GinFlow Documentation

Release 2.0.0

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Aug 11, 2016

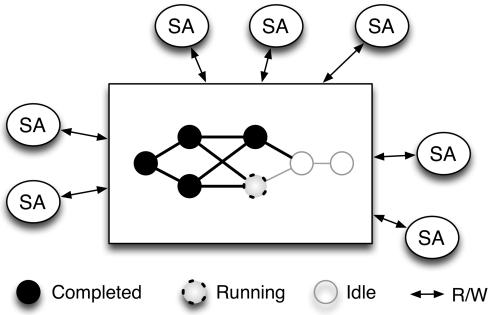
CHAPTER

ONE

BACKGROUND

1.1 What is GinFlow ?

GinFlow is a decentralised workflow engine. As illustrated on the image below, the GinFlow workflow manager decentralizes the execution coordination of workflow-based applications by relying on an architecture where multiple workflow co-engines, *a.k.a.*, service agents (SAs) coordinate each others through the use of a shared space containing the description of the current status of the workflow execution.



At run time, the shared space gets fed with the description of the initial workflow description, namely, its tasks and the dependencies between them. Also, a set of agents, typically one per task of the workflow get started. These agents, concurrently, will pull a subportion of the space, more precisely the information of their assigned task, process it locally, and trigger the execution of their task if all its incoming dependencies are satisfied. Once the task is terminated, its results are collected by the agent and forwarded to their destination agents in a P2P fashion. The shared space is also rewritten by the agent so as to reflect this termination (and change in the state of the workflow).

The description of the workflow and its interpretation by the agents rely on an adaptive, chemistry-inspired rule-based programming language, namely the *Higher Order Chemical Language* (HOCL). This language relies on concurrent rewriting of a (multiset) space. You can find more information on HOCL here: *[HOCL]*.

1.1.1 Executors

GinFlow exposes a high-level API (either JSON-based or Java code-based) to describe your workflow and lets you run it over various distributed environments. GinFlow supports the following workflow executors:

The *centralised executor* runs your workflow using a single agent containing an HOCL interpreter responsible for the whole coordination and invocation of commands realising the tasks.

The *SSH executor* deploys your workflow over a set of agents and fills the initial shared space. It relies on SSH to connect and start the agents on a set of worker nodes to be specified in the GinFlow YAML configuration file.

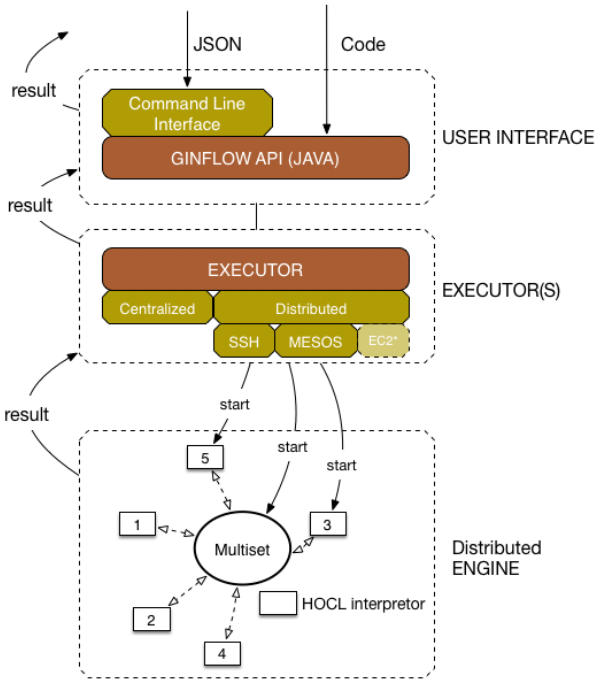
The *Mesos executor* submits your workflow to a dedicated Mesos[1] instance managing your worker nodes and uses Mesos primitives to control the agents.

1.1.2 Message brokers

The communication between agents and between an agent and the shared space relies on a persistent communication middleware. In practice, two message brokers are supported: AciveMQ[2] (which is the default broker) and the Kafka[3] / Zookeeper[4] broker (which provides state recovery of an agent in case it fails). Your preferred broker can be chosen at set-up, in the YAML configuration file.

1.2 Architecture

The GinFlow architecture is composed of three layers, illustrated on the figure below :



The GinFlow architecture comprises three layers.

