Antmicro

Pipeline Manager

2025-02-10

CONTENTS

CHAPTER

ONE

INTRODUCTION

Pipeline Manager is a data-based web application for creating, visualizing and managing pipelines for various applications.

This documentation contains the following chapters:

- *Pipeline Manager* - a quickstart guide for the project
- *Specification format* - description of the node specification format
- *Dataflow format* - graph description format overview
- *Front-end features* - description of front-end features and front end testing
- *Communication with an external application* - external application integration overview
- *Sample third-party server* - describes how to configure server for testing frontend features
- *Specification Builder* - describes the Python's `SpecificationBuilder` module for constructing the specification.
- *Graph Builder* - describes the Python's `GraphBuilder` class for constructing and manipulating the dataflow graph.
- *Dataflow and specification format changelog* - lists changes and versions in the format of dataflow and specification files
- *Front end demo* - Pipeline Manager's front end demonstration.

CHAPTER

TWO

PIPELINE MANAGER

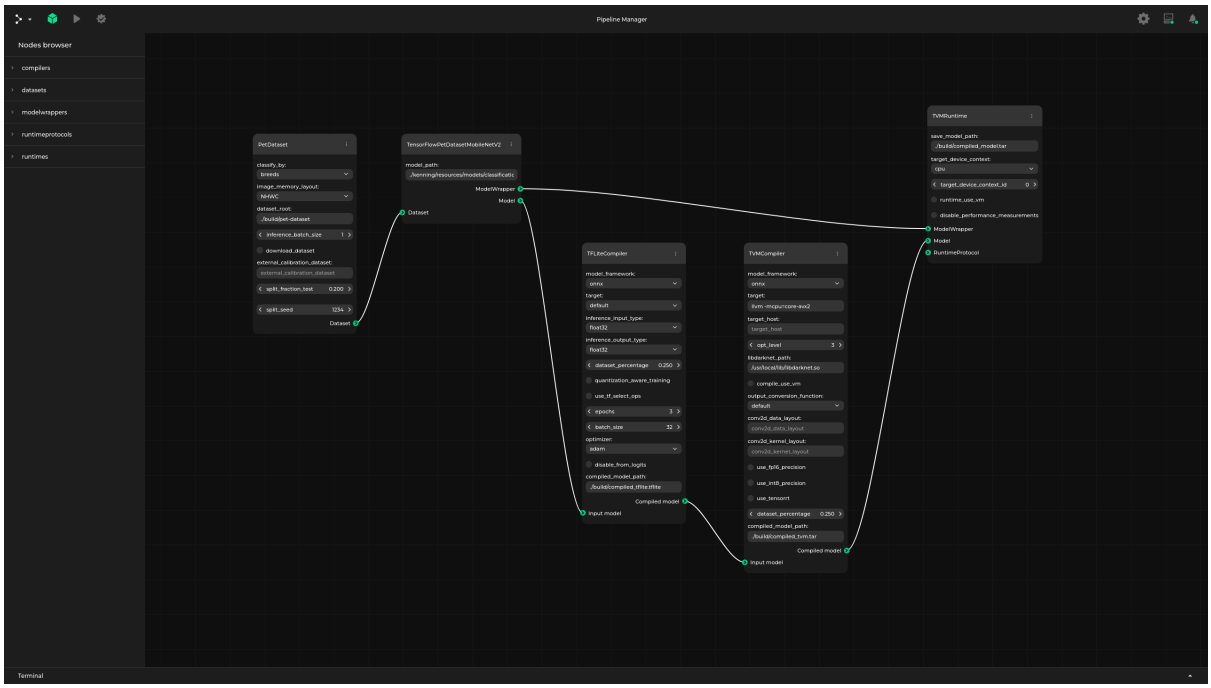
Pipeline Manager is a data-based, application-agnostic web application for creating, visualizing and managing dataflows in various applications. It does not assume any properties of the application it is working with, thanks to which fast integration with various formats is possible.

Pipeline Manager documentation | Demo application

It provides functionality for:

- visualizing and editing dataflows,
- saving and loading dataflows,
- communicating with an external application to delegate advanced validation, execution of the defined graph and conversions to and from native formats of the graphs.

Pipeline Manager aims to simplify the process of developing graph-based graphical interfaces for applications that are modular and have a graph-like nature.



2.1 Prerequisites

Pipeline Manager requires `npm` (at least 10.8.2 version is recommended, along with Node.js starting from 20.10.0), `python` and `pip` for installing dependencies, building and (optionally) running - use package manager to install those packages.

The backend of the application has a list of requirements in the `pyproject.toml` file. They can be installed using `pip`:

```
pip install .
```

All of `npm` modules needed for the frontend of the application are installed automatically during build. They can be found in the `./pipeline_manager/frontend/node_modules` directory after the application is built.

2.2 Building and running

Pipeline Manager can be built in two different ways as:

- static HTML application, that can be run in a browser, without any additional backend server,
- regular web application that is designated to communicate and cooperate with an external application (like Kenning).

2.2.1 Static HTML application

To build Pipeline Manager as a static HTML application, in the root directory run:

```
./build static-html
```

For available flags, run:

```
./build static-html -h
```

To run the built application, open `./pipeline_manager/frontend/dist/index.html` in a preferred browser. As an example, if the browser of your choice is `firefox` you should run:

```
firefox ./pipeline_manager/frontend/dist/index.html
```

After running Pipeline Manager you can use sample specification under `./examples/sample_specification.json` to check the visualization and editing of pipelines. Additionally, `./examples/sample_dataflow.json` can be used to see how dataflows are stored.

The specification can be loaded in the webpage using the `Load specification` option in the main menu. The dataflow can be loaded in the webpage using the `Load graph file` option in the main menu.

What is more, the specification and the dataflow can be provided as URL arguments:

- `spec` - should contain URL to the specification file,
- `graph` - should contain URL to the dataflow file,

- `preview` - if `true`, the graph is displayed in preview mode (read only, no HUD),
- `include` - to alter the specification from the level of URL, it is possible to provide a URL to additional includes with this field.

For example:

```
firefox "https://antmicro.github.io/kenning-pipeline-manager/_static/pipeline-
↪manager.html?spec=https%3A%2F%2Fraw.githubusercontent.com%2Fantmicro%2Fkenning-
↪pipeline-manager%2Frefs%2Fheads%2Fmain%2Fexamples%2Fsample-specification.json&
↪graph=https%3A%2F%2Fraw.githubusercontent.com%2Fantmicro%2Fkenning-pipeline-
↪manager%2Frefs%2Fheads%2Fmain%2Fexamples%2Fsample-dataflow.json"
```

Will fetch and use specification and dataflow from the GitHub repository for this project. The URLs need to be encoded.

It is possible to add a default specification JSON to the generated HTML. It just needs to be provided as the second argument of the `./build` script:

```
./build static-html <path-to-specification-json>
```

It is also possible to add a default dataflow that will be loaded on the start of the application, e.g.:

```
./build static-html <path-to-specification> <path-to-dataflow>
```

To be able to use some additional assets, like icons for nodes, run:

```
./build --assets-directory <path-to-assets-dir> static-html <path-to-
↪specification> <path-to-dataflow>
```

To change the title of the editor and page, use `--editor-title` flag, e.g.:

```
./build --editor-title 'Graph editor' static-html <path-to-specification> <path-
↪to-dataflow>
```

For details on how to write specification, check:

- Pipeline Manager documentation
- Specification format
- Dataflow format
- Examples in `examples/` directory - in the directory you can find sample specification files (with `-specification.json` suffix), usually paired with supported dataflow files (with `-dataflow.json` suffix)

For example, run:

```
./build static-html ./examples/sample-specification.json ./examples/sample-
↪dataflow.json --output-directory ./pipeline-manager-demo
```

After successful build, run:

```
firefox ./pipeline-manager-demo/index.html
```

You should get a graph view similar to the one in the documentation's demo.

2.2.2 Web application

To build Pipeline Manager to work with an external application (like Kenning), in the root directory run:

```
./build server-app
```

For available flags, check:

```
./build server-app -h
```

In this scenario, the backend server is expected to serve the Pipeline Manager content. To do that, in the root directory run:

```
./run
```

By default, the backend server runs on `http://127.0.0.1:5000`. In addition to using the sample specification you can also connect the third-party application (e.g. Kenning), edit its pipeline, validate it and run it.

2.2.3 Miscellaneous

Development

To run a development server which automatically recompiles the project after detecting any changes, in `./pipeline_manager/frontend` directory run:

```
npm run serve-static
```

in case of a static mode, and run:

```
npm run serve
```

in case of a regular web application mode.

Validation

Pipeline Manager also includes a validation tool you can use during specification and dataflow development.

To validate an existing specification, run the following in the root directory:

```
./validate <specification-path>
```

To validate an existing specification and one or more dataflows, run the following in the root directory:

```
./validate <specification-path> <dataflow-path> <dataflow-path> ...
```

Replace both `specification-path` and `dataflow-path` with the actual paths to the JSON configuration file you want to validate. When running the validation tool for the first time, make sure to include the `--instal-dependencies` flag.

Cleanup

To remove the installed `npm` dependencies and the built application, run the following in the root directory:

```
./cleanup
```

2.2.4 Using Pipeline Manager as a Python module

To install Pipeline Manager with `pip`, run:

```
pip install -U git+https://github.com/antmicro/kenning-pipeline-manager.git
```

To work directly with the repository, install the module with:

```
pip install -e .
```

All Pipeline Manager scripts can then be used from the command-line interface:

```
pipeline_manager
usage: pipeline_manager {build,run,validate,cleanup}
```

CHAPTER

THREE

SPECIFICATION FORMAT

Pipeline Manager requires a JSON specification that defines the working environment. It specifies all nodes, properties, available connections, and metadata for the editor. It can be either provided from a file or fetched from an *external application*.

Such a specification defining the nodes needs to be loaded through the front end in order for you to be able to load any dataflow.

3.1 Format description

The specification needs to be provided in a JSON file. The specification consists of:

- `metadata` - object of type *Metadata* that specifies editor styling and metadata
- `nodes` - array that specifies valid nodes, where every element is of type *Node*.
- `graphs` - array of dataflow-like objects defining graph nodes, of type *Graph*.
- `include` - array of string objects pointing to a remote url to the specifications to include.
- `includeGraphs` - array of objects of type *Included Graph*, that specifies graph instances to be included in the specification from a remote url.
- `version` - string determining version of the specification. Should be set to the newest version described in *Changelogs*. Pipeline Manager uses that value to check the compatibility of the specification with the current implementation, giving warnings about inconsistency in versions.

Note: Graph node named `New Graph Node` is available by default after loading a specification. It can be used to create new, custom graphs. That is why using this name for a graph will result in an error.

3.1.1 Metadata

This object specifies additional editor options and contains the following optional properties:

- `interfaces` - a dictionary which defines interface and connection styling for particular interface types. The key in the dictionary is the name of the interface type, and the value is of type *Interface style*.
- `allowLoopbacks` - boolean value that determines whether connections with endpoints at the same node are allowed. Default value is `false`.
- `readonly` - boolean value determining whether the editor is in read-only mode. In read-only mode, the user cannot create or remove nodes and connections. Modification of any properties is also disabled. The user is only allowed to load existing dataflows. Default value is `false`.
- `twoColumn` - boolean value determining the layout of the nodes. If set to `true`, then input and output sockets are both rendered in the top part of the node and properties are displayed below. Default value is `false`.
- `connectionStyle` - string value that determines the connection style. Can choose one out of the two options: `curved` or `orthogonal`. Default value is `curved`
- `hideHud` - boolean value determining whether UI elements should be hidden. Components affected by this flag are: popup notifications, navigation bar and terminal window. Default value is `false`
- `layers` - layers specifying groups of interfaces and nodes that can be hidden in the viewer from settings level. The entries are of type *Layer*. By default there are no layers.
- `urls` - list of URL classes present in the specification and flow. It is a dictionary, where key is the name of the URL class, and value is of type *URL class specification*. The given URL classes can be referred to later in *Nodes* with proper link suffix.
- `collapseSidebar` - boolean value determining whether nodes sidebar should be collapsed by default. Default value is `true`
- `movementStep` - Defines offset to which nodes snap in the grid. Default value is `1`.
- `backgroundSize` - Defines size of the background grid. Default value is `100`.
- `layout` - String specifying the name of autolayout algorithm used in placing nodes from dataflow Default value is `NoLayout`
- `icons` - contains definition of icon classes. Icon classes are key-value pairs, where key is the name of the icon class, and value is the URL prefix that is used to compute the actual path.
- `navbarItems` - list of buttons that are displayed in the navbar in `server-app` mode, that allow for calling custom procedures. The entries are of type *Navbar item*.
- `logLevel` - string specifying minimum level of verbosity notification has to have to be displayed. It can be one of `INFO`, `WARNING`, `ERROR`.

An example:

```
"metadata": {
    "interfaces": {
        "Dataset": {
```

(continues on next page)

(continued from previous page)

```
            "interfaceColor": "#FF00FF",
            "interfaceConnectionPattern": "dashed",
            "interfaceConnectionColor": "#FF0000"
        }
    },
    "allowLoopbacks": false,
    "readonly": true,
    "connectionStyle": "orthogonal",
    "hideHud": false,
    "layers": [
        {
            "name": "Example Layer",
            "nodeLayers": ["processing"],
            "nodeInterfaces": ["BinaryImage"]
        }
    ],
    "layout": "NoLayout"
}
```

Layer

Layer is used to describe a set of types of nodes and interfaces. Layers can be used to hide nodes of given types. They can be also used to hide connections for given interface types.

The layers can be enabled or disabled in editor settings.

Every layer has three properties (at least `name` and one of `nodeLayers` or `nodeInterfaces` need to be defined):

- `name` - name of the layer displayed in the editor,
- `nodeLayers` (optional) - array of names of node types that belong to the layer,
- `nodeInterfaces` (optional) - array of names of interface types that belong to the layer.

URL class

URL class provides links with additional information for a given node. They are represented in nodes as icons leading to a URL with additional information on nodes.

The name of the URL class is specified as key in `urls` entry in metadata.

The URL class parameters are following:

- `name` - name of the URL class, appears as hint on hover over the icon,
- `icon` - path to the icon representing the URL class,
- `url` - base URL for URL class. The suffixes for URLs are present in *Node* parameters.

Interface style

Interface style describes how interfaces of a given type should look like, as well as its input or output connections. It consists of the following properties:

- `interfaceColor` - describes the color of the interface, should be a hexadecimal number representing RGB values.
- `interfaceConnectionPattern` - describes how the connection line should look like. The possible variants are `solid`, `dashed` and `dotted`.
- `interfaceConnectionColor` - describes the color of connection lines, should be a hexadecimal number representing RGB values.

Navbar item

Describes a list of custom buttons displayed in the navbar. Every element consists of the following properties:

- `name` - displayed as a tooltip to the user when the button is hovered. Names have to be unique.
- `stopName` - name displayed in the tooltip when the corresponding procedure is running and is stoppable. If not specified simply 'Stop' is added as a prefix to the name.
- `iconName` - name of the icon that is used. It can be either a file in the assets directory, or an icon described in `/pipeline-manager/pipeline_manager/frontend/src/icons/index.ts`.
- `procedureName` - name of the procedure (either a built-in *API procedure* or a *custom procedure*) to be called. It is assumed that the procedure accepts a does not need any arguments, or takes one argument which is the currently displayed dataflow (similarly to [dataflow_run(#external-dataflow-run)]).
- `allowToRunInParallelWith` - a list of procedure names that can be started in parallel to the currently running job.

Example of a button that is used to run the current graph using a dedicated procedure `dataflow_run` looks as follows:

```
{
    "name": "Run",
    "stopName": "Stop",
    "iconName": "Run",
    "procedureName": "dataflow_run",
    "allowToRunInParallelWith": [
        "dataflow_validate",
        "custom_lint_files"
    ]
}
```

This will create a button called Run, with the `Run` icon (available built-in icon), which upon clicking will run `dataflow_run` method. During execution of the `dataflow_run` method, we can run in parallel `dataflow_validate` and `custom_lint_files` procedures.

Note: By default, only single action can be called from NavBar at a time.

Warning: `allowToRunInParallelWith` is a one-way relation. This means that if we have two actions that can be started when the other one is running, then `allowToRunInParallelWith` needs to be defined in both actions.

3.1.2 Node

This object specifies a single node.

- `name` - name displayed in the editor.
- `layer` - layer type used for styling and toggling the node visibility in the editor.
- `category` - context menu category displayed in the editor.
- `icon` - name of an SVG icon that is going to be displayed next to the name of the node. The value of `icon` can be:
  - `string` containing the path to the icon relative to the `assets` directory, e.g. `filter.svg` for `pipeline_manager/frontend/dist/assets/filter.svg`
  - `string` containing the URL to the remote image file
  - `{"key": "value"}` pair, where `key` is the name of the icon class created in `icons`, in *Metadata*, and `value` is a suffix of the URL.

  Note: The `assets` directory can be created and filled manually or added by `build` script with `--assets-directory <path-to-directory-with-icons>`, e.g.:

  ```
  ./build --assets-directory examples/sample-assets static-html static-html␣
  ↪examples/sample-specification.json
  ```

- `interfaces` - array representing inputs, outputs and bidirectional ports for nodes. The entries are of type *Interface*.
- `properties` - array with elements of type *Property*,
- `interfaceGroups` - array with elements of type *Interface Groups*,
- `defaultInterfaceGroups` - array of objects that specifies which interface groups are enabled by default. Every object should contain a `name` and `direction` of an *Interface Groups*.
- `urls` - a dictionary of *URL class* and URL suffixes pairs. The key should be a URL class key from `urls` in `metadata`. The value of the entry is appended to the URL base from the URL class.
- `abstract` - boolean determining whether the node type is abstract or not. Abstract node types are used only for inheritance purposes, they do not appear in the final list of available nodes. They only have one mandatory field - `name`. The rest of the fields can be provided to introduce some common properties of classes inheriting from it.

- `additionalData` - can be any JSON-like object (array, dictionary, number, string, ...), it is only used for storing some additional, node-specific data, such as comments etc.
- `description` - description of the node in markdown format that is displayed in a sidebar node.
- `isCategory` - determines whether the node is both a category and a node. If set to true, then the `name` of the node is inferred from the last text segment in the `category` parameter. If any node has a node category in its `category` path then it has to extend from the nearest ancestor category node. Additionally, if a node extends from a category node, then it has to be in its subtree.

Some or all of the properties above (except for `name`) can be derived from existing node types using the `extends` list - check *Node type inheritance*.

