

Grid Projects: Overview, Status, and Plans

LCG Launching Workshop

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Why Grids for HEP and Other Science?

Grids are persistent environments that enable software applications to integrate instruments, displays, computational and information resources that are managed by diverse organizations in widespread locations.

Data grids for data intensive science promise to provide seamless (or at least convenient) remote access to data, to compute and storage resources, and to the experiment's software environment and tools to permit effective collaboration from home institutions.

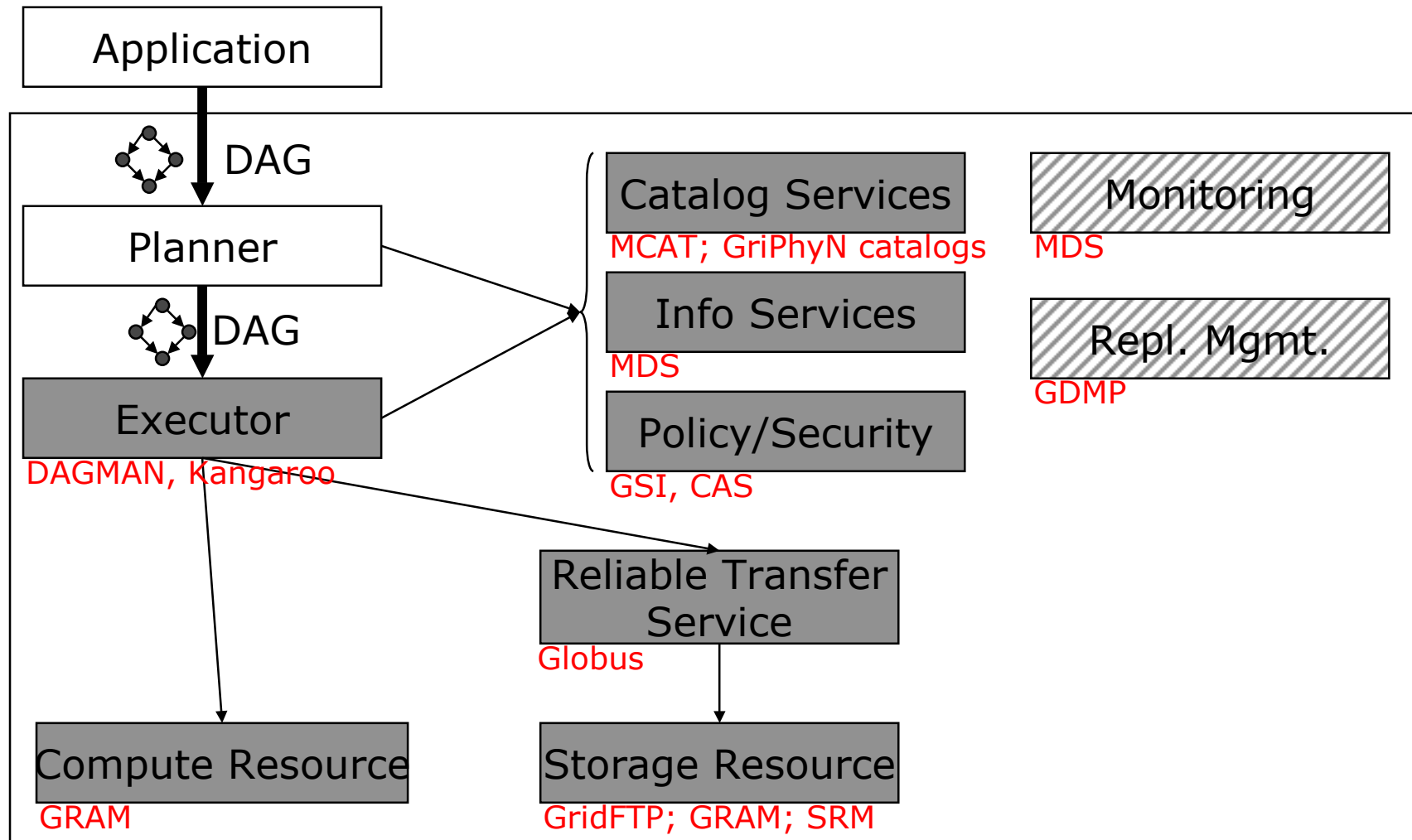
Grids as the Future of Computing?

