

## THEOCLUSTER ZEFIRO



Characteristics - Functionality - Tools

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**INFN Pisa** computational environment counts a total number of ~9000 core grouped in 15 farms and 3 clusters, 1.7 PB of disk space and a total WAN bandwidth of 2x10GE. GPUs and Intel Xeon Phi coprocessors are also available.

More than 4000 cores are dedicated to **Grid Computing**: all INFN VO are supported, with CMS and THEOPHYS as stockholders. The center is a WLCG-T2 for the CMS Experiment.

More than 2000 cores are part of the newest **HPC** cluster(**Zefiro**)  
Other ~2000 are part of other HPC cluster connected via Infiniband DDR 20Gb/s and used for collaboration with the Engineering Department of Pisa University and external industrial collaborations for CFD.



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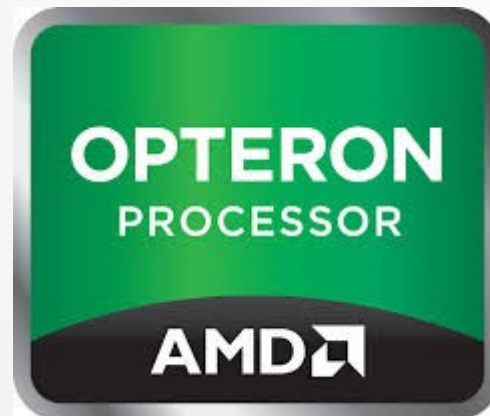
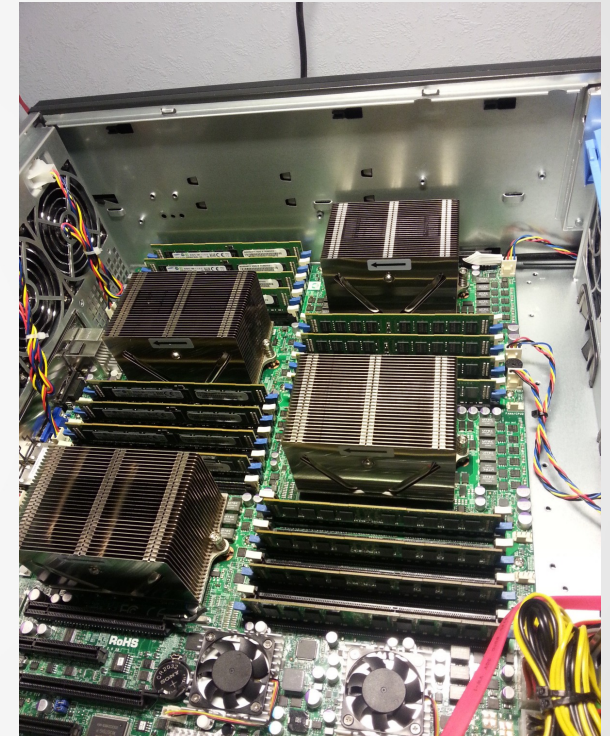


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The theocluster “**Zefiro**” for local calculations consists of **32 compute nodes** each with 512 GB of RAM and **4 processors (each with 16 cores grouped into 2 jobslot)** so it has a total of **2048 computing cores(64 jobslot)** AMD Opteron 6380 (2.5GHz)



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The compute nodes are connected by **Infiniband QDR connections** operated with **Mellanox IS5100 switch** with 108 ports. The accesses are regulated by the **IBM LSF scheduler IBM v. 9.**

Specific user interfaces has ben created to use Zefiro(**localui3**)



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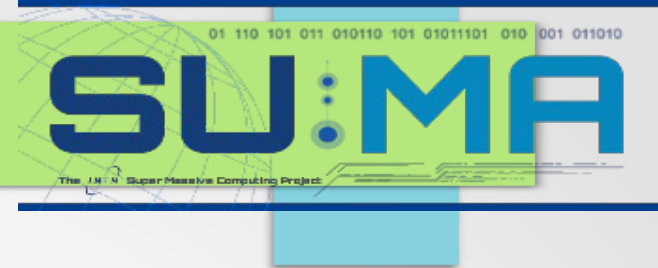
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There is also a dedicated machine for the **compilation of job** with a specified queue not belonging to the architecture of the 32 machines of Zefiro; this compute node is equipped with 2 processors each with 16 cores for a total of 32 cores and 256 GB of RAM; the cores have not been grouped together in a bunch so 1 core is considered a jobslot



