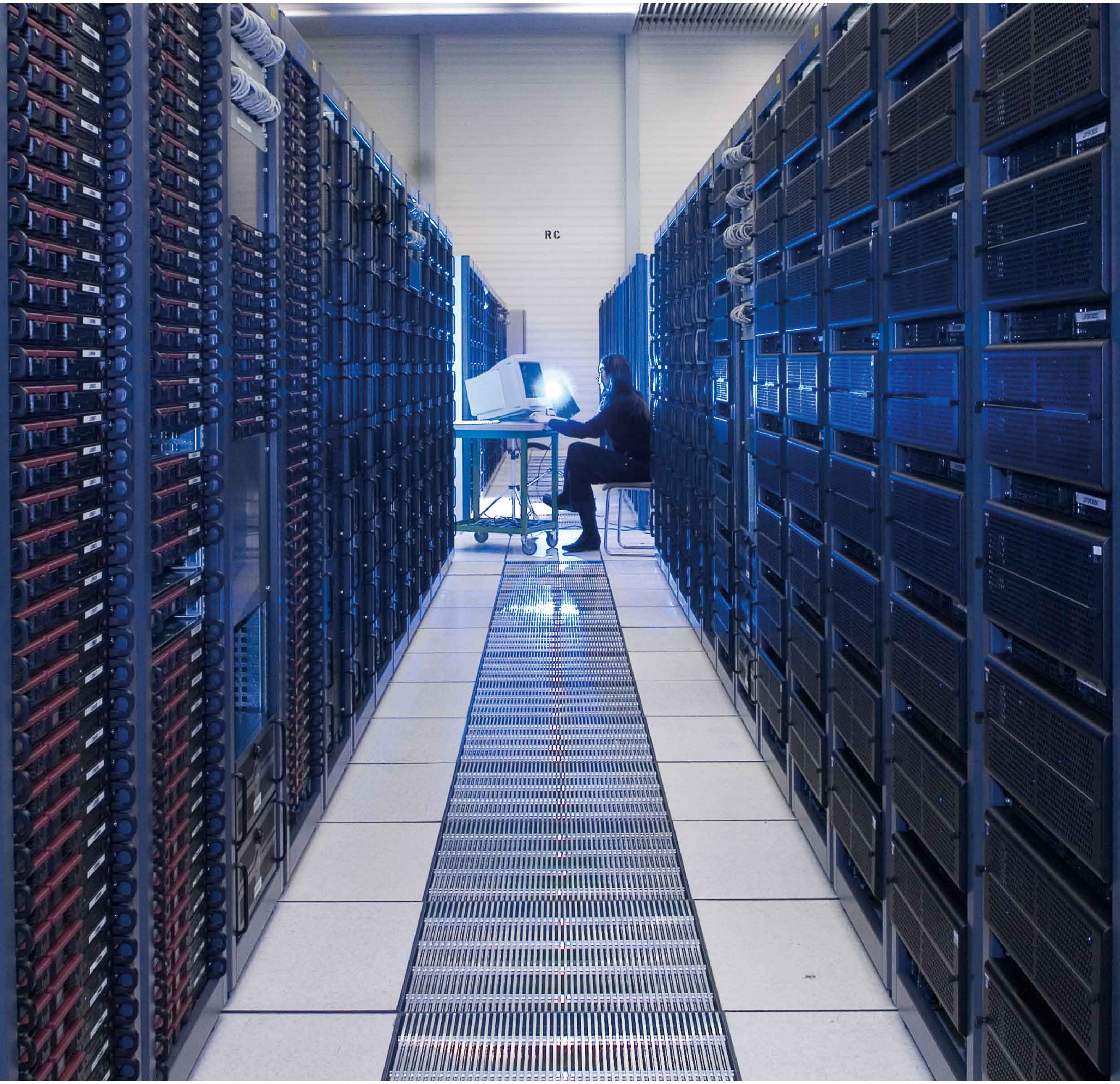
# Annual Report
## May 2006 – May 2007



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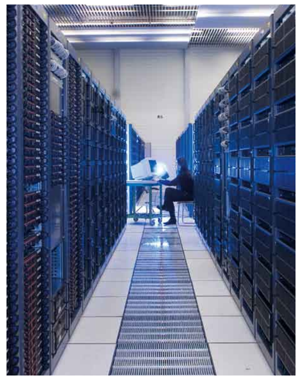

Cover illustration: server farm in CERN Computer Centre

First annual report of CERN openlab - Second Phase
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# CERN openlab – the second phase

On 17 May 2006, the second three-year phase of CERN openlab, a partnership between CERN and leading IT companies, was officially launched at a ceremony at CERN. At that time, I welcomed the industrial partners and contributors to the second phase, and encouraged them to build on experience from a first three-year partnership that had produced many excellent technical results in the field of cluster and Grid computing. Those results demonstrated that CERN openlab is an effective framework for collaboration between multiple industrial partners, in a pre-competitive spirit and based on open standards.

As well as the technical results that CERN openlab has provided, this partnership has given CERN a means to share our vision of the future of scientific computing with industry leaders, and gain deep insights into how industry sees computer hardware and IT services evolving. Therefore, there are both sound technical and strategic reasons for renewing this collaboration in a second phase.

A great deal can happen in a year, and that is the case both for CERN openlab, and for CERN as a whole. The rapid progress towards completion of the Large Hadron Collider (LHC) project, CERN's flagship accelerator and the world's largest scientific instrument, has been marked by many unparalleled feats of engineering prowess. This has put CERN very much at the centre of worldwide scientific and media attention.

Within CERN openlab, progress has also been considerable. In particular, it is encouraging to see that the technical results from CERN openlab, as outlined in this report, are having an increasingly direct and positive impact on the LHC Computing Grid project, and the related European multi-science Grid project EGEE. This synergy is vital, as the LHC Computing Grid is an essential ingredient to the overall success of the LHC.

CERN openlab's track record of successful public-private partnership has also helped raise awareness of CERN's Grid activities in the business world. This was illustrated in September of last year, when CERN was honoured with two awards for "Most Innovative Grid Implementation in Public Sector Research" and "Overall Top Research Grid" at GridWorld, a major conference for enterprise Grids. The CERN openlab partnership has contributed a great deal to the wider recognition of CERN's achievements that these awards represent.

I therefore thank all CERN openlab partners and contributors for their continued support of our joint effort. I look forward to the future shared benefits of this unique collaboration, as we prepare to enter a new age of fundamental physics – the LHC era.

