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A year in the life of a large scale experimental distributed system: the Grid'5000 platform in 2008

Anne-Cécile Orgerie, Laurent Lefèvre

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INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

*A year in the life of a large scale experimental
distributed system: the Grid'5000 platform in 2008*

Anne-Cécile Orgerie — Laurent Lefèvre

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A year in the life of a large scale experimental distributed system: the Grid'5000 platform in 2008

Anne-Cécile Orgerie , Laurent Lefèvre

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Abstract: This report presents the usage results of Grid'5000 over year 2008. Usage of the main operationnal Grid'5000 sites (Bordeaux, Lille, Lyon, Nancy, Orsay, Rennes, Sophia-Antipolis, Toulouse) is presented and analyzed.

Key-words: Large scale distributed system, usage, Grid'5000

Une année dans la vie d'un système distribué expérimental à grande échelle : la plate-forme Grid'5000 en 2008

Résumé : Ce rapport présente les résultats d'usage de la plateforme expérimentale Grid'5000 pendant l'année 2008. L'usage des principaux sites opérationnels de Grid'5000 (Bordeaux, Lille, Lyon, Nancy, Orsay, Rennes, Sophia-Antipolis, Toulouse) est présenté et analysé.

Mots-clés : Système distribué à grande échelle, usage, Grid'5000

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1 Introduction

Some previous work on operational Grids [IDE⁺06] show that grids are not utilized at their full capacity. We focus on the utilization of a large-scale experimental distributed system by relying on the case study of Grid'5000[Cea05]¹, a French experimental Grid. We collected and analyzed the logs of the Grid'5000 platform for a full year of usage (2008). We present the main statistics observed for each site and some specific and representative computing nodes. A special analysis is dedicated to the grid usage of this experimental platform. This usage analysis has been used in some works on energy-efficient experimental distributed infrastructures [OLG08a, OLG08b]. A similar analysis has been done for 2007 logs of Grid'5000 and can be found in [OL09].

This paper briefly presents the Grid'5000 experimental platform and the followed methodology in Section 2. The usage statistics are then presented for each Grid'5000 site (Section 3).

2 Definitions and Methodology

2.1 Grid'5000: a Large-Scale Experimental Distributed System

The Grid'5000 platform is an experimental testbed dedicated for research in computer science, made up of more than 3400 processors geographically distributed on 9 sites in France (see Fig. 1). This platform can be defined as a highly reconfigurable, controllable, and monitorable experimental large-scale distributed system.

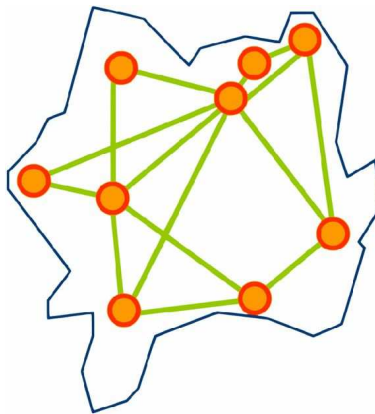


Figure 1: The Grid'5000 map

¹Some experiments of this article were performed on the Grid'5000 platform, an initiative from the French Ministry of Research through the ACI GRID incentive action, INRIA, CNRS and RENATER and other contributing partners (<http://www.grid5000.fr>). This research is supported by the GREEN-NET INRIA Cooperative Research Action: <http://www.ens-lyon.fr/LIP/RESO/Projects/GREEN-NET/>

The utilization of Grid'5000 can be very specific. Each user can reserve (in advance) some computing nodes. During its reservation time, the user can be root on his reserved nodes and he can deploy his own system images, collect data, launch applications, reboot the nodes, and so on. The nodes are entirely dedicated to the user during his reservation.

2.2 Experiment Methodology

The user gives the resource manager (at least) a start time, a duration, and the number of required resources. These characteristics define the job (a reservation). The resource manager is in charge of the job's acceptance. It verifies if that job is compatible with previously accepted jobs and, if it is, it gives a job id to the user.

There are three different type of jobs:

- *deploy*: the user deploys its own environment,
- *default*: the user uses the default environment.
- *besteffort*: they get scheduled on processes when no other job use them and these jobs are killed when a regular (deploy or default) job recently submitted needs the nodes used by a besteffort job.

When a resource is not available for the user, it can be in different states:

- **dead**: the resource is down (due to a component failure for example);
- **suspected**: the resource does not work properly;
- **absent**: the resource is not available for the user (not physically present).

Moreover, the platform has changed between the beginning and the end of the measurements. For that reason, we present the results as percentages of the platform's capacity at the time of measurement (100% at a given time does not represent the same number of resources as 100% at another time).

In order to obtain the utilization traces, we have used a history function provided by OAR² [CCG+05] called *oarstat*. This function provides the user with all the events that occur during a time period. An event can be a job or a problem on a resource (it is dead, absent or suspected) for a given period. Our goal is to obtain a detailed overview of the usage of an experimental grid.

3 Results per Grid'5000 site

For each Grid'5000 site, we provide several values and figures which represent the global usage of the site. All the times are given in seconds. A resource is a core and a job is actually a reservation.

We have split the proposed statistics in three categories:

²OAR is a resource manager (or batch scheduler) for large clusters.(<http://oar.imag.fr/index.html>)

- the “platform and resources” part which lists the available number of resources and some statistics on the resources’ states. We also compute the real work time of the Grid’5000 site. The “real” percentage of work time is calculated without taking into account dead time or absent time (i.e. work time over total time minus dead time and absent time for all the resources).
- the “jobs” part proposes some statistics on the number of submitted jobs (reservations), the mean time and mean number of resources per job, and the maximal duration of a job on a site. We also list the number of reservations used for deploying system images (*deploy jobs*).
- the “users” section contains the number of users and the impact of users from other Grid’5000 sites. The percentage of users coming from other sites does not take into account any consideration of proportionality in terms of jobs. It is just the number of users coming from other sites over the total number of users (each user is counted once).

For each site, we provide four diagrams. The first one represents the weekly repartition in time of the resources between the different states: in red when some cores are dead (*Dead* state), in orange when they are suspected (*Suspected* state), in yellow when they are absent (*Absent* state), in green when they are working (a job is running) (*Work* state), and in white when they are unoccupied (no job, no other state) (*Idle* state).

The two other diagrams present the weekly time repartition of two particular resources: the median and the maximal resources. The "maximal resource" is the resource which has the maximal work time among the resources which are present for the whole 2008 year. The "median resource" is a resource which is present for the whole 2008 year and is the nearest to the median value of cumulative work over the experiment’s duration.

3.1 Usage of Grid’5000’s Bordeaux site in 2008

- Platform and resources:
 - Maximal number of resources (cores): 650
 - Mean time spent in each state for all the resources, in percentage:
 - * Dead: 3.48%
 - * Suspected: 5.53%
 - * Absent: 4.06%
 - * Work: 49.19%
 - Real percentage of work time (without taking into account the time when the resources are dead or absent): 53.20%
- Jobs:
 - Number of jobs (reservations): 356222

- Mean time of a job: 2473.38 (41 minutes and 13 seconds)
 - Maximal duration: 794428 s. (9 days 4 hours 40 minutes and 28 seconds) for job number 407783
 - Mean number of resources (cores) per job: 7.44
 - Percentage of deploy jobs: 0.97%
 - Percentage of time spent in deploy jobs compared to the work time: 22.32%
 - Percentage of jobs coming from other sites: 83.28%
 - Percentage of besteffort jobs: 58.03%
 - Percentage of time spent in besteffort jobs compared to the work time: 34.90%
- Users:
 - Number of users: 223
 - Percentage of users coming from other sites: 87%

