Cloud

- The term **Cloud** refers to a **Network** or **Internet.** In other words, we can say that Cloud is something, which is present at remote location. Cloud can provide services over public and private networks, i.e., WAN, LAN or VPN.
- Applications such as e-mail, web conferencing, customer relationship management (CRM) execute on cloud.
- It comprises a set of approaches that can help organizations quickly and effectively add and subtract resources in almost real time.
- Cloud computing is a business and an economic model.
- The term *cloud* in cloud computing refers to the means through which everything—from computing power to computing infrastructure,

  applications, business processes, and personal collaboration—can be

  delivered to you as a service wherever and whenever you need it.
- A cloud is a group of interconnected network servers or PCs that may

  be private or public.

Cloud

- The following equation helps clarify the different parts that are combined to make up the cloud:

Hardware (virtualization of hardware, multi-core chips)

+ Internet Technologies (web services, SOA, Web 3.0)

+ Systems Management (autonomic computing)

+ Distributed Computing (grid computing, utility computing)

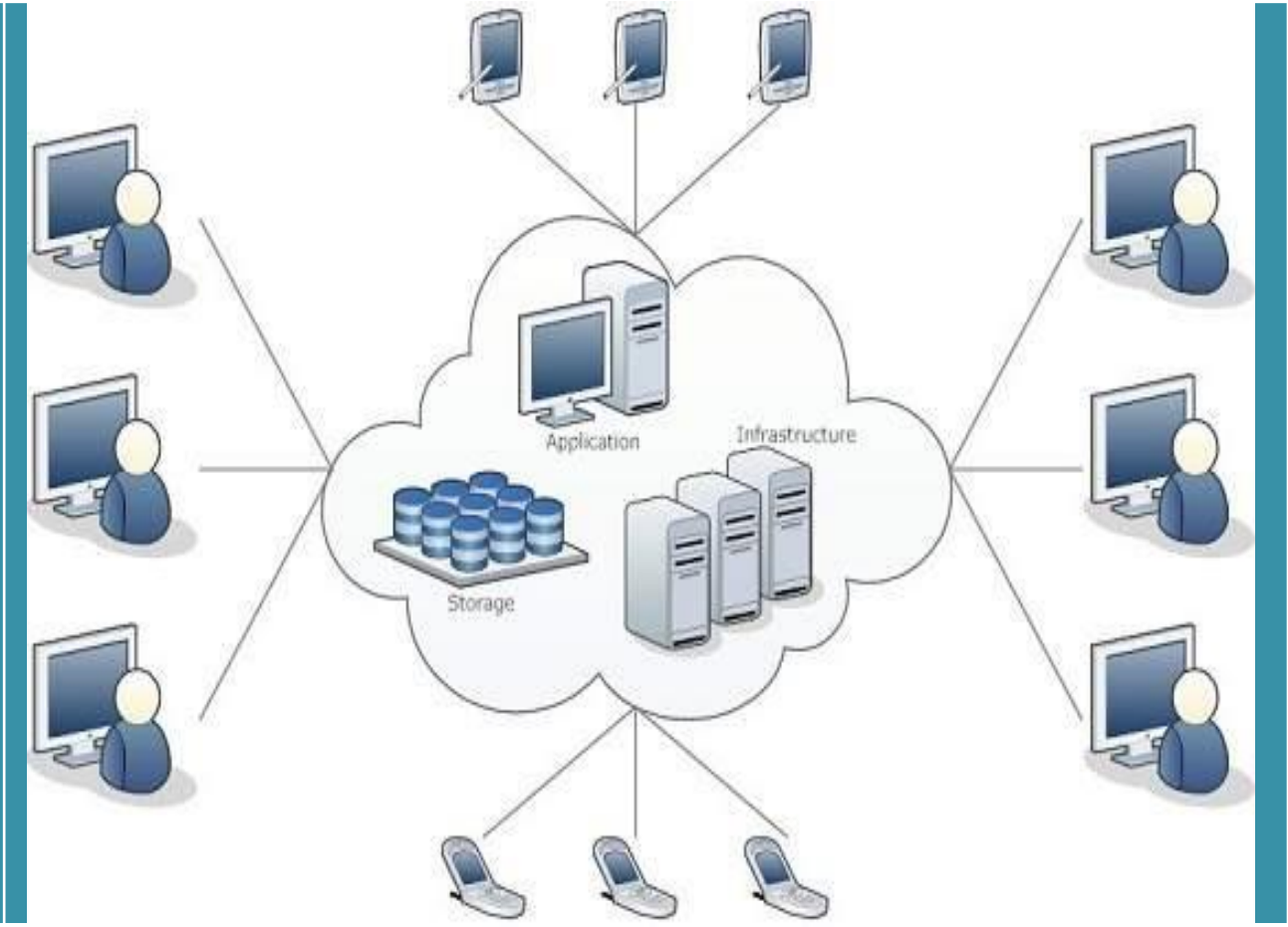
= The cloud

Cloud computing

Cloud Computing refers to **manipulating,**

configuring, and **accessing** the hardware and software resources remotely. It offers online data storage, infrastructure, and application.

Cloud computing offers platform independency, as the software is not required to be installed locally on the PC. Hence, the Cloud Computing is making our business applications mobile and c ollaborative.



Principle of Cloud computing

The principle of cloud computing is to offer computing, storage and software “as-a-service.” Several researchers have given different definitions of the cloud Some of them are as follows:

1. “Cloud Computing is a paradigm in which information is permanently stored in servers on the Internet and cached temporarily on clients that include desktops, entertainment centers, table computers, notebooks, wall computers, handhelds, sensors, monitors, etc.” [Carl Hewitt]
2. “It is an information processing model in which centrally administered computing capabilities are delivered as services, on an as-needed basis, across the network to a variety of user-facing devices.” [Brian et al. 2014]
3. “It is a model for enabling 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.” [NIST, USA, 800-145]
4. “It is an umbrella term to describe a category of sophisticated on-demand computing services initially offered by commercial providers like Amazon, Google and Microsoft.”

Parallel Vs cloud computing

- Parallel computing means running several computers, which may be kept in one room, but they are made to solve one problem only.
- Such architectures are called *advanced computer architectures* and the computers are known as *parallel computers* or *supercomputers*.
- These computers use parallel programming constructs.
- examples - the CRAY-XMP, CRAY-Y-MP, PARAGON, PARAM, and JUGENE.
- On the other hand, cloud computing refers to the use of resources available on the Internet via a time- and cost-effective method.
- This is possible due to the sharing of the resources.
- **Cloud provide Iaas, paAs, saas, etc. which we will discuss later in this chapter.**

GRid Vs cloud computing

- Grid computing is a form of distributed computing whereby a “super and virtual computer” is composed of a cluster of networked, loosely coupled computers, acting in concert to perform very large tasks. This technology has been applied to computationally intensive scientific, mathematical and academic problems through volunteer computing and it is used in commercial enterprises for such diverse applications as drug discovery, economic forecasting, seismic analysis and back-office data processing in support of e-commerce and web services.
- SETI - is a grid computing system.
- People all over the world share idle CPU cycles of their computers with the SETI project.

Peer to peer vs Cloud computing

- In a peer-to-peer network of hosts, resource sharing, processing, and communications control are fully decentralized.
- Each *host acts as a server* (provider) of some services. However, some services depend on the other nodes within the network.
- All clients are the same on the network.

- cloud computing is elastic and scalable in terms of resource sharing.
- Cloud computing requires a heavy initial financial investment and good technological expertise while peer-to-peer deployments have limited extensibility properties

Client–Server Architectures vs Cloud computing

- A client–server architecture is a form of distributed computing wherein the clients depend on the number of servers that will provide them with services.
- Thus, its scalability involves higher costs (processing power cost, management costs, and administrative costs).
- In client–server deployments, a minimum of one server is a must. Thus, more costs are involved.

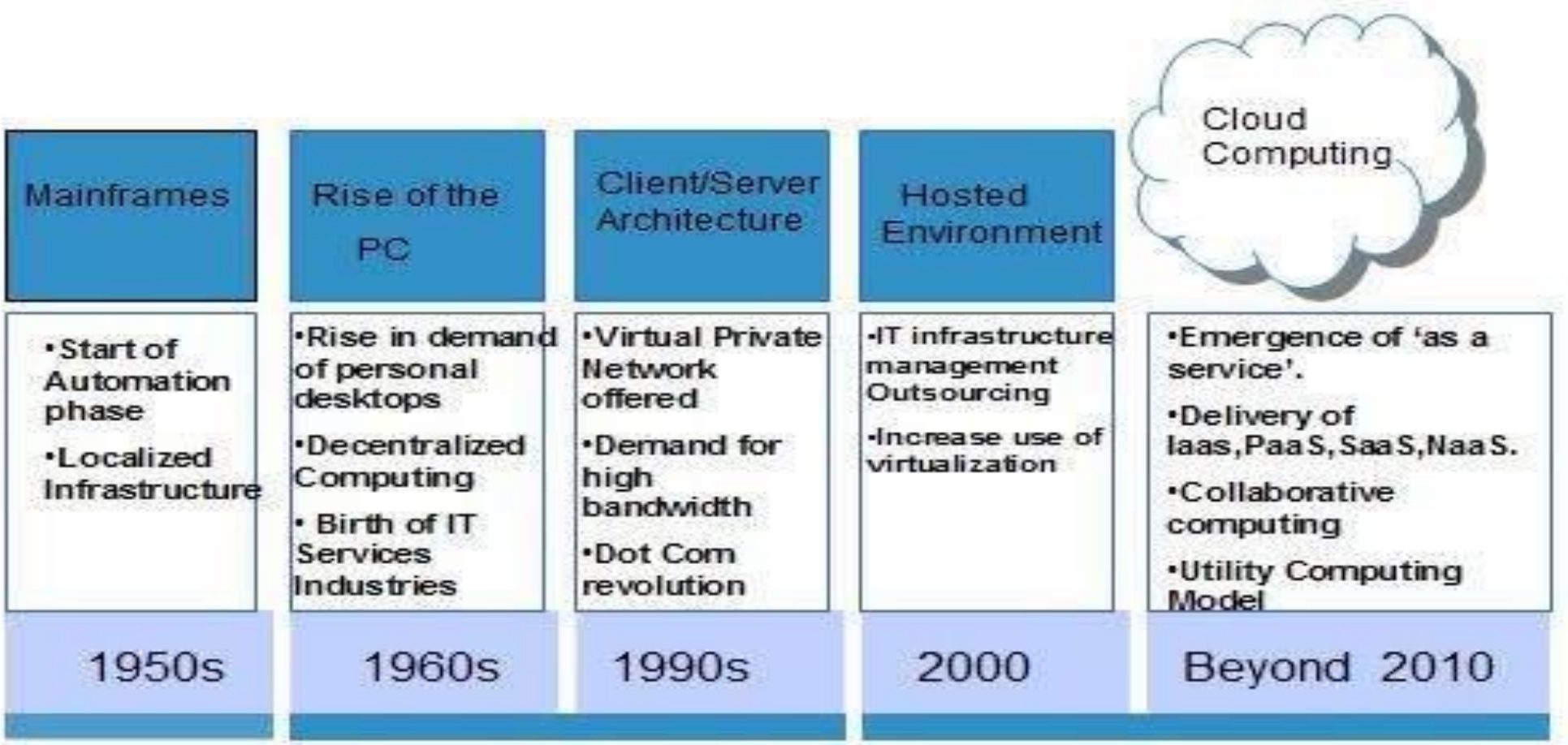
- Cloud saves money, time, and manpower. All resources are shared by the customers.
- There are no additional costs involved because all resources are available in the client–server architectures.
- The cloud is cheaper.

manets

- Ad hoc networks are formed when there is a pressing requirement to set up a network in an area.
- They are defined as a category of wireless networks that use multihop transmissions.
- They are capable of operating without any support from the existing infrastructure. Barring natural disasters, in rural areas, ad hoc networks can be set up easily.
- MANETS stands for Mobile Ad hoc Networks. According to the routing strategy, the routing protocols can be classified as table-driven and source-initiated protocols.
- On the other hand, based on the network structure, they can be classified as flat-routing, hierarchical routing, and geographical position-assisted routing protocols.

history of **Cloud Computing**

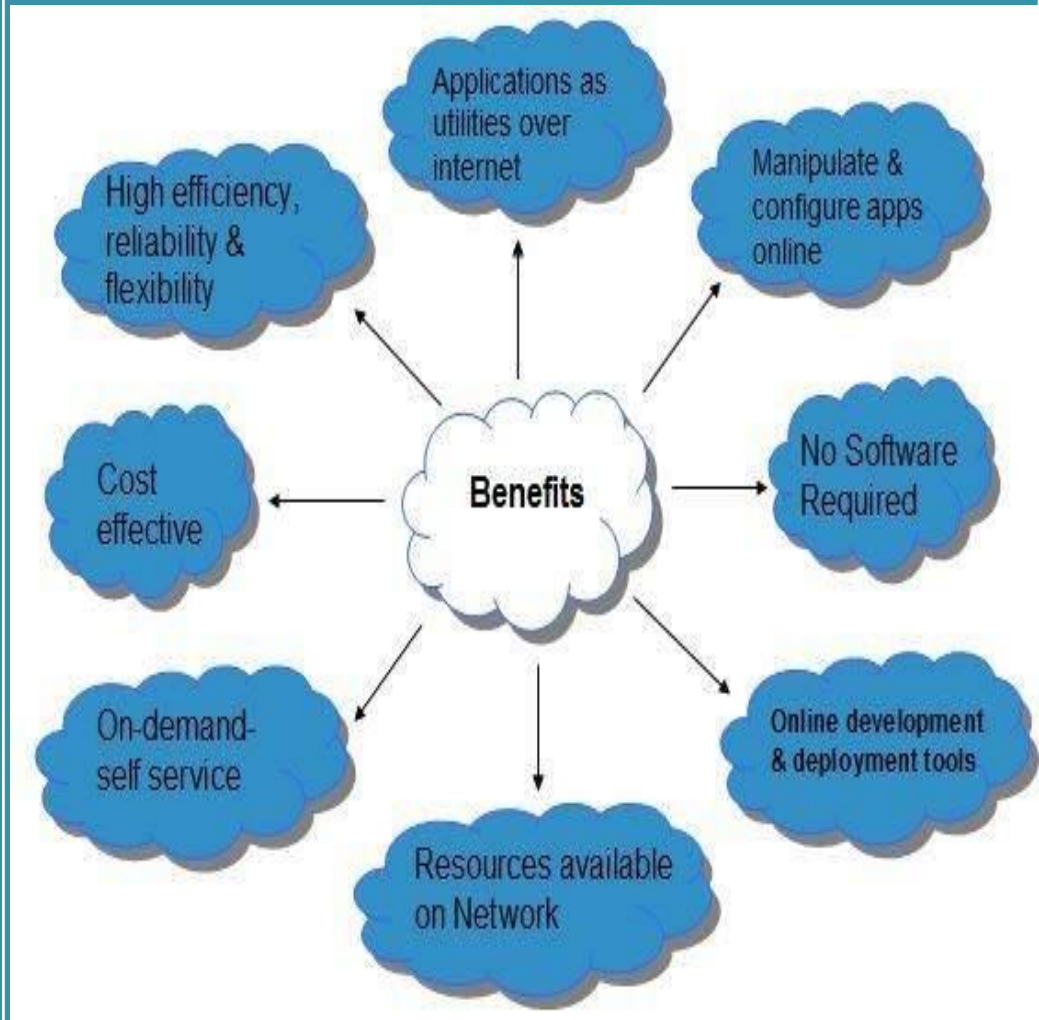
The concept of **Cloud Computing** came into existence in the year 1950 with implementation of mainframe computers, accessible via **thin/static clients.** Since then, cloud computing has been evolved from static clients to dynamic ones and from software to services. The following diagram explains the evolution of cloud computing:



Cloud Computing: benefits

The concept of **Cloud Computing** came into existence in the year 1950 with implementation of mainframe computers, accessible via **thin/static clients.** Since then, cloud computing has been evolved from static clients to dynamic ones and from software to services.

- **One can access applications as utilities, over the Internet.**
- **One can manipulate and configure the applications online at any time.**
- **It does not require to install a software to access or manipulate cloud application.**
- **Cloud Computing offers online development and deployment tools, programming runtime environment through PaaS model.**
- **Cloud resources are available over the network in a manner that provide platform independent access to any type of clients.**
- **Cloud Computing offers on-demand self-service. The resources can be used without interaction with cloud service provider.**
- **Cloud Computing is highly cost effective because it operates at high efficiency with optimum utilization. It just requires an Internet connection**
- **Cloud Computing offers load balancing that makes it more reliable.**



Risks related to Cloud Computing

Security and Privacy

It is the biggest concern about cloud computing. Since data management and infrastructure management in cloud is provided by third-party, it is always a risk to handover the sensitive information to cloud service providers.

Although the cloud computing vendors ensure highly secured password protected accounts, any sign of security breach may result in loss of customers and businesses.

Lock In

It is very difficult for the customers to switch from one **Cloud Service Provider (CSP)** to another. It results in dependency on a particular CSP for service.

Isolation Failure

This risk involves the failure of isolation mechanism that separates storage, memory, and routing between the different tenants.

Risks related to Cloud Computing

Management Interface Compromise

In case of public cloud provider, the customer management interfaces are accessible through the Internet.

Insecure or Incomplete Data Deletion

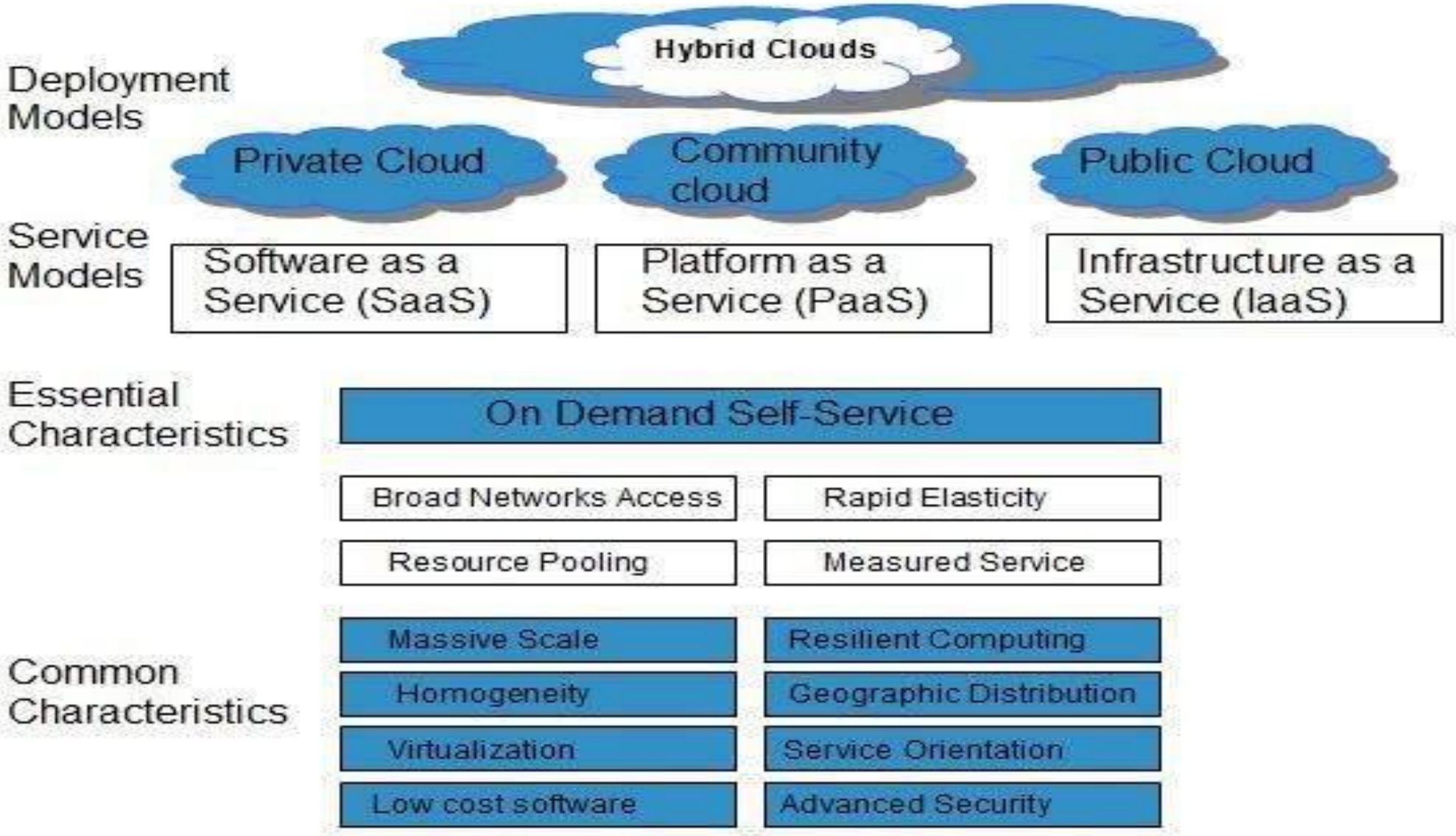
It is possible that the data requested for deletion may not get deleted. It happens because either of the following reasons

Extra copies of data are stored but are not available at the time of deletion Disk that stores data of multiple tenants is destroyed.

vision of Cloud Computing

- ✓ Cloud computing can save money and time.
- ✓ This is the major goal of the cloud. Big companies who provide their customers with cloud services also provide SLA, i.e., Service Level Agreement. We define an SLA as a contract in which the service providing companies agree on a specified level of service
- ✓ The system administrator has a role. They should ensure that the uptime is constant. They can easily achieve this because of the redundancy of cloud computing.
- ✓ Several SLA promote an uptime level of 99.999% but cannot always provide for data redundancy to be commensurate.
- ✓ This problem can be solved by making sure that data integrity is written into the SLA agreement itself to prevent any kind of confusior

Characteristics of Cloud Computing



Characteristics of Cloud Computing

On Demand Self Service

Cloud Computing allows the users to use web services and resources on demand. One can logon to a website at any time and use them.