- The top layer is the user interface. It comes in two flavours allowing you to specify your workflow either using a simple JSON file or programmatically using the Java interface.
- The middle layer is the *executor* It is the GinFlow layer which is responsible for the actual deployment of your workflow on your infrastructure. Three executors are currently proposed:
  - The *centralised executor* starts your workflow in a centralised mode where a single HOCL interpreter is started, fed with your workflow's description and will be responsible for the whole execution, the satisfaction of data dependencies and the actual calls to the commands realising the tasks.

[1] http://mesos.apache.org/
[2] http://activemq.apache.org/
[3] http://kafka.apache.org/
[4] https://zookeeper.apache.org/

  - The *SSH executor* deploys your workflow on a set of worker nodes and fills the initial shared space with your workflow description. It relies on SSH connections to start and configure the agents. Once the agents are started and the shared space is initialised, the workflow execution is autonomous.
  - The *Mesos executor* allows you to use your own Mesos instance managing your computing nodes. It is interfaced with the Mesos primitives to start and control the status of the agents.

- The bottow layer is the core of GinFlow and implements the workflow agents through a set of HOCL interpreters and a shared space containing an HOCL dynamic description of the workflow. The direct communication between the agents is assured by a persistent message broker. Two message brokers are currently supported: ActiveMQ and Kafka. The former is the default one. The latter provides a state recovery of agents in case of failure. More specifically, if some agent fails during execution, it can be restarted, without any further action from the user: kafka ensures that all the messages will be replayed so as to ensure the workflow will eventually recover. You will find more information on the bottow GinFlow layer in publication *[FGCS]*.

CHAPTER

TWO

QUICK START

This section will help you to go through the basics of running workflows with GinFlow and is organised in four steps:

- Writing and executing your first workflow
- Changing the centralised executor to the distributed, SSH-based executor
- Creating a configuration file
- Using the environment variables

2.1 Your first workflow

In this part you will learn how to create a simple workflow and run it on the central executor.

1. Download the hocl-workflow-2.0.0-SNAPSHOT.jar file from http://ginflow.inria.fr/download/.
2. Create your first workflow file *wf.json*. The following example creates a sequence of two services : the first outputs "!" and the second will output "?" concatenated to the output of the first service.

```
{
  "name" : "test-workflow",
  "services": [{
    "name"  : ["1"],
    "srv"   : ["echo"],
    "in"    : ["!"],
    "dst"   : ["2"]
   }, {
     "name" : ["2"],
     "srv"  : ["echo"],
     "in"   : ["?"],
     "src"  : ["1"]
   }]
}
```

- Launch it through the following command:

```
java -jar hocl-workflow-2.0.0-SNAPSHOT.jar launch -w wf.json
```

- Check the result by having a look at the *wf.json.ginout* file generated at the end of the workflow execution. It contains the HOCL respresentation of the final state of the workflow. Without worrying too much about HOCL code, notice that it is comprised of the final state of both services in some arbitrary order. Notice in particular the "out":... which contains the output of the service. In case of the second service, it is:

```
.... "out":["! ?"] ...
```

Note finally that, `"err":[...]` and `"exit":[...]` artifacts similarly contain the exit code and potential errors collected at run time, respectively (from the execution of the echo command in this particular case.)

2.2 Changing the executor to SSH

You executed your first workflow using the central (by default) executor. In this section, you will learn how to use the SSH executor on your local machine.

- Configure passwordless connection to your local machine.

```
ssh-keygen -t rsa -f /tmp/ginkey -q -N ''
cat /tmp/ginkey.pub >> ~/.ssh/authorized_keys
```

- Run the workflow using the SSH executor:

```
java -jar hocl-workflow-2.0.0-SNAPSHOT.jar launch -w wf.json -e ssh -o ssh.private.key=/tmp
```

```
ssh.private.key=[path to your private key] # this private key will be used to
                                            initiate the passwordless SSH
                                            connection to the machines
                                            specified by ssh.machines
```

2.3 Using a configuration file

GinFlow can read its options from a file called "ginflow.yaml" in the current directory. In the previous case the content will be :

```
ssh.private.key: [path to your private key]
```