Grids may be the general direction for business and other access to computing and information resources

There is a growing opinion in the commercial world that Grids may represent as powerful a new tool as the Internet or World Wide Web

Note recent announcements from IBM and other mainstream computing and software suppliers and strong participation in Global Grid Forum

Data Grid Architecture



Grey box = some [perhaps partial] solution exists

The Grid Before HEP Interest

Condor

- develop, implement, deploy, and evaluate mechanisms and policies that support High Throughput Computing (HTC) on large collections of distributively owned computing resources.
 - ◆ *University of Wisconsin; Begun 1988*

Globus

- Developing fundamental technologies needed to build computational grids
 - ◆ *Argonne National Laboratory and USC Information Sciences Institute; Begun 1996*

Storage Resource Broker

- Client-server middleware that provides a uniform interface for connecting to heterogeneous data resources over a network and accessing replicated data sets.
 - ◆ *San Diego Supercomputer Center; Begun 1996*

Current HEP-Related Data Grid Projects

Particle Physics Data Grid (PPDG) *US HENP Experiments*

EU DataGrid (EDG) and National Projects

- Italy *HEP, Earth Observation, Biology*
- UK
- France
- Holland
- Others

Grid Physics Network (GriPhyN) *ATLAS, CMS, LIGO, SDSS*

Data TAG

International Virtual Data Laboratory (iVDGL)
ATLAS, CMS, LIGO, SDSS, NVO

Cross Grid

Japanese Grid Projects

LHC Grid Computing Grid Project

Particle Physics Data Grid (PPDG)

<http://www.ppdg.net/>

Started 1999; funded by US DOE; SciDAC project 2001-2004

Goal: Enabling and enhancing data intensive experimental particle physics by “vertical integration” of Grid middleware components into HENP experiments’ ongoing work; Pragmatic development of common Grid services and standards - data replication, storage and job management, monitoring and planning.

Deliverables

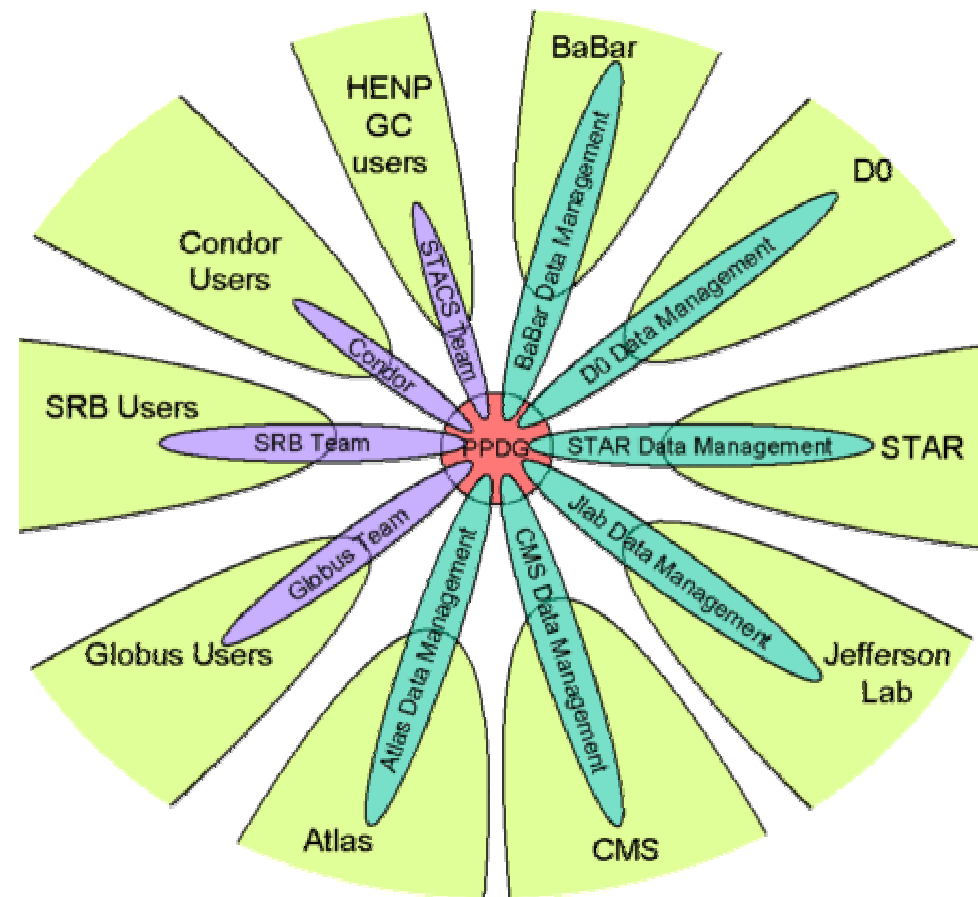
- Deploy reliable file transfer, replica catalog
- Resource monitoring & status reporting
- Job description language specification
- Deploy PKI Registration Authority under DOESG CA
- Integration of file transfer, replica catalog and job control in some experiments’ production services
- Deploy file replication services with reliable file transfer and cache management
- Storage resource discovery and prototype storage resource scheduling
- Experiment specific event & object collection replication in addition to file-based replication service
- Deployment of production distributed data analysis and remote job submission for end-user physicists

