The GRID and the Linux Farm at the RCF

A. Chan, R. Hogue, C. Hollowell, O. Rind, J. Smith, T. Throwe, T. Wlodek, D. Yu
Brookhaven National Laboratory, NY 11973, USA

The emergence of the GRID architecture and related tools will have a large impact in the operation and design of present and future large clusters. We present here the ongoing efforts to equip the Linux Farm at the RHIC Computing Facility with Grid-like capabilities.

I. BACKGROUND

The RHIC Computing Facility (RCF) is a large scale data processing facility at Brookhaven National Laboratory (BNL) for the Relativistic Heavy Ion Collider (RHIC), a collider dedicated to high-energy nuclear physics experiments.

RHIC's first physics collisions occurred in the Summer of 2000, when all four experiments began recording data from the collisions. Year 3 of RHIC operations is currently underway.

The RCF provides for the computational needs of the five RHIC experiments (BRAHMS, PHENIX, PHOBOS, PP2PP and STAR), including batch, mail, printing and data storage. In addition, BNL is the U.S. Tier 1 Center for ATLAS computing, and the RCF also provides for the computational needs of the U.S. collaborators in ATLAS.

The Linux Farm at the RCF provides the majority of the CPU power in the RCF. It is currently listed as the 3^{rd} largest cluster, according to "Clusters Top500" (http://clusters.top500.org). Figure 1 shows the rapid growth of the Linux Farm in the last few years.

All aspects of its development (hardware and software), operations and maintenance are overseen by the Linux Farm group, currently a staff of 5 FTE within the RCF.

II. HARDWARE

The Linux Farm is built with commercially available thin rack-mounted, Intel-based servers (1-U and 2-U form factors). Currently, there are 1097 dual-CPU production servers with approximately 917,728 SpecInt2000. Table 1 summarizes the hardware currently in service in the Linux Farm. Hardware reliability has not been an issue at the RCF. The average failure rate is 0.0052 $failures/(machine \cdot month)$, which translates to 5.7 hardware failures per month at its present size. Hardware failures are dominated by disk and power supply failures. A detailed breakdown of the hardware failures by category is shown in Figure 2.

TABLE I: Linux Farm hardware

Brand	CPU	RAM	Storage	Quantity
VA Linux	450 MHz	0.5-1 GB	9-120 GB	154
VA Linux	700 MHz	0.5 GB	9-36 GB	48
VA Linux	800 MHz	0.5-1 GB	18-480 GB	168
IBM	1.0 GHz	0.5-1 GB	18-144 GB	315
IBM	1.4 GHz	1 GB	36-144 GB	160
IBM	2.4 GHz	1 GB	240 GB	252

III. SOFTWARE

The Linux Farm at the RCF uses a custom image of RedHat 7.2, modified to conform to the requirements of the RHIC experiments and to the security protocols of BNL. The customized image is installed via KickStart [1], the RedHat Linux automated installation tool.

The Linux Farm servers are equipped with a variety of compilers (gcc, PGI, Intel) and debuggers (gdb, Totalview, Intel) to provide a large degree of flexibility to its end users. In addition, the servers also support network file systems (AFS, NFS) and batch services, LSF and a RCF-designed software compatible with our MDS system. Figure 3 shows the GUI for the RCF-designed batch software.

Monitoring and control of the cluster hardware, software and infrastructure (power and cooling) is provided via a mix of open-source software, RCF-designed software and vendor-provided software. Figures 4 and 5 display some of our cluster monitoring tools, while figure 6 shows the historical temperature data of the cluster equipment, one of the tools we use to monitor the infrastructure supporting the Linux Farm.

IV. SECURITY

Because of general cyber-security standards at BNL and as part of the general security policy of the RCF, several measures were taken to insure that only authorized users can access the Linux Farm.