It simplifies the command line to the following (you only need to specify which executor you use by using the `-e` option:

```
java -jar hocl-workflow-2.0.0-SNAPSHOT.jar launch -w wf.json -e ssh
```

2.4 Using environment variables

Alternatively, GinFlow can read all these options from environment variables. The mapping from the environment variable and an option is handled by the following rule :

```
env var GINFLOW_X_Y <-> option x.y
ex :
GINFLOW_SSH_PRIVATE_KEY <-> ssh.private.key
```

Thus the following command will launch the same workflow as before :

```
GINFLOW_SSH_PRIVATE_KEY=/tmp/ginkey java -jar hocl-workflow-X.Y.Z.jar launch -w wf.
↪json -e ssh
```

CHAPTER

THREE

USER GUIDE

3.1 Command line Interface

3.1.1 *launch*

We already met the *launch* subcommand. It allows you to launch a workflow. Let's list its options:

```
Usage: launch [options]
Options:
  -c, --config
     Config file
     Default: ginflow.yaml

  -d, --debug
     Default: 0

  -e, --executor
     Executor to use, possible values are : central, mesos, ssh
     Default: central

  -h, --help
     Default: false

  -o, --option
     Executor options
     Syntax: -o key=value
     Default: {}

* -w, --workflow
     Path to the json file containing the workflow definition
```

3.1.2 *clean*

The *clean* subcommand can be used to clean service invokers on remote machines. Usually the executor is responsible for cleaning the processes after the execution, but in some rare cases (e.g: connection error to some nodes during the deployment) you can use this subcommand to clean the remaining processes.

```
Usage: clean [options]
Options:
  -c, --config
     Config file
     Default: ginflow.yaml
```

```
  -d, --debug
     Default: 0

  -h, --help
     Default: false

  -o, --option
     Executor options
     Syntax: -okey=value
     Default: {}

* -w, --workflow
     workflow id
```

3.1.3 *update*

The *update* subcommand can be used to trigger an adaptation of the running workflow.

```
Usage: update [options]
 Options:
   -c, --config
      Config file
      Default: ginflow.yaml
   -d, --debug

      Default: 0
   -h, --help

      Default: false
   -o, --option
      Executor options
      Syntax: -okey=value
      Default: {}
 * -id, --uid
      workflow id
 * -w, --workflow
      Path to the json file containing the update to apply to the workflow
```

3.1.4 *listen*

The *listen* subcommand allows you to create and launch a workflow via the graphical interface. To have a complete monitoring of the execution, the execution should be distributed (set executor to mesos or ssh). Let's list its options:

```
Usage: listen [options]
Options:
  -c, --config
     Config file
     Default: ginflow.yaml

  -d, --debug
     Default: 0

  -e, --executor
```

```
    Executor to use, possible values are : central, mesos, ssh
    Default: central

  -h, --help
    Default: false

  -o, --option
    Executor options
    Syntax: -o key=value
    Default: {}
```

3.2 Configuration File

By default the command line tries to load a file named *ginflow.yaml* in the current directory. An alternative file may be specified using the *-c* switch of the command line. Here is the full specification of the options you may find in the configuration file.

Notice first the Kafka part. Switching to a Kafka broker requires firstly having a Kafka installation running (including a ZooKeeper server), and secondly modifying the configuration file. The `broker` parameter must be changed for `Kafka` , and the Kafka and ZooKeeper servers fields need to be filled.

If you have a Mesos instance running on top of your resources, and you want GinFlow workers to be scheduled on your resources through it, you need to fill the Mesos part of the configuration file (the four `mesos.*` parameters).

```
## Distribution

distribution.home: # absolute path to the directory containing GinFlow JAR
distribution.name: # GinFlow  binary e.g hocl-workflow-0.0.1-SNAPSHOT.jar

#
# Distributed parameters
#
### -e mesos
mesos.user         : # user to use to launch local invoker on mesos slaves
mesos.master       : # adress:port of the mesos master
mesos.resources.cpu: # cpu to use for running the local invoker e.g: "1"
mesos.resources.mem: # memory ammount to use for running the local invoker e.g: "128"

### -e ssh
ssh.machines   : # comma separated list of remote machines to use
ssh.user       : # user login used to connect to the remote machines
ssh.private_key: # path to the private key to use

#
# Communication parameters
#
broker: # broker to use, possible values are activeMQ, Kafka
broker.standalone: # true if the broker is provided externally,
                   false if an embedded broker shoud be started.
                   Default to false.

## ActiveMQ options
activemq.broker.url: # endpoint of the activeMQ broker
                     # e.g: "failover://(tcp://localhost:61616)"

## Kafka
```

```
kafka.bootstrap.servers: # comma separated list of bootstrap servers
                         # e.g: "localhost:9092"
kafka.zookeeper.connect: # comma separated list of zookeeper nodes
                         # e.g: "localhost:2181"

# hocl
hocl.debug: # debug level of HOCL engine, possible value are "0", ... "9"

# chaos
chaos.threshold: # probability that a service agent fails
                 # e.g : "0.5"
chaos.sleep:     # time before failure (ms)
                 # e.g : "10000"
```