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The Theocluster Zefiro offers:

**Debug** of the job

**Compilation** of job.

**Submission** of job



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## **DEBUG (2 different queues)**

The first queue is called **debug** and addressed on a dedicated node that is not part of Zefiro. This dedicated node have 2 processors each with 16 cores for a total of 32 cores and 256 GB of RAM , the cores of this machine are grouped into 1 bunch core then considered a jobslot. So 32 JOBSLOTS are available.

The second queue is called **longDebug** and work on cluster Zefiro where the cores are grouped into bunch of 32 cores that correspond to physical cores of two of the 4 processors of a machine. Each bunch of 32 core is considered a jobslot. So each node have 2 JOBSLOTS.

## **DEBUG (2 different queues) – characteristics**

**debug:** (openmpi-1.6 / 2 allowed jobs max number / 30 min WallTime max / 4(4core) available jobslot max number / switch -ls option for interactive uses):

*The option to use the interactive mode allows to open a shell on the compute node used by the queue directly in the home user; It is possible to find all the files on the home user .*

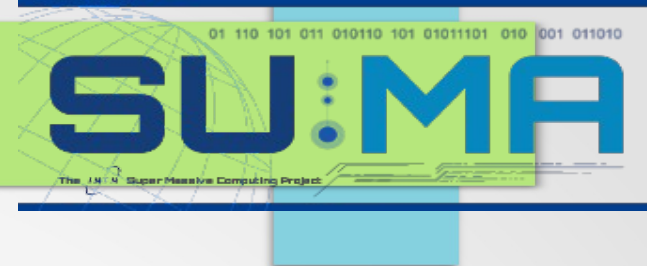
**longDebug:** (openmpi-1.6 / 2 allowed jobs max number / 30min WallTime max / 2(64core) available jobslot max number / No Reservation / YES Backfill):

*If user do not enter the name of one of the groups or Specific initiatives, the system will assign the resources considering the number of hours of the specific initiative with the highest priority. If user belongs to a single group, and this is not inserted through the appropriate submission option, resources will not be assegned.*



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## COMPILATION (1 queue)

The job's compilation will be done via a specific queue called **compilation** and addressed on a dedicated node that is not part of Zefiro. This node have 2 processors each with 16 cores for a total of 32 cores and 256 Gb of ram, the cores of this machine are grouped into 1 bunch core then considered a jobslot. So a total of 32 JOBSLOTS are available.



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## COMPILATIONS (1 queue) – characteristics

**compilation:** (openmpi-1.6 / 1 allowed jobs max number / 360min (6h) WallTime max / 1(1core) available jobslot max number / switch -ls option for interactive uses)

*The option to use the interactive mode allows to open a shell on the compute node used by the queue directly in the home user; It is possible to find all the files on the home user .*

*If user do not enter the name of one of the groups or Specific initiatives, the system will assign the resources considering the number of hours of the specific initiative with the highest priority. If user belongs to a single group, and this is not inserted through the appropriate submission option, resources will not be assegned.*

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## SUBMISSION (3 different queues)

The submission of a job will be done by three specific queues called **parallel**, **longparallel** and **neparallel** and directed on Zefiro cluster where the cores are grouped in 32 cores bunchs that correspond to physical cores of two of the four processors a machine. Each bunch of 32core is considered a jobslot. So each node have 2 JOBSLOTS.