A firewall has been placed around the RCF (including the Linux Farm) to minimize security breaches. In addition, users are only allowed interactive access

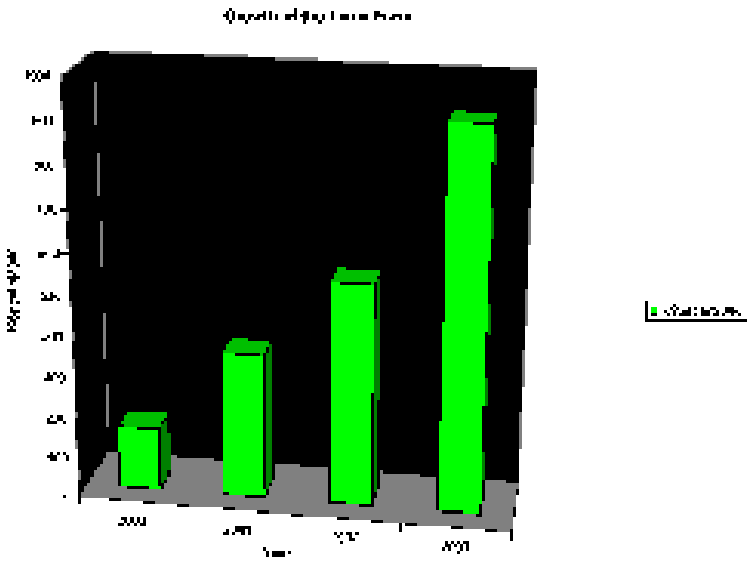

FIG. 1: The growth of the Linux Farm at the RCF.

to the Linux Farm via dedicated gatekeeper systems whose software is kept up-to-date to minimize the exploitation of security weaknesses in the software. No other method is provided for interactive access to the Linux Farm. The operating system in the Linux Farm servers has been modified to accomodate these security measures and to enhance our ability to detect unauthorized access.

The RCF has also begun the deployment of a Kerberos 5 single sign-on system that will eventually replace our current authentication system.

V. GRID-LIKE CAPABILITIES

GRID-like technology has evolved from conceptual designs to promising prototypes with real capabilities in the last few years. It is a natural fit to increasingly powerful Linux clusters coupled with geographically diverse end-users and increasingly large data samples typical of large scale high energy & nuclear physics experiments. GRID-like technology is also making significant inroads into industrial applications and has attracted the interest and support of well-known software manufacturers, such as Platform Computing [2].

The Linux Farm has begun to investigate, install and support (where appropriate) prototypes of GRID-like software that possess capabilities that are of interest to our users, such as Ganglia, Condor and GLOBUS.

A. GANGLIA

Ganglia [3] is a full-feature, open source distributed monitoring software for high-performance computer clusters. It is based on a hierarchical design targeted at federation of clusters, and it supports clusters up to 2000 servers in size. Early prototypes are already equipped with a end-user Web interface, historical data information and clustering of remote systems. The monitoring data collected by ganglia can be used as the basis of a batch system job scheduler mechanism, although this has not yet been tested.

The Linux Farm has deployed a ganglia prototype for the STAR experiment. In the prototype, the ganglia collector has been configured to gather information from each of the nodes where a ganglia client daemon is running. This master collector then makes this information available to qualified external collectors. Figure 9 illustrates the ganglia deployment within the RCF.

Security issues with this ganglia prototype are being investigated. Of particular concern, currently there

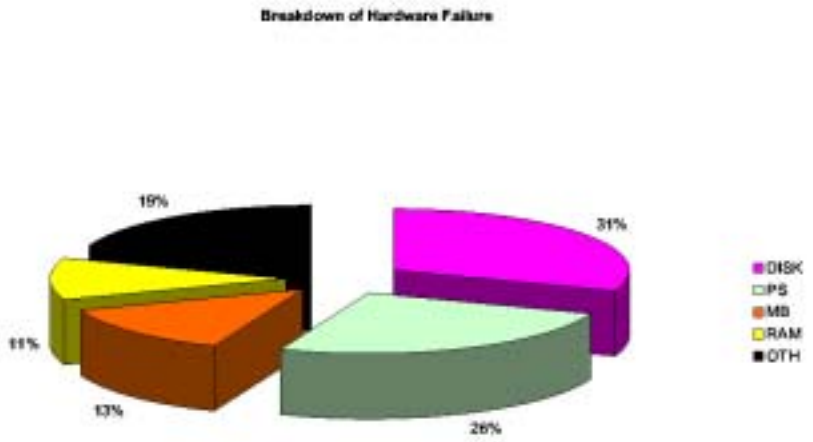

FIG. 2: Breakdown of hardware failure by category.