3.3 JSON workflow description

As illustrated above, the simpler way to describe your workflow is to use the JSON format. A GinFlow workflow is basically a JSON list of services, preceeded by a name:

```
{
  "name" : "workflow-name",
  "services": [
  ...
  ]

}
```

Each service's description comprises the following possible fields:

```
{
    "name"  : ["..."],
    "srv"   : ["..."],
    "in"    : ["..."],
    "src"   : ["..."],
    "dst"   : ["..."],
    "src_control" : ["..."],
    "dst_control" : ["..."],
    "alt"   : <int>,
    "sup"   : <int>
}
```

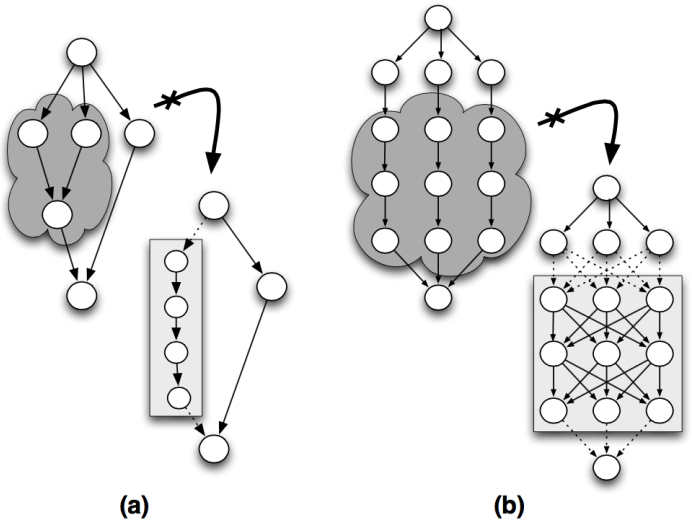
Let us briefly review these (all string) fields:

1. The `name` field is a name you give to the service. It will be used as an identifier for references from the other services. `MANDATORY`
2. The `srv` field gives the command line to be executed when triggering this service. `MANDATORY`
3. The `src` field is a comma separated list of service identifiers denoting the incoming data dependencies of the service. All output from this list of services will be used as input to this service. `OPTIONAL,default = [""]`
4. The `dst` field is a comma separated list of service identifiers to which send the output of this service. Note that the data dependencies are redundant: if there is a data dependency from *i* to *j*, `i` appears in the `src` field of service `j` , and `j` appears in the `dst` field of service `i` . `OPTIONAL,default = [""]`

5. The `src_control` and `dst_control` fields are similar to `src` and `dst` fields respectively, except that they express *control* dependencies instead of *data* dependencies. A *control* dependency expresses that some service has to wait for the completion of another one to start, but will not take its output as input. `OPTIONAL,default = [""]`
6. The `alt` and `sup` fields are exclusive and are related to the adaptation mechanism in play in GinFlow.
   - `sup` indicates that the service is under supervision. It means that if the service returns and non zero status code, the adaptation mecanism will occur for the group the service belongs to. The integer value identifies the group of the service.
   - `alt` indicates that the service is an alternative for the group identified by the given integer value.

3.4 Adaptation Mecanisms

GinFlow introduces an easy way to specify and execute alternative scenarios. Alternative sub-workflow get triggered on-the-fly by the engine in a transparent way for the user. Below you will find two examples of workflow whose shapes are changed at run-time.



In both cases one group of services is changed in another group of services. The former group is called the `supervised` group and the latter the `alternative` group. GinFlow allows the definition of several `supervised` groups as long there exists corresponding `alternative` groups.

