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Part 1: Inventory of ICT Stakeholders

Reference

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee GRID (GRID).

The present document is part 1 of a multi-part deliverable covering the Study of ICT Grid interoperability gaps, as identified below:

Part 1: "Inventory of ICT Stakeholders";

Part 2: "Interoperability Gaps and proposed solutions".

Introduction

It is the aim of this multipart deliverable to contribute to an improvement in worldwide co-operation in the ICT-Telecom collaborative Grid standardization efforts. This activity is aligned with the i2010 initiative, NESSI ETP and the Next Generation Grid (NGG) vision of the Service Oriented Knowledge Utility (SOKU).

Recognizing the valuable work already undertaken within the Grid communities, the present document seeks to identify the current status of Grid technologies and identifies specifications used within a Grid environment and will form a basis for the Gap analysis which will be contained in TR 102 659-2 [i.105]:

- Provides an introduction to Grid requirements and architectures.
- Identifies the key Grid stakeholders, these include:
  - Organizations developing Specifications and Standards specifically for Grids;
  - Organizations developing Specifications and Standards which are developed for other, or general use, and are used by Grids;
  - Key European Grid Projects;
  - Implementations with Grid like characteristics;
  - Companies with Grid like products.
- Identifies an initial set of interoperability scenarios in order to assist in the task of capturing gaps and overlaps in standards.
- Identifies the interoperable standards created by, or used by, Grid stakeholders.

It is recognized that Grid is evolving at a fast pace. The intention of the present document is to capture the current status of Grid standardization and form a basis of TR 102 659-2 which will, analyse the standards used, identify interoperability gaps and overlaps and recommend how to address and resolve these.

1 Scope

The present document addresses the need to identify interoperability gaps in existing and emerging Global/European Grid standards. It provides an inventory and analysis across the range of relevant standards-making bodies with a view to determining the shortcomings; overlaps and loopholes in current, proposed, and *de facto* Grid standards at all levels of the middleware/protocol stack (network to application interfaces), with specific consideration for large-scale commercialization and interoperability of standards/systems relevant to the ICT sector (*i.e.* the ETSI constituency).

The present document is part 1 of a multi-part deliverable providing a study of ICT Grid interoperability gaps. The present document captures the current state of Grid technologies and identifies the key stakeholders, including standards making bodies, research projects, production grids and other initiatives. Additionally, it identifies a recommended base of standards and *de facto* standards in the form of a Grid ICT Profile, taking into account the requirements for interoperability in the ICT domain.

Part 2 provides a gap analysis and recommendations on how to address and resolve them.

The present document is a response to Item 1, Action 2 of the EC 2006 ICT Standardization Work Programme.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

- For a specific reference, subsequent revisions do not apply.
- Non-specific reference may be made only to a complete document or a part thereof and only in the following cases:
  - if it is accepted that it will be possible to use all future changes of the referenced document for the purposes of the referring document;
  - for informative references.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

Not applicable.

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

consumer: person, organization, software component or higher-level system that is authorized, by the Service Customer, to makes use of a service offered by a service provider

NOTE 1: Service Consumer is synonymous the terms Service Requestor (GFD-120), User (ETR 309 [i.102]) and End User (ES 202 488-2 [i.103]).

NOTE 2: The above definition is based on the definition of Service Requester in the OGSA Glossary (GFD-120).

cloud or cloud computing: rapidly provisioned infrastructure (e.g. compute, storage, network resources) that supports dynamic scaling with uniform interfaces to these resources

customer: role that contracts for the services offered by a service provider based on a contractual relationship

NOTE: The above definition is based on the definition of "customer" in TS 188 003 [i.104].

Grid or Grid computing: Grid is a system that is concerned with the integration, virtualization, and management of services and resources in a distributed, heterogeneous environment that supports collections of users and resources (virtual organizations) across traditional administrative and organizational domains (real organizations)

NOTE 1: Source OGF GWD-I 120 [i.1].

NOTE 2: In the present document, the terms "a Grid" or "Grids" are used for implementations of Grid technologies. The term "the Grid", is used by many organizations to describe their activities, however it is thought that this term implies a single "global" fully interoperable Grid. It is recommended that this term is reserved for the, as yet unrealized, goal of a single world wide interoperable Grid.

Grid infrastructure: entirety of all entities and services, hardware and software, that realize a Grid environment

EXAMPLE: This includes pools of virtualized resources, core and user focused services.

Grid Middleware: software designed to provide a uniform interface between higher level software and lower level generic functionality in a grid environment

NOTE: Source TR 102 767 [i.66].

Grid resource: physical or logical entity that supports use or operation of a computing application or environment in a grid context

NOTE 1: It is an entity that is accessed through core Grid services and provides either a capability or capacity (e.g. servers, networks, compute clusters, disks, memory, databases, IP addresses, and software licenses).

NOTE 2: This definition is adapted from OGSA Glossary - GFD.120 (Source OGF GWD-I 120 [i.1]).

Grid service: service interface associated with a Grid resource

NOTE 1: A resource, logical or physical, and its state (statefulness is the defining characteristic of a Grid service) is controlled and managed via Grid services in a Grid environment.

NOTE 2: This definition is based on IBM Redbook "Introduction to Grid Computing" (http://www.redbooks.ibm.com/redbooks/pdfs/sg246778.pdf).

Service Provider: entity that provides a service, or a set of services, to one or more service consumers based on a contractual agreement with the service customer

Virtual Organization (VO): set of individuals and/or institutions having direct access to computers, software, data, and other resources for collaborative problem-solving or other purposes

NOTE 1: VOs are a concept that supplies a context for operation of a Grid that can be used to associate users, their requests, and a set of resources. The sharing of resources in a VO is necessarily highly controlled, with resource providers and consumers defining clearly and carefully just what is shared, who is allowed to share, and the conditions under which sharing occurs. (Source OGF GWD-I 120 [i.1].)

NOTE 2: Use of the term "application" is discouraged, but if used, the term should always be further qualified or defined when used (e.g. User Application, Grid Application).

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AAF	Application Archive Format
AD	Area Directors
AI-ESTATE	Artificial Intelligence Exchange and Service Tie to All Test Environments
API	Application Programming Interface
ARC	Advanced Resource Connector
ARI	Application Repository Interface
ASF	Alert Standard Format
ATE	Automatic Test Equipment
ATM	Asynchronous Transfer Mode
BEEP	Blocks Extensible Exchange Protocol
BMBF	German Federal Ministry of Education and Research
BPEL	Business Process Execution Language
CERN	European laboratory for particle physics
CERNET	China Education and Research NETwork
CGM Open	Computer Graphics Metafile Open
CGSP	ChinaGrid Supporting Platform
CIFS	Common Internet File System
CIM	Common Information Model
CLP	Command Line Protocol
CNRS	Centre National de la Recherche Scientifique (National Scientific Research Centre)
COPS	Agent Communication Language
CPPA	Collaboration Protocol Profile and Agreement
CPU	Central Processing Unit
CSG	Candidate Set Generator
CSS	Cascading Style Sheets
DASC	Design Automation Standards Committee
DBMS	DataBase Management Systems
DDF	Disk Data Format
DDFDL	Data Format Description Language

DEN	Directory Enabled Networks
DGI	D-Grid Infrastructure
DMI	Desktop Management Interface
DMTF	Distributed Management Task Force
DRM	Distributed Resource Management
EAP	Extensible Authentication Protocol
EbXML	Electronic business using eXtensible Markup Language
EDA	Electronic Design Automation
EDR	Electronic Data Records
EGA	Enterprise Grid Alliance
EGEE	Enabling Grids for E-sciencE
EKMI	Enterprise Key Management Infrastructure
EMS	Execution Management Services
E-NNI	External Network-Network Interface
EPS	Execution Planning System
ERP	Enterprise Resource Planning
eTOM™	Telecom Operations Map
ETSI	European Telecommunications Standards Institute
FCAS	Fixed Content Aware Storage
FCIA	Fibre Channel Industry Association
FIPA ACL	Foundation for Intelligent Physical Agents Agent Communication Language
FP	Framework Programme
FSM	File System Management
FWSI	Framework for Web Services Implementation
GAT	Grid Application Toolbox
GCM	Grid Component Model
GFD	Grid Forum Document
GGF	Global Grid Forum
GMA	Grid Monitoring Architecture
GMAS	Grid Medical Archive Solution
GPFS	General Parallel File System
GRDDL	Gleaning Resource Descriptions from Dialects of Languages
GSS-API	Generic Security Services API
GT	Globus Toolkit
HCG	Hypertext Coordination Group
HPC	High Performance Computing
HTML	HyperText Markup Language
HTTP	HyperText Transfer Protocol
I/O	Input/Output
IAB	Internet Architecture Board
IANA	Internet Assigned Numbers Authority
IAs	Implementation Agreements
ICS	Information and Communications Services
ICT	Information and Communication Technology
IDE	Integrated Drive Electronics
Idtrust	Identity and trusted infrastructure
IEEE	Institute of Electrical and Electronics Engineers
IESG	Internet Engineering Steering Group
IETF	Internet Engineering Task Force
IIC	Implementation Interoperability and Conformance
IKE	Internet Key Exchange
ILM	Information Lifecycle Management
IM	Instant Messaging
IMAP	Internet Message Access Protocol extension
IMS	IP Multimedia Subsystem
INRIA	Institut National de Recherche en Informatique at en Automatique (National Institute for Research in Computer Science and Control
IOTTA	I/O Traces, Tools, and Analysis
IP	Internet Protocol
IPS	IP Storage
IPTV	IP TeleVision
IR	Information Retrieval

ISDN	Integrated Switched Digital Network
ISOC	Internet SOCiety
ISV	Independent Software Vendor
IT	Information Technology
ITU	International Telecommunication Union
ITU-D	International Telecommunication Union - Development sector
ITU-R	International Telecommunication Union - Radio sector
ITU-T	International Telecommunication Union - Telecom sector
JDL	Job Description Language
JMX	Java Management eXtensions
JSDL	Job Submission Description Language
LAN/MAN	Local Area Network/ Metropolitan Area Network
LDAP	Lightweight Directory Access Protocol
LegalXML	Legal eXtensible Markup Language
MAP	Management APplication
MF	Management Frameworks
MIB	Management Information Base
MIP6	Mobility for IPv6
MPI	Message Passing Interface
MPLS	Multi-Protocol Label Switching
MS-MPI	MicroSoft Message Passing Interface
MTOM	Message Transmission Optimization Mechanism
NDMP	Network Data Management Protocol
NEA	Network Endpoint Assessment
NESSI	Networked European Software and Services Initiative
NFRs	Non-Functional Requirements
NFS	Network File System (protocol)
NGG	Next Generation Grid
NGN	Next Generation Network
NGOSS	New Generation Operations Systems and Software
NGS	National Grid System
NNI	Network Network Interface
NREN	National Research and Education Network
NRNs	National Research Networks
NSF	National Science Foundation
OAI	Optimized Analytic Infrastructure
OAM&P	Operations Administration, Maintenance, & Provisioning
OASIS	Organization for the Advancement of Structured Information Standards
oBIX	open Building Information eXchange
OBS/OPS	Optical Burst/Packet Switching
OCS	Optical Circuit Switching
OGF	Open Grid Forum
OGSA	Open Grid Services Architecture
OIF	Optical Internetworking Forum
Open CSA	Open Composite Services Architecture
OSD	Object-based Storage Devices
OSG	Open Science Grid
OSS/BSS	Operational (Operation) Support System / Business Support System
OSS/J	OSS through Java™ Initiative
OTN	Optical Transport Network
OWL	Web Ontology Language
P2P	Peer-to-Peer
PACS	Picture Archiving and Communication Systems
PANA	Protocol for carrying Authentication for Network Access
PDH	Plesiochronous Digital Hierarchy
PGP	Pretty Good Privacy
PKI	Public-Key Infrastructure
PKIA	Public Key Infrastructure Adoption
PLL	Physical and Link Layer
PLM	Product Lifecycle Management
PLUG	Physical Layer User working Group
POP	Post Office Protocol

POWDER	PrOtocol for Web DEscription Resources
PPP	Point-to-Point Protocol
PSM	Policy-based Storage Management
PSTN	Public Switched Telephone Network
PWIN	Partner World Industry Network
QoS	Quality of Service
RAID	Redundant Array of Independent Disks
RAL	Rutherford Appleton Laboratory
RDF	Resource Description Framework
RFC	Request For Comments
RFI	Receiver Fixture Interface
RFI	Request For Information
RNS	Resource Naming Service
ROI	Return On Investment
RPC	Remote Procedure Call
RSS	Resource Selection Services
RSVP	Resource ReserVation Protocol
RTP	Transport for Real-Time Applications
RUS	Resource Usage Service
SAML	OASIS Security Services
SAS	Security ASsociations
SASL	Simple Authentication and Security Layer
SCA	Service Component Architecture
SCC 20	Standards Coordinating Committee 20
SCSI	Small Computer System Interface
SDD	Solution Deployment Descriptor
SDP	Session Description Protocol
SGML	Standard Generalized Markup Language
SID	Shared Information/Data model
SIMICA	Software Interface to Maintenance Information Collection and Analysis
SIP	Session Initiation Protocol
SLA	Service Level Agreement
SLP	Service Location Protocol
SM	Server Management
SMASH	Systems Management Architecture for Server Hardware
SMBIOS	System Management BIOS
SMI	Storage Management Initiative
SMIL	Synchronized Multimedia Integration Language
SMI-S CIM	Storage Management Initiative Specification Common Information Model
SMI-S	Storage Management Initiative Specification
SML	Storage Media Library
SMS	Short Message Service
SMTP	Simple Mail Transfer Protocol
SNIA	Storage Networking Industry Association
SNMP	Simple Network Management Protocol
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
SOKU	Service Oriented Knowledge Utilities
SONET/SDH	Synchronous Optical NETworking / Synchronous Digital Hierarchy
SP	Service Provider
SPARQL	SPARQL Protocol and RDF Query Language
SPC	Service Provider Council
SRM	Storage Resource Manager
SSE	Smart Storage Element
SSL	Secure Socket Layer
STFC	Science and Technology Facilities Council
STIL	Standard Test Interface Language
SVG	Scalable Vector Graphics
SWEO	Semantic Web Education and Outreach
TC	Technical Committee
TCP	Transmission Control Protocol
TISPAN	Telecommunication and Internet converged Services and Protocols for Advanced Networking

TLS	Transport Layer Security
TMF	TM Forum (formerly teleManagement Forum)
TNA	Technology Neutral Architecture
TPS	Test Program Set
TWG	Technical Work Group
UCS	Usage Control Service
UDDI	Universal Description, Discovery and Integration
UI	User Interface
UIML	User Interface Markup Language
UML	Unified Modelling Language
UNI	User Network Interface
USM	User-based Security Model
VDT	Virtual Data Toolkit
VHDL	VHSIC (Very High Speed Integrated Circuit) Hardware Description Language
VHDL-AMS	HDL Analogue and Mixed-Signal extensions
VLP	Virtual Loaner Program
VO	Virtual Organization
VOMS	Virtual Organization Management System
VPN	Virtual Private Network
W3C	World Wide Web Consortium
WBEM	Web-Based Enterprise Management
WCF	Windows Communication Foundation
WG	Working Group
WLCG	World-wide LHC Computing Grid
WS	Web Services
WS-BPEL	Web Services Business Process Execution Language
WSDL	Web Services Definition Language
WSFED	Web Services FEDeration
WSLA	Web Service Level Agreement
WSN	Web Services Notification
WSNR	Web-Service Name Resolution
WSRF	Web Services Resource Framework
WSRP	Web Services for Remote Portlets
WS-RX	Web Services Reliable eXchange
WS-SX	Web Services Secure eXchange
WS-TX	Web Services Transaction
XACML	eXtensible Access Control Markup Language
XAM SDK	XAM Software Development Kit
XAM	eXtensible Access Method
XDI	XRI Data Interchange
XHTML	extensible HyperText Markup Language
XML	eXtensible Markup Language
XRI	eXtensible Resource Identifier
XSD	XML Schema Definition
XSL	eXtensible Stylesheet Language

4 Grid Introduction

In this clause, Grids are introduced as a necessary foundation for the rest of the document:

- first the idea and properties of Grids based on leading players in the field; a presentation of the diversity of concepts covered by the term Grid, which can lead to confusion if not understood;
- the idea that Grids are commonly seen as a service-oriented concept; and an understanding of the evolution of Grids - Next Generation Grids as seen by an EU Experts' Group and the relationship of Grids to Next Generation Networks.

4.1 The idea and characteristics of Grids

Grid computing is an initiative which gives impetus to a collaboration of people and resources, initially in scientific research on a major scale, but now increasingly in business and multi-enterprise applications.

Collaboration - people and applications …
… supported by…
… the Grid …
… which gives access to …
… geographically distributed heterogeneous [network, storage, and computing] resources.

An article by Ian Foster [i.2], one of the trail blazers of Grid technology, provides a brief check list for a Grid. In this article, a Grid is a distributed computing system that:

- coordinates resources that are not subject to centralized control;
- use standard, open, general-purpose protocols and interfaces;
- to deliver nontrivial qualities of service.

In order to achieve this, Grids provide a means of access to distributed resources which satisfy a number of characteristics: scalable, dynamic, inter-operable, extensible, secure, heterogeneous, offering non-trivial quality of service, usable, manageable, federated across independent administrative domains, geographically distributed and reliable. We expand on these in clause 5.

An example of an application which may require the use of a Grid is a flood warning system. The causes of a flood may cross national boundaries so that multiple administrations and heterogeneous software solutions to manage underlying resources are involved. Resources can include large scale distributed data management, intensive compute resources, sensor fusion and collaboration among diverse experts. The application requires to respond to changing events. The overall system needs to be robust even in the presence of unreliable components.

4.2 Diverse Grid systems - both in scope and use

Recent documents from the OGF (see GFD.112 [i.4] and GFD.113 [i.3]) discuss different types of Grid. They distinguish between Grid systems in the broadest sense, which offer a platform for all types of distributed applications or services in a flexible infrastructure and more specific Grid systems (some are referred to as "Narrow Grids" in GFD.113). Specific Grid systems are justified not through broad, distributed computing implications but through application-specific requirements, technology tradeoffs and return-on-investment projections. Although in the present document we are primarily concerned with Grids that are heterogeneous, interoperable, and offer demanding QoS, it is recognized that specific Grid systems solve real problems and offer experience which can lead to improvements in future Grids in the broadest sense.

Several of these types of Grid systems are in use:

- Cluster Grid: this often refers to a homogeneous collection of equipment, nowadays offering Grid protocols to the external world. It could be regarded as a single node in a more comprehensive Grid.
- Enterprise Grid: virtualization and sharing of mission-critical applications, storage, and compute resources in a uniform way with a dynamic and heterogeneous underlying topology.
- Collaboration Grid (GFD.113) [i.3] (or Collaborative Grid (GFD.112) [i.4]): the emphasis here is on Grids used by multiple organizations or individuals who share their resources to make the most effective use of it for their combined user communities. This is close to the general, comprehensive vision of a Grid.
- Data Centre Grid: a Grid which is focussed on the specific task of data management and often focussed on the needs of a specific organization.
- High Performance Computing Grid: a Grid which is focussed on the specific task of providing compute resources to problems with large scale computing needs.
- Utility Grid: on demand basic cluster computing resources on which all user- or application-specific configuration, data, and software are then subsequently installed.

- Desktop Grid: a Desktop Grid (occasionally called a Volunteer Grid, or volunteer computing systems) utilise the free resources available in intranet and internet environments for supporting large scale computation and storage.

4.3 Service Oriented Architecture (SOA)

Closely linked to Web technologies, the Service Oriented Architecture (SOA) is a paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. In other words, SOA principles place a strong emphasis on decoupling service consumers from service providers, both at the technical as well as at the business level.

Applied at the technical level, decoupling emphasizes technologies such as Web services and asynchronous message delivery that enable consumers to make choices of implementation and availability independently of the service provider. As far as related to the business level, the service consumer should be insulated as far as possible from the details of the business logic implemented by the service provider.

SOA provides the uniform means to offer, discover, interact with and use capabilities to produce the desired effects. The SOA is defined by OASIS who has published the SOA Reference Model [i.5].

The SOA approach has been identified as a candidate for interconnecting Grid Users with Grid Services and is the foundation of the OGF's Open Grid Services Architecture (OGSA). See clause 6.1.

4.4 Next Generation Grid (NGG)

Starting in 2004, the European Commission has convened a group of experts, named the Next Generation Grid (NGG) expert group, to develop a European vision for Grid research. The NGG vision consists of three complementary dimensions:

- the end-user perspective where the simplicity of access to and use of Grid technologies is exemplified;
- the architectural perspective where the Grid is seen as a large evolutionary system made of billions of interconnected nodes of any type; and
- the software perspective of a fully programmable and customizable Grid.

To date the NGG expert group has published 3 public reports. All the three reports are available at: http://cordis.europa.eu/ist/grids/ngg.htm.

The first of the three documents entitled "European Grid Research 2005 - 2010" [i.44] was published in June 2003. It provides an expert's view on the 5 to 7 years research priorities for the European context.

The second document "Next Generation Grids 2 Requirements and Options for European Grids Research 2005 - 2010 and Beyond" [i.45] identifies the requirements and options for European Grids Research 2005 - 2010 and beyond. It was published in July 2004.

The NGG last report was published in January 2006. This report, entitled "Future for European Grids: Grids and Service Oriented Knowledge Utilities" [i.46] outlines vision and research directions 2010 and beyond.

In order to realize the Next Generation Grid vision, numerous research priorities have been identified in terms of properties, facilities, models, tools, etc., which have inspired national and international research programmes for Grid research. The previous NGG work had identified the need for two aspects:

- semantically rich facilities; and
- a service-oriented approach.

The convergence of the evolving NGG vision with the service-oriented vision of significant European industry stakeholders in Networked European Software and Services Initiative (NESSI) led the NGG group to define the scientific and technological requirements necessary to evolve Grids towards the wider and more ambitious vision of Service Oriented Knowledge Utilities (SOKU).

The SOKU vision builds on and extends the Next Generation Grids vision. It captures three key notions:

- Service Oriented - The architecture comprises services which may be instantiated and assembled dynamically, hence the structure, behaviour and location of software is changing at run-time;
- Knowledge - SOKU services are knowledge-assisted ("semantic") to facilitate automation and advanced functionality, the knowledge aspect reinforced by the emphasis on delivering high level services to the user;
- Utility - A utility is a directly and immediately useable service with established functionality, performance and dependability, illustrating the emphasis on user needs and issues such as trust.

The architectural vision provided in the first NGG report was based on the locus of services between the middleware and the operating system. In the second NGG report, this vision has been made more accurate. It assumes an architecture where the Grid's service middleware provides:

- provides a target interface for applications such that the applications request and receive the services they require;
- provides the services themselves.

While the Next Generation Grid's Foundations Middleware layer provides mappings to operating systems capabilities to make possible those services or components required of them where unavailable. This allows for multiple operating systems to be utilized within nodes in the Grid's environment. This extends the range of entities (devices, services) available in the Grid environment since it allows to include embedded systems and mobile phones or PDAs. It predicates the requirement for well-defined interfaces above and below the Grid service middleware layer and the Grid foundations middleware layer. The common interfaces are above (to applications, i.e. the Grid surface) and below (to Grid foundations middleware i.e. the defined Grid OS interface) the Grid service middleware layer

The primary difference between the SOKU vision and earlier approaches is a switch from a prescribed layered view to a multi-dimensional mesh of concepts, applying the same mechanisms along each dimension across the traditional layers.

SOKU services are distinguished from services in a typical SOA (such as Web Services) because they are described by explicit, machine-processable knowledge and they also work with explicit, machine-processable knowledge:

- SOKU services are semantically described, i.e. annotated with machine-processable metadata which facilitates their automated use. This enables them to be dynamically composed and configured, and for them to adapt automatically, providing self-management and autonomic behaviour. A SOKU service may itself consist of collections of services which are statically or dynamically orchestrated.
- SOKU services also work with semantically described content and semantic descriptions, i.e. they process knowledge - they may contain and use it, consume it, or produce it. This leads to a more generic set of services which are configured to the task at hand using explicit representations of the appropriate vocabularies, schema or ontologies.

A layered architecture might typically place middleware layers between the underlying infrastructure and the applications. However, resources and services at any level may be semantically described and may contain, consume, use or produce knowledge. Hence SOKU is not a layer in itself, but any services within an SOA can be classified as various kinds of SOKU.

It should be noted that a Next Generation Grid involves both SOKU and non-SOKU services. The SOKU vision does not mandate that all services have SOKU properties, but rather that SOKU services are used within the service-oriented architecture. SOKU services will enable the creation and orchestration of dynamic Virtual Organizations (VO) across multiple domains, ensuring secure and trusted knowledge sharing. They will involve the management of VO membership and communities, allocation of knowledge resources as well as supporting the lifecycle of the knowledge.

The three scenarios are presented in the document to illustrate the broad application of Next Generation Grids and SOKU:

- Enterprise Scenario.
- End-user Scenario.
- Manufacturing/Industrial Scenario.

The "Enterprise Scenario" illustrates the power of the virtualization and interoperability provided by Grids and SOKU within the enterprise context. The "End-user Scenario" shows the role of Grid in delivering public information services ("knowledge utilities") which respect ownership and privacy issues, and the "Manufacturing/Industrial Scenario" shows how these approaches benefit collaborative processes within industry.

The three scenarios illustrate three traditional dimensions of Grid computing - coordinated computation, the datagrid and support for distributed collaboration - and in each case this is enhanced by the adoption of the SOKU concept which provides semantically described services and the delivery of knowledge to users.

4.5 Next Generation Network (NGN)

The NGN is an initiative from the Telecoms Industry and provides interoperable, inter-domain all IP-based network solution with enhanced multimedia capabilities. Independently from the access technology, It supports mobility and nomadicity and services including:

- Person-to-Person services: voice mail, voice call, multimedia sessions, etc.
- Messaging services: e-mail, SMS, IM and presence services.
- Content-on-demand services: IPTV, browsing, download, streaming, push, and broadcast services.

The NGN functional Architecture (ES 282 001 [i.7]) identifies 2 NGN layers. A Service Layer and an IP Based Transport Layer. The NGN Release 2 definition is contained in TR 180 002 [i.8].

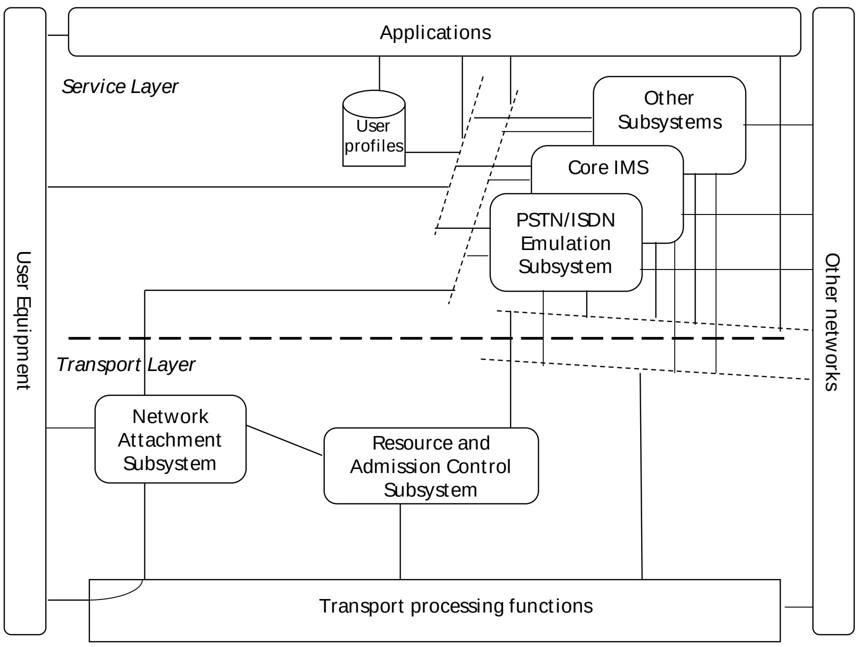

Figure 1: NGN Functional Architecture

In order to support Grid services, it is probable that the current NGN architecture would need to be extended beyond the current model. This enhanced NGN would then need to consider whether Grid aspects can be considered as:

1) a separate subsystem (Like Core IMS and PSTN/ISDN Emulation Subsystem);
2) an application;
3) another interfacing network;
4) a combination of all three.

The options above would all result in different interfaces between Grid technologies and the NGN and a different division of functionality between Grids and the NGN. The implications of these options are for further study.

The requirements for Grid services over telecom networks linked with the NGN architecture can be realized in numerous ways. From an increasingly services-oriented meta-architecture, it is possible to compose a Grid and NGN services in different ways to realize different Grid-over-NGN architectures operating concurrently. In this regard, the classical telecom view of a single system architecture is abandoned, although it is likely that there will be convergence to a small number of specific service compositions (i.e. architectures) which meet the needs of most users and service providers.

4.6 Grids and Clouds

4.6.1 The growth of Clouds

The term "Cloud computing" originates with the Amazon Elastic Compute Cloud (EC2) [i.95], the first large scale, commercial "commodity computing" service, which started with a limited beta programme in August 2006. Similar services have followed from other Internet giants such as Google, Yahoo and Sun. Amazon themselves have followed up with storage services - S3 (Simple Storage Service) and SimpleDB. "Cloud computing" is intended to convey a sense of flexible, abstracted resources featuring scalability, a pay as you use model, reliability, performance and client-initiated variation of resources accessed.

Confusingly, in some quarters Cloud can mean almost anything to do with IT on the Internet., The Wikipedia page on Cloud computing [i.71] includes BitTorrent, Skype and SETI@home. Topologically, these match the semantics of the term "cloud computing", however they are very distinct from the current usage of the term, and we would suggest are better classified simply as "Internet computing". Furthermore, products which were called Grid (and, by the definition used here, were not) are now being called Cloud (and, similarly, are not). In [i.64], 95 Cloud-related products or services are listed; the author himself seems to doubt the accuracy of the broad categorization by encouraging readers to examine carefully the features of the various products and services listed in the article. As an example, one service, SmugMug (a photo sharing web site), uses the Amazon S3 storage Cloud [i.65] but does not itself offer a Cloud service. Some of the entries also describe "grid" features, indicating the lack of distinction between the terms "grid" and "cloud", or the shift from one "buzz word" to another. A common decomposition of Cloud computing is into three layers: Infrastructure, Platform, and Software. Cloud computing, it is claimed, provides each of these "as a service" (aaS), giving rise to the acronyms IaaS, PaaS, and SaaS. SaaS has been around for a decade, and evolved with the use of web servers as portals to advanced applications. The web-browser then became the "universal" client interface, and HTTP the "universal" client-server protocol. Ubiquitous high-speed Internet access, improved browsers, AJAX features (aka Web 2.0), and advanced web server architectures have enabled the development of increasingly complex SaaS offerings. While others may include SaaS as part of "cloud computing", we choose to limit the definition to IaaS (the dynamic, scalable provisioning of virtualized compute and storage resources using service interfaces - as this is new and distinct from SaaS, and touches on our mandate for reviewing Grid interoperability and standards) and possibly PaaS (a paradigm for delivering operating systems and associated services over the Internet without downloads or installation. PaaS is sometimes called "cloudware" because it moves resources from privately owned computers into the Internet "cloud [i.72]). However, there is a danger of PaaS being insufficiently distinct from IaaS and SaaS. Virtualization is important on two levels: users see a virtualized resource (compute, application or storage); and service providers use abstraction layers (virtualization) themselves to provide a reliable, uniform, scalable service. An individual or organization therefore has a choice between managing their own resources or using a Cloud. [i.73] is a recent and widely cited report from Berkeley that examines the economics and looks at a number of case studies and tradeoffs around. If the user's workload is constant or is dwarfed by data transfer into or out of the Cloud, current pricing models may cause this to be a higher cost than a non-cloud alternative. Where a Cloud shows distinct advantages is where the user's work load varies unpredictably or rarely hits the peak demand (less than once a month), thus allowing the dynamic scalability (and directly correlated costs) of a Cloud to provide operational and cost benefits.

In the present document the term cloud or cloud computing is considered to describe a rapidly provisioned infrastructure (e.g. compute, storage, network resources) that supports dynamic scaling with uniform interfaces to these resources (see clause 4.6.2), Comparison: Grids and Clouds.

It is important to distinguish Grid computing from Cloud computing. Grid computing has a longer history and has primarily been adopted by public sector compute or data intensive user groups. This community has a pressing need for large scale federated computing systems, and the development of standards has been in support of this. Cloud computing, by contrast, originated in the private sector where virtualization technology and efficient operation of massive data centres became an alternative to the cost and operational challenges many businesses faced with in-house management and operation of data centres.

Both offer a vision of facilitating access to large data and computing resources. Many of the ideas which now are covered by the term "Cloud" were originally part of the "Grid" or "Utility" computing vision. The earlier definition of Cloud computing identified key concepts: dynamic, scalable, rapidly provisioned, virtualized, uniform interfaces. The definition refers to these properties in the context of foundational infrastructure resources. Grid computing, in contrast, assumes physical infrastructure is present, does not (currently) address virtualization issues, and instead focuses on a middleware service-oriented layer that emphasizes the key concepts of federated, distributed, and heterogeneous - none of these are visibly a part of a Cloud computing offering, although distributed and heterogeneous properties certainly are addressed by a Cloud provider through virtualization of the physical infrastructure they own and operate. Both Cloud and Grid deal with large scale and scalable systems, Cloud in terms of infrastructure, Grid in terms of software services and service interaction. The higher level features of Grid computing provide common components for building large distributed applications, systems, and computational workflows. The low-level uniform interfaces of Cloud computing provides a blank slate with tremendous aggregate potential to the end user, however there can still be significant effort required to deploy an integrated system onto a Cloud.

Grids and Clouds are answer to different questions. For Clouds the question potential users are asking is how to get economical access to reliable, scalable computing and storage, given the difficulties in managing this internally. Cloud providers answer this with their expertise and economies of scale in their massive shared data centres. For Grids, potential users are faced with a data deluge, distributed user communities, and federated computing centres all of which need to interoperate in a secure way, and provide mechanisms for extensibility. Grid technology aims to provide software and services to achieve those ends.

Cloud computing provides a simple model for access and development. Users can contract access to an arbitrary number of processors and storage for an arbitrary length of time, with charging directly related to usage. User requests are satisfied by allocating a partition of the underlying physical infrastructure and instantiating virtual interfaces to the allocated physical resources that are only controllable by the requesting user. Currently, there is limited support for coordinated resource access, however if users are able to treat each virtual resource they are allocated independently then they can dynamically scale their partition simply by requesting new allocations. Deploying data and applications into a Cloud environment, however, limits an organization to a single Cloud provider or requires duplicated effort to repeat the deployment process for additional Cloud environments. The current state of the art favours Cloud computing for single organization commercial applications that can be deployed in their entirety onto a Cloud environment. The dynamic provisioning of storage, computing power, and network bandwidth allows rapid scaling for intensive utilization either directly by the organization or by the public via Internet-based interfaces.

This dynamic, on-demand, model is attracting value chains of suppliers and customers, for example the SmugMug photo sharing system, mentioned earlier, which has been in operation since 2006. A Cloud instance is typically offered to a single user at a time or possibly to groupings of clients that would normally be expected to be part of the same organization. Any further sharing of the resource is managed by the end user(s), rather than via interfaces presented by the Cloud provider. Cloud computing offers a solution to the problem of organizations that need resources (computing, storage, or network bandwidth) either quickly or with a highly dynamic level of demand. Operating in steady state at or near full capacity, Cloud computing is more expensive than direct ownership of computing resources. Cloud systems currently only provide the foundation. Grid computing addresses different issues around federated interoperation of computing facilities, security, shared data management, application deployment, system monitoring, and application or job execution. These are given little or no consideration at present within Cloud computing offerings.

By contrast Grid computing aims to provide a collection of service interfaces which may be implemented and deployed by a range of providers. A user of EGEE may, without necessarily knowing it, use resources in France on one day and a differently implemented resource cluster in Bulgaria on another; some problems can be split between independent resource providers, such as multi-parameter sweep problems. EGEE (and other large Grids) are able to offer a large collection of services, from diverse organizations, because heterogeneity is allowed. The diversity within a Grid is a strength but also adds complexity to the process of establishing a relationship between service level agreement and charging.

Grid computing offers the concept of virtual organizations and support for single multi-enterprise applications, involving multiple service providers, such those demonstrated in a number of EU Framework 6 projects. Users and resources are part of a federated network. A Grid provides a security framework for identifying inter-organizational entities (both human and electronic) and managing data and service access between them. Grid technology continues to dominate public sector scientific computing environments due to the collaborative nature of this work and the need to manage existing data sets and computing resources across organizational boundaries. The more advanced state of interface standardization within Grid technology allows some degree of choice between various software and hardware systems.

There has been discussion about whether Grids could use Clouds or Clouds use Grids. [i.74] and [i.75] present the idea of a Grid infrastructure being used to instantiate a Cloud computing environment. It is also possible in principle to add multiple Clouds to a Grid. Each Cloud would simply form one class of diverse resource that the Grid makes available. Thus one could have a Grid making use of Clouds. This is explored in the work of Keahey and Freeman [Keahey&Freeman08].