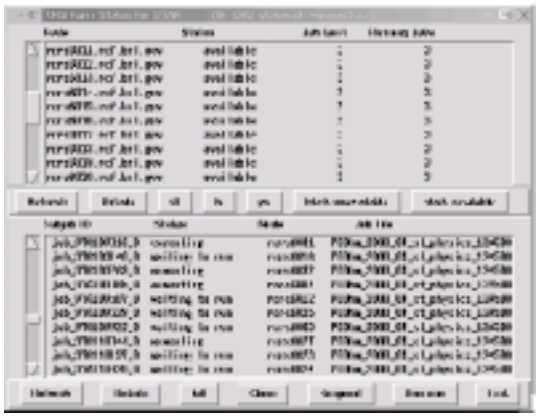

FIG. 3: GUI for RCF-designed batch software.

FIG. 4: Alert status of Linux Farm nodes.

is no user-friendly method to restrict the type and amount of information transmitted to external collectors. Wrap-around scripts written by RCF staff were used to restrict the information (see figures 7 and 8). In addition, as more servers are added to the ganglia master collector, scalability issues will become a major concern as well. The Linux Farm group plans to continue to test and expand the scope of the ganglia prototype where appropriate.

B. CONDOR

Condor is a open-source batch software created and supported by the University of Wisconsin [4]. Condor is a full-feature batch software that include features such as job queuing mechanism, configurable scheduling policy, priority scheme, checkpoint capability and

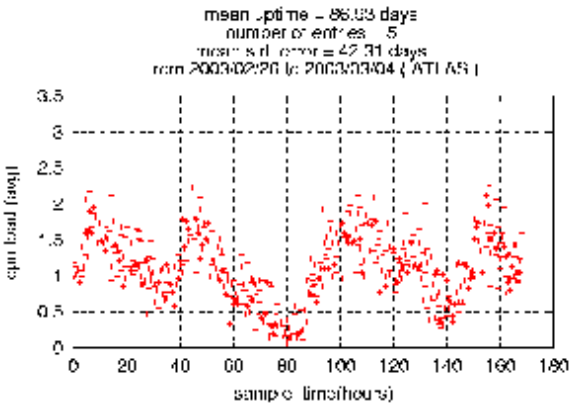

FIG. 5: Historical load information on the ATLAS cluster.

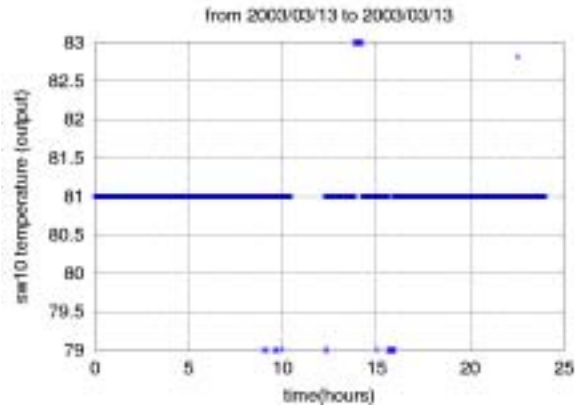

FIG. 6: Historical temperature data in the vicinity of the Linux Farm equipment.

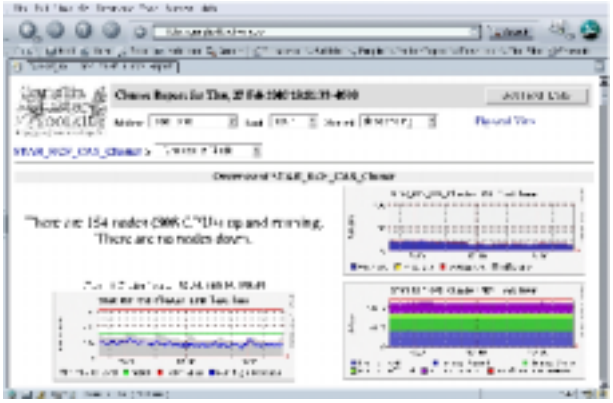

FIG. 7: Summary view of the ganglia prototype for STAR.

