Cloud Computing

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What is a Cloud?

- It's a cluster!
- It's a supercomputer!
- It's a datastore!
- It's superman!

- Cloud = Lots of storage + compute cycles nearby

What is a Cloud?

- A single-site cloud (aka “Datacenter”) consists of
  - Compute nodes (grouped into racks) (2)
  - Switches, connecting the racks
  - A network topology, e.g., hierarchical
  - Storage (backend) nodes connected to the network (3)
  - Front-end for submitting jobs and receiving client requests (1)
  - (1-3: Often called “three-tier architecture”)
  - Software Services
- A geographically distributed cloud consists of
  - Multiple such sites
  - Each site perhaps with a different structure and services

What is Cloud Computing?

- Cloud computing 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) [Mell_2009], [Berkely_2009].
- It can be *rapidly provisioned* and *released* with minimal management effort.
- It provides *high level abstraction* of computation and storage model.
- It has some essential **characteristics, service models**, and **deployment models**.

CLOUD COMPUTING

- Cloud computing means assessing the resources by internet , anytime anywhere .
- It is = combination of software and hardware based computing resources delivered as a network service.

  Internet-based computing in which large groups of remote servers are networked so as to allow sharing of data-processing tasks, centralized data storage, and online access to computer services or resources.

  Any computer related task that is done entirely on the Internet.

What is Cloud Computing?

- **Cloud Computing** = 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 Internet for communication and transport provides hardware, software and networking services to clients
- These platforms hide the complexity and details of the underlying infrastructure from users and applications by providing 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**: result is a utility computing model similar to traditional that of traditional utilities, like gas and electricity – user to pay for what he would want

Cloud Computing

NIST Definition

The National Institute of Standards and Technology (NIST) defines cloud computing as *"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."*

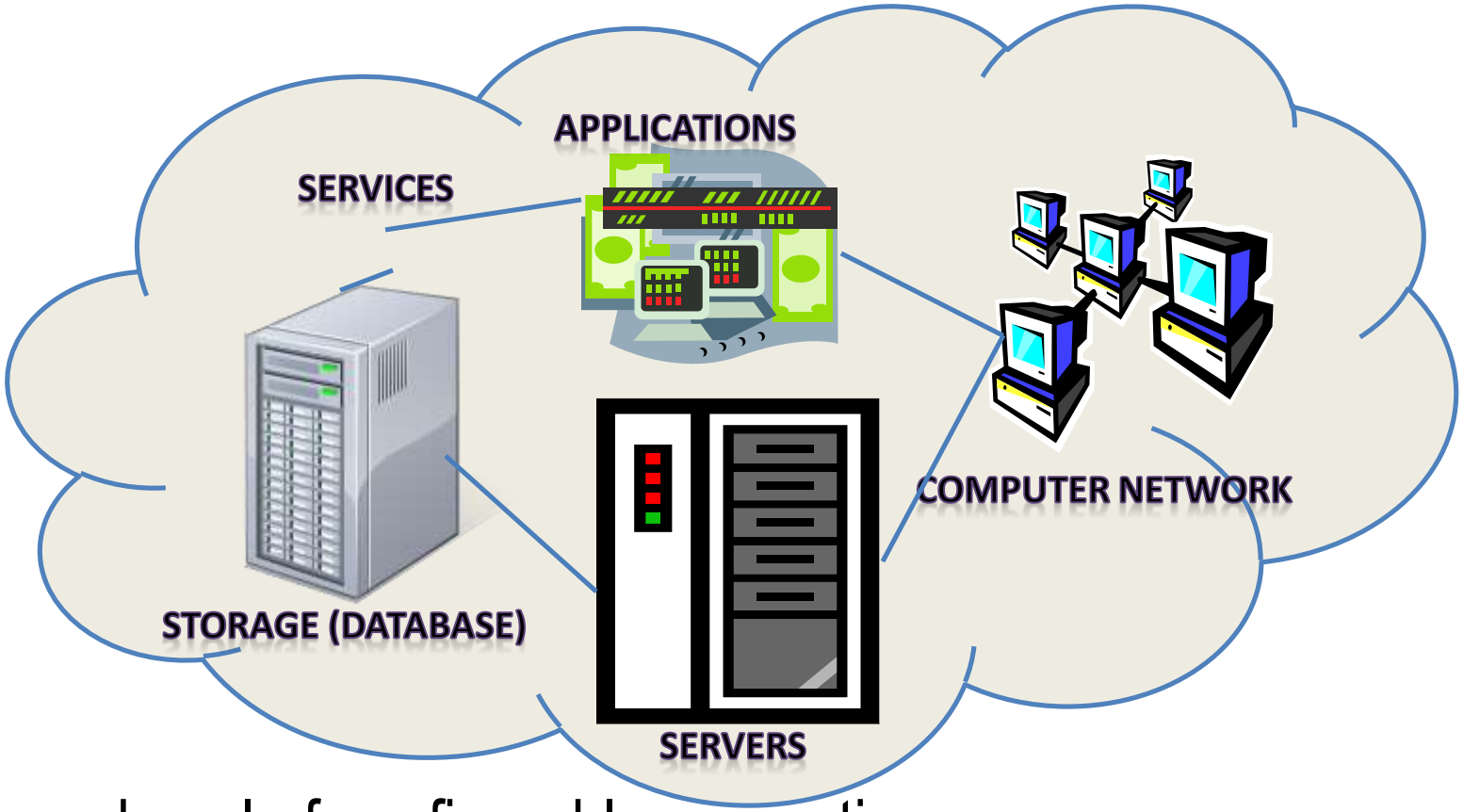
Essence = Allows users to **deal with the software without having the hardware.**

