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Next Generation Network: Collaboration of Grid and Cloud Computing, A Theoretical Approach

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Abstract

A Next generation network (NGN) is a packet-based network which can provide services including Telecommunication Services and able to make use of multiple broadband, Quality of Service-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies. The goal of NGN is to provide a more flexible network infrastructure that supports not just data and voice traffic routing, but also higher level services and interfaces for third party enhancements. Within this paper, opportunities to integrate grid and cloud computing strategies and standards into NGN are considered. The importance of standardized interfaces and interoperability testing demanded by carrier-grade networks are discussed. Finally, a proposal how the testing methods developed at the European Telecommunications Standards Institute (ETSI) can be applied to improve the quality of standards and implementations is presented.

Keywords: Interoperability; Next generation network (NGN); Grid computing; Cloud Standards Testing; ETSI

1. Introduction

A NGN is a broad term to describe key architectural evolutions in telecommunication core and access networks. The general idea behind the NGN is that one network transports all information and services (voice, data, and all sorts of media such as video) by encapsulating these into packets, like it is on the Internet. NGNs are commonly built around the Internet Protocol, and therefore the term "all-IP" is also sometimes used to describe the transformation toward NGN.

Telecom operators are bound to become key players in a grid and cloud computing value chain as they provide connectivity and own computing resources. Moreover they have established customer relationships and accounting/billing experience, essential for business/commercial grids and clouds. Defining the best ways to integrate existing as well as future telecommunication equipment and network infrastructure with grids and clouds assumes the availability of interoperable Grid solutions built by IT in conjunction with the Telecom industry .Carrier-grade networks form the global communications infrastructure that support millions of phone calls each day and, even more importantly, the massive global data transfers, predominantly resulting from the Internet. These carrier-grade networks are operated by hundreds of companies often deployed on top of physical infrastructure (cabling and switches). These infrastructures are usually not owned by the network operator but have to follow different regulations in each country and likely traverse several billing domains at any given point-to-point connection. This globally integrated system operates with extremely low down time and transparently to the end users. The latest evolution of the global communications networks, the *Next Generation Network* (NGN), is designed to support converged fixed and wireless networks carrying both voice and data traffic. These future networks incorporate a richer set of features to provide more services to customers, and hence increased revenue opportunities for the network providers. Increased flexibility around network-level services has also opened the door to third party services built on top of the NGN infrastructure. Grid and cloud computing systems would benefit from enhanced capabilities of NGN, the global reach of existing communications networks, and the stability of carrier-grade networks. Interoperability has been one of the key contributors to widespread commercial success of technologies used in the telecommunications sector, due to the interconnected nature of networks, and the plethora of network operators. Interoperability fosters diversity as well as competition in a market. Vendors can achieve interoperability of their products only if they agree and implement a common set of open standards. The value of standardization has also been recognized by the grid community, and is predominantly championed by the *Open Grid Forum* (OGF) [1] for grid-specific standards. Standardization, however, does not necessarily lead to interoperability. In this article, the accomplishments of the work completed by the *Technical Committee GRID* (TC GRID)of the *European Telecommunications Standards Institute* (ETSI)[2] are reported. The interoperability events are used to compare various implementations in a controlled setting and can provide detailed feedback on the quality of a standard based on the level of interoperability that is achieved. In the longer term, ETSI plans to establish standards that will support the convergence between NGN, grid, and cloud computing environments.

The article is structured as follows: the standards landscape for grid, cloud and NGN domains are presented inSection2. Section 3. Differentiating Cloud Computing and Grid Computing In Section 4, ETSI's approach to grid testing is introduced describes Standard Grid Models. In Section 5, The Architecture of NGN & & Convergence of NGN. Finally, we conclude with a summary in Section 6.

2. Landscape for Grid, Cloud and NGN Domains

The wide range of organizations involved with one or more of grid, cloud, and NGN technology each have their own priorities. Where operational systems have been designed or deployed, this range of priorities has resulted in competing architectures and interfaces. Although NGN does not yet exist as an integrated global telecommunications platform, there is a coordinated effort to develop the suite of standards to cover a high level NGN architecture [3]. In contrast, grid computing offers a few high level conceptual models, typically using the hour-glass middleware imagery. This envisages a wide range of high level applications connected to a wide range of heterogeneous low level resources via a limited number of intermediate standard interfaces. In addition, there are a few concrete architectural models for grid infrastructures [4,5]. These concrete models have a distinct disconnection: either they present an architecture which is not or only partially implemented in any operational grid, or an architecture which describes a particular grid infrastructure with limited references to standards or interfaces.

