THE ANATOMY OF CLOUD COMPUTING

C.S.V. Murthy

Himalaya Publishing House
ISO 9001:2015 CERTIFIED

THE ANATOMY OF CLOUD COMPUTING

(An Upcoming Technology)

C.S.V. Murthy
B.Sc., B.E., M.I.E., Chartered Engineer,
Industrial Consultant,
Visiting Faculty at Various Management Colleges,
Bengaluru, India.

Himalaya Publishing House
ISO 9001:2015 CERTIFIED

FIRST EDITION : 2019

Published by : Mrs. Meena Pandey for **Himalaya Publishing House Pvt. Ltd.,**
Ramdoot, Dr. Bhalerao Marg, Girgaon, Mumbai - 400 004
Phone: 022-23860170/23863863; **Fax:** 022-23877178
E-mail: himpub@vsnl.com; **Website:** www.himpub.com

Branch Offices :

New Delhi : Pooja Apartments, 4-B, Murari Lal Street, Ansari Road, Darya Ganj,
New Delhi - 110 002. Phone: 011-23270392, 23278631; Fax: 011-23256286

Nagpur : Kundanlal Chandak Industrial Estate, Ghat Road, Nagpur - 440 018.
Phone: 0712-2738731, 3296733; Telefax: 0712-2721216

Bengaluru : Plot No. 91-33, 2nd Main Road, Seshadripuram, Behind Nataraja Theatre,
Bengaluru - 560 020. Phone: 080-41138821;
Mobile: 09379847017, 09379847005

Hyderabad : No. 3-4-184, Lingampally, Besides Raghavendra Swamy Matham, Kachiguda,
Hyderabad - 500 027. Phone: 040-27560041, 27550139

Chennai : New No. 48/2, Old No. 28/2, Ground Floor, Sarangapani Street, T. Nagar,
Chennai-600 012. Mobile: 09380460419

Pune : First Floor, Laksha Apartment, No. 527, Mehunpura, Shaniwarpeth
(Near Prabhat Theatre), Pune - 411 030. Phone: 020-24496323, 24496333;
Mobile: 09370579333

Lucknow : House No. 731, Shekhupura Colony, Near B.D. Convent School, Aliganj,
Lucknow - 226 022. Phone: 0522-4012353; Mobile: 09307501549

Ahmedabad : 114, SHAIL, 1st Floor, Opp. Madhu Sudan House, C.G. Road, Navrang Pura,
Ahmedabad - 380 009. Phone: 079-26560126; Mobile: 09377088847

Ernakulam : 39/176 (New No. 60/251), 1st Floor, Karikkamuri Road, Ernakulam,
Kochi - 682011. Phone: 0484-2378012, 2378016; Mobile: 09387122121

Bhubaneswar : Plot No. 214/1342, Budheswari Colony, Behind Durga Mandap,
Bhubaneswar - 751 006. Phone: 0674-2575129; Mobile: 09338746007

Kolkata : 108/4, Beliaghata Main Road, Near ID Hospital, Opp. SBI Bank, Kolkata - 700 010,
Phone: 033-32449649; Mobile: 07439040301

DTP by : **Sudhakar Shetty**

Printed at : M/s. Aditya Offset Process (I) Pvt. Ltd., Hyderabad. On behalf of HPH.

PREFACE

"The Anatomy of Cloud Computing (An Upcoming Technology)" when we think over, is changing the way we provision our hardware and software for on-demand capacity fulfillment. Gone are the days of idle CPU, empty memory or unused drive space, etc. We have to think about the ways on-demand servers, storages and CDNs are changing the way. We develop web applications and make business decisions. The cloud charges us for what we use as we like it, assuming capacity is available.

In this book, the reader would find an overview of the cloud hosting landscape with a particular focus on cloud utilisation by web companies. He may also walk through at a glance a managed infrastructure stack and examine a few major business targets. This book will also be helpful for the students who are the beginners of learning **'cloud computing'** and its related subjects and who want to proceed further on this line at a later date for higher studies or starting business or joining industry at a later date and to think of utilising cloud computing technique for their use. It may be a boon for them to know the fundamentals of cloud computing immediately and later on how to utilise them fully in the future years.

Cloud computing is picking up steam and those who start and proceed early may be early winners and benefit them. The most promising solution from large vendors are still in a technology preview stage and not decided yet. These are open for general use in the subsequent years. Start-ups on the cloud computing subject are many and they are developing new applications now and then. They should be open for general use shortly at any time on a full scale, though considerable improvements are taking place fast. Start-ups developing new applications should pick the best solutions as providers based on the strength of their stack offering and usage pricing. Some cloud layers can easily be abstracted to the best-of-breed solutions.

With this small background, I hope this book with 12 chapters based on my own categorisation will provide sufficient information for the users to start with in thinking about its usage for their further strengthening activities in their organisations or institutions. I am highly grateful to the top brasses of M/s Himalaya Publishing House Pvt. Ltd. in bringing this book on top priority, specially to the Pandey family of Himalaya Publishing House Pvt. Ltd. (HPH) and other persons who are responsible in bringing this book at short notice. I am also grateful to Nimisha, Lalita and other HPH Technical staff, who have taken personal interest and for the creation of this book in framing and designing cover page in a way attractable to the readers and in bringing this book at a short notice, through the excellent sketches of DTP work. On the homefront also, I am grateful to my family who supported me, while writing this book at Detroit, USA during my 4 months' stay at that place. I thank Mr. Arakere Ramesh of Phoenix, USA who helped me in providing some useful material about this subject.

Detroit, USA **C.S.V. MURTHY**
07-08-2017

CONTENTS

CHAPTER 1

An Introduction to Cloud Computing

Learning Objectives:

After reading and studying this chapter, you should be able to:

- Explain the definition of cloud and cloud computing, types of clouds, difference between Internet and Cloud, uses of cloud and cloud computing to the ultimate users of the same.
- Experiment what further new things to be done with the cloud after studying the benefits and characteristics of the same.
- Give examples to illustrate how the cloud information can support the industries and the services offered by the cloud providers for the same.
- Study the security measures provided and the delivery of various major cloud services such as SaaS, PaaS and IaaS and the computer hardware virtualisation.
- Identify the building blocks involved in cloud computing.
- Examine the delivery of cloud services, evolution of the cloud computing, various stages, good vendors, conceptual views, ideas, history of cloud computing, various computing models, delivery models, etc.
- Understand new computing areas like grid computing, cloud computing, challenges and issues, opportunities in the cloud computing delivery, what cloud computing provides to customers? etc.
- Study of auto scaling, utility computing, cluster computing, distributed computing, new technologies, new formats, etc. with certain fundamentals for further study.

Structure:

1.1 DEFINITION OF CLOUD AND CLOUD COMPUTING