Here is an example of a node:

```
{
    "name": "Filter2D",
    "layer": "filters",
    "category": "Filters",
    "icon": "filter.svg",
    "description": "Node that applies a *2D* filter.",
    "properties": [
        {
            "name": "iterations",
            "type": "integer",
            "default": 1
        },
        {
            "name": "border type",
            "type": "select",
            "values": ["constant", "replicate", "wrap", "reflect"],
            "default": "constant"
        }
    ],
    "interfaces": [
        {
            "name": "image",
            "type": "Image",
            "direction": "input"
        },
        {
            "name": "kernel",
            "type": "Image",
            "direction": "input"
        },
        {
            "name": "output",
            "type": "Image",
            "direction": "output"
        }
    ]
```

(continues on next page)

(continued from previous page)

```
}
```

Interface

An object that specifies a single input, output or inout interface of node. Every interface object has following properties:

- `name` - name of the input displayed in the editor
- `type` - type of the input used for styling and validation purposes. Can be either a list of strings or a single string. If two interfaces have at least one matching type, they can be connected. The first type in the list is a "base" type - it is used to color the interface based on *Interface style*. If only one type between two interfaces is matching, the connection style matches the one defined for this particular type. Otherwise, if multiple types are matching, a white solid line for connection is rendered.
- `direction` (optional) - type of the interface in terms of direction, it can be:
  - `input` - interface accepts input data,
  - `output` - interface returns output data.
  - `inout` - interface can both produce outputs and receive inputs.

  The default value is `inout`.
- `maxConnectionsCount` (optional) - specifies the maximum allowed number of connections for a given port. Value less than 0 means no limit for connections for a given interface. Value equal to 0 means default behavior - one allowed connection to inputs, many allowed connections from outputs. The default value is 0.
- `side` (optional) - specifies the side on which the interface is rendered. Value can be either `left` or `right`. Interfaces with `direction` set to `input` or `inout` are by default rendered on the left side of the node. Interfaces with `direction` set to `output` are by default rendered on the right side of the node.
- `dynamic` (optional) - determines whether the interface should be dynamic, which means that the number of interfaces created of this definition can be changed in the editor. For each dynamic interface definition, a new property is added to the node that allows the user to change the number of interfaces. The name of the property is determined by the `name` and `direction` of the dynamic interface. The format is `{name} {direction} count`, so it is important not to create conflicting properties. The name of the dynamic interfaces is `{name}[{i}]`, where `i` is the index of the interface. `dynamic` property can be either `true`, then the maximum number of interfaces is not limited, or an array in a form of `[min, max]` that specifies the range of interfaces. All created interfaces share the same `maxConnectionCount` and `type` values.
- `array` (optional) - special keyword to easily define a range of interfaces. Value has to be a list with two integer values that specify the range of interfaces. For example, for an `example` interface with `array: [0, 2]` two interfaces called `example[0]` and `example[1]` are created.
- `sidePosition` (optional) - specifies the row on which the interface is rendered. Values for interfaces of the same `side` value have to be unique. If the value is not provided then

rows are automatically provided by iterating from the first upper row. This value does not work for `array` keyword, as it produces more than one interface.

- `externalName` (optional) - used for graph nodes only, to expose an interface of a node within the graph. It specifies the name of the interface of the graph. Both the interface of the graph node and the interface of the node within the graph must have the same `id` and `direction` fields. Note that values of `externalName` of the graph node have to be unique.

Note: Only interfaces of the same `type` can be connected together.

Property

An object that specifies a single property. Every project object has three required base properties:

- `name` - name of the property.
- `type` - type of the property.
- `default` - specifies a default selected value Its type depends on the `type` chosen.

There are nine possible values for the `type` property.

- `text` - property is a string. A text field is displayed to the user.
- `constant` - property is a string. A non-modifiable text field is displayed to the user.
- `number` - property is a float. A number field is displayed to the user.
- `integer` - property is an int. A number field that only accepts integers is displayed to the user.
- `select` - property is a string with a defined range. It requires a `values` property.
- `bool` - property is a bool. A bool representing boolean value
- `slider` - property is a float with a specified range. It requires `min` and `max` properties.
- `list` - property is a list of arguments of the same type, which can be specified using `dtype`.
- `hex` - property is a string representing base-16 number which has to match the following regex: `/0x[a-fA-F0-9]`.

Additional properties:

- `min` - specifies the left end of a range or minimal value of the base-16 number.
- `max` - specifies the right end of a range or maximal value of the base-16 number.
- `values` - specifies a range of possible values for `select`.
- `dtype` - specifies data type of elements in a `list`. Supported values are `string`, `number`, `integer`, `boolean`.
- `description` - description of the property. In some cases, it can be displayed to the user.
- `group` - object of type *Group*.

Group

Array with elements of type *Property*. It defines properties that are toggled by the property. `group` can only be used with property of type `bool`.

Example group of properties:

```
{
    "name": "Group", "type": "bool", "default": true, "group": [
        {"name": "prop-a", "type": "integer", "default": 1},
        {"name": "prop-b", "type": "text", "default": ""}
    ]
}
```

Node type inheritance

It is possible to inherit:

- `layer`
- `category`
- `icon`
- `interfaces`
- `properties`
- `urls`

From existing node types using the `extends` parameter. The parameter accepts a list of node types. The node type is computed by iteratively updating node type definition structures, going through all node types in the `extends` list (in the specified order), and then applying parameters from the current node type.

Below is a sample specification with used inheritance mechanism:

```
{
    "nodes": [
        {
            "name": "Type A",
            "layer": "class",
            "category": "Classes",
            "properties": [
                {"name": "prop-a", "type": "text", "default": ""}
            ],
            "interfaces": [
                {"name": "output-a", "type": "Interface", "direction": "output"}
            ]
        },
        {
            "name": "Type B",
            "extends": ["Type A"],
            "properties": [
```

(continues on next page)

(continued from previous page)

```
                {"name": "prop-b", "type": "text", "default": ""}
            ],
            "interfaces": [
                {"name": "output-b", "type": "Interface", "direction": "output"}
            ]
        },
        {
            "name": "Type C",
            "layer": "class",
            "category": "Classes",
            "properties": [
                {"name": "prop-c", "type": "text", "default": ""}
            ],
            "interfaces": [
                {"name": "input-c", "type": "Interface", "direction": "input"}
            ]
        },
        {
            "name": "Type D",
            "extends": ["Type B", "Type C"],
            "properties": [
                {"name": "prop-d", "type": "text", "default": ""}
            ],
            "interfaces": [
                {"name": "inout-d", "type": "Interface", "direction": "inout"}
            ]
        }
    ]
}
```

Warning: Node types can not be repeated (explicitly in list or implicitly through inheritance) in the `extends` list.

Moreover, it is possible to override inherited properties and interfaces. This mechanism requires using the same name and `"override"` attribute set to `true`. Only attributes used in the child node are overridden, others are inherited without change. For instance:

```
        {
            "name": "Type D",
            "extends": ["Type B", "Type C"],
            "properties": [
                {"name": "prop-a", "type": "number", "default": 1.4, "override":␣
↪true},
                {"name": "prop-c", "type": "integer", "default": 5, "override":␣
↪true},
                {"name": "prop-d", "type": "text", "default": ""}
            ],
            "interfaces": [
```

(continues on next page)

(continued from previous page)

```
                {"name": "inout-d", "type": "Interface", "direction": "inout"},
                {"name": "output-a", "type": "Interface", "direction": "inout",
↪"override": true}
            ]
        }
```

3.1.3 Interface Groups

Object similar to a single interface but reserves a range of interfaces. `name`, `type`, `direction`, `maxConnectionsCount` and `side` are the same as in a regular *Interface*. The only difference is that a range of interfaces has to be defined which describes constraints of an interface. For example two interface groups can be defined that consist of common interfaces and thus cannot coexist.

```
"interfaceGroups": [
  {
    "name": "1",
    "type": "test",
    "direction": "input",
    "interfaces": [
      {"name": "1[1]", "direction": "output"},
      {"name": "1", "array": [3, 15], "direction": "output"},
      {"name": "1", "array": [35, 48], "direction": "output"}
    ]
  }
]
```

The interface group called `1` consists of three ranges of interfaces: `1[1]`, interfaces `1[3]`, `1[4]`, `...`, `1[14]` and `1[35]`, `1[36]`, `...`, `1[47]`.

3.1.4 Included Graphs

Object that specifies a graph instance to be included in the specification. The included graphs are available in the node palette and can be used in the editor.

Note: Included graphs cannot consist of more than one graph.

- `name` - name of the included graph, if not passed, the name of the graph is inferred from the graph.
- `category` - category in which the included graph is placed in the node palette, uses `/` as a delimiter. By default, the category is set to `default`.
- `url` - URL, where the graph file is located. The file has to be in a valid *dataflow* format.

3.2 Example

Below, you can see a sample specification containing a hypothetical definition of nodes for image processing purposes:

```
{
    "nodes": [
        {
            "name": "LoadVideo",
            "layer": "filesystem",
            "category": "Filesystem",
            "properties": [
                {"name": "filename", "type": "text", "default": ""}
            ],
            "interfaces": [{"name": "frames", "type": "Image", "direction":
↪"output"}]
        },
        {
            "name": "SaveVideo",
            "layer": "filesystem",
            "category": "Filesystem",
            "properties": [
                {"name": "filename", "type": "text", "default": ""}
            ],
            "interfaces": [
                {"name": "color", "type": "Image", "direction": "input"},
                {"name": "binary", "type": "BinaryImage", "direction": "input"}
            ]
        },
        {
            "name": "GaussianKernel",
            "layer": "kernel",
            "category": "Generators",
            "properties": [
                {"name": "size", "type": "integer", "default": 5},
                {"name": "sigma", "type": "number", "default": 1.0}
            ],
            "interfaces": [{"name": "kernel", "type": "Image", "direction":
↪"output"}]
        },
        {
            "name": "StructuringElement",
            "layer": "kernel",
            "category": "Generators",
            "properties": [
                {"name": "size", "type": "integer", "default": 5},
                {
                    "name": "shape",
                    "type": "select",
                    "values": ["Rectangle", "Cross", "Ellipse"],
```

(continues on next page)

(continued from previous page)

```
                    "default": "Cross"
                }
            ],
            "interfaces": [{"name": "kernel", "type": "BinaryImage", "direction":
↪"output"}]
        },
        {
            "name": "Filter2D",
            "layer": "processing",
            "category": "Processing",
            "properties": [
                {"name": "iterations", "type": "integer", "default": 1},
                {
                    "name": "border type",
                    "type": "select",
                    "values": ["constant", "replicate", "wrap", "reflect"],
                    "default": "constant"
                }
            ],
            "interfaces": [
                {"name": "image", "type": "Image", "direction": "input"},
                {"name": "kernel", "type": "Image", "direction": "input"},
                {"name": "output", "type": "Image", "direction": "output"}
            ]
        },
        {
            "name": "Threshold",
            "layer": "processing",
            "category": "Processing",
            "properties": [
                {"name": "threshold_value", "type": "integer", "default": 1},
                {
                    "name": "threshold_type",
                    "type": "select",
                    "values": ["Binary", "Truncate", "Otsu"],
                    "default": "constant"
                }
            ],
            "interfaces": [
                {"name": "image", "type": "Image", "direction": "input"},
                {"name": "output", "type": "BinaryImage", "direction": "output"}
            ]
        },
        {
            "name": "Morphological operation",
            "layer": "processing",
            "category": "Processing",
            "properties": [
                {
```

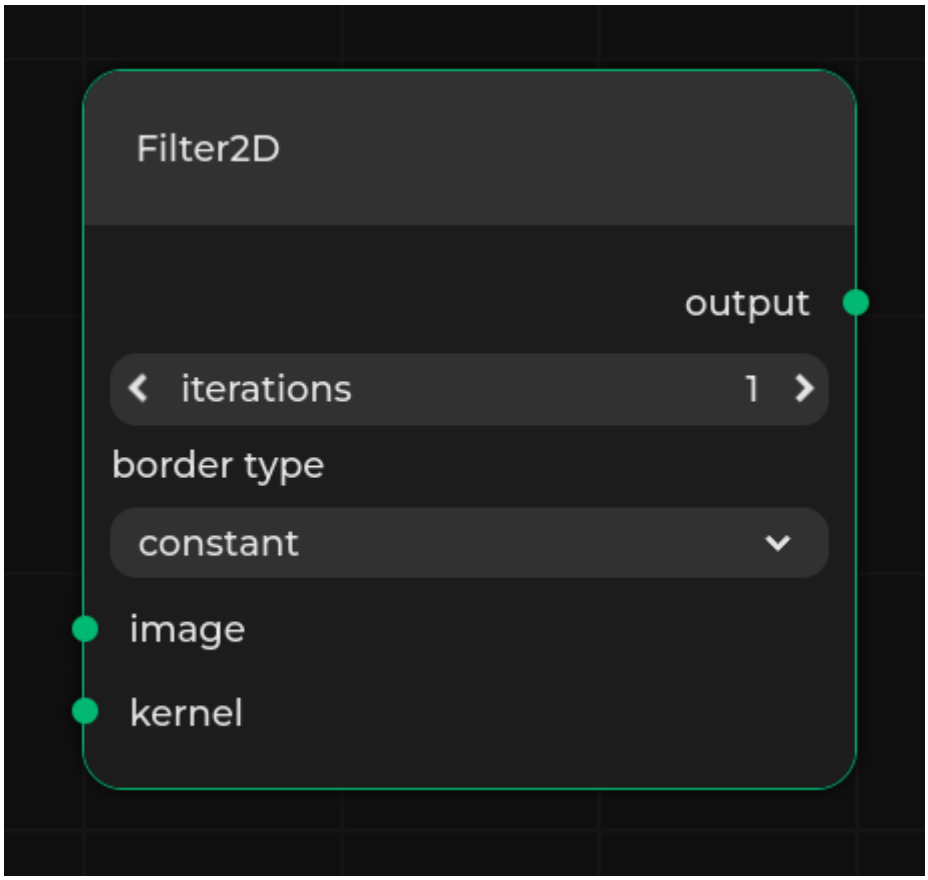
(continues on next page)

(continued from previous page)

```
                    "name": "Enable operations", "type": "bool", "default": true,
↪"group": [
                        {"name": "iterations", "type": "integer", "default": 1},
                        {
                            "name": "border type",
                            "type": "select",
                            "values": ["constant", "replicate", "wrap", "reflect
↪"],
                            "default": "constant"
                        },
                        {
                            "name": "operation type",
                            "type": "select",
                            "values": ["dilation", "erosion", "closing", "opening
↪"],
                            "default": "dilation"
                        }
                    ]
                }
            ],
            "interfaces": [
                {"name": "image", "type": "BinaryImage", "direction": "input"},
                {"name": "kernel", "type": "BinaryImage", "direction": "input"},
                {"name": "output", "type": "BinaryImage", "direction": "output"}
            ]
        }
    ],
    "metadata": {
        "interfaces": {
            "Image": "#00FF00",
            "BinaryImage": "#FF0000"
        }
    },
    "version": "20230830.10"
}
```

Thanks to the flexibility of the specification format, you can use any combination of properties and interfaces to create a custom node. It is also readable and divided into distinct parts, so you can implement a process of automated specification generation into an external application. See the *External App Communication* section to find out more.

A sample node created from the specification above:


Filter2D
output
iterations
1
border type
constant
image
kernel

CHAPTER

FOUR

DATAFLOW FORMAT

A rendered graph with all its nodes, their properties, values, and connections is called a dataflow. Its state can be serialized and saved as a JSON file.

4.1 Format description

The root of the dataflow format consists of four main attributes.

- `metadata` - structure of type *Metadata*. It is used to override metadata settings from the *Specification format*. In general, values from dataflow's `metadata` override settings from specification. For simple types, such as strings or integers, values are changed. For arrays and dictionaries, the values are updated (values of existing keys are replaced with new ones, and the new values in arrays are appended to the existing entries).
- `entryGraph` - string that specifies the ID of the graph from `graphs` list that should be rendered when the dataflow is loaded. If not specified, the first graph in the list is rendered.
- `graphs` - array of objects of type *Graph* that describe available graphs in the dataflow. Each graph is a separate entity that can be rendered in the editor. If `entryGraph` is not specified, the first graph in the list is rendered when the dataflow is loaded.
- `version` - string that identifies the version of the specification and dataflow. It is used to check compatibility between provided dataflow and the current version of the implementation.

4.1.1 Graph

Graphs are a way to encapsulate a part of the dataflow into a separate entity. They can be used to simplify the dataflow structure, group nodes, or create reusable components. On the frontend level, graphs are rendered as distinct nodes, which can be interacted with in the same way as standard nodes, but can be entered and expanded to show the content of the subgraph. On top of that, interfaces of such graph nodes may be exposed and accessed outside the graph, allowing to create more complex, multi-layer graph structures.

Each graph can be described with the following properties:

- `id` - unique value that identifies the graph.
- `name` - human-readable name of the graph.
- `additionalData` - any JSON-like data that provides additional information regarding the graph.

- `nodes` - array that specifies all nodes in the dataflow. Every element is of type *Node*.
- `connections` - array that specifies all connections in the dataflow. Every element is of type *Connection*.
- `panning` - object of type *Panning* that defines the position of the top-left corner in the rendered editor.
- `scaling` - floating-point number that defines the zoom level in the editor.

Node

An object that describes a single node in the editor. Each node has:

- `name` - node name, as defined in the specification.
- `id` - unique value assigned to the node.
- `instanceName` - optional field defining a node's title rendered to the user. If set, `instancename (name)` will be displayed, otherwise, just the `name` will be rendered.
- `properties` - list describing the node's parameterized values. Every element is of type *Property*.
- `interfaces` - list describing the node's interfaces. Every element is of type *Interface*.
- `width` - the node's width in the editor.
- `twoColumn` - boolean value. If set to `true`, the interfaces on opposite sides will be arranged parallel to each other. Otherwise, each interface will be positioned on a separate line.
- `subgraph` - optional field defining the `id` of the subgraph that this node represents. It refers to one of the *Graphs* entries from `graphs` with a matching `id`.
- `enabledInterfaceGroups` - optional array describing enabled interface groups. Every element is of type *Enabled Interface Groups*.

Property

Each property is described by an object with three attributes:

- `id` - unique value assigned to the property
- `name` - name of the property
- `value` - actual value of the property.

