Chapter-01

Introduction to Cloud

What is Cloud Computing?

- Cloud computing is the on-demand delivery of IT resources over the Internet with pay-as-you-go pricing.

- Instead of buying, owning, and maintaining physical data centers and servers,

- we can access technology services, such as
  - computing power,
  - storage,
  - and databases,

- on an as-needed basis from a cloud provider like Amazon Web Services (AWS).

What is Cloud Computing?

- **Cloud Computing** is a general term used to describe a new class of network based computing that takes place over the Internet.
  - basically a step on from Utility Computing.
  - a collection/group of integrated and networked hardware, software and Internet infrastructure (called a platform).
  - Using the Internet for communication and transport provides hardware, software and networking services to clients.

What is Cloud Computing?

- These platforms hide the complexity and details of the underlying infrastructure from users and applications.

- Provides very simple graphical interface or API (Applications Programming Interface).

What is Cloud Computing?

- In addition, the platform provides on demand services, that are always on, anywhere, anytime and any place.

- Pay for use and as needed, elastic
  - scale up and down in capacity and functionalities.

- The hardware and software services are available to
  - general public, enterprises, corporations and businesses markets.

Cloud Summary

- Cloud computing is an umbrella term used to refer to Internet based development and services

- A number of characteristics define cloud data, applications services and infrastructure:

  - **Remotely hosted**: Services or data are hosted on remote infrastructure.

  - **Ubiquitous**: Services or data are available from anywhere.

  - **Commodified**: The result is a utility computing model similar to traditional that of traditional utilities, like gas and electricity - you pay for what you would want!

- **Cloud** is a model where user can have convenient on demand access to shared pool of resources over internet such as
  - Servers
  - Storage
  - Applications

- Cloud is owned and managed by the cloud provider.

- Users don’t have control of underlying hardware infrastructure of cloud.

- User can only access the services or allocated resources by using a Web browser.

- Features of cloud

  - On-Demand Self Service:
    - Consumer can set up computing capabilities such as server time and network storage without having any direct communication with each service provider

  - Broad Network Access:
    - Capabilities are available over the network and accessed through normal mechanisms used by various devices such as mobile phones, tablets, laptops or workstations.

- Features of cloud

  - Resource Pooling:
    - The providers computing resources such as storage, processing, memory and network bandwidth are pooled to serve multiple consumers by using a multi tenant model.

  - Rapid Elasticity:
    - Cloud computing capabilities can be systematically provisioned to meet demand and load requirements.

    - To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time.

–Measured Service:

- Cloud system can automatically control and optimize the use of resources by leveraging a metering capability at some level of abstraction that is appropriate for the type of service

- Resource usage can be monitored controlled and reported transparently for both the provider and consumer.

- # Cloud and Other Similar Configurations
  - There are several multi-tenant implementations that are similar to cloud computing .
  - We can distinguish *Cloud Computing* from these multi-tenant implementation as follows,
    - Application Service Provider(ASP): ASP was defined as an organization that hosts and manages one or more applications and its underlying infrastructure.

      Customers could use these applications over Internet and would be billed for the amount of utilization.

- Cluster: It is group of networked system sharing the same set of resources where
  - all nodes are actively working
  - Or some nodes are in the stand by mode waiting to take over after the failure of an active node.

- Automatic computing: It is set of self managing characteristics of distributed computing resources that operate on the basis of a set of pre-defined policies.

- These systems are capable of,
  - discovering and correcting their faults,
  - self configuration of their components,
  - self optimization of their resources,
  - and self protection from malware and attacks.

- Distributed Computing:
- This is an implementation technique where different roles or tasks are distributed among separate nodes in the network.

- Some forms of distributed computing are as follows,
  - Grid computing
  - Peer to peer architecture
  - Client Server architecture

- High Performance Computing(HPC):

- This technique divides a task into pieces and use parallel processing algorithms to execute each piece on different processors on the same node or multiple nodes in the network

- Utility Computing:

- Mainframes were very expensive even for large profitable companies.

- Mainframe manufacturers provided a form of utility computing called time sharing.

- They offered database storage and compute power to banks and other large organizations for free.

Cloud Computing Characteristics

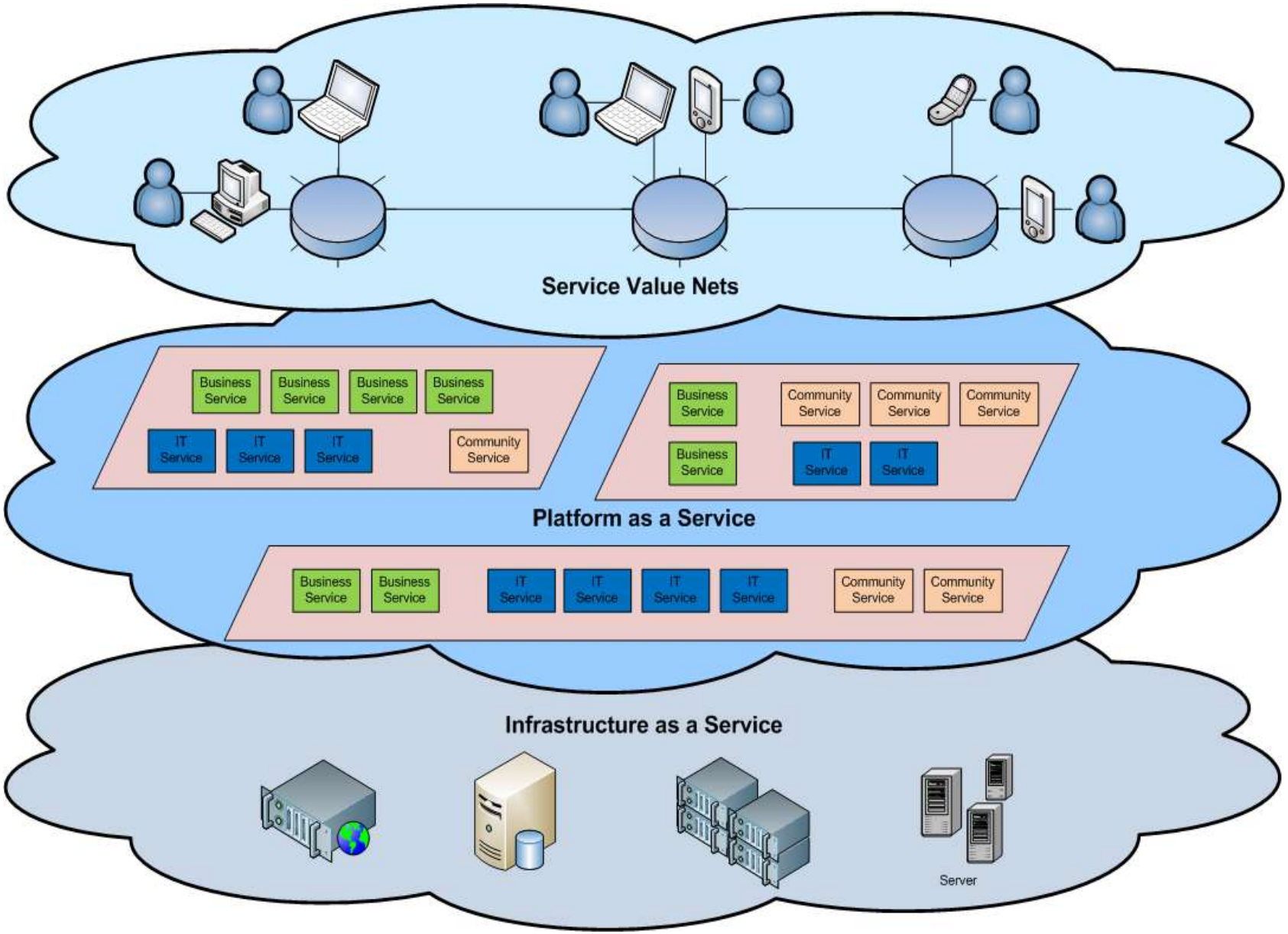
Common Characteristics:

- Massive Scale
- Resilient Computing
- Homogeneity
- Geographic Distribution
- Virtualization
- Service Orientation
- Low Cost Software
- Advanced Security

