

ALL-IN-ONE GRAPHICAL TOOL FOR THE MANAGEMENT OF DIET A GRIDRPC MIDDLEWARE

Eddy Caron

ENS LYON, UNIVERSITÉ DE LYON, LIP UMR 5668, CNRS-ENS-LYON-UCBL-INRIA
46 Allée d'Italie, 69364 Lyon Cedex 07. France
Eddy.Caron@ens-lyon.fr

Frederic Desprez

INRIA, UNIVERSITÉ DE LYON, LIP UMR 5668, CNRS-ENS-LYON-UCBL-INRIA
46 Allée d'Italie, 69364 Lyon Cedex 07. France
Frederic.Desprez@ens-lyon.fr

David Loureiro

INRIA, UNIVERSITÉ DE LYON, LIP UMR 5668, CNRS-ENS-LYON-UCBL-INRIA
46 Allée d'Italie, 69364 Lyon Cedex 07. France
David.Loureiro@ens-lyon.fr

Abstract Grid middleware are the link between large scale (and distributed) platforms and applications. Managing such a software system and the grid environment itself can be a hard task when no dedicated (and integrated) tool exist. Some can be used through nice graphical interfaces, but they are usually dedicated to one or some limited tasks. They do not fulfill all the needs of a grid end-user who wants to deploy grid applications easily and rapidly.

The aim of this paper is to present the case study of an all-in-one software system, designed for the management of a grid middleware and gathering user-friendly graphical interfaces answering to the various needs of end-users. Moreover the software system eases the use of the grid by avoiding the scripting layer under a nice GUI enabling the user a faster and more efficient use of the grid environment. By this means we demonstrate how the DIET Dashboard fulfills all the needs of a unified tool for grid management. This paper gives a comparison with existing and well-known tools dedicated to some specific tasks such as grid resources management, grid monitoring, or middleware management.

Keywords: Grid middleware, Grid management, Grid monitoring, Deployment, Workflow management.

1. Introduction

Large problems ranging from huge numerical simulations to large scale data processing can now be solved through the Internet using grid middleware software systems. Several approaches exist for porting applications to grid platforms. Examples include classical message-passing, batch processing, web portals, and GridRPC systems. This last approach implements a grid version of the classical Remote Procedure Call (RPC) model. A more sophisticated extension of this includes high level scheduling mechanisms and data management. Thus clients spread over the Internet submit computation requests to a scheduler that locates one or more servers available on the grid using some performance measure.

The aim of the DIET¹ (**D**istributed **I**nteractive **E**ngineering **T**oolbox) project is to develop a set of tools to build, deploy, and execute computational server daemons. It focuses on the development of scalable middleware with initial efforts concentrated on distributing the scheduling problem across multiple agents. DIET consists of a set of elements that can be used together to build applications using the GridRPC paradigm. This middleware is able to find an appropriate server according to the information given in the client's request (e.g. problem to be solved, size of the data involved), the performance of the target platform (e.g. server load, available memory, communication performance) and the local availability of data stored during previous computations. The scheduler is distributed using several collaborating hierarchies connected either statically or dynamically (in a peer-to-peer fashion). Data management is provided to allow persistent data to stay within the system for future re-use. This feature avoids unnecessary communications when dependencies exist between different requests.

In a grid environment, we need several complex tools for the management of resources, grid middlewares, and client/server applications. Most grid software systems use command-line interfaces without any Graphical User Interface (GUI). For the creation of a tool dedicated to the management of grid middleware and grid environments, different functions are mandatory. We can consider three main graphical interfaces for such framework: one for resource management, one for grid monitoring, and one for the management of the grid middleware. DIET Dashboard² answers to the need of an unified set of tools providing the user with a complete, modular, portable, and powerful way to manage grid resources of the applications that run on it.

The goal of this paper is to show the various aspects to be taken into account for the design of a graphical tool for grid middleware management and how it can ease the interaction with a grid by avoiding the scripting layer. Thus we designed a tool to make the grid as user-friendly as possible, in order to simplify its use. Many GUI tools dedicated to grid management exist but they are all targeting one or two tasks. The aim of the DIET Dashboard is to provide an all-in-one and flexible software that gathers these tools in an efficient manner. We give a comparison with existing tools dedicated to some specific tasks such as grid resources management, grid monitoring, or middleware management. By this way we demonstrate how the DIET Dashboard fulfilled all the needs of an unified tool making it easy to manage a grid middleware on grid platforms.

The rest of the paper is organized as follows. In Section 2, we briefly review existing works on graphical tools for the grid. Sections 3 and 4 describes the architectures of DIET and DIET Dashboard. Section 4.1 presents the features related to the grid resources management of DIET Dashboard. Section 4.2 presents the features of DIET Dashboard related to grid monitoring. Section 4.3 describes how it can manage the DIET grid middleware. To illustrate the use the DIET Dashboard, we present an experiment in Section 5. Finally, Section 6 concludes the paper.

¹<http://graa.ens-lyon.fr/DIET>

²<http://graa.ens-lyon.fr/DIET/dietdashboard.html>

2. Related Work

In this paper we focus on graphical tools designed for grid environments. Here we will give a description of the three main families of tools dedicated to grid middleware software systems and grid environments.