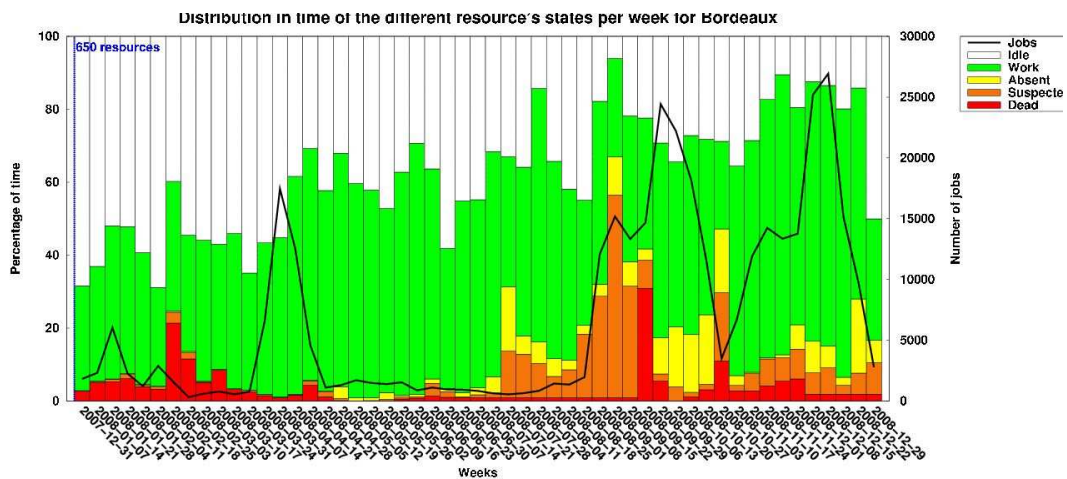


Figure 2: Global diagram with dead time for Grid'5000's Bordeaux site

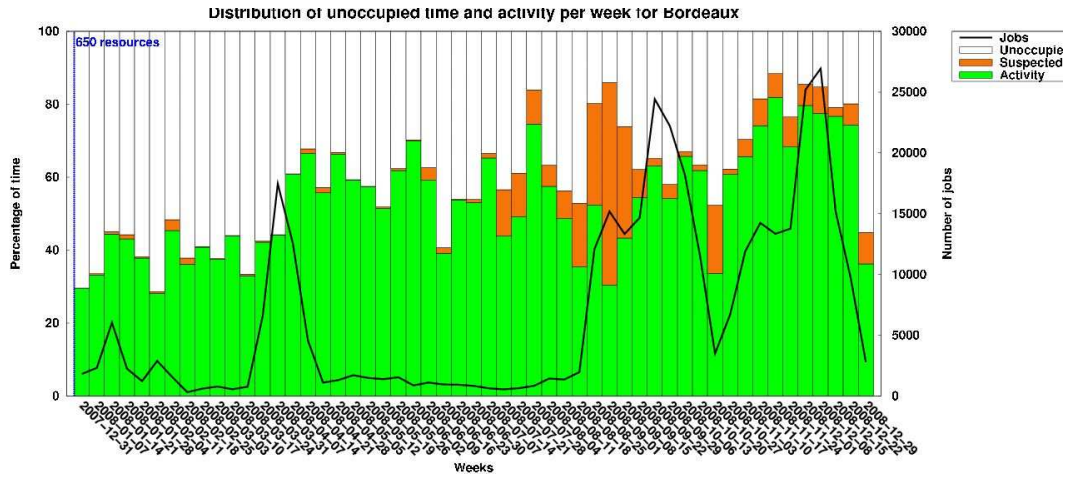


Figure 3: Global diagram without dead time for Grid'5000's Bordeaux site

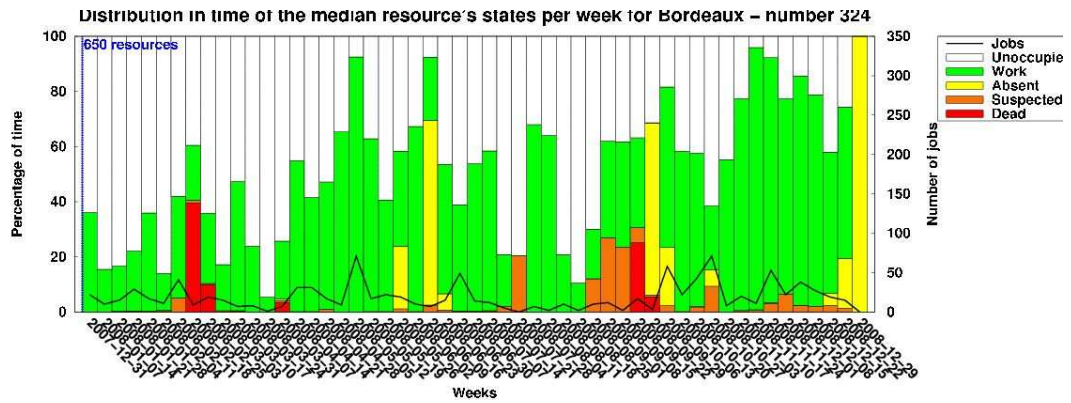


Figure 4: Median resource diagram for Grid'5000's Bordeaux site

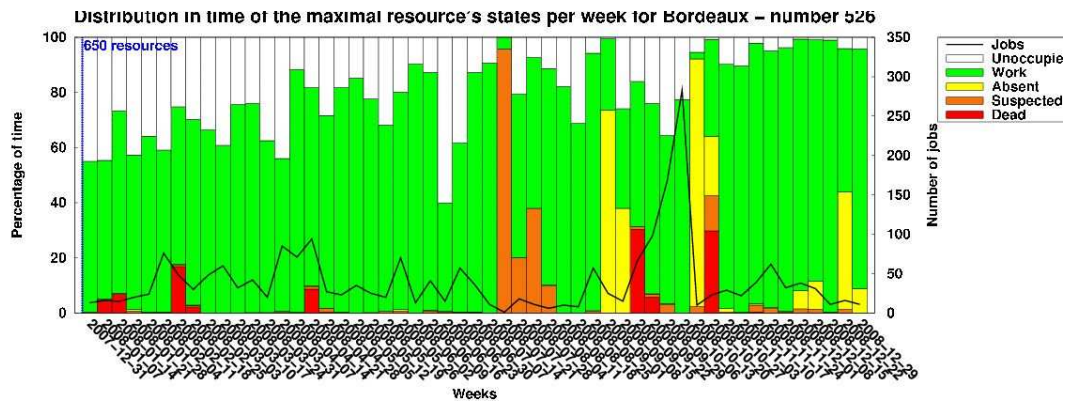


Figure 5: Maximal resource diagram for Grid'5000's Bordeaux site



We can see on these graphs that the site load is not related to the number of jobs. Indeed, between May and August, there are few jobs but the percentage of activity is high (Figure 2). Bordeaux is the less used Grid'5000 site for 2008 in terms of real activity. However, its activity has increased compared to the previous year [OL09].

3.2 Usage of Grid'5000's Lille site in 2008

- Platform and resources:
 - Maximal number of resources (cores): 618
 - Mean time spent in each state for all the resources, in percentage:
 - * Dead: 16.21%
 - * Suspected: 4.67%
 - * Absent: 8.61%
 - * Work: 54.80%
 - Real percentage of work time (without taking into account the time when the resources are dead or absent): 72.89%
- Jobs:
 - Number of jobs (reservations): 344538
 - Mean time of a job: 3154.58 s. (52 minutes and 34 seconds)
 - Maximal duration: 756077 s. (8 days 18 hours 1 minute and 17 seconds) for job number 693546
 - Mean number of resources (cores) per job: 8.11

- Percentage of deploy jobs: 0.61%
- Percentage of time spent in deploy jobs compared to the work time: 7.24%
- Percentage of jobs coming from other sites: 38.97%
- Percentage of besteffort jobs: 19.01%
- Percentage of time spent in besteffort jobs compared to the work time: 37.88%
- Users:
 - Number of users: 198
 - Percentage of users coming from other sites: 65.66%