4.6.2 Standardization and interoperability

At present interoperability between Clouds is hindered by the prevalence of proprietary interfaces. A Cloud provider keeps the contracted abstract resources available without any need for the end user to be concerned with physical underlying resources. This reduces the ability of one Cloud to make use of another in order to handle peak loads and also reduces the ability of a user to move between one Cloud and another in the event of failures or changing requirements. As users develop experience with Cloud computing concepts, they have been content to work within a single environment - and only a handful of cloud computing services are currently available, despite long lists to suggesting otherwise. There is, however, the beginnings of interest in Cloud interoperability with the formation of the Cloud Computing Interoperability Forum (CCIF) [i.65]. It is our expectation that the Cloud community will face similar problems to those faced by the Grid community: problems such as service level agreements, monitoring, authorization and authentication, data replication, usage recording and so on. The fact that some Clouds (e.g. Amazon WS) makes use of Web Services based on HTTP and SOAP opens the possibility that existing specifications based on WS could be adopted for Clouds, and several Cloud consolidators are using the Amazon Cloud services as *de facto* interface standards.

Although it is often asserted that Cloud interoperability standards are needed, it is also assumed that the appropriate standards do not exist. In [i.77] there is an implicit assumption that standards for distributed service and data interaction have not already been established, when, in fact, the Grid community has experience and standards which address these problems. Cloud computing will face interoperability problems but some of these problems have been addressed within the Grid world - whether by OASIS, OGF, ETSI TC GRID or W3C. For instance GLUE, DMTF, GridFTP and OGSA-DAI should at least be studied for possible application to data standards for Cloud interoperability.

Cloud computing can benefit from grid concepts by integrating standard interfaces, federated access control, and distributed resource sharing. Grid computing can benefit from infrastructure normalization and rapid provisioning provided by Cloud computing. Currently there is a general lack of standards in the Cloud computing domain, while Grid computing benefits from numerous standards and active standards development groups, but there is still difficulty in achieving comprehensive, integrated standards suites as evidenced by the high level of bespoke grid components and difficulties in achieving interoperability with existing grid infrastructures.

5 Grid requirements

In the same way the Web has federated and liberated un-structured information exchange between individuals, companies, and the academic community, there is a desire to do the same with data, software systems, services, compute resources, and storage resources. Progress has been made over the last decade to achieve this in an interoperable and extensible way. However, in many cases, users and providers of these more "advanced" services are forced to use proprietary systems, which do not inter-operate, do not scale, cannot easily be replaced, and cannot easily be reused by others. In a sentence, the Grid concept is "*coordinated resource sharing and problem solving in a dynamic, multi-institutional virtual organization.*" [i.9] where a "virtual organization" is simply a set of individuals, organizations, and resources and their mutually agreed/accepted sharing and access policy. This rest of this clause expands on this and describes first some high level non-functional requirements (NFR) which infer our definition of "a Grid", followed by a categorized list of functional requirements (FR) drawn from key Grid overview documents.

NOTE: Non-functional requirements can be thought of as properties which should be present in the final system but, in contrast to functional requirements, cannot directly be designed or implemented.

We present here a summary of the high-level non-functional requirements faced by today's enterprise or collaborative research IT infrastructure. Following on from discussions such as [i.10], we present a Grid as a computing system which provides the following core NFRs:

- **Large scale:** Incorporating resources on a scale larger than what is typically provided by a single site or accessible to an average user.
- **Scalable:** Ability to increase in size by orders of magnitude.

- **Dynamic:** Resource state and availability may change during the course of system operation. Such changes may be planned or unplanned. New resources may be added or removed without significant impact to the system behaviour.
- **Inter-operable:** Services provided by the components of the system can be replicated or replaced with alternate implementations, and dynamic resource interaction patterns are possible based on common resource interfaces.
- **Extensible:** New services and functionality can be incorporated or realized by integrating existing services in new ways.
- **Secure:** Providing a high level of trustworthiness between resources and users with configurable access control policies.
- **Heterogeneous:** Resources with different underlying properties integrated into the overall system via common interfaces. Ability to access these resources at abstract (common) interface layer, or via resource-specific interfaces.
- **Non-trivial service provision:** Services should provide capabilities beyond what is already available to the user or a collaboration group.
- **Usable:** The provided functionality should be at least as easy to access and utilize than a comparable custom solution.
- **Manageable:** Providing facilities to track and control user and resource activity.

Besides these core NFRs, the following lists a set of desirable NFRs. These are separated from the core NFRs due to variations in high level requirements for industry (where federation or geographic distribution are not mandatory) versus academia (where low reliability can be tolerated for the benefit of more ambitious or prototype (and therefore likely unstable) functionality).

- **Federated:** Multiple wholly independent administrative domains with policies for resource sharing, user authorization, charging.
- **Geographically distributed:** Resources located at numerous independent sites.
- **Reliable:** Providing fault tolerance and a suitable level of service for long term continuous use.

Foster, Kesselman, and Tuecke, leaders in the area of grid computing, published a document in 2000 (revised in 2002) entitled *The Anatomy of the Grid* [i.9] which outlines key functional requirements for their vision of "the Grid". Below we describe requirements extracted primarily from the present document, categorized into high level functional groups.

- Application or Task Execution.
- Application Development.
- Compute Access.
- Data Access.
- Resource Sharing.
- Security Infrastructure.
- Monitoring, Logging, and Accounting.
- System Management (Deployment, Update, Migration, and Scaling).
- Network Management and Reservation.

6 Grid Architecture

In this clause we provide a brief introduction to Grid architecture.

6.1 Grid Software Architectures

The OGF's Open Grid Services Architecture (OGSA) [i.6] builds on the SOA and realizes the logical middle layer (OGSA focus) in figure 2 in terms of services, the interfaces these services expose, the individual and collective state of resources belonging to these services, and the interaction between these services within a service-oriented architecture (SOA).

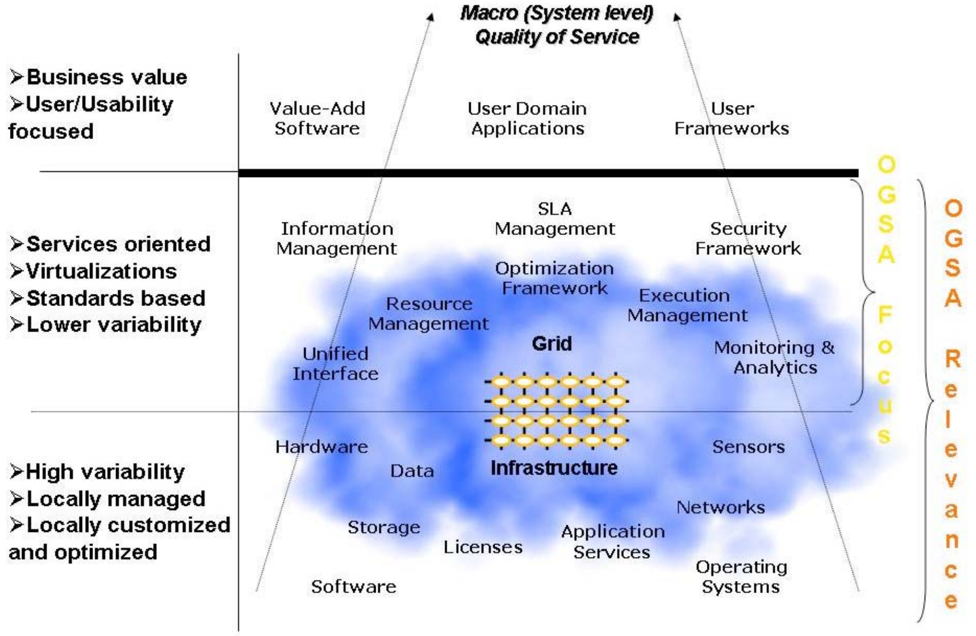

Figure 2: OGSA Capabilities (from OGF GFD-80 [i.6])

OGSA [i.6] provides the standard reference for grid software architectures. In figure 2, the upper of the 3 layers is populated by application services which rely on the Grid environment offered by OGSA services. The lowest layer contains the resources which are required by applications but which without a suitable unifying environment are fragmented, disparate and unmanaged. The middle layer, the OGSA focus, provides to the application a uniform interface to the heterogeneous resources with a managed QoS.

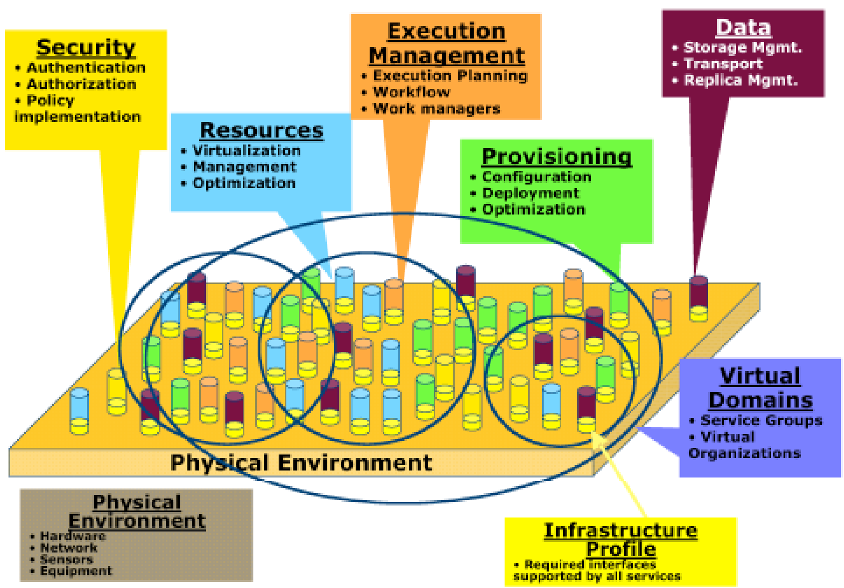

Figure 3: OGSA Framework (from OGF GFD-80 [i.6])

In the OGSA services framework, above, the cylinders represent individual services. The services are built on Web Service standards, with semantics, additional extensions and modifications that are relevant to Grids. Figure 3 provides more information about the structure of OGSA. In figure 3, the cylinders represent individual services. The ovals represent groups of services and VOs. The cylinder colours correspond to different types of OGSA service and each VO may contain a mix of them.

6.2 Grid Infrastructure Architectures

Grid infrastructures consist of many components, consisting of hardware, software, and networking. There are various ways these components can be grouped, however in the interest of simplicity we choose here a small set of six categories:

- Workload Management.
- Data Management.
- Security.
- Monitoring, Logging, and Accounting.
- Networking.
- Deployment and Infrastructure Management.

The various grid architectures which are reviewed will group the components into these categories, naming the component and any standard interfaces/protocols that the component uses.

6.3 Conceptual model of a grid and associated roles

To discuss grid infrastructure in a telecoms context, a conceptual model has been developed. This can be depicted as a layering of services which can be utilized independently or together. In figure 4a, these are grouped by the type of services they deliver. The lowest level represents the foundation of the infrastructure: networking, storage, computing power, and pre-existing software applications. These are wrapped and presented as software services. The next layer represents services that are central to the operation of the grid, while the outer layer provides user-focused services. These services are utilized by consumers, customers and providers. The consumer models the individual or organization using a grid services. The customer models the entity responsible for contracting the grid services, and pays for usage by consumers they have authorized. The provider models the entity providing grid services.

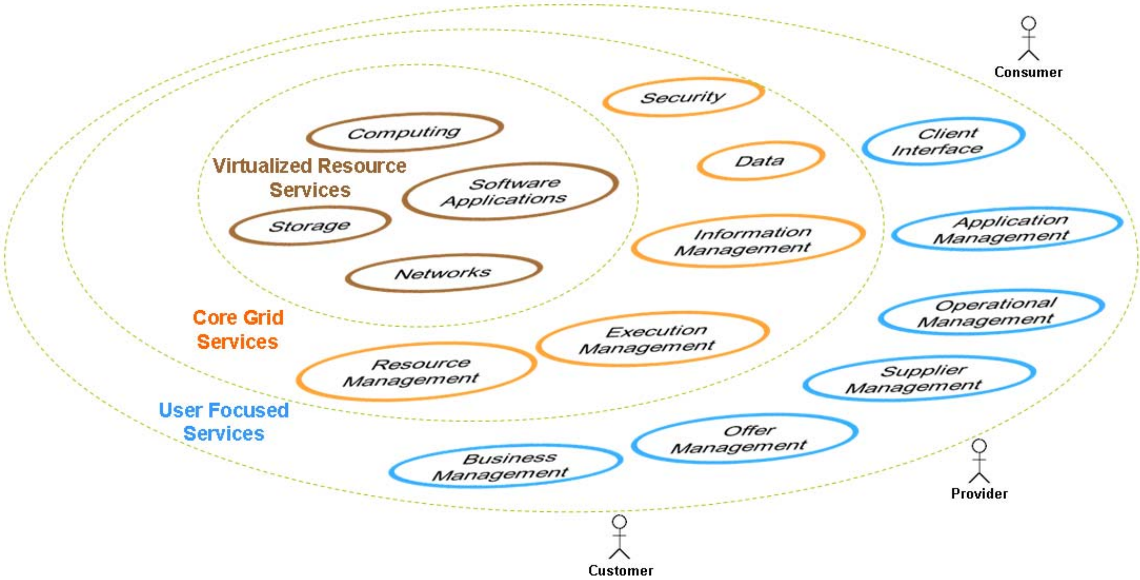

Figure 4a: Conceptual model of a grid and associated roles

7 Telcos in the Grid/cloud market

In this clause we provide some views on the role of telecommunication operators in the grid/cloud computing environment plus some examples of actual telecom operators activities.

7.1 Eurescom

The following clause is heavily based on the Eurescom Project 1349 Report: "TelcoGrid: Business Opportunities for Telecom Operators in the Grid market" (June 2004, not publicly available). Although this report has been overtaken by developments, it is included to give a historical perspective to the interest of the Telecoms industry in Grid/cloud computing.

The Report [i.97] provides an analysis of the Grid technology, the existing players in the emerging market, a strategic analysis and recommendations for Telecom operators how to position themselves with regard to the emerging Grid market.

Grids, in various forms and stages of development, offer several promising business opportunities for the Telecom operators:

- If business critical applications are moved onto the Grid, there will be a demand for enhanced network services, with e.g. QoS guarantees and pre-allocation of network resources.
- Telecom operators have unique experience in managing complex, distributed and heterogeneous systems. This competence could form the basis for selling consultancy services regarding Grid solutions.
- Most major Telecom operators are active in the IT system hosting market, either directly or through daughter companies. To stay competitive (or even strengthen their position) in the hosting market, Telecom operators should prepare for a shift towards Grid based systems by strengthening their Grid competence.
- Telecom operators have an extensive customer base, and are generally viewed as trustworthy. This gives Telecom operators a good position for assuming the roles as mediator, clearinghouse and provider of security in the global Grid market.
- Telecom operators have a large experience in charging and billing issues which can be re-used in order to strength this aspect of Grid standards, which is currently very immature.

The assessment of the potential role telecom operators can play in the emerging grid market is based on SWOT analysis, the results of which have been used here for the identification of gaps with respect to positioning of telecom operators in the Grid market.

Table 1

Identified Gaps	Notes
Software development	Having ceded software development to software companies, in general, Telecom operators lack the credibility on software development.
Applications development and control	In general, telecom operators neither develop, nor control applications. Also NGN intends to support (not to control) the third-party service providers and applications through suitable control interfaces [i.96].
Slow to react	Telecom operators made a lot of investments to digital network technologies. Long time is needed the return on investment is realized.
Large companies	As common for all large companies, modelling processes are often very long and complicated.
Absence of the ICT image	Even though progressively changing towards the ICT company, Telecom operators are still considered by a majority of customers more as monopoly telephone companies.
"Transport" oriented vs. "service" oriented network	Even though revenues are coming rather from services and content than from transport, networks owned by Telecom operators have been built with "transport" as a principal function in mind.

7.2 An Analyst's View

In its report on "Grid Computing, A vertical market Perspective 2006 - 2011", the Insight Research Corporation state, "Telecommunications services will certainly be needed to support grid-enabled Web service applications. While no consensus currently exists on the specific characteristics of local, metropolitan, and wide area network (WAN) services that would best meet the price, performance, and functionality requirements of grid computing applications in the future, several major players-including British Telecommunications (BT) and Telefonica of Spain-continue to make the investments required to measure the market potential of grids."

http://www.insight-corp.com/ExecSummaries/Grid06ExecSum.pdf

7.3 An IT Industry Vendors View

http://www.xchangemag.com/webexclusives/64h2092240.html

In an article Peter Lee, the CEO of DataSynapse states, "It's not news to anyone that telecommunications carriers constantly are faced with new challenges and unrelenting cost pressures. Providers are beginning to turn to a technology that has become a de facto standard at the world's largest financial institutions. Grid computing is making inroads in telco operators' IT infrastructure plans - helping carriers reduce costs, accelerate time-to-market, better serve growing customer bases and extend competitive advantages. This technology serves as an IT model that enables the virtualization of a large number of computing resources on demand, no matter where they are located.

By creating a shared grid environment, telcos are able to create an agile and responsive infrastructure that automatically shares and manages systems resources - software, processors, storage and networks - across all applications within the enterprise. The virtual processing platform solves application performance constraints, while significantly boosting the utilization of existing infrastructure and bypassing the involvement of costly IT professionals. Grid computing provides a cost-effective alternative to satisfy the insatiable demand for more processing power - a requirement that traditionally has been answered by purchasing more system resources.

Not surprisingly, initial interest in grid computing within telecommunications has been focused around its potential to reduce costs. Grid enables firms to "do more with less." By taking advantage of existing, underutilized resources, drastic savings can be achieved - not just by avoiding hardware purchases, but by dramatically reducing administration and support costs. Virtualization facilitates the move from high, fixed-cost models to low, variable-cost models.

While the cost-reduction opportunity always will be a key driver, there are several other reasons why grid computing is so beneficial to telco operators.

The value proposition for grid computing is about achieving scale with simplicity and optimizing existing resources for business gain. Grid infrastructure software creates an on-demand operating environment that powers all types of business- and mission-critical applications. Major telecommunication carriers, including Telefonica, achieved dramatically improved performance, response times and service levels since implementing grid computing systems. From legacy applications to third-party vendor software to Web services, grid computing optimizes application performance across computing resources.

What is clear is that while grid adoption among telcos is in its early stages, the value grid computing and application virtualization bring to telco organizations can not be ignored. Grid helps achieve scale, while drastically reducing costs. To successfully deploy a grid infrastructure, telco operators must form partnerships with vendors that have proven track records of virtualizing a breadth of applications to help dramatically improve performance, response time and service levels. For telco carriers, grid computing makes the impossible, possible.

7.4 AT&T

AT&T announced in August 2008 the availability of an enterprise-class cloud computing service named "Synaptic Hosting".

AT&T Synaptic Hosting [i.78] is a utility-based turnkey hosting solution. With this service, AT&T intends to provide a complete, managed IT ecosystem for consumers to load and run applications. It includes a fully on-demand infrastructure or it can be combined it with dedicated components to meet specialized requirements.

AT&T Synaptic Hosting service uses the AT&T Synaptic Infrastructure^{SM}, a virtual IT infrastructure that scales to match IT capacity with business's changing demands. This infrastructure is a next-generation utility computing platform that gives each customer their own secure, virtualized operating environment.

The AT&T Synaptic Infrastructure is aimed at companies with fluctuating or hard-to-predict needs.

The AT&T Synaptic Hosting service includes the licensing, installation and management of the Operating System (OS), web server software, and database software and provides the option of using a virtual or dedicated platform.

It enables customers to use AT&Ts hardware, networking, storage and security, supported by Service Level Agreements (SLAs).

A recent on-line article in "On-Demand Enterprise" (formerly GridToday) [i.79] entitled "10 Reasons Why Telcos Will Dominate Enterprise Cloud Computing" by Joe Weinman, Vice President of Solutions Sales at AT&T, makes some valuable points regarding the advantage traditional telco network operators have in this market. Below we summarize the ten points:

1) Enterprise sales capability. Corporate CIOs will want to manage access to cloud computing services, and will expect dedicated account teams as part of any long term cloud computing contract. They will resist or reject individual employees or departments making credit card purchases for outsourced storage or compute power.

2) Lifecycle service and support. Around the clock support of systems and well defined SLAs, allowing cloud computing to become an integrated part of a corporate computing platform.

3) Reliable operations at scale. Enterprise computing requires stability of outsourced services and capability to scale to enterprise levels (1e3 to 1e5 cores, 1-1000 TB).

4) Service Level Agreements. Contracts with well defined metrics and penalties for failure to meet SLA.

5) Full enterprise solutions portfolio. Capability to outsource a wide range of enterprise computing needs.

6) Integrated hosting and network services. Hosting is "close" or "at" major network hubs, reducing cost, and improving performance and reliability.

7) Vendor independence. Hosting service sells business capability, and hides technical detail. Economies of scale allow service provider to acquire most suitable systems solution at minimum price.

8) Global footprint. Telcos have a global presence and experience in managing global data networking. This will translate to an efficient global presence for hosted cloud computing services.

9) Financial stability and market commitment. Telcos have a large and established presence which reduces the risk associated with outsourcing key business infrastructure.

10) Technologies are easier to replicate than relationships and operations. Allow the service hosting companies to manage the replication of enterprise computing infrastructure.

7.5 BT

7.5.1 NGN

BT's next-generation network (NGN), known as 21 CN (21st Century Network), is currently being rolled out throughout BT's global network. The 21CN brings together voice, data, internet and video services, creating a single and seamless environment that allows real-time interaction, wherever the consumer is and whatever device is being used. The 21CN is an advanced broadband network based on intelligent systems, Internet Protocol (IP), Session Initiation Protocol (SIP) and Multi-Protocol Label Switching (MPLS). IP is key to 21CN because it has the potential to act as a common transport protocol for all types of communication and applications; SIP allows the service provider to control the communications activity to meet a customer's requirements and MPLS enables the efficient designation and routing of IP traffic flows. The first customers were transferred to the NGN in November 2006.

http://www.btplc.com/21CN/Whatis21CN/inde7.htm

BT is also introducing a single enterprise architecture, known as the Matrix and based on service-oriented architecture (SOA) principles, this provides BT with a flexible, standardized platform containing re-usable blocks of functionality. Alignment with core customer-focused business processes would ensure that BT became process driven instead of systems driven, providing the agility needed for business transformation [i.80].

7.5.2 Grid/Cloud computing Services

Among the utility, grid/cloud services being developed by BT are the following.

7.5.2.1 Virtual data centres

BT is currently launching its Virtual Data Centre (VDC) service, aimed at helping large business and public sector organizations succeed in the current economy and prepare for the future. It provides a dynamic and virtualized infrastructure platform that enables them to consume their IT and networking infrastructure as a service and forms the base for future cloud services [i.90].

Virtual data centres provide an integrated set of 21CN inspired flexible and virtual hosting environments. They use the latest service and infrastructure technology to deliver highly available integrated data centre applications and services on demand through an end-to-end managed, pay as you use service.

Its features include [i.81]:

- Data centre efficiencies by using 21CN.
- Rationalize your data centres and servers, and gain economies of scale.
- Secure managed data centre environment.
- End to end SLA (higher than traditional approaches).
- Offers a virtualized services platform.
- Provides end-to-end assurance services.
- Only pay for what you use, as you use it.

7.5.2.2 Software-As-A-Service (SAAS)

In 2008 BT announced that it was developing Software as a Service (SaaS) for business customers [i.82].

BT has traditionally been a communications company, with SaaS, BT is working to bring applications and communications together.

Chris Lindsay, BT's Business head of SaaS, states that "applications and communications are coming together, but still around 60-70 per cent of IT spend is driven off companies having different departments, all running different processes and different applications. In the old world, you'd buy a fixed application and someone would install it on your premises. So IT does the information gathering, gets a business case together, gets sign off, then needs to code, build, test and deploy the application, and if they then find it does not do what they want it to, it'll go through another cycle. With the SaaS model you can try out an app before you buy it, so you can see if it will work or not, and the risk has therefore been mitigated".

7.5.2.3 Ribbit for Salesforce

Through its business division, BT is making Ribbit for Salesforce available to a range of its clients [i.83]. The program allows firms to link voice communications with accounts and is delivered as a cloud computing service. Chris Lindsay, general manager, BT Business applications, said: "As the first supplier to integrate voice services with Salesforce CRM through a cloud computing platform, BT is providing its customers with a huge competitive edge in today's highly dynamic environment. Helping to improve business processes, the application will help firms make the most of every customer opportunity during the recession and put them in a strong position to thrive when it ends."

7.6 DT

7.6.1 NGN

Building on the IT 2010 initiative launched in March 2007, the Group-wide project Next Generation IT (NG IT) was launched in February 2008 as part of the updated IT strategy [i.84]. NG IT is the framework for all IT-related components in the Group's transformation programs. The aim of the program is to develop the future IT architecture in the Group. NG IT looks at the Group's information technology at all architectural levels: IT infrastructure, applications, data, and systems. Group-wide projects work on preparing, for example, the joint product data model, solutions for forward-looking, comprehensive customer relationship management (CRM), and future IT support for the Finance, Human Resources, and Procurement functions.

There are long-term plans to develop and implement an IP platform that supports both fixed-network and mobile communications services. Deutsche Telekom will completely replace the existing network platform by an IP-based system. This is aimed to be provided by the NGF (Next Generation Factory) project that will upgrade DT's network from circuit-switched to IP-based, improving performance and reducing network complexity [i.85]. It will also simplify the carrier's network architecture, integrate the several platforms being used now, and provide the flexibility necessary for new services through common service capabilities.

7.6.2 Grid/Cloud computing Services

Deutsche Telekom Laboratories has recently spun off its own open-source cloud-computing start-up called Zimory GmbH. Based in Berlin, Zimory aims to help bring the benefits of cloud computing to private enterprises, Zimory Public Cloud provides companies of all sizes instant and flexible access to external computing power worldwide while also enabling businesses with excess server capacity to offer their resources to businesses around the world [i.86]. Zimory Public Cloud for sellers aggregates available server computing capacity from around the world and makes it available through an Internet trading platform. Zimory's open-source code enables not only private clouds, but also the ability to profit from under-utilized cloud resources in much the same way that Amazon has opened up its excess computing capacity through services like its Elastic Compute Cloud, or EC2. Using Zimory Public Cloud, companies looking for computing resources can buy capacity quickly - as needed - without long-term contractual commitment. Zimory handles pricing, contracts, security, virtual machine migration and billing.

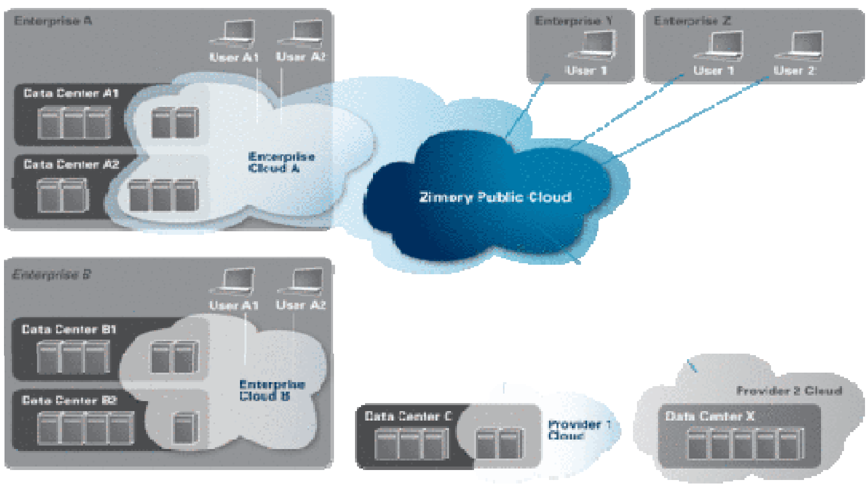

Figure 4b: Zimmory Public Cloud

Zimory has simplified the buying and selling process by standardizing service level agreements (SLAs). Sellers choose gold, silver or bronze based on availability and security certifications:

- **Gold:** A gold SLA cloud delivers the strongest quality standards. This includes availability and security standards. The providers offering these resources are compliant with all relevant security certifications.

- **Silver:** A silver SLA offers high availability and security standards. The providers are known brands.
- **Bronze:** A bronze SLA delivers the usual quality and availability standards of hosting providers. It does not contain certifications and additional security offerings.

Buyers select the SLA they need for their deployment based on price and their specific requirements.

Zimory's Enterprise Cloud, already available, combines existing different virtual servers (currently Xen and VMware) into a homogeneous computing cloud - enabling data centre managers to move applications quickly within a single or multiple locations.

7.7 France Telecom

France Telecom collaboration with Fujitsu have developed a system based on grid computing that enables telecommunications carriers to optimize use of their IT resources, and have successfully completed testing of the system. In these tests, service loads were automatically allocated among servers located in Paris, Tokyo, and Kawasaki, enabling the overall system to handle loads that would have been beyond the capacity of conventional systems.

This project is one outcome of an R&D partnership between Fujitsu and France Telecom announced in December 2004. Grid Computing is a distributed-computing technique in which multiple distributed computers are treated as a single, virtual, high-performance computer. By putting to use processing and storage capacity that would otherwise be going unused, and distributing processes among multiple computers, grid computing can handle intensive loads that are beyond the capacity of a single computer.

Probably the most famous Grid Computing application is the SETI@home project which uses thousands of home computers to process queries.

Nowadays, France Telecom is transforming itself with a three-year program so that it can deliver the services people want and need. The program is called NExT (New Experience in Telecommunications) [i.87]. Launched in 2005, it combined the company's Internet, television, and mobile services under the Orange brand. NExT is also about fostering innovations in new and converged services, such as IP TV (Internet-based television). As part of NExT, France Telecom is committed to sustainable development. The company wants to reduce the environmental impact of its operations and products. As part of NExT, the France Telecom's IT team plans to consolidate 17 existing data centres into two new and more efficient ones. This IT initiative is called "Eco Center". Driving the Eco Center are five key objectives-support growth yet use less power and space, gain greater flexibility, get services to market faster, improve performance, and enhance disaster recovery.

The benefits of the transformation are already substantial. The 20 000 servers that power the company are being consolidated and will be reduced by about half through virtualization. In the past 18 months, the France Telecom's IT team created 5 750 virtual machines and has the goal of increasing that number to at least 7 500 by the end of 2009.

Since 30 percent of France Telecom's annual revenue is realized in the month of December, the team needs to accommodate spikes in demand. Now it can do so much more cost-efficiently thanks to the use of capacity management tools that dynamically allocate and balance existing resources as needed for the busiest month.

Moreover, the France Telecom's IT team has classified each of France Telecom's applications as gold, silver, or bronze, depending on the speed with which it needs to be recovered in the event of a disaster. Gold and silver applications have service-level agreements (SLAs) for faster recovery.

7.7.1 Background

One of the key requirements for a telecom carrier's system is that it be able to respond to dramatic load fluctuations. With conventional fixed systems, servers would need to be ready in advance of demand peaks for each service, which is not an efficient way of allocating IT investment resources.

7.7.2 Test Overview

Fujitsu, Fujitsu Laboratories and France Telecom co-developed a grid service platform (GSP) which allocates resources automatically in response to application loads, by using grid technologies to virtualize and integrate 24 servers located in the three locations of Paris, Tokyo, and Kawasaki, Japan.

The tests involved two applications: an interactive application called eConf and a data analysis batch job, both which were run in the GSP environment and each with loads that varied over time. The tests successfully demonstrated that, using the GSP environment, server resources in the three locations can be autonomously distributed in response to application load volumes and business priorities, resulting in an efficient system configuration that takes full advantage of existing IT resources.

7.7.3 Developments

The grid computing-based project was initiated in December 2004 as part of the strategic R&D partnership between France Telecom and Fujitsu. In the first phase of the project which was completed in January 2005, existing products and applications such as CyberGRIP middleware from Fujitsu, and data mining and video compression applications from France Telecom were brought together to verify that grid computing technologies could be deployed with these products. In the latest tests, the second phase of the project, joint development began in February 2005 with the objective to develop a platform that enables telecom carriers to widely make efficient and full use of their IT resources. Based on the results of these latest tests, the companies plan to conduct verification with actual services."

7.8 Telefónica

7.8.1 Background

Telefónica, through its R&D subsidiary Telefónica I+D, has been involved in several different R&D Grid-related projects of the European ICT 6th Framework Programme, for example, coordinating NESSI-Grid (supporting for the Service-Oriented Infrastructures Working Group of the NESSI ETP), BREIN (Business-Oriented Grids) and Akogrimo (Grid in a mobile world), and participating in BeinGrid (Business Experiments in Grid) and XtreemOS (Linux OS for next generation Grids).

The 7^{th} Framework Programme identifies Cloud Computing as a key enabler of Internet of Services. Telefónica I+D is participating with key roles in RESERVOIR (next generation federated cloud middleware), SLA@SOI (QoS management in Service-Oriented Infrastructures), IRMOS (Real-time Cloud) and NEXOF-RA (NESSI's Internet of Service Reference Architecture).

7.8.2 Cloud Vision

European Technology Platforms envision a Future Internet based on four key pillars (the Internet by and for People, the Internet of Contents and Knowledge, the Internet of Services and the Internet of Things) that build on top of a new Internet Network Infrastructure.

Telecom Operators are key actors in the Future Internet, not only being an enabler (by providing the underlying communication infrastructure), but, also, an active stakeholder that provides services and technologies for the four key pillars mentioned above. In the case of Internet of Services, the ICT sector should build an ecosystem that enables the emergence of a service-oriented economy. Service-Oriented Architecture brings Telco Operators new business opportunities by means of:

- Offering **Service Platforms (SaaS & PaaS)** where third-party services can be developed and integrated with Telecom Capabilities (IMS capabilities, accounting, billing, service management, etc.).
- Playing a new role as a **Computing Infrastructure Operator (IaaS**) that aggregates external infrastructure from different providers and provides them together with internal services (costs reduction) and third party services (new business opportunities).

Although it would be very difficult to compete with current Cloud Providers by simply offering the same services (a great investment in infrastructures would be necessary only to start competing with well established key players), a Telco Operator can intermediate between enterprise customers and Cloud providers (IaaS or SaaS) thanks to the privileged position it has. Telco Operators own the access network to the Clouds, can provide standard QoS levels, manage the links established with enterprise customers and can add new Cloud support services, and offer powerful and flexible billing capabilities.

For a Telco Operator, the Cloud should become a Service Delivery Center integrating best of class products in the market. The Cloud should be based on utility-like, vendor neutral and energy efficient principles, making the Infrastructure a Commodity.

7.8.3 Open Telefónica

Open Telefónica is an initiative of the Strategy Unit of the Telefónica Corporate Centre to coordinate the innovation activities of the different Telefónica companies with the main aim of creating an ecosystem that allows customers and small developers to offer services over Telecom capabilities (X as a Service).

Within the Telefónica Group there are already some local initiatives that have started. For example, Telefónica España's OpenMovilforum, O2 UK's Litmus offering Mobile capabilities (API to access Mobile services), and Telefónica I+D's Morfeo Open Source Community where different Software Platforms (developed with other parthers) for Web Application development and integration (EzWeb, FAST and MyMobileWeb), collaborative development tools (Vulcano Forge) and Cloud Middleware (OpenNebula and Nephele) are being researched and developed.

Open Telefónica defines a service-architecture, identifying APIs and a set of tools to help customers develop services over the Telefónica capabilities, where The Web 2.0 EzWeb mash-up is the glue platform for application integration. Web 2.0 has been shown to be a powerful tool to develop services. Users increasingly combine available Internet Web resources form different pools, creating value for all contributors:

- Internet Resources (hosting, processing, contents, maps, payment, distribution, etc.).
- Telco Resources (SMS, Customer info, geo-reference, etc.).
- Device Resources (Operating Systems, PC capabilities, Device SDKs, handset enhancements, etc.).

A first version of EzWeb services integrating Open MovilForum capabilities can be found at http://ezweb.tid.es.

Open Telefónica also relies on basic principles such as Open Standards (for APIs) and Open Source Software (for development tools and software platforms) as key enablers of collaboration for co-development of new services.

7.8.4 Open Cloud

Telefónica I+D, through different research lines (Cloud, Service Front-ends, Green IT and Open Innovation), is defining a next generation Open Cloud, where Services are dynamically provisioned with virtualized resources (virtual machines, virtual networks, software, services, etc.) based on QoS (Elasticity Rules and SLA objectives), Energy Efficiency and Business (framework agreements, marketing cost objectives, etc.) targets. This reference architecture will be contributed to different collaboration groups at European level, targeting Business PaaS/SaaS Cloud initiatives and the Open Telefónica Platform.

The results of this research are going to be delivered as Open Source Software at the Morfeo Community (http://cloudtechnologies.morfeo-project.org) and developed jointly with other partners that collaborate with Telefónica I+D in different research projects. Furthermore, these results will be used as reference implementations of the standard proposals where Telefónica I+D is involved.

In this regard, very recently, Telefónica joined the Open Cloud Manifesto (http://opencloudmanifesto.org). The present document is meant to start discussions on many details (e.g. different taxonomies, definitions and scenarios) that are still subject to intense debate and further evolution within the Cloud community. The present document outlines the challenges for the organizations that want to use the cloud while ensuring that it remains as open as all other IT technologies.