Robert Aymar
Director General of CERN

# THE CONTEXT

## Countdown to collisions

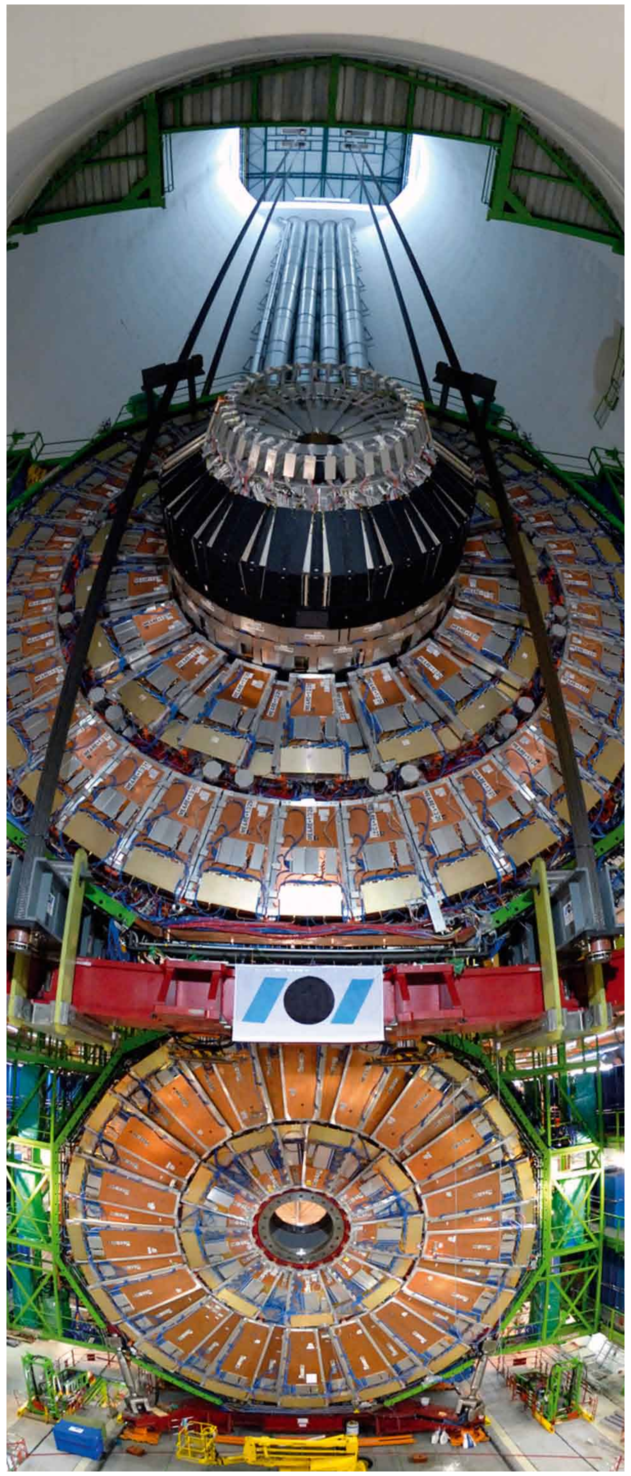
Housed in a 27 kilometre circular tunnel beneath the French-Swiss border near Geneva, the Large Hadron Collider (LHC) is the world's largest and most complex scientific instrument. Experiments at the LHC will allow physicists to complete a journey that started with Newton's description of gravity. Gravity acts on mass, but so far science is unable to explain why the fundamental particles have the masses they have. By colliding two proton beams together at ultra-relativistic speeds, and analyzing the results of such collisions, the LHC may provide the answer.

LHC experiments will also search for the mysterious missing mass and dark energy of the Universe – visible matter seems to account for just 4% of what must exist. They will investigate the reason for nature's preference for matter over antimatter, and they will probe matter as it existed at the very beginning of time. The experiments will achieve this by fleetingly creating conditions, at the impact point of colliding protons, that resemble the Universe a fraction of a second after the Big Bang.

During 2006 and early 2007, the installation of the LHC's superconducting magnets, the main components of the new machine required to keep the high-energy proton beams on track, has progressed rapidly towards completion. Already, a complete sector of the machine has been cooled down to its operating temperature of just 1.9 degrees above absolute zero, colder than outer space, making it the largest superconducting installation of its kind in the world.

Progress has been equally impressive for the four large experiments preparing to take data with the LHC's colliding particle beams. Named ALICE, ATLAS, CMS and LHCb, all are striving to be ready for the startup of the LHC, planned for late 2007. For example, in November 2006, the largest superconducting magnet ever built was successfully powered up to its nominal operating conditions at the first attempt. This magnet provides a powerful magnetic field for the ATLAS detector. In February 2007, the heaviest piece of the CMS detector began a momentous journey into the experiment's cavern, 100 metres underground. Using a huge gantry crane, the pre-assembled structure, weighing as much as five Jumbo jets (1920 tonnes) was gently lowered into place.

When data flow from these four experiments gets up to speed, it will be produced at a prodigious rate, reaching close to one percent of the world's information production rate. Handling this amount of data demands a new approach to distributed computing, called the Grid. In 2006, the LHC Computing Grid began offering a baseline service to the LHC community, right on schedule for a full service to begin in 2007.



Lowering of the CMS endcap disk, January 2007



## The worldwide Grid

From the early stages of planning the LHC, it was clear that the storage and processing requirements of the LHC experiments would dwarf any facility that could reasonably be assembled at CERN. As a result, a distributed solution – a data and computing Grid – was chosen. This Grid relies on the fact that CERN has over 250 institutional partners in Europe and 200 more in the rest of the world, many of which have significant computing resources to contribute.

The Grid architecture for the LHC builds on a hierarchy of sites. CERN, the Tier-0 centre, is a central hub, storing a copy of all data on tape, and also distributing them to 11 Tier-1 centres. The Tier-1 centres will store data from one or more experiments, for access by regional Tier-2 centres, of which there are already over 100. These centres will contribute a significant fraction of the computing resources needed for the LHC data analysis. Estimates of total processing capacity for analysis of the LHC data as well as theory-based simulations stand at around 100 000 of today's standard processors. In CERN's computer centre alone, preparations are underway for a near doubling of the number of processors available, from the current level of about 8500 processors.

In 2006, as a result of a global effort that pushed computing technology to the limits, the Worldwide LHC Computing Grid collaboration (WLCG) announced the successful completion of a service challenge involving a continuous flow of physics data on a worldwide Grid infrastructure at up to 1 Gigabyte/s. This data rate corresponds to transferring a DVD worth of scientific data from CERN every five seconds. The data was transferred around the globe using 10Gbit/s private optical networks linking CERN to the 11 Tier-1 sites. When it is fully operational, the LHC will produce about 15 million Gigabytes of data annually.

A further milestone demonstrating the reliability of the Grid technology for the LHC was reached in September, when the EGEE project announced that its global Grid infrastructure had sustained over a million jobs per month for a period of six months. While most of these computing tasks were for the LHC physics community, they also included many jobs submitted by scientists from diverse fields of research, ranging from simulations of molecular drug docking for neglected diseases to geophysical analysis of oil and gas fields.

The EGEE project is an example of how CERN is leveraging external resources to ensure the deployment of the Grid infrastructure that the LHC will rely on, while also helping other fields of science and industry benefit from this emerging technology. EGEE, the world's largest multi-science Grid infrastructure, is co-funded by the European Commission and involves over 90 partner institutions in Europe, Asia and North America.

Network flow to Tier-1 sites during an LCG data challenge

# THE STATUS

## Building on success

CERN has a three-fold Grid strategy. The LHC Computing Grid (LCG) project provides the core Grid services for the LHC experiments. The Enabling Grids for E-sciencE (EGEE) project, co-funded by the EU, runs a Grid infrastructure for a wide range of scientific and industrial applications. CERN is the lead partner of EGEE, and LCG is the flagship scientific application for this Grid. CERN openlab complements these two projects with longer-term test and validation of new commercial technologies, to assess their merits for the future of the Grid.

In January 2003, CERN openlab was launched as a new framework for multilateral projects between CERN and the IT industry. During a first three-year phase, the partners were Enterasys, HP, Intel, IBM and Oracle. These partners brought state-of-the-art technologies – both hardware and software – to the collaboration, as well as sponsoring young researchers at CERN, summer students, training and outreach events, and contributing a considerable amount of time and effort by their own engineers.

The focal point of the first three year phase of CERN openlab was to build a state-of-the-art computing cluster – the CERN opencluster – and test its performance in CERN's uniquely demanding computing environment and on the Grid.

In addition to the CERN openlab partner status, a contributor status was created for shorter-term involvement in specific technological areas, the first contributor being Voltaire in 2004.

For the second phase of CERN openlab, four major initiatives have been defined with our partners HP, Intel and Oracle, and contributors F-Secure and Stonesoft. A Platform Competence Centre focuses on platform virtualisation as well as software and hardware optimisation. A Grid Interoperability Centre, closely linked to the EGEE project, enables partners to participate in the integration and certification of Grid middleware. A Relational Databases Activity tackles the rapidly evolving requirements for data management on the LHC Computing Grid. A Networking and Security activity addresses the sharply increasing trend in IT security threats to major organisations, and to the internet as a whole.