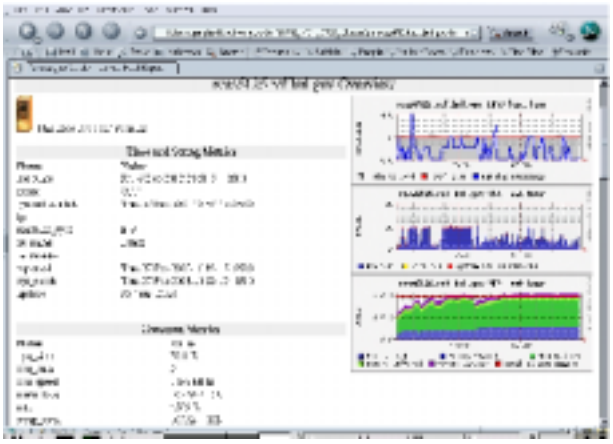

FIG. 8: Detailed view of a STAR node with ganglia.

resource monitoring & management. Condor can be used to connect remote clusters at geographically diverse locations, so it is a natural fit to the GRID computational philosophy. Condor has an interface to the GRID via Condor-G.

The Linux Farm group is in the midst of upgrading its MDS-compatible batch system to improve reliability & scalability and add functionality. As part of the upgrade, Condor is being evaluated as a job scheduler for the new MDS-compatible batch system. Since media-based MDS systems is expected to play a considerable role at the RCF for the foreseable future, an effort is being made to integrate Condor with the MDS-interface API software. The current batch system does not have an interface to GRID-like architectures, and Condor can add this missing functionality via Condor-G. The basic design of the new batch system is shown in figure 10.

Once the prototype of the upgraded MDS-compatible batch system is installed, Condor scalability studies will be done to understand how performance is affected under the expected heavy usage.

C. GLOBUS & LSF

The ability of users to submit jobs to remote clusters has been one of the principal motivations for the Linux Farm group to explore interfacing our batch system with GRID-like software.

The Linux Farm has a prototype GLOBUS [5] gatekeeper server that interfaces with LSF for the ATLAS experiment. Authorized users at remote sites can submit jobs to the gatekeeper. The gatekeeper interprets the GLOBUS commands and submits jobs to the proper LSF queues running on the ATLAS Linux cluster at the RCF. A diagram of the prototype is shown in figure 11. Figure 12 shows actual LSF jobs submitted by remote users via the GLOBUS gatekeeper.

Currently, the system is being expanded to include both PHENIX and STAR experiments in RHIC, and additional GLOBUS gatekeepers are being brought on-line.