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## SUBMISSION (3 different queues) – characteristics

**parallel:** (Openmpi-1.6 / no limit allowed jobs / 8(256core) available jobslot max number / 480min (8h) WallTime max / NO Reservation / YES Backfill/switch -Is option for interactive uses)

*The option to use the interactive mode allows to open a shell on the compute node used by the queue directly in the home user; It is possible to find all the files on the home user .*

**longparallel:** (Openmpi-1.6 / no limit allowed jobs / 16(512core) available jobslot max number / 1440min (24h) WallTime max / 24h Max Reservation time)

**neparallel:** (Openmpi-1.6 / the queue permit a job limit, in relation to how many jobslot each of these request for the total jobslot is at most equal to 4 (128 cores) / 1,440 minutes (24 hours) of walltime that can be extended up to one week / 24h Max Reservation time)



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## **SUBMISSION (3 different queues) – characteristics**

Only for **neparallel**, if user wants to extend the walltime (default 24h), up to a maximum of 1 week(10080 minutes), is necessary add the parameter `-W 10080(max)` to `bsub` command

*If user do not enter the name of one of the groups or Specific initiatives, the system will assign the resources considering the number of hours of the specific initiative with the highest priority. If user belongs to a single group, and this is not inserted through the appropriate submission option, resources will not be assegned.*



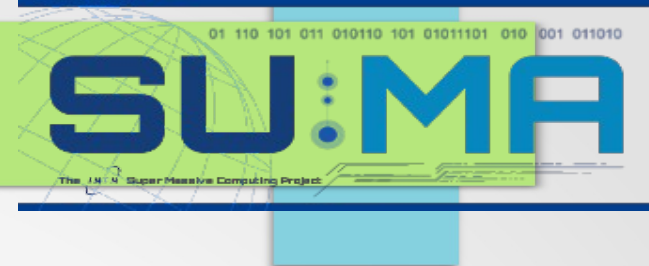
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## Available Libraries and Software

The available libraries are:

*hdf5, hdf5-openmpi, glpk, fftw, libgomp, blas, gsl, gmp, numactl, lapack, hdf5-devel, hdf5-openmpi-devel, glpk-devel, fftw-devel, blas-devel, gsl-devel, gmp-devel, numactl-devel, lapack-devel.*

Some of the most common software-compiler are:

*mpicc, cmake, gromacs.*

The compilers are not present on the User Interface, but only on the hosts so to build, user must submit through the appropriate queues (see 'DEBUG OF JOBS' and 'COMPILATION').



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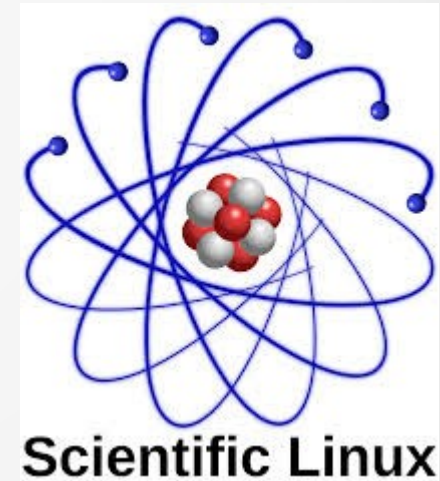
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All the computing nodes have installed **SUSE** Linux Enterprise Server (SLES), for the basic operation ; and **Scientific Linux v.6** (SL6) inside specific chroot directory for theoretical physics software.



chroot



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The entire infrastructure used for data storage is based on AFS and GPFS filesystems.

## **AFS**

Used for the software distribution on different systems.

## **GPFS**

Used for managing disk space for all users, only one filesystem about 1.5PB is available. The disk space is organized in a filesets that correspond to various groups and/or types of use, each fileset have assigned specific quota. The home user's area has total of 22TB.

We are working to reconfigure the HPC storage area using GPFS filesystem for the scratch area and AFS filesystem for the home user with implementations of automatic cleaning systems considering the user's quota assigned.

