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Comparison between Cloud Computing, Grid Computing, Cluster Computing and Virtualization

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Abstract: Technologies like cloud, grid and cluster computing have all aimed at allowing access to large amounts of computing power in a fully virtualized manner, by aggregating resources as well as offering a single system view. This paper includes the introduction, characteristics, advantages, disadvantages, benefits and drawbacks of Virtualization, Cloud, Grid and Cluster Computing. Further this paper contains comparison between cloud, cluster and grid computing, comparison between grid and cluster computing and at last covering comparison between cloud computing and virtualization as well as comparison between grid and cloud computing. The aim of this paper is to show importance and comparison between virtualization, cloud, grid and cluster computing.

Keywords: Cloud Computing, Cluster Computing, Grid Computing, Virtualization

I. INTRODUCTION

Cloud computing [1, 11, 15] is a computing style in which flexible and scalable IT functionalities are delivered as a service to end users using Internet. Grid computing [22] has proven to be an important field focusing on the sharing of resources and provides solution to performance as well as capacity problems for several applications. Cluster Computing [16] mainly addresses the latest results in different fields that support High Performance Distributed Computing (HPDC). Using virtualization software (VMware), it became possible to execute one or many operating systems simultaneously in an isolated environment.

II. CLOUD COMPUTING

Cloud Computing [1] is a modern computing paradigm that providing IT infrastructure and essential services i.e. infrastructure as a service (IaaS), platform as a service (PaaS), software as a service (SaaS) etc. Cloud computing [2] is an important model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources like networks, servers, storage, applications, and services that can be rapidly provisioned as well as released with minimal management effort.

III. CLOUD COMPUTING CHARACTERISTICS

The essential characteristics of cloud computing can be elaborated as follows [11]:

1. On-demand self-service
2. Broad network access
3. Resource pooling
4. Rapid elasticity
5. Measured service

Advantages	Disadvantages
Shared Resources	Internet Required
Automatic Software Integration	Dependency and vendor lock-in
Cost Efficient	Non-Interoperability
Easy Access to Information	Less Reliability
Quick Deployment	Technical Issues
Almost Unlimited Storage	Security in the Cloud
Backup and Recovery	Prone to Attack
Better Hardware Management	Increased Vulnerability
Mobility	Less Control
Versatile Compatibility	No always many room

Table1-1: Advantages and Disadvantages of Cloud Computing

IV. BENEFITS OF CLOUD COMPUTING

Cloud computing [3] increases scalability, efficiency, helps improve cash flow as well as offers many more benefits such as:

1. Disaster recovery
2. Flexibility

3. Increased Scalability
4. Metered Service
5. Increased collaboration
6. Faster Deployment
7. Resource Pooling
8. Automatic software updates
9. Inherited Resiliency
10. Highly Automated

V. DRAWBACKS OF CLOUD COMPUTING

1. Constant Internet Connection
2. High Speed Internet Required
3. Data Stored is not secure
4. Limited Features

VI. GRID COMPUTING

In grid computing [3, 17], individual users obtain computing resources like storage, applications, data, processors etc. on demand with limited knowledge of where the resources are located. Grid computing [1, 4] captures the basics of distributed computing that involves coordinating as well as sharing computing, data, application and storage or network resources across dynamic and geographically dispersed organization. The management features [14] of grid software enables the linking of computer resources together in a way that lets an individual use a single machine to leverage as well as access the collected power of all the machines within the grid computing system. The purpose of grid computing [5] was to allow access to computer based resources like from CPU cycles to data servers in the same manner as real world utilities [23].