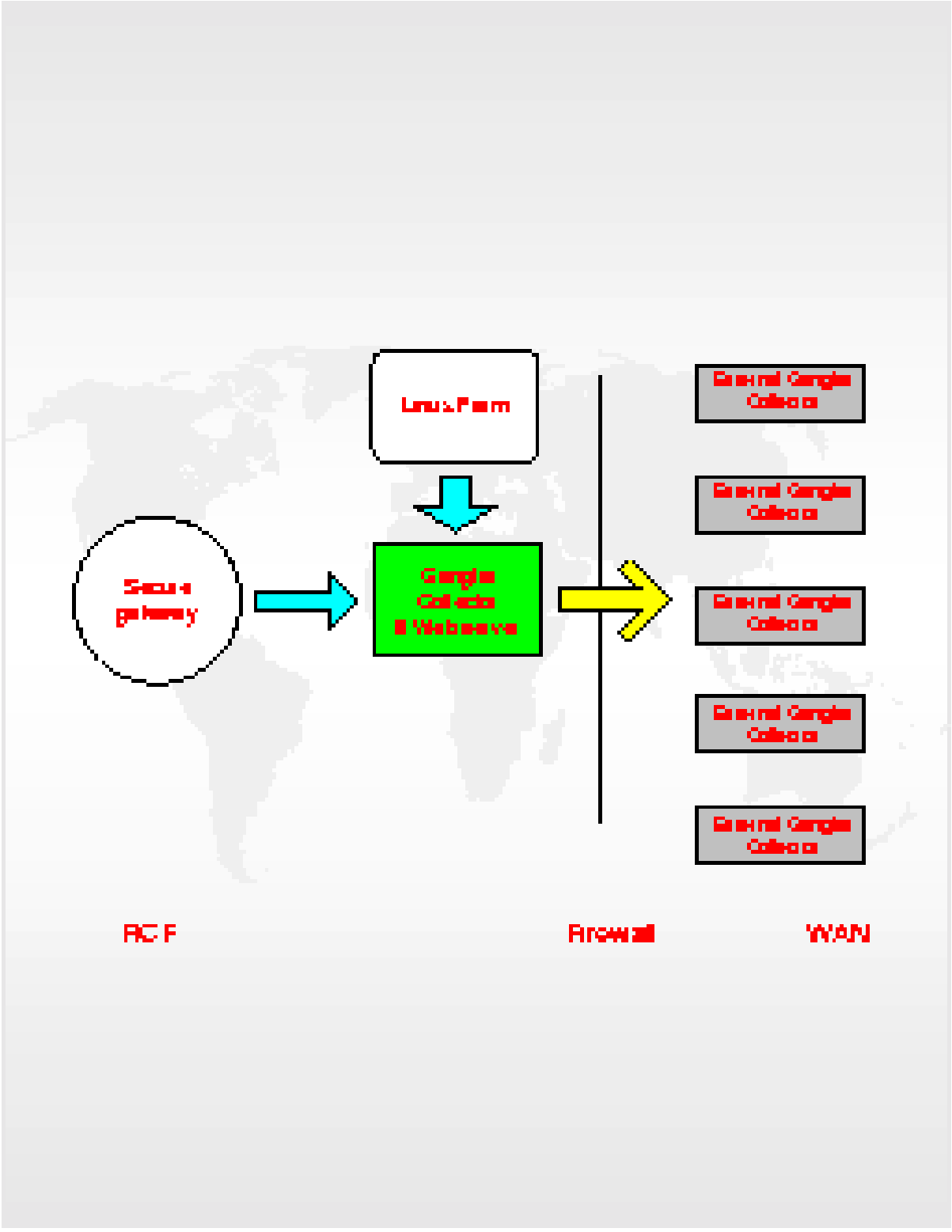

FIG. 9: Ganglia prototype in the RCF Linux Farm.

