

COMP SUPERSCALAR

User Manual

Application execution guide

VERSION: 1.3

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This manual provides information about how to execute COMPSs applications, how to retrieve the results and the logs of an execution and it provides an overview of the COMPSs tools usage. It is highly recommended to test the examples described in this manual with a working COMPSs installation. For this purpose we provide a *COMPSs Virtual Machine* available at http://compss.bsc.es/.

For information about the installation process please refer to the $COMPSs\ Installation\ Guide$ available at http://compss.bsc.es/ .

For further information about the application development please refer to the *COMPSs User Manual: Application development guide* available at http://compss.bsc.es/.

For an extensive list of COMPSs application examples (codes, execution commands, results, logs, etc.) please refer to the *COMPSs Sample Applications* guide at http://compss.bsc.es/.

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1 COMP Superscalar (COMPSs)

COMP Superscalar (COMPSs) is a programming model which aims to ease the development of applications for distributed infrastructures, such as Clusters, Grids and Clouds. COMP Superscalar also features a runtime system that exploits the inherent parallelism of applications at execution time.

For the sake of programming productivity, the COMPSs model has four key characteristics:

- Sequential programming: COMPSs programmers do not need to deal with the typical duties of parallelization and distribution, such as thread creation and synchronization, data distribution, messaging or fault tolerance. Instead, the model is based on sequential programming, which makes it appealing to users that either lack parallel programming expertise or are looking for better programmability. A task is a method or a service called from the application code that is intended to be spawned asynchronously and possibly run in parallel with other tasks on a set of resources, instead of locally and sequentially.
- Infrastructure unaware: COMPSs offers a model that abstracts the application from the underlying distributed infrastructure. Hence, COMPSs programs do not include any detail that could tie them to a particular platform, like deployment or resource management. This makes applications portable between infrastructures with diverse characteristics.
- Standard programming languages: COMPSs is based on the popular programming language Java, but also offers language bindings for Python and C/C++ applications. This facilitates the learning of the model, since programmers can reuse most of their previous knowledge.
- No APIs: In the case of COMPSs applications in Java, the model does not require to use any special API call, pragma or construct in the application; everything is pure standard Java syntax and libraries. With regard the Python and C/C++ bindings, a small set of API calls should be used on the COMPSs applications.

2 Executing COMPSs applications

2.1 Prerequisites

Prerequisites vary depending on the application's code language: for Java applications the users need to have a **jar archive** containing all the application classes, for Python applications there are no requirements and for C/C++ applications the code must have been previously compiled by using the *buildapp* command.

For further information about how to develop COMPSs applications please refer to the COMPSs User Manual: Application development guide available at the http://compss.bsc.es/webpage.

2.2 Runcompss command

COMPSs applications are executed using the **runcompss** command:

```
compss@bsc:~$ runcompss [options] application_name [application_arguments]
```

The application name must be the fully qualified name of the application in Java, the path to the .py file containing the main program in Python and the path to the master binary in C/C++.

The application arguments are the ones passed as command line to main application. This parameter can be empty.

The *runcompss* command allows the users to customize a COMPSs execution by specifying different options. For clarity purposes, parameters are grouped in *Runtime configuration*, *Tools enablers* and *Advanced options*.

```
compss@bsc:~$ runcompss -h
 Runtime configuration options:
    --project=<path>
                                           Path to the project XML file
                                            Default: /opt/COMPSs/Runtime/configuration/
                                            xml/projects/project.xml
    --resources=<path>
                                           Path to the resources XML file
                                            Default: /opt/COMPSs/Runtime/configuration/
                                            xml/resources/resources.xml
   --lang=<name>
                                           Language of the application (java/c/python)
                                            Default: java
   --log_level=<level>, --debug, -d
                                          Set the debug level: off | info | debug
 Tools enablers:
    --graph=<bool>, --graph, -g
                                          Generation of the complete graph (true/false)
                                            When no value is provided it is set to true
                                            Default: false
    --tracing=<bool>, --tracing, -t
                                          Generation of traces (true/false)
                                            When no value is provided it is set to true
                                            Default: false
    --monitoring=<int>, --monitoring, -m Period between monitoring samples
                                            (milliseconds)
                                            When no value is provided it is set to 2000
```

Default: 0 Advanced options: Class that implements the adaptor for --comm=<path> communications Default: integratedtoolkit.nio.master. NIOAdaptor --library_path=<path> Non-standard directories to search for libraries (e.g. Java JVM library, Python library, C binding library) Default: . Path for the application classes / modules --classpath=<path> Default: current working directory. --task_count=<int> Only for C/Python Bindings. Maximum number of different functions/methods invoked from the application that have been selected as tasks Default: 50 Preset an application UUID --uuid=<int> Default: Automatic random generation --PyObject_serialize=<bool> Only for Python Binding. Enable the object serialization to string when possible (true/false). Default: false

2.3 Running a COMPSs application

Before running COMPSs applications the application files **must** be in the **CLASSPATH**. Thus, when launching a COMPSs application, users can manually pre-set the **CLASS-PATH** environment variable or can add the *-classpath* option to the *runcompss* command.

The next three sections provide specific information for launching COMPSs applications developed in different code languages (Java, Python and C/C++). For clarity purposes we will use the Simple application (developed in Java, Python and C++) available in the COMPSs Virtual Machine or at https://compss.bsc.es/projects/bar webpage. This application takes an integer as input parameter and increases it by one unit using a task. For further details about the codes please refer to the Sample Applications document available at http://compss.bsc.es.

2.3.1 Running Java applications

A Java COMPSs application can be launched through the following command:

```
compss@bsc:~$ cd workspace_java/simple/jar/
compss@bsc:~/workspace_java/simple/jar$ runcompss simple.Simple <initial_number>
```

In this first execution we use the default value of the *-classpath* option to automatically add the jar file to the classpath (by executing runcompss in the directory which contains the jar file). However, we can explicitly do this by exporting the **CLASSPATH** variable or by providing the *-*classpath value. Next, we provide two more ways to perform the same execution:

Figure 1: Execution of a Java COMPSs application.

```
compss@bsc:~$ runcompss --classpath=/home/compss/workspace_java/simple/jar/simple.jar
simple.Simple <initial_number>
```

2.3.2 Running Python applications

To launch a COMPSs Python application users have to provide the *-lang=python* option to the runcompss command.

```
compss@bsc:~$ cd workspace_python/simple/
compss@bsc:~/workspace_python/simple$ runcompss --lang=python simple.py <initial_number>
```

Figure 2: Execution of a Python COMPSs application.

2.3.3 Running C/C++ applications

To launch a COMPSs C/C++ application users have to compile the C/C++ application by means of the buildapp command. For further information please refer to the COMPSs User Manual: Application development guide document available at http://compss.bsc.es. Once complied, the -lang=c option must be provided to the runcompss command.

```
compss@bsc:~$ cd workspace_c/simple/
compss@bsc:~/workspace_c/simple$ runcompss --lang=c simple <initial_number>
```

Figure 3: Execution of a C++ COMPSs application.