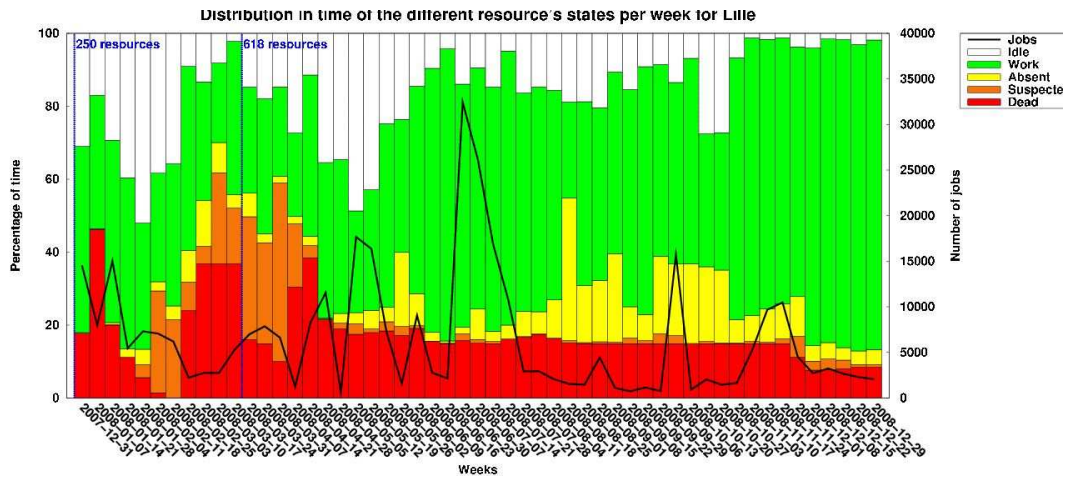


Figure 6: Global diagram with dead time for Grid'5000's Lille site

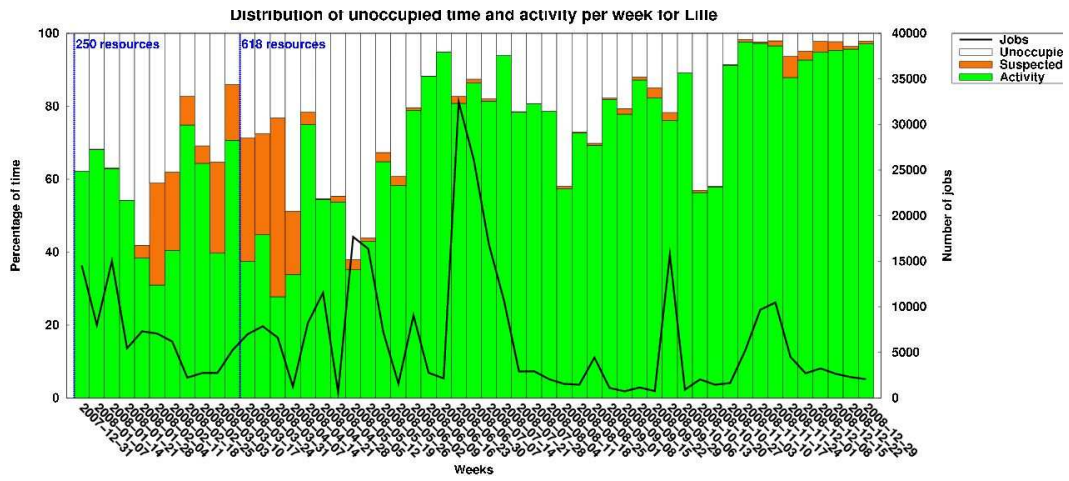


Figure 7: Global diagram without dead time for Grid'5000's Lille site

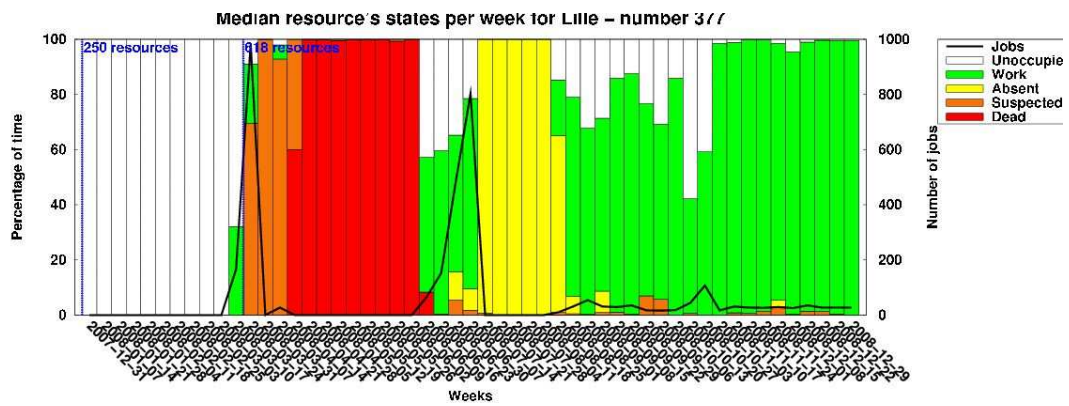


Figure 8: Median resource diagram for Grid'5000's Lille site

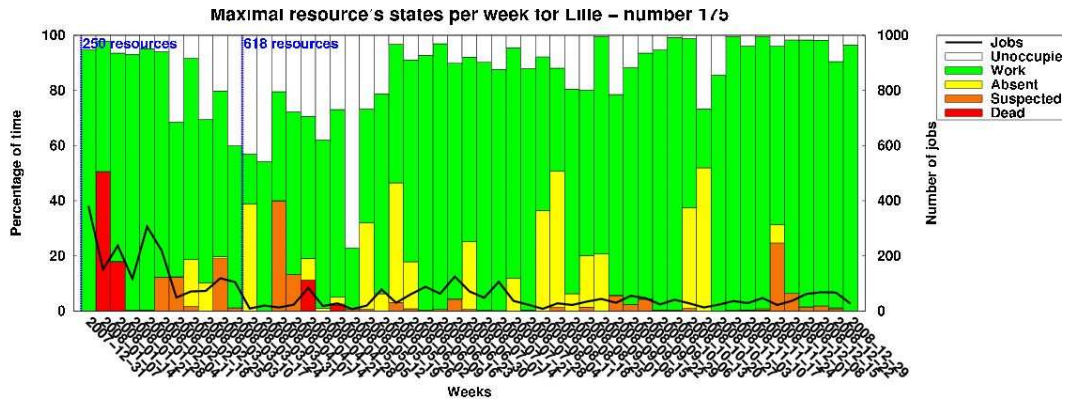



Figure 9: Maximal resource diagram for Grid'5000's Lille site

 The number of resources has greatly increase from 250 to 618 cores during the year 2008. The last two months of the year show a really high utilization of this site (over 95% during those two months). Moreover, we can see on Figure 8 that even the oldest resources are reserved and used for experiments on Grid'5000 Lille site.

3.3 Usage of Grid'5000's Lyon site in 2008

- Platform and resources:
 - Maximal number of resources (cores): 322
 - Mean time spent in each state for all the resources, in percentage:
 - * Dead: 1.82%
 - * Suspected: 2.78%
 - * Absent: 3.43%
 - * Work: 65.64%
 - Real percentage of work time (without taking into account the time when the resources are dead or absent): 69.27%
- Jobs:
 - Number of jobs (reservations): 138217
 - Mean time of a job: 3723.55 s. (1 hour 2 minutes and 4 seconds)
 - Maximal duration: 1080001 s. (12 days 12 hours and 1 second) for job number 124333
 - Mean number of resources (cores) per job: 4.39

- Percentage of deploy jobs: 3.88%
- Percentage of time spent in deploy jobs compared to the work time: 49.69%
- Percentage of jobs coming from other sites: 87.07%
- Percentage of besteffort jobs: 44.00%
- Percentage of time spent in besteffort jobs compared to the work time: 24.14%
- Users:
 - Number of users: 169
 - Percentage of users coming from other sites: 73.37%