Broad Network Access

Since cloud computing is completely web based, it can be accessed from anywhere and at any time.

Resource Pooling

Cloud computing allows multiple tenants to share a pool of resources. One can share single physical instance of hardware, database and basic infrastructure.

Rapid Elasticity

It is very easy to scale the resources vertically or horizontally at any time. Scaling of resources means the ability of resources to deal with increasing or decreasing demand.

The resources being used by customers at any given point of time are automatically monitored.

Cloud resiliency

Cloud resiliency is the term used to describe **the ability of a server, storage system, data server, or entire network to both recover and continue operations** without systems connected to the network going down, stopping their function, or losing their operational capabilities.

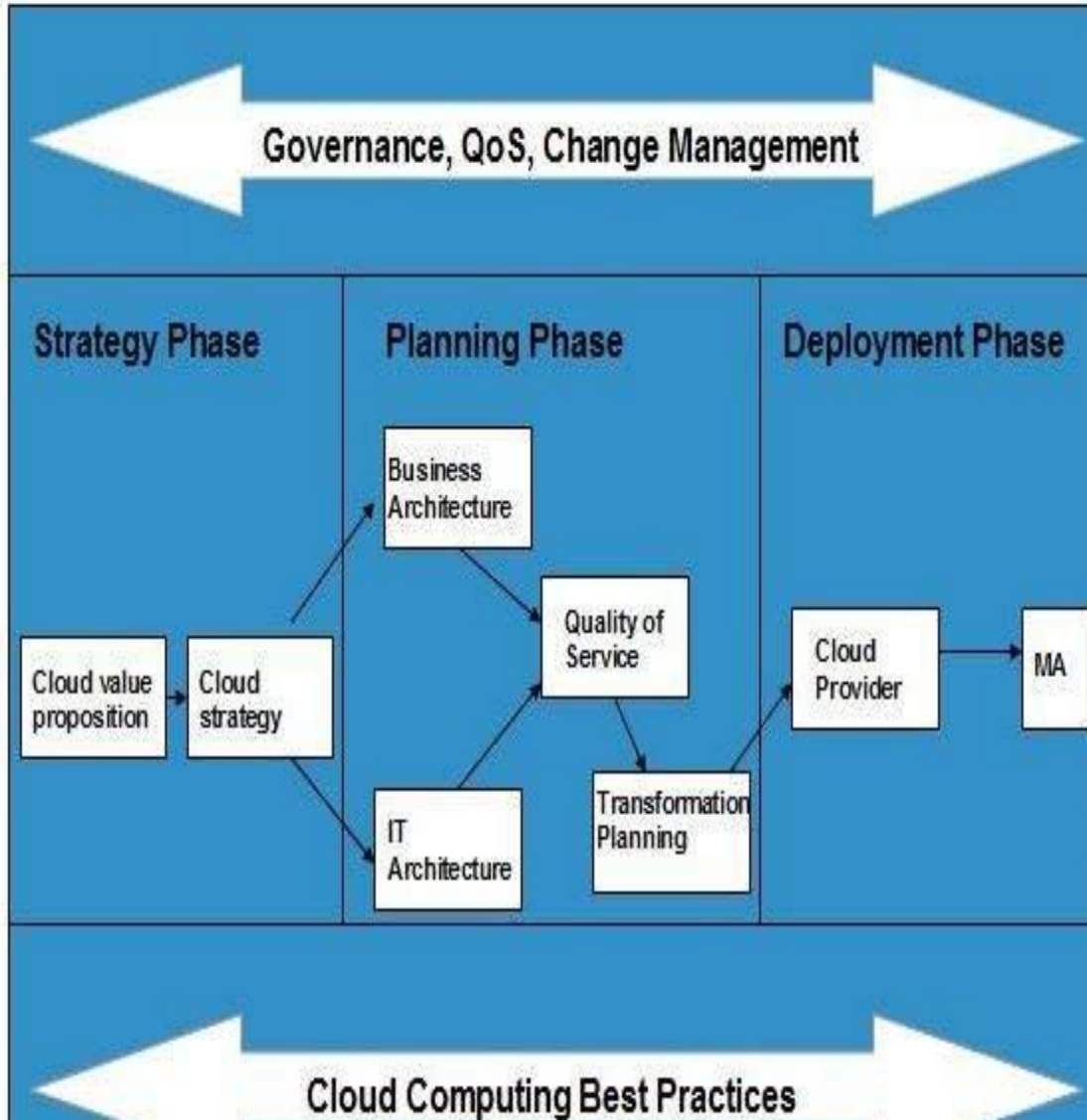
Characteristics of Cloud Computing

- It is possible to measure, manage, and control cloud computing resource practices. The cloud works on a "pay-as-you-go" principle just as our electricity meters work. Thus, you are charged only for the time you are using cloud services.
- Cloud computing is not a quick fix solution. It requires considerable thought before implementing it in an organization.
- It requires a strong foundation of best practices in software development, software architecture, and service management foundations.
- It is user-centric, task-centric, document-centric, powerful, accessible, intelligent, and programmable.
- Cloud computing is not network computing. Nor is it traditional outsourcing.
- It should facilitate a shift from remote data to current data, from applications to tasks and from computer to the user, with the objective of access from any place and sharing it with anyone. Authorized users have instant access.
- The cloud when used with IT will be more beneficial than when used in isolation

Cloud Computing planning

Before deploying applications to cloud, it is necessary to consider your business requirements. Following are the issues one must consider:

- **Data Security and Privacy Requirement**
- **Budget Requirements**
- **Type of cloud - public, private or hybrid**
- **Data backup requirements**
- **Training requirements**
- **Dashboard and reporting requirements**
- **Client access requirements**



Cloud Computing technologies

1. **Virtualization** - It is a technique, which allows to share single physical instance of an application or resource among multiple organizations or tenants (customers). It does this by assigning a logical name to a physical resource and providing a pointer to that physical resource when demanded.
2. **Service-Oriented Architecture (SOA)** **-** Service-Oriented Architecture helps to use applications as a service for other applications regardless the type of vendor, product or technology.

3. Grid Computing - it refers to distributed computing, in which a group of computers from multiple locations are connected with each other to achieve a common objective. These computer resources are heterogeneous and geographically dispersed. Grid Computing breaks complex task into smaller pieces, which are distributed to CPUs that reside within the grid.

4. Utility Computing - Utility computing is based on **Pay-per-Use model.** It offers computational resources on demand as a metered service. Cloud computing, grid computing, and managed IT services are based on the concept of utility computing.

Cloud Computing: reference(service) model

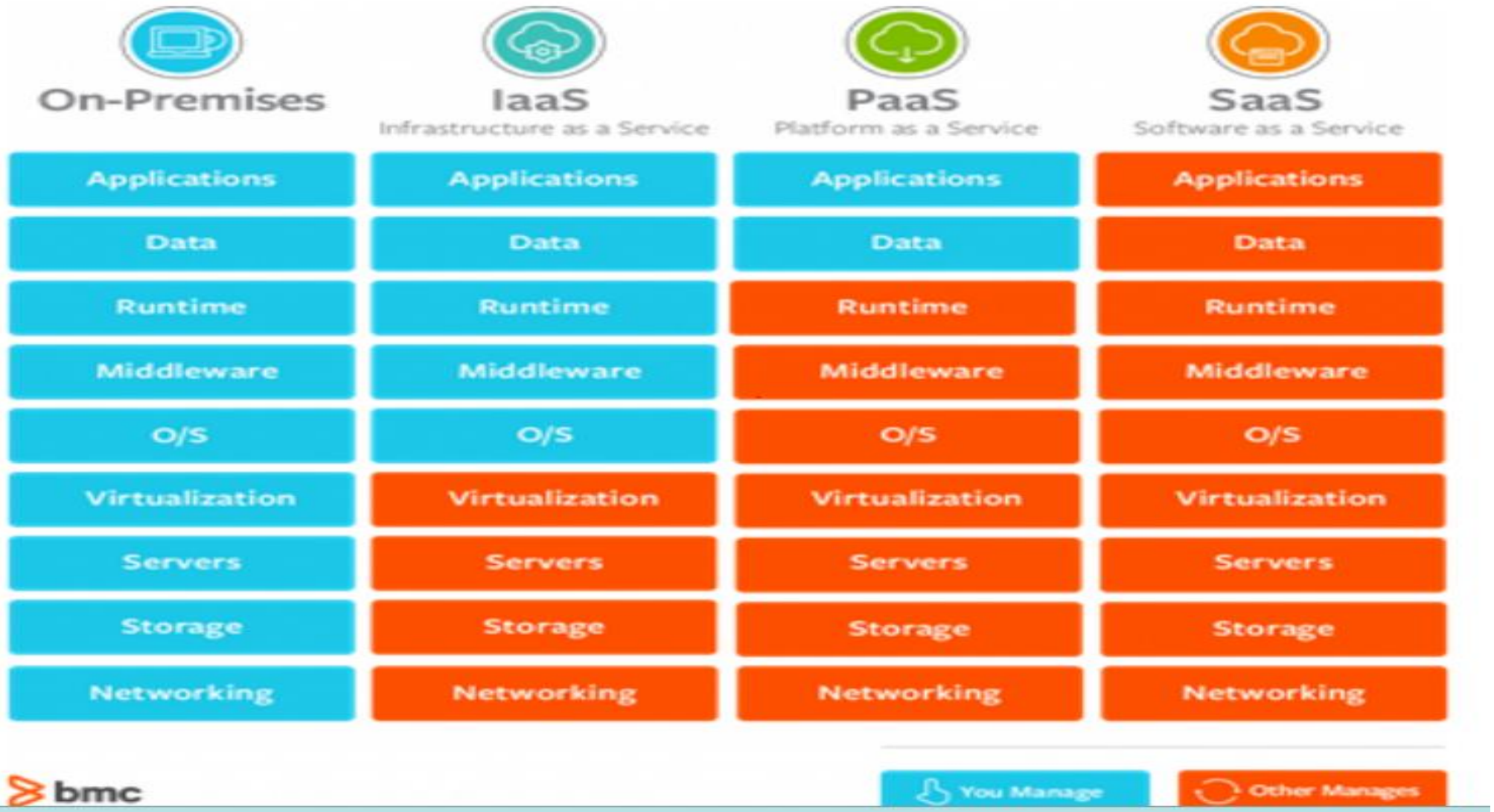
MODEL	EXPLANATION	EXAMPLE
IaaS (Infrastructure As A Service)	The customer gets resources such as processing power, storage, network bandwidth, CPU, and power. Once the user gets the infrastructure, he controls the OS, data, applications, services, host-based security, and so on.	Amazon WebServices(AWS), RackSpace, GoGrid, Verizon, IBM, AT&T, ETC.
PaaS (Platform As A Service)	The customer is provided with the Hardware infrastructure, network, and Operating system to form a hosting environment. The user can install his applications and activate services from the hosting environment.	MS Azure Google App Engine force.com Informatica OnDemand KeyNote System WaveMaker

Cloud Computing: reference(service) model

MODEL	EXPLANATION	EXAMPLE
SaaS (Software As A Service)	The customer/user is provided access to an application. He has no control over the hardware, network, security, or OS.	Salesforce.com Google, MS, Ramco, Zoho

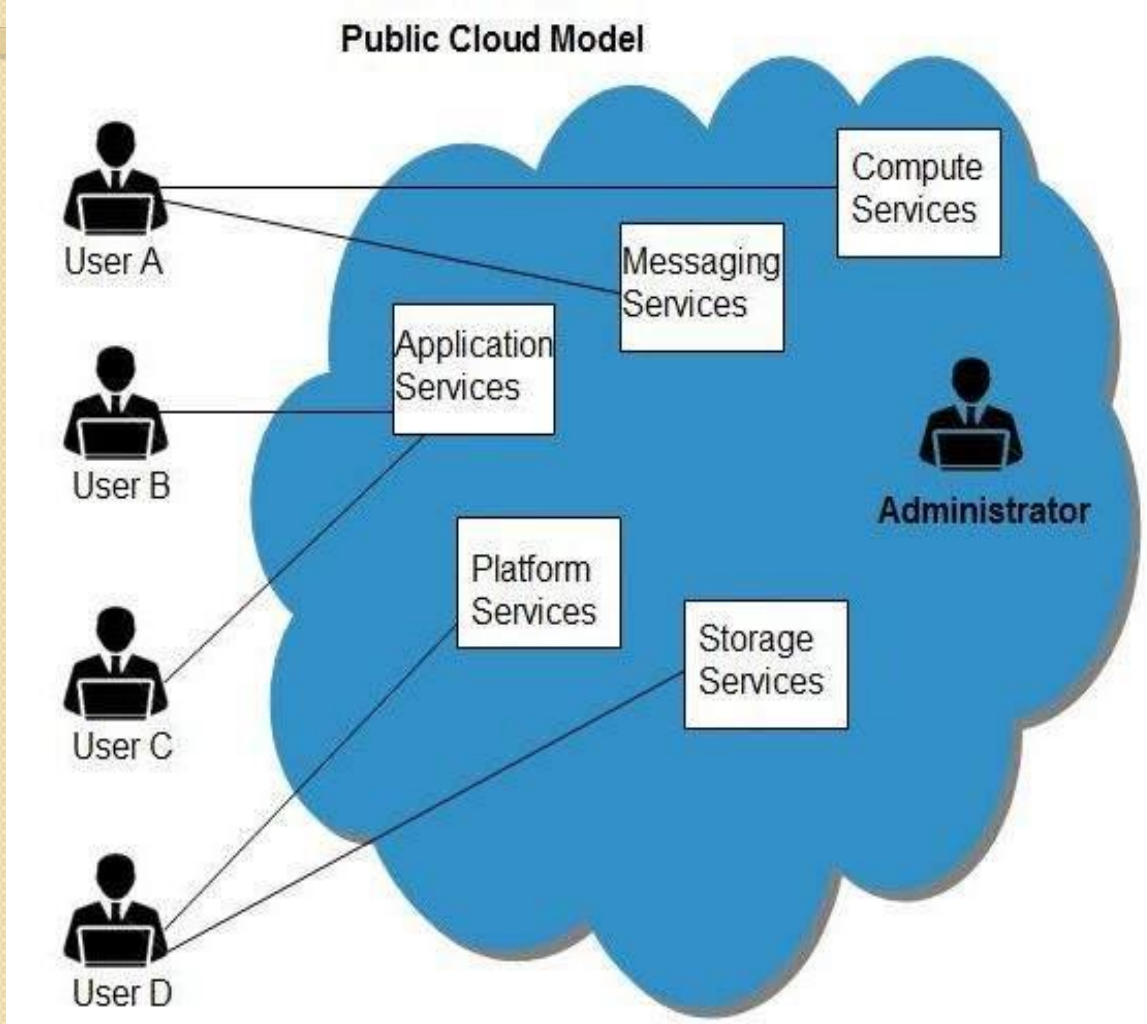
Comparison: Iaas, PaaS, SaaS

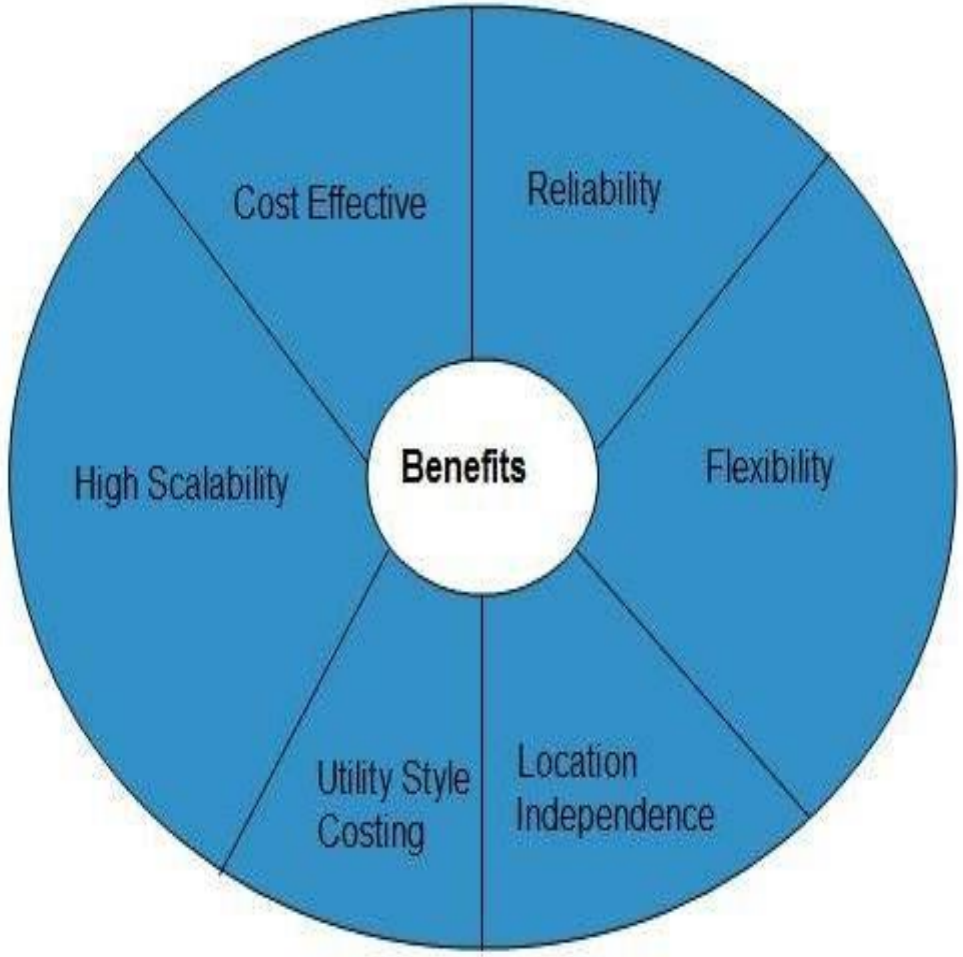
Comparison: Iaas, PaaS, SaaS



Cloud Deployment model: public cloud

Public Cloud allows systems and services to be easily accessible to general public. The IT giants such as **Google, Amazon** and **Microsoft** offe cloud services via Internet.





Cloud Deployment model: public cloud- Benefits

Since **public cloud** shares same resources with large number of customers it turns out inexpensive.

Reliability

The **public cloud** employs large number of resources from different locations. If any of the resources fails, public cloud can employ another one.

Flexibility

The public cloud can smoothly integrate with private cloud, which gives custome a flexible approach.

Cost Effective

Cloud Deployment model: public cloud- Benefits

Location Independence

Public cloud services are delivered through Internet, ensuring location independence.