8 Key Stakeholders

In this clause, the key ICT Grid stakeholders are identified. They include key standards specification development organizations, European Grid research projects funded under the FP6 and FP7, Grid like implementations, initiatives on interoperability and companies related to Grid.

8.1 Key Organizations developing Standards and Specifications

While the Open Grid Forum (OGF) is directly developing specifications for Grid computing, the rest of the organizations listed in this clause are involved in Grid indirectly in that sense they are developing standards used by Grids rather than the Grid standards themselves.

It should be noted that apart from the OGF, only those Working Groups/Committees/Areas of the other organizations are listed that are considered to be important for Grids or that are used by Grids.

This clause has been compiled, in the most part, by capturing data from the various organizations web sites. This information will be reviewed and refined in future releases of the present document.

8.1.1 OGF

http://www.gridforum.org/

8.1.1.1 Overview

The Open Grid Forum's mission is to accelerate grid adoption to enable business value and scientific discovery by providing an open forum for grid innovation and developing open standards for grid software interoperability.

The OGF community consists of thousands of individuals in industry and research, representing over 400 organizations in more than 50 countries. The work of OGF is carried out through community-initiated working groups, which develop standards and specifications in cooperation with other leading standards organizations, software vendors, and users. OGF is funded through its Organizational Members, including technology companies and academic and government research institutions. The OGF hosts three one week conferences each year where working groups can meet face to face, report on their progress, and share with others. These meetings are also open to non-members and typically attract 200 to 600 people.

8.1.1.2 Functions, areas and Groups

The OGF organizes much of the day to day work of the organization into functions, areas and groups. There are 6 major functions within the OGF - Enterprise, eScience, Standards, Marketing, Regional Issues and Operations. Within each Function are Areas and within these there are Groups. The Standards function is responsible for development of architectures, specifications, roadmaps, and activities associated with the standardization and interoperability of grid software. The Standards function includes technical liaisons with other Standards Development Organizations (SDOs).

8.1.1.3 Standards function

The Standards function is composed of the following areas and groups.

Applications area

The Applications Area explores grid application development issues and programming interfaces required by grid applications.

- **Distributed Resource Management Application API WG (DRMAA-WG)**

  This group will develop an API specification for the submission and control of jobs to one or more Distributed Resource Management (DRM) systems. The scope of this specification is all the high level functionality which is necessary for an application to consign a job to a DRM system including common operations on jobs like termination or suspension.

- **Grid Information Retrieval WG (GIR-WG)**

  The GIR WG will establish a specific set of requirements, an architecture, and detailed specifications for Information Retrieval (IR) on computational grids. GIR will provide document collection management, indexing/searching, and query processing services to grid users and applications.

- **Grid Remote Procedure Call WG (GRIDRPC-WG)**

  The GridRPC Working Group was originally chartered to produce a GGF Proposed Recommendation for a grid-enabled, remote procedure call (RPC) mechanism. In the course of this work, it became clear that there was a natural division between a GridRPC mechanism for end-users and for middleware developers. GridRPC Working Group has divided its work into two documents, one for end-users and a second for middleware developers. The first document is entitled A GridRPC Model and API for End-User Applications. The second document will be A GridRPC Model and API for Middleware Developers. This rechartering document captures the specific requirements, goals, milestones and deliverables for producing this second document.

- **Simple API for Grid Applications Core Working Group (SAGA-CORE-WG)**

  The initial SAGA-RG collected a number of application use cases which are published in the SAGA-RG Document "SAGA Use Case Document" [i.47]. The work of this group will be based on these use cases, which will define the scope and target application areas for the API. Simplicity and parsimony will be the governing design principles for the API.

- **Simple API for Grid Apps RG (SAGA-RG)**

  The group will build on the results and feedback of the work of the former SAGA RG. As such, it will provide a forum in GGF to consolidate application driven API specifications.

Architecture Area

The Architecture Area hosts working and research groups that aim to define architectures for Grid computing. Architectures form the frameworks and design patterns for grids.

- **OGSA Naming Working Group (OGSA-NAMING-WG)**

  The objective of this working group is to work on two specifications (RNS and WSNR) to realize a three level name space for OGSA and to produce WS-Naming naming specification based on WS-Addressing. Thus, both RNS and WS-Naming can be combinable with OGSA Basic Profile.

- **Open Grid Services Architecture WG (OGSA-WG)**

  The Open Grid Forum (OGF) has embraced the Open Grid Services Architecture as the blueprint for standards-based grid computing. "Open" refers to the process used to develop standards that achieve interoperability. "Grid" is concerned with the integration, virtualization, and management of services and resources in a distributed, heterogeneous environment. It is "service-oriented" because it delivers functionality as loosely coupled, interacting services aligned with industry-accepted Web service standards. The "architecture" defines the components, their organizations and interactions, and the design philosophy used. OGSA-WG is developing the architecture and its constituent specifications and profiles in collaboration with a number of fellow working groups.

- **Reference Model Working Group (RM-WG)**

  The goal of this group is providing formal description and associated terminology for the sets of components (both services and resources) that comprise a grid, their relationships and their life-cycles.

Compute Area

The Compute Area is focused on the description and execution of computational tasks, and the scheduling and negotiation of grid resources.

- **Grid Resource Allocation Agreement Protocol WG (GRAAP-WG)**

  The goal of the GRAAP Working Group is to produce a set of specifications and supporting documents which describe methods and means to establish Service Level Agreements between different entities in a distributed environment. The WS-Agreement Specification V1.0 [i.11], a Web Services protocol to establish agreements between two services, has recently (May 2007) been published as an OGF Proposed Recommendation (GFD.107) [i.12]. Currently, the groups focuses on WS-Agreement interoperability and usage scenarios.

- **Grid Scheduling Architecture RG (GSA-RG)**

  The goal of the Grid Scheduling Architecture Research Group (GSA-RG) is to define a scheduling architecture that supports cooperation between different scheduling instances for arbitrary Grid resources. The group currently focuses on the interoperation of different schedulers in an OGF-complaint ecosystem.

- **High Performance Computing Profile WG (HPCP-WG)**

  The JSDL-WG has produced a language that describes the requirements of jobs for submission to Grids. JSDL 1.0 (published as GGF recommendation GFD-R-P.056 [i.13] is an XML-based language that focuses mainly on computational jobs. The JSDL-WG is working on extending this language to address a wider class of jobs.

- **OGSA Basic Execution Services WG (OGSA-BES-WG)**

  The objective of the OGSA-BES working group is to focus on a minimal sub-set of the EMS services and develop a recommendations document (i.e. specification) for them.

- **OGSA Resource Selection Services WG (OGSA-RSS-WG)**

  The OGSA-RSS-WG defines protocols for the scheduling functionality within the OGSA framework, namely protocols and interface definitions for the Selection Services portion of the Execution Management Services (EMS) part of the Open Grid Services Architecture. The Resource Selection Services (RSS) consist of the Candidate Set Generator (CSG) and the Execution Planning System (EPS). The CSG can be used to generate a set of computational resources that are able to run a job in general, while the EPS uses this list to decide where to run the job. Other resources such as data are out of scope of these services.

Data Area

The Data Area groups explore the access, management and transport of data on grids.

- **OGSA ByteIO Working Group (BYTEIO-WG)**

  The objective of the OGSA ByteIO working group is to define a minimal Web Service interface for providing "POSIX-like" file functionality. Essentially this allows any service which implements the interface to be accessed in a file-like way. The WG will produce a use case informational document, a recommendation document and an experience document.

- **Database Access and Integration Services WG (DAIS-WG)**

  The group is developing standards for grid data services, focusing principally on providing consistent access to existing, autonomously managed databases from web services. By focusing on services, the intention is to ease application development through the provision of composable components. The group does not seek to develop new data storage systems, but rather to make such systems more readily usable individually or collectively within a grid framework. The group has been working on the development of a family of data access and integration specifications. The WS-DAI specification defines data model independent properties and operations that are shared by interfaces to different kinds of data resource. These properties are then extended and the templates instantiated by realizations - data model specific data access services. To date, the group has focused on realizations for accessing relational (WS-DAIR) and XML (WS-DAIX) data resources. The specifications for WS-DAI, WS-DAIR and WS-DAIX are have all been submitted to the GGF Recommendations track.

- **Data Format Description Language WG (DFDL-WG)**

  The aim of this working group is to define an XML-based language, the Data Format Description Language (DFDL), for describing the structure of binary and character encoded (ASCII/Unicode) files and data streams so that their format, structure, and metadata can be exposed.

- **Grid File System Working Group (GFS-WG)**

  GFS-WG works on standard service interface(s) and architecture of a logical file system that can be used in data grid management systems for both inter and intra enterprise grid environments. This group also collaborates with the SNIA ILM and other similar efforts in the industry.

- **GridFTP WG (GRIDFTP-WG)**

  This group focuses on improvements of FTP and GridFTP v1.0 protocol with the goal to produce bulk file transfer protocol suitable for grid applications. New protocols should be backward compatible with RFC 959 [i.43] FTP as much as possible with new features added as (negotiable) extensions. Some desired extensions are:

  - parallel transfers;
  - GSI authentication; and
  - striped transfers.

- **Grid Storage Management WG (GSM-WG)**

  The focus of this group is on the definition of the functionality of a standard Storage Resource Manager (SRM) interface. We define Storage Resource Managers (SRMs) as middleware components whose function is to provide dynamic space allocation and file management of shared storage components on the Grid. We see this as a short-term effort to have a workable interface that Grid projects could immediately make use of to resolve interoperability issues between storage systems.

- **Info Dissemination WG (INFOD-WG)**

  The purpose of this group is to develop a model for Information Dissemination to support the timely delivery of valuable information, and to develop one or more specifications backed up by appropriate use cases.

- **OGSA-Data Working Group (OGSA-D-WG)**

  The OGSA Data WG is producing a data architecture as part of the larger OGSA effort. This data architecture describes the data services in the OGSA architecture and explains how they can be orchestrated to implement a range of data-oriented capabilities.

- **OGSA Data Movement Interface WG (OGSA-DMI-WG)**

  The OGSA DMI Working Group tackles the problems of discovering of data transport protocols available at the data's source and destination location and agreeing on one of them, and the actual invocation of the agreed data movement. This includes direct data movements and 3rd party data movements. The OGSA DMI Working Group, though clearly associated to its roots, the OGSA Working Group, aims to define a set of interfaces that is independent of the "umbrella use case" of Grid Applications so that it can be used in scenarios and deployments other than the Grid.

Infrastructure Area

The Infrastructure groups explore and define what is needed to interface physical and virtual resources to higher level constructs such as OGSA. These include networks and network devices, computers and virtual machines, storage, visualization devices, instruments, and sensor technologies.

- **Grid High-Performance Networking RG (GHPN-RG)**

  The Grid High-Performance Networking Research Group focuses on the relationship between network research and Grid application and infrastructure development. Two specific goals of the GHPN-RG are identifying:

  a) grid application requirements and implementations that are not supported or understood by the networking community; and

  b) advanced networking features that are not being utilized by grid applications.

- **Grid and Virtualization Working Group (GRIDVIRT-WG)**

  System virtualization breaks new grounds in isolation, consolidation, and migration of resources. In turn, Grids offer new paradigms for dissemination and aggregation of IT operations, often on a large scale. In this WG, the system virtualization and Grids are considered to be complementary and highly synergistic in maximizing the yield of an IT infrastructure.

- **Network Measurements Working Group (NM-WG)**

  The performance of most grid applications is dependent on the performance of the networks forming the grid. The Network Measurements Working Group (NMWG) identifies network metrics (aka characteristics) useful to grid applications and middleware, and develops standard mechanisms to describe and publish these characteristics to the Grid.

- **Network Mark-up Language Working Group (NML-WG)**

  The purpose of the Network Mark-up Language Working Group is to combine efforts of multiple projects to describe network topologies, so that the outcome is a standardized network description ontology and schema, facilitating interoperability between different projects. The scope of the Network Markup Language Working Group is to define one or more schemas to describe:

  - a layer independent network topology; and
  - properties that are common across for multiple network technologies; as well as
  - a mechanism so that other working groups or other projects may combine technology specific schemas with the schemas created by the NML working group.

Liaison Area

The mission of OGF liaisons is to facilitate information exchange and promote collaboration with Standards Development Organizations, industry groups and grid projects. Each liaison presents OGF's position to peer organizations and periodically updates and synchronizes collaborative activities.

- **Standards development organizations Collaboration on networked Resources Management (SCRM-WG)**

  The scope of SCRM centres around the standards associated with the management of resources used in a network or individually, by means of structured data standards. Individual experts from participating SDOs are pursuing a first deliverable a "landscape document" designed to provide information regarding the definitions, taxonomy and interplay of the various specifications of each respective organization.

Management Area

The Management Area covers the management of essential grid operating components, such as policies, processes, equipment, and data, for overall effectiveness of grid systems, storage, applications, and services.

- **Application Contents Service WG (ACS-WG)**

  The ACS-WG aims at establishing a standard interface for the storing and exchanging the Archives of the Application Contents, defining the Application Repository Interface (ARI) as an OGSA service and the standard Application Archive Format (AAF). They will promote efficient and automated deployments in the Grid systems and the interoperability among the Grid implementations.

- **Configuration Description, Deployment, and Lifecycle Management WG (CDDLM-WG)**

  The CDDLM-WG will address how to:

  - describe configuration of services;
  - deploy them on the Grid;
  - and manage their deployment lifecycle (instantiate, initiate, start, stop, restart, etc.).

  The group envisages that complex applications and services will be deployed on Grid infrastructures. Such applications will have multiple, inter-related software elements. The goal is to describe the required configurations of such complete software systems, to automate their deployment onto the Grid infrastructure, and to allow subsequent management.

- **Glue Schema Working Group (GLUE-WG)**

  The GLUE-WG will provide a recommendation for an abstract information model which is expressed via a schema independent of information system implementations. The schema will define the set of attributes and attribute semantics, the relationship between the attributes and the syntax for attribute values where applicable. The main purpose of the schema is to facilitate interoperation between Grid infrastructures via enabling the development of interoperating Grid middleware components and as such the schema will be designed in response to existing use cases. The focus will be on use cases which span multiple Grid infrastructures that may rely on different middleware.

- **OGSA Resource Usage Service WG (RUS-WG)**

  The purpose of this group is to define a Resource Usage Service (RUS) for deployment within an OGSA hosting environment that will track resource usage (accounting in the traditional UNIX sense), but will not concern itself with payment for the use of the resource.

- **Usage Record WG (UR-WG)**

  In order for resources to be shared, across sites a common format for exchanging basic accounting and usage data is required. This working group proposes to define a common usage record based on those in current practice.

Security Area

The Security Area is concerned with technical and operational security issues in Grid environments, including authentication, authorization, privacy, confidentiality, auditing, firewalls, trust establishment, policy establishment, and dynamics, scalability and management aspects of all of the above.

- **Firewall Issues RG (FI-RG)**

  The research group will first document the type of issues that Grid applications experience when the need arises to control data transport policy enforcement devices. Once the types of issues have been identified, the group will relate these issues to specific categories of enforcement devices.

- **Levels of Authentication Assurance Research Group (LOA-RG)**

  The LoA Research Group (LoA-RG) is aimed at investigating use case scenarios in the e-Science/Grid contexts, and identifying gaps in applying existing LoA definitions to such contexts. Robust authentication and authorization services are keys to the deployment of a secure Virtual Organizational (VO) environment where students, researchers, staff with different roles and responsibilities from different institutions are expected to share resources distributed in the Internet environment with components administered locally and independently. Authentication is the first line of defence in any secure systems, and it is particularly important in VO environments playing a critical role in the provision of a number of essential security services including authorization, auditing and accounting.

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- **OGSA Authorization WG (OGSA-AUTHZ-WG)**
  The objective of the OGSA Authorization WG is to define the specifications needed to allow for basic interoperability and plug-ability of authorization components in the OGSA framework.

8.1.2 Distributed Management Task Force (DMTF)

http://dmtf.org

8.1.2.1 Overview

The Distributed Management Task Force (DMTF), the developer of Common Information Model (CIM) [i.14], is the industry organization leading the development, adoption, and interoperability of management standards and initiatives for enterprise and Internet environments. Founded in 1992, the DMTF brings the technology industry's customers and top vendors together in a collaborative, working group approach that involves DMTF members in all aspects of specification development and refinement.

The DMTF Common Information Model (CIM) [i.14] is a conceptual information model for describing computing and business entities in enterprise and Internet environments. It provides a consistent definition and structure of data, using object-oriented techniques. CIM does not require any particular instrumentation or repository format. It is only an information model - unifying the data, using an object-oriented format, made available from any number of sources. In addition, CIM's goal is to model all the various aspects of the managed environment, not just a single problem space. To this end, various "Common Models" have been created to address System, Device, Network, User, Application, and other problem spaces. All of the problem domains are interrelated via associations and sub-classing. They all derive from the same fundamental objects and concepts - as defined in the Core Model.

8.1.2.2 Key Working Groups

DMTF has several initiatives and standards which are managed by those initiatives.

Common Information Model (CIM): CIM allows for the exchange of management information in a platform-independent and technology-neutral way. It is an object-oriented model, describing an organization's computing and networking environments (its hardware, software and services). All managed elements are positioned within this model, clarifying semantics, streamlining integration and reducing costs by enabling end-to-end multi-vendor interoperability in management systems.

Web-Based Enterprise Management (WBEM): WBEM leverages existing Internet and Web services technologies for the interoperable exchange of management information. WBEM is a set of technologies, including an information model (CIM) [i.14], an encoding specification (xmlCIM Encoding Specification) [i.15], and a set of operations against the model with a transport mechanism (CIM Operations over HTTP).

Directory Enabled Networks (DEN): DEN is focused on communicating the benefits, usage and structure of a directory as a component in a complete management environment. Classes are mapped from CIM to a directory, and this information is integrated with other elements of the management infrastructure. DEN utilizes existing user and enterprise-wide data already present in a company's directory, empowers end-to-end services, and supports distributed, network-wide service creation, provisioning and management operations.

Desktop Management Interface (DMI): The industry's first desktop management standard, DMI gave component vendors - for the first time - a consistent and non-proprietary way to make their products manageable. DMI generates a standard framework for managing and tracking components in a desktop PC, notebook or server. Due to the rapid advancement of newer DMTF technologies, DMTF has announced an "End of Life" process for DMI, which ended March 31, 2005.

Alert Standard Format (ASF): ASF is designed to fill the gap of OS-absent systems management. The problem of systems manageability without an operating system has historically been solved with proprietary and relatively expensive solutions. ASF defines remote control and alerting interfaces for networked devices, and thereby reduces the downtime associated with typical triage and repair required to solve hardware and software failures.

Systems Management Architecture for Server Hardware (SMASH): SMASH is a suite of specifications that deliver architectural semantics, industry standard protocols and profiles to unify the management of the data centre. The Server Management (SM) Command Line Protocol (CLP) specification enables simple and intuitive management of heterogeneous servers in the data centre independent of machine state, operating system state, server system topology or access method, facilitating local and remote management of server hardware in both Out-of-Service and Out-of-Band management environments. SMASH also includes the SM Managed Element Addressing Specification, SM CLP-to-CIM Mapping Specification, SM CLP Discovery Specification and Server Management Profiles.

System Management BIOS (SMBIOS): The SMBIOS Specification addresses how motherboard and personal computer vendors present management information about their products in a standard format, extending the BIOS interface on Intel architecture systems. SMBIOS defines the structure of this system information, allowing its retrieval by management applications that use DMI, CIM or direct access, and eliminating the need for error prone operations, such as probing system hardware for presence detection.

Virtualization Management (VMAN) initiative: VMAN [i.88] is a DMTF initiative launched in 2008 to deliver interoperability and portability standards for virtualized resources.

Open Virtualization Format (OVF): is the DMTF standard [i.89], managed by the VMAN initiative [DMTF-VMAN-2008], describing a format for the packaging and distribution of software to be run in virtual machines. "This enables software developers to ship pre-configured, ready-to-deploy standard solutions, allowing end-users to literally distribute applications into their environments with minimal effort." It originated with the Vmware company [VMWARE-OVF] who also provided co-editors of the DMTF standard.

To promote the adoption of OVF standards, the Open-OVF project provides an open source library and tools designed to promote adoption of the OVF specification as an industry standard. It provides complete support for creating, using and maintaining OVF appliances. It aims to establish itself as a de-facto standard toolkit for working with OVF. Open-ovf is under EPL (Eclipse Public License) and plans to build an open community around OVF. Development resources from all across will be leveraged to create the common plumbing, this will help build cross-hypervisor components and prevent fragmentation of the OVF across industry. It promotes the usage of OVF and its adoption as a standard VM appliance format.

http://open-ovf.wiki.sourceforge.net/

8.1.3 ETSI

http://www.etsi.org

8.1.3.1 Overview

The European Telecommunications Standards Institute (ETSI) is an independent, non-profit organization, whose mission is to produce telecommunications standards for today and for the future. Based in Sophia-Antipolis in the south of France, ETSI unites almost 700 members from 55 countries, and brings together manufacturers, network operators and service providers, administrations, research bodies and users - providing a forum in which all key players can contribute.

ETSI's Members determine the Institute's work programme, allocate resources and approve its deliverables. As a result, ETSI's activities are closely aligned with market needs and there is wide acceptance of its products. ETSI's standards are built on consensus.

8.1.3.2 Key technical subcommittees and projects

8.1.3.2.1 GRID

Current Grid related activities are being lead by the Technical Committee called GRID. In a unique approach, TC GRID's initial goal is to address issues associated with the convergence between Information Technology (IT) and Telecommunications, with particular reference to the lack of interoperable Grid solutions in situations which involve contributions from both the IT and Telecom industries. Furthermore, convergence is viewed in a broad sense, since including embodiment, combination, and or synthesis of knowledge in:

- IT and Telecommunications.
- Grid and Web Services.
- Fixed and mobile communications.
- Ubiquitous services.

TC GRID creates and commits to a strategic focus for codifying innovation in ICT. Its original approach is to actively involve and support existing Grid stakeholders by complementing the standardization with codification activities by other stakeholders from the Telecommunications industry. Specifically, TC GRID will indeed address interoperability aspects of end-to-end Grid applications and develop formal test specifications with the aim of assuring end-to-end interoperability. This places the focus on scenarios where connectivity goes beyond the local, proprietary or scientific/research networks. The TC GRID activities have an emphasis on interoperable Grid applications and services based on global standards and the validation tools to support these standards.

The technical scope of TC GRID is broad, however. It includes, but is not restricted to aspects belonging to:

- Resource and service access.
- Protocols, middleware.
- Security.
- Service engineering across the full lifecycle.

8.1.3.2.2 TISPAN

TISPAN is the ETSI core competence centre for fixed networks and for migration from switched circuit networks to packet-based networks with an architecture that can serve in both.

TISPAN is responsible for all aspects of standardization for present and future converged networks including the NGN (Next Generation Network) and including, service aspects, architectural aspects, protocol aspects, QoS studies, security related studies, mobility aspects within fixed networks, using existing and emerging technologies. This work is in line with, and driven by, the commercial objectives of the ETSI membership.

A number of standards developed by TISPAN could potentially be reused to support the work done in TC GRID, for example, in Security, Accounting, support for QoS, and SLA.

8.1.4 IEEE

http://www.ieee.org

8.1.4.1 Overview

The Institute of Electrical and Electronics Engineers (IEEE) is a non-profit, technical professional association of more than 360 000 individual members in approximately 175 countries. Through its members, the IEEE is a leading authority in technical areas ranging from computer engineering, biomedical technology and telecommunications, to electric power, aerospace and consumer electronics, among others.

8.1.4.2 Key technical committees and working groups

For the present document, the key technical committees, subcommittees, working groups and/or projects organized under the Information technology topic are identified.

IEEE Standards Coordinating Committee 20 on Test and Diagnosis for Electronic Systems (SCC 20)

SCC20 is organized in subcommittees:

- **Diagnostics and Maintenance Control Subcommittee (DMC)**

  The subcommittee is responsible for the Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE) standard, the Testability and Diagnosability Characteristics and Metrics standard, and the Software Interface to Maintenance Information Collection and Analysis (SIMICA).

- **Hardware Interfaces Subcommittee (HI)**

  The Hardware Interfaces sub-Committee works on the IEEE-1505 RFI and Associated Pin Map (IEEE-P1505.1 CTI) Standards. The RFI standard is focused on development of an Open-Architecture, scalable Interface Standard to the Unit Under Test. The CTI is focused on developing a Pin Map definition to support Test Program Set (TPS) Interoperability.

- **Test and ATS Description Subcommittee (TAD)**

  This subcommittee was formerly known as the ATLAS subcommittee because its primary activity was concerned with the development of ATLAS standards. It is now responsible for the development and maintenance of the SCC20 standards that support the description of signals, tests, test requirements and test systems.

- **Test Information Integration (TII)**

  The objective of the project is to define a collection of XML schemas that allows ATE and test information to be exchanged in a common format adhering to the XML standard.

Floating-Point Arithmetic (P754)

IEEE 754-1985 governs binary floating-point arithmetic. It specifies number formats, basic operations, conversions, and exceptional conditions. The related standard IEEE 854-1987 generalizes 754 to cover decimal arithmetic as well as binary.

IEEE 802 LAN/MAN Standards Committee

The IEEE 802 LAN/MAN Standards Committee develops Local Area Network standards and Metropolitan Area Network standards. The most widely used standards are for the Ethernet family, Token Ring, Wireless LAN, Bridging and Virtual Bridged LANs. An individual Working Group provides the focus for each area.

IEEE Portable Applications Standards Committee

The committee is chartered with defining standard application service interfaces - most notably those in the POSIX family. PASC was formerly known as the Technical Committee on Operating Systems.

IEEE Standard for Boundary-Scan-based In System Configuration of Programmable Devices (IEEE 1532)

The objective of this project is to describe the series of mandatory and optional boundary-scan instructions and associated data registers that define a standard methodology for accessing and configuring programmable devices that already support IEEE Std 1149.1.

IEEE P1363

The IEEE P1363 project develops Standard Specifications For Public-Key Cryptography.

Simulation Interoperability

In 2003, the IEEE Computer Society Standards Activities Board decided to grant the SISO Standards Activities Committee (SAC) status as a recognized IEEE Sponsor Committee. The Simulation Interoperability Standards Organization (SISO) (http://www.sisostds.org) is an international organization dedicated to the promotion of modelling and simulation interoperability and reuse for the benefit of a broad range of M&S communities. SISO's Conference Committee organizes Simulation Interoperability Workshops (SIWs) in the US and Europe. SISO's Standards Activity Committee develops and supports simulation interoperability standards, both independently and in conjunction with other organizations.

Software Life Cycle Process (P1074 WorkGroup)

This is a project of the Institute of Electrical and Electronics Engineers (IEEE) Computer Society's Software and Systems Engineering Standards Committee (S2ESC). Its objective is to facilitate the revision of IEEE 1074-1997, Standard for Developing Software Life Cycle Process.

IEEE 1450 - Standard Test Interface Language (STIL)

The original STIL effort of this Working group (now known as IEEE 1450.0-1999) was purposefully scoped to expand. There are currently seven additional standards projects (IEEE P1450 - dotted extensions) in the STIL effort.

Storage System Standards Committee (SSSC)

The committee includes:

- **SISWG:** Security in Storage Working Group is chartered to develop standards for cryptographic algorithms and methods for encrypting data before it is sent to the storage device.
- **SSSWG:** Storage System Standards Working Group.
- **MSSTC:** Mass Storage Systems Technical Committee (MSSTC) promotes technical innovations in this field of information access.
- Joint Security in Storage Projects with the Information Assurance Standards Committee (see http://ieeeia.org/projects.html).

IEEE SystemVerilog WG

SystemVerilog is a Unified Hardware Design, Specification and Verification language that is based on the work done by Accellera, a consortium of Electronic Design Automation (EDA), semiconductor, and system companies. The proposed project will create an IEEE standard that is leverage from Accellera SystemVerilog 3.1a. The new standard will include design specification methods, embedded assertions language, test bench language including coverage and assertions API, and a direct programming interface. The proposed SystemVerilog standard enables a productivity boost in design and validation, and covers design, simulating, validation, and formal assertions based verification flows.

VASG: VHDL Analysis and Standardization Group

VASG is responsible for maintaining and extending the VHDL standard (IEEE 1076). Currently VASG collaborating with the Accellera VHDL TSC to accomplish this task. VHDL is an IEEE/IEC dual-logo standard and VASG coordinates revisions with IEC TC 93 on Design Automation.

IEEE 1076.1 (VHDL-AMS) Working Group

The IEEE 1076.1 (VHDL-AMS) Working Group has been created under the auspices of the IEEE Design Automation Standards Committee (DASC) with the charter to maintain the IEEE 1076.1 standard, also informally known as the VHDL-AMS hardware description language. The VHDL-AMS language is an extension of the IEEE 1076 (VHDL) standard that supports the description and the simulation of analogue, digital, and mixed-signal circuits and systems. The first release of the IEEE 1076.1 standard has been available since 1999. A revision of the standard that corrects editorial errors and clarify aspects of the language definitions is being completed. The next steps after the 2007 revision will be to evaluate the needs for new features in the VHDL-AMS language and new standard packages.

8.1.5 IETF

http://www.ietf.org.

8.1.5.1 Overview

The Internet Engineering Task Force is a large open international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet. It is open to any interested individual. The actual technical work of the IETF is done in its working groups, which are organized by topic into several areas (e.g. routing, transport, security, etc.). Much of the work is handled via mailing lists. The IETF holds meetings three times per year.

The IETF working groups are grouped into areas, and managed by Area Directors, or ADs. The Ads are members of the Internet Engineering Steering Group (IESG). Providing architectural oversight is the Internet Architecture Board, (IAB). The IAB also adjudicates appeals when someone complains that the IESG has failed. The IAB and IESG are chartered by the Internet Society (ISOC) for these purposes. The General Area Director also serves as the chair of the IESG and of the IETF, and is an ex-officio member of the IAB.

The Internet Assigned Numbers Authority (IANA) is the central coordinator for the assignment of unique parameter values for Internet protocols. The IANA is chartered by the Internet Society (ISOC) to act as the clearinghouse to assign and coordinate the use of numerous Internet protocol parameters.

8.1.5.2 Key Working Groups

From the Grid point of view, the key Working Groups are in the Security Area and those Working Groups in the Internet area that are dealing with the IPv6.

Key Working Groups in the **Security Area** are listed below :

- **Better-Than-Nothing Security (btns)**

  The primary purpose of this working group is to specify extensions to the IPsec architecture, and possibly extensions or profiles of Internet Key Exchange protocol (IKE), so that IPsec will support creation of unauthenticated security associations (SAs).

- **EAP Method Update (emu)**

  The Extensible Authentication Protocol (EAP) [RFC 3748] [i.48] is a network access authentication framework used in the PPP, 802.11, 802.16, VPN, PANA, and in some functions in 3G networks. EAP itself is a simple protocol and actual authentication happens in EAP methods. This group is chartered to work on some extending types of mechanisms to meet RFC 3748 [i.48] and RFC 4017 [i.49] (which documents IEEE 802.11 [i.50] requirements for EAP methods) requirements.

- **Handover Keying (hokey)**

  The goal of this Working group is to specify extensions to current EAP key framework will be needed to facilitate inter-authenticator handover and roaming.

- **Integrated Security Model for SNMP (isms)**

  The goal of the ISMS working group is developing a new security model for the Simple Network Management Protocol version 3 (SNMP) that integrates with widely deployed user and key management systems, as a supplement to the User-based Security Model (USM) security model.

- **Kitten (GSS-API Next Generation) (kitten)**

  The Generic Security Services API RFC 2743 [i.51], RFC 2744 [i.52] provides an API for applications to set up security contexts and to use these contexts for per-message protection services. The Common Authentication Technology Next Generation Working Group (Kitten) works on standardizing extensions and improvements to the core GSS-API specification and language bindings.

- **Kerberos (krb-wg)**

  The Kerberos Working Group aims to improve the core Kerberos specification, develop extensions to address new needs and technologies related to improving the process of client authentication, and produce specifications for missing functionality.

- **Long-Term Archive and Notary Services (ltans)**

  The objective of the this working group is to define requirements, data structures and protocols for the secure usage of the necessary archive and notary services.

- **Multicast Security (msec)**

  The purpose of the this WG is to standardize protocols for securing group communication over internets, and in particular over the global Internet. Initial efforts will focus on scalable solutions for groups with a single source and a very large number of recipients. Additional emphasis will be put on groups where the data is transmitted via IP-layer multicast routing protocols (with or without guaranteed reliability).

- **Network Endpoint Assessment (nea)**

  Network Endpoint Assessment (NEA) architectures have been implemented in the industry to assess the "posture" of endpoint devices for the purposes of monitoring compliance to an organization's posture policy and optionally restricting access until the endpoint has been updated to satisfy the posture requirements. An endpoint that does not comply with posture policy may be vulnerable to a number of known threats that may exist on the network. The intent of NEA is to facilitate corrective actions to address these known vulnerabilities before a host is exposed to potential attack.

- **Network Configuration (netconf)**

  The goal of the netconf working group is to produce a protocol suitable for network configuration. Netconf will provide, retrieval mechanisms which can differentiate between configuration data and non-configuration data, is extensible enough so that vendors will provide access to all configuration data on the device using a single protocol, has a programmatic interface (avoids screen scraping and formatting-related changes between releases), uses a textual data representation, that can be easily manipulated using non-specialized text manipulation tools, supports integration with existing user authentication methods; supports integration with existing configuration database systems, supports network wide configuration transactions (with features such as locking and rollback capability), is as transport-independent as possible and provides support for asynchronous notifications.

- **An Open Specification for Pretty Good Privacy (openpgp)**

  The goal of the OpenPGP working group is to provide IETF standards for the algorithms and formats of Pretty Good Privacy (PGP) processed objects as well as providing the MIME framework for exchanging them via e-mail or other transport protocols.

- **Public-Key Infrastructure (X.509) [**i.53**](pkix)**

  The PKIX Working Group's initial intent was to develop Internet standards needed to support an X.509-based PKI. The scope of PKIX work has expanded beyond this initial goal. PKIX not only profiles ITU PKI standards, but also develops new standards apropos to the use of X.509-based PKIs in the Internet.

- **Simple Authentication and Security Layer (sasl)**

  The Simple Authentication and Security Layer (RFC 2222) [i.54] provides key security services to a number of application protocols including the Blocks Extensible Exchange Protocol (BEEP), Internet Message Access Protocol Extension (IMAP), Lightweight Directory Access Protocol (LDAP), Post Office Protocol (POP), and Simple Mail Transfer Protocol (SMTP). The purpose of this working group is to shepherd SASL, including select SASL mechanisms, through the Internet Standards process.

- **Security Issues in Network Event Logging (syslog)**

  Syslog is a de-facto standard for logging system events. However, the protocol component of this event logging system has not been formally documented. While the protocol has been very useful and scalable, it has some known security problems. The goal of this working group is to address the security and integrity problems, and to standardize the syslog protocol, transport, and a select set of mechanisms in a manner that considers the ease of migration between and the co-existence of existing versions and the standard.

- **Transport Layer Security (tls)**

  The primary goal of the WG is to publish a revision of the Transport Layer Security (TLS) protocol, version 1.2.

Key Working Groups in the Internet Area are listed below:

- **IPv6 Maintenance (6man)**

  The 6man working group is responsible for the maintenance, upkeep, and advancement of the IPv6 protocol specifications and addressing architecture. It is not chartered to develop major changes or additions to the IPv6 specifications. The working group will address protocol limitations/issues discovered during deployment and operation.

- **IP over IEEE 802.16 Networks (16ng)**

  The principal objective of the 16ng working group is to specify the operation of IPv4 and IPv6 over WiMax (IEEE 802.16), taking into account the IPv4, IPv6 and Ethernet Convergence Sublayers.

- **IPv6 over Low power WPAN (6lowpan)**

  The Working Group aims to specify IPv6 over IEEE 802.15.4 [i.55] specifications.

- **Mobility for IPv6 (mip6)**

  The primary goal of the MIP6 working group is to enhance base IPv6 mobility by continuing work on developments that are required for wide-scale deployments. Additionally the working group addresses the issues identified by implementation and interoperability experience.

- **Site Multihoming by IPv6 Intermediation (shim6)**

  The objective of the Working Group is to produce specifications for an IPv6-based site multi-homing solution that inserts a new sub-layer (shim) into the IP stack of end-system hosts. It will enable hosts on multi-homed sites to use a set of provider-assigned IP address prefixes and switch between them without upsetting transport protocols or applications.

8.1.6 ITU

http://www.itu.int/home/index.html.

8.1.6.1 Overview

The International Telecommunication Union (ITU), headquartered in Geneva, Switzerland is an international organization within the United Nations System where governments and the private sector coordinate global telecom networks and services.

The ITU has 3 Sectors, the Radio Sector (ITU-R), The Telecom Sector (ITU-T) and the Development Sector (ITU-D).

The Telecom Sector of the ITU-T (ITU-T) hosted a workshop NGN and Grids in collaboration with the Open Grid Forum (OGF) in Geneva, 23 to 24 October 2006. The joint ITU-T/OGF workshop brought together the telecoms industry and the Grid community.