2.4 Additional configurations

The COMPSs runtime has two configuration files: resources.xml and project.xml. These files contain information about the execution environment and are completely independent from the application.

For each execution users can load the default configuration files or specify their custom configurations by using, respectively, the $--resources = < absolute_path_to_resources.xml >$ and the $--project = < absolute_path_to_project.xml >$ in the runcompss command. The default files are located in the /opt/COMPSs/Runtime/configuration/xml/ path. Users can manually edit these files or can use the $Eclipse\ IDE$ tool developed for COMPSs. For further information about the $Eclipse\ IDE$ please refer to Section 4.4.

Next sections describe in detail the *resources.xml* and the *project.xml* files, explaining the available options.

2.4.1 Resources file

The resources file provides information about all the available resources that can be used for an execution. This file should normally be managed by the system administrators. Its full definition schema can be found at

/opt/COMPSs/Runtime/configuration/xml/resources/resource_schema.xsd.

It contains one entry per available resource defining its name, its capabilities and its requirements. Administrators can define several resource capabilities (see example in the next listing) but we would like to underline the importance of **Processor CoreCount**.

This capability represents the number of available cores in the described resource and it is used to schedule the correct number of tasks. Thus, it becomes essential to define it accordingly to the number of cores in the physical resource.

```
compss@bsc:~$ cat /opt/COMPSs/Runtime/configuration/xml/resources/resources.xml
<?xml version="1.0" encoding="UTF-8"?>
<ResourceList>
        <Resource Name="localhost">
                <Capabilities>
                        <Host>
                                 <TaskCount>0</TaskCount>
                                 <Queue>short</Queue>
                                 <Queue/>
                        </Host>
                        <Processor>
                                 <Architecture>IA32</Architecture>
                                 <Speed>3.0</Speed>
                                 < CoreCount > 4 < /CoreCount >
                        </Processor>
                         < 0.5 >
                                 <OSType>Linux</OSType>
                                 <MaxProcessesPerUser>32</MaxProcessesPerUser>
                         </0S>
                         <StorageElement>
                                 <Size>8</Size>
                         </StorageElement>
                         <Memory>
                                 <PhysicalSize>4</PhysicalSize>
                                 <VirtualSize>8</VirtualSize>
                        </Memory>
                         <ApplicationSoftware>
                                 <Software>Java</Software>
                        </ApplicationSoftware>
                         <Service/>
                        < 0/0/>
                        <Cluster/>
                         <FileSystem/>
                        <NetworkAdaptor/>
                         <JobPolicy/>
                         <AccessControlPolicy/>
                </Capabilities>
                <Requirements/>
                <Adaptors>
                        <Adaptor name="integratedtoolkit.nio.master.NIOAdaptor">
                                 <MinPort>43001</MinPort>
                                 <MaxPort>43002</MaxPort>
                        </Adaptor>
                </Adaptors>
        </Resource>
</ResourceList>
```

2.4.2 Project file

The project file provides information about the resources used in a specific execution. Consequently, the resources that appear in this file are a subset of the resources described in the *resources.xml* file. This file, that contains one entry per worker, is usually edited by the users and changes from execution to execution. Its full definition schema can be found at

 $/opt/COMPSs/Runtime/configuration/xml/projects/project_schema.xsd.$

We emphasize the importance of correctly defining the following entries:

installDir Indicates the path of the COMPSs installation inside the resource (not necessarily the same than in the local machine).

User Indicates the username used to connect via ssh to the resource. This user must have passwordless access to the resource (for more information check the *COMPSs Installation Manual* available at our website http://compss.bsc.es). If left empty COMPSs will automatically try to access the resource with the same username than the one that lauches the COMPSs main application.

LimitOfTasks The maximum number of tasks that can be simultaneously scheduled to a resource. Considering that a task can use more than one core of a node, this value must be lower or equal to the number of available cores in the resource.

2.5 Configuration examples

In the next subsections we provide specific information about the services, shared disks, cluster and cloud configurations and several *project.xml* and *resources.xml* examples.

2.5.1 Services configuration

To allow COMPSs applications to use WebServices as tasks, the *resources.xml* can include a special type of resource called *Service*. For each WebService it is necessary to specify its wsdl, its name, its namespace and its port.

When configuring the *project.xml* file it is necessary to include the service as a worker by adding an special entry indicating only the name and the limit of tasks as shown in the following example:

2.5.2 Cluster and grid configuration (static resources)

In order to use external resources to execute the applications, the following steps have to be followed:

- 1. Install the COMPSs Worker package (or the full COMPSs Framework package) on all the new resources following the Installation manual available at http://compss.bsc.es.
- 2. Set SSH passwordless access to the rest of the remote resources.
- 3. Create the *WorkingDir* directory in the resource (remember this path because it is needed for the *project.xml* configuration).
- 4. Manually deploy the application on each node.

The *resources.xml* and the *project.xml* files must be configured accordingly. Here we provide examples about configuration files for Grid and Cluster environments.