Utility Style Costing

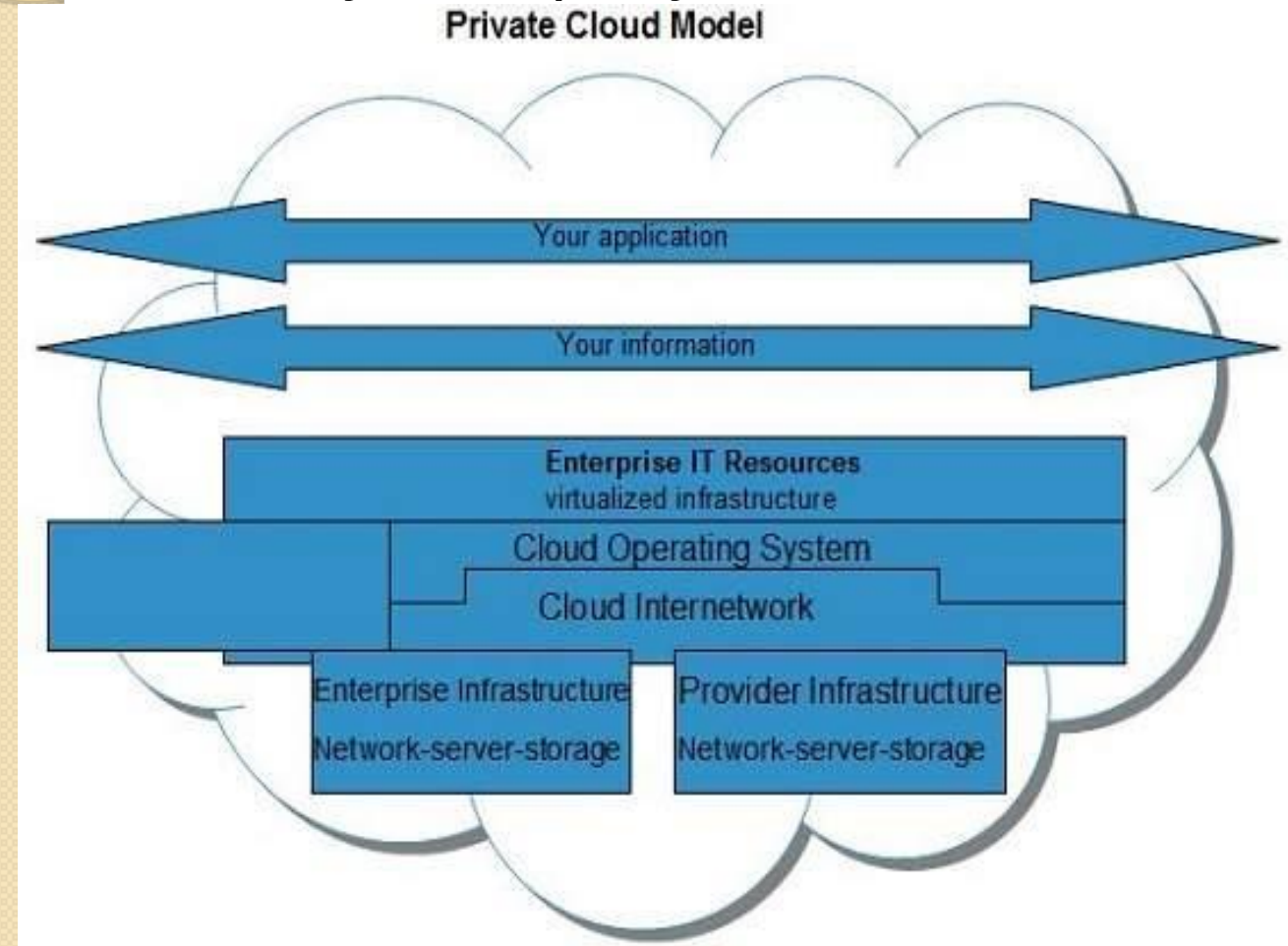
Public cloud is also based on **pay-per-use** model and resources are accessible whenever customer needs them.

High Scalability

Cloud resources are made available on demand from a pool of resources, i.e., the can be scaled up or down according the requirement.

Cloud Deployment model: private cloud

Private Cloud allows systems and services to be accessible within an organization. The Private Cloud is operated only within a single organization. However, it may be managed internally by the organization itself or by third-party.



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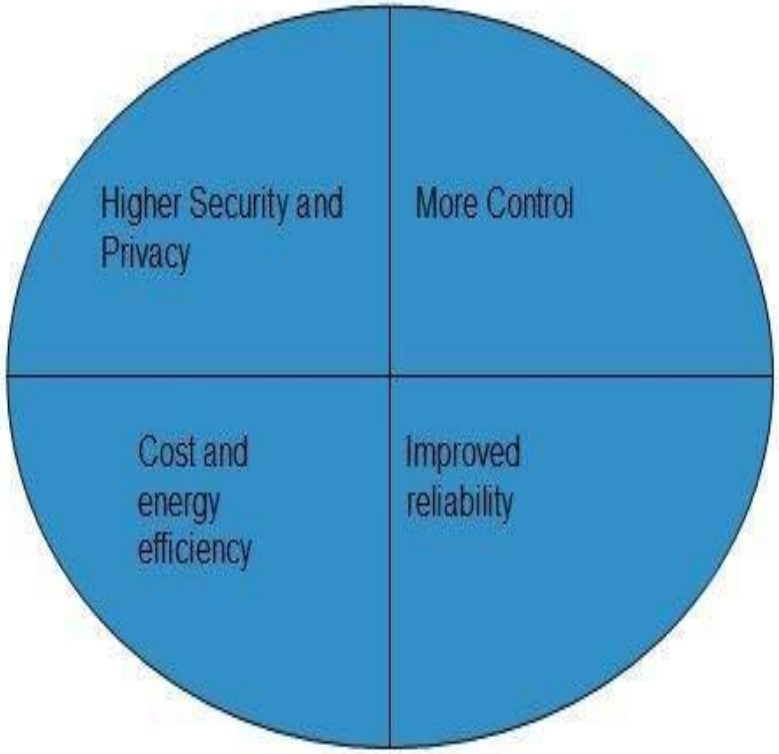


Cloud Deployment model: private cloud- Benefits

High Security and Privacy

- **Private cloud** operations are not available to general public and resource are shared from distinct pool of resources. Therefore, it ensures high **security** and **privacy.**

More Control

The **private cloud** has more control on its resources and hardware than public cloud because it is accessed only within an organization.

Cost and Energy Efficiency

The **private cloud** resources are not as cost effective as resources in public clouds but they offer more efficiency than public cloud resources.

Cloud Deployment model: private cloud- Disadvantages

Restricted Area of Operation

The private cloud is only accessible locally and is very difficult to deploy globally.

High Priced

Purchasing new hardware in order to fulfill the demand is a costly transaction.

Limited Scalability

The private cloud can be scaled only within capacity of internal hosted resources.

Additional Skills

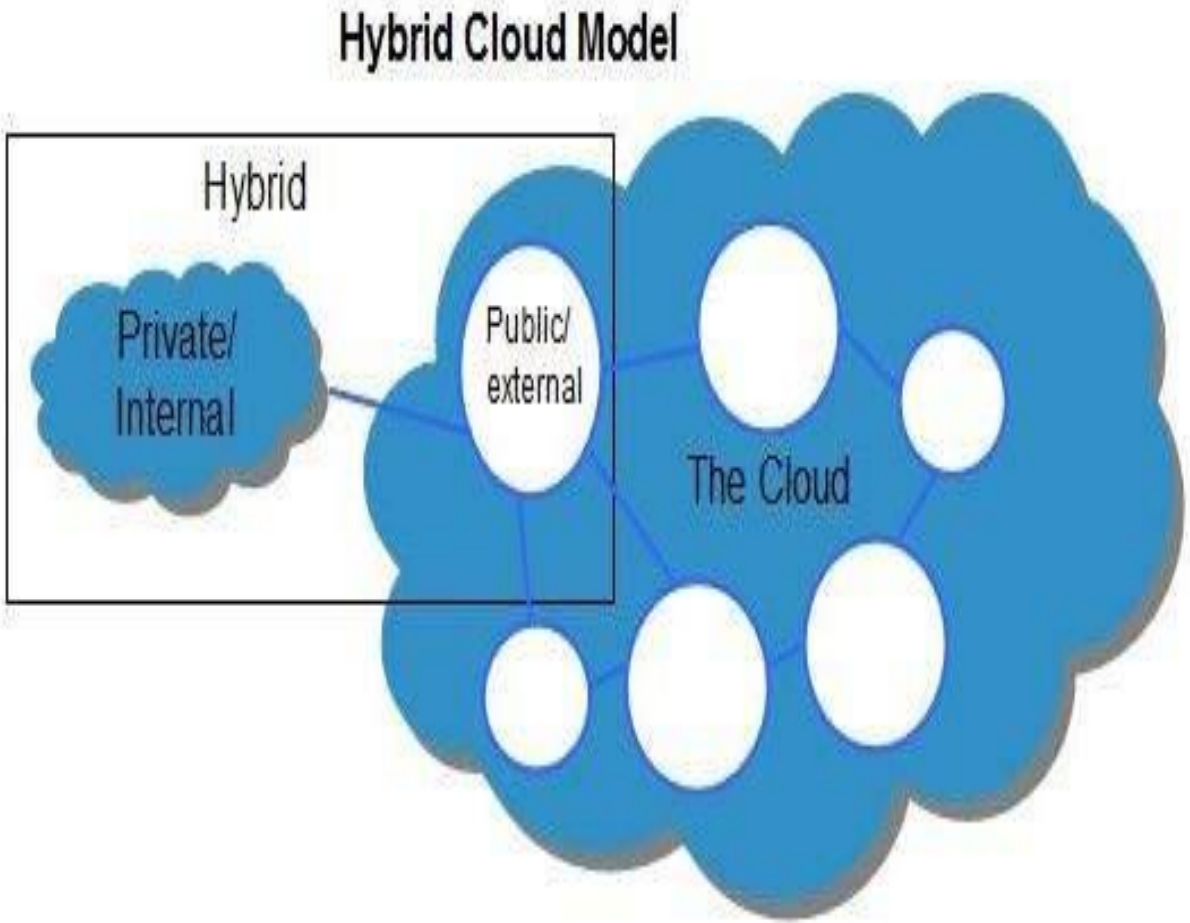
In order to maintain cloud deployment, organization requires skilled expertise.

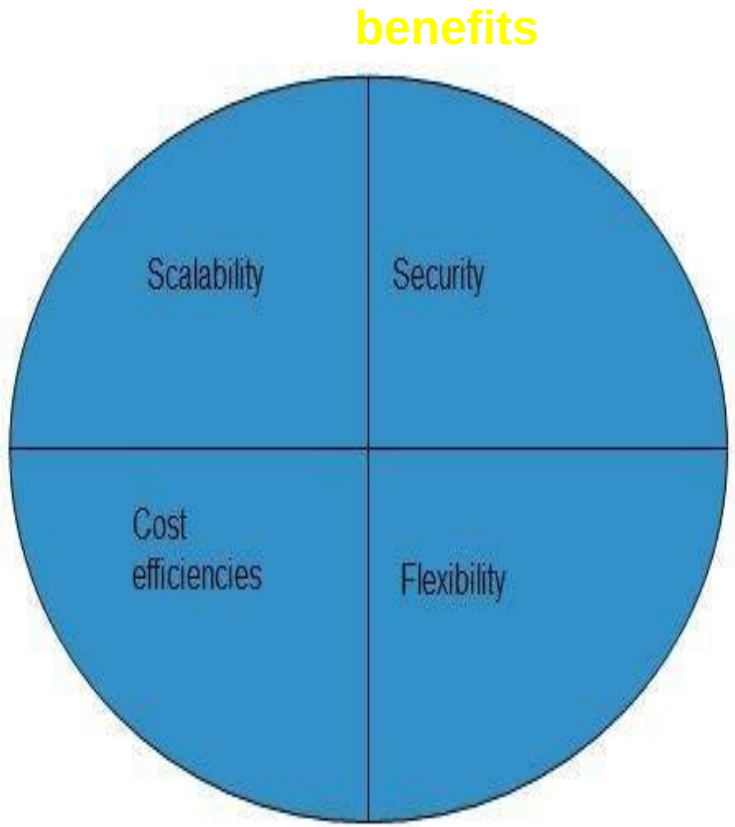
Private Vs public cloud

Public Cloud	Private Cloud
1. Its owner is the cloud provider or third party.	1. Its owner is solely the organization.
2. It involves lower costs.	2. It involves more costs.
3. Scalability is on demand and unlimited.	3. Scalability is limited to the infrastructure installed.
4. Less security.	4. Higher security.
5. Testing it is difficult because everything is public.	5. Testing is easier because it is a private cloud.
6. Performance is difficult to achieve.	6. Its performance is guaranteed.
7. Less management and control is needed because it works on the concept of virtualization.	7. More management and control is needed because it has a higher level of control over resources.

Cloud Deployment model: hybrid cloud

Hybrid Cloud is a mixture of **public** and **private** cloud. Non-critical activities are performed using public cloud while the critical activities are performed using private cloud.





Cloud Deployment model: hybrid cloud- Benefits

Scalability

It offers features of both, the public cloud scalability and the private cloud scalability.

Flexibility

It offers secure resources and scalable public resources.

Cost Efficiency

Public clouds are more cost effective than private ones. Therefore, hybrid clouds can be cost saving.

Security

The private cloud in hybrid cloud ensures higher degree of security.

Cloud Deployment model: hybrid cloud-disadvantage

Networking Issues

Networking becomes complex due to presence of private and public cloud.

Security Compliance

It is necessary to ensure that cloud services are compliant with security policies of the organization.

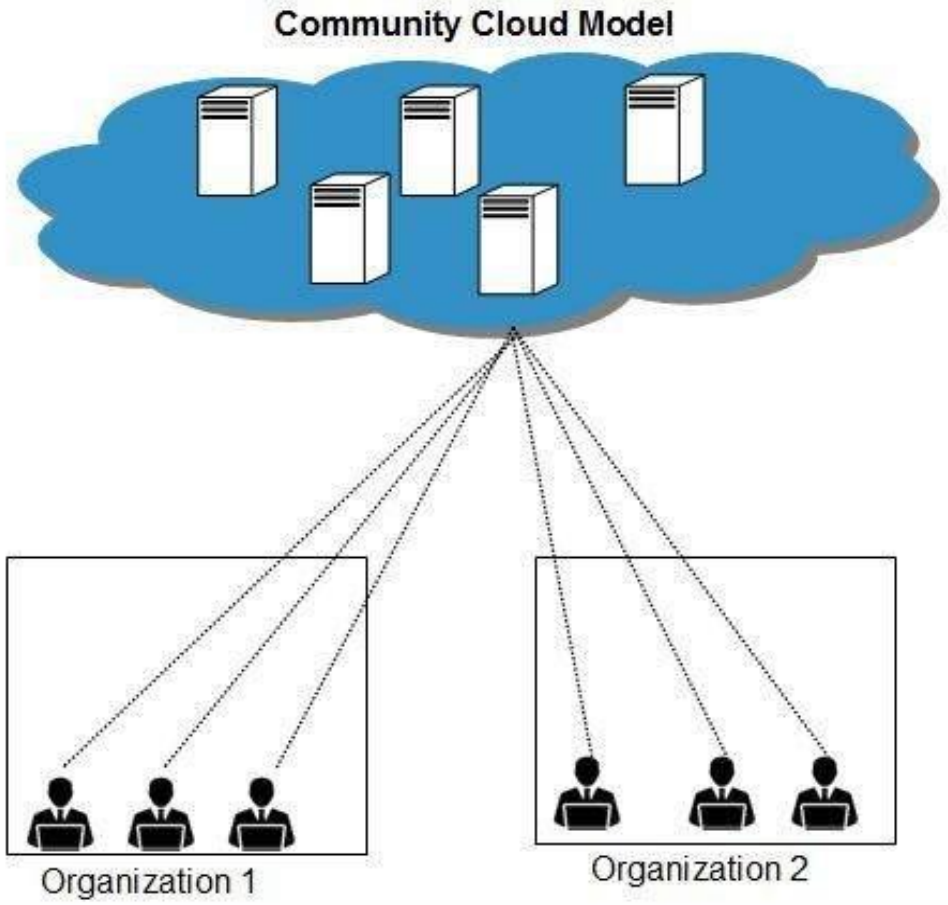
I

nfrastructure Dependency

The **hybrid cloud model** is dependent on internal IT infrastructure, therefore it is necessary to ensure redundancy across data centers.

Cloud Deployment model: community cloud

Community Cloud allows system and services to be accessible by group of organizations. It shares the infrastructure between several organizations from a specific community. It may be managed internally by organizations or by the third-party.



Cloud Deployment model: community cloud- Benefits and issues

Cost Effective

Community cloud offers same advantages as that of private cloud at low cost.

Sharing Among Organizations

Community cloud provides an infrastructure to share cloud resources and capabilities among several organizations.

Security

The community cloud is comparatively more secure than the public cloud but less secured than the private cloud.

Issues

Since all data is located at one place, one must be careful in storing data in community cloud because it might be accessible to others.

the cloud: dynamic infrastructure applications

Benefits of Dynamic Infrastructures:

- ✓ Enhancing performance
- ✓ Scalability
- ✓ System availability and uptime
- ✓ Better server utilizations
- ✓ Performing routine maintenance of physical or virtual systems
- ✓ Mitigating interruption to business operations
- ✓ Reducing IT costs
- ✓ Providing business continuity

Note: For networking companies, Infrastructure 2.0 refers to the ability of networks to keep up with the movement and scale requirements of new enterprise IT initiatives, like virtualization and cloud computing. As per the reports of big companies like Cisco, F5 Networks, and Infoblox, network automation and connectivity intelligence between networks, applications, and endpoints will be required to reap the full benefits of virtualization and cloud computing.

dynamic infrastructure applications

1. Transportation companies can optimize their vehicle's routes leveraging GPS and traffic information.

2. Technology systems can be optimized for energy efficiency, managing spikes in demand, and ensuring disaster recovery readiness.

3. Utility companies can reduce energy with a "smart grid."

Gartner et al. reports that:

1. Virtualized applications can reduce the cost of testing, packaging, and supporting an application by 60% and that they reduced overall TCO by 5% to 7% in their model.

2. Green issues are the primary driver in 10% of current data center outsourcing and hosting initiatives. Cost reduction initiatives are a driver of 47% of the time and are now aligned well with green goals. Furthermore, combining these two means that at least 57% of data center outsourcing and hosting initiatives are driven by going green.

3. They also report that by 2013, more than 50% of midsize organizations and more than 75% of large enterprises will implement layered recovery architectures.

why to adopt cloud?

1. Reduced organizational cost (a pay-as-you-go model is used)
2. Better storage
3. More automation
4. Better flexibility
5. Better mobility
6. Better IT personnel utilization
7. More security
8. Better investment
9. Better service
10. No need for software installations
11. Shorter deployment times needed
12. Better Customer Relationship Management (CRM)

Cloud Orchestration

Cloud Orchestration is the process of automating the tasks needed to manage connections and operations of workloads on private and public clouds. Cloud orchestration technologies integrate automated tasks and processes into a workflow to perform specific business functions.[vmware.com]

Cloud orchestration tools entail policy enforcement and ensure that processes have the proper permission to execute or connect to a workload. Typical cloud orchestration tasks are to provision or start server workloads, provision storage capacity as needed, and instantiate virtual machines (VMs) by orchestrating services, workloads, and resources in the cloud.

The rapid adoption of containerized, micro-services based applications that communicate via APIs has created the demand for automation of deploying and managing applications across the cloud. As organizations increasingly adopt a hybrid cloud architecture, the need for both public cloud orchestration and hybrid cloud orchestration has continued to grow.

Most importantly, cloud orchestration reduces the need for IT staff to manually handle automation tasks, freeing up resources for more productive

what is the need of Cloud Orchestration

The rapid adoption of containerized, micro-services based applications that communicate via APIs has created the demand for automation of deploying and managing applications across the cloud. This increasing complexity has created the demand for cloud orchestration software that can manage the myriad dependencies across multiple clouds, with policy-driven security and management capabilities.