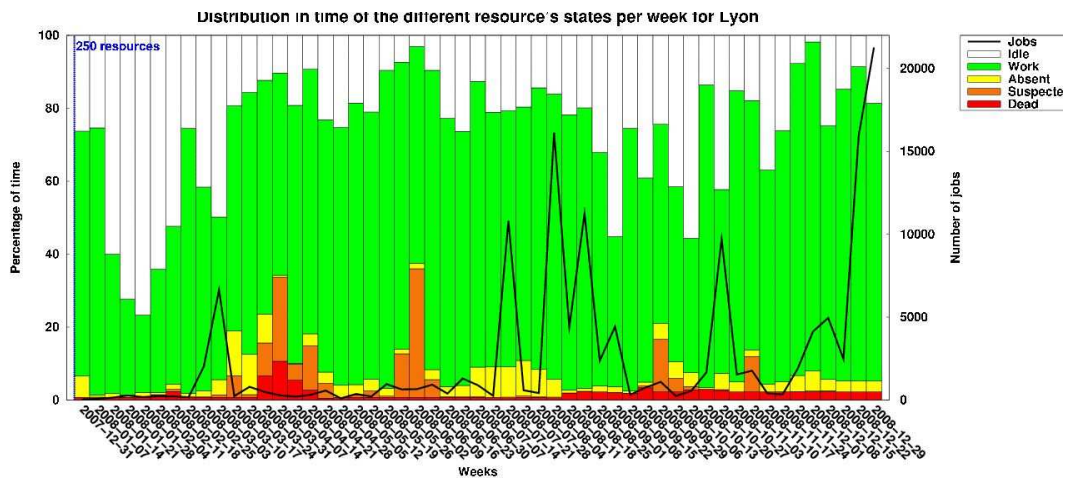


Figure 10: Global diagram with dead time for Grid'5000's Lyon site

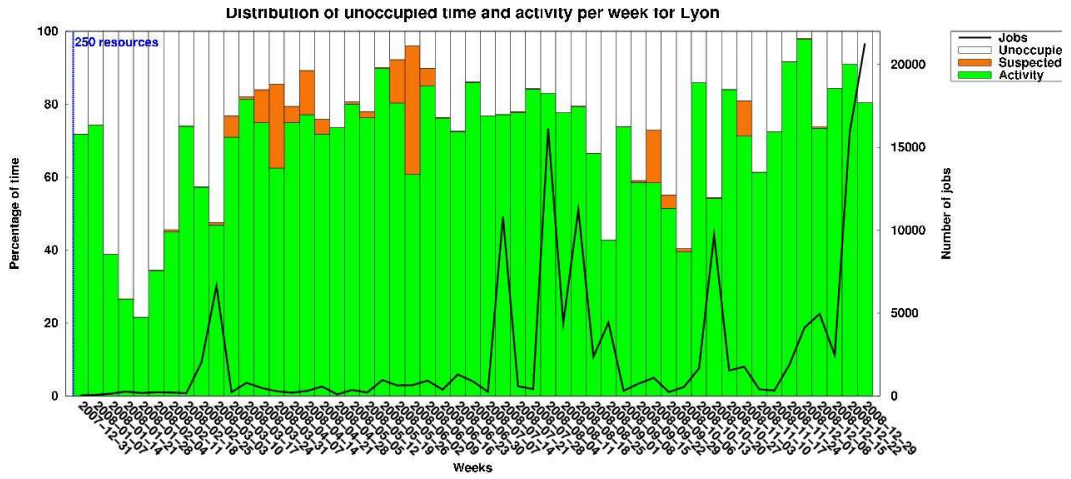


Figure 11: Global diagram without dead time for Grid'5000's Lyon site

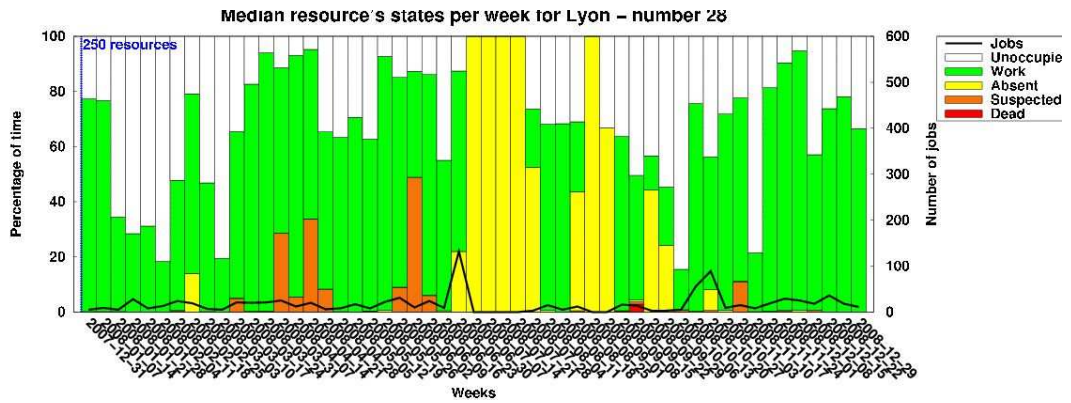


Figure 12: Median resource diagram for Grid'5000's Lyon site

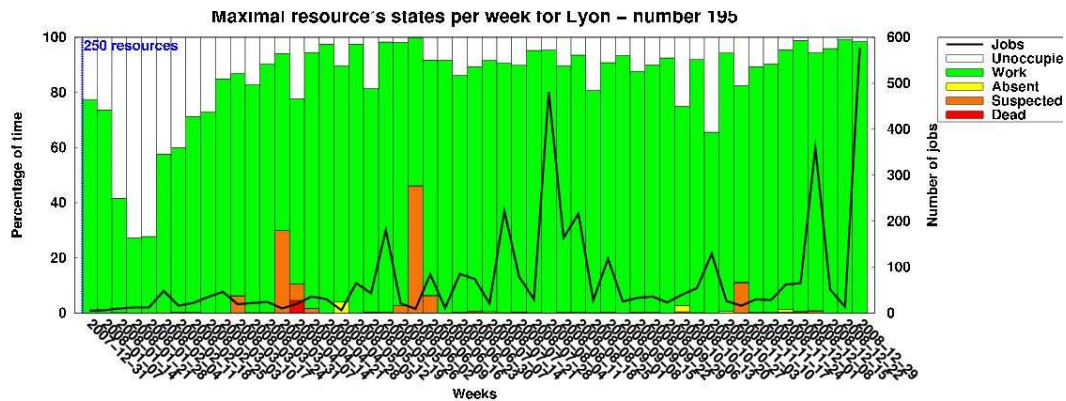



Figure 13: Maximal resource diagram for Grid'5000's Lyon site

 Lyon is the smallest Grid'5000 site for the year 2008. No machine has been added during this year to this site. However, it is really used. Another peculiarity of this site is that it gets the smallest reservations in terms of mean number of resources per reservation and among the smallest reservations in terms of mean length. It also gets the biggest time spent (in percentage) in deploy jobs: almost half of the time nodes are working with user's environments.

3.4 Usage of Grid'5000's Nancy site in 2008

- Platform and resources:
 - Maximal number of resources (cores): 574
 - Mean time spent in each state for all the resources, in percentage:
 - * Dead: 0.11%
 - * Suspected: 0.90%
 - * Absent: 1.95%
 - * Work: 58.84%
 - Real percentage of work time (without taking into account the time when the resources are dead or absent): 60.08%
- Jobs:
 - Number of jobs (reservations): 74592
 - Mean time of a job: 8912.82 s. (2 hours 28 minutes and 33 seconds)
 - Maximal duration: 1695503 s. (19 days 14 hours 58 minutes and 23 seconds) for job number 213465

- Mean number of resources (cores) per job: 14.63
 - Percentage of deploy jobs: 4.23%
 - Percentage of time spent in deploy jobs compared to the work time: 29.95%
 - Percentage of jobs coming from other sites: 20.11%
 - Percentage of besteffort jobs: 76.16%
 - Percentage of time spent in besteffort jobs compared to the work time: 17.05%
- Users:
 - Number of users: 157
 - Percentage of users coming from other sites: 83.44%