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<ResourceList>
   <Resource Name="hostname1.domain.es">
        <Capabilities>
                <TaskCount>0</TaskCount>
                <Queue>Short</Queue>
            </Host>
            <Processor>
                <Architecture>x86_64</Architecture>
                <Speed>2.5</Speed>
                <CoreCount>4</CoreCount>
            </Processor>
            <0S>
                <OSType>Linux</OSType>
            </0S>
            <StorageElement>
                <Size>250.0</Size>
            </StorageElement>
            <Memory>
                <PhysicalSize>4.0</PhysicalSize>
            </Memory>
            <ApplicationSoftware>
                <Software>BLAST</Software>
            </ApplicationSoftware>
        </Capabilities>
        <Requirements/>
```

2.5.3 Shared Disks configuration example

Configuring shared disks might reduce the amount of data transfers improving the application performance. To configure a shared disk the users must edit the *resources.xml* indicating how the shared disk is hosted in the master node and how the shared disk is mounted in each worker.

To indicate a shared disk hosted in the master node the resources.xml file must include a Disk tag describing the disk and the mount point. The following example states that in the master node there is a shared disk labelled sharedDisk0 mounted on the /sharedDisk directory.

On the other side, to declare that a worker has a shared disk mounted the resources.xml file must include a Disk tag inside the specific worker indicating its name (defined in the master Disk tag) and its mount point inside the worker. In the following example the sharedDisk0 is mounted on the resource hostname1.domain.es under the path /home-/user/mySharedDisk/.

The Disks tag can have multiple disk children nodes.

2.5.4 Cloud configuration (dynamic resources)

In order to use cloud resources to execute the applications, the following steps have to be followed:

- 1. Prepare cloud images with the COMPSs Worker package or the full COMPSs Framework package installed.
- 2. The application will be deployed automatically during execution but the users need to set up the configuration files to specify the application files that must be deployed.

The COMPSs runtime communicates with a cloud manager by means of connectors. Each connector implements the interaction of the runtime with a given provider's API, supporting four basic operations: ask for the price of a certain VM in the provider, get the time needed to create a VM, create a new VM and terminate a VM. This design allows connectors to abstract the runtime from the particular API of each provider and facilitates the addition of new connectors for other providers.

The resources.xml file must contain one or more < CloudProvider > tags that include the information about a particular provider, associated to a given connector. The tag **must** have an attribute **name** to uniquely identify the provider. Table 1 summarizes the information to be specified by the user inside this tag.

Server	Endpoint of the provider's server
Connector	Class that implements the connector

ImageList	Multiple entries of VM templates
• Image	• VM image
- Architecture	- Architeture of the VM image
- OSType	 Operative System installed in the VM image
- ApplicationSoftware	 Multiple entries of software installed in the VM image
* Software	* Software installed in the VM image
- SharedDisks	 Multiple entries of shared disks mounted in the VM im- age
* Disk	* Disk description
- Adaptors	 Multiple entries of adaptors available at the VM image
* Adaptor	* Adaptor name and specific properties
InstanceTypes	Multiple entries of resource templates
• Resource	• Instance type offered by the provider
- Capabilities	 Hardware details of instance type
* Processor	* Architecture and number of available cores
* StorageElement	* Size in GB of the storage
* Memory	* PhysicalSize, in GB of the available RAM
Table 1: Configuration of	resources well file test

Table 1: Configuration of resources.xml file, tag < CloudProvider >

The project.xml complements the information about a provider listed in the resources.xml file. This file can contain a < Cloud > tag where to specify a list of providers, each with a < Provider > tag, whose \mathbf{name} attribute must match one of the providers in the resources.xml file. Thus, the project.xml file \mathbf{must} contain a subset of the providers specified in the resources.xml file. Table 3 summarizes the information that users need to specify inside the < Cloud > tag and Table 2 summarizes the information that users need to specify inside the < Provider > tag of the project.xml file.

InitialVMs	Number of VM to be created at the beginning of the application
minVMCount	Minimum number of VMs available in the computation
maxVMCount	Maximum number of VMs available in the computation
Provider	Multiple entries of Cloud providers

Table 2: Configuration of project.xml file, tag < Cloud >

LimitOfVMs	Maximum number of VMs allowed by the provider
Property	Multiple entries of provider-specific properties
• Name	• Name of the property
• Value	• Value of the property
ImageList	Multiple entries of VM images available at the provider
• Image	• VM image
– InstallDir	 Path of the COMPSs worker scripts in the image
– WorkingDir	 COMPSs working directory in the de- ployed instances
– User	- Account username
– Package	 Multiple entries of local packages that have to be deployed in new instances
* Source	* Local path of the package
* Target	* Path where to deploy the package in the new instance
* InstalledSoftware	* List of software included in the package
InstanceTypes	List of resource types that are available in the provider
• Resource	• Resource description

Table 3: Configuration of project.xml file, tag < Provider >

The next sections provide a description of each of the currently available connectors. $12\,$

2.5.4.1 Cloud connectors: Amazon EC2

The COMPSs runtime features a connector to interact with the Amazon Elastic Compute Cloud (EC2).

Amazon EC2 offers a well-defined pricing system for VM rental. A total of 8 pricing zones are established, corresponding to 8 different locations of Amazon datacenters around the globe. Besides, inside each zone, several per-hour prices exist for VM instances with different capabilities. The EC2 connector stores the prices of standard on-demand VM instance types (t1.micro, m1.small, m1.medium, m1.large and m1.xlarge) for each zone. Spot instances are not currently supported by the connector.

When the COMPSs runtime chooses to create a VM in the Amazon public Cloud, the EC2 connector receives the information about the requested characteristics of the new VM, namely the number of cores, memory, disk and architecture (32/64 bits). According to that information, the connector tries to find the VM instance type in Amazon that better matches those characteristics and then requests the creation of a new VM instance of that type.

Once an EC2 VM is created, a whole hour slot is paid in advance; for that reason, the connector keeps the VM alive at least during such period, saving it for later use if necessary. When the task load decreases and a VM is no longer used, the connector puts it aside if the hour slot has not expired yet, instead of terminating it. After that, if the task load increases again and the EC2 connector requests a VM, first the set of saved VMs is examined in order to find a VM that is compatible with the requested characteristics. If one is found, the VM is reused and becomes eligible again for the execution of tasks; hence, the cost and time to create a new VM are not paid. A VM is only destroyed when the end of its hour slot is approaching and it is still in saved state.

Table 4 summarizes the provider-specific properties that must be defined in the project.xml file for the Amazon EC2 connector.

Placement	Location of the amazon datacentre to use
Access Key Id	Identifier of the access key of the Amazon EC2 account
Secret Key Id	Identifier of the secret key of the Amazon EC2 account
Key host location	Path to the SSH key in the local host, used to connect to the VMs
KeyPair name	Name of the key pair to use
SecurityGroup name	Name of the security group to use

Table 4: Properties of the Amazon EC2 connector.

2.5.4.2 Cloud connectors: rOCCI

The connector uses the rOCCI binary client¹ (version newer or equal than 4.2.5) which has to be installed in the node where the COMPSs main application is executed.

This connector needs additional files providing details about the resource templates available on each provider. This file is located under $< COMPSs_INSTALL_DIR > /configuration/xml/templates$ path. Additionally, the user must define the virtual images flavors and instance types offered by each provider; thus, when the runtime decides the creation of a VM, the connector selects the appropriate image and resource template according to the requirements (in terms of CPU, memory, disk, etc) by invoking the rOCCI client through Mixins (heritable classes that override and extend the base templates).

Table 5 contains the rOCCI specific properties that must be defined under the *Provider* tag in the *project.xml* file and Table 5 contains the specific properties that must be defined under the *Instance* tag.

Provider	
ca-path	Path to CA certificates directory
user-cred	Path of the VOMS proxy
auth	Authentication method, x509 only supported
owner	Optional. Used by the VENUS-C Job Manager (PMES)
jobname	Optional. Used by the VEIVOS-C 300 Manager (1 MES)

Table 5: rOCCI extensions in the project.xml file.

Instance	Multiple entries of resource templates.
Type	Name of the resource template. It has to be the same name than in the previous files
CPU	Number of cores
Memory	Size in GB of the available RAM
Disk	Size in GB of the storage
Price	Cost per hour of the instance

Table 6: Configuration of the < provider > .xml templates file.

https://appdb.egi.eu/store/software/rocci.cli

3 Results and logs

3.1 Results

When executing a COMPSs application we consider different type of results:

- Application Output: Output generated by the application.
- Application Files: Files used or generated by the application.
- Tasks Output: Output generated by the tasks invoked from the application.

Regarding the application output, COMPSs will preserve the application output but will add some pre and post output to indicate the COMPSs Runtime state. Figure 4 shows the standard output generated by the execution of the Simple Java application. The green box highlights the application *stdout* while the rest of the output is produced by COMPSs.

Figure 4: Output generated by the execution of the Simple Java application with COMPSs

Regarding the application files, COMPSs does not modify any of them and thus, the results obtained by executing the application with COMPSs are the same than the ones generated by the sequential execution of the application.

Regarding the tasks output, COMPSs introduces some modifications due to the fact that tasks can be executed in remote machines. After the execution, COMPSs stores the *stdout* and the *stderr* of each job (a task execution) inside the

/home/\$USER/.COMPSs/\$APPNAME/\$EXEC_NUMBER/jobs/ directory of the main application node.

Figures 5 and 6 show an example of the results obtained from the execution of the *Hello* Java application. While Figure 5 provides the output of the sequential execution of the application (without COMPSs), Figure 6 provides the output of the equivalent COMPSs execution. Please note that the sequential execution produces the "Hello World! (from a task)" message in the *stdout* while the COMPSs execution stores the message inside the *job1_NEW.out* file.

