

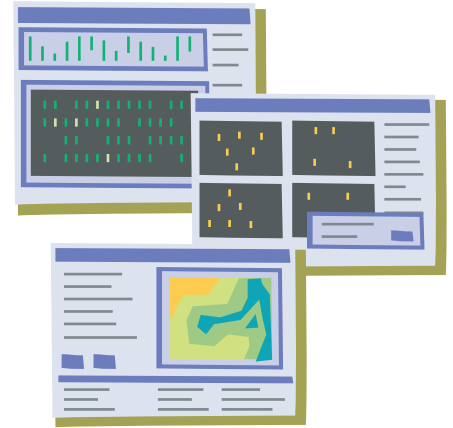
Components of LCG

Grid middleware

A challenge for the LCG project is to select and deploy appropriate middleware – the software that provides seamless access to the computing Grid, and controls and monitors its performance.

The LCG project needs tools that go beyond what is commercially available to satisfy the dynamically changing demands of the HEP community. The concept of Virtual Organization, launched by academic Grid initiatives, is a particularly powerful tool in this context.

The Grid middleware must also ensure optimal load balancing between the centres. For this, it is necessary to accurately monitor the resources in each of the LCG sites, the data they are storing and the status of the network between the sites. For this purpose, the LCG project depends upon several other projects for the supply of much of the specialized software used to manage data distribution and access as well as job submission and user authentication and authorization, software known collectively as the Grid middleware. The contributing projects include Globus, Condor, the Virtual Data Toolkit and the gLite toolkit of the EGEE project.



Fabric management

Each of the centres participating in the LCG project must manage a large collection of computers and storage systems, referred to as the fabric. Installing and regularly upgrading the necessary software manually is labour intensive. In addition, each of the Tier-1 centres must maintain large disk and tape servers which need to be upgraded regularly.



For these reasons, the sites involved in LCG will use fabric management systems, such as the Quattor system developed at CERN, to automate the running of a service based on large numbers of commodity components – always ensuring that the correct software is installed, from the operating system all the way to the experiment-specific physics libraries. The fabric management software also publishes this information so that it is available to the overall Grid scheduling system, which decides which centres are able and available to run a particular job.

The LCG centres use specialised tools to manage the massive disk and magnetic tape storage systems needed for LHC, and allow applications to access the data for simulation and analysis, independent of the storage medium (tape or disk) that the data resides on. These tools include the dCache system developed at the DESY laboratory in Germany, the ENSTORE system at the Fermi National Accelerator Laboratory and the CASTOR system developed at CERN. Exchanging data between LCG centres is managed by the File Transfer Service developed by the EGEE project.

Physics software

CERN and the HEP community have a long history of collaborative development of physics applications software, and the LCG project is extending this tradition into the Grid era. The unprecedented scale and distributed nature of computing and data management at the LHC require that software in many areas be extended or newly developed, and integrated and validated in the complex software environments of the experiments. Activities include:

POOL, a data persistency framework providing petabyte-scale event data storage via a hybrid approach that combines object serialization based on ROOT I/O for bulk data storage with a transaction safe metadata component based on relational databases. POOL integrates with Grid middleware to provide navigational access to distributed data via implementation-neutral interfaces.

SEAL provides the software infrastructure, basic frameworks, libraries and tools that are common among the LHC experiments. Components include the component model, plug-in manager, an object dictionary, math libraries and scripting services.

ROOT, an object-oriented data analysis framework used by all the LHC experiments and widely used in the HEP community. It includes facilities for statistical analysis and visualization of data, storage of complex C++ object data structures (used by POOL), and distributed analysis.

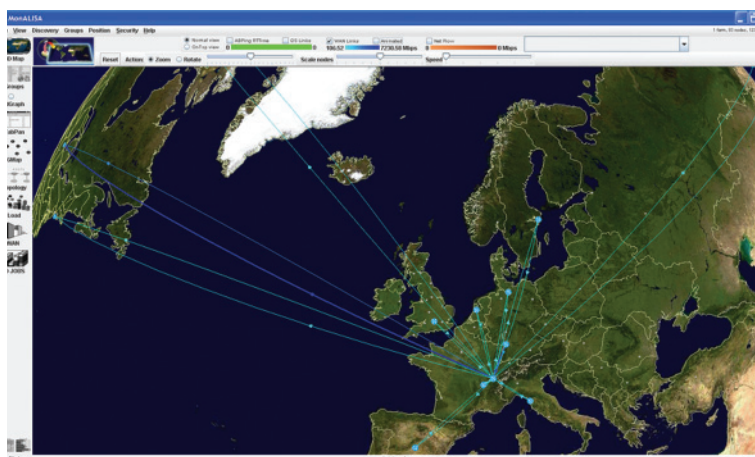
Simulation for modelling detector systems and simulating the propagation and physics interactions of particles passing through them. This project encompasses common work on the development of a generic simulation framework and infrastructure, CERN and LHC participation in Geant4, integration of FLUKA into the generic framework, physics validation of the simulation, and MC generator services.

ARDA (A Realisation of Distributed Analysis) is a project which aims to integrate generic middleware from the EU-funded EGEE project (specifically, the gLite initiative) with the physics software for the individual LHC experiments.

Networking

In the networking area, the basic requirement for storing the data from the LHC experiments is an aggregate guaranteed bandwidth between CERN and Tier-1 centres that will reach 1.6 GBytes/sec when the accelerator comes online in 2007.

Networking connectivity used by the LCG project is provided by the GEANT backbone network in Europe as well as regional and national science, education and research networks throughout the world. In order to be certain that all the data can be stored in at least two physical locations, the wide area network bandwidth between CERN and the major centres must be of the order of 10 Gbits/sec.



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