The first family concerns graphical tools for cluster resource management. They provide a Graphical User Interface (GUI) to check all information from batch schedulers. For example, QMON [16], the GUI designed for N1 Grid Engine from SUN, can examine the properties of any queue on the grid (running, disabled, suspended, etc.). A second graphical menu provides a job submission interface with all the options available. A third interface monitors the jobs status (running, suspended, deleted, pending, etc.).

To illustrate the second family, we can consider Ganglia [12], the graphical tool designed for grid monitoring. Based on a protocol using announces, this tool monitors a cluster or a set of clusters using XML, XDR and RRDtool to represent, retrieve and display the data. For each node Ganglia provides instantaneous information and history about the load, memory, I/O, etc. through a web interface.

The third family concerns tools designed for grid middleware software systems. Many tools exist for the visual specification and execution of scientific workflows as Kepler [1], Taverna [14], SGSDesigner [10], ScyFlow [13], or GridNexus [4]. For example, GridNexus is a graphical system for the creation and the execution of scientific workflows in a grid environment. The user can assemble complex processes involving data retrieval, analysis and visualization by building a directed acyclic graph in a visual environment. Future works talk about the use of GridNexus to help creating and deploying new grid services in addition to scripting existing services. This project plans to develop a generic module to provide interactive feedback while executing a workflow.

Graphical tools mentioned here are all designed with a specific aim. DIET Dashboard combines workflow management, resources reservation, resources mapping, automatic configuration, visualization, and deployment tools in one integrated graphical application.

3. DIET Architecture

The DIET component architecture is structured hierarchically for an improved scalability. Such an architecture is flexible and can be adapted to diverse environments including arbitrary heterogeneous computing platforms. The DIET toolkit [7] is implemented in CORBA and thus benefits from the many standardized, stable services provided by freely-available and high performance CORBA implementations. CORBA systems provide a remote method invocation facility with a high level of transparency. This transparency should not affect the performance substantially, as the communication layers in most CORBA implementations are highly optimized [8]. These factors motivate their decision to use CORBA as the communication and remote invocation fabric in DIET.

The DIET framework comprises several components. A **Client** is an application that uses the DIET infrastructure to solve problems using an RPC approach. Clients access DIET through various interfaces: web portals or programs using C, C++, or Java APIs. A **SeD**, or server daemon, acts as the service provider, exporting a functionality through a standardized computational service interface. A single SeD can offer any number of computational services (depending on the capacity of the machine). A SeD can also serve as the interface and execution mechanism for either a stand-alone interactive machine or a parallel supercomputer (or cluster) using an interface with a batch scheduler. The third component of the DIET architecture, **agents**, facilitate the service location and invocation interactions between clients and SeDs. Collectively, a hierarchy of agents provides higher-level services such as scheduling and data management. These services are made scalable by distributing them across a hierarchy of agents composed of a single **Master Agent (MA)** and several **Local Agents (LA)**. Figure 1 shows an example of a DIET hierarchy.

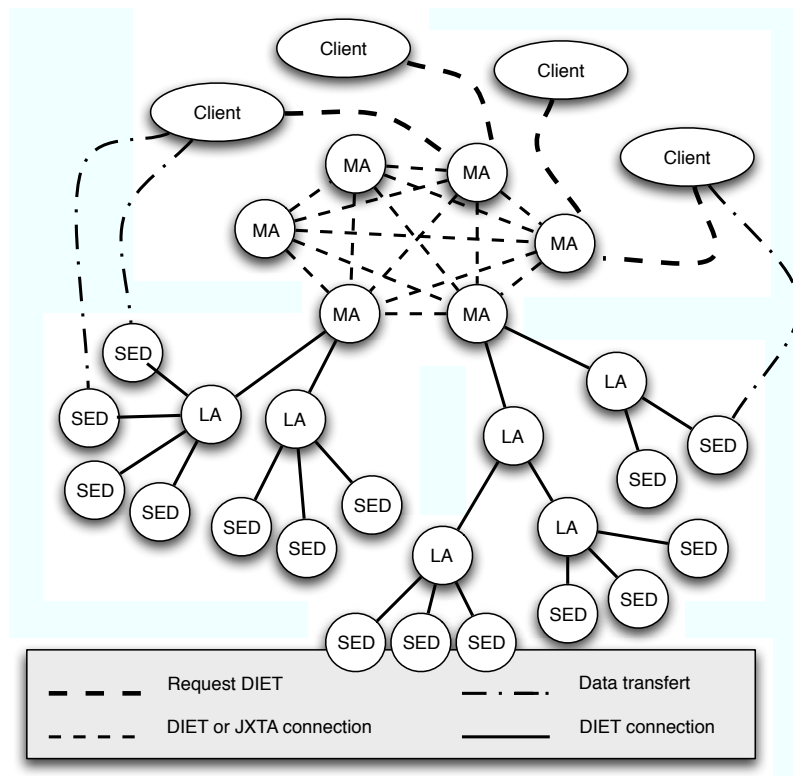


Figure 1. DIET hierarchical organization.

4. DIET Dashboard

When the goal is to monitor a grid, or deploy a grid middleware on it, several tasks are involved.

