParseError – If an unexpected token is encountered

parse_not() → tuple[Literal['NAME'], str] | tuple[Literal['NOT'], ExprNode] | tuple[Literal['AND', 'OR'], ExprNode, ExprNode]

Parse a NOT expression.

Returns
The parsed NOT expression AST node

Return type
ExprNode

parse_or() → tuple[Literal['NAME'], str] | tuple[Literal['NOT'], ExprNode] | tuple[Literal['AND', 'OR'], ExprNode, ExprNode]

Parse an OR expression.

Returns
The parsed OR expression AST node

Return type
ExprNode

peek() → tuple[str, str] | None

Peek at the next token without consuming it.

Returns
The next token if available, otherwise None

Return type
Token | None

class mafw.db.db_filter.**FilterNode**

Bases: object

Abstract base for nodes.

class mafw.db.db_filter.**LogicalNode**(*op: str*, **children: FilterNode*)

Bases: *FilterNode*

Logical combination of child nodes.

This class represents logical operations (AND, OR, NOT) applied to filter nodes. It enables building complex filter expressions by combining simpler filter nodes with logical operators.

Added in version v2.0.0.

Initialize a logical node.

Parameters

- **op** (*str*) – The logical operation ('AND', 'OR', 'NOT')
- **children** (FilterNode) – Child filter nodes to combine with the logical operation

to_expression(*model: type[Model]*) → Expression | bool

Convert this logical node to a Peewee expression.

This method evaluates the logical operation on the child nodes and returns the corresponding Peewee expression.

Parameters
model (*type[Model]*) – The model class to generate the expression for

Returns
A Peewee expression representing this logical node

Return type
peewee.Expression | bool

Raises
ValueError – If an unknown logical operation is specified

class mafw.db.db_filter.**ModelFilter**(*name_: str*, ***kwargs: Any*)

Bases: object

Class to filter rows from a model.

The filter object can be used to generate a where clause to be applied to Model.select().

The construction of a ModelFilter is normally done via a configuration file using the *from_conf()* class method. The name of the filter is playing a key role in this. If it follows a dot structure like:

ProcessorName.__filter__.ModelName

then the corresponding table from the TOML configuration object will be used.

For each processor, there might be many Filters, up to one for each Model used to get the input list. If a processor is joining together three Models when performing the input select, there will be up to three Filters collaborating on making the selection.

The filter configuration can contain the following key, value pair:

- key / string pairs, where the key is the name of a field in the corresponding Model
- key / numeric pairs
- key / arrays
- key / dict pairs with 'op' and 'value' keys for explicit operation specification

All fields from the configuration file will be added to the instance namespace, thus accessible with the dot notation. Moreover, the field names and their filter value will be added to a private dictionary to simplify the generation of the filter SQL code.

The user can use the filter object to store selection criteria. He can construct queries using the filter contents in the same way as he could use processor parameters.

If he wants to automatically generate valid filtering expression, he can use the `filter()` method. In order for this to work, the ModelFilter object be *bound* to a Model. Without this binding the ModelFilter will not be able to automatically generate expressions.

For each field in the filter, one condition will be generated according to the following scheme:

Filter field type	Logical operation	Example
Numeric, boolean	==	Field == 3.14
String	GLOB	Field GLOB '*ree'
List	IN	Field IN [1, 2, 3]
Dict (explicit)	op from dict	Field BIT_AND 5

All conditions will be joined with a AND logic by default, but this can be changed.

The ModelFilter also supports logical expressions to combine multiple filter conditions using AND, OR, and NOT operators. These expressions can reference named filter conditions within the same filter or even combine conditions from different filters when used with `ProcessorFilter`.

Conditional filters allow expressing logic like: "IF field_a IN [x, y] THEN field_b IN [1, 2] ELSE no constraint on field_b"

Consider the following example:

```python
class MeasModel(MAFwBaseModel):
    meas_id = AutoField(primary_key=True)
    sample_name = TextField()
    successful = BooleanField()
    flags = IntegerField()
    composite_image_id = IntegerField()
    sample_id = IntegerField()


# Traditional simplified usage
flt = ModelFilter(
    'MyProcessor.__filter__.MyModel',
    sample_name='sample_00*',
    meas_id=[1, 2, 3],
    successful=True,
)

# New explicit operation usage
flt = ModelFilter(
    'MyProcessor.__filter__.MyModel',
    sample_name={'op': 'LIKE', 'value': 'sample_00%'},
    flags={'op': 'BIT_AND', 'value': 5},
    meas_id={'op': 'IN', 'value': [1, 2, 3]},
```

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```
)

# Logical expression usage
flt = ModelFilter(
    'MyProcessor.__filter__.MyModel',
    sample_name={'op': 'LIKE', 'value': 'sample_00%'},
    flags={'op': 'BIT_AND', 'value': 5},
    meas_id={'op': 'IN', 'value': [1, 2, 3]},
    __logic__='sample_name AND (flags OR meas_id)',
)

# Conditional filter usage
flt = ModelFilter(
    'MyProcessor.__filter__.MyModel',
    sample_name='sample_00*',
    composite_image_id=[100, 101],
    sample_id=[1, 2],
    __conditional__=[
        {
            'condition_field': 'composite_image_id',
            'condition_op': 'IN',
            'condition_value': [100, 101],
            'then_field': 'sample_id',
            'then_op': 'IN',
            'then_value': [1, 2],
        }
    ],
)

flt.bind(MeasModel)
filtered_query = MeasModel.select().where(flt.filter())
```

The explicit operation format allows for bitwise operations and other advanced filtering.

TOML Configuration Examples:

```
[MyProcessor.__filter__.MyModel]
sample_name = "sample_00*"  # Traditional GLOB
successful = true           # Traditional equality

# Explicit operations
flags = { op = "BIT_AND", value = 5 }
score = { op = ">=", value = 75.0 }
category = { op = "IN", value = ["A", "B", "C"] }
date_range = { op = "BETWEEN", value = ["2024-01-01", "2024-12-31"] }

# Logical expression for combining conditions
__logic__ = "sample_name AND (successful OR flags)"

# Conditional filters
[[MyProcessor.__filter__.MyModel.__conditional__]]
condition_field = "composite_image_id"
condition_op = "IN"
condition_value = [100, 101]
then_field = "sample_id"
then_op = "IN"
then_value = [1, 2]
```

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```
# Nested conditions with logical expressions
[MyProcessor.__filter__.MyModel.nested_conditions]
__logic__ = "a OR b"
a = { op = "LIKE", value = "test%" }
b = { op = "IN", value = [1, 2, 3] }
```

See also

- *mafw.db.db_filter.ProcessorFilter* - For combining multiple ModelFilters with logical expressions
- *mafw.db.db_filter.ConditionalFilterCondition* - For conditional filtering logic
- *mafw.db.db_filter.ExprParser* - For parsing logical expressions

Constructor parameters:

Parameters

- **name_** (*str*) – The name of the filter. It should be in dotted format to facilitate the configuration via the steering file. The _ is used to allow the user to have a keyword argument named name.
- **kwargs** – Keyword parameters corresponding to fields and filter values.

Changed in version v1.2.0: The parameter *name* has been renamed as *name_*.

Changed in version v1.3.0: Implementation of explicit operation.

Changed in version v2.0.0: Introduction of conditional filters, logical expression and hierarchical structure. Introduction of autobinding for MAFwBaseModels

classmethod from_conf(*name: str*, *conf: dict[str, Any]*) → Self

Builds a Filter object from a steering file dictionary.

If the name is in dotted notation, then this should be corresponding to the table in the configuration file. If a default configuration is provided, this will be used as a starting point for the filter, and it will be updated by the actual configuration in `conf`.

In normal use, you would provide the specific configuration via the conf parameter.

See details in the *class documentation*

Parameters

- **name** (*str*) – The name of the filter in dotted notation.
- **conf** (*dict*) – The configuration dictionary.

Returns
A Filter object

Return type
ModelFilter

static _create_condition_node_from_value(*value: Any*, *field_name: str*, *node_name: str | None = None*) → *ConditionNode*

Create a FilterCondition based on value type (backward compatibility).

Parameters

- **value** – The filter value
- **field_name** – The field name

Returns
A FilterCondition

_build_logical_node_from_ast(*ast: tuple[Literal['NAME'], str] | tuple[Literal['NOT'], tuple[Literal['NAME'], str] | tuple[Literal['NOT'], ExprNode] | tuple[Literal['AND', 'OR'], ExprNode, ExprNode]] | tuple[Literal['AND', 'OR'], tuple[Literal['NAME'], str] | tuple[Literal['NOT'], ExprNode] | tuple[Literal['AND', 'OR'], ExprNode, ExprNode], tuple[Literal['NAME'], str] | tuple[Literal['NOT'], ExprNode] | tuple[Literal['AND', 'OR'], ExprNode, ExprNode]], name_to_nodes: Dict[str,* FilterNode*], model_name_placeholder: str | None = None*) → *FilterNode*

Recursively build LogicalNode from AST using a mapping name->FilterNode.

_evaluate_logic_ast(*ast: tuple[Literal['NAME'], str] | tuple[Literal['NOT'], tuple[Literal['NAME'], str] | tuple[Literal['NOT'], ExprNode] | tuple[Literal['AND', 'OR'], ExprNode, ExprNode]] | tuple[Literal['AND', 'OR'], tuple[Literal['NAME'], str] | tuple[Literal['NOT'], ExprNode] | tuple[Literal['AND', 'OR'], ExprNode, ExprNode], tuple[Literal['NAME'], str] | tuple[Literal['NOT'], ExprNode] | tuple[Literal['AND', 'OR'], ExprNode, ExprNode]]*) → Expression | bool

Evaluate an abstract syntax tree (AST) representing a logical expression.

This method recursively evaluates the AST nodes to produce a Peewee expression or boolean value representing the logical combination of filter conditions.

Parameters
ast (*Any*) – The abstract syntax tree node to evaluate

Returns
A Peewee expression for logical operations or boolean True/False

Return type
peewee.Expression | bool

Raises

- **KeyError** – If a referenced condition name is not found in the filter
- **ValueError** – If an unsupported AST node type is encountered

add_conditional(*conditional:* ConditionalFilterCondition) → None

Add a conditional filter.

Added in version v2.0.0.

Parameters
conditional (`ConditionalFilterCondition`) – The conditional filter condition

add_conditional_from_dict(*config: dict[str, Any]*) → None

Add a conditional filter from a configuration dictionary.

Added in version v2.0.0.

Parameters
config (*dict[str, Any]*) – Dictionary with conditional filter configuration

bind(*model: type[Model]*) → None

Connects a filter to a Model class.

Parameters
model (*Model*) – Model to be bound.

filter(*join_with: Literal['AND', 'OR'] = 'AND'*) → Expression | bool

Generates a filtering expression joining all filtering fields.

See details in the *class documentation*

Changed in version v1.3.0: Add the possibility to specify a *join_with* function

Changed in version v2.0.0: Add support for conditional filters and for logical expression

Parameters
join_with (*Literal['AND', 'OR'], default 'AND'*) – How to join conditions ('AND' or 'OR'). Defaults to 'AND'.

Returns
The filtering expression.

Return type
peewee.Expression | bool

Raises

- **TypeError** – when the field value type is not supported.
- **ValueError** – when join_with is not 'AND' or 'OR'.

conditional_name = '__conditional__'

The conditional keyword identifier.

This value cannot be used as field name in the filter bound model.

property is_bound: bool

Returns true if the ModelFilter has been bound to a Model

logic_name = '__logic__'

The logic keyword identifier.

This value cannot be used as field name in the filter bound model.

class mafw.db.db_filter.**ProcessorFilter**(*data: dict[str,* ModelFilter*] | None = None, / (Positional-only parameter separator (PEP 570)), **kwargs: Any*)

Bases: UserDict[str, *ModelFilter*]

A special dictionary to store all *Filters* in a processors.

It contains a publicly accessible dictionary with the configuration of each ModelFilter using the Model name as keyword.

It contains a private dictionary with the global filter configuration as well. The global filter is not directly accessible, but only some of its members will be exposed via properties. In particular, the new_only flag that is relevant only at the Processor level can be accessed directly using the *new_only*. If not specified in the configuration file, the new_only is by default True.

It is possible to assign a logic operation string to the register that is used to join all the filters together when performing the *filter_all()*. If no logic operation string is provided, the register will provide a join condition using either AND (default) or OR.

Constructor parameters:

Parameters

- **data** (*dict*) – Initial data
- **kwargs** – Keywords arguments

bind_all(*models: list[type[Model]] | dict[str, type[Model]]*) → None

Binds all filters to their models.

The models list or dictionary should contain a valid model for all the ModelFilters in the registry. In the case of a dictionary, the key value should be the model name.

Parameters
models (*list[type(Model)] | dict[str,type(Model)]*) – List or dictionary of a databank of Models from which the ModelFilter can be bound.

filter_all(*join_with: Literal['AND', 'OR'] = 'AND'*) → Expression | bool

Generates a where clause joining all filters.

If a logic expression is present, it will be used to combine named filters. Otherwise, fall back to the legacy behaviour using join_with.

Raises

`ValueError` – If the parsing of the logical expression fails

Parameters

join_with (*Literal['AND', 'OR'], default: 'AND'*) – Logical function to join the filters if no logic expression is provided.

Returns

ModelFilter expression

Return type

peewee.Expression

property new_only: bool

The new only flag.

Returns

True, if only new items, not already in the output database table must be processed.

Return type

bool

mafw.db.db_filter.**tokenize**(*text: str*) → list[tuple[str, str]]

Tokenize a logical expression string into a list of tokens.

This function breaks down a logical expression string into individual tokens based on the defined token specifications. It skips whitespace and raises a *ParseError* for unexpected characters.

Parameters

text (*str*) – The logical expression string to tokenize

Returns

A list of tokens represented as (token_type, token_value) tuples

Return type

list[*Token*]

Raises

ParseError – If an unexpected character is encountered in the text

mafw.db.db_filter.**BinaryNode**

AND/OR nodes are tuples of the operator and two recursive nodes

alias of `tuple[Literal['AND', 'OR'], ExprNode, ExprNode]`

mafw.db.db_filter.**ExprNode**

The main recursive type combining all options

This type represents the abstract syntax tree (AST) nodes used in logical expressions. It can be one of:

- *NameNode*: A named element (field name or filter name)
- *NotNode*: A negation operation
- *BinaryNode*: An AND/OR operation between two nodes

alias of `tuple[Literal['NAME'], str] | tuple[Literal['NOT'], ExprNode] | tuple[Literal['AND', 'OR'], ExprNode, ExprNode]`

mafw.db.db_filter.**MASTER_RE = re.compile('(?P<LPAREN>\\()|(?P<RPAREN>\\))|(?P<AND>\\bAND\\b)|(?P<OR>\\bOR\\b)|(?P<NOT>\\bNOT\\b)|(?P<NAME>[A-Za-z_][A-Za-z0-9_\\.]*(?:\\:[A-Za-z_][A-Za-z0-9_]*)?)|(?P<SKIP>[\\t\\n\\r]+)|(?P<MISMATCH>.)')**

Compiled regular expression to interpret the logical expression grammar

mafw.db.db_filter.**NameNode**

An atom is a tuple of the literal string 'NAME' and the value

alias of `tuple`[`Literal`['NAME'], `str`]

mafw.db.db_filter.**NotNode**

A NOT node is a tuple of 'NOT' and a recursive node

alias of `tuple`[`Literal`['NOT'], ExprNode]

mafw.db.db_filter.**TOKEN_SPECIFICATION = [('LPAREN', '\\('), ('RPAREN', '\\)'), ('AND', '\\bAND\\b'), ('OR', '\\bOR\\b'), ('NOT', '\\bNOT\\b'), ('NAME', '[A-Za-z_][A-Za-z0-9_\\.]*(?:\\:[A-Za-z_][A-Za-z0-9_]*)?'), ('SKIP', '[\\t\\n\\r]+'), ('MISMATCH', '.')]**

Token specifications

mafw.db.db_filter.**Token**

Type definition for a logical expression token

alias of `tuple`[`str`, `str`]

mafw.db.db_model

The module provides functionality to MAFw to interface to a DB.

Module Attributes

database_proxy	This is a placeholder for the real database object that will be known only at run time
mafw_model_register	This is the instance of the ModelRegister

Functions

make_prefixed_suffixed_name(model_class)	Generate a table name with optional prefix and suffix for a given model class.

Classes

MAFwBaseModel(*args, **kwargs)	The base model for the MAFw library.
RegisteredMeta(name, bases, attrs, **kwargs)	Metaclass for registering models with the MAFw model registry.

Exceptions

MAFwBaseModelDoesNotExist	Raised when the base model class is not existing.

exception mafw.db.db_model.**MAFwBaseModelDoesNotExist**

Bases: *MAFwException*

Raised when the base model class is not existing.

class mafw.db.db_model.**MAFwBaseModel**(**args*, ***kwargs*)

Bases: `Model`

The base model for the MAFw library.

Every model class (table) that the user wants to interface must inherit from this base.

This class extends peewee's Model with several additional features:

1. Automatic model registration: Models are automatically registered with the MAFw model registry during class definition, enabling dynamic discovery and management of database models.
2. Trigger support: The class supports defining database triggers through the `triggers()` method, which are automatically created when the table is created. File removal triggers can also be automatically generated using the *file_trigger_auto_create* boolean flag in the *meta class*. See also `file_removal_triggers()`.
3. Standard upsert operations: Provides `std_upsert()` and `std_upsert_many()` methods for performing upsert operations that work with SQLite and PostgreSQL.
4. Dictionary conversion utilities: Includes `to_dict()`, `from_dict()`, and `update_from_dict()` methods for easy serialization and deserialization of model instances.
5. Customizable table naming: Supports table name prefixes and suffixes through the Meta class with *prefix* and *suffix* attributes. See `make_prefixed_suffixed_name()`.
6. Automatic table creation control: The *automatic_creation* Meta attribute controls whether tables are automatically created when the application starts.

> **Note**
>
> The automatic model registration can be disabled for one single model class using the keyword argument *do_not_register* passed to the `RegisteredMeta` meta-class. For example:
>
> ```
> class AutoRegisterModel(MAFwBaseModel):
>     pass
>
>
> class NoRegisterModel(MAFwBaseModel, do_not_register=True):
>     pass
> ```
>
> the first class will be automatically registered, while the second one will not. This is particularly useful if the user wants to define a base model class for the whole project without having it in the register where only concrete Model implementations are stored.

DoesNotExist

alias of `MAFwBaseModelDoesNotExist`

classmethod create_table(*safe: bool = True*, ***options: Any*) → None

Create the table in the underlying DB and all the related trigger as well.

If the creation of a trigger fails, then the whole table dropped, and the original exception is re-raised.

> **Warning**
>
> Trigger creation has been extensively tested with SQLite, but not with the other database implementation. Please report any malfunction.

Parameters

- **safe** (*bool, Optional*) – Flag to add an IF NOT EXISTS to the creation statement. Defaults to True.

- **options** – Additional options passed to the super method.

classmethod file_removal_triggers() → list[*Trigger*]

Generate a list of triggers for automatic file removal when records are deleted.

This method creates database triggers that automatically handle file cleanup when records containing `FileNameField` fields are removed from the database table. The triggers insert the filenames and checksums into the `OrphanFile` table for later processing.

The triggers are only created if the model has at least one field of type `FileNameField`. If no such fields exist, an empty list is returned.

`FileNameListField` is a subclass of `FileNameField` and is treated in the same way.

Added in version v2.0.0.

> **Note**
>
> This functionality requires the `file_trigger_auto_create` attribute in the model's Meta class to be set to `True` for automatic trigger creation.

Returns
A list containing the trigger object for file removal, or an empty list if no `FileNameField` fields are found.

Return type
list[`Trigger`]

classmethod from_dict(*data: dict[str, Any]*, *ignore_unknown: bool = False*) → *MAFwBaseModel*

Create a new model instance from dictionary

Parameters

- **data** (*dict[str, Any]*) – The dictionary containing the key/value pairs of the model.
- **ignore_unknown** (*bool*) – If unknown dictionary keys should be ignored.

Returns
A new model instance.

Return type
MAFwBaseModel

classmethod get_fields_by_type(*field_type: type[Field]*) → dict[str, Field]

Return a dict {field_name: field_object} for all fields of the given type.

Added in version v2.0.0.

Parameters
field_type (*peewee.Field*) – Field type

Returns
A dict {field_name: field_object} for all fields of the given type.

Return type
dict[str, peewee.Field]

classmethod std_upsert(*_MAFwBaseModel__data: dict[str, Any] | None = None*, ***mapping: Any*) → ModelInsert

Perform a so-called standard upsert.

An upsert statement is not part of the standard SQL and different databases have different ways to implement it. This method will work for modern versions of sqlite and postgreSQL. Here is a detailed explanation for SQLite.

An upsert is a statement in which we try to insert some data in a table where there are some constraints. If one constraint is failing, then instead of inserting a new row, we will try to update the existing row causing the constraint violation.

A standard upsert, in the naming convention of MAFw, is setting the conflict cause to the primary key with all other fields being updated. In other words, the database will try to insert the data provided in the table, but if the primary key already exists, then all other fields will be updated.

This method is equivalent to the following:

```
class Sample(MAFwBaseModel):
    sample_id = AutoField(
        primary_key=True,
        help_text='The sample id primary key',
    )
    sample_name = TextField(help_text='The sample name')


(
    Sample.insert(sample_id=1, sample_name='my_sample')
    .on_conflict(
        preserve=[Sample.sample_name]
    )  # use the value we would have inserted
    .execute()
)
```

Parameters

- **__data** (*dict, Optional*) – A dictionary containing the key/value pair for the insert. The key is the column name. Defaults to None
- **mapping** – Keyword arguments representing the value to be inserted.

classmethod std_upsert_many(*rows: Iterable[Any], fields: list[str] | None = None*) → ModelInsert

Perform a standard upsert with many rows.

> **See also**
>
> Read the *std_upsert()* documentation for an explanation of this method.

Parameters

- **rows** (*Iterable*) – A list with the rows to be inserted. Each item can be a dictionary or a tuple of values. If a tuple is provided, then the *fields* must be provided.
- **fields** (*list[str], Optional*) – A list of field names. Defaults to None.

classmethod triggers() → list[*Trigger*]

Returns an iterable of *Trigger* objects to create upon table creation.

The user must overload this returning all the triggers that must be created along with this class.

to_dict(*recurse: bool = True, backrefs: bool = False, only: list[str] | None = None, exclude: list[str] | None = None, **kwargs: Any*) → dict[str, Any]

Convert model instance to dictionary with optional parameters

See full documentation directly on the peewee documentation.

Parameters

- **recurse** (*bool, Optional*) – If to recurse through foreign keys. Default to True.

- **backrefs** (*bool, Optional*) – If to include backrefs. Default to False.
- **only** (*list[str], Optional*) – A list of fields to be included. Defaults to None.
- **exclude** (*list[str], Optional*) – A list of fields to be excluded. Defaults to None.
- **kwargs** – Other keyword arguments to be passed to peewee playhouse shortcut.

Returns
A dictionary containing the key/value of the model.

Return type
dict[str, Any]

update_from_dict(*data: dict[str, Any]*, *ignore_unknown: bool = False*) → *MAFwBaseModel*

Update current model instance from dictionary

The model instance is returned for daisy-chaining.

Parameters

- **data** (*dict[str, Any]*) – The dictionary containing the key/value pairs of the model.
- **ignore_unknown** (*bool*) – If unknown dictionary keys should be ignored.

class mafw.db.db_model.**RegisteredMeta**(*name: str*, *bases: tuple[type, ...]*, *attrs: dict[str, Any]*, ***kwargs: dict[str, Any]*)

Bases: `ModelBase`

Metaclass for registering models with the MAFw model registry.

This metaclass automatically registers model classes with the global model registry when they are defined, allowing for dynamic discovery and management of database models. It ensures that only concrete model classes (not the base classes themselves) are registered.

The registration process uses the table name from the model's metadata or generates a snake_case version of the class name if no explicit table name is set.

Create a new model class and register it if applicable.

This method is called during class definition to create the actual class and register it with the MAFw model registry if it's a concrete model class.

Parameters

- **name** (*str*) – The name of the class being created.
- **bases** (*tuple*) – The base classes of the class being created.
- **attrs** (*dict*) – The attributes of the class being created.
- **kwargs** (*dict[str, Any]*) – Other keyword attributes passed to the class.

Returns
The newly created class.

Return type
type

mafw.db.db_model.**make_prefixed_suffixed_name**(*model_class:* RegisteredMeta) → str

Generate a table name with optional prefix and suffix for a given model class.

This function constructs a table name by combining the prefix, the snake_case version of the model class name, and the suffix. If either prefix or suffix are not defined in the model's metadata, empty strings are used instead.

The prefix, table name, and suffix are joined using underscores. For example:

- If a model class is named "UserAccount" with prefix="app", suffix="data", the resulting table name will be "app_user_account_data"

- If a model class is named “Product” with prefix=”ecommerce”, suffix=”_latest”, the resulting table name will be “ecommerce_product_latest”

> **Note**
>
> Underscores (_) will be automatically added to prefix and suffix if not already present.

Parameters
`model_class` (`RegisteredMeta`) – The model class for which to generate the table name.

Returns
The constructed table name including prefix and suffix if applicable.

Return type
str

`mafw.db.db_model.`**`database_proxy = <peewee.DatabaseProxy object>`**

This is a placeholder for the real database object that will be known only at run time

`mafw.db.db_model.`**`mafw_model_register = <mafw.db.model_register.ModelRegister object>`**

This is the instance of the ModelRegister

> **See also**
>
> *`ModelRegister`* for more information on how to retrieve models and *`RegisteredMeta`* and *`MAFwBaseModel`* for the automatic registration of models`

mafw.db.db_types

Database Type Definitions

This module provides type definitions for database models and related components.

It defines Protocol classes that represent the expected interfaces for database models, helping with static type checking when working with ORM frameworks like Peewee.

Classes

`PeeweeModelWithMeta`(*args, **kwargs)	Protocol defining the interface for Peewee model classes with metadata.

`class` `mafw.db.db_types.`**`PeeweeModelWithMeta`**`(*args, **kwargs)`

Bases: `Protocol`

Protocol defining the interface for Peewee model classes with metadata.

This Protocol helps with static type checking for Peewee ORM models, ensuring that objects passed to functions expecting Peewee models have the necessary methods and attributes.

Attributes

_meta : Any
The metadata object associated with the Peewee model class. Contains information about the table, fields, and other model properties.

Methods

select(*args: Any, **kwargs: Any) -> Any
Select records from the database.

delete(*args: Any, **kwargs: Any) -> Any
Delete records from the database.

mafw.db.db_wizard

The module allows to generate a DB model structure starting from an existing DB.

It is strongly based on the peewee playhouse module *pwiz*.

Functions

dump_models(output_file, introspector[, ...])	Dumps all the ORM models in the output file.

Classes

UnknownField(*_, **__)	Placeholder class for an Unknown Field.

class mafw.db.db_wizard.**UnknownField**(**_: Any*, ***__: Any*)

Bases: `object`

Placeholder class for an Unknown Field.

mafw.db.db_wizard.**dump_models**(*output_file: TextIO*, *introspector: Introspector*, *tables: list[str] | tuple[str, ...] | None = None*, *preserve_order: bool = True*, *include_views: bool = False*, *ignore_unknown: bool = False*, *snake_case: bool = True*) → None

Dumps all the ORM models in the output file.

This function will write to the output stream a fully functional python module with all the models that the introspector class can access. The user has the possibility to pre-select a subset of tables to be dumped and also to optionally include views.

> **See also**
>
> This function is the core of the db wizard.

Parameters

- **output_file** (*TextIO*) – The output file. It must be open in text/write mode.
- **introspector** (*Introspector*) – A database introspector from the reflection module.
- **tables** (*list | None, Optional*) – A list of table names to be dumped. If None, then all tables in the DB will be dumped. Defaults to None.
- **preserve_order** (*bool, Optional*) – Preserve the order of the columns in the model. Defaults to True.
- **include_views** (*bool, Optional*) – Include saved views to be dumped. Views can be obtained joining tables. Defaults to False.
- **ignore_unknown** (*bool, Optional*) – Ignore unknown fields. If True, then an UnknownField type will be used as a placeholder. Defaults to False.
- **snake_case** (*bool, Optional*) – Use snake case for column and table name. Defaults to True.

mafw.db.fields

Module provides customised model fields specific for MAFw.

Classes

FileChecksumField([null, index, unique, ...])	A field to be used for file checksum.
FileChecksumFieldAccessor(model, field, name)	Field accessor specialized for file checksum fields.
FileNameField([checksum_field])	Field to be used for filenames.
FileNameFieldAccessor(model, field, name)	A field accessor specialized for filename fields.
FileNameListField([checksum_field])	A field for a list of file names.

class mafw.db.fields.FileChecksumField(*null=False*, *index=False*, *unique=False*, *column_name=None*, *default=None*, *primary_key=False*, *constraints=None*, *sequence=None*, *collation=None*, *unindexed=False*, *choices=None*, *help_text=None*, *verbose_name=None*, *index_type=None*, *db_column=None*, *_hidden=False*)

Bases: `TextField`

A field to be used for file checksum.

It is the evolution of the TextField for storing file checksum hexadecimal digest.

If linked to a *FileNameField* or *FileNameListField*, then it will be automatically filled when the primary file name (or list of file names) field is set.

If the user decides to set its value manually, then he can provide either the string with the hexadecimal characters as calculated by *file_checksum()*, or simply the filename (or filename list) and the field will perform the calculation automatically.

accessor_class

The specific field accessor class

alias of *FileChecksumFieldAccessor*

db_value(*value: str | Path | list[str | Path]*) → str

Converts the python assigned value to the DB type.

The checksum will be stored in the DB as a string containing only hexadecimal characters (see hexdigest).

The user can provide the checksum directly or the path to the file or a list of path to files. If a Path, or list of Path, is provided, then the checksum will be calculated, if a str (a path converted into a string) is provided, the function will try to see if a file with that path exists. If so, the checksum will be calculated, if not, the original string is assumed to be the checksum.