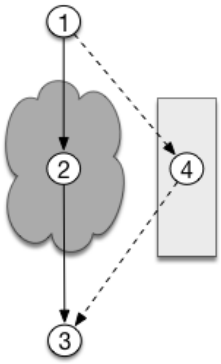
3.4.1 Use in the JSON workflow file

Version 1

Let's consider a sequence of three services where the second service is supervised and replaced by an alternative in case of failure. The resulting workflow after the adaptation is also a sequence of three services. For this scenario we thus define :

- one `supervised` group with id 1 which contains the second service * one

`alternative` group with id 1 which contains the alternative service



A rebranching plan will be generated by GinFlow to allow the alternatives to run in case of a failure in one of the supervised services

```
{
  "name"    : "wf1",
  "services": [
    {
      "name"        : ["1"],
      "srv"         : ["echo"],
      "in"          : ["1"],
      "src_control" : [],
      "dst_control" : ["2"]
    },
    {
      "name"       : ["2"],
      "srv"        : ["thiscommanndisnotfound"],
      "in"         : ["2"],
      "sup"        : 1,
      "dst_control": ["3"],
      "src_control": ["1"]
    },
    {
      "name"        : ["3"],
      "srv"         : ["echo"],
      "in"          : ["3"],
      "src_control" : ["2"],
      "dst_control" : []
    },
    {
      "name"        : ["4"],
      "srv"         : ["echo"],
      "in"          : ["4"],
      "alt"         : 1,
      "dst_control" : ["3"],
      "src_control" : ["1"]
    }
  ]
}
```

The execution of the previous workflow leads to the following output :

```
- Initializing the workflow
- Workflow initialized with id 2061eea6-7b3d-40fc-8f11-4f70ce527a4c
- Starting the ssh executor
- Initial description to 4 services is being transmitted
```

```
- -> Service 1 done
- -> Service 1 done
- -> Service 4 done
- -> Service 3 done
- -> Result received 1/1
- Worklow terminated
- Cleaning remaining processes
- Writing json output to test.json.ginout
- Exiting
```

Version 2

Here we specify the rebranching information directly in the description :

```
{
  "name"    : "wf2",
  "services": [
  {
    "name"        : ["1"],
    "srv"         : ["echo"],
    "in"          : ["1"],
    "src_control" : [],
    "dst_control" : ["2"]
  },
  {
    "name"       : ["2"],
    "srv"        : ["thiscommanndisnotfound"],
    "in"         : ["2"],
    "dst_control": ["3"],
    "src_control": ["1"]
  },
  {
    "name"        : ["3"],
    "srv"         : ["echo"],
    "in"          : ["3"],
    "src_control" : ["2"],
    "dst_control" : []
  },
  {
    "name": ["4"],
    "srv" : ["echo"],
    "in"  : ["alternative!"],
    "src" : ["1"],
    "dst" : ["3"]
  }],
  "rebranchings": [{
    "supervised": ["2"],
    "updateSrc" : {"1": ["4"]},
    "updateDst" : {"3": ["4"]}
  }]
}
```

3.4.2 At runtime adaptation

GinFlow allows the user to adapt the workflow on the fly. It consists in giving the list of the alternative services as well as the rebranching plan.

Let's assume that the original workflow is the following :

```
{
  "name"    : "wf3",
  "services": [
    {
      "name"        : ["1"],
      "srv"         : ["echo"],
      "in"          : ["1"],
      "src_control" : [],
      "dst_control" : ["2"]
    },
    {
      "name"       : ["2"],
      "srv"        : ["thiscommanndisnotfound"],
      "in"         : ["2"],
      "dst_control": ["3"],
      "src_control": ["1"]
    },
    {
      "name"        : ["3"],
      "srv"         : ["echo"],
      "in"          : ["3"],
      "src_control" : ["2"],
      "dst_control" : []
    },
    {
      "name"        : ["4"],
      "srv"         : ["echo"],
      "in"          : ["4"],
      "dst_control" : ["3"],
      "src_control" : ["1"]
    }
  ]
}
```

While this workflow is running, a user can trigger an adaptation with the following command :

```
java -jar hocl-workflow-2.0.0-SNAPSHOT.jar update -id <id> -w update_wf.json
```