In addition, the openlab team is continuously evaluating new opportunities for technological partnership with leading IT companies, and I am happy to announce a new contributor who is joining in 2007, EDS, in the area of Grid monitoring.

In conclusion, I would like to thank all the openlab partners and contributors, past and present, for their support of this ambitious partnership. I look forward to a period of exciting technical developments, as our joint efforts continue to bear fruit, and make an increasing impact on the world of scientific Grids.

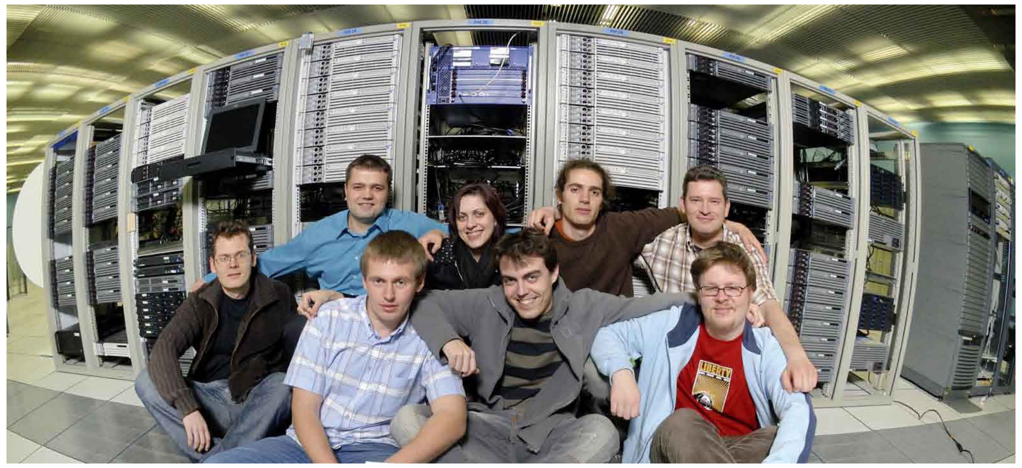
Wolfgang von Rüden
Head of CERN openlab
Head of CERN's IT Department



## The openlab team: a global effort

The work of CERN openlab is carried out by people from several groups in CERN's IT Department, in particular CS (Communication Systems), DES (Databases and Engineering Systems), IS (Internet Services) and PSS (Physics Services Support), as well as the Department's security section and communications team. Many of these are sponsored by the openlab partners, the EU or national programmes. There is, in addition, close collaboration with computing experts in the LHC experiments. A list of the IT Department staff most closely involved in the CERN openlab activities is given below.

It should be emphasized that the openlab partners contribute significant amounts of manpower to these activities through the time and effort invested by many of their engineers and scientists from around the world. Principal liaisons with partners and contributors, both at the technical and partnership management levels, are also listed below. In addition, substantial contributions are made by students participating in the CERN openlab student programme, both directly to openlab activities (6 students during summer 2006) and more widely to LCG, EGEE and other Grid-related activities in the IT Department (14 students).



Some of the CERN openlab fellows and staff in front of the CERN opencluster.

From left to right:
Havard Bjerke, Anton Topurov, Ryszard Jurga, Eva Dafonte Perez, José M. Dana Pérez, Xavier Gréhant, Andreas Hirstius, Andrzej Nowak

### CERN openlab Board of Sponsors

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| Robert Aymar | CERN (head of Board) |
| Wolfgang von Rüden | Head of CERN openlab |
| Michel Benard | HP |
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### CERN openlab Management Unit

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| François Fluckiger | CERN openlab Manager |
| Sverre Jarp | Chief Technology Officer |
| Séverine Pizzera | Administrative Assistant |

### CERN openlab Staff and Fellows (sponsor indicated)

| | |
|---|---|
| Michael Bindrup | Intern (Intel) |
| Havard Bjerke | Fellow (Intel) |
| Xavier Gréhant | Fellow (HP) |
| Ryszard Jurga | Fellow (EU Marie Curie) |
| Andreas Hirtsius | Staff (Intel) |
| Andrzej Nowak | Fellow (EU Marie Curie) |
| Eva Dafonte Perez | Staff (Oracle) |
| José M. Dana Pérez | CERN openlab fellow (HP) |
| Antti Pirinen | Contributor (TEKES, Finland) |
| Anton Topurov | Fellow (Oracle) |
| Dawid Wójcik | Fellow (Oracle) |

### Other IT Department staff contributing to CERN openlab

| | |
|---|---|
| Dirk Düllman | PSS group |
| David Foster | CS group leader |
| Maria Girone | PSS group |
| Eric Grancher | DES group |
| François Grey | communications team |
| Denise Heagerty | security section |
| Jean-Michel Jouanigot | CS group |
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### Industry Partner Liaisons with CERN (Technical/Management)

| | |
|---|---|
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| Arnaud Pierson | HP (M) |
| Herbert Cornelius | Intel (T) |
| Russel R. Beutler | Intel (M) |
| Bjørn Engsig | Oracle (T) |
| Graeme Kerr | Oracle (T) |
| Monica Marinucci Lopez | Oracle (M) |

### Industry Contributor Liaison with CERN

| | |
|---|---|
| Pär Andler | F-Secure |
| Mika Rautila | Stonesoft |
| Rolf Kubli | EDS |

# THE RESULTS

## Platform Competence Centre

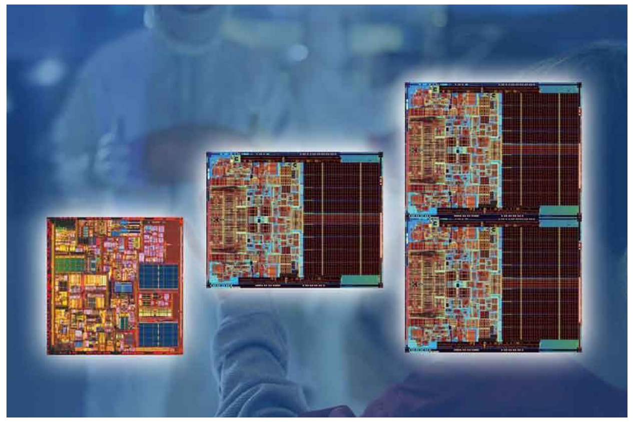
Software and hardware optimization is seen as a vital part of the LCG deployment, since the demand for resources by the scientists is very likely to outstrip the available resources, even inside the Grid. Such optimisation relies on profound knowledge of the architecture of the entire computing platform. On one hand the activities in CERN openlab's Platform Competence Centre cover hardware items, such as processors, memory, buses, input/output channels, on the other hand they cover the ability to use proficiently advanced tools, such as profilers, compilers and linkers, specially optimised library functions, and so on.

CERN openlab received the first quad core chips for testing in Europe in 2006, after doing extensive tests on dual core. The results confirmed that,both for Intel Xeon® and Itanium® 2 processors prototypes, multi-core processors are well suited to high energy physics (HEP). Thanks to the fact that HEP jobs are embarrassingly parallel (each physics event is independent of the others) as many processes and jobs can be launched as there are cores on a die. This requires that the memory size is increased to accommodate the extra processes, increasing computer cost. However, as long as the memory traffic does not become a bottleneck, we see a practically linear increase in the throughput from single to dual to quad core systems with core number. An analysis demo using PROOF, the parallelized version of the popular HEP package ROOT, elegantly demonstrated this during the launch of the quad-core chip at CERN.

Benchmarking is a common approach to measuring, and hence being able to optimize, CPU performance. LHC software frameworks are very complex, so it is challenging to find a benchmark which reflects a realistic workload. For HEP usage, the SPEC2000 benchmark has certain limitations. For example, depending on the compiler and the compiler options, results can differ significantly. The benchmarking project inside openlab has made progress on several fronts, helping to better understand typical HEP workloads and correlate them with benchmark results, evaluating a new SPEC2006 benchmark as a possible replacement for SPEC2000 as well as testing and evaluation of pre-production systems provided by Intel.