In the cloud domain, there is currently a prevalence of independent services with minimal interest in interoperability or consideration of standards. While this is in the process of changing, there is currently no sufficient activity in this area to report on. While the original motivation for grid computing originated with large scientific collaborations, it is now established that the same new technology and perspective on distributed computing is applicable in many domains. The *Networked European Software and Services Initiative- Grid* (NESSI-Grid) review considered the impact of grid technology on business IT infrastructure [6], while several projects have considered the application of grid computing to eHealth .The recent popularity of cloud computing also demonstrates the industry benefits of shared, distributed computing infrastructure.

3. Differentiating Cloud Computing and Grid Computing

Grid computing is a term referring to the combination of computer resources from multiple administrative domains to reach a common goal. The Grid can be thought of as a distributed system with non-interactive workloads that involve a large number of files. What distinguishes grid computing from conventional high performance computing systems such as cluster computing is that grids tend to be more loosely coupled, heterogeneous, and geographically dispersed. Although a grid can be dedicated to a specialized application, it is more common that a single grid will be used for a variety of different purposes. Cloud computing is Internet-based computing, whereby shared resources, software, and information are provided to computers and other devices on demand, as with the electricity grid. Cloud computing is a adoption of virtualization, Service-oriented architecture and utility computing which originated in the private sector where virtualization technology and large data centers have been turned into the foundation for products and services to be resold. This section will help clarify the difference between the two. Subsequent sections will focus primarily on grid computing, as cloud computing still lacks any substantive standards or possibilities for interoperation, making any discussion around cloud computing and the telecommunications industry purely speculative. The grid concept has a complementary but independent relationship to the concept of cloud computing. The similarities are that both aim to provide access to a large computing (CPU) or storage (disk) resource. Current cloud environments only provide direct support for single user or single organization access, and current models typically have a high cost to integrate computing, data, or network transfers from outside of *the cloud*.

This model suits environments where computing and data resource needs can be isolated to a single location and rapid scaling (up or down) of computing, network, and data availability are important. Pricing models are variations on normalized CPU-hours, GB/day storage, and MB network I/O, or are based on a *cloud* product that can be licensed and used with local physical resources. In contrast, grid computing aims to provide a standard set of services and software that enable the collaborative sharing of federated and geographically distributed computing and storage resources. It provides a security framework for identifying inter-organizational parties (both human and electronic), managing data access and movement, and utilization of remote computing resources. 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 still more expensive than

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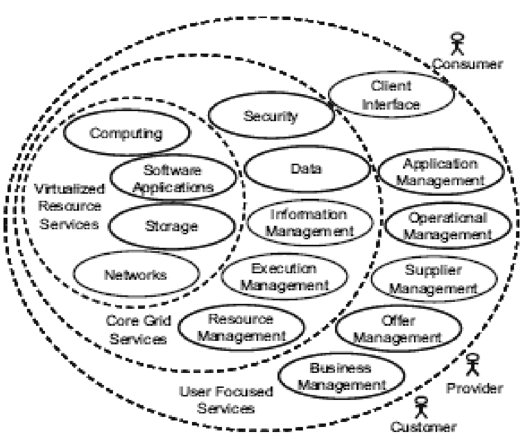
direct ownership of computing resources, even if these are co-located in a shared data center. Cloud computing, at the present time, also only offers relatively *bare bones* systems on top of which a user or organization needs to deploy and manage their applications and data. Grid computing can benefit from the development of cloud computing by harnessing new commercially available computing and storage resources, and by deploying cloud technology on grid-enabled resources to improve the management and reliability of those resources via the virtualization layer. Cloud computing can benefit from grid concepts by integrating standard interfaces, federated access control, and distributed resource sharing.