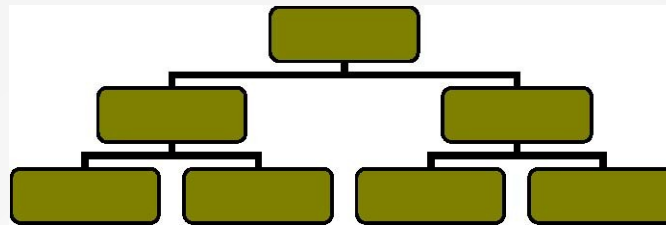


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Filesets:.

- /gpfs/ddn/teorici

It is the disk space that is now available to the entire community,

- /gpfs/ddn/thnuc

It is the disk space available to theoretical nuclear and contains a folder for each section

- /gpfs/ddn/srm/theophys

disk space served via SRM (alias GRID); currently 51% of 3.8TB of space is occupied.

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The cluster is available only for national users so we have chosen an access mechanism that uses systems of authentication and authorization based on a national DB.

INFN has a system of **IAM (Identity and Access Management)** through which it provides services of Authentication and Authorization to the community of employees and associates.

The system is based on **LDAP DataBase** organized with national and local branches. The system offers access via web for many services including those of the Information Systems INFN and it is maintained and updated regularly.



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The implementation we have done in Pisa provides access to a national branch through which the information of all employees and associates who are registered in the DB INFN as researchers of group IV, are updated every day. In particular information for username and password are transferred, and then made available on the user interface to access the theocluster Zefiro (localui3). For each user the information about the Specific Initiative to which they belong is transferred too.

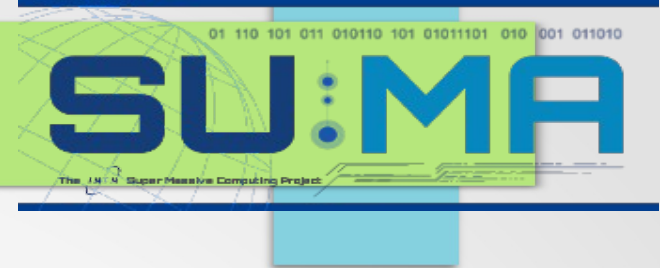


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Each afferent to the group IV have the ability to access the cluster , but only those belonging to the Initiatives specifications can submit jobs.

The technical realizations that we have done is very flexible because it also allows you to integrate national users with other users who need to access the cluster. (i.e SISSA).



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Other HPC available resources are:

-2 compute nodes each with 4x nvidia K20 GPU and Infiniband QDR 40Gb/s interconnections used for lattice QCD by INFN group in Pisa and INFN group in Ferrara.

-1 compute node with 2x nvidia K40 GPU used for CFD by engineering department in Pisa

We are working to install a single compute node with 4 Intel Xeon Phi Coprocessor in the next days.



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## First access

For new users, to create the home directory under GPFS file system, must necessarily make a ssh access to the “setupUI” host using AAI credentials:

***ssh username@setupui.pi.infn.it***

The setup procedure requires a username and password and no other.

## CHusage

Typing 'CHusage' on the default path on localui3, users can have the list of core hours used by individual specific initiatives. All the work is done by the script that monitors and manages the fair share of LSF scheduler. We are working to implement the specif script to show the detailed user core hours utilizations.



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Group	CH used	CH assigned	Group	CH requested
sisssa	1,038,391	456,667	sisssa	we are waiting
thdevel	3,212	0	thdevel	
flag	0	0	flag	
ftecp	235,117	300,000	ftecp	300,000
npqcd	4,129,063	2,200,000	npqcd	3,000,000
qcldat	2,581,159	1,500,000	qcldat	4,500,000
aae	158,692	0	aae	
lqcd123	1,186	300,000	lqcd123	150,000
qftatcolliders	138,314	149,333	qftatcolliders	300,000
qnp	50	0	qnp	
wsip	6	0	wsip	
manybody	322,848	270,000	manybody	750,000
ninpha	876,175	1,000,000	ninpha	1,000,000
strength	15,115	0	strength	150,000
dynsysmath	4,652	50,000	dynsysmath	50,000
indark	416,957	824,000	indark	1,000,000
tasp	135,678	230,000	tasp	1,200,000
teongrav	220,499	690,000	teongrav	500,000
biophys	344,985	300,000	biophys	500,000
fieldturb	468,002	300,000	fieldturb	1,500,000
			pieces	130,000
<b>TOTALS</b>	<b>11,090,101</b>	<b>12,253,074</b>	<b>TOTALS</b>	<b>15,030,000</b>
	<b>90.50%</b>	<b>of available cluster CH</b>		