Particle Physics Data Grid (PPDG)

<http://www.ppdg.net/>

Major dependencies:
PPDG is primarily
aimed at making grid
middleware work for
experiments

Current status: Focus has
been on high
performance file
transfer and
replication and on
registration/
authentication
services.



EU DataGrid (EDG)

<http://www.eu-datagrid.org/>



EDG Project Objectives

- To build on the emerging Grid technology to develop a sustainable computing model for effective share of computing resources and data with special focus on LHC and HEP applications
- Supported by IST programme of EU with 9.8 Millions Euros over 3 years, 2001-2003 (mostly for staff, 90% for HEP)
- Specific project objectives:
 - Middleware for fabric & Grid management (mostly funded by the EU):
 - evaluation, test, and integration of existing M/W S/W
 - research and development of new S/W as appropriate
 - Large scale testbed (mostly funded by the partners)
 - Production quality demonstrations (partially funded by the EU)
- To collaborate with and complement other European and US projects (i.e. of RN/Geant)
- Contribute to Open Standards and international bodies:
 - Co-founder of Global GRID Forum and host of GGF1 and GGF3
 - Industry and Research Forum for dissemination of project results
- Main Partners: CERN, France: (CNRS), Italy (ESA/ESRIN, INFN), Netherlands (NIKHEF), UK (PPARC)

EDG Organization and Schedule

- WP 1 Grid Workload Management
- WP 2 Grid Data Management
- WP 3 Grid Monitoring services
- WP 4 Fabric Management
- WP 5 Mass Storage Management
- WP 6 Integration Testbed
- WP 7 Network Services
- WP 8 HEP Applications
- WP 9 EO Science Applications
- WP 10 Biology Applications
- WP 11 Dissemination
- WP 12 Project Management

- TestBed 0 (early 2001)

 - International test bed 0 infrastructure deployed

 - Globus 1 only - no EDG middleware

- TestBed 1 (now)

 - First release of EU DataGrid software to defined users within the project:

 - LHC/HEP experiments, Biology applications, Earth Observation

- **Successfully passed First EU Review on March 1st 2002**

- TestBed 2 (Sept-Oct. 2002)

 - Builds on TestBed 1 to extend facilities of EU DataGrid

- TestBed 3 (March 2003) & 4 (Sept 2003)

- Final project release by 31 December 2003

EDG National Components: Italy

INFN-Grid is



- Project, funded by INFN (total funding ~ 10MEuro), started Jan 2000 and it will last till Dec 2003
- Driven by LHC experiments: Alice, Atlas, CMS, LHCb and by other experiment and projects like Virgo and APE.
- Support for: LHC Computing Grid Project, DataTAG, National Italian GRID project (submitted last year), SecureGRID (submitted in Feb. this year).
- Dedicated Man power (~ 55 FTE shared between IT and Physicists, 9 funded by Datagrid, 8 by DataTAG)

EDG National Components: Italy

Present testbed and results



- INFN testbed includes:
 - Dedicated resources for middleware testing and validation (18 sites)
 - Tier1 prototype at CNAF
 - Experiments Tier2, Tier3 structure
- Extensive trials of remote job submission using CMS applications (first half of 2001):CNAF,PD,PI
- First productions for Alice, using Globus-1 and a web interface (summer 2001 Catania, Cagliari and Torino)
- Atlas tests between INFN(milano,roma) and CERN using globus-1 and grid-ftp