4. Standard Grid Models

Grid models are either explicitly stated or implicitly defined in a particular implementation. As a minimum, all grid models address security, networking, computing resources, storage resources, and information systems. How these areas are brought together, and what services, systems, and sub-systems provide a specific capability or interface, form the grid model and act as the basis for any standardization effort. The Globus project proposed the *Open Grid Service Architecture* (OGSA) in 2002 [7], later refined in 2006 [4]. This model presents a grid as a *Service Oriented Architecture* (SOA). To discuss grid infrastructure in a telecoms context, ETSI TC GRID has a developed a working model [8]. This can be depicted as a layering of services which can be utilized independently or together. In Fig. 1, these are grouped by the type of services they deliver. The lowest level represents the foundation of the infrastructure: networking, storage, computing power, and preexisting software applications. These are wrapped and presented as software 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.

5. The Architecture of NGN



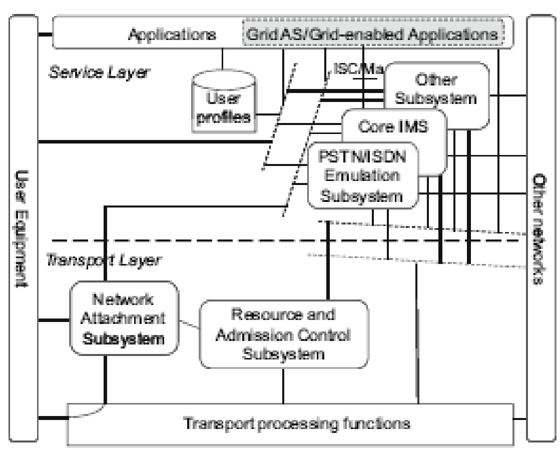


Fig. 1 ETSI conceptual model of a grid and cloud computing **Fig.2** Grid-enabled NGN application

The NGN [9] is a global initiative from the telecoms industry using standards developed by ETSI and the International Telecommunication Union Telecommunication Standardization Sector (ITU-T) [10]. This involves also members of ETSI TC *Telecoms and Internet converged Services and Protocols for Advanced Network* (TISPAN) that include telecom operators such as British Telecom, like with other telecommunications technologies, such as ISDN or GSM, NGN standards intent to achieve interoperability. NGN is being designed to provide interoperable, inter-domain all IP-based network standards with enhanced multimedia capabilities. NGN offers unrestricted access by users to different service providers. These include voice telephony, data services, multimedia services, virtual private networks, public network computing, and unified messaging [11]. The NGN design has aimed to support a dynamic architecture and can, therefore, accommodate new services as they are identified. The NGN functional architecture that is defined by TISPAN [12] identifies two NGN layers. IP-connectivity is provided to NGN user equipment (UE) by the transport layer, under the control of the *Network Attachment Subsystem* (NASS) and the *Resource and Admission Control Subsystem* (RACS).

These subsystems hide the transport technology that is used in access and core networks below the IP layer. The service layer comprises the following subsystems:

– *PSTN/ISDN Emulation Subsystem* (PES): PES supports the emulation of PSTN/ISDN services through residential gateways or access gateways for legacy terminals connected to the NGN.

– Core Internet Protocol *(IP) Multimedia Subsystem* (IMS): IMS supports the provisionof *Session Initiated Protocol* (SIP)-based services.

– Other subsystems, e.g. *Internet Protocol Television* (IPTV) dedicated subsystem) and applications.

– Common components for accessing applications, charging functions, user profile management, security management, routing databases that are used by several subsystems. TISPAN also defines an *Application Server Function* (ASF) [3] that can provide standalone services or value added services on top of a basic session.

5.1 Convergence of NGN, Grid and Cloud Computing

For telecom operators, the future lies in converging fixed, mobile and data services onto NGN. Historically, each service had its own platform with minimal interoperability. Integrating new services was made difficult by the lack of interoperability, resulting in high development and deployment costs, and consequently unattractive rates for the end users. Extending the NGN subsystem model to directly provide grid services, or at least provide mechanisms by which third parties can develop and deploy onto NGN grid services, would be the basis for significant new revenue potential and opportunities for a new era of networked applications and services. With advances in commodity computer components in terms of speed, cost, and reliability, many parts of NGN can utilize *commercial-off the- shelf* (COTS) hardware, rather than high cost specialized chips, switches, and associated hardware.