In a more competitive vein, openlab launched an initiative to enter the TOP500 list of supercomputers, by attempting to achieve of order 4000 GFlops using a large cluster with Intel Xeon Dual Core 5100 processor 3.0 GHz. CERN's Ethernet-based clusters have latencies up to 0.6ms, 100x larger than many tightly connected supercomputing clusters. Nevertheless, using the standard benchmark High Performance Linpack and Intel's message passing interface (MPI), an optimum performance of 8329 GFlops was obtained on a 340 machine cluster (1360 cores). The result would have ranked 79 in the November 2006 TOP500 and has been submitted for the June 2007 list.

In order to optimize HEP software, it is necessary to monitor the performance of applications. CERN openlab has been involved in testing and validation the pfmon monitoring tool and the perfmon2 interface, both developed by HP initially for Itanium, and now covering all Linux-supported processors. Performance monitoring was carried out in collaboration with two of the LHC experiments, ATLAS and LHCb. Results, presented both to the physics community and the Gelato collaboration, confirmed the general suitability of tools that are scalable and portable across multiple platforms, while establishing improvements needed for the tools to achieve this goal. A particular focus in openlab has been performance reporting for complex LHC frameworks operating with hundreds of dynamic libraries.



Intel single core,
Dual Core and QuadCore chips.

Left :
HP servers in CERN opencluster

Another way of improving the performance of HEP programs is to work with the compiler writers to seek improvements that will have a broad impact on source codes. In the second phase of openlab, the compiler effort has broadened to include Intel Xeon 64-bit processor as well as Intel Itanium 2 processor. Also, other compilers such as gcc and Open64 are being tested, in addition to the Intel compilers. Small assembly routines – so-called snippets – are being generated to demonstrate upper limits of potential compiler improvements.

Another facet of performance being studied in openlab concerns I/O. When LHC is running, the experiments will deliver data at rates over 1GByte/s for long periods. This data has to be handled efficiently when receiving it from the experiment, writing it to tape, exporting to the LHC Computing Grid sites, and so on. Based on experience with Infiniband in the first phase of CERN openlab, investigations are being made of new trends in efficient use of I/O capabilities, in particular, the openfabrics software stack. For example, 10Gb connections to a new generation of disk servers was investigated by openlab, and is now being studied by the Fabrics and Infrastructure Operations (FIO) Group at CERN, for deployment in production. This is yet another example of the knock-on effect of openlab test and validation studies on choices made by CERN and the HEP community.

> *"CERN is by far the best and most effective reporter of bugs in the Intel C++ compiler"*
> *Pat Gelsinger, Senior Vice President, Intel (2007).*

Power consumption is an increasingly important part of global performance measurement for a data centre. For example, the CERN computing center has a limitiation for electric power of 2.5MW. Given this hard limit, there is a strong interest to optimize performance per Watt. For example, compiler optimization can improve the SPEC2000/Watt figures by large amounts for certain processors. Different hardware configurations, such as blade systems, are also being investigated.

The activity of openlab in this area goes beyond just measuring power consumption under load, aiming to better understand where in a server the power is consumed. The CPU has traditionally been the main power consumer, but with the new generation of very power efficient CPUs, the power consumption of the main memory comes into focus now. Results so far indicate, for example, that memory in servers with Intel Xeon Dual Core 5100 series processors (FB-DIMM) consumes about ~10W per GByte under full load, amounting to 80 W, since there are 2GB per core. Hard disks add about 10W when idle, 15W under load, for the models tested.

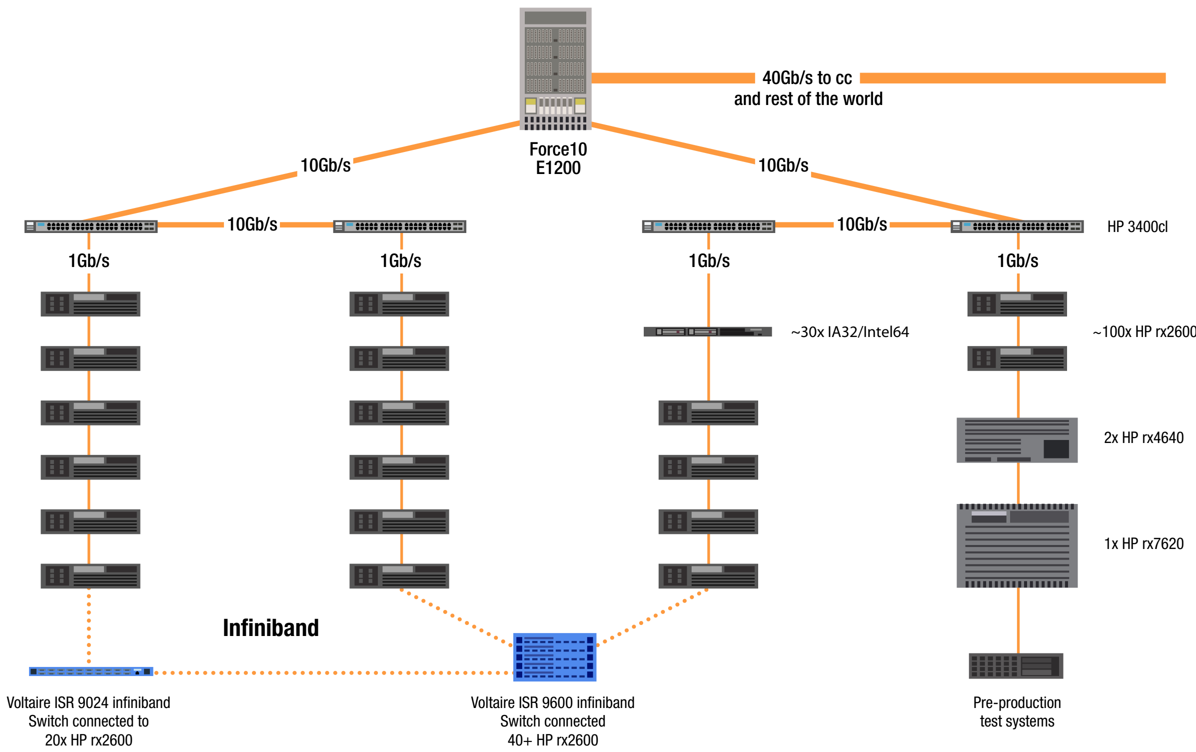


# The CERN opencluster

Set up during the first phase of CERN openlab, the CERN opencluster continues to be a central workhorse for much of the technical collaboration in CERN openlab. It comprises about 100 Intel Itanium dual processor HP Integrity servers as well as a rack of HP Proliant servers with Intel Xeon 64-bit processors. Both processors types were used to accelerate the conversion to 64-bit addressability with special emphasis on the validation of High Energy Physics software, middleware and Scientific Linux. Many servers were equipped with Intel's 10 GbE Network Interface Card (NIC) for use in LHC Computing Grid Data Challenges. In the second phase of CERN openlab, several nodes will be upgraded to Montecito dual core.

The cluster is used extensively for benchmarking and development. Soon after it was installed, it became clear that the I/O capacity of the HP servers was excellent. Subsequently many tests were carried out on a transatlantic scale, together with DataTAG, the ATLAS experiment, Caltech (CMS) and others. After multiple tests of this nature (which were done memory to memory) the focus shifted to "next-generation" disk servers that could drive both the 10Gb network and a storage subsystem at a compatible speed.

CERN opencluster architecture




Two 4-way servers (HP Infinity RX4640) with Intel Itanium 2 processors, each with three RAID controllers were deployed for this purpose.

The servers with Intel Itanium 2 processors participated in several ALICE Data Challenges and LCG Service Challenges. The excellent floating-point computing capability of the Itanium processors led to the agreement to use up to 40 servers as a service for Computational Fluid Dynamics codes for verification of the cooling setup in the LHC detector caverns. This service continues to this day. A separate IB switch was purchased from Voltaire for this purpose.