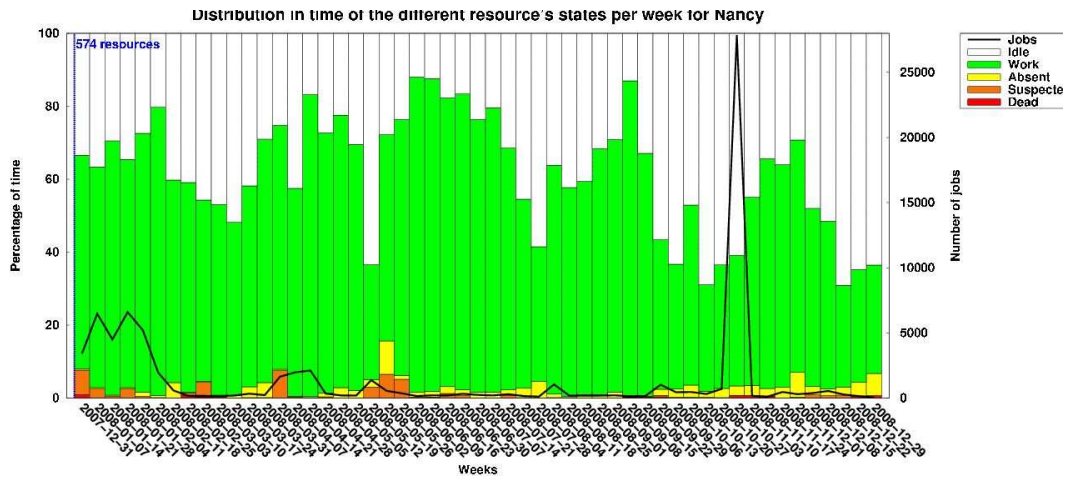


Figure 14: Global diagram with dead time for Grid'5000's Nancy site

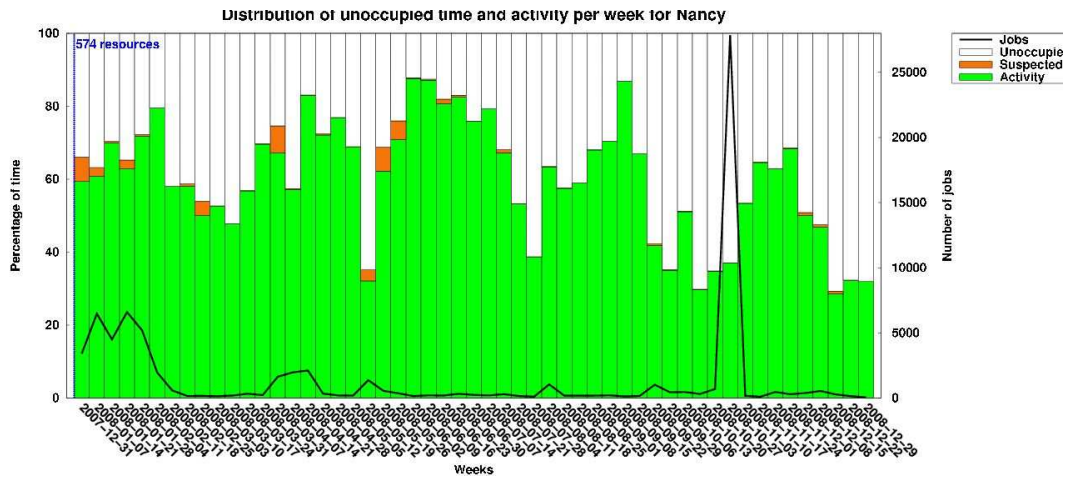


Figure 15: Global diagram without dead time for Grid'5000's Nancy site

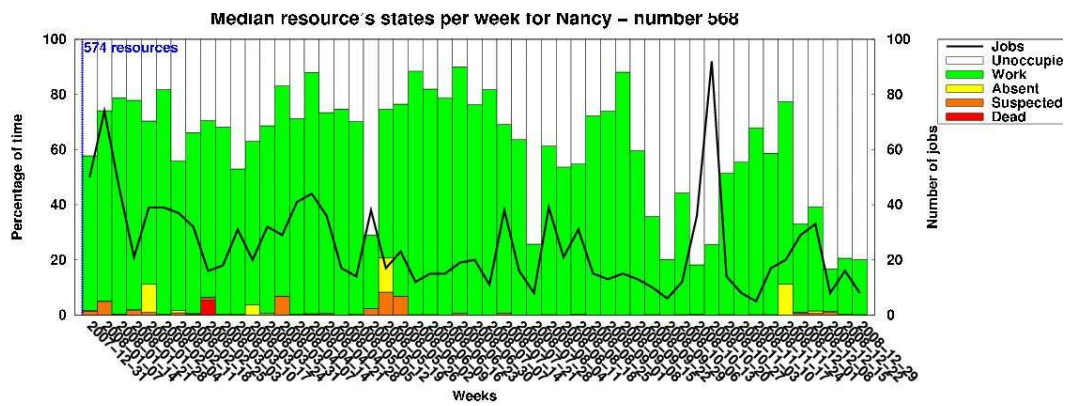


Figure 16: Median resource diagram for Grid'5000's Nancy site

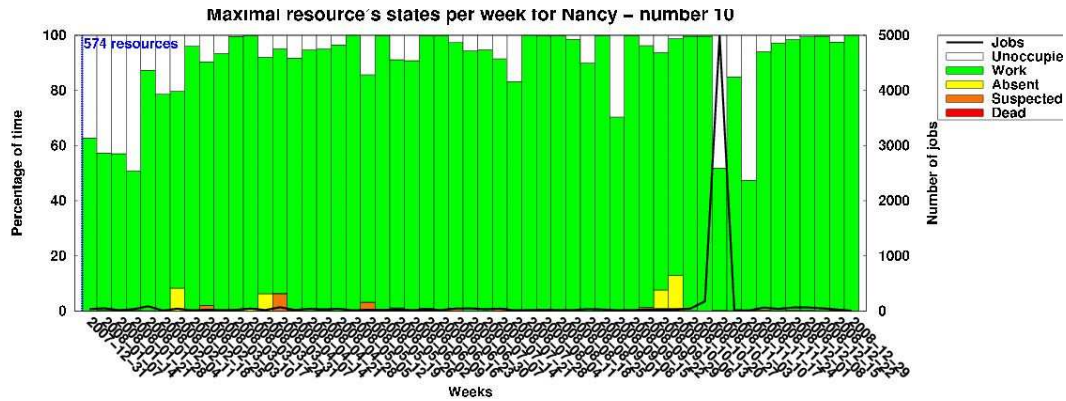


Figure 17: Maximal resource diagram for Grid'5000's Nancy site



The amount of available resources remains constant during the year 2008. This site presents a healthy working: almost no dead, suspected and absent periods. However, the load is not really balanced between the nodes as shown by Figures 16 and 17.

3.5 Usage of Grid'5000's Orsay site in 2008

- Platform and resources:
 - Maximal number of resources (cores): 684
 - Mean time spent in each state for all the resources, in percentage:
 - * Dead: 5.82%
 - * Suspected: 12.20%
 - * Absent: 6.45%
 - * Work: 50.73%
 - Real percentage of work time (without taking into account the time when the resources are dead or absent): 57.82%
- Jobs:
 - Number of jobs (reservations): 92862
 - Mean time of a job: 6246.07 s. (1 hour 44 minutes and 6 seconds)
 - Maximal duration: 1060487 s. (12 days 6 hours 34 minutes and 47 seconds) for job number 101189
 - Mean number of resources (cores) per job: 14.58
 - Percentage of deploy jobs: 3.59%

- Percentage of time spent in deploy jobs compared to the work time: 38.98%
- Percentage of jobs coming from other sites: 96.28%
- Percentage of besteffort jobs: 38.91%
- Percentage of time spent in besteffort jobs compared to the work time: 27.17%
- Users:
 - Number of users: 172
 - Percentage of users coming from other sites: 76.16%

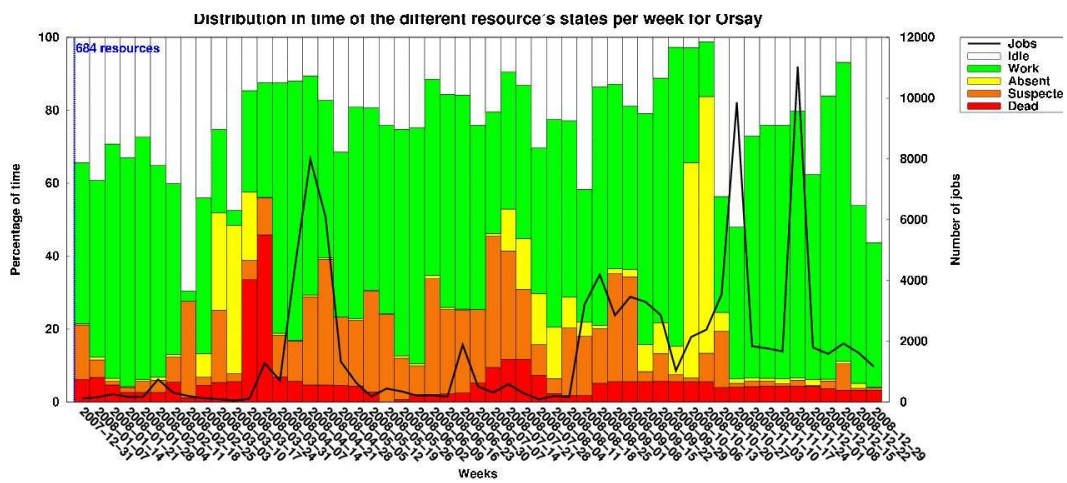


Figure 18: Global diagram with dead time for Grid'5000's Orsay site

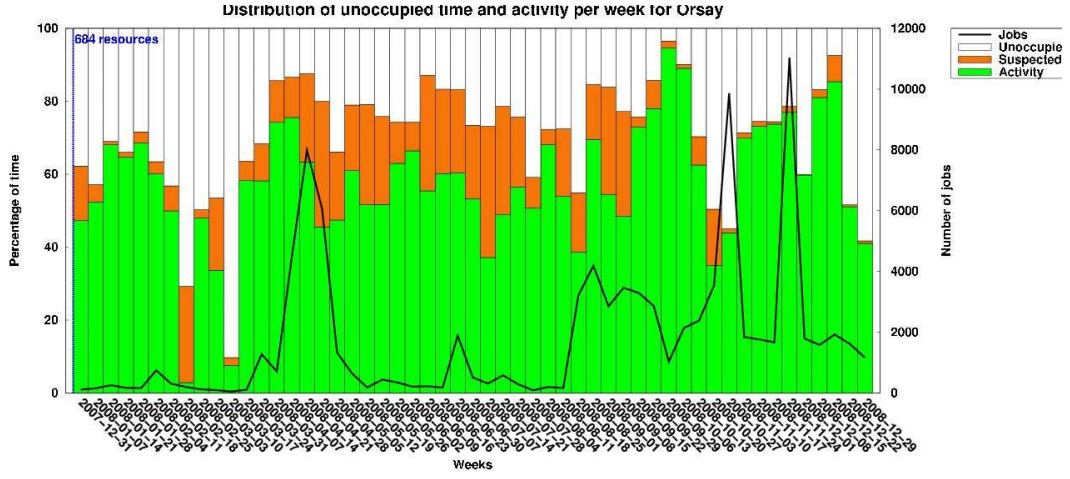


Figure 19: Global diagram without dead time for Grid'5000's Orsay site

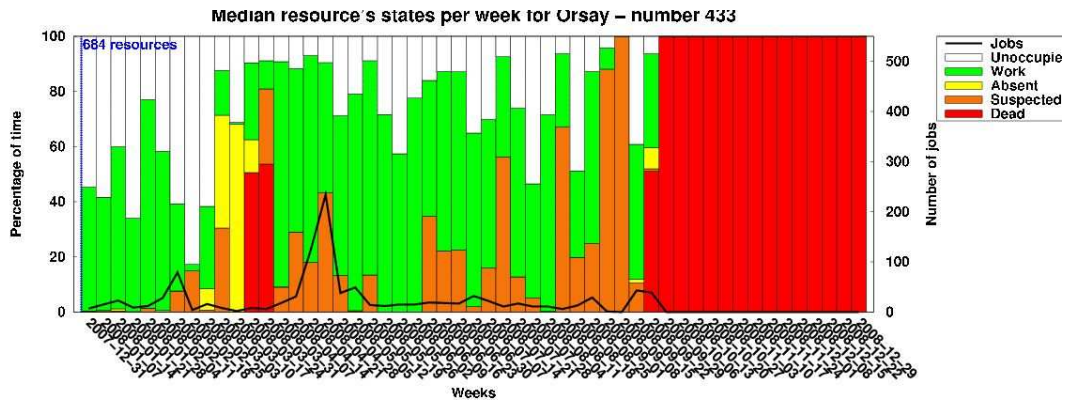


Figure 20: Median resource diagram for Grid'5000's Orsay site

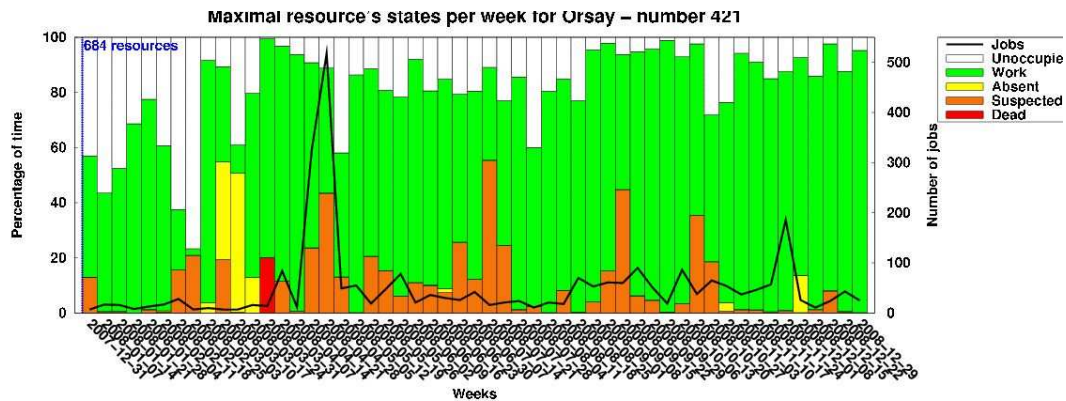



Figure 21: Maximal resource diagram for Grid'5000's Orsay site

 This site is really more used than the previous year (18.88% of real activity in 2007 [OL09]). It is one of the biggest sites in terms of resources and attracts a lot of jobs coming from other sites.