Everything is done by remote, nothing is saved locally.

World's Largest Datacenter

- (2018) China Telecom. 10.7 Million sq. ft.
- (2017) "The Citadel" Nevada. 7.2 Million sq. ft.
- (2015) In Chicago
  - 350 East Cermak, Chicago, 1.1 MILLION sq. ft.
  - Shared by many different "carriers"
  - Critical to Chicago Mercantile Exchange

Cloud Computing



- Shared pool of configurable computing resources
- On-demand network access
- Provisioned by the Service Provider

Basic Cloud Characteristics

- The "**no-need-to-know**" = underlying details of infrastructure, applications interface with the infrastructure via the APIs.
- The "**flexibility and elasticity**" allows these systems to scale up and down at will
  - utilising the resources of all kinds
    - CPU, storage, server capacity, load balancing, and databases
- The "**pay as much as used and needed**" type of utility computing and the "**always on, anywhere and any place**" type of network-based computing.

Basic Cloud Characteristics

- Cloud are transparent to users and applications, they can be built in multiple ways
  - branded products, proprietary open source, hardware or software, or just off-the-shelf PCs.
- In general, they are built on clusters of PC servers and off-the-shelf components plus Open Source software combined with in-house applications and/or system software.

Types of Clouds

- **Infrastructure as a service** (IaaS)
  - You rent a virtual server
  - Amazon, Rackspace, GoGrid, etc.
- **Platform as a service** (PaaS)
  - You rent an abstract machine
  - Google app engine, Salesforce, etc.
- **Software as a service** (SaaS)
  - You rent a capability
  - Exchange hosting, Wordpress hosting, etc.