Node having two parameters: `example_text` of value `example_value` and `example_number` of value `123` would have the following `options` value:

```
[
    {
        "id": 1,
        "name": "example_text",
        "value": "example_value"
    },
    {
```

(continues on next page)

(continued from previous page)

```
        "id": 2,
        "name": "example_number",
        "value": 123
    }
]
```

Interface

Each input, output, and inout is described by an object with the following attributes:

- `id` - unique value assigned to the property. It is used to describe connections in the dataflow.
- `name` - name of the interface
- `direction` - value determining the type of the interfaces. Can be either `input`, `output`, or `inout`.
- `side` - tells on which side of the node the interface should be placed.
- `sidePosition` - specifies a row on which the interface is rendered. Values for interfaces of the same `side` value have to be unique.
- `externalName` - name of the interface displayed in the editor. For every interface in each node, it is possible to make it a graph interface. A graph interface has its own unique external name, which is visible when the graph is nested within another graph. It is used to create multi-layer graphs, with subgraphs that can be connected to others nodes/graphs. Both the interface of the graph node and the interface of the node within the graph have the same `id` and `direction` fields. Note that values of `externalName` within the graph have to be unique.

Example of graph interfaces:

```
{
    "graphs": [
        {
            "id": "9c4d5349-9d3b-401f-86bb-021b7b3e5b81",
            "nodes": [
                {
                    "id": "0bfba841-a1e8-429c-aa8a-d98338339960",
                    "position": {
                        "x": 0,
                        "y": 0
                    },
                    "width": 200,
                    "twoColumn": false,
                    "interfaces": [
                        {
                            "name": "Exposed Name",
                            "id": "29cd9a27-2b49-4ae7-a164-a574c07fc684",
                            "direction": "input",
                            "side": "left",
```

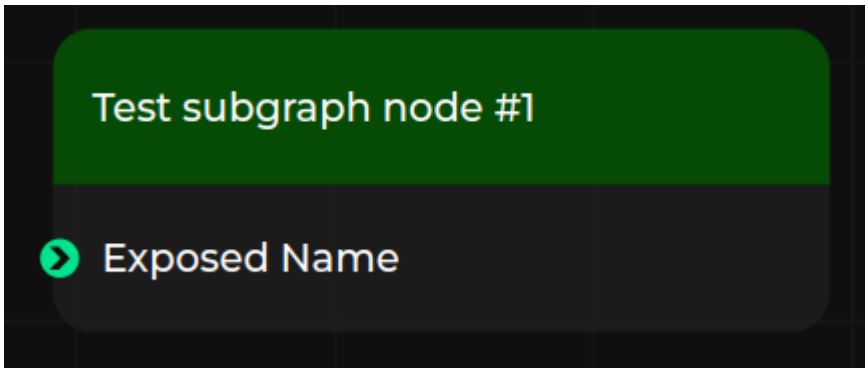
(continues on next page)

(continued from previous page)

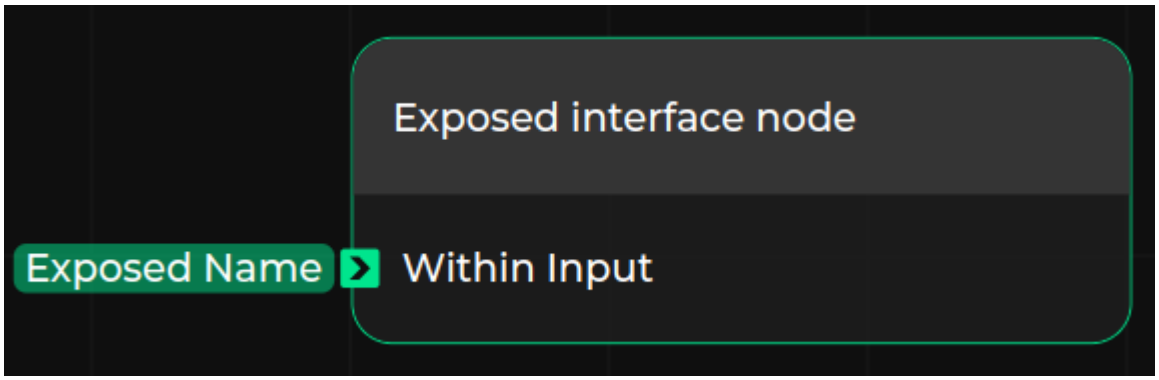

```
                            "sidePosition": 0
                        }
                    ],
                    "subgraph": "569edd54-0f42-4c24-a809-1509febbe23a",
                    "name": "Test subgraph node #1"
                }
            ],
            "connections": []
        },
        {
            "id": "569edd54-0f42-4c24-a809-1509febbe23a",
            "nodes": [
                {
                    "id": "56910b7a-9fe9-4db1-9d19-71037711d718",
                    "position": {
                        "x": 871,
                        "y": 316
                    },
                    "width": 200,
                    "twoColumn": false,
                    "interfaces": [
                        {
                            "name": "Within Input",
                            "externalName": "Exposed Name",
                            "id": "29cd9a27-2b49-4ae7-a164-a574c07fc684",
                            "direction": "input",
                            "side": "left",
                            "sidePosition": 0
                        }
                    ],
                    "name": "Exposed interface node"
                }
            ],
            "connections": []
        }
    ],
    "entryGraph": "9c4d5349-9d3b-401f-86bb-021b7b3e5b81",
    "version": "20240723.13"
}
```


The example consists of two graphs. The first graph of id `9c4d5349-9d3b-401f-86bb-021b7b3e5b81` consists of a single graph node with an interface of id `29cd9a27-2b49-4ae7-a164-a574c07fc684`. The node represents a graph of id `569edd54-0f42-4c24-a809-1509febbe23a`, which is a graph with a single node with an interface of id `29cd9a27-2b49-4ae7-a164-a574c07fc684`. The interface of the graph node is exposed as `Exposed name` thanks to which it can be accessed from the outside of the graph. Because the interface is exposed, both of those interfaces have to have the same `id` and `direction` value.

Graph node:



Node within graph:



Connection

Object that describes a singular connection. It has three attributes:

- `id` - unique value assigned to the connection
- `from` - the connection's output interface id
- `to` - the connection's input interface id.
- `anchors` - optional list of *Anchor* objects.

Anchor

This object describes a single anchor that is used to render connections divided into subparts. Every part of the connection is rendered between two adjacent anchors. Two attributes are used:

- `x` - x coordinate of the anchor
- `y` - y coordinate of the anchor.

Panning

This object describes the position of the top-left corner of the rendered editor in the browser. Defines the camera position in the editor space. Two attributes are used:

- `x` - x coordinate of the corner
- `y` - y coordinate of the corner.

Enabled Interface Groups

Each enabled interface group is described by the following properties:

- `name` - name of the interface group
- `direction` - value determining the type of the interfaces. Can be either `input`, `output` or `inout`.

> **Warning:** Make sure that enabled interface groups use disjoint interfaces.

4.2 Example dataflow

The example dataflow for a specification defined in *Specification format* is defined as below:

```
{
    "graphs": [
        {
            "id": "2035108300",
            "nodes": [
                {
                    "name": "Filter2D",
                    "id": "node_168064109167511",
                    "position": {
                        "x": 544,
                        "y": 77
                    },
                    "width": 200,
                    "twoColumn": false,
                    "interfaces": [
                        {
                            "name": "image",
                            "id": "ni_168064109167612",
                            "direction": "input"
                        },
                        {
                            "name": "kernel",
                            "id": "ni_168064109167613",
                            "direction": "input"
                        },
```

(continues on next page)

(continued from previous page)


```
                    {
                        "name": "output",
                        "id": "ni_168064109167714",
                        "direction": "output"
                    }
                ],
                "properties": [
                    {
                        "name": "iterations",
                        "id": "8434027854",
                        "value": 1
                    },
                    {
                        "name": "border type",
                        "id": "7165552813",
                        "value": "constant"
                    }
                ],
                "instanceName": "Filter"
            },
            {
                "name": "LoadVideo",
                "id": "node_168064220761015",
                "position": {
                    "x": -60,
                    "y": -36
                },
                "width": 200,
                "twoColumn": false,
                "interfaces": [
                    {
                        "name": "frames",
                        "id": "ni_168064220761016",
                        "direction": "output"
                    }
                ],
                "properties": [
                    {
                        "name": "filename",
                        "id": "8887517324",
                        "value": "input.mp4"
                    }
                ]
            },
            {
                "name": "GaussianKernel",
                "id": "node_168064222522321",
                "position": {
                    "x": -65,
```


(continues on next page)

(continued from previous page)


```
                    "y": 295
                },
                "width": 200,
                "twoColumn": false,
                "interfaces": [
                    {
                        "name": "kernel",
                        "id": "ni_168064222522422",
                        "direction": "output"
                    }
                ],
                "properties": [
                    {
                        "name": "size",
                        "id": "1247863780",
                        "value": 5
                    },
                    {
                        "name": "sigma",
                        "id": "0187870808",
                        "value": 1
                    }
                ]
            },
            {
                "name": "Threshold",
                "id": "node_168064225320530",
                "position": {
                    "x": 999,
                    "y": 100
                },
                "width": 200,
                "twoColumn": false,
                "interfaces": [
                    {
                        "name": "image",
                        "id": "ni_168064225320531",
                        "direction": "input"
                    },
                    {
                        "name": "output",
                        "id": "ni_168064225320532",
                        "direction": "output"
                    }
                ],
                "properties": [
                    {
                        "name": "threshold_value",
                        "id": "8770324282",
```


(continues on next page)

(continued from previous page)


```
                        "value": 1
                    },
                    {
                        "name": "threshold_type",
                        "id": "8305532648",
                        "value": "Otsu"
                    }
                ]
            },
            {
                "name": "StructuringElement",
                "id": "node_168064227787336",
                "position": {
                    "x": 1010,
                    "y": 409
                },
                "width": 200,
                "twoColumn": false,
                "interfaces": [
                    {
                        "name": "kernel",
                        "id": "ni_168064227787437",
                        "direction": "output"
                    }
                ],
                "properties": [
                    {
                        "name": "size",
                        "id": "1587558664",
                        "value": 5
                    },
                    {
                        "name": "shape",
                        "id": "1375086555",
                        "value": "Cross"
                    }
                ]
            },
            {
                "name": "Morphological operation",
                "id": "node_168064228786538",
                "position": {
                    "x": 1422,
                    "y": 54
                },
                "width": 200,
                "twoColumn": false,
                "interfaces": [
                    {
```


(continues on next page)

(continued from previous page)


```
                    "name": "image",
                    "id": "ni_168064228786539",
                    "direction": "input"
                },
                {
                    "name": "kernel",
                    "id": "ni_168064228786540",
                    "direction": "input"
                },
                {
                    "name": "output",
                    "id": "ni_168064228786641",
                    "direction": "output"
                }
            ],
            "properties": [
                {
                    "name": "iterations",
                    "id": "0605526715",
                    "value": 1
                },
                {
                    "name": "border type",
                    "id": "2810748353",
                    "value": "constant"
                },
                {
                    "name": "operation type",
                    "id": "8413506138",
                    "value": "dilation"
                }
            ]
        },
        {
            "name": "SaveVideo",
            "id": "node_168064231007448",
            "position": {
                "x": 1773,
                "y": 76
            },
            "width": 200,
            "twoColumn": false,
            "interfaces": [
                {
                    "name": "color",
                    "id": "ni_168064231007449",
                    "direction": "input"
                },
                {
```


(continues on next page)

(continued from previous page)


```
                        "name": "binary",
                        "id": "ni_168064231007450",
                        "direction": "input"
                    }
                ],
                "properties": [
                    {
                        "name": "filename",
                        "id": "3087244218",
                        "value": "output.mp4"
                    }
                ]
            }
        ],
        "connections": [
            {
                "id": "168064222082820",
                "from": "ni_168064220761016",
                "to": "ni_168064109167612"
            },
            {
                "id": "168064222926625",
                "from": "ni_168064222522422",
                "to": "ni_168064109167613"
            },
            {
                "id": "168064225938335",
                "from": "ni_168064109167714",
                "to": "ni_168064225320531"
            },
            {
                "id": "168064230015344",
                "from": "ni_168064225320532",
                "to": "ni_168064228786539"
            },
            {
                "id": "168064230253147",
                "from": "ni_168064227787437",
                "to": "ni_168064228786540"
            },
            {
                "id": "168064231874053",
                "from": "ni_168064228786641",
                "to": "ni_168064231007450"
            }
        ]
        "panning": {
            "x": 0,
            "y": 0
```


(continues on next page)

(continued from previous page)

```
            },
            "scaling": 1
        },
    ]
}
```

The highlighted bits of code represent all code fragments relevant to the `Filter2D` node. In the `nodes` list, there is a full specification of the state of the `Filter2D` node:

- Its unique `id`
- Its `name`
- Its parameters (stored in `parameters`), e.g. `border_type` equal to `constant`
- Its interfaces, with unique `id` representing each input and output
- Rendering data, such as `position` or `width`.

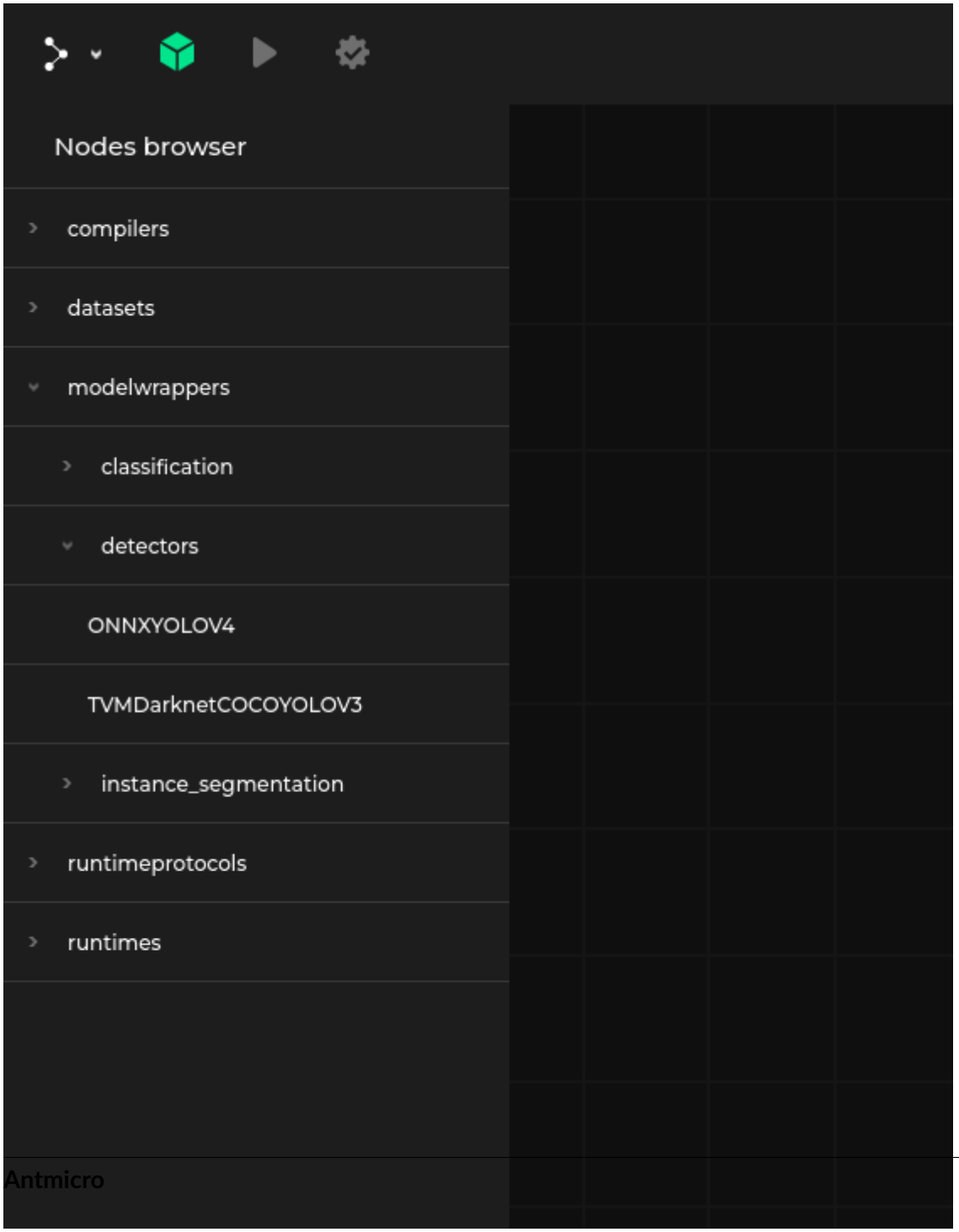
Later, in `connections`, you can see triples representing to which interfaces the interfaces of `Filter2D` are connected.

CHAPTER

FIVE

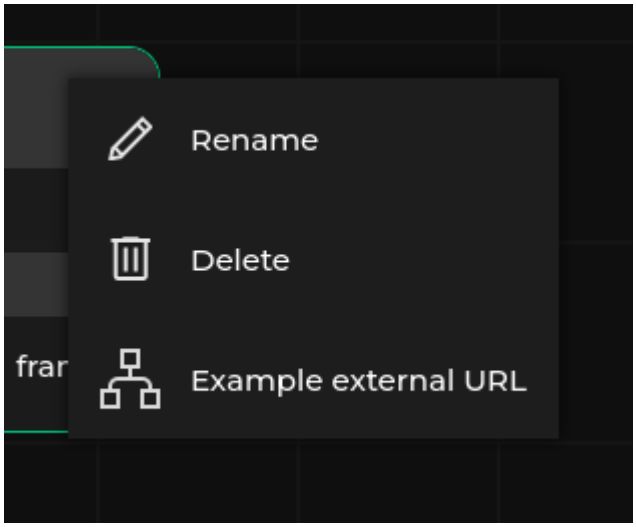
FRONT-END FEATURES

5.1 Graph manipulation



On the left side there is a node palette (which can be turned off or on using the green icon in the upper left corner). To add a new node to the graph, click the node in the palette and drag it to the editor. You can also select existing nodes and copy and paste them using `ctrl-c` and `ctrl-v` keyboard shortcuts.

After loading a specification, the palette will contain all the nodes defined in it and will be divided into hierarchical categories. Additionally, a graph node named `New Graph Node` is always available under a `Graphs` category and can be used to design custom graphs.