- Managing the resources of a grid: allocating resources, deploying nodes with several operating systems, etc.
- Monitoring the grid: getting the status of the clusters (number of available nodes in each state, number and main properties of each job, Gantt chart of the jobs history), the status of the jobs (number, status, owner, walltime, scheduled start, Ganglia information of the nodes) running on the platform, etc.
- Managing the grid middleware software system within a grid environment: designing hierarchies (manually or automatically by matching resources on patterns), deploying them directly or through workflows of applications, etc.

The DIET Dashboard provides tools trying to answer these needs with an environment dedicated to the DIET GridRPC middleware. It consists of a set of graphical tools that can be used separately or together. These tools can be divided in three categories:

- 1 Workflow tools: including workflow designer and workflow log service.
- 2 DIET tools: including tools to design and deploy DIET applications.
- 3 Grid tools (aka GRUDU ³): these tools are used to manage, monitor and access user grid resources.

³<http://graal.ens-lyon.fr/GRUDU>

4.1 Grid Resources Management

When deploying an application over a grid a user should be able to allocate resources for computation tasks by specifying the number of nodes needed, the duration of the jobs (also called walltime), the date when each job will start, their priority, etc. But they should have the possibility to choose between the default environment of the node and a user-defined one if the parallel implementation or even the default operating system provided (for example) does not fit the application needs. This management should be easy to realize in order to improve the grid usage.

The following sections present how the grid resources management was designed in the DIET Dashboard and an existing software dedicated to Sun Grid Engine called QMON.

4.1.1 DIET Dashboard functionalities. The grid resources management is realized inside GRUDU, the grid resources module of DIET Dashboard. GRUDU can be easily configured to use different batch schedulers, or different grids. GRUDU can be used inside DIET Dashboard, but also in a standalone mode for users that just want to monitor, manage, or realize reservations on the grid.

Grid'5000⁴ [3] project aims at building a highly reconfigurable, controllable and monitorable experimental Grid platform gathering 9 sites geographically distributed in France featuring a total of 5000 processors. The main purpose of this platform is to serve as an experimental testbed for research in grid Computing.

To allocate resources on Grid'5000, the resource tool offers a user-friendly interface allowing the selection of the number of nodes needed at each site, and the definition of the date, walltime of reservation and the queue where the job will be started. The user can select a job type (for example, deploy if you plan to change the operating system) for the reservation itself and launch a script on the reserved resources (see Figure 2). Concerning the clusters, the OAR batch scheduler⁵ [5] uses properties for the reservations (for example, to select nodes with Myrinet interfaces) and the allocation tool provides an interface for the definition of these properties.

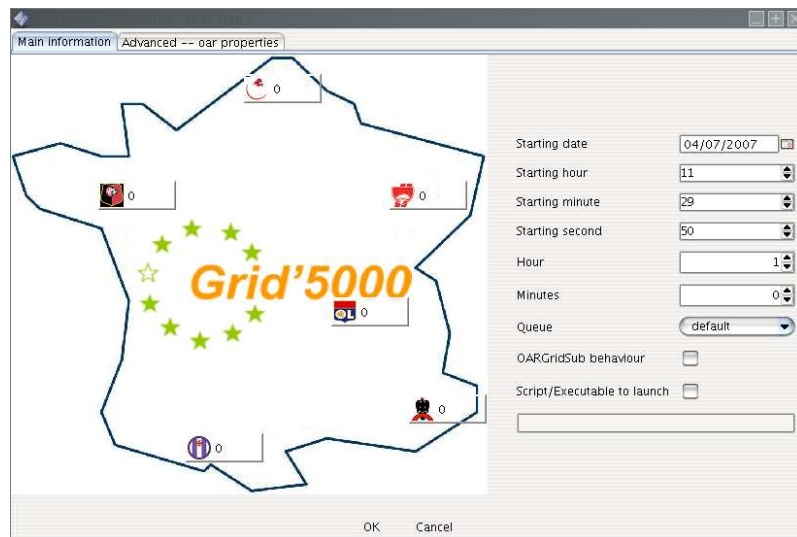


Figure 2. Resources allocation

To manage resources, the user can deploy images on nodes with the operating system needed for the computations. The resources tool also provides a GUI for the deployment of images over

⁴<https://www.grid5000.fr>

⁵<http://oar.imag.fr/>

Grid'5000 clusters through Kadeploy⁶ [9]. (The deployment through Kadeploy allows the user to have its own operating system that he/she can tune and configure as he/she wants.) The nodes and the images (if the user plans to deploy on different clusters, one image per cluster) needed for the experiment (see Figure 3).