The CERN opencluster contributed to many data challenges and service challenges run by LCG over the past three years. These include: contributing to a storage-to-tape challenge that achieved 1.1GB/s sustained in 2003; playing a key role in a data transfer challenge which achieved 5.44GB/s in 2003, a feat which won CERN and the California Institute of Technology the Internet-2 landspeed record and a place in the Guinness Book of Records; facilitating service challenges carried out in 2005, where CERN sustained continuous flows of data at 600MB/s to seven Tier-1 centres.


# Grid Interoperability Centre

The Grid Interoperability Centre focuses on testing and validation of partner software solutions in connection with the EGEE project and its middleware stack, gLite. The objective is to provide mutually beneficial results for the EGEE project and CERN openlab partners.

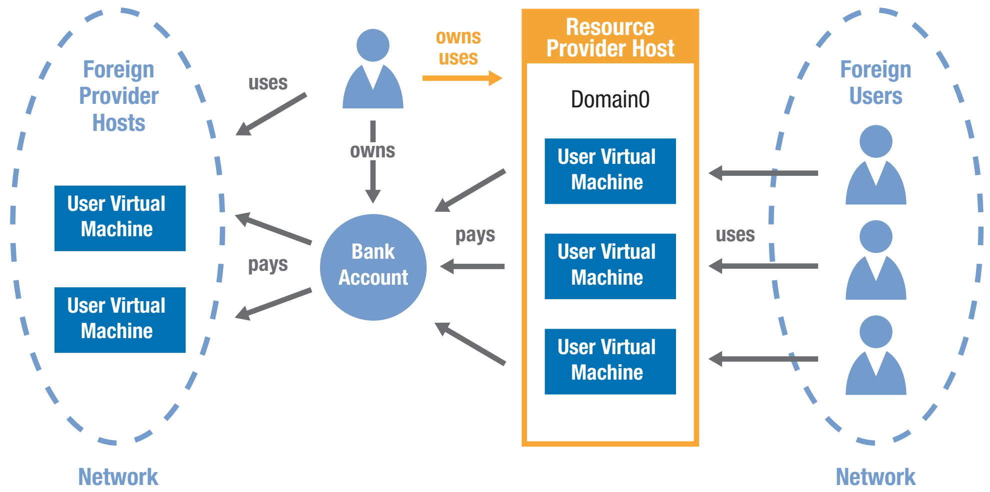
One example is the development by openlab of SmartDomains, a virtual domain manager for Xen that is powered by SmartFrog, an open source configuration management system developed at HP Labs. SmartDomains enables users to write configurations of virtual machine pools and their workflows. Using SmartDomains, virtual machines can be launched in a whole computing centre with little effort. SmartDomains is based on a peer-to-peer layer that distributes the management work seamlessly. A collaboration between CERN openlab and the IT Department's Grid Deployment group is using SmartDomains in the context of gLite certification.

Tycoon is an open source project launched in HP Labs Palo Alto, that enables the emergence of markets where CPU cycle delivery to a user automatically adapts to competition in demand. Such a system is expected to be a necessary step towards broader Grid usage. The current exchange of resources on the Grid is determined by static contracts between providers and users, based each time on explicit interests on both sides. With Tycoon, contracts are implicit and the exchange is made dynamic and seamless. Tycoon's pay-per-use model could help provide incentive for commercial companies to contribute and share resources.

Tycoon, which is based on Xen virtualization, is being tested by CERN openlab to evaluate its benefits on a large scale grid environment, targetting HEP physics users as an advanced research community with a high demand for resources. Scalability tests have been carried out with the collaboration of EGEE partners, especially from the BalticGrid sites. The system has proved easy to implement with unmodified gLite, and this work has led to several proposed enhancements which are being discussed with the Tycoon implementers.

The Intel Grid Programming Environment (GPE) is an API for developing Grid applications that can use any OGSA compliant middleware with an "Atomic Services" interface on top of it. A comparison with gLite conducted in CERN openlab points to several potential advantages, including the fact that GPE offers full virtualization support. Scenarios for adaptation of GPE by the LHC Computing Grid community have been identified, including establishing interoperability between gLite and GPE-based Grids, and using GPE to provide an API on top of gLite.

Schematic of Tycoon usage model






Left : Intel-based disk farm for the Tier-0 of the LHC Computing Grid at CERN.

# Relational Database Activity

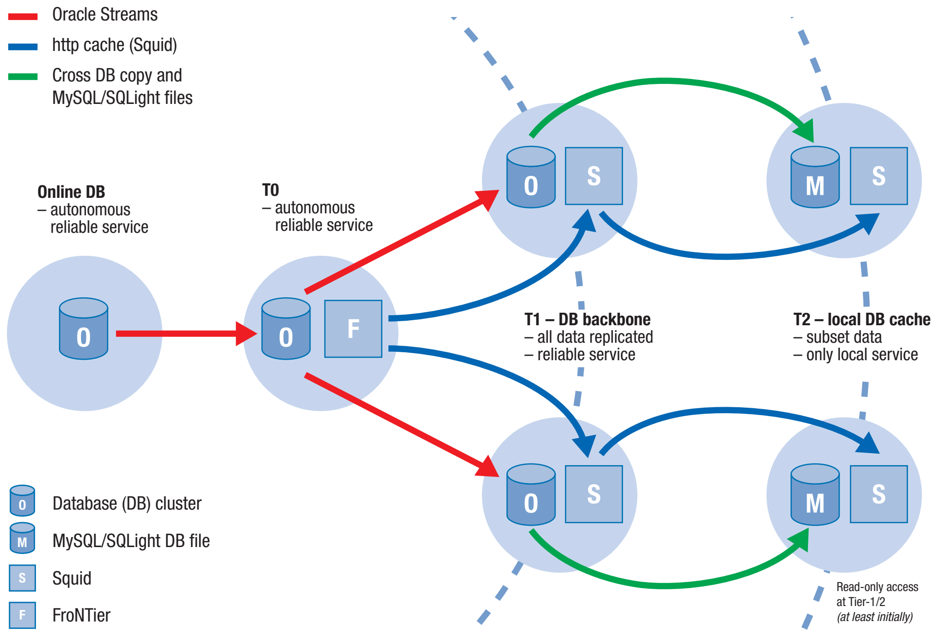

Physics metadata stored in relational databases play a crucial role in the operation of the LHC experiments and LHC Computing Grid services. A large proportion of non-event data such as detector conditions, calibration, geometry and production bookkeeping relies heavily on databases. Also, the core Grid services that catalogue and distribute LHC data cannot operate without a reliable database infrastructure at CERN and the LCG sites.

Most of the LHC data can be stored and distributed as read-only files. Nevertheless, a significant proportion of data from the central experiment and the Grid requires database services such as: consistent and highly available storage for data that is simultaneously accessed or updated; recovery to a consistent state after hardware, software or human failures; support for efficient ad hoc queries.

To address these issues, a Distributed Deployment of Databases project was launched in 2004. Representatives from 11 Tier-1 sites and three LHC experiments (ATLAS, CMS and LHCb) are profiting from a close cooperation with Oracle as part of CERN openlab. The project also involves two teams from IT Department's Physics Services Support group, which provide the main LCG database services and applications. From the start the project has focused on using database clusters as the main building-blocks in the database service architecture (figure below).

Oracle Real Application Clusters (RACs) are used to implement reliable database services at the different stages of the main data flow, from online to offline up to Tier-1 sites. Each database cluster (figure next page) consists of several processing nodes that access data shared in a storage area network (SAN). Today, for each experiment there are typically eight nodes at Tier-0 and two to three nodes at Tier-1. The cluster nodes use a dedicated network to share cached data blocks to minimize the number of disk operations. Work by the Database and Engineering Systems (DES) group on RAC scalability, resulted in improvements of an order of magnitude in the number of changes per second that could be made to a table, with commensurate benefits when shipping data from CERN to Tier-1 sites.