3.6 Usage of Grid'5000's Rennes site in 2008

- Platform and resources:
 - Maximal number of resources (cores): 714
 - Mean time spent in each state for all the resources, in percentage:
 - * Dead: 4.79%
 - * Suspected: 0.44%
 - * Absent: 0.79%
 - * Work: 60.98%
 - Real percentage of work time (without taking into account the time when the resources are dead or absent): 64.58%
- Jobs:
 - Number of jobs (reservations): 58843
 - Mean time of a job: 7069.33 s. (1 hour 57 minutes and 49 seconds)
 - Maximal duration: 604825 s. (7 days and 25 seconds) for job number 289263
 - Mean number of resources (cores) per job: 27.32
 - Percentage of deploy jobs: 7.84%
 - Percentage of time spent in deploy jobs compared to the work time: 35.96%

- Percentage of jobs coming from other sites: 87.41%
- Percentage of besteffort jobs: 50.01%
- Percentage of time spent in besteffort jobs compared to the work time: 23.38%
- Users:
 - Number of users: 213
 - Percentage of users coming from other sites: 82.63%

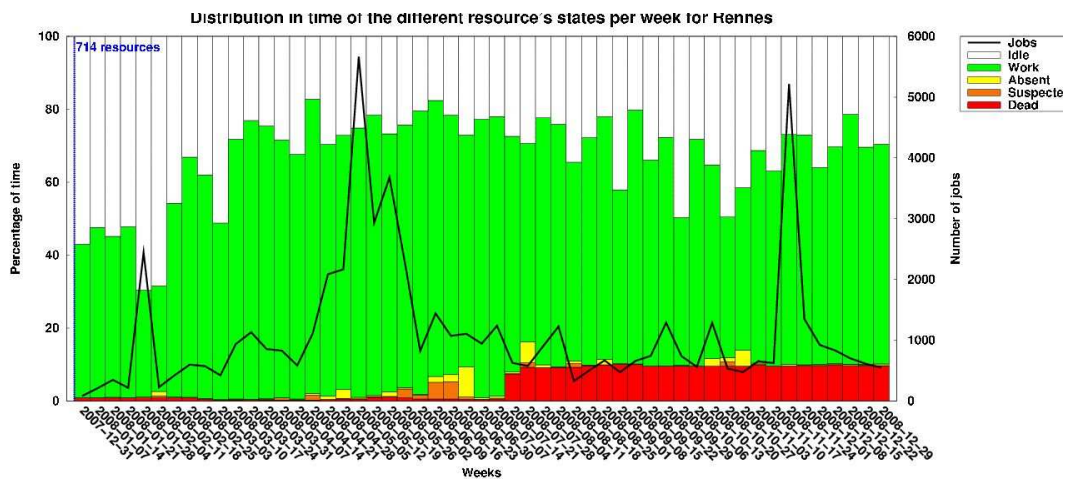


Figure 22: Global diagram with dead time for Grid'5000's Rennes site

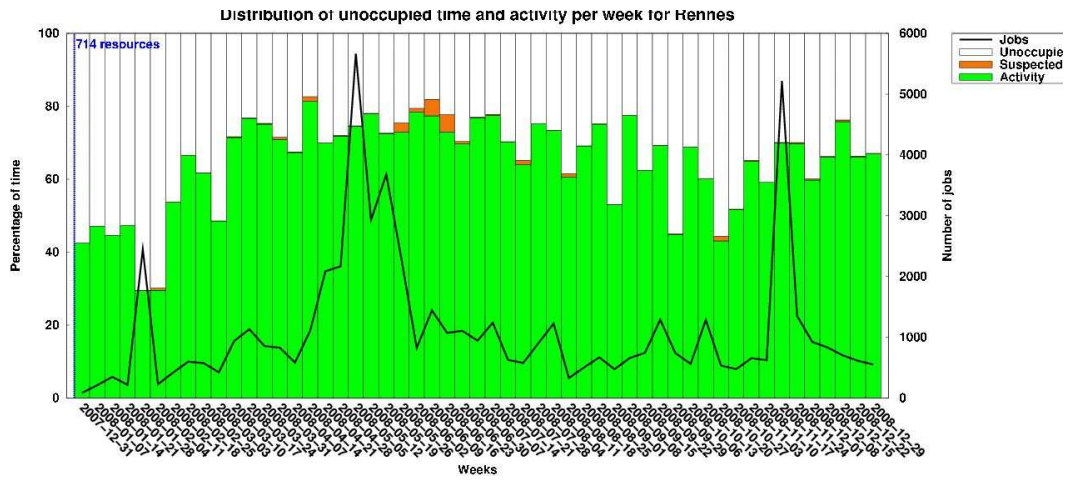


Figure 23: Global diagram without dead time for Grid'5000's Rennes site

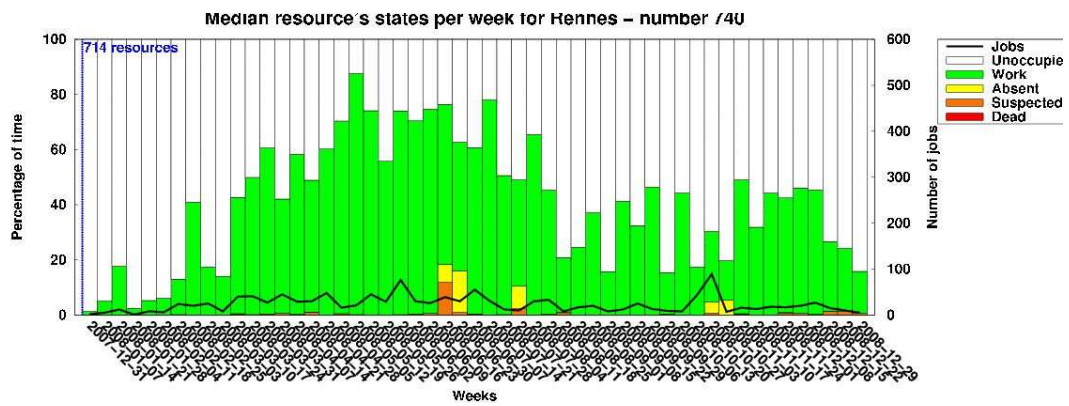


Figure 24: Median resource diagram for Grid'5000's Rennes site

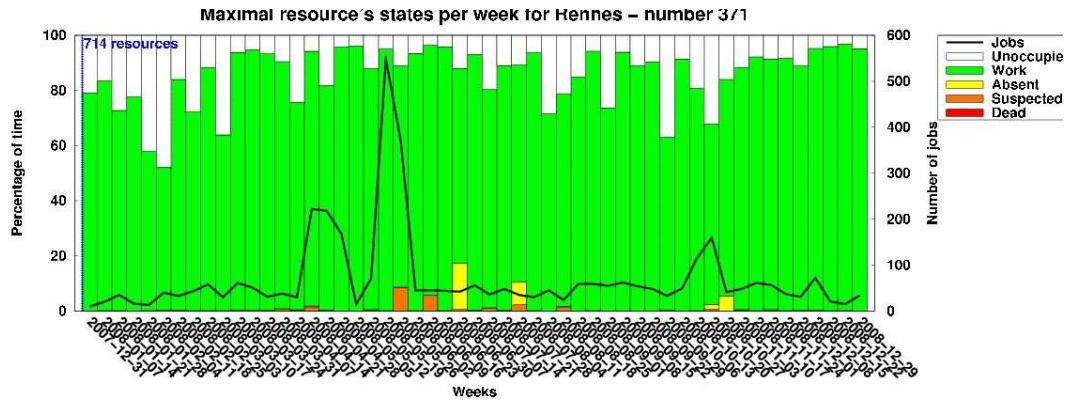


Figure 25: Maximal resource diagram for Grid'5000's Rennes site

From Figures 24 and 25, we see a really heterogeneous usage of the resources (probably) due to the heterogeneity of the nodes. This site is the biggest one in terms of resources and its activity percentage is really on the average. Due to its size, it allows bigger reservation. So, it has the higher mean number of resources per reservation (27.32) but one of the smallest number of reservations for the whole year.