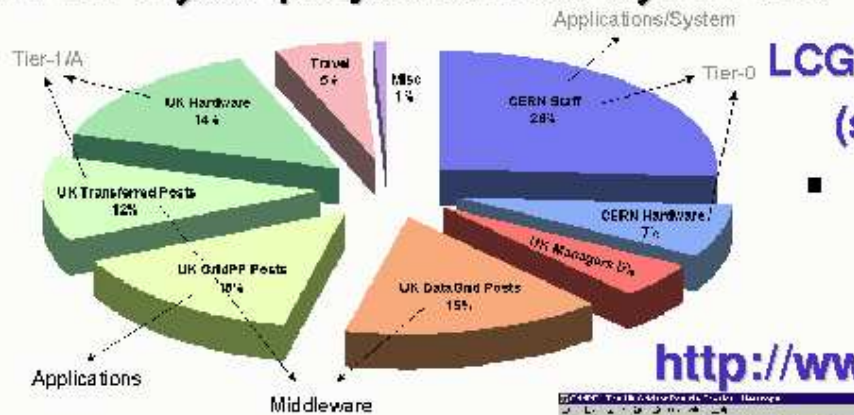
EDG National Components: UK



GridPP



£17m 3-year project funded by PPARC



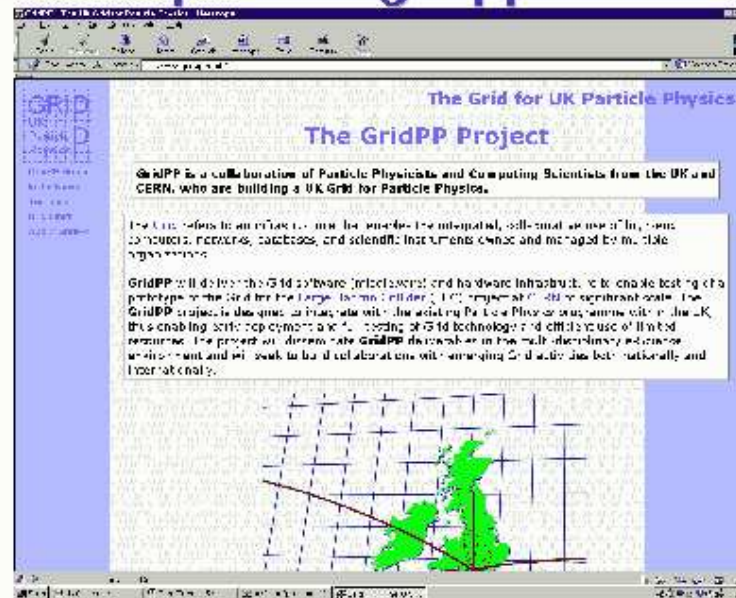
(start-up phase)

- funding for staff and hardware...

<http://www.gridpp.ac.uk>

Applications (start-up phase)

- BaBar
- CDF/D0 (SAM)
- ATLAS/LHCb
- CMS
- (ALICE)
- UKQCD



EDG - UK Contributions

- Architecture
- Testbed-1
- Network Monitoring
- Certificates & Security
- Storage Element
- R-GMA
- LCFG
- MDS deployment
- GridSite
- SlashGrid
- Spitfire...

UK Tier1/A Status



Current setup

14 Dual 1GHz PIII, 500MB RAM
40GB disks

Compute Element (CE)

Storage Element (SE)

User Interface (UI)

Information Node (IN)



+Central Facilities

(Non Grid)

250 CPUs

10TB Disk

35TB Tape

(Capacity 330 TB)



Hardware Purchase for delivery in March 2002

156 Dual 1.4GHz 1GB RAM, 30GB disks

26 Disk servers (Dual 1.266GHz) each with 1.9TB disk

Expand the capacity of the tape robot by about 35TB

EDG National Components: France

The French DATAGRID effort

- ⌘ --25 FTEs (7 EU recruited)
- ⌘ **Test Bed** (F. Etienne (Marseille) WP manager)
 - ⊠ IN2P3 labs : Lyon Computing Center, Marseille, LAL Orsay, Grenoble, Nantes, Clermont
 - ⊠ HEP applications
- ⌘ **Networking** (P. Primet, Lyon, WP manager)
 - ⊠ ENS Lyon, Lyon CC
- ⌘ **Biology** (C. Michau/ V. Breton (Clermont Ferrand) WP manager)
 - ⊠ Parasitology genomics (Clermont Ferrand)
 - ⊠ Human genome, medical imaging (Lyon)
 - ⊠ Collaborations starting with EMBL, EBI, etc...
- ⌘ Plus **participation** in some other workpackages (Earth Observation, fabric management, data storage)
- ⌘ **Important contribution** of CS in Dissemination and Project Management