Most importantly, cloud orchestration reduces the need for IT staff to manually handle automation tasks, freeing up resources for more productive works.

Cloud Orchestration softwares

1. Salt stack
2. Ansible
3. Kubernetes
4. Google cloud run

Cloud Orchestration Vs automation

1. **Orchestration is automating many tasks together**. It's automation not of a single task but an entire IT-driven process. Orchestrating a process, then, is automating a series of individual tasks to work together. If orchestration sounds more fancier than automation, that's because it is—at least it is more complex.

cloud computing: advantages

1. **Resource Management:** When you deploy your application and services to the cloud, the necessary virtual machines, network bandwidth, and other infrastructure resources are provided for you. If machines go down for hardware updates or because of unexpected failures, the cloud locates new virtual machines for your application automatically. Because you will *only pay for what you use*, you can start with a smaller investment.

2. Dynamic Scaling: It is also known as *elastic scaling*. With cloud services, you create roles that work together to implement your application logic. For example, one web role could host the ASP.NET front end of your application. One or more worker roles could perform necessary background tasks. One or more virtual machines hosting each role are called *role instances*. Requests are load balanced across these instances. In this scenario, as resource demands increase, you can provision new role instances to handle the load.

cloud computing: advantages

3. Highly Available Services: Say, there is an online store that is deployed in MS Azure. Note that because this online store is a revenue generator, it is important and critical to keep it up and running. To achieve this objective, the Azure data center performs service monitoring and automatic instance management. The online store must also stay responsive to customer demand. The elastic scaling ability of MS Azure accomplishes this. During peak shopping times, new instances can come online to handle the increased usage. Additionally, the online store must not lose orders. Both MS Azure and the Azure SQL Database provide highly available and durable storage options to hold the order details and state throughout the order life cycle. For the highest level of availability, you can deploy the same application to multiple MS Azure regions.

4. Periodic Workloads: These workloads include some applications like a demo or a utility application that you want to make available for only several days or weeks. They do not have to be run continuously. MS Azure allows you to easily create, deploy, and share that application. Once this purpose is achieved, you can remove the application and you are charged only for the time it was deployed. E.g.- complex sales data analysis app.

cloud computing: advantages

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cloud computing: advantages

5. **Workload Spikes:** This workload pattern also works on the principle of elastic scale, as explained earlier. Consider the example of a sports news portal once again. Now, even because its business is steadily growing, there is still the possibility of temporary spikes or bursts of activity. For example, assume that another popular news outlet refers to the site. This means that the number of visitors to the site could dramatically increase in a single day.

Example: Consider a service that processes daily reports at the end of the day. When the business day closes, each office sends in a report that the company headquarters processes. Because the process is only active a few hours each day, it is also a candidate for elastic scaling and deployment. MS Azure is suitable for temporarily scaling out an application to handle load spikes and then scaling back after the event has passed.

cloud computing: advantages

6. Resource management, dynamic scaling, and high availability and durability are some of the main advantages of running applications in the cloud.

7. To ensure the highest levels of availability, for managing unpredictable growth and for handling workload spikes, MS Azure is preferred.

8. Quick service, safe and secure service, multiple user access, a development environment, and unlimited storage are some of its benefits.

9. Fewer operational issues, more reliability, more flexibility, innovation, and easier communication among teams and customers are real advantages.

cloud computing: applications

1. The cloud can be used with web and mobile applications easily because these applications a n -99e easily scalable.
2. Cloud testing can be done using constantly configured resources, lower expenditure, and fewer release cycles.
3. Gaming applications can be easily implemented in the cloud.
4. ECG analysis can easily be done in the cloud.
5. Studying protein structures.
6. Satellite image processing.
7. The cloud takes CRM and ERP to the next level.
8. Social networking is very common nowadays. Thus, social cloud architecture is now available in the literature. In the social cloud, services can be mapped to particular users through Facebook identification.

COMPONENTS OF CLOUDS—LOGICAL REFERENCE MODEL

The Cloud Computing Reference Model (CCRM) consists of four supporting models as follows:

(a) **Cloud Enablement Model:** This is the core model of the CCRM. It explains the fundamental technology tiers of cloud computing capabilities provided by the cloud platform and cloud service providers to potential consumers of cloud-enabled technology.

(b) **Cloud Deployment Model:** This model describes the range of cloud deployment scenarios available to your enterprise—internal/private cloud, external/public cloud, hybrid/integrated cloud, and community or vertical cloud. These deployment scenarios may be mixed and matched.

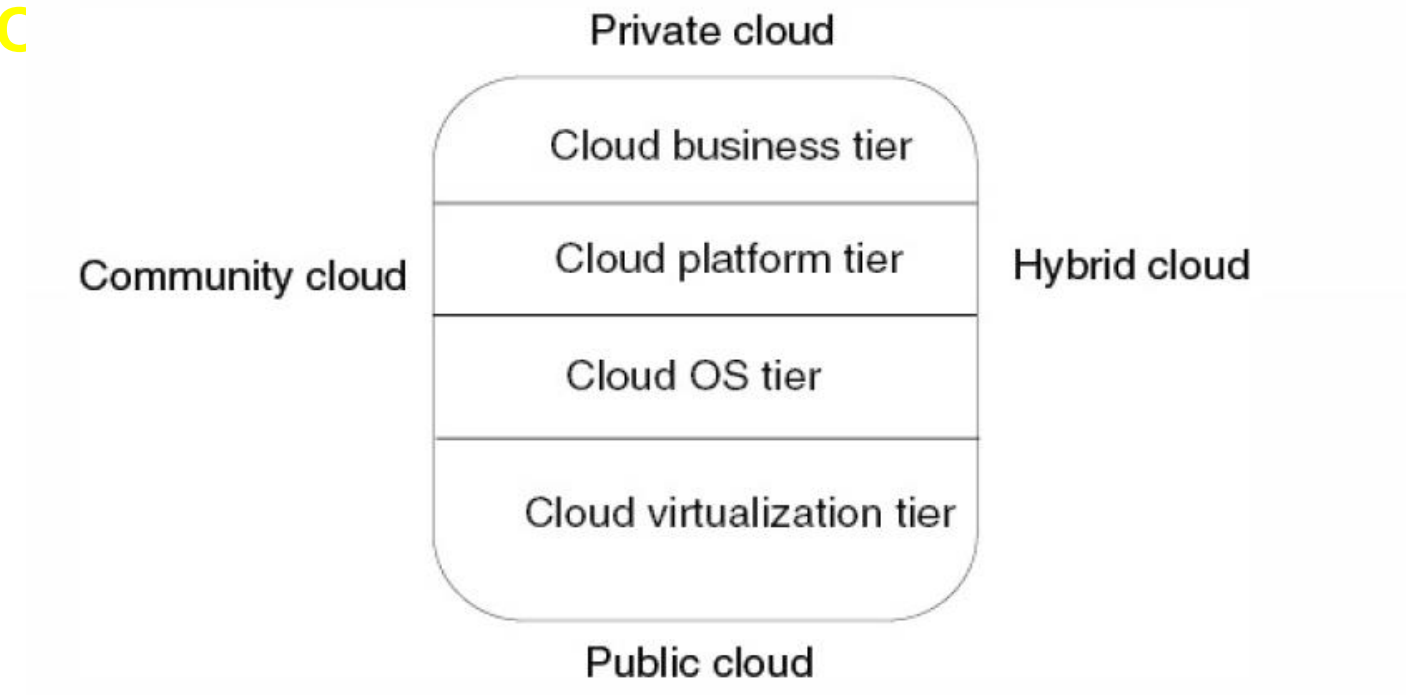
(c) **Cloud Governance and Operations Model:** This model describes the governance, security operations, support, management, and monitoring requirements for cloud computing to ensure that you have considered all of the potential operational risks for adopting the cloud for your organization

COMPONENTS OF CLOUDS—LOGICAL REFERENCE MODEL

Cloud Ecosystem Model: This model considers the requirements of developing and

sustaining a cloud ecosystem comprised of cloud providers, cloud consumers, and cloud intermediaries, as well as the cloud network and *cloud dial tone* necessary to ensure that the cloud is always there for you.

C



Main COMPONENTS of ccrm

1. **Cloud Enablement Model:**
   - Cloud virtualization tier
   - Cloud operating system tier
   - Cloud platform tier
   - Cloud business tier

2. **Cloud Deployment Model:**
   - Internal/private cloud
   - External/public cloud
   - Hybrid/integrated cloud
   - Community/vertical/shared by a community

3. **Cloud Governance and Operations Model**
   - Governance, culture, and behavior
   - Security and privacy
   - Management and monitoring
   - Operations and support

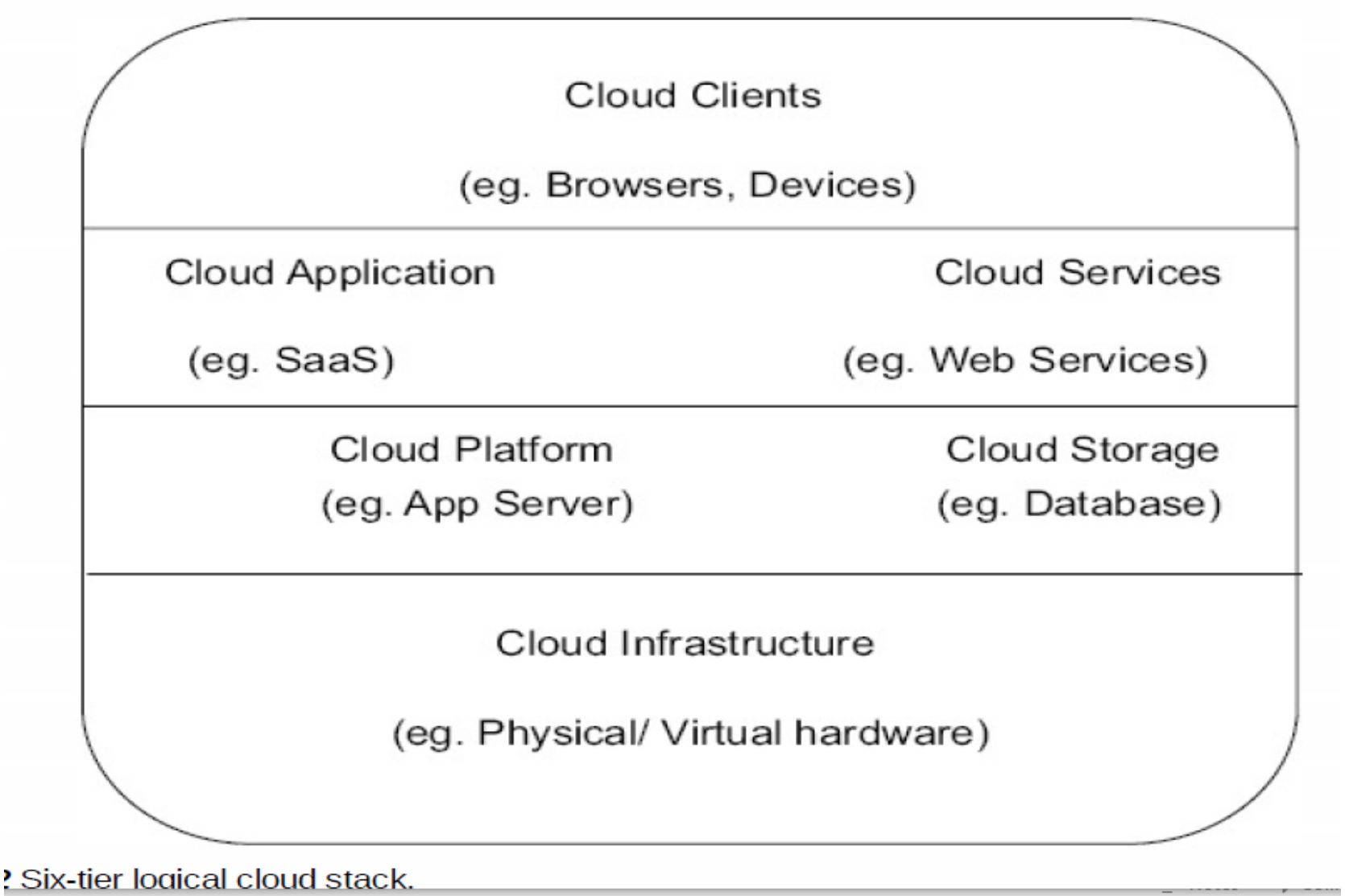
4. **Cloud Ecosystem Model:**
   - Cloud network/dial tone
   - Cloud ecosystem enablement
   - Cloud consumers and cloud providers
   - Cloud physical access, integration, and distribution

Logical Architecture Foundation

- The logical architecture of the cloud first requires that we separate the layers of the cloud architecture.
- NIST provides us with a cloud reference architecture.
- According to NIST, it is a high-level model consisting of three tiers of cloud capabilities “as-a-service.”
- NIST specifies that there are three categories of the cloud:
  1. infrastructure
  2. platform,
  3. software—all as a “service” architecture.

Logical Architecture Foundation

Figure : the NIST architecture



? Six-tier logical cloud stack.

Logical Architecture Foundation

1. **Cloud Physical Tier:** This tier provides the physical computing, storage, network, and security resources that are virtualized and cloud enabled to support cloud requirements. It is important to understand that this physical tier provides the substrate on which cloud virtualization technologies and cloud operating system platforms are built to enable higher-order cloud patterns to be realized.
2. **Cloud Virtualization Tier:** This tier provides core physical hardware virtualization and provides a potentially useful foundation for cloud computing.
3. **Cloud Operating System Tier:** This tier provides the cloud computing “fabric” as well as application virtualization, core cloud provisioning, metering, billing, load balancing, workflow, and related functionality typical of cloud platforms. This tier is represented by a wide variety of new cloud platforms and cloud enablement technologies.

Logical Architecture Foundation

4. Cloud Platform Tier: This tier provides technical solutions, application and messaging middleware, application servers, and so on, that comprise cloud and/or application platforms as well as pre-integrated cloud and application platforms themselves, offered via PaaS delivery models.

5. Cloud Business Tier: This tier comprises the business or mission exploitation of cloud enabled business applications, software, data, content, knowledge, and the associated analysis frameworks and other cloud consumption models that facilitate and enable end user business value from the cloud consumer's ability to access, bind, and consume cloud capabilities.

Cloud DBMS(CDBMS)

- Cloud Database Management Systems (CDBMSs) are defined as distributed databases that provide computing as a service but not a product. The challenge is to manage persistent data.
- The challenge is bigger now because database servers existing in the cloud are less reliable (can fail easily). When this happens then files related to DBMS may also become corrupted.
- However, it is easier to recover a server from a failure in a virtualized environment than in a physical environment. This is because the database administrator can simply replace the

  corrupt image with a new instance from the database machine image.

Two techniques may be used here:

(a) Clustering

(b) Replication

Cloud DBMS(CDBMS)

Clustering

- This is a technique where multiple (many) database servers will work together as a single logical database server in a clustered database environment.
- It is very complex and also more costly.
- It requires an expert database administrator (DBA).
- The advantage here is that the database clients do not know when a node fails and they can continue operating.
- It depends on the clusters.
- It is important to note that the more complex the clustering is, the more potential points of failure there will be.
- Even if there is dynamic assignment of IP addresses within the cloud, new issues will arise.

replication

- This technique is where the database is replicated and it contains a main server known as a *database master.*
- It is an alternative to the clustering technique.
- A single database server, the database master, replicates the data to one or more database slaves.
- The client applications performs write transactions to the database master.
- The transactions that become successful are then reflected to the database servers.
- The advantage here is that it is easy to implement replication without also requiring a large numbers of servers.
- However, clustering is more reliable than the replication method. This is because with the replication method, if the master-database

Characteristics of saas

1. The customers rent software that is hosted by the vendor such as Microsoft or Amazon, and so on.
2. An Internet connection is required here.
4. All customers can use the same software version.
5. Global accessibility and easier administration are some of its benefits.
6. Tasks like software deployment, software maintenance (changes), cloud software testing, patching, and so on, are all managed by the provider.
7. In a nutshell, SaaS is what a provider hosts as software (service) that is centrally located and that can be made easily available to customers via the Internet on a pay-per-use basis.
8. Thus, commercial software is accessible through the web.
9. APIs allow for integration between different pieces of software.

Characteristics of saas

10. Security is a serious issue here because all the data is available in the cloud.
11. There is slow switching between different SaaS vendors.
12. Time critical applications, that is, applications that demand response time in milliseconds, are not benefited by SaaS.
13. Multi-tenancy means sharing of the resources by many users. SaaS has two modes— simple multi-tenancy and fine-grained multi-tenancy. In the simple multi-tenancy case, every user has their own resources, which are different from other users. On the other hand, in fine-grained multi-tenancy all resources are shared except customer-related data.
14. Web applications like blogs, social networks, web content management, and WIKI services are all applications of SaaS only.
15. Enterprise services like desktop software, workflow management, supply chainmanagement, and CRM are all applications of SaaS only.

Characteristics of saas

16. Clients are very much interested in moving their applications to SaaS platforms because they can reduce their monitoring of many servers.

17. In the SaaS cloud, the vendor supplies the hardware infrastructure, software, and applications. The customer interacts with the application through a portal.

18. Some SaaS providers include MS Live CRM, MS Azure, Google Apps, Trend Micro, Symantec, and Zoho.

21. Applications reside on top of the cloud stack. Services are provided by this layer. These services can be accessed by the end users through web portals. Conventional applications like MS Word, MS Excel, and so on, are accessed as a service on the web in real time.

22. Salesforce.com relies on the SaaS model only. It offers business productivity applications that reside fully on their servers. Thus, customers can customize according to their needs in real time.

what is paas?

- In this model, the developer creates software using tools and the other utilities of a cloud provider. For example, websites are designed, developed, and hosted on the cloud.
- PaaS fills the needs of those who want to build and run custom applications as services.
- PaaS offers hosted application servers that have near-finite scalability owing to their reliance on large resource pools.
- PaaS also offers the necessary supporting services such as storage, security, integration, infrastructure, and development tools for a complet platform.
- A service provider offers a preconfigured, virtualized application server environment to which applications can be deployed by the development staff.

Paas: A case study on accuweather

- This company provides weather forecasts. It needed better solutions to handle more than 4 billion daily data requests. To increase scalability, the company began delivering content from the cloud on the Windows Azure platform(or GCP – app engine, a paas).

As a result, the company could bring in the downtime required for development and proofs of concept without worrying about provisional infrastructure. It also gained on-demand scalability, improved access to real-time weather data, and cut IT costs by up to 40%.

The vice president of the company stated, “With MS Azure we gained velocity because we can be innovative without worrying about complex infrastructure. A proof of concept that might have taken three months to execute, but now it takes three days.”

Characteristics of Paas

1. It provides hardware, OS, storage, and network capacity on a pay-per-use basis via Internet only.
2. It provides services for application development and deployment.
3. It allows users to create web applications rapidly. There is no overhead for the cost and complexity of buying and hardware/software management.
4. It is used to build multi-tenant applications, that is, services that can be accessed by multiple users simultaneously.
5. The applications can be deployed on the cloud using tools and different programming languages supported by a particular provider. The web developer will simply write the code using PaaS services. It is the job of the PaaS provider to upload that code and make it online available through the Internet.
6. There is more security because customer environments are separated from each other.

Characteristics of Paas

8. Google App Engine (GAE), LongJump, Force.com, WaveMaker, MS Azure, and CloudBees are some of the PaaS providers.

9. The main aim of the GAE is to run the user's web application efficiently. It maintains Java-Runtime-Environments (JRE) and Python on the application servers. It includes simple APIs to access Google services. Now applications are able to integrate data services and other GAE services like email, image storage, and so on.

10. MS Azure offers a service called *SQL Azure* that stores data in the cloud.

11. When looking for a PaaS provider, the basic goal should be reduced time-to-market and not cost savings. Other factors like high availability, security, and scalability are also vital for developers and cloud testers.

12. A good PaaS environment should support caching for cloud resources because it increases performance. This functionality needs APIs to put an object or a resource in the cache.

13. Hadoop software enables applications to work easily with thousands of nodes and petabytes of data and is based on Java. PaaS must be able to monitor such operations.

What is iaas?