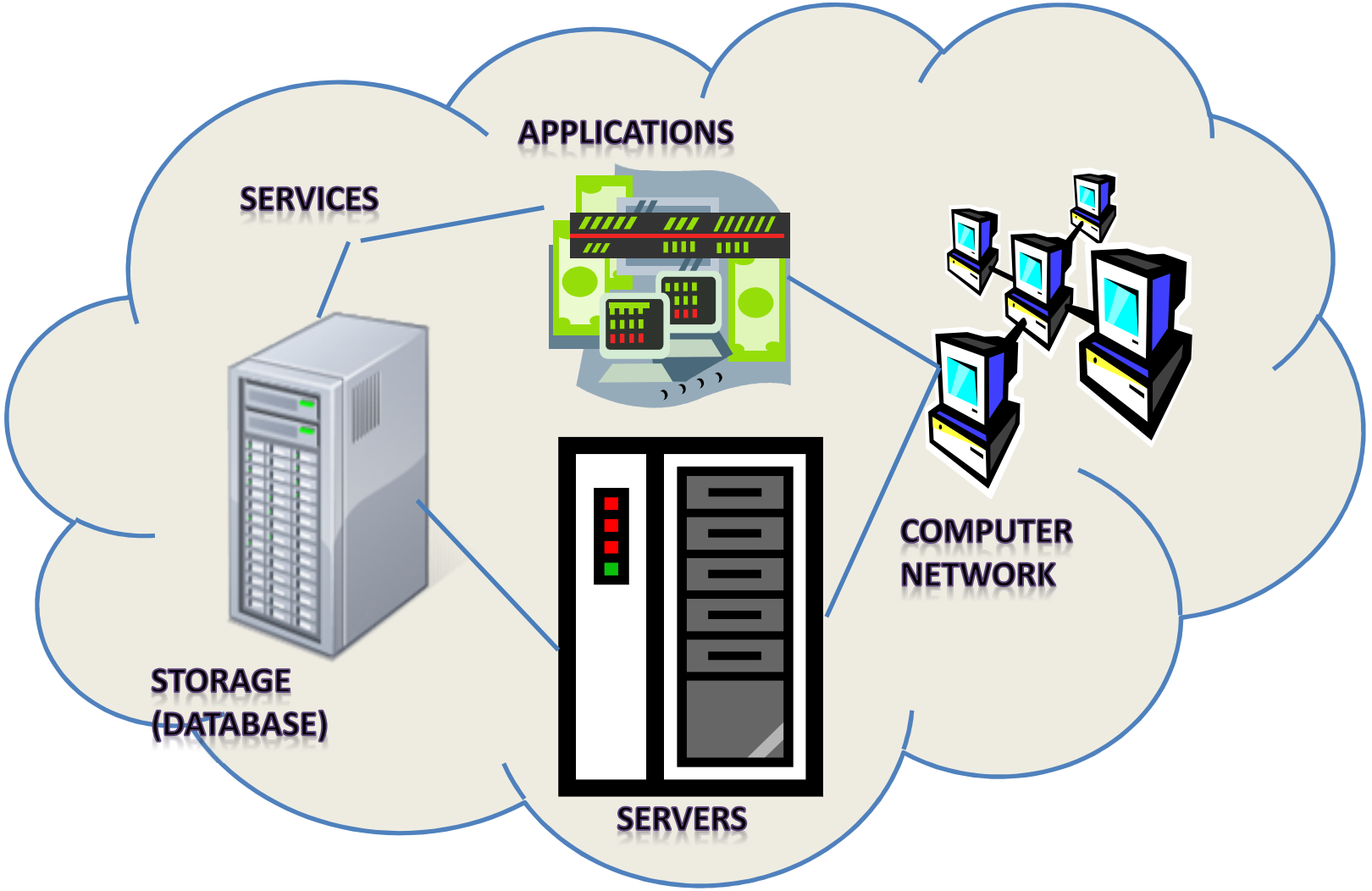
Essential Characteristics:

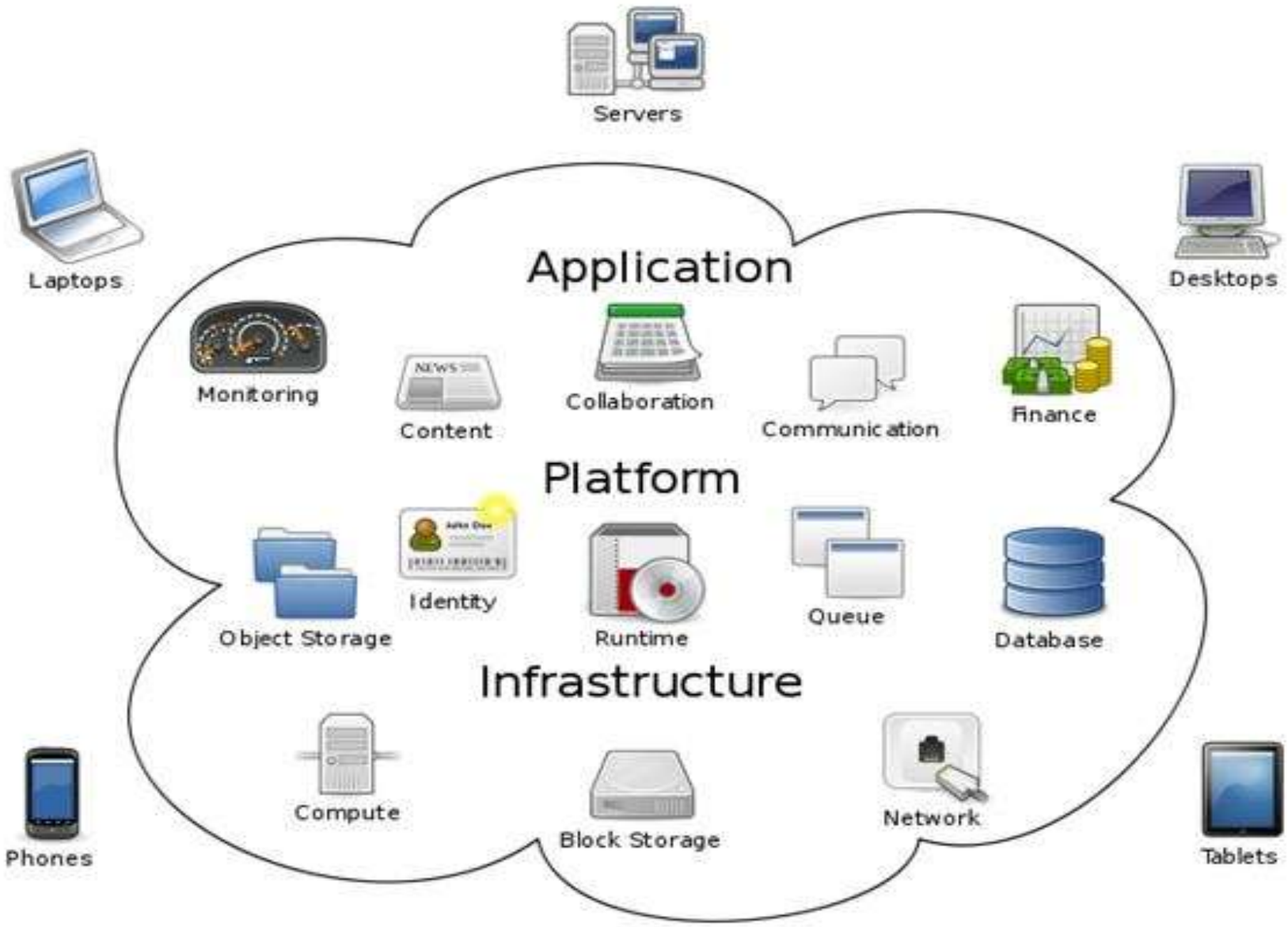
- On Demand Self-Service
- Broad Network Access
- Rapid Elasticity
- Resource Pooling
- Measured Service

Cloud Architecture



Cloud Computing





Cloud Computing

- Cloud Computing versus Peer to Peer Architecture

  - A peer to peer architecture is a network of hosts in which, resource sharing, processing, communication controls are completely decentralized.

  - Each host act as a server or provider of certain services.

  - It relies on other nodes within the network for other devices.

- Cloud Computing versus Peer to Peer Architecture

  - All clients on the network are equal in terms of providing and using resources and users are authenticated by each individual workstations.

  - Peer to peer architecture is easy and inexpensive.

  - It is only practical for very small organizations because of lack of central data storage and administration.