8.1.6.2 Outcomes from the ITU-T/OGF workshop

ITU-T hosted a workshop NGN and Grids in collaboration with the Open Grid Forum (OGF) in Geneva, 23 to 24 October 2006. The joint ITU-T/OGF workshop brought together the telecoms industry and the Grid community.

The workshop was organized in several sessions. Summary of those presentation that are of major importance for the purpose of the present document as well as session conclusions, are provided in the following clause.

Session 1: Visions of Grids and NGN.

Revenues in the IT sector are clearly shifting from products to services. IT services accessible over wide-area networks have the potential to radically change the way business is conducted both locally and globally. Grid technologies can make a major contribution to realizing this potential. However, technical solutions suitable for widespread commercial adoption and the open standards needed to provide interoperability are still immature.

To meet the needs of business, Grids must:

- offer users predictable price and performance together with flexibility and control over their own business processes;
- also allow service providers to manage their service offerings efficiently to a wide range of customers through the full service lifecycle;
- solve the technical and interoperability challenges associated with current Grid technology.

The European Union's vision for a Next Generation was provided including the detailed EU Grid research strategy and Grid research projects that were being funded. Next Generation Grids and the evolution from Grids to Service Oriented Knowledge Utilities were discussed, too.

Session 2: Implications of Grids for Telco networks including technical requirements for Telco networks.

The network is an all important factor in the Grid equation. A key point is that Grids pose new requirements, above and beyond fat-and-fatter pipes or low-latency pipes. While these help in general, a Grid's footprint expands and contracts over time, as dictated by a precise workflow, with network requirements also changing in space and time over the lifecycle of a Grid. Therefore, premium features such as bandwidth on demand and advance reservations resulted in greater confidence in a Grid's operation, yet without resorting to some wasteful, static peak allocation. Ideally, a Grid will harness an agile network much the same way it drives allocation of CPU (Central Processing Unit) and Data resources (multi-resource orchestration). Experimentation indicates that IP services and optical services have their own strengths and weaknesses in meeting Grid's requirements.

Session 3: Management, control and interoperability issues

Network management issues were presented by the use of "factoring" Network Management into Grids. A digital video rendering use case to facilitate understanding of the technical proposal was presented. Multi-autonomous domain constructs and associated challenges were also discussed.

A grid optimized network control plane was presented. It addressed the requirements placed on carrier networks by grid applications. It discussed current practices and various operational models and the implications and the levels of grid application and network control associated with the various operational models.

The implications for next generation networks and grid computing to support IPTV and IMS infrastructures were discussed including an overview of IPTV, IMS and the emerging Web 2.0 as well as the observations related to the applicability of Grids for IP services.

Session 4: QoS, Performance and Security aspects

Qos and security issues NGN as well as for Grid have been identified. SLA (Service Level Agreement) is another area for using Grid in NGN. To ensure the possibility of an automated offer/acceptance process and interoperability between different service providers it is mandatory to standardize the semantics of SLA objectives and parameters.

Session 5: Future trends and issues likely to turn up to support Grid applications and their impact on the standardization framework

- **Self Adaptive Overlay Network Innovating NGN Architecture**

  Overlay networking and P2P (Peer-to-Peer) concepts prove to be powerful in enabling pervasive adoption of services. It is important to learn from these emerging concepts and apply the features to the evolution of NGN and Grid infrastructure. A perspective for future NGN and Grid based on Self Adaptive Overlays and attempts to broaden the vision of Overlay for Future Generation Networks was presented.

- **Advanced Grid applications**

  Some recent application domains where grid computing may play a major role were presented. A first application area is the production of Media content (e.g. in broadcaster environments) where the major challenge is the distributed storage and processing of video based content. A second application area is the consumer environment where grids may offer an alternative to classical desktop computing. A last application area is wireless thin client computing where the terminal has limited capabilities (processing, storage and power).

Main conclusions on future evolution for Grids and NGNs:

- NGNs must include IT resources in internal operations, if full potential is to be realized. Grid technologies are required to realize this potential.
- Managed Grid services are a potential service for customers.
- Evolution of existing networks and services to support new requirements.

Main conclusions on Grid challenges:

- Multimedia processing is a major driver for new grid applications.
- Multimedia requirements will drive the need for optical solutions, e.g.:
  - Optical Circuit Switching (OCS);
  - Optical Burst/Packet Switching (OBS/OPS);
  - hybrid solutions.
- Evolution will occur from the professional market (Media Grid) towards the home/office (Consumer Grid) and mobile market (W-Thin Client Grid).
- Scalability, security, and optimization of resource management, both network and no-network resources.
- Network aspects include:
  - high performance in heterogeneous network environments;
  - network control and end to end transfer delay bounds;
  - end to end security;
  - optimizing network resource utilization;
  - hybrid QoS strategy that combines QoS differentiation and advance reservation.

8.1.6.3 ITU-T Study Group 13

Study Group 13 leads ITU's work on standards for next generation networks (NGN).

NGN refers to the move from circuit switched to packet based networks that many operators worldwide are undertaking, or will undertake in the next few years. It will mean reduced costs for service providers who will in turn be able to offer a richer variety of services.

Convergence is a key word in the NGN field. Built upon the Internet protocol (IP), the convergence between networks and/or technologies such as public switched telephone network (PSTN), digital subscriber line (DSL), cable television (CATV), wireless local area network (WLAN) and mobile technologies is a task that many believe is impossible without the development of global standards.

As with the ETSI TISPAN Standards, a number of the NGN Standards developed by Study Group 13 could be reused to support the work done in TC GRID.

8.1.6.4 Other ITU-T Study Groups

In addition to the NGN standards developed by Study Group 13, other ITU-T Study Groups have developed standards which are, or could be, reused to support the work of TC GRID, for example in the area of security.

8.1.7 Organization for the Advancement of Structured Information Standards (OASIS)

8.1.7.1 Overview

Organization for the Advancement of Structured Information Standards (OASIS) is a not-for-profit consortium that drives the development, convergence and adoption of open standards for the global information society. The consortium produces more Web services standards than any other organization along with standards for security, e-business, and standardization efforts in the public sector and for application-specific markets. Founded in 1993, OASIS has more than 5 000 participants representing over 600 organizations and individual members in 100 countries.

The Consortium hosts two of the most widely respected information portals on XML and Web services standards, Cover Pages and XML.org. OASIS Member Sections include CGM Open, IDtrust, LegalXML, and Open CSA.

8.1.7.2 Key Technical Committees

A list of key OASIS Committees by Category is provided below:

Adoption Services

The objective is to facilitate adoption, OASIS members develop guidelines, best practices, test suites, and other tools that promote the interoperability and conformance of structured information standards.

Key Technical Committees:

- **OASIS ebXML Implementation Interoperability and Conformance (IIC) TC**

  The goal is to enable software providers to create infrastructure and applications which interoperate with and adhere to the ebXML specifications.

- **OASIS Public Key Infrastructure Adoption (PKIA) TC**

  The TC aims to advance the use of digital certificates as a foundation for managing access to network resources and conducting electronic transactions.

Computing Management

In a service-oriented architecture, the providers and consumers of services need to communicate clearly about their availability and location, and the services themselves need to be able to talk to and depend on each other. OASIS members work on many fronts to standardize the reliable management of distributed resources, utility computing and grid systems.

Key Technical Committees:

- **OASIS eXtensible Access Control Markup Language (XACML) TC**

  The primary objective is to represent and evaluate access control policies.

- **OASIS Provisioning Services TC**

  The TC is providing an XML framework for managing the provisioning and allocation of identity information and system resources within and between organizations.

- **OASIS Solution Deployment Descriptor (SDD) TC**

  The TC aims to define a standardized way to express software installation characteristics required for lifecycle management in a multi-platform environment.

- **OASIS Web Services Quality Model TC**

  The objective is to define common criteria to evaluate quality levels for interoperability, security, and manageability of services.

Security

OASIS develops security standards needed in e-business and Web services applications. Members define foundational as well as application-level specifications.

Key Technical Committees:

- **OASIS Enterprise Key Management Infrastructure (EKMI) Technical Committee**

  The primary goal is to manage symmetric encryption cryptographic keys across the enterprise.

- **OASIS eXtensible Access Control Markup Language (XACML) TC**

  The TC deals with representation and evaluation of access control policies.

- **OASIS Provisioning Services TC**

  The TC is providing an XML framework for managing the provisioning and allocation of identity information and system resources within and between organizations.

- **OASIS Public Key Infrastructure Adoption (PKIA) TC**

  The TC aims to advance the use of digital certificates as a foundation for managing access to network resources and conducting electronic transactions.

- **OASIS Security Services (SAML) TC**

  The TC is defining and maintaining a standard, XML-based framework for creating and exchanging security information between online partners.

- **OASIS Web Services Federation (WSFED) TC**

  The objective is to extend identity management to enable federations of trust across organizations.

- **OASIS Web Services Secure Exchange (WS-SX) TC**

  The TC is defining WS-Security extensions and policies to enable the trusted exchange of multiple SOAP messages.

Service Oriented Architecture (SOA)

Service Oriented Architecture (SOA) represents a collection of best practices principles and patterns related to service-aware, enterprise-level, distributed computing. SOA standardization efforts at OASIS focus on workflows, translation coordination, orchestration, collaboration, loose coupling, business process modeling, and other concepts that support agile computing.

Technical Committees:

- **OASIS Framework for Web Services Implementation (FWSI) TC**

  The objective of the TC is to define methods and functional components for broad, multi-platform, vendor-neutral cross-industry implementation of Web services.

- **OASIS Semantic Execution Environment TC**

  The TC is developing guidelines, justifications, and implementation directions for deploying Semantic Web services in SOA.

- **OASIS Service Component Architecture / Assembly (SCA-Assembly) TC**

  The TC aims to define core SCA composition model to simplify SOA application development.

- **OASIS Service Component Architecture / Bindings (SCA-Bindings) TC**

  The TC is standardizing bindings for SCA services and references to communication protocols, technologies and frameworks.

- **OASIS Service Component Architecture / BPEL (SCA-BPEL) TC**

  The primary goal is to specify how SCA component implementations for SOA can be written using BPEL.

- **OASIS Service Component Architecture / C and C++ (SCA-C-C++) TC**

  The TC is standardizing C and C++ use within an SCA domain for SOA.

- **OASIS Service Component Architecture / J (SCA-J) TC**

  The TC is standardizing Java (tm) use within an SCA domain for SOA.

- **OASIS Service Component Architecture / Policy (SCA-Policy) TC**

  The objective of the TC is to define an SCA policy framework to simplify SOA application development.

- **OASIS Service Data Objects (SDO) TC**

  The TC aims to simplify how SOA applications handle data from heterogeneous sources, e.g. relational databases, Web services, and enterprise information systems.

- **OASIS SOA Reference Model TC**

  This TC is developing a core reference model to guide and foster the creation of specific, service-oriented architectures.

- **OASIS Web Services Quality Model TC**

  The objective of this TC is to define common criteria to evaluate quality levels for interoperability, security, and manageability of services.

Web Services

Web services allow applications to communicate across platforms and programming languages using standard protocols based on XML. OASIS members are defining many of the infrastructure standards that enable Web services as well as the implementation standards that are used in specific communities and across industries.

Technical Committees:

- **OASIS ebXML Business Process TC**

  The TC provides a standards-based business process foundation that promotes the automation and predictable exchange of business collaboration definitions using XML.

- **OASIS ebXML Collaboration Protocol Profile and Agreement (CPPA) TC**

  The TC specifies the description on how trading partners engage in electronic business collaborations through the exchange of electronic messages.

- **OASIS ebXML Implementation Interoperability and Conformance (IIC) TC**

  The TC aims to enable software providers to create infrastructure and applications which interoperate with and adhere to the ebXML specifications.

- **OASIS ebXML Messaging Services TC**

  The TC is defining the transport, routing and packaging of e-business transactions.

- **OASIS ebXML Registry TC**

  This TC is defining and managing interoperable registries and repositories.

- **OASIS Framework for Web Services Implementation (FWSI) TC**

  The objective is to define methods and functional components for broad, multi-platform, vendor-neutral cross-industry implementation of Web services.

- **OASIS Open Building Information Exchange (oBIX) TC**

  The TC specifies mechanical and electrical control systems in buildings to communicate with enterprise applications.

- **OASIS Search Web Services TC**

  This TC is developing Web services definitions for search and retrieval applications.

- **OASIS Translation Web Services TC**

  The TC specifies how to automate the translation and localization process as a Web service.

- **OASIS UDDI Specification TC**

  The TC is defining a standard method for enterprises to dynamically discover and invoke Web services.

- **OASIS Web Services Federation (WSFED) TC**

  This TC aims to extend identity management to enable federations of trust across organizations.

- **OASIS Web Services for Remote Portlets (WSRP) TC**

  The TC is standardizing presentation-oriented Web services for use by aggregating intermediaries, such as portals.

- **OASIS Web Services Quality Model TC**

  The TC is defining common criteria to evaluate quality levels for interoperability, security, and manageability of services.

- **OASIS Web Services Reliable Exchange (WS-RX) TC**

  The TC aims to advance a protocol for reliable message exchange using Web services.

- **OASIS Web Services Secure Exchange (WS-SX) TC**

  The TC is defining WS-Security extensions and policies to enable the trusted exchange of multiple SOAP messages.

- **OASIS Web Services Transaction (WS-TX) TC**

  The objective of this TC is to define protocols for coordinating the outcome of distributed application actions.

XML Processing

Covering the spectrum of XML applications, OASIS technical committees continue to work on the underlying architecture that facilitates XML processing.

Technical Committees:

- **OASIS Extensible Resource Identifier (XRI) TC**

  The TC is defining a royalty-free URI-compatible scheme and resolution protocol for abstract structured identifiers used to identify and share resources across domains and applications.

- **OASIS RELAX NG TC**

  This TC aims to advance a lightweight, easy-to-use XML schema language.

- **OASIS User Interface Markup Language (UIML) TC**

  The TC is developing a specification for an abstract meta-language that can provide a canonical XML representation of any User Interface (UI).

- **OASIS XRI Data Interchange (XDI) TC**

  The objective of this TC is to create a standard for sharing, linking, and synchronizing data ("dataweb") over the Internet and other networks using XML documents and Extensible Resource Identifiers (XRIs).

8.1.8 Optical Internetworking Forum (OIF)

http://www.oifforum.com

8.1.8.1 Overview

The mission of the Optical Internetworking Forum (OIF) is to promote the development and deployment of interoperable networking solutions and services through the creation of Implementation Agreements (IAs) for optical networking products, network processing elements, and component technologies. Implementation agreements will be based on requirements developed cooperatively by end-users, service providers, equipment vendors and technology providers, and aligned with worldwide standards, augmented if necessary. This is accomplished through industry member participation working together to develop specifications (IAs) for:

- External network element interfaces.
- Software interfaces internal to network elements.
- Hardware component interfaces internal to network elements.

The OIF will create Benchmarks, perform worldwide interoperability testing, build market awareness and promote education for technologies, services and solutions. The OIF will provide feedback to worldwide standards organizations to help achieve a set of implementable, interoperable solutions. Implementation Agreements currently include:

- Electrical Interfaces.
- Optical Transponder Interoperability.
- Tunable Laser.
- UNI - NNI.
- Very Short Reach Interface.
- Benchmarking.
- Hardware.
- Software.

8.1.8.2 Key Working Groups

Working Groups of the Technical Committee focus on specific areas where there is a need for Implementation Agreements.

Architecture and Signaling Working Group

The OIF Architecture and Signaling Working Group solicits and analyzes requirements from service providers. Based on these requirements, it develops implementation agreements related to architectures and signaling for Optical Internetworks and optical network elements.

Specifically, the working group may specify the definition of Optical Internetworking functions, the interfaces between functions, and the interfaces with other network components. In general, elements of the optical internetworking architecture may be physical entities or logical abstractions, and may lend themselves to different implementation approaches. The group will also define specific physical layer mechanisms for the exchange of signaling information among optical elements, and will develop signaling protocols to be used to exchange signaling information for connectivity among optical elements. The Architecture and Signaling Working Group works closely with other working groups in helping to define implementation agreements related to architectural and signaling requirements. These implementation agreements will enable clients of optical networks to dynamically establish optical channels with desired sets of attributes. Where possible, the group reuses or leverages the work of other standards groups or forums.

Current Focus Areas include:

- E-NNI, UNI 1.0 revision 2; and
- UNI 2.0.

Carrier Working Group

The OIF Carrier Working Group develops requirements and guidelines for the services and functions to be supported by the future optical networking products to be installed in the service providers networks, thus providing a common direction to the equipment vendors community as well as the other OIF working groups. Specifically, the OIF Carrier Working Group may specify interworking requirements; delineate issues with the installed base or Greenfield applications. As appropriate the OIF Carrier Working Group will provide input and guidance to other OIF working groups; develop service concepts; and provide inputs to other standards bodies and forums. The OIF Carrier Working Group will be open to all OIF members, but only Carriers will have the right to vote in the working group.

Interoperability Working Group

The Interoperability Working Group would facilitate the definition of testing methodologies to validate conformance to implementation agreements and contribute technical leadership for interoperability trials. Conformance criteria will be extracted from implementation agreements, and methods will be defined with support of the source technical working group. Where possible the group reuses or leverages the work of other standards groups or forums. This working group is not chartered to certify conformance to implementation agreements.

OAM&P Working Group

The Operations Administration, Maintenance, and Provisioning (OAM&P) working group would develop operations, administration, maintenance and provisioning requirements, guidelines, and implementation agreements related to optical internetworking. These requirements and guidelines may apply to planning, engineering and provisioning of network resources; to operations, maintenance or administration processes; or to requirements and recommendations for support systems and equipment that may be used to support these management functions. The OAM&P working group will also develop positions on related subjects under consideration in other domestic and international fora and standards bodies. Of necessity, the scope of this work requires a close and coordinated working liaison with other OIF groups, fora, and standards setting bodies.

Physical and Link Layer Working Group

The Physical and Link Layer (PLL) Working Group develops Implementation Agreements related to physical and data link layer interfaces between Optical Internetworking elements and between their internal components, reusing existing standards when applicable. The OIF PLL Working Group is guided by the requirements developed by the Physical Layer User Working Group (PLUG).

Physical Layer User Group

The Physical Layer User Working Group develops requirements and guidelines for components, modules, subsystems and communication links used in networking equipment thus providing common direction to the PLL vendor community as well as the other OIF working groups.

Software Working Group

The Software Working Group's purpose is to define, publish, and promote software interfaces that facilitate integration between multiple software modules for networking platforms. Software interfaces include application programming interfaces (APIs) and the contextual framework in which they operate.

The benefits of these software interfaces apply to several categories:

- **Carrier/Network Service Providers**

  Facilitate developing and deploying software defined networking products/services using sets of modular, interoperable, reusable, common software building blocks linked through software interfaces that are able to run in standardized software environments on standardized hardware platforms. Direct advantages are flexibility, and accelerated time to market for new services, at reduced cost.

- **Network Equipment Providers**

  Facilitate the integration of the data plane elements in component devices and various control plane and management plane applications running in control components/processors.

  Typical APIs would be used in controlling various components such as SSL acceleration, IPv4, IPv6, MPLS, Ethernet, SONET/SDH, ATM, PDH, OTN, etc.

- **Component Providers**

  Facilitate the integration of multiple software or firmware functional blocks that provide the networking control plane, management plane, and/or data plane processing functionality in component devices.

  Facilitate reducing time to market and cost in the integration of OIF Hardware Interfaces as defined by the OIF PLL WG, when such Hardware Interfaces have complementary OIF developed APIs.

8.1.9 World Wide Web Consortium (W3C)

http://www.w3.org/

8.1.9.1 Overview

The World Wide Web Consortium's (W3C's) mission is to lead the World Wide Web to its full potential by developing protocols and guidelines that ensure long-term growth for the Web. W3C primarily pursues its mission through the creation of Web standards and guidelines. Since 1994, W3C has published more than ninety such standards, called W3C Recommendations. W3C also engages in education and outreach, develops software, and serves as an open forum for discussion about the Web. In order for the Web to reach its full potential, the most fundamental Web technologies need to be compatible with one another and allow any hardware and software used to access the Web to work together. W3C refers to this goal as "Web interoperability." By publishing open (non-proprietary) standards for Web languages and protocols, W3C seeks to avoid market fragmentation and thus Web fragmentation.

8.1.9.2 Key Activities and Working Groups

The list of key W3C Activities and Working groups related to Grid is provided below:

Extensible Markup Language (XML)

The Extensible Markup Language (XML) is a simple, flexible text format derived from SGML (ISO 8879) [i.56]. The W3C created, developed and continues to maintain the XML specification. The W3C is also the primary centre for developing other cross-industry specifications that are based on XML. Some of these are being done within the XML Activity, such as XML Query and XML Schema, and some are being done in other W3C Activities, such as Web Services, SVG and XHTML. The XML Activity tries to keep a balance between maintaining stability and backwards compatibility, making improvements that help to encourage interoperability, and bringing new communities into the world of XML.

There are 10 Working Groups in this Activity (part of the Architecture Domain):

- Efficient XML Interchange Working Group;
- Service Modeling Language Working Group;
- XML Coordination Group;
- XML Core Working Group;
- XML Plenary Interest Group;
- XML Processing Model Working Group;
- XML Query Working Group;
- XML Schema Interest Group;
- XML Schema Working Group;
- XSL Working Group.

HTML

HTML is the family name for the group of languages that form the lingua franca of the World Wide Web.

The **XHTML2 Working Group** is chartered to continue to evolve HTML into an XML-based markup, modularize it to make it easier to combine with other markup languages, and correct the problems known still to exist in areas such as internationalization, accessibility, device independence and forms processing.

The HTML WG has been recently chartered to evolve traditional HTML.

The **Hypertext Coordination Group (HCG)** is chartered to address issues that may arise concerning several working groups in the Hypertext area. Members of the HCG may also include liaison representatives of other standards bodies.

Security

The work of the Security Activity follows two main directions. The **Web Security Context Working Group** focuses on the challenges that arise when users encounter currently deployed security technology, such as TLS: While this technology achieves its goals on a technical level, attackers' strategies shift towards bypassing the security technology instead of breaking it. When users do not understand the security context in which they operate, then it becomes easy to deceive and defraud them.

The **XML Security Specifications Maintenance Working Group** is chartered to do limited revisions on core XML Security specifications, document best practices in the deployment and implementation of these technologies, and deliver a charter for further work that may possibly be broader.

Semantic Web

The goal of the Semantic Web initiative is as broad as that of the Web: to create a universal medium for the exchange of data. It is envisaged to smoothly interconnect personal information management, enterprise application integration, and the global sharing of commercial, scientific and cultural data. Facilities to put machine-understandable data on the Web are quickly becoming a high priority for many organizations, individuals and communities. The principal technologies of the Semantic Web fit into a set of layered specifications. The current components are the Resource Description Framework (RDF) Core Model, the RDF Schema language and the Web Ontology Language (OWL). Building on these core components is a standardized query language, SPARQL (pronounced "sparkle"), for RDF enabling the "joining" of decentralized collections of RDF data. The GRDDL Recommendation and the work on RDFa aims at creating bridges between the RDF model and various XML formats, like XHTML.

There are 10 groups in this Activity (part of the Technology and Society Domain):

- GRDDL Working Group;
- OWL Working Group;
- Protocol for Web Description Resources (POWDER) Working Group;
- RDF Data Access Working Group;
- Rule Interchange Format Working Group;
- Semantic Web Coordination Group;
- Semantic Web Deployment Working Group;
- Semantic Web Education and Outreach (SWEO) Interest Group;
- Semantic Web Health Care and Life Sciences Interest Group;
- Semantic Web Interest Group.

Style

W3C's style sheets offer extensive control over the presentation of Web pages. The Cascading Style Sheets (CSS) language is widely implemented. It is playing an important role in styling not just HTML, but also many kinds of XML documents: XHTML, SVG (Scalable Vector Graphics) and SMIL (the Synchronized Multimedia Integration Language), to name a few. It is also an important means of adapting pages to different devices, such as mobile phones or printers.

W3C is also developing the Extensible Stylesheet Language (XSL). XSL applies a "style sheet" to transform one XML-based document into another. XSL and CSS can be combined. XSL is described in the XML Activity statement.

W3C has a page on CSS resources, including browsers, authoring tools and tutorials.

There is 1 group in this Activity (part of the Interaction Domain):

- Cascading Style Sheets (CSS) Working Group.

Web services

Web services provide a standard means of interoperating between different software applications, running on a variety of platforms and/or frameworks. Web services are characterized by their great interoperability and extensibility, as well as their machine-processable descriptions thanks to the use of XML. They can be combined in a loosely coupled way in order to achieve complex operations. Programs providing simple services can interact with each other in order to deliver sophisticated added-value services.

The W3C Web Services Activity is designing the infrastructure, defining the architecture and creating the core technologies for Web services. The SOAP 1.2 XML-based messaging framework became a W3C Recommendation in June 2003 and the SOAP Message Transmission Optimization Mechanism (MTOM) in January 2005.

Six Working Groups are involved in this Activity (part of the Architecture Domain):

- Semantic Web Services Interest Group;
- Web Services Coordination Group;
- Web Services Choreography Working Group;
- Web Services Policy Working Group;
- XML Schema Patterns for Databinding Working Group;
- XML Protocol Working Group.

XForms

XForms is a markup language that addresses the modern needs of electronic forms. It is based on XML and can deliver the collected values as an XML document. It addresses questions of authorability, usability, accessibility, device independence, internationalization, integration into different host languages, and reducing the need for scripting.

There is one Working Group is in this Activity (part of the Interaction Domain):

- Forms Working Group.

8.1.10 Storage network Industry Association (SNIA)

http://www.snia.org/home

8.1.10.1 Overview

Incorporated in December 1997, the Storage network Industry Association (SNIA) is a registered 501(c)6 non-profit trade association. SNIA members are dedicated to developing and promoting standards, technologies, and educational services to empower organizations in the management of information.

The SNIA works toward this goal by forming and sponsoring Technical Work Groups (TWGs), producing (with the SNIA's strategic partner Computerworld) the Storage Networking World Conference series, building and maintaining a vendor neutral Technology Center in Colorado Springs, and promoting activities that expand the breadth and quality of the storage and information management market.

The SNIA has built a strong Alliances program, one that establishes collaborative, working relationships with other industry associations to increase the level of integrated storage solutions in general business and IT environments. The SNIA currently has formal strategic alliances with the following organizations:

- ARMA International.
- Distributed Management Task Force (DMTF).
- Eclipse Aperi Storage Management Project.
- Enterprise Grid Alliance (EGA).
- Fibre Channel Industry Association (FCIA).
- Open Grid Forum (OGF).

8.1.10.2 Key Technical Work Groups

Common RAID Disk Data Format TWG

The Common RAID Disk Data Format (DDF) TWG is developing a standard methodology for representing the data structures that contain information describing how data is distributed across the drives in a RAID group. The methodology will include the location, size, and format of common descriptive data structures and will include methods for allowing the representation of proprietary formats and functions to support innovation and differentiation between RAID offerings from different vendors.

Disk Resource Management TWG

The Disk Resource Management (DRM) Work Group is defining standard data and interfaces for the management of disk storage facilities, as well as creating guidelines for implementing well-managed storage solutions. Data and interfaces are provided in support of the following management disciplines - Asset Management, Capacity Management and Planning, Availability and Performance Management, Configuration Management, Policy-based Management and Event Management. The goal is to allow an application or administrator to obtain all pertinent storage-related information, via a standard and secure infrastructure.

File Systems Management TWG

The File System Management (FSM) Technical Work Group is dedicated to developing and defining or promoting standards for file system related Management of products, such as Network Attached Storage, Host File Systems, cluster File Systems and SAN File Systems, and developing supporting educational materials. The work group acts as an organizing and coordinating entity for File System Management efforts. The primary function of the TWG is to ensure consistency of file standards and messages across the various file system related efforts.

Fixed Content Aware Storage TWG

The Fixed Content Aware Storage (FCAS) TWG serves as a centre of technical activities related to new application-level interfaces for storage of unchanging data (fixed content) and associated metadata based on a variety of naming schemas including Content Addressed Storage and global content-independent identifiers.

Host TWG

The Host TWG serves as a centre of technical activity related to management of storage hardware and hardware-enabling software associated with hosts. This includes development of SMI-S CIM profiles and sub profiles that cover host storage resources. The TWG also addresses host-focused storage APIs.

Information Lifecycle Management TWG

The Information Lifecycle Management (ILM) TWG ties together the storage services associated with storage, and the data management services associated with data movement, data redundancy, and other data management applications. In particular, the ILM TWG is defining standards for the management of data storage from an application requirements perspective as an addition to the management of storage from the administrative perspective. This results in the ability to provision and manage varying configurations of networked storage and data management services that provide equivalent levels of service to user applications. The ILM TWG is also defining standard methods to manage changes to requirements as they change with respect to time and events.

I/O Traces, Tools & Analysis TWG

The primary focus of the I/O Traces, Tools, and Analysis (IOTTA) TWG is to create a worldwide repository for storage-related I/O trace collection and analysis tools, application workloads, I/O traces, and best practices around such topics. The I/O traces of interest to the IOTTA TWG include those up at the host (e.g. system call, file system), those involving a file server (e.g. NFS, CIFS) and those at the "transport level" (e.g. SCSI, Fibre Channel). I/O traces of application workloads along with the analysis and definition of common, recommended semantics and formats for I/O traces are also specific areas of focus for the TWG. Standardized I/O trace formats/semantics will enable the development and use of common I/O trace collection and analysis tools as well as facilitate the sharing of the I/O traces themselves.

IP Storage TWG

The IP Storage (IPS) TWG is the primary technical focal point at SNIA for IP Storage technical issues, coordinating with the IP Storage Forum. Its current focus is the management of IP Storage technologies.

Management Application TWG

The Management Application (MAP) TWG provides management application vendors an opportunity to participate in and influence the SNIA Storage Management Initiative to meet the needs of the Management Application community. The MAP TWG works with Management Application representatives and the other TWGs to identify and develop SMI-S requirements and issues resolutions that meet the needs of storage management applications. The MAP TWG also drives the definition of end-to-end management capabilities in SMI-S that include cross-profile considerations and recipes, SMI-S scalability, health and fault management, performance management, and SMI-S management services.

Management Frameworks TWG

The Management Frameworks (MF) TWG is dedicated to developing and defining standards for Management Framework common components. The work group acts as an organizing and coordinating entity for such Management Framework efforts. The primary function of the TWG is to ensure consistency of interface standards and messages across the various framework-related standardization efforts in other TWGs and subgroups and produce a comprehensive specification.

Management Protocol TWG

The Management Protocol TWG works on the management protocol components of the SNIA Storage Management Initiative Specification (SMI-S).

NDMP Software TWG

The provisional NDMP Software TWG is a SNIA Software Development project which will create a set of code which implements current and future versions of the Network Data Management Protocol, an industry standard for network based backup of file servers. NDMP to date has been standardized by the NDMP organization at http://www.ndmp.org.

Object-Based Storage Device TWG

Object-Based Storage Devices (OSD) enable the creation of self-managed, heterogeneous, shared storage by moving low-level storage functions into the storage device itself and accessing the device through a standard object interface rather than a traditional block-based interface such as SCSI or IDE. The OSD TWG develops models and guidelines, requirement statements, preliminary standards definitions, reference code, and prototype demonstrations for OSD storage subsystems.

Policy-based Storage Management TWG

The Policy-based Storage Management TWG (PSM TWG) is focused on the definition and operation of policy-based storage management. They are looking to augment the SNIA SMI specification and the DMTF CIM policy schema (as necessary) to support the use of SLA-derived policies in the management of network storage and the data that resides on it.

Security TWG

The Security TWG provides architectures and frameworks for the establishment of information security capabilities within the storage networking industry, including that of stored information in heterogeneous environments. The focus of the Security Work Group is directed toward long-term security solutions, taking into account any security inherent in underlying transports or technologies.

SMI-S Core TWG

The SMI-S Core TWG is responsible for all the common profiles and spec clauses within the SMI-S specification that are not owned by other TWGs.

Storage Media Library TWG

The Storage Media Library (SML) Work Group addresses issues with and opportunities for exploiting media libraries in a networked storage environment.

XAM Software Development Kit TWG

The XAM Software Development Kit Technical Working Group (XAM SDK TWG) is a SNIA Software Development project according to the new governance documents recently approved by the SNIA membership. The group proposes to develop SNIA Software that implements current and future versions of the Fixed Content Aware Storage (FCAS) TWG XAM Specification(s), an industry standard for fixed content storage. This software (binaries and source) is intended to go through the SNIA Software adoption process and be made available to non-SNIA members.

It should be also noted that the SNIA Grid Task Force was set up in 2005 to deal with the storage Grid management issues.

8.1.11 TM Forum (TMF)

http://www.tmforum.org

8.1.11.1 Overview

The TM Forum (formerly teleManagement Forum and historically the OSI Network management Forum) is a non-profit global organization that provides leadership, strategic guidance and practical solutions to improve the management and operation of information and communications services. Our open membership of more than 600 companies comprises incumbent and new-entrant service providers, computing and network equipment suppliers, software solution suppliers and customers of communications services. TM Forum has been contributing to the Information and Communications Services (ICS) industry for over 18 years.

The TM Forum has established a number of Technical Programmes, these comprise:

- NGOSS - NGOSS is the industry's only true standard for definition, development and deployment of easy to integrate, flexible, easy to manage OSS/BSS components. NGOSS supplies resources for business requirements definition and software development, and a set of pre-defined interfaces.
- Catalyst Projects - Where technology comes to life in real solutions built with commercial products The Catalyst Program is the proving ground for TM Forum work - where vendors come together to meet real service provider challenges using commercial products, and demonstrate the results twice per year at TeleManagement World.
- OSS/J - Now a part of the TM Forum, OSS/J provides a set of ready-made NGOSS-compliant and Java-based integration technologies supporting the cost-effective deployment and maintenance of software solutions that can easily fit into a service provider's IT environment.
- Prosspero - it is the TM Forum's new program that provides a vehicle to package TM Forum standards and proven technical assets in a way that will make them easy to use and adopt, as well as fostering the emergence of supporting ecosystems.

8.1.11.2 NGOSS Program

NGOSS is a comprehensive, integrated framework for developing, procuring and deploying operational and business support systems and software. It is available as a toolkit of industry-agreed specifications and guidelines that cover key business and technical areas including:

- Business Process Automation delivered in the enhanced Telecom Operations Map (eTOM™).
- Systems Analysis and Design delivered in the Shared Information/Data Model (SID).
- Solution Design and Integration delivered in the Contract Interface and Technology Neutral Architecture (TNA).
- Conformance Testing delivered in the NGOSS Compliance Tests.
- Procurement and Implementation delivered in ROI Model, RFI Template, and Implementation Guide documents.

The elements of NGOSS are as follows:

1) **enhanced Telecom Operations Map (eTOM):**

   The eTOM provides the map and common language of business processes that are used in Telecom Operations. In addition, process flows are provided for an ever expanding list of key processes. The eTOM can be used to inventory existing processes at a Service Provider, act as a framework for defining scope of a software-based solution, or simply enable better lines of communication between a service provider and their system integrator.

2) **Shared Information/Data Model (SID):**

   The shared information and data model provides a "common language" for software providers and integrators to use in describing management information, which will in turn allows easier and more effective integration across OSS/BSS software applications provided by multiple vendors. The SID provides the concepts and principles needed to defined a shared information model, the elements or entities of the model, the business oriented UML class models, as well as design oriented UML class models and sequence diagrams to provide a system view of the information and data.

3) **Technology Neutral Architecture and Contract Interface:**

These two components make up the heart of the NGOSS integration framework. In order to successfully integrate applications provided by multiple software vendors, the "plumbing" of the system needs to be common. The Technology Neutral Architecture defines architectural principles to guide OSS developers to create OSS components that operate successfully in a distributed environment; and the Contract Interface defines the "API" for interfacing those elements to each other across the architecture. This architecture is specifically called "Technology Neutral" as it does not define how to implement the architecture, rather what principles are applied for a particular technology specific architecture to be NGOSS compliant.

4) **NGOSS Compliance:**

In order to improve the probability that OSS components will truly integrate with each other, NGOSS provides a suite of tests for compliance to the eTOM, SID, architecture, and contract interface components. NGOSS compliance can be achieved any or all of these components either singly, or in combination with other components.

8.1.11.3 Service Delivery Framework Program

The goal of the TM Forum's Service Delivery Framework (SDF) is to define a generic management framework for next generation services regardless of the software or network technologies used to implement those services. This management framework is aimed at addressing the full lifecycle of the services, from concept to cash.

The Service Delivery Framework defines a reference model that consists of the essential building blocks that need to be put in place in order to provide a managed SDF Service environment.

Delivery of next generation services happens in a framework where the lines between network and IT are blurred. Within this framework, profitability as well as customer experience can be driven by managing the complete service lifecycle in a Service Oriented Architecture (SOA) aligned environment.

8.1.11.4 IPsphere Program

In 2008 the IPsphere Forum moved its work programs into the TM Forum with the intention of integrating with the TM Forum's Service Delivery Framework Program

Using the principles of a service-oriented architecture (SOA), the IPsphere Framework defines a business layer that automates offer, purchase and provisioning of service components among multiple stakeholders. The framework also offers support for a standardized registration and discovery process, payments for resource usage and quality assurance, and interworking with session-based service environments.