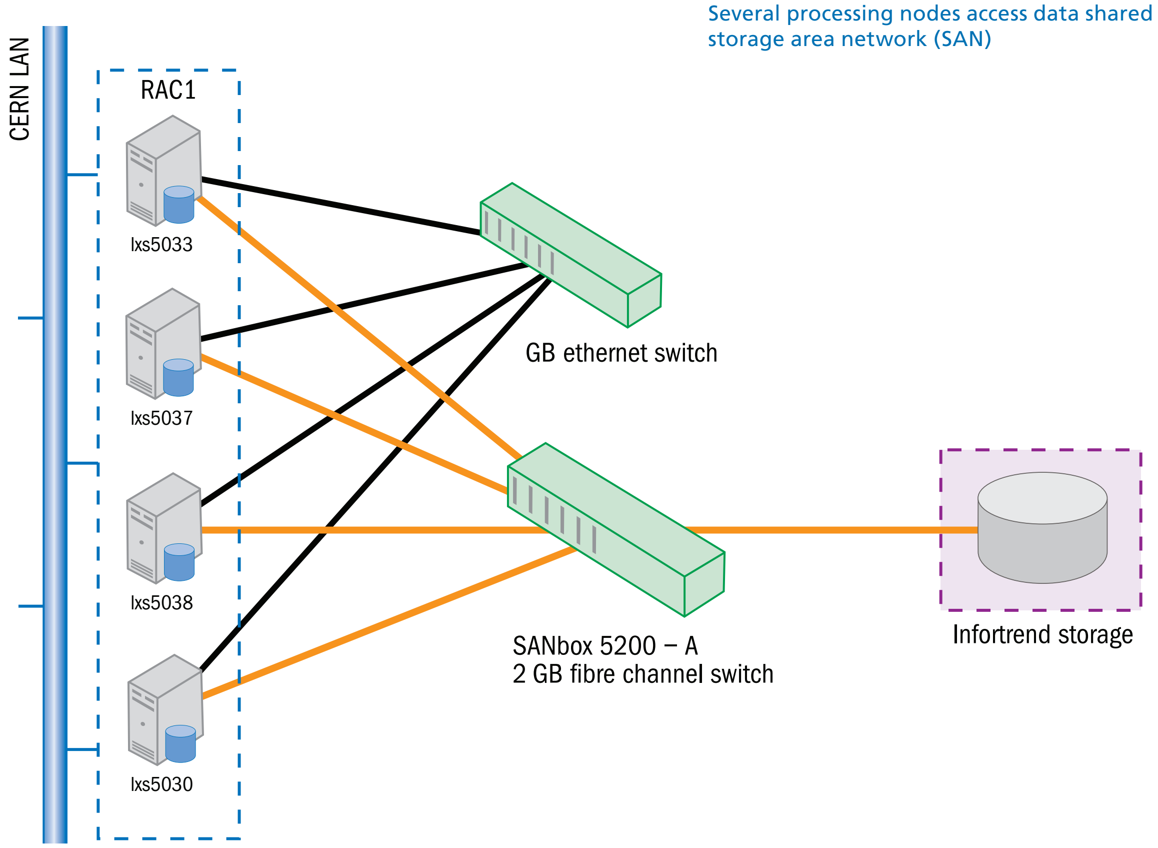
A public network connects the database cluster to client applications, which may execute queries in parallel on several nodes. The set-up provides important flexibility to expand the database server resources (CPU and storage independently) according to users' needs. This is particularly important during the early phases of the LHC operation, since several applications are still under development and data volume and access patterns may change. In addition to its intrinsic scalability, the cluster also increases significantly the availability of the database. Should individual nodes fail, applications can failover to one of the remaining cluster nodes and many regular service interventions can be performed without database downtime node by node.




Database clusters form the main building blocks of the service architecture in the LCG Distributed Deployment of Databases project. Oracle clusters are used up to Tier-1.

Left : View of CERN administrative computing area with Oracle database servers in foreground.

An example of a database service provided by Oracle Real Application Clusters
Several processing nodes access data shared in a storage area network (SAN)




During the last year the physics database service run by the PSS group has undertaken major preparations for the start-up of the LHC and is now fully based on Oracle clusters on Intel/Linux. More than 100 database server nodes are deployed in some 15 clusters serving almost 2 million database sessions per week. The positive experience with this new architecture at CERN and other sites has led to the setting up of similar database installations at the Tier-1 partner sites worldwide, forming one of the largest Oracle RAC installations.

Migrations to new hardware are done using Oracle Data Guard, to provide as minimum downtime as possible. In particular, testing and deployment of Oracle Data Guard Automatic failover was carried out by DES group as part of the openlab collaboration.

All RAC installations use Oracle Automatic Storage Management (ASM) to manage high data volumes and provide necessary redundancy. The service is monitored from the users services down to the computer hardware, including ASM, database software and the operating system. The primary monitoring solution is Oracle Enterprise Manager, complemented by tools developed in house.

CERN openlab has also helped to stimulate ongoing evaluation of new enterprise hardware and software solutions for databases, in particular quad-core servers and 64 bit Oracle software. Tests of the performance of Oracle Relational Database Management System (RDBMS) on the dual CPU Woodcrest–based machine and dual CPU Clovertown-based machine confirm that Oracle RDBMS can make use of the all cores offered. The response time test showed almost double performance gain. Logical IO tests showed 33% IO per second gain.





## Security Activity

With the sharply increasing trend in IT security threats to major organisations, and to the internet as a whole, there is an urgent need to address the issue of Grid security and site security more holistically. Therefore, the CERN openlab has launched initiatives in the field of computer security. The Helsinki Institute of Physics (HIP) was instrumental in setting-up some of these activities.

F-Secure is contributing in the fields of malware protection, anti-spyware, intrusion detection and intrusion prevention with a particular focus on client security and mail server security. F-Secure software is being evaluated by the Internet Services group in CERN's IT Department, and has been found to be particularly effective in the area of virus detection.

Stonesoft also contributes in the fields intrusion detection and intrusion prevention with a particular focus on combining events from network and client level security systems. Stonesoft software is being evaluated by the security section in the IT Department. The integration of data from F-Secure and Stonesoft data logs is being carried out by a researcher hosted by HIP at CERN and funded by a Finnish national research project, NetGate, which includes HIP, F-Secure and StoneSoft.