DaaS – Desktop as a Service

Common points

- In all clouds, someone else is providing the physical machines
- User not concerned about power, bandwidth, maintenance, physical security,
- User only pays for what he uses
- With a cloud, users don't "own" a physical machine
  - In fact, users don't own a virtual machine either
- Users are renting some "slice" of a bigger physical machine
- CSP guarantees RAM & some level of performance

Virtualization

- Started in 1967 with the IBM CP-40
- Virtual machine (VM) software is a program that emulates a physical machine
- A VM needs to act *exactly* like its physical machine

Virtualization

- **Virtual workspaces:**
  - An abstraction of an execution environment that can be made dynamically available to authorized clients by using well-defined protocols,
  - Resource quota (e.g. CPU, memory share),
  - Software configuration (e.g. O/S, provided services).
- **Implement on Virtual Machines (VMs):**
  - Abstraction of a physical host machine,
  - Hypervisor intercepts and emulates instructions from VMs, and allows management of VMs,
  - VMWare, Xen, etc.
- **Provide infrastructure API:**
  - Plug-ins to hardware/support structures

Software as a Service (SaaS)

- SaaS is a software delivery methodology that provides licensed multi-tenant access to software and its functions remotely as a Web-based service.
  Usually billed based on usage
  - Usually multi tenant environment
  - Highly scalable architecture
- Also referred to as "software on demand," this service model involves outsourcing the infrastructure, platform, and software/applications.
- Typically, these services are available to the customer for a fee, pay-as-you-go, or a no charge model.
- The customer accesses the applications over the internet.

Infrastructure as a Service (IaaS)

- IaaS is the delivery of technology infrastructure as an on demand scalable service
  - Usually billed based on usage
  - Usually multi tenant virtualized environment
  - Can be coupled with Managed Services for OS and application support
- A service model that involves outsourcing the basic infrastructure used to support operations--including storage, hardware, servers, and networking components.
- The **service provider owns the infrastructure equipment** and is responsible for housing, running, and maintaining . The customer typically pays on a per-use basis.
- **The customer uses their own platform (Windows, Unix), and applications**

What is EC2 ?

- Amazon Elastic Compute Cloud (EC2) is a web service that provides resizeable computing capacity that one uses to build and host different software systems.
- Designed to make web-scale computing easier for developers.
- A user can create, launch, and terminate server instances as needed, paying by the hour for active servers, hence the term "elastic".
  - Provides scalable, pay as-you-go compute capacity
  - Elastic - scales in both direction

Amazon Machine Images (AMI)

- Is an immutable representation of a set of disks that contain an operating system, user applications and/or data.
- From an AMI, one can launch multiple **instances**, which are running copies of the AMI.

Amazon S3

- S3 = Simple storage Service
- A SOA – Service Oriented Architecture which provides online storage using web services.
- Allows read, write and delete permissions on objects.

Platform as a Service (PaaS)

- PaaS provides all of the facilities required to support the complete life cycle of building and delivering web applications and services entirely from the Internet.
  A service model = involves outsourcing the basic infrastructure and platform (Windows, Unix)

- PaaS facilitates deploying applications without the cost and complexity of buying and managing the underlying hardware and software where the applications are hosted.
- Users have an (essentially) unlimited machine
  - CPU resources scale up or down as needed
  - No need to spin up new machines, manage load balancing, etc.
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Enterprise Cloud Solutions

1. Hybrid Cloud
   - Scalability of the Public Cloud with the control and security of a private cloud
2. Test / Development / QA Platform
   - Use cloud infrastructure servers as your test and development platform
3. Disaster Recovery
   - Keep images of your servers on cloud infrastructure ready to go in case of a disaster
4. Cloud File Storage
   - Backup or Archive your company data to cloud file storage
5. Load Balancing
   - Use cloud infrastructure for overflow management during peak usage times

Enterprise Cloud Solutions (cont)

6. Overhead Control
   - Lower overhead costs and make your bids more competitive
7. Distributed Network Control and Cost Reporting
   - Create an individual private networks for each of your subsidiaries or contracts
8. Messaging Alternatives
   - Replace Microsoft Exchange and SharePoint with Google Apps
9. Rapid Deployment
   - Turn up servers immediately to fulfill project timelines
10. Functional IT Labor Shift
    - Refocus your IT labor expense on revenue producing activities

Cloud Migration

-: Migrating applications and data to the cloud = routine activity in the digital age, one that business and IT stakeholders can launch quickly, efficiently and effectively.