In the upper right corner of each node there is a context menu toggle. It contains the following options:

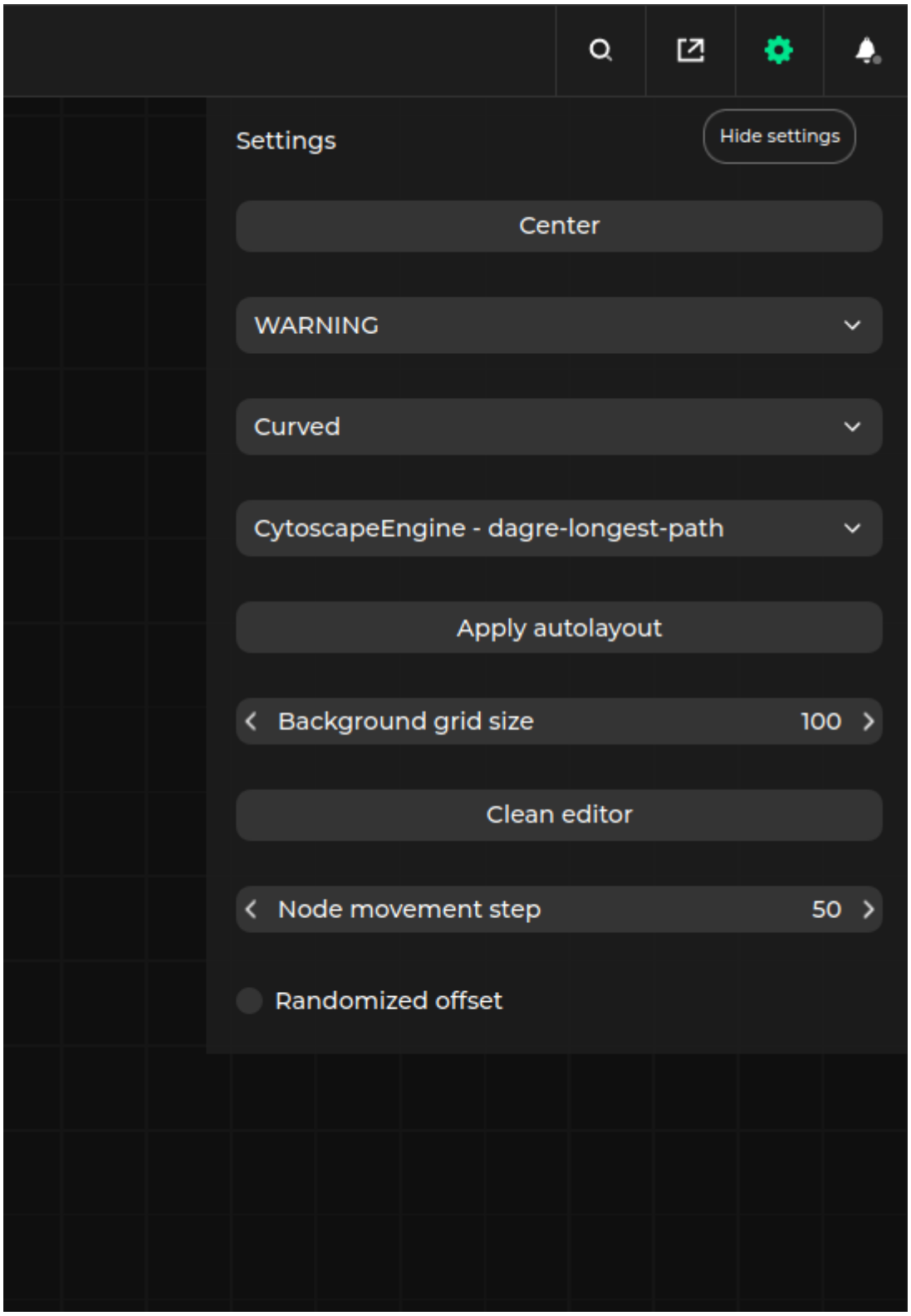
- `Rename` - Changes instanceName of the node. More details regarding node naming can be found in the *'instanceName' field of dataflow format*
- `Delete` - Deletes the node from the dataflow. Another way of deleting nodes is to select and press the `Delete` key.
- Additional, user defined URLs. More details in the *URL specification*

Scroll lets you to zoom in and out. Left-clicking and dragging the editor background allows you to move around the editor area.

Left-clicking on a node allows you to select and drag the node within the editor area. Pressing the `ctrl` key while moving a node allows you to align the node with another one along some axis.

To create a connection, left-click a node's connector and connect it to a connector (of a matching type, see *Specification format*) on another node. Double left-click on an existing connection removes it.

5.2 Settings

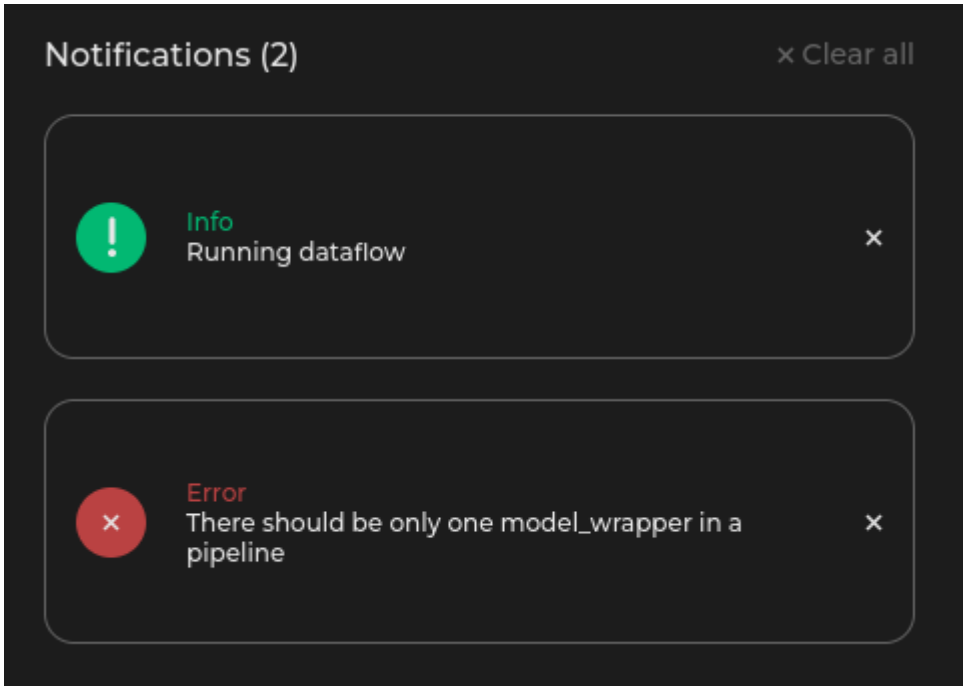


On the upper right corner of Pipeline Manager window there is a gear icon toggling settings tab. In the tab following options can be found:

- `Connection style` - Switch the style of the connection between `orthogonal` and `curved`

- `AutoLayout algorithm` - Choose the algorithm for automatic node placement. Autolayout algorithm is triggered in the following situations:
  - When loading the dataflow autolayout is used to place nodes without the `position` parameter set. Dataflow load can be triggered either via external application or choosing the `Load graph file` option. In this case autolayout is applied to both the main graph and the nodes in the subgraphs.
  - By pressing the `Apply autolayout` button in the settings tab. In this case autolayout is applied to the entire graph.
- `Background grid size` - Sets the size of single grid cell visible in the background
- `Node movement step` - Sets the minimum step size which can be taken along each axis when moving node.
- `Center` - Pressing this buttons moves the viewport to the center of graph and sets the zoom level so that whole dataflow is visible
- `Hide layers` - *Metadata* allows to specify layers for a certain set of interface types and connections. Toggling this checkbox allows to hide connections belonging to said layer

5.3 Notifications

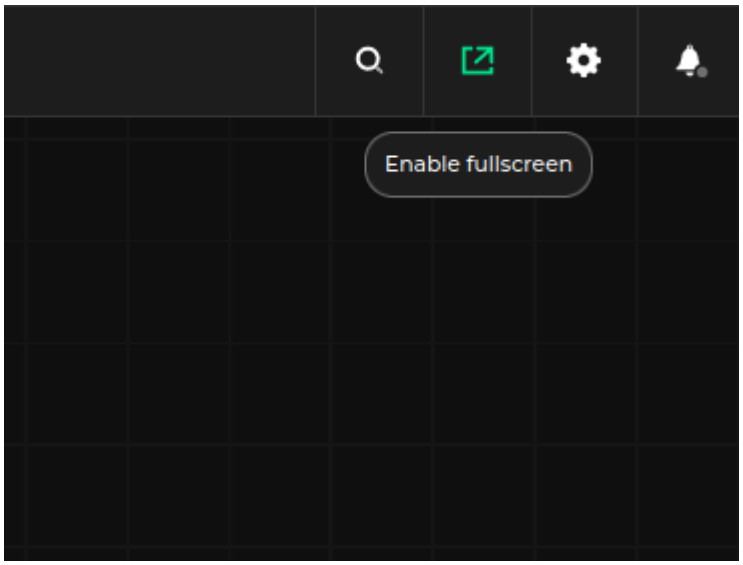


Pipeline Manager provides notifications describing errors occurring in:

- The front end, such as invalid input specification, or invalid dataflow
- The back end (see *Communication with an external application*)

During pipeline development or execution, notifications can display various messages to the user.

5.4 Full screen

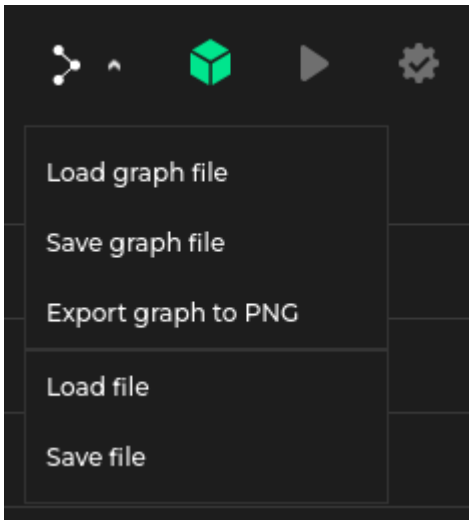


Near the settings tab, there is a full screen icon. Clicking it will expand the Pipeline Manager window to full screen. Note that this feature may be disabled during embedding Pipeline Manager in an external application, make sure to allow full screen mode.

For example, in the case of embedding Pipeline Manager in an iframe, the `allow="fullscreen"` attribute must be set:

```
<iframe src="https://url" allow="fullscreen">
  <p>Your browser does not support iframes.</p>
</iframe>
```

5.5 Editor menu



Depending the application's mode (`static-html` or `server-app`), the following options will be available in the Pipeline Manager menu:

- `Load specification` - lets the user load a specification file describing the nodes that can appear in the graph (see *Specification format*)

Note: It appears only in the `static-html` build mode, where a specification is not delivered by a third-party app.

- `Load graph file` - lets the user load a graph specification in Pipeline Manager's internal format (see *Dataflow specification*).
- `Save graph file` - Saves the graph currently stored in the editor into JSON using Pipeline Manager's internal format.
- `Export graph to PNG` - Saves the graph currently stored in the editor as PNG image
- `Load file` - lets the user load a file describing a graph in the native format supported by the third-party application using Pipeline Manager for visualization.

Note: It appears only in the `server-app` build mode, since the third-party app performs conversion from its native format to the *Dataflow format*

- `Save file` - saves the current graph in a native format supported by the third-party application using Pipeline Manager for visualization.

Note: It appears only in the `server-app` build mode, since the third-party app performs conversion from the *Dataflow format* received from the editor to its native format.

5.6 Working with the server

When Pipeline Manager works in the `server-app` mode, it is connected to an external application, making it possible to manipulate or execute a graph as well as save and load files in the application's native format.

Status of the connection is displayed in the upper right corner of the editor. The color of the icon indicates the status of the connection with the server:

- `Red` - No connection with the server.
- `Green` - Connection with the server is established.

Extrnal application may deliver additional features by providing additional buttons in the editor menu. More details can be found in the *Specification format* section.

5.7 URL parameters for the frontend

The frontend of Pipeline Manager provides a set of URL parameters that can be used to change the specification, graph or default behavior of the application. Those arguments need to be encoded - we need to escape all URL-specific characters. This can be achieved either with `urllib.parse.urlencode` in Python:

```
import urllib.parse

urllib.parse.urlencode({
    "spec": "https://github.com/antmicro/kenning-pipeline-manager/blob/main/
↪examples/sample-specification.json",
    "graph": "https://github.com/antmicro/kenning-pipeline-manager/blob/main/
↪examples/sample-dataflow.json"
})

# RESULT: 'spec=https%3A%2F%2Fgithub.com%2Fantmicro%2Fkenning-pipeline-manager
↪%2Fblob%2Fmain%2Fexamples%2Fsample-specification.json&graph=https%3A%2F
↪%2Fgithub.com%2Fantmicro%2Fkenning-pipeline-manager%2Fblob%2Fmain%2Fexamples
↪%2Fsample-dataflow.json'
```

or with `encodeURIComponent` in Javascript:

```
encodeURIComponent("https://github.com/antmicro/kenning-pipeline-manager/blob/
↪main/examples/sample-specification.json")

// RESULT: 'https%3A%2F%2Fgithub.com%2Fantmicro%2Fkenning-pipeline-manager%2Fblob
↪%2Fmain%2Fexamples%2Fsample-specification.json'
```

Available parameters are as follows:

- `spec` - URL to the specification, by default it can be a HTTP/HTTPS URL.
- `graph` - URL to the graph, by default it can be a HTTP/HTTPS URL.
- `preview` - starts Pipeline Manager in read only mode, without HUD
- `include` - allows to provide includes for the specification.

When it comes to `spec` and `graph`, by default we can use following URI schemes:

- `http://`, `https://`
- `relative://` - picks a path relative to the Pipeline Manager URL

To add more URI schemes, we need to define `VUE_APP_JSON_URL_SUBSTITUTES` variable holding a dictionary mapping scheme name to appropriate template/prefix.

The JSON for URL substitutes can look as follows:

```
{
    "examples": "https://github.com/antmicro/kenning-pipeline-manager/examples/{}"
}
```

And be later be referred to as `examples://sample-specification.json` in URL.

Note: The URI schemes can be passed to `pipeline_manager build` via `--json_url_specification` argument.

5.8 Passing JSON objects directly

There is also a possibility to pass JSON objects directly to the frontend, without having to save them to a file and add to URL.

This can be done by sending POST requests from an external app opening Pipeline Manager, e.g:

```
const iframe = document.getElementById({PipelineManagerIframe});
iframe.contentWindow.postMessage({"type": "specification", "content": data},
↪{PipelineManagerURL});
```

This piece of code opens Pipeline Manager in an iframe and provides it with a `data` JSON object containing the requested specification.

The following message types are supported:

- `specification`
- `dataflow`

The requested JSON object has to be included in the `content` field.

5.9 Testing the front-end features

The best way to test the front-end features is to use the `pipeline_manager.frontend_tester.tester_client`, *Third-party server example*.

CHAPTER

SIX

COMMUNICATION WITH AN EXTERNAL APPLICATION

The communication with an external application is based on a JSON-RPC, BSD sockets and SocketIO. Pipeline Manager implements a TCP server that is listening on a specified port and waiting for the client to connect. Pipeline Manager frontend sends JSON-RPC requests to this server through SocketIO, which redirects messages to connected client for specific actions described in this chapter. External application can also request actions from Pipeline Manager in similar manner.

6.1 Communication protocol

The application layer protocol specifies two blocks:

- `size` - four first bytes form an unsigned integer and tell the size of the content of the message in bytes.
- `content` - the rest of the message holding additional data in JSON-RPC format described in *API Specification*.

The `size` and `content` are stored in big-endian.

6.1.1 Communication structure

By default, Pipeline Manager in `server-app` mode will wait for an external application to connect and then request the specification. If connection is established successfully, Pipeline Manager frontend will check if external application is still connected every 0.5 second. Apart from that, both Pipeline Manager frontend and external application can send requests which pass through Pipeline Manager backend.

Figure 6.1: Communication sequence diagram

As Pipeline Manager part of communication is done with SocketIO, it is based on events, which are precisely defined for both sides and can trigger different actions.

Frontend listens to:

- **api** – received messages are JSON-RPC requests, they are validated with *specification*, executed and generated responds are resend,
- **api-response** – received messages are JSON-RPC responses, they are also validated and returned as result of previous request.

Backend implements the following events:

- **backend-api** – receives all JSON-RPC requests, runs methods and responds,
- **external-api** – redirects messages to external application through BSD socket.

On the other hand, communication between backend and external application is done through BSD socket. To manage this, both sides run socket listener as separate coroutine task, which waits for messages and responds or redirects them.

Following communication structure diagram below, we have:

- blue lines describing *Backend API* request from frontend,
- red lines describing *External App API* request from frontend,
- purple lines describing *Frontend API* request from external application.

Figure 6.2: Communication structure diagram

6.2 Response messages types - sent by the external application

6.2.1 OK

Message of `type` `OK` (0) is used to indicate a success and optionally includes an answer to a previous request. Its `content` may vary depending on the request type.

6.2.2 ERROR

Message of `type` `ERROR` (1) is used to indicate a failure and optionally includes an answer to a previous request. Its `content` may vary depending on the answered request.

6.2.3 PROGRESS

Message of optional `type` `PROGRESS` (2) is used to inform Pipeline Manager about the status of a running dataflow. The `PROGRESS` message type can only be used once a message of type `RUN` is received and can be sent multiple times before sending a final response message of type either `ERROR` or `OK` that indicates the end of the run. The progress information is conveyed in `content` using a number ranging `0 - 100` encoded in UTF-8 that signals the percentage of completion of the run. See *RUN* for more information.

6.2.4 WARNING

Message of `type` `WARNING` (3) is used to indicate a success but also alerts of a condition that might cause a problem in the future. It optionally includes an answer to a previous request. Its `content` may vary depending on the answered request.

6.3 API Specification

6.3.1 Frontend API

graph_get

Returns dataflow used by frontend

- **`params`**: Refer to null_or_empty.
- **`result`**: Refer to dataflow_object.

node_get

Procedure to read node state

- **`params`**
  - **All of**
    - Refer to node_object.
- **`result`** *(object)*: Cannot contain additional properties.
  - **`node`** *(object, required)*: State of the node.

properties_get

Procedure to alter values of a node

- **`params`** *(object)*: Cannot contain unevaluated properties.
  - **All of**
    - Refer to node_object.
  - **`properties`** *([array, null])*: Properties which values are going to be read specified by either a name of id. If undefined then all properties are returned.
    - **Items** *(object)*
      - **One of**
        - *object*: Cannot contain additional properties.
          - **`id`** *(string, required)*: Id of the property to read.
        - *object*: Cannot contain additional properties.
          - **`name`** *(string, required)*: Name of the property to read.
- **`result`** *(array)*
  - **Items** *(object)*: Values of the searched properties. Cannot contain additional properties.
    - **`id`** *(string, required)*: Id of the property.
    - **`name`** *(string, required)*: Name of the property.