- IaaS is a model where the cloud provides both hardware and software.
- IaaS can be compared to the creation of Virtual Machines (VM) on the cloud infrastructure.
- With VM's one can launch Windows Server, MS SQL Server, Oracle, MangoDB, SharePoint Server, and Linux in minutes and then scale up from one to thousands of VM instances.
- VM's can be used on-demand to get a scalable compute infrastructure when you need flexible resources.
- It is also possible to create VMs that run Windows, Linux, and enterprise applications or capture your own images to create custom VM's.
- customers like Webzeb, Telenor, Avanade, Toyota, and so on, are using VM's over the **MS Azure** platform.

Iaas: A case study on Telenor and toyota

1. Using MS Azure-based VMs, the Telenor company has dramatically reduced the costs needed for test, development, and demo environments, reduced the time to make the environments

available to the project, and saved on long-term investments in hardware that would have only needed to be used in the short term.

2. Toyota is a company that has 16 websites that deliver more than 100 million page views per month. To enhance site content, increase scalability, and reduce the cost of ownership, Toyota is rebuilding the site using the MS Azure cloud development environment.

Characteristics of iaas

1. This service provider owns the required equipment and is responsible for configuring, running, and maintaining it.

2. It is defined as a process for making available cloud computing infrastructure resources, that is, servers, storage, network, and operating systems as an on-demand service. Rather than purchasing servers, software, data center space, or network items, clients instead buy those resources as a fully outsourced service on demand. Amazon Web Services (AWS) is an IaaS provider.

4. IaaS can be considered a basic template for other services in the cloud like SaaS and PaaS.

6. IaaS providers will act promptly when there is a need to scale up or down and this is known as *autoscaling.*

7. It provides elastic load balancing that auto-distributes the incoming traffic related to an application to different instances of virtual computers. Thus, elasticity is also possible.

8. It is a platform independent service.

Characteristics of iaas

17. IaaS comprises two types:

(a) Computation as a service: Here, VM servers are charged per hour. It depends on the VM capacity including RAM size and CPU, OS, and the features of that VM.

(b) Data as a service: In this IaaS, there is no restriction on storage space to store the data related to the user. Charging is done on a per GB basis for data transfer.

18. ***InstaCompute*** is an example of an IaaS provider by Tata communications that is costeffective, flexible, and reliable. It offers variable computing power that can meet different business needs as per requirements. It allows removal of virtual servers, metered Internet connectivity, storage capacity, and dynamic additions. It is secure, uses a pay-per-use model, and assures service levels per business requirements.

19. IaaS clouds can even be one of three types: private IaaS clouds, public IaaS clouds, and hybrid IaaS clouds.

20. Companies such as Amazon EC2, Bluelock, and GoGrid offer IaaS. Amazon EC2 is a web service that offers dynamic scaling of computing capacity in the cloud. Bluelock offers cloud services supported by VMware cloud data center services.

Scalability and fault tolerance in cloud

1. **Resource Management:** When you deploy your application and services to the cloud, resource management provides the necessary virtual machines, network bandwidth, and other infrastructure resources. It is important to understand that if machines go down for hardware updates or because of unexpected failures, the cloud locates new virtual machines for your application automatically. Because you will only pay for what you use, you can start with a smaller investment. Doing so avoids incurring the typical upfront costs required for an on-premises deployment.

2. Dynamic Scaling: The process of scaling out and scaling back your application depending on resource requirements is known as *dynamic scaling.* It is also known as *elastic scaling.* With cloud services, you create roles that work together. to implement your application logic. It is important to understand that in this scenario, as resource demands increase, you can provision new role instances to handle the load. In addition, when demand decreases, you can remove these instances so that you do no have to pay for unnecessary computing power. There are also options for automatically scaling up and down based on pre-defined rules and policies

Scalability and fault tolerance in cloud

3. High Availability and Durability: Cloud vendors like MS Azure, provide a platform for applications that can reliably store and access server data through its storage services. Cloud applications like MS Azure have an MS Azure SQL Database for the same purpose. It ensures high availability of compute resources. For websites, you can meet

the requirements of the Service Level Agreement (SLA) with only a single instance. For cloud services and virtual machines, you can meet the SLA requirements by having at least two instances per role or machine type.

4. Highly Available Services: Say there is an online store that is deployed in MS Azure. This online store is a revenue generator, so it is important and critical to keep it running. To achieve this objective, the Azure data center performs service monitoring and automatic instance management. The online store must also stay responsive to customer demand. The elastic scaling ability of MS Azure accomplishes this. During peak shopping times, new instances can come online to handle the increased usage. In addition, the online store must not lose orders.

Scalability and fault tolerance in cloud

5. Periodic Workloads: Some applications such as demos or utility applications are ones you want to make available for only several days or weeks. They need not run continuously. MS Azure allows you to easily create, deploy, and share that application. Once this purpose is achieved, you can remove the application, and you are charged only for the time it was deployed.

Case Study

Consider a big company that runs complex **data analysis of sales** numbers at the end of each month. Although processing intensive, the total time required to complete analysis is at most two days. In an on-premises scenario, the server required for this work would be underutilized for the majority of the month. In MS Azure, the business would pay only for the time the analysis application is running in the cloud. Assume that the application architecture is designed for parallel processing. The scale out features of MS Azure would allow the company to create large numbers of worker role instances or virtual machines. Working together these can complete more complex work in less time.

Scalability and fault tolerance in cloud

6. Workload Spikes: This workload pattern also works on the principle of elastic scale, as explained earlier. Consider the example of the sports news portal once again. Now, even because its business is steadily growing, there is still a possibility of temporary spikes or bursts of activity. For example assume that another popular news outlet refers to the site. This means that the number of visitors to the site could dramatically increase in a single day.

Case study

Consider a service that processes daily reports at the end of the day. When

the business day closes, each office sends in a report that the company headquarters processes. However because the process is only active a few hours each day, it is also a candidate for elastic scaling and deployment. In addition, MS Azure is suitable for temporarily scaling out an application to handle load spikes and then scaling back afterthe event has passed.

Scalability and fault tolerance in cloud

7. Infrastructure Offloading: It has been observed that most cloud scenarios make use of the elastic scaling of MS Azure. In addition, even applications that show steady workload patterns will incur a significant cost savings using MS Azure cloud services.

- It is difficult and costlier to manage your own data center because it is more expensive in terms of energy, people, skills, hardware, software licensing, and facilities.
- In addition, it can be difficult to understand how costs are tied to individual applications.
- MS Azure, however, brings those costs to a minimum and with more transparency as well.

MS Azure provides a pricing calculator for understanding specific costs.

It also provides a Total Cost of Ownership (TCO) calculator for estimating the overall cost reduction that clouds incur by adopting MS Azure.

Duty cycle

As we know, cloud data centers have several servers. This increases the energy consumption.These servers are designed to be overloaded and overdesigned for better reliability.

They must support redundancy, error-correcting RAM, parity disk drives, (n + 1) power supplies, for example.

All this functionality needs energy to cool and power it, light the data center, provide security, and so on.

This concept of purposely overdesigning a true server

for a constant reliable operation is known as a ***duty cycle***.

CLOUD BUSINESS PROCESS MANAGEMENT

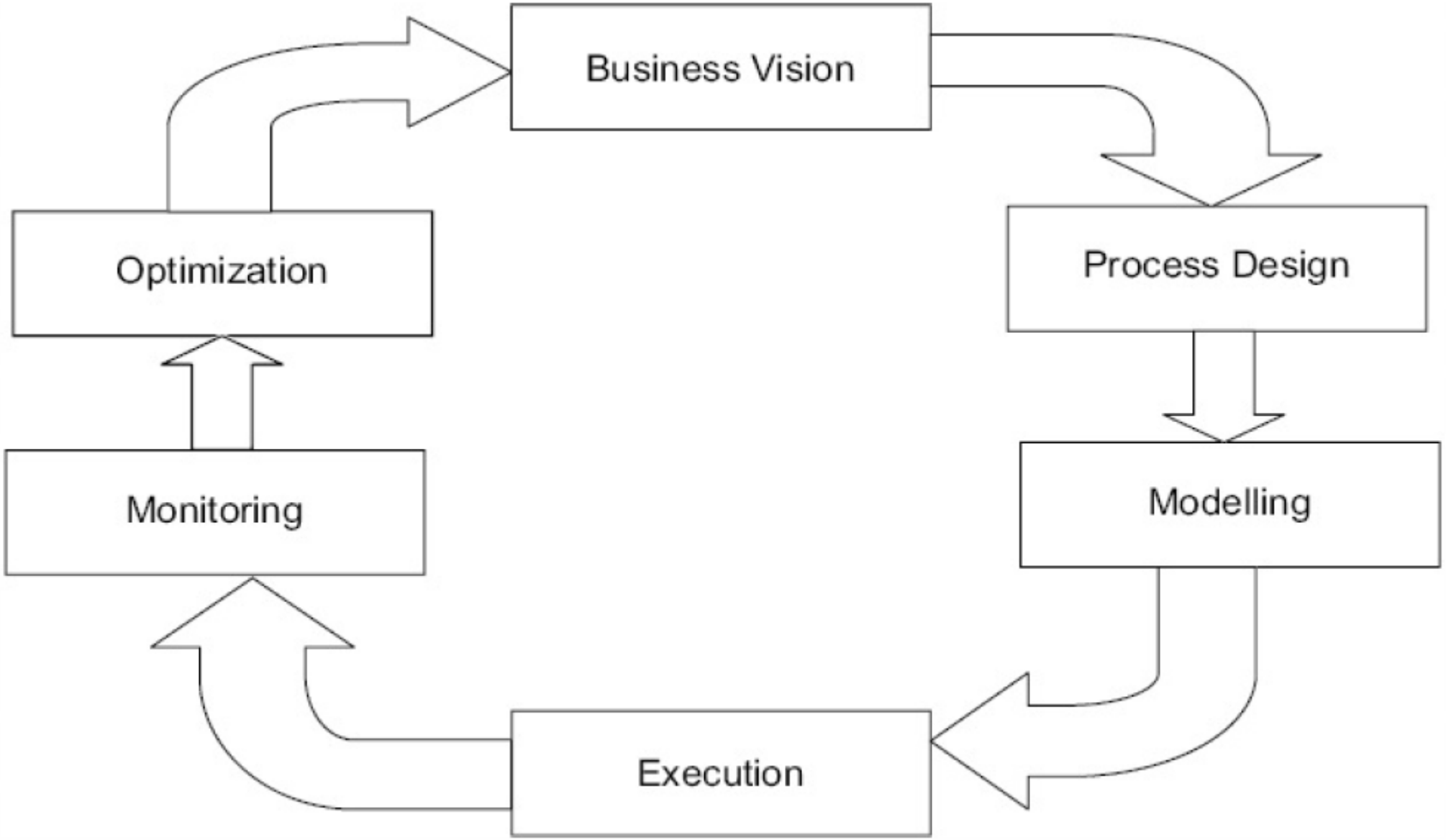


FIGURE 2.7 Cloud BPM.

CLOUD BUSINESS PROCESS MANAGEMENT

Phase-1: Business Vision - The objectives and goals of any business are attached to its vision. Functions are planned around them. Each function is in turn associated with a list of processes. Thus, functions and processes help in achieving managerial goals.

Phase-2: Process Design - The existing processes and the required processes must be taken care of and designed. Proper process flow is needed.

Phase-3: Modeling - This phase takes design as an input and creates a business model.

Phase-4: Execution - The requirement is to develop software that executes all these steps properly. Buying is also an option but not an efficient solution. The process becomes more complex when we mix software and humans.

Phase-5: Monitoring - At this stage, it is necessary to track the identified processes, understand them, and build statistics on them. All customer transactions must be monitored and made better, if needed.

Phase-6: Process Optimization - Optimization here means minimization of potential bottlenecks, of costs, and so on, because this adds a “value” to the system.

Chapter 3
Cloud Services:
IAM, Compute Services, Storage Services, Networking Services, Auto scaling and Cost Estimation / Budgeting

IAM (Identity and Access Management)

- AWS IAM may be a service that helps you control access to AWS resources securely.
- You use IAM to regulate who is allowed and have permissions to AWS Resources.

- With IAM, you manage access control by defining *who* (identity) has *what access* (role) for *which resource*. For example,

Compute Engine virtual machine instances, and Cloud Storage buckets are all Google Cloud resources.

- IAM enables you to manage access to AWS services and resources securely.
- We can attach Policies to AWS users, groups, and roles.

Basics of IAM:

- IAM gives shared access to your AWS Account.
- You can grant people to administer your AWS Account without sharing the password and access key.
- IAM service is PCI DSS compliant.
- You can add MFA to your account also.
- You can allow users to login using identity federation.
- For example, you'll use your corporate mail id to get access to your AWS Account.
- Using CloudTrail, we receive log records that include information about those who made requests for AWS Account requests.

Principal: An Entity that will make a call for action or operation on an AWS Resource. User, Groups, Roles all are AWS Principal. AWS Account Root user is the first principal.

IAM & Root User (AWS)

Root User - When you first create an AWS account, you begin with an email (Username) and Password with complete access to all AWS services and resources in the account. This is the AWS account, root user.

IAM User - A user that you create in AWS. The IAM user represents the person or service who interacts with AWS. IAM users' primary purpose is to give people the ability to sign in to AWS individually without sharing the password with others. Access rights will be depending on the policies which are assigned to the IAM User.

IAM Group- A group is a collection of IAM users. You can assign specific permission to a group and add the users to that group. This way makes permission easier to manage for those users. For example, you could have a group called DB Admins and give that type of permission that Database administrators typically need.

IAM Role - The IAM Role allows one service to talk to another service. It is like a user with policies attached to it that decides what identity can or cannot do. It will not have any credentials/Password attached to it. An IAM Role can attach to anyone who needs it. A Role can be assigned to a federated user who signed in from an external Identity Provider. IAM users can temporarily assume a role and get different permission for the task.

IAM Policies:

- IAM Policy decides what level of access an Identity or AWS Resource will possess.
- A Policy is an object associated with identity and defines their level of access to a certain resource.
- These policies are evaluated when an IAM principal (user or role) makes a request.
- Policies are JSON based on documents.
- Permissions inside policies decide if the request is allowed or denied.

o Resource-Based Policies: These JSON based policy documents attached to a resource such as Amazon S3 Bucket.

o These policies grant permission to perform an action on that resource and define under what condition it will apply.

o These policies are the inline policies, not managed resource-based policies.

o IAM supports only one type of resource-based policy called trust policy, and this policy is attached to a role. o Identity-Based Policies: These policies have complete control over the identity that it can perform on which resource and under which condition.

o Managed policies: Managed policies can attach to the multiple users, groups, and roles in the AWS Account.

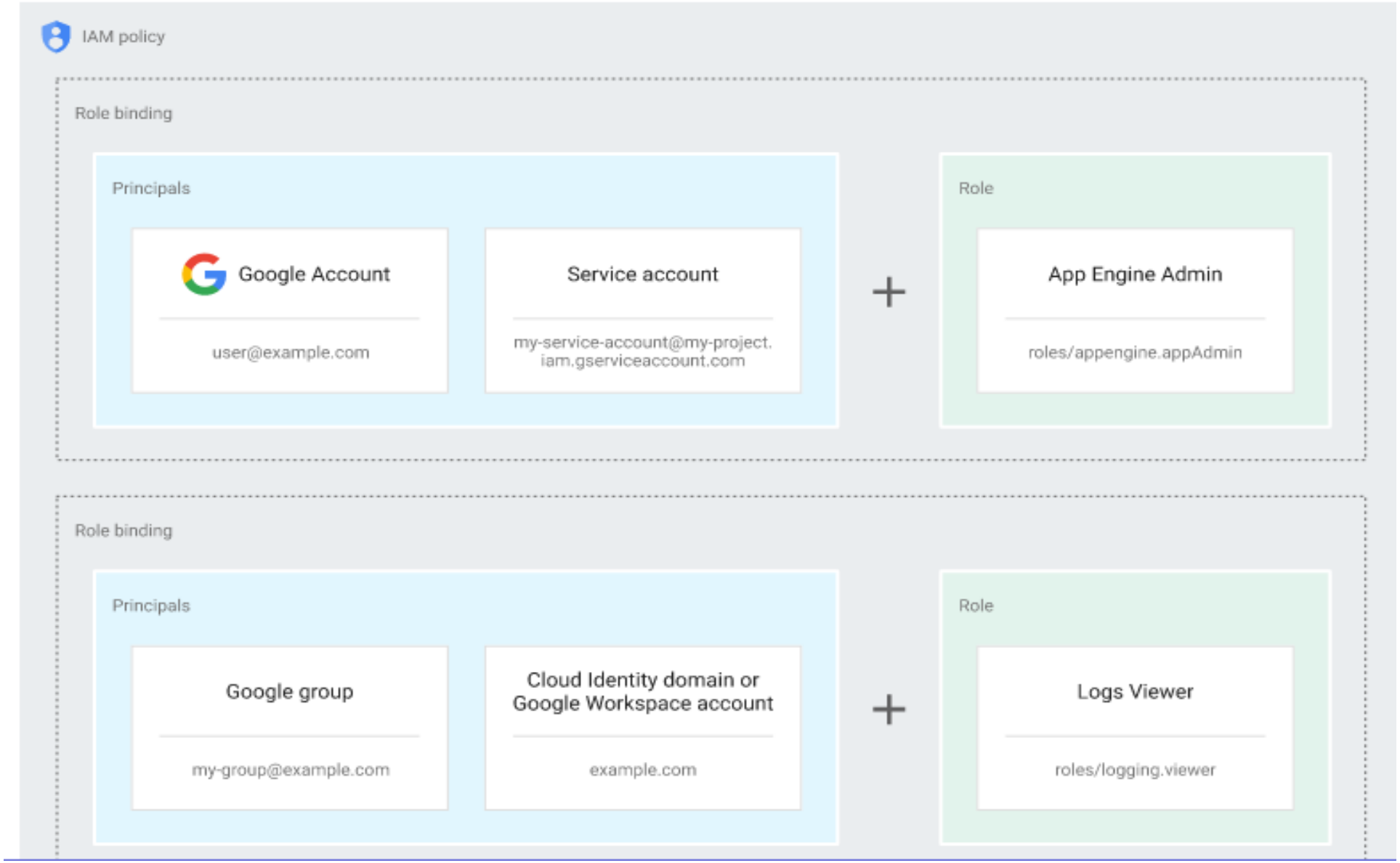
- **AWS managed policies:** These policies are created and managed by AWS.
- **Customer managed policies:** These policies are created and managed by you. It provides more precise control than AWS Managed policies.

o Inline policies: Inline policies are the policies that can directly be attached to any individual user, group, or role. It maintains a one-to-one relationship between the policy and the identity.

IAM Security Best Practices (AWS)

- Create individual IAM users or create a group and assign users to that group.
- Grant least possible access rights.
- Enable multi-factor authentication (MFA).
- Monitor activity in your AWS account using CloudTrail.
- Use policy conditions for extra security.
- Create a strong password policy for your users.
- Remove unnecessary credentials.

The following diagram illustrates permission management in IAM.



Source: https://cloud.google.com/iam/docs/overview

What is AWS EC2?

- EC2 stands for Elastic Compute Cloud. It is **same as Compute Engine in GCP.**
- Amazon EC2 is the virtual machine in the Cloud Environment.
- Amazon EC2 provides scalable capacity. Instances can scale up and down automatically based on the traffic.
- You do not have to invest in the hardware.
- You can launch as many servers as you want and you will have complete control over the servers and can manage security, networking, and storage.