```
compss@bsc:~/workspace_java/hello/jar$ java -cp hello.jar hello.Hello
Hello World! (from main application)
Hello World! (from a task)
```

Figure 5: Sequential execution of the *Hello* java application

```
Compss@bsc:-/workspace_java/hello/jar$ runcompss -d hello.Hello
Using default location for project file: /opt/COMPss/Runtime/scripts/user/../.configuration/xml/projects/project.xml
Using default location for resources file: /opt/COMPss/Runtime/scripts/user/../../configuration/xml/projects/project.xml

WARNING: IT Properties file is null. Setting default values

[ API] - Deploying COMPss Runtime v1.3 (build 20150820-1617.rnull)

[ API] - Starting COMPss Runtime v1.3 (build 20150820-1617.rnull)

[ API] - Initializing components

[ API] - Ready to process tasks

Hello World! (from main application)

[ API] - Creating task from method sayHello in hello.HelloImpl

[ API] - There is 0 parameter

[ API] - No more tasks for app 1

[ API] - Stoping Result Files 1

[ API] - Stoping Result Files 1

[ API] - Stopping AP...

[ API] - Stopping Comm...

[ API] - Stopping Comm...

[ API] - Execution Finished

Compss@bsc:-S more ~/.COMPss/hello.Hello_01/jobs/jobi_NEW.out

2015-08-20 16:47:31,615 [DEBUG|integratedtoolkit.Worker|Executor] Creating sandbox for job 1

WORKER - Parameters of execution:

* Method class: hello.HelloImpl

* Method name: sayHello
* Parameter values:

* Parameter values:
```

Figure 6: COMPSs execution of the *Hello* java application

3.2 Logs

COMPSs includes three log levels for running applications but users can modify them or add more levels by editing the logger files under the /opt/COMPSs/Runtime/configuration/log/ folder. Any of these log levels can be selected by adding the $--log_level = < debug|info|off >$ flag to the runcompss command. The default value is off.

The logs generated by the NUM_EXEC execution of the application APP by the user USER are stored under $/home/\$USER/.COMPSs/\$APP/\$EXEC_NUMBER/$ folder (from this point on: **base log folder**). The $EXEC_NUMBER$ execution number is automatically used by COMPSs to prevent mixing the logs of data of different executions.

When running COMPSs with **log level off** only the errors are reported. This means that the *base log folder* will contain two empty files (**runtime.log** and **resources.log**) and one empty folder (*jobs*). If somehow the application has failed, the *runtime.log* and/or the *resources.log* will not be empty and a new file per failed job will appear inside the *jobs* folder to store the *stdout* and the *stderr*. Figure 7 shows the logs generated by the execution of the Simple java application (without errors) in **off** mode.

```
.COMPSs/

[4.0K] simple.Simple_01

[4.0K] jobs

[ 0] resources.log

[ 0] runtime.log

[4.0K] tmpFiles
```

Figure 7: Structure of the logs folder for the Simple java application in **off** mode

When running COMPSs with **log level info** the *base log folder* will contain two files (**runtime.log** and **resources.log**) and one folder (*jobs*). The **runtime.log** file contains the execution information retrieved from the master resource, including the file

transfers and the job submission details. The **resources.log** file contains information about the available resources such as the number of processors of each resource (slots), the information about running or pending tasks in the resource queue and the created and destroyed resources. The jobs folder will be empty unless there has been a failed job. In this case it will store, for each failed job, one file for the *stdout* and another for the *stderr*. As an example, Figure 8 shows the logs generated by the same execution than the previous case but with **info** mode.

```
.COMPSs/

[4.0K] simple.Simple_02

[4.0K] jobs

[612] resources.log

[10K] runtime.log

[4.0K] tmpFiles
```

Figure 8: Structure of the logs folder for the Simple java application in **info** mode

The runtime.log and resources.log are quite large files, thus they should be only checked by advanced users. For an easier interpretation of these files the COMPSs Framework includes a monitor tool. For further information about the COMPSs Monitor please check Section 4.2.

Figures 9 and 10 provide the content of these two files generated by the execution of the *Simple* java application.

Figure 9: runtime.log generated by the execution of the Simple java application

Running COMPSs with **log level debug** generates the same files as the info log level but with more detailed information. Additionally, the *jobs* folder contains two files per **submitted** job; one for the *stdout* and another for the *stderr*. In the other hand, the COMPSs Runtime state is printed out on the *stdout*. Figure 11 shows the logs generated by the same execution than the previous cases but with **debug** mode.

The runtime.log and the resources.log files generated in this mode can be **extremely** large. Consequently, the users should take care of their quota and manually erase these files if needed.

When running Python applications a *pycompss.log* file is written inside the *base log* folder containing debug information about the specific calls to PyCOMPSs.

Figure 10: resources.log generated by the execution of the Simple java application

```
.COMPSs/

[4.0K] simple.Simple_03

[4.0K] jobs

[0] job1_NEW.err

[380] job1_NEW.out

[612] resources.log

[70K] runtime.log

[4.0K] tmpFiles
```

Figure 11: Structure of the logs folder for the Simple java application in **debug** mode

Furthermore, when running *runcompss* with additional flags (such as monitoring or tracing) additional folders will appear inside the *base log folder*. The meaning of the files inside these folders is explained in Section 4.

4 COMPSs Tools

4.1 Application graph

At the end of the application execution a dependency graph can be generated representing the order of execution of each type of task and their dependencies. To allow the final graph generation the -g flag has to be passed to the runcompss command; the graph file is written in the $base_log_folder/monitor/complete_graph$.dot at the end of the execution.

Figure 12 shows a dependency graph example of a SparseLU java application. The graph can be visualized by running the following command:

compss@bsc:~\$ gengraph ~/.COMPSs/sparseLU.arrays.SparseLU_01/monitor/complete_graph.dot

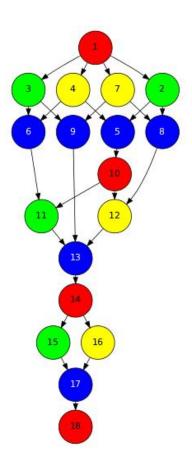


Figure 12: The dependency graph of the SparseLU application

4.2 COMPSs Monitor

The COMPSs Framework includes a Web graphical interface that can be used to monitor the execution of COMPSs applications. COMPSs Monitor is installed as a service and can be easily managed by running any of the following commands:

```
compss@bsc:~$ sudo service compss-monitor usage
Usage: /usr/sbin/service compss-monitor
{start | stop | reload | restart | try-restart | force-reload | status}
```

4.2.1 Service configuration

The COMPSs Monitor service can be configured by editing the /opt/COMPSs/Tools/monitor/apache-tomcat/conf/compss-monitor.conf file which contains one line per property:

- IT_MONITOR Default directory to retrieve monitored applications (defaults to the .COMPSs folder inside the root user).
- COMPSs_MONITOR_PORT Port where to run the compss-monitor web service (defaults to 8080).
- COMPSs_MONITOR_TIMEOUT Web page timeout between browser and server (defaults to 20s).

4.2.2 Usage

In order to use the COMPSs Monitor users need to start the service as shown in Figure 13.