    * **value**: Value of the property. Its type depends on the property.

properties_change

Procedure to alter properties of a node

- **params**: Refer to properties_diff.
- **result**: Refer to null_or_empty.

position_change

Procedure to alter position of a node

- **params**: Refer to position_diff.
- **result**: Refer to null_or_empty.

nodes_change

Procedure to add and delete nodes

- **params**: Refer to nodes_diff.
- **result**: Refer to null_or_empty.

connections_change

Procedure to add and delete connections

- **params**: Refer to connections_diff.
- **result**: Refer to null_or_empty.

graph_change

Procedure to add and delete nodes

- **params**: Refer to dataflow_object.
- **result**: Refer to null_or_empty.

progress_change

Notification with progress of job ran by external application

- **params** *(object)*: Parameters for notification. Cannot contain additional properties.
  - **method** *(string, required)*: Name of the method used to run the job.
  - **progress** *(number, required)*: Progress of job ran be external application. If between 0 and 100 progress will be set and if -1, animation will ran.

metadata_change

Updates the editor's metadata

- **params**: Refer to metadata.

viewport_center

Center the editor

- **params**: Refer to null_or_empty.

terminal_add

Create new terminal instance

- **params** *(object)*: Parameters for request.
  - **name** *(string, required)*: Unique name for the new terminal instance. This name is used for any communication.
  - **readonly** *(boolean)*: Specifies whether the terminal should be read-only, or editable by user. Default: `true`.
- **result**: Refer to null_or_empty.

terminal_write

Writes a message line to a terminal instance. Allows to send both text and hterm's control sequences. For more details on available control sequences check hterm Control Sequences.

> **Warning:** Since data is sent in JSON format, the hexadecimal values need to be escaped with `\u`, not `\x`, e.g. `\u001b[38:2:238:178:17mexample`.

- **params** *(object)*: Parameters for request.
  - **name** *(string, required)*: Name of the terminal to which the message is written.
  - **message** *(string, required)*: Message to be written to the terminal.
- **result**: Refer to null_or_empty.

notification_send

Sends a notification to the frontend. It will display the message both in the notifications and in the default terminal

- **params** *(object)*: Parameters for notification.
  - **type**: Type of the notification. Must be one of: `["error", "warning", "info"]`.
  - **title** *(string, required)*: Title of the notification, appearing both in the terminal and notification.

    - **details** *(string, required)*: Details of the notification, displayed only in the terminal.
- **result**: Refer to null_or_empty.

specification_change

Procedure to update specification

- **params**: Refer to specification_object.
- **result**: Refer to null_or_empty.

6.3.2 Backend API

status_get

Returns status of connection with external application

- **params**: Refer to null_or_empty.
- **result** *(object)*: Description of backend status. Cannot contain additional properties.
    - **status** *(object, required)*: Status. Cannot contain additional properties.
        * **connected** *(boolean, required)*: Connection with external application.

external_app_connect

Request to wait till connection with external application is established

- **params**: Refer to null_or_empty.
- **result**: Refer to empty.

connected_frontends_get

Request the number of connected fronteds

- **params**: Refer to null_or_empty.
- **result** *(object)*: Cannot contain additional properties.
    - **connections** *(number, required)*: Number of connections.

6.3.3 External App API

specification_get

Request specification used by external application

- **params**: Refer to null_or_empty.
- **result**: Refer to external_endpoint_return_type.

app_capabilities_get

Request external application capabilities

- **`params`**: Refer to null_or_empty.
- **`result`** *(object)*: External application capabilities. Cannot contain additional properties.
  - **`stoppable_methods`** *(array)*: List with methods that can be stopped with *dataflow_stop* request.
    - **Items** *(string)*: Name of the stoppable method.

dataflow_import

Request to convert dataflow in external app to Pipeline Manager format and import it

- **`params`** *(object)*: Parameters for request. Cannot contain additional properties.
  - **`external_application_dataflow`** *(string, required)*: Dataflow in external application format. If loaded file cannot be represented as text, it will be sent as base64 string. To make sure received data are in readable format `convert_message_to_string` from `pipeline_manager_backend_communication.utils` can be used. Optionally, for conversion to bytes `convert_message_to_bytes` function is available.
  - **`mime`** *(string, required)*: MIME type.
  - **`base64`** *(boolean, required)*: Specifies whether `external_application_dataflow` is in byte64 format.
- **`result`**: Refer to external_endpoint_return_type.

dataflow_validate

Request external application to validate dataflow

- **`params`**: Refer to dataflow_object.
- **`result`**: Refer to external_endpoint_return_type.

dataflow_run

Request external application to run dataflow

- **`params`**: Refer to dataflow_object.
- **`result`**: Refer to external_endpoint_return_type.

dataflow_stop

Request external application to run dataflow

- **params** *(object)*: Parameters for stopping dataflow. Cannot contain additional properties.
  - **method** *(string, required)*: Name of the method used to start run.
- **result**: Refer to external_endpoint_return_type.

dataflow_export

Request external application to export dataflow

- **params**: Refer to dataflow_object.
- **result** *(object)*: Common type returned by external app. Cannot contain additional properties.
  - **type** *(number, required)*: *MessageType* specifying success or error.
  - **content** *([object, string])*: Exported dataflow, which is then saved by the frontend user. Should be either a json object, or a base64 encoded string. If any error occurred then it should contain a proper message.
  - **filename** *(string)*: Suggested filename used to save the file.

frontend_on_connect

Request send when Pipeline Manager frontend connects to backend

- **params**: Refer to null_or_empty.
- **result**: Refer to null_or_empty.

properties_on_change

Request send when properties of any node changes

- **params**: Refer to properties_diff.
- **result**: Refer to null_or_empty.

position_on_change

Request send when position of any node changes

- **params**: Refer to position_diff.
- **result**: Refer to null_or_empty.

nodes_on_change

Request send when node was added or deleted

- **params**: Refer to nodes_diff.
- **result**: Refer to null_or_empty.

connections_on_change

Request send when connection was added or deleted

- **params**: Refer to connections_diff.
- **result**: Refer to null_or_empty.

graph_on_change

Request send when whole dataflow changed, e.g. when dataflow is loaded

- **params**: Refer to dataflow_object.
- **result**: Refer to null_or_empty.

metadata_on_change

Request send when metadata was changed

- **params**: Refer to metadata.
- **result**: Refer to null_or_empty.

viewport_on_center

Request send when editor was centered

- **params**: Refer to null_or_empty.
- **result**: Refer to null_or_empty.

terminal_read

Request sent by the frontend when terminal received an input

- **params** *(object)*: Parameters for request.
  - **name** *(string, required)*: Name of the terminal to which the message was written. Terminal has to be not read-only.
  - **message** *(string, required)*: Terminal input.
- **result**: Refer to null_or_empty.

6.3.4 Common Types

empty

- *object*: Empty object definition. Cannot contain additional properties.

null_or_empty

- *[object, null]*: Empty or missing object definition. Cannot contain additional properties.

node_object

- *object*: Schema that identifies a node in a graph.
  - **`graph_id`** *(string, required)*: Id of the graph.
  - **`node_id`** *(string, required)*: Id of the node.

dataflow_object

- *object*: Definition containing `dataflow` object. Cannot contain additional properties.
  - **`dataflow`** *(object)*: JSON with graph definition in PM format.

specification_object

- *object*: Definition containing `specification` object. Cannot contain additional properties.
  - **`specification`** *(object)*: JSON with specification definition in PM format.

properties_diff

- *object*: Schema that represents differences in properties of the node. Cannot contain unevaluated properties.
  - **All of**
    - Refer to node_object.
  - **`properties`** *(array, required)*: Properties to change specified by either a name or id.
    - **Items** *(object)*
      - **One of**
        - *object*: Cannot contain additional properties.
          - **`id`** *(string, required)*: Id of the property to alter.
          - **`new_value`**: New value of the property.
        - *object*: Cannot contain additional properties.
          - **`name`** *(string, required)*: Name of the property to alter.
          - **`new_value`**: New value of the property.

position_diff

- *object*: Schema that represent differences in position of the node. Cannot contain unevaluated properties.
  - **All of**
    - Refer to node_object.
  - **`position`** *(object, required)*: Position to change specified by either a name or id.
    - **`x`** *(number)*: X coordinate.
    - **`y`** *(number)*: Y coordinate.

nodes_diff

- *object*: Schema that represents nodes' differences in a graph.
  - **`graph_id`** *(string, required)*: Id of the graph.
  - **`nodes`** *(object, required)*: .
    - **`added`** *(array)*: List with created nodes.
      - **Items** *(object)*: JSON with node definition.
    - **`deleted`** *(array)*: List with removed nodes.
      - **Items** *(string)*: ID of node to delete.
  - **`remove_with_connections`** *(boolean)*: Should node be removed with connections.

connections_diff

- *object*: Schema that represents connections' differences in a graph.
  - **`graph_id`** *(string, required)*: Id of the graph.
  - **`connections`** *(object, required)*: .
    - **`added`** *(array)*: List with created connections.
      - **Items** *(object)*: JSON with connection definition.
    - **`deleted`** *(array)*: List with removed connections.
      - **Items** *(object)*: Connection defined with its beginning and end.
        - **`from`** *(string)*: ID of output interface.
        - **`to`** *(string)*: ID of input interface.

metadata

- *object*: Type with PM metadata. Cannot contain additional properties.
  - **`metadata`** *(object, required)*: JSON with metadata description in PM format.

external_endpoint_return_type

- *object*: Common type returned by external app. Cannot contain additional properties.
  - **`type`** *(number, required)*: *MessageType* specifying success, error or progress.
  - **`content`** *([object, string])*: Additional information, either message or dataflow.

6.3.5 Custom procedures

External application can define new remote procedures, which will be called by custom *Navbar button*. To use it, procedure's name has to start with `custom_` prefix, e.g. `custom_simulate_design`.

Such remote procedures can be called from the frontend using custom Navbar buttons defined in the *metadata's* `navbarItems` *field*, e.g.:

```
{
    "name": "Simulate design",
    "stopName": "Stop simulation",
    "iconName": "Run",
    "procedureName": "custom_simulate_design"
}
```

Custom procedure has the same parameters and return type as *dataflow_run* method.

6.4 Implementing a Python-based client for Pipeline Manager

The communication described above is necessary to integrate an application with Pipeline Manager. The client needs to be able to read requests coming from Pipeline Manager and send proper responses.

For applications written in Python, you can use the pipeline-manager-backend-communication library. It implements an easy-to-use interface that is able to communicate with Pipeline Manager along with helper structures and enumerations.

The main structures provided by the `pipeline-manager-backend-communication` library are:

- `CommunicationBackend` - class that implements the functionality for receiving and sending messages.
- `MessageType` - enum used to easily distinguish message types.
- `Status` - enum that describes the current state of the client.

The following code is an example of how to receive requests and send responses to Pipeline Manager: As Pipeline Manager communication is based on JSON-RPC, application should implement method that can be requested. They are described in *Backend API*.

```
# Class containing all implemented methods
class RPCMethods:
    def specification_get(self) -> Dict:
        # ...
        return {'type': MessageType.OK.value, 'content': specification}

    # ...
```

Defined methods have to have appropriate (matching with specification) name, input and output.

```
    # Function name matches with the dataflow_import endpoint from External App␣
↪API
    def dataflow_import(self, external_application_dataflow: str, mime: str,␣
↪base64: bool) -> Dict:
        # Function will receive one parameter, it's name has to be the same
        # as the one from API specification `params`.
        # Optional, but you can convert the received file to string format
        # with `convert_message_to_string`
        # from pipeline_manager_backend_communication.utils import (
        #     convert_message_to_string
        # )
        data_as_string = convert_message_to_string(
            external_application_dataflow,
            base64,
            mime
        )
        # ...
        # pipeline_manager_dataflow here is the converted input file to the
        # Pipeline Manager's graph representation
        return {
            'type': MessageType.OK.value,
            'content': pipeline_manager_dataflow
        }

    def dataflow_validate(self, dataflow: Dict) -> Dict:
        # ...
        # Returned object has to match API specification `returns`
        return {'type': MessageType.OK.value}

    def dataflow_run(self, **kwargs: Dict) -> Dict:
        # All params can also be retrieved as one dictionary
        print(kwargs['dataflow'])
        # ...
        return {'type': MessageType.OK.value}

    # Custom procedure example
    def custom_build(self, dataflow: Dict) -> Dict:
        # ...
        return {'type': MessageType.OK.value}
```

Moreover, every uncaught exception will be classified as error.

```
    def dataflow_export(self, dataflow: Dict) -> Dict:
        # ...
        raise Exception('Something went very, very bad...')
```

RPC methods can also be asynchronous. It is automatically detected by server and awaited.

```
    async def dataflow_stop(self) -> Dict:
        # ...
        return {'type': MessageType.OK.value}
```

Therefore, the following JSON-RPC error message will be returned to frontend application.

```
{
    "id": 1,
    "jsonrpc": "2.0",
    "error": {
        "code": -3,
        "message": "Something went very, very bad...",
        "data": {}
    }
}
```

TCP client, that connects to Pipeline Manager using `host` and `port` parameters provided has to be created. It has to be initialized with object containing JSON-RPC methods.

```
host = '127.0.0.1'
port = 5000

# Creating a client instance with host and port specified
client = CommunicationBackend(host, port)
# Registering implemented methods and
# connecting to Pipeline Manager
await client.initialize_client(RPCMethods())
```

Once the connection is established, the application can start listening for the incoming requests.

```
await client.start_json_rpc_client()
```

These methods can be wrapped into the `async` function and run with `asyncio.run` function.

6.4.1 Sending JSON-RPC requests to Pipeline Manager

Sending requests is defined as coroutine which has to be awaited.

```
response = await client.request('graph_get')
```

This method sends *graph-get* request to frontend application and receive following response:

```
{
    "id": 1,
    "jsonrpc": "2.0",
    "result": {
        "dataflow": {
            // ...
        }
    }
}
```

CHAPTER

SEVEN

SAMPLE THIRD-PARTY SERVER

Some front-end features can be tested with the `frontend_tester` application that acts as a third-party application in the `server-app` scenario. It allows the user to create graph representations of basic front end use cases.

To be able to test the front end, start with building the front end in the `server-app` mode. In the root of the project, run:

```
python -m pipeline_manager build server-app
```

Note: If the specification requires additional assets (e.g. icons), provide them with `--assets-directory <path-to-assets>` flag, for example:

```
python -m pipeline_manager build server-app --assets-directory examples/sample-
↪assets
```

Now, start the Pipeline Manager server application:

```
python -m pipeline_manager run --verbosity INFO
```

Once the server has started, it waits for the third-party application to connect to. Let's run the front end tester with:

```
python -m pipeline_manager.frontend_tester.tester_client
```

After this, the entire testing setup should be up and running at http://127.0.0.1:5000. From there, it is possible to add mini scenarios mocking the work of the server to check various front-end features.

The implementation of the tester_client is documented and quite straightforward. You can also easily extend it to test other front-end (or back-end) features.

CHAPTER

EIGHT

SPECIFICATION BUILDER

Creating a specification, especially in external applications written in Python, can be significantly simplified with the `SpecificationBuilder` class. This tool:

- Provides methods to update the contents of the specification
- Provides an API that allows modifying the specification without worrying about the changes in the format
- Provides sanity checks of URLs, prevents duplicates and validates the specification with the frontend.

Note that this chapter only presents the initial steps of constructing a specification in Pipeline Manager. Check the *specification format* for some more comprehensive details.

8.1 Example usage of the `SpecificationBuilder`

8.1.1 Creating the builder

Import the package, specify the specification version to use and create an instance:

```
from pathlib import Path
from pipeline_manager.specification_builder import SpecificationBuilder

SPECIFICATION_VERSION = '20240723.13'
ASSETS_DIRECTORY = Path("./assets")

specification_builder = SpecificationBuilder(
    spec_version=SPECIFICATION_VERSION,
    assets_dir=ASSETS_DIRECTORY,
    check_urls=True
)
```

`assets_dir` is a path to additional assets (icons, visualizations) - it is used during validation to inform the user that e.g. paths provided in the specification do not have corresponding files. `check_urls` determines whether the `SpecificationBuilder` should check URLs provided in the specification for availability and raise errors when pages are not found.

8.1.2 Creating node types

Node types can be created with:

```
specification_builder.add_node_type(
    name='Digital camera',
    category='Video provider'
)
```

This method requires a unique name of the node type. We can also specify category, parent classes, layer and abstract fields. Follow the documentation of the class for more details.

8.1.3 Add node type "as category"

To create a node type that can act as a category grouping the child node types, we can use `add_node_type_as_category`:

```
specification_builder.add_node_type_as_category(
    categoryname='Filter',
)
```

To add a node that extends this node type as category, just provide its name in the `extends` field in the child node:

```
specification_builder.add_node_type(
    name='GaussianFilter',
    extends='Filter'
)
```

8.1.4 Adding interfaces to node types

The following snippets show how to add interfaces to node types. Note that one or more values can be passed to the `interfacetype` argument, signifying which types of other interfaces can be connected to it.

```
specification_builder.add_node_type_interface(
    name='Digital camera',
    interfacename='Video output',
    interfacetype='video',
    direction='output'
)

specification_builder.add_node_type_interface(
    name='Filter',
    interfacename='Video',
    interfacetype=['video', 'filtered_output'],
    direction='input'
)

specification_builder.add_node_type_interface(
```

(continues on next page)

(continued from previous page)

```
    name='Filter',
    interfacename='Output',
    interfacetype='filtered_output',
    direction='output',
)
```

8.1.5 Adding properties to node types

To create a property in Pipeline Manager, we need to pass three required arguments:

- `name` - the name of the property
- `type` - the type of the property, which has nine possible values:
  - `text`, `constant`, `number`, `integer`, `select`, `bool`, `slider`, `list`, `hex`,
- `default` - specifies a default value, its type depends on the `type` of the property

```
specification_builder.add_node_type_property(
    name='Digital camera',
    propname='Focal length',
    proptype='slider',
    min=14,
    max=135,
    default=50,
    description='Value signifying a camera\'s angle of view'
)

specification_builder.add_node_type_property(
    name='Filter',
    propname='Kernel size',
    proptype='select',
    values=['3x3', '5x5', '7x7'],
    default='3x3',
    description='Small matrix used for convolution'
)
```

There are some additional arguments, available in the *specification format*.