VII. GRID CHARACTERISTICS

Grid computing [6, 18] is applying the resources of many computers in a network to a single problem at the same time - usually to solve a scientific as well as technical problem that requires a great number of computer processing cycles [22]. The essential characteristics of grid can be elaborated as follows [1, 2, 3]:

1. Resource sharing
2. Geographical distribution
3. Heterogeneity
4. Large scale
5. Multiple administrations
6. Resource coordination
7. Transparent access
8. Dependable access
9. Consistent access
10. Pervasive access
11. Decentralization (Loosely coupled)
12. Dynamism and Diversity
13. Distributed Job Management & scheduling

Advantages	Disadvantages
Can solve larger, more complex problems in a shorter time	Grid software and standards are still evolving
Reliability	High Internet Connection Required
Easier to collaborate with other organizations	Non-interactive job submission
Resource Balancing	Not Stable
Access to Additional Resources	Different Administrator Domains
Make better use of existing hardware	Learning curve to get started
Computers working together	Technology support to utilize the grid
Unused computing capacity is effectively used	Some applications cannot be parallelized

Table1-2: Advantages and Disadvantages of Grid Computing

VIII. BENEFITS OF GRID COMPUTING

1. Enables applications to be easily scaled
2. Better utilization of underused resources
3. Enables the linking of cheaper computers together, instead of spending a lot of money on one machine
4. Technologies being used are open source, trust and transparency is encouraged
5. Increased reliability of computing
6. Allows the sharing of computer resources across networks
7. Parallelization of processing
8. Resource balancing

IX. DRAWBACKS OF GRID COMPUTING

1. Proprietary approach should be eliminated
2. Reliability and Complexity
3. There is a single point of failure if one unit on the grid degrades

X. GRID USES

Grid [1,2,3] is a computing paradigm for providing computational resources for grand-challenge applications as well as it is an infrastructure that bonds globally remote and diverse resources in order to provide computing support for a wide range of applications. Grid [7] not defined in terms of

applications (as usually found in the literature) but rather of the computing support the grid provides such as:

1. Distributed supercomputing
2. High-throughput computing
3. On-demand computing
4. Data-intensive computing
5. Collaborative computing
6. Multimedia computing

XI. CLUSTER COMPUTING

Cluster computing [8, 18] is the growing field to link together inexpensive commodity computers as well as helps to find an answer to many problems. Cluster programmers [13] require mainly the environment so that they can easily allow them to take the advantage of the clusters performance capabilities. Locality and consideration [21] of data distribution are primarily to the success of any cluster. Cluster [9] is the journal of applications and networks that are parallel processing distributed computing. Cluster is easily defined as the technique of linking between two or more computers into a local area network.

XII. CLUSTER COMPUTING CHARACTERISTICS

The essential characteristics of cluster computing can be elaborated as follows [11]:

1. Tightly coupled systems
2. Single system image
3. Centralized Job management & scheduling system

Advantages	Disadvantages
Reducing cost	Programmability Issues
Manageability	Problem in Finding Fault
Single System Image	Difficult to handle by a Layman
High Availability	Difficult for developing software for distributed system
Improves network technology	Easily accessed and applied to secret data

Table1-3: Advantages and Disadvantages of Cluster Computing

XIII. VIRTUALIZATION

Virtualization [10] is a building block in today's computer infrastructures. Virtualization [19] means to create a virtual version of a resource or device, like storage device, server, network or even an OS where the framework divides the resource into one or more execution environments. Ganeti [12] is an important cluster virtualization system developed by Google and also used by many organizations worldwide. Ganeti is very lightweight, simple to install as well as manage, and it does not demand any special storage hardware.

XIV. BENEFITS OF VIRTUALIZATION

Virtualization [10] is a great innovation in technology world and the end of 2012, roughly 70% of all companies were running at least few application workloads as virtual instances. Access to the virtual resources is controlled by a Virtual Machine Manager (hypervisor). Some of the benefits of virtualization include such as:

1. Testing and learning
2. VMs are portable
3. Decreased hardware investment
4. Lower maintenance costs
5. Improved Performance and disaster recovery
6. Lower energy consumption, environment friendly
7. Easier Migration into the cloud
8. Easily host a guest operating system(VM)
9. Create lots of webservers

XV. DRAWBACKS OF VIRTUALIZATION

1. High Risk in Physical fault
2. Single point of failure
3. Powerful machines
4. Lower performance
5. Specific applications that can't be virtualized