Parameters
value (*str | Path | list[str | Path]*) – The checksum or path to the file, or list of path to files for which the checksum has to be stored.

Returns
The checksum string for the database storage.

Return type
str

class mafw.db.fields.FileChecksumFieldAccessor(*model*, *field*, *name*)

Bases: `FieldAccessor`

Field accessor specialized for file checksum fields.

When the field is directly set, then an initialization flag in the model instance is turned to True to avoid that the linked primary field will overrule this value again.

For each checksum field named my_checksum, the model instance will get an attribute: init_my_checksum to be used as an initialization flag.

Once the field is manually set, to re-establish the automatic mechanism, the user has to manually toggle the initialization flag.

class mafw.db.fields.**FileNameField**(*checksum_field: str | None = None*, **args: Any*, ***kwargs: Any*)

Bases: `TextField`

Field to be used for filenames.

It is just an overload of TextField, that allows to apply filters and python functions specific to filenames.

If the user specifies the name of a file checksum field, then when this field is updated, the checksum one will also be automatically updated.

See also

- `FileNameListField` for a field able to store a list of filenames.
- `remove_widow_db_rows()` for a function removing entries from a database table where the corresponding files on disk are missing.
- `verify_checksum()` for a function comparing the actual checksum with the stored one and in case removing outdated entries from the DB.

Constructor parameter:

Parameters

checksum_field (*str, Optional*) – The name of the checksum field linked to this filename. Defaults to None.

accessor_class

The specific accessor class

alias of `FileNameFieldAccessor`

db_value(*value: str | Path*) → str

Converts the input python value into a string for the DB.

python_value(*value: str*) → Path | None

Converts the db value from str to Path

The return value might also be None, if the user set the field value to null.

Parameters

value (*str*) – The value of the field as stored in the database.

Returns

The converted value as a path. It can be None, if value was stored as null.

Return type

Path | None

class mafw.db.fields.**FileNameFieldAccessor**(*model*, *field*, *name*)

Bases: `FieldAccessor`

A field accessor specialized for filename fields.

In the constructor of the `FileNameField` and subclasses, the user can specify the name of a checksum field linked to this filename. This is very useful because in this way, the user does not have to manually assign any value to this field that will simply be automatically updated when the filename field is updated.

The user can disable this automatic feature either removing the link in the `FileNameField` or simply assigning a value to the `FileChecksumField`.

class mafw.db.fields.**FileNameListField**(*checksum_field: str | None = None*, **args: Any*, ***kwargs: Any*)

Bases: `FileNameField`

A field for a list of file names.

The evolution of the `FileNameField`, this field is able to store a list of filenames as a ';' separated string of full paths.

It is meant to be used when a processor is saving a bunch of correlated files that are to be used all together.

In a similar way as its parent class, it can be link to a checksum field, in this case, the checksum of the whole file list will be calculated.

Constructor parameter:

Parameters

checksum_field (*str, Optional*) – The name of the checksum field linked to this filename. Defaults to None.

db_value(*value: list[str | Path] | str | Path*) → str

Converts the list of paths in a ';' separated string

python_value(*value: str*) → list[Path]

Converts the ';' separated string in a list of paths

mafw.db.model_register

Module for registering and retrieving database models.

This module provides functionality to register database models with table names as key and retrieve them using flexible naming conventions that support prefixes and suffixes.

Added in version v2.0.0.

Classes

`ModelRegister`()	A registry for database models with support for prefixes and suffixes.

class mafw.db.model_register.**ModelRegister**

Bases: `object`

A registry for database models with support for prefixes and suffixes.

This class allows registration of database models with table names and provides flexible retrieval mechanisms that can handle different naming conventions.

The following implemented methods are thread-safe:

- `register_model()`
- `register_prefix()`
- `register_suffix()`
- `get_model()`
- `get_model_names()`
- `get_table_names()`
- `items()`

Accessing the class underling containers is instead **not** thread safe.

Added in version v2.0.0.

clear() → None

Clear all registered models, prefixes, and suffixes from the registry.

This method removes all entries from the internal dictionaries and lists, effectively resetting the ModelRegister to its initial empty state.

> **Note**
>
> This operation cannot be undone. All previously registered models and naming conventions will be lost after calling this method.

Return type
None

get_model(*name: str*) → ModelBase

Retrieve a model by name, supporting prefixes and suffixes.

name could be either the table_name or the ModelName.

This method attempts to find a model by the given name, considering registered prefixes and suffixes. It also handles conversion between CamelCase model names and snake_case table names using peewee's utility.

Parameters
name (*str*) – The name to search for

Returns
The registered peewee Model class

Return type
peewee.Model

Raises
KeyError – If no matching model is found or multiple similar models exist

get_model_names() → list[str]

Get a list of all registered model names.

Returns
List of registered model names

Return type
list[str]

get_standard_tables() → List[Type[*StandardTable*]]

Retrieve all registered models that are instances of `StandardTable`.

This method filters the registered models and returns only those that inherit from the `StandardTable` base class.

This is useful for identifying and working with standard database tables that follow a specific structure or interface.

Since the introduction of the `ModelRegister`, there is no need any more for a standard table plugin hook, instead the user can use this method to retrieve all standard tables.

Returns
A list of registered model classes that are standard tables

Return type
list[peewee.ModelBase]

get_table_names() → list[str]

Get a list of all registered table names.

Returns
List of registered table names

Return type
list[str]

items() → list[tuple[str, ModelBase]]

Return the items list of the registered models dictionary.

This method provides access to all registered models through a dictionary-like items view, allowing iteration over key-value pairs of table names and their corresponding model classes.

In order to release the thread lock as soon as possible, instead of providing an iterator a list of the current snapshot of the dictionary is provided.

Returns
An items view of the registered models

Return type
list[[str, peewee.ModelBase]]

register_model(*table_name: str*, *model: ModelBase*) → None

Register a model with a specific table name.

If a model with the same table name already exists, it will be replaced with a warning message.

Parameters

- **table_name** (*str*) – The table name to register the model under
- **model** (*peewee.Model*) – The peewee Model class to register

register_prefix(*prefix: str*) → None

Register a prefix to be used when searching for models.

Parameters
prefix (*str*) – The prefix string to register

register_suffix(*suffix: str*) → None

Register a suffix to be used when searching for models.

Parameters
suffix (*str*) – The suffix string to register

mafw.db.std_tables

Module provides standard tables that are included in all database created by MAFw processor.

Standard tables are automatically created and initialized by a `Processor` or a `ProcessorList` when opening a database connection.

This means that if a processor receives a valid database object, then it will suppose that the connection was already opened somewhere else (either from a ProcessorList or a third party) and thus it is not creating the standard tables.

If a processor is constructed using a database configuration dictionary, then it will first try to open a connection to the DB, then creating all standard tables and finally executing their `StandardTable.init` method. The same apply for the Processor list.

In other words, object responsible to open the database connection is taking care also of creating the standard tables and of initializing them. If the user opens the connection and passes it to a Processor or ProcessorList, then the user is responsible to create the standard tables and to initialize them.

All standard tables must derive from the `StandardTable` to have the same interface for the initialization.

Classes

OrphanFile(*args, **kwargs)	A Model for the files to be removed from disc
PlotterOutput(*args, **kwargs)	A model for the output of the plotter processors.
StandardTable(*args, **kwargs)	A base class for tables that are generated automatically by the MAFw processor.
TriggerDisabler(trigger_type_id)	A helper tool to disable a specific type of triggers.
TriggerStatus(*args, **kwargs)	A Model for the trigger status

Exceptions

OrphanFileDoesNotExist	An exception raised when trying to access a not existing table.
PlotterOutputDoesNotExist	An exception raised when trying to access a not existing table.
StandardTableDoesNotExist	An exception raised when trying to access a not existing table.
TriggerStatusDoesNotExist	An exception raised when trying to access a not existing table.

exception `mafw.db.std_tables.`**`OrphanFileDoesNotExist`**

Bases: `DoesNotExist`

An exception raised when trying to access a not existing table.

exception `mafw.db.std_tables.`**`PlotterOutputDoesNotExist`**

Bases: `DoesNotExist`

An exception raised when trying to access a not existing table.

exception `mafw.db.std_tables.`**`StandardTableDoesNotExist`**

Bases: `Exception`

An exception raised when trying to access a not existing table.

exception `mafw.db.std_tables.`**`TriggerStatusDoesNotExist`**

Bases: `Exception`

An exception raised when trying to access a not existing table.

class `mafw.db.std_tables.`**`OrphanFile`**(**args*, ***kwargs*)

Bases: *StandardTable*

A Model for the files to be removed from disc

Changed in version v2.0.0: The checksum field is set to allow null values. The class is set not to automatically generate triggers for file removal

`DoesNotExist`

alias of *OrphanFileDoesNotExist*

class `mafw.db.std_tables.`**`PlotterOutput`**(**args*, ***kwargs*)

Bases: *StandardTable*

A model for the output of the plotter processors.

The model has a trigger activated on delete queries to insert filenames and checksum in the OrphanFile model via the automatic file delete trigger generation.

`DoesNotExist`

alias of *PlotterOutputDoesNotExist*

class mafw.db.std_tables.**StandardTable**(**args*, ***kwargs*)

Bases: *MAFwBaseModel*

A base class for tables that are generated automatically by the MAFw processor.

DoesNotExist

alias of *StandardTableDoesNotExist*

classmethod init() → None

The user must overload this method, if he wants some specific operations to be performed on the model everytime the database is connected.

class mafw.db.std_tables.**TriggerDisabler**(*trigger_type_id: int*)

Bases: object

A helper tool to disable a specific type of triggers.

Not all SQL dialects allow to temporarily disable trigger execution.

In order overcome this limitation, MAFw has introduced a practical workaround. All types of triggers are active by default but they can be temporarily disabled, by changing their status in the *TriggerStatus* table.

In order to disable the trigger execution, the user has to set the status of the corresponding status to 0 and also add a when condition to the trigger definition.

Here is an example code:

```
class MyTable(MAFwBaseModel):
    id_ = AutoField(primary_key=True)
    integer = IntegerField()
    float_num = FloatField()

    @classmethod
    def triggers(cls):
        return [
            Trigger(
                'mytable_after_insert',
                (TriggerWhen.After, TriggerAction.Insert),
                cls,
                safe=True,
            )
            .add_sql(
                'INSERT INTO target_table (id__id, half_float_num) VALUES (NEW.
↪id_, NEW.float_num / 2)'
            )
            .add_when(
                '1 == (SELECT status FROM trigger_status WHERE trigger_type_id␣
↪== 1)'
            )
        ]
```

When you want to perform a database action with the trigger disabled, you can either use this class as context manager or call the *disable()* and *enable()* methods.

```
# as a context manager
with TriggerDisabler(trigger_type_id = 1):
    # do something without triggering any trigger of type 1.

# with the explicit methods
disabler = TriggerDisabler(1)
disabler.disable()
```

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```
# do something without triggering any trigger of type 1.
disabler.enable()
```

When using the two explicit methods, the responsibility to assure that the triggers are re-enabled in on the user.

Constructor parameters:

Parameters
trigger_type_id (*int*) – the id of the trigger to be temporary disabled.

disable() → None
Disable the trigger

enable() → None
Enable the trigger

class mafw.db.std_tables.**TriggerStatus**(**args*, ***kwargs*)
Bases: *StandardTable*

A Model for the trigger status

DoesNotExist
alias of *TriggerStatusDoesNotExist*

classmethod init() → None
Resets all triggers to enable when the database connection is opened.

mafw.db.trigger

Module provides a Trigger class and related tools to create triggers in the database via the ORM.

It supports SQLite, MySQL and PostgreSQL with dialect-specific SQL generation.

Functions

*and_*(*conditions)	Concatenates conditions with logical AND.
*or_*(*conditions)	Concatenates conditions with logical OR.

Classes

MySQLDialect()	MySQL-specific trigger SQL generation.
PostgreSQLDialect()	PostgreSQL-specific trigger SQL generation.
SQLiteDialect()	SQLite-specific trigger SQL generation.
Trigger(trigger_name, trigger_type, source_table)	Trigger template wrapper for use with peewee ORM.
TriggerAction(value)	String enumerator for the trigger action (Delete, Insert, Update)
TriggerDialect()	Abstract base class for database-specific trigger SQL generation.
TriggerWhen(value)	String enumerator for the trigger execution time (Before, After or Instead Of)

class mafw.db.trigger.**MySQLDialect**
Bases: *TriggerDialect*

MySQL-specific trigger SQL generation.

create_trigger_sql(*trigger: Trigger*) → str

Generate MySQL trigger SQL.

drop_trigger_sql(*trigger_name: str*, *safe: bool = True*, *table_name: str | None = None*) → str

Generate MySQL drop trigger SQL.

supports_safe_create() → bool

MySQL supports IF NOT EXISTS for triggers.

supports_trigger_type(*when: TriggerWhen*, *action: TriggerAction*, *on_view: bool = False*) → bool

MySQL doesn't support INSTEAD OF triggers.

supports_update_of_columns() → bool

MySQL doesn't support column-specific UPDATE triggers.

supports_when_clause() → bool

MySQL supports conditions but through WHERE instead of WHEN.

class mafw.db.trigger.**PostgreSQLDialect**

Bases: *TriggerDialect*

PostgreSQL-specific trigger SQL generation.

_clean_sql(*sql: str*) → str

Remove RETURNING clauses from SQL statements for PostgreSQL trigger functions.

Parameters

sql – The SQL statement

Returns

SQL statement without RETURNING clause

create_trigger_sql(*trigger: Trigger*) → str

Generate PostgreSQL trigger SQL.

drop_trigger_sql(*trigger_name: str*, *safe: bool = True*, *table_name: str | None = None*) → str

Generate PostgreSQL drop trigger SQL.

supports_safe_create() → bool

PostgreSQL doesn't support IF NOT EXISTS for triggers before v14, but we implement safety differently.

supports_trigger_type(*when: TriggerWhen*, *action: TriggerAction*, *on_view: bool = False*) → bool

PostgreSQL supports INSTEAD OF only on views.

supports_update_of_columns() → bool

PostgreSQL supports column-specific UPDATE triggers.

supports_when_clause() → bool

PostgreSQL supports WHEN conditions.

class mafw.db.trigger.**SQLiteDialect**

Bases: *TriggerDialect*

SQLite-specific trigger SQL generation.

create_trigger_sql(*trigger: Trigger*) → str

Generate SQLite trigger SQL.

drop_trigger_sql(*trigger_name: str*, *safe: bool = True*, *table_name: str | None = None*) → str

Generate SQLite drop trigger SQL.

supports_safe_create() → bool

SQLite supports IF NOT EXISTS for triggers.

supports_trigger_type(*when: TriggerWhen*, *action: TriggerAction*, *on_view: bool = False*) → bool

SQLite supports all trigger types except INSTEAD OF on tables (only on views).

supports_update_of_columns() → bool

SQLite supports column-specific UPDATE triggers.

supports_when_clause() → bool

SQLite supports WHEN conditions.

class mafw.db.trigger.**Trigger**(*trigger_name: str*, *trigger_type: tuple[TriggerWhen, TriggerAction]*, *source_table: type[Model] | Model | str*, *safe: bool = False*, *for_each_row: bool = False*, *update_columns: list[str] | None = None*, *on_view: bool = False*)

Bases: `object`

Trigger template wrapper for use with peewee ORM.

Constructor parameters:

Parameters

- **trigger_name** (*str*) – The name of this trigger. It needs to be unique!
- **trigger_type** (*tuple[TriggerWhen, TriggerAction]*) – A tuple with *TriggerWhen* and *TriggerAction* to specify on which action the trigger should be invoked and if before, after or instead of.
- **source_table** (*type[Model] | Model | str*) – The table originating the trigger. It can be a model class, instance, or also the name of the table.
- **safe** (*bool, Optional*) – A boolean flag to define if in the trigger creation statement a 'IF NOT EXISTS' clause should be included. Defaults to False
- **for_each_row** (*bool, Optional*) – A boolean flag to repeat the script content for each modified row in the table. Defaults to False.
- **update_columns** (*list[str], Optional*) – A list of column names. When defining a trigger on a table update, it is possible to restrict the firing of the trigger to the cases when a subset of all columns have been updated. An column is updated also when the new value is equal to the old one. If you want to discriminate this case, use the *add_when()* method. Defaults to None.
- **on_view** (*bool, Optional*) – A boolean flag to indicate if the target is a view. This affects the support for INSTEAD OF. Defaults to False.

_get_dialect() → *TriggerDialect*

Get the appropriate dialect based on the database type.

Returns

A dialect instance

_node_to_sql(*node: Node*) → str

Convert a peewee Node (Expression, Query, etc.) to a SQL string with interpolated parameters.

This is based on peewee's internal query_to_string function for debugging/logging purposes.

Added in version v2.0.0.

Parameters

node – A peewee Node object

Returns

SQL string with parameters interpolated

_value_to_sql(*value: Any*) → str

Convert a Python value to its SQL representation.

Added in version v2.0.0.

Parameters
value – A Python value (string, int, float, None, etc.)

Returns
SQL string representation of the value

add_sql(*sql: str | Query*) → Self

Add an SQL statement to be executed by the trigger.

The sql can be either a string containing the sql statement, or it can be any other peewee Query.

For example:

```
# assuming you have created a trigger ...

sql = AnotherTable.insert(
    field1=some_value, field2=another_value
)
trigger.add_sql(sql)
```

In this way the SQL code is generated with parametric placeholder if needed.

Parameters
sql (*str | peewee.Query*) – The SQL statement.

Returns
self for easy chaining

Return type
Trigger

add_when(**conditions: str | Node*) → Self

Add conditions to the *when* statements.

Conditions are logically ANDed. To have mixed *OR* and *AND* logic, use the functions *and_()* and *or_()*.

The conditions can be either strings containing SQL conditions, or peewee Node objects (such as Expression or Query objects).

For example:

```
# String condition
trigger.add_when("NEW.status = 'active'")

# Peewee expression
subq = TriggerStatus.select(TriggerStatus.status).where(
    TriggerStatus.trigger_type == 'DELETE_FILES'
)
trigger.add_when(Value(1) == subq)
```

Changed in version v2.0.0: The argument can also be a generic peewee Node.

Parameters
conditions (*str | peewee.Node*) – Conditions to be added with logical AND. Can be strings or peewee Node objects.

Returns
self for easy chaining

Return type
Trigger

`create()` → str

Generates the SQL create statement.

Returns
The trigger creation statement.

Raises

- *MissingSQLStatement* – if no SQL statements are provided.
- *UnsupportedDatabaseError* – if the trigger type is not supported by the database.

`drop`(*safe: bool = True*) → str

Generates the SQL drop statement.

Parameters
safe (*bool, Optional*) – If True, add an IF EXIST. Defaults to True.

Returns
The drop statement

Return type
str

`set_database`(*database: Database | DatabaseProxy*) → Self

Set the database to use for this trigger.

Parameters
database – The database instance

Returns
self for easy chaining

`class mafw.db.trigger.TriggerAction`(*value*)

Bases: `StrEnum`

String enumerator for the trigger action (Delete, Insert, Update)

`_generate_next_value_`(*start*, *count*, *last_values*)

Return the lower-cased version of the member name.

`class mafw.db.trigger.TriggerDialect`

Bases: `ABC`

Abstract base class for database-specific trigger SQL generation.

`abstractmethod create_trigger_sql`(*trigger:* Trigger) → str

Generate the SQL to create a trigger for a specific database dialect.

Parameters
trigger – The trigger object

Returns
SQL string to create the trigger

`abstractmethod drop_trigger_sql`(*trigger_name: str*, *safe: bool = True*, *table_name: str | None = None*) → str

Generate the SQL to drop a trigger for a specific database dialect.

Parameters

- **trigger_name** (*str*) – The name of the trigger to drop
- **safe** (*bool, Optional*) – If True, add an IF EXISTS clause. Defaults to True.

- **table_name** (*str, Optional*) – The name of the target table for the trigger. Defaults to None.

Returns
SQL string to drop the trigger

Return type
str

abstractmethod supports_safe_create() → bool

Check if the database supports IF NOT EXISTS for triggers.

Returns
True if supported, False otherwise

abstractmethod supports_trigger_type(*when: TriggerWhen*, *action: TriggerAction*, *on_view: bool = False*) → bool

Check if the database supports the specified trigger type.

Parameters

- **when** – When the trigger should fire (BEFORE, AFTER, INSTEAD OF)
- **action** – The action that triggers the trigger (INSERT, UPDATE, DELETE)
- **on_view** – Whether the trigger is on a view

Returns
True if supported, False otherwise

abstractmethod supports_update_of_columns() → bool

Check if the database supports column-specific UPDATE triggers.

Returns
True if supported, False otherwise

abstractmethod supports_when_clause() → bool

Check if the database supports WHEN conditions.

Returns
True if supported, False otherwise

class mafw.db.trigger.**TriggerWhen**(*value*)

Bases: StrEnum

String enumerator for the trigger execution time (Before, After or Instead Of)

_generate_next_value_(*start*, *count*, *last_values*)

Return the lower-cased version of the member name.

mafw.db.trigger.**and_**(**conditions: str*) → str

Concatenates conditions with logical AND.

Parameters
conditions (*str*) – The condition to join.

Returns
The and-concatenated string of conditions

Return type
str

mafw.db.trigger.**or_**(**conditions: str*) → str

Concatenates conditions with logical OR.

Parameters
conditions (*str*) – The condition to join.

Returns
The or-concatenated string of conditions.

Return type
str

12.1.3 mafw.decorators

The module provides some general decorator utilities that are used in several parts of the code, and that can be reused by the user community.

Module Attributes

F	TypeVar for generic function.
P	TypeVar for generic processor.
single_loop(cls)	A decorator shortcut to define a single execution processor.
for_loop(cls)	A decorator shortcut to define a for loop execution processor.
while_loop(cls)	A decorator shortcut to define a while loop execution processor.

Functions

class_depends_on_optional(module_name[, ...])	Class decorator factory to check if module module_name is available.
database_required(cls)	Modify the processor start method to check if a database object exists.
depends_on_optional(module_name[, raise_ex, ...])	Function decorator to check if module_name is available.
execution_workflow([loop_type])	A decorator factory for the definition of the looping strategy.
for_loop(cls)	A decorator shortcut to define a for loop execution processor.
orphan_protector(cls)	A class decorator to modify the init method of a Processor so that the remove_orphan_files is set to False and no orphan files will be removed.
processor_depends_on_optional(module_name[, ...])	Class decorator factory to check if module module_name is available.
single_loop(cls)	A decorator shortcut to define a single execution processor.
singleton(cls)	Make a class a Singleton class (only one instance)
suppress_warnings(func)	Decorator to suppress warnings during the execution of a test function.
while_loop(cls)	A decorator shortcut to define a while loop execution processor.

class `mafw.decorators.`**`F`**

TypeVar for generic function.

alias of TypeVar('F', bound=`Callable`[[...], `object`])

class `mafw.decorators.`**`P`**

TypeVar for generic processor.

alias of TypeVar('P', bound=*Processor*) `mafw.decorators.`**`class_depends_on_optional`**(*module_name: str*, *raise_ex: bool = False*, *warn: bool = True*) → Callable[[Type[Any]], Type[Any]]

Class decorator factory to check if module module_name is available.

It checks if all the optional modules listed in *module_name* separated by a ';' can be found.

If all modules are found, then the class is returned as it is.

If at least one module is not found:

- and raise_ex is True, an ImportError exception is raised and the user is responsible to deal with it.
- if raise_ex is False, instead of returning the class, a new empty class is returned.
- depending on the value of warn, the user will be informed with a warning message or not.

Parameters

- **module_name** (*str*) – The optional module(s) from which the class depends on. A ";" separated list of modules can also be provided.
- **raise_ex** (*bool, Optional*) – Flag to raise an exception if module_name not found, defaults to False.
- **warn** (*bool, Optional*) – Flag to display a warning message if module_name is not found, defaults to True.

Returns
The wrapped class.

Return type
type(object)

Raises
ImportError – if module_name is not found and raise_ex is True.

`mafw.decorators.`**`database_required`**(*cls*)

Modify the processor start method to check if a database object exists.

This decorator must be applied to processors requiring a database connection.

Parameters
cls – A Processor class.

`mafw.decorators.`**`depends_on_optional`**(*module_name: str*, *raise_ex: bool = False*, *warn: bool = True*) → Callable[[*F*], Callable[[...], Any]]

Function decorator to check if module_name is available.

If module_name is found, then returns the wrapped function. If not, its behavior depends on the raise_ex and warn_only values. If raise_ex is True, then an ImportError exception is raised. If it is False and warn is True, then a warning message is displayed but no exception is raised. If they are both False, then function is silently skipped.

If raise_ex is True, the value of *warn* is not taken into account.

Typical usage

The user should decorate functions or class methods when they cannot be executed without the optional library. In the specific case of Processor subclass, where the class itself can be created also without the missing library, but it is required somewhere in the processor execution, then the user is suggested to decorate the execute method with this decorator.

Parameters

- **module_name** (*str*) – The optional module(s) from which the function depends on. A ";" separated list of modules can also be provided.

- **raise_ex** (*bool, Optional*) – Flag to raise an exception if module_name is not found, defaults to False.
- **warn** (*bool, Optional*) – Flag to display a warning message if module_name is not found, default to True.

Returns
The wrapped function

Return type
Callable

Raises
ImportError – if module_name is not found and raise_ex is True.

`mafw.decorators.`**`execution_workflow`**(*loop_type: LoopType | str = LoopType.ForLoop*)

A decorator factory for the definition of the looping strategy.

This decorator factory must be applied to Processor subclasses to modify their value of loop_type in order to change the execution workflow.

See `single_loop()`, `for_loop()` and `while_loop()` decorator shortcuts.

Parameters
loop_type (*LoopType | str, Optional*) – The type of execution workflow requested for the decorated class. Defaults to LoopType.ForLoop.

`mafw.decorators.`**`for_loop`**(*cls*)

A decorator shortcut to define a for loop execution processor.

`mafw.decorators.`**`orphan_protector`**(*cls*)

A class decorator to modify the init method of a Processor so that the remove_orphan_files is set to False and no orphan files will be removed.

`mafw.decorators.`**`processor_depends_on_optional`**(*module_name: str, raise_ex: bool = False, warn: bool = True*) → Callable[[Type[*P*]], Type[*Processor*]]

Class decorator factory to check if module module_name is available.

It checks if all the optional modules listed in *module_name* separated by a ';' can be found.

If all modules are found, then the class is returned as it is.

If at least one module is not found:

- and raise_ex is True, an ImportError exception is raised and the user is responsible to deal with it.
- if raise_ex is False, instead of returning the class, the `Processor` is returned.
- depending on the value of warn, the user will be informed with a warning message or not.

Typical usage

The user should decorate Processor subclasses everytime the optional module is required in their __init__ method. Should the check on the optional module have a positive outcome, then the Processor subclass is returned. Otherwise, if raise_ex is False, an instance of the base `Processor` is returned. In this way, the returned class can still be executed without breaking the execution scheme but of course, without producing any output.

Should be possible to run the __init__ method of the class without the missing library, then the user can also follow the approach described in this other `example`.

Parameters

- **module_name** (*str*) – The optional module(s) from which the class depends on. A ";" separated list of modules can also be provided.
- **raise_ex** (*bool, Optional*) – Flag to raise an exception if module_name not found, defaults to False.

- **warn** (*bool, Optional*) – Flag to display a warning message if module_name is not found, defaults to True.

Returns
The wrapped processor.

Return type
type(*Processor*)

Raises
ImportError – if module_name is not found and raise_ex is True.

mafw.decorators.**single_loop**(*cls*)

A decorator shortcut to define a single execution processor.

mafw.decorators.**singleton**(*cls*)

Make a class a Singleton class (only one instance)

mafw.decorators.**suppress_warnings**(*func: F*) → *F*

Decorator to suppress warnings during the execution of a test function.

This decorator uses the *warnings.catch_warnings()* context manager to temporarily change the warning filter to ignore all warnings. It is useful when you want to run a test without having warnings clutter the output.

Usage:

```
@suppress_warnings
def test_function():
    # Your test code that might emit warnings
```

Parameters
func (*Callable*) – The test function to be decorated.

Returns
The wrapped function with suppressed warnings.

Return type
Callable

mafw.decorators.**while_loop**(*cls*)

A decorator shortcut to define a while loop execution processor.

12.1.4 mafw.enumerators

Module provides a set of enumerators for dealing with standard tasks.

Classes

LogicalOp(value)	Enumeration of supported logical operations.
LoopType(value)	The loop strategy for the processor.
LoopingStatus(value)	Enumerator to modify the looping cycle.
ProcessorExitStatus(value)	The processor exit status enumerator class
ProcessorStatus(value)	Enumerator to describe the status of a processor.

class mafw.enumerators.**LogicalOp**(*value*)

Bases: Enum

Enumeration of supported logical operations.

Added in version v1.3.0.

class mafw.enumerators.**LoopType**(*value*)

Bases: StrEnum

The loop strategy for the processor.

Each processor can be executed in one of the following modes:

1. **Single mode.** The process method is executed only once.
2. **For loop mode.** The process method is executed inside a for loop after the start and before the finish. The loop is based on a list of elements, the user **must** overload the *get_items()* method to define the list of items for the loop.
3. **While loop mode.** The process method is executed inside a while loop after the start and before the finish. The user **must** overload the *while_condition()* to define when to stop the loop.

Future development

Implement concurrent loop. Depending on the development of the free-threading capabilities of future python releases, this concurrent looping strategy might be based on threads or a porting of the autorad multi-processor approach.

_generate_next_value_(*start*, *count*, *last_values*)

Return the lower-cased version of the member name.

ForLoop = 'for_loop'

Value for the for loop on item list execution.

SingleLoop = 'single'

Value for the single mode execution.

WhileLoop = 'while_loop'

Value for the while loop execution.

class mafw.enumerators.**LoopingStatus**(*value*)

Bases: IntEnum

Enumerator to modify the looping cycle.

In the case of a looping Processor, the user has the ability to slightly modify the looping structure using this enumerator.

In the *process()* the user can set the variable *looping_status* to one of the following values:

- *LoopingStatus.Continue*. It means that everything is working well and the loop cycle must go ahead as foreseen and the *accept_item()* will be invoked.
- *LoopingStatus.Skip*. The *skip_item()* will be called soon after the *process()* is finished. The status will be reset to Continue and the next item will be processed.
- *LoopingStatus.Abort*. The cycle is broken immediately.
- *LoopingStatus.Quit*. The cycle is broken immediately.

The last two options are apparently identical, but they offer the possibility to implement a different behaviour in the *finish()* method. When abort is used, then the AbortProcessorException will be raised. For example, the user can decide to rollback all changes if an abort as occurred or to save what done so far in case of a quit.

Abort = 3

Break the loop and force the outside container (*mafw.processor.ProcessorList*) to quit.

Continue = 1

The loop can continue

Quit = 4

Break the loop but let the outside container (*mafw.processor.ProcessorList*) to continue.

Skip = 2

Skip this item.

class mafw.enumerators.**ProcessorExitStatus**(*value*)

Bases: IntEnum

The processor exit status enumerator class

- Successful: means that the processor reached the end with success
- Failed: means that the processor did not reach the end with success
- Aborted: means that the user aborted the processor execution

Aborted = 3

The processor execution was aborted by the user

Failed = 2

The processor execution was failed

Successful = 1

The processor execution was successfully concluded

class mafw.enumerators.**ProcessorStatus**(*value*)

Bases: StrEnum

Enumerator to describe the status of a processor.

_generate_next_value_(*start*, *count*, *last_values*)

Return the lower-cased version of the member name.

Finish = 'finishing'

Finished

Init = 'initializing'

Initialized

Run = 'processing'

Running

Start = 'starting'

Started

Unknown = 'unknown'

Unknown status

12.1.5 mafw.examples

A library of examples.

Modules

db_processors	The module provides some basic processors with DB interaction for demonstrating the basic functionalities.
importer_example	The module provides one concrete implementation of an Importer, as it was used in the autorad paper2.
loop_modifier	The module provides examples on how the user can change the looping structure in a looping processor using the looping status.

continues on next page

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multi_primary	Module demonstrates how to use multicolumn primary keys and foreign keys.
processor_list	The module provides some examples on how to use ProcessorList to combine several processors.
sum_processor	The module provides some examples for the user to develop their own processors.

mafw.examples.db_processors

The module provides some basic processors with DB interaction for demonstrating the basic functionalities.

Classes

CountStandardTables(*args, **kwargs)	A processor to count the number of standard tables
File(*args, **kwargs)	The Model class representing the table in the database
FillFileTableProcessor(*args, **kwargs)	Processor to fill a table with the content of a directory

Exceptions

FileDoesNotExist	Exception raised if the table corresponding to the File model does not exist.

exception `mafw.examples.db_processors.`**`FileDoesNotExist`**

Bases: `Exception`

Exception raised if the table corresponding to the File model does not exist.

class `mafw.examples.db_processors.`**`CountStandardTables`**(**args: Any*, ***kwargs: Any*)

Bases: *Processor*

A processor to count the number of standard tables

Processor parameters

- **n_tables**: The number of standard tables (default: -1)

Constructor parameters

Parameters

- **name** (*str, Optional*) – The name of the processor. If None is provided, the class name is used instead. Defaults to None.
- **description** (*str, Optional*) – A short description of the processor task. Defaults to the processor name.
- **config** (*dict, Optional*) – A configuration dictionary for this processor. Defaults to None.
- **looper** (LoopType, *Optional*) – Enumerator to define the looping type. Defaults to LoopType.ForLoop
- **user_interface** (UserInterfaceBase, *Optional*) – A user interface instance to be used by the processor to interact with the user.
- **timer** (Timer, *Optional*) – A timer object to measure process duration.
- **timer_params** (*dict, Optional*) – Parameters for the timer object.
- **database** (*Database, Optional*) – A database instance. Defaults to None.

- **database_conf** (*dict, Optional*) – Configuration for the database. Default to None.
- **remove_orphan_files** (*bool, Optional*) – Boolean flag to remove files on disc without a reference to the database. See *Standard tables* and `_remove_orphan_files()`. Defaults to True
- **replica_id** (*str, Optional*) – The replica identifier for the current processor.
- **create_standard_tables** (*bool, Optional*) – Boolean flag to create std tables on disk. Defaults to True
- **kwargs** – Keyword arguments that can be used to set processor parameters.

`process()`

Processes the current item.

This is the core of the Processor, where the user has to define the calculations required.

`start()` → None

Start method.

The user can overload this method, including all steps that should be performed at the beginning of the operation.

If the user decides to overload it, it should include a call to the super method.

`class mafw.examples.db_processors.File(*args, **kwargs)`

Bases: `MAFwBaseModel`

The Model class representing the table in the database

`DoesNotExist`

alias of `FileDoesNotExist`

`class mafw.examples.db_processors.FillFileTableProcessor(*args: Any, **kwargs: Any)`

Bases: `Processor`

Processor to fill a table with the content of a directory

Processor parameters

- **root_folder**: The root folder for the file listing (default: PosixPath('/builds/kada/mafw'))

Constructor parameter:

Parameters

root_folder (*Path, Optional*) – ActiveParameter corresponding to the directory from where to start the recursive search

`finish()`

Transfers all the data to the File table via an atomic transaction.

`format_progress_message()`

Customizes the progress message with information about the current item.

The user can overload this method in order to modify the message being displayed during the process loop with information about the current item.

The user can access the current value, its position in the looping cycle and the total number of items using `Processor.item`, `Processor.i_item` and `Processor.n_item`.

`get_items()` → list[Path]

Retrieves the list of files.

Insert or update the files from the root folder to the database

Returns

The list of full filename

Return type
list[Path]

process()
Add all information to the data list

start()
Starts the execution.

Be sure that the table corresponding to the File model exists. It it does already exists, it is not a problem.

mafw.examples.importer_example

The module provides one concrete implementation of an Importer, as it was used in the autorad paper2.

Classes

ImporterExample(*args, **kwargs)	An exemplary implementation of an importer processor.
InputElement(*args, **kwargs)	A model to store the input elements

Exceptions

InputElementDoesNotExist	Exception raised if the InputElement does not exist

exception `mafw.examples.importer_example.`**`InputElementDoesNotExist`**

Bases: `DoesNotExist`

Exception raised if the InputElement does not exist

class `mafw.examples.importer_example.`**`ImporterExample`**(**args: Any*, ***kwargs: Any*)

Bases: *Importer*

An exemplary implementation of an importer processor.

This importer subclass is looking for tif files in the `input_folder` and using the information stored in the filename, all required database fields will be obtained.

For this importer, we will use a filename parser including two compulsory elements and one optional ones. Those are:

- Sample name, in the form of sample_xyz, where xyz are three numerical digits (**compulsory**).
- Exposure time, in the form of expYh, where Y is the exposure time in hours. It can be an integer number or a floating number using . as decimal separator (**compulsory**).
- Resolution, in the form of rXYu, where XY is the readout granularity in micrometer. It is optional and its default is 25 µm if not provided.

This processor is subclassing:

1. The *start()*: in order to be sure that the database table is existing.
2. The *get_items()*: where the list of input files is retrieved. There we also verify that the table is still updated using the *verify_checksum()* and in case the user wants to process only new files, we will have to filter out from the list all items already stored in the database.
3. The *process()*: where we create a dictionary with the values to be stored in the database. This approach allows a much more efficient database transaction.
4. The *finish()*: where we actually do the database insert in a single go.
5. The *format_progress_message()*: to keep the user informed about the progress (optional).

Processor parameters

- **input_folder**: The input folder from where the images have to be imported. (default: '/builds/kada/mafw')
- **parser_configuration**: The path to the TOML file with the filename parser configuration (default: 'parser_configuration.toml')
- **recursive**: Extend the search to sub-folder (default: True)

Constructor parameters

Parameters

- **name** (*str, Optional*) – The name of the processor. If None is provided, the class name is used instead. Defaults to None.
- **description** (*str, Optional*) – A short description of the processor task. Defaults to the processor name.
- **config** (*dict, Optional*) – A configuration dictionary for this processor. Defaults to None.
- **looper** (LoopType, *Optional*) – Enumerator to define the looping type. Defaults to LoopType.ForLoop
- **user_interface** (UserInterfaceBase, *Optional*) – A user interface instance to be used by the processor to interact with the user.
- **timer** (Timer, *Optional*) – A timer object to measure process duration.
- **timer_params** (*dict, Optional*) – Parameters for the timer object.
- **database** (*Database, Optional*) – A database instance. Defaults to None.
- **database_conf** (*dict, Optional*) – Configuration for the database. Default to None.
- **remove_orphan_files** (*bool, Optional*) – Boolean flag to remove files on disc without a reference to the database. See *Standard tables* and `_remove_orphan_files()`. Defaults to True
- **replica_id** (*str, Optional*) – The replica identifier for the current processor.
- **create_standard_tables** (*bool, Optional*) – Boolean flag to create std tables on disk. Defaults to True
- **kwargs** – Keyword arguments that can be used to set processor parameters.

finish() → None

The finish method overload.

Here is where we do the database insert with a on_conflict_replace to cope with the unique constraint.

format_progress_message() → None

Customizes the progress message with information about the current item.

The user can overload this method in order to modify the message being displayed during the process loop with information about the current item.

The user can access the current value, its position in the looping cycle and the total number of items using `Processor.item`, `Processor.i_item` and `Processor.n_item`.

get_items() → Collection[Any]

Retrieves the list of element to be imported.

The base folder is provided in the configuration file, along with the recursive flags and all the filter options.

Returns
The list of items full file names to be processed.

Return type
list[Path]

`process()`

The process method overload.

This is where the whole list of files is scanned.

The current item is a filename, so we can feed it directly to the FilenameParser interpret command, to have it parsed. To maximise the efficiency of the database transaction, instead of inserting each file singularly, we are collecting them all in a list and then insert all of them in the *finish()* method.

In case the parsing is failing, then the element is skipped and an error message is printed.

`start()` → None

The start method.

The filename parser is ready to use because it has been already configured in the super method. We need to be sure that the input table exists, otherwise we create it from scratch.

`class mafw.examples.importer_example.InputElement(*args, **kwargs)`

Bases: *MAFwBaseModel*

A model to store the input elements

`DoesNotExist`

alias of *InputElementDoesNotExist*

mafw.examples.loop_modifier

The module provides examples on how the user can change the looping structure in a looping processor using the looping status.

Functions

is_prime(n)	Check if n is a prime number.

Classes

FindNPrimeNumber(*args, **kwargs)	An example of Processor to search for N prime numbers starting from a given starting integer.
FindPrimeNumberInRange(*args, **kwargs)	An example processor to find prime numbers in the defined interval from `start_from` to `stop_at`.
ModifyLoopProcessor(*args, **kwargs)	Example processor demonstrating how it is possible to change the looping structure.

`class mafw.examples.loop_modifier.FindNPrimeNumber(*args: Any, **kwargs: Any)`

Bases: *Processor*

An example of Processor to search for N prime numbers starting from a given starting integer.

This processor is meant to demonstrate the use of a while_loop execution workflow.

Let us say we need to find 1000 prime numbers starting from 12347. One possible brute force approach to solve this problem is to start checking if the initial value is a prime number. If this is not the case, then check the next odd number. If it is the case, then add the current number to the list of found prime numbers and continue until the size of this list is 1000.

This is a perfect application for a while loop execution workflow.

Processor parameters

- **prime_num_to_find**: How many prime number we have to find (default: 100)
- **start_from**: From which number to start the search (default: 50)

Processor parameters:

Parameters

- **prime_num_to_find** (*int*) – The number of prime numbers to be found.
- **start_from** (*int*) – The initial integer number from where to start the search.

finish() → None

Overload of the finish method.

Remember: The finish method is called only once just after the last loop interaction. Always put a call to its *super* when you overload finish.

The loop is over, it means that the while condition was returning false, and now we can do something with our list of prime numbers.

format_progress_message() → None

Customizes the progress message with information about the current item.

The user can overload this method in order to modify the message being displayed during the process loop with information about the current item.

The user can access the current value, its position in the looping cycle and the total number of items using `Processor.item`, `Processor.i_item` and `Processor.n_item`.

process() → None

The overload of the process method.

Remember: The process method is called inside the while loop. It has access to the looping parameters: `Processor.i_item`, `Processor.item` and `Processor.n_item`.

In our specific case, the process contains another while loop. We start by checking if the current `Processor.item` is a prime number or not. If so, then we have found the next prime number, we add it to the list, we increment by two units the value of `Processor.item` and we leave the process method ready for the next iteration.

If `Processor.item` is not prime, then increment it by 2 and check it again.

start() → None

The overload of the start method.

Remember: The start method is called just before the while loop is started. So all instructions in this method will be executed only once at the beginning of the process execution. Always put a call to its *super* when you overload start.

First, we empty the list of found prime numbers. It should not be necessary, but it makes the code more readable. Then set the `Processor.n_item` to the total number of prime numbers we need to find. In this way, the progress bar will display useful progress.

If the start value is smaller than 2, then let's add 2 to the list of found prime number and set our first item to check at 3. In principle, we could already add 3 as well, but maybe the user wanted to find only 1 prime number, and we are returning a list with two, that is not what he was expecting.

Since prime numbers different from 2 can only be odd, if the starting number is even, increment it already by 1 unit.

while_condition() → bool

Define the while condition.

First, it checks if the prime_num_to_find is positive. Otherwise, it does not make sense to start. Then it will check if the length of the list with the already found prime numbers is enough. If so, then we can stop the loop return False, otherwise, it will return True and continue the loop.

Differently from the for_loop execution, we are responsible to assign the value to the looping variables *Processor.i_item*, *Processor.item* and *Processor.n_item*.

In this case, we will use the *Processor.i_item* to count how many prime numbers we have found and *Processor.n_item* will be our target. In this way, the progress bar will work as expected.

In the while condition, we set the *Processor.i_item* to the current length of the found prime number list.

Returns
True if the loop has to continue, False otherwise

prime_num_found: list[int]

The list with the found prime numbers

class mafw.examples.loop_modifier.**FindPrimeNumberInRange**(**args: Any*, ***kwargs: Any*)

Bases: *Processor*

An example processor to find prime numbers in the defined interval from `start_from` to `stop_at`.

This processor is meant to demonstrate the use of a for_loop execution workflow.

Let us say we want to select only the prime numbers in a user defined range. One possible brute force approach is to generate the list of integers between the range extremes and check if it is prime or not. If yes, then add it to the list of prime numbers, if not continue with the next element.

This is a perfect application for a loop execution workflow.

Processor parameters

- **start_from**: From which number to start the search (default: 50)
- **stop_at**: At which number to stop the search (default: 100)

Processor parameters:

Parameters

- **start_from** (*int*) – First element of the range under investigation.
- **stop_at** (*int*) – Last element of the range under investigation.

finish() → None

Overload of the finish method.

Remember: to call the super method when you overload the finish method.

In this case, we just print out some information about the prime number found in the range.

format_progress_message() → None

Customizes the progress message with information about the current item.

The user can overload this method in order to modify the message being displayed during the process loop with information about the current item.

The user can access the current value, its position in the looping cycle and the total number of items using *Processor.item*, *Processor.i_item* and *Processor.n_item*.

get_items() → Collection[Any]

Overload of the get_items method.

This method must be overloaded when you select a for loop workflow.

Here we generate the list of odd numbers between the start and stop that we need to check. We also check that the stop is actually larger than the start, otherwise we print an error message, and we return an empty list of items.

Returns
A list of odd integer numbers between start_from and stop_at.

Return type
list[int]

process() → None

The process method.

In this case, it is very simple. We check if *Processor.item* is a prime number, if so we added to the list, otherwise we let the loop continue.

start() → None

Overload of the start method.

Remember: to call the super method when you overload the start.

In this specific case, we just make sure that the list of found prime numbers is empty.

prime_num_found: list[int]

The list with the found prime numbers

class mafw.examples.loop_modifier.**ModifyLoopProcessor**(**args: Any*, ***kwargs: Any*)

Bases: *Processor*

Example processor demonstrating how it is possible to change the looping structure.

It is a looping processor where some events will be skipped, and at some point one event will trigger an abort.

Processor parameters

- **item_to_abort**: Item to abort (default: 65)
- **items_to_skip**: List of items to be skipped. (default: [12, 16, 25])
- **total_item**: Total item in the loop. (default: 100)

Processor Parameters:

Parameters

- **total_item** (*int*) – The total number of items
- **items_to_skip** (*list[int]*) – A list of items to skip.
- **item_to_abort** (*int*) – The item where to trigger an abort.

get_items() → list[int]

Returns the list of items, the range from 0 to total_item.

process()

Processes the item

skip_item()

Add skipped item to the skipped item list.

start()

Resets the skipped item container.

skipped_items: [list[int]]

A list with the skipped items.

mafw.examples.loop_modifier.**is_prime**(*n: int*) → bool

Check if n is a prime number.

Parameters
n (*int*) – The integer number to be checked.

Returns
True if n is a prime number. False, otherwise.

Return type
bool

mafw.examples.multi_primary

Module demonstrates how to use multicolumn primary keys and foreign keys.

mafw.examples.processor_list

The module provides some examples on how to use ProcessorList to combine several processors.

Functions

run_processor_list_with_loop_modifier()	Example on deal with processors inside a processor list changing the loop structure.
run_simple_processor_list()	Simplest way to run several processors in a go.

`mafw.examples.processor_list.`**`run_processor_list_with_loop_modifier`**`()`

Example on deal with processors inside a processor list changing the loop structure.

In this example there are two processors, one that will run until the end and the other that will set the looping status to abort half way. The user can see what happens when the *ProcessorList* is executed.

`mafw.examples.processor_list.`**`run_simple_processor_list`**`()`

Simplest way to run several processors in a go.

mafw.examples.sum_processor

The module provides some examples for the user to develop their own processors.

Those implemented here are mainly used in the test suit.

Classes

AccumulatorProcessor(*args, **kwargs)	A processor to calculate the sum of the first n values via a looping approach.
GaussAdder(*args, **kwargs)	A processor to calculate the sum of the first n values via the so called *Gauss formula*.

class `mafw.examples.sum_processor.`**`AccumulatorProcessor`**`(*args: Any, **kwargs: Any)`

Bases: *Processor*

A processor to calculate the sum of the first n values via a looping approach.

In mathematical terms, this processor solves this easy equation:

$$N = \sum_{i=0}^{n} i$$

by looping. It is a terribly inefficient approach, but it works as a demonstration of the looping structure.

The user can get the results by retrieving the *accumulated_value* parameter at the end of the processor execution.

Processor parameters

- **last_value**: Last value of the series (default: 100)

Constructor parameters:

Parameters

- **last_value** (*int*) – The *n* in the equation above. Defaults to 100
- **accumulated_value** (*int*) – The *N* in the equation above at the end of the process.

get_items() → list[int]

Returns the list of the first *last_value* integers.

process()

Increase the accumulated value by the current item.

start()

Resets the accumulated value to 0 before starting.

class mafw.examples.sum_processor.**GaussAdder**(**args: Any*, ***kwargs: Any*)

Bases: *Processor*

A processor to calculate the sum of the first n values via the so called *Gauss formula*.

In mathematical terms, this processor solves this easy equation:

$$N = \frac{n * (n-1)}{2}$$

without any looping

The user can get the results by retrieving the *sum_value* parameter at the end of the processor execution.

Processor parameters

- **last_value**: Last value of the series. (default: 100)

Constructor parameters:

Parameters

- **last_value** (*int*) – The *n* in the equation above. Defaults to 100
- **sum_value** (*int*) – The *N* in the equation above.

process()

Compute the sum using the Gauss formula.

start()

Sets the sum value to 0.

12.1.6 mafw.hookspecs

Defines the hook specification decorator bound the MAFw library.

Functions

register_db_model_modules()	Register database model modules
register_processors()	Register multiple processor classes
register_user_interfaces()	Register multiple user interfaces

mafw.hookspecs.**register_db_model_modules**() → list[str]

Register database model modules

mafw.hookspecs.**register_processors**() → List[*ProcessorClassProtocol*]

Register multiple processor classes

mafw.hookspecs.**register_user_interfaces**() → List[*UserInterfaceClassProtocol*]

Register multiple user interfaces

12.1.7 mafw.lazy_import

This module provides classes for lazy importing of plugins, ensuring thread-safe access and transparent usage.

Classes:

- LazyImportPlugin: A generic class for lazy importing of plugin classes.
- LazyImportProcessor: A specialised class for lazy importing of Processor plugins.
- LazyImportUserInterface: A specialised class for lazy importing of UserInterface plugins.

Protocols:

- ProcessorClassProtocol: Defines the expected interface for Processor classes.
- UserInterfaceClassProtocol: Defines the expected interface for UserInterface classes.

Added in version v2.0.0.

Module Attributes

T	The class type to be used for the generic lazy import plugin.
R	The instance type to be used for the generic lazy import plugin.

Classes

LazyImportPlugin(module, class_name)	Proxy object that lazily imports a plugin class only when accessed.
LazyImportProcessor(module, class_name)	Lazy import proxy for Processor classes.
LazyImportUserInterface(module, class_name, ...)	Lazy import proxy for UserInterface classes.
ProcessorClassProtocol(*args, **kwargs)	Protocol for Processor classes.
UserInterfaceClassProtocol(*args, **kwargs)	Protocol for UserInterface classes.

class mafw.lazy_import.**LazyImportPlugin**(*module: str*, *class_name: str*)

Bases: `Generic[T, R]`, `ABC`

Proxy object that lazily imports a plugin class only when accessed. Thread-safe and transparent to the user.

Added in version v2.0.0.

Constructor parameter:

Parameters

- **module** (*str*) – The module name where the class is located.
- **class_name** (*str*) – The name of the class to be lazily imported.

_load() → Type[*T*]

Load the class from the specified module.

Returns
The loaded class type.

Return type
Type[*T*]

abstractmethod **_post_load**(*cls: Type[T]*) → Type[*T*]

Perform operations after loading the class.

Parameters
`cls` (*Type[T]*) – The class type that has been loaded.

Returns
The class type after post-load operations.

Return type
Type[*T*]

`class mafw.lazy_import.LazyImportProcessor(module: str, class_name: str)`

Bases: `LazyImportPlugin[Processor, Processor]`

Lazy import proxy for Processor classes.

Added in version v2.0.0.

Constructor parameter:

Parameters

- **module** (*str*) – The module name where the class is located.
- **class_name** (*str*) – The name of the class to be lazily imported.

`_post_load(cls: Type[Processor]) → Type[Processor]`

Perform operations after loading the Processor class.

Parameters
`cls` (*Type[Processor]*) – The Processor class type that has been loaded.

Returns
The Processor class type after post-load operations.

Return type
Type[*Processor*]

`class mafw.lazy_import.LazyImportUserInterface(module: str, class_name: str, ui_name: str)`

Bases: `LazyImportPlugin[UserInterfaceBase, UserInterfaceBase]`

Lazy import proxy for UserInterface classes.

Added in version v2.0.0.

Constructor parameter:

Parameters

- **module** (*str*) – The module name where the class is located.
- **class_name** (*str*) – The name of the class to be lazily imported.
- **ui_name** (*str*) – The expected name of the user interface.

`_post_load(cls: Type[UserInterfaceBase]) → Type[UserInterfaceBase]`

Perform operations after loading the UserInterface class.

Parameters
`cls` (*Type[UserInterfaceBase]*) – The UserInterface class type that has been loaded.

Returns
The UserInterface class type after post-load operations.

Return type
Type[*UserInterfaceBase*]

Raises
ValueError – If the class name is inconsistent with the expected name.

class mafw.lazy_import.**ProcessorClassProtocol**(**args*, ***kwargs*)

Bases: `Protocol`

Protocol for Processor classes.

Added in version v2.0.0.

Variables

- **plugin_name** – The name of the plugin.
- **plugin_qualname** – The qualified name of the plugin.
- **__name__** – The name of the class.

class mafw.lazy_import.**R**

The instance type to be used for the generic lazy import plugin.

alias of TypeVar('R')

class mafw.lazy_import.**T**

The class type to be used for the generic lazy import plugin.

alias of TypeVar('T')

class mafw.lazy_import.**UserInterfaceClassProtocol**(**args*, ***kwargs*)

Bases: `Protocol`

Protocol for UserInterface classes.

Added in version v2.0.0.

Variables

- **plugin_name** – The name of the plugin.
- **plugin_qualname** – The qualified name of the plugin.
- **name** – The name of the user interface.

12.1.8 mafw.mafw_errors

Module defines MAFw exceptions

Exceptions

AbortProcessorException	Exception raised during the execution of a processor requiring immediate exit.
InvalidConfigurationError	Error with the configuration of a processor
InvalidSteeringFile	Exception raised when validating an invalid steering file
MAFwException	Base class for MAFwException
MissingAttribute	Exception raised when an attempt is made to execute a statement without a required parameter/attributes
MissingDatabase	Exception raised when a processor requiring a database connection is being operated without a database
MissingOptionalDependency	UserWarning raised when an optional dependency is required
MissingOverloadedMethod	Warning issued when the user did not overload a required method.
MissingSQLStatement	Exception raised when a Trigger is created without any SQL statements.

continues on next page

Table 12.40 – continued from previous page

MissingSuperCall	Warning issued when the user did not invoke the super method for some specific processor methods.
ModelError	Exception raised when an error in a DB Model class occurs
ParserConfigurationError	Exception raised when an error occurred during the configuration of a filename parser
ParsingError	Exception raised when a regular expression parsing failed
PlotterMixinNotInitialized	Exception raised when a plotter mixin has not properly initialized
ProcessorParameterError	Error with a processor parameter
RunnerNotInitialized	Exception raised when attempting to run a not initialized Runner.
UnknownDBEngine	Exception raised when the user provided an unknown db engine
UnknownProcessor	Exception raised when an attempt is made to create an unknown processor
UnknownProcessorGroup	Exception raised when an attempt is made to create an unknown processor group
UnsupportedDatabaseError	Error raised when a feature is not supported by the database.

exception `mafw.mafw_errors.`**`AbortProcessorException`**

Bases: *MAFwException*

Exception raised during the execution of a processor requiring immediate exit.

exception `mafw.mafw_errors.`**`InvalidConfigurationError`**

Bases: *MAFwException*

Error with the configuration of a processor

exception `mafw.mafw_errors.`**`InvalidSteeringFile`**

Bases: *MAFwException*

Exception raised when validating an invalid steering file

exception `mafw.mafw_errors.`**`MAFwException`**

Bases: `Exception`

Base class for MAFwException

exception `mafw.mafw_errors.`**`MissingAttribute`**

Bases: *MAFwException*

Exception raised when an attempt is made to execute a statement without a required parameter/attributes

exception `mafw.mafw_errors.`**`MissingDatabase`**

Bases: *MAFwException*

Exception raised when a processor requiring a database connection is being operated without a database

exception `mafw.mafw_errors.`**`MissingOptionalDependency`**

Bases: `UserWarning`

UserWarning raised when an optional dependency is required

exception `mafw.mafw_errors.`**`MissingOverloadedMethod`**

Bases: `UserWarning`

Warning issued when the user did not overload a required method.

It is a warning and not an error because the execution framework might still work, but the results might be different from what is expected.

exception mafw.mafw_errors.**MissingSQLStatement**

Bases: *MAFwException*

Exception raised when a Trigger is created without any SQL statements.

exception mafw.mafw_errors.**MissingSuperCall**

Bases: UserWarning

Warning issued when the user did not invoke the super method for some specific processor methods.

Those methods (like *start()* and *finish()*) have not empty implementation also in the base class, meaning that if the user forgets to call *super* in their overloads, then the basic implementation will be gone.

It is a warning and not an error because the execution framework might sill work, but the results might be different from what is expected.

exception mafw.mafw_errors.**ModelError**

Bases: *MAFwException*

Exception raised when an error in a DB Model class occurs

exception mafw.mafw_errors.**ParserConfigurationError**

Bases: *MAFwException*

Exception raised when an error occurred during the configuration of a filename parser

exception mafw.mafw_errors.**ParsingError**

Bases: *MAFwException*

Exception raised when a regular expression parsing failed

exception mafw.mafw_errors.**PlotterMixinNotInitialized**

Bases: *MAFwException*

Exception raised when a plotter mixin has not properly initialized

exception mafw.mafw_errors.**ProcessorParameterError**

Bases: *MAFwException*

Error with a processor parameter

exception mafw.mafw_errors.**RunnerNotInitialized**

Bases: *MAFwException*

Exception raised when attempting to run a not initialized Runner.

exception mafw.mafw_errors.**UnknownDBEngine**

Bases: *MAFwException*

Exception raised when the user provided an unknown db engine

exception mafw.mafw_errors.**UnknownProcessor**

Bases: *MAFwException*

Exception raised when an attempt is made to create an unknown processor

exception mafw.mafw_errors.**UnknownProcessorGroup**

Bases: *MAFwException*

Exception raised when an attempt is made to create an unknown processor group

exception mafw.mafw_errors.**UnsupportedDatabaseError**

Bases: Exception

Error raised when a feature is not supported by the database.

12.1.9 mafw.plugin_manager

Plugin management system for MAFw framework.

This module provides the core functionality for loading and managing plugins within the MAFw framework. It supports loading various types of plugins including processors, standard tables, database models, and user interfaces.

The plugin manager uses the pluggy library to handle plugin discovery and registration through entry points and hooks.

When plugins are loaded using the `MAFwPluginManager.load_plugins()` function, the job is divided into multiple threads to improve performance.

Key features:

- Asynchronous plugin loading with progress indication
- Support for both internal and external plugins
- Type-safe plugin handling with proper data structures
- Logging integration for monitoring plugin loading processes
- Global plugin manager singleton for consistent access

The module defines several key components:

- `LoadedPlugins`: Data container for loaded plugins
- `MAFwPluginManager`: Main plugin manager class
- `get_plugin_manager()`: Factory function for accessing the plugin manager

Plugin types supported:

- Processors (*processors*): Classes that implement data processing logic
- Database Modules (*db_modules*): Model modules for database interaction
- User Interfaces (*ui*): UI implementations for different interfaces

Changed in version v2.0.0: Complete refactoring of the plugin manager system.

Module Attributes

`PluginTypes`	Type alias for accepted types of plugins.
`global_mafw_plugin_manager`	The global mafw plugin manager dictionary.

Functions

`get_plugin_manager`([force_recreate])	Create a new or return an existing plugin manager for a given project

Classes

`LoadedPlugins`(processor_list, ...)	Container class for storing loaded plugins of various types.
`MAFwPluginManager`([project_name])	The MAFw plugin manager.

class mafw.plugin_manager.**LoadedPlugins**(*processor_list: ~typing.List[~mafw.lazy_import.ProcessorClassProtocol] = <factory>, processor_dict: ~typing.Dict[str, ~mafw.lazy_import.ProcessorClassProtocol] = <factory>, db_model_modules: ~typing.List[str] = <factory>, ui_list: ~typing.List[~mafw.lazy_import.UserInterfaceClassProtocol] = <factory>, ui_dict: ~typing.Dict[str, ~mafw.lazy_import.UserInterfaceClassProtocol] = <factory>*)

Bases: `object`

Container class for storing loaded plugins of various types.

This dataclass holds collections of different plugin types that have been loaded by the `MAFwPluginManager`. It provides organized storage for processors, database modules, and user interfaces.

Added in version v2.0.0.

db_model_modules: List[str]

List of database model module names.

processor_dict: Dict[str, ProcessorClassProtocol]

Dictionary mapping processor names to their classes.

processor_list: List[ProcessorClassProtocol]

List of loaded processor classes.

ui_dict: Dict[str, UserInterfaceClassProtocol]

Dictionary mapping user interface names to their classes.

ui_list: List[UserInterfaceClassProtocol]

List of loaded user interface classes.

class mafw.plugin_manager.**MAFwPluginManager**(*project_name: str = 'mafw'*)

Bases: `PluginManager`

The MAFw plugin manager.

The MAFwPluginManager class manages the loading and registration of plugins within the MAFw framework. It supports asynchronous loading of various plugin types, including processors, database modules, and user interfaces, using a thread pool executor for improved performance.

The class provides methods to load each type of plugin and handles delayed status messages if loading takes longer than expected.

Added in version v2.0.0.

_delayed_status_message(*futures: List[Future[Any]]*) → None

Display a warning message if plugin loading takes longer than expected.

This method is called after a delay to check if all plugin loading operations have completed. If not, it logs a warning message to inform the user that plugin loading is taking longer than expected.

Parameters

futures (*list[concurrent.futures.Future]*) – List of futures representing ongoing plugin loading operations

load_db_models_plugins() → list[str]

Load database model modules from the plugin manager.

This method retrieves all database model modules registered through the plugin manager's `register_db_model_modules()` hook and imports them.

Returns

List of database model module names

Return type
list[str]

load_plugins(*plugins_to_load: Iterable[Literal['processors', 'db_modules', 'ui']]*) → *LoadedPlugins*

Load plugins of specified types in multiple threads.

This method loads plugins of the specified types using a thread pool executor for improved performance. It handles different plugin types including processors, standard tables, database modules, and user interfaces.

Parameters
plugins_to_load (Iterable[*PluginTypes*]) – Iterable of plugin types to load

Returns
Container with loaded plugins of all requested types

Return type
LoadedPlugins

load_processor_plugins() → Tuple[List[*ProcessorClassProtocol*], Dict[str, *ProcessorClassProtocol*]]

Load available processor plugins from the plugin manager.

This method retrieves all processor plugins registered through the plugin manager's *register_processors()* hook. *register_processors()* hook.

Returns
A tuple containing: - List of available processor classes - Dictionary mapping processor names to their classes

Return type
tuple[list[type[*Processor*]], dict[str, type[*Processor*]]]

load_user_interface_plugins() → Tuple[List[*UserInterfaceClassProtocol*], Dict[str, *UserInterfaceClassProtocol*]]

Load available user interface plugins from the plugin manager.

This method retrieves all user interface plugins registered through the plugin manager's *register_user_interfaces()* hook.

Returns
A tuple containing: - List of available user interface classes - Dictionary mapping user interface names to their classes

Return type
tuple[list[type[*UserInterfaceBase*]], dict[str, type[*UserInterfaceBase*]]]

max_loading_delay = 1

Loading delay before displaying a message.

If the loading of the external plugins is taking more than this value, a message is displayed to inform the user.

mafw.plugin_manager.**_as_db_module_result**(*obj: object*) → list[str]

Cast an object to the expected database module result type.

This helper function is used to convert the raw result from plugin loading operations into the expected list format for database modules.

Added in version v2.0.0.

Parameters
obj (*object*) – The object to cast

Returns
A list of database module names

Return type
list[str]

`mafw.plugin_manager._as_processor_result`(*obj: object*) → tuple[list[*ProcessorClassProtocol*], dict[str, *ProcessorClassProtocol*]]

Cast an object to the expected processor result type.

This helper function is used to convert the raw result from plugin loading operations into the expected tuple format for processors.

Added in version v2.0.0.

Parameters
obj (*object*) – The object to cast

Returns
A tuple containing a list of processor classes and a dictionary mapping processor names to their classes

Return type
tuple[list[*ProcessorClassProtocol*], dict[str, *ProcessorClassProtocol*]]

`mafw.plugin_manager._as_ui_result`(*obj: object*) → tuple[list[*UserInterfaceClassProtocol*], dict[str, *UserInterfaceClassProtocol*]]

Cast an object to the expected UI result type.

This helper function is used to convert the raw result from plugin loading operations into the expected tuple format for user interfaces.

Added in version v2.0.0.

Parameters
obj (*object*) – The object to cast

Returns
A tuple containing a list of UI classes and a dictionary mapping UI names to their classes

Return type
tuple[list[*UserInterfaceClassProtocol*], dict[str, *UserInterfaceClassProtocol*]]

`mafw.plugin_manager.get_plugin_manager`(*force_recreate: bool = False*) → *MAFwPluginManager*

Create a new or return an existing plugin manager for a given project

Parameters
force_recreate (*bool, Optional*) – Flag to force the creation of a new plugin manager. Defaults to False

Returns
The plugin manager

Return type
pluggy.PluginManager

`mafw.plugin_manager.PluginTypes`

Type alias for accepted types of plugins.

alias of `Literal`['processors', 'db_modules', 'ui']

`mafw.plugin_manager.global_mafw_plugin_manager: dict[str, MAFwPluginManager] = {}`

The global mafw plugin manager dictionary.

12.1.10 mafw.plugins

Exports Processor classes to the execution script.

Functions

register_db_model_modules()	Returns the list of modules with the database model definitions
register_processors()	Returns a list of processors to be registered
register_user_interfaces()	Returns a list of user interfaces that can be used

mafw.plugins.**register_db_model_modules**() → List[str]

Returns the list of modules with the database model definitions

mafw.plugins.**register_processors**() → List[*ProcessorClassProtocol*]

Returns a list of processors to be registered

mafw.plugins.**register_user_interfaces**() → List[*UserInterfaceClassProtocol*]

Returns a list of user interfaces that can be used

12.1.11 mafw.processor

Module implements the basic Processor class, the ProcessorList and all helper classes to achieve the core functionality of the MAFw.

Module Attributes

ParameterType	Generic variable type for the *ActiveParameter* and *PassiveParameter*.
F	Type variable for generic callable with any return value.

Functions

ensure_parameter_registration(func)	Decorator to ensure that before calling *func* the processor parameters have been registered.
validate_database_conf([database_conf])	Validates the database configuration.

Classes

ActiveParameter(name[, value, default, help_doc])	The public interface to the processor parameter.
PassiveParameter(name[, value, default, ...])	An helper class to store processor parameter value and metadata.
Processor(*args, **kwargs)	The basic processor.
ProcessorList(*args[, name, description, ...])	A list like collection of processors.
ProcessorMeta	A metaclass to implement the post-init method.

class mafw.processor.**ActiveParameter**(*name: str*, *value:* ParameterType | *None = None*, *default:* ParameterType | *None = None*, *help_doc: str = ''*)

Bases: Generic[*ParameterType*]

The public interface to the processor parameter.

The behaviour of a *Processor* can be customised by using processor parameters. The value of these parameters can be either set via a configuration file or directly when creating the class.

If the user wants to benefit from this facility, they have to add in the instance of the Processor subclass an ActiveParameter instance in this way:

```
class MyProcessor(Processor):

    # this is the input folder
    input_folder = ActiveParameter('input_folder', Path(r'C:\'), help_doc='This␣
↪is where to look for input files')

    def __init__(self, *args, **kwargs):
        super().__init(*args, **kwargs)

        # change the input folder to something else
        self.input_folder = Path(r'D:\data')

        # get the value of the parameter
        print(self.input_folder)
```

The ActiveParameter is a descriptor, it means that when you create one of them, a lot of work is done behind the scene.

In simple words, a processor parameter is made by two objects: a public interface where the user can easily access the value of the parameter and a private interface where all other information (default, documentation…) is also stored.

The user does not have to take care of all of this. When a new ActiveParameter instance is added to the class as in the code snippet above, the private interface is automatically created and will stay in the class instance until the end of the class lifetime.

To access the private interface, the user can use the `Processor.get_parameter()` method using the parameter name as a key.

The user can assign to an ActiveParameter almost any name. There are just a few invalid parameter names that are used for other purposes. The list of reserved names is available *here*. Should the user inadvertently use a reserved named, a *ProcessorParameterError* is raised.

See also

The private counter part in the *PassiveParameter*.

An explanation on how processor parameters work and should be used is given in *Understanding processor parameters*

The list of `reserved names`.

Constructor parameters:

Parameters

- **name** (*str*) – The name of the parameter.
- **value** (ParameterType, *Optional*) – The initial value of the parameter. Defaults to None.
- **default** (ParameterType, *Optional*) – The default value of the parameter, to be used when `value` is not set., Defaults to None.
- **help_doc** (*str, Optional*) – An explanatory text describing the parameter.

_validate_name(*proposed_name: str*) → str

Validate that the proposed parameter name is not in the list of forbidden names.

This private method checks if the provided name is allowed for use as a processor parameter. Names that are listed in *reserved_names* cannot be used as parameter names.

Parameters

proposed_name (*str*) – The name to be validated for use as a processor parameter.

Returns
The validated name if it passes the forbidden names check.

Return type
str

Raises
ProcessorParameterError – If the proposed name is in the list of forbidden names.

reserved_names: list[str] = ['__logic__', '__filter__', '__new_only__', '__inheritance__']

A list of names that cannot be used as processor parameter names.

- *__logic__*
- *__filter__*
- *__new_only__*
- *__inheritance__*

class mafw.processor.F

Type variable for generic callable with any return value.

alias of TypeVar('F', bound=Callable[[...], Any])

class mafw.processor.ParameterType

Generic variable type for the *ActiveParameter* and *PassiveParameter*.

alias of TypeVar('ParameterType')

class mafw.processor.PassiveParameter(*name: str*, *value:* ParameterType | *None = None*, *default:* ParameterType | *None = None*, *help_doc: str = ''*)

Bases: Generic[*ParameterType*]

An helper class to store processor parameter value and metadata.

This class is the private interface used by the *ActiveParameter* descriptor to store its value and metadata.

When a new *ActiveParameter* is added to a class, an instance of a PassiveParameter is added to the processor parameter *register*.

> **See also**
>
> An explanation on how processor parameters work and should be used is given in *Understanding processor parameters*

Changed in version v2.0.0: User should only use *ActiveParameter* and never manually instantiate *PassiveParameter*.

Constructor parameters:

Parameters

- **name** (*str*) – The name of the parameter. It must be a valid python identifier.
- **value** (ParameterType, *Optional*) – The set value of the parameter. If None, then the default value will be used. Defaults to None.
- **default** (ParameterType, *Optional*) – The default value for the parameter. It is used if the *value* is not provided. Defaults to None.
- **help_doc** (*str, Optional*) – A brief explanation of the parameter.

Raises
ProcessorParameterError – if both *value* and *default* are not provided or if *name* is not a valid identifier.

property is_optional: bool

Property to check if the parameter is optional.

Returns
True if the parameter is optional

Return type
bool

property is_set: bool

Property to check if the value has been set.

It is useful for optional parameter to see if the current value is the default one, or if the user set it.

property value: *ParameterType*

Gets the parameter value.

Returns
The parameter value.

Return type
ParameterType

Raises
ProcessorParameterError – if both value and default were not defined.

class mafw.processor.**Processor**(**args: Any*, ***kwargs: Any*)

Bases: `object`

The basic processor.

A very comprehensive description of what a Processor does and how it works is available at *Processor: The core of MAFw*.

Constructor parameters

Parameters

- **name** (*str, Optional*) – The name of the processor. If None is provided, the class name is used instead. Defaults to None.
- **description** (*str, Optional*) – A short description of the processor task. Defaults to the processor name.
- **config** (*dict, Optional*) – A configuration dictionary for this processor. Defaults to None.
- **looper** (LoopType, *Optional*) – Enumerator to define the looping type. Defaults to LoopType.ForLoop
- **user_interface** (UserInterfaceBase, *Optional*) – A user interface instance to be used by the processor to interact with the user.
- **timer** (Timer, *Optional*) – A timer object to measure process duration.
- **timer_params** (*dict, Optional*) – Parameters for the timer object.
- **database** (*Database, Optional*) – A database instance. Defaults to None.
- **database_conf** (*dict, Optional*) – Configuration for the database. Default to None.
- **remove_orphan_files** (*bool, Optional*) – Boolean flag to remove files on disc without a reference to the database. See *Standard tables* and *_remove_orphan_files()*. Defaults to True
- **replica_id** (*str, Optional*) – The replica identifier for the current processor.
- **create_standard_tables** (*bool, Optional*) – Boolean flag to create std tables on disk. Defaults to True

- **kwargs** – Keyword arguments that can be used to set processor parameters.

_check_method_overload() → None

Check if the user overloaded the required methods.

Depending on the loop type, the user must overload different methods. This method is doing the check and if the required methods are not overloaded a warning is emitted.

_check_method_super() → None

Check if some specific methods are calling their super.

For some specific methods (for example: start and finish), the user should always call their super method. This method verifies that the user implementation of these methods is including a super call, otherwise a warning is emitted to inform the user about the problem and possible misbehaviour of the processor.

The list of methods to be verified is stored in a private class attribute *_methods_to_be_checked_for_super* as a list of tuples, made by the name of the methods to be verified and the base class for comparison. The base class is required because Processor subclasses may be extending this list with methods that are not present in the base Processor. See, for example, the *patch_data_frame()* that is required to have a super call, but it is not present in the base Processor.

_execute_for_loop() → None

Executes the processor within a for loop.

Private method. Do not overload nor invoke it directly. The *execute()* method will call the appropriate implementation depending on the processor LoopType.

_execute_single() → None

Execute the processor in single mode.

Private method. Do not overload nor invoke it directly. The *execute()* method will call the appropriate implementation depending on the processor LoopType.

_execute_while_loop() → None

Executes the processor within a while loop.

Private method. Do not overload nor invoke it directly. The *execute()* method will call the appropriate implementation depending on the processor LoopType.

_load_parameter_configuration() → None

Load processor parameter configuration from the internal configuration dictionary.

This method processes the processor's configuration dictionary to set parameter values. It handles two configuration formats:

1. Nested format: `{'ProcessorName':  {'param1':  value1, ...}}`
2. Flat format: `{'param1':  value1, ...}`

The method also handles filter configurations by collecting filter table names and deferring their initialisation until after the global filter has been processed.

Changed in version v2.0.0: For option 1 combining configuration from name and name_replica

Raises

ProcessorParameterError – If a parameter in the configuration is not registered.

See also

mafw.db.db_filter.ModelFilter.from_conf()

_override_defaults() → None

Override default parameter values with values from *new_defaults*.

This private method iterates through the *new_defaults* dictionary and updates the corresponding processor parameters with new values. Only parameters that exist in both *new_defaults* and *_processor_parameters* are updated.

Added in version v2.0.0.

_overrule_kws_parameters() → None

Override processor parameters with values from keyword arguments.

This method applies parameter values passed as keyword arguments during processor initialisation. It ensures that the parameter types match the expected types before setting the values.

> **See also**
>
> *_register_parameters()*, *_load_parameter_configuration()*, *set_parameter_value()*

_register_parameters() → None

Register processor parameters defined as ActiveParameter instances in the class.

This private method scans the class definition for any *ActiveParameter* instances and creates corresponding *PassiveParameter* instances to store the actual parameter values and metadata. It ensures that all processor parameters are properly initialised and available for configuration through the processor's configuration system.

The method checks for duplicate parameter names and raises a *ProcessorParameterError* if duplicates are detected. It also sets the internal flag *_parameter_registered* to True once registration is complete.

> **Note**
>
> This method is automatically called during processor initialisation and should not be called directly by users.

> **See also**
>
> *Processor*, *Processor._override_defaults()*, *Processor._load_parameter_configuration()*, *Processor._overrule_kws_parameters()*

Changed in version v2.0.0: Only *ActiveParameter* are not registered. The use of *PassiveParameter* is only meant to store the value and metadata of the active counter part.

_remove_orphan_files() → None

Remove orphan files.

If a connection to the database is available, then the OrphanFile standard table is queried for all its entries, and all the files are then removed.

The user can turn off this behaviour by switching the *remove_orphan_files* to False.

_reset_parameters() → None

Reset processor parameters to their initial state.

This method clears all currently registered processor parameters and triggers a fresh registration process. It's useful when parameter configurations need to be reinitialized or when parameters have been modified and need to be reset.

> **See also**
>
> *_register_parameters()*, *_register_parameters()*

accept_item() → None

Does post process actions on a successfully processed item.

Within the *process()*, the user left the looping status to Continue, so it means that everything looks good and this is the right place to perform database updates or file savings.

acquire_resources() → None

Acquires resources and add them to the resource stack.

The whole body of the *execute()* method is within a context structure. The idea is that if any part of the code inside should throw an exception that breaking the execution, we want to be sure that all stateful resources are properly closed.

Since the number of resources may vary, the variable number of nested *with* statements has been replaced by an ExitStack. Resources, like open files, timers, db connections, need to be added to the resource stacks in this method.

In the case a processor is being executed within a *ProcessorList*, then some resources might be shared, and for this reason they are not added to the stack. This selection can be done via the private *local_resource_acquisition*. This is normally True, meaning that the processor will handle its resources independently, but when the processor is executed from a *ProcessorList*, this flag is automatically turned to False.

If the user wants to add additional resources, he has to overload this method calling the super to preserve the original resources. If he wants to have shared resources among different processors executed from inside a processor list, he has to overload the *ProcessorList* class as well.

delete_parameter(*name: str*) → None

Deletes a processor parameter.

Parameters
: **name** (*str*) – The name of the parameter to be deleted.

Raises
: ***ProcessorParameterError*** – If a parameter with *name* is not registered.

dump_parameter_configuration(*option: int = 1*) → dict[str, Any]

Dumps the processor parameter values in a dictionary.

The snippet below explains the meaning of *option*.

```
# option 1
conf_dict1 = {
    'Processor': {'param1': 5, 'input_table': 'my_table'}
}

# option 2
conf_dict2 = {'param1': 5, 'input_table': 'my_table'}
```

In the case of option 1, the replica aware name (*replica_name()*) will be used as a key for the configuration dictionary.

Changed in version v2.0.0: With option 1, using *replica_name()* instead of *name* as key of the configuration dictionary.

Parameters
: **option** (*int, Optional*) – Select the dictionary style. Defaults to 1.

Returns
: A parameter configuration dictionary.

Return type
dict

execute() → None

Execute the processor tasks.

This method works as a dispatcher, reassigning the call to a more specific execution implementation depending on the `loop_type`.

finish() → None

Concludes the execution.

The user can reimplement this method if there are some conclusive tasks that must be achieved. Always include a call to super().

format_progress_message() → None

Customizes the progress message with information about the current item.

The user can overload this method in order to modify the message being displayed during the process loop with information about the current item.

The user can access the current value, its position in the looping cycle and the total number of items using `Processor.item`, `Processor.i_item` and `Processor.n_item`.

get_filter(*model_name: str*) → *ModelFilter*

Returns a registered `ModelFilter` via the model name.

If a filter for the provided model_name does not exist, a KeyError is raised.

Parameters
model_name (*str*) – The model name for which the filter will be returned.

Returns
The registered filter

Return type
mafw.db.db_filter.ModelFilter

Raises
KeyError is a filter with the give name is not found.

get_items() → Collection[Any]

Returns the item collections for the processor loop.

This method must be overloaded for the processor to work. Generally, this is getting a list of rows from the database, or a list of files from the disk to be processed.

Returns
A collection of items for the loop

Return type
Collection[Any]

get_parameter(*name: str*) → *PassiveParameter*[*ParameterType*]

Gets the processor parameter named name.

Parameters
name (*str*) – The name of the parameter.

Returns
The processor parameter

Return type
PassiveParameter

Raises
ProcessorParameterError – If a parameter with *name* is not registered.

`get_parameters()` → dict[str, *PassiveParameter*[*ParameterType*]]

Returns the full dictionary of registered parameters for this processor.

Useful when dumping the parameter specification in a configuration file, for example.

Returns
The dictionary with the registered parameters.

Return type
dict[str, *PassiveParameter*[*ParameterType*]

`initialise_parameters()` → None

Initialises processor parameters by registering them and applying various configuration sources.

This method orchestrates the parameter initialisation process by performing the following steps in order:

1. Registers processor parameters defined as `ActiveParameter` instances
2. Overrides default parameter values with any configured overrides
3. Loads parameter configuration from the processor's configuration dictionary
4. Applies keyword arguments as parameter overrides

The method ensures that all processor parameters are properly configured before the processor execution begins. It is automatically called during processor initialisation and should not typically be called directly by users.

See also

`_register_parameters()`, *`_override_defaults()`*, *`_load_parameter_configuration()`*, *`_overrule_kws_parameters()`*

Added in version v2.0.0.

`on_looping_status_set`(*status:* LoopingStatus) → None

Call back invoked when the looping status is set.

The user can overload this method according to the needs.

Parameters
status (`LoopingStatus`) – The set looping status.

`on_processor_status_change`(*old_status:* ProcessorStatus, *new_status:* ProcessorStatus) → None

Callback invoked when the processor status is changed.

Parameters

- **old_status** (`ProcessorStatus`) – The old processor status.
- **new_status** (`ProcessorStatus`) – The new processor status.

`print_process_statistics()` → None

Print the process statistics.

A utility method to display the fastest, the slowest and the average timing required to process on a single item. This is particularly useful when the looping processor is part of a ProcessorList.

`process()` → None

Processes the current item.

This is the core of the Processor, where the user has to define the calculations required.

`set_parameter_value`(*name:* str, *value:* ParameterType) → None

Sets the value of a processor parameter.

Parameters

- **name** (*str*) – The name of the parameter to be deleted.
- **value** (ParameterType) – The value to be assigned to the parameter.

Raises

ProcessorParameterError – If a parameter with *name* is not registered.

skip_item() → None

Does post process actions on a *NOT* successfully processed item.

Within the *process()*, the user set the looping status to Skip, so it means that something went wrong and here corrective actions can be taken if needed.

start() → None

Start method.

The user can overload this method, including all steps that should be performed at the beginning of the operation.

If the user decides to overload it, it should include a call to the super method.

validate_configuration() → None

Validate the configuration provided via the processor parameters.

Method to be implemented by subclasses if a configuration validation is needed.

The method should silently check for the proper configuration, if this is not obtained, then the *InvalidConfigurationError* must be raised.

Added in version v2.0.0.

while_condition() → bool

Return the while condition

Returns

True if the while loop has to continue, false otherwise.

Return type

bool

_config: dict[str, Any]

A dictionary containing the processor configuration object.

This dictionary is populated with configuration parameter (always type 2) during the *_load_parameter_configuration()* method.

The original value of the configuration dictionary that is passed to the constructor is stored in *_orig_config*.

Changed in version v2.0.0: Now it is an empty dictionary until the *_load_parameter_configuration()* is called.

_ids = count(0)

A counter for all processor instances

_methods_to_be_checked_for_super

List of methods to be checked for super inclusion.

It is a list of tuple, with the first element the name of the method to be checked and the second the base class to the be compared.

_orig_config

A copy of the original configuration dictionary.

Added in version v2.0.0.

_parameter_registered

A boolean flag to confirm successful parameter registration.

`_processor_parameters: dict[str, PassiveParameter[ParameterType]]`

A dictionary to store all the processor parameter instances.

The name of the parameter is used as a key, while for the value an instance of the `PassiveParameter` is used.

`create_standard_tables`

The boolean flag to proceed or skip with standard table creation and initialisation

`property database: Database`

Returns the database instance

Returns
A database object.

Raises
`MissingDatabase` – If the database connection has not been established.

`description`

A short description of the processor task.

`filter_register: ProcessorFilter`

The DB filter register of the Processor.

`property i_item: int`

The enumeration of the current item being processed.

`item: Any`

The current item of the loop.

`property local_resource_acquisition: bool`

Checks if resources should be acquired locally.

When the processor is executed in stand-alone mode, it is responsible to acquire and release its own external resources, but when it is executed from a ProcessorList, then is a good practice to share and distribute resources among the whole processor list. In this case, resources should not be acquired locally by the single processor, but from the parent execution context.

Returns
True if resources are to be acquired locally by the processor. False, otherwise.

Return type
bool

`loop_type: LoopType`

The loop type.

The value of this parameter can also be changed by the `execution_workflow()` decorator factory.

See `LoopType` for more details.

`looping_status`

Looping modifier

`property n_item: int | None`

The total number of items to be processed or None for an undefined loop

`name`

The name of the processor.

`new_defaults: dict[str, Any] = {}`

A dictionary containing defaults value for the parameters to be overridden

Added in version v2.0.0.

processor_exit_status

Processor exit status

processor_status

Processor execution status

progress_message: str = 'Processor is working'

Message displayed to show the progress.

It can be customized with information about the current item in the loop by overloading the *format_progress_message()*.

remove_orphan_files: bool

The flag to remove or protect the orphan files. Defaults to True

replica_id

The replica identifier specified in the constructor

Added in version v2.0.0.

property replica_name: str

Returns the replica aware name of the processor.

If no replica_id is specified, then return the pure name, otherwise join the two string using the '#' symbol.

Added in version v2.0.0.

Returns
The replica aware name of the processor.

Return type
str

unique_id

A unique identifier representing how many instances of Processor has been created.

property unique_name: str

Returns the unique name for the processor.

class mafw.processor.ProcessorList(**args: Processor | ProcessorList, name: str | None = None, description: str | None = None, timer: Timer | None = None, timer_params: dict[str, Any] | None = None, user_interface: UserInterfaceBase | None = None, database: Database | None = None, database_conf: dict[str, Any] | None = None, create_standard_tables: bool = True*)

Bases: list[*Processor* | *ProcessorList*]

A list like collection of processors.

ProcessorList is a subclass of list containing only Processor subclasses or other ProcessorList.

An attempt to add an element that is not a Processor or a ProcessorList will raise a TypeError.

Along with an iterable of processors, a new processor list can be built using the following parameters.

Constructor parameters:

Parameters

- **name** (*str, Optional*) – The name of the processor list. Defaults to ProcessorList.
- **description** (*str, Optional*) – An optional short description. Default to ProcessorList.
- **timer** (*Timer, Optional*) – The timer object. If None is provided, a new one will be created. Defaults to None.

- **timer_params** (*dict, Optional*) – A dictionary of parameter to build the timer object. Defaults to None.
- **user_interface** (UserInterfaceBase*, Optional*) – A user interface. Defaults to None
- **database** (*Database, Optional*) – A database instance. Defaults to None.
- **database_conf** (*dict, Optional*) – Configuration for the database. Default to None.
- **create_standard_tables** (*bool, Optional*) – Whether or not to create the standard tables. Defaults to True.

`static validate_item`(*item:* Processor | ProcessorList) → *Processor* | *ProcessorList*

Validates the item being added.

`static validate_items`(*items: tuple[*Processor | ProcessorList*, ...] = ()*) → tuple[*Processor* | *ProcessorList*, ...]

Validates a tuple of items being added.

`acquire_resources`() → None

Acquires external resources.

`append`(*_ProcessorList__object:* Processor | ProcessorList) → None

Appends a new processor at the end of the list.

`distribute_resources`(*processor:* Processor | *Self*) → None

Distributes the external resources to the items in the list.

`execute`() → *ProcessorExitStatus*

Execute the list of processors.

Similarly to the `Processor`, ProcessorList can be executed. In simple words, the execute method of each processor in the list is called exactly in the same sequence as they were added.

`extend`(*_ProcessorList__iterable: Iterable[*Processor | ProcessorList*]*) → None

Extends the processor list with a list of processors.

`insert`(*_ProcessorList__index: SupportsIndex*, *_ProcessorList__object:* Processor | ProcessorList) → None

Adds a new processor at the specified index.

`create_standard_tables`

The boolean flag to proceed or skip with standard table creation and initialisation

`property database: Database`

Returns the database instance

Returns
A database instance

Raises
`MissingDatabase` – if a database connection is missing.

`property name: str`

The name of the processor list

Returns
The name of the processor list

Return type
str

nested_list

Boolean flag to identify that this list is actually inside another list.

Similarly to the local resource flag for the *Processor*, this flag prevent the user interface to be added to the resource stack.

property processor_exit_status: *ProcessorExitStatus*

The processor exit status.

It refers to the whole processor list execution.

class `mafw.processor.`**ProcessorMeta**

Bases: `type`

A metaclass to implement the post-init method.

`mafw.processor.`**ensure_parameter_registration**(*func: F*) → *F*

Decorator to ensure that before calling *func* the processor parameters have been registered.

`mafw.processor.`**validate_database_conf**(*database_conf: dict[str, Any] | None = None*) → dict[str, Any] | None

Validates the database configuration.

Parameters

database_conf (*dict, Optional*) – The input database configuration. Defaults to None.

Returns

Either the validated database configuration or None if it is invalid.

Return type

dict, None

12.1.12 mafw.processor_library

Library of generic processors.

Subpackage containing a library of general purpose processors that the user can either use directly or overload them to implement their analytical tasks.

Modules

abstract_plotter	Module implements the abstract base interface to a processor to generate plots.
db_init	Database initialisation processor module.
importer	Provides a basic element importer.
sns_plotter	Module implements a Seaborn plotter processor with a mixin structure to generate seaborn plots.

mafw.processor_library.abstract_plotter

Module implements the abstract base interface to a processor to generate plots.

This abstract interface is needed because MAFw does not force the user to select a specific plot and data manipulation library.

The basic idea is to have a *basic processor class* featuring a modified *process()* method where a skeleton of the standard operations required to generate a graphical representation of a dataset is provided.

The user has the possibility to compose the *GenericPlotter* by mixing it with one *DataRetriever* and a *FigurePlotter*.

For a specific implementation based on seaborn, please refer to *sns_plotter*.

Classes

DataRetriever(*args, **kwargs)	Base mixin class to retrieve a data frame from an external source
FigurePlotter()	
GenericPlotter(*args, **kwargs)	The Generic Plotter processor.
PlotterMeta(name, bases, namespace, /, **kwargs)	Metaclass for the plotter mixed classes

class mafw.processor_library.abstract_plotter.**DataRetriever**(**args: Any*, ***kwargs: Any*)

Bases: ABC

Base mixin class to retrieve a data frame from an external source

The dataframe instance. It will be filled for the main class

abstractmethod get_data_frame() → None

The mixin implementation of the shared method with the base class

abstractmethod patch_data_frame() → None

The mixin implementation of the shared method with the base class

class mafw.processor_library.abstract_plotter.**FigurePlotter**

Bases: ABC

class mafw.processor_library.abstract_plotter.**GenericPlotter**(**args: Any*, ***kwargs: Any*)

Bases: *Processor*

The Generic Plotter processor.

This is a subclass of a Processor with advanced functionality to fetch data in the form of a dataframe and to produce plots. When mentioning dataframe in the context of the generic plotter, we do not have in mind any specific dataframe implementation.

The GenericPlotter is actually a kind of abstract class: since MAFw is not forcing you to use any specific plotting and data manipulation library, you need to subclass the GenericPlotter in your code, be sure that the required dependencies are available for import and use it as a normal processor.

If you are ok with using seaborn (with matplotlib as a graphical backend and pandas for data storage and manipulation), then be sure to install mafw with the optional feature *seaborn* (`pip install mafw[seaborn]`) and have a look at the *sns_plotter* for an already prepared implementation of a Plotter.

The key difference with respect to a normal processor is its *process()* method that has been already implemented as follows:

```
def process(self) -> None:
    """
    Process method overload.