Instance Type:

- Instance type is providing a range of instance types for various use cases.
- The instance is the processor and memory of your EC2 instance.
- The EC2 instance types are generally categorized into 6 types. **These are:**

o **General Purpose – (T2, M5, M4)**
o Compute Optimized – (C5, C4)
o Memory Optimized – (X1, R4)
o Accelerated Computing - (P3, P2, G3, F1)
o Storage optimized - (I3, H1, D2) EBS Volume:

- **EBS Stands for Elastic Block Storage.**
- Virtual Hard Disk in the Cloud.
- It is the block-level storage that is assigned to your single EC2 Instance.
- It persists independently from running EC2.

o Types of EBS Storage

- General Purpose (SSD)
- Throughput Optimized Hard Disk Drive
- Provisioned IOPS (SSD)
- Cold Hard Disk Drive

AMI: AMI Stands for Amazon Machine Image.
● AMI decides the OS, installs dependencies, libraries, data of your EC2 instances.
● Multiple instances can be launched using a single AMI.
● Used when there is a need for multiple instances with the same configuration.
Security Group: A Security group acts as a virtual firewall for your EC2 Instances.
● It decides the type of port and kind of traffic to allow.
Security groups are active at the instance level.
● Network ACLs are active at the subnet level.
● Inbound rules are the traffic that can come inside your EC2 Instance. i.e., Incoming HTTP/HTTPS request in port 80 and port 443.
● Outbound rules are the traffic for outside of your EC2 Instance. i.e., Outgoing HTTP/HTTPS response from port 80 and port 443.
● Security Groups can only allow but can’t deny the rules.
Key Pair: A key pair, consisting of a private key and a public key, is a set of security credentials that you can use to prove your identity while connecting to an instance.
● Amazon EC2 instances use two keys, one is the public key which is attached to your EC2 instance.
● Another is the private key which is with you. You can get access to the EC2 instance only if these keys get matched.
Charges- It shows once you select a machine instance at the right side of GCP interface.

Amazon S3(Storage):S3 stands for Simple Storage Service.

Amazon S3 is object storage that allows us to store any kind of data in the bucket.
It provides availability in multiple AZs, durability, security, and performance at a very low cost. Any type of customer can use it to store and protect any amount of data for use cases, like static and dynamic websites, data analytics, and backu

Basics of S3

● It is object-based storage. ● Files are stored in Buckets.
● The bucket is a kind of folder. ● Folders can be from 0 to 5 TB. ● S3 bucket names must be unique globally.
● When you upload a file in S3, you will receive an HTTP 200 code if the upload was successful.
● S3 offers Strong consistency for PUTs of new objects, overwrites or delete of current object and List operations.
● By Default, All the Objects in the bucket are not public.

Features or Properties of Amazon S3.

● Versioning: This allows you to keep multiple versions of Objects in the same bucket.
● Static Website Hosting: S3 can be used to host a Static Website, which does not require any server-side Technology.
● Encryption: Encrypt Object at rest with Amazon S3 Managed keys (SSE-S3), or Amazon KMS Managed Keys (SS3-KMS).
● Objects Lock: Block Version deletion of the object for a defined period.

Free Tier Limit:

● 5GB of storage in S3 Standard storage per month. ● 2000 PUT and GET requests per month.
● 15 GB of data out from all your S3 buckets per month. Storage Class/Pricing model of S3
● S3 Standard ● S3 Standard-IA (Infrequent Access)
● S3 Intelligent Tiering (No need to mentioned Life Cycle Policy)
● S3 One Zone-IA (Kept in a Single Zone) ● S3 Glacier (For Archiving Purpose)
● S3 Glacier Deep Archive (For Archiving Purpose)

Virtualization

- 1. It is an abstraction of four computing resources—storage, processing power, memory, and network (I/O).
- 2. Conceptually, it is similar to emulation where a system pretends to be another system, whereas virtualization is a system pretending to be two or more of the same system type.
- 3. Today virtualization is better than parallelism. It has helped to evolve the cloud data center techniques and tools.
- 4. These technologies manage the dynamic data center infrastructure as well. Virtualization partitions the physical resources of the underlying physical server into multiple virtual machines with different workloads.
- 5. The virtualization layer schedules and allocates the physical resources
- and makes each virtual machine think that it completely owns all of the physical resources of the underlying hardware.
- 6. This technology is very useful for cloud computing because it improves resource utilization by multiplexing many virtual machines on one physical host.
- 7. Thus, these machines can be scaled up or down on-demand, and thus, better management techniques are required

Virtualization

- The complex applications of today cannot be feasibly run on the existing physical hardware alone. It is, however, possible to implement, test, and run large applications with the help of this virtualization technology.
- Virtual technology creates virtual versions of hardware, operating systems (OSs), networking devices, and storage devices. Therefore, many guests OSs can now be run on a single physical machine called a *host machine* and multiple guest applications run on a single server called a *host server*.
- Additionally, this technology allows a single physical resource to work as multiple virtual resources and multiple physical resources as a single virtual resource.
- Virtualization may be achieved through several methods including hypervisors, virtual storage engines, and virtual networks, for example.
- With respect to virtualization technology, a cloud may be defined as a virtualization of resources that can be maintained and managed by itself. This maximizes the rate of utilization for each server and decreases the number of servers. Technologies like Xen and VMware, VPNs, and so on, are some of the virtualization technologies today.
- Thus, virtualization decouples (software is put under a separate container so that it is isolated from the OS) the software from the hardware

CREATING A VIRTUALIZED ARCHITECTURE

During virtualization, software known as a *Virtual Machine Monitor* (VMM) or a ***Hypervisor*** is used.

- **A hypervisor** is an operating system (OS) that knows how to act as a traffic policeman to guide processes in an orderly manner. It is set at the lowest levels of the hardware environment.
- In cloud computing, it is necessary to support several types of OSs and a hypervisor is the correct method to do this. It helps you to show and use the same application on several systems without having to physically copy that application onto each system.
- With virtualization technology, it is possible to use the hypervisor to split the physical computer's resources.
- The resources can be split 50–50 or 80–20 between two guest operating systems.
- The advantage here is that the hypervisor does all the heavy lifting.
- The guest OS does not care that it is running in a virtual partition. It thinks it has the computer all to itself.

TYPES OF HYPERVISORS

1. **Native Hypervisors:** They sit on the hardware platform directly. They give better performance to the end users.

2. **Embedded Hypervisors:** They are integrated into a CPU on a separate chip.

3. **Hosted Hypervisors:** They run as a different software layer above both the hardware and the OS. This type is useful for both private and public clouds because it improves performance.

Two different virtualization structures are thus formed as follows:

1. **Hosted Virtualization.**
2. **Bare-Metal Virtualization**.

TYPES OF HYPERVISORS

1. Hosted Virtualization Structure Containerization → Docker engine, Docker hub

This structure enables users to run different guest application windows on top of a base OS (e.g., the Windows x86 OS) with the help of a VMM or hypervisor. Examples include the VMware Workstation and Mac Parallels Desktop. DevOps

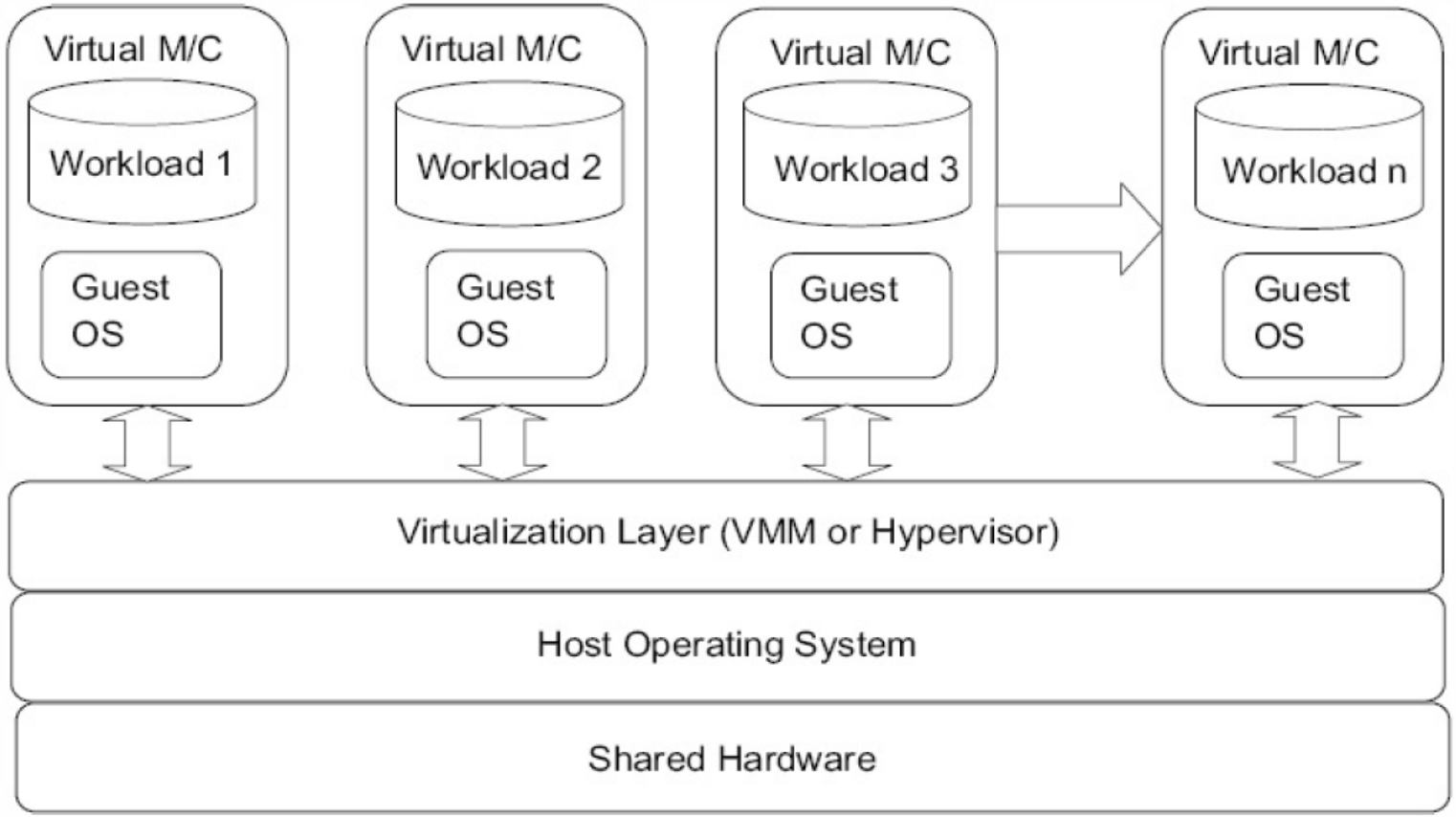


FIGURE 3.1 Layered hosted virtualization structure.

TYPES OF HYPERVISORS

1. Hosted Virtualization Structure

- virtualization layer partitions the physical resources of the underlying physical server into multiple virtual machines with different workloads.
- This virtualization layer schedules and allocates the physical resources and makes each virtual machine think that it owns all of the underlying hardware physical resources including the processor, disks, RAMs, and so on.
- This type of structure enables you to run different guest applications in Windows on your own on top of a base OS with the help of the hypervisor or VMM. The I/O requests must pass through the host OS.
- The virtual or guest operating systems (see Figure 3.1) has limited access to the I/O devices. Only a defined subset of I/O devices with guest systems may be used. The I/O connections to a given physical system are owned only by the host systems while their emulated view is presented by the VMM to every single guest machine running on the same base system.

TYPES OF HYPERVISORS

1. **Hosted Virtualization Structure**

Advantages of a hosted structure

1. Here, multiple guest systems are easily installed, configured, and executed.

2. Next, a hypervisor or VMM is installed. You can run several guest systems on different platforms without any need for extra physical resources.

3. It is also possible to run these different VMMs so that they are shared across different PCs. They require no customization because the drivers provided by the host Oss establish communication with the low-level hardware.

Disadvantages of a hosted structure

1. This structure is not capable of providing pass-through to many I/O devices.

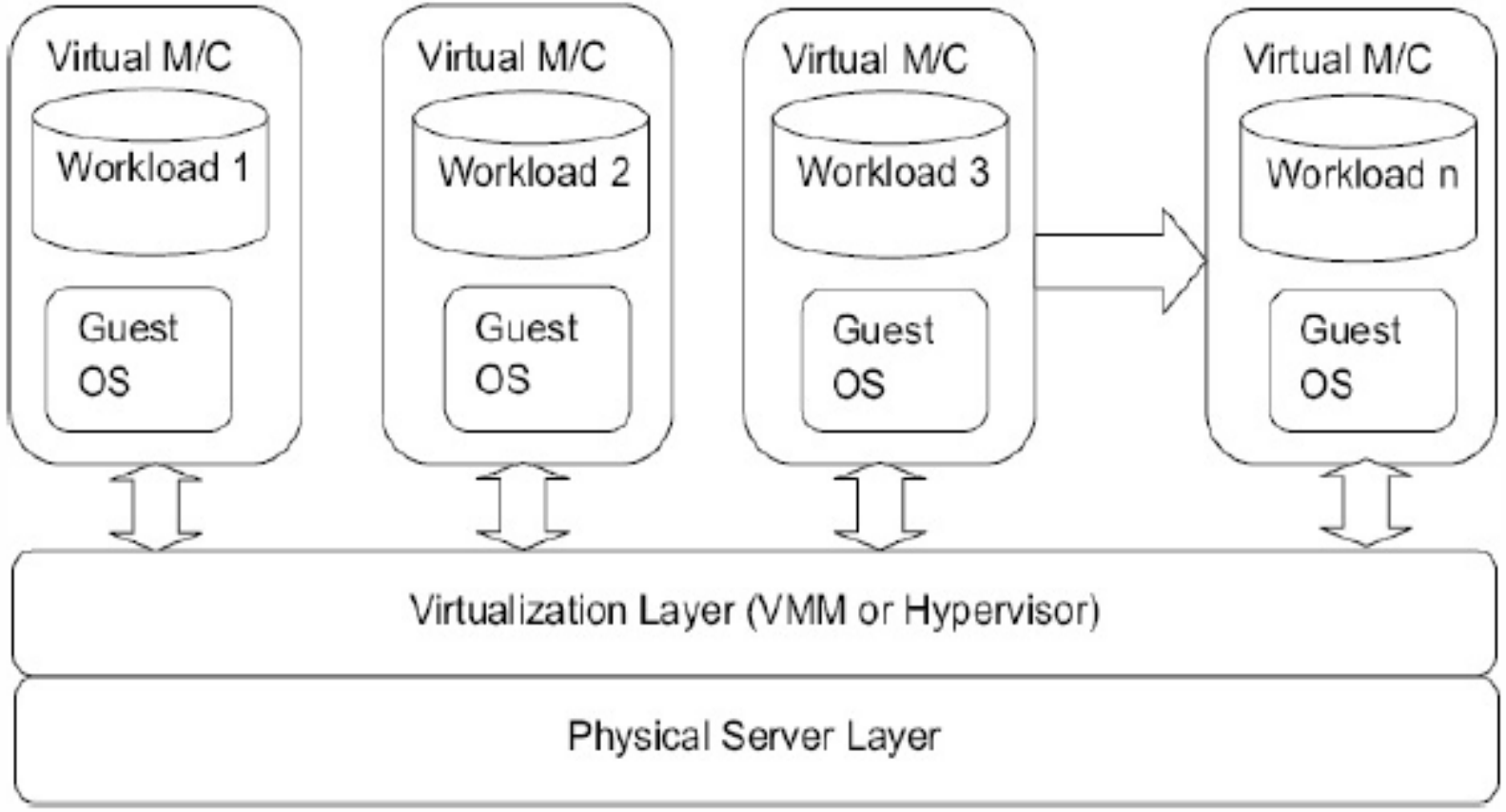
2. The performance of hosted systems may be downgraded as the I/O request made by the guest systems must be passed through a host OS.

3. This structure does not support real-time operating systems because there is full control of the host OS in the scheduling of its applications and the hypervisor.

TYPES OF HYPERVISORS

2. Bare-Metal Virtualization Structure

- With this structure, the hypervisor/VMM is installed to establish direct communication with the hardware that is being used by the base system. Here, the hypervisor or VMM does not rely on the host system for pass-through permissions (see Figure).



TYPES OF HYPERVISORS

2. Bare-Metal Virtualization Structure

- With this structure, the hypervisor/VMM is installed to establish direct communication with the hardware that is being used by the base system. Here, the hypervisor or VMM does not rely on the host system for pass-through permissions (see Figure).
- With this structure, different options exist to access I/O devices from the guest systems. The VMM can have direct communication with the I/O devices because the host OS is not relied upon.
- A shared usage of I/O devices between these virtual systems needs the hypervisor to have a low-level driver (to communicate with the device). It is necessary for the VMM to have the ability to emulate the shared devices for the guest virtual machines.
- The hypervisor uses a partitioning technique to access the I/O devices. Partitioning is defined as the process of assigning individual I/O devices to particular VMs, which improves the performance of the I/O system.

TYPES OF HYPERVISORS

Advantages of a bare-metal structure

1. It is possible to run a real-time OS on systems with a bare-metal virtualization structure. This is possible because of the partitioning of only the I/O devices.
2. A single hardware platform can be made to run real-time and general purpose OSs in parallel. Thus, the bare-metal-type VMMs can be used for binding the interrupt latency and allowing deterministic performance.

Disadvantages of a bare-metal structure

1. The VMM must include supporting drivers for hardware platforms along with the drivers for sharing the I/O devices among the guest systems.
2. It is difficult to install the VMM in this structure model compared to hosted structures because the VMMs are not installed on top of a base OS.

CLOUD DATA CENTER

Data centers with 10,000 or more servers on site are considered a Cloud Data Center (CDC).

The main features of CDCs are as follows:

- They are constructed for a different purpose.
- They are created at different times.
- They are built to a different scale.
- They are not constrained by the same limitations as in traditional data centers.
- They perform different workloads from those of traditional data centers.
- CDCs support many customers with a large number of servers executing a single application.
- They optimize IT productivity and resource utilization.
- They allow superior scale-up and scale-out server/storage consolidation and virtualization.
- They have lower costs and higher utilization.
- They achieve reduced operations costs through streamlining management and provisioning pooled resources.

CLOUD DATA CENTER Vs Traditional Data Center

Traditional Data Center (TDC)	Cloud Data Center (CDC)
It has thousands of different applications.	It has a fewer number of applications.
It has a mixed hardware environment.	It has a homogeneous hardware environment.
It supports multiple management tools.	It supports standardized management tools.
It needs frequent application patching and updating.	It has minimal application patching and updating.
It includes complex workloads.	It includes simple workloads

Locations of CLOUD DATA CENTER

The locations of some data centers are:

1. North America (California, Chicago, Virginia etc.)
2. South America (Brazil)
3. Asia (China, Hong Kong, Singapore)
4. Europe (Dublin, Ireland, Amsterdam, Netherlands)
5. Japan (Osaka, Saitama)
6. Oceania (Sydney, Wales, Victoria, Melbourne)
7. **etc…..few more at various locations.**

CDC Resilience & Agility

Resilience

- Resilience is defined as the ability of a data center and its components to continue operating in case of any damage such as a power outage, malfunctioning of equipment, or natural disasters like earthquakes, and so on.
- It creates an environment that protects valuable applications, services, and the information infrastructure. It ensures regulatory compliance by providing a resilient network infrastructure that supports security, improved Service-Level Agreements (SLAs), and application delivery-optimization services.

Agility

Agility facilitates the adoption of new IT strategies like SOA (Service Oriented Architecture), virtualization, and on-demand computing, which allow faster responses to changes.

Deployment and Migration

Assessment and Design leads to a working solutions document (published best practice solutions guides)

- Solutions planning
- Investment planning & acquisition
- Integration & test
- Deployment, documentation, operations & maintenance

What is SOAP?

SOAP provides a way for a program executing in one kind of OS to communicate with the program executing in the same or another OS with the help of WWW, HTTP, and XML as the methods of information exchange.

What is Silo?

A Silo is an isolated piece of software and hardware that cannot interact with other components in Cloud.

