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Cloud Computing Vs. Grid Computing

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ABSTRACT

Cloud computing emerges as one of the hottest topic in field of information technology. Cloud computing is based on several other computing research areas such as HPC, virtualization, utility computing and grid computing. In order to make clear the essential of cloud computing, we propose the characteristics of this area which make cloud computing being cloud computing and distinguish it from other research areas. The service oriented, loose coupling, strong fault tolerant, business model and ease use are main characteristics of cloud computing. Grid computing in the simplest case refers to cooperation of multiple processors on multiple machines and its objective is to boost the computational power in the fields which require high capacity of the CPU. In grid computing multiple servers which use common operating systems and software have interactions with each other. Grid computing is hardware and software infrastructure which offer a cheap, distributable, coordinated and reliable access to powerful computational capabilities. This paper strives to compare and contrast cloud computing with grid computing from various angles and give insights into the essential characteristics of both.

Keywords: *cloud computing; grid computing; comparison*

1. INTRODUCTION

Cloud computing is TCP/IP based high development and integrations of computer technologies such as fast micro processor, huge memory, high-speed network and reliable system architecture. Without the standard inter-connect protocols and mature of assembling data center technologies, cloud computing would not become reality too. In October 2007, IBM and Google announced collaboration in cloud computing [1]. The term “cloud computing” become popular from then on. Beside the web email, the Amazon Elastic Compute Cloud (EC2) [2], Google App Engine [3] and Sales force’s CRM [4] largely represent a promising conceptual foundation of cloud services. The services of cloud computing are broadly divided into three categories: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS) [5, 6]. Cloud computing also is divided into five layers including clients, applications, platform, infrastructure and servers. The five layers look like more reasonable and clearer than the three categories [7]. There are more than 20 definitions of cloud computing that seem to only focus on certain aspects of this technology [8]. Mixed-machine heterogeneous computing (HC) environments utilize a distributed suite of different machines, interconnected with computer network, to perform different computationally intensive applications that have diverse requirements [9]. Miscellaneous resources should be orchestrated to perform a number of tasks in parallel or to solve complex tasks atomized to variety of independent subtasks [10]. Grid computing is a promising technology for future computing platforms and is expected to provide easier access to remote computational resources that are usually locally limited. According to Foster in [11], grid computing is hardware and software infrastructure which offer a cheap, distributable, coordinated and reliable access to powerful computational capabilities. The purpose of this paper is to characterize and present a side by side comparison of grid and cloud computing and present what open areas of research exist. We describe the concept of cloud computing and grid computing and compare them.

2. CLOUD COMPUTING

Nowadays, nearly everybody, every IT company is discussing the cloud. Though there is no precise definition about cloud computing , you can understand it in many ways [5]. Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. The United States government is a major consumer of computer services and, therefore, one of the major users of cloud computing networks. The U.S. National Institute of Standards and Technology (NIST) has a set of working definitions that separate cloud computing into service models and deployment models. Those models and their relationship to essential characteristics of cloud computing are shown in Figure 1 [12].

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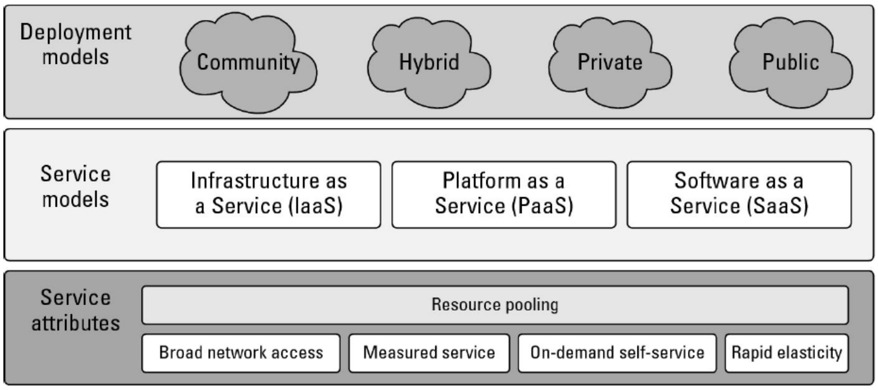