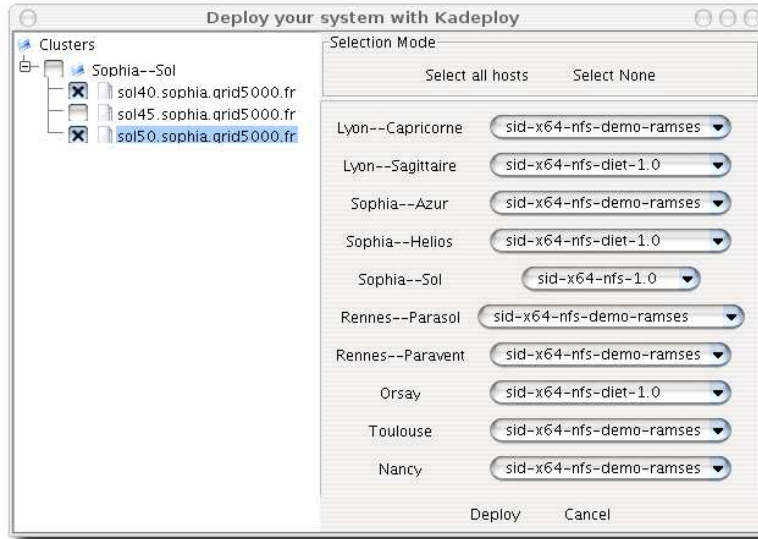


Figure 3. Image deployment through KaDeploy.

4.1.2 Comparison with QMON. QMON is the GUI to the N1 Sun Grid Engine (SGE) [16]. It provides an interface for the job submission and the resources management of a grid and the SGE batch scheduler.

QMON allows the user to submit either simple or parallel jobs on queues⁷ that are run in a passive and non interactive mode. The users can then monitor the jobs and the grid status. But QMON does not provide an access to the computation nodes for interactive work, and a specific system can not be deployed to get a user-defined system for the duration of the reservation. Moreover, to use different queues, the user must use a parallel job with a defined parallel environment such as MPI or PVM, whereas different nodes can be used on different clusters without the mandatory use of some parallel environment with OAR and the DIET Dashboard.

4.2 Grid Monitoring

Grid monitoring is important for a default user before he reserved resources, but also after he has reserved resources. Before submitting any job to a grid, the user should be aware of the available nodes considering their states (free/already used/dead). Whenever there is not enough resources, the user should be able to know when these will be available for computation. After having successfully submitted some jobs, the user should have some interface to get the information about his jobs but also the other jobs running on the grid. Even if sometimes more information could be interesting for expert users, too lower level information could be unusable for the default user who only wants to perform computations on some resources for a given period of time.

The following sections will present how the grid monitoring is implemented within the DIET Dashboard and an existing software dealing with the monitoring called Ganglia.

⁶<http://kadeploy.imag.fr/>

⁷A QMON queue corresponds to a cluster in the DIET Dashboard for the batch scheduler OAR.

4.2.1 Functionalities of DIET Dashboard . Thanks to the resource tool we can monitor the state of the platform with charts presenting the load of the different clusters, the state of all clusters and all the users' jobs on the grid (see Figure 4).

We are also able to monitor the status of a particular cluster with charts summarizing the nodes states and a table composed of the jobs (running or waiting) on that cluster. A Gantt chart is also available helping the user to define when he can reserve some resources.

The resource tool also provides the user with all necessary information about every job that are present on a cluster, with, among others, the job Name, the job State, the job hosts, etc.

Finally a plugin generates instantaneous data and history concerning the main metrics (the CPU load, the disk/memory/swap used, the in/out bytes, etc.) of the user reserved nodes with information taken from the Ganglia data.

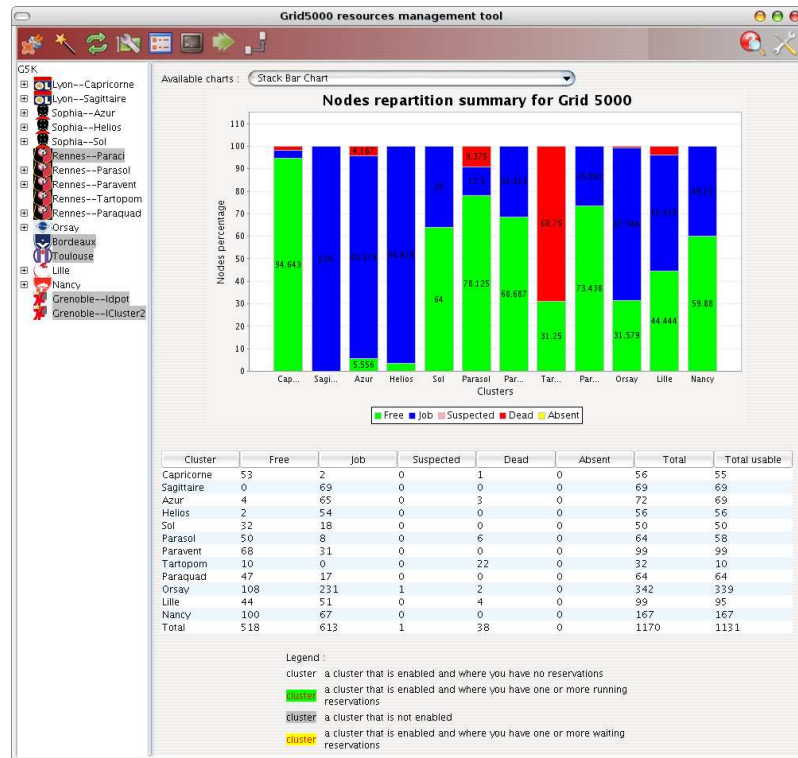


Figure 4. Grid'5000 grid status.