NGN with cloud computing approaches which would allow a network operator to virtualized various NGN subsystems, thus providing dynamic scalability, load-balancing, and fault tolerance. The average load, could be re-deployed onto a more efficient shared physical infrastructure. With expertise in the domain of managing virtualized servers for NGN operations in large data centers, it is a small step for network operators to consider partitioning their virtualized server platforms and making these available as cloud

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computing services in a manner similar to the cloud services offered by Amazon [13]Telecom operators are increasingly considering SOA in order to:
– decouple applications via middleware from IT server/storage/network resources,
– flexibly compose new services using standards-based technologies and protocols,
– reuse architectural components to lower costs, and time-to-revenue.
In summary, there are four possible scenarios:
1. Grid-enabled NGN application
2. NGN subsystems offering grid and cloud services
3. Combining grid and networking resources in a new architecture
4. Grid and cloud technology for implementing NGN functionality

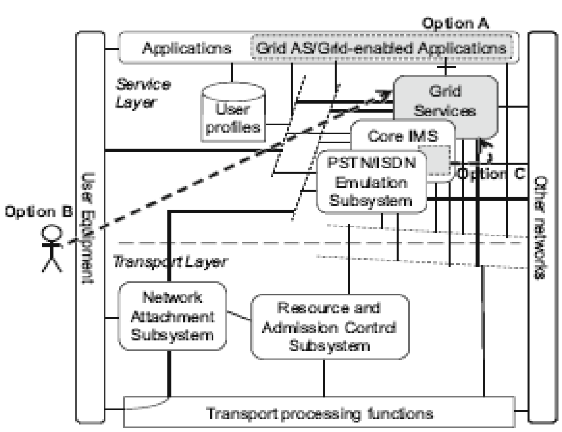

Fig. 3 NGN subsystems offering grid and cloud services

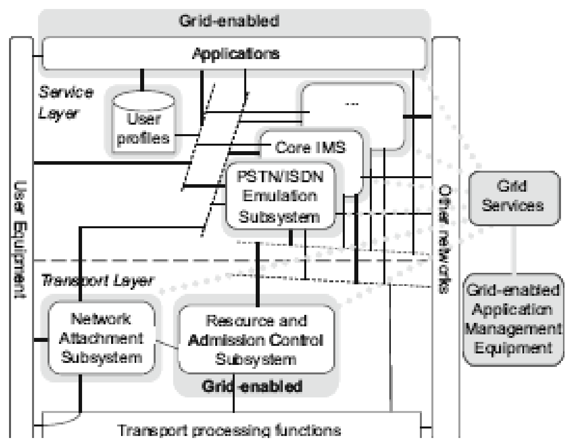

Fig. 4 Grid and cloud for implementing NGN functionality

In the first scenario, as depicted in Fig. 3, a new NGN subsystem is added to the NGN Service layer to support the provisioning of grid or cloud services. This *Grid Services Subsystem* (GSS) gives access to virtualized grid-enabled cloud resources, through a new service interface to the virtual resources and grid services.

In the second scenario “Combining grid and networking resources in a new architecture” a separate grid service manages shared resources such as computing power, network and storage. This would enable the assignment of resources to the grid or the NGN in a flexible, generic way.

The third scenario “Grid and cloud technology for implementing NGN functionality” enhances the entire NGN architecture with capabilities for harnessing virtualized cloud resources and grid-enabled services, as depicted in Fig. 4.The logical NGN functions and entire NGN subsystems are refined in light of grid and cloud capabilities. This allows the optimization of the resources used by these functions and provides greater flexibility in the deployment and operation of various NGN subsystems.

Conclusion

Telecom operators are expecting that grid enabled services can improve their internal network operation as well as enrich the services they offer to their customers. For this, interoperability between grid technology and telecom networks has to be achieved. ETSI and its TC GRID have a key role to play in establishing priorities, standards, and testing mechanisms. ETSI intends to continue standardizing software protocols and interfaces relevant to NGN and adopting grid and cloud computing technology into the global telecommunications network. The telecom industry will gain valuable experience with third party services and sub-systems offering advanced functionality with the roll-out of NGN. We expect that this roll-out will lead to increased efforts to develop interoperating grid, cloud, and telecom systems.

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