The IN2P3 Lyon Computing Center

- ⌘ The **main asset** for HEP in France is the **IN2P3 Computing Center** in Lyon (D. Linylin, director)
 - ⌘ - 1000 CPU
 - ⌘ 6 tape silos , 36000 slots 0.7 to 2 PBytes
 - ⌘ - 40 TB disk space
 - ⌘ 2000 users, **40 experiments** from all over the world 4 LHC experiments, BABAR, D0, VIRGO, AUGER, etc...
 - ⌘ 40 FTE, 8 M€/€ consolidated annual budget
 - ⌘ - **20 years of experience**
- ⌘ Was reserved to national use (used and co financed by DAPNIA since 1994) but is recently opening towards **international usage**
- ⌘ One of the few major computing center in the world not attached to an accelerator site

February 8 , 2002

Guy Wormser, LISHEP 2002

EDG National Components: Holland



The DutchGrid Platform

- Collaboration of projects from
 - Computer Science, HEP and service providers
- Participating and supported projects
 - [Virtual Laboratory](#) (national, 1999-2002 +follow-up)
 - Computer Science distributed cluster computer [DAS-2](#) (national, 2002–)
 - EU [DataGrid](#)
 - EU [DataTAG](#)
 - [D0 Grid](#)
- [Coordination is primary goal](#) → resource sharing between different projects

EDG National Components: Holland



Various Deliverables

- Security for local centres and the Grid at large
 - WP4 Gridification
 - IRTF AAAARCH research group
 - policy languages
 - inter-domain AAA protocol (for resource co-allocation)
- Large testbed taken from many organizations
 - see resource overview
- Applications
 - Common Application Toolkit architecture for LHC
 - VO support
 - Extensive Grid support for developers in experiments



GriPhyN Project Overview

<http://www.griphyn.org/>

- Goal: increase scientific productivity
 - ◆ Facilitate data finding, sharing, auditing & re-creation through *virtual data techniques*
 - ◆ Make a global peta-scale data grid as *easy to use as a workstation* through *automated planning*
 - ◆ Engage schools and industry through *outreach*
- NSF Sponsored: \$11.9M (+ \$1.6M matching)
- 5 year project – started October 2000
- 17 universities, 3 national labs, SDSC
- 4 frontier experiments: ATLAS, CMS, LIGO, SDSS
- > 40 active participants
- Focus is *IT research*: 2/3 CS + 1/3 physics



GriPhyN Deliverables

- **Develop a data grid architecture**
 - ◆ Joint with PPDG and other parties
- **Implement Virtual Data Toolkit**
 - ◆ Base Grid technologies: Globus, Condor, DataGrid components (GDMP,...)
 - ◆ Virtual Data Catalog
 - ◆ Request Planners – transform DAGs for execution
 - ◆ Request Executors – DAGman/Condor-G with enhancements as research proceeds
- **Successful use of virtual data and advanced planners by our 4 experiments**

Data TAG

<http://www.datatag.org/>



In a nutshell

- ◆ Start date: January, 1, 2002
- ◆ Duration: 2 years (aligned on DataGrid)
- ◆ Funded manpower: ~ 15 persons/year
- ◆ Two main focus:
 - Grid related network research (WP2, WP3)
 - Interoperability between European and US Grids (WP4)
- ◆ 2.5 Gbps transatlantic lambda between CERN (Geneva) and StarLight (Chicago) around July 2002.
 - Dedicated to research (no production traffic)
 - In principle open to other EU Grid projects & ESA for demonstrations



Goals & outcomes

- End to end Gigabit Ethernet performance using innovative high performance transport protocols.
- Assess inter-domain QoS and bandwidth reservation techniques.
- Interoperability between some major GRID projects in Europe and North America
 - DataGrid, possibly other EU funded Grid projects
 - PPDG, GriPhyN, Teragrid, IVDGL (USA)

International Virtual Data Grid Laboratory (iVDGL) <http://www.iVDGL.org/>

iVDGL: A Global Grid Laboratory

“We propose to create, operate and evaluate, over a sustained period of time, an international research laboratory for data-intensive science.”