4.2.2 Comparison with Ganglia. Ganglia is a scalable distributed monitoring system for high-performance computing systems such as clusters and grids. Ganglia provides resources usage metrics (memory, CPU, jobs...) for individual sites or whole grids. These are low level and can be used to monitor the hardware of sites of whole grids.

But Ganglia does not provide information of higher level such as the node states, the available resources of clusters or the information about the jobs existing in the clusters. From an user point of view that needs to reserve resources and realize some computations on that nodes, the information about the jobs and the clusters in DIET Dashboard can be sufficient, whereas the ones from Ganglia can be useless because of a too lower level for a standard use. These informations are to be considered as a complement to the monitoring part of the DIET Dashboard (and it is moreover the purpose of a plugin as described in Section 4.2.1).

4.3 Grid Middleware Management

When using a tool managing grids and grid middleware such as DIET, a user expects features such as the design a hierarchy of middleware elements, the remote deployment of locally created hierarchies, or the discovery of online existing and usable services for further use in workflows. Others functionalities can also be offered like log service or real-time execution for running workflows, or resources dependent generation of hierarchies according to predefined existing models. The following sections present how the grid middleware management is implemented in the DIET Dashboard as well as an existing software with monitoring features called GridNexus.

4.3.1 Workflow tools.

Workflow designer A large number of scientific applications are represented by graphs of tasks which are connected based on their control and data dependencies. The workflow paradigm on grids is well adapted for representing such applications and the development of several workflow engines [2, 11, 15] illustrates significant and growing interest in workflow management within the grid community. The success of this paradigm in complex scientific applications can be explained by the ability to describe such applications in high levels of abstraction and in a way that makes it easy to understand, change, and execute them.

Several techniques have been established in the grid community to define workflows. The most commonly used model is the graph and especially the Directed Acyclic Graph (DAG). Since there is no standard language to describe scientific workflows, the description language is environment dependent and usually XML based, though some environments use scripts. In order to support workflow applications in the DIET environment, we have developed and integrated a workflow engine. Our approach has a simple and a high level API, the ability to use different advanced scheduling algorithms, and it should allow the management of multi-workflows sent concurrently to the DIET platform.

In this context, a workflow designer was developed to help users to design workflow applications but also to execute them. Figure 5(a) shows an overview of this tool, where they can have a description of the available services (discovered with online mode) and design a workflow by a drag and drop mechanism. The user does not need to know details about the requested services neither to define them. Once the workflow designed, one can either save it to an XML format supported by the DIET workflow engine or execute it directly. In the second case, the workflow input must be defined.

The XML representation of designed workflows describes required tasks and data dependencies. A task is a DIET service and a data dependency is a link between two parameters. The workflow designer checks and guarantees data type compatibility between source and target ports of each created link.

The workflow description level used here is known as “abstract description”. This level of description does not include any runtime information but is sufficient for the workflow execution. DIET hierarchy and workflow engine manage automatically and transparently the user tasks scheduling and execution.

Workflow log service To improve workflow monitoring, we propose a tool dedicated to workflow monitoring that displays the real-time execution processes of different workflows. This graphical tool has two major roles: first it is a central event service that receives and handles the events related to tasks execution progression. Secondly it provides a graphical representation of workflow state. This tool, shown in Figure 5(b), displays the different workflows after they start their execution. Each node of the workflow can be in one of the following states: “waiting”, “running”, or “done”.

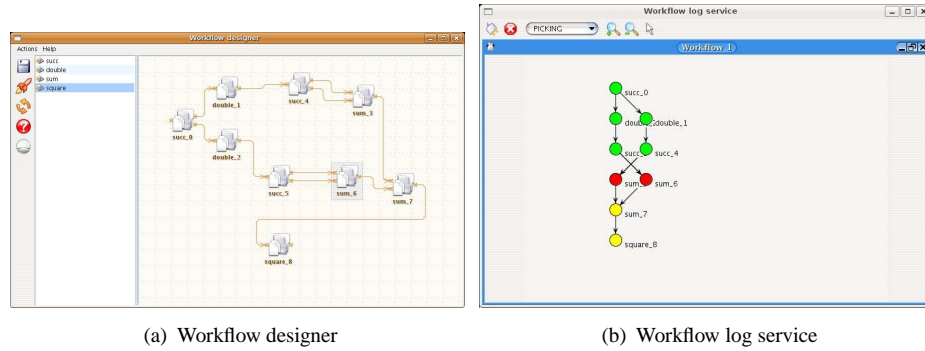


Figure 5. Workflow tools.

4.3.2 DIET tools. A DIET platform can be represented by a hierarchy of agents and servers. Designing and deploying such a hierarchy of distributed and heterogeneous elements can be a hard task for the end user. In our previous works [6], we have defined a XML format to describe DIET platforms. This format describes a DIET hierarchy but also the information about used resources and environments.