**UPDATE 12-31-2015**

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Monitoring and management systems has been developed, it's called **"Clusteralive"**.

is an integrated system developed in order to monitor and manage few important tasks in HPC environment.

Users can know immediately, just seeing the screen, if Clusters are up and running and to know that the most important functionalities are well instanced.

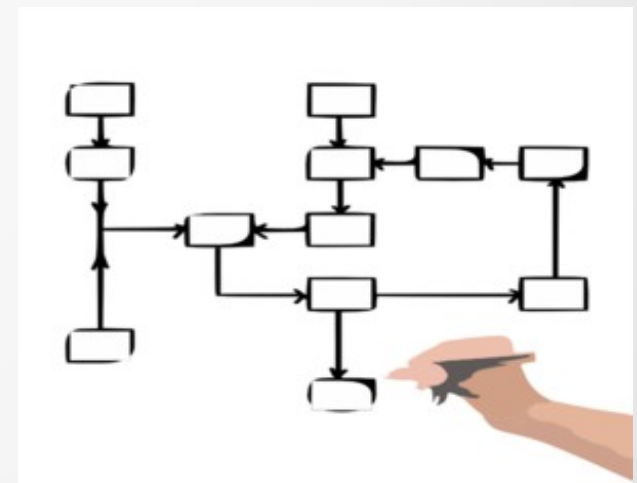
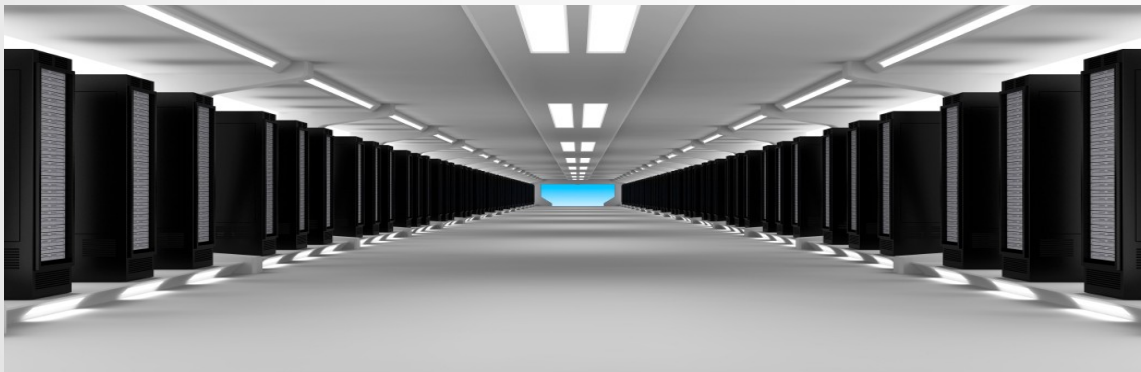


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Clusterwide monitoring and management system is also able to perform tasks of automatic management about services, parameters and basic activities related in particular to computing nodes of the HPC clusters but also of the entire computing infrastructure.



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[http://farmsmon.pi.infn.it/clusteralive/monitoring\\_Zefiro.php](http://farmsmon.pi.infn.it/clusteralive/monitoring_Zefiro.php)

For each computing node few informations are displayed (**used / free / closed for maintenance**), **users that have assigned resources on it (used or reserved)**, information about the **communication between the nodes (ping) via Ethernet and via Infiniband with RDMA tests**, the percentage of used disk space, the used or reserved resources, the **CPU load**, the locked processes called **zombie** (due to a termination or to a bug in the application), **daemons for user's authentication (nscd / nslcd)**, **communication daemons (sshd) and node status daemons (gmond / hsflowd)**.



