Unit-1

Cloud Computing

Cloud computing is a computing paradigm, where a large pool of systems are connected in private or public networks, to provide dynamically scalable infrastructure for application, data and file storage. With the advent of this technology, the cost of computation, application hosting, content storage and delivery is reduced significantly.
Cloud computing is a practical approach to experience direct cost benefits and it has the potential to transform a data center from a capital-intensive set up to a variable priced environment.
The idea of cloud computing is based on a very fundamental principal of 'reusability of IT capabilities'. The difference that cloud computing brings compared to traditional concepts of "grid computing", "distributed computing", "utility computing", or "autonomic computing" is to broaden horizons across organizational boundaries.

Characteristics of cloud computing:

On-demand self-service: A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.

1. **Broad network access:** Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., **mobile** phones, tablets, laptops and workstations).
2. **Resource pooling:** The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state or datacenter). Examples of resources include storage, processing, memory and network bandwidth.
3. **Rapid elasticity:** Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time.
4. **Measured service:** Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth and active user accounts). Resource usage can be monitored, controlled and reported, providing transparency for the provider and consumer.

Advantages of Cloud Computing

Enterprises would need to align their applications, so as to exploit the architecture models that Cloud Computing offers. Some of the typical benefits are listed below:

1. **Reduced Cost**

There are a number of reasons to attribute Cloud technology with lower costs. The billing model is pay as per usage; the infrastructure is not purchased thus lowering maintenance. Initial expense and recurring expenses are much lower than traditional computing.

2. Increased Storage

With the massive Infrastructure that is offered by Cloud providers today, storage & maintenance of large volumes of data is a reality. Sudden workload spikes are also managed effectively & efficiently, since the cloud can scale dynamically.

3. Flexibility

This is an extremely important characteristic. With enterprises having to adapt, even more rapidly, to changing business conditions, speed to deliver is critical. Cloud computing stresses on getting applications to market very quickly, by using the most appropriate building blocks necessary for deployment.

Cloud Computing Challenges

Despite its growing influence, concerns regarding cloud computing still remain. In our opinion, the benefits outweigh the drawbacks and the model is worth exploring. Some common challenges are:

1. Data Protection

Data Security is a crucial element that warrants scrutiny. Enterprises are reluctant to buy an assurance of business data security from vendors. They fear losing data to competition and the data confidentiality of consumers. In many instances, the actual storage location is not disclosed, adding onto the security concerns of enterprises. In the existing models, firewalls across data centers (owned by enterprises) protect this sensitive information. In the cloud model, Service providers are responsible for maintaining data security and enterprises would have to rely on them.

2. Data Recovery and Availability

All business applications have Service level agreements that are stringently followed. Operational teams play a key role in management of service level agreements and runtime governance of applications. In production environments, operational teams support:-

Appropriate clustering and Fail over
Data Replication
System monitoring (Transactions monitoring, logs monitoring and others)
Maintenance (Runtime Governance)
Disaster recovery
Capacity and performance management

3. Management Capabilities

Despite there being multiple cloud providers, the management of platform and infrastructure is still in its infancy. Features like „Auto-scaling“ for example, are a crucial requirement for many enterprises. There is huge potential to improve on the scalability and load balancing features provided today.

4. Regulatory and Compliance Restrictions

In some of the European countries, Government regulations do not allow customer's personal information and other sensitive information to be physically located outside the state or country. In order to meet such requirements, cloud providers need to setup a data center or a storage site exclusively within the country to comply with regulations. Having such an infrastructure may not always be feasible and is a big challenge for cloud providers.

Cloud Computing Applications:

Cloud computing has many applications and those applications are sub-divided as per all the cloud services but major applications of cloud computing are in:

- Business, Telecommunication, Health Care , Education, Banking, IT-companies etc

Big Data Analytics

Businesses create a huge amount of data in various formats; structured as in SQL databases, semi-structured often stored in data warehouses, and unstructured usually stored in data lakes. Unstructured data includes documents, emails, images. All of this data needs to be analyzed for reporting, metrics and business predictions. Cloud computing is flexible and companies analyze their big data in the cloud because they do not have to buy large computing systems to do the work. Less cost, more flexibility.

File Storage

Cloud offers you the possibility of storing, accessing and retrieving your files anywhere anytime from various web interfaces. With cloud computing, you get high speed, availability, and scalability for your business environment. Cloud storage comes in several forms depending on the use case: long term storage, stable storage, or the need for flexible storage amounts to handle computing peaks. In addition, for distributed companies, having file access available anywhere lowers the cost of company networks and improves security.

Backup

Backing up data is a risky operation. You can backup that data in-house, but there is always a risk of inadequate storage space, corrupted data and restore time. Cloud backup services provide off-site storage, easily configured backup/replication processes and easily increased space so you have less risk of "disk full" type errors. Plus backups are available to multiple locations thanks to the cloud.

Cost Effective Computing

Because cloud computing companies install large server farms, their cost per Gb for storage or applications is very low. For their customers, this lower cost is passed on (with the usual markup) along with management services, 24x7 availability and providing upgrades to the latest technology. For smaller companies especially, this is a boon. They do not have to incur the costs of building and maintaining servers, including hiring more IT personnel. They can upgrade their services at any time at a fraction of the in house cost.

Unit-2

Cloud service models

Cloud service models can be broadly defined in three categories – SaaS (Software as a Service), PaaS (Platform as a Service) and IaaS (Infrastructure as a Service).

Infrastructure as a service (IaaS) is a cloud computing offering in which a vendor provides users access to computing resources such as servers, storage and networking. Organizations use their own platforms and applications within a service provider's infrastructure.

Key features

- Instead of purchasing hardware outright, users pay for IaaS on demand.
- Infrastructure is scalable depending on processing and storage needs.
- Saves enterprises the costs of buying and maintaining their own hardware.
- Because data is on the cloud, there can be no single point of failure.
- Enables the virtualization of administrative tasks, freeing up time for other work.

Platform as a service (PaaS) is a cloud computing offering that provides users with a cloud environment in which they can develop, manage and deliver applications. In addition to storage and other computing resources, users are able to use a suite of prebuilt tools to develop, customize and test their own applications.

Key features

- PaaS provides a platform with tools to test, develop and host applications in the same environment.
- Enables organizations to focus on development without having to worry about underlying infrastructure.
- Providers manage security, operating systems, server software and backups.
- Facilitates collaborative work even if teams work remotely.

Software as a service (SaaS) is a cloud computing offering that provides users with access to a vendor's cloud-based software. Users do not install applications on their local devices. Instead, the applications reside on a remote cloud network accessed through the web or an API. Through the application, users can store and analyze data and collaborate on projects.

Key features

- SaaS vendors provide users with software and applications via a subscription model.
- Users do not have to manage, install or upgrade software; SaaS providers manage this.
- Data is secure in the cloud; equipment failure does not result in loss of data.
- Use of resources can be scaled depending on service needs.
- Applications are accessible from almost any internet-connected device, from virtually anywhere in the world.

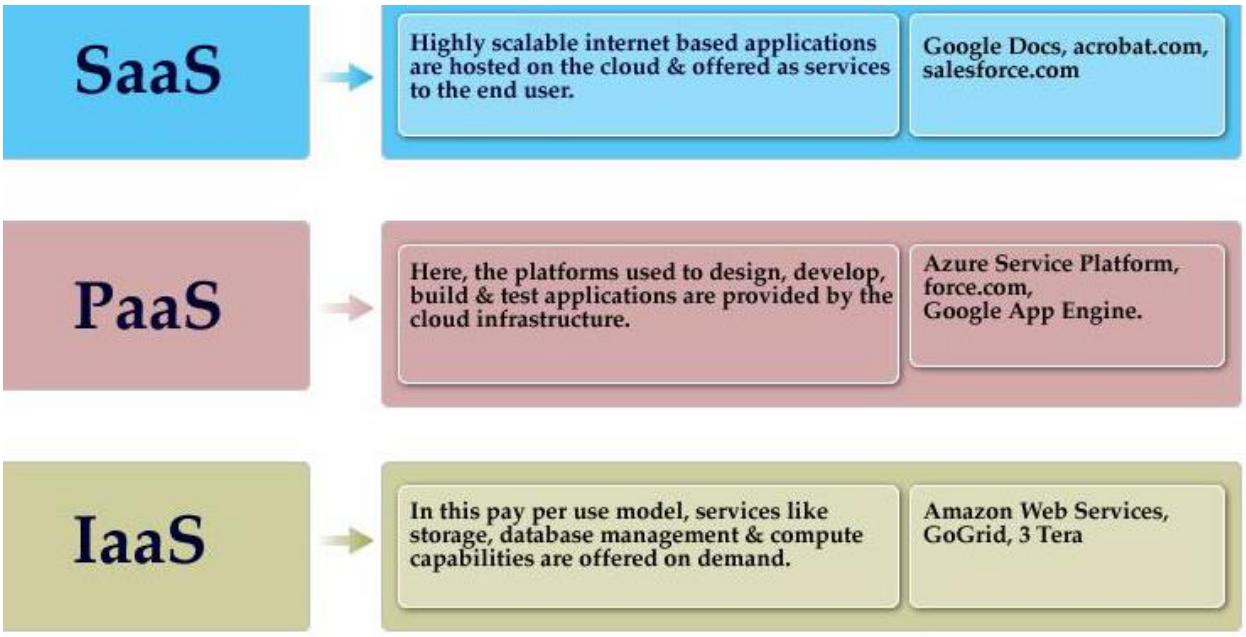


Figure: Cloud models

Cloud Deployment Models

Cloud computing refers to the use of network of remote servers that are hosted over the Internet, and there are many cloud deployment models.
One of the most unique characteristics of cloud computing is that the services from data storage to creation of software applications can be availed on pay-per-use basis.
There are four basic cloud deployment models, which are:

1) **Private cloud model**
In this system, the cloud infrastructure is set up on the premise for the exclusive use of an organization and its customers. In terms of cost efficiency, this deployment model doesn't bring many benefits. However, many large enterprises choose it because of the security it offers.
The advantages of a private model:

- Individual development
- Storage and network components are customizable
- High control over the corporate information
- High security, privacy and reliability

The major disadvantage of the private cloud deployment model is its cost intensiveness, as it entails considerable expenses on hardware, software and staff training.

2) **Public cloud model**
Public cloud is hosted on the premise of the service provider. The service provider than provides cloud services to all of its customers. This deployment is generally adopted by many small to mid-sized organizations for their non-core and some of their core functions.
The pros of a public cloud are:

- Unsophisticated setup and use
- Easy access to data
- Flexibility to add and reduce capacity

- Cost-effectiveness
- Continuous operation time
- 24/7 upkeep
- Scalability
- Eliminated need for software

The cons of a public model:

- Data security and privacy
- Compromised reliability
- The lack of individual approach

3) **Community cloud**

Community cloud model is a cloud infrastructure shared by a group of organizations of similar industries and backgrounds with similar requirements i.e. mission, security, compliance and IT policies. It may exist on or off premise and can be managed by a community of these organizations.

The strengths of a community computing type include the following:

- Cost reduction
- Improved security, privacy and reliability
- Ease of data sharing and collaboration

The shortcomings are:

- Higher cost than that of a public one
- Sharing of fixed storage and bandwidth capacity
- It is not widespread so far

4) **Hybrid cloud model**

Hybrid cloud is a combination of two or more models, private cloud, public cloud or community cloud. Though these models maintain their separate entities they are amalgamated through a standard technology that enables the portability of data and applications.

The benefits of a hybrid model are:

- Improved security and privacy
- Enhanced scalability and flexibility
- Reasonable price

Unit-3

Grid computing

Grid computing is a group of networked computers that work together as a virtual supercomputer to perform large tasks, such as analyzing huge sets of data or weather modeling. Through the cloud, you can assemble and use vast computer grids for specific time periods and purposes, paying, if necessary, only for what you use to save both the time and expense of purchasing and deploying the necessary resources yourself. Also by splitting tasks over multiple machines, processing time is significantly reduced to increase efficiency and minimize wasted resources.
Unlike with parallel computing, grid computing projects typically have no time dependency associated with them. They use computers that are part of the grid only when idle, and operators can perform tasks unrelated to the grid at any time. Security must be considered when using computer grids as controls on member nodes are usually very loose. Redundancy should also be built in as many computers may disconnect or fail during processing.

Pros of Grid Computing

Cheaper Servers
No need to buy large SMP servers! Applications would be able to break apart and run across smaller servers. Those servers cost far less than SMP servers.
More Efficient
Much more efficient use of idle resources. Idle servers and desktops would be able to accept jobs! Many resources sit idle, especially during off business hours.
This is not the case anymore with a grid computing setup.
Fail-safe
Grid computer environments are modular and don't have just one fail point. Hence if one of the machines within the grid fails, there are plenty of others able to pick the load. Jobs can automatically restart if a failure occurs.

Disadvantages

- Grid software and standards are still evolving
- Learning curve to get started
- Non-interactive job submission

Applications of Grid Computing

Currently, there are five general applications for Grid Computing:

- **Super distributed computing-** They are those applications whose needs can not get met in a single node. The needs occur at specific times of time and consume many resources.
- **Systems distributed in real time-** They are applications that generate a flow of data at high speed that must be analyzed and processed in real time.
- **Specific services-** Here we do not take into account the computing power and storage capacity but the resources that an organization can consider as not necessary. Grid presents these resources to the organization.

- **The intensive process of data-** Are those applications that make great use of storage space. These types of applications overwhelm the storage capacity of a single node, and the data gets distributed throughout the grid. In addition to the benefits of the increase in space, the distribution of data along the grid allows access to them in a distributed manner.
- **Virtual collaboration environments-** Area associated with the concept of Tele-immersion. So that the substantial computational resources of the grid and its distributed nature are used to generate distributed 3D virtual environments.

Virtual organization

Virtual organization (VO) is an important abstraction for designing large-scale distributed applications involving extensive resource-sharing. Existing works on VO mostly assumes that the VO already exists or is created by mechanisms outside of their system model. The VO construction is challenging and critical due to its dynamic and distributed nature. This paper presents a VO Construction Model and an implementation algorithm which is based on a threshold approach and is secure and robust in that events such as member admission, member revocation, VO splitting and merging etc. can be handled without centralized administration. Also authentication and communications among VO members are efficient and without tedious key exchanges and management usually needed in VO built upon the Grid Security Infrastructure (GSI).

Unit-4

Cluster computing

Cluster computing or *High-Performance computing* frameworks is a form of computing in which bunch of computers (often called nodes) that are connected through a LAN (local area network) so that, they behave like a single machine. A computer cluster help to solve complex operations more efficiently with much faster processing speed, better data integrity than a single computer and they only used for mission-critical applications.

The Clustering methods have identified as- HPC IAAS, HPC PAAS, that are more expensive and difficult to setup and maintain than a single computer.

A computer cluster defined as the addition of processes for delivering large-scale processing to reduce downtime and larger storage capacity as compared to other desktop workstation or computer.

Some of the critical Applications of Cluster Computers are Google Search Engine, Petroleum Reservoir Simulation, Earthquake Simulation, Weather Forecasting.

Cluster Can be classified into two category Open and Close Cluster.

Open Cluster: All nodes in Open Cluster are needed IPs, and that are accessible through internet/web, that cause more security concern.
Close Cluster: On the other hand Close Cluster are hide behind the gateway node and provide better security.

Types of Cluster computing

1. **Load-balancing clusters**: As the name implies, This system is used to distribute workload across multiple computers. That system

distributes the processing load as possible across a cluster of computers.
2. **High availability (HA) clusters**: A high availability clusters (HA cluster) are the bunch of computers that can reliably utilise for

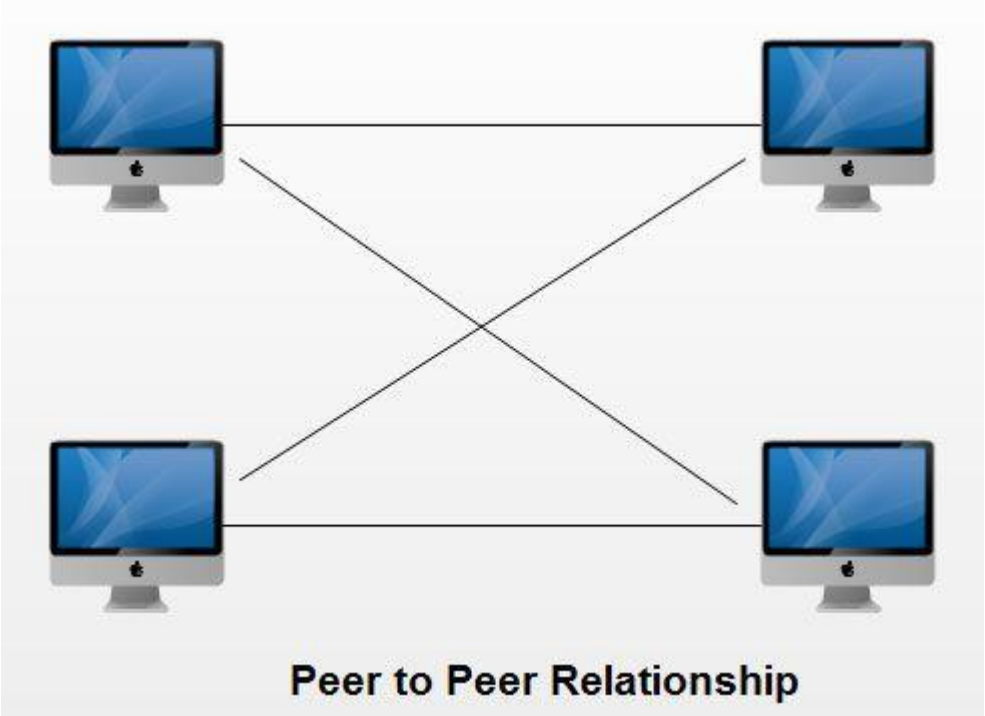
redundant operations in the event of nodes failure in Cluster computing.
3. **High performance (HP) clusters**: This computer networking methodology use supercomputers and Cluster computing to solve advanced computation problems.

Advantages of using Cluster computing

1. **Cost efficiency**: In a Cluster computing Cost efficiency is the ratio of cost to output, that is the connecting group of the computer as computer cluster much cheaper as compared to mainframe computers.
   2. **Processing speed**: The Processing speed of computer cluster is the same as a mainframe computer.
   3. **Expandability**: The best benefit of Cluster Computing is that it can be expanded easily by adding the additional desktop workstation to the system.
   4. **High availability of resources**: If any node fails in a computer cluster, another node within the cluster continue to provide uninterrupted processing. When a mainframe system fails, the entire system fails.

Peer-to-Peer Networks

1. In the peer to peer computer network model we simply use the same Workgroup for all the computers and a unique name for each computer in a computer network.
2. There is no master or controller or central server in this computer network and computers join hands to share files, printers and Internet access.
3. It is practical for workgroups of a dozen or less computers making it common environments, where each PC acts as an independent workstation and maintaining its own security that stores data on its own disk but which can share it with all other PCs on the network.
4. Software for peer-to-peer network is included with most modern desktop operating systems such as Windows and Mac OS.
5. Peer to peer relationship is suitable for small networks having less than 10 computers on a single LAN.
6. In a peer to peer network each computer can not act as both a server and a client.



Advantages of Peer to Peer Networks

1. Such networks are easy to set up and maintain as each computer manages itself.

2. It eliminates extra cost required in setting up the server.

3. Since each device is master of its own, they an: not dependent on other computers for their operations.

Disadvantages of Peer to Peer Networks

1. In peer-to-peer network, the absence of centralized server make it difficult to backup data as data is located on different workstations.

2. Security is weak as each system manages itself only.

3. There is no central point of data storage for file archiving.

Utility computing

Utility computing is referred to be known as a facility provided by such providers to variety of users on there demand and also charge them in return of using this service on the basis of using in short specific usage. As well as it also provides infrastructure to the users or customers. Utility computing is a model of providing facilities on demand of customers as other demands are fulfilled of grid computing etc. The utility model provides the benefit of using the tools maximum on demand as well as better usage of resources and to minimize the costs. The word utility is an analogy for the customers to use and pay for the quantity of usage. Like electricity is charged on the extent we use rather than paying full part as school fees or college to join class or not but have to pay but the utility computing provides this facility of pay per use. The term utility computing is taking place in society in different dimensions also like enterprise computing, website access, file sharing, different applications, used by the consumers in markets. Some other version of utility computing is taken from the enterprise known as a shared pool utility model which centralizes its computing resources to serve a larger number of users without unnecessary redundancy.

Utility computing provides the ability to all companies to access computing services, business processes, and applications from a utility-like service over a network. This influences in term of being saving their money via using the capability on just pay per use. This means all companies can save their money via this utility.

Importance of utility computing:

The utility computing sometime demands a kind of cloud strategy because it highlights the model, which can be known as business model that also provides the computing services. The customer receives computing resources in utility computing resources that resources provide service like hardware, or software. It is like you would do for your electric service at home. It is defined in the term of ‘pay by the drink’ which is an analogy from ‘the big switch’ by Nicholas

Features of Utility Computing

The major advantage and benefit that can be getting from utility computing is better economics. Corporate data centers are better used in a way that with the resources, often idle 85 percent of the time. The main cause behind this is the large number of buying the hardware that is more than average need of that hardware which causes the problem to handle the expected future burdens. So the utility computing plays its best by allowing the companies to only pay for the computing resources they need.

Pervasive computing allows us to use modern technologies together to create interconnected device system. It is also known as ubiquitous computing. Pervasive computing goes beyond the concept of personal computing because it can connect basic home, kitchen, electronic appliances, could be embedded with microchips, could be controlled from anywhere. Pervasive computing is modern field in which many computational devices used to process information.

What is ubiquitous computing?

- Any computing technology that permits human interaction away from a single workstation.
- This includes
  - pen-based technology,
  - handheld or portable devices,
  - large-scale interactive screens,
  - voice or vision technology.

- Human-centered vision with these technologies presents many challenges. Here we Focus
  - defining the appropriate physical interaction experience;
  - discovering general application features;
  - theories for designing and evaluating the human experience within ubiquitous computing.

Device scales

- Inch
  - PDAs
  - Voice Recorders
  - Smart phones

- Individuals own many of them and they can all communicate with each other and environment.

Ubiquitous Computing is also known as Pervasive Computing. Generally it is present in devices and sensors. Most of the Internet of Things (IOT) devices are based on Ubiquitous Computing.

Some of the examples are:

- Apple Watch
- Amazon Echo Speaker
- Amazon EchoDot
- Fitbit
- Electronic Toll Systems
- Smart Traffic Lights
- Self Driving Cars
- Home Automation
- Smart Locks

Applications

1. Traffic Control System – In India we use traditional signal system to manage traffic on busy roads. Many utomobile companies provide smart features that assists driver of vehicle. Addition to this we can provide networking to connect such systems with city traffic control system. If all such systems are interconnected we can provide better solution. This is the actual aim of pervasive computing.
2. Internet Commerce – Pervasive computing system allow selling and buying products smartly over the internet. Location based monitoring ads; quality shipping service, Smart systems can assist in delivering products on time.
3. Communication - Pervasive computing can be used in data transmission and communication. All traditional networking devices communicate through networks which will become smart with use of pervasive computing
4. Defense Sector – Pervasive computing system can be used for the security of people and to protect public life. In India providing security to public is state's responsibility. Internal security, law and order, flood management, disaster management are state subjects. On the other hand Indian Army provides security to entire nation. Pervasive system can include sensor system, monitoring system and identification system to provide better security to people using more resources together.
5. Home Pervasive system – Smart home pervasive system consists network of home equipment's like air conditioner, electrical system and home Wi-Fi network. Many day to day tasks can be automatized using pervasive system.

Comparison Chart

BASIS FOR COMPARISON	CLOUD COMPUTING	GRID COMPUTING
Application focus	business and web-based applications.	Collaborative purposes.
Architecture used	Client-server	Distributed computing
Management	Centralized	Decentralized
Business model	Pay per use	No defined business model
Accessibility of services	High because it is real-time	Low because of scheduled services.
Programming	Eucalyptus, Open Nebula,	Different middlewares are

BASIS FOR COMPARISON	CLOUD COMPUTING	GRID COMPUTING
models	Open stack etc, for Iaas but no middleware exists.	available such as Globus gLite, Unicore, etc.
Resource usage patterns	Centralized manner	Collaborative manner
Flexibility	High	Low
Interoperability	Vendor lock-in and integration are some issues	Easily deals with interoperability between providers.

There are many differences between Grid and Clusters. The following table shows comparison of Grid and Clusters.

CHARACTERISTIC	CLUSTER	GRID
Population	Commodity Computers	Commodity and High-end computers
Ownership	Single	Multiple
Discovery	Membership Services	Centralized Index and Decentralized Info
User Management	Centralized	Decentralized
Resource management	Centralized	Distributed
Allocation/ Scheduling	Centralized	Decentralized
Inter-Operability	VIA and Proprietary	No standards being developed

Single System Image	Yes	No
Scalability	100s	1000?
Capacity	Guaranteed	Varies, but high
Throughput	Medium	High
Speed(Lat. Bandwidth)	Low, high	High, Low