    In the case of a plotter subclass, the process method is already implemented␣
↪and the user should not overload
    it. On the contrary, the user must overload the other implementation methods␣
↪described in the general
    :class:`class description <.SNSPlotter>`.
    """
    if self.filter_register.new_only:
        if self.is_output_existing():
            return

    self.in_loop_customization()
    self.get_data_frame()
```

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```
    self.patch_data_frame()
    self.slice_data_frame()
    self.group_and_aggregate_data_frame()
    if not self.is_data_frame_empty():
        self.plot()
        self.customize_plot()
        self.save()
        self.update_db()
```

This actually means that when you are subclassing a GenericPlotter you do not have to implement the process method as you would do for a normal Processor, but you will have to implement the following methods:

- *in_loop_customization()*.

  The processor execution workflow (LoopType) can be any of the available, so actually the process method might be invoked only once, or multiple times inside a loop structure (for or while). If the execution is cyclic, then you may want to have the possibility to do some customisation for each iteration, for example, changing the plot title, or modifying the data selection, or the filename where the plots will be saved.

  You can use this method also in case of a single loop processor, in this case you will not have access to the loop parameters.

- *get_data_frame()*.

  This method has the task to get the data to be plotted. Since it is an almost abstract class, you need to

- *patch_data_frame()*.

  A convenient method to apply data frame manipulation to the data just retrieved. A typical use case is for conversion of unit of measurement. Imagine you saved the data in the S.I. units, but for the visualization you prefer to use practical units, so you can subclass this method to add a new column containing the same converted values of the original one.

- *slice_data_frame()*.

  Slicing a dataframe is similar as applying a where clause in a SQL query. Implement this method to select which row should be used in the generation of your plot.

- *group_and_aggregate_data_frame()*.

  In this method, you can manipulate your data frame to perform row grouping and aggregation.

- *is_data_frame_empty()*.

  A simple method to test if the dataframe contains any data to be plotted. In fact, after the slicing, grouping and aggregation operations, it is possible that the dataframe is now left without any row. In this case, it makes no sense to waste time in plotting an empty graph.

- *plot()*.

  This method is where the actual plotting occurs.

- *customize_plot()*.

  This method can be optionally used to customize the appearance of the facet grid produced by the *plot()* method. It is particularly useful when the user is mixing this class with one of the *FigurePlotter* mixin, thus not having direct access to the plot method.

- *save()*.

  This method is where the produced plot is saved in a file. Remember to append the output file name to the *list of produced outputs* so that the *_update_plotter_db()* method will automatically store this file in the database during the *finish()* execution.

- *update_db()*.

If the user wants to update a specific table in the database, they can use this method.

It is worth reminding that all plotters are saving all generated files in the standard table PlotterOutput. This is automatically done by the `_update_plotter_db()` method that is called in the `finish()` method.

Processor parameters

- **force_replot**: Whether to force re-plotting even if the output file already exists (default: False)
- **output_folder**: The path where the output file will be saved (default: PosixPath('/builds/kada/mafw'))

Constructor parameters

Parameters

- **name** (*str, Optional*) – The name of the processor. If None is provided, the class name is used instead. Defaults to None.
- **description** (*str, Optional*) – A short description of the processor task. Defaults to the processor name.
- **config** (*dict, Optional*) – A configuration dictionary for this processor. Defaults to None.
- **looper** (LoopType, *Optional*) – Enumerator to define the looping type. Defaults to LoopType.ForLoop
- **user_interface** (UserInterfaceBase, *Optional*) – A user interface instance to be used by the processor to interact with the user.
- **timer** (Timer, *Optional*) – A timer object to measure process duration.
- **timer_params** (*dict, Optional*) – Parameters for the timer object.
- **database** (*Database, Optional*) – A database instance. Defaults to None.
- **database_conf** (*dict, Optional*) – Configuration for the database. Default to None.
- **remove_orphan_files** (*bool, Optional*) – Boolean flag to remove files on disc without a reference to the database. See *Standard tables* and `_remove_orphan_files()`. Defaults to True
- **replica_id** (*str, Optional*) – The replica identifier for the current processor.
- **create_standard_tables** (*bool, Optional*) – Boolean flag to create std tables on disk. Defaults to True
- **kwargs** – Keyword arguments that can be used to set processor parameters.

_update_plotter_db() → None

Updates the Plotter DB.

A plotter subclass primarily generates plots as output in most cases, which means that no additional information needs to be stored in the database. This is sufficient to prevent unnecessary execution of the processor when it is not required.

This method is actually protected against execution without a valid database instance.

Changed in version v2.0.0: Using the `Processor.replica_name` instead of the `Processor.name` as plotter_name in the `PlotterOutput` Model.

customize_plot() → None

The customize plot method.

The user can overload this method to customize the output produced by the `plot()` method, like, for example, adding meaningful axis titles, changing format, and so on.

As usual, it is possible to use the `item`, `i_item` and `n_item` to access the loop parameters.

finish() → None

Concludes the execution.

The user can reimplement this method if there are some conclusive tasks that must be achieved. Always include a call to super().

format_progress_message() → None

Customizes the progress message with information about the current item.

The user can overload this method in order to modify the message being displayed during the process loop with information about the current item.

The user can access the current value, its position in the looping cycle and the total number of items using `Processor.item`, `Processor.i_item` and `Processor.n_item`.

get_data_frame() → None

Get the data frame with the data to be plotted.

This method can be either implemented in the SNSPlotter subclass or via a `DataRetriever` mixin class.

in_loop_customization() → None

Customize the parameters for the output or input data for each execution iteration.

is_data_frame_empty() → bool

Check if the data frame is empty

is_output_existing() → bool

Check for plotter output existence.

Generally, plotter subclasses do not have a real output that can be saved to a database. This class is meant to generate one or more graphical output files.

One of the biggest advantages of having the output of a processor stored in the database is the ability to conditionally execute the processor if, and only if, the output is missing or changed.

In order to allow also plotter processor to benefit from this feature, a `dedicated table` is available among the *standard tables*.

If a connection to the database is provided, then this method is invoked at the beginning of the `process()` and a select query over the `PlotterOutput` model is executed filtering by processor name. All files in the filename lists are checked for existence and also the checksum is verified.

Especially during debugging phase of the processor, it is often needed to generate the plot several times, for this reason the user can switch the `force_replot` parameter to True in the steering file and the output file will be generated even if it is already existing.

This method will return True, if the output of the processor is already existing and valid, False, otherwise.

Changed in version v2.0.0: Using `Processor.replica_name` instead of `Processor.name` for storage in the `PlotterOutput`

Returns
True if the processor output exists and it is valid.

Return type
bool

patch_data_frame() → None

Modify the data frame

This method can be used to perform operation on the data frame, like adding new columns. It can be either implemented in the plotter processor subclasses or via a mixin class.

plot() → None

The plot method.

This is where the user has to implement the real plot generation

process() → None

Process method overload.

In the case of a plotter subclass, the process method is already implemented and the user should not overload it. On the contrary, the user must overload the other implementation methods described in the general *class description*.

save() → None

The save method.

This is where the user has to implement the saving of the plot on disc.

update_db() → None

The update database method.

This is where the user has to implement the optional update of the database.

_config: dict[str, Any]

A dictionary containing the processor configuration object.

This dictionary is populated with configuration parameter (always type 2) during the *_load_parameter_configuration()* method.

The original value of the configuration dictionary that is passed to the constructor is stored in *_orig_config*.

Changed in version v2.0.0: Now it is an empty dictionary until the *_load_parameter_configuration()* is called.

_processor_parameters: dict[str, *PassiveParameter*[*ParameterType*]]

A dictionary to store all the processor parameter instances.

The name of the parameter is used as a key, while for the value an instance of the *PassiveParameter* is used.

filter_register: *mafw.db.db_filter.ProcessorFilter*

The DB filter register of the Processor.

force_replot

Flag to force the regeneration of the output file even if it is already existing.

item: Any

The current item of the loop.

loop_type: *LoopType*

The loop type.

The value of this parameter can also be changed by the *execution_workflow()* decorator factory.

See *LoopType* for more details.

remove_orphan_files: bool

The flag to remove or protect the orphan files. Defaults to True

class mafw.processor_library.abstract_plotter.**PlotterMeta**(*name*, *bases*, *namespace*, /, ***kwargs*)

Bases: _ProtocolMeta, *ProcessorMeta*

Metaclass for the plotter mixed classes

mafw.processor_library.db_init

Database initialisation processor module.

This module contains the following processors:

TableCreator
: processor which handles the creation of database tables based on registered models. It provides functionality to create tables automatically while respecting existing tables and offering options for forced recreation.

TriggerRefresher
: processor to safely update the trigger definitions. It removes all existing triggers and regenerates them according to the new definition. Particularly useful when debugging triggers, it can also be left at the beginning of all analysis pipelines since it does not cause any loss of data.

SQLScriptRunner
: processor to execute SQL scripts from files against the database. It reads SQL files, removes block comments, splits the content into individual statements, and executes them within a transaction.

Added in version v2.0.0.

Classes

SQLScriptRunner(*args, **kwargs)	Processor to execute SQL scripts from files against the database.
TableCreator(*args, **kwargs)	Processor to create all tables in the database.
TriggerRefresher(*args, **kwargs)	Processor to recreate all triggers.

class mafw.processor_library.db_init.**SQLScriptRunner**(**args: Any*, ***kwargs: Any*)

Bases: *Processor*

Processor to execute SQL scripts from files against the database.

This processor reads SQL files, removes multi-line block comments, splits the content into individual statements, and executes them within a transaction. It is designed to handle SQL script execution in a safe manner by wrapping all statements in a single atomic transaction.

The processor accepts a list of SQL files through the *sql_files* parameter. Each file is validated to ensure it exists and is a regular file before processing. Block comments (`/* ... */`) are removed from the SQL content before statement parsing.

Added in version v2.0.0.

Processor parameters

- **sql_files**: A list of SQL files to be processed (default: [])

Constructor parameters

Parameters

- **name** (*str, Optional*) – The name of the processor. If None is provided, the class name is used instead. Defaults to None.
- **description** (*str, Optional*) – A short description of the processor task. Defaults to the processor name.
- **config** (*dict, Optional*) – A configuration dictionary for this processor. Defaults to None.
- **looper** (LoopType, *Optional*) – Enumerator to define the looping type. Defaults to LoopType.ForLoop
- **user_interface** (UserInterfaceBase, *Optional*) – A user interface instance to be used by the processor to interact with the user.

- **timer** (Timer, *Optional*) – A timer object to measure process duration.
- **timer_params** (*dict, Optional*) – Parameters for the timer object.
- **database** (*Database, Optional*) – A database instance. Defaults to None.
- **database_conf** (*dict, Optional*) – Configuration for the database. Default to None.
- **remove_orphan_files** (*bool, Optional*) – Boolean flag to remove files on disc without a reference to the database. See *Standard tables* and *_remove_orphan_files()*. Defaults to True
- **replica_id** (*str, Optional*) – The replica identifier for the current processor.
- **create_standard_tables** (*bool, Optional*) – Boolean flag to create std tables on disk. Defaults to True
- **kwargs** – Keyword arguments that can be used to set processor parameters.

format_progress_message() → None

Customizes the progress message with information about the current item.

The user can overload this method in order to modify the message being displayed during the process loop with information about the current item.

The user can access the current value, its position in the looping cycle and the total number of items using *Processor.item*, *Processor.i_item* and *Processor.n_item*.

get_items() → Collection[Any]

Get the collection of SQL files to be processed.

Returns

A collection of SQL file paths to be processed

Return type

Collection[Any]

process() → None

Process a single SQL file by reading, parsing, and executing its statements.

Reads the SQL file content, removes multi-line block comments, splits the content into individual SQL statements, and executes them within a transaction.

If no statements are found in the file, a warning is logged. If an error occurs during execution, the transaction is rolled back and the exception is re-raised.

Raises

Exception – If an error occurs during SQL statement execution.

start() → None

Start method.

The user can overload this method, including all steps that should be performed at the beginning of the operation.

If the user decides to overload it, it should include a call to the super method.

validate_configuration() → None

Validate the configuration of SQL script runner.

Ensures that all specified SQL files exist and are regular files.

Raises

InvalidConfigurationError – if any of the specified files does not exist or is not a regular file.

_config: dict[str, Any]

A dictionary containing the processor configuration object.

This dictionary is populated with configuration parameter (always type 2) during the *_load_parameter_configuration()* method.

The original value of the configuration dictionary that is passed to the constructor is stored in *_orig_config*.

Changed in version v2.0.0: Now it is an empty dictionary until the *_load_parameter_configuration()* is called.

_processor_parameters: dict[str, PassiveParameter[ParameterType]]

A dictionary to store all the processor parameter instances.

The name of the parameter is used as a key, while for the value an instance of the *PassiveParameter* is used.

filter_register: mafw.db.db_filter.ProcessorFilter

The DB filter register of the Processor.

item: Any

The current item of the loop.

loop_type: LoopType

The loop type.

The value of this parameter can also be changed by the *execution_workflow()* decorator factory.

See *LoopType* for more details.

remove_orphan_files: bool

The flag to remove or protect the orphan files. Defaults to True

sql_files

List of SQL files to be processed

class mafw.processor_library.db_init.TableCreator(**args: Any*, ***kwargs: Any*)

Bases: *Processor*

Processor to create all tables in the database.

This processor can be included in all pipelines in order to create all tables in the database. Its functionality is based on the fact that all *MAFwBaseModel* subclasses are automatically included in a global register (*mafw_model_register*).

This processor will perform the following:

1. Get a list of all tables already existing in the database.
2. Prune from the lists of models the ones for which already exist in the database.
3. Create the remaining tables.

This overall behaviour can be modified via the following parameters:

- *force_recreate* (bool, default = False): Use with extreme care. When set to True, all tables in the database and in the model register will be first dropped and then recreated. It is almost equivalent to a re-initialization of the whole DB with all the data being lost.
- *soft_recreate* (bool, default = True): When set to true, all tables whose model is in the mafw model register will be recreated with the safe flag. It means that there won't be any table drop. If a table is already existing, nothing will happen. If a new trigger is added to the table this will be created. When set to False, only tables whose model is in the register and that are not existing will be created.
- *apply_only_to_prefix* (list[str], default = []): This parameter allows to create only the tables that do not already exist and whose name start with one of the provided prefixes.

Added in version v2.0.0.

Processor parameters

- **apply_only_to_prefix**: Create only tables whose name start with the provided prefixes. (default: [])
- **force_recreate**: First drop and then create the tables. LOSS OF ALL DATA!!! (default: False)
- **soft_recreate**: Safe recreate tables without dropping. No data loss (default: True)

Constructor parameters

Parameters

- **name** (*str, Optional*) – The name of the processor. If None is provided, the class name is used instead. Defaults to None.
- **description** (*str, Optional*) – A short description of the processor task. Defaults to the processor name.
- **config** (*dict, Optional*) – A configuration dictionary for this processor. Defaults to None.
- **looper** (LoopType, *Optional*) – Enumerator to define the looping type. Defaults to LoopType.ForLoop
- **user_interface** (UserInterfaceBase, *Optional*) – A user interface instance to be used by the processor to interact with the user.
- **timer** (Timer, *Optional*) – A timer object to measure process duration.
- **timer_params** (*dict, Optional*) – Parameters for the timer object.
- **database** (*Database, Optional*) – A database instance. Defaults to None.
- **database_conf** (*dict, Optional*) – Configuration for the database. Default to None.
- **remove_orphan_files** (*bool, Optional*) – Boolean flag to remove files on disc without a reference to the database. See *Standard tables* and *_remove_orphan_files()*. Defaults to True
- **replica_id** (*str, Optional*) – The replica identifier for the current processor.
- **create_standard_tables** (*bool, Optional*) – Boolean flag to create std tables on disk. Defaults to True
- **kwargs** – Keyword arguments that can be used to set processor parameters.

process() → None

Execute the table creation process.

This method performs the following steps:

1. Identify all models that have automatic creation enabled.
2. Filter models based on the apply_only_to_prefix parameter if specified.
3. Handle forced recreation if requested, including user confirmation.
4. Handle soft recreation if requested, letting all tables with a known model be recreated.
5. Create the required tables.
6. Initialise standard tables after recreation if needed.

If user cancel the creation, the processor exit status is set to *ProcessorExitStatus.Aborted* so that the whole processor list is blocked.

start() → None

Start method.

The user can overload this method, including all steps that should be performed at the beginning of the operation.

If the user decides to overload it, it should include a call to the super method.

validate_configuration() → None

Configuration validation

force_recreate and *soft_recreate* cannot be both valid.

Raises

InvalidConfigurationError – if both recreate types are True.

_config: dict[str, Any]

A dictionary containing the processor configuration object.

This dictionary is populated with configuration parameter (always type 2) during the *_load_parameter_configuration()* method.

The original value of the configuration dictionary that is passed to the constructor is stored in *_orig_config*.

Changed in version v2.0.0: Now it is an empty dictionary until the *_load_parameter_configuration()* is called.

_processor_parameters: dict[str, PassiveParameter[ParameterType]]

A dictionary to store all the processor parameter instances.

The name of the parameter is used as a key, while for the value an instance of the *PassiveParameter* is used.

apply_only_to_prefix

Apply only to tables starting with prefix (list[str], default = []).

This parameter allows to create only the tables that do not already exist and whose name start with one of the provided prefixes.

existing_table_names: list[str]

The list of all existing tables in the database.

filter_register: mafw.db.db_filter.ProcessorFilter

The DB filter register of the Processor.

force_recreate

Force recreate (bool, default = False).

Use with extreme care. When set to True, all tables in the database and in the model register will be first dropped and then recreated. It is almost equivalent to a re-initialization of the whole DB with all the data being lost.

item: Any

The current item of the loop.

loop_type: LoopType

The loop type.

The value of this parameter can also be changed by the *execution_workflow()* decorator factory.

See *LoopType* for more details.

remove_orphan_files: bool

The flag to remove or protect the orphan files. Defaults to True

soft_recreate

Soft recreate (bool default = True).

When set to true, all tables whose model is in the mafw model register will be recreated with the safe flag. It means that there won't be any table drop. If a table is already existing, nothing will happen. If a new trigger is added to the table, this will be created. When set to False, only tables whose model is in the register and that are not existing will be created.

class mafw.processor_library.db_init.**TriggerRefresher**(**args: Any*, ***kwargs: Any*)

Bases: `Processor`

Processor to recreate all triggers.

Triggers are database objects, and even though they could be created, dropped and modified at any moment, within the MAFw execution cycle they are normally created along with the table they are targeting.

When the table is created, also all its triggers are created, but unless differently specified, with the safe flag on, that means that they are created if they do not exist.

This might be particularly annoying when modifying an existing trigger, because you need to manually drop the trigger to let the table creation mechanism to create the newer version.

The goal of this processor is to drop all existing triggers and then recreate the corresponding tables so to have an updated version of the triggers.

The processor is relying on the fact that all subclasses of `MAFwBaseModel` are automatically inserted in the `mafw_model_register` so that the model class can be retrieved from the table name.

Before removing any trigger, the processor will build a list with all the affected tables and check if all of them are in the `mafw_model_register`, if so, it will proceed without asking any further confirmation. Otherwise, if some affected tables are not in the register, then it will ask the user to decide what to do:

- Remove only the triggers whose tables are in the register and thus recreated afterward.
- Remove all triggers, in this case, some of them will not be recreated.
- Abort the processor.

Trigger manipulations (drop and creation) are not directly implemented in peewee and are an extension provided by MAFw. In order to be compatible with the three main databases (sqlite, mysql and postgresql), the SQL generation is obtained via the `TriggerDialect` interface.

See also

The `Trigger` class and also the *trigger chapter* for a deeper explanation on triggers.

The `ModelRegister` class, the `mafw_model_register` and the *related chapter* on the automatic registration mechanism.

The `TriggerDialect` and its subclasses, for a database independent way to generate SQL statement related to triggers.

Added in version v2.0.0.

Constructor parameters

Parameters

- **name** (*str, Optional*) – The name of the processor. If None is provided, the class name is used instead. Defaults to None.
- **description** (*str, Optional*) – A short description of the processor task. Defaults to the processor name.
- **config** (*dict, Optional*) – A configuration dictionary for this processor. Defaults to None.

- **looper** (LoopType, *Optional*) – Enumerator to define the looping type. Defaults to LoopType.ForLoop
- **user_interface** (UserInterfaceBase, *Optional*) – A user interface instance to be used by the processor to interact with the user.
- **timer** (Timer, *Optional*) – A timer object to measure process duration.
- **timer_params** (*dict*, *Optional*) – Parameters for the timer object.
- **database** (*Database*, *Optional*) – A database instance. Defaults to None.
- **database_conf** (*dict*, *Optional*) – Configuration for the database. Default to None.
- **remove_orphan_files** (*bool*, *Optional*) – Boolean flag to remove files on disc without a reference to the database. See *Standard tables* and *_remove_orphan_files()*. Defaults to True
- **replica_id** (*str*, *Optional*) – The replica identifier for the current processor.
- **create_standard_tables** (*bool*, *Optional*) – Boolean flag to create std tables on disk. Defaults to True
- **kwargs** – Keyword arguments that can be used to set processor parameters.

finish() → None

Recreate the tables from which triggers were dropped.

This is only done if the user did not abort the process.

format_progress_message() → None

Customizes the progress message with information about the current item.

The user can overload this method in order to modify the message being displayed during the process loop with information about the current item.

The user can access the current value, its position in the looping cycle and the total number of items using *Processor.item*, *Processor.i_item* and *Processor.n_item*.

get_dialect() → *TriggerDialect*

Get the valid SQL dialect based on the type of Database

Returns
The SQL trigger dialect

Type
TriggerDialect

Raises
UnsupportedDatabaseError if there is no dialect for the current DB.

get_items() → Collection[Any]

Retrieves a list of database triggers and interacts with the user to determine which ones to process.

This method fetches all currently defined database triggers. If any tables associated with these triggers are not known (i.e., not registered in *mafw_model_register*), it enters an interactive mode to prompt the user for a course of action:

1. **Remove All Triggers (A):** Processes all triggers for subsequent removal, but only marks 'rebuildable' tables for rebuilding.
2. **Remove Only Rebuildable Triggers (O):** Processes only triggers associated with 'rebuildable' tables.
3. **Quit (Q):** Aborts the entire process.

If no unknown tables are found, or the user chooses to process rebuildable tables, the list of triggers and the set of tables to be rebuilt are prepared for the next stage.

Returns
A collection of database triggers to be processed, in the for tuple trigger_name, table_name

Return type
List[Tuple[str, str]]

`process()` → None

Delete the current trigger from its table

`start()` → None

Start method.

The user can overload this method, including all steps that should be performed at the beginning of the operation.

If the user decides to overload it, it should include a call to the super method.

`_config: dict[str, Any]`

A dictionary containing the processor configuration object.

This dictionary is populated with configuration parameter (always type 2) during the `_load_parameter_configuration()` method.

The original value of the configuration dictionary that is passed to the constructor is stored in `_orig_config`.

Changed in version v2.0.0: Now it is an empty dictionary until the `_load_parameter_configuration()` is called.

`_processor_parameters: dict[str, PassiveParameter[ParameterType]]`

A dictionary to store all the processor parameter instances.

The name of the parameter is used as a key, while for the value an instance of the `PassiveParameter` is used.

`filter_register: mafw.db.db_filter.ProcessorFilter`

The DB filter register of the Processor.

`item: Any`

The current item of the loop.

`loop_type: LoopType`

The loop type.

The value of this parameter can also be changed by the `execution_workflow()` decorator factory.

See `LoopType` for more details.

`remove_orphan_files: bool`

The flag to remove or protect the orphan files. Defaults to True

mafw.processor_library.importer

Provides a basic element importer.

The first step in the setting up of the analytical framework of a data analysis procedure is to add new elements to the input set. These elements can encompass a wide range of data, including results from experiments or simulations, as well as information gathered through from webscraping or other data sources.

Independently of where the data are coming from, one common task is to add those data to your collection inside the DB, so that the following analytical steps know where the data are and what they are.

This module provides a generic processor that the user can subclass and customize to their needs to import input files. Thanks to a smart filename parsing, other information can be extracted from the filename itself and used to populate additional columns in the dedicated database table.

Classes

`FilenameElement`(name, regex, value_type, ...)	Helper class for the definition of filename element.
`FilenameParser`(configuration_file[, filename])	Helper class to interpret all elements in a filename.
`Importer`(*args, **kwargs)	Importer is the base class for importing elements in the Database structure.

class mafw.processor_library.importer.**FilenameElement**(*name: str, regex: str | ~re.Pattern[str], value_type: type = <class 'str'>, default_value: str | int | float | None = None*)

Bases: `object`

Helper class for the definition of filename element.

While importing an element to the DB, several parameters can be retrieved directly from the filename. The role of this helper class is to provide an easy way to define patterns in the filename representing a specific piece of information that has to be transferred to the DB.

The element is characterized by a name, a regular expression, the expected python type for the parsed value and an optional default value. The regular expression should contain a named group in the form `?P<name>` where name is matching the FilenameElement name.

To make a filename element optional, it is enough to provide a default value different from None. In this case, if the parsing is failing, then the default value will be returned.

Constructor parameters:

Parameters

- **name** (*str*) – The name of the filename element
- **regex** (*str | re.Pattern[str]*) – The regular expression associated to this filename element. It must contain a named group in the form ?P<name>.
- **value_type** (*type, Optional*) – The type the output value should be converted into. It defaults to str.
- **default_value** (*Any, Optional*) – The default value to assign to the filename element if the pattern is not found in the filename. It defaults to None

classmethod _get_value_type(*type_as_string: str*) → type

Returns the value type.

This method is used by the class method constructor to check if the user provided type in the form of a string is a valid one.

If so, then the corresponding python type is returned, otherwise a ValueError exception is raised.

Parameters
type_as_string (*str*) – The type of the value as a string.

Returns
The corresponding python type.

Return type
type

Raises
ValueError – if type_as_string is not any of the acceptable type for the value.

classmethod from_dict(*name: str, info_dict: dict[str, str | int | float]*) → *FilenameElement*

Generates a FilenameElement starting from external information stored in a dictionary.

***info_dict* should contain the following three keys:**

- regexp: the Regular expression for the element search.
- type: a string with the python type name (int, float, str) for the element conversion.
- default (*optional*): a default value.

Parameters

- **name** (*str*) – The name of the element.
- **info_dict** (*dict*) – The dictionary with the required parameters for the class constructor.

Returns

An instance of FilenameElement.

Return type

FilenameElement

_validate_default_type() → None

Checks that the default has a type matching the value type. The check is actually performed if and only if a default value is provided. If None, then the validation is skipped.

Raises

TypeError – if the default value type does not match the declared value type.

_validate_regexp() → None

Checks if the regular expression contains a named group named after the element itself.

Raises

ValueError – if the regular expression is not valid.

reset() → None

Resets the value to the default value.

Remember: that the default value is None for compulsory elements.

search(*string: str | Path*) → None

Searches the string for the regular expression.

If the pattern is found in the string, then the matched value is transferred to the FilenameElement value.