- A nscd dentro chroot
- B nscd fuori chroot
- C nslcd
- D sshd dentro chroot
- E sshd fuori chroot
- F hsflowd

Master Node Disk Space %: 68%

Infiniband SM status: gio 15 gen 2015, 13.29.41, CET OpenSM is running... pid=3847

Eventuali nodi con indicazione dei JS occupati che non presentano l'etichetta dell'utente, sono nodi che sono stati riservati come da specifica indicazione 'RSV JS'.

<b>o2wn1 USED</b> Auth ok USER bonati Ping to 31/ 31 Fail: IB Status 4x 10.0 Gbps Active/ LinkUp NW Advanced Info IB PingPong to 32/ 32 Fail: IB RDMA test to 32/ 32 Fail: Performance Info Used DS% 12% USED JS: 1 RSV JS: 1 CPU: 50% Working... ■	<b>o2wn2 USED</b> Auth ok USER mossa Ping to 31/ 31 Fail: IB Status 4x 10.0 Gbps Active/ LinkUp NW Advanced Info IB PingPong to 32/ 32 Fail: IB RDMA test to 32/ 32 Fail: Performance Info Used DS% 3% USED JS: 2 RSV JS: 0 CPU: 100% Working... ■	<b>o2wn3 USED</b> Auth ok USER direnzo Ping to 31/ 31 Fail: IB Status 4x 10.0 Gbps Active/ LinkUp NW Advanced Info IB PingPong to 32/ 32 Fail: IB RDMA test to 32/ 32 Fail: Performance Info Used DS% 3% USED JS: 2 RSV JS: 0 CPU: 100% Working... ■	<b>o2wn4 USED</b> Auth ok USER minicoz Ping to 31/ 31 Fail: IB Status 4x 10.0 Gbps Active/ LinkUp NW Advanced Info IB PingPong to 32/ 32 Fail: IB RDMA test to 32/ 32 Fail: Performance Info Used DS% 3% USED JS: 2 RSV JS: 0 CPU: 100% Working... ■
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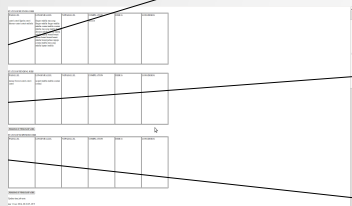
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For the entire cluster the status of jobs on the specific queues are shown (running/pending and suspended jobs and the reasons for the specific status).

STATUS OF PENDING JOBS				STATUS OF RUNNING JOBS			
PARALLEL	LONGPARALLEL	NEPARALLEL	C	PARALLEL	LONGPARALLEL	NEPARALLEL	C
cuteri cuteri cuteri cuteri cuteri cuteri	stellat			cuteri cuteri cuteri cuteri cuteri cuteri cuteri cuteri direnzo cuteri cuteri	bonati mdelia mdelia mdelia mdelia mdelia mdelia mdelia mdelia meccang bonati bonati bonati bonati bonati direnzo direnzo grasso bonati minicoz minicoz minicoz minicoz mossa mossa		



The monitoring system also shows the physically turned off and turned on computing nodes and the nodes with the file system unmounted

REASONS OF PEND/SUSP JOBS			
STATUS OF SUSPENDED JOBS			
PARALLEL	LONGPARALLEL	NEPARALLEL	C



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Automatic closing system for all compute nodes in case of malfunction of the filesystem,

Automatic restart of stopped and blocked services like:

- services necessary for communication between computing nodes
- services necessary for user identification.

has been implemented together



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An example of additional feature is going to be implemented and will permit the automatic cleaning of processes (zombie) after an unexpected termination or at the end of specific job.



The natural evolution of " Clusteralive ", will be the integration with the features included in the various gpfs updates , and functionality for network traffic analysis and optimizations.