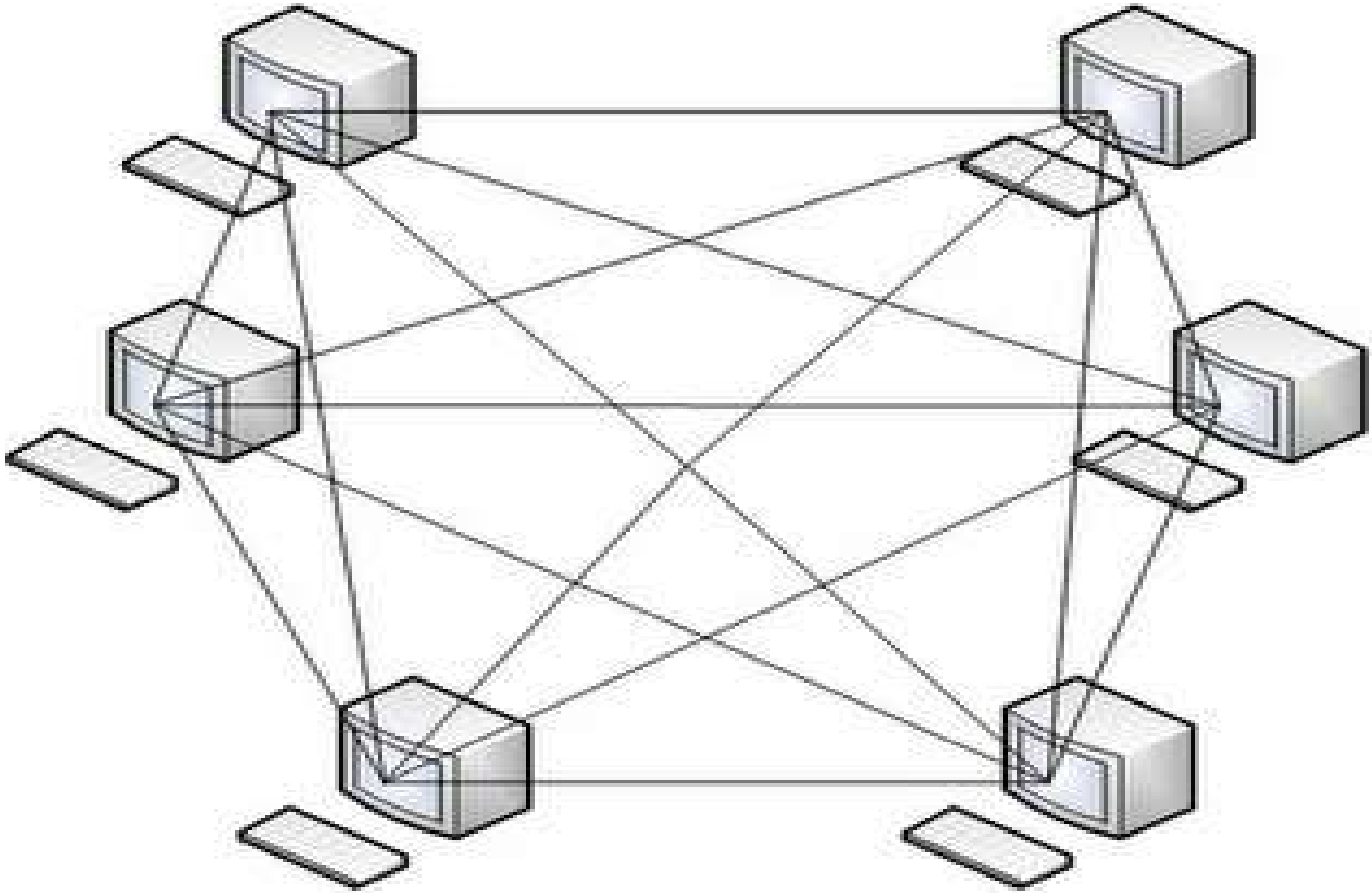
- Cloud computing deployments can be
  - easily scaled to meet growth of demands
  - enables access to any type of hosted applications,
  - does not burden user end devices,
  - and needs to be configured with the highest level of security

- Peer to peer deployments are relatively inexpensive and simple to setup and manage.

- LIMITATIONS

  - Cloud computing include high initial capital investment and good technology expertise to establish and manage it.

  - Peer to peer architecture is limited in extensibility,
  - Tends to overburden user workstations by making them work as server for other users.
  - Unable to provide any type of system wide service.



A peer-to-peer network.

- Cloud Computing versus Client-Server Architecture

- Client server architecture is form of distributed computing, where
  - Requests (clients) are depend on a number of provider(servers) for various services
  - or resources such as database application, security, printing and backups.
  - There is at least one server that provides central authentication services as well as access to,
    - Shared files
    - Printers
    - Hardware storage
    - Applications

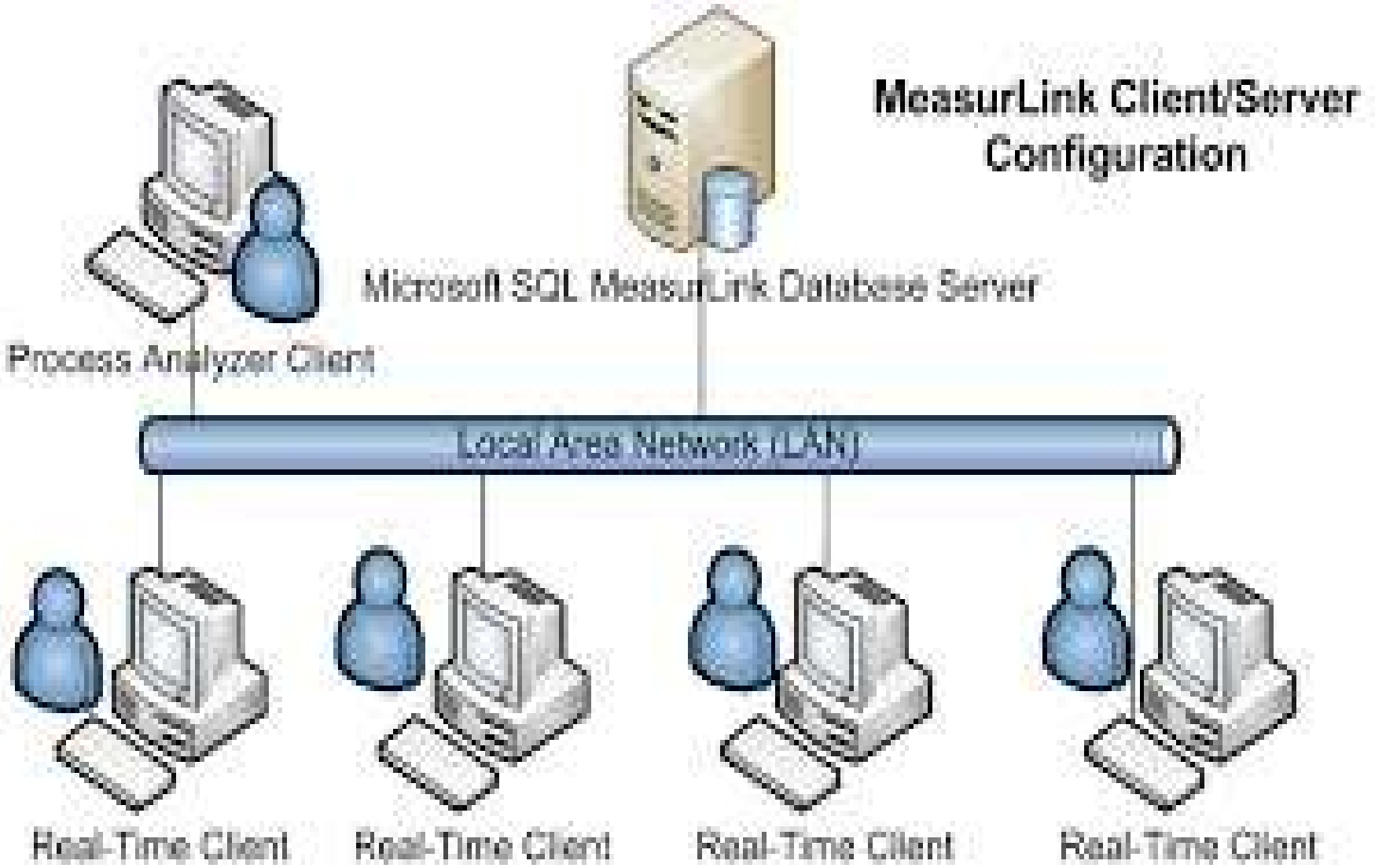
- When a user runs an application from the cloud it is part of client-server application.