From NSF proposal, 2001

→ International Virtual-Data Grid Laboratory

- ◆ A global Grid laboratory (US, EU, Asia, South America, ...)
- ◆ A place to conduct Data Grid tests “at scale”
- ◆ A mechanism to create common Grid infrastructure
- ◆ A facility to perform production exercises for US-CMS, US-ATLAS
- ◆ A laboratory for other disciplines to perform Data Grid tests
- ◆ A focus of outreach efforts to small institutions

→ U.S. part funded by NSF (2001-2006)

- ◆ \$13.7M (NSF) + \$2M (matching)

iVDGL Participants

→ Funded by NSF proposal

- ◆ US-CMS, US-ATLAS, LIGO, SDSS, NVO
- ◆ U.S. Universities and laboratories (Tier1, Tier2, Tier3)
- ◆ U.S. Grid Operations Center (GOC) at Indiana
- ◆ U.S. CS support teams for supporting Grid toolkits
- ◆ Outreach efforts

Not just HEP



→ Experiments/labs requesting participation

- ◆ ALICE, CMS-HI, D0, BaBar, BTeV, PDC (Sweden)

→ Partners

- ◆ Now: TeraGrid, EU DataGrid, EU projects, Japan, Australia
- ◆ Later: (1) Brazil, (2) LCG?, (3) GOCs in EU, Asia?

→ High level of coordination with DataTAG

- ◆ Transatlantic networking (2.5 Gb/s) connecting sites
- ◆ Jointly provide staff for GLUE coordination effort



<http://www.cyfronet.krakow.pl/crossgrid/>

New Grid Project funded by EU IST Directorate Funding Received 1 March 2002

Main goals

- **Extend grids more broadly**
 - ◆ *11 additional countries*
- **Focus on applications that are interactive or require near-real-time response in addition to being compute and data intensive**
 - ◆ *Biomedical imaging*
 - ◆ *Distributed data analysis in HEP*
- **Interoperate with other grid projects**
- **User friendly environment**
- **International Testbeds**

Japanese Grid Projects

Grid Cluster Federation

- Proposed to government: waiting for approval
- 2002-2006
- Includes peta-scale distributed data storage system
- 1,250 Million JPY (= 10M USD) requested from METI
- Multiple applications envisioned
 - ◆ *KEK high energy physics*
 - ◆ *Digital human project -- scanning a human body with MRI/X-ray CT*
 - ◆ *Astrophysics*
 - ◆ *Others*

Japanese Grid Projects

High Energy Physics

- **KEKB/BELLE**

- **KEKB is the $e^+ e^-$ collision (3.5 GeV + 8 GeV) experiment to search for CP violation**
Similar to SLAC/BaBar experiment

- **LHC/ATLAS**

- **Japan is a member of ATLAS group**
- **Experiment starts in 2006**
- **Tier 1 Regional Center at Univ. of Tokyo**

- **Typical Tier 1 Center would have**

- **200,000 SPECint95**
- **Storage (1/3 of Event Summary Data)**
Disk 500TB + Tape 250 TB = Total ~1 PB

**80 cpu cluster
planned for DC1;
100 cpu cluster now
at KEK; use of 256
cpu's at Tokyo Inst.
Tech.**

Grids Beyond HENP: US Grids Center

www.grids-center.org

GRIDS: Grid Research, Integration, Deployment, & Support

- www.grids-center.org

Part of NSF Middleware Initiative

- Integration participants are GRIDS Center and Internet-2

NSF-funded center to provide

- State-of-the-art middleware infrastructure to support national-scale collaborative science and engineering
- Integration platform for experimental middleware technologies

ISI, NCSA, SDSC, UC, UW + commercial partners

NMI Software releases provide foundation for VDT

- GriPhyN early target for NMI software

Mature VDT elements will be folded into NMI releases

NMI initiating cross agency Grid coordination

Grids Beyond HENP

EuroGrid <http://www.eurogrid.org/>

Earth Systems Grid

UK eScience Initiative <http://www.research-councils.ac.uk/escience/>

TeraGrid <http://www.teragrid.org/>

- **National scale infrastructure for computational science**
 - ◆ *Joint project between NPACI and The Alliance (NCSA)*
- **Next generation computational environment with focus on Grid-based applications**
- **Heterogeneous resource base**
 - ◆ *Computer, storage, graphics*
- **GriPhyN called out as target TeraGrid application community**
- **Common Grid infrastructure elements between TeraGrid & GriPhyN**
 - ◆ *NMI, SRB, etc.*