```
compss@bsc:-S_fetc/init.d/compss-monitor start

* Starting COMPs Monitor

* Checking JAVA Installation..
Warning: JRE_HOME not defined
Info: JAVA_HOME found.
Loading JRE_HOME from JAVA_HOME
Success

* Checking IT HOME...

**ARNING: IT_HOME not defined. Trying default location /opt/COMPSs/
Success

* Checking IT_MONITOR...

**IT_MONITOR=/home/compss/.COMPSs/
Success

* Checking COMPSs Monitor Port...
Warning: COMPSs_MONITOR_PORT not defined.
Loading from configuration file.

**COMPSs_MONITOR_PORT=8888

**Success

* Checking COMPSs Monitor Timeout..

Warning: COMPSs_MONITOR_PORT=8880

**Success

* Checking COMPSs_MONITOR_TIMEOUT not defined.
Loading from configuration file.

**COMPSs_MONITOR_TIMEOUT.**
COMPSs_MONITOR_TIMEOUT.**

**Compss_Monitor_Timeout...

**Warning: COMPSs_Monitor_Timeout...

**Warning: Comps_Monitor_Timeout...

**Warning: Comps_Monitor_Timeout..
```

Figure 13: COMPSs Monitor start command

And use a web browser to open the specific URL:

```
compss@bsc:~$ firefox http://localhost:8080/compss-monitor &
```

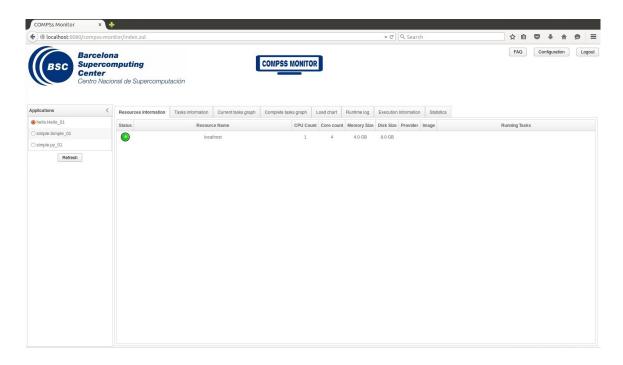


Figure 14: COMPSs monitoring interface

The COMPSs Monitor allows to monitor applications from different users and thus, users need to first login to access their applications. As shown in Figure 14, the users can select any of their executed or running COMPSs applications and display it.

To enable **all** the COMPSs Monitor features, applications must run the runcompss command with the -m flag. This flag allows the COMPSs Runtime to store special information inside inside the log base folder under the monitor folder (see Figures 15 and 16). Only advanced users should modify or delete any of these files. If the application that a user is trying to monitor has not been executed with this flag, some of the COMPSs Monitor features will be disabled.

Figure 15: Execution of the Simple Java application with the monitoring flag enabled

Figure 16: Logs generated by the Simple java application with the monitoring flag enabled

4.2.3 Graphical Interface features

In this section we provide a summary of the COMPSs Monitor supported features available through the graphical interface:

• Resources information

Provides information about the resources used by the application

• Tasks information

Provides information about the tasks definition used by the application

• Current tasks graph

Shows the tasks dependency graph currently stored into the COMPSs Runtime

• Complete tasks graph

Shows the complete tasks dependecy graph of the application

• Load chart

Shows different dynamic charts representing the evolution over time of the resources load and the tasks load

• Runtime log

Shows the runtime log

• Execution Information

Shows specific job information allowing users to easily select failed or uncompleted jobs

• Statistics

Shows application statistics such as the accumulated cloud cost.

The webpage also allows users to configure some performance parameters of the monitoring service by accessing the *Configuration* button at the top-right corner of the web page.

For specific COMPSs Monitor feature configuration please check our FAQ section at the top-right corner of the web page.

Attention: To enable all the COMPSs Monitor features applications must run with the -m flag.

4.3 Application tracing

COMPSs Runtime can generate a post-execution trace of the execution of the application. This trace is useful for performance analysis and diagnosis.

A trace file may contain different events to determine the COMPSs master state, the task execution state or the file-transfers. The current release does not support file-transfers informations.

During the execution of the application, an XML file is created in the worker nodes to keep track of these events. At the end of the execution, all the XML files are merged to get a final trace file.

In this manual we only provide information about how to obtain a trace and about the available Paraver (the tool used to analyze the traces) configurations. For further information about the application instrumentation or the trace visualization please check the *COMPSs Tracing Manual* available at http://compss.bsc.es.

4.3.1 Trace Command

In order to obtain a post-execution trace file the option **-t** must be added to the runcompss command. Next we provide an example of the command execution with the tracing option enabled for the Hmmer java application.

```
compss@bsc:~$ runcompss -t --classpath=/home/compss/workspace_java/hmmerobj/jar/hmmerobj.jar
                       hmmerobi.HMMPfam
                       /sharedDisk/Hmmer/smart.HMMs.bin /sharedDisk/Hmmer/256seq
                       /home/compss/out.txt 2 8 -A 222
           ---- Executing hmmerobj.HMMPfam -----
WARNING: IT Properties file is null. Setting default values
Welcome to Extrae 3.1.1rc (revision 3360 based on extrae/trunk)
Extrae: Warning! EXTRAE_HOME has not been defined!.
Extrae: Generating intermediate files for Paraver traces.
Extrae: Intermediate files will be stored in /home/compss/workspace_java/hmmerobj/jar
Extrae: Tracing buffer can hold 500000 events
Extrae: Tracing mode is set to: Detail.
Extrae: Successfully initiated with 1 tasks
Extrae: Warning! API tries to initialize more than once
               Previous initialization was done by API
[ API] - Starting COMPSs Runtime v1.3 (build 20151016-1931.rnull)
  API] - No more tasks for app 1
  API] - Getting Result Files 1
   API] - Execution Finished
```

```
Extrae: Intermediate raw trace file created: /home/compss/workspace_java/hmmerobj/jar/set-0/TRACE@bsc .000003163700000000000.mpit

Extrae: Intermediate raw sym file created: /home/compss/workspace_java/hmmerobj/jar/set-0/TRACE@bsc .0000031637000000000000.sym

Extrae: Deallocating memory.