- Cloud computing can provide
  - Increased performance
  - Flexibility.
  - And significant cost savings because
    - » Application hosting and support is the responsibility of the cloud service provider
    - » The amount of available resources appears to be infinite to the consumer.

- In client server architecture, the processing power, management services, and administrative services can be concentrated when needed.

- While clients can still perform many basic end user tasks on their own.

- In the client server architecture, additional investment is required
  - for an accelerate deployment of new resources to meet sudden changes during demand upsurge.


MeasurLink Client/Server Configuration
Microsoft SQL MeasurLink Database Server
Process Analyzer Client
Local Area Network (LAN)
Real-Time Client
Real-Time Client
Real-Time Client
Real-Time Client

- Client server is a method where information processing is split between a client and a server.

- Back in the old days, we had time share computers (mini's, mainframes, etc) that were accessed by terminals that only manipulated the display of information, but didn't do any processing.

- Much of what we do with web apps today are not really client-server for the same reason.

- The server is doing the work and the browser is displaying the results.

- With Javascript, we can make the display fancy and dynamic and even do some processing, but in most cases, the application model is still the browser displays information and the servers process information.

- A better example of client/server is email.
- Your email client processes incoming email and then presents it to you.
- The mail server processes email and figures out where it goes next.
- Both sides are processing information.
- Other examples of client server are: a web application that uses a RDBMS or a web services that relies on another web service for processing or data.

- Cloud computing is a different animal altogether.

- Cloud computing embodies the ideas that you can abstract the software from hardware, have applications that can scale up and down based on reasons such as demand, time, etc.

- The act of provisioning services in the cloud is automated and requires no user intervention.

- Clouds are also on-demand and can be metered meaning that you are only charged for the resources that you use.

- It's a consumption model.

- You can have a public cloud where someone else manages the hardware and infrastructure and you just put your OS's and apps into it.

- There is a private cloud where you own the hardware and infrastructure (locally or in a co-locally) and you have a scalable, automated, metered service.

- And there is hybrid which is where you have apps that reside in both.

- Client server describes how applications are modeled.

- Cloud computing describes the environment that applications reside in.

- You can have client/server apps that live in a cloud environment and ones that don't.

- If you put a client/server app into a cloud, that doesn't mean it will get all the benefits of cloud computing like auto-scaling

- As auto-scaling requires the application be designed to specifically for independent scaling.

- Similarly, we can take cloud apps often run them in a non-cloud environment just fine.

- Cloud Computing versus Grid Computing

  - Grid computing is cluster of computer systems

  - That were geographically distributed but worked together to perform common task.

  - In a grid a cluster of loosely coupled computers work together to solve a single problem.

- The problem involves massive amount of numerical calculation and compute cycles.

- Grid computing uses grid controlling software's.

- These software's divides the work into smaller pieces and assigns each piece to a pool of thousands of computers.

- The controlling unit later assembles the results to built the output.

- Grids are usually used to harness idle computer power.
- The concept of grid computing was similar to the concept of electricity grid.
- Electricity grid user could connect and use the power at any time.
- The amount of power used was measured using an electric meter

- Cloud computing harnesses idle computer power over a network connection.

- Users have metered utility service to keep a track of the amount of utilization and generate a periodic bill.

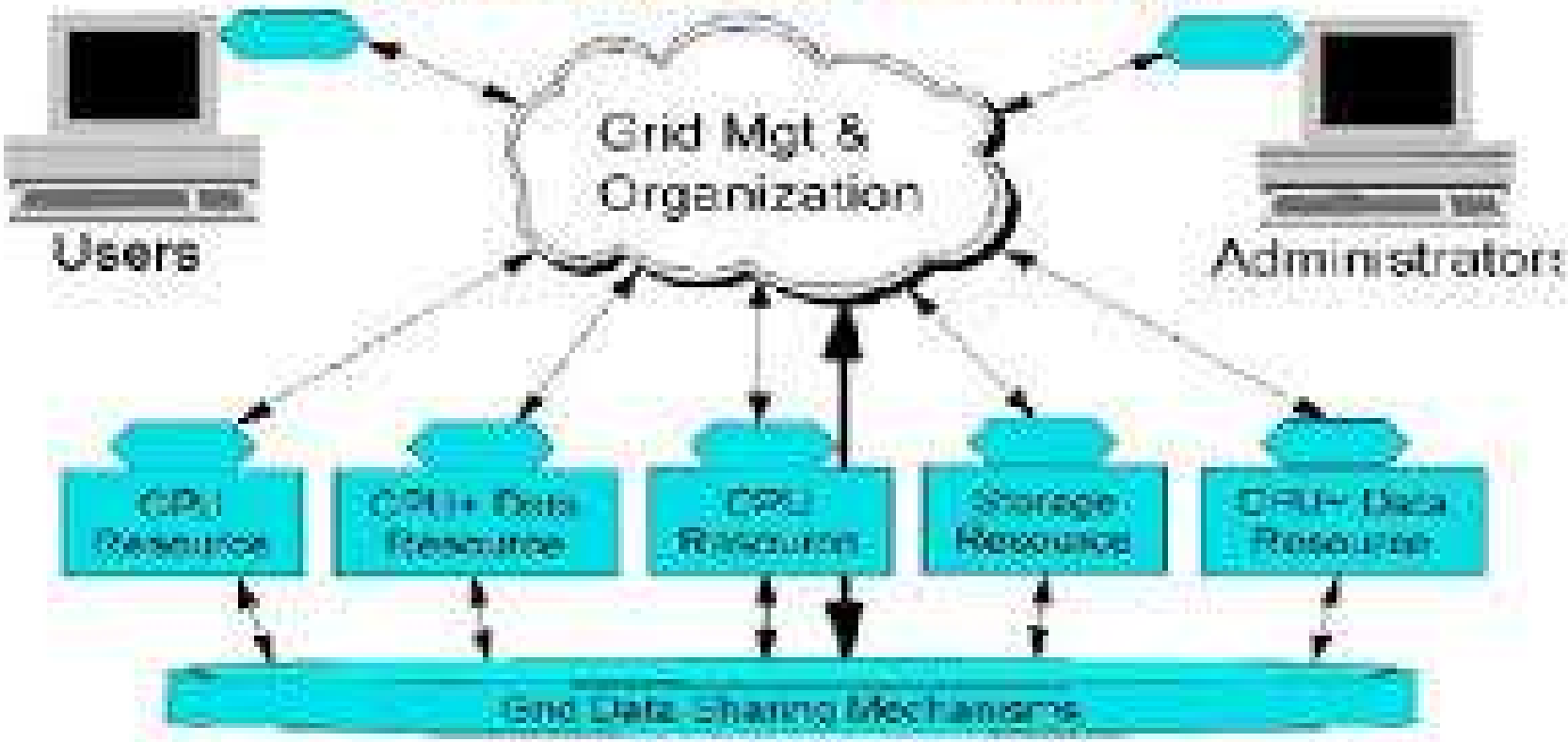
- Like an electric or computer grid cloud computing has no upfront, implementation, or capital expenses for user.

- The user only pay for the amount used.

- Cloud computing is a term used for technologies that provide compute and application services that do not require users to know the,
    - IT hardware infrastructure,
    - physical location,
    - and configuration of the system that deliver the services

- Cloud computing specifies a new provisioning and delivery mechanism for IT services with
    - dynamic scalability
    - and virtualized pool of resources
    - and has the potential to completely disrupt the traditional IT models and go to market techniques.

Grid Computing



- The difference between grid computing and cloud computing is hard to grasp because they are not always mutually exclusive.

- In fact, they are both used to economize computing by maximizing existing resources.

- Additionally, both architectures use abstraction extensively, and both have distinct elements which interact with each other.

- The difference between the two lies in the way the tasks are computed in each respective environment.

- In a computational grid, one large job is divided into many small portions and executed on multiple machines.

- This characteristic is fundamental to a grid; not so in a cloud.

- The computing cloud is intended to allow the user to avail of various services without investing in the underlying architecture.

- While grid computing also offers a similar facility for computing power, cloud computing isn’t restricted to just that.

- A cloud can offer many different services, from web hosting, right down to word processing.

- In fact, a computing cloud can combine services to present a user with a homogenous optimized result.

- Server computers are still needed to distribute the pieces of data and collect the results from participating clients on grid.

- Cloud offers more services than grid computing. In fact almost all the services on the Internet can be obtained from cloud, e.g. web hosting, multiple Operating systems, DB support and much more.