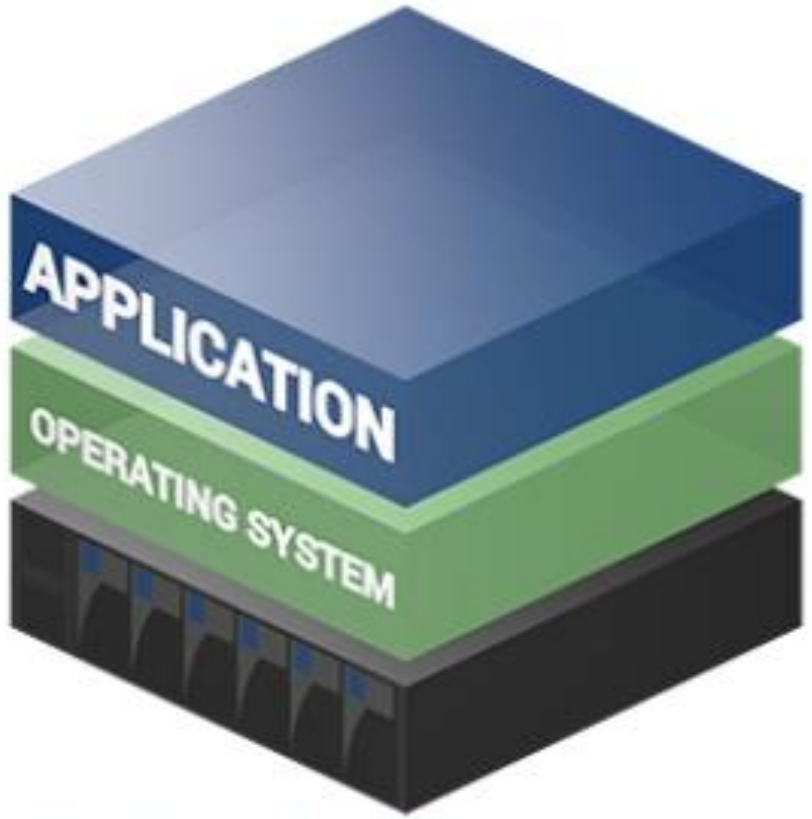
Types of Virtualization

Today the term virtualization is widely applied to a number of concepts, some of which are described below −

1. Server Virtualization
2. Client & Desktop Virtualization
3. Services and Applications Virtualization
4. Network Virtualization
5. Storage Virtualization

Server Virtualization

It is virtualizing your server infrastructure where you do not have to use any more physical servers for different purposes.

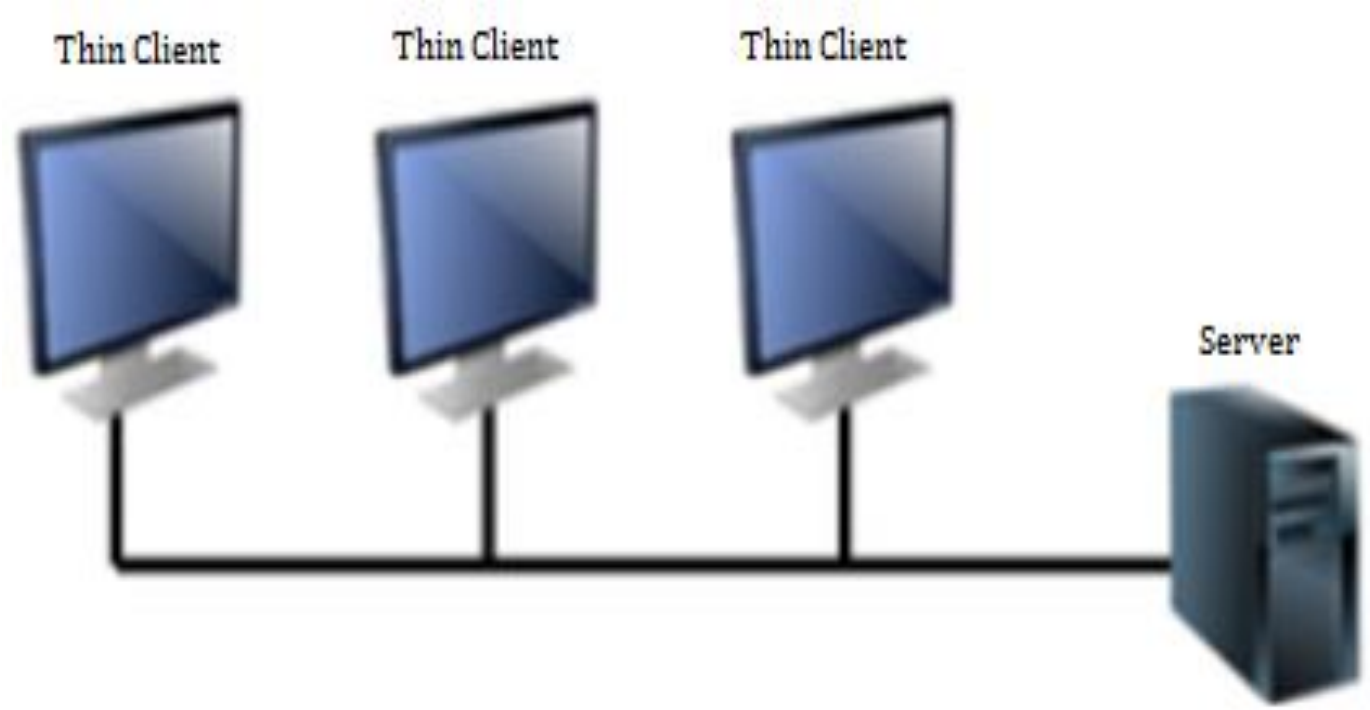


Clasic Server Installation

Virtualized server Intallation

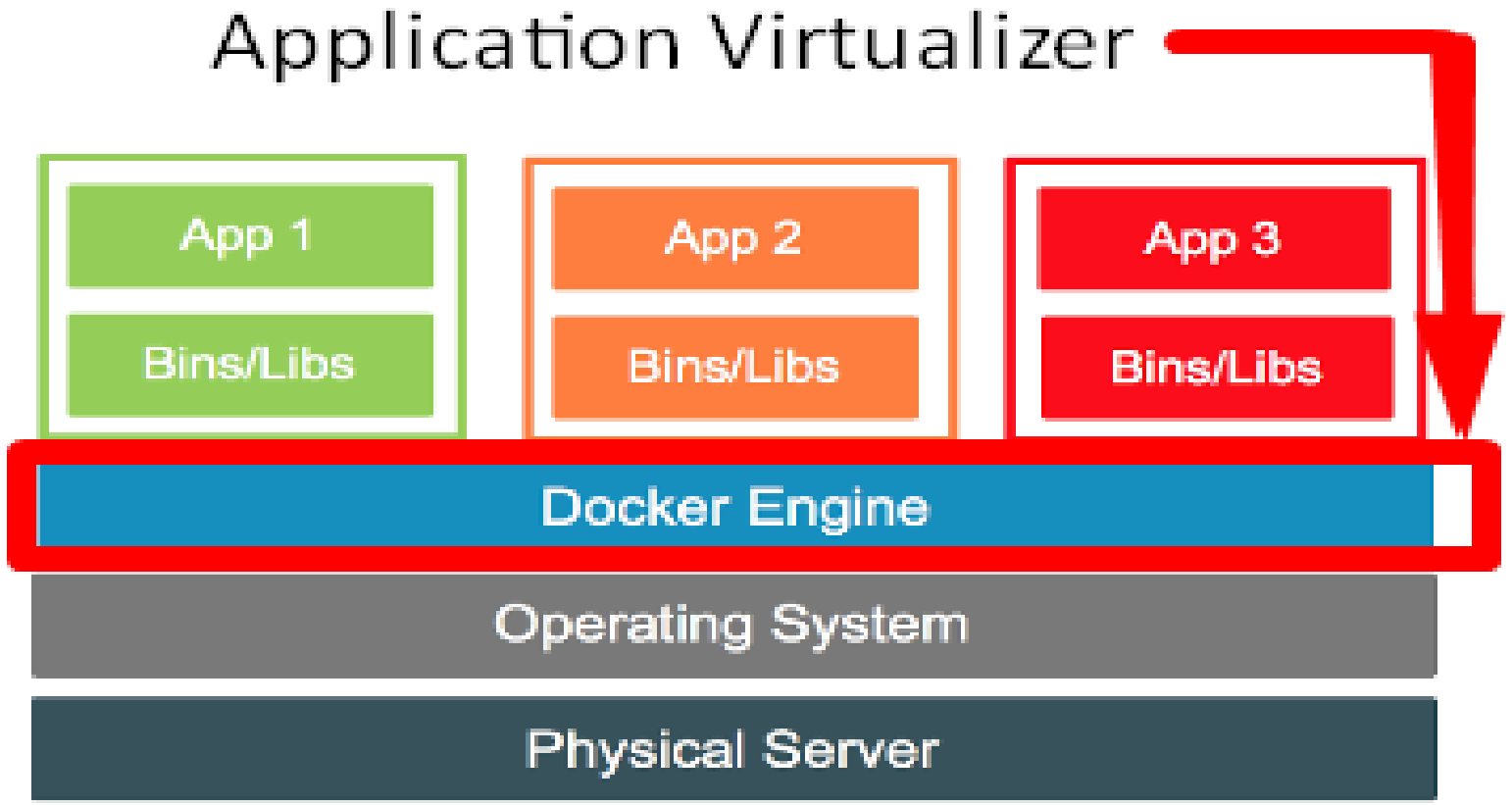
Client and Desktop Virtualization

This is similar to server virtualization, but this time is on the user's site where you virtualize their desktops. We change their desktops with thin clients and by utilizing the datacenter resources.



Services and Applications Virtualization

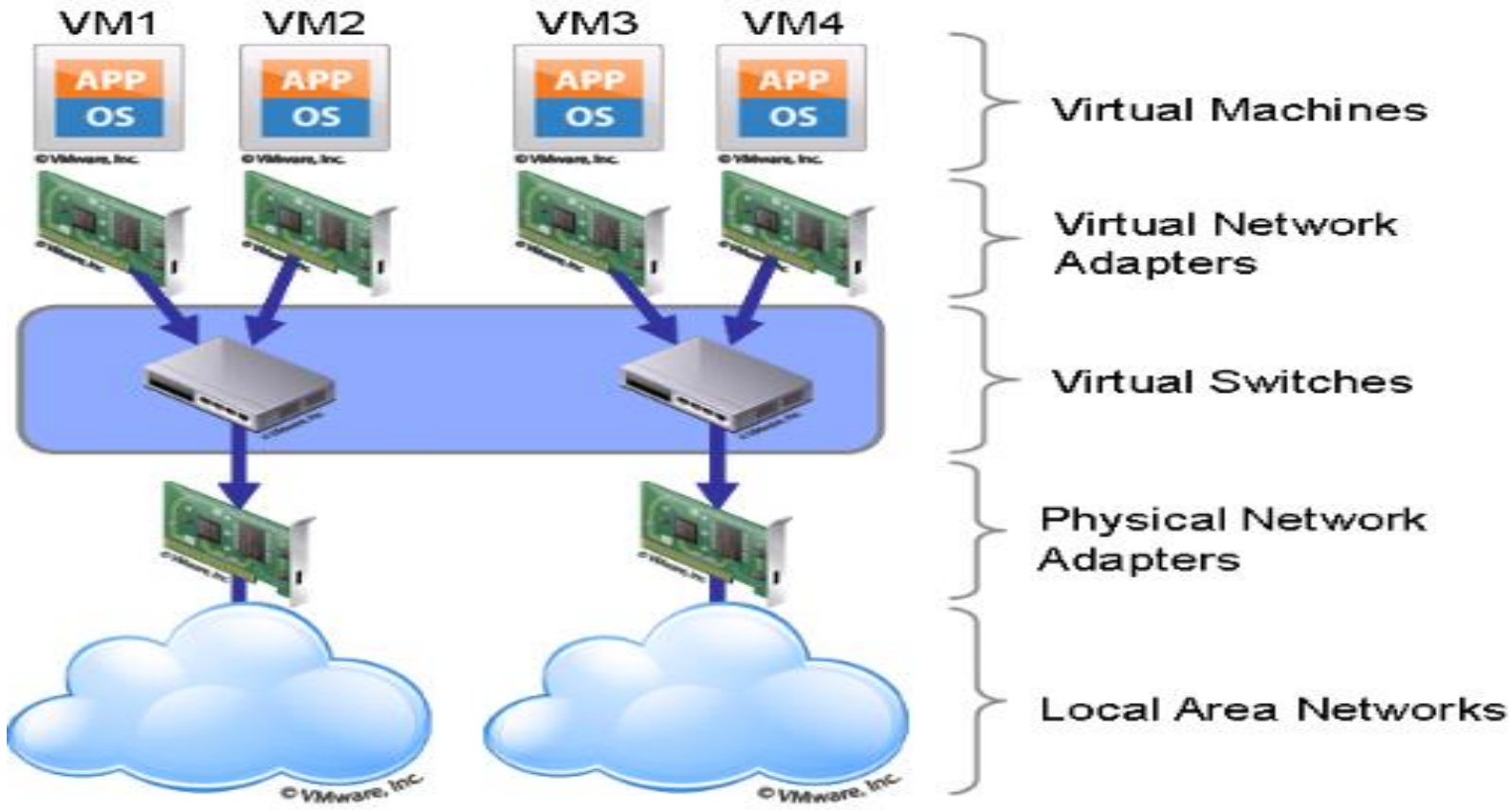
The virtualization technology isolates applications from the underlying operating system and from other applications, in order to increase compatibility and manageability. For example – Docker can be used for that purpose.



Network Virtualization

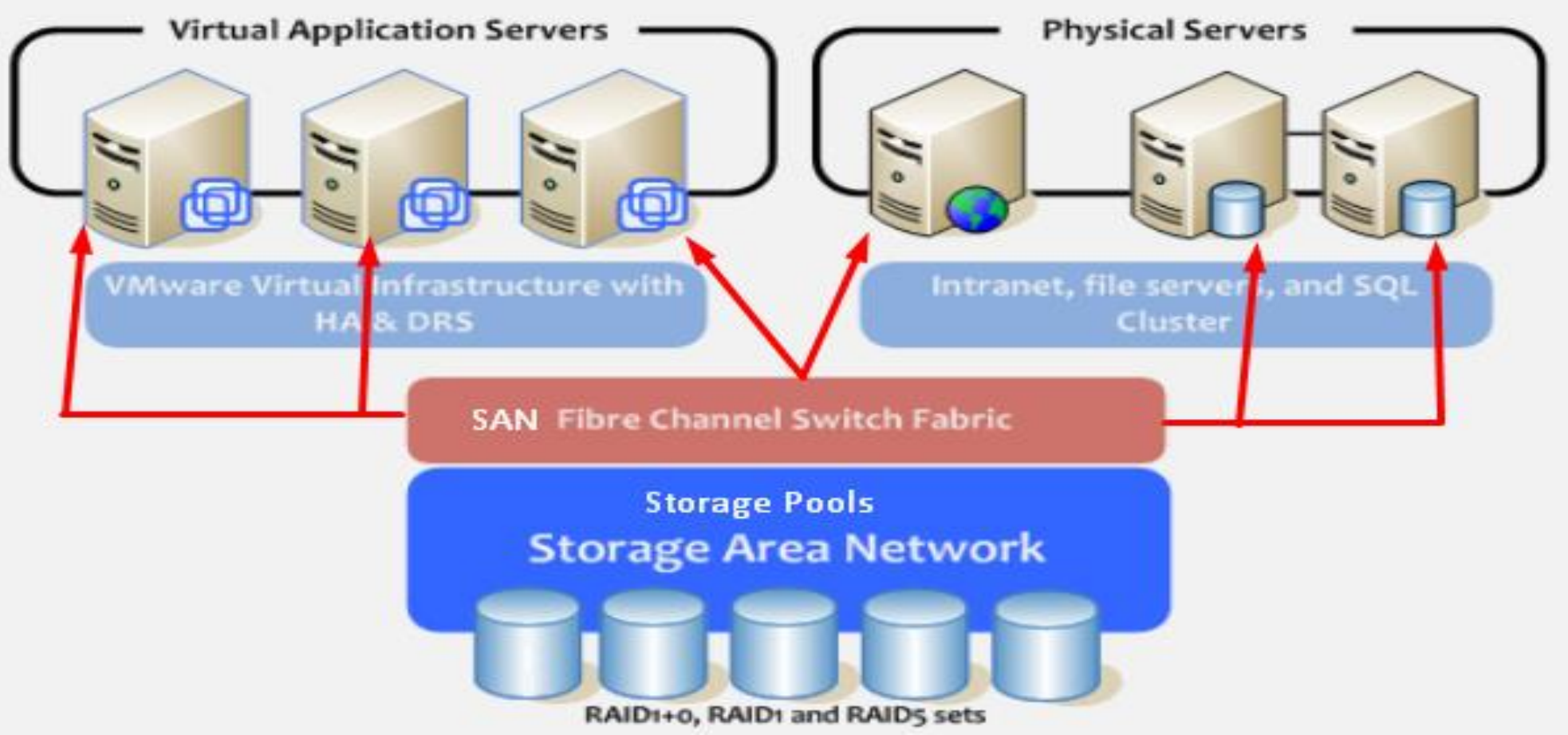
It is a part of virtualization infrastructure, which is used especially if you are going to visualize your servers. It helps you in creating multiple switching, Vlans, NAT-ing, etc.

The following illustration shows the VMware schema −



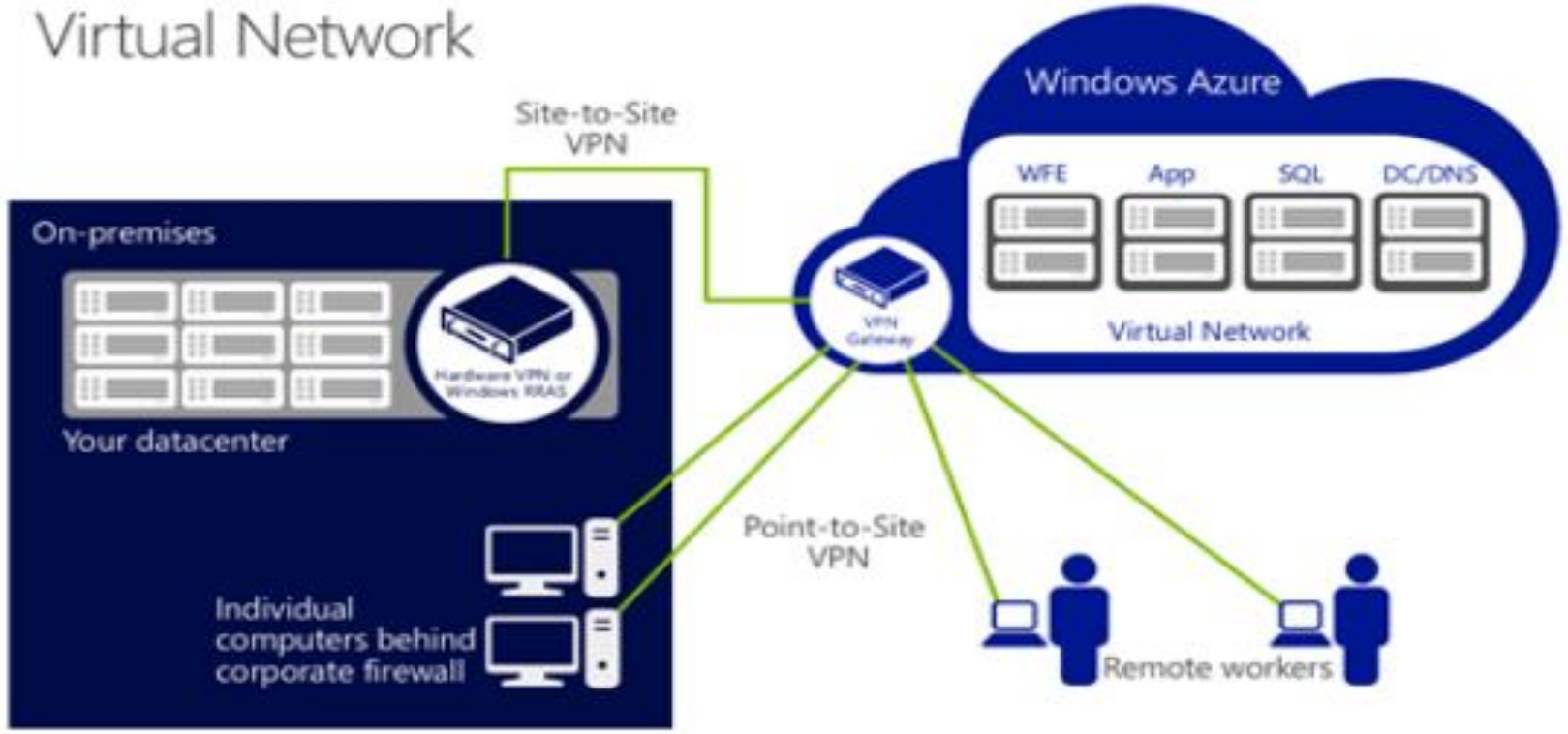
Storage Virtualization

This is widely used in datacenters where you have a big storage and it helps you to create, delete, allocated storage to different hardware. This allocation is done through network connection. The leader on storage is SAN. A schematic illustration is given below –



Local Virtualization and Cloud Virtualization

The following illustration is provided by Microsoft where you can understand how utilizing extra infrastructure for your business without the need to spend extra money helps. You can have the on-premises base infrastructure, while on cloud you can have all your services, which are based on Virtualized technology.