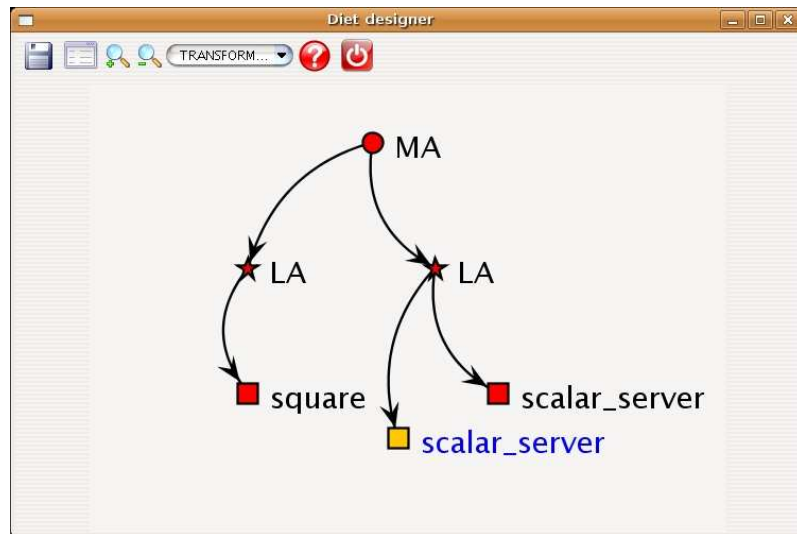


Figure 6. DIET designer.

To deploy DIET hierarchies on a grid environment the DIET Dashboard provides two methods:

In two steps: First the user creates by hand his DIET hierarchy with the DIET designer. Instead of manipulating complex XML files, the user simply adds Local Agents or Server Daemons to the Master Agent or already added Local Agents. Concerning the Server Daemons you can define the binary to launch, the input parameters etc. This level describes only the application level, and the obtained application description can be extended with runtime information. The main frame of the DIET designer is presented in Figure 6.

To extend this application level hierarchy the user should use the DIET mapping tool (see Figure 7). This tool allows the user to map the allocated Grid'5000 resources to a DIET application. For each Grid'5000 site, the nodes (or hosts) are used in a homogeneous manner but the user can select a particular host if needed.

in one step: The XMLGoDIETGenerator builds a GoDIET XML file that can be used with the DIET deployment tool from a compact description and a reservation directory. For large experiments, writing the GoDIET file by hand is time consuming and if the user should redo this experiment with a different set of machines, the GoDIET file will be generated according to the available resources.

The way hierarchies are described (through a framework from which their are created according to the available resources) have also to be the most flexible to let the user write all possible hierarchies. One should notice that the XMLGoDIETGenerator is “resources driven” because the final hierarchy will directly depend on the available resources provided, whereas the ones created with the DIET designer and mapping tools will not change if there is more or less available resources.

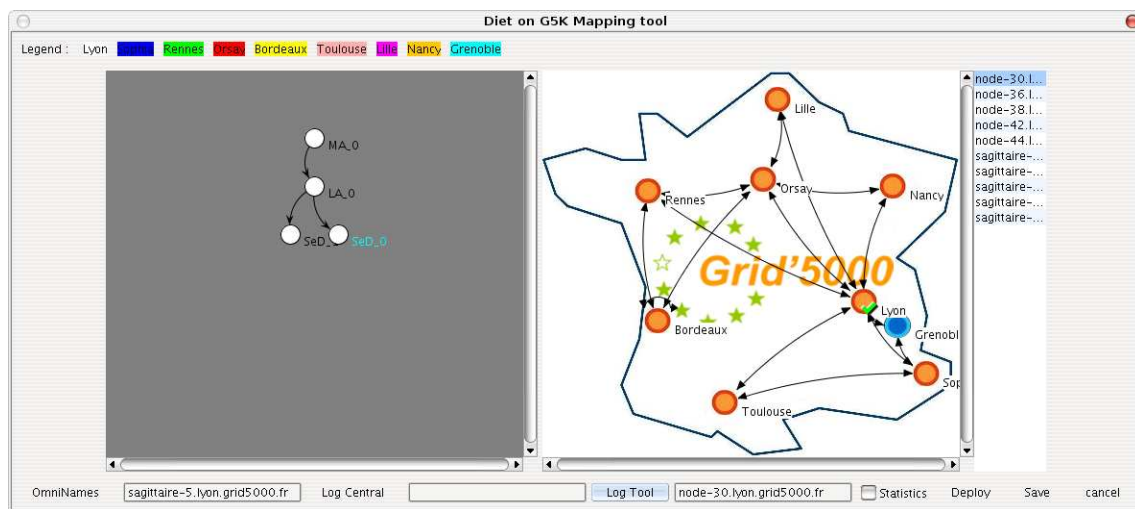


Figure 7. DIET mapping Tool.

When the DIET hierarchies are generated the user can deploy these hierarchies on the grid thanks to the DIET deploy tool (see Figure 8). This tool is a graphical interface to GoDIET. It provides the basic GoDIET operations: open, launch, stop, and also a monitoring mechanism to check if DIET application elements are still alive (the states are the same as for the workflow log service). As the workflow log service, the DIET deployment tool can be used in a local or a remote mode.