- Grids tends to be more loosely coupled, heterogeneous, and geographically dispersed compared to conventional cluster computing systems.

- Server Virtualization v/s Cloud Computing

  - Virtualization is the process of creating Virtual Machines(VM's) or replicas of computing resources.

  - The server administrator uses a software application (hypervisor).

  - Hypervisor divide a physical server into several isolated virtual environments called VM's.

- Virtualization was used to partition large mainframe hardware to improve utilization.

- Large mainframes could be used to host up to 10000 VM's.

  - Mainframe provides advantages like,
    - Dynamic capacity management
    - High energy efficiency
    - Transparent multi-tenancy for user applications
    - Flawless reliability
    - Better performance
    - Tight security

- Virtualization supports running of multiple VM's on a single physical machine.

- Virtualization is one of fundamental element or building block of cloud computing.

- It enables efficient use of resource and applications, and protects services from hardware failure

- Services can still function independent of the hardware.

- If an underlying physical hardware fails the VM's are transferred to another healthy physical server.

- If VM, needs more resources to meet users load it dynamically schedules more resources for the VM.

- It does not provide load balancing across VM's nor does it improve communication between VM's.

- Hypervisor improves the security of the VM's

- Hypervisor does nothing to enforce security within the OS internals or components.

- Cloud computing takes virtualization to the next level by,
  - Providing load based provisioning
  - De-provisioning of computing resources
  - Self service portals
  - Pay per use billing.

- Cloud computing tightens the security by
  - regulating user authentication
  - use of cloud resources
  - monitoring user traffic activities.

- Components of Cloud Computing
  - Cloud computing comprises a virtualized pool of infrastructure resources with applications and services
  - Resources, applications and services can be used directly through a self service portal.
  - Cloud computing consist of
    - Client
    - Cloud network
    - Cloud application programming interface (API's)

- Client- A client is an access device or software interface that a user can use to access cloud services.
- Cloud clients are divided into three categories as,
  - Mobile clients
  - Thin clients
  - Thick clients

- Client types can include
  - Computers
  - Mobiles
  - Smart phones
  - Tablets
  - Servers.

- Client devices communicates with cloud services by using cloud API’s and browsers.

- Cloud network- network is connecting link between the user and cloud services.

- The internet is the most straightforward and common choice for accessing the cloud

- Employing advanced network services such as
  - encryption
  - compression during transit

- It will benefit both the service provider and the user.

- Cloud Application Programming Interface(API)

  - A cloud API is a set of programming instruction and tool that provides abstractions over a specific provides cloud.

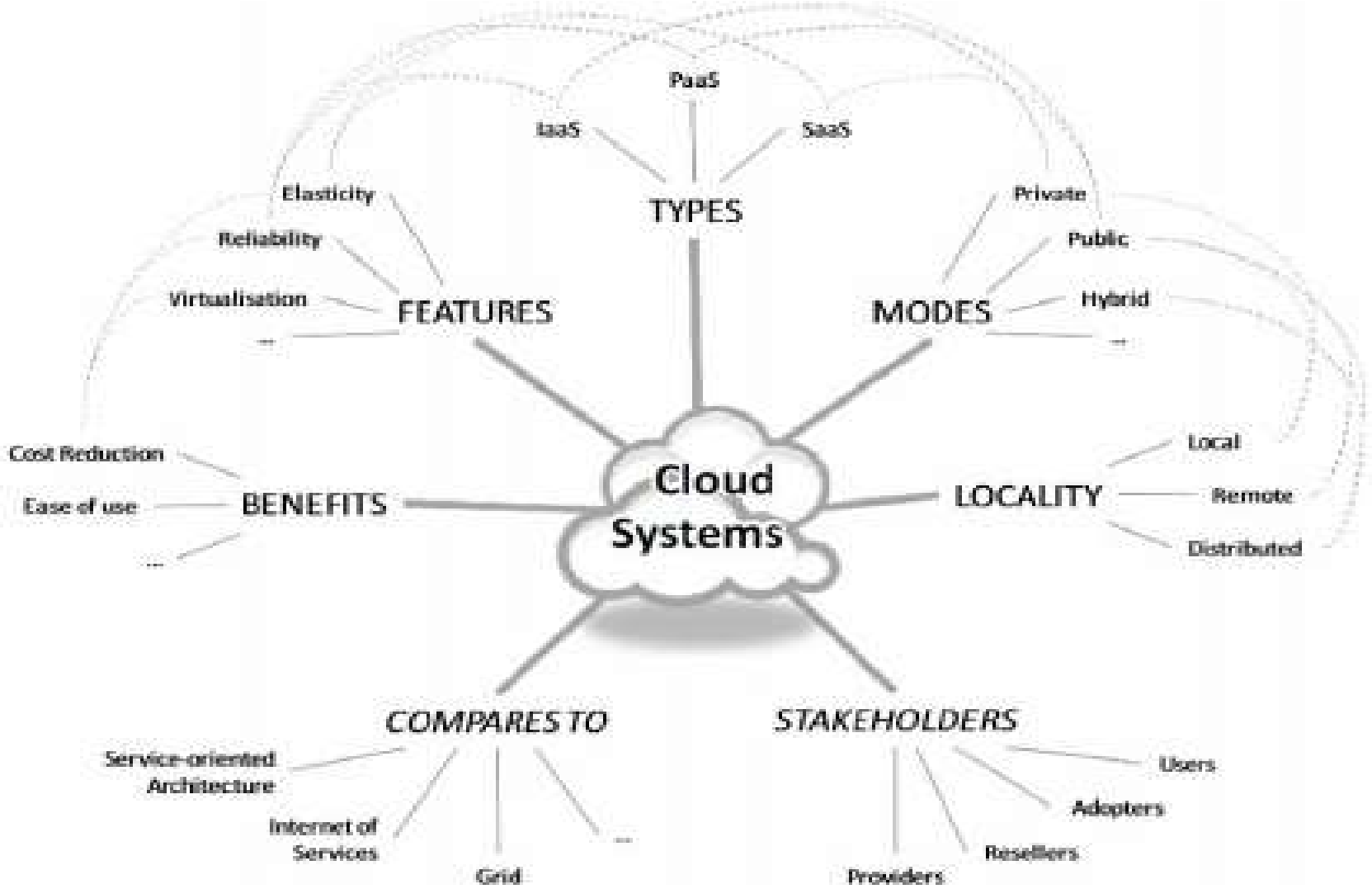
  - It includes custom or unique provider call to enhance the amount of control over a cloud implementation.

  - These calls can be used to build applications for accessing and communicating with the cloud services.

- API’s help programmers to have a common mechanism for connecting to a particular cloud service.

- Following fig illustrate the various aspects of cloud computing which includes
  - features
  - types
  - modes
  - benefits
  - comparisons
  - and stakeholders

- Aspects of cloud computing



- Cloud Types

- Cloud computing can be classified on basis of
  - Location
  - Type of service being provided.

- On the basis of location cloud computing classified as
  - Public cloud
  - Private cloud
  - Hybrid cloud
  - And Community cloud

- The Public Clouds
  - The clouds accessed or used by general masses and hosted are maintained as well as managed by cloud service provider

- E.g.,
  - Amazon
  - Google
  - Microsoft

- The Service providers charge the companies according to their usage

- A public cloud is basically the internet.

- Service providers use the internet to make resources, such as applications (also known as Software-as-a-service) and storage, available to the general public, or on a public cloud.