Extrae: Application has ended. Tracing has been terminated.

merger: Output trace format is: Paraver merger: Extrae 3.1.1rc (revision 3360 based on extrae/trunk)

mpi2prv: Checking for target directory existance... exists, ok! mpi2prv: Selected output trace format is Paraver mpi2prv: Stored trace format is Paraver mpi2prv: Parsing intermediate files mpi2prv: Removing temporal files... done mpi2prv: Congratulations! ./trace/hmmerobj.HMMPfam_compss_trace_1440151114.prv has been generated.
```

At the end of the execution the trace will be stored inside the *trace* folder under the application log directory.

```
compss@bsc:~$ cd .COMPSs/hmmerobj.HMMPfam/trace/
compss@bsc:~$ ls -1
hmmerobj.HMMPfam_compss_trace_1444922077.pcf
hmmerobj.HMMPfam_compss_trace_1444922077.prv
hmmerobj.HMMPfam_compss_trace_1444922077.row
```

4.3.2 Trace Configurations

The traces generated by an application execution are ready to be visualized with *Paraver*. *Paraver* is a powerful tool developed by *BSC* that allows users to show many views of the trace data by means of different configuration files. Users can manually load, edit or create configuration files to obtain different trace data views.

In Table 7 we provide information about the different pre-build configurations that we distribute with COMPSs and that can be found under the /opt/COMPSs/Dependencies/paraver/cfgs/ folder.

For further information about *Paraver* please visit the following site:

http://www.bsc.es/computer-sciences/performance-tools/paraver

4.3.3 Trace examples

COMPSs traces can be very complex as the number of workers or tasks grows. Just to illustrate this, the following pictures show traces with a greater number of workers and tasks.

$2dp_runtime_state.cfg$	2D plot of runtime state
$2dp_tasks.cfg$	2D plot of tasks duration
$3dh_duration_runtime.cfg$	3D Histogram of runtime execution
$3dh_duration_tasks.cfg$	3D Histogram of tasks duration
$compss_runtime.cfg$	Shows COMPSs Runtime events (at master and workers)
$compss_tasks_and_runtime.cfg$	Shows COMPSs Runtime events (at master and workers) and tasks execution
$compss_tasks.cfg$	Shows tasks execution
$compss_tasks_numbers.cfg$	Shows tasks execution by task id
$compss_transfers.cfg$	Shows transfer time spent by each worker

Table 7: Available paraver configurations for COMPSs Applications

4.4 COMPSs IDE

COMPSs IDE is an Integrated Development Environment to develop, compile, deploy and execute COMPSs applications. It is available through the *Eclipse Market* as a plugin and provides an even easier way to work with COMPSs.

For further information please check the $COMPSs\ IDE\ User\ Guide$ available at: http://compss.bsc.es .

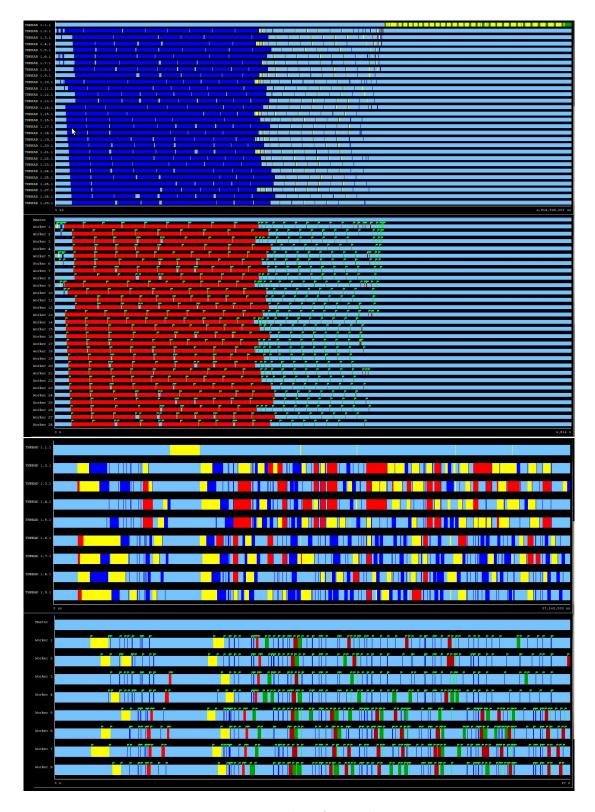


Figure 17: Examples of complex traces

5 Special Execution Platforms

This section provides information about how to run COMPSs Applications in specific platforms such as *Docker*, *Chameleon* or *MareNostrum*.

5.1 Docker

5.1.1 Introduction

Docker is an open-source project that automates the deployment of applications inside software containers, by providing an additional layer of abstraction and automation of operating-system-level virtualization on Linux. As actions are done to a Docker base image, union filesystem layers are created and documented, such that each layer fully describes how to recreate an action. This strategy enables Docker's lightweight images, as only layer updates need to be propagated (compared to full VMs, for example). COMPSs supports running a distributed application in a Docker swarm cluster.

We have a COMPSs 1.3 Docker image. In case you need it, you can pull it from Docker using:

• docker pull compss/compss

5.1.2 Requirements

In order to use COMPSs with Docker, some requirements must be fulfilled:

- Have **Docker** and **Docker-Compose** installed in your local machine.
- Have an available **Docker swarm cluster** and its swarm manager ip and port to access it remotely.
- A **Dockerhub account**. Dockerhub is an online repository for Docker images. We don't currently support another sharing method besides uploading to Dockerhub, so you will need to provide a username. This has the advantage that it takes very little to upload the image, since Dockerhub will just need the delta layers from the base image of COMPSs.

5.1.3 Execution

To execute COMPSs in a Docker swarm cluster, you must use the **runcompss-docker** command, instead of runcompss.

The command **runcompss-docker** has some **additional arguments** that will be needed by COMPSs to run your application in a distributed Docker swarm cluster environment. The rest of typical arguments (classpath, project, etc.) will be delegated to runcompss command.

These **mandatory** additional arguments must go **before** the typical runcompss arguments. The **runcompss-docker additional arguments** are:

• --w, --worker-containers:

Specifies the number of **worker containers** the app will execute on. One more container will be created to host the **master**. If you have enough nodes in the swarm cluster, each container will be executed by one node.

Example: --worker-containers=3

• --c, --context-dir:

Specifies the **context directory** of the app. The context directory is a local directory that **must contain the needed binaries and input files of the app**. In its simplest case, it will contain the executable file (a .jar for example). Take into account that you should not put unnecessary files in the context-directory, since **it will be copied to all the nodes** that need it.

Example: --context-dir='/home/compss-user/my-app-dir', where my-app-dir contains 'app.jar', 'data1.dat' and 'data2.csv', for example.

• --s, --swarm-manager:

Specifies the swarm manager ip and port (format: ¡ip¿:¡port¿). You can test if the swarm manager really works and is reachable from your machine running from your machine the Docker hello-world container.

Example: --swarm-manager='129.114.108.8:4000'

• --u, --username:

Specifies a **Dockerhub username**, to upload the app image, so the workers can pull it in runtime. As stated in the requirements sections, this is needed to share your container application image with the nodes that need it.

As an **optional** argument:

• --n, --no-refresh-app-image:

If this flag is on, the **app image won't be uploaded** to Dockerhub. Workers won't pull the image either. Use this flag if the application has not changed since the last running. This way the execution will be **faster**, and you won't need to specify the Dockerhub username nor write its password. But remember! If you make any change to the application, run an execution without this flag at least once, to update the online application image.

Here is the **format** you must use with **runcompss-docker** command:

```
runcompss-docker --worker-containers=N
--context-dir='CTX_DIR'
--swarm-manager='<ip>:<port>'
--username='dockerhub_username'
[rest of classic runcompss args]
```

Or alternatively, in its shortest form:

```
runcompss-docker --w=N --c='CTX_DIR' --s='<ip>:<port>' --u='dockerhub_username'
[rest of classic runcompss args]
```

5.1.4 Execution results

The execution results will be retrieved from the master container of your application.

If your context-directory name is 'matmul', then your results will be saved in the 'matmul-results' directory, which is located in the SAME directory as your context-directory is in.

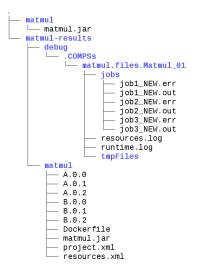
Inside the 'matmul-results' directory you will have:

• A folder named 'matmul' with all the result files that were in the same directory as the executable when the application execution ended. More precisely, this will contain the context-directory state right after finishing your application execution.

Additionally, and for more advanced debug purposes, you will have some intermidiate files created by runcompss-docker(Dockerfile, project.xml, resources.xml), in case you want to check for more complex errors or details.

• A folder named 'debug', which (in case you used the runcompss debug option (-d)), will contain the '.COMPSs' directory, which contains another directory in which there are the typical debug files runtime.log, jobs, etc. Remember .COMPSs is a hidden directory, take this into account if you do ls inside the debug directory (add the -a option).

To make it simpler, we provide a **tree visualization** of an example of what your directories should look like after the execution. In this case we executed the **Matmul example application** that we provide you:



5.1.5 Execution examples

And here is one example to run the Matmul example application. In this case, we are specifying:

- Use **5 worker docker containers**. They will be distributed amongst the swarm cluster nodes as balanced as possible.
- The **context directory** will be '/home/compss-user/my-app-dir'.
- The swarm-manager ip will be 129.114.108.8, with the swarm manager located in the port 4000.
- The **Dockerhub username** will be john123 (the **password** will be asked when executing runcompss-docker).
- The **classpath** will be '/home/compss-user-john/matmul/matmul.jar', and we will use **debug** (-d).
- Finally, as we would do with the typical runcompss, we specify the **main class** name and its **parameters** (16 and 4 in this case).

And this is how you would run runcompss-docker:

Here we show another example using the short arguments form, with the KMeans example application, that we provide to you:

5.2 Chameleon

5.2.1 Introduction

The Chameleon project is a configurable experimental environment for large-scale cloud research based on a *OpenStack* KVM Cloud. With funding from the *National Science Foundation (NSF)*, it provides a large-scale platform to the open research community allowing them explore transformative concepts in deeply programmable cloud services, design, and core technologies. The Chameleon testbed, is deployed at the *University of Chicago* and the *Texas Advanced Computing Center* and consists of 650 multi-core cloud nodes, 5PB of total disk space, and leverage 100 Gbps connection between the sites.

The project is led by the Computation Institute at the University of Chicago and partners from the Texas Advanced Computing Center at the University of Texas at Austin, the International Center for Advanced Internet Research at Northwestern University, the Ohio State University, and University of Texas at San Antoni, comprising a highly qualified and experienced team. The team includes members from the NSF supported FutureGrid project and from the GENI community, both forerunners of the NSFCloud solicitation under which this project is funded. Chameleon will also sets of partnerships with commercial and academic clouds, such as Rackspace, CERN and Open Science Data Cloud (OSDC).

For more information please check https://www.chameleoncloud.org/.

5.2.2 Execution

Currently, COMPSs can only handle the Chameleon infrastructure as a cluster (deployed inside a lease). Next, we provide the steps needed to execute COMPSs applications at Chameleon:

- Make a lease reservation with 1 minimum node (for the COMPSs master instance) and a maximum number of nodes equal to the number of COMPSs workers needed plus one
- Instantiate the master image (based on the published image COMPSs_1.3_CC-CentOS7)
- Attach a public IP and login to the master instance (the instance is correctly contextualized for COMPSs executions if you see a COMPSs login banner)
- Set the instance as COMPSs master by running /etc/init.d/chameleon_init start
- Copy your CH file (API credentials) to the Master and source it
- Run the *chameleon_cluster_setup* script and fill the information when prompted (you will be asked for the name of the master instance, the reservation id and number of workers). This scripts may take several minutes since it sets up the all cluster.
- Execute your COMPSs applications normally using the runcompss script

As an example you can check this video https://www.youtube.com/watch?v=BrQ6anPHjAU performing a full setup and execution of a COMPSs application at Chameleon.

5.3 SuperComputers

To maintain the portability between different environments, COMPSs has a pre-build structure (see Figure 18) to execute applications in SuperComputers. For this purpose, users must use the *enqueue_compss* script provided in the COMPSs installation. This script has several parameters (see *enqueue_compss -h*) that allow users to customize their executions for any SuperComputer.

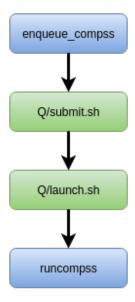


Figure 18: Structure of COMPSs queue scripts. In Blue general scripts, in Green system dependant scripts

To make this structure work, the administrators must define a submit and a launch script that are system dependant. To develop this scripts the current COMPSs installation provides scripts for the *MareNostrum III* SuperComputer that can be used as an example (based on LSF) or you can contact us at support-compss@bsc.es .

5.3.1 MareNostrum III

For information about how to submit COMPSs applications at MareNostrum III (BSC) please refer to the *COMPSs at BSC* manual available at http://compss.bsc.es/releases/compss/latest/docs/COMPSs_MareNostrum_Manual.pdf.

6 Common Issues

This section provides answers for the most common issues of the execution of COMPSs applications. For specific issues not covered in this section, please do not hesitate to contact us at:

support-compss@bsc.es

6.1 How to debug

When the application does not behave as expected the first thing users must do is to run it in **debug** mode executing the *runcompss* command withthe -*d* flag to enable the debug log level.

In this case the application execution will produce the following files:

- runtime.log
- resources.log
- jobs folder

First, users should check the last lines of the runtime.log. If the file-transfers or the tasks are failing an error message will appear in this file. If the file-transfers are successfully and the jobs are submitted, users should check the *jobs* folder and look at the error messages produced inside each job. Users should notice that if there are _RESUBMITTED files something inside the job is failing.

6.2 Tasks are not executed

If the tasks remain in **Blocked** state probably there are no existing resources matching the specific task constraints. This error can be potentially caused by two facts: the resources are not correctly loaded into the runtime, or the task constraints do not match with any resource.

In the first case, users should take a look at the *resources.log* and check that all the resources defined in the *project.xml* file are available to the runtime. In the second case users should re-define the task constraints taking into account the resources capabilities defined into the *resources.xml* and *project.xml* files.

6.3 Jobs fail

If all the application's tasks fail because all the submitted jobs fail, it is probably due to the fact that there is a resource miss-configuration. In most of the cases, the resource that the application is trying to access has no passwordless access through the configured user. This can be checked by:

• Open the project.xml. (The default file is stored under /opt/COMPSs/Runtime/-configuration/xml/projects/project.xml

- For each resource annotate its name and the value inside the *User* tag. Remember that if there is no *User* tag COMPSs will try to connect this resource with the same username than the one that launches the main application.
- For each annotated resourceName user please try ssh user@resourceName. If the connection asks for a password then there is an error in the configuration of the ssh access in the resource.

The problem can be solved running the following commands:

```
compss@bsc:~$ scp ~/.ssh/id_dsa.pub user@resourceName:./mydsa.pub compss@bsc:~$ ssh user@resourceName "cat mydsa.pub >> ~/.ssh/authorized_keys; rm ./mydsa.pub"
```

These commands are a quick solution, for further details please check the *Additional Configuration* section inside the *COMPSs Installation Manual* available at our website http://compss.bsc.es.

6.4 Compilation error: @Method not found

When trying to compile Java applications users can get some of the following compilation errors:

```
error: package integratedtoolkit.types.annotations does not exist
import integratedtoolkit.types.annotations.Constraints;
error: package integratedtoolkit.types.annotations does not exist
import integratedtoolkit.types.annotations.Method;
error: package integratedtoolkit.types.annotations does not exist
import integratedtoolkit.types.annotations.Parameter;
error: package integratedtoolkit.types.annotations.Parameter does not exist
import integratedtoolkit.types.annotations.Parameter.Direction;
error: package integratedtoolkit.types.annotations.Parameter does not exist
import integratedtoolkit.types.annotations.Parameter.Type;
error: cannot find symbol
@Parameter(type = Type.FILE, direction = Direction.INOUT)
 symbol:
          class Parameter
 location: interface APPLICATION_Itf
error: cannot find symbol
@Constraints(processorCoreCount = 2)
 symbol: class Constraints
 location: interface APPLICATION_Itf
error: cannot find symbol
@Method(declaringClass = "application.ApplicationImpl")
          class Method
 location: interface APPLICATION_Itf
```

All these errors are raised because the *compss-engine.jar* is not listed in the CLASS-PATH. The default COMPSs installation automatically inserts this package into the

CLASSPATH but it may have been overwritten or deleted. Please check that your environment variable CLASSPATH containts the *compss-engine.jar* location by running the following command:

```
$ echo $CLASSPATH | grep compss-engine
```

If the result of the previous command is empty it means that you are missing the *compss-engine.jar* package in your classpath.

The easiest solution is to manually export the CLASSPATH variable into the user session:

```
$ export CLASSPATH=$CLASSPATH:/opt/COMPSs/Runtime/compss-engine.jar
```

However, you will need to remember to export this variable every time you log out and back in again. Consequently, we recommend to add this export to the *.bashrc* file:

```
$ echo "# COMPSs variables for Java compilation" >> ~/.bashrc
$ echo "export CLASSPATH=$CLASSPATH:/opt/COMPSs/Runtime/compss-engine.jar" >> ~/.bashrc
```

Attention: The *compss-engine.jar* is installed inside the COMPSs installation directory. If you have performed a custom installation, the path of the package may be different.

6.5 Jobs failed on method reflection

When executing an application the main code gets stuck executing a task. Taking a look at the runtime.log users can check that the job associated to the task has failed (and all its resubmissions too). Then, opening the $jobX_NEW.out$ or the $jobX_NEW.err$ files users find the following error:

```
[ERROR|integratedtoolkit.Worker|Executor] Can not get method by reflection
integratedtoolkit.nio.worker.executors.Executor$JobExecutionException: Can not get method by reflection
at integratedtoolkit.nio.worker.executors.JavaExecutor.executeTask(JavaExecutor.java:142)
at integratedtoolkit.nio.worker.executors.Executor.execute(Executor.java:42)
at integratedtoolkit.nio.worker.JobLauncher.executeTask(JobLauncher.java:46)
at integratedtoolkit.nio.worker.JobLauncher.processRequests(JobLauncher.java:34)
at integratedtoolkit.util.RequestDispatcher.run(RequestDispatcher.java:46)
at java.lang.Thread.run(Thread.java:745)

Caused by: java.lang.NoSuchMethodException: simple.Simple.increment(java.lang.String)
at java.lang.Class.getMethod(Class.java:1678)
at integratedtoolkit.nio.worker.executors.JavaExecutor.executeTask(JavaExecutor.java:140)
... 5 more
```

This error is due to the fact that COMPSs cannot find one of the tasks declared in the Java Interface. Commonly this is triggered by one of the following errors:

- The declaring Class of the tasks in the Java Interface has not been correctly defined.
- The parameters of the tasks in the Java Interface do not match the task call.
- The tasks have not been defined as *public*.

6.6 Jobs failed on reflect target invocation null pointer

When executing an application the main code gets stuck executing a task. Taking a look at the runtime.log users can check that the job associated to the task has failed (and all its resubmissions too). Then, opening the $jobX_NEW.out$ or the $jobX_NEW.err$ files users find the following error:

```
[ERROR|integratedtoolkit.Worker|Executor]
java.lang.reflect.InvocationTargetException
        at sun.reflect.NativeMethodAccessorImpl.invokeO(Native Method)
        \verb|at sun.reflect.NativeMethodAccessorImpl.invoke(NativeMethodAccessorImpl.java:57)| \\
        at sun.reflect.DelegatingMethodAccessorImpl.invoke(DelegatingMethodAccessorImpl.java:43)
        at java.lang.reflect.Method.invoke(Method.java:606)
        \verb|at integrated toolkit.nio.worker.executors.JavaExecutor.executeTask(JavaExecutor.java:154)| \\
        at integratedtoolkit.nio.worker.executors.Executor.execute(Executor.java:42)
        at integratedtoolkit.nio.worker.JobLauncher.executeTask(JobLauncher.java:46)
        at integratedtoolkit.nio.worker.JobLauncher.processRequests(JobLauncher.java:34)
        \verb|at integrated to olkit.util.Request Dispatcher.run (Request Dispatcher.java: 46)|\\
        at java.lang.Thread.run(Thread.java:745)
Caused by: java.lang.NullPointerException
        at simple.Ll.printY(Ll.java:25)
        at simple.Simple.task(Simple.java:72)
        ... 10 more
```

This cause of this error is that the Java object accessed by the task has not been correctly transferred and one or more of its fields is null. The transfer failure is normally caused because the transferred object is not serializable.

Users should check that all the object parameters in the task are either implementing the serializable interface or following the *java beans* model (by implementing an empty constructor and getters and setters for each attribute).

Please find more details on the COMPSs framework at

http://compss.bsc.es