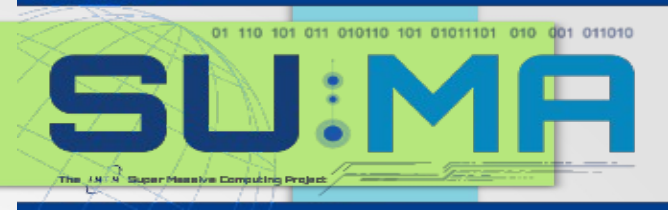


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“Clusteralive” is always evolving, updates on computing infrastructure and modern technology are a wide field of study for future functionality. It isn't a universal tools but was developed for our specific architecture(i.e 2 jobslot for each HPC compute nodes); is the result of an integration of many elements and not an acquisition and it can be useful for other computing centers which should try it.



Some solutions that are being planned for the future, concern the use of commercial cluster management solutions instead “Clusteralive” . The use of commercial software such as **Bright**, allow simplified compute node installations simplified to have more efficiency.



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Problems instead linked to the state of the file system shared with the grid environment , also present at the section of Pisa were managed by implementing a **preexecution script** that monitors the state of the file system on the compute nodes selected by the scheduler .

We are working to configure one AFS server, linked to the national cell, to transfer all of the home users of the theocluster Zefiro and gradually everything related to the HPC world.



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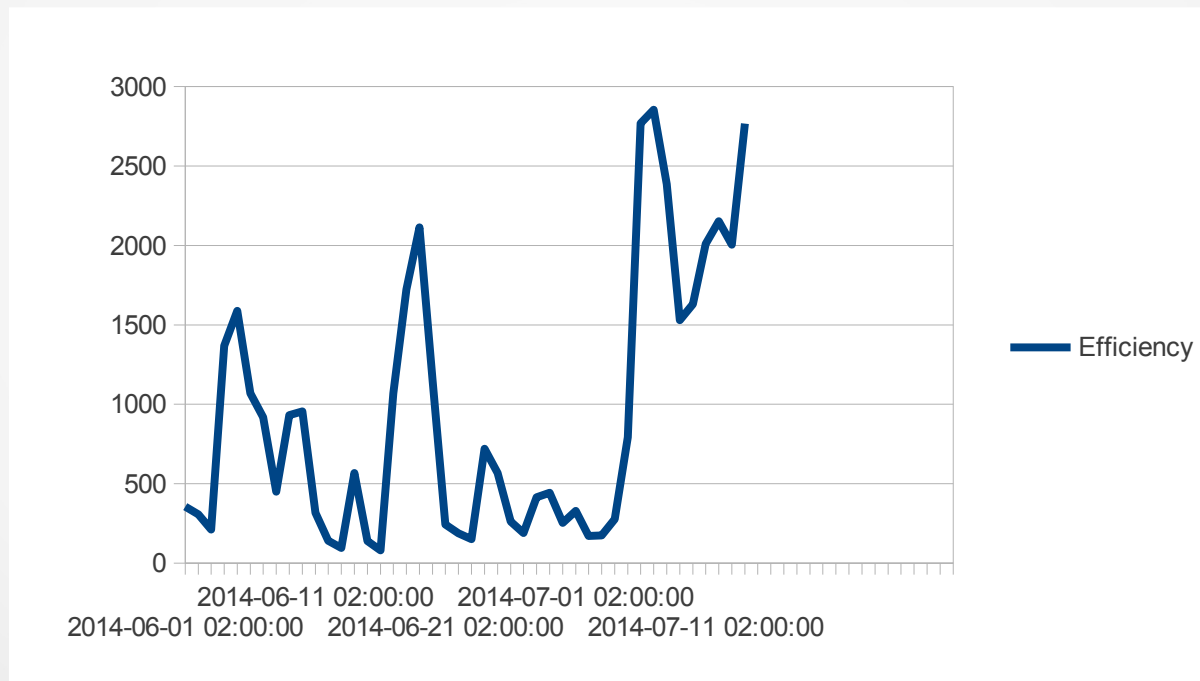


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He have had a large improvement of efficiency from July 2014 when we have started with the modifications shown in the previous slides of this presentation.