> **Note**
>
> This method is not returning the match value. It is only searching the input string for the registered pattern. If the pattern is found, then the user can retrieve the matched value by invoking the `value()` method. If the pattern is not found, the `value()` will return either None, for a compulsory element, or the default value for an optional one.

Parameters

string (*str | Path*) – The string to be parsed. In most of the case, this is a filename, that is why the method is accepting also a Path type.

property is_found: bool

Returns if the file element is found

property is_optional: bool

Returns if the element is optional

property name: str

Returns the class name

property pattern: str | bytes

Returns the regular expression pattern

type_lut: dict[str, type[str] | type[int] | type[float]] = {'float': <class 'float'>, 'int': <class 'int'>, 'str': <class 'str'>}

A lookup table for converting type definition as string into python types

property value: str | int | float | None

Returns the class value

class mafw.processor_library.importer.**FilenameParser**(*configuration_file: str | Path*, *filename: str | Path | None = None*)

Bases: `object`

Helper class to interpret all elements in a filename.

Inside a filename, there might be many elements containing information about the item that must be stored in the DB. This class will parse the filename, and after a successful identification of them all, it will make them available for the importer class to fill in the fields in the database.

The `FilenameParser` needs to be configured to be able to recognise each element in the filename. Such configuration is saved in a *toml* file. An example of such a configuration is provided `here`.

Each element must start with its name and a valid regular expression and a python type (in string). If an element is optional, then a default value must be provided as well.

After the configuration, the filename can be interpreted invoking the `interpret()` method. This will perform the actual parsing of the filename. If an error occurs during the parsing process, meaning that a compulsory element is not found, then the `ParsingError` exception will be raised. So remember to protect the interpretation with a try/except block.

The value of each file element is available upon request. The user has simply to invoke the `get_element_value()` providing the element name.

Constructor parameters:

Parameters

- **filename** (*str | Path*) – The filename to be interpreted.
- **configuration_file** (*str | Path*) – The configuration file for the interpreter.

Raises

`ParserConfigurationError` – If the configuration file is invalid.

_parser_configuration() → None

Loads the parser configuration, generates the required FilenameElement and adds them element dictionary.

The configuration file is stored in a TOML file.

This private method is automatically invoked by the class constructor.

Raises

`ParserConfigurationError` – if the provided configuration file is invalid.

get_element(*element_name: str*) → *FilenameElement* | None

Gets the FilenameElement named element_name

get_element_value(*element_name: str*) → str | int | float | None

Gets the value of the FilenameElement named element_name.

It is equivalent to call `self.get_element('element_name').value`

interpret(*filename: str | Path | None = None*) → None

Performs the interpretation of the filename.

The filename can be provided either as constructor argument or here as an argument. If both, then the local one will have the precedence.

Raises

- *ParsingError* – if a compulsory element is not found in the filename
- *MissingAttribute* – if no filename has been specified.

reset() → None

Resets all filename elements

_configuration_file

The configuration file for the interpreter.

_element_dict: dict[str, *FilenameElement*]

A dictionary with all the FilenameElement

_filename

The filename for this interpreter. If None, it should be specified before interpretation.

property elements: dict[str, *FilenameElement*]

Returns the filename element dictionary

class mafw.processor_library.importer.**Importer**(**args: Any*, ***kwargs: Any*)

Bases: *Processor*

Importer is the base class for importing elements in the Database structure.

It provides an easy skeleton to be subclassed by a more specific importer related to a certain project.

It can be customised with three processor parameters:

- The `parser_configuration`: the path to the configuration file for the *FilenameParser*.
- The `input_folder`: the path where the input files to be imported are.
- The `recursive` flag: to specify if all subfolders should be also scanned.

For a concrete implementation, have a look at the *ImporterExample* from the example library.

Processor parameters

- **input_folder**: The input folder from where the images have to be imported. (default: '/builds/kada/mafw')
- **parser_configuration**: The path to the TOML file with the filename parser configuration (default: 'parser_configuration.toml')
- **recursive**: Extend the search to sub-folder (default: True)

Constructor parameters

Parameters

- **name** (*str, Optional*) – The name of the processor. If None is provided, the class name is used instead. Defaults to None.
- **description** (*str, Optional*) – A short description of the processor task. Defaults to the processor name.
- **config** (*dict, Optional*) – A configuration dictionary for this processor. Defaults to None.
- **looper** (LoopType, *Optional*) – Enumerator to define the looping type. Defaults to LoopType.ForLoop

- **user_interface** (UserInterfaceBase, *Optional*) – A user interface instance to be used by the processor to interact with the user.
- **timer** (Timer, *Optional*) – A timer object to measure process duration.
- **timer_params** (*dict, Optional*) – Parameters for the timer object.
- **database** (*Database, Optional*) – A database instance. Defaults to None.
- **database_conf** (*dict, Optional*) – Configuration for the database. Default to None.
- **remove_orphan_files** (*bool, Optional*) – Boolean flag to remove files on disc without a reference to the database. See *Standard tables* and *_remove_orphan_files()*. Defaults to True
- **replica_id** (*str, Optional*) – The replica identifier for the current processor.
- **create_standard_tables** (*bool, Optional*) – Boolean flag to create std tables on disk. Defaults to True
- **kwargs** – Keyword arguments that can be used to set processor parameters.

format_progress_message() → None

Customizes the progress message with information about the current item.

The user can overload this method in order to modify the message being displayed during the process loop with information about the current item.

The user can access the current value, its position in the looping cycle and the total number of items using *Processor.item*, *Processor.i_item* and *Processor.n_item*.

start() → None

The start method.

The filename parser is created using the provided configuration file.

Raises

ParserConfigurationError – If the configuration file is not valid.

_filename_parser: *FilenameParser*

The filename parser instance

mafw.processor_library.sns_plotter

Module implements a Seaborn plotter processor with a mixin structure to generate seaborn plots.

This module implements the *abstract_plotter* functionalities using seaborn and pandas.

These two packages are not installed in the default installation of MAFw, unless the user decided to include the optional feature *seaborn*.

Along with the *SNSPlotter*, it includes a set of standard data retriever specific for pandas data frames.

Classes

CatPlot([x, y, hue, row, col, palette, ...])	The categorical plot mixin.
DisPlot([x, y, hue, row, col, palette, ...])	The distribution plot mixin.
FromDatasetDataRetriever([dataset_name])	A data retriever to get a dataframe from a seaborn dataset
HDFPdDataRetriever([hdf_filename, key])	Retrieve a data frame from a HDF file
LMPlot([x, y, hue, row, col, palette, ...])	The linear regression model plot mixin.
PdDataRetriever(*args, **kwargs)	The dataframe instance.
RelPlot([x, y, hue, row, col, palette, ...])	The relational plot mixin.

continues on next page

Table 12.52 – continued from previous page

SNSFigurePlotter(*args, **kwargs)	Base mixin class to generate a seaborn Figure level plot
SNSPlotter(*args, **kwargs)	The Generic Plotter processor.
SQLPdDataRetriever([table_name, ...])	A specialized data retriever to get a data frame from a database table.

class mafw.processor_library.sns_plotter.**CatPlot**(*x: str | bytes | date | datetime | timedelta | bool | complex | Timestamp | Timedelta | Iterable[float | complex | int] | None = None*, *y: str | bytes | date | datetime | timedelta | bool | complex | Timestamp | Timedelta | Iterable[float | complex | int] | None = None*, *hue: str | bytes | date | datetime | timedelta | bool | complex | Timestamp | Timedelta | Iterable[float | complex | int] | None = None*, *row: str | bytes | date | datetime | timedelta | bool | complex | Timestamp | Timedelta | Iterable[float | complex | int] | None = None*, *col: str | bytes | date | datetime | timedelta | bool | complex | Timestamp | Timedelta | Iterable[float | complex | int] | None = None*, *palette: str | Sequence[tuple[float, float, float] | str | tuple[float, float, float, float] | tuple[tuple[float, float, float] | str, float] | tuple[tuple[float, float, float, float], float]] | Mapping[Any, tuple[float, float, float] | str | tuple[float, float, float, float] | tuple[tuple[float, float, float] | str, float] | tuple[tuple[float, float, float, float], float]] | None = None*, *kind: Literal['strip', 'swarm', 'box', 'violin', 'boxen', 'point', 'bar', 'count'] = 'strip'*, *legend: Literal['auto', 'brief', 'full'] | bool = 'auto'*, *native_scale: bool = False*, *plot_kws: Mapping[str, Any] | None = None*, *facet_kws: dict[str, Any] | None = None*, **args: Any*, ***kwargs: Any*)

Bases: *SNSFigurePlotter*

The categorical plot mixin.

This mixin will produce a figure level categorical plot as described here.

Constructor parameters:

Parameters

- **x** (*str | Iterable, Optional*) – The name of the x variable or an iterable containing the x values.
- **y** (*str | Iterable, Optional*) – The name of the y variable or an iterable containing the y values.
- **hue** (*str | Iterable, Optional*) – The name of the hue variable or an iterable containing the hue values.
- **row** (*str | Iterable, Optional*) – The name of the row category or an iterable containing the row values.
- **col** (*str | Iterable, Optional*) – The name of the column category or an iterable containing the column values.
- **palette** (*str, Optional*) – The colour palette to be used.

- **kind** (*str, Optional*) – The type of relational plot (scatter or line). Defaults to scatter.
- **legend** (*str | bool, Optional*) – How to draw the legend. If "brief", numeric hue and size variables will be represented with a sample of evenly spaced values. If "full", every group will get an entry in the legend. If "auto", choose between brief or full representation based on number of levels. If False, no legend data is added and no legend is drawn. Defaults to auto.
- **native_scale** (*bool, Optional*) – When True, numeric or datetime values on the categorical axis will maintain their original scaling rather than being converted to fixed indices. Defaults to False.
- **plot_kws** (*dict[str, Any], Optional*) – A dictionary like list of keywords passed to the underlying seaborn.catplot.
- **facet_kws** (*dict[str, Any], Optional*) – A dictionary like list of keywords passed to the underlying seaborn.FacetGrid

plot() → None

Implements the plot method of a figure-level categorical graph.

class mafw.processor_library.sns_plotter.**DisPlot**(*x: str | bytes | date | datetime | timedelta | bool | complex | Timestamp | Timedelta | Iterable[float | complex | int] | None = None, y: str | bytes | date | datetime | timedelta | bool | complex | Timestamp | Timedelta | Iterable[float | complex | int] | None = None, hue: str | bytes | date | datetime | timedelta | bool | complex | Timestamp | Timedelta | Iterable[float | complex | int] | None = None, row: str | bytes | date | datetime | timedelta | bool | complex | Timestamp | Timedelta | Iterable[float | complex | int] | None = None, col: str | bytes | date | datetime | timedelta | bool | complex | Timestamp | Timedelta | Iterable[float | complex | int] | None = None, palette: str | Sequence[tuple[float, float, float] | str | tuple[float, float, float, float] | tuple[tuple[float, float, float] | str, float] | tuple[tuple[float, float, float, float], float]] | Mapping[Any, tuple[float, float, float] | str | tuple[float, float, float, float] | tuple[tuple[float, float, float] | str, float] | tuple[tuple[float, float, float, float], float]] | Colormap | None = None, kind: Literal['hist', 'kde', 'ecdf'] = 'hist', legend: bool = True, rug: bool = False, rug_kws: dict[str, Any] | None = None, plot_kws: Mapping[str, Any] | None = None, facet_kws: dict[str, Any] | None = None, *args: Any, **kwargs: Any*)

Bases: *SNSFigurePlotter*

The distribution plot mixin.

This mixin is the MAFw implementation of the seaborn displot and will produce one of the following figure level plots:

- **histplot**: a simple histogram plot
- **kdeplot**: a kernel density estimate plot
- **ecdfplot**: an empirical cumulative distribution functions plot
- **rugplot**: a plot of the marginal distributions as ticks.

Constructor parameters:

Parameters

- **x** (*str | Iterable, Optional*) – The name of the x variable or an iterable containing the x values.
- **y** (*str | Iterable, Optional*) – The name of the y variable or an iterable containing the y values.
- **hue** (*str | Iterable, Optional*) – The name of the hue variable or an iterable containing the hue values.
- **row** (*str | Iterable, Optional*) – The name of the row category or an iterable containing the row values.
- **col** (*str | Iterable, Optional*) – The name of the column category or an iterable containing the column values.
- **palette** (*str | Colormap, Optional*) – The colour palette to be used.
- **kind** (*str, Optional*) – The type of distribution plot (hist, kde or ecdf). Defaults to hist.
- **legend** (*bool, Optional*) – If false, suppress the legend for the semantic variables. Defaults to True.
- **rug** (*bool, Optional*) – If true, show each observation with marginal ticks. Defaults to False.
- **rug_kws** (*Mapping[str, Any], Optional*) – Parameters to control the appearance of the rug plot.
- **plot_kws** (*Mapping[str, Any], Optional*) – Parameters passed to the underlying plotting object.
- **facet_kws** (*Mapping[str, Any], Optional*) – Parameters passed to the facet grid object.

plot() → None

Implements the plot method for a figure-level distribution graph

class mafw.processor_library.sns_plotter.**FromDatasetDataRetriever**(*dataset_name: str | None = None*, **args: Any*, ***kwargs: Any*)

Bases: *PdDataRetriever*

A data retriever to get a dataframe from a seaborn dataset

The dataframe instance. It will be filled for the main class

_attributes_valid() → bool

Checks if the attributes of the mixin are all valid

get_data_frame() → None

Gets the data frame from the standard seaborn datasets

class mafw.processor_library.sns_plotter.**HDFPdDataRetriever**(*hdf_filename: str | Path | None = None*, *key: str | None = None*, **args: Any*, ***kwargs: Any*)

Bases: *DataRetriever*

Retrieve a data frame from a HDF file

This data retriever is getting a dataframe from a HDF file provided the filename and the object key.

Constructor parameters:

Parameters

- **hdf_filename** (*str | Path, Optional*) – The filename of the HDF file
- **key** (*str, Optional*) – The key of the HDF store with the dataframe

get_data_frame() → None

Retrieve the dataframe from a HDF file

Raises

PlotterMixinNotInitialized – if some of the required attributes are not initialised or invalid.

patch_data_frame() → None

The mixin implementation of the shared method with the base class

class mafw.processor_library.sns_plotter.**LMPlot**(*x: str | None = None*, *y: str | None = None*, *hue: str | None = None*, *row: str | None = None*, *col: str | None = None*, *palette: str | Sequence[tuple[float, float, float] | str | tuple[float, float, float, float] | tuple[tuple[float, float, float] | str, float] | tuple[tuple[float, float, float, float], float]] | Mapping[Any, tuple[float, float, float] | str | tuple[float, float, float, float] | tuple[tuple[float, float, float] | str, float] | tuple[tuple[float, float, float, float], float]] | None = None*, *legend: bool = True*, *scatter_kws: dict[str, Any] | None = None*, *line_kws: dict[str, Any] | None = None*, *facet_kws: dict[str, Any] | None = None*, **args: Any*, ***kwargs: Any*)

Bases: *SNSFigurePlotter*

The linear regression model plot mixin.

This mixin will produce a figure level regression model as described here

Constructor parameters:

Parameters

- **x** (*str, Optional*) – The name of the x variable or an iterable containing the x values.
- **y** (*str, Optional*) – The name of the y variable or an iterable containing the y values.
- **hue** (*str, Optional*) – The name of the hue variable or an iterable containing the hue values.
- **row** (*str, Optional*) – The name of the row category or an iterable containing the row values.
- **col** (*str, Optional*) – The name of the column category or an iterable containing the column values.
- **palette** (*str, Optional*) – The colour palette to be used.
- **legend** (*bool, Optional*) – If True and there is a hue variable, add a legend.
- **scatter_kws** (*dict[str, Any], Optional*) – A dictionary like list of keywords passed to the underlying scatter.
- **scatter_kws** – A dictionary like list of keywords passed to the underlying scatter.
- **line_kws** (*dict[str, Any], Optional*) – A dictionary like list of keywords passed to the underlying plot.
- **facet_kws** (*dict[str, Any], Optional*) – A dictionary like list of keywords passed to the underlying seaborn.FacetGrid

plot() → None

Implements the plot method for a figure-level regression model.

class mafw.processor_library.sns_plotter.**PdDataRetriever**(**args: Any*, ***kwargs: Any*)

Bases: `DataRetriever`

The dataframe instance. It will be filled for the main class

get_data_frame() → None

The mixin implementation of the shared method with the base class

patch_data_frame() → None

The mixin implementation of the shared method with the base class

class mafw.processor_library.sns_plotter.**RelPlot**(*x: str | bytes | date | datetime | timedelta | bool | complex | Timestamp | Timedelta | Iterable[float | complex | int] | None = None*, *y: str | bytes | date | datetime | timedelta | bool | complex | Timestamp | Timedelta | Iterable[float | complex | int] | None = None*, *hue: str | bytes | date | datetime | timedelta | bool | complex | Timestamp | Timedelta | Iterable[float | complex | int] | None = None*, *row: str | bytes | date | datetime | timedelta | bool | complex | Timestamp | Timedelta | Iterable[float | complex | int] | None = None*, *col: str | bytes | date | datetime | timedelta | bool | complex | Timestamp | Timedelta | Iterable[float | complex | int] | None = None*, *palette: str | Sequence[tuple[float, float, float] | str | tuple[float, float, float, float] | tuple[tuple[float, float, float] | str, float] | tuple[tuple[float, float, float, float], float]] | Mapping[Any, tuple[float, float, float] | str | tuple[float, float, float, float] | tuple[tuple[float, float, float] | str, float] | tuple[tuple[float, float, float, float], float]] | Colormap | None = None*, *kind: Literal['scatter', 'line'] = 'scatter'*, *legend: Literal['auto', 'brief', 'full'] | bool = 'auto'*, *plot_kws: Mapping[str, Any] | None = None*, *facet_kws: dict[str, Any] | None = None*, **args: Any*, ***kwargs: Any*)

Bases: `SNSFigurePlotter`

The relational plot mixin.

This mixin will produce either a scatter or a line figure level plot.

The full documentation of the relplot object can be read at this link.

Constructor parameters:

Parameters

- **x** (*str | Iterable, Optional*) – The name of the x variable or an iterable containing the x values.
- **y** (*str | Iterable, Optional*) – The name of the y variable or an iterable containing the y values.
- **hue** (*str | Iterable, Optional*) – The name of the hue variable or an iterable containing the hue values.
- **row** (*str | Iterable, Optional*) – The name of the row category or an iterable containing the row values.

- **col** (*str | Iterable, Optional*) – The name of the column category or an iterable containing the column values.
- **palette** (*str | Colormap, Optional*) – The colour palette to be used.
- **kind** (*str, Optional*) – The type of relational plot (scatter or line). Defaults to scatter.
- **legend** (*str | bool, Optional*) – How to draw the legend. If "brief", numeric hue and size variables will be represented with a sample of evenly spaced values. If "full", every group will get an entry in the legend. If "auto", choose between brief or full representation based on number of levels. If False, no legend data is added and no legend is drawn. Defaults to auto.
- **plot_kws** (*dict[str, Any], Optional*) – A dictionary like list of keywords passed to the underlying seaborn.relplot.
- **facet_kws** (*dict[str, Any], Optional*) – A dictionary like list of keywords passed to the underlying seaborn.FacetGrid

plot() → None

Implements the plot method of a figure-level relational graph.

class mafw.processor_library.sns_plotter.**SNSFigurePlotter**(**args: Any*, ***kwargs: Any*)

Bases: *FigurePlotter*

Base mixin class to generate a seaborn Figure level plot

data_frame: DataFrame

The dataframe instance shared with the main class

facet_grid: FacetGrid

The facet grid instance shared with the main class

class mafw.processor_library.sns_plotter.**SNSPlotter**(**args: Any*, ***kwargs: Any*)

Bases: *GenericPlotter*

The Generic Plotter processor.

This is a subclass of a Processor with advanced functionality to fetch data in the form of a dataframe and to produce plots.

The key difference with respect to a normal processor is it *process()* method that has been already implemented as follows:

```
def process(self) -> None:
    """
    Specific implementation of the process method for the Seaborn plotter.

    It is almost the same as the GenericProcessor, with the addition that all␣
↪open pyplot figures are closed
    after the process is finished.

    This part cannot be moved upward to the :class:`~.GenericPlotter` because the␣
↪user might have selected
    another plotting library different from :link:`matplotlib`.
    """
    super().process()
    if not self.is_data_frame_empty():
        plt.close('all')
```

This actually means that when you are subclassing a SNSPlotter you do not have to implement the process method as you would do for a normal Processor, but you will have to implement the following methods:

- *in_loop_customization()*.

The processor execution workflow (LoopType) can be any of the available, so actually the process method might be invoked only once, or multiple times inside a loop structure (for or while). If the execution is cyclic, then you may want to have the possibility to do some customisation for each iteration, for example, changing the plot title, or modifying the data selection, or the filename where the plots will be saved.

You can use this method also in case of a single loop processor, in this case you will not have access to the loop parameters.

- *get_data_frame()*.

  This method has the task to get the data to be plotted in the form of a pandas DataFrame. The processor has the `data_frame` attribute where the data will be stored to make them accessible from all other methods.

- *patch_data_frame()*.

  A convenient method to apply data frame manipulation to the data just retrieved.

- *plot()*.

  This method is where the actual plotting occurs. Use the *data_frame* to plot the quantities you want.

- *customize_plot()*.

  This method can be optionally used to customize the appearance of the facet grid produced by the *plot()* method. It is particularly useful when the user is mixing this class with one of the *FigurePlotter* mixin, thus not having direct access to the plot method.

- *save()*.

  This method is where the produced plot is saved in a file. Remember to append the output file name to the *list of produced outputs* so that the *_update_plotter_db()* method will automatically store this file in the database during the *finish()* execution.

- *update_db()*.

  If the user wants to update a specific table in the database, they can use this method.

  It is worth reminding that all plotters are saving all generated files in the standard table PlotterOutput. This is automatically done by the *_update_plotter_db()* method that is called in the *finish()* method.

You do not need to overload the *slice_data_frame()* nor the *group_and_aggregate_data_frame()* methods, but you can simply use them by setting the *slicing_dict* and the *grouping_columns* and the *aggregation_functions*.

The processor comes with two processors parameters that can be used by user-defined subclasses:

1. The output_folder that is the path where the output file will be saved
2. The force_replot flag to be used whether the user wants the plot to be regenerated even if the output file already exists.

The default value of these parameters can be changed using the *Processor.new_defaults* dictionary as shown in *this example*.

Processor parameters

- **force_replot**: Whether to force re-plotting even if the output file already exists (default: False)
- **output_folder**: The path where the output file will be saved (default: PosixPath('/builds/kada/mafw'))

Constructor parameters:

Parameters

- **slicing_dict** (*dict[str, Any], Optional*) – A dictionary with key, value pairs to slice the input data frame before the plotting occurs.

- **grouping_columns** (*list[str], Optional*) – A list of columns for the groupby operation on the data frame.
- **aggregation_functions** (*list[str | Callable[[Any], Any], Optional*) – A list of functions for the aggregation on the grouped data frame.
- **matplotlib_backend** (*str, Optional*) – The name of the matplotlib backend to be used. Defaults to 'Agg'
- **output_folder** (*Path, Optional*) – The path where the output file will be saved
- **force_replot** (*bool, Optional*) – Whether to force re-plotting even if the output file already exists.

get_data_frame() → None

Specific implementation of the get data frame for the Seaborn plotter.

It must be overloaded.

The method is **NOT** returning the data_frame, but in your implementation you need to assign the data frame to the class *data_frame* attribute.

group_and_aggregate_data_frame() → None

Performs groupyby and aggregation of the data frame.

If the user provided some *grouping columns* and *aggregation functions* then the *group_and_aggregate_data_frame()* is invoked accordingly.

The user can update the values of those attributes during each cycle iteration within the implementation of the *in_loop_customization()*.

> **See also**
>
> This method is simply invoking the *group_and_aggregate_data_frame()* function from the *pandas_tools*.

is_data_frame_empty() → bool

Check if the data frame is empty

process() → None

Specific implementation of the process method for the Seaborn plotter.

It is almost the same as the GenericProcessor, with the addition that all open pyplot figures are closed after the process is finished.

This part cannot be moved upward to the *GenericPlotter* because the user might have selected another plotting library different from matplotlib.

slice_data_frame() → None

Perform data frame slicing

The user can set some slicing criteria in the *slicing_dict* to select some specific data subset. The values of the slicing dict can be changed during each iteration within the implementation of the *in_loop_customization()*.

> **See also**
>
> This method is simply invoking the *slice_data_frame()* function from the *pandas_tools*.

start() → None

Overload of the start method.

The *SNSPlotter* is overloading the *start()* in order to allow the user to change the matplotlib backend.

The user can selected which backend to use either directly in the class constructor or assign it to the class attribute *matplotlib_backend*.

_config: dict[str, Any]

A dictionary containing the processor configuration object.

This dictionary is populated with configuration parameter (always type 2) during the *_load_parameter_configuration()* method.

The original value of the configuration dictionary that is passed to the constructor is stored in *_orig_config*.

Changed in version v2.0.0: Now it is an empty dictionary until the *_load_parameter_configuration()* is called.

_processor_parameters: dict[str, *PassiveParameter*[*ParameterType*]]

A dictionary to store all the processor parameter instances.

The name of the parameter is used as a key, while for the value an instance of the *PassiveParameter* is used.

aggregation_functions: Iterable[str | Callable[[Any], Any]] | None

The list of aggregation functions to be applied to the grouped dataframe

data_frame: pd.DataFrame

The pandas DataFrame containing the data to be plotted.

facet_grid: sns.FacetGrid | None

The reference to the facet grid.

filter_register: *mafw.db.db_filter.ProcessorFilter*

The DB filter register of the Processor.

grouping_columns: Iterable[str] | None

The list of columns for grouping the data frame

item: Any

The current item of the loop.

loop_type: *LoopType*

The loop type.

The value of this parameter can also be changed by the *execution_workflow()* decorator factory.

See *LoopType* for more details.

matplotlib_backend: str

The backend to be used for matplotlib.

output_filename_list: list[Path]

The list of produced filenames.

remove_orphan_files: bool

The flag to remove or protect the orphan files. Defaults to True

slicing_dict: MutableMapping[str, Any] | None

The dictionary for slicing the input data frame

class mafw.processor_library.sns_plotter.**SQLPdDataRetriever**(*table_name: str | None = None, required_cols: Iterable[str] | str | None = None, where_clause: str | None = None, *args: Any, **kwargs: Any*)

Bases: *PdDataRetriever*

A specialized data retriever to get a data frame from a database table.

The idea is to implement an interface to the pandas `read_sql`. The user has to provide the *table name*, the *the list of required columns* and an optional *where clause*.

Constructor parameters:

Parameters

- **table_name** (*str, Optional*) – The name of the table from where to get the data
- **required_cols** (*Iterable[str] | str | None, Optional*) – A list of columns to be selected from the table and transferred as column in the dataframe.
- **where_clause** (*str, Optional*) – The where clause used in the select SQL statement. If None is provided, then all rows will be selected.

_attributes_valid() → bool

Check if all required parameters are provided and valid.

get_data_frame() → None

Retrieve the dataframe from a database table.

Raises

PlotterMixinNotInitialized – If some of the required attributes are missing.

database: Database

The database instance. It comes from the main class

required_columns: Iterable[str]

The iterable of columns.

Those are the column names to be selected from the *table_name* and included in the dataframe.

table_name: str

The table from where the data should be taken.

where_clause: str

The where clause of the SQL statement

12.1.13 mafw.runner

Provides a container to run configurable and modular analytical tasks.

Classes

MAFwApplication([steering_file, ...])	The MAFw Application.

class mafw.runner.**MAFwApplication**(*steering_file: Path | str | None = None*, *user_interface: UserInterfaceBase | type[UserInterfaceBase] | str | None = None*, *plugin_manager: MAFwPluginManager | None = None*)

Bases: `object`

The MAFw Application.

This class takes care of reading a steering file and from the information retrieved construct a *ProcessorList* from the processor listed there and execute it.

It is very practical because any combination of processors can be run without having to write dedicated scripts but simply modifying a steering file.

The application will search for processors not only among the ones available in the MAFw library, but also in all other packages exposing processors via the *plugin mechanism*.

All parameters in the constructor are optional.

An instance can be created also without the *steering_file*, but such an instance cannot be executed. The steering file can be provided in a later stage via the `init()` method or directly to the `run()` method.

The user interface can be either provided directly in the constructor, or it will be taken from the steering file. In the worst case, the fallback `ConsoleInterface` will be used.

The plugin manager, if not provided, the global plugin manager will be retrieved from the `get_plugin_manager()`.

A simple example is provided here below:

Listing 12.1: Creation and execution of a MAFwApplication

```
import logging
from pathlib import Path

from mafw.runner import MAFwApplication

log = logging.getLogger(__name__)

# put here your steering file
steering_file = Path('path_to_my_steering_file.toml')

try:
    # create the app
    app = MAFwApplication(steering_file)

    # run it!
    app.run()

except Exception as e:
    log.error('An error occurred!')
    log.exception(e)
```

Constructor parameters:

Parameters

- **steering_file** (*Path | str, Optional*) – The path to the steering file.
- **user_interface** (UserInterfaceBase | *type*[UserInterfaceBase] | *str, Optional*) – The user interface to be used by the application.
- **plugin_manager** (*PluginManager, Optional*) – The plugin manager.

_expand_processors_to_run(*items: list[str]*, *config: dict[str, Any]*, *plugins:* LoadedPlugins, *seen: set[str] | None = None*) → *ProcessorList*

Constructs a `ProcessorList` from a list of processor names or groups.

This method recursively expands a list of processor names or group definitions into a *ProcessorList* object, which can be executed. It handles three cases: direct processor class matches, group definitions in the configuration, and unknown entries.

Added in version v2.0.0.

Parameters

- **items** (*list[str]*) – A list of processor names or group identifiers to be expanded.
- **config** (*dict[str, Any]*) – The configuration dictionary containing processor and group definitions.