Figure 1: The NIST cloud computing definitions

2.1 Deployment Models

A deployment model defines the purpose of the cloud and the nature of how the cloud is located. The NIST definition for the four deployment models is as follows [12]:

• Public cloud: The public cloud infrastructure is available for public use alternatively for a large industry group and is owned by an organization selling cloud services.

• Private cloud: The private cloud infrastructure is operated for the exclusive use of an organization. The cloud may be managed by that organization or a third party.

• Hybrid cloud: A hybrid cloud combines multiple clouds (private, community of public) where those clouds retain their unique identities, but are bound together as a unit. A hybrid cloud may offer standardized or proprietary access to data and applications, as well as application portability.

• Community cloud: A community cloud is one where the cloud has been organized to serve a common function or purpose. It may be for one organization or for several organizations, but they share common concerns such as their mission, policies, security, regulatory compliance needs, and so on. A community cloud may be managed by the constituent organization(s) or by a third party.

2.2 Service Models

Infrastructure-as-a-Service is the delivery of huge computing resources such as the capacity of processing, storage and network. Taking storage as an example, when a user use the storage service of cloud computing, he just pay the consuming part without buying any disks or even knowing nothing about the location of the data he deals with. Sometimes the IaaS is also called Hardware-as-a-Service (HaaS) [5, 13].

Platform-as-a-Service generally abstracts the infrastructures and supports a set of application program interface to cloud applications. It is the middle bridge between hardware and application. Because of the importance of platform, many big companies want to grasp the chance of pre-dominating the platform of cloud computing as Microsoft does in personal computer time. The well known examples are Google App Engine [3] and Microsoft's Azure Services Platform [14].

Software-as-a-Service aims at replacing the applications running on PC. There is no need to install and run the special software on your computer if you use the SaaS. Instead of buying the software at a relative higher price, you just follow the pay-per-use pattern which can reduce you total cost. The concept of SaaS is attractive and some software runs well as cloud computing, but the delay of network is fatal to real time or half real time applications such as 3D online game.

3. GRID COMPUTING

Grid computing is a form of distributed computing that involves coordinating and sharing computing, application, data and storage or network resources across dynamic and geographically dispersed organization [15]. Grid technologies promise to change the way organizations tackle complex computational problems. The vision of grid computing was to allow access to computer based resources (from CPU cycles to data servers) in the same manner as real world utilities [16, 17, 18]. This gave rise to the idea of Virtual Organizations (VOs). Through the creation of VOs, it was possible to access all resources as though all resources were owned by a single organization. Two key outcomes exist in grids: the Open Grid Service Architecture (OGSA) [19] and the Globus Toolkit [20].

3.1 Grid Characteristics

These characteristics may be described as follows:

Large scale: a grid must be able to deal with a number of resources ranging from just a few to millions. This raises the very serious problem of avoiding potential performance degradation as the grid size increases.

Geographical distribution: grid's resources may be located at distant places.

Heterogeneity: a grid hosts both software and hardware resources that can be very varied ranging from data, files, software components or programs to sensors, scientific instruments, display devices, personal digital organizers, computers, super-computers and networks.

Resource sharing: resources in a grid belong to many different organizations that allow other organizations (i.e. users) to access them. Nonlocal resources can thus be used by applications, promoting efficiency and reducing costs [21].

Multiple administrations: each organization may establish different security and administrative policies under which their owned resources can be accessed and used. As a result, the already challenging network security problem is complicated even more with the need of taking into account all different policies.

Resource coordination: resources in a grid must be coordinated in order to provide aggregated computing capabilities.

Transparent access: a grid should be seen as a single virtual computer [22].