3.7 Usage of Grid'5000's Sophia site in 2008

- Platform and resources:
 - Maximal number of resources (cores): 568
 - Mean time spent in each state for all the resources, in percentage:
 - * Dead: 2.04%
 - * Suspected: 0.37%
 - * Absent: 1.98%
 - * Work: 78.25%
 - Real percentage of work time (without taking into account the time when the resources are dead or absent): 81.51%
- Jobs:
 - Number of jobs (reservations): 58142
 - Mean time of a job: 8767.35 s. (2 hours 26 minutes and 7 seconds)
 - Maximal duration: 485924 s. (5 days 14 hours 58 minutes and 44 seconds) for job number 345959
 - Mean number of resources (cores) per job: 22.14

- Percentage of deploy jobs: 8.76%
- Percentage of time spent in deploy jobs compared to the work time: 25.64%
- Percentage of jobs coming from other sites: 87.24%
- Percentage of besteffort jobs: 54.36%
- Percentage of time spent in besteffort jobs compared to the work time: 19.57%
- Users:
 - Number of users: 187
 - Percentage of users coming from other sites: 85.03%

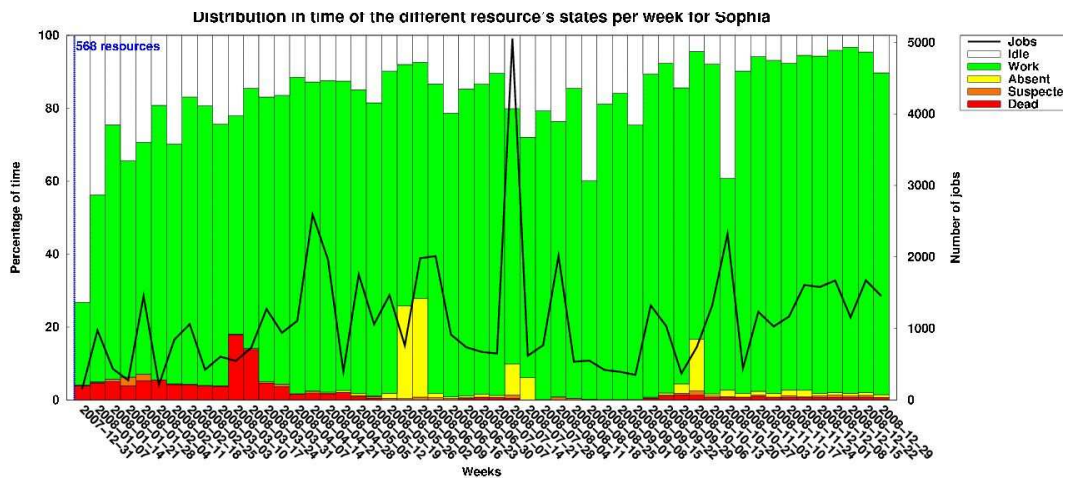


Figure 26: Global diagram with dead time for Grid'5000's Sophia site

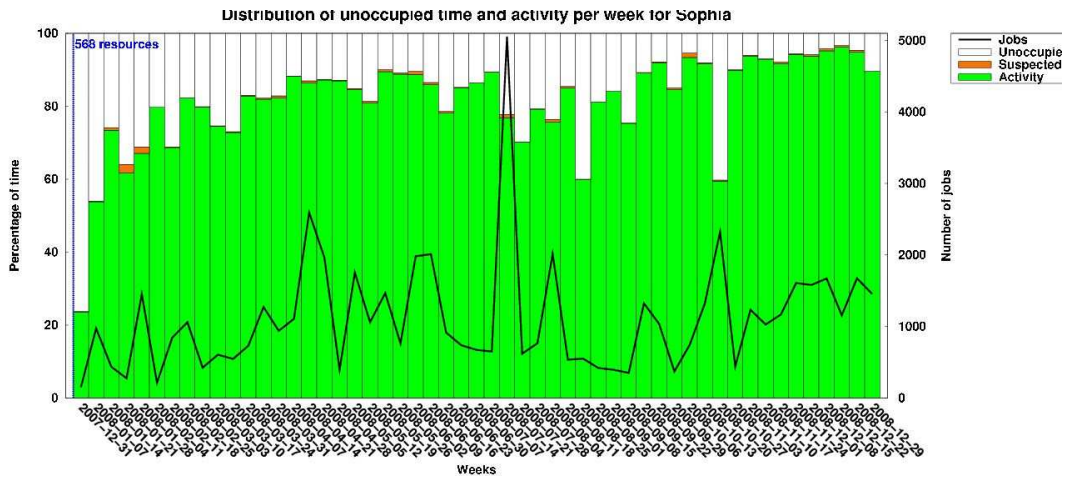


Figure 27: Global diagram without dead time for Grid'5000's Sophia site

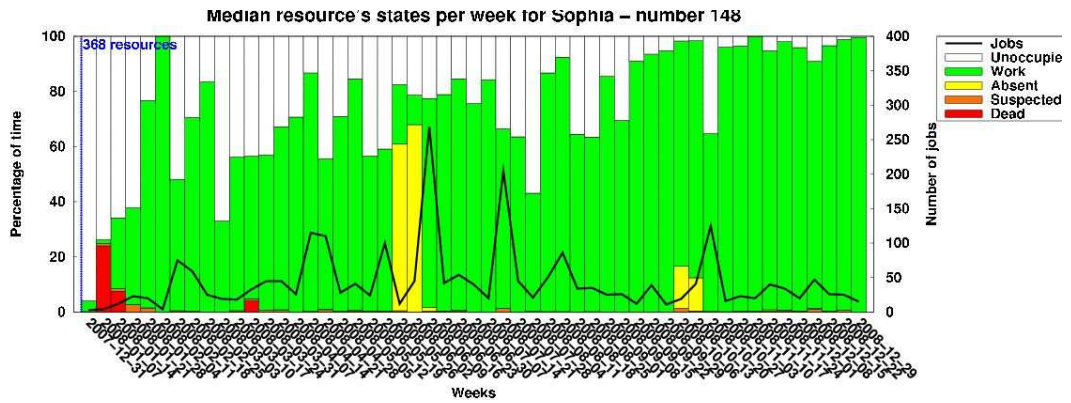


Figure 28: Median resource diagram for Grid'5000's Sophia site

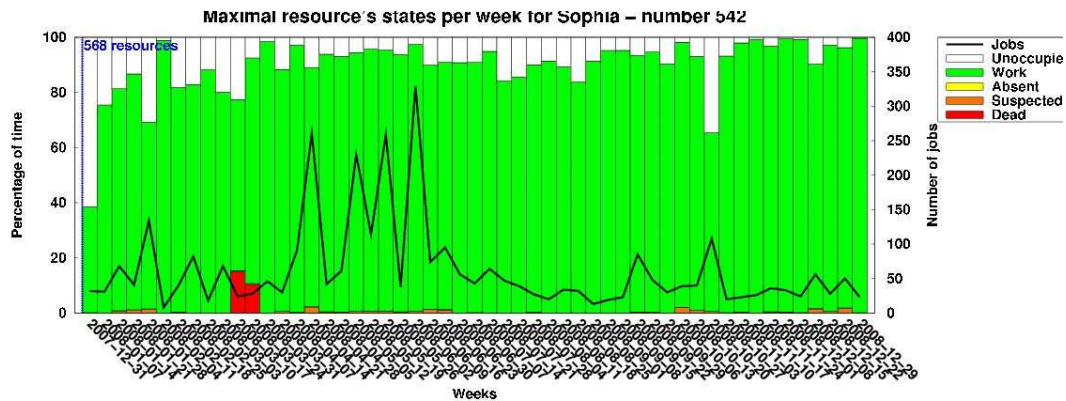



Figure 29: Maximal resource diagram for Grid'5000's Sophia site

 This site has the smallest number of jobs for the whole year compared to the other Grid'5000 sites. But, due to a high mean number of resources per reservation, it gets the highest percentage of activity (81.51%). This is illustrated on Figures 26 and 27.

3.8 Usage of Grid'5000's Toulouse site in 2008

- Platform and resources:
 - Maximal number of resources (cores): 434
 - Mean time spent in each state for all the resources, in percentage:
 - * Dead: 5.00%
 - * Suspected: 1.22%
 - * Absent: 14.86%
 - * Work: 49.42%
 - Real percentage of work time (without taking into account the time when the resources are dead or absent): 61.67%
- Jobs:
 - Number of jobs (reservations): 166191
 - Mean time of a job: 2211.80 s. (36 minutes and 52 seconds)
 - Maximal duration: 1080018 s. (12 days 12 hours and 18 seconds) for job number 94101
 - Mean number of resources (cores) per job: 6.29
 - Percentage of deploy jobs: 1.47%

- Percentage of time spent in deploy jobs compared to the work time: 28.37%
- Percentage of jobs coming from other sites: 96.15%
- Percentage of besteffort jobs: 6.86%
- Percentage of time spent in besteffort jobs compared to the work time: 24.85%
- Users:
 - Number of users: 160
 - Percentage of users coming from other sites: 81.88%