- **plugins** (LoadedPlugins) – The loaded plugins containing available processors and groups.
- **seen** (*set[str] | None*) – A set of group names that have already been processed to detect cyclic definitions.

Returns
A *ProcessorList* containing the expanded processors ready for execution.

Return type
ProcessorList

Raises

- ***UnknownProcessorGroup*** – If a group is defined without processors or if a cyclic group definition is detected.
- ***UnknownProcessor*** – If a processor name is not recognized in the plugin library.

get_user_interface(*user_interface: str*) → *UserInterfaceBase*

Retrieves the user interface from the plugin managers.

User interfaces are exposed via the plugin manager.

If the requested *user_interface* is not available, then the fallback console interface is used.

Parameters
user_interface (*str*) – The name of the user interface to be used. Normally rich or console.

init(*steering_file: Path | str*) → None

Initializes the application.

This method is normally automatically invoked by the class constructor. It can be called in a later moment to force the parsing of the provided steering file.

Parameters
steering_file (*Path | str*) – The path to the steering file.

run(*steering_file: Path | str | None = None*) → *ProcessorExitStatus*

Runs the application.

This method builds the `ProcessorList` with the processors listed in the steering file and launches its execution.

A steering file can be provided at this stage if it was not done before.

Changed in version v2.0.0: Refactor to accept replica names in the processor to run list.

Parameters
steering_file (*Path | str, Optional*) – The steering file. Defaults to None.

Raises

- ***RunnerNotInitialized*** – if the application has not been initialized. Very likely a steering file was never provided.
- ***UnknownProcessor*** – if a processor listed in the steering file is not available in the plugin library.

exit_status

the exit status of the application

name

the name of the application instance

plugin_manager

the plugin manager of the application instance

12.1.14 mafw.scripts

Executables.

This package includes the executables necessary to run MAFw.

Modules

doc_versioning	Helper tool for the generation of versioned documentation files.
mafw_exe	The execution framework.
update_changelog	Module provides a simplified script to perform MAFw changelog update using `auto-changelog`.
update_notice	Module provides a simplified script to perform an update of the version number hard coded in the NOTICE.txt file.

mafw.scripts.doc_versioning

Helper tool for the generation of versioned documentation files.

Build Sphinx docs for every stable tag (excluding rc/alpha/beta), label highest tag as "stable", optionally label current branch as "dev" if it's ahead. Generates a versions.json and creates redirect index pages for stable/dev. Now with optional PDF generation!

Requirements:

- Git with worktree support
- sphinx-build available on PATH (install Sphinx in the env)
- For PDF: latexmk and pdflatex (TeX Live or similar)

multiversion-doc

Build and manage versioned documentation.

Usage

```
multiversion-doc [OPTIONS] COMMAND [ARGS]...
```

build

Build multiversion documentation.

param outdir
Output directory for built documentation

type outdir
Path

param include_dev
Whether to include dev alias if current branch is ahead

type include_dev
bool

param min_vers
Minimum version to consider

type min_vers
str

param keep_temp
Whether to keep temporary files

type keep_temp
bool

param use_latest_conf
Whether to use latest conf.py for all builds

type use_latest_conf
bool

param build_pdf
Whether to also build PDF versions

type build_pdf
bool

param project_name
Project name for PDF index page

type project_name
str

param use_symlinks
Whether to use symlinks instead of copying

type use_symlinks
bool

param max_size
Maximum artifact size in MB (0 = no limit)

type max_size
int

Usage

```
multiversion-doc build [OPTIONS]
```

Options

-o, --outdir <outdir>
Output directory (docs/build/doc)

--include-dev, --no-include-dev
If true and current branch is ahead of stable, create dev redirect. (True)

--min-vers <min_vers>
Minimum version to consider (default: v1.0.0).

--keep-temp, --no-keep-temp
Do not remove temp dir (for debugging).

--use-latest-conf, --no-use-latest-conf
Use the latest conf.py for all builds. (True)

--build-pdf, --no-build-pdf
Also build PDF versions. (False)

--project-name <project_name>
Project name for PDF index page.

--use-symlinks, --no-use-symlinks
Use symlinks for stable/dev aliases instead of copying. (True)

-s, --max-size <max_size>

Maximum artifact size in MB. If exceeded, prune old versions (0 = no limit)

clean

Clean the output directory. TARGET can be 'all' (remove everything) or 'latest' (remove only latest folder).

param target
What to clean - 'all' or 'latest'

type target
str

param outdir
Output directory to clean

type outdir
Path

Usage

```
multiversion-doc clean [OPTIONS] [[all|latest]]
```

Options

-o, --outdir <outdir>

Output directory to clean

Arguments

TARGET

Optional argument

current

Build documentation only for the current working tree (no git worktrees). Places output in the 'latest' folder.

param outdir
Output directory for built documentation

type outdir
Path

param build_pdf
Whether to also build PDF version

type build_pdf
bool

param project_name
Project name for PDF

type project_name
str

Usage

```
multiversion-doc current [OPTIONS]
```

Options

-o, --outdir <outdir>

Output directory (docs/build/doc)

--build-pdf, --no-build-pdf

Also build PDF versions. (False)

landing

Generate root landing page for project.

param build_root
Build root directory

type build_root
Path

param project_name
Project name

type project_name
str

Usage

```
multiversion-doc landing [OPTIONS]
```

Options

-b, --build-root <build_root>

Build root directory containing doc/ subdirectory

--project-name <project_name>

Project name for the landing page

prune

Prune old documentation versions to stay within size limit.

This command removes the oldest version directories (keeping stable, latest, dev) until the total size is below the specified threshold.

param outdir
Output directory to prune

type outdir
Path

param max_size
Maximum size in megabytes

type max_size
int

param dry_run
Whether to do a dry run

type dry_run
bool

param auto_prune
Whether to prune automatically without confirmation

type auto_prune
bool

Usage

```
multiversion-doc prune [OPTIONS]
```

Options

-o, --outdir <outdir>
Output directory to check

-s, --max-size <max_size>
Maximum size in MB (default: 100)

--dry-run, --no-dry-run
Show what would be removed without actually removing

--auto-prune, --no-auto-prune
Automatically prune without confirmation

redirects

Generate _redirects file for GitLab Pages.

param outdir
Output directory for _redirects file

type outdir
Path

param old_pdf_path
Old PDF URL path to redirect from

type old_pdf_path
Path

param new_pdf_path
New PDF downloads page to redirect to

type new_pdf_path
Path

param redirect_root
Whether to redirect /doc/ root to stable

type redirect_root
bool

Usage

```
multiversion-doc redirects [OPTIONS]
```

Options

-o, --outdir <outdir>
Output directory for _redirects file

--old-pdf-path <old_pdf_path>
Old PDF URL path to redirect from

--new-pdf-path <new_pdf_path>
: New PDF downloads page to redirect to

--redirect-root, --no-redirect-root
: Redirect /doc/ root to stable

Functions

build_for_tag(tag, outdir, tmproot[, ...])	Create worktree for tag, run sphinx-build, save log.
build_pdf_for_tag(tag, html_tag_dir, tmproot)	Create worktree for tag, run sphinx-build with latex builder, then make PDF.
check_multiversion_structure(outdir)	Check if multiversion structure exists (other version directories).
copy_patch_files(docs_src)	Copy patch files needed for older versions.
ensure_versions_json_exists(outdir)	Ensure versions.json exists in outdir.
filter_latest_micro(versions)	Keep only the latest micro version per minor (major.minor).
filter_stable_tags(tags, regex)	Filter tags based on a regular expression pattern.
format_size(bytes_size)	Format bytes to human-readable size.
generate_pdf_index_page(html_outdir, pdf_info)	Generate an HTML page listing all available PDFs.
get_current_branch()	Get the name of the currently checked out branch.
get_directory_size(path)	Calculate total size of a directory in bytes.
get_git_tags([min_version])	Return list of (Version, tag) tuples sorted ascending.
git_rev_of(ref)	Get the git revision hash for a given reference.
is_ancestor(a, b)	Return True if commit a is ancestor of commit b (git merge-base --is-ancestor).
mirror_version(outdir, src_tag, target_tag)	Mirror a version directory from one tag to another.
parse_sphinx_log(log_content)	Parse Sphinx build log to extract warning and error counts, and warning messages.
parse_version_tuple(tag)	Parse vX.Y.Z(.W) into tuple of ints for sorting.
prune_old_versions(outdir[, max_size_mb, ...])	Remove oldest version directories until total size is below threshold.
regenerate_versions_json_after_pruning(...)	Regenerate versions.json after pruning, excluding removed versions.
report_build_status(tag, success, log[, ...])	Report build status with warning/error summary.
run(cmd[, cwd])	Helper to run commands with consistent behavior.
sort_tags_semver(tags)	Sort tags using semantic versioning comparison.
write_legacy_redirect_page(outdir)	Create a legacy redirect page at the root of the output directory.
write_redirect_page(outdir, name, target_tag)	Create a redirect page for a version alias.
write_redirects_file(outdir)	Create a _redirects file for GitLab Pages.
write_root_landing_page(build_root[, ...])	Create a landing page for the project root with links to documentation and coverage.
write_versions_json(outdir, versions)	Write versions information to a JSON file.

mafw.scripts.doc_versioning.**build_for_tag**(*tag: str*, *outdir: Path*, *tmproot: Path*, *use_latest_conf: bool = False*, *keep_tmp: bool = False*) → Tuple[bool, str]

Create worktree for tag, run sphinx-build, save log. Returns (success, log_contents).

Parameters

- **tag** (*str*) – Git tag to build documentation for
- **outdir** (*Path*) – Output directory for built documentation
- **tmproot** (*Path*) – Root temporary directory
- **use_latest_conf** (*bool*) – Whether to use latest conf.py, defaults to False
- **keep_tmp** (*bool*) – Whether to keep temporary files, defaults to False

Returns
Tuple of (success, log_contents)

Return type
Tuple[bool, str]

`mafw.scripts.doc_versioning.`**`build_pdf_for_tag`**(*tag: str*, *html_tag_dir: Path*, *tmproot: Path*, *use_latest_conf: bool = False*, *keep_tmp: bool = False*) → Tuple[bool, str, Path | None]

Create worktree for tag, run sphinx-build with latex builder, then make PDF. Places PDF in the same directory as the HTML output for that tag. Returns (success, log_contents, pdf_path).

Parameters

- **tag** (*str*) – Git tag to build PDF for
- **html_tag_dir** (*Path*) – Directory containing HTML output for the tag
- **tmproot** (*Path*) – Root temporary directory
- **use_latest_conf** (*bool*) – Whether to use latest conf.py, defaults to False
- **keep_tmp** (*bool*) – Whether to keep temporary files, defaults to False

Returns
Tuple of (success, log_contents, pdf_path)

Return type
Tuple[bool, str, Path | None]

`mafw.scripts.doc_versioning.`**`check_multiversion_structure`**(*outdir: Path*) → bool

Check if multiversion structure exists (other version directories).

Parameters
outdir (*Path*) – Output directory to check

Returns
True if other versions exist

Return type
bool

`mafw.scripts.doc_versioning.`**`copy_patch_files`**(*docs_src: Path*) → None

Copy patch files needed for older versions.

Parameters
docs_src (*Path*) – Path to documentation source directory

`mafw.scripts.doc_versioning.`**`ensure_versions_json_exists`**(*outdir: Path*) → bool

Ensure versions.json exists in outdir. If not, try to copy from another version.

Parameters
outdir (*Path*) – Output directory that should contain versions.json

Returns
True if versions.json exists or was successfully copied

Return type
bool

`mafw.scripts.doc_versioning.`**`filter_latest_micro`**(*versions: List[Tuple[Version, Any]]*) → List[Tuple[Version, Any]]

Keep only the latest micro version per minor (major.minor).

Parameters
versions (*List[Tuple[Version, Any]]*) – List of (Version, tag) tuples

Returns
Filtered list of (Version, tag) tuples

Return type
List[Tuple[Version, Any]]

`mafw.scripts.doc_versioning.`**`filter_stable_tags`**(*tags: List[str]*, *regex: str*) → List[str]

Filter tags based on a regular expression pattern.

Parameters

- **tags** (*List[str]*) – List of tag strings to filter
- **regex** (*str*) – Regular expression pattern to match against

Returns
Filtered list of matching tags

Return type
List[str]

`mafw.scripts.doc_versioning.`**`format_size`**(*bytes_size: float*) → str

Format bytes to human-readable size.

Parameters
bytes_size (*int*) – Size in bytes

Returns
Formatted size string

Return type
str

`mafw.scripts.doc_versioning.`**`generate_pdf_index_page`**(*html_outdir: Path*, *pdf_info: List[dict[str, str]]*, *project_name: str = 'Documentation'*) → None

Generate an HTML page listing all available PDFs. This page will be placed in the root html_versions directory. Order: stable first, then latest, then other releases sorted by version (newest first).

Parameters

- **html_outdir** (*Path*) – Output directory for HTML files
- **pdf_info** (*List[dict[str, str]]*) – List of dictionaries containing PDF information
- **project_name** (*str*) – Name of the project for the page title, defaults to 'Documentation'

`mafw.scripts.doc_versioning.`**`get_current_branch`**() → str

Get the name of the currently checked out branch.

Returns
Name of the current branch

Return type
str

`mafw.scripts.doc_versioning.`**`get_directory_size`**(*path: Path*) → int

Calculate total size of a directory in bytes.

Parameters
path (*Path*) – Directory path

Returns
Total size in bytes

Return type
int

mafw.scripts.doc_versioning.**get_git_tags**(*min_version: str | None = None*) → List[Tuple[Version, Any]]

Return list of (Version, tag) tuples sorted ascending.

Parameters
min_version (*str | None*) – Minimum version to consider, defaults to None

Returns
List of (Version, tag) tuples

Return type
List[Tuple[Version, Any]]

mafw.scripts.doc_versioning.**git_rev_of**(*ref: str*) → str

Get the git revision hash for a given reference.

Parameters
ref (*str*) – Git reference (tag, branch, commit hash)

Returns
Git revision hash

Return type
str

Raises
RuntimeError – If git rev-list fails

mafw.scripts.doc_versioning.**is_ancestor**(*a: str*, *b: str*) → bool

Return True if commit a is ancestor of commit b (git merge-base –is-ancestor).

Parameters

- **a** (*str*) – First commit reference
- **b** (*str*) – Second commit reference

Returns
True if a is ancestor of b

Return type
bool

mafw.scripts.doc_versioning.**mirror_version**(*outdir: Path*, *src_tag: str*, *target_tag: str*, *use_symlink: bool = True*) → None

Mirror a version directory from one tag to another. Can use symlinks for efficiency or copy for compatibility.

Parameters

- **outdir** (*Path*) – Output directory containing version directories
- **src_tag** (*str*) – Source tag directory name
- **target_tag** (*str*) – Target tag directory name
- **use_symlink** (*bool*) – Whether to use symlink instead of copying, defaults to True

mafw.scripts.doc_versioning.**parse_sphinx_log**(*log_content: str*) → Tuple[int, int, List[str]]

Parse Sphinx build log to extract warning and error counts, and warning messages.

Only three warnings are reported

Parameters
log_content (*str*) – Sphinx build log

Returns
Tuple of warning, error count, warning messages

Return type
Tuple[int, int, List[str]]

`mafw.scripts.doc_versioning.`**`parse_version_tuple`**(*tag: str*) → Tuple[int, ...]

Parse vX.Y.Z(.W) into tuple of ints for sorting.

Parameters
tag (*str*) – Version tag string

Returns
Tuple of integers representing the version

Return type
Tuple[int, . . .]

`mafw.scripts.doc_versioning.`**`prune_old_versions`**(*outdir: Path*, *max_size_mb: int = 100*, *dry_run: bool = False*) → Tuple[List[str], int]

Remove oldest version directories until total size is below threshold. Always keeps 'stable', 'latest', and 'dev' (if present).

Parameters

- **outdir** (*Path*) – Output directory containing version directories
- **max_size_mb** (*int*) – Maximum size in megabytes
- **dry_run** (*bool*) – If True, only report what would be deleted

Returns
Tuple of (list of removed versions, final size in bytes)

Return type
Tuple[List[str], int]

`mafw.scripts.doc_versioning.`**`regenerate_versions_json_after_pruning`**(*outdir: Path*, *removed_versions: List[str]*) → None

Regenerate versions.json after pruning, excluding removed versions.

Parameters

- **outdir** (*Path*) – Output directory containing version directories
- **removed_versions** (*List[str]*) – List of version names that were removed

`mafw.scripts.doc_versioning.`**`report_build_status`**(*tag: str*, *success: bool*, *log: str*, *build_type: str = 'HTML'*) → None

Report build status with warning/error summary.

Parameters

- **tag** (*str*) – Version tag being built
- **success** (*bool*) – Whether build succeeded
- **log** (*str*) – Build log content
- **build_type** (*str*) – Type of build (HTML or PDF)

`mafw.scripts.doc_versioning.`**`run`**(*cmd: List[str]*, *cwd: Path | None = None*) → CompletedProcess[str]

Helper to run commands with consistent behavior.

Parameters

- **cmd** (*List[str]*) – Command to execute as a list of strings
- **cwd** (*Path | None*) – Working directory for command execution, defaults to None

Returns
Completed process result

Return type
subprocess.CompletedProcess[str]

`mafw.scripts.doc_versioning.`**`sort_tags_semver`**(*tags: List[str]*) → List[str]

Sort tags using semantic versioning comparison.

Parameters
tags (*List[str]*) – List of tag strings to sort

Returns
Sorted list of tag strings

Return type
List[str]

`mafw.scripts.doc_versioning.`**`write_legacy_redirect_page`**(*outdir: Path*) → None

Create a legacy redirect page at the root of the output directory.

Parameters
outdir (*Path*) – Output directory for the redirect page

`mafw.scripts.doc_versioning.`**`write_redirect_page`**(*outdir: Path*, *name: str*, *target_tag: str*) → None

Create a redirect page for a version alias.

Parameters

- **outdir** (*Path*) – Output directory for the redirect page
- **name** (*str*) – Name of the redirect alias (e.g., 'stable', 'dev')
- **target_tag** (*str*) – Tag that the redirect should point to

`mafw.scripts.doc_versioning.`**`write_redirects_file`**(*outdir: Path*) → None

Create a _redirects file for GitLab Pages.

Parameters
outdir (*Path*) – Output directory for the redirects file

`mafw.scripts.doc_versioning.`**`write_root_landing_page`**(*build_root: Path*, *project_name: str = 'MAFw'*) → None

Create a landing page for the project root with links to documentation and coverage.

Parameters

- **build_root** (*Path*) – Root build directory (should contain 'doc' subdirectory)
- **project_name** (*str*) – Project name for the page title

`mafw.scripts.doc_versioning.`**`write_versions_json`**(*outdir: Path*, *versions: List[dict[str, str]]*) → None

Write versions information to a JSON file.

Parameters

- **outdir** (*Path*) – Output directory for the JSON file
- **versions** (*List[dict[str, str]]*) – List of version information dictionaries

mafw.scripts.mafw_exe

The execution framework.

This module provides the run functionality to the whole library.

It is heavily relying on `click` for the generation of commands, options, and arguments.

mafw

The Modular Analysis Framework execution.

This is the command line interface where you can configure and launch your analysis tasks.

More information on our documentation page.

param ctx
The click context.

type ctx
click.core.Context

param log_level
The logging level as a string. Choice from debug, info, warning, error and critical.

type log_level
str

param ui
The user interface as a string. Choice from console and rich.

type ui
str

param debug
Flag to show debug information about exception.

type debug
bool

param no_banner
Flag to disable the welcome banner.

type no_banner
bool

Usage

```
mafw [OPTIONS] COMMAND [ARGS]...
```

Options

--log-level <log_level>

Log level

Default
'info'

Options
debug | info | warning | error | critical

--ui <ui>

The user interface

Default
'rich'

Options
console | rich

-D, --debug

Show debug information about errors

--no-banner
Disable the welcome banner

-v, --version
Show the version and exit.

db

Advanced database commands.

The db group of commands offers a set of useful database operations. Invoke the help option of each command for more details.

param ctx
The click context.

type ctx
click.core.Context

Usage

```
mafw db [OPTIONS] COMMAND [ARGS]...
```

wizard

Reflect an existing DB into a python module.

mafw db wizard [Options] Database

Database Name of the Database to be reflected.

About connection options (user / host / port):

That information will be used only in case you are trying to access a network database (MySQL or PostgreSQL). In case of Sqlite, the parameters will be discarded.

About passwords:

If you need to specify a password to connect to the DB server, just add –password in the command line without typing your password as clear text. You will be prompted to insert the password with hidden characters at the start of the processor.

About engines:

The full list of supported engines is provided in the option below. If you do not specify any engine and the database is actually an existing filename, then engine is set to Sqlite, otherwise to postgresql.

param database
The name of the database.

type database
str

param schema
The database schema to be reflected.

type schema
str

param engine
The database engine. A selection of possible values is provided in the script help.

type engine
str

param password
The password for the DB connection. Not used in case of Sqlite.

type password
str

param user
The username for the DB connection. Not used in case of Sqlite.

type user
str

param port
The port number of the database server. Not used in case of Sqlite.

type port
int

param host
The database hostname. Not used in case of Sqlite.

type host
str

param output_file
The filename for the output python module.

type output_file
click.Path | pathlib.Path | str

param snake_case
Flag to select snake_case convention for table and field names, or all small letter formatting.

type snake_case
bool

param ignore_unknown
Flag to ignore unknown fields. If False, an unknown field will be labelled with UnknownField.

type ignore_unknown
bool

param with_views
Flag to include views in the reflected elements.

type with_views
bool

param preserve_order
Flag to select if table fields should be reflected in the original order (True) or in alphabetical order (False)

type preserve_order
bool

param tables
A tuple containing a selection of table names to be reflected.

type tables
tuple[str, …]

param overwrite
Flag to overwrite the output file if exists. If False and the output file already exists, the user can decide what to do.

type overwrite
bool

param ctx
The click context, that includes the original object with global options.

type ctx
click.core.Context

return
The script return value

Usage

```
mafw db wizard [OPTIONS] DATABASE
```

Options

-o, --output-file <output_file>
The name of the output file with the reflected model.

-s, --schema <schema>
The name of the DB schema

-t, --tables <tables>
Generate model for selected tables. Multiple option possible.

--overwrite, --no-overwrite
Overwrite output file if already exists.

--preserve-order, --no-preserve-order
Preserve column order.

--with-views, --without-views
Include also database views.

--ignore-unknown, --no-ignore-unknown
Ignore unknown fields.

--snake-case, --no-snake-case
Use snake case for table and field names.

--host <host>
Hostname for the DB server.

-p, --port <port>
Port number for the DB server.

-u, --user, --username <user>
Username for the connection to the DB server.

--password <password>
Insert password when prompted

-e, --engine <engine>
The DB engine

Options
cockroach | cockroachdb | crdb | mysql | mysqldb | postgres | postgresql | sqlite | sqlite3

Arguments

DATABASE
Required argument

list

Display the list of available processors.

This command will retrieve all available processors via the plugin manager. Both internal and external processors will be listed if the ext-plugins option is passed.

Usage

```
mafw list [OPTIONS]
```

run

Runs a steering file.

STEERING_FILE A path to the steering file to execute.

param obj
The context object being passed from the main command.

type obj
dict

param steering_file
The path to the output steering file.

type steering_file
Path

Usage

```
mafw run [OPTIONS] STEERING_FILE
```

Arguments

STEERING_FILE
Required argument

steering

Generates a steering file with the default parameters of all available processors.

STEERING_FILE A path to the steering file to execute.

The user must modify the generated steering file to ensure it can be executed using the run command.

param obj
The context object being passed from the main command.

type obj
dict

param show
Display the steering file in the console after the generation. Defaults to False.

type show
bool

param ext_plugins
Extend the search for processor to external libraries.

type ext_plugins
bool

param open_editor
Open a text editor after the generation to allow direct editing.

type open_editor
bool

param steering_file
The steering file path.

type steering_file
Path

param db_engine
The name of the db engine.

type db_engine
str

param db_url
The URL of the database.

type db_url
str

Usage

```
mafw steering [OPTIONS] STEERING_FILE
```

Options

--show, --no-show
Display the generated steering file on console

--ext-plugins, --no-ext-plugin
Load external plugins

--open-editor, --no-open-editor
Open the file in your editor.

--db-engine <db_engine>
Select a DB engine

Options
sqlite | mysql | postgresql

--db-url <db_url>
URL to the DB

Arguments

STEERING_FILE
Required argument

Functions

custom_formatwarning(message, category, ...)	Return the pure message of the warning.
display_exception(exception[, show_traceback])	Display exception information with optional debug details.
logger_setup(level, ui, tracebacks)	Set up the logger.
print_banner(ctx)	Print the welcome banner only once, only for rich UI, and only if not disabled.

continues on next page

Table 12.56 – continued from previous page

Classes

MAFwGroup([name, commands, ...])	Custom Click Group for MAFw runner.
ReturnValue(value)	Enumerator to handle the script return value.

class `mafw.scripts.mafw_exe.`**`MAFwGroup`**(*name: str | None = None*, *commands: MutableMapping[str, Command] | Sequence[Command] | None = None*, *invoke_without_command: bool = False*, *no_args_is_help: bool | None = None*, *subcommand_metavar: str | None = None*, *chain: bool = False*, *result_callback: Callable[[...], Any] | None = None*, ***kwargs: Any*)

Bases: `Group`

Custom Click Group for MAFw runner.

It implements two main features:

1. Support commands abbreviation. Instead of providing the whole command, the user can use whatever abbreviation instead as long as it is unique. So for example, instead of *mafw list*, the use can provide *mafw l* and the result will be the same.
2. Implements the cascading of return values among different command levels.

`get_command`(*ctx: Context*, *cmd_name: str*) → Command | None

Return a command.

Given a context and a command name as passed from the CLI, the click.Command is returned. This method overloads the basic one allowing to use command abbreviations.

If more than one match is found, then an error is raised.

If no matches are found, then click will handle this case as in the standard situation.

Parameters

- **ctx** – The click context
- **cmd_name** – The command name as provided from the CLI

Returns

The corresponding command or None if no command is found.

`invoke`(*ctx: Context*) → Any

Invoke the command.

This override method is just wrapping the base invoke call in a try / except block.

In the case of a ClickException, then this is shown and its exit code is used passed to the sys.exit call. In case of a SystemExit or click.exceptions.Exit, then this is simply re-raised, so that Click can handle it as in normal circumstances In all other cases, the exception is caught and the sys.exit is called with the *ReturnValue.Error*.

Parameters

ctx – The click context

Returns

The return value of the invoked command

`main`(**args: Any*, ***kwargs: Any*) → None

Override main to handle return values properly.

class `mafw.scripts.mafw_exe.`**`ReturnValue`**(*value*)

Bases: `IntEnum`

Enumerator to handle the script return value.

`Error = 1`

Generic error

`OK = 0`

No error

`mafw.scripts.mafw_exe.`**`custom_formatwarning`**(*message: Warning | str*, *category: type[Warning]*, *filename: str*, *lineno: int*, *line: str | None = None*) → str

Return the pure message of the warning.

`mafw.scripts.mafw_exe.`**`display_exception`**(*exception: Exception*, *show_traceback: bool = False*) → None

Display exception information with optional debug details.

This function logs exception information at the critical level. When show_traceback is enabled, it logs the full exception including traceback information. Otherwise, it logs a simplified message directing users to enable debug mode for more details.

Parameters

- **`exception`** (*`Exception`*) – The exception to be displayed and logged.
- **`show_traceback`** (*`bool`*) – Flag indicating whether to show detailed traceback information. Defaults to False

`mafw.scripts.mafw_exe.`**`logger_setup`**(*level: str*, *ui: str*, *tracebacks: bool*) → None

Set up the logger.

This function is actually configuring the root logger level from the command line options and it attaches either a RichHandler or a StreamHandler depending on the user interface type.

The *tracebacks* flag is used only by the RichHandler. Printing the tracebacks is rather useful when debugging the code, but it could be detrimental for final users. In normal circumstances, tracebacks is set to False, and is turned on when the debug flag is activated.

Parameters

- **`level`** (*`str`*) – Logging level as a string.
- **`ui`** (*`str`*) – User interface as a string ('rich' or 'console').
- **`tracebacks`** – Enable/disable the logging of exception tracebacks.

`mafw.scripts.mafw_exe.`**`print_banner`**(*ctx: Context*) → None

Print the welcome banner only once, only for rich UI, and only if not disabled.

> **Note**
>
> ctx.obj is not yet populated when Group.invoke() is called, but ctx.params contains parsed options for the current group. We therefore inspect the root context params.

mafw.scripts.update_changelog

Module provides a simplified script to perform MAFw changelog update using `auto-changelog`. It can be used as pre-commit entry point and also in CI.

The basic idea is that this command is invoking the auto-changelog tool to generate a temporary changelog. The checksum of the temporary changelog is compared with the existing one. If the two checksums differs, the current changelog is replaced with the newly created version.

When committing the changelog update please use mute as commit type, to avoid having a new changelog generated containing the changelog update commit.

Functions

commit_changelog_changes()	Commit the changes to CHANGELOG.md.
get_last_commit_message()	Get the message of the last commit.
get_latest_tag()	Get the latest git tag.
main()	Script entry point

mafw.scripts.update_changelog.**commit_changelog_changes**() → None

Commit the changes to CHANGELOG.md.

mafw.scripts.update_changelog.**get_last_commit_message**() → str

Get the message of the last commit.

Returns
The last commit message

Return type
str

mafw.scripts.update_changelog.**get_latest_tag**() → str

Get the latest git tag.

Returns
The last git tag.

Return type
str

mafw.scripts.update_changelog.**main**() → None

Script entry point

mafw.scripts.update_notice

Module provides a simplified script to perform an update of the version number hard coded in the NOTICE.txt file. It is meant to be used as a pre-commit hook.

Maybe one day it will be detached from MAFw to become a real hook on its own.