8.1.6 Adding node type descriptions

Adding descriptions is just a matter of providing a node name and a description string.

```
specification_builder.add_node_description(
    name='Digital camera',
    description='Camera providing digital video output'
)
```

8.1.7 Adding metadata

Metadata specifies additional editor options, like `connectionStyle` or `movementStep`. All parameters are defined in the *specification format*.

```
specification_builder.metadata_add_param(
    paramname='connectionStyle',
    paramvalue='orthogonal'
)
```

8.1.8 Adding URLs to node types

To add a URL, first specify the URL group, which is part of the metadata. The icon argument can be a path to an asset file or a link.

```
specification_builder.metadata_add_url(
    groupname='wikipedia',
    displayname='Wikipedia',
    icon='https://en.wikipedia.org/static/favicon/wikipedia.ico',
    url='https://en.wikipedia.org/'
)
```

Then, add the node URL by defining the suffix that will be appended to the group URL.

```
specification_builder.add_node_type_url(
    name='Digital camera',
    urlgroup='wikipedia',
    suffix='wiki/Digital_camera'
)
```

8.1.9 Constructing and validating the specification

This function will generate and check the validity of the specification:

```
specification = specification_builder.create_and_validate_spec()
```

The possible arguments are:

- `workspacedir` - The path to the workspace directory for Pipeline Manager, the same that has been provided for the build script
- `fail_on_warnings` - Determines whether the validation should fail on warnings
- `dump_spec` - A path to where the specification should be dumped as a file before validation. Useful for debugging purposes.
- `sort_spec` - Return specification that has introduced ordering to dictionaries and lists. In lists containing dictionaries the unique field of each dictionary is used to sort entries.

The created `specification` upon successful run should contain a full specification based on `SpecificationBuilder`. It is a regular Python dictionary that can be saved to a JSON file using the `json.dump` method.

Note: To make sure the entries in the specification are sorted (mostly dictionaries) after using `sort_spec`, in case of Python's `json.dump` and `json.dumps` methods use `sort_keys=True`, e.g.:

```
json.dumps(spec, sort_keys=True, indent=4)
```

8.2 `SpecificationBuilder` documentation

class pipeline_manager.specification_builder.**SpecificationBuilder**(spec_version: *str*, assets_dir: *Path* | *None* = **None**, check_urls: *bool* = **False**)

Creates a specification file and checks validity of files.

This class allows to:

- Create and modify specification entries using simple API
- Merge existing specifications with some consistency checks
- Check URLs to remote resources in terms of availability
- Checks correctness of paths to assets from the given directory

This class also performs very strict checking, e.g. it does not allow creating duplicates. In case of any errors spotted it raises a SpecificationBuilderException.

add_include(include: *str*)

Adds include defined by url to the specification.

Parameters

include : str
URL to the specification to include

Raises
SpecificationBuilderException – Raised when include already exists.

add_include_subgraph(dataflow: *dict[tuple[str, str], str]*)

Adds dataflow to the include subgraph defined by url.

Parameters

dataflow : Dict[Tuple[str, str], str]
Dataflow to include. Keys are tuples of node names and node urls

Raises
SpecificationBuilderException – Raised when included subgraph already exists

add_node_description(name: *str*, description: *str*)

Sets description for the node if it is not defined.

Parameters

name : str
Name of the node type

description : str
Description

Raises
SpecificationBuilderException – Raised if description is already defined

add_node_type(name: *str*, category: *str* | *None* = **None**, layer: *str* | *None* = **None**, extends: *str* | *list[str]* | *None* = **None**, abstract: *bool* | *None* = **False**)

Adds a node type to the specification.

Parameters

name : str
Name of the node type

category : Optional[str]
Category of the node

layer : Optional[str]
Name of the layer metatype

extends : Optional[Union[str, List[str]]]
Base classes for the node type

abstract : Optional[bool]
Tells if the type is abstract or not. Abstract types do not need to be complete, they are also not added to the final specification. They are templates for other classes.

Raises
SpecificationBuilderException – Raised if the node type is redefined.

add_node_type_additional_data(name: *str*, additionaldata: *Any*)

Adds additional data to the node, in JSON-like format.

Parameters

name : str
Name of the node type

additionaldata : Any
Any JSON-like construct

Raises
SpecificationBuilderException – Raised if additionalData already exists.

add_node_type_as_category(categoryname: *str*, categoryparent: *str* = '', layer: *str* | *None* = **None**, extends: *str* | *list[str]* | *None* = **None**)

Adds a node type “as category” to the specification.

Parameters

categoryname : str
Name of the newly added category

categoryparent : str
Path to the new category

layer : Optional[str]
Name of the layer metatype

extends : Optional[Union[str, List[str]]]
Base classes for the node type

Raises
SpecificationBuilderException – Raised when node type is redefined.

add_node_type_category(name: *str*, category: *str*)

Adds a category to the given node. Raises an error if different category is already added.

Parameters

name : str
name of the node type

category : str
category for the node type

Raises
SpecificationBuilderException – Raised if there is already a node type category.

add_node_type_from_spec(node)

Adds single node type defined in JSON-like format.

add_node_type_icon(name: *str*, iconpath: *dict* | *str*) → None

Adds icon for the node type.

Parameters

name : str
Name of the node type

iconpath : Union[dict, str]
Icon path

Raises
SpecificationBuilderException – Raised when given icon is not available in metadata or is invalid.

add_node_type_interface(name: *str*, interfacename: *str*, interfacetype: *str* | *list[str]* | *None* = **None**, direction: *str* = `'inout'`, dynamic: *bool* | *list[int]* = **False**, side: *str* | *None* = **None**, maxcount: *int* | *None* = **None**, override: *bool* | *None* = **None**, array: *list[int]* | *None* = **None**)

Adds interface to the node type.

Parameters

name : str
Name of the node type

interfacename : str
Name of the interface

interfacetype : Optional[Union[str, List[str]]]
List of matching types for interfaces

direction : str
Direction of the connection, by default “inout”.

dynamic : Union[bool, List[int]]
Determine whether a number of interfaces may be dynamically adjusted. By default, False.

side : Optional[str]
On which side the interface should be placed by default

maxcount : Optional[int]
The maximum connections to the given interface

override : Optional[bool]
Determines whether interface should be overridden

array : Optional[List[int]]
Creates an array of interfaces with given name. Accepts two integers - minimal and maximal value

Raises

SpecificationBuilderException – Raised when interface already exists.

add_node_type_parent(name: *str*, parent_names: *str | list[str]*)

Adds a parent class to the node type. Raises an exception if the base name does not exist.

Parameters

name : str
name of the node type

parent_names : Union[str, List[str]]
name of the base class, or list of base classes’ names.

Raises

SpecificationBuilderException – Raised when base/parent class is not found.

add_node_type_property(name: *str*, propname: *str*, proptype: *str*, default: *Any*, description: *str | None* = **None**, min: *Any* = **None**, max: *Any* = **None**, values: *list[Any] | None* = **None**, dtype: *str | None* = **None**, override: *bool | None* = **None**)

Adds property to the node.

Parameters

name : str
Name of the node type

propname : str
Name of the property

proptype : str
Type of the property

default : Any
Default value of the property

description : Optional[str]
Optional description for the property

min : Any
Minimal value

max : Any
Maximal value

values : Optional[List[Any]]
List of allowed values

dtype : Optional[str]
Type of elements in property type is list

override : Optional[bool]
Determines whether property should be overridden

Raises
SpecificationBuilderException – Raised when the property exists already.

add_node_type_property_group(name: *str*, propgroupname: *str*, propname: *str*, proptype: *str*, default: *Any*, description: *str* | *None* = None, min: *Any* = None, max: *Any* = None, values: *list[Any]* | *None* = None, dtype: *str* | *None* = None, override: *bool* | *None* = None)

Adds a property to a property group.

Parameters

name : str
Name of the node type

propgroupname : str
Name of the group of property

propname : str
Name of the property

proptype : str
Type of the property

default : Any
Default value of the property

description : Optional[str]
Optional description for the property

min : Any
Minimal value

max : Any
Maximal value

values : Optional[List[Any]]
List of allowed values

dtype : Optional[str]
Type of elements in property type is list

override : Optional[bool]
Determines whether property should be overridden

Raises

SpecificationBuilderException – Raised when no properties are found that could be bound to the group.

add_node_type_url(name: *str*, urlgroup: *str*, suffix: *str*)

Adds URL for the node type.

Parameters

name : str
Name of the node type

urlgroup : str
Name of the URL group the entry is defined for. URL group defines prefix, and icon for the URL.

suffix : str
Appended suffix to the URL group

Raises

SpecificationBuilderException – Raised if provided urlgroup does not exist.

add_subgraph_from_spec(subgraph)

Adds subgraph defined in JSON-like format.

create_and_validate_spec(workspacedir: *Path* | *None* = **None**, resolved_specification: *Path* | *None* = **None**, fail_on_warnings: *bool* = **True**, sort_spec: *bool* = **False**, dump_spec: *Path* | *None* = **None**) → dict

Creates a specification and validates it using schema.

Parameters

workspacedir : Optional[Path]
Path to the workspace directory for Pipeline Manager

resolved_specification : Optional[Path]
Path to specification that has have resolved inheritance, i.e. resolved 'extends' attributes. If none then the specification is not resolved.

fail_on_warnings : bool
Tells if the specification creation should fail on warnings

sort_spec : bool
True if the entries in the specification should be sorted.

dump_spec : Optional[Path]
Tells where the specification should be dumped to file before validation and resolving for debugging purposes.

Returns
Built specification, if successful

Return type
Dict

Raises
SpecificationBuilderException – Raised when specification is not valid or when warnings appeared.

create_property(propname: *str*, proptype: *str*, default: *Any*, description: *str* | *None* = None, min: *Any* = None, max: *Any* = None, values: *list[Any]* | *None* = None, dtype: *str* | *None* = None, override: *bool* | *None* = None) → dict

Creates and returns a property.

Parameters

propname : str
Name of the property

proptype : str
Type of the property

default : Any
Default value of the property

description : Optional[str]
Optional description for the property

min : Any
Minimal value

max : Any
Maximal value

values : Optional[List[Any]]
List of allowed values

dtype : Optional[str]
Type of elements in property type is list

override : Optional[bool]
Determines whether property should be overridden

Returns
Creates a single property for the node type

Return type
dict

get_node_description(name: *str*) → str

Gets description for the node type.

Parameters

name : str
Name of the node type

Returns
Description of the node type

Return type
str

metadata_add_interface_styling(interfacename: *str*, interfacecolor: *str* | *None* = **None**, interfaceconnpattern: *str* | *None* = **None**, interfaceconncolor: *str* | *None* = **None**)

Adds interface styling to metadata.

interfacename: str
Name of the interface type

interfacecolor: Optional[str]
Color of the interface

interfaceconnpattern: Optional[str]
Interface connection line pattern

interfaceconncolor: Optional[str]
Color of the interface connection line

metadata_add_layer(name: *str*, nodelayers: *str* | *list[str]* | *None* = **None**, nodeinterfaces: *str* | *list[str]* | *None* = **None**)

Adds nodes' layer to metadata.

Parameters

name : str
Name of the layer

nodelayers : Optional[Union[str, List[str]]]
List of node layers in the layer

nodeinterfaces : Optional[Union[str, List[str]]]
List of interface types in the layer

Raises
SpecificationBuilderException – Raised when provided layer already exists.

metadata_add_param(paramname: *str*, paramvalue: *Any*, metadata: *dict* | *None* = **None**)

Sets parameter in metadata. Modifies the metadata dictionary in place.

The following rules apply: * If the parameter is a list and the value is a list, the parameter is extended by the value. * If the parameter is a dictionary and the value is a dictionary, the parameter is recursively updated by the value. * Otherwise, the parameter is set to the value.

Parameters

paramname : str
Name of the metadata parameter

paramvalue : Any
Value of the parameter

metadata : Optional[Dict]
Metadata dictionary to modify. if None, the class metadata is used

metadata_add_url(groupname: *str*, displayname: *str*, icon: *str*, url: *str*)

Adds URL group to metadata.

Parameters

groupname : str
Name of the URL group

displayname : str
Displayable name of the URL group

icon : str
Path in assets directory or URL to the icon

url : str
URL prefix for the URL group

Raises

SpecificationBuilderException – Raised when URL group already exists and differs in format with the existing entry.

register_category(categorypath: *str*)

Adds a category to the set of available categories.

Parameters

categorypath : str
Category. Subcategories are added via path-like string.

reset()

Resets all fields for the specification.

set_node_description(name: *str*, description: *str*)

Sets description for the node type.

Parameters

name : str
Name of the node type

description : str
Description for the node

update_spec_from_other(otherspec: *Any*)

Updates the specification from other specification. It can be also used to merge partial specifications.

Parameters

otherspec : Any
JSON-like structure with other specification

Raises

SpecificationBuilderException – Raised when “extends” in any node has non-existent classes

CHAPTER

NINE

DATAFLOW GRAPH BUILDER

Class `GraphBuilder` (available in `pipeline_manager.dataflow_builder.dataflow_builder`) provides a convenient Python API for creating and editing a dataflow graph.

9.1 Examples of GraphBuilder usage

9.1.1 Creating GraphBuilder

In order to create an instance of `GraphBuilder`:

```
from pipeline_manager.dataflow_builder.dataflow_builder import GraphBuilder

builder = GraphBuilder(
    specification="examples/sample-specification.json",
    specification_version="20240723.13",
)
```

The code creates an instance of `GraphBuilder` with the `sample-specification.json` loaded.

9.1.2 Obtaining a dataflow graph

A dataflow graph may be either loaded from a dataflow file or created.

To create a new empty dataflow graph:

```
from pipeline_manager.dataflow_builder.dataflow_graph import DataflowGraph

graph = builder.create_graph()
```

To load an existing specification from a file:

```
builder.load_graphs(dataflow_path='examples/sample-dataflow.json')
graph = builder.graphs[0]
```

In both cases, the dataflow graph:

- has to be compliant with the provided specification.
- is retrieved and may be edited with its public methods.

9.1.3 Creating a node

Having obtained the `DataflowGraph` object (in the previous examples, stored in the `graph` variable), a new node may be added to the graph in the following way:

```
from pipeline_manager.dataflow_builder.entities import Node

node = graph.create_node(
    name="LoadVideo", # Required.
    position=Vector2(0, 0), # Optional.
)
```

Only keyword parameters are allowed. The available parameters of the `create_node` method are attributes of the `Node` dataclass (which is located under `pipeline_manager.dataflow_builder.entities.Node`).

9.1.4 Getting a node

A dataflow graphs stores nodes. Thus, nodes are retrieved from the dataflow graph in the following way:

```
from pipeline_manager.dataflow_builder.dataflow_graph import AttributeType

nodes = graph.get(AttributeType.NODE, name="LoadVideo")
if len(nodes) > 0:
    node = nodes[0]
```

Only nodes with `name` equal to `LoadVideo` will be retrieved.

The `DataflowGraph.get` method retrieves not only nodes but other objects present in the `AttributeType` enum: connections, interfaces, and nodes. In this case, nodes are retrieved. Parameters other than `type` are filters, which specify what values should the obtained objects (here: nodes) have. Take a look at the next example to see such usage.

9.1.5 Getting a node matching multiple criteria

To get a node, which satisfies all the matching criteria, use the `get` method once again:

```
from pipeline_manager.dataflow_builder.entities import Vector2

[node] = graph.get(AttributeType.NODE, position=Vector2(0, 0), name="LoadVideo")
```

The code above puts in the `node` variable a node with name `LoadVideo` and position with coordinates `[0, 0]`.

9.1.6 Manipulating a node

After having a node retrieved from a graph, it is time to modify its attributes. For example, to change an instance name of the node, run:

```
node.instance_name = 'Instance name of a node'
```

To change the property of the node, `set_property` can be used:

```
try:
    # Use of `set_property` is recommended to set values of properties of a node.
    node.set_property('compression_rate', 1)
except KeyError:
    print('Cannot set compression_rate to 1 as the property does not exists.')
```

To move the node from its current position, use `move`:

```
# Move a node to [1000, 1000].
node.move(Vector2(1000, 1000))

# Move the node by 500 pixels to the right, relative to its previous position.
node.move(new_position=Vector2(500, 0), relative=True)
```

9.2 Specification of GraphBuilder

class pipeline_manager.dataflow_builder.dataflow_builder.**GraphBuilder**(specification: *Path*, specification_version: *str*, workspace_directory: *Path* | *None* = **None**)

Class for building dataflow graphs.

Each instance of the GraphBuilder must be associated with a single specification to ensure proper validation.

create_graph(based_on: *Path* | *str* | DataflowGraph | *None* = **None**) → *DataflowGraph*

Create a dataflow graph and return its instance.

Create an instance of a dataflow graph, add it to the internal list and return it. The dataflow graph is based on the graph provided in *based_on* parameter.

Parameters

based_on : Union[Path, str, *DataflowGraph*, None], optional
Dataflow graph, on which the new graph should be based on. When *Path* or *str*, it should be a path to dataflow graph in a JSON format. When *DataflowGraph*, it should be a valid representation (as its deep copy will be added). When *None*, the new dataflow graph will not be based on anything, by default None.

Returns
Instance a of a dataflow graph, preserved in the GraphBuilder.

Return type
DataflowGraph

`load_graphs`(dataflow_path: *Path*)

Load all dataflow graphs from a file.

Parameters

`dataflow_path` : Path
Path to a dataflow graph.

Raises
`ValueError` – Raised if a dataflow graph could not be loaded.

`load_specification`(specification_path: *Path*, purge_old_graphs: *bool* = `True`)

Load a specification from a file to use in GraphBuilder.

The default behaviour is to remove loaded dataflow graphs when loading a new specification. That is due to the fact that a dataflow graph is closely linked with its specification. Notice that loading a specification overrides the old one.

Parameters

`specification_path` : Path
Path to a specification file.

`purge_old_graphs` : bool, optional
Determine if dataflow graphs loaded to memory should be purged. It makes sense as after changing a specification dataflow graphs may no longer be valid. By default True.

Raises
`ValueError` – Raised if specification file cannot be loaded or is invalid.

`save`(json_file: *Path*)

Save graphs to a JSON file.

Parameters

`json_file` : Path
Path, where an output JSON file will be created.

`validate`()

Validate the entire dataflow file including all the included graphs.

Raises
`RuntimeError` – Raised if an external validator failed to validate either a dataflow or specification file. An error message is provided by the external validator.

9.3 Specification of DataflowGraph

class pipeline_manager.dataflow_builder.dataflow_graph.**DataflowGraph**(builder_with_spec: SpecificationBuilder, dataflow: *dict[str, Any]* | *None* = **None**)

Representation of a dataflow graph.

create_connection(from_interface: Interface | *str*, to_interface: Interface | *str*, connection_id: *str* | *None* = **None**) → *InterfaceConnection*

Create a connection between two existing interfaces.