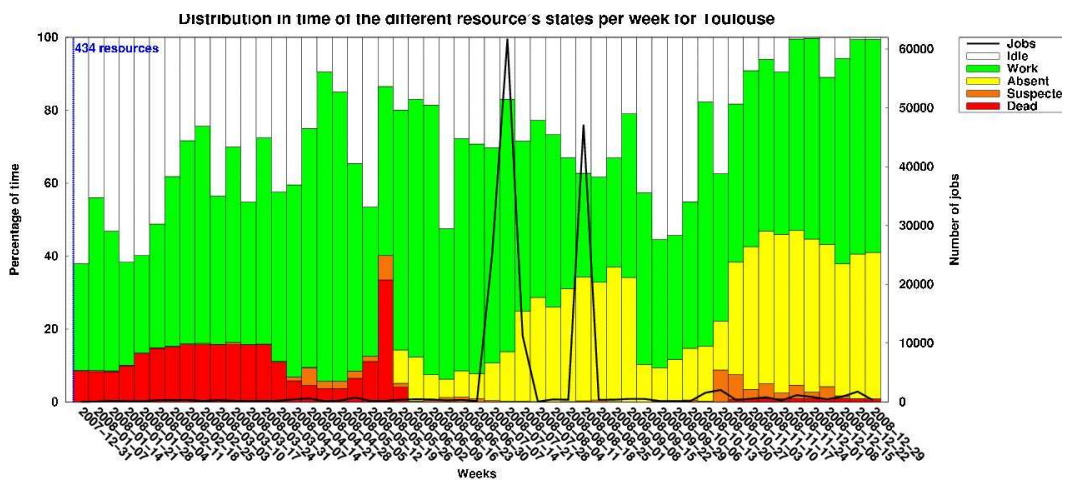


Figure 30: Global diagram with dead time for Grid'5000's Toulouse site

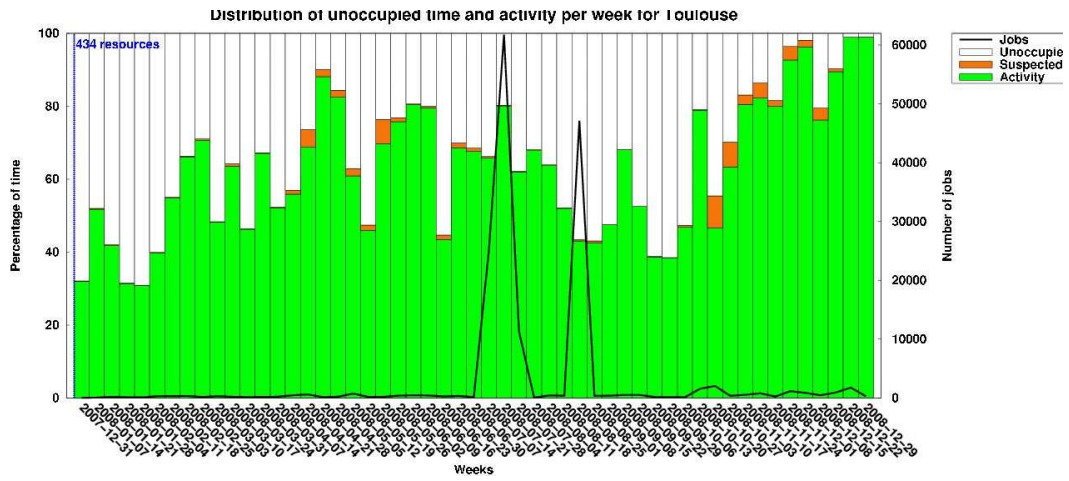


Figure 31: Global diagram without dead time for Grid'5000's Toulouse site

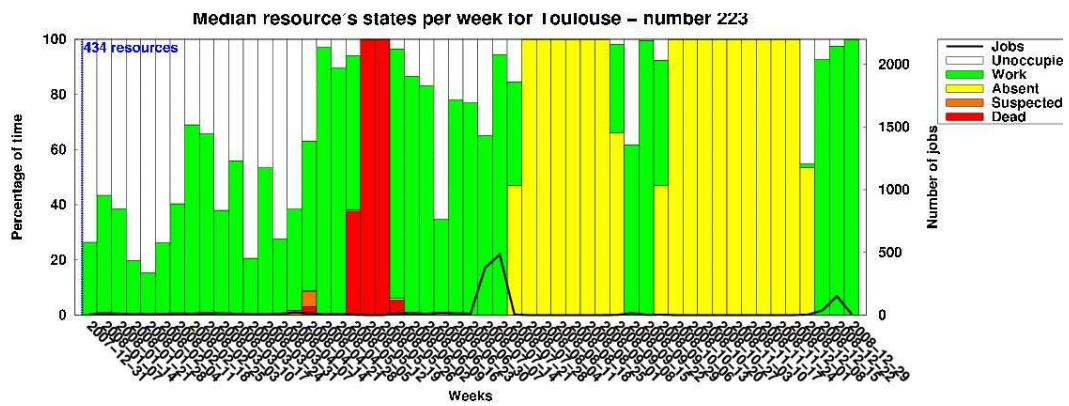


Figure 32: Median resource diagram for Grid'5000's Toulouse site

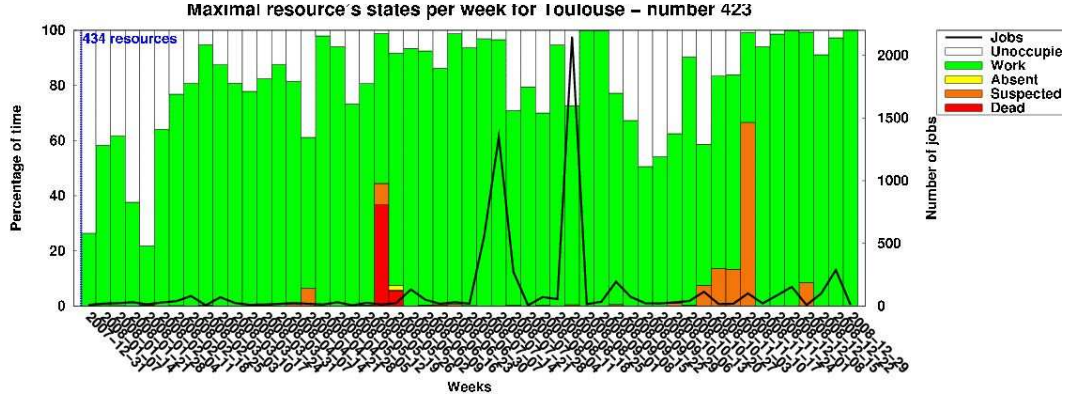


Figure 33: Maximal resource diagram for Grid'5000's Toulouse site



Toulouse has the shortest reservations with an average around 36 minutes. During the last two weeks of the year, the site is used at its full capacity (about 98% of activity). This site is one of the smallest Grid'5000 sites.

3.9 Results summary

Tables 1, 2, 3, 4, summarize the main observed statistics in terms of resources, jobs and users. These results show that the Grid5000 platform faces some heterogeneous usage depending on the involved sites.

- Platform and resources:

Site	Number of resources (cores)	Percentage of 'real' activity
Bordeaux	650	53.20%
Lille	618	72.89%
Lyon	322	69.27%
Nancy	574	60.08%
Orsay	684	57.82%
Rennes	714	64.58%
Sophia	568	81.51%
Toulouse	434	61.67%
Total Grid'5000	4564	64.67%

Table 1: Resource-related statistics

- Jobs:

Site	Number of jobs (reservations)	Mean number of resources per job	Mean duration of a job (seconds)	Jobs coming from other sites
Bordeaux	356222	7.44	2473.38	83.28%
Lille	344538	8.11	3154.58	38.97%
Lyon	138217	4.39	3723.55	87.07%
Nancy	74592	14.63	8912.82	20.11%
Orsay	92862	14.58	6246.07	96.28%
Rennes	58843	27.32	7069.33	87.41%
Sophia	58142	22.14	8767.35	87.24%
Toulouse	166191	6.29	2211.80	96.15%

Table 2: Job-related statistics

Site	Percentage of deploy jobs	Time spent in deploy jobs	Percentage of besteffort jobs	Time spent in besteffort jobs	Percentage of default jobs	Time spent in default jobs
Bordeaux	0.97%	22.33%	58.03%	34.90%	41.00%	42.77%
Lille	0.61%	7.24%	19.10%	37.88%	80.29%	54.88%
Lyon	3.88%	49.69%	44.00%	24.14%	52.12%	26.17%
Nancy	4.23%	29.95%	76.16%	17.05%	19.61%	53.00%
Orsay	3.59%	38.98%	38.91%	27.17%	57.50%	33.85%
Rennes	7.84%	35.96%	50.01%	23.38%	42.15%	40.66%
Sophia	8.76%	25.64%	54.36%	19.57%	36.88%	54.79%
Toulouse	1.47%	28.37%	6.86%	24.85%	91.67%	46.78%

Table 3: Job-related statistics

- Users:

Site	Number of users	Users from other sites
Bordeaux	223	87.00%
Lille	198	65.66%
Lyon	169	73.37%
Nancy	157	83.44%
Orsay	172	76.16%
Rennes	213	82.63%
Sophia	187	85.03%
Toulouse	160	81.88%

Table 4: User-related statistics

4 Conclusions

We have observed an activity increase for all the Grid'5000 sites compared to 2007 year [OL09]. The global activity of the platform has grown from 40% to 65%. 2007 was still a development year for Grid'5000, whereas in 2008, the platform is fully working and it reaches its cruising speed.

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Unité de recherche INRIA Rhône-Alpes
655, avenue de l'Europe - 38334 Montbonnot Saint-Ismier (France)

Unité de recherche INRIA Futurs : Parc Club Orsay Université - ZAC des Vignes
4, rue Jacques Monod - 91893 ORSAY Cedex (France)

Unité de recherche INRIA Lorraine : LORIA, Technopôle de Nancy-Brabois - Campus scientifique
615, rue du Jardin Botanique - BP 101 - 54602 Villers-lès-Nancy Cedex (France)

Unité de recherche INRIA Rennes : IRISA, Campus universitaire de Beaulieu - 35042 Rennes Cedex (France)

Unité de recherche INRIA Rocquencourt : Domaine de Voluceau - Rocquencourt - BP 105 - 78153 Le Chesnay Cedex (France)

Unité de recherche INRIA Sophia Antipolis : 2004, route des Lucioles - BP 93 - 06902 Sophia Antipolis Cedex (France)

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