Where the id of the workflow is given by the `launch` command and `update_wf.json` is

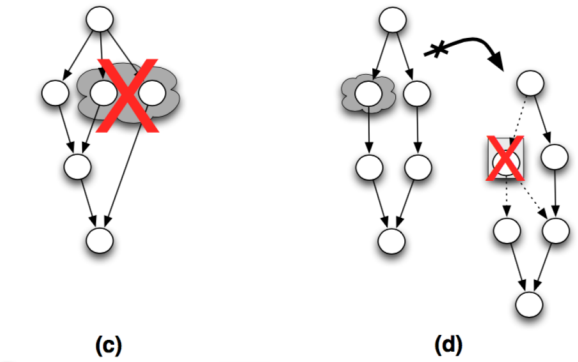
```
{
  "name"    : "wf4",
  "services": [
  {
    "name": ["4"],
    "srv" : ["echo"],
    "in"  : ["alternative!"],
    "src" : ["1"],
    "dst" : ["3"]
  }],
  "rebranchings": [{
    "supervised": ["2"],
```

```
    "updateSrc" : {"1": ["4"]},
    "updateDst" : {"3": ["4"]}
  }]
}
```

Note that `wf4` it is exactly the difference between `wf2` and `wf3`.

3.4.3 Restrictions

- Two groups (of supervised services or alternative services) can not overlap.
- There must be only one destination for all final services of both (initial and replacement). Illustrations below.



3.5 Java API

Definition, execution of workflows can be done through the Java API of GinFlow. Please refer to the developper section to learn more about this feature.

3.6 Deploying on Grid'5000

The following steps will guide you through the basic use of GinFlow on the Grid'5000 platform[1].

1. Install one of the latest ActiveMQ releases (http://activemq.apache.org/download-archives.html)
2. Make a reservation :

```
screen oarsub -t allow_classic_ssh -l "nodes=N,walltime=XX:YY:ZZ" -I
```

3. Start ActiveMQ
4. Get the list of machines you reserved:

```
s=""; for i in $(uniq $OAR_FILE_NODES); do s=$s,$i; done; echo $s
```

5. **In the config file `ginflow.yaml`**
    - copy/paste the list of nodes in the `ssh.machines` field.
    - set the other parameters accordingly to your installation.

[1] http://www.grid5000.fr

You are now ready to use the `ssh executor` with ActiveMQ.

Note : Depending on your needs Kafka and Zookeeper may replace ActiveMQ. You can refer to their respective documentations to install them.

CHAPTER

FOUR

DEVELOPPER GUIDE

4.1 Source code

The code base is hosted on Bitbucket : https://bitbucket.org/ginflow/hocl-workflow. Releases are tagged with the version number and can be found on the *release* branch.

4.2 Developping with Maven

4.2.1 Set up your project

You can add the GinFlow artifact as a maven dependency to your project. This can be done by adding the following lines to your *pom.xml*

```
<repository>
  <id>ginflow-snapshots-repository</id>
  <name>ginflow-snapshots-repository</name>
  <url>http://hocl-server.irisa.fr/downloads/maven/snapshots</url>
</repository>
<repository>
  <id>ginflow-releases-repository</id>
  <name>ginflow-releases-repository</name>
  <url>http://hocl-server.irisa.fr/downloads/maven/releases</url>
</repository>

<dependency>
  <groupId>fr.inria</groupId>
  <artifactId>hocl-workflow</artifactId>
  <version>X.Y.Z</version>
</dependency>
```

Fill the hocl-workflow version accordingly to your needs.

4.2.2 Using the Java API

This examples are extracted from the test suite. They aim at illustrating how to build and launch a workflow programmatically.