-: According to a survey by LogicMonitor1 , it is predicted that 41% of enterprise workloads will be run on public cloud platforms by 2025, driven by the need for digital transformation and IT agility.

Advantages

- ❖Back up and restore
- ❖Lower cost
- ❖Deploy globally in minutes
- ❖Unlimited storage capacity

- We use clouds everyday
- Used to save huge amounts of data
- Make maintaining information easy
- Makes security easy
- Maintainability and sustainability are better

Adopting to Cloud Computing(Benefits)

- Lower Computer Costs.
- Improved performance.
- Instant Software Updates.
- Unlimited storage capacity.
- Universal document access.
- Easier Group Collaboration.
- Latest Version Availability.
- Device Independence.
- Reduce Hardware Cost.

CC benefits

- Cloud computing enables companies and applications, which are system infrastructure dependent, to be infrastructure-less.
- By using Cloud infrastructure on “pay as used and on demand”, all of us can save in capital and operational investment
- **Clients can:**
  - Put their data on the platform instead of on their own desktop PCs and/or on their own servers.
  - They can put their applications on the cloud and use the servers within the cloud to do processing and data manipulations etc.

CC = Opportunities and Challenges

- 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 in 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
  - most cloud computing applications today, such as 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.
  - PC'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 slow, 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 unauthorised 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.

Top 6 Cloud Governance Principles

- 1. Financial Management:
- 2. Cost optimization:
- 3. Operational governance:
- 4. Performance management: location.
- 5. Asset & configuration management:
- 6. Security & Incident management:
- For example, Encryption, Access controls, Security groups, Audit trails, Application access rules.

IS Audit
Steps in CC environment

- Communication
- Security incidents
- Network security
- System development or change management
- Risk management
- Data management

Cloud = leading players

1. AMAZON WEB SERVICES (AWS)

- Amazon Web Services (AWS) is an Amazon company that was launched in the year 2002. AWS is the most popular cloud service provider in the world.
- Amazon Web Services (AWS) is the world's most comprehensive and broadly adopted cloud platform, offering over 165 fully-featured services from data centers globally. This service is used by millions of customers.
- AWS offers hundreds of services. Some of these include Virtual Private Cloud, EC2, AWS Data Transfer, Simple Storage Service, DynamoDB, Elastic Compute Cloud, AWS Key Management Services.
- Amazon's Elastic Compute Cloud (EC2) & Simple Storage Solution (S3) are well known examples

Amazon EC2

- Amazon EC2 is one large complex web service.
- EC2 provided an API for instantiating computing instances with any of the operating systems supported.
- It can facilitate computations through Amazon Machine Images (AMIs) for various other models.
- Signature features: S3, Cloud Management Console, MapReduce Cloud, Amazon Machine Image (AMI)
- Excellent distribution, load balancing, cloud monitoring tools

2. Microsoft Azure

- Microsoft Azure is one of the fastest-growing clouds among them all. It recently won a $10 billion US government contract.
- Microsoft broke down its revenue of the last quarter into three categories, Productivity and Business Processes, Intelligent Cloud, and Personal Computing.
- Microsoft's Azure revenue is expected to grow between $33 billion to $35 billion.
- This makes Azure one of the most profitable cloud services in the world.
- Azure offers hundreds of services within various categories including:
- AI + Machine Learning, Analytics,
- Blockchain, Compute, Containers, Databases, Developer Tools, Identity, Integration, Internet of Things,

Windows Azure

- Enterprise-level on-demand capacity builder
- Fabric of cycles and storage available on-request for a cost
- User to use Azure API to work with the infrastructure offered by Microsoft
- Significant features: web role, worker role , blob storage, table and drive-storage