4.3.3 Comparison with GridNexus. GridNexus provides a GUI for the workflow construction and execution. This interface is a “Drag and Drop” environment that can be used to build workflows from generic grid and web services. The output is XML-based and easy to modify or use from specialized tools around GridNexus. The user designs the workflow by linking elements as for the workflow designer of DIET Dashboard. After having designed the workflow it can be run and the user can see the results of the workflow or get the corresponding script of the workflow. The workflows can be abstracted to simplify the workflow design. These “composites” can then be used as elements of other workflows. GridNexus comes with a library of pre-defined elements that can be used from the GUI, but we can also generate workflows from URL of WSDL that define services.

However GridNexus does not show the evolution of the workflow execution, and it does not provide some log functions in order to prevent from services failures or anything else. Moreover GridNexus does not discover online services but the user should provide him the services which

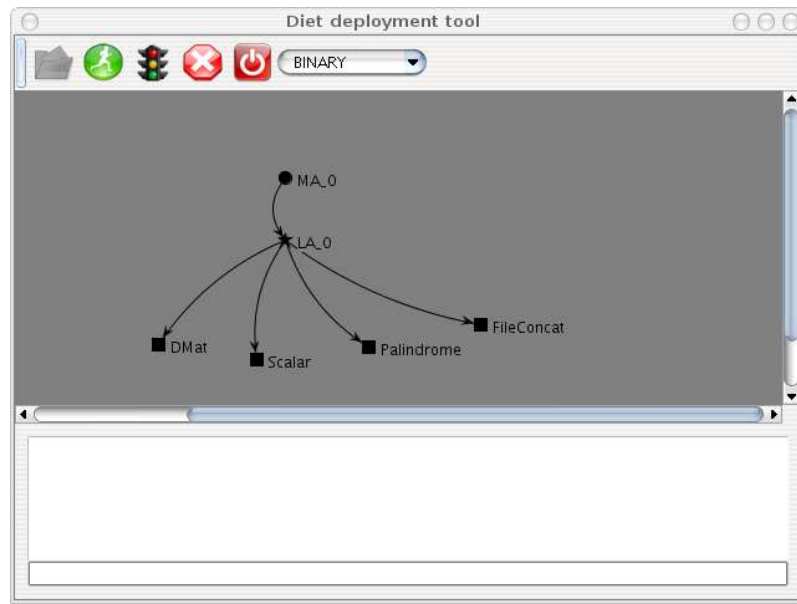


Figure 8. DIET deployment tool.

could be complicated for the end-user that might not know where those services are located. Finally GridNexus only manages workflows of tasks, and does not allow the user to design and execute her/his own hierarchies of elements, in order to later execute clients (the ones that are not workflows of executions) on computations nodes.

5. Experiments

An experiment has been realized to test the capabilities of DIET and DIET Dashboard for a large number of machines. This experiment has been realized on Grid'5000, and the chosen application was cosmological computations. For this experiment, the entire Grid'5000 platform was reserved⁸ which gave us 12 clusters used on 7 sites for a duration of 48 hours. Finally 979 machines were used with an user-defined environment containing all the needed software for the experiment. Figure 9 gives a bar chart representing the occupation of the cluster with the jobs for the experiment, taken from the resources tool of the DIET Dashboard.

The aim of the experiment was also to start the largest machines reservation over the grid, for the deployment of the largest DIET hierarchy in order to execute the maximum number of cosmological application jobs. The MPI code executed by the DIET servers called RAMSES⁹ [17] was developed in Saclay (DAPNIA/CEA) to study large scale structures and galaxies formation. This code is a grid-based hydro solver with adaptive mesh refinement.

Thanks to GRUDU, reservations were done at the grid level and not on each cluster in 20 seconds. To get an user-defined environment on each machine, GRUDU was able to realize the deployment of every machines of the 12 clusters involved at the same time in roughly 25 minutes. Finally the DIET hierarchy was created through the use of the XMLGoDIETGenerator in 5 seconds and deployed through the DIET Deploy tool and GoDIET in 23 seconds.

If these tasks would have been done without GRUDU:

- the reservation would have been realized with `oargridsub` (a non-graphical utility dedicated to OAR) by hand by reserving every nodes of each cluster at a time.

⁸among the uncrashed nodes.

⁹<http://irfu.cea.fr/Projets/COAST/ramses.htm>

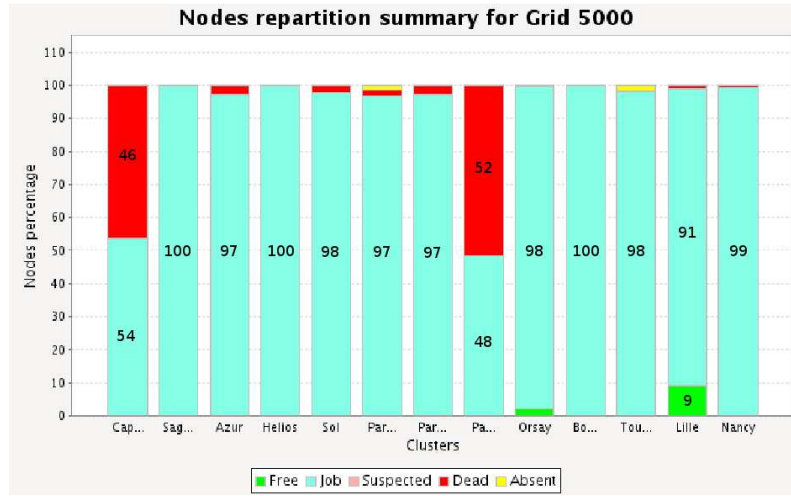


Figure 9. Chart representing the occupation of the different clusters and the node repartition between the different job states (Free/Job/Dead/Absent).