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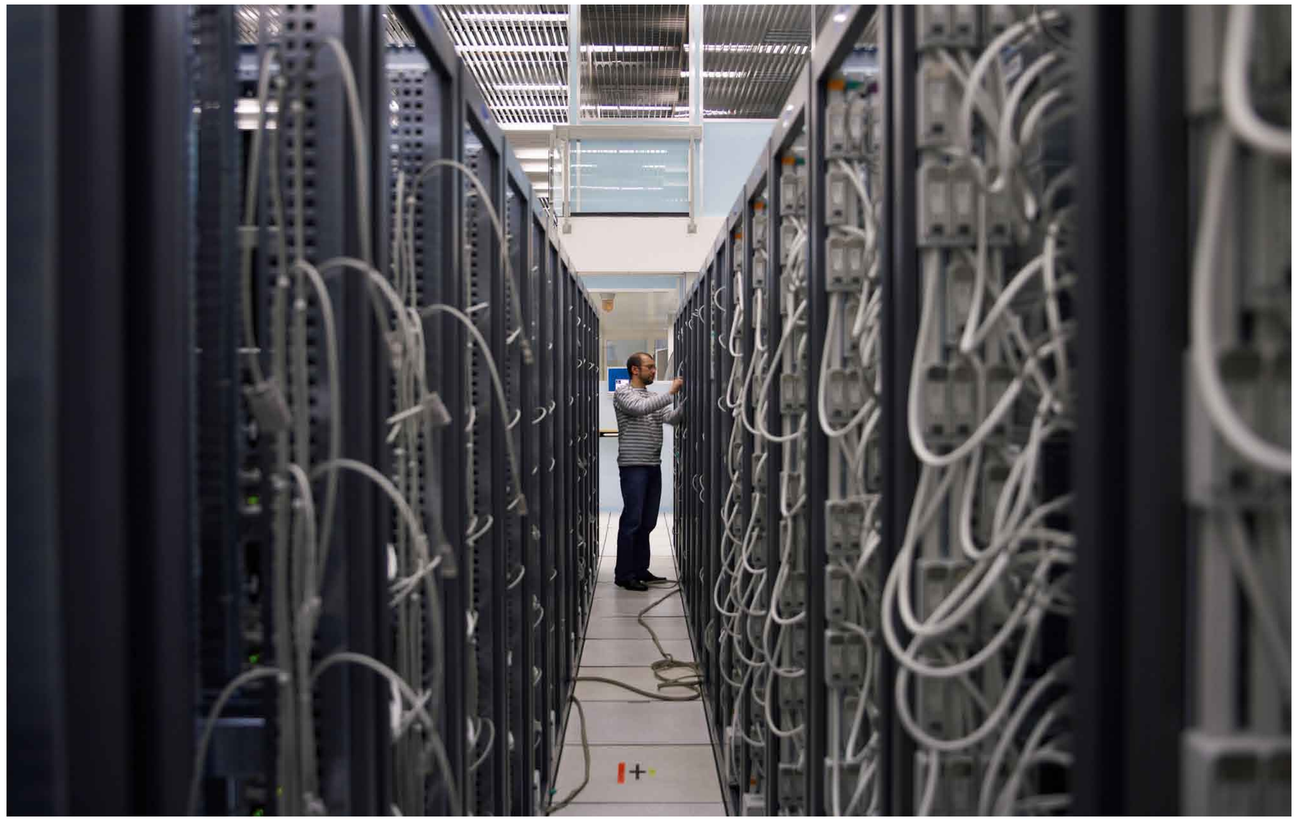


# Publications and Presentations

CERN openlab results have been disseminated at a wide range of international conferences, listed below. For a full record of the presentions, consult the CERN openlab website. In addition, key results of CERN openlab have been the subject of a large number of press articles in the both the general and IT-specific press and on the Web.

Articles:

- D. Düllman and M. Girone, Distributed database project ensures replication to LCG sites, CNL, 42, 6-8, April - May 2007
- X. Grehant, SmartDomains deploys Xen VMs, CNL, 42, 10-11, April-May 2007
- S. Jarp, Processors size up for physics at the LHC, CERN Courier, 47, 18-22, April 2007

Presentations:

- E. Dafonte Perez, Streams Resynchronisation Scenarios and Tests, LCG 3D workshop, CERN, 13-14 September 2006
- E. Dafonte Perez, Oracle Streams Optimisations and Database recovery tests at Tier 0 and Tier 1 sites, WLCG workshop, CERN 22-26 January 2007
- E. Dafonte Perez, Oracle and Streams Diagnostics and Monitoring, LCG 3D - Database Administrator Workshop, SARA, Netherlands, 20-21 March 2007
- J. M. Dana, CERN Snippets Dissected, Gelato ICE, San Jose, 15-18 April 2007
- J. M. Dana and X. Grehant, Tycoon market-based system: integration with EGEE, EGEE User Forum, Manchester, 9-11 May
- D. Düllmann, LCG 3D project status and production plans, CHEP06, Mumbai, 13-17 February 2006
- D. Düllmann, Database Technologies and Distribution Techniques, HEPIX, Rome, 3-7 April 2006
- F. Fluckiger, openlab-II: where are we, where are we going, CHEP06, Mumbai, 13-17 February 2006
- X. Grehant, A tool for grid sites to supply heterogeneous computing resources, 2nd EuroSys Autoring Workshop, Lisbon, 20 March 2007
- S. Jarp, Software kernels, CHEP06, Mumbai, 13-17 February 2006
- S. Jarp and R. Jurga, Performance and Bottleneck Analysis, HEPiX, Rome, 3-7 April 2006
- S. Jarp, An approach to Performance and Bottleneck Analysis, Gelato ICE, San Jose, 24-26 April 2006
- S. Jarp, Getting ready for LHC in 2007, Gelato ICE, San Jose, 24-26 April 2006
- S. Jarp, Storage and I/O requirements of the LHC experiments, OpenFabrics Paris Conference, 22-23 June 2006
- S. Jarp, CERN openlab II Grid-related activities, EGEE'06 Conference, Geneva, 25-29 September, 2006
- R. Jurga, Practical experience with Performance Monitors on Xeon and Itanium, Gelato ICE, Singapore, 2-4 October 2006
- R. Jurga, Profiling Geant4 applications, Geant4 Technical Forum, 31 January 2007, Geneva
- R. Jurga, Performance Profiling of Experiments' Geant4 Simulations, Geant4 Collaboration WorkShop, 14 October 2006, Lisbon
- W. von Rüden, Travelling securely on the Grid to the origin of the Universe, F-Secure Species 2007 conference, Zürich, 24 January 2007

Posters:

- X. Grehant, Grid and virtualization experience in openlab, EuroSys2007 conference, 21-23 March 2007, Lisbon
- X. Grehant, Investingating Tycoon in openlab EGEE'06 Conference, Geneva, 25-29 September 2006

# Events and Outreach

As well as the many excellent technical results that CERN openlab provides, the partnership gives CERN a means to share a vision of the future of scientific computing with its partners, through joint workshops and events, as well as to disseminate to a wider audience, including partner clients, the press and the general public.

CERN is regularly visited by top delegations from governments and industry, as well as customer and press visits organised by openlab partners. These groups are briefed about CERN openlab in a dedicated VIP meeting room known as the CERN openlab openspace.

**Intel HPC meeting, 15-16 May 2006**
Intel client event taking place with CERN participation and site visit

**CERN openlab/EGEE/ETICS gLite Industry Readinesss Workshop 15-16 June 2006**
Brainstorming organized by HP with openlab partners and EGEE, ETICS project representatives

**OpenFabrics / Infiniband Workshop, 26 June 2006**
Various infiniband providers, organised by CERN openlab,

**Supercomputing 2006, 13-17 November 2006**
CERN openlab presence on joint CERN/Caltech stand, CERN participation in HP and Intel stand talks and events

**Intel European Quad Core launch event, 14 November 2006**
30 Journalists from EMEA participated in day-long event in CERN Globe of Innovation


Sverre Jarp, CTO of CERN openlab, speaking at the European launch event for Intel QuadCore, held at CERN's Globe of Science and Innovation in November 2006



# Education

Einar Bjorgo of the CERN-based UN activity UNOSAT, and Patricia Mendez Lorenzo of the Physics Service Support group, two openlab student supervisors

The CERN openlab student programme was launched in 2002, to enable undergraduate, Masters and Ph.D. students to get hands-on experience with Grid technology. In 2006, some 20 computer science and physics students took part in the programme at CERN, coming from Europe, the US and Japan. The students work on Grid-related projects supervised by openlab staff as well as staff from the LCG and EGEE Grid projects, other Grid-related groups in the Department, and Grid-related activities in the rest of CERN. Several of these students were co-funded by openlab partners HP and Intel. The students are listed below, with home institute and project topic.

The programme included study tours to the HP-Intel Business Solutions Laboratory in Grenoble, as well as to the University of Geneva's Computing Department. A dedicated lecture series for the students was given by Grid experts in CERN's IT Department. A special Grid Entrepreneurship Day was organized on 26 July, to stimulate interest in possible spin-offs from Grid technologies being developed by EGEE. UK-based consultants Qi3 provided an introduction to entrepreneurship, and CEOs of two European start-up companies in this area, Kerlabs and MESH Technologies, shared their experience of starting a company with the participants, which included interested CERN staff as well as the openlab students.