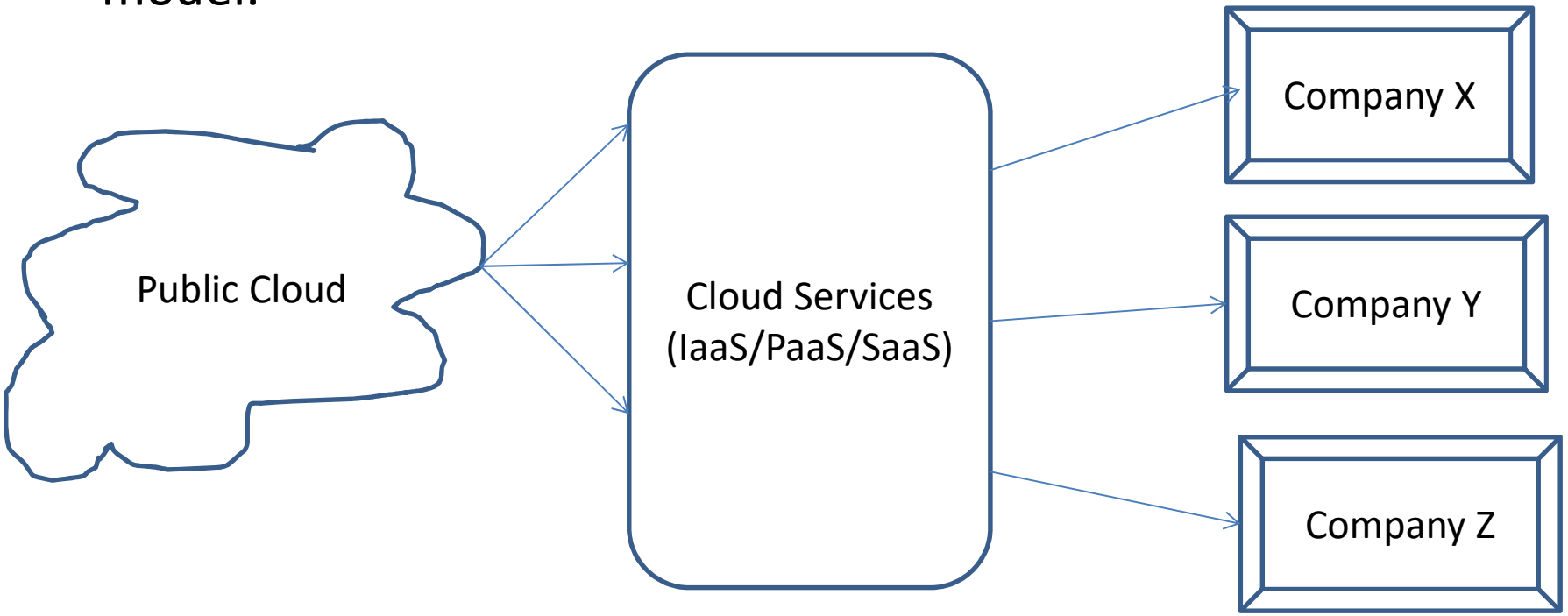
- In the public cloud there is no need for organization (customer) to control or manage the resources.

- They are being administered by a third party.
- E.g. public cloud providers,
  - Savvis
  - Verizon,
  - Amazon web services
  - Rackspace.
- In the public cloud the resources are owned and hosted by the cloud service providers(company)
- Services are sold to other companies.

- A public cloud is one based on the standard cloud computing model,

- Service provider makes resources, such as applications and storage, available to the general public over the Internet.

- Public cloud services may be free or offered on a pay-per-usage model.



- **Public Cloud Computing**
  - Utility Model – Public Clouds typically deliver a pay-as-you-go model, where you pay by the hour for the compute resources you use.
  - This is an economical way to go if you're spinning up & tearing down development servers on a regular basis.
  - No Contracts – Along with the utility model, you're only paying by the hour – if you want to shut down your server after only 2 hours of use, there is no contract requiring your ongoing use of the server.

- Shared Hardware – Because the public cloud is by definition a multi-tenant environment, your server shares the same
  - hardware, storage and network devices as the other tenants in the cloud.

  - Meeting compliance requirements, such as PCI or SOX, is not possible in the public cloud.

- No Control of Hardware Performance – In the public cloud, you can't select the hardware, cache or storage performance (SATA or SAS).
  - Your virtual server is placed on whatever hardware and network, the public cloud provider designates for you.

- **Self Managed** – with the high volume, utility model, self managed systems are required for this business model to make sense.
  - Advantage here for the technical buyers that like to setup and manage the details of their servers.
  - Disadvantage for those that want a fully managed solution.

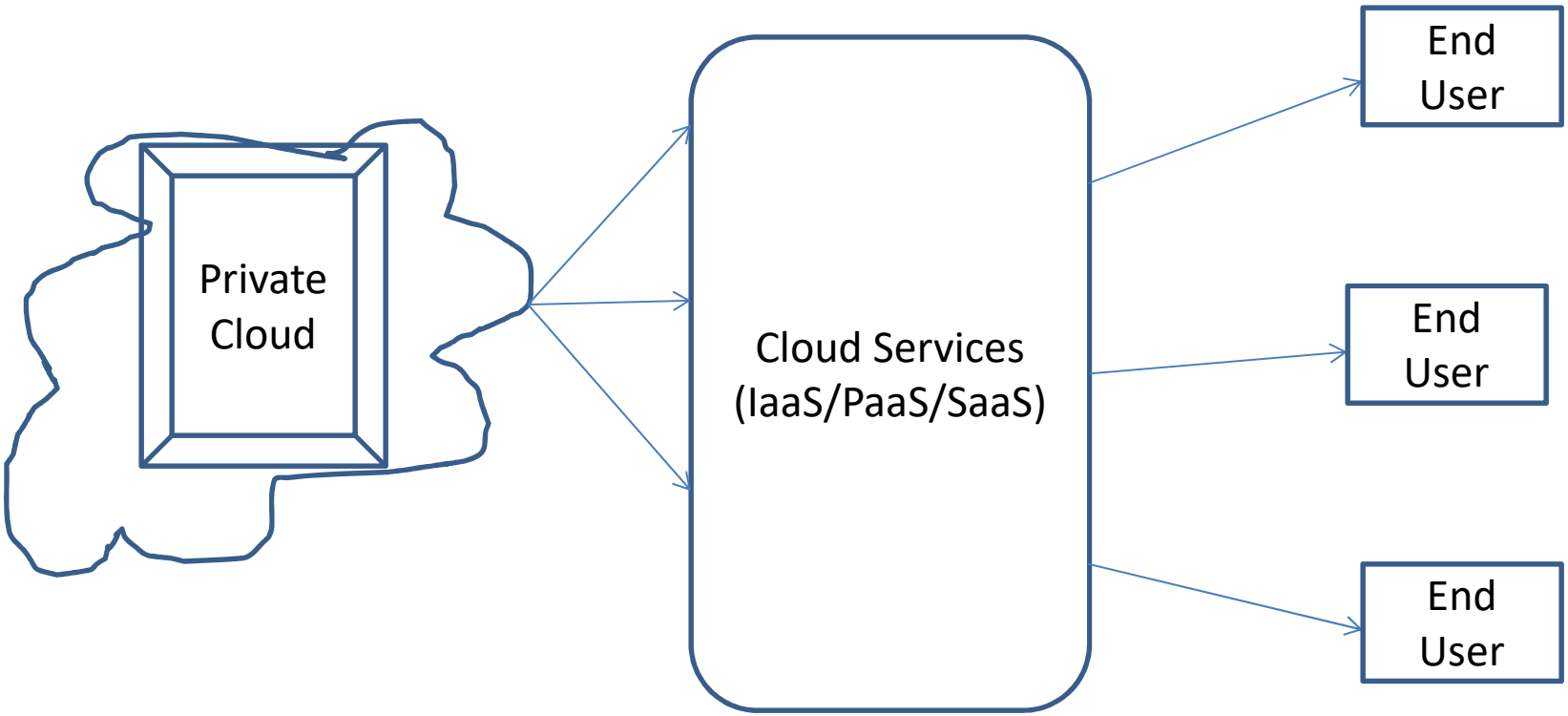
- The majority of public cloud deployments are generally used for web servers or development systems where security and compliance requirements of larger organizations and their customers is not an issue.

- The Private Clouds
  - The cloud computing infrastructure is solely designed for a single organization
  - It can not be accessed or shared with other organization.
  - Private clouds are more costly as well as secure
  - Can be either on-premise or hosted externally

- On-premise private cloud the service is exclusively used and hosted by a single organization
- Private clouds hosted externally are used by a single organization and not shared with the other organizations.
- On premise private clouds are costlier as compared to externally hosted private clouds.
- In private cloud security is kept in mind at every level of design.

- The general objective of private cloud is not to sell the cloud services to the external organization

- It get the advantages of cloud architecture by not providing the privilege to manage your own data center.



- Private clouds are data center architectures.

- Owned by a single company that provides
  - flexibility,
  - scalability,
  - provisioning,
  - automation and
  - monitoring.

- The goal of a private cloud is not sell “as-a-service” offerings to external customers.

- It gain the benefits of cloud architecture without giving up the control of maintaining your own data center.

- Private clouds can be expensive with typically modest economies of scale.

- This is usually not an option for the average Small-to-Medium sized business and is most typically put to use by large enterprises.