XVI. COMPARISON BETWEEN CLOUD, CLUSTER AND GRID COMPUTING

	Cloud	Cluster	Grid
On-demand self-Service	Yes	No	No
Broad network access	Yes	Yes	Yes
Resource pooling	Yes	Yes	Yes
Rapid elasticity	Yes	No	No
Measured service	Yes	No	Yes

Table1-4: Comparison between Cloud, Cluster and Grid Computing

XVII. COMPARISON BETWEEN GRID COMPUTING AND CLUSTER COMPUTING

Grid Computing	Cluster Computing
Heterogeneous	Homogenous

The computers that are part of a grid can run different hardware as well as have different OS	The cluster computers all have the same hardware and OS
Grid can make use of spare computing power on a desktop computer	The machines in a cluster are dedicated to work as a single unit as well as nothing else
Grid are inherently distributed by its nature over a LAN, MAN or WAN	The computers in the cluster are normally contained in a single location
Every node is autonomous (it has its own resource manager as well as behaves like an independent entity)	Whole system (all nodes) behave like a single system view as well as resources are managed by centralized resource manager

Table1-5: Comparison between Grid and Cluster Computing

XVIII. COMPARISON BETWEEN CLOUD COMPUTING AND VIRTUALIZATION

Cloud Computing	**Virtualization**
Delivery of computing resources as a service to end-users over a network	Part of the logical infrastructure
Cloud treats computing as a utility rather than a specific technology	itself does not provide the customer a self-service layer and without that layer you cannot deliver compute as a service
An approach for the delivery of services to an end-user	One possible service that could be delivered
Cannot exist without virtualization – at least, not in its current format	Exist without the cloud
Cloud computing takes the use of those resources to another level by delivering access to those components on-demand as a service, thus reducing complexity for the end user, cost and burden	Virtualization by itself allows an organization to utilize and effectively use its IT resources

Table1-6: Comparison between Cloud Computing and Virtualization

XIX. COMPARISON BETWEEN GRID COMPUTING AND CLOUD COMPUTING

Grid Computing	**Cloud Computing**
Resources are pre-reserved	Resources are on-demand
Not rapid elasticity	Rapid elasticity
Distributed computing architecture	Client-server architecture
Used for specific purposes	Used for business and public needs
Grids evolve slower than cloud	Clouds evolve faster than grid
Level of expertise to use a grid is higher than cloud	Level of expertise to use a cloud is lower than grid
It is the base concept of cloud computing	Cloud offers more services than grid computing
A grid is not necessarily a cloud or part of a cloud	A cloud would usually use a grid
Grids tends to be more loosely coupled, heterogeneous, and geographically dispersed compared to conventional cluster computing systems	In fact almost all the services on the Internet can be obtained from cloud, e.g. web hosting, multiple OS, DB support and much more.
Grid computing federates resources located within different organizations	Cloud computing is typically provided within a single organization (Amazon), that simplifies many aspects, particularly security, availability and heterogeneity
Failure management (Selfhealing) is limited (often failed tasks/applications are restarted)	Strong support for failover and content replication. VMs can be easily migrated from one node to other
Resource management is distributed	Resource management is centralized/distributed

Table1-7: Comparison between Grid and Cloud Computing

XX. CONCLUSION

In this paper, we have presented a detailed comparison on the cloud, grid, cluster computing and virtualization [1]. The concept of cloud computing is becoming more and more popular and it is in the beginning stage. Reputed companies are providing all types of cloud computing service, from software

application to net storage and mail filter and we believe cloud computing will become main technology in our information life. The dream of grid computing [20] will be realized by cloud computing. Grid, cloud and more computing appears to be a promising model especially focusing on standardizing APIs, security, interoperability, new business models, as well as dynamic pricing systems for complex services. So there is a large scope for further research in these areas [1].

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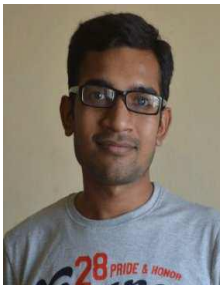

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