Grid Deliverables for LHC

EU Datagrid so far (Software releases for testbed starting Dec. 2001)

- WP1: development of "super scheduling" component using application data and computing elements requirements
- WP2: deployment of GDMP in testbed1; foreseen future developments on Replica Manager based on testbed1 usage
- WP3: development of Ftree caching backend module based on OpenLDAP, deployed in testbed 1; design of Relational Grid Monitoring Architecture (R-GMA) (D3.2)
- WP4: defined an agreed architecture for fabric management (D4.2); initial implementation deployed at several sites in testbed 1
- WP5: Definition of Architecture and Design for DataGrid storage Element (D5.2) and review of requirements
- WP6: successful integration of first EDG S/W release and deployment on testbed 1 at approx 8 sites.
- WP7: initial network monitoring architecture defined (D7.2) and first tools deployed in testbed 1
- WP8: definition of common layer for HEP experiments started
- WP12: 21 partners up and running, 3 subsidiaries EU projects (DataTAG, CrossGrid, GridSTART) launched, 2000 pages of documentation delivered to the EU

Grid Deliverables for LHC

EU Datagrid still to come with successive testbeds

- WP1: Support for automatic proxy renewal (via MyProxy); Development of APIs for the applications; Specification of job dependencies; Deployment of Accounting infrastructure over Testbed; Advance reservation API; Support for job partitioning
- WP2: New Hierarchical Replica Catalog; Replica Catalog & Replica Catalog Meta-data integrated; Replica Manager; Grid Metadata service
- WP3: GRRP (develop multi machine tests); schema and registry replication; Notification services
- WP4: Add Simple LCAS (Local Community Authorization Service) Library; High Level Definition language and compiler ; Monitoring: alarm display; transport layer & repository management
- WP5: Disk manager system for standalone disk-only SE; SE control software with reservation, pinning, quotas
- WP7: Define network inputs that will be used by schedulers; define network quality of service requirements; Quality of Services implementation
- WP8: definition of common layer for HEP experiments started
- WP12: 21 partners up and running, 3 subsidiaries EU projects (DataTAG, CrossGrid, GridSTART) launched, 2000 pages of documentation delivered to the EU

Grid Deliverables for LHC

Particle Physics DataGrid (PPDG)

- Integration of Applications and Middleware - Working with the local environment
- End-to-End Applications - Integrate with the existing landscape.
- Address holes that would prevent Experiment use - Ensure Useful Work
- Recognise project effort small compared with available and active experiment effort and CS development groups - Think Globally Act Locally

- Focus on:
 - Year 1 - robust and performant file transfers and replication
 - Year 2 - distributed job management and production for experiment data processing and analysis
 - monitoring and performance analysis
 - Year 3 - prediction, planning, job and data placement
 - extensions up the experiment application stack.

Grid Deliverables for LHC

GriPhyN: bringing CS research to bear on experiment application needs

- Virtual Data - Materialization and Transformation of data. Addressing issues of multiple experiment catalogs at the application layers.
virtual data catalog (VDC): a relational schema that describes entities and relationships involved in tracking the derivation of data objects and virtual data language (VDL): a textual language that is used to (a) define how data objects are derived and (b) request the execution of those derivations
- Job Request Planning and Optimization
- Fault Tolerance - research into algorithms for production use of 1000s of grid sites.
- Optimized data selection, data and job placement
- Provide results of the work as an integrated toolkit for application use
- Demonstrations “pushing the boundaries” for challenges such as SCxxx, iGrid etc.

Grid Deliverables for LHC

iVDGL: Testbed Extension of GriPhyN with international partners

- Deploy the Physics Grids in the US
- Ensure the US Physics Grids work with the European, South American, Asian.. Physics Grids.
- Provide central operational support - iGOC
- Use and support the common software - VDT support and operation
- Reuse the hardware for range of applications. Deploy applications on new Grids as they emerge.