Complementary to that work is the TM Forum's Service Delivery Framework, which focuses on enabling control of service lifecycle management across all execution environments allowing flexibility in binding services with product catalogues.

Integrating the principles and technical work of these two frameworks will create a pre-commercial test bed for pilot program testing and the demonstration of multi-vendor interoperability.

8.2 Key Projects

8.2.1 Key European Projects

An initial search on CORDIS revealed more that 70 projects in Grid technologies. Obviously, it is be preferable to produce meaningful information about a selection of these projects. The EU Grid Standards Co-ordination Group (GSCG) [i.16] http://www.eu-ecss.eu/events/concertation-meeting-1/parallel-sessions-details/standardisation has a mailing list of 30+ projects in the EU IST Grids unit (now absorbed into Software and Services). COPRAS (http://www.w3.org/2004/copras/) reported on the early FP6 projects (approx 12 in number).

The following clause provides the information on the organization of European research activities funded by the European Commission and on selected research projects. The information on the projects is structured to cover the following issues:

- focus of the project on a specific area(s);
- applications implemented by the project;
- type of infrastructure operated;
- type of information provided about standards;
- list of relevant standards;
- interoperability concerns between standards, i.e. interoperability issues between different standards for the same set of functionality or for different sets of functionality;
- interoperability concerns between implementations of a standard, i.e. some interoperability issues discovered between competing implementations of the same standard.

8.2.1.1 EU FP6

European research activities are structured around consecutive four-year programmes, or so-called Framework Programmes. The Sixth Framework Programme (FP6) sets out the thematic priorities - including the Information Society Technologies (IST) priority - for the period 2002 to 2006.

In addition to the IST Thematic Priority, Information Society related activities can be funded in another parts of the FP6 programme, which includes, among others, Research Infrastructures for GÉANT and Grids.

Grid projects funded by the EU under the FP6 IST Thematic priority

In the summer of 2004 the European Commission launched 12 research projects in the area of Grid technologies that will receive 52 M € of EU funding. The bulk of the EU funding is going to 4 projects - SIMDAT, NextGRID, Akogrimo and CoreGRID - which are each receiving an EU contribution of around 9 M€. Together with 8 smaller projects, these bring together dozens of universities, research institutes, large and small companies from across Europe to muster the "critical mass" of expertise and resources necessary to trigger change.

Their approach to Grid research combines "technology push" (developing underlying technologies and interoperability standards), with "application pull" (developing the enabling technologies needed for real-world applications, such as modeling, simulation, data mining and collaborative working tools).

In the summer of 2006 the European Commission launched 20 new Grid projects receiving more than 70 M € of EU funding. They included three large Integrated Projects: BEinGRID, BREIN and XtreemOS. In the beginning of 2007 three additional projects were launched focusing on the cooperation with China on Grid Technologies.

For information on individual projects, including the scope of the project's research work and the partners involved, please refer to: http://cordis.europa.eu/ist/grids/projects.htm.

Grid projects funded by the EU under the FP6 by "Research Infrastructure" Unit

Unit F3 "Research Infrastructure" supports the provision of computer and communications infrastructures of the highest quality and performance to Europe's researchers, namely by establishing a high-capacity and high-speed communications network for all researchers in Europe (GÉANT) and specific high performance Grid- enabled advanced test-beds, exploiting the benefits of a strong co-ordination between Research Infrastructures and the IST and an enlarged co-operation with corresponding national and international initiatives.

The work of the Unit directly supports the Communication Network Development Initiative defined in the Research Infrastructures Action of the "Structuring the ERA" FP6 Programme. It will exploit the potential of the new Instruments in FP6 to ensure critical mass, economies of scale and a cohesive approach to the deployment of Infrastructures for the ERA.

Within FP6, the "Research Infrastructure" Unit is responsible for implementing the following parts of the Specific Programme "Structuring the European Research Area" within the Research Infrastructures activity:

- **GÉANT:** provision of a high-capacity and high-speed communications network interconnecting the European National Research and Education Networks. It will represent a significant step forward as compared to FP5, both in terms of services, communities served, geographical scope, bandwidth and readiness to adopt relevant new technologies.

- **Grids:** deployment of advanced Grids-empowered infrastructures. They should exhibit production-level performance capabilities and constitute themselves distributed facilities at gigabit/terabit scales (in terms of computing, storage and communication power).

The Unit also take part in implementing the "Integrating and strengthening the European Research Area" Specific Programme, within the Information Society Technologies Priority, focusing on:

- **Research networking test-beds:** deployment of advanced, user-driven large scale test-beds with the goal to integrate and validate the state-of-the-art technology.

The full list of Research Infrastructures Projects and IST projects funded under the FP6 is available on: http://cordis.europa.eu/ist/rn/ri-cnd/projects.htm.

Key projects funded by FP6 IST research

It should be noted that the list of the projects and the information provided will be modified in future versions of the present document, based on the projects' responses to the questionnaire sent them by the STF.

IP projects: Call 2 - Agokrimo, NextGrid, SIMDAT, Call 4 - BEinGRID, BREIN, XtreemOS.

NoE: CoreGRID (not included in the list).

Akogrimo (Access to Knowledge through the Grid in a mobile World).

http://www.mobilegrids.org/.

- **Focus:** Mobile Grid - this has involved a degree of integration o0066 standards proposals and implementation between Grids and Networks and telecommunications.

- **Applications:** eHealth (patient monitoring resulting in an emergency being triggered); Disaster Handling and Crisis Management.

- **Type of infrastructure.**

- **Type of information provided about standards:** usage table; small set of standards to focus active participation.

- **List of standards:**

  - Higher level specifications to support Grid application services: BPEL, WS-Agreement, WSLA.

  - Grid foundations: OGSA, SAML, SOAP, WSDL, WS-Policy, WS-Security, WSRF and WS Base Notification, X.509 Public Key Infrastructure.

  - Networking: A4C (including DIAMETER), COPS, Mobile IPv6, Presence Information, RSVP (Resource Reservation Protocol), RTP (Transport for Real-Time Applications) SDP (Session Description Protocol), SIP (Session Initiation Protocol), SLP (Service Location Protocol).

- **Interoperability concerns between standards** and name these standards where known: a large number of standards.

- **Interoperability concerns between implementations of a standard:** in general, single implementations were used. However in the case of WSRF, two widely known implementations were used (Globus GT4 and WSRF.NET) and a document has been written on interoperability problems *(reference to ETSI Grid TC #4 submission).*

BEinGRID (Business experiments in Grid)

http://www.beingrid.eu/.

- **Focus:** BEinGRID aims at fostering the adoption of the Next Generation Grid technologies by the realization of several business experiments and the creation of a toolset repository of Grid middleware upper layers. It will undertake a series of targeted business experiment pilots designed to implement and deploy Grid solutions in a broad spectrum of European business sectors (entertainment, financial, industrial, chemistry, gaming, retail, textile, etc).
- **Applications:** eighteen business experiments are planned in the initial stage of the project with a second call for proposals in the latter stage. Secondly, a toolset repository of Grid service components and best practise will be created to support European businesses that wish to take-up this important new technology.
- **Type of infrastructure.**
- **Type of information provided about standards:** no information available from the project web site.
- **List of standards:** no information available from the project web site.
- **Interoperability concerns between standards:** no information available from the project web site.
- **Interoperability concerns between implementations of a standard:** no information available from the project web site.

BREIN (Business objective driven reliable and intelligent grids for real business)

http://www.eu-brein.com/.

- **Focus:** enabling business participants to use Grid technologies more effectively.
- **Applications implemented:** to be provided.
- **Type of infrastructure.**
- **Type of information provided about standards:** BREIN document (Sept 07) on standards includes a table of relevant to the project. Columns include status of standard and value as input to the project and likelihood of making output to standards process. (reference http://www.eu-brein.com/index.php?option=com_docman&task=doc_download&gid=24&Itemid=31).
- **List of standards:** high value input or some prospect of output to standards bodies: OGSA Arch; OGSA BES; OGSA HPC Profile; JSDL; WSRF and WSN, but monitor competitors; X509 PKI; XML signature; XML encryption; WS-Security; WS-Security token profiles; WS-SecureConversation; WS-Trust; WS-Federation; SAML Tokens (SAML Protocols: low value); OGSA "Express" Authentication Profiles (for interoperable security between Grid middleware); OWL, RDF, SPARQL; FIPA ACL (for Agents); WS-BPEL; WS-CDL.
- **Interoperability concerns between standards** - and name these standards where known: to be provided.
- **Interoperability concerns between implementations of a standard:** to be provided.

NextGRID (The Next Generation Grid)

http://www.nextgrid.org/.

- **Focus:** to develop Grid architecture to support mainstream use, to meet the needs of business users by addressing security and economically viable business models, to address legal and privacy issues and to consolidate and standardize these enhancements.
- **Applications:** Financial Applications, Digital Media Application, Supply Chain Management, EDR (Electronic Data Records) Processing.
- **Type of infrastructure.**
- **Type of information provided about standards:** the information has been extracted from the publicly available papers and presentations: http://www.nextgrid.org/publications.html.

- **List of standards:** Web Services Addressing (WS-Addressing), Web Services resource Framework (WSRF), WS-Agreement, WS-Naming Specification (Draft), Web Service Security (WS-Security) Core Specification v1.1, OGSA Basic Profile, The Open Grid Services Architecture, Version 1.0", Global Grid Forum (GFD-I.030), "AAA Authorization Framework," Informational RFC 2904, Web Services Business Process Execution Language. Version 2.0, OASIS Committee Draft, Business Process Execution Language for Web Services version 1.1, Information Technology - Role Based Access Control, Document Number: ANSI/INCITS 359-2004, GT 4.0: Security: Authorization Framework, "Use of SAML for OGSI Authorization", GGF Draft, gLite Security Subsystem, eXtensible Access Control Markup Language (XACML) Version 2.0, OASIS Standard, Assertions and Protocols for the OASIS Security Assertion Markup Language (SAML) V2.0, OASIS Standard, Core and hierarchical role based access control (RBAC) profile of XACML v2.0, OASIS Standard.

- **Interoperability concerns between standards:** Lifecycle Management, Producer/Consumer Notification, and State access based on WSRF.

- **Interoperability concerns between implementations:** interoperability of Grid services and legacy applications.

SIMDAT (Data Grids for Process and Product Development using Numerical Simulation and Knowledge Discovery)

http://www.scai.fraunhofer.de/simdat.html.

- **Focus:** Grid in simplifying processes used for the solution of complex, data-centric problems.

- **Applications:** Automotive, Aerospace, Pharmaceutical, Meteorology applications.

- **Type of infrastructure.**

- **Type of information provided about standards:** D.21.1.7 SIMDAT Standardization Plans publicly available on: http://www.scai.fraunhofer.de/fileadmin/SimDat/Deliverables/SIMDAT_D.21.1.7_Standardisation_Report_Public.pdf.

- **List of standards:** WS-Addressing, Web Service Resource Framework, WS-Notification, OGSA Profiles.

- **Interoperability concerns between standards:** Connectivity interoperability (network, file transfer, etc.), Data format interoperability (OS specific data formats), Data processing interoperability (performance, scales, precision, calculation), Authentication interoperability, Federation supporting web services (process integration and optimization).

- **Interoperability concerns between implementations of a standard:** to be provided.

XtreemOS (Building and promoting a Linux-based operating system to support virtual organizations for next generation grids)

http://www.xtreemos.org/.

- **Focus:** Producing a Grid OS.

- **Applications implemented:** None yet (project started July 2006). But several applications have been used to determine requirements.

- **Type of infrastructure.**

- **Type of information provided about standards:** x.

- **List of standards:** no publicly visible statement on standards usage and influence yet.

- **Interoperability concerns between standards - and name these standards where known:** security; VO Management (not yet the subject of standards work); SAGA; EMS.

- **Interoperability concerns between implementations of a standard:** XtreemOS will be producing an OS which will enable nodes running XtreemOS to interoperate with each other and as far as possible with nodes running other software. The topics include:
  - security;
  - VO Management;
  - Application Execution Management;
  - Data management (XtreemOS File System).

  The main tool for interoperability is that the product will be based on the OGF SAGA specification. This will include what is currently defined in SAGA and will also make use of the SAGA extension capability.

Selected STREPs and SSAs:

AssessGrid (Advanced Risk Assessment and Management for Trustable Grids)

http://wwwcs.uni-paderborn.de/pc2/index.php?id=306.

- **Focus:** AssessGrid focuses on the risk awareness and consideration in SLA negotiation, self-organizing fault-tolerant actions, and capacity planning. It will develop an open-source software for risk assessment, risk management, and decision-support in each Grid layer.
- **Applications:** to be checked.
- **Type of infrastructure.**
- **Type of information provided about standards:** the information has been extracted from the projects' publicly available documents. However, there is no publicly visible statement on standards usage and influence yet.
- **List of standards:** WS-Agreement, WSRF, SLA.
- **Interoperability concerns between standards:** WS-Agreement.
- **Interoperability concerns between implementations of a standard:** Dynamic Service Level Agreements (SLAs) in Grids; Distributed Collaborations and Workflows.

EC-GIN (Europe-China grid InterNetworking)

http://www.ec-gin.eu/corpsite/display/main.asp

- **Focus:** EC-GIN aims to develop tailored network technology in dedicated support of Grid applications. The technical solutions will be supplemented with a secure and incentive-based Grid services network traffic management system, which will balance the conflicting performance demand and the economic use of resources in the network and within a Grid.
- **Applications:**
  - "European applications - generally split to:
    - Client-Server (Application/Storage Service Providers)
    - Beyond Client-Server (P2P computing, enterprise integrated computing solutions)
    - Service-oriented architectures (e-Science, e-Business).
  - Chinese applications:
    - Biology Information grid, Image processing grid, Computing Fluid Dynamics grid, Large-scale information process grid, Online University Courses, Shanghai Education and Research grid".
- **Type of infrastructure.**

- **Type of information provided about standards:** Project website: http://www.ec-gin.eu/corpsite/display/dsp_Entity.asp?EN_ID=204.
- **List of standards:** improvements to TCP, new algorithms at the application layer, and employing parallel TCP connections (MulTCP); WS-Agreement model; Simple Network Management Protocol (SNMP).
- **Interoperability concerns between standards:** this information is not available from the project web site.
- **Interoperability concerns between implementations of a standard:** this information is not available from the project web site.

GridCOMP (GRID programming with Components: an advanced component platform for an effective invisible grid)

http://gridcomp.ercim.org/

- **Focus:** to implement the Grid Component Model (GCM) - key person here is Denis Caromel @ INRIA.
- **Applications** implemented: to be provided.
- **Type of infrastructure.**
- **Type of information provided about standards:** the idea is to provide a mechanism (the GCM) for interoperability. I believe that the intent is not to interoperate directly with legacy and low level Grid interfaces, but rather to provide some wrapping for them.
- **List of standards:** the GCM is the subject of a new ETSI Grid work item, but not directly the subject of this STF.
- **Interoperability concerns between standards - and name these standards where known:** this is about providing a mechanism for Grid components to interoperate in general and is intended to provide a mechanism at a higher level than (say) WSRF or WS-Transfer.
- **Interoperability concerns between implementations of a standard.**

Grid4All (Self- Grid: Dynamic virtual organizations for schools, families, and all)

http://grid4all.elibel.tm.fr/

- **Focus:** the project will provide the application of component based management architectures to self-organizing peer-to-peer overlay services, self-management capabilities - improve scalability, resilience to failures and volatility, on-demand creation and maintenance of dynamically evolving scalable virtual organizations, even short lived, advanced application frameworks for collaborative data sharing applications executing in dynamic environments.
- **Applications:** two different application domains: collaborative tools for e-learning, targeting schools and digital content processing applications targeting residential users.
- **Type of infrastructure.**
- **Type of information provided about standards:** no Deliverable publicly available yet.
- **List of standards:** no Deliverable publicly available yet.
- **Interoperability concerns between standards:** no Deliverable publicly available yet.
- **Interoperability concerns between implementations of a standard:** no Deliverable publicly available yet.

GridTrust (Trust and security for next generation grids)

https://dev.moviquity.com/

- **Focus:** trust and Security for Next Generation Grids.
- **Applications implemented:** to be provided.

- **Type of infrastructure:**
- **Type of information provided about standards:** no publicly visible statement on standards usage and influence yet.
- **List of standards:** general area of trust, security, usage control. No list as yet.
- **Interoperability concerns between standards - and name these standards where known:** there will need to be some interoperability between standards on security, trust, certificates, usage control, authentication and authorization.
- **Interoperability concerns between implementations of a standard:** GridTrust are producing some tools in the subject of trust and security and VOs and (for example - Usage Control Service - UCS) this will be a module to be integrated into Globus. Therefore at this experimental stage, there will not be an interoperability concern between implementations, but this will be an issue in this subject at a later date - maybe beyond the lifetime of the Project.

KnowARC (Grid-enabled Know-how sharing technology based on ARC services and open standards)

http://www.knowarc.eu/

- **Focus:** the project's focus is on the extension and improvement of the Advanced Resource Connector (ARC) middleware.
- **Applications implemented:** High Energy Physics data processing and Monte Carlo simulation; bioinformatics (eQTL); medical image analysis.
- **Type of infrastructure:** not applicable, the project does not provide infrastructure.
- **Type of information provided about standards:** the information is available from the public report: D3.3-1 KnowARC Standards Conformance Roadmap (second release): http://www.knowarc.eu/documents/Knowarc_D3.3-1_08.pdf
- **List of standards:**
  - Highly relevant specifications: WS-I Basic Profile 1.1, XML Path Language (XPath) v1.0, WS-Resource Framework v1.2 (WSRF), Web Services Addressing (WS-Addressing) v1.0, The Open Grid Services Architecture (OGSA), v1.5 (GFD.80), Open Grid Services Architecture Glossary of Terms v1.6 (GFD.120), OGSA WSRF Basic Profile 1.0 (WSRF-BP) (GFD.72), OGSA Basic Execution Service (BES) v1.0 (GFD.108), Job Submission Description Language (JSDL) Specification v1.0 (GFD.136), HPC Basic Profile (HPC-BP) v1.0 (GFD.114), JSDL HPC Profile Application Extension, v1.0 (GFD.111), GLUE Schema v2.0 (OGF draft doc15023), Usage Record - Format recommendation (GFD.98), GridFTP Protocol Description v2.0 (GFD.47), The Storage Resource Manager Interface (SRM) Specification v2.2 (GFD.129), Internet X.509 Public Key Infrastructure (PKI), Proxy Certificate Profile (RFC 3820), WS-I Basic Security Profile (BSP) v1.0.
  - Specifications of potential relevance: Distributed Resource Management Application API (DRMAA) Specification v1.0 (GFD.22), Authorization Glossary (GFD.42), Conceptual Grid Authorization Framework and Classification (GFD.38), Extensible Access Control Markup Language (XACML) v2.0, Security Assertion Markup Language (SAML) v2.0, A Simple API for Grid Applications (SAGA) (GFD.90), ByteIO Specification v1.0 (GFD.87), HPC File Staging Profile, Version 1.0 (OGF draft).
- **Interoperability concerns between standards:** on one hand, there is notable overlap in membership between standards-developing groups; on the other hand, there is little integration effort that would ensure consistency and compatibility. The newly created PGI-WG is a step towards solving this dilemma.
- **Interoperability concerns between implementations of a standard**: there is a strong tendency to implement *profiles* as either subsets of standards, or subsets with extensions. In a long run, there is a risk that one will have to talk not about interoperability between standards or middlewares, but about compatibility of profiles.

Nessi-Grid (Networked European software and services initiative-grid) - SSA

- **Focus:** the focus is on SOKU (Service Oriented Knowledge Utilities) and software infrastructures.

- **Key technology domains:**
    - Infrastructure:

      The infrastructure domain aims at the virtualization of resources across servers, storage, distributed systems (including Grid) and the network. Infrastructures have to be architected and implemented to be robust, fault-tolerant and secure. From a users' perspective, infrastructures need to be transparent (almost invisible) during the entire lifecycle - allowing a plug-and-play approach to infrastructure usage as well as to Grid provisioning and operation of services. New foundation core layers including the development of Grid-aware network-oriented operating systems are necessary to cope with new challenges in providing such an infrastructure. To support and enable the customers in migrating their applications to new virtualized infrastructure models, a structured methodology for application migrations is required.

      - Service Integration:

      In the NESSI vision, Service Oriented Architectures (SOA) will become the primary architecture for business systems of the near future. SOA provide means to create by configuration complex systems in a new modular way. This modularity will allow reusability of published services by other applications within a virtual organization paradigm. The service integration platform also aims at providing tools and methods for configuration and composition in the same way as existing CASE tools provide support for programming. Moreover, the platform also supports dynamic reconfiguration, where software can be modified without stopping execution.

      - Semantics:

      Semantics will be a key element for the transformation of information to knowledge. One way to build knowledge will be through advanced search engines that allow fast search in large unstructured data. Semantic Web technology based on ontologies will enable far more effective machine to machine communication about the nature and the manipulation of data they hold and actions based upon that data. On the business process level, business modelling provides the semantics that is required for business process management, process transformation and inter-company cooperation. In a knowledge-based economy, learning and knowledge management finally will have to converge to a work place utility.

    - Cross-domain aspects (quality and reliability, security and trust, interoperability, management services).

Grid projects under FP6 - Unit F3 - Research Infrastructure

There have been 4 projects funded by the Unit 3 - Research Infrastructure:

- DEISA (Distributed European Infrastructure for Supercomputing Applications).
- EGEE (Enabling Grids for E-sciencE).
- GÉANT2.
- SEE-GRID (South Eastern European Grid-enabled eInfrastructure Development).

DEISA and EGEE are listed in clause 8.3 (Real Grids).

GÉANT2 provides a key underlying resource for grids.

8.2.1.2 Grid within the FP 7

There are ten directorates within the European Commission "Information Society and Media Directorate-General". Grid related activities are organized by Directorate F - Emerging Technologies and Infrastructures and since January 2007 Directorate D - Network and Communication Technologies.

In the new FP7, the F2 Unit on Grid technologies has been replaced by the Future and Emerging Technologies - Open Unit. Most of the active research projects funded by this former F2 Unit have been transferred to Unit D3 and F3 (see below).

Unit F3 "Research Infrastructure" supports the provision of computer and communications infrastructures of the highest quality and performance to Europe's researchers, namely by establishing a high-capacity and high-speed communications network for all researchers in Europe (GÉANT) and specific high performance Grid-enabled advanced test-beds, exploiting the benefits of a strong co-ordination between Research Infrastructures and the IST (Information Society Technologies) and an enlarged co-operation with corresponding national and international initiatives. This first call for proposal under FP7 closed in May 2007.

The mission of the Unit D3 "Software & Service Architectures and Infrastructures Unit" is to promote global competitiveness of the European industry in software and services by supporting research activities and developing policies in the field of Software, Services and Distributed Systems. Since 1 January 2007, most contracts managed under Unit F2 have been transferred to Unit D3.

There are several new Projects starting in 2008 with a possible impact on ETSI/GRID.

Recently, the EGI Knowledge Base has been set-up [i.98]. It is intended to provide up to date information on National Grid Initiatives (NGIs), and plans for the future European Grid Infrastructure. The EGI Knowledge Base is part of the EGI Design Study, a project funded by the European Union [i.99].

A complete list of EU projects funded under the FP7 is provided on:
http://knowledge.eu-egi.eu/knowledge/index.php/FP7_Grid_Projects.

In addition a number of collaboration working groups have been established. These include Service Architectures (this working group follows the activities of the NEXOF-RA project), QoS and SLAs, Virtualized Service Platforms, Standards. A list of these collaboration groups is provided on:
http://www.eu-ecss.eu/private-area/qos-and-slas/contents/collaboration-working-groups

Since the majority of the FP 7 projects were launched during the last year only, the information on the projects provided below has been based on the data available from the EGI Knowledge Base, from the projects' web sites and publicly available projects' deliverables. It should be noted that the information on standards and standardization issues is limited and provided for those projects only for which it has been available in the sources mentioned earlier in this clause.

BalticGrid-II

http://www.balticgrid.eu/

- **Focus:** to increase the impact, adoption and reach, and to further improve the support of services and users of the recently created e-Infrastructure in the Baltic States. This is aimed to be achieved by an extension of the BalticGrid infrastructure to Belarus; interoperation of the gLite-based infrastructure with UNICORE and ARC based Grid resources in the region; identifying and addressing the specific needs of new scientific communities such as nano-science and engineering sciences; and by establishing new Grid services for linguistic research, Baltic Sea environmental research, data mining tools for communication modelling and bioinformatics.

- **Applications to be implemented:** the first three pilot applications selected include NWCHEM (a computational chemistry package that is designed to run on high-performance parallel supercomputers as well as conventional workstation clusters), E-SM - Evolutionary Secondary Structures Matching (Latvian Grid system is used for comparison of protein structures) and COR-LT - Corpus of Academic Lithuanian (a resource of authentic language data for linguistic research of academic discourse, for interdisciplinary studies, lexicographical practice, and terminology studies in theory and practice).

- **Type of infrastructure:** gLite-based infrastructure with UNICORE and ARC based Grid resources.

- **Type of information provided about standards:** not available yet.

D4Science (DIstributed colLaboratories Infrastructure on Grid ENabled Technology 4 Science)

http://www.d4science.eu/

- **Focus:** to deploy the e-Infrastructures built so far by the EGEE and DILIGENT projects so that they address the needs of several new scientific communities affiliated with the broad disciplines of Environmental Monitoring and Fisheries and Aquaculture Resources Management.

- **Type of infrastructure:** gLite and gCube resource nodes.

- **Type of information provided about standards:** not available yet.

DEISA 2 (Distributed European Infrastructure for Supercomputing Applications)

http://www.deisa.eu/

- **Focus:** to develop and support the pan-European distributed high performance computing infrastructure established since 2002 within the predecessor project DEISA 1 that was funded in FP6.
- **Applications to be implemented:** Data Management, Job Management, User Management, Production Environment, Science Gateways, Application Support.
- **Type of infrastructure:** DEISA incorporates several different platforms and operating systems (IBM AIX on Power5-6, IBM Linux on PowerPC, SGI Linux on Itanium, Cray XT, and NEC vector systems), and the consortium has deployed middleware that enables the access to distributed resources, high performance data sharing and transparent job migration across similar platforms.
- **Type of information provided about standards:** DEISA identified standardization needs in the area of high-performance computing, AAA (Authentication, Authorization, Accounting), job scheduling, data management, monitoring of services and infrastructure components, Grid middleware allowing for a seamless access to HPC facilities across different e-infrastructures.
- **List of standards:** OGF: JSDL, BES, HPCBP, GLUE, DAIS, UR, RUS; OASIS: WS-*, Others: OpenID, REST.
- **Interoperability concerns between standards - and name these standards where known:** DEISA is part of the GIN (Grid Interoperation Now). UNICORE 6 which is built on Grid standards has been deployed at some DEISA sites.

DIESIS (Design of an Interoperable European federated Simulation network for critical InfraStructures)

www.diesis-project.eu

- **Focus:** to establish the basis for a European modelling and simulation e-Infrastructure based upon open standards to foster and support research on all aspects of critical infrastructures with a specific focus on their protection.
- **Applications to be implemented:** not envisaged.
- **Type of infrastructure:** not available yet at the project web site.

DORII (Deployment of Remote Instrumentation Infrastructure)

http://www.dorii.eu/

- **Focus:** to deploy e-Infrastructure for new scientific communities such as the earthquake community (with various sensor networks), environmental science community, experimental science community (with synchrotron and free electron lasers).
- **Applications to be implemented:**
- **Experimental Science:** SAXS (Small Angle X-ray Scattering), XRD (X-Ray Diffraction), SYRMEp (SYnchrotron Radiation for MEdical Physics),
- **Earthquake:** Network centric simulation and Early warning
- **Environmental:** Oceanographic and coastal observation and modelling Mediterranean Ocean Observing Network, Oceanographic and coastal observation and modelling using imaging, Monitoring inland waters and reservoir.
- **Demonstration:** Lego Mindstorm Robots Demo.
- **Type of infrastructure:** mainly based on the EGEE infrastructure and its middleware of choice gLite.

- **Type of information provided about standards:** DORII partners were taking part in the progress of establishing a research group in OGF, which focus on topics presented at the project, i.e. RI-GE - Remote Instrumentation Services in a Grid Environment. RISGE-RG explores issues related to the exploitation of Grid technologies for conducting and monitoring measurement tasks and experiments on complex remote scientific equipment.

DRIVER-II (Digital Repository Infrastructure Vision for European Research

- **Focus:** Establishment of a "European Confederation of Digital Repositories", Inclusion of Digital Repositories with non-textual or non-publication content, e.g. images, presentations, and possibly primary data; Construction of "enhanced publications", which combine interrelated information objects into a logical whole; Provision of advanced functionality to address the requirements raised by the above innovations or to serve varied modes of scientists' research explorations.

- **Applications to be implemented:** Services on top of the repositories (International registries, Search engines, Other services (Listed in the library catalogue of the Institute, Listed in a Regional/national catalogue, Printing on demand service).

- **Type of infrastructure:** Digital Repositories that provide the content as a third layer to the existing data network (GEANT2 and NREN's) and Grid-middleware infrastructure layers.

- **Type of information provided about standards:** Standardization organzations and the standards and/or specifications related to data repository are listed.

- **List of standards**: Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH), Open Archives Initiative Object Reuse and Exchange (OAI-ORE).

- **Interoperability concerns between standards - and name these standards where known:** Interoperability issues for shared distributed resources including articles, data sets, images (enhanced publications) and other types of records taking into account different levels of interoperability (record level, metadata level, repository level, protocol level, etc.).

- **Interoperability concerns between implementations of a standard:** not available yet.

E-NMR (Deploying and unifying the NMR e-Infrastructure in System Biology)

http://www.e-nmr.eu/

- **Focus:** to optimize and extend the use of the NMR (Nuclear Magnetic Resonance) Research Infrastructures of EU-NMR through the implementation of an e-Infrastructure in order to provide the biomolecular NMR user community with a platform integrating and streamlining the computational approaches necessary for NMR data analysis and structural modelling (e-NMR). Access to the e-NMR infrastructure will be provided through a portal integrating commonly NMR software and GRID technology.

- **Applications to be implemented:** NMR-related applications.

- **Type of infrastructure:** infrastructure realized by EGEE/EGEE II project is supposed to be used. gLite 3.1 middleware customized and distributed by the INFNGRID (National Institute of Nuclear Physics, Italy) Release [R7] has been deployed.

EDGeS (enabling Desktop Grids for e-Science)

http://www.edges-grid.eu/

- **Focus:** to create an integrate Grid infrastructure across Europe that seamlessly integrates a variety of Desktop Grids with EGEE type of service Grids.

- **Applications to be implemented:** Combined EGEE-DG Service Management - an activity to establish and maintain an integrated e-infrastructure, a production service that combines EGEE and existing local and public Desktop Grid systems.

- **Type of infrastructure:** interconnection of the EGEE infrastructure with existing Desktop Grid (DG) systems.

EELA2 (E-science grid facility for Europe and Latin America)

http://www.eu-eela.eu/

- **Focus:** to build a high capacity, production-quality, scalable Grid Facility, providing round-the-clock, worldwide access to distributed computing, storage and network resources needed by the wide spectrum of Applications from European - Latin American Scientific Collaborations, with special focus on offering a complete set of versatile services fulfilling Applications requirements.

- **Applications to be implemented:** the full list of supported applications is provided on: http://applications.eu-eela.eu/.

- **Type of infrastructure:** EELA-2 Networking Support Centre (ENSC) will develop interoperation agreements consolidating relationships with GÉANT2, RedCLARA and the NRENs in Europe and Latin America, and engage with projects likely to share resources.

EGEE-III (Enabling Grids for E-sciencE)

http://www.eu-egee.org/

- **Focus:** to expand and optimize the Grid infrastructure, which currently processes up to 300, 000 jobs per day from scientific domains ranging from biomedicine to fusion science.

- **Applications to be implemented:** applications cover a range of domains such as multimedia, finance, archaeology, and civil protection.

- **Type of infrastructure:** A set of middleware services deployed on a worldwide collection of computational and storage resources, plus the services and support structures put in place to operate them:

  - Production Service infrastructure is a large multi-science Grid infrastructure, federating some 250 resource centres world-wide.

  - Pre-Production Service (PPS) provides access to grid services in preview to interested users, in order to test, evaluate and give feedback to changes and new features of the middleware.

  - EGEE Network Operations Centre (ENOC) which caters for the network operational coordination between EGEE and the network providers (GEANT2 /NRENs).

- **Type of information provided about standards:** Standards and standardization working groups the project members are actively involved or monitoring include: CAOPS-WG: Certification Authority Operations, ET-CG: Education and Training Community Group, GIN-CG: Grid Interoperation Now Community Group, GLUE-WG: Grid Laboratory Uniform Environment, GSM-WG: Grid Storage Management, INFOD-WG: Information Dissemination, IPAW: International Provenance and Annotation, JSDL-WG: Job Submission Description Language, NM-WG: Network Measurements, OGSA AUTHZ-WG: Open Grid Service Architecture Authorization, OGSA-BES-WG: Open Grid Service Architecture Basic Execution Service, OGSA-DMI-WG: Open Grid Service Architecture Data Movement Interface, RUS-WG: Resource Usage Service, SAGA-CORE-WG: Simple API for Grid Applications Core, UR-WG: Usage Record.

ETICS 2 (eInfrastructure for Testing, Integration and Configuration of Software - Phase 2)

http://etics.web.cern.ch/etics/

- **Focus:** To provide multi-platform and open source for building, testing and quality checking of the software.

- **Applications to be implemented:** Open for the development by the projector by the ETICS user community. Project focus is on the improvement of developed services especially in the security and reliability areas.

- **Type of infrastructure:** The hardware resources where the services are run are contributed as unfunded contribution by three of the ETICS 2 beneficiaries, CERN, INFN (National Institute of Nuclear Physics, Italy) and University of Wisconsin.

- **Type of information provided about standards:**: The project aims to maintain, improve and promote the ETICS Grid Quality Certification Model (GridQCM) by contributing to OGF Build, Test and Certification Working Group and presenting the model to the ISO for standardization.

- **List of standards:** To be provided.
- **Interoperability concerns between standards - and name these standards where known:** Integration of the ETICS services with other test frameworks to ease the adoption of ETICS in existing software validation environment especially in commercial applications.
- **Interoperability concerns between implementations of a standard:** to identify, adapt and develop test management tools especially in the field of test workflow management with the goal of reducing the complexity of designing and implementing complex tests for applications.

ETSF (European Theoretical Spectroscopy Facility)

http://www.etsf.eu/

- **Focus:** To carry out state-of-the-art research on theoretical and computational methods for studying electronic and optical properties of materials.
- **Applications to be implemented:** Development of highly efficient computational software, E-Libraries, publication database in the field of spectroscopy.
- **Type of infrastructure:** To be provided.
- **Type of information provided about standards:** Within the network, different software is developed. All codes are released under Free Software licenses. Project aims to facilitate their use by unifying input/output files and by using the same standards.
- **List of standards:** XML, NetCDF.
- **Interoperability concerns between** implementations of a standard: To developed standard file formats to allow better integration and better interoperability between codes. 78odellinoach is based on existing file formats, such as XML or NetCDF. Focus is on the capability to read or write these formats on a wide variety of platforms and using different programming languages (in particular Fortran 90, C, and Python).

EUAsiaGrid

http://www.euasiagrid.org/

- **Focus:** Support Action that aimes to promote international interoperation between similar infrastructures and to reinforce the global relevance and impact of European e-Infrastructures.

EUFORIA (EU Fusion fOR Iter Applications)

http://www.euforia-project.eu/EUFORIA/

- **Focus:** To provide a comprehensive framework and infrastructure for core and edge transport and turbulence simulation, linking grid and High Performance Computing (HPC) to the fusion modelling community.
- **Applications to be implemented:** Deployment of both a grid service and a High Performance Computing services.
- **Type of infrastructure:** The context of this project relies on the consolidation of a Grid-based research space across Europe. The infrastructure will be compatible with EGEE middleware services.
- **Type of information provided about standards:** Project aims to contribute to the standardization of the Grid middleware and to follow the recommendations of international bodies such as e-IRG (e-Infrastructure Reflection Group) and GGF (Global Grid Forum).
- **List of standards:** not available yet.

EVALSO: Enabling virtual access to Latin-american southern observatories

- **Focus:** To create a physical infrastructure (and the tools to exploit it) to efficiently connect experimental facilities created in Chile by the European Astronomical Community to Europe.
- **Type of infrastructure:** The infrastructure created by the project will be complementary to the international infrastructures created in the last years with the EC support (RedCLARA, ALICE, GEANT).

- **Type of information provided about standards:** Little if any standardization work, Application of existing standard and tuning of the parameters to the specific field [i.100].

EuroVO-AIDA (European Virtual Observatory - Astronomical Infrastructure for Data Access)

http://cds.u-strasbg.fr/twikiAIDA/bin/view/EuroVOAIDA/WebHome

- **Focus:** EuroVO-AIDA aims at unifying the digital data collections of European astronomy, integrating their access mechanisms with evolving e-technologies, and enhancing the science extracted from these datasets. The EuroVO-AIDA project is proposed to lead the transition of Euro-VO into an operational phase.