Functions

main()	Script entry point
update_notice_version()	Perform the update of the version number in the NOTICE.txt file

mafw.scripts.update_notice.**main**() → None

Script entry point

mafw.scripts.update_notice.**update_notice_version**() → None

Perform the update of the version number in the NOTICE.txt file

Raises
RuntimeError – if the target NOTICE.txt file is not found

12.1.15 mafw.timer

Module implements a simple timer to measure the execution duration.

Basic usage:

```
from mafw import timer

with Timer() as timer:
    do_long_lasting_operation()
```

When exiting from the context manager, a message with the duration of the process is printed.

Functions

pretty_format_duration(duration_s[, n_digits])	Return a formatted version of the duration with increased human readability.
rreplace(inp_string, old_string, new_string, ...)	Utility function to replace a substring in a given string a certain number of times starting from the right-most one.

Classes

Timer([suppress_message])	The timer class.

class mafw.timer.**Timer**(*suppress_message: bool = False*)

Bases: `object`

The timer class.

Constructor parameter:

Parameters
suppress_message (*bool*) – A boolean flag to mute the timer

format_duration() → str

Nicely format the timer duration.

Returns
A string with the timer duration in a human-readable formatted string

Return type
str

property duration: float

The elapsed time of the timer.

Returns
Elapsed time in seconds.

mafw.timer.**pretty_format_duration**(*duration_s: float*, *n_digits: int = 1*) → str

Return a formatted version of the duration with increased human readability.

Parameters

- **duration_s** (*float*) – The duration to be printed in seconds. If negative, a ValueError exception is raised.
- **n_digits** (*int, Optional*) – The number of decimal digits to show. Defaults to 1. If negative, a ValueError exception is raised.

Returns
The formatted string.

Return type
str

Raises
ValueError – if a negative duration or a negative number of digits is provided

`mafw.timer.rreplace`(*inp_string: str*, *old_string: str*, *new_string: str*, *counts: int*) → str

Utility function to replace a substring in a given string a certain number of times starting from the right-most one.

This function is mimicking the behavior of the string.replace method, but instead of replacing from the left, it is replacing from the right.

Parameters

- **inp_string** (*str*) – The input string
- **old_string** (*str*) – The old substring to be matched. If empty, a ValueError is raised.
- **new_string** (*str*) – The new substring to be replaced
- **counts** (*int*) – The number of times the old substring has to be replaced.

Returns
The modified string

Return type
str

Raises
ValueError – if old_string is empty.

12.1.16 mafw.tools

The package provides a set of tools for different range of applications.

Modules

db_tools	Database Tools
file_tools	The module provides utilities for handling file, filename, hashing and so on.
generics	
pandas_tools	A collection of useful convenience functions for common pandas operations
regexp	Module implements some basic functions involving regular expressions.
toml_tools	The module provides tools to read / write / modify specific TOML files.

mafw.tools.db_tools

Database Tools

This module provides utility functions for working with database models using the Peewee ORM. It offers helper functions for creating key-value mappings, retrieving primary key information, and combining fields for composite keys or display purposes.

Functions

`combine_fields`(fields[, join_str])	Combine multiple database fields into a single concatenated string expression.
`combine_pk`(model[, alias_name, join_str])	Combine primary key fields of a database model into a single aliased field expression.
`get_pk`(model)	Retrieve the primary key fields of a database model.
`make_kv`(model, key, value)	Create a key-value mapping from a database model.

mafw.tools.db_tools.**combine_fields**(*fields: list[Field]*, *join_str: str = ' x '*) → Function

Combine multiple database fields into a single concatenated string expression.

This function creates an SQL CONCAT expression that combines multiple field values into a single string using the specified separator. It's particularly useful for creating composite keys or display strings from multiple fields.

Parameters

- **fields** (*list[peewee.Field]*) – List of field objects to be combined.
- **join_str** (*str*) – String to use as separator between fields. Defaults to ' x '.

Returns

A SQL CONCAT function expression combining the fields.

Return type

peewee.Function

mafw.tools.db_tools.**combine_pk**(*model: MAFwBaseModel* | *type[MAFwBaseModel]*, *alias_name: str = 'combo_pk'*, *join_str: str = ' x '*) → Alias

Combine primary key fields of a database model into a single aliased field expression.

This function retrieves the primary key fields from the given model using `get_pk()` and combines them into a single field expression. For models with a single primary key field, it simply aliases that field. For composite primary keys, it uses :func:combine_fields` to concatenate the fields with the specified separator.

Parameters

- **model** (*MAFwBaseModel | type[MAFwBaseModel]*) – The database model or model class to examine for primary key fields.
- **alias_name** (*str*) – The alias name to apply to the resulting field expression. Defaults to 'combo_pk'.
- **join_str** (*str*) – String to use as separator between primary key fields when combining. Defaults to ' x '.

Returns

An aliased field expression representing the combined primary key.

Return type

peewee.Alias

mafw.tools.db_tools.**get_pk**(*model: MAFwBaseModel* | *type[MAFwBaseModel]*) → list[Field]

Retrieve the primary key fields of a database model.

This function examines the primary key of the provided model and returns a list of field objects that constitute the primary key. For composite primary keys, it returns all constituent fields; for simple primary keys, it returns a list containing just the primary key field.

Parameters

model (*MAFwBaseModel | type[MAFwBaseModel]*) – The database model or model class to examine.

Returns
A list of field objects representing the primary key fields.

Return type
list[peewee.Field]

`mafw.tools.db_tools.make_kv`(*model: MAFwBaseModel* | *type[MAFwBaseModel]*, *key: Field*, *value: Field*) → dict[Any, Any]

Create a key-value mapping from a database model.

This function selects data from a given model using specified key and value fields, and returns a dictionary where keys are values from the key field and values are values from the value field.

Parameters

- **model** (*MAFwBaseModel | type[MAFwBaseModel]*) – The database model or model class to query.
- **key** (*peewee.Field*) – The field to use as dictionary keys.
- **value** (*peewee.Field*) – The field to use as dictionary values.

Returns
A dictionary mapping key field values to value field values.

Return type
dict[Any, Any]

Raises
AttributeError – If the model parameter doesn't have the required methods.

mafw.tools.file_tools

The module provides utilities for handling file, filename, hashing and so on.

Functions

file_checksum(filenames[, buf_size])	Generates the hexadecimal digest of a file or a list of files.
remove_widow_db_rows(models)	Removes widow rows from a database table.
verify_checksum(models)	Verifies the goodness of FileChecksumField.

`mafw.tools.file_tools.file_checksum`(*filenames: str* | *Path* | *Sequence[str* | *Path]*, *buf_size: int = 65536*) → str

Generates the hexadecimal digest of a file or a list of files.

The digest is calculated using the sha256 algorithm.

Parameters

- **filenames** (*str, Path, list*) – The filename or the list of filenames for digest calculations.
- **buf_size** (*int, Optional*) – The buffer size in bytes for reading the input files. Defaults to 64kB.

Returns
The hexadecimal digest.

Return type
str

`mafw.tools.file_tools.remove_widow_db_rows`(*models: list[Model | type[Model]] | Model | type[Model]*) → None

Removes widow rows from a database table.

According to MAFw architecture, the Database is mainly providing I/O support to the various processors.

This means that the processor retrieves a list of items from a database table for processing and subsequently updates a result table with the newly generated outputs.

Very often the input and output data are not stored directly in the database, but rather in files saved on the disc. In this case, the database is just providing a valid path where the input (or output) data can be found.

From this point of view, a **widow row** is a database entry in which the file referenced by the FilenameField has been deleted. A typical example is the following: the user wants a certain processor to regenerate a given result stored inside an output file. Instead of setting up a complex filter so that the processor receives only this element to process, the user can delete the actual output file and ask the processor to process all new items.

The provided `models` can be either a list or a single element, representing either an instance of a DB model or a model class. If a model class is provided, then a select over all its entries is performed.

The function will look at all fields of *FileNameField* and *FileNameListField* and check if it corresponds to an existing path or list of paths. If not, then the corresponding row is removed from the DB table.

Parameters
models (*list[Model | type(Model)] | Model | type(Model)*) – A list or a single Model instance or Model class for widow rows removal.

Raises
TypeError – if `models` is not of the right type.

`mafw.tools.file_tools.verify_checksum`(*models: list[Model | type[Model]] | Model | type[Model]*) → None

Verifies the goodness of FileChecksumField.

If in a model there is a FileChecksumField, this must be connected to a FileNameField or a FileNameListField in the same model. The goal of this function is to recalculate the checksum of the FileNameField / FileNameListField and compare it with the actual stored value. If the newly calculated value differs from the stored one, the corresponding row in the model will be removed, as it is no longer valid.

If a file is missing, then the checksum check is not performed, but the row is removed right away.

This function can be CPU and I/O intensive and last a lot, so use it with care, especially when dealing with long tables and large files.

Parameters
models (*list[Model | type(Model)] | Model | type(Model)*) – A list or a single Model instance or Model class for checksum verification.

Raises

- **TypeError** – if `models` is not of the right type.
- *mafw.mafw_errors.ModelError* – if the FileCheckSumField is referring to a FileNameField that does not exist.

mafw.tools.generics

Functions

deep_update(base_dict, update_dict[, copy_first])	Recursively updates a dictionary.

`mafw.tools.generics.deep_update`(*base_dict: dict[Any, Any]*, *update_dict: dict[Any, Any]*, *copy_first: bool = True*) → dict[Any, Any]

Recursively updates a dictionary.

If copy_first is set to False, then the base_dict is actually updated.

Parameters

- **base_dict** (*dict[Any, Any]*) – The dictionary to update.
- **update_dict** (*dict[Any, Any]*) – The dictionary containing the updated fields
- **copy_first** (*bool, Optional*) – Whether the base dictionary should be copied or updated. Defaults to True

Returns

The recursively updated dictionary

Return type

dict[Any, Any]

mafw.tools.pandas_tools

A collection of useful convenience functions for common pandas operations

Functions

group_and_aggregate_data_frame(data_frame, ...)	Utility function to perform dataframe groupby and aggregation.
slice_data_frame(input_data_frame[, ...])	Slice a data frame according to *slicing_dict*.

mafw.tools.pandas_tools.**group_and_aggregate_data_frame**(*data_frame: DataFrame*, *grouping_columns: Iterable[str]*, *aggregation_functions: Iterable[str | Callable[[Any], Any]]*) → DataFrame

Utility function to perform dataframe groupby and aggregation.

This function is a simple wrapper to perform group by and aggregation operations on a dataframe. The user must provide a list of columns to perform the group by on and a list of functions for the aggregation of the other columns.

The output dataframe will have the aggregated columns renamed as originalname_aggregationfunction.

> **Note**
>
> Only numeric columns (and columns that can be aggregated) will be included in the aggregation. String columns that are not used for grouping will be automatically excluded from aggregation.

Parameters

- **data_frame** (*pandas.DataFrame*) – The input data frame
- **grouping_columns** (*Iterable[str]*) – The list of columns to group by on.
- **aggregation_functions** (*Iterable[str | Callable[[Any], Any]*) – The list of functions to be used for the aggregation of the not grouped columns.

Returns

The aggregated dataframe after the groupby operation.

Return type

pandas.DataFrame

`mafw.tools.pandas_tools.`**`slice_data_frame`**(*input_data_frame: DataFrame*, *slicing_dict: MutableMapping[str, Any] | None = None*, ***kwargs: Any*) → DataFrame

Slice a data frame according to *slicing_dict*.

The input data frame will be sliced using the items of the *slicing_dict* applying the loc operator in this way: `sliced = input_data_frame[(input_data_frame[key]==value)]`.

If the slicing_dict is empty, then the full input_data_frame is returned.

Instead of the slicing_dict, the user can also provide key and value pairs as keyword arguments.

`slice_data_frame(data_frame, {'A':14})`

is equivalent to

`slice_data_frame(data_frame, A=14)`.

If the user provides a keyword argument that also exists in the slicing_dict, then the keyword argument will update the slicing_dict.

No checks on the column name is done, should a label be missing, the loc method will raise a KeyError.

Parameters

- **`input_data_frame`** (*`pd.DataFrame`*) – The data frame to be sliced.
- **`slicing_dict`** (*`dict, Optional`*) – A dictionary with columns and values for the slicing. Defaults to None
- **`kwargs`** – Keyword arguments to be used instead of the slicing dictionary.

Returns

The sliced dataframe

Return type

pd.DataFrame

mafw.tools.regexp

Module implements some basic functions involving regular expressions.

Functions

`extract_protocol`(url)	Extract the protocol portion from a database connection URL.
`normalize_sql_spaces`(sql_string)	Normalize multiple consecutive spaces in SQL string to single spaces.
`parse_processor_name`(processor_string)	Parse a processor name string into name and replica identifier components.

`mafw.tools.regexp.`**`extract_protocol`**(*url: str*) → str | None

Extract the protocol portion from a database connection URL.

The extract_protocol function takes a database connection URL string as input and extracts the protocol portion (the part before "://"). This function is useful for identifying the database type from connection strings.

Parameters

`url` (*`str`*) – The url from which the protocol will be extracted.

Returns

The protocol or None, if the extraction failed

Return type

str | None

`mafw.tools.regexp.`**`normalize_sql_spaces`**(*sql_string: str*) → str

Normalize multiple consecutive spaces in SQL string to single spaces. Only handles spaces, preserves other whitespace characters.

Parameters
`sql_string` (*str*) – The SQL string for space normalization.

Returns
The normalized SQL command.

Return type
str

`mafw.tools.regexp.`**`parse_processor_name`**(*processor_string: str*) → tuple[str, str | None]

Parse a processor name string into name and replica identifier components.

Given a string in the form 'MyProcessorName#156a', returns a tuple ('MyProcessorName', '156a'). If the input string is 'MyProcessorName' only, then it returns ('MyProcessorName', None). If it gets 'MyProcessorName#', it returns ('MyProcessorName', None) but emits a warning informing of a possible malformed name.

The processor name must be a valid Python identifier (class name).

Parameters
`processor_string` (*str*) – The processor name string to parse.

Returns
A tuple of (name, replica_id) where replica_id can be None.

Return type
tuple[str, str | None]

Raises
UnknownProcessor – if the name part is empty or not a valid Python identifier

mafw.tools.toml_tools

The module provides tools to read / write / modify specific TOML files.

Functions

dump_processor_parameters_to_toml(...)	Dumps a toml file with processor parameters.
generate_steering_file(output_file, processors)	Generates a steering file.
load_steering_file(steering_file[, validate])	Load a steering file for the execution framework.
path_encoder(obj)	Encoder for PathItem.
processor_validator(processors)	Validates that all items in the list are valid processor instances or classes.

Classes

PathItem(t, value, original, trivia)	TOML item representing a Path

class `mafw.tools.toml_tools.`**`PathItem`**(*t*, *value*, *original*, *trivia*)

Bases: `String`

TOML item representing a Path

`unwrap`() → Path

Returns as pure python object (ppo)

mafw.tools.toml_tools.**_add_db_configuration**(*database_conf: dict[str, Any] | None = None*, *db_engine: str = 'sqlite'*, *doc: TOMLDocument | None = None*) → TOMLDocument

Add the DB configuration to the TOML document

The expected structure of the database_conf dictionary is one of these two:

```
option1 = {
    'DBConfiguration': {
        'URL': 'sqlite:///:memory:',
        'pragmas': {
            'journal_mode': 'wal',
            'cache_size': -64000,
            'foreign_keys': 1,
            'synchronous': 0,
        },
    }
}

option2 = {
    'URL': 'sqlite:///:memory:',
    'pragmas': {
        'journal_mode': 'wal',
        'cache_size': -64000,
        'foreign_keys': 1,
        'synchronous': 0,
    },
}
```

We will always convert the option1 in option2.

Parameters

- **database_conf** (*dict*) – A dictionary with the database configuration. See comments above. If None, then the default is used.
- **db_engine** (*str, Optional*) – The database engine. It is used only in case the provided database configuration is invalid to retrieve the default configuration. Defaults to sqlite.
- **doc** (*TOMLDocument, Optional*) – The TOML document to add the DB configuration. If None, one will be created.

Returns

The modified document.

Return type

TOMLDocument

Raises

UnknownDBEngine – if the *database_conf* is invalid and the db_engine is not yet implemented.

mafw.tools.toml_tools.**dump_processor_parameters_to_toml**(*processors: list[ProcessorClassProtocol] | ProcessorClassProtocol*, *output_file: Path | str*) → None

Dumps a toml file with processor parameters.

This helper function can be used when the parameters of one or many processors have to be dumped to a TOML file. For each Processor in the *processors* a table in the TOML file will be added with their parameters is the shape of parameter name = value.

It must be noted that *processors* can be:

- a list of processor classes (list[type[Processor]])
- a list of processor instances (list[Processor]])
- one single processor class (type[Processor])
- one single processor instance (Processor)

What value of the parameters will be dumped?

Good question, have a look at this *explanation*.

param processors
One or more processors for which the parameters should be dumped.

type processors
list[type[Processor | Processor]] | type[Processor] | Processor

param output_file
The name of the output file for the dump.

type output_file
Path | str

raise KeyAlreadyPresent
if an attempt to add twice, the same processor is made.

raise TypeError
if the list contains items different from Processor classes and instances.

`mafw.tools.toml_tools.`**`generate_steering_file`**(*output_file: Path* | *str*, *processors: list[ProcessorClassProtocol]* | *ProcessorClassProtocol*, *database_conf: dict[str, Any]* | *None = None*, *db_engine: str = 'sqlite'*) → None

Generates a steering file.

Parameters

- **output_file** (*Path | str*) – The output filename where the steering file will be save.
- **processors** (*list[type[Processor] | Processor], type[Processor], Processor*) – The processors list for which the steering file will be generated.
- **database_conf** (*dict, Optional*) – The database configuration dictionary
- **db_engine** – A string representing the DB engine to be used. Possible values are: *sqlite*, *postgresql* and *mysql*.

Type
str

`mafw.tools.toml_tools.`**`load_steering_file`**(*steering_file: Path* | *str*, *validate: bool = True*) → dict[str, Any]

Load a steering file for the execution framework.

Changed in version v2.0.0: Introduce support for replica names along with base names in file validation

Parameters

- **steering_file** (*Path, str*) – The path to the steering file.
- **validate** (*bool, Optional*) – A flag to validate the content. Defaults to True.

Returns
The configuration dictionary.

Return type
dict

Raises
FileNotFound – if steering_file does not exist.

`mafw.tools.toml_tools.`**`path_encoder`**`(`*obj: Any*`)` → Item

Encoder for PathItem.

`mafw.tools.toml_tools.`**`processor_validator`**`(`*processors: list[ProcessorClassProtocol]*`)` → bool

Validates that all items in the list are valid processor instances or classes.

Parameters
processors (*list[type[Processor] | Processor]*) – The list of items to be validated.

Returns
True if all items are valid.

Return type
bool

12.1.17 mafw.ui

User interface modules.

In this subpackage, there are some implementations of possible user interfaces to connect the library to the execution framework.

Modules

abstract_user_interface	An abstract generic user interface.
console_user_interface	The console user interface.
rich_user_interface	The rich user interface.

mafw.ui.abstract_user_interface

An abstract generic user interface.

The module provides a generic user interface that can be implemented to allow MAFw to communicate with different user interfaces.

MAFw is designed to operate seamlessly without a user interface; however, users often appreciate the added benefit of communication between the process execution and themselves.

There are several different interfaces and different interface types (Command Line, Textual, Graphical…) and everyone has its own preferences. In order to be as generic as possible, MAFw is allowing for an abstract interface layer so that the user can either decide to use one of the few coming with MAFw or to implement the interface to their favorite interface.

Classes

UserInterfaceBase()	An abstract base user interface class that defines the interface for communicating with different user interfaces.
UserInterfaceMeta	A metaclass used for the creation of user interface

class `mafw.ui.abstract_user_interface.`**`UserInterfaceBase`**

Bases: `object`

An abstract base user interface class that defines the interface for communicating with different user interfaces.

This class provides a standardized way for MAFw to interact with various user interfaces including command-line, textual, and graphical interfaces. It defines the required methods that any concrete implementation must provide.

The interface allows for task management, progress reporting, status updates, and user interaction capabilities.

Added in version v1.0.

`create_task`(*task_name: str*, *task_description: str = ''*, *completed: int = 0*, *increment: int | None = None*, *total: int | None = None*, ***kwargs: Any*) → None

Create a new task.

Parameters

- **task_name** (*str*) – A unique identifier for the task. You cannot have more than 1 task with the same name in the whole execution. If you want to use the processor name, it is recommended to use the `unique_name`.
- **task_description** (*str, Optional*) – A short description for the task. Defaults to None.
- **completed** (*int, Optional*) – The amount of task already completed. Defaults to None.
- **increment** (*int, Optional*) – How much of the task has been done since last update. Defaults to None.
- **total** (*int, Optional*) – The total amount of task. Defaults to None.

`display_progress_message`(*message: str*, *i_item: int*, *n_item: int | None*, *frequency: float*) → None

Display a message during the process execution.

Parameters

- **message** (*str*) – The message to be displayed.
- **i_item** (*int*) – The current item enumerator.
- **n_item** (*int | None*) – The total number of items or None for an indeterminate progress (while loop).
- **frequency** (*float*) – How often (in percentage of n_item) to display the message.

`enter_interactive_mode`() → Generator[None, Any, None]

A context manager for entering interactive mode.

This method provides a way to temporarily switch to interactive mode, allowing for direct user interaction during processing. It should be used as a context manager with a `with` statement.

Added in version v2.0.0.

Returns
A context manager that yields control to the interactive section

Return type
Generator

`prompt_question`(*question: str*, ***kwargs: Any*) → Any

Prompt the user with a question and return their response.

This method should display a question to the user and wait for their input. The implementation may vary depending on the specific user interface being used.

Added in version v2.0.0.

Parameters

- **question** (*str*) – The question to be asked to the user.
- **kwargs** – Additional keyword arguments that might be used by specific implementations.

Returns
The user's response to the question.

Return type
Any

update_task(*task_name: str*, *completed: int = 0*, *increment: int | None = None*, *total: int | None = None*, ***kwargs: Any*) → None

Update an existing task.

Parameters

- **task_name** (*str*) – A unique identifier for the task. You cannot have more than 1 task with the same name in the whole execution. If you want to use the processor name, it is recommended to use the *replica_name*.
- **completed** (*int, Optional*) – The amount of task already completed. Defaults to None.
- **increment** (*int, Optional*) – How much of the task has been done since last update. Defaults to None.
- **total** (*int, Optional*) – The total amount of task. Defaults to None.

always_display_progress_message = 10

Threshold for displaying progress messages.

If the total number of events is below this value, then the progress message is always displayed, otherwise follow the standard update frequency.

name = 'base'

The name of the interface

class mafw.ui.abstract_user_interface.**UserInterfaceMeta**

Bases: `type`

A metaclass used for the creation of user interface

mafw.ui.console_user_interface

The console user interface.

The module provides a simple, still efficient user interface ideal for code execution of a headless system where it is not possible to observe the output in real-time. Nevertheless, important messages are logged via the logging library and thus it is also possible to save them to a file, if a proper logging handler is set up.

Classes

ConsoleInterface()	A console user interface.

class mafw.ui.console_user_interface.**ConsoleInterface**

Bases: *UserInterfaceBase*

A console user interface.

Ideal for execution in a headless environment.

Messages are sent via the logging system, so they can also be saved to a file is a logging handler is properly set up in the execution framework.

change_of_processor_status(*processor_name: str*, *old_status:* ProcessorStatus, *new_status:* ProcessorStatus) → None

Log a processor status change.

This method logs when a processor changes its status, using debug level logging.

Parameters

- **processor_name** (*str*) – The name of the processor whose status changed.
- **old_status** (ProcessorStatus) – The previous status of the processor.
- **new_status** (ProcessorStatus) – The new status of the processor.

create_task(*task_name: str*, *task_description: str = ''*, *completed: int = 0*, *increment: int | None = None*, *total: int | None = None*, ***kwargs: Any*) → None

Create a new task.

Parameters

- **task_name** (*str*) – A unique identifier for the task. You cannot have more than 1 task with the same name in the whole execution. If you want to use the processor name, it is recommended to use the `unique_name`.
- **task_description** (*str, Optional*) – A short description for the task. Defaults to None.
- **completed** (*int, Optional*) – The amount of task already completed. Defaults to None.
- **increment** (*int, Optional*) – How much of the task has been done since last update. Defaults to None.
- **total** (*int, Optional*) – The total amount of task. Defaults to None.

display_progress_message(*message: str*, *i_item: int*, *n_item: int | None*, *frequency: float*) → None

Display a progress message with item counter.

This method displays progress information at specified intervals based on the frequency parameter. It formats the message with a counter showing the current item and total items.

Parameters

- **message** (*str*) – The progress message to display.
- **i_item** (*int*) – The current item number (0-based index).
- **n_item** (*int | None*) – The total number of items, or None if unknown.
- **frequency** (*float*) – The frequency at which messages should be displayed (in seconds).

prompt_question(*question: str*, ***kwargs: Any*) → Any

Prompt the user with a question and return their input.

This method displays a question to the user and waits for their input. Additional keyword arguments can be passed through to the underlying input function.

Added in version v2.0.0.

Parameters

- **question** (*str*) – The question to display to the user.
- **kwargs** – Additional keyword arguments to pass to the input function.

Returns

The user's input.

Return type

Any

update_task(*task_name: str*, *completed: int | None = None*, *increment: int | None = None*, *total: int | None = None*, ***kwargs: Any*) → None

Update an existing task.

Parameters

- **task_name** (*str*) – A unique identifier for the task. You cannot have more than one task with the same name in the whole execution. If you want to use the processor name, it is recommended to use the *replica_name*.
- **completed** (*int, Optional*) – The amount of task already completed. Defaults to None.
- **increment** (*int, Optional*) – How much of the task has been done since last update. Defaults to None.
- **total** (*int, Optional*) – The total amount of task. Defaults to None.

name = 'console'

The name of the interface

mafw.ui.rich_user_interface

The rich user interface.

The module provides an implementation of the abstract user interface that takes advantage from the *rich* library. Progress bars and spinners are shown during the processor execution along with log messages including markup language. In order for this logging message to appear properly rendered, the logger should be connected to a RichHandler.

Classes

RichInterface([progress_kws])	Implementation of the interface for rich.

class mafw.ui.rich_user_interface.**RichInterface**(*progress_kws: dict[str, Any] | None = None*)

Bases: *UserInterfaceBase*

Implementation of the interface for rich.

Parameters

progress_kws (*dict, Optional*) – A dictionary of keywords passed to the *rich.Progress*. Defaults to None

change_of_processor_status(*processor_name: str*, *old_status: ProcessorStatus*, *new_status: ProcessorStatus*) → None

Display a message when a processor status changes.

This method logs a debug message indicating that a processor has changed its status. The message uses rich markup to highlight the processor name and new status.

Parameters

- **processor_name** (*str*) – The name of the processor whose status has changed.
- **old_status** (*ProcessorStatus*) – The previous status of the processor.
- **new_status** (*ProcessorStatus*) – The new status of the processor.

create_task(*task_name: str*, *task_description: str = ''*, *completed: int = 0*, *increment: int | None = None*, *total: int | None = None*, ***kwargs: Any*) → None

Create a new task.

Parameters

- **task_name** (*str*) – A unique identifier for the task. You cannot have more than 1 task with the same name in the whole execution. If you want to use the processor name, it is recommended to use the `unique_name`.
- **task_description** (*str, Optional*) – A short description for the task. Defaults to ''.
- **completed** (*int, Optional*) – The amount of task already completed. Defaults to 0.
- **increment** (*int, Optional*) – How much of the task has been done since last update. Defaults to None.
- **total** (*int, Optional*) – The total amount of task. Defaults to None.

display_progress_message(*message: str, i_item: int, n_item: int | None, frequency: float*) → None

Display a message during the process execution.

Parameters

- **message** (*str*) – The message to be displayed.
- **i_item** (*int*) – The current item enumerator.
- **n_item** (*int | None*) – The total number of items or None for an indeterminate progress (while loop).
- **frequency** (*float*) – How often (in percentage of n_item) to display the message.

enter_interactive_mode() → Generator[None, Any, None]

Context manager to temporarily switch to interactive mode.

This method temporarily stops the progress display to allow for interactive input while preserving the original transient state. After yielding control, it restores the progress display with appropriate spacing to avoid overwriting previous output.

Added in version v2.0.0.

> **Note**
>
> This method should be used within a `with` statement to ensure proper cleanup.

prompt_question(*question: str, **kwargs: Any*) → Any

Prompt the user with a question and return their response.

This method uses the rich library's prompt functionality to ask the user a question. It supports various prompt types including confirmation, input, and choice prompts.

Added in version v2.0.0.

Parameters

- **question** (*str*) – The question to ask the user.
- **kwargs** – Additional arguments to pass to the prompt function.
- **prompt_type** – The type of prompt to use. Defaults to `rich.prompt.Confirm`.
- **console** – The console to use for the prompt. Defaults to None.
- **password** – Whether to hide input when prompting for passwords. Defaults to False.
- **choices** – List of valid choices for choice prompts. Defaults to None.
- **default** – Default value for prompts that support it. Defaults to None.
- **show_default** – Whether to show the default value. Defaults to True.
- **show_choices** – Whether to show available choices. Defaults to True.

- **case_sensitive** – Whether choices are case sensitive. Defaults to True.

Returns
The user’s response based on the prompt type.

Return type
Any

update_task(*task_name: str*, *completed: int | None = None*, *increment: int | None = None*, *total: int | None = None*, ***kwargs: Any*) → None

Update an existing task.

Parameters

- **task_name** (*str*) – A unique identifier for the task. You cannot have more than one task with the same name in the whole execution. If you want to use the processor name, it is recommended to use the `replica_name`.
- **completed** (*int, Optional*) – The amount of task already completed. Defaults to 0.
- **increment** (*int, Optional*) – How much of the task has been done since last update. Defaults to None.
- **total** (*int, Optional*) – The total amount of task. Defaults to None.

name = 'rich'

The name of the interface

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