DataTAG: Networking Extension of EDG

- Grid-Related Network Research
- Interoperability between European and US Grids
- 2.5 Gbps Transatlantic Research Link
- QoS (Quality of Service)
- TCP/IP performance over high bandwidth, long distance networks
- Line Error rates
- End to end performance in the presence of firewalls
- Evolution of LAN infrastructure to 1Gbps/10Gbps

HEP Grid Coordination Effort: HICB

<http://www.hicb.org/>

Participants in HICB

- GriPhyN, PPDG, iVDGL, TeraGrid, EU-DataGrid, CERN
- National efforts (USA, France, Italy, UK, NL, Japan, ...)

Have agreed to collaborate, develop joint infrastructure

- 1st meeting Mar. 2001 Amsterdam (GGF1)
- 2nd meeting Jun. 2001 Rome
- 3rd meeting Oct. 2001 Rome (GGF3)
- 4th meeting Feb. 2002 Toronto (GGF4)

Coordination details

- Joint management, technical boards, open software agreement
- Inter-project dependencies, mostly High energy physics
- Grid middleware development & integration into applications
- Major Grid and network testbeds ⇒ iVDGL + DataTAG

Complementary

HEP Grid Coordination Effort: HIJTB

<http://www.hicb.org/>

HIJTB is the Technical Coordination Subcommittee of HICB

- Europe, US, and Asia Representatives
- Meet monthly by telephone or video (starting October 2001)

Topics for HIJTB

- Common Infrastructure Issues
 - ◆ *Certificate and Registration Authorities*
 - ◆ *Alignment and Interoperation of Grid Architectures*
 - ◆ *Joint Testbeds*
 - Many experiment projects interested in making their testbeds cooperative with HIJTB (BaBar, D0, LHC expts,...)
 - “Infrastructure” testbed to test low-level compatibility of middleware from different projects

GLUE: Grid Laboratory Universal Environment

- Evolution of HIJTB proposal of infrastructure testbed
- NOT yet another testbed, but a collaboration of existing and planned testbeds, especially iVDGL and DataTAG

HEP Grid Coordination Effort: GLUE

<http://www.hicb.org/>

GLUE Statement of Purpose

- GLUE, as the interoperability activity of the HIJTB, will be a collaboration of other datagrid projects, especially iVDGL and DataTAG who will supply effort.
- The HIJTB will be the forum for coordination and planning of the joint effort and will encourage the participants to develop an appropriate organization of the work with well defined responsibilities, and will track progress.
- GLUE will work to assemble a core of common software components of grid middleware drawn from EDG, GriPhyN, PPDG, and others, designed to become the base middleware of the grids that will be run by each project separately.

HEP Grid Coordination Effort: GLUE

<http://www.hicb.org/>

GLUE Statement of Purpose (continued)

- One result should be that EDG and GriPhyN/PPDG testbeds will be able to function as a single entity.
- GLUE will not necessarily assemble a complete system of middleware, but will choose components to work on that raise particular issues of interoperability or are otherwise central.
- As the Glue collaboration begins to have a usable suite of components working together, experiments will be invited to join the collaboration to build and test their applications with the GRIT suite.
- Glue will work with grid projects to encourage experiments to build their grids using the common grid software components.

Global Grid Forum

International Working Group on Grid Computing

Has grown from first meeting in Amsterdam (Mar 2001) with 200 registrants to 4th meeting in Toronto (Feb 2002) with 450 registrants

Strong participation by developers, application users, industry

Promote Grid technologies via "best practices," implementation guidelines, and standards

Meetings three times a year

- International participation, hundreds of attendees

Many HENP participants contributing to GGF

- Working group chairs, document production, etc.

Mature HENP technologies should transition to GGF

Conditions for Success

Although Grids have become fashionable and there are many projects, including several focused on HEP, the *aggregate* is only *approaching* the total needed for success with LHC and other projects

No project, including LCG, can deliver the grid middleware and integration with experiment software alone

The HEP-oriented data grid projects must continue to organized themselves in a highly coordinated way to eliminate duplication and ensure completeness

Continued collaboration with other disciplines is important for us and for sponsors so our software is as compatible with emerging standards as possible

Conclusions

The Grid concept promises important relief from the problems of distributed data-intensive science (in addition to compute-intensive applications)

LHC (and LCG) has a large set of grid projects to draw on for tools and assistance

Although the Grid concept is well established, many of the required practical tools remain to be invented and much work is needed

Advances in distributed and cooperative project management will also be needed if the LHC projects are going to succeed.