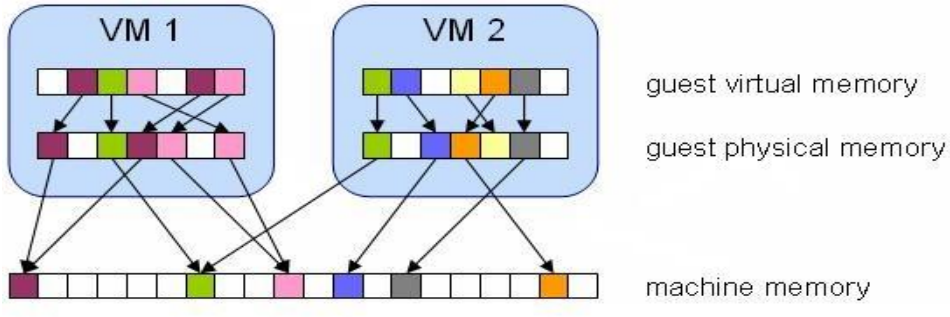
Virtualization of Hardware: Memory Virtualization

Virtual Memory in simple words is the RAM of the machine. The memory resource settings for a virtual machine determines how much of the host's memory is allocated to the virtual machine. The virtual hardware memory size determines how much memory is available to applications that run in the virtual machine.

A virtual machine cannot benefit from more memory resources than its configured virtual hardware memory size. The **ESXi hosts** limit the memory resource use to the maximum amount useful for the virtual machine, so that you can accept the default of unlimited memory resources.

You can add, change, and configure virtual machine memory resources or options to enhance virtual machine performance. You can set most of the memory parameters while creating the virtual machine or it can also be done after the **Guest Operating System** is installed. Most of the hypervisors require to power off the virtual machine before changing the settings.

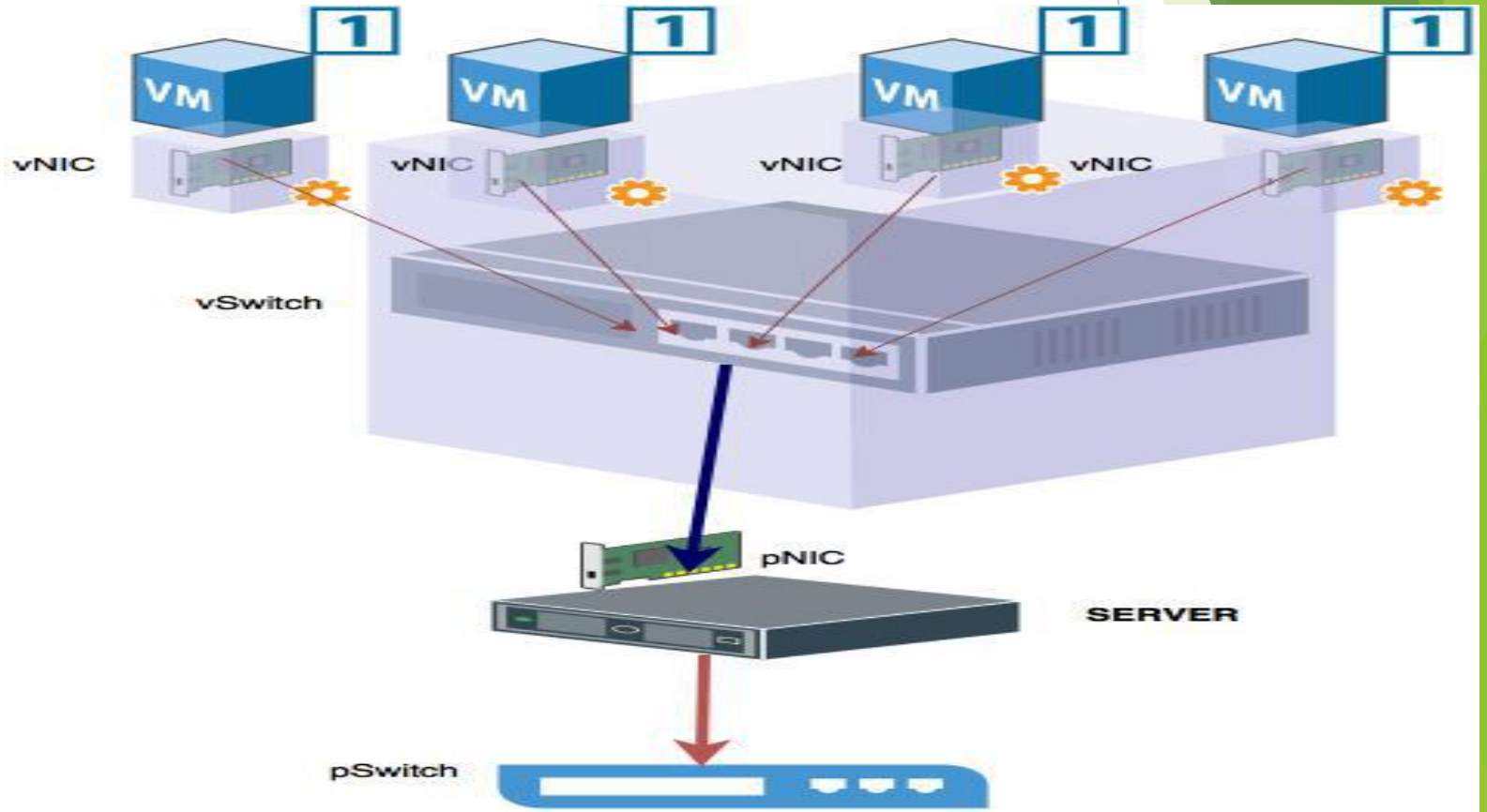
In the following schematic illustration, you can see that the total physical memory is divided between two virtual machines.



Virtualization of Hardware: Network Virtualization

We have Virtual Machine 1, 2, 3 and 4 running on the same host. They would like to send the network traffic back and forth. This is done by virtual networking cards as shown in the following illustration (vNIC), which connects virtually with a virtual switch (vSwitch) that is created by the hypervisor.

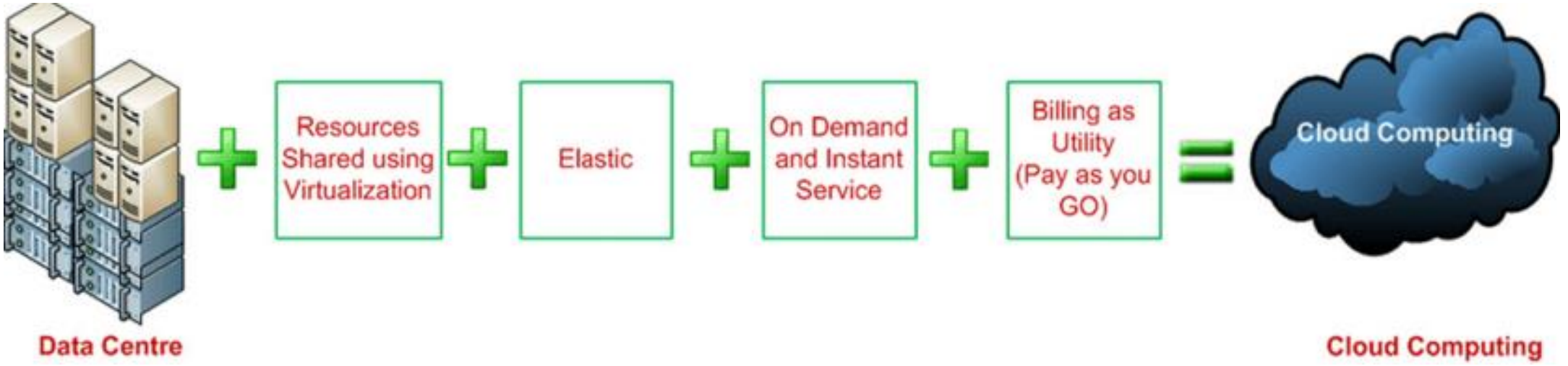
This virtual switch communicates with a physical card of the server (pNIC), which is connected with a physical switch (pSwitch) and then communicates with the rest of the network equipment.



OpenStack https://openstack.org/software

Chapter 5 – P1

What is Cloud Computing



Reference:M. T. Khorshed, A. B. M. S. Ali, and S. A. Wasimi, "A survey on gaps, threat remediation challenges and some thoughts for proactive attack detection in cloud computing," *Futur. Gener. Comput. Syst*

Cloud Computing Architecture

Frontend

Network(Internet)

SaaS

- application level

PaaS

- execution Environment
- Programming Environment

IaaS

- Network & Connectivity (Openflow, vSwitch)
- Data Storage(e.g GoogleFS, HDFS)
- Computational (e.g MapReduce , Hadoop)
- Virtualization (e.g Amazon EC2)

Cloud Operating System

- e.g OpenStack, Nimbus and OpenNebula

Physical infrastructure

- Networking devices
- Storage hard-disk
- Servers

Virtualization Vs Containerization

If you're looking to improve scalability, reduce overhead costs, and standardize software deployments across multiple machines and platforms, **containers** and **virtual machines (VMs)** are two of the top approaches in use today. They can help your IT team become more agile and responsive to business demands.

Before containers came along, the "virtual machine" was the technology of choice for optimizing server capacity. Programmed to emulate the hardware of a physical computer with a complete operating system, VMs (and hypervisors) make it possible to run what appear to be multiple computers with multiple different operating systems on the hardware of a single physical server.

Disadvantages of Virtualization

1. Since each VM includes an OS and a virtual copy of all the hardware the OS requires, VMs require significant RAM and CPU resources.
2. Due to the increase in virtual copies and required resources, the software development life cycle is more complex with VMs
3. Moving VMs between public clouds, private clouds and traditional data centers can be challenging.
4. If we need more RAM (8GB, which is more than the allocated size, e.g. 4 GB) to run an application then in that case it will fail.

Virtualization Vs Containerization

- The container shares the kernel of the host OS with other containers, and the shared part of the OS is read-only.
- Therefore, the containers are lightweight, so you can deploy multiple containers on a single server (or a VM)—no more dedicating an entire server to a single application. And, you only have one OS to maintain.
- Scaling up becomes fast and easy, without the need for more server space.
- Containerization solves any number of problems for software development and deployment.

Disadvantages of Containerization

1. All containers on a particular host machine must be designed to run on the same kind of OS. Containers based on a different OS will require a different host.
2. Because the OS is shared, a security vulnerability in the OS kernel is a threat to all containers on the host machine.
3. Containerization is still a new solution with wide variances in implementation plans and skilled resources, making adoption a challenging process for some

Virtualization Vs Containerization

- **Virtualization** enables you to run multiple operating systems on the hardware of a single physical server, while **containerization** enables you to deploy multiple applications using the same operating system on a single virtual machine or server.

- Virtual machines are great for supporting applications that require an operating system's full functionality when you want to deploy multiple applications on a server, or when you have a wide variety of operating systems to manage. Containers are a better choice when your biggest priority is to minimize the number of servers you're using for multiple applications.

- Your use case matters too. Containers are an excellent choice for tasks with a much shorter lifecycle. With their fast set up time, they are suitable for tasks that may only take a few hours. Virtual machines have a longer lifecycle than containers, and are best used for longer periods of time.

- The way forward for your organization will depend on everything from the size of your operations and workflows to your IT culture and skill sets. And, containerization and virtualization technologies are coming together in a way that could influence your decision making.

OpenStack Partners

Resource link: https://www.sparksupport.com/blog/openstack-the-most-preferred-private-cloud-platform-for-enterprises

Get started with OpenStack

The OpenStack project is an **open source** cloud computing **platform** for all types of clouds, which aims to be simple to implement, massively scalable, and feature rich. Developers and cloud computing technologists from around the world create the OpenStack project.

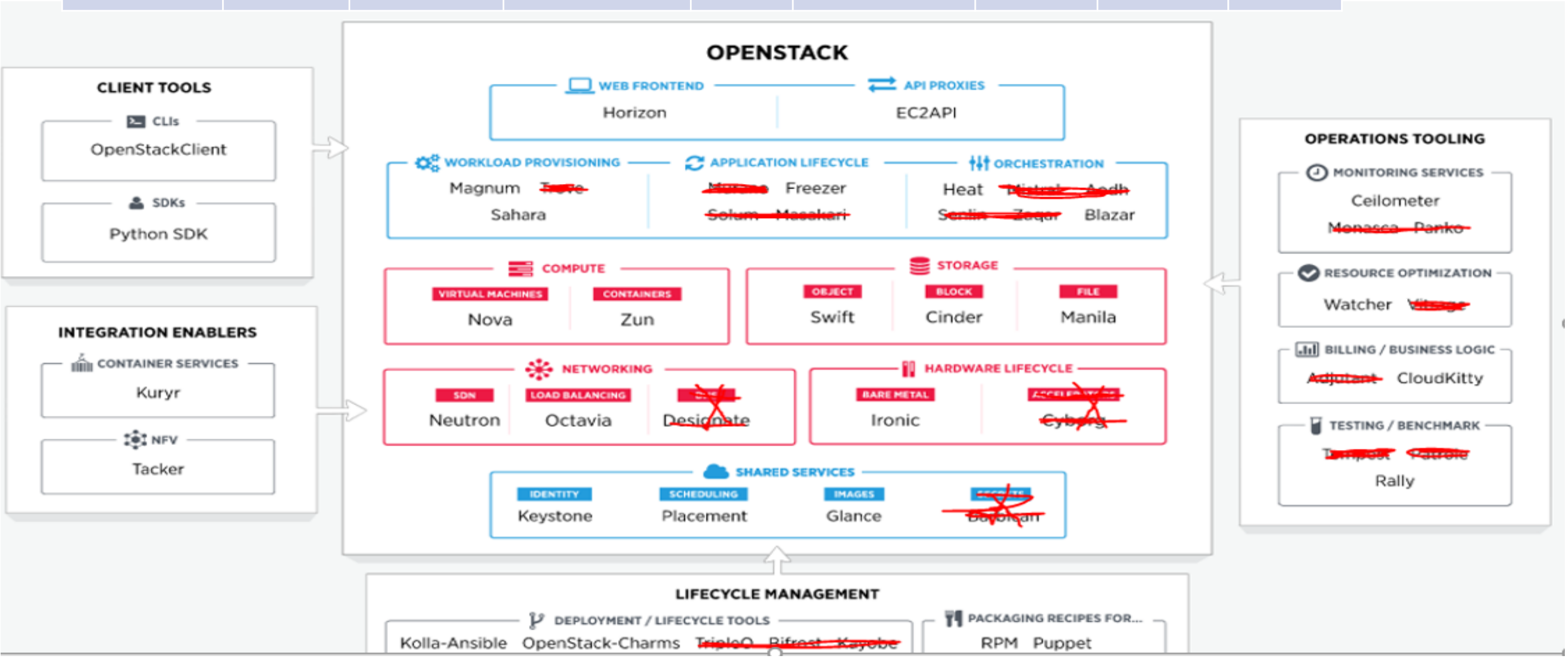
OpenStack provides an **Infrastructure-as-a-Service (IaaS)** solution through a set of interrelated services. Each service offers an **application programming interface (API)** that facilitates this integration. Depending on your needs, you can install some or all services.

Get started with OpenStack

- The OpenStack system consists of **several key services** that are separately installed.
- These services work together **depending on your cloud needs** and include the Compute, Identity, Networking, Image, Block Storage, Object Storage, Telemetry, Orchestration, and Database services.
- You can install any of these projects **separately** and configure them **stand-alone** or as connected entities.

OpenStack - Overall architecture

Identity service	Image service	Compute service	Networking service	Storage Service	Orchestration	Frontend	Billing & Testing	Deployment and Packaging
Keystone	Glance	Nova	Neutron	Swift, Cinder	Heat	Horizon	CloudKitty, Rally	Ansible, Puppet



Exercise 1: The data of a data science research project is transmitted through a high speed network (fiber-optic cables) and provide a bandwidth of 56 Gbps.

a) How long does it take to transfer the 35 PB (1 PetaBytes = 2^{50} Byte) through a 56 Gbps network?
b) What will be the best choice of network service if you want faster data transfer (Public Cloud, ~~Private Cloud or Own Network Infrastructure/ Data Centre~~) and why?

Accessibility, durability, fast data access, flexibility, Availability

Solution:

56 Gbps bandwidth = 56 * 2^{30} b / s = (56/8) *

= 7 x 2^{30} Bytes / s (since, 1 Byte = 8 bits)

Time = Distance / Speed

Duration of transmission(T) = 35 x 2^{50} / 7 x 2^{30} = 5 x 2^{50-30} = 5 x 2^{20} sec

= 5 * 1024 * 1024

= 5,242,880 s = (5242880 / 60) minutes

= 87,381 minutes

= 1456 hours

= 60.66 days

= Approx 61 days

It will take approximately 61 days

1 byte = 8 bits

1 K Byte = 1024 = 2^{10} Byte = 1024 bytes

1 MByte = 2^{10} K byte = 2^{10} * 2^{10} Byte = 2^{20} Bytes

1 GB = 2^{10} Mbyte = 2^{10} * 2^{10} K Byte = 2^{10} * 2^{10} * 2^{10} Byte = 2^{30} Bytes

1 TB = 2^{40} Bytes

1 Peta Byte = 2^{50} Bytes

1 Zeta Byte = 2^{60} Bytes

Exercise 1: The data of a data science research project is transmitted through a high speed network (fiber-optic cables) and provide a bandwidth of 24 Gbps.

a) How much time does it take to transfer the 96 ZB through a 24 Gbps network?
b) What will be the best choice of network service (Public Cloud or Own Network Infrastructure) and why?
Accessibility, durability, fast data access, flexibility, Availability

Cost Benefit Analysis & Calculation of Return on Investment(ROI)

Q1: The **Total Cost of Physical and Virtual** Layer Setup (H/w purchases) in **Majan IT Infra** is given below

No.	Description	Price($)	Quantity	Amount
Computing Hardware				
1.	CPU	$1250	2	2500
2.	Motherboard (C-422 chipset)	$450	4	1800
3.	RAM	$1540	5	7700
4.	Cooling	$1000	3	3000
5.	Power Supply	$350	4	1400
6.	Hard Drive	$90	5	0450
7.	Video Card	$700	5	3500
Storage Hardware				
1.	Disk Drives	$480	10	4800
2.	Enclosure	$1500	2	3000
Networking Hardware				
1.	Router	$450	2	0900
2.	Switch	$3100	5	15500
	Grand Total (Cost)			**$44550**

The Majan IT Infra company wants to merge their available H/w and other infrastructure with a Cloud provider
The **Total Cost of Using Cloud Services** for the above configuration is given below→

Type	Standard **Deploy in cloud provider accounts owned by Red Hat**	Bring your own cloud **Leverage your existing cloud provider discounts and settings(Red Hat)**
~~Single availability-zone cluster~~	~~Starts at $36,000/yr~~	~~Starts at $16,000/yr~~
Multiple availability-zone cluster	~~Starts at $91,000/yr~~	Starts at **$64,000/yr**

The service that is recommended is the multiple availability zone cluster. It provides a cluster administrator console which allow to view and control the cluster. It allows to track down the issues.

Total Cost of security solutions

Item/Function	Description	Cost
RSA Authentication Manager (Multifactor Authentication)	Authentication Manager Base Edition, 30 – 100 Users	$70 per month = $840
Encryption(2 user)	The price of full disk encryption	$350 per user per year=350*2 =$700
Backup	1000GB (4TB)	$450, per TB per year= $1800
Total		**$3340**

Using the data given in the above tables, calculate the Return Of Investment(ROI) for Year I, II and III.

YEAR	1	2	3
COSTS	64000+44550+3340 =$111890	64000+3340 = =$67340	64000+3340 = =$67340
ESTIMATED Gain	$70000	$85000	$100000
ROI = [(Gain – Cost) / Cost]*100 %	**= (70000-111890)/111890** **= - 0.374 x 100%** **= - 37.4%**	=(85000-67340)/67340 =0.262 x 100 % =26.2 %	