- **Applications to be implemented:** Web 2.0 for data centres, Semantics and ontologies, with applications to the astronomical semantic web and to the definition and usage of an astronomical vocabulary, Data Mining.

- **Type of infrastructure:** To be provided.

- **Type of information provided about standards:** Participation in IVOA (International Virtual Observatory Alliance) Working Groups [i.101].

- **List of standards:** IVOA standards, DAL (Data Access Layer), Observation DM (Data Model), VOQL (Virtual Observatory Query Language), Web 2.0.

FEDERICA (Federated E-infrastructure Dedicated to European Researchers Innovating in Computing network Architectures)

http://www.fp7-federica.eu/

- **Focus:** To implement an experimental network infrastructure for trialling new networking technologies. This infrastructure is intended to be agnostic as to the type of protocols, services and applications that may be trialled, whilst allowing disruptive experiments to be undertaken. The aim is to develop mechanisms that will allow such experiments to be run over existing production networks without adverse effect.

- **Applications to be implemented:** Solutions for allocating, controlling and managing virtualized network resources in a multi-domain infrastructure.

- **Type of infrastructure:** European National Research and Education Networks, GÉANT2).

- **Type of information provided about standards:** Project aims to follow standardization work in the the multi-domain area service brokering area of data networking, and is likely to provide contribution in standardization of virtual resources and services.

- **List of standards:** IETF Common Control and Measurement Plane (CCAMP) and Virtual Private Networks at various layers, OGF and OGF-Europe - requirements of (virtual) resources and OGF NML-WG - topologies modelling, enhancement of the IPSF (IPSphere Forum) framework to include virtualization.

- **Interoperability concerns between standands - and name these standards where known:** not available yet.

- **Interoperability concerns between implementations of a standard:** not available yet.

GENESI-DR (Ground European Network for Earth Science Interoperations - Digital Repositories)

http://www.genesi-dr.eu/

- **Focus:** To establish open Earth Science Digital Repository access for European and world-wide science users to seamlessly access and share all data, information, products and knowledge originating from space, airborne and in-situ sensors.

- **Applications to be implemented:** distributed data archiving, discovery, access and processing.

- **List of standards:** Standard interfaces for data access: Import / export support for ISO (ISO 19115, 19139) and OGC standards for geospatial metadata and processing (WPS), Conformance with basis of emerging INSPIRE Implementing Rules for Metadata and Discovery, CSW interfaces via GeoNetwork, Atom+GeoRSS+Dublin Core for wider use and OpenSearch protocol with Geo extensions.

GridTalk

http://www.gridtalk.org/

- **Focus:** Project coordinates the dissemination outputs of EGEE and other European grid computing efforts.

IMPACT (Improving protein annotation and co-ordination through technology

http://www.ebi.ac.uk/impact/page.phb

- **Focus:** To create a single resource (a database called "InterPro") to search genomes and proteomes for "protein signatures" - diagnostic entities that are used to recognize a particular domain or protein family.

- **Type of information provided about standards:** Project will define and adopt new data formats to facilitate information exchange between partners, as well as enabling delivery of new data to users.

- **List of standards:** not available yet.

- **Interoperability concerns between standands - and name these standards where known:** Project aims to ensure inter-operability with other resources, such as those in the GRID computing community.

- **Interoperability concerns between implementations of a standard.**

METAFOR

http://metafor.enes.org/

- **Focus:** To define a Common Information Model (CIM) that describes in a standard way climate data and the models that produce the data. METAFOR will build on existing metadata (data describing data) currently used in existing data repositories and address issues like metadata fragmentation, gaps, or duplication. In close interaction with related initiatives at the international level, METAFOR will propose solutions to identify, access and use the climate data in these repositories and standardize model description.

NMDB (real-time Neutron Monitor DataBase)

http://record.oulu.fi/

- **Focus:** To create a European digital repository for cosmic ray data by pooling existing data archives and by developing a real-time database with the data of as many European neutron monitor stations as possible. The data will be available through internet.

NOTE: No detailed information has been publicly available.

NeuGRID (A GRID-BASED e-INFRASTRUCTURE FOR DATA ARCHIVING/ COMMUNICATION AND COMPUTATIONALLY INTENSIVE APPLICATIONS IN THE MEDICAL SCIENCES

http://www.neugrid.eu/pagine/home.php

- **Focus:** Grid-based research e-Infrastructure enabling the European neuroscience community to carry out research required for the pressing study of degenerative brain diseases.

- **Type of information provided about standards:** neuGRID will be compliant with EU and international standards regarding data collection, data management, and Grid construction.

- **List of standards:** not available yet.

NOTE: No detailed information has been publicly available.

NEXOF-RA

http://www.nexof-ra.eu/

- **Focus:** The overall goal of NEXOF-RA is independence such that NEXOF can be implemented into a broad range of application domains supporting any business size by all user communities using different technologies. NEXOF-RA will deliver a coherent set of technologies globally applicable intended to provide Europe with digital service to improve flexibility, interoperability and quality. In addition, NEXOF-RA will try to establish strategies and policies to speed up the dynamics of the services eco-system as well as to foster safety, security and well being of citizens by means of new societal applications. The scope of NEXOF-RA is to deliver:
    - **The NEXOF Reference Architecture:** Following an Open Architecture Specification Process which will allow contributions from many sources also outside NEXOF-RA, focusing on the "NESSI Framework" as defined in the NESSI Holistic Model;
    - **A Proof-of-Concept:** This will be a set of software artifacts the project team will use to validate the key architectural choices made; and
    - **The NEXOF Roadmap:** This will define the roadmap for the implementation and adoption of the whole of NEXOF.

OGF-EUROPE (Mobilizing & Integrating Communities on Grids, Standards & Best Practices across Europe)

http://www.ogfeurope.eu/

- **Focus:** To influence the drive towards global standardization efforts and in bringing best practices back into the EU computing environment.

PARSE.Insight (Permanent Access to the Records of Science in Europe)

http://www.parse-insight.eu/

- **Focus:** to develop a roadmap and recommendations for developing the e-infrastructure in order to maintain the long-term accessibility and usability of scientific digital information in Europe.

PRACE (Partnership for Advanced Computing in Europe)

http://www.prace-project.eu/

- **Focus:** creation of a persistent pan-European HPC service, consisting of several tier-0 centres providing European researchers with access to capability computers and forming the top level of the European HPC ecosystem.

- **Type of infrastructure:** PACE will prepare for the implementation of the infrastructure in 2009/2010 by defining and setting up a legal and organizational structure involving HPC centres, national funding agencies, and scientific user communities. In parallel PACE will prepare the deployment of Petaflop/s systems in 2009/2010.

RESERVOIR

http://www.reservoir-fp7.eu/

- **Focus:** The project will provide a foundation for a service-based online economy, where - using virtualization technologies - resources and services are transparently provisioned and managed on an on-demand basis at competitive costs with high quality of service.The prime deliverable of the project will be a definition of the architecture and reference implementation built on open standards along with new technologies to provide a scalable, flexible and dependable framework for delivering services as utilities while federating diverse infrastructures. It is envisioned that these deliverables will serve the European community, as well as RESERVOIR partners and their customers, in the development of next generation data centers demonstrating quantified and significant improvements in service delivery productivity, quality, availability and cost.

SEE-GRID-SCI (SEE-GRID eInfrastructure for Regional eScience)

http://www.see-grid.eu/

- **Focus:** Establishment of collaborative models for use of computing and data resources across various in the region South-East Europe (SEe) region.

- **Applications to be implemented:** The complete list is available on: http://wiki.egee-see.org/index.php/SEE-GRID_Wiki#SEE-GRID-2_Developped_applications.

IRMOS (Interactive Realtime Multimedia Applications on Service Oriented Infrastructure), Project Start 01.02.2008

http://www.irmosproject.eu

- **Focus:** to design, develop and validate a Service Oriented Infrastructure which will allow the adoption of interactive real-time applications, and especially multimedia applications, enabling their rich set of attributes (from time-constrained operation to dynamic service control and adaptation) and their efficient integration into the infrastructure.
- **Applications implemented:** the infrastructure will be demonstrated in sectors with major economic and social importance by focusing on Collaborative Digital Film Postproduction, virtual and augmented reality and interactive real-time collaborative learning.
- **Type of infrastructure:** IRMOS will design, develop, integrate and validate a Service Oriented Infrastructure that enables a broad range of interactive real-time applications. It will support the development and deployment of real time applications in a distributed, managed, secure and cost effective way. The IRMOS vision is motivated by combining the benefits of SOAs with the ability to support real-time applications with stringent performance, reliability and temporal constraints.
- **Type of information provided about standards:** IRMOS will contribute the resulted work into related Standardization Bodies such as:
  - W3C, ETSI TC Grid, OGF, etc.
- **List of standards:** nothing available yet. To be provided.
- **Interoperability concerns between standards - and name these standards where known:** to be provided.
- **Interoperability concerns between implementations** of a standard: to be provided.

8.3 Examples of Grids

Inclusion in this clause does not imply that these are true Grids (degree of gridlyness) but only that they are examples of implementations with Grid like qualities.

8.3.1 China Grid

In 2002, the China Ministry of Education (MoE) launched the largest grid computing project in China, called the ChinaGrid project, aiming at providing the nationwide grid computing platform and services for research and education among 100 key universities in China.

There are currently at least three large grid initiatives in China:

- China National Grid - CNGrid (Ministry of Science and Technology).
- China Education and Research Grid - ChinaGrid (Ministry of Education).
- China Science Grid Project (National Science Foundation).

The most widely known and perhaps advanced grid initiative is ChinaGrid with its focus on education and research. The first phase was 2003 to 2005, with 12 key universities involved (20 universities at the end of 2004). At that time, the systems in the ChinaGrid had a performance of more than 16Tflops, with 180TB storage.

ChinaGrid network infrastructure

The underlying infrastructure for the ChinaGrid project is the CERNET (China Education and Research Network). The bandwidth of the CERNET backbone is (currently) 2,5 Gbps, connecting 7 cities, called local network centres. The bandwidth of the CERNET local backbone is 155 Mbps.

ChinaGrid software

The underlying common grid computing middleware platform for the ChinaGrid project is called ChinaGrid Supporting Platform (CGSP). The current version, CGSP 2.0, is based on Globus Toolkit 4.0, and is WSRF and OGSA compatible. The previous version, CGSP 1.0, has been released in October 2004. There are the following five 5 building blocks in CGSP 1.0:

- Grid Portal.
- Grid Development Toolkits.
- Information Service.
- Grid Management.
- Grid security.

ChinaGrid applications

The focus of the first stage of ChinaGrid is on the compute grid platform and on applications (e-science). These applications are from a variety of scientific disciplines, from life science to computational physics. The second stage of ChinaGrid project is from 2007 to 2010. The focus will extend from computational grid applications to information service grid (e-information), including applications for a distance learning grid, digital Olympic grid, etc. The third stage will be from 2011 to 2015, extending the coverage of the ChinaGrid project to all the 100 key universities. The focus of the third stage grid application will be even more diverse, including instrument sharing (e-instrument).

China National Grid (CNGrid)

It is a four-year project launched in May 2002. The China National Grid II (CNGrid-II) will run for another 4 years (2006 to 2010).

CNGrid network infrastructure

There have been eight Grid nodes set up across the country that are interconnected by available networks (IPv6 ready). CNGrid-II will connect 12 grid nodes across the country.

CNGrid software

The SOA (Service Oriented Architecture) concept is utilized and embodied in CNGrid software 2.0 architecture. The computing, storage and information resources can be wrapped as different plain Web services and managed by CNGrid software. The CNGrid software 2.0 can be divided into four layers from bottom up. They are CNGrid hosting environment, core layer, system layer and application layer. Currently, the CNGrid software is hosted by J2SE/Tomcat environment.

CNGrid applications

The following applications have been developed:

- Emergency response and disaster prediction (Flooding, Climate, etc.).
- National Geological Survey Grid.
- New Drug Discovery.
- Aviation Manufacturing Grid.
- Bioinformatics Application Grid.
- Digital Forestry Grid.
- SeisGrid for applications of petroleum seismic exploration.
- Intelligent Transportation.
- Meteorological application Grid.

- Simulation Grid.

8.3.2 D-Grid

The German Grid Initiative (D-Grid) is a joint initiative with German research and industry [i.17]. It is funded by the German Federal Ministry of Education and Research (BMBF). Detailed information about D-Grid can be accessed via the D-Grid Web pages http://www.d-grid.de.

The first D-Grid projects started in September 2005 with the goal of developing a distributed, integrated resource platform for high-performance computing and related services to enable the processing of large amounts of scientific data and information.

Development and operation of this Grid infrastructure is proceeding in several overlapping stages:

- *D-Grid 1* (2005 to 2008) provides IT services for scientists, designed and developed by the "early adopters" of the computer science and scientific computing communities. This global services infrastructure is being tested and used by so-called Community Grids in the areas of high-energy physics (HEP-Grid), astrophysics (AstroGrid-D), alternative energy (WISENT), medicine (MediGrid), climate research (C3-Grid), engineering (In-Grid), and scientific libraries (TextGrid).

- *D-Grid 2* (2007 to 2010) provides IT services for scientists, industry, and business, including applications in the construction industry, finance, aerospace and automotive, enterprise information and resource planning systems, geographical data, and general IT services.

Next phases will extend the D-Ggrid infrastructure with a professional management and operation layer, including Service Level Agreements for negotiation between providers and users, providing knowledge management, adding several virtual competence centres, encouraging global service-oriented architectures in the industry, and using this grid infrastructure for the benefit of our whole society.

D-Grid network infrastructure

The D-Grid Infrastructure project DGI [i.18] provides the infrastructure for all D-Grid projects. As shown in figure 4c, several layers are used to offer Grid services to the Grid communities. In September 2007, the D-Grid resources (bottom layer in figure 4c) comprise 2 200 CPUs, 800 TB of disk space and 1 600 TB of Tape space [i.22], [i.23]. The D-Grid resources distributed among 25 sites which are connected via Germany's National Research and Education Network (DFN) [i.16].

D-Grid software

Basic services and Grid service functions (the middle layers in figure 4) are provided by means of the open source Grid middleware implementations Globus Toolkit [i.22], gLite [i.19] and Unicore [i.24]. The user and applications interfaces for the community Grids are provided by APIs of the Grid Application Toolbox (GAT) of GridLab [i.20], GridSphere-based community specific portals (for GridSphere please refer to [i.21] or direct access to Unicore. The Grid services of the DGI project provided to the community projects include not only services like scheduling and workflow management, monitoring, accounting and billing, security and VO management, data management and data management, but also non-technical services like training, support or legal advice.

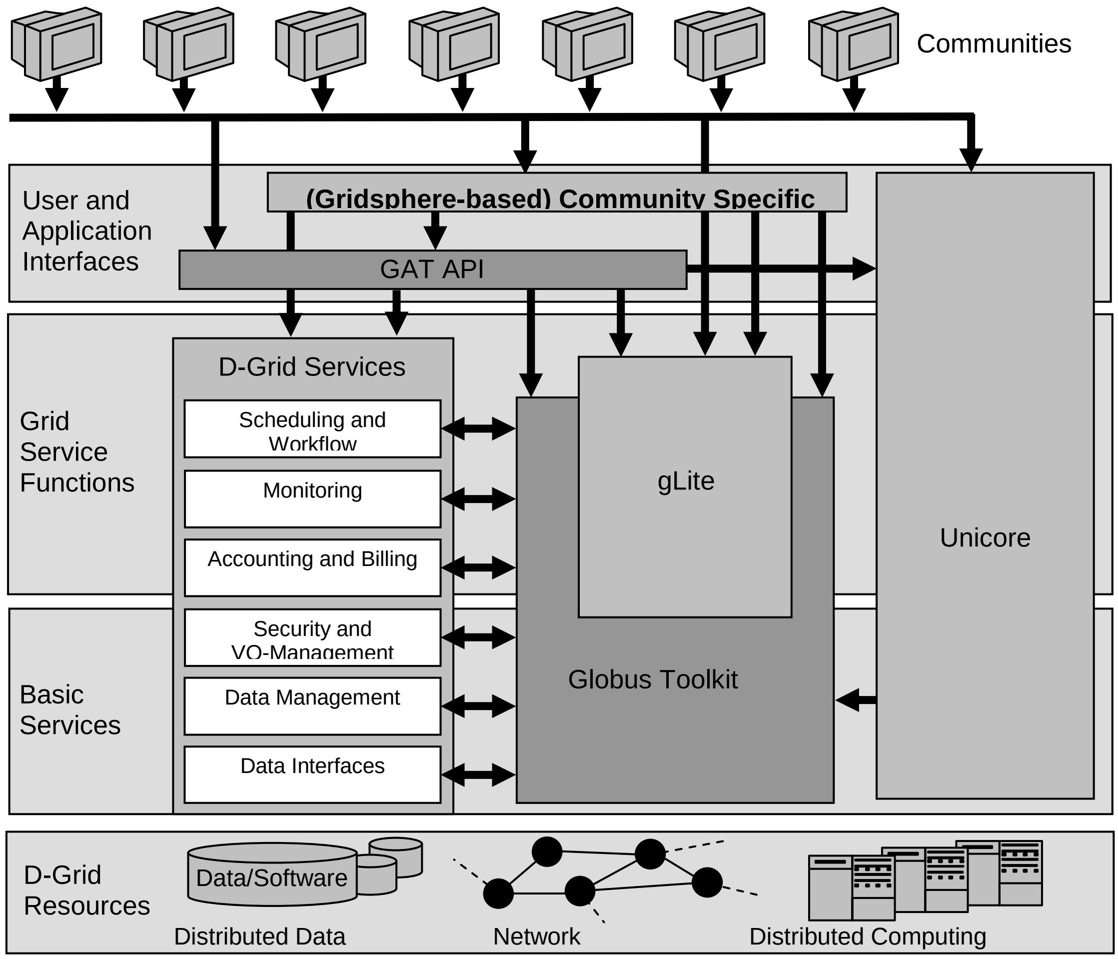


Figure 4c: Organization of D-Grid Infrastructure [Mikel-Slides-07]

D-Grid applications

D-Grid applications are related to community Grids. Currently, there exist community Grids in the areas of:

- high-energy physics (HEP-Grid);
- astrophysics (AstroGrid-D);
- alternative energy (WISENT);
- medicine (MediGrid);
- climate research (C3-Grid);
- engineering (In-Grid); and
- scientific libraries (TextGrid).

More information about the community Grids can be found on the Web-pages of the D-Grid initiative [i.17].

8.3.3 DEISA (Distributed European Infrastructure for Supercomputing Applications)

http://www.deisa.org/

The DEISA supercomputing Grid is a European research infrastructure resulting from the integration of national High Performance Computing (HPC) infrastructures. DEISA is structured as a layer on top of the national supercomputing services, and coexists with them.

DEISA network infrastructure

Within DEISA network phase 1 the DEISA supercomputing environment has used a virtual dedicated 1 Gb/s internal network provided by GEANT and the National Research Networks (NRNs) and has offered reserved bandwidth connecting the supercomputers spread across Europe. This internal network has been built in addition to the standard Internet connectivity that each national supercomputer centre already offers.

An intermediate phase connecting the 1 Gb/s Phase 1 network and the evolving star-like configuration 10 Gb/s Phase 2 network has been initiated in Autumn 2006. This intermediate Phase infrastructure became operational in February 2007, connecting six sites.

The remaining sites are planned to be connected within the next months with high speed links also, allowing the Phase 2 network being fully operational beginning second half of 2007. The new network uses dedicated wavelength on NRENs and GEANT2 fibre links footprint. It will be managed by DEISA itself and operates at 10 Gb/s between all DEISA sites.

DEISA software

All high performance computing systems share data among the computing nodes with a Cluster File System, which offers users a single system data view and transparent data access. The extension of this data sharing model to a grid of geographically distributed HPC systems over a wide area network leads to the concept of a Global File System or Grid File System, which avoids data replication.

Additional software enables hierarchical storage management functionality on top of GPFS (General Parallel File System). New developments in the Global File System area are planned, and systems, such as Lustre, NFSv4 and OpenAFS are investigated.

DEISA applications

The DEISA Grid services focus on four strategic kinds of applications:

- Support for workflow applications.
- Global data management.
- Co-scheduling services for distributed applications.
- Portals and Web services.

8.3.4 EGEE-II (Enabling Grids for E-sciencE)

http://egee-technical.web.cern.ch/egee-technical/index.htm

Enabling Grids for E-sciencE II (EGEE-II) is a project co-funded under the European Commission (EC) Sixth Framework Programme to build a seamless Grid infrastructure available 24 hours a day to the research community. It features 91 partners in 32 countries from Europe, and beyond to the USA and Asia, as well as 48 non-contracting partners participating through Joint Research Units.

EGEE-II is the follow up to the EGEE project, which began in April 2004. The work of both projects was conceived as a four-year programme to unite regional and thematic Grid initiatives in Europe to produce a production quality Grid infrastructure to support the European Research Area.

EGEE network infrastructure

The project operates the EGEE Grid Infrastructure with more than 200 sites, offering Grid services to users from around the world. The users are organized in 60 Virtual Organizations (VOs) from nine scientific and research domains. As of the start of EGEE-II, the project has linked to several large scale projects and 14 such smaller "related projects", with some others predicated to connect to the project during its two-year lifespan.

Between January and October 2005 (during the earlier EGEE project), the production service completed in excess of 2,2 million jobs, with daily averages of more than 10 000 jobs sustained for more than a month, equating to approximately 6 million kSI2K (Kilo SpecInt 2000, a common measure of computer power) CPU hours, or around 700 CPU years. With the addition of new partners and sites in EGEE-II, this capacity is expected to grow over the two years of the project, and by the start of EGEE-II the infrastructure already processed in excess of 20 000 jobs per day.

EGEE software

At the start of the earlier EGEE project, a two track approach to middleware was selected. The original production middleware was LCG-2 (LHC Computing Grid), based on the work of the earlier European DataGrid project and developed by the LCG project. In parallel EGEE launched the gLite middleware for prototyping and testing new, lightweight functionalities. The gLite distribution was designed as a new approach to middleware, combining components from many different international sources.

At the start of EGEE-II the decision was made to merge the two releases into a single distribution under the name gLite 3.0. This combines the best of the earlier LCG 2.7 components with those from gLite 1.5 to produce a single distribution.

Interoperability

EGEE-II interoperates with other major international Grids, notably the American Open Science Grid (OSG, successor to the Grid3 project) and the European supercomputing Grid DEISA. In addition, work is ongoing on interoperation with the NorduGrid project and its Advanced Resource Connector (ARC) middleware.

EGEE applications

EGEE-II supports nine applications domains:

- Astrophysics;
- computational chemistry;
- earth sciences;
- finance;
- fusion;
- geophysics;
- high energy physics
- life sciences;
- multimedia.

EGEE [i.28] (Enabling Grids for e-Science in Europe) is a European-based computational grid environment, primarily developed for use by the CERN particle physics community, but with increasing (10 % to 20 %) utilization by other groups. In terms of computational resources, data/storage, users, sites, and budget it is by far the largest grid infrastructure in the world. It currently contains over 40 000 CPUs at over 200 sites around the world, and provides 5 PB of storage.

The initial EGEE architecture was inherited from the EDG [i.29] (European Data Grid) project and at a high level largely remains the same. This system forms the core of the WLCG [i.30] (World-wide LHC Computing Grid), although OSG [i.31] (Open Science Grid) and NorduGrid [i.32] are also part of the overall grid infrastructure utilized by WLCG.

Initially EGEE was based on the American NSF project which produced the VDT (Virtual Data Toolkit) software package containing patched and "hardened" grid middleware, in particular including releases of Globus Toolkit 2.4 and Condor. It has since evolved and uses parts of the Globus Toolkit, Condor, and the gLite [i.33] software. There is no single document describing the overall architecture. An old description of this system (2004) is available in the CERN EDMS document 498709 [i.58]. It provides a concise overview which is still generally accurate.

Workload Management

- User Interface (UI).
- Network Server.
- Resource Broker (RB): GRAM, Condor-G, Condor Matchmaker, Job Description Language (JDL).
- Computing Element (CE).
- Local Resource Management System (LRMS): OpenPBS, Torque/Maui, LSF, BQS, Sun GridEngine.
- Worker Node (WN).
- Job Controller (JC).

Data Management

- Data Location Interface (DLI).
- Replica Location Service (RLS)/File Catalog (FC).
- File Transfer Service: GridFTP.
- Storage Resource Manager (SRM).
- Replica Meta-Data Catalog (RMC).
- Storage Element (SE): dCache, RFIO, iRODS, SRB, Disk Pool Manager (DPM), CASTOR.

Security

- Virtual Organization Management System (VOMS).
- X.509 PKI: Attribute Certificates, Proxy Certificates, Role Based Access Control.
- Local Centre Authorization System (LCAS): Local Credential Mapping Service (LCMAPS).
- MyProxy.
- Certificate Authority: OpenCA.

Monitoring, Logging, and Accounting

- Berkley Database Information Index (BDII): LDAP, GLUE.
- Grid Resource Information Server: Grid Information Index Service, OpenLDAP.
- Grid Resource Infor.
- Monitoring and Discovery Service (MDS).
- Relational Grid Monitoring Architecture (R-GMA).
- Logging and Bookkeeping Service (LB).
- Job Provenance.
- GridICE.
- MonaLisa.

Networking

- No specific services.

Deployment and Infrastructure Management

- Grid Operations Centre (GOC): GOC-DB.
- Lemon.
- LCFGng.
- Global Grid User Support Centre (GGUS).

8.3.5 Grid5000

https://www.grid5000.fr/mediawiki/index.php/Grid5000:Home

Grid'5000 is a research effort funded by the French ministry of Education and Research, INRIA, CNRS, the Universities of all sites and some regional councils. The objective of Grid'5000 is to develop a large scale nation wide infrastructure for Grid research. There are seventeen laboratories involved, nation wide, in the objective of providing the community of Grid researchers a test bed allowing experiments in all the software layers between the network protocols up to the applications.

Grid'5000 network infrastructure

The current plans are to assemble a physical platform featuring nine local platforms (at least one cluster per site), each with a hundred to a thousand PCs, connected by the RENATER Education and Research Network. The plan is to connect all clusters to RENATER with a 10 Gb/s link (or at least 1 Gb/s, when 10 Gb/s is not available yet).

The initial design of Grid'5000 sites interconnection has been addressed within the RENATER backbone using a Ethernet Over MPLS (EoMPLS) solution. It is a full mesh topology based on MPLS tunnels (LSPs) established between the RENATER POPs on which are connected the Grid'5000 sites. In practice sites are interconnected through 1 Gbit/s VLANs.

RENATER-4 also introduced a dark fibre infrastructure allowing allocating dedicated 10 Gbit/s "lambdas" for specific research projects. It also provides interconnection with GEANT-2, with increased capacity compared to GEANT-1 and dedicated interconnection for projects.

Inside the RENATER POPs, Grid'5000 sites are directly connected to the switches, by-passing the routers which are used for "standard" IP traffic (and Grid'5000 sites that are still using the EoMPLS initial solution).

Grid'5000 software

Software mainly developed in Grid'5000 and available for its users is listed below:

- **OAR 2** is a resource manager (or batch scheduler) for large clusters. It allows cluster users to submit or reserve nodes either in an interactive or a batch mode.
- **Kadeploy 2** is a scalable deployment system towards cluster and grid computing. It provides a set of tools, for cloning, configuring (post installation) and managing a set of nodes.
- **TakTuk 3** is a tool for deploying parallel remote executions of commands to a potentially large set of remote nodes.
- **KAAPI** means Kernel for Adaptative, Asynchronous Parallel and Interactive programming. It is a C++ library that allows execution of multithreaded computation with data flow synchronization between threads. The library is able to schedule fine/medium size grain program on distributed machine. The data flow graph is dynamic (unfold at runtime).Target architectures are clusters of SMP machines.
- **KaVlan** is a VLAN manipulation tool for network isolation of experiment.
- **Katapult** is a script to automatically start experiments using deployments.
- **GRUDU** for Grid5000 Reservation Utility for Deployment Usage is a tool for managing Grid5000 resources, reservations and deployments.
- **Marcel** is a POSIX-compliant thread library featuring a programmable scheduler designed for hierarchical multiprocessor architectures.

- **Mad-MPI** is an implementation of MPI (Message Passing Interface) for fast networks.
- **MPICH-Madeleine** is an MPI implementation for clusters and clusters of clusters with heterogeneous networks.
- **NewMadeleine** is the communication library that provides extended capabilities for dynamic communication optimization on top of high performance networks.
- **Wrekavoc** is software developed for definition and controlling the heterogeneity of a given platform by degrading CPU, network or memory capabilities of each node composing this platform. The degradation is done remotely, without restarting the hardware.

Grid'5000 experiments

Experiments actually performed on the platform are grouped into different domains as listed below. The complete list of experiments is available on: https://www.grid5000.fr/mediawiki/index.php/Special:G5KExperiments

- Networking.
- Operating System.
- Middleware.
- Programming.
- Application.
- Other.

8.3.6 NAREGI

http://www.naregi.org

The Japanese Computational Grid Research Project, NAREGI, corresponds to one of the major Japanese national IT projects as part of the National Research Grid Initiative, based on collaborations among industry, academia, and the government. The efforts consists of research and development in high-performance, scalable Grid middleware technologies, as well as research on leading-edge, Grid-enabled nanoscience and nanotechnology simulation applications.

One of the primary goals of NAREGI is to contribute to the OGF standardization activities. NAREGI has been interested in, participated in, and, where possible, given feedback to numerous OGF working groups and research groups. Amongst the various groups, NAREGI has recently placed high emphasis on the OGSA-WG activities, being the first project or group to implement the EMS architecture described in the OGSA architecture. In particular, for collaborative research activity, a closed user group environment, the network allows to setup Virtual Private Networks (VPN) as an essential service for security reasons.

NAREGI network infrastructure

The integrated network provides all transfer layer services: IP layer, Ethernet layer, and Layer 1 services. Users can freely choose best transfer layer for their Grid applications. The multiple-service layered network architecture provides economically advantageous service provision and flexible network resource assignment for ever-changing and unpredictable service demands.

Users can choose from L3VPN (IP), L2VPN/VPLS (Ethernet), and L1VPN services. Furthermore, Ethernet services include two types of VPNs:

- Point-to-point-based VPN (L2VPN).
- Broadcast-based VPN - Virtual Private LAN Service (VPLS).

The network further provides Bandwidth on Demand services as part of Layer 1 services. For which users can specify the destinations, duration, bandwidth, and route option. The BoD server receives reservation requests, schedules accepted reservations, and triggers Layer 1 path setup.

The network architecture is formed as:

- Adaptive Network Control Platform (GMPLS: RSVP-TE, OSPF-TE, and GMPLS-UNI):
    - Dynamic resource control.
    - Resilient network control.
    - Performance monitoring.
- User-oriented Service Control Platform.
- Hybrid Optical and IP/MPLS network.

NAREGI software

The NAREGI middleware is compliant with Globus, Condor, and Unicore in view with the OGSA standards. It is called production-quality, industry-strength Grid middleware for petascale supercomputing Grids. Standards-based (OGF/W3C/OASIS/DMTF etc.) specific middleware functions include:

- Super Scheduler: Meta scheduler.
- GridVM: Job manager on resources.
- Info Service: Grid resource info and accounting.
- Network Services: Network performance measurement and routing control.

NAREGI developed the interoperation with EGEE/gLite (prototype) where gLite clients can access to both data resources.

NAREGI experiments

The NAREGI Grid system was tested using various multi-organizational use cases such as electronic structure analysis on proton transfer in Lysozyme, integrated parallel visualization for massive data for the motion of 1 million molecules, Various examples can be found in the NAREGI Web site.

8.3.7 NGS (UK National Grid System)

The UK National Grid System (NGS) aims to "provide coherent electronic access for UK researchers to all computational and data based resources and facilities required to carry out their research, independent of resource or researcher location" (http://www.ngs.ac.uk/). It entered full production in September 2004 and has recently been substantially upgraded (NGS2).

Infrastructure

Resources are provided by the four core sites STFC/RAL, University of Oxford, White Rose Grid (University of Leeds) and University of Manchester and more than 10 other university partners and affiliates. The resources include computational and data resources. The NGS is also developing Grid interfaces to large scale scientific experimental facilities to enable experimental data to be selectively transferred to NGS compute and data resources. Grid resources are connected by means of the UK JANET education and research network (http://www.ja.net/).

Software for access

There are several means of accessing NGS ("How to connect to the NGS" http://www.grid-support.ac.uk/content/view/216/121/). By using the NGS Applications Repository portal, applications on the NGS can be used without requiring Grid software on the user's local computer. Applications are fully described using middleware agnostic JSDL (Job Submission Description Language) documents. Alternatively the NGS can be accessed from a Windows PC using GSI-SSH terminal. On a Linux operating system, the recommendation is to install the VDT distribution, based on Globus 2.

Interoperability

The NGS deploys a common grid infrastructure for combining services and information from multiple sources. At the toolkit level this is based on providing a service based on a common implementation of GT2, but is introducing nodes based on GT4 (WSRF).

The NGS has a requirement to interoperate with other national grids and international ones such as EGEE. It took part in the Grid Interoperability Now demonstration at SC07 and is participating in the proposal for a European Grid Infrastructure (http://web.eu-egi.org/).

8.3.8 OSG

OSG (Open Science Grid) is the successor to the Grid3 project, providing a production scientific computing grid in the US, based on the Virtual Data Toolkit software distribution (a meta-package of various other grid software packages). It is part of the WLCG and provides US particle physicists with grid computing facilities, as well as several other VOs. OSG provides over 10 000 cores, and is providing an average of 10 000 CPU-hours per hour. Daily job completion rate averages 80 000, across 30 VOs and approximates 60 sites.

Workload Management

GRAM (GT4), ReSS, ClassAds, EGEE RB.

Data Management

RFT, GridFTP, SRM, dCache.

Security

X.509, VOMS.

Monitoring, Logging, and Accounting

GRATIA.

Networking

N/a.

Deployment and Infrastructure Management

Pacman and VDT.

8.3.9 TeraGrid

TeraGrid [TeraGrid] provides 600 TFLOPS of computing power through a federation of 11 US supercomputing centres. It has 3 200 users, and over 1 000 VOs (projects). TeraGrid emphasizes parallel computing, and therefore jobs typically run at a single site. Users are responsible for manually identifying the appropriate site/cluster for their job (depending on hardware, software, and networking configuration). The TeraGrid clusters are linked via a private network, and projects are encouraged to develop portals to allow users to define their computational tasks and then using the portal to select an appropriate site. There are some common tools, high bandwidth inter-site connections, and a Single Sign On mechanism (although not for all sites/clusters).

Workload Management

N/a.

Data Management

SRB, GridFTP, tgcp.

Security

Various: X.509, ssh, username/password.

Monitoring, Logging, and Accounting

TG-Monitor, Inca Software Monitor.

Networking

N/a.

Deployment and Infrastructure Management

CTSS (Coordinated TeraGrid Software and Services), SoftEnv.

8.4 Examples of Companies Related to Grid Computing

This clause identifies a small number of examples of companies related to Grid computing, it does not claim to be a complete list. It will be updated and extended in future versions of the present document. Candidates include Altair, NetApp, XenServer, GigaSpaces, Digipede.

This clause has been compiled, in the most part, by capturing data from the various organizations web sites. This information will be reviewed and refined in future releases of the present document.

8.4.1 Amazon

About the Company

Amazon is one of the leading companies for e-commerce. The headquarters are located in Seattle, Washington and the company was founded in 1995 by Jeff Bezos. Since 1995 the range of products has been continuously expanded and worldwide logistic and customer service centres have been created. Amazon sells products ranging from book and electronic devices to tennis rackets and diamonds. In addition, it offers a variety of services such as storage for the Internet or a web service that provides resizable compute capacity.

Products

Amazon Simple Storage Service (Amazon S3)

> Amazon S3 is storage for the Internet. It provides a simple web services interface that can be used to store and retrieve any amount of data, at any time, from anywhere on the web. It gives any developer access to the same highly scalable, reliable, fast, inexpensive data storage infrastructure that Amazon uses to run its own global network of web sites. The service aims to maximize benefits of scale and to pass those benefits on to developers. [AMAZON-S3-WWW].

Amazon Elastic Compute Cloud (*Amazon EC2*) - Beta

> Amazon Elastic Compute Cloud (Amazon EC2) is a web service that provides resizable compute capacity in the cloud. It is designed to make web-scale computing easier for developers. [AMAZON-EC2-WWW].

Alexa Web Services

> Alexa's Web Services offer a platform for creating innovative web solutions and services based on Alexa's vast repository of information about the web. Developers, researchers, web site owners, and merchants can incorporate information about web sites directly into their own web sites or services. Users can access web site traffic data, related links, contact information, as well as a powerful search engine based on the Alexa crawl, and a wide variety of other functionality and data.

Standards

REST, SOAP, WSDL.

References

[AMAZON-S3-WWW] *Amazon Simple Storage Service (Amazon S3).* http://www.amazon.com/gp/browse.html?node=16427261 (last visit: 8.11.2007).

[AMAZON-EC2-WWW] *Amazon Elastic Compute Cloud (Amazon E-2) - Beta.* http://www.amazon.com/gp/browse.html?node=201590011 (last visit: 8.11.2007).