Dependable access: a grid must assure the delivery of services under established Quality of Service (QoS) requirements. The need for dependable service is fundamental since users require assurances that they will receive predictable, sustained and often high levels of performance [23, 24].

Consistent access: a grid must be built with standard services, protocols and inter-faces thus hiding the heterogeneity of the resources while allowing its scalability. Without such standards, application development and pervasive use would not be possible.

Pervasive access: the grid must grant access to available resources by adapting to a dynamic environment in which resource failure is commonplace. This does not imply that resources are everywhere or universally available but that the grid must tailor its behavior as to extract the maximum performance from the available resources [16].

4. COMPARISON

Viewed in a broad sense, the concepts of grid and cloud computing seems to have similar features. This section puts light to differentiate in different perspectives and give an end-to-end comparison. It could be understood easily when represented in a tabular form as given in table 1.

Table 1: *GC Vs. CC*

Parameter	Grid computing	Cloud computing
Goal	Collaborative sharing of resources	Use of service (eliminates the detail)
Computational focuses	Computationally intensive operations	Standard and high-level instances
Workflow management	In one physical node	In EC2 instance (Amazon EC2+S3)
Level of abstraction	Low (more details)	High (eliminate details)
Degree of scalability	Normal	High
Multitask	Yes	Yes
Transparency	Low	High
Time to run	Not real-time	Real-time services
Requests type	Few but large allocation	Lots of small allocation
Allocation unit	Job or task (small)	All shapes and sizes (wide & narrow)
Virtualization	Not a commodity	Vital
Portal accessible	Via a DNS system	Only using IP (no DNS registered)
Transmission	Suffered from internet delays	Was significantly fast
Security	Low (grid certificate service)	High (Virtualization)
Infrastructure	Low level command	High level services (SaaS)
Operating System	Any standard OS	A hypervisor (VM) on which multiple OSs run
Ownership	Multiple	Single
Interconnection network	Mostly internet with latency and low bandwidth	Dedicated, high-end with low latency and high bandwidth
Discovery	Centralized indexing and decentralized info services	Membership services
Service negotiation	SLA based	SLA based
User management	Decentralized and also Virtual Organization (VO)-based	Centralized or can be delegated to third party
Resource management	Distributed	Centralized/Distributed
Allocation/Scheduling	Decentralized	Both centralized/decentralized
Interoperability	Open grid forum standards	Web Services (SOAP and REST)
Failure management	Limited (often failed tasks/applications are restarted)	Strong (VMs can be easily migrated from one node to other)

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Pricing of services	Dominated by public good or privately assigned	Utility pricing, discounted for larger customers
User friendly	Low	High
Type of service	CPU, network, memory, bandwidth, device, storage,…	IaaS, PaaS, SaaS, Everything as a service
Data intensive storage	Suited for that	Not suited for that
Example of real world	SETI, BOINC, Folding@home, GIMPS	Amazon Web Service (AWS), Google apps
Response Time	Can't be serviced at a time and need to be scheduled	Real-time
Critical object	Computer resource	Service
Number of users	Few	More
Resource	Limited (because hardware are limited)	Unlimited
Configuration	Difficult as users haven't administrator privilege	Very easy to configure
Future	Cloud computing	Next generation of internet

One indicator of the buzz or hype of a particular technology can be examined by the search volume of keywords in popular search engines. Google has just this type of tool with their Google Trends. With this tool, we can compare different search terms against each other and view how the search volume changes over time. The Google trends showed in Figure 2. In red is "Grid Computing" and in blue is "Cloud Computing". If we now compare "Cloud Computing" against "Dedicated Server" and "Virtualization", figure 3 is the result. Here in blue is "Cloud Computing", in red is "Grid computing", in orange is "Dedicated server", and in green is "Virtualization".