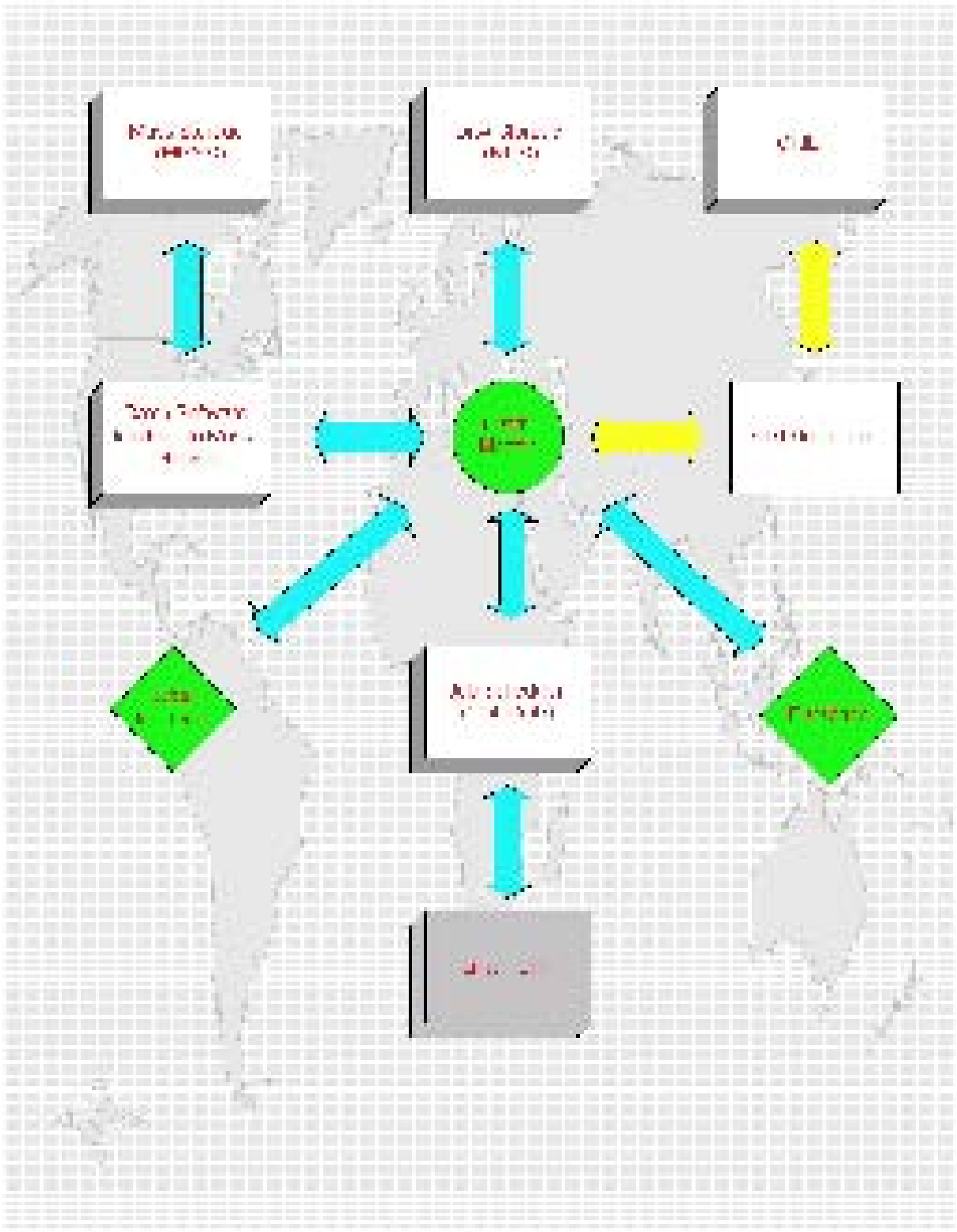

FIG. 10: MDS-compatible batch system at the RCF.