- Private clouds are driven by concerns around security and compliance, and keeping assets within the firewall.

- **Private Cloud Computing**

- Private cloud hosting, is a single-tenant environment where the hardware, storage and network are dedicated to a single client or company.

- **Security –** Because private clouds are dedicated to a single organization, the hardware, data storage and network can be designed to assure high levels of security that cannot be accessed by other clients in the same data center.

- **Compliance** – Sarbanes Oxley, PCI and HIPAA compliance can not be delivered through a public cloud deployment.

- Because the hardware, storage and network configuration is dedicated to a single client, compliance is much easier to achieve.

- Customizable – Hardware performance, network performance and storage performance can be specified and customized in the private cloud.

- Hybrid Deployments – If a dedicated server is required to run a high speed database application, that hardware can be integrated into a private cloud, in effect, hybridizing the solution between virtual servers and dedicated servers.
- This can't be achieved in a public cloud.

- As opposed to public clouds, private clouds are not delivered through a utility model or pay-as-you-go basis because the hardware is dedicated.

- Private clouds are generally preferred by mid and large size enterprises because they meet the security and compliance requirements of these larger organizations and their customers.

- The Community Cloud

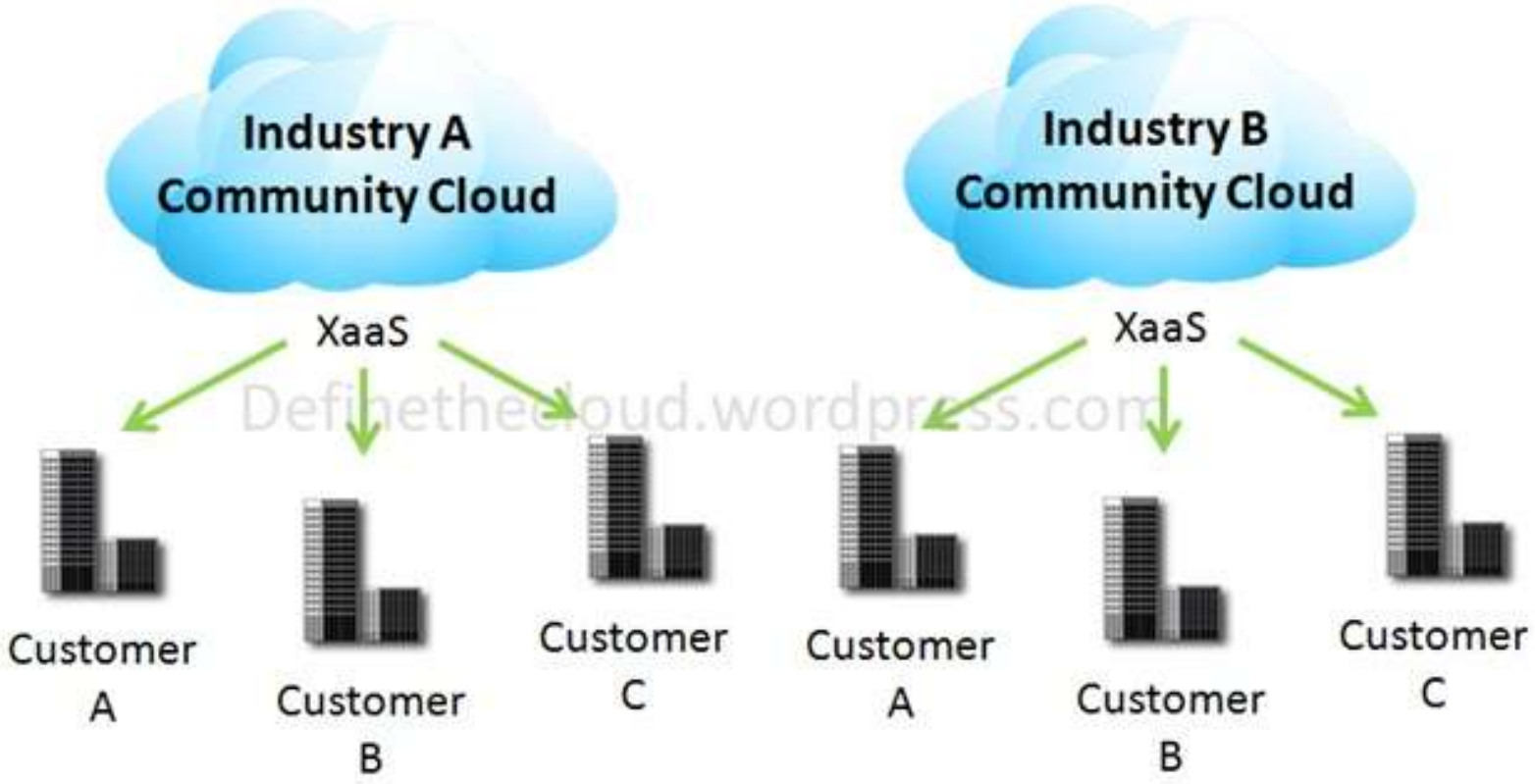
  - Community cloud is a type of cloud that is shared among various organization with a common tie.

  - It is generally managed by a third party offering the cloud service

  - It can be made available on or off premises.

  - E.g. In any state or country the community cloud can be provided so that all government organizations of that state can share resources available on the cloud.

- Sharing cloud resources on community cloud data of all citizens of that state can be easily managed by the government organization.



- A community cloud in computing is a collaborative effort
- A community cloud infrastructure is shared between several organizations from a specific community with common concerns as,
  - security,
  - compliance,
  - jurisdiction, etc.
- A community cloud managed internally or by a third-party and hosted internally or externally.
- This is controlled and used by a group of organizations that have shared interest.

- The Hybrid Cloud
- The cloud environment in which various internal or external service providers provide services to many organizations is known as hybrid cloud.

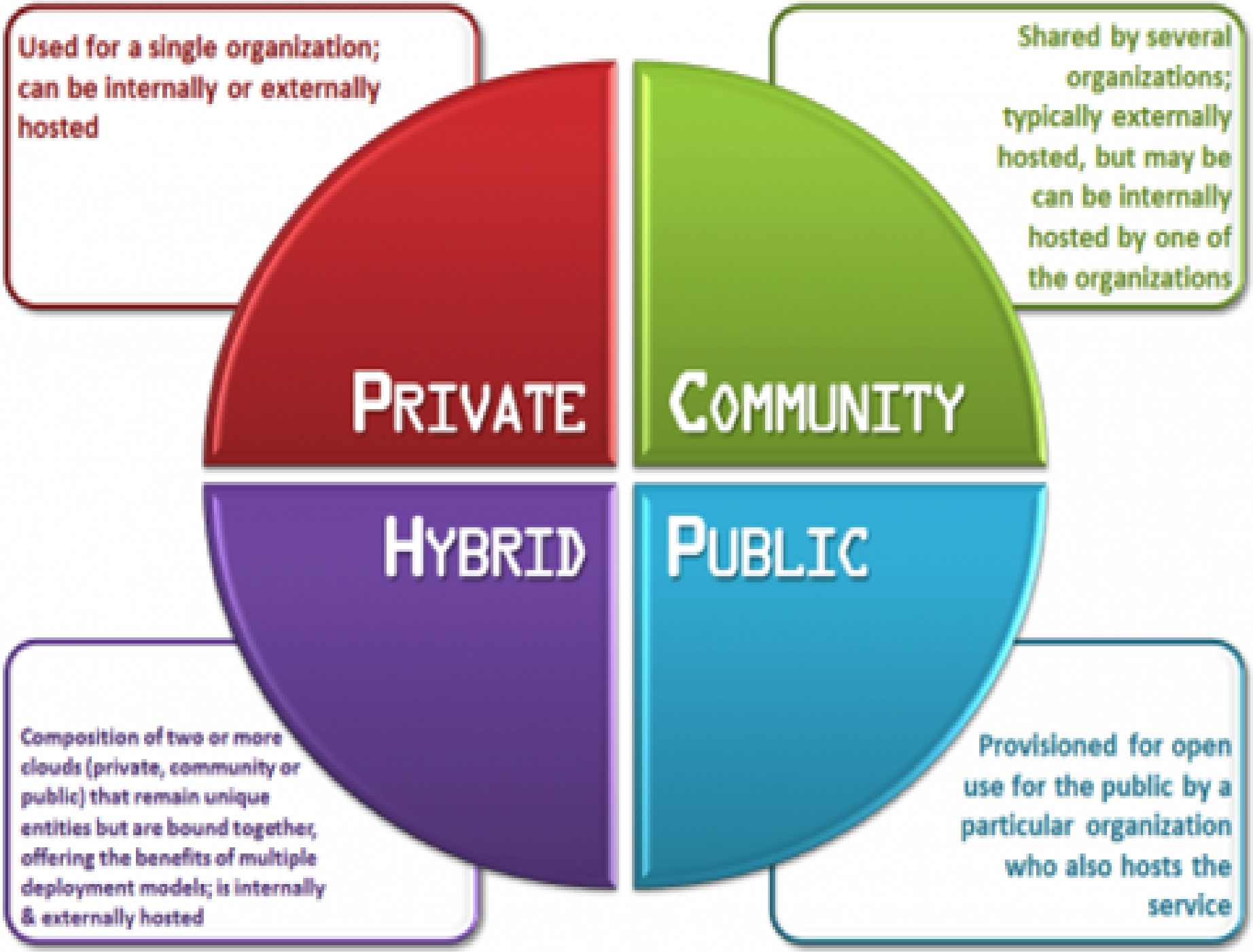
- The application which require high level of security and are critical hosts on private cloud.