Figure 2: Google trends of Grid computing and Cloud computing

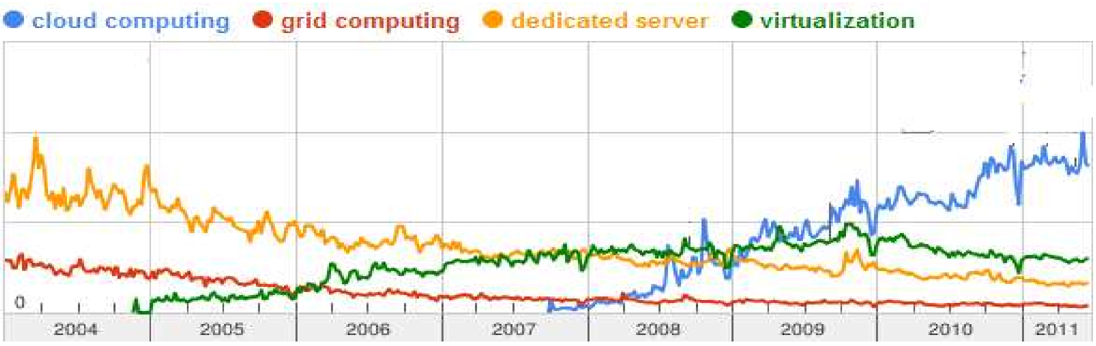

Figure 3: Google trends of new concepts

The cloud is the same basic idea as the grid, but scaled down in some ways, scaled up in others, and thoroughly democratized. Like the grid, the cloud is a utility computing model that involves a dynamically growing and shrinking collection of heterogeneous, loosely coupled nodes, all of which are aggregated

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together and present themselves to a client as a single pool of compute and/or storage resources. But though the server side of the model may look similar, most the major differences between cloud and grid stem from the differences between their respective clients. Instead of a few clients running massive, multimode jobs, the cloud services thousands or millions of clients, typically serving multiple clients per node. These clients have small, fleeting tasks—e.g., database queries or HTTP requests—that are often computationally very lightweight but possibly storage- or bandwidth-intensive (Figure 4). See Figure 5 for an overview of the relationship between Clouds and other domains that it overlaps with. Web 2.0 covers almost the whole spectrum of service-oriented applications, where Cloud Computing lies at the large-scale side. Grid Computing overlaps with all these fields where it is generally considered of lesser scale than supercomputers and Clouds. Some of the applications and tools in grid computing and cloud computing are briefed here (see table 2 and 3).