[AMAZON-AWS-WWW] *Alexa Web Services*. http://www.amazon.com/b/ref=sc_fe_l_2/104-6754323-7494305?ie=UTF8&node=239513011&no=342430011&me=A36L942TSJ2AJA (last visit: 9.11.2007).

8.4.2 Cluster Resources

About the Company

"Incorporated in 2001, Cluster Resources, Inc. is a leading provider of workload and resource management software and services for cluster, grid and utility-based computing environments. The company's technology enterprise, which began initial development in the mid-1990s by the founders of the company under the name Supercluster Development Group, has resulted in Moab Cluster Suite,® Moab Grid Suite,® Maui Scheduler and other related products. Cluster Resources is a recognized and trusted leader in innovation and ROI." [i.93].

Products

Moab Grid Suite:

- It is an optimizing, reservation-based job meta-scheduler that allows organizations to consolidate reporting and/or migrate jobs and data across independent clusters. Moab facilitates the management of grid workload through a graphical management portal, as well as monitor and report on grid activity.
- Moab Grid Suite enables these grid services in a near-transparent way, provides intelligent scheduling to take advantage of unused cycles, and handles all key grid requirements, including security, data staging and credential mapping, all with little to no end-user training [i.94].

Standards

Void.

References

Void.

8.4.3 DataSynapse

About the Company

DataSynapse [i.95] is a global provider of application virtualization software. The company has been incorporated in early 2000. It is headquartered in New York and has offices several other cities in the US and all over the world (e.g. London, Paris, Milan, Frankfurt, Madrid, Tokyo, and Beijing). The target markets of DataSynapse are companies in the energy, financial services, industrial, media and public sectors.

DataSynapse is a private company and therefore, no official financial and size information about the company can be found on the Web page. However, the key investors of the company include Bain Capital, Goldman Sachs and Intel Capital.

Products

The main products of the company are GridServer, FabricServer and GRIDesign. DataSynapse also offers consultancy, implementation, training, education and product support services.

1) **GridServer** virtualizes and scales application services across disparate resources that range from desktops to mainframes. It provides a complete Grid infrastructure including dynamic scheduling, resource sharing, adaptive load balancing, state management, data distribution, guaranteed execution, self-management, utility computing, and application scalability.

2) **FabricServer** centralizes the command and control of application deployment and execution by virtualizing application platforms and guaranteeing that capacity is available on demand. It provides a complete Grid infrastructure including real-time infrastructure, centralized command and control, adaptive runtime provision, policy-based management, capacity-on-demand, and real-time response. The functionality of FabricServer and GridServer overlap with respect to application deployment, agent technology, Web management, and communication infrastructure.

3) **GRIDesign** is a methodology which can be characterized as a blueprint for transitioning from current build-to-order IT infrastructure to shared services infrastructure. The methodology supports the introduction of the GridServer and the FabricServer software.

Standards

The product descriptions refer to XML, XSD, WSDL, SOAP, SNMP MIB (v2 and v3 definitions) and JMX. Furthermore, support for emerging standards (e.g. OGSA, WSRF, etc.) is mentioned.

8.4.4 HP

About the Company

Hewlett-Packard Company is the world's largest information technology corporation and is known worldwide for its printers, personal computers, high-end servers, and network management software [i.96].

Products

HP Flexible Computing Services

This includes a direct access to highly available data center computing - including the latest technologies and tools - based on industry-standard platforms and resources.

Grid consulting

HP offers senior-level expertise in enterprise grid architecture, systems integration and management, applications migration and optimization, security, network performance, data management, implementation program management, and more. HP developed a unique methodology for aligning your grid-related IT and business goals. HP provides a single point of accountability to help you design, implement, and manage a state-of-the-art grid solution.

Standards

HP champions open, vendor-neutral standards and technology to make grid more broadly adaptable. An HP executive heads the Open Grid Forum, an organization formed by the merger of the Global Grid Forum, the grid standards body that is developing the widely-endorsed Open Grid Services Architecture (OGSA); and the Enterprise Grid Alliance, formed to advance the use of grids in the enterprise. HP co-founded other key standards organizations, including the Globus Consortium, to facilitate enterprise use of the Globus Toolkit.

Pioneering research by HP Labs has helped organizations overcome the hurdles to grid computing and simplify implementation:

- HP co-developed the Web Services Resource Frameworks (WS-RF) and Web Services Notification (WS-N) specifications and the Web Services Distributed Management (WSDM) standard, a uniform way of managing and controlling all types of IT resources. We are working with the Organization for the Advancement of Structured Information Standards (OASIS) to make WSDM grid-compatible.

- HP developed robust implementations of WSDM, WS-RF, and WS-N in concert with the Globus Alliance and Apache Software Foundation, and submitted these as open source to Apache.
- HP developed Smart Framework for Object Groups (SmartFrog), an open-source toolkit that formed the basis for a Global Grid Forum working group standard on the configuration, description, deployment and lifecycle management of resources on a grid [i.97].
- Open Grid Services Architecture (OGSA).
- Web Services Distributed Management.
- Globus Toolkit for HP Platforms.
- Smart Framework for Object Groups (SmartFrog).
- Open Grid ForumOrganization for the Advancement of Structured Information Standards (OASIS) [i.98].

8.4.5 IBM

About the Company

IBM is a multinational computer technology and consulting corporation headquartered in Armonk, New York, USA. The company history dates back to the 19th century. IBM manufactures and sells computer hardware and software. In addition it offers infrastructure services, hosting services, and consulting services in areas ranging from mainframe computers to nanotechnology [i.99].

IBM is the largest information technology company in the world. It has over 350 000 employees worldwide and revenues of $96 billion (figures from 2004). Its engineers and consultants are located in over 170 countries and development laboratories all over the world [i.99].

Products

IBM® Grid Solution for Data Intensive Computing

> A suite of solution elements applying the power of grid to data intensive computing challenges. The solution accelerates analytics and eliminates bottlenecks by delivering data quickly [i.100].

IBM® Grid and Grow™ for Actuarial Analysis

> A suite of solution elements to provide insurers the dynamic infrastructure necessary to improve performance and resolve data issues surrounding sophisticated modelling performed using industry leading applications [i.100].

Optimized Analytic Infrastructure (OIA)

> The IBM Optimized Analytic Infrastructure comprises a proven, pre-engineered, tested and integrated offering designed to help financial services firms reduce risk and increase speed of implementation [i.100].
>
> The IBM OAI includes products such as IBM's GPFS for data management, IBM LoadLeveler® for workload management, Cluster System Management for centralized administration, and the IBM ApplicationWeb. These solutions have been used by some of the largest supercomputing labs for over a decade to support a range of applications, such as high-energy physics, search analytics, weather modeling, and electronic chip design on geographically distributed systems in very large and dispersed user communities [i.59].
>
> The IBM Optimized Analytic Infrastructure solution complements IBM technologies with products from ISVs such as Altair PBS Professional (highly scalable scheduling environment), Scali MPI Connect™ (MPI programming model) and GemStone Systems (message board/virtual shared memory application environment) and the Linux operating systems (Red Hat and Novell SUSE). All the IBM and ISV products have been tested using representative workloads to help ensure full interoperability. Solutions like the IBM OAI will enable businesses to significantly improve the speed and accuracy of decisions through the use of grid and HPC technologies [i.59].

IBM® Grid and Grow™ Express

Grid offers incredible benefits, but many customers are challenged with how to get started with a grid implementation. The IBM® Grid and Grow™ Express provides an easy to deploy, integrated solution for customers interested in beginning the grid journey [IBMGRID-WWW].

IBM Grid Medical Archive Solution (GMAS)

Increasing storage demands and rising costs add pressures to managing healthcare. The IBM Grid Medical Archive Solution helps healthcare providers overcome these challenges and lets them focus on improving patient care [i.100].

Based on Bycast StorageGRID software, IBM GMAS is designed to cost effectively deliver enterprise-wide medical image access, regardless of the image's physical location or sourcing system in an environment rich with security features. IBM GMAS delivers a unified storage system that can support multiple Picture Archiving and Communication Systems (PACS), enabling clinicians to view and share patient images at any time, from any location, using familiar PACS interface [i.59].

IBM Grid Offering for Engineering Design:

Clash Analysis in Automotive and Aerospace helps automotive and aerospace design engineers use grid technology for more rapid evaluation of design alternatives during sub-assembly clash analysis. Developed in cooperation with Platform Computing, the offering includes CATIA® and ENOVIA® application software. It helps reduce the time required to capture, compile and analyze clash research data and can accelerate product development and time to market [i.59].

The offering also includes a Grid Innovation Workshop for assessing and planning a grid network, a pilot design and implementation services and comprehensive portfolio of IBM Global Services Product Lifecycle Management (PLM) for implementing and tuning product design, data management and clash analysis software [i.59].

developerWorks GridZone:

The developerWorks GridZone provides software developers with tools, online training, IBM Redbooks, articles, emerging technologies from IBM Research, and more, to help them develop grid computing applications.

IBM Innovation Centers:

At the centers, the technical consultants work with the ISVs to help them implement their application topologies on a grid infrastructure. The infrastructure can consist of any hardware platforms or any of the supported operations systems.

The Solutions Enablement Virtual Loaner Program (VLP):

The VLP uses grid computing and other on demand technologies, such as the IBM Tivoli Provisioning Manager, to provide a rich and flexible software development environment for remote-access use by ISVs. ISVs are able to reserve, in advance, resources on a Grid to satisfy their need for low-cost access to current IBM hardware and middleware to develop, port, test and validate their applications.

IBM Ready for Grid Program:

IBM's Ready for Grid computing program validates that an application is capable of executing and realizing benefits from running in a grid computing environment. The new program also includes "The Ready for IBM GRID Computing" mark, which is a critical component of IBM's strategy to create a robust ecosystem with our partners around open grid standards.

Value Network Initiative:

The Value Network Initiative builds networks of partners who can effectively deliver grid solutions. This program offers select partners access to enhanced PartnerWorld Industry Network (PWIN) co-marketing benefits.

Standards

Web Services: A Foundation for Grid Computing.

IBM has provided significant technical leadership to develop the WS-Resource Framework (WSRF) and WS-Notification Framework under the auspices of the Organization for the Advancement of Structured Information Standards (OASIS). WS-RF and WS-Notification provide the needed "stateful" web services environment on top of which other grid specific standards can be implemented [Kou06].

In addition to these very fundamental web services standards, there are additional standards being worked on that add important functional capabilities like security (WS-Security), service level management (WS-Agreement), policy expression (WS-Policy), etc. [Kou06].

Higher Level of Grid Specific Standards.

Grid Standards.

Some important OGSA-related specifications include:

- OGSA Basic Profile.
- OGSA Security Profile.
- Basic Execution Services (OGSA-BES).
- Job Submission Description Language (JSDL).
- Data Access and Integration Services (DAIS).
- Configuration Description, Deployment, and Lifecycle Management (CDDLM).
- OGSA Byte I/O (ByteIO).

Information Model

The Distributed Management Task Force (DMTF) Common Information Model (CIM) has been developed over a number of years to describe all kind of IT resources, from very high level conceptual capabilities to very specific low level components. While the GGF and OGSA working groups have not yet formally identified DMTF CIM as the information model that they will use for grid computing, they are working towards that direction [i.35].

Management Standards

OASIS' Web Services Distributed Management (WS-DM) is an industry-wide standard for management both using web services and managing web services. WS-DM attempts to exploit web services technology to create a universal and consistent abstraction for management and manageability interfaces that leverage key features of web services protocols. The specific types of management capabilities exposed by WS-DM include [i.35]:

- Monitoring the quality of a service associate with a service.
- Enforcing a service level agreement (quality of service).
- Querying or controlling the basic operational state of a resource.
- Managing a resources lifecycle (create/destroy).

In summary, there is a growing collection of related standards and architecture being developed in open standards bodies like IETF, W3C, OASIS, DMTF and GGF that are all based on web services and can be composed to help develop interoperable grid middleware and infrastructure [i.35].

IBM has been a leader in the definition and development of these open standards and is driving its important implementations along the present documents roadmap [i.35].

References

Void.

8.4.6 Microsoft

About the Company

Microsoft Corporation is an American multinational computer technology corporation with 79 000 employees in 102 countries and global annual revenue of US $51,12 billion as of 2007. It develops, manufactures, licenses and supports a wide range of software products for computing devices. Headquartered in Redmond, Washington, USA, its best selling products are the Microsoft Windows operating system and the Microsoft Office suite of productivity software [i.35].

Products

Windows Compute Cluster Server 2003 (WCCS)

> Windows Compute Cluster Server 2003 can be easily and quickly deployed using standard Windows deployment technologies, and additional compute nodes can be added to the compute cluster by simply plugging in the nodes and connecting them. The Microsoft Message Passing Interface (MS-MPI) implementation is fully compatible with the reference MPICH2. Integration with Active Directory enables role-based security for administration and users, and the use of Microsoft Management Console provides a familiar administrative and scheduling interface [i.36].

Windows HPC Server 2008,

> the successor to Windows Computer Cluster Server 2003, is based on the Windows Server 2008 operating system and is designed to increase productivity, scalability and manageability. This new name reflects Microsoft HPC's readiness to tackle the most challenging HPC workloads. Windows HPC Server 2008 includes key features, such as new high-speed networking, highly efficient and scalable cluster management tools, advanced failover capabilities, a service oriented architecture (SOA) job scheduler, and support for partners' clustered file systems.
>
> The centralized management and deployment interface helps to simplify deployment for both large and small compute clusters and provide a simple and effective management experience in order to increase cluster administrator productivity. The Microsoft HPC Pack includes a highly scalable job scheduler that provides support for interactive Service Oriented Architecture (SOA) applications using High Performance Computing for Windows Communication Foundation (HPC for WCF) and parallel jobs using the Microsoft Message Passing Interface (MS-MPI). Essential applications from key independent software providers (ISVs) can be run on the cluster to help you meet your business needs in a timely, cost-effective, and highly productive manner. Integration with the Windows operating system helps to provide seamless security, storage, and desktop access to cluster resources and management. Microsoft Visual Studio® 2005 provides parallel debugging capabilities for use with Windows HPC Server 2008, and MS-MPI is now integrated with the Event Tracing for Windows infrastructure. This consolidates application, networking, and operating system events from many compute nodes into a single, time-correlated record to speed debugging [i.37].

Standards

Void.

References

Void.

8.4.7 Oracle

About the Company

Oracle Corporation is one of the major companies developing DataBase Management Systems (DBMS), tools for database development, middle-tier software, Enterprise Resource Planning software (ERP), Customer Relationship Management software (CRM) and supply chain management (SCM) software. Oracle was founded in 1977, and has offices in more than 145 countries around the world. As of 2005, it employed more than 50 000 people worldwide and is the world's second largest software company.

Products

Oracle 10g

It is an infrastructure that has full grid server cluster capabilities for all applications-transaction processing (OLTP), decision support (DSS), and enterprise content management [i.38].

Oracle Database 11g

The Oracle database delivers unlimited scalability to manage and maintain all types of data on line in a Grid environment. Automatic Storage Management creates a single pool of shared storage that can be provisioned on demand and automatically managed to ensure space utilization is optimized and that I/O bottlenecks are avoided. Real Application Clusters have no single point of failure and can scale incrementally by adding more nodes as and when workloads increase. Workload Management ensures applications always receive the necessary processing resources meet defined service levels. Streams and Transportable Tablespaces provide the ability to provision data as resource on an enterprise-wide basis [i.38].

Oracle Fusion Middleware

It is a comprehensive middleware product family comprised of the company's industry-leading SOA and middleware products including: Oracle Application Server 10g, related Oracle Application Server products and options such as Oracle Identity Management, Oracle Business Intelligence, Oracle BPEL Process Manager, Oracle Web Services Manager, Oracle Business Activity Monitoring, Oracle COREid Products, Oracle Portal and Oracle Integration; Oracle Data Hubs; and Oracle Content Services 10g, Oracle Real Time Collaboration 10g and Oracle Unified Messaging [i.102].

The Application Server is tightly integrated with the database. It exploits clustering technology to deliver unmatched scalability, availability, manageability and security. Dynamic Resource Management monitors resource utilization throughout the mid-tier and dynamically adjusts capacity-on-demand using application specific policies to maintain service levels. Coherence virtualizes data to create a mid-tier in-memory distributed data Grid for real-time data analysis, compute intensive operations, and parallel transaction and event processing [i.38].

Oracle Enterprise Manager

Oracle Enterprise Manager with Oracle Grid Control provides a single, integrated interface for the top down administration and monitoring of applications and systems in an Oracle Grid. It continually monitors resource allocations and utilization. It automatically provides alerts and takes corrective action whenever defined service levels are at risk and business performance is compromised from capacity overload or from failure. Enterprise manager supports the wider Oracle ecosystem in a Grid environment through a wide range of connector and adapter plug-ins to third party technologies and software [i.38].

Oracle Application Server 10g

This grid enabled application server is an integrated, standards-based software platform that allows organizations of all sizes to be more responsive to changing business requirements. Oracle Application Server 10g features full support for J2EE and grid computing, built-in enterprise portal software, high-speed caching, business intelligence, rapid application development, application and business integration, wireless capabilities, Web services and more, all in one package. Because Oracle Application Server 10g is optimized for enterprise grid computing, it enables customers to realize better availability of their IT systems and lower hardware and administration costs [i.38].

Oracle Application Server 10g Release 3 features support for a host of standards required to build next-generation SOAs, including WS-Reliable Messaging, WS-Security, WS-Federation, Web Services Metadata, Web Services Invocation Framework (WSIF) and REST Web Services. This release will also include a UDDI v3- compliant enterprise business services registry. Oracle Application Server 10g Release 3 is scheduled to interoperate with more than 128 products including middleware products such as Microsoft NET; IBM WebSphere; IBM MQ-Series; Cisco Local Director; F5 Big IP; Checkpoint firewalls; content management; and systems management.

Standards

The Oracle Application Server 10g implements WS-Reliable Messaging, WS-Security, WS-Federation, Web Services Metadata, Web Services Invocation Framework (WSIF) and REST Web Services [OracleAppServer07WWW].

References

Void.

8.4.8 Platform

About the Company

"Platform Computing™ is a pioneer and the global leader in High Performance Computing (HPC) infrastructure software. The company delivers integrated software solutions that enable organizations to improve time-to-results and reduce computing costs. Many of the world's largest companies rely on Platform for workload management and cluster and grid management. Platform has over 2 000 global customers and strategic relationships with Dell, HP, IBM, Intel, Microsoft, Red Hat and SAS, along with the industry's broadest support for HPC applications. Building on 15 years of market leadership, Platform continues to define the HPC market." [i.40].

Products

Platform Enterprise Grid Orchestrator (EGO)

This Grid platform delivers the power of virtualization, automation and the sharing of all IT resources to every application type. Platform EGO provides a flexible way to orchestrate all enterprise application types into a single, cohesive, efficient system. By de-coupling resource management from workload management, Platform EGO effectively allocates, prioritizes and manages the supply of resources with business policies across the enterprise. This enables organizations to scale up and scale out, while improving application performance, resource utilization and achieving better SLA management [i.40].

It is a single enterprise grid environment that is scalable, flexible, extensible and fully customizable. It is a single, cohesive management environment with an extensible framework to provide the core services across multiple enterprise application types. EGO implements policy based resource allocation decisions in real-time and realizes an open, standards-based approach [i.41].

Platform Symphony

Platform Symphony enables you to solve mission critical pricing and risk problems in real time, delivering unsurpassed performance and competitive advantage. Built on Platform EGO, Symphony allows you to build, test, grid-enable, and manage application services on a highly fault-tolerant, shared, scaled-out infrastructure [i.40].

Standards

Platform computing is a founding member of the New Productivity Initiative (NPi), now the Global Grid Forum (GGF), to which Platform continues to be a major contributor. Platform contributed specifications to the Open Grid Services Architecture (OGSA) with The Globus Alliance and IBM. In consultation with The Globus Alliance, Platform created the Community Scheduler Framework (CSF), an open source metascheduler framework that provides basic protocols to help resources work together in different environments [PlatformFacts07WWW].

References

Void.

8.4.9 Sun Microsystems Inc

About the Company

Sun Microsystems Inc., (NASDAQ: JAVA) provides network computing infrastructure solutions that include computer systems, software, storage, and services. Its core brands include the Java technology platform, the Solaris operating system, StorageTek and the UltraSPARC processor [SunAbout07WWW].

Products

Void.

Standards

Void.

References

[SunAbout07WWW] *Company Profile*. http://www.sun.com/aboutsun/company/index.jsp (last visit: 09.11.2007).

8.4.10 Univa UD

About the company

In 2007 Univa and United Devices merged into the company Univa United Devices (Univa UD). Univa has been founded in 1995 by the Grid pioneers Carl Kesselman und Ian Foster. Kesselman and Foster have been the main drivers of the Globus Toolkit development and thus, Univa UD offers commercial versions of and commercial support for the Globus Toolkit. Univa UD characterizes itself in the following manner [Univa07WWW]:

> *"Univa UD is the global leader in open source grid and cluster computing. The company's industrial-strength products represent the proven and cost-effective alternative to traditional proprietary offerings that customers have been waiting for. Based on a combination of open source and commercial components, Univa UD products operate production environments across a range of Fortune 1000 companies. The company also delivers policy-driven automation solutions for data center environments."*

Univa UD is a private company and therefore, no official financial and size information about the company can be found on the Web page.

Products

Univa UD advertises the following three software products on its webpage:

1) **Cluster Express** is a package of commercially proven open source components for a full-function cluster management solution with all the functions needed to get applications running in a cluster environment. The functionality of Cluster Express includes job scheduling, monitoring, security, remote access, deployment and integrated installation, configuration, monitoring, and management.

2) **Cluster Pro** (advertised for Q2 2008) builds on the core functionality of Cluster Express with value-added components and full support.

3) **Grid MP** is an infrastructure product for implementing and managing grid implementations on small-scale PC grids, global enterprise-class grids and even world wide Internet-based grids. Grid MP provides:

   a) Virtualization, Provisioning and Control.

   b) Secure Execution and Automation Layer (SEAL) Technology.

   c) Workload Optimization.

   d) Application Framework.

   e) Seamless Integration with Enterprise Environments.

In addition to the mentioned software products, Univa UD also offers services, support and training for their products and for Grid and cluster computing in general.

Standards

Conformance to standards is implicitly given by the standards implemented in the Globus Toolkit.

References

[Univa07WWW] Web pages of Univa UD. http://www.univaud.com/ (last visit: 06.11.2007).

8.4.11 Examples of other Companies Related to Grid Computing

8.4.11.1 Overall view

Some companies seem not to see themselves as Grid technology providers, but offer products typical for Grid computing like, for example, products for virtualization. The main companies together with their products are listed below.

8.4.11.1.1 Virtualization

8.4.11.1.1.1 VMware

VMware [VMware07WWW] is a provider of virtualization solutions for x86-based servers and desktops. VMware technology works to separate the software from the underlying hardware. This allows a single computer to run multiple operating systems and applications, delivering significant improvements in efficiency, availability, flexibility and manageability. VMware was founded in 1998 and is headquartered in Palo Alto, California. VMware's customer base consists of more than 20 000 organizations of all sizes, including 100 % of the Fortune 100 companies.

VMware offers products for the virtualization of platforms, virtual infrastructures and for the management of virtual infrastructures. Products are offered for the virtualization of clients and servers.

The company is specialized in the virtualization of x86-based infrastructures. Compliance to standards or to Grid technology is not required. Standardized interfaces are not advertised in the products data sheets. For the management purposes, Web-based interfaces are mentioned.

8.4.11.2 Citrix XenServer Product Group (formerly XenSource)

The Citrix XenServer Product Group [Citrix07WWW] is a division of Citrix and was formed by the acquisition of XenSource by Citrix in 2007. Citrix is a global leader and trusted name in application delivery infrastructure. More than 200 000 organizations around the world use Citrix products. Citrix customers include all Fortune 100 companies and 98 % of the Fortune Global 500 companies. Citrex annual revenues in 2006 were $1,134 billion. Citrix has offices in 22 countries, and more than 6 200 channel and alliance partners in more than 100 countries.

The Citrix XenServer Product Group plays the dual role of leading the open source Xen community, while simultaneously selling value-added enterprise solutions based on Xen technology. From its beginnings as XenSource, which was founded and run by the original Xen development team, the group is committed to nurturing and growing the Xen community, and dedicates a significant amount of its own engineering resources to developing open source technology.

Citrix XenServer Product Group offers three products for virtualization: the Citrix XenServer Express Edition, the Citrix XenServer Standard Edition, and Citrix XenServer Enterprise Edition. All three products are based on the Citrix XenServer v4 software and are tailored for different usages. The Express Edition is a free, product ready virtualization platform that enables everyone to quickly get started with Xen virtualization. The Standard Edition is the Express Edition enhanced with multi-server management features and basic support. The Enterprise Edition enhances the Standard Edition with resource pools.

The company is specialized on the virtualization of x86-based infrastructures. Compliance to standards or to Grid technology is not required. Standardized interfaces are not advertised in the products data sheets.

8.4.11.3 References

[VMware07WWW] Web pages of VMware. http://www.vmware.com/ (last visit: 09.11.2007).

[Citrix07WWW] Web pages of the Citrix XenServer Product Group. http://www.citrixxenserver.com/ (last visit: 09.11.2007).

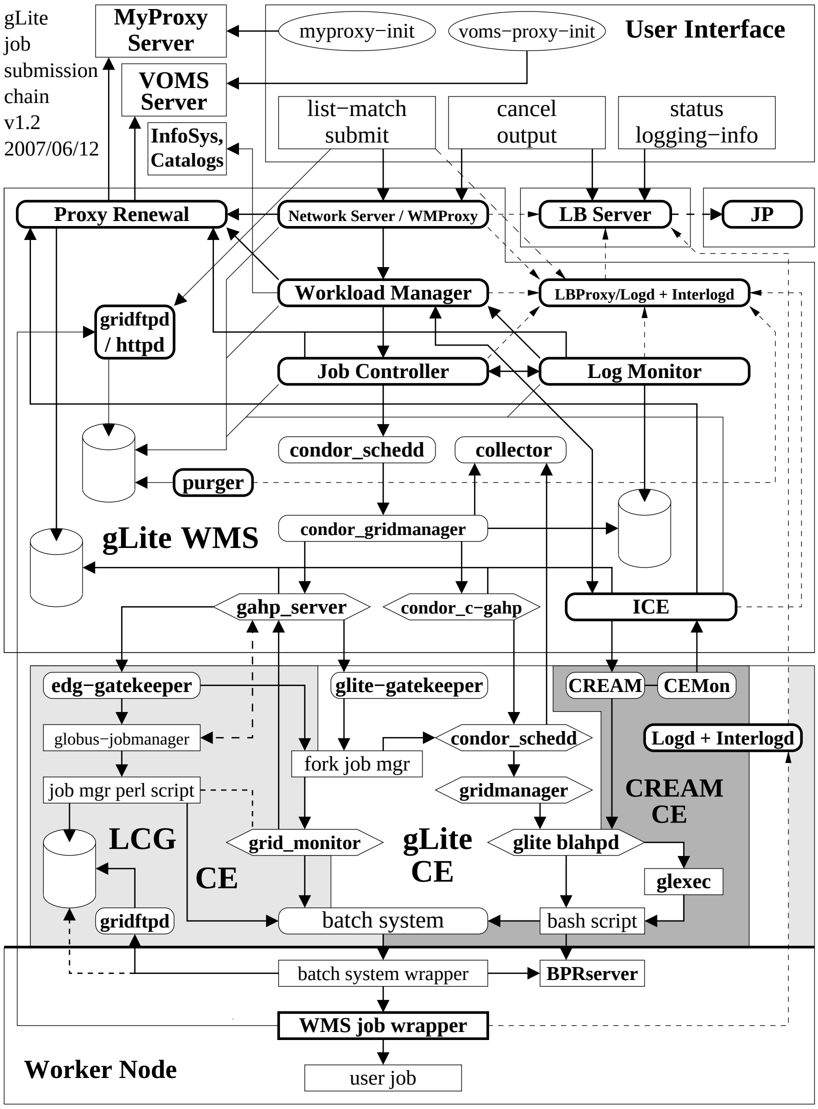
8.5 Open Source

This clause contains examples of Open Source solutions, it does not claim to be a complete list. It will be updated and extended in future versions of the present document.

8.5.1 gLite

The gLite distribution is an integrated set of components designed to enable resource sharing. In other words, this is middleware for building a Grid. The gLite middleware is produced by the EGEE project. In addition to code developed within the project, the gLite distribution combines components from different providers, e.g. Condor and Globus (via VDT), LCG, EDG/EGEE. The distribution model is to construct different services ("node-types") from these components and then ensure easy installation and configuration on the chosen platforms. After prototyping phases in 2004 and 2005, a convergence with the LCG-2 distribution resulted in gLite 3.0 that has been released in May 2006 [Grandi07].

gLite middleware is currently deployed on hundreds of sites as part of the EGEE project and enables global science in a number of disciplines, notably serving the LCG project [gLite-WWW].



NOTE: https://twiki.cern.ch/twiki/bin/view/EGEE/EGEEgLiteJobSubmissionSchema

Figure 5: gLite job submission chain

8.5.1.1 Implemented Standards

The implemented standards are listed related to the foundational components of a Grid middleware. These comprise security, information systems, data management, and job management.

Interoperability needs to be provided for Foundation Grid Middleware:

- **Security: Authentication and Authorization**
  - Authentication is based on X.509 PKI.
  - Certificates for AuthN and VOMS for AuthZ.
  - VOMS (WS/HTTPS), MyProxy.
- **Information systems: Information Schema and Service Discovery**
  - Lite SD currently supports Relational Grid Monitoring Architecture (R-GMA), BDII and XML files back ends.
  - Globus Monitoring and Discovery Service (MDS) implements GLUE schema (version 1.3) using OpenLDAP, an open source implementation of the Lightweight Directory Access Protocol (LDAP).
  - R-GMA is an implementation of the Grid Monitoring Architecture (GMA) proposed by the Global Grid Forum (GGF).
  - (OGF GMA).
- **Data Management: Data Access and Data Transfer**
  - External transfers via gridFTP (de-facto standard).
  - Storage Resource Manager (SRM) 2.2 interface for data access.
  - POSIX.
  - GridFTP (GDF.20, GDF.21).
- **Job Management: Job submission and monitoring**
  - WS-I Compute Element.
  - JDL, JSDL.

References

[Grandi07] C. Grandi. *The gLite middleware.* EGEE07, Budapest, 1-5 October 2007.

[EGEE-WWW] EGEE Objectives. http://www.eu-egee.org/introduction/objectives (last visit: 29.10.2007).

[gLite-WWW] gLite - Introduction. http://glite.web.cern.ch/glite/common/introduction.asp (last visit: 29.10.2007).

8.5.2 Globus Alliance and Globus Toolkit

8.5.2.1 Globus Alliance

Globus was first established as an open source software project in 1996. Since that time, the Globus development team has expanded from a few individuals to a distributed, international community. This community, the Globus Alliance, describes itself on its Web page as follows [Globus-WWW]:

"The Globus Alliance a community of organizations and individuals developing fundamental technologies behind the "Grid", which lets people share computing power, databases, instruments, and other on-line tools securely across corporate, institutional, and geographic boundaries without sacrificing local autonomy.

Based at Argonne National Laboratory, the University of Southern California's Information Sciences Institute, the University of Chicago, the University of Edinburgh, the Swedish Center for Parallel Computers, and the National Center for Supercomputing Applications (NCSA), the Alliance produces open-source software that is central to science and engineering activities totalling nearly a half-billion dollars internationally and is the substrate for significant Grid products offered by leading IT companies. The Globus Alliance Affiliates program recognizes the participation of other important organizations as contributors or as users."

The core Globus team at the locations mentioned above consists of round about 65 persons. The open source tool developed and maintained by the Globus community is the Globus Toolkit. This toolkit is the best known Grid middleware implementation. The Globus Toolkit is used in many different projects of various areas such as astronomy, chemistry, civil engineering, climate studies, collaboration, computer science, geology, infrastructure, medicine, oceanography and physics. A list of links to actual projects can be found on [Globus-Projects-WWW]. In the following, clauses we will describe some details about the Globus Toolkit.

8.5.2.2 Globus Toolkit

The Globus Toolkit has been developed since the late 1990s. It is an open source software toolkit used for building grids. The Globus Toolkit has been developed by the Globus Alliance and many others all over the world. The core Globus Toolkit components address, within a common framework, basic issues relating to security, resource access and management, data movement, resource discovery, and so forth. The core components enable a broader "Globus ecosystem" of tools and components of tools to provide a wide range of useful application-level functions. A short summary of the functionality the Globus Toolkit Version 4 can be found in [Foster06]. Further readings and tutorial material is accessible on the Web pages of the Globus Toolkit [Globus-Toolkit-WWW] and [Globus-Publications-WWW].

8.5.2.3 Implemented Standards

The implemented standards are listed related to the foundational components of a Grid middleware. These comprise security, information systems, data management, and job management:

- **Security: Authentication and Authorization**
  - GSSAPI Extensions.
  - JAAS.
  - RFC 3820 [i.57] Proxy Certificates.
  - RFC 2818 [i.59] HTTP over TLS.
  - RFC 2744 [i.52] GSSAPI: C-bindings.
  - RFC 2743 [i.51] GSSAPI.
  - RFC 2246 [i.61] TLS.
  - Simple Assertion Markup Language (SAML).
  - SAML Schema Protocol.

- WS-Security.
- WS-Security: X.509 Certificate Tokens.
- WS-Security: Username Tokens.
- WS-Trust.
- WS-Secure Conversation.
- WS-I Basic Security Profile.

- **Information systems: Information Schema and Service Discovery**
  - HyperText Transfer Protocol (HTTP).
  - HyperText Markup Language (HTML).
  - XSL Transformations (XSLT).
  - WebMDS is implemented as a Java Servlet.
  - WS-ResourceProperties (WSRF-RP).
  - WS-ResourceLifetime (WSRF-RL).
  - WS-ServiceGroup (WSRF-SG).
  - WS-BaseFaults (WSRF-BF).
  - WS-BaseNotification.
  - WS-Topics.
- **Data Management: Data Access and Data Transfer**
  - Open Grid Services Architecture Data Access and Integration (OGSA-DAI).
  - WSRF.
  - WS-Addressing.
  - WS-Security.
  - RFC 959 [i.43] Base FTP protocol.
  - RFC 2228 [i.62] gssapi security extensions for FTP RFC 2389 [i.63] FEAT, OPTS, etc.
  - extensions to FTP (IETF FTP Working group draft) for structured directory listings, SIZE, MDTM commands.
  - GFD.020 GridFTP extensions.
- **Job Management: Job submission and monitoring**
  - WS-ResourceProperties.
  - WSRF.

[Globus-Doc-WWW].

References

[Foster06]I. Foster. *Globus Toolkit Version 4: Software for Service-Oriented Systems***.** IFIP International Conference on Network and Parallel Computing, Springer-Verlag LNCS 3779, pp 2-13, 2006.

[Globus-WWW] Web pages of the Globus Alliance. http://www.globus.org/ (last visit: 05.10.2007).

[Globus-Projects-WWW] List of projects where the Globus Toolkit is used. http://www.globus.org/alliance/projects.php (last visit: 05.10.2007).

[Globus-Doc-WWW] Globus Toolkit 4.0 Release Manual. http://www.globus.org/toolkit/docs/4.0/ (last visit: 23.10.2007).

8.5.3 Gridbus

8.5.3.1 Gridbus

The Grid Computing and Distributed Systems (GRIDS) Laboratory of the University of Melbourne developed the Gridbus middleware that is included in the Gridbus project. This project is engaged in the creation of open-source specifications, architecture and a reference Grid toolkit implementation of service oriented Grid and utility computing technologies for e-Science and e-Business applications. The Gridbus software is being used in Grid-enabling a number of applications in science, engineering, and commerce. Their research and innovation sponsors include: Australian Research Council, Storage Technology Corporation, Sun Microsystems, VPAC, Microsoft, IBM, and Singapore Computer Systems [Gridbus-flyer-WWW].

Some of the Gridbus technologies have been developed by making use of Web Services technologies and services provided by low-level Grid middleware, particularly Globus Toolkit and Alchemi. A summary and status of various Gridbus technologies is listed on [Gridbus-middleware-WWW].

8.5.3.2 Implemented Standards

The implemented standards are listed related to the foundational components of a Grid middleware. These comprise security, information systems, data management, and job management.

- Security: Authentication and Authorization.
- Information systems: Information Schema and Service Discovery.
- Data Management: Data Access and Data Transfer:
  - WSRF.
- Job Management: Job submission and monitoring:
  - JSDL;
  - WSRF.

[Gridbus-broker-WWW].

References

[Gridbus-flyer-WWW] Gridbus flyer. http://www.gridbus.org/gridbus_flyer.pdf (last visit: 29.10.2007).

[Gridbus-middleware-WWW] The Gridbus Middleware. http://www.gridbus.org/middleware/ (last visit: 29.10.2007).

[Gridbus-broker-WWW] Grid Service Broker: A Grid Scheduler for Computational and Data Grids. http://www.gridbus.org/broker/ (last visit: 30.10.2007).