The function performs numerous checks to verify validity of the desired connection, including if the connection already exists, interfaces' types are matching and so on. The connection is added, given it has passed these checks.

Parameters

from_interface : Union[*Interface*, str]
Source interface, where data will flow from.

to_interface : Union[*Interface*, str]
Destination interface, where data will flow to.

connection_id : Optional[str]
Identifier of a connection. If not supplied, one will be generated.

Returns
Created connection added to the graph.

Return type
InterfaceConnection

Raises
ValueError – Raised if: - a source interface does not belong to the graph. - a destination interface does not belong to the graph. - a source interface direction is *input*. - a destination interface direction is *output*. - a mismatch between source and destination interfaces' types occurs.

create_node(name: *str*, **kwargs) → *Node*

Create the node initialized with the supplied arguments.

Use this method instead of manually adding a node. Default values are taken from the specification, based on the provided *name* parameter. The default values may be overridden by the values supplied in *kwargs*. *id* is already initialized.

Parameters

name : str
Name of a node, based on which default values will be derived.

****kwargs**
Keyword arguments to initialise a newly created node. Check attributes of *Node* dataclass, to find all available keys.

Returns
The initialized node that belongs to the dataflow graph.

Return type
Node

Raises
ValueError – Raised if *name* key is missing in the *kwargs* directory or the provided name of the node does not exists in the specification.

get(type: *AttributeType*, **kwargs) → list[*Node*] | list[*InterfaceConnection*] | list[*Interface*]

Get items of a given type, which satisfy all the desired criteria.

Items are understood as either nodes or connections or interfaces. The function finds objects by eliminating these, which do not match the criteria. Thus, between all the criteria is *AND* logical operator.

Parameters

type : AttributeType
Type of the output objects.

****kwargs**
Contains search criteria. Available: - Keys: the attributes of the object of he chosen type. - Values: values to be matched.

Returns
List of items satisfying the criteria.

Return type
Union[List[*Node*], List[*InterfaceConnection*], List[*Interface*]]

get_by_id(type: *AttributeType*, id: *str*) → *InterfaceConnection* | *Node* | *Interface* | None

Fast getter, which finds an item of a supplied type and with the provided id.

It has complexity of O(1) (except for interfaces) in juxtaposition to the *get* method, which iterates over all items.

Parameters

type : AttributeType
Type of the output objects.

id : str
ID of the sought object.

Returns
Either an single instance of InterfaceConnection or Node or Interface depending on the provided *type*. If does not exist, None is returned.

Return type
Optional[Union[*InterfaceConnection*, *Node*, *Interface*]]

to_json(as_str: *bool* = **True**) → str | dict

Convert a dataflow graph to the JSON format.

Parameters

as_str : bool, optional
Determine return type. By default, True.

Returns
Representation of the dataflow graph in JSON. If *as_str* is *True*, JSON in str is returned. Otherwise, a Python dictionary is returned.

Return type
Union[Dict, str]

9.4 Specification of Node

class pipeline_manager.dataflow_builder.entities.**Node**(specification_builder: SpecificationBuilder, **kwargs)

Representation of a node in a dataflow graph.

get(type: *NodeAttributeType*, **kwargs) → list[*Property*] | list[*Interface*]

Get either properties or interfaces matching criteria.

Parameters

type : NodeAttributeType
Type of an item to retrieve.

kwargs : Any
Criteria, which items have to satisfy.

Returns
List of either Property or Interface instances.

Return type
Union[List[*Property*], List[*Interface*]]

move(new_position: *Vector2*, relative: *bool* = **False**)

Change a position of the node.

Change a position of the node either in a relative manner or an absolute manner. Values are clamped to stay in the range of values.

Parameters

new_position : Vector2
If *relative* is False, then this a new position. Otherwise, it is a displacement (movement) vector.

relative : bool, optional
Whether position should be calculated based on the previous one (True) or not (False), by default False.

set_property(property_name: *str*, property_value: *Any*) → None

Convenient setter to change value of a property of the node.

Parameters

property_name : str
Name of the property.

property_value : Any
New value of a property.

Return type
None

Raises
KeyError – Raised if property with the supplied *property_named* was not found.

to_json(as_str=**True**) → str | dict

Convert a dataflow graph to the JSON format.

Parameters

as_str : bool, optional
Determine return type. By default, True.

Returns
Representation of the dataflow graph in JSON. If *as_str* is *True*, JSON in str is returned. Otherwise, a Python dictionary is returned.

Return type
Union[Dict, str]

9.5 Specification of Interface

class pipeline_manager.dataflow_builder.entities.**Interface**(name: str, direction: ~pipeline_manager.dataflow_builder.entit side: ~pipeline_manager.dataflow_builder.entit | None = None, side_position: int | None = None, external_name: str | None = None, id: str = <factory>, type: ~typing.List[str] = <factory>)

Representation of a node's interface.

to_json(as_str: *bool*) → str | dict

Convert a dataflow graph to the JSON format.

Parameters

as_str : bool, optional
Determine return type. By default, True.

Returns
Representation of the dataflow graph in JSON. If *as_str* is *True*, JSON in str is returned. Otherwise, a Python dictionary is returned.

Return type
Union[Dict, str]

9.6 Specification of Connection

Notice that name of the class representing connection is `InterfaceConnection`, not `Connection`.

class pipeline_manager.dataflow_builder.entities.**InterfaceConnection**(from_interface: ~pipeline_manager.dataflow_b to_interface: ~pipeline_manager.dataflow_b anchors: ~typ- ing.List[~pipeline_manager.da | None = None, id: str = <factory>)

Representation of a connection between two interfaces in a dataflow graph.

to_json(as_str: *bool* = **True**) → str | dict

Convert a dataflow graph to the JSON format.

Parameters

as_str : bool, optional
Determine return type. By default, True.

Returns
Representation of the dataflow graph in JSON. If *as_str* is *True*, JSON in str is returned. Otherwise, a Python dictionary is returned.

Return type
Union[Dict, str]

9.7 Specification of Property

class pipeline_manager.dataflow_builder.entities.**Property**(name: str, value: ~typing.Any, id: str = <factory>)

A property of a node.

to_json(as_str: *bool* = **True**) → dict | str

Convert a dataflow graph to the JSON format.

Parameters

as_str : bool, optional
Determine return type. By default, True.

Returns
Representation of the dataflow graph in JSON. If *as_str* is *True*, JSON in str is returned. Otherwise, a Python dictionary is returned.

Return type
Union[Dict, str]

CHAPTER

TEN

DATAFLOW AND SPECIFICATION FORMAT CHANGELOG

Formats of dataflows and specification is often updated with new features, that makes former formats incompatible with the new ones. This section lists all versions, related features and breaking changes.

10.1 20240723.13

> **Warning:** This update changes the existing format of specification and dataflow.

Commit SHA - TODO

- Added `includeGraphs` field allowing to include graphs in the specification as subgraphs
- Added `include` field allowing to include partial specification to the specification
- Replaced `graph` field with `graphs` list
- The default graph now can be:
  - the first entry in the `graphs` list
  - the graph from `graphs`, where `id` of the graph is equal to `entryGraph`
- Replaced `subgraphs` in specification with `graphs` that have the exact same format as regular graphs
- Introduced `externalName` for graph nodes
- Fixed `list` type for properties - now they can be defined as lists in the graph, and display/modified as space-separated entries
- Improved Markdown-based rendering of description

10.2 20230523.12

> **Warning:** This update changes the existing format of specification and dataflow.

Commit SHA - `006998910f871da00c49ef00625e5d8bccf3a9c3`

- Introduced changes in dataflow and specification formats:
  - Removed `interfaces` property from graphs, which were used to define interface nodes for subgraphs.
  - Instead of "interface nodes", a new property was added to regular interfaces of nodes, called `externalName`.
  - `externalName`, when not empty, indicates that the interface is an outer interface of the subgraph, which should be exposed with the name from this field.

10.3 20230830.11

> **Warning:** This update changes the existing format of specification and dataflow.

Commit SHA - `0bee99e152a408650590bb6ea4210e96502b33ef`

- Introduced changes in dataflow and specification formats:
  - `type -> name` for dataflows for consistency with specification naming
  - `name -> instanceName` for dataflows to make it more explicit and avoid conflicts
  - `type -> layer` for nodes in specification. This property is now also optional.
  - `nodeTypes -> nodeLayers` in `layers` keywords in metadata
  - `checkbox -> bool` for property type
  - `graphTemplateInstances -> subgraphs` for dataflow and specification.
- Added converter from version `20230824.10` to `20230523.12`
- Added `abstract` parameter for node types to define abstract types.
- Added `isCategory` parameter that allows defining category nodes which serve both as a node and category.

10.4 20230824.10

Commit SHA - `6ce3bf106353bc58fb8e7217b9bc8aa7db9ebd20`

- Choosing an entry graph that is rendered to the user when loading a subgraph dataflow is now possible using the `entryGraph` property.

10.5 20230824.9

Commit SHA - `de31d01d9b6591993559e3b10851815f3320e545`

- Introduced `description` keyword for nodes that allows displaying Markdown-based description in a sidebar.

10.6 20230818.8

Commit SHA - `d4abcc80bce3e280120078a47d784eff92821a8a`

- Introduced `group` keyword for checkbox property which allows defining groups of properties that can be disabled.

10.7 20230817.7

Commit SHA - `5946db06d8f42a33934a07fba95634aa8a70c78e`

- Format of subgraph dataflows and specifications is redesigned. Details can be found in *Dataflow format* and *Specification format*.
- Dataflow
  - `SubgraphIO` was renamed to `interfaces` and its properties were changed.
  - Connections are now defined using `connections` property instead of `nodeInterfaceId` keyword.
- Specification
  - `id` property for nodes and connections in subgraphs is no longer required.
  - Connections are now defined using `connections` property instead of `nodeInterface` keyword.

10.8 20230809.6

Commit SHA - `59b04f8bc9cd0ce1cb757dcc4027750e1275d935`

- Introduced `anchors` for connections, which is a list of coordinates that allows rendering custom connections shapes.

10.9 20230619.5

Commit SHA - `84fe865ca44b3a80b87a2be418eedc1d1c025ee4`

- Introduced `defaultInterfaceGroups` groups of interfaces that are enabled by default.
- Implemented more verbose error logging both for interfaces and interface groups.

10.10 20230619.4

Commit SHA - `bdc4b2fb998ed9d6318a676d4ac77f92c1603d39`

- Introduced `interfaceGroups` and `enabledInterfaceGroups` keywords that allow defining groups of interfaces.
- Introduced arrays of interfaces that can be easily created using `array` keyword.
- Simplified dataflows as interfaces that have no connections are no longer saved into output `.json` files.

10.11 20230619.3

Commit SHA - `84559ae8327d7aa214c388200c5b48d112021679`

- Introduced two new keywords to the specification's `metadata`:
  - `backgroundSize` - defines size of the background grid. It has strictly visual effects.
  - `movementStep` - minimal node movement step.
- Added `additionalData` for storing some node-related data, not relevant to Pipeline Manager
- Changed `connectionSide` to `side` in dataflow and specification
- `type` of interface now can be either a single string or a list of strings.
- Introduced optional metadata keyword `layout` specifying algorithm used for automatic node position calculation.
- Introduced `randomizedOffset` keyword that adds a random offset to connections so that a layout from complex graphs can be created easier. This value propagates into dataflows.

10.12 20230615.2

Commit SHA - `711ea7224e30d342924319c3964f1cb076939a29`

- Introduced inheritance mechanism in specification - for each node type it is possible to specify `extends` list that provides information which are the base classes for a given type.

10.13 20230615.1

Commit SHA - `4e0cf99ccaa5bc3513804e8184b907ed0230985f`

- Introduced versioning for dataflow and specification format, starting with version `20230615.1`. Pipeline Manager saves the current version in a dataflow save so that when loading a dataflow an appropriate message is displayed.
- Implemented a dataflow format converter that can apply a range of patches so that an obsolete dataflow can be updated to the current format.

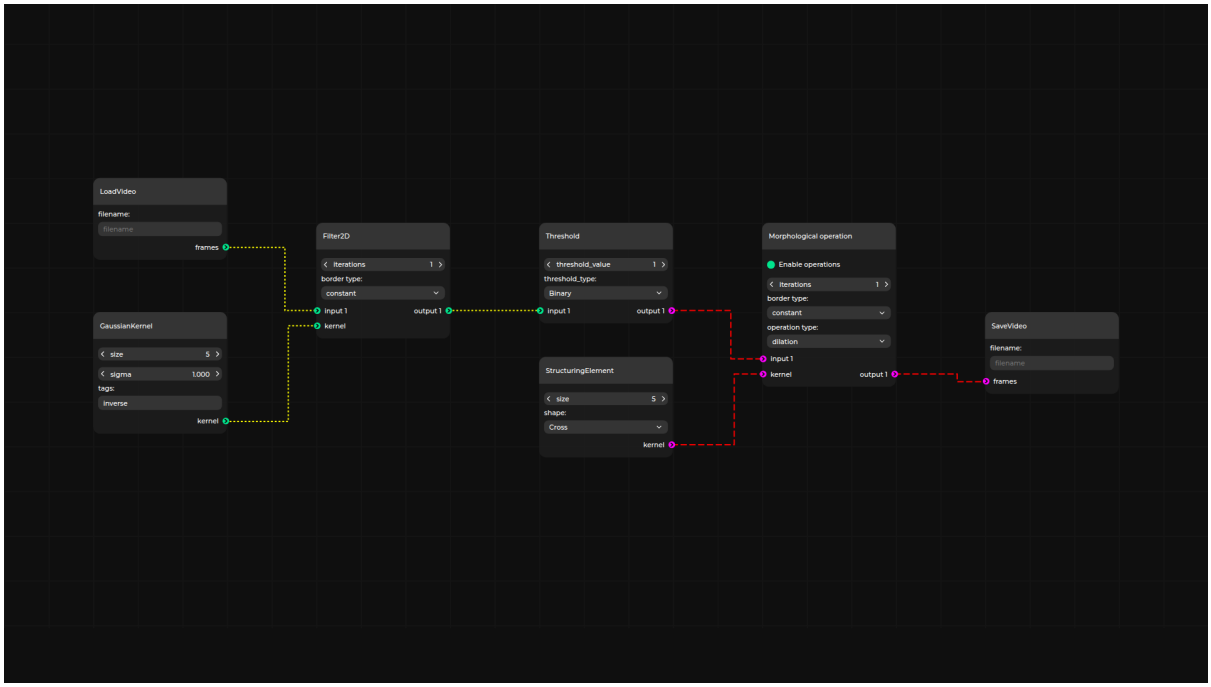
CHAPTER

ELEVEN

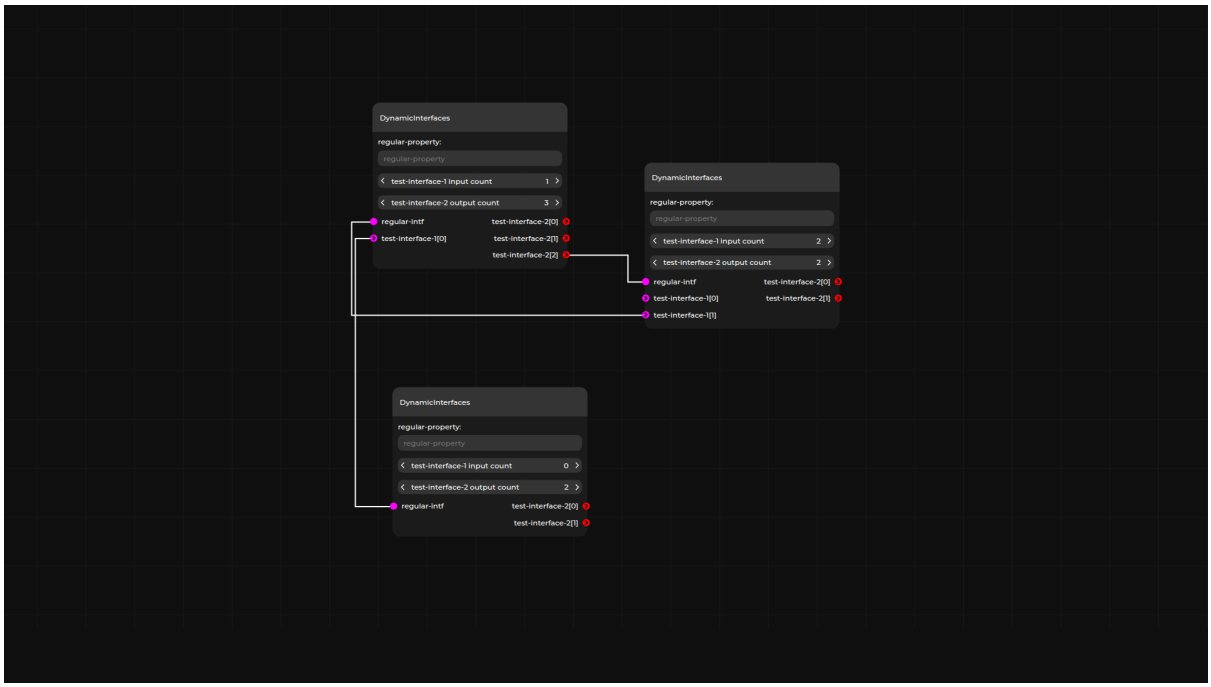
DEMONSTRATION OF THE FRONTEND

To see the work of the frontend check one of the below examples:

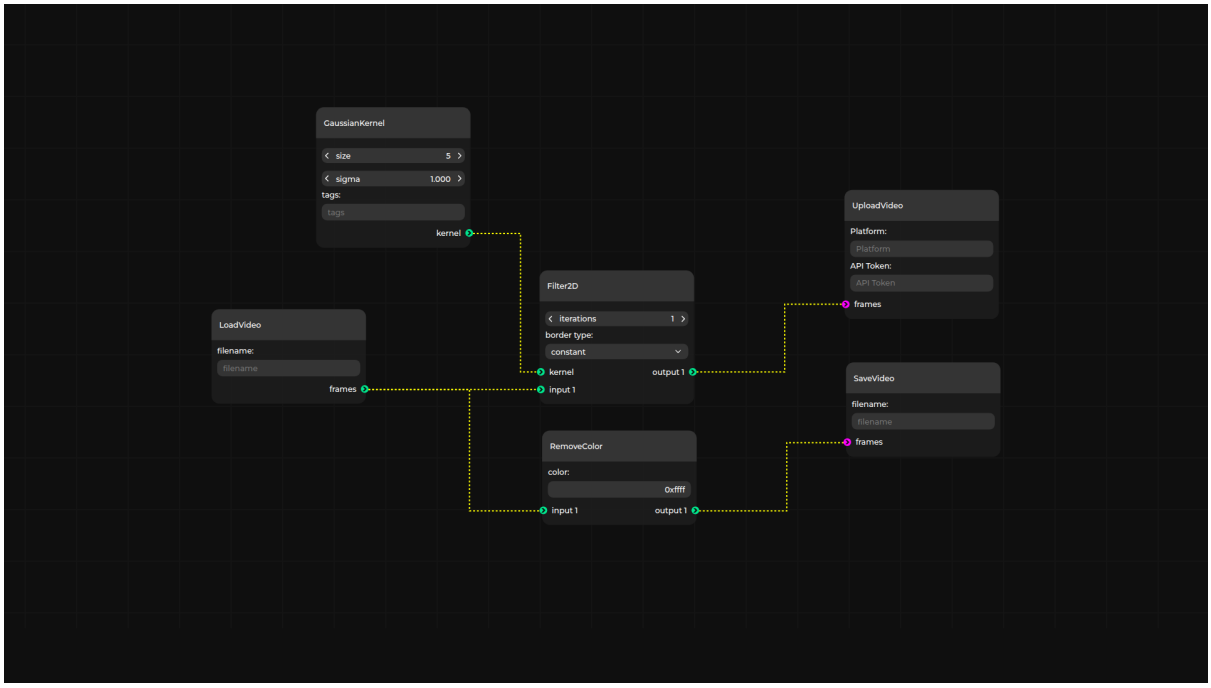
- Example of a more complex graph with nodes as interfaces, inheritance and more



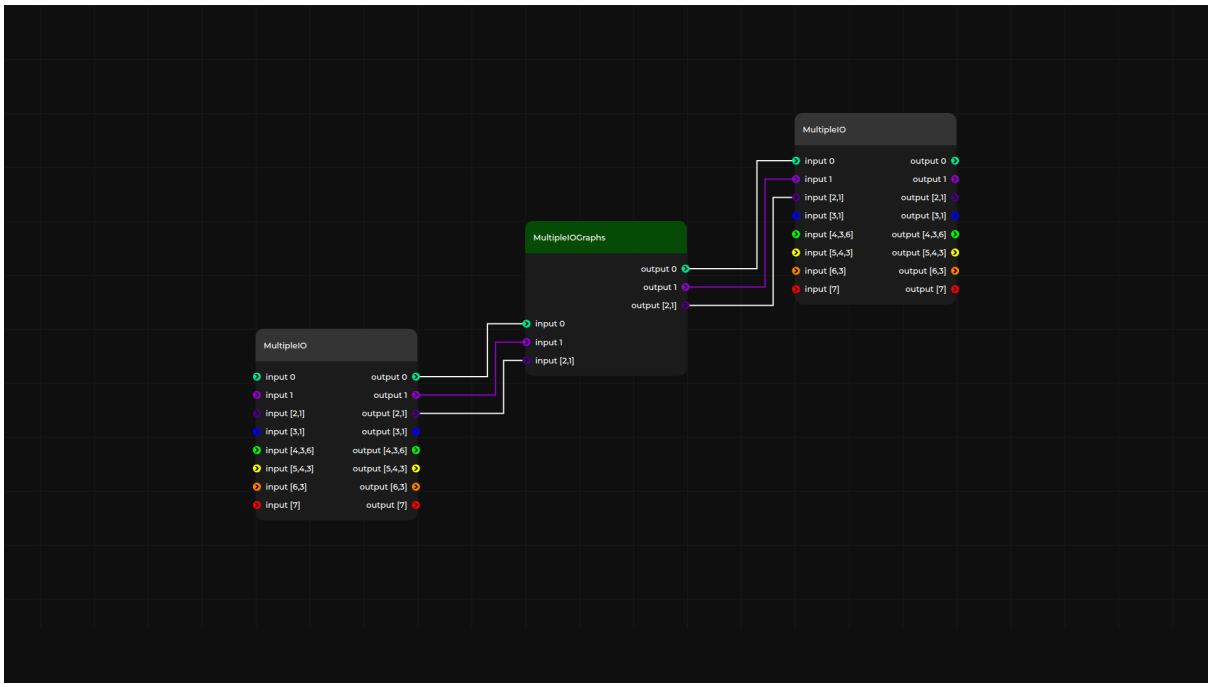
- Example of a graph with dynamic number of interfaces



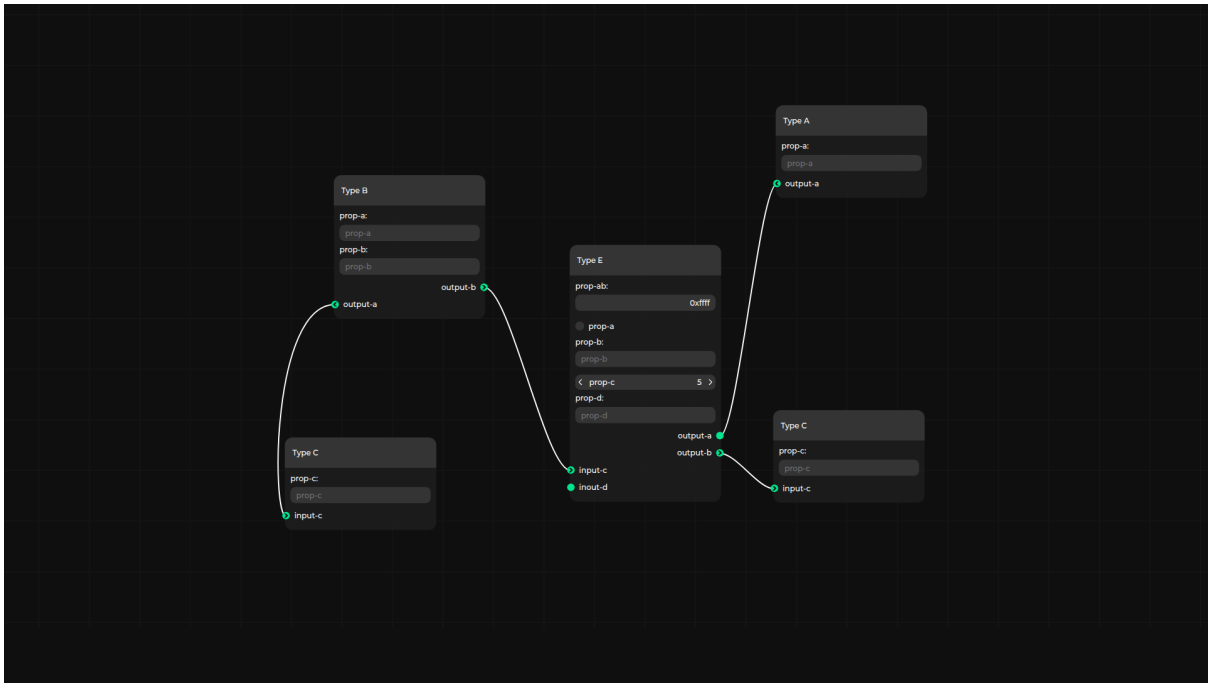
- Example of the graph with include mechanisms



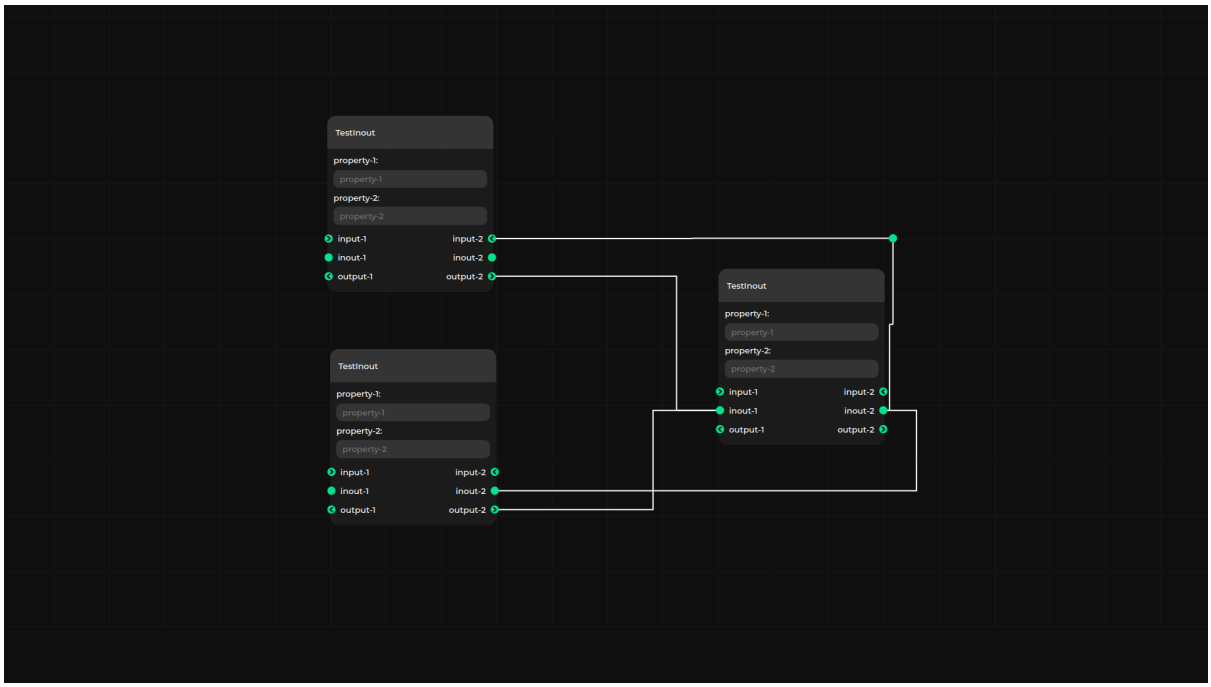
- Example of the graph with top-level interfaces exposed



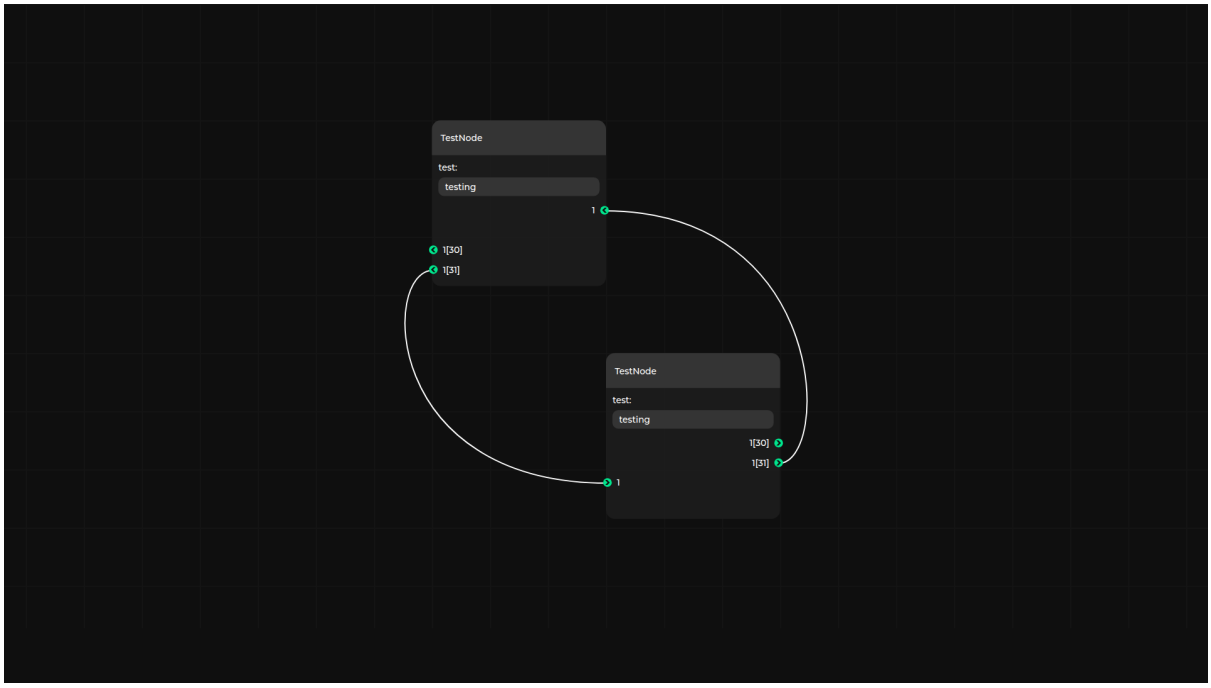
- Example of graph with inheritance



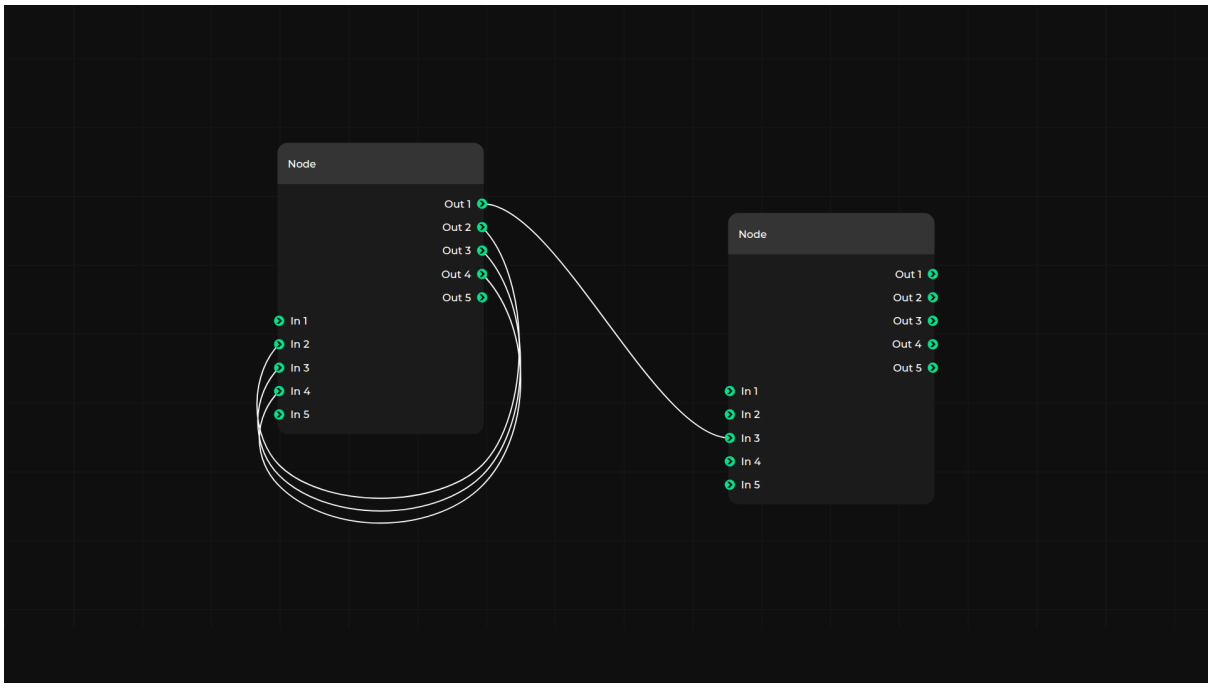
- Example of Input-Output interfaces



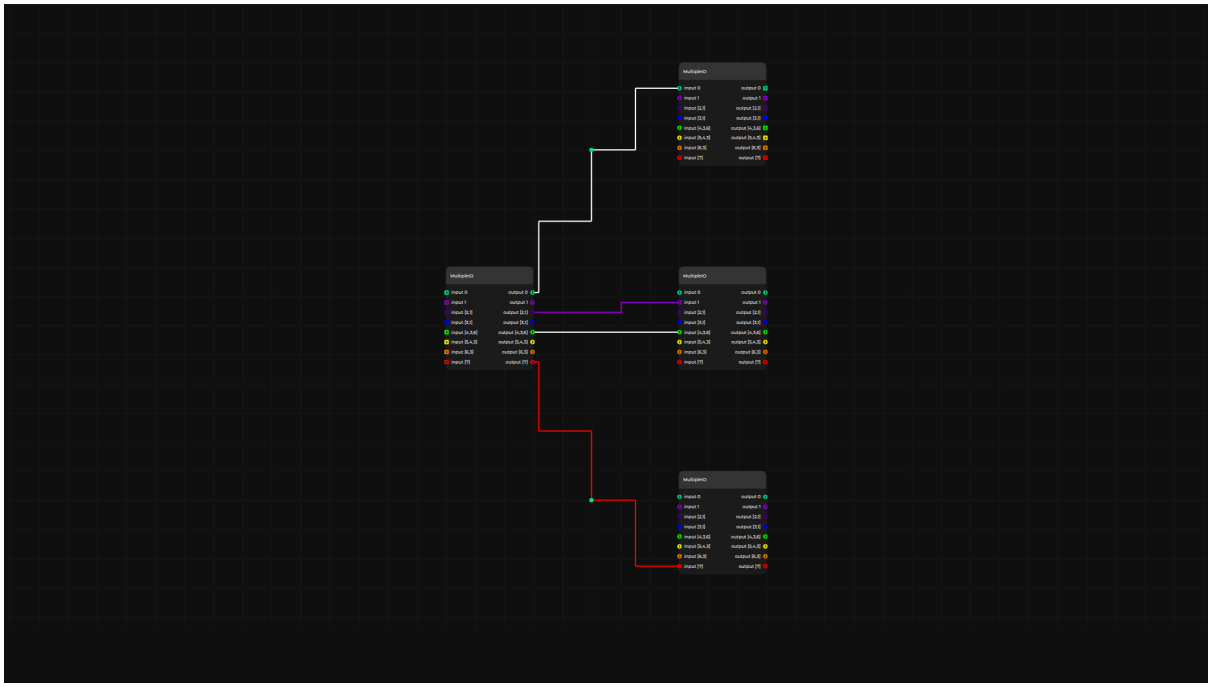
- Example of interface grouping



- Example of graphs with connection loopbacks



- Example of Multiple Input-Output node



- Example of the graph with graph nodes


Test subgraph node #1
Subgraph Inout 1
Subgraph Inout 2
Subgraph Input 1
Subgraph Output 2
Test node #1
Inout
Output
Input
Test node #2
Sample option:
Option 2
Output
Input
Inout
Test subgraph node #2
Subgraph Inout 1
Subgraph Output 2
Subgraph Input 1
Subgraph Inout 2

INDEX