IBM RTM -  
Informations



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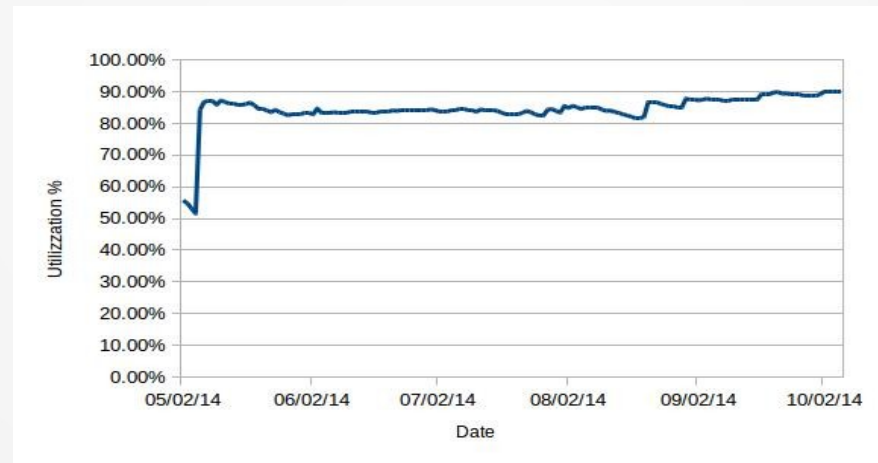


# SUMA Workshop 2015

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The improvement of performances of theocluster Zefiro in terms of core hours shows that the percentage of use amounts currently to a little more than 90 % to be compared with about 83 % before the entire control system of the system has done.



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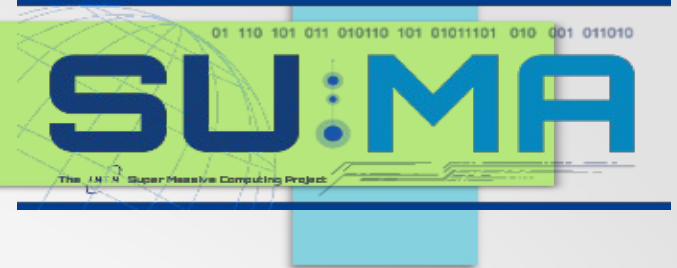


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Other field of interest for the Scientific Computing Center, are the collaborations with the Department of Engineering of Pisa and other engineering groups for CFD (fluent, starccm+,...) and other industrial applications.

Theocluster Zefiro, like other clusters used by industrial collaborations, has shown high performance and high efficiency; the interest for them is increasing every days.

We are working to prepare a report that contains all informations received on the scientific activities and publications of the last year.

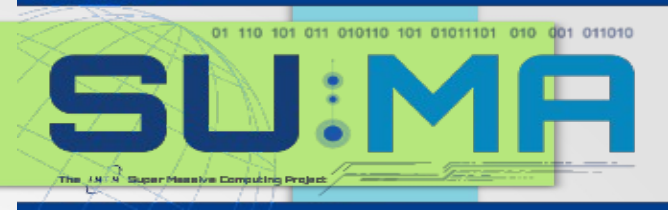


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## FUTURE???

There's too many characteristics to optimize (storage, network traffic, scheduler rules) to improve the efficiency of the clusters (Zefiro and other).

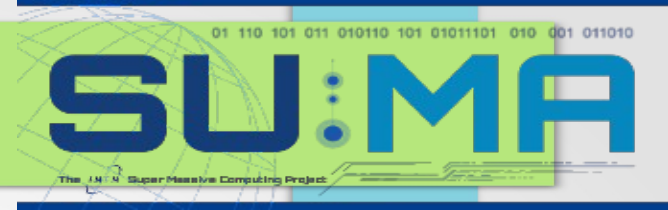
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THANK YOU FOR YOUR  
ATTENTION



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