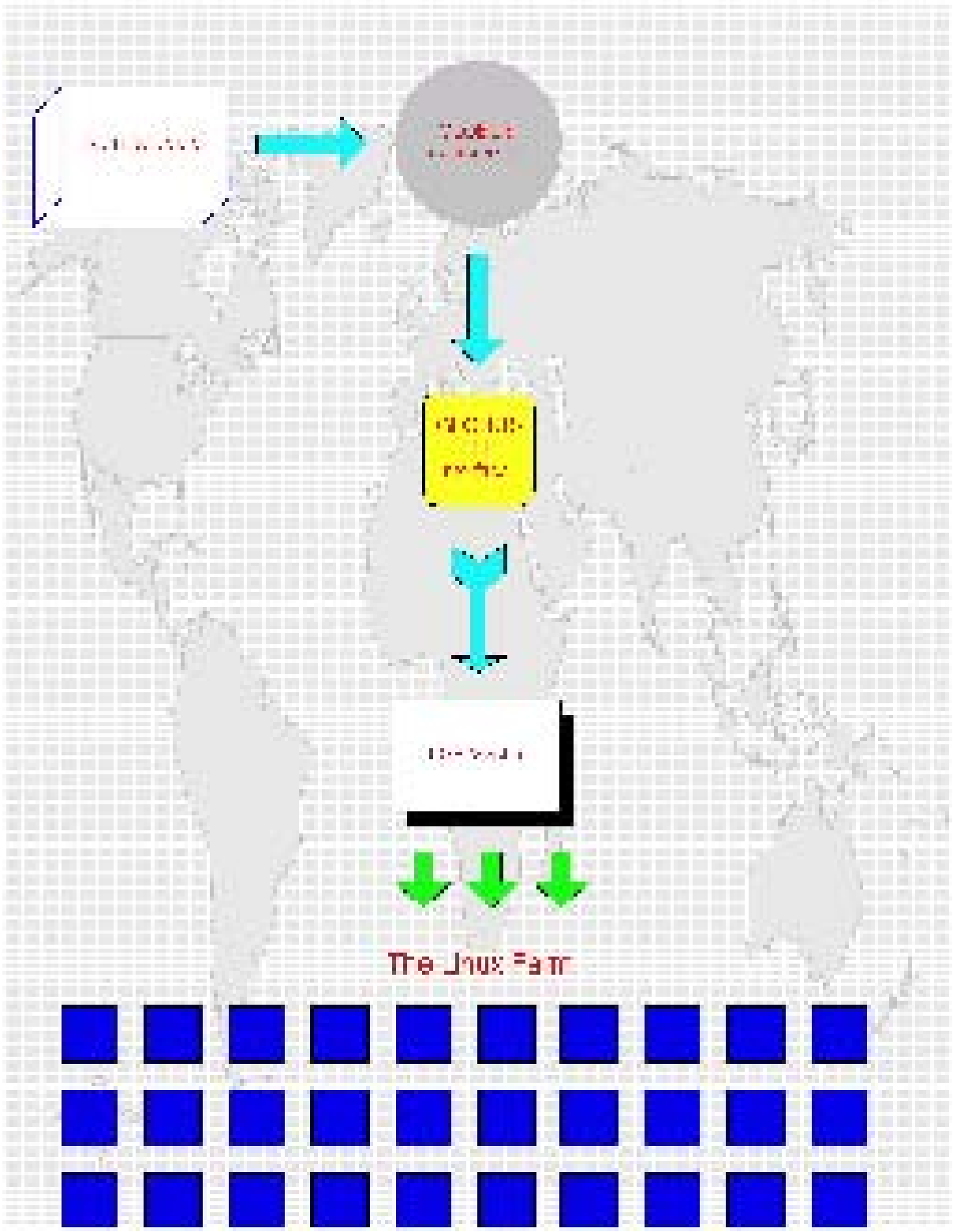

FIG. 11: LSF batch access via GLOBUS at the RCF.

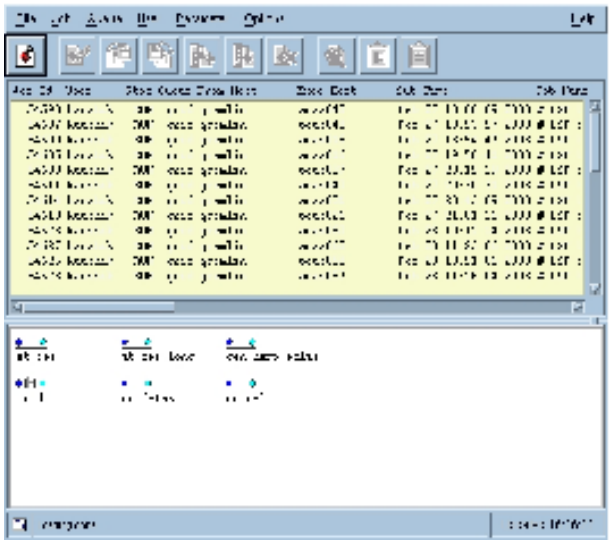

FIG. 12: LSF batch jobs submitted from the GLOBUS gatekeeper.

VI. NEAR-TERM PLANS

In the near-term, the current prototypes are expected to expand and slowly mature into production tools, as the outstanding issues are resolved.

Ganglia has already gone through two upgrades within the RCF, and the Linux Farm group is expecting that it will become part of the standard software packages on all its production servers in the near future.

Condor has been evaluated continuously on a small number of servers as the future job scheduler of the upgraded MDS-compatible batch system. Many of the oustanding issues have been resolved or are being studied, and we expect the batch system upgrade to be a year-long project.

The Linux Farm is currently using LSF v.4.2, and we plan to upgrade it to LSF v.5.x together with an OS upgrade in the next few months. New LSF features such as advance resource reservation and GRID membership protocols match well with the GRID computational architecture and can further integrate the GLOBUS gatekeepers with the LSF batch system.

Acknowledgments

The authors wish to thank the Information Technology Division and the Physics Department at BNL for their support to the RCF mission.

[1] http://www.redhat.com
[2] http://www.platform.com
[3] http://sourceforge.net/projects/ganglia
[4] http://www.cs.wisc.edu/condor
[5] http://www.globus.org