Google App Engine

- This is more a web interface for a development environment that offers a one stop facility for design, development and deployment Java and Python-based applications in Java, Go and Python.
- Google offers = same reliability, availability and scalability at par with Google's own applications
- Interface is software programming based
- Comprehensive programming platform irrespective of the size (small or large)
- **Signature features**: templates and appspot, excellent monitoring and management console

3. Google Cloud

- Google cloud platform is Google's cloud. Similar to AWS and Azure, Google Cloud also offers similar services in various categories, including compute, storage, identity, security, database, AI and machine learning, virtualization, DevOps and more.
- Services:-AI and Machine Learning, API Management, Compute, Containers, Data Analytics, Databases, Developer Tools, Healthcare and Life Sciences, Hybrid and Multi-cloud, Internet of Things, Management Tools, Media and Gaming, Migration, Networking, Security and Identity, Serverless Computing, and Storage.
- Google products are also offered in the cloud, including G Suite, Google Maps Platform, Google Hardware, Google Identity, Chrome Enterprise, Android Enterprise, Apigee, Firebase, and Orbiter.
- Google Cloud Services are available in 20 regions, 61 zones, and 200+ countries.

Cloud Governance

- The Cloud Governance policy must include:
- • Standards for the design of infrastructure.
- • Monitoring of infrastructure and application.
- • Security Policy.
- • Programming standards.
- • Backup recovery services.

FUTURE OF CLOUD COMPUTING

- Enhanced performance of Internet
- Modular software will be priority
- I.o.T along with cloud computing
- Improvement in cloud service

- ***Total cost of ownership:***
- To put the cost of a cloud solution into perspective, user need to calculate the total cost of ownership (TCO) for the onpremises first.
- User can calculate that by figuring out the cost of the equipment user need, the cost of the capital and the project lifespan of the equipment.
- User can also include the installation and maintenance costs as well.

Cost of User Current Data Center:

- That's the first step, to calculate the amount of time, money and infrastructure required in running user current data center.
- Once user determines scope and scale of user current IT infrastructure, it will provide user with the baseline to help user calculate the potential cost of the cloud resources the user will consume and compare it to current cost levels.
- To precisely calculate the cost of user current data center, make sure to include all aspects. For example, IT infrastructure consisting of hardware and software that can include physical servers, software licenses, maintenance contracts, warranties, supplies, material, spare parts, and anything else that user directly pay for.
- User need the cost of all these to correctly estimate how much user current IT infrastructure cost.
- Then there are operational costs as well that include labour, facilities used to house IT hardware, internet connectivity.
- These operational costs are part of the cost of user data center as well.

- ***Cost of estimated Cloud Infrastructure:***
- Once the cost of user current data center is determined, user now need to calculate the estimated cost of cloud infrastructure.
- While cloud pricing can vary depending on the number of factors and can be quite complicated, it depends on user cloud provider to provide a simplified pricing structure that is easier to understand.
- Alternatively, user can contact user cloud provider of choice for a quote.
- ***Cost of Cloud Migration Execution:***
- The next step is accounting for the costs involved in executing the migration of the IT operations to the cloud.
- It is determined by the scope of user Current IT infrastructure and how much of its user plan on moving to the cloud will be.
- Moreover, there is a cost involved in integrating and testing of apps or even consultation fees.

- ***Additional Post-migration Cost:***
- Often, many cloud providers require a monthly infrastructure fee to maintain and improve user new cloud environment.
- Costs such as continuous integration and testing of apps, training, labour, security, and compliance, administration, others need to be forecasted in order to determine an accurate post-migration budget.
- **Benefits of Cloud Computing Versus Cost:**
- Cloud computing is about storing and accessing data, programs, and applications users are using over the internet instead of storing and accessing the same thing from user computer's hard drive.
- Hence, the cost of shifting to the cloud may seem steep but in actual, maintenance of on-premises infrastructure is more expensive than cloud computing in the long run.
- Moreover, cloud computing offers the flexibility to scale services to fit as per the company's needs and customize applications.