- Viacheslav Burenkov, Imperial College, UK (CERN School of Computing support)
- Emilio Castillo, Uni. Cantabria, Spain (Indico web-based conference planner)
- Mihai Liviu Ciubancan, National Institute of Physics, Romania (Integration and Deployment for Diligent project)
- Ciprian Mihai Dobre, Politechnica Bucharest, Romania (Grid site monitor for public events)
- Martin Flechl, Uppsala University, Sweden, (EGEE/NorduGrid interoperation)
- Tim Hartnack, Christian Albrechts Uni Kiel, Germany (Grid and volunteer computing interoperation)
- Jukka Kommeri, Helsinki Uni Technology, Finland (Grids for mobile access to satellite imagery)
- Kevin Liu, Uni California Berkeley, USA (compiler testing).
- Kalle Lundahn, Helsinki Uni Technology, Finland (J2EE architecture and open source)
- Helen McGlone, University of Glasgow, UK, (porting HEP applications to volunteer computing)
- Louise Oakes, Imperial College, UK (porting HEP applications to volunteer computing)
- Olivier Pernet, ENSIMAG, Grenoble, France (Adapting SmartFrog to the Grid)
- Danilo Piparo, University of Milano, Italy (Browser application for gLite)
- Atle Rudshaug, NTNU, Norway (Database Virtualisation)
- Halvor Sakshaug, NTNU, Norway (Digital logbook)
- Tanya Sandoval, Imperial College, London (Benchmarking hardware platforms)
- Hitoshi Sato, Tokyo Inst. Technology, Japan (EGEE/NAREGI Interoperations)
- Fermin Serrano Sanz, Uni Zaragoza, Spain (Aspect Oriented Grid Programming)
- Martin Tingstad, NTNU, Norway (CPU Performance measurements)
- Salman Toor, Uppsala University, (Tycoon for use in LCG)

# THE FUTURE

## New projects, new contributors

After one year, CERN openlab continues to develop on several fronts. A project has been established with ProCurve Networking by HP, which begins in May 2007. ProCurve is a provider of wired and wireless LAN and WAN networking products, services and solutions, and a major supplier of high-speed switching equipment to CERN.

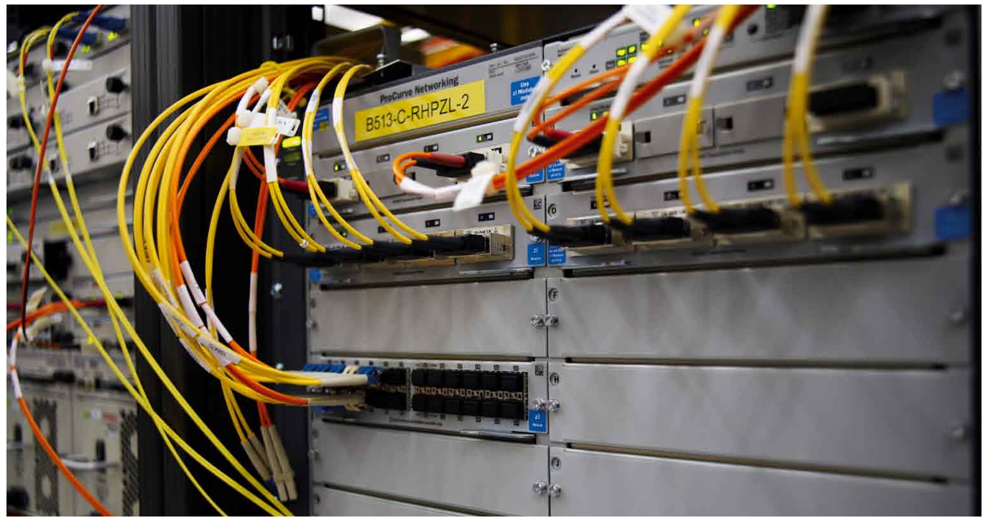
Within CERN openlab, the goal of the collaboration is to understand the behaviour of large computer networks (10,000 or more nodes) in High Performance Computing or large campus installations. Specific objectives will be to detect traffic anomalies in these systems, perform trend analysis, automatically take countermeasures and provide post mortem analysis facilities. The research project will involve two fellows sponsored by HP ProCurve.

A new contributor to CERN openlab is EDS, a company which provides a broad portfolio of business and technology solutions to help its clients worldwide improve their business performance. EDS is a member of the EGEE Industry Forum, and has joined CERN openlab to gain experience with the sort of Grid technology that is being developed for the LHC and other sciences.

Specifically, the project will contribute to the development and enhancement of tools and systems to monitor Grid Services. Grid infrastructures such as EGEE and LCG currently provide a variety of monitoring systems. These range from classical fabric monitors to a relatively new type of monitor activity on the Grid applications side. The ad hoc evolution of these monitors means that there is a risk of important information not being gathered, or multiple monitors storing redundant data.

For the accumulation of sensor data, data repositories and transport mechanisms have been developed. Understanding how to present high level views in an intuitive and useful way, whilst providing the ability to understand the underlying problems, is an open issue. EDS engineers will work together with experts and tool providers to evaluate existing solutions. A fellow sponsored by EDS will implement solutions by adapting existing tools, including the Experiment Dashboard, an aggregator of monitor information, developed through a collaboration of the EGEE and LCG projects.

The event that will dominate the coming year, even for openlab, is the launch of the LHC. As physicists are at last confronted with real data, the computing systems will be tested to the limit. This will surely push the demand for new solutions to cope with data storage and analysis on a global Grid. This demand will in turn provide CERN and its openlab partners with renewed impetus to innovate for many years to come.




HP ProCurve switches in CERN campus network





This is the first annual sponsors meeting of the second phase of CERN openlab. It was presented to the Board of Sponsors at the Annual Sponsors meeting, 26-27 April 2007, finalised for publication 25 May

Participants in the Annual Sponsors Meeting, from left to right: David Myers (CERN), Mika Rautila (Stonesoft), François Fluckiger (CERN), Andrey Semin (Intel), Bill Johnson (HP ProCurve), Stephan Gillich (Intel), Frederic Hemmer (CERN), Robert Aymar (CERN), Rolf Kubli (EDS), Wolfgang von Rüden (CERN), Graeme Kerr (Oracle), Jean-Michel Jouanigot (CERN), Sverre Jarp (CERN), Tony Cass (CERN), Bjorn Engsig (Oracle), Russ Beutler (Intel), Alberto Pace (CERN), Mats Moller (CERN),Arnaud Pierson (HP).

### CERN openlab partners

**HP** is a leading global provider of products, technologies, solutions and services to consumers and businesses. The company's offerings span IT infrastructure, personal computing and access devices, global services and imaging and printing. HP completed its merger transaction involving Compaq Computer Corp. on May 3, 2002. More information about HP is available at www.hp.com.

**Intel**, the world leader in silicon innovation, develops technologies, products and initiatives to continually advance how people work and live. Additional information about Intel is available at www.intel.com/pressroom.

For 30 years, **Oracle** has been helping customers manage critical information. The company's goal is to make sure that customers spend less money on their systems while getting the most up-to-date and accurate information from them. Oracle does this by simplifying or outsourcing IT infrastructure to reduce costs, and by integrating disparate systems to create a single, global view of the customer's business. www.oracle.com.

### CERN openlab contributors

**EDS** provides a broad portfolio of business and technology solutions to help its clients worldwide improve their business performance.

**F-Secure** Corporation protects consumers and businesses against computer viruses and other threats from the Internet and mobile networks.

**Stonesoft** Corporation (OMX: SFT1V) is an innovative provider of integrated network security and business continuity solutions.

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http://www.cern.ch/openlab

**CERN**, The European Organization for Nuclear Research, is the world's leading laboratory for particle physics. It has its headquarters in Geneva. At present, its Member States are Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom. India, Israel, Japan, the Russian Federation, the United States of America, Turkey, the European Commission and UNESCO have Observer status.

CERN openlab

www.cern.ch/openlab

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