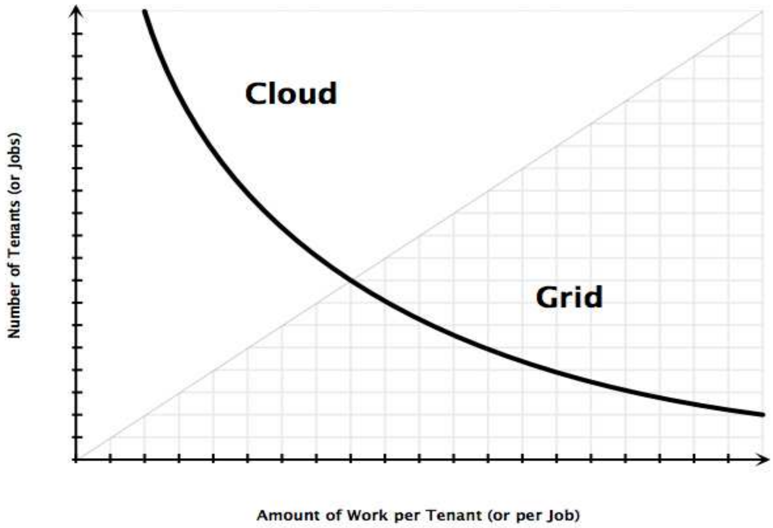

Figure 4: Scale comparison

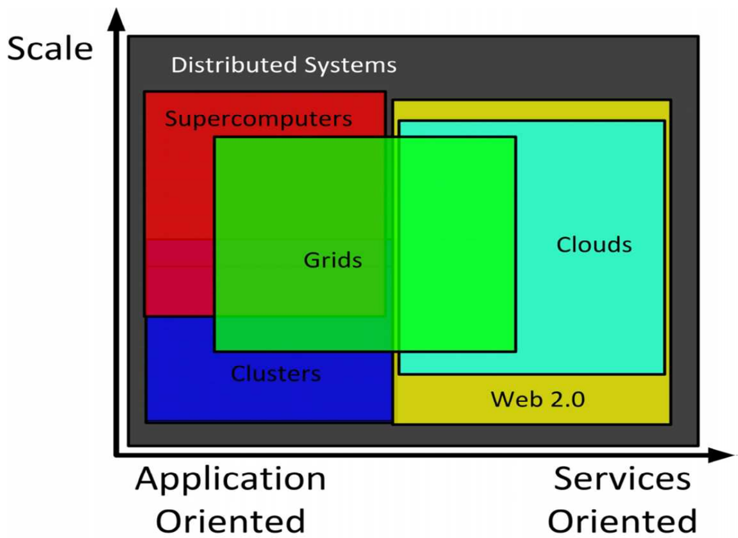

Figure 5: Grids and Clouds Overview [25]

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Table 2: Grid and Cloud applications

Technology	Application	Comment
Grid	DDGrid (Drug Discovery Grid)	This project aims to build a collaboration platform for drug discovery using the state-of-the-art P2P and grid computing technology [27].
	MammoGrid	It is a service-oriented architecture based medical grid application [26].
	Geodise	Geodise aims to provide a Grid-based generic integration framework for computation and data intensive multidisciplinary design optimization tasks.
Cloud	Cloudo	A free computer that lives on the Internet, right in the web browser.
	RoboEarth	Is a European project led by the Eindhoven University of Technology, Netherlands, to develop a WWW for robots, a giant database where robots can share information about objects [28].
	Panda Cloud antivirus	The first free antivirus from the cloud [29].

Table 3: Grid and Cloud tools

Technology	Tool	Comment
Grid	Nimrod-G	Uses the Globus middleware services for dynamic resource discovery and dispatching jobs over computational grids [30].
	Gridbus	(GRID computing and BUSiness) toolkit project is associated with the design and development of cluster and grid middleware technologies for service oriented computing [31].
	Legion	Is an object-based meta-system that supports transparent core scheduling, data management, fault tolerance, site autonomy, and a middleware with a wide range of security options [32].
Cloud	Cloudera	An open-source Hadoop software framework is increasingly used in cloud computing deployments due to its flexibility with cluster-based, data intensive queries and other tasks [33].
	CloudSim	Important for developers to evaluate the requirements of large-scale cloud applications.
	Zenoss	A single, integrated product that monitors the entire IT infrastructure, wherever it is deployed (physical, virtual, or in cloud).

5. CONCLUSION

In this paper, we have presented a detailed comparison on the two computing models, grid and cloud computing. We believe a close comparison such as this can help the two communities understand, share and evolve infrastructure and technology within and across, and accelerate Cloud Computing from early prototypes to production systems. When it comes to grid and cloud computing, the two are often seen as the same computing paradigm under different names. In this paper, we sought to separate grids from clouds and provide a side by side comparison in how they are assembled and what services are offered. In a word, the concept of cloud computing is becoming more and more popular. Now cloud computing is in the beginning stage. All kinds of companies are providing all kinds of cloud computing service, from software application to net storage and mail filter. We believe cloud computing will become main technology in our information life. Cloud has owned all the conditions. Now the dream of grid computing will be realized by cloud computing. It will be a great event in the IT history. Grid and cloud computing appears to be a promising model especially focusing on standardizing APIs, security, interoperability, new business models, and dynamic pricing systems for complex services. Hence there is a scope for further research in these areas.

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