Here is a dummy example of `oargridsub` command:

```
oargridsub
cluster1:rdef="nodes=2",cluster2:rdef="nodes=1",cluster3:rdef="nodes=1",
cluster4:rdef="nodes=2",cluster5:rdef="nodes=1",cluster6:rdef="nodes=1",
cluster7:rdef="nodes=2",cluster8:rdef="nodes=1",cluster9:rdef="nodes=1",
cluster10:rdef="nodes=2",cluster11:rdef="nodes=1",cluster12:rdef="nodes=1",
-s '2007-09-07 16:00:00'
-w '0:10:00'
-p ~/runhpl/runhpl
```

- The use of an user-defined environment would have been impossible without KaDeploy, it would have taken the same amount of time per cluster and not for all of them, and the configuration of the deployment would have been more difficult because of several conditional choices.
- The DIET hierarchy would have been written by hand and not easily readable because of the resources-dependency of the hierarchy description file avoided by the pattern-matching realized by the XMLGoDIETGenerator.

The DIET platform deployed was composed of one Master Agent, 12 Local Agents, and 29 Server Daemons. One job can be executed on each SeD at a given time. 816 nodes were used for the application jobs. As far as the different clusters do not provide the same compilation environment, an image of an environment specially created has been deployed on every reserved nodes.

During the experiments, the main difficulties came from the hardware limitations (typically the disk space which was not large enough to backup data, or some no well defined permissions of /tmp directories on some clusters), and not from DIET or the DIET Dashboard that allowed a good dispatching of the middleware requests and the fast and efficient management of these hardware problems.

6. Conclusion

With the development of grid technologies and the availability of large scale platforms, it becomes mandatory to manage grid applications efficiently and easily. In this paper, they have presented the DIET Dashboard environment which is a complete, modular, portable, and powerful

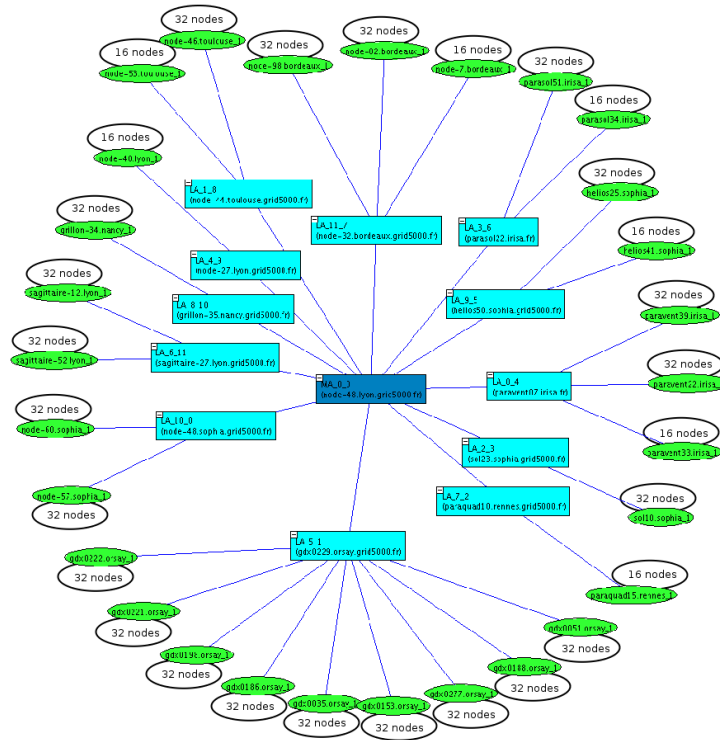


Figure 10. DIET hierarchy deployed during the experiment.

set of tools dedicated to a grid middleware. With this tool, a non-expert user can manage grid resources, monitor the grid itself and manage the grid middleware by designing its grid applications or using workflows and then deploying these grid applications over the grid platform.

The DIET Dashboard offers a large number of modules, created to answer the different needs of tools appearing in a grid context. The software architecture design of DIET Dashboard makes its extensible (modules can easily be added to the core of the application).

The performance of the DIET Dashboard and GRUDU (the tool dedicated to the grid management) have been tested through the experiment realized on Grid'5000. This experiment showed that the resources tool is able to monitor the entire grid, and reserve resources on a large number of sites and clusters. GRUDU is one answer to the need of an efficient tool for the management of both hardware and software part of the grid. GRUDU abstracts the scripting part of the management of a grid, in order to provide to the user a easy-to-use GUI where all the necessary operations are available. Users do not need to write obscure and complex command lines for the management of their resources anymore, which is often one of the main barriers in the use of grid environments.

All these elements prove that the DIET Dashboard is as stable and efficient tool that unifies different tools into one single modular graphical application.

Acknowledgments

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