8.5.4 UNICORE

In 1997, the development of the UNICORE - Uniform Interface to Computing Resources - system was initiated to enable German supercomputer centres to provide their users with a seamless, secure, and intuitive access to their heterogeneous computing resources. The UNICORE vision was proposed to the German Ministry for Education and Research (BMBF) and received funding. A first prototype was developed in the "UNICORE" project. The foundations for the current production version were laid in the follow- up project "UNICORE Plus", which was successfully completed in 2002.

In recent years, UNICORE has undergone a major restructuring and re-implementation of core components. This has been done in the European UniGrids project. Now, UNICORE is based on Web Services as proposed by the Open Grid Services Architecture maintained by the Open Grid Forum. In fact, UNICORE 6 is the most up-to-date implementation of the core specifications (such as WS-RF).

UNICORE offers a ready-to-run Grid system including client and server software. UNICORE makes distributed computing and data resources available in a seamless and secure way in intranets and the internet.

8.5.4.1 Implemented Standards

The implemented standards are listed related to the foundational components of a Grid middleware. These comprise security, information systems, data management, and job management.

Interoperability needs to be provided for Foundation Grid Middleware:

- Security: Authentication and Authorization:
  - Authentication is based on X.509 PKI.
  - SAML assertions for security.
  - XACML policy validations (in conjunction with SAML).
  - SAML Delegation (no proxies are necessary anymore).
  - OASIS Standard (WSRF 1.2).
- Information systems: Information Schema and Service Discovery.
- Data Management: Data Access and Data Transfer:
  - WS-RF full stack.
  - WS-Addressing.
  - OGSA-ByteIO.
  - Common Information Model (CIM).
- Job Management: Job submission and monitoring:
  - Job submission and description language (JSDL) with Atomic Services (proprietary interface).
  - WS-RF full stack.

8.5.4.2 Upcoming standard implementations

- JSDL with OGSA-BES (beta now, production release of 2007).
- HPC-P Profile, release of 2007.
- Initial prototype of OGSA-RUS (beta now, production release March 2008).
- JSDL - SPMD support (+extensions for real world supercomputers).

UoEdinburgh develops OGSA-DAI4UNICORE (WS-DAIx standard).

References

[UNICORE-WWW] Web pages of the UNICORE. http://www.unicore.eu/ (last visit: 29.10.2007).

8.5.5 NORDU Grid and the Advance Resource Connector (ARC)

8.5.5.1 NorduGrid

http://www.nordugrid.org/

NorduGrid is a Grid Research and Development collaboration aiming at development, maintenance and support of the free Grid middleware, known as the Advance Resource Connector (ARC). Their aim is to deliver a robust, scalable, portable and fully featured solution for a global computational and data Grid system. NorduGrid develops and deploys a set of tools and services - the so-called ARC middleware, which is a free software. The goals are:

- Develop and support the ARC middleware.
- Coordinate contributions to the ARC code.
- Define strategical directions for development of the ARC middleware following latest tendencies in Grid technologies.
- Promote ARC middleware solutions in such areas as Grid development, deployment and usage.
- Contribute to development of Grid standards, e.g. via GGF.

8.5.5.2 Advanced Resource Connector (ARC)

The Advanced Resource Connector (ARC) is a free Grid middleware developed and maintained by the NorduGrid. ARC is an out-of-the-box Grid solution that offers its own services some of which are built upon the GT libraries. It integrates computing resources that can be commodity computing clusters managed by a batch system or standalone workstations and Storage Elements and makes them available via a secure common Grid layer.

ARC is designed to be a scalable, non-intrusive and portable solution. The development is user- and application-driven, with the main requirements being those of performance, stability, usability and portability. As a result of this approach, the *standalone client* is available for a dozen of platforms and can be installed in a few minutes. The server installation does not require a full site reconfiguration. The middleware can be built on any platform where the external software packages (like GT libraries) are available. While being deployed on a large production Grid and being used by real users, the middleware is naturally undergoing continuous real life tests.

8.5.5.3 Implemented Standards

The implemented standards are listed related to the foundational components of a Grid middleware. These comprise security, information systems, data management, and job management.

- Security: Authentication and Authorization
  - Authentication is based on X.509 PKI (inherited from globus).
  - RFC 3820 [i.57].
  - VOMS, LDAP, HTTPS.
  - GFD.54.
- Information systems: Information Schema and Service Discovery
  - ARC information system is an OpenLDAP-based system which makes use of the OpenLDAP modifications provided by the Globus Monitoring and Discovery Services framework [i.24].
  - LDAP.

- Data Management: Data Access and Data Transfer
  - Smart Storage Element (SSE): SSE is a replacement of the current ARC gridftpd-based simple storage element. SSE is based on standard protocols such as HTTPS/G and SOAP. SSE will provide flexible access control, data integrity between resources and support for autonomous and reliable data replication.
  - GridFTP (GDF.20, GDF.21).
  - SRM.
  - HTTPS (RFC 2818 [i.59]).
  - FTP (RFC 959 [i.43]).
- Job Management: Job submission and monitoring
  - OGSA BES/JSDL compliant job execution service.
  - [i.26] and [i.27].

8.5.5.3.1 References

- "Advanced Resource Connector middleware for lightweight computational Grids". M.Ellert et al., Future Generation Computer Systems 23 (2007) 219-240. http://dx.doi.org/10.1016/j.future.2006.05.008
- KnowARC Design Document, http://www.knowarc.eu/documents/Knowarc_D1.1-1_07.pdf
- KnowARC Standards Conformance Roadmap (second release): http://www.knowarc.eu/documents/Knowarc_D3.3-1_08.pdf

8.5.6 Proactive

ProActive is a Java Grid middleware (part of the ObjectWeb/OW2 consortium and developed by INRIA, CNRS and University of Nice Sophia Antipolis, with Open Source code under GPL license) for parallel, distributed and multi-threaded computing.

ProActive provides a comprehensive framework and parallel programming model to simplify the programming and execution of parallel applications: running on multi-core processors, distributed on Local Area Network (LAN), on clusters and data centers, on intranets and Internet Grids.

The ProActive programming model combines the Active Object design pattern with Futures objects.

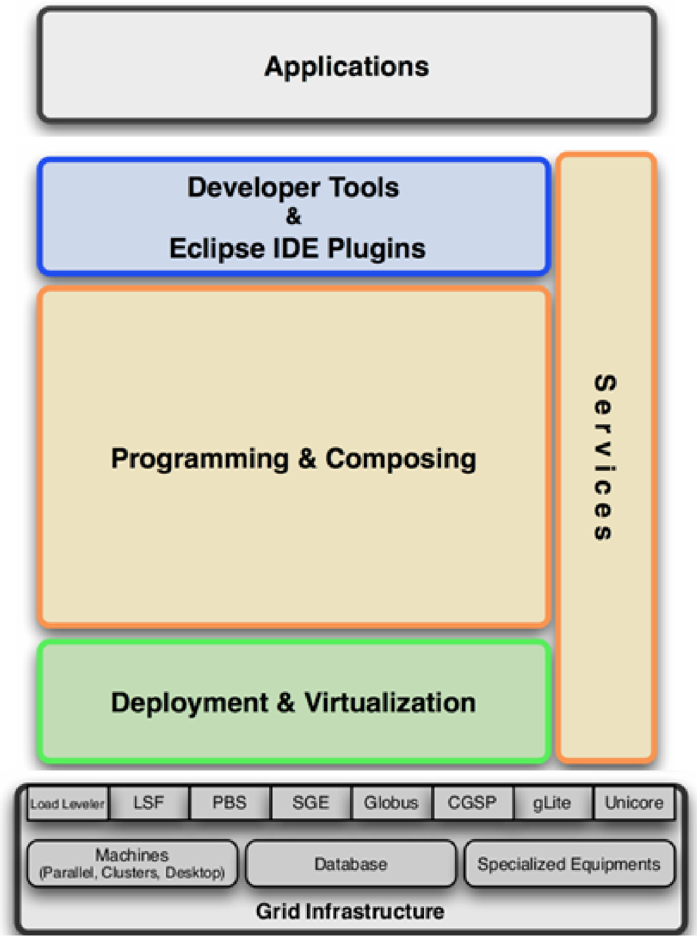


Figure 6: Proactive High level Architecture

ProActive interfaces with many de facto grid standards (e.g. Globus, LSF, PBS, SGE, LoadLeveler, EGEE gLite, Unicore, ssh).

8.5.6.1 Implemented Standards

- Eclipse;
- OGSI;
- Web services;
- http;
- JMX;
- Jini;
- Java Services;
- ETSI GCM.

8.5.7 Various Grid tools

8.5.7.1 Grid Schedulers

- **Condor:** A specialized workload management system for compute-intensive jobs.
  - http://www.cs.wisc.edu/condor/.

- **Grid Service Broker:** A Grid Scheduler for Computational and Data Grids.
  - http://www.gridbus.org/broker/.
- **Nimrod:** Tools for Distributed Parametric Modelling.
  - http://www.csse.monash.edu.au/~davida/nimrod/.

8.5.7.2 Grid Portals

- **GridSphere Portal Framework:** enables developers to quickly develop and package third-party portlet web applications that can be run and administered within the GridSphere portlet container.
  - http://www.gridsphere.org.
- **Gridscape II:** A Customizable and Pluggable Grid Monitoring Portal and its Integration with Google Maps.
  - http://www.gridbus.org/gridscape/.
- **G-Monitor:** A Web Portal for Monitoring and Steering Application Execution on Global Grids.
  - http://www.gridbus.org/papers/gmonitor.pdf.
- **Ganglia** is a scalable distributed monitoring system for high-performance computing systems such as clusters and Grids.
  - http://ganglia.sourceforge.net/.

8.5.7.3 Grid Programming Environments

- CactusC-de - Its modular structure easily enables parallel computation across different architectures and collaborative code development between different groups.
  - http://www.cactuscode.org/.
- **Meta-PI** - Flexible Coupling of Heterogeneous MPI Systems
  - http://www.lfbs.rwth-aachen.de/~martin/MetaMPICH/metaframe.html.
- **Commodity Grid (CoG)** Kits allow Grid users, Grid application developers, and Grid administrators to use, program, and administer Grids from a higher-level framework.
  - http://wiki.cogkit.org/index.php/Main_Page.
- With **GRID superscalar** a sequential application composed of tasks of a certain granularity is automatically converted into a parallel application where the tasks are executed in different servers of a computational Grid.
  - http://www.bsc.es/plantillaG.php?cat_id=69.

Annex A:
Grid Specifications

Standards Body	Document ID	Title	Description	Category	User	URI	Relevance (1=low)	Pages
OGF		GLUE Scema v2.0			KnowARC			
OGF	GFD.145	Guidelines of Requirements for Grid Systems v1.0				http://www.ogf.org/documents/GFD.145.pdf		
OGF	GFD.144	SAGA API Extension: Service Discovery API				http://www.ogf.org/documents/GFD.144.pdf		
OGF	GFD.143	Distributed Resource Management Application API 1.0 - Python Language Binding				http://www.ogf.org/documents/GFD.143.pdf		
OGF	GFD.142	Requirements on operating Grids in Firewalled Environments				http://www.ogf.org/documents/GFD.142.pdf		
OGF	GFD.141	Independent Software Vendors (ISV) Remote Computing Usage Primer				http://www.ogf.org/documents/GFD.141.pdf		
OGF	GFD.140	Implementation and Interoperability Experiences with the Job Submission Description Language(JSDL) 1.0				http://www.ogf.org/documents/GFD.140.pdf		
OGF	GFD.138	OGSA® Basic Security Profile 2.0 [Obsoletes GFD.86, GFD.99]				http://www.ogf.org/documents/GFD.138.pdf		
OGF	GFD.137	Information and Data Modeling in OGSA® Grids				http://www.ogf.org/documents/GFD.137.pdf		
OGF	GFD.136	Job Submission Description Language (JSDL) Specification, Version 1.0 [Obsoletes GFD.56]			KnowARC	http://www.ogf.org/documents/GFD.136.pdf		

Standards Body	Document ID	Title	Description	Category	User	URI	Relevance (1=low)	Pages
OGF	GFD.135	HPC File Staging Profile, Version 1.0				http://www.ogf.org/documents/GFD.135.pdf		
OGF	GFD.134	OGSA-DMI Functional Specification 1.0				http://www.ogf.org/documents/GFD.134.pdf		
OGF	GFD.133	Distributed Resource Management Application API Specification 1.0 [Obsoletes GFD.22]				http://www.ogf.org/documents/GFD.133.pdf		
OGF	GFD.132	Secure Communication Profile 1.0				http://www.ogf.org/documents/GFD.132.pdf		
OGF	GFD.131	Secure Addressing Profile 1.0				http://www.ogf.org/documents/GFD.131.pdf		
OGF	GFD.130	Distributed Resource Management Application API 1.0 - IDL Specification				http://www.ogf.org/documents/GFD.130.pdf		
OGF	GFD.129	The Storage Resource Manager Interface Specification Version 2.2			KnowARC	http://www.ogf.org/documents/GFD.129.pdf		
OGF	GFD.128	Grid Optical Burst Switched Networks (GOBS)				http://www.ogf.org/documents/GFD.128.pdf		
OGF	GFD.127	Configuration Description, Deployment and Lifecycle Management Working Group (CDDLM-WG) Final Report				http://www.ogf.org/documents/GFD.126.pdf		
OGF	GFD.125	Grid Certificate Profile				http://www.ogf.org/documents/GFD.125.pdf		
OGF	GFD.124	Interoperability Experiences with the High Performance Computing Basic Profile (HPCBP), Version 1.0				http://www.ogf.org/documents/GFD.124.pdf		

Standards Body	Document ID	Title	Description	Category	User	URI	Relevance (1=low)	Pages
OGF	GFD.123	Defining the Grid: A Roadmap for OGSA® Standards v1.1 [Obsoletes GFD.53]				http://www.ogf.org/documents/GFD.123.pdf		
OGF	GFD.122	Grid Network Services Use Cases from the e-Science Community				http://www.ogf.org/documents/GFD.122.pdf		
OGF	GFD.121	OGSA® Data Architecture				http://www.ogf.org/documents/GFD.121.pdf		
OGF	GFD.120	Open Grid Services Architecture® Glossary of Terms Version 1.6 [Obsoletes GFD.81]			KnowARC	http://www.ogf.org/documents/GFD.120.pdf		
OGF	GFD.119	Execution Environment and Basic Execution Service Model in OGSA® Grids				http://www.ogf.org/documents/GFD.119.pdf		
OGF	GFD.118	Guidelines for Information Modeling for OGSA® Entities				http://www.ogf.org/documents/GFD.118.pdf		
OGF	GFD.115	JSDL SPMD Application Extension	Addition of 5 SPMD instructions to JSDL			http://www.ogf.org/documents/GFD.115.pdf	3	
OGF	GFD.114	HPC Basic Profile	Combines BES, JSDL, and HPC extension to JSDL		BREIN KnowARC	http://www.ogf.org/documents/GFD.114.pdf	1	
OGF	GFD.111	JSDL HPC Profile Application Extension	Addition of 9 HPC instructions to JSDL		KnowARC	http://www.ogf.org/documents/GFD.111.pdf	1	
OGF	GFD.110	Information Dissemination in the Grid Environment	INFOD publish/subscribe/notify information distribution mechanism (very similar to GMA model)			http://www.ogf.org/documents/GFD.110.pdf	2	
OGF	GFD.109	WS-Naming Specification	Extension to WS-Addressing			http://www.ogf.org/documents/GFD.109.pdf	1	
OGF	GFD.108	OGSA Basic Execution Service	Standard for submitting, monitoring, and managing basic computational tasks.		BREIN KnowARC	http://www.ogf.org/documents/GFD.108.pdf	2	
OGF	GFD.107	Web Services Agreement Specification (WS-Agreement)	SLA Negotiation		Akogrimo, AssessGrid, NextGRID	http://www.ogf.org/documents/GFD.107.pdf	3	

Standards Body	Document ID	Title	Description	Category	User	URI	Relevance (1=low)	Pages
OGF	GFD.101	Resource Namespace Service Specification	RNS analog of DNS, mapping names to actual resource end-points. Developed specifically for data resources, but applicable to services and other entities with "abstract" or "mobile" names.			http://www.ogf.org/documents/GFD.101.pdf	1	
OGF	GFD.99	OGSA Security Profile - 0 - Secure Channel	Provides guidance on standards to use for establishing a secure channel between Web Services. This extends the WS-I Basic Security Profile and WSRF Basic Profile.			http://www.ogf.org/documents/GFD.99.pdf	1	
OGF	GFD.98	Usage Record - Format Recommendation	Defines aspects and meta-data for reporting on computational jobs for accounting.		KnowARC	http://www.ogf.org/documents/GFD.98.pdf	2	
OGF	GFD.88	ByteIO OGSA WSRF Basic Profile Rendering	Describes a dozen properties which can be applied as meta-data to a ByteIO resource		NextGRID, Simdat	http://www.ogf.org/documents/GFD.88.pdf	1	
OGF	GFD.87	ByteIO Specification	Provides a POSIX-like interface to data resources.			http://www.ogf.org/documents/GFD.878.pdf	2	
OGF	GFD.86	OGSA Basic Security Profile 1.0 - Core	Standard can be summarized as follows: "Place information to guide resource consumer/client on key selection into the wsa:Metadata/bsp:EndpointKeyinfo element"			http://www.ogf.org/documents/GFD.86.pdf	1	
OGF	GFD.85	CDDLM Configuration Description Language	Configuration Description, Deployment, and Lifecycle Management (CDDLM) has adapted the HP SmartFrog Web Service deployment language into an OGF specification. CDL provides a hierarchical template mechanism for defining name/value pairs of configuration information. This allows a set of resources to be quickly, easily, and consistently configured, with appropriate customizations where necessary.			http://www.ogf.org/documents/GFD.85.pdf	2	
OGF	GFD 80	OGSA v1.5			KnowARC			
OGF	GFD.76	Web Services Data Access and Integration - The Relational Realization (WS-DAIR) Specification	Extensions to WS-DAI to consider relational data sources (DBs)			http://www.ogf.org/documents/GFD.76.pdf	1	

Standards Body	Document ID	Title	Description	Category	User	URI	Relevance (1=low)	Pages
OGF	GFD.75	Web Services Data Access and Integration - The XML Realization (WS-DAIX) Specification	Extensions to WS-DAI to consider XML data sources			http://www.ogf.org/documents/GFD.75.pdf	1	
OGF	GFD.74	Web Services Data Access and Integration - The Core (WS-DAI) Specification	Describes general data resource access through a Web Services interface			http://www.ogf.org/documents/GFD.74.pdf	2	
OGF	GFD.73	Application Contents Service	An XML standard to specify a set of files required for an application. Includes mechanisms to embed files in the ACS XML.			http://www.ogf.org/documents/GFD.73.pdf	1	
OGF	GFD.72	OGSA WSRF Basic Profile			BREIN, Access Grid, KnowARC, Akogrim			
OGF	GFD.69	CDDLM Deployment API	Draws on MUWS, MOWS, WSDM WS-Notification to describe a Web Service which takes CDL and manages the deployment of the system of resources.			http://www.ogf.org/documents/GFD.69.pdf	2	

Standards Body	Document ID	Title	Description	Category	User	URI	Relevance (1=low)	Pages
OGF	GFD.65	CDDLM Component Model	Describes how systems of components are combined and their lifecycle managed (from deployment, to initiation, to shutdown), including fault handling.			http://www.ogf.org/documents/GFD.65.pdf	2	
OGF	GFD.56	Job Submission Description Language (JSDL) Specification	Proposes a standard syntax for specifying requirements of a job in XML.		KnowARC, BREIN	http://www.gridforum.org/documents/GFD.56.pdf	2	
	GFD.54	MyProxy Protocol			KnowARC, gLite			
OGF	GFD.52	A GridRPC Model and API for End-User Applications	Describes functions and structures to provide an RPC mechanism for grids. Very C-like syntax. Includes session identifiers and asynchronous calls.			http://www.ogf.org/documents/GFD.52.pdf	2	
OGF	GFD.51	CDDLM SmartFrog-Based Language Specification	Describes a custom syntax fcr CDDLM components and templates.			http://www.ogf.org/documents/GFD.51.pdf	2	
OGF	GFD.47	GridFTP v2 Protocol Description	Describes extensions to the FTP standard to support large file transfers over "long fat" connections (high latency but high bandwidth).		KnowARC	http://www.ogf.org/documents/GFD.47.pdf	2	
OGF	GDF.30	OGSA Architecture			BREIN, Akogrimo, NextGRID, KnowARC			
OGF	GDF-I.30				NextGRID			
OGF	GFD.23	A Hierarchy of Network Performance Characteristics for Grid Applications and Services	Describes a common ontology for network monitoring.			http://www.ogf.org/documents/GFD.23.pdf	2	
OGF	GFD.22	Distributed Resource Management Application API	Using an IDL like syntax, describes an API for job submission, job monitoring and control, and retrieval of the finished job status.			http://www.ogf.org/documents/GFD.22.pdf	2	
OGF	GFD.21	GridFTP Protocol Improvements			KnowARC			
OGF	GFD.20	GridFTP: Protocol Extensions to FTP for the Grid						
OGF	GFD.15	Open Grid Services Infrastructure (OGSI)	Describes the Grid Services model as an extension to Web Services. Made obsolete by the introduction of WSRF, but the ideological precursor.			http://www.ogf.org/documents/GFD.15.pdf	1	

Standards Body	Document ID	Title	Description	Category	User	URI	Relevance (1=low)	Pages
OGF	GDF.87	OGSA WSRF Basic Profile Rendering 1.0	The ByteIO Specification is a description of a set of port types that give users a concise, standard way of interacting with bulk data sources and sinks in the grid.	DM	UNICORE	http://www.ogf.org/documents/GFD.87.pdf		
OGF	JSDL				UNICORE			
ITU	X.509	Information technology - Open Systems Interconnection - The Directory: Public-key and attribute certificate frameworks	This Recommendation defines a framework for public-key certificates and attribute certificates.	S	UNICORE gLite, BREIN, Akogrimo, KnowARC	http://www.itu.int/rec/T-REC-X.509		
OASIS	SAML	Security Assertion Markup Language		S	UNICORE, NextGRID, Akogrimo, KnowARC, BREIN,	http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=security#samlv20		
OASIS	XACML	eXtensible Access Control Markup Language		S	UNICORE NextGRID, KnowARC	http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=xacml#technical		
OASIS	WS-RF	Web Services Resource Framework		S	UNICORE	http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wsrf#technical		
WS-I	WS-I BP	Basic Profile 1.1			KnowARC			
WS-I	WS-I BSP	Basic Security Profile (BSP) v1.o			KnowARC			
W3C	Web Services Addressing 1.0 - Core	WS-Addressing		DM	UNICORE, NextGRID, Akogrimo, KnowARC, BREIN, SIMDAT	http://www.w3.org/TR/2006/REC-ws-addr-core-20060509		
W3C	Web Services Addressing 1.0 - SOAP Binding	WS-Addressing		DM	UNICORE	http://www.w3.org/TR/2006/REC-ws-addr-soap-20060509		
W3C	Web Services Addressing 1.0 - Metadata	WS-Addressing		DM	UNICORE	http://www.w3.org/TR/2007/REC-ws-addr-metadata-20070904		
?	Web Services Agreement	Web Services Agreement						
IBM	Web Services Federation	Web Services Federation			BREIN			
IBM	WSLA	Web Service Level Agreement (WSLA)			Akoggrimo			
OASIS	Web Services Security	Web Services Security						

Standards Body	Document ID	Title	Description	Category	User	URI	Relevance (1=low)	Pages
OASIS	BPEL	Web Services Business Process Execution Language (BPEL)		Akogrmo, BREIN, NextGRID				
W3C	Web Services Definition Language (WSDL)	Web Services Definition Language (WSDL)						
W3C	Web Services Choreography Description Language (WS-CDL)	Web Services Choreography Description Language (WS-CDL)						
OASIS	Web Services Notification (WS-N)	Web Services Notification (WS-N)			SIMDAT, KnowARC			
	Web Services Policy (WS-P)	Web Services Policy (WS-P)			Akogrimo			
	Web Services SecureConversation	Web Services SecureConversation			BREIN			
	Web Services Security token profiles	Web Services Security token profiles			BREIN			
	Web Services Trust	Web Services Trust			BREIN			
DMTF	CIM	Common Information Model	CIM provides a common definition of management information for systems, networks, applications and services, and allows for vendor extensions. CIM's common definitions enable vendors to exchange semantically rich management information between systems throughout the network.	DM	UNICORE	http://www.dmtf.org/standards/cim		
IETF	RFC 2904	AAA Authorization Framework			NextGRID			
IETF	RFC 959 [i.43]	File transfer Protocol			KnowARC			
IETF	RFC 2818 [i.59]	HTTPS			KnowARC			
IETF	RFC 3820 [i.57]	X.509 PKI Proxy Certificate Profile			KnowARC			
IETF	RFC 4510	Lightweight Directory Access Protocol (LDAP)			KnowARC+ J78			
FIPA	ACL	Agent Communication Language Specification			BREIN			

Standards Body	Document ID	Title	Description	Category	User	URI	Relevance (1=low)	Pages
IETF	GSS-API	Generic Security Services API	GSS-API specified in RFCs 2743, 2744, 1964, 4121, 4178, 2025, 2847		KnowARC			
Globus		Globus Toolkit 4.0: Security: Authorization Framework			NextGRID			
ANSI	INCITS 359-2004	EDAC Compliance with ANSI Role Based Access Control (RBAC)			NextGRID			
OGF		OGSA Express Authentication Profile			BREIN			
OGF	ggf-ogsa-bes-spec-1.0	OGSA Basic Service Execution Service			KnowARC			
OGF		OGSA Basic Profile			NextGRID			
OGF		OGSA BES/JSDL compliant job execution Service			KnowARC			
OGF		OGSA-SBP-SecChan Grid Laboratory Uniform Environment (GLUE)			KnowARC			
W3C	XPath	XML Path Language v1.0			KnowARC			
W3C	OWL	Web Ontology Language			BREIN			
W3C	RDF	resource Description Framework			BREIN			
W3C	SPARQL	Query Language for RDF			BREIN			
NORDUGRID	Tech-10	Smart Storage Element			KnowARC			
W3C	SOAP	SOAP			Akrogrimo			
European DataGrid Project	VOMS	Virtual Organization Membership Service			KnowARC, gLite, Globus			
OASIS	WS-Security	Web Services Security C- Core Specification			NextGRID, BREIN, Akogrimo			
WS-I	BP	WS-I Basic Profile			KnowARC			
WS-I	Basic Security Profile	WS-I Basic Security Profile			KnowARC			

Standards Body	Document ID	Title	Description	Category	User	URI	Relevance (1=low)	Pages
OASIS	WS-BaseNotification	WS Base Notification			Akogrimo			
W3C	XML encryption	XML encryption			BREIN			
W3C		XML signature			BREIN			
ITU	X.509	Information technology - Open Systems Interconnection - The Directory: Public-key and attribute certificate frameworks	This Recommendation defines a framework for public-key certificates and attribute certificates.	S	UNICORE gLite KnowARC	http://www.itu.int/rec/T-REC-X.509		
OASIS	SAML	Security Assertion Markup Language		S	UNICORE	http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=security#samlv20		
OASIS	XACML	eXtensible Access Control Markup Language		S	UNICORE	http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=xacml#technical		
OASIS	WS-RF	Web Services Resource Framework		S	UNICORE KnowARC	http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wsrf#technical		
W3C	Web Services Addressing 1.0 - Core	WS-Addressing		DM	UNICORE KnowARC	http://www.w3.org/TR/2006/REC-ws-addr-core-20060509		
W3C	Web Services Addressing 1.0 - SOAP Binding	WS-Addressing		DM	UNICORE KnowARC	http://www.w3.org/TR/2006/REC-ws-addr-soap-20060509		
W3C	Web Services Addressing 1.0 - Metadata	WS-Addressing		DM	UNICORE KnowARC	http://www.w3.org/TR/2007/REC-ws-addr-metadata-20070904		
OGF	GDF.87	OGSA WSRF Basic Profile Rendering 1.0	The ByteIO Specification is a description of a set of port types that give users a concise, standard way of interacting with bulk data sources and sinks in the grid.	DM	UNICORE	http://www.ogf.org/documents/GFD.87.pdf		
DMTF	CIM	Common Information Model	CIM provides a common definition of management information for systems, networks, applications and services, and allows for vendor extensions. CIM's common definitions enable vendors to exchange semantically rich management information between systems throughout the network.	DM	UNICORE	http://www.dmtf.org/standards/cim		
OGF	JSDL				UNICORE			

Standards Body	Document ID	Title	Description	Category	User	URI	Relevance (1=low)	Pages
WS-I	WS-I Basic profile				KnowARC	http://www.ws-i.org/Profiles/BasicProfile-1.0-2004-04-16.html		
WS-I	WS-I Basic Security Profile				KnowARC	http://www.ws-i.org/Profiles/BasicSecurityProfile-1.0.html		
ETSI	TS 102 827	GRID;Grid Component Model (GCM);GCM Interoperability Deployment			Proactive			
ETSI	TS 102 828	GRID;Grid Component Model (GCM);GCM Application Description			Proactive			

Annex B: Background to a possible methodology for Gap Analysis

"When technology adds to the complexity of experience, it makes sense to endorse it; when it adds to conflict and confusion, it makes sense to resist it." M. Csikszentmihalyi.

Standards are developed as a key agent to absorbing and using new technologies. Evaluating standards for a given science and technology domain requires an organized structuring of suitable evaluation indicators and the linkages between them.

Given the identified evaluation grid for standards, the present document reports the technological pertinence, progress, and effect of the various initiatives, projects, and standards, basis for the creation, exchange, and management of information on Grid and incident technologies.

Driven by the need and opportunity of bringing new Information and Communication Technology (ICT) capabilities to European business and citizens, a group of high-level experts, named the Next Generation Grid (NGG) Expert Group, has developed a vision for European Grid research. The NGG was entrusted with the task of redefining the scientific and technological requirements necessary to evolve Grid technology towards the wider and more ambitious vision of Service Oriented Knowledge Utilities (SOKU). Strongly dependent on the production, distribution, and use of knowledge than ever before, SOKU results from a fuller recognition of the role of knowledge and technology in economic growth. Knowledge-intensive industry and service sectors, such as science-based high technology manufacturing, education, and information, are growing even faster in an increasingly communication dense environment.

NOTE: The SOKU acronym is formed from the following triple guidelines [NGG]:

- Service Orientation: The architecture comprises services, which may be instantiated and assembled dynamically, hence the structure, behaviour, and location of software is changing at run-time.
- Knowledge: Services are knowledge-assisted ("semantic") to facilitate automation and advanced functionality, the knowledge aspect reinforced by the emphasis on delivering high level services to the user.
- Utility: A directly and immediately useable service with established functionality, performance and dependability, illustrating the emphasis on user needs and issues such as trust.

Information as well as processing resources - increasingly connected through various communications networks - represent the components of an emerging, universally available knowledge structuring and processing platform. Viewed as new technologies and investments in knowledge, the European concept SOKU is focusing on multiple objectives combining Grid technologies, Service Oriented Architectures, and Utility Services. In this prospect, SOKU identifies a future Grid ecosystem "that promotes collaboration and self-organization", with "increased agility, lower overhead costs and broader availability of useful services for everybody, shifting the balance of power from traditional ICT players towards intermediaries and end-consumers of ICT." The SOKU vision will clearly give shape to the next-generation Grid, with intensive use of information technology and communications infrastructure, both located on a convergence curve.

Grid technology is contributing to the closing gap between the previously independent IT and Communication realms, with emerging standards for Grid covering a spectrum of functionality ranging from basic communication protocols, through the standardized access of individual resources, such as mass storage servers, up to the interoperability between different Grid middleware systems. Currently enabling large-scale multimedia applications, ICT-intensive solutions for use by businesses, science, and society appear as a new paradigm for the next decade.

Far away from its origins in the late 90s, the envisioned Grid technology is occurring in an era of deeply intensified and ubiquitous telecommunications.

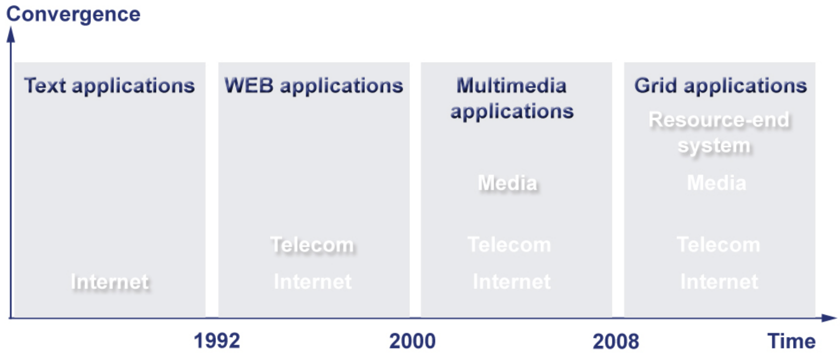


Figure B.1: Converging IT-Telecom technologies for the support of Grid applications

On the Curve of Convergence IT-Telecom

Both IT and Telecom technologies, in a remarkably short period of time, radically transformed the world's information infrastructure. The recent trend in convergence between them, however, shows a painful transition to consistency in terminology. The problematic issue of terminology comes from the radically diverse application of scientific and technological knowledge. Major terminological inconsistencies may occur between the Grid and Telecom communities, raising the challenge for anticipating them as much as possible in the present document.

Indicators for Grid standards

In line with the rapid evolution in telecommunications in particular, a consistent Grid programme in technology background development needs to leverage core standards in various domains, since history demonstrates that successful interaction is achieved through standardization. Indicators are measures that summarize at a glance how a standard is performing in the specific emerging international/European Grid standard landscape. But to the extent that the European SOKU vision in Grid technologies works differently from the traditional Grid vision, current indicators may fail to capture fundamental aspects of performance and lead to misinformed policies.

Given the objective to provide a detailed inventory and analysis across the range of involved Grid standards, the traditional indicators may not be completely satisfactory. Traditional indicators may ignore the complexity of Grid technology, as required in the conceptualized SOKU, as they fail to capture qualitative and quantitative performance beyond the individual value of technology components. On the other hand, the current standard evaluation work is proceeding on extending indicators to cover the entire, aggregate Grid technology realm with the goal of recognizing the right ICT scope.

Methodology to identify indicators

It is difficult to stabilize the indicators in an activity like standards, since strongly linked to knowledge creation, exchange, and management.

Even though, generally, standards contribute to knowledge creation since propose knowledge as outputs, they have to add to the sense of increased complexity, for instance, "switch from a prescribed layered view to a multi-dimensional mesh of concepts" [ngg]. New technology creation is not necessarily a net addition to the technologically relevant knowledge recipes, in this file the standards, since it may render older technologies obsolete. New technology might be the modified manifestation of an old idea, responding to old requirements. In that case, shift in technology does not necessarily fit knowledge creation. These relevance, performance and impact indicators may show the direct effort for a single or a group of standard bodies to enlarge the standard base into the technology developed for the specific Grid techno- (socio-) ecosystem.

The problem of developing indicators for appropriately evaluating Grid standards requires clearly defined concepts and measures, which track many aspects beyond the conventional Grid technology insight. Indicators serving the analysis for each standard may be built considering the following interleaved criteria.

Relevance

Inter-industry or academia-industry R&D motivates different styles of standards, with different base requirements and objectives. The global R&D intensity reflected by a standard shows, on the one hand, the source of funding, public and private. On the other hand, it indicates the general interest in the domain the standard addresses. From the large number of potential "standards" which could be considered in the present document, only those which satisfy a minimum level of relevancy will be analysed at any length. The following measures will be applied:

- Appropriateness: Relevance portrayed with reference to the covered technology domains.
- Academia and/or industrial R&D intensity: Ratio of proposed inputs and expenditures for innovation by academia and industrial organizations on the support to research and development to the technology domains. R&D intensity, with the financial commitments, is positively related to amount and size of initiatives coming from academia or industrial companies.

Performance

Expenditures on research and development act as an indicator, as well as inputs to the standardization process such as academia-conducted surveys, input from manufacturing and service sectors, formal and informal professional exchanges, and experiences of users. Other factors such as working processes and information flow impact standard formation. Research papers and citations are strong indicators of the academic interest in a particular standard or implementation/adoption of a standard. To evaluate the performance of a standard, we will consider:

- Inputs: A working standard needs to be a well-organized and functioning body with active contributions from members.
- Working processes, informational flows, and knowledge creation methodologies: Embodied skills and know-how assembled by the standard management to produce the standard.
- Outputs: Knowledge creation as well as adoption together with the force of shaping organizations to accommodate various specific technology solutions.

Impact

The impact criteria for a standard are generally estimated by evaluating the benefits in productivity growth and long-term economic growth of an industry sector. Without measuring financial return from R&D investments, the impact analysis may include customer or consumer evaluation of product quality and reliability and estimates of the effectiveness of the transfer of new technology to manufacturing lines. Socio-economic impact is an important, though difficult to measure quality, as it may affect standard performance by altering the domain in which the standard is applied. We will measure impact by:

- Techno-economic impact: Adoption in consumer and manufacturing products.
- Incident networks: Diffusion, dissemination, and use of information, know-who, and knowledge coming from the standard, including relationships, which are created among industry, government, and academia.
- Socio-economic impact: The transformation of the socio-economic position of a technology domain in the society.

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