First we define a method to build the i-th service in a numbered sequence of services. Note that the first and the last service in a sequence need a special attention regarding their sources and destinations:

```
/**
 *
 * Construct a service in sequence.
 *
 * Ti-1 -> Ti -> Ti+1
 *
 * @param max       max number of service in the sequence
 * @param i         current id in the sequence
 * @param command   the command to run
 * @return  The built service.
 */
protected Service Ti(int max, int i, String command) {
    Service service = Service.newService(String.valueOf(i))
                             .setCommand(Command.newCommand(command));
    Destination destination = Destination.newDestination();
    Source source = Source.newSource();
    if (i < max - 1) {
        destination = Destination.newDestination()
                .add(String.valueOf(i + 1));
    }
    if (i>0) {
        source = Source.newSource()
                .add(String.valueOf(i - 1));
    }

    return service.setSource(source)
            .setDestination(destination);
}
```

Next we define the workflow containing all the services in sequences (in this case, all services are executing the *echo* command):

```
/**
 *
 * Build a sequence of max services, each running the same command.
 *
 * @param max           The number of services
 * @param command       The command
 * @return
 */
protected Workflow sequence(int max, String command) {
    Workflow workflow = Workflow.newWorkflow("sequence");
    for (int i = 0 ; i < max ; i++) {
        workflow.registerService(String.valueOf(i), Ti(max, i, command));
    }
    // set the last service has terminal.
    workflow.getTerminalServices().add(String.valueOf(max - 1));
    return workflow;
}
```

Then we can instantiate a workflow and an executor object to handle the execution of the workflow:

```
int max = 2;
Workflow workflow = sequence(max, "echo !");
GinflowExecutor executor = new CentralisedExecutor(workflow, new Options());
executor.decorate();
executor.execute();
```

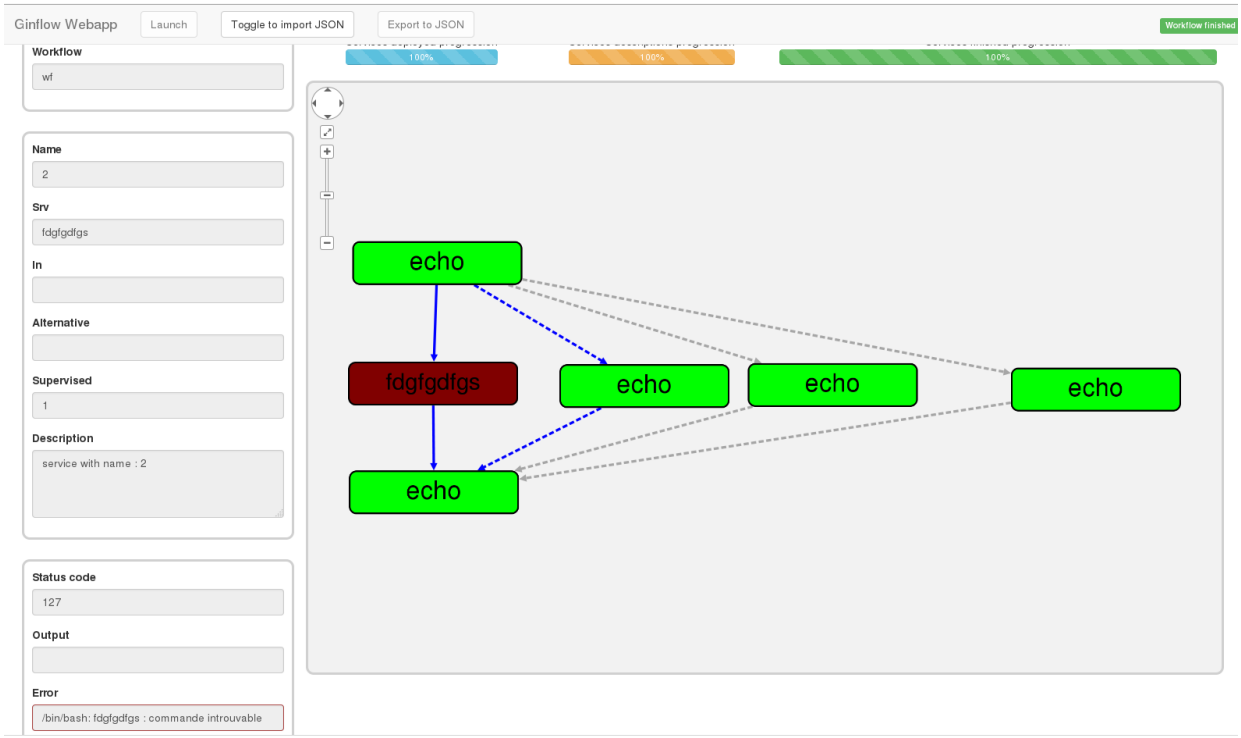
To go further, please refer to the API documentation.

CHAPTER

FIVE

GRAPHICAL INTERFACE

5.1 Ginflow Webapp



Ginflow introduces a new way to create a workflow, another way than by command line. You can now specify a workflow with the graphical user interface, Ginflow Webapp.

The code of this graphical interface is available on BitBucket : https://bitbucket.org/ginflow/ginflow-webapp

Ginflow Webapp relies on a graph-oriented JavaScript library : Cytoscape.js The application is an Angular 2 application and communicate with the API Java of Ginflow.

This client application only works when the listen command is launched on Ginflow. See the *listen* command.

With this interface, you can:

- Create a workflow from scratch
- Import workflow by giving a JSON object
- Export the current workflow in a JSON format
- Execute the workflow
- Visualize the state of a service before, during and after the execution

5.1.1 Create your workflow from scratch

Features

- Create an empty service

To create a service, you just have to click on the grey part of the application.

- Update a service

When you create a service, this service is empty. To complete the description of a service, you just have to click on this service, a form will appear on the left of the screen. You can modify its description easily with this.

- Remove a service

To remove a service from the workflow, just right-click on the service. This will also remove all its connected links.

- Add a src or dst dependency on a service

To do this, you just have to create a link between two services. For example if you want to create a link between a service "1" and a service "2", "1" will have "2" in its dst and "2" will have "1" in its src.

- Add a src_control or dst_control dependency on a service

It's the same thing before, but when you select the link you can change the dependency data by control.

5.1.2 Import a workflow by giving a JSON

To import a workflow, you can click on a button "Toggle to import JSON". Then a text-field will appear on the left, you just have to put a JSON text in it and submit it, then it will create the workflow.

Format of the JSON object

```
{
  "name": "wf",
  "services": [
      {
          "position": {
              "x": 279,
              "y": 52
          },
          "service": {
              "description": "Service with id1",
              "dst": [
                  "2",
                  "4"
              ],
```

```
            "dstControl": [],
            "id": "1",
            "in": "1",
            "name": "1",
            "src": [],
            "srcControl": [],
            "srv": "echo"
        }
    },
    {
        "position": {
            "x": 274,
            "y": 195
        },
        "service": {
            "description": "Service with id2",
            "dst": [
                "3"
            ],
            "dstControl": [],
            "id": "2",
            "in": [],
            "name": "2",
            "src": [
                "1"
            ],
            "srcControl": [],
            "srv": "fdgfgdfgs",
            "sup": "1"
        }
    },
    {
        "position": {
            "x": 275,
            "y": 324
        },
        "service": {
            "description": "Service with id3",
            "dst": [],
            "dstControl": [],
            "id": "3",
            "in": "3",
            "name": "3",
            "src": [
                "4",
                "2"
            ],
            "srcControl": [],
            "srv": "echo"
        }
    },
    {
        "position": {
            "x": 525,
            "y": 198
        },
        "service": {
            "alt": "1",
```

```
                "description": "Service with id4",
                "dst": [
                    "3"
                ],
                "dstControl": [],
                "id": "4",
                "in": "4",
                "name": "4",
                "src": [
                    "1"
                ],
                "srcControl": [],
                "srv": "echo"
            }
        }
    ]
}
```

The description looks like the workflow description that ginflow takes to execute the workflow, but we must define an object position to know where the service will be created on the screen.

5.1.3 Get the JSON object of the workflow

A button "Export to JSON" allows you to get the JSON text of the current workflow. The JSON format is the same as the format to import workflow.

5.1.4 Execute the workflow

Prerequisites

Ginflow must be launched with the listen command before launching the workflow.

The button "Launch" will launch the workflow, just like the launch command of Ginflow.

5.1.5 Visualize the result of a service

When the execution of a service is terminated, you can select it to show different informations like:

- The exit code
- The standard output
- The error output

A service which has failed, will be colored in red. A service which has been executed successfully will be colored in green.

[HOCL] Jean-Pierre Banâtre, Pascal Fradet, Yann Radenac: Generalised multisets for chemical programming. Mathematical Structures in Computer Science 16(4): 557-580 (2006)

[FGCS] Héctor Fernandez, Cédric Tedeschi, Thierry Priol: Rule-driven service coordination middleware for scientific applications. Future Generation Comp. Syst. 35: 1-13 (2014)