- The applications requiring less of concern can be hosted on the public cloud.

- In hybrid cloud an organization can use both types of cloud.

- Hybrid type of cloud is generally used in situations such as cloud bursting.
- In cloud bursting an organization generally uses it’s own computing infrastructure.
- In high load requirements the organization can access clouds.
- Organization using hybrid cloud can manage an internal private cloud for general usage
- Also it migrate the entire or part of an application to the public cloud during the peak period.

- Hybrid cloud is a cloud computing environment which uses a mix of on-premises, private cloud and third-party, public cloud services with orchestration between the two platforms.


Used for a single organization; can be internally or externally hosted
Shared by several organizations; typically externally hosted, but may be can be internally hosted by one of the organizations
PRIVATE
COMMUNITY
HYBRID
PUBLIC
Composition of two or more clouds (private, community or public) that remain unique entities but are bound together, offering the benefits of multiple deployment models; is internally & externally hosted
Provisioned for open use for the public by a particular organization who also hosts the service

Opportunities and Challenges

- The use of the cloud provides a number of opportunities:
  - It enables services to be used without any understanding of their infrastructure.
  - Cloud computing works using economies of scale:
    - It potentially lowers the outlay expense for start up companies, as they would no longer need to buy their own software or servers.
    - Cost would be by on-demand pricing.
    - Vendors and Service providers claim costs by establishing an ongoing revenue stream.
  - Data and services are stored remotely but accessible from “anywhere”.

Opportunities and Challenges

- In parallel there has been backlash against cloud computing:
  - Use of cloud computing means dependence on others and that could possibly limit flexibility and innovation:
    - The others are likely become the bigger Internet companies like Google and IBM, who may monopolise the market.
    - Some argue that this use of supercomputers is a return to the time of mainframe computing that the PC was a reaction against.
  - Security could prove to be a big issue:
    - It is still unclear how safe out-sourced data is and when using these services ownership of data is not always clear.
  - There are also issues relating to policy and access:
    - If your data is stored abroad whose policy do you adhere to?
    - What happens if the remote server goes down?
    - How will you then access files?
    - There have been cases of users being locked out of accounts and losing access to data.

Advantages of Cloud Computing

- Lower computer costs:
  - You do not need a high-powered and high-priced computer to run cloud computing's web-based applications.
  - Since applications run in the cloud, not on the desktop PC, your desktop PC does not need the processing power or hard disk space demanded by traditional desktop software.
  - When you are using web-based applications, your PC can be less expensive, with a smaller hard disk, less memory, more efficient processor.
  - In fact, your PC in this scenario does not even need a CD or DVD drive, as no software programs have to be loaded and no document files need to be saved.

Advantages of Cloud Computing

- Improved performance:
  - With few large programs hogging your computer's memory, you will see better performance from your PC.
  - Computers in a cloud computing system boot and run faster because they have fewer programs and processes loaded into memory…
- Reduced software costs:
  - Instead of purchasing expensive software applications, you can get most of what you need for free-ish!
    - most cloud computing applications today, such as the Google Docs suite.
  - better than paying for similar commercial software
    - which alone may be justification for switching to cloud applications.

Advantages of Cloud Computing

- Instant software updates:
  - Another advantage to cloud computing is that you are no longer faced with choosing between obsolete software and high upgrade costs.
  - When the application is web-based, updates happen automatically
    - available the next time you log into the cloud.
  - When you access a web-based application, you get the latest version
    - without needing to pay for or download an upgrade.

- Improved document format compatibility.
  - You do not have to worry about the documents you create on your machine being compatible with other users' applications or OSes
  - There are potentially no format incompatibilities when everyone is sharing documents and applications in the cloud.

Advantages of Cloud Computing

- Unlimited storage capacity:
  - Cloud computing offers virtually limitless storage.
  - Your computer's current 1 Tbyte hard drive is small compared to the hundreds of Pbytes available in the cloud.
- Increased data reliability:
  - Unlike desktop computing, in which if a hard disk crashes and destroy all your valuable data, a computer crashing in the cloud should not affect the storage of your data.
    - if your personal computer crashes, all your data is still out there in the cloud, still accessible
  - In a world where few individual desktop PC users back up their data on a regular basis, cloud computing is a data-safe computing platform!

Advantages of Cloud Computing

- Universal document access:
  - That is not a problem with cloud computing, because you do not take your documents with you.
  - Instead, they stay in the cloud, and you can access them whenever you have a computer and an Internet connection
  - Documents are instantly available from wherever you are

- Latest version availability:
  - When you edit a document at home, that edited version is what you see when you access the document at work.
  - The cloud always hosts the latest version of your documents
    - as long as you are connected, you are not in danger of having an outdated version

Advantages of Cloud Computing

- Easier group collaboration:
  - Sharing documents leads directly to better collaboration.
  - Many users do this as it is an important advantages of cloud computing
    - multiple users can collaborate easily on documents and projects
- Device independence.
  - You are no longer tethered to a single computer or network.
  - Changes to computers, applications and documents follow you through the cloud.
  - Move to a portable device, and your applications and documents are still available.

Disadvantages of Cloud Computing

- Requires a constant Internet connection:
  - Cloud computing is impossible if you cannot connect to the Internet.
  - Since you use the Internet to connect to both your applications and documents, if you do not have an Internet connection you cannot access anything, even your own documents.
  - A dead Internet connection means no work and in areas where Internet connections are few or inherently unreliable, this could be a deal-breaker.

Disadvantages of Cloud Computing

- Does not work well with low-speed connections:
  - Similarly, a low-speed Internet connection, such as that found with dial-up services, makes cloud computing painful at best and often impossible.
  - Web-based applications require a lot of bandwidth to download, as do large documents.
- Features might be limited:
  - This situation is bound to change, but today many web-based applications simply are not as full-featured as their desktop-based applications.
    - For example, you can do a lot more with Microsoft PowerPoint than with Google Presentation's web-based offering

Disadvantages of Cloud Computing

- Can be slow:
  - Even with a fast connection, web-based applications can sometimes be slower than accessing a similar software program on your desktop PC.
  - Everything about the program, from the interface to the current document, has to be sent back and forth from your computer to the computers in the cloud.
  - If the cloud servers happen to be backed up at that moment, or if the Internet is having a slow day, you would not get the instantaneous access you might expect from desktop applications.

Disadvantages of Cloud Computing

- Stored data might not be secure:
  - With cloud computing, all your data is stored on the cloud.
    - The questions is How secure is the cloud?
  - Can unauthorized users gain access to your confidential data?
- Stored data can be lost:
  - Theoretically, data stored in the cloud is safe, replicated across multiple machines.
  - But on the off chance that your data goes missing, you have no physical or local backup.
    - Put simply, relying on the cloud puts you at risk if the cloud lets you down.

Disadvantages of Cloud Computing

- HPC Systems:
  - Not clear that you can run compute-intensive HPC applications that use MPI/OpenMP!
  - Scheduling is important with this type of application
    - as you want all the VM to be co-located to minimize communication latency!

- General Concerns:
  - Each cloud systems uses different protocols and different APIs
    - may not be possible to run applications between cloud based systems
  - Amazon has created its own DB system (not SQL 92), and workflow system (many popular workflow systems out there)
    - so your normal applications will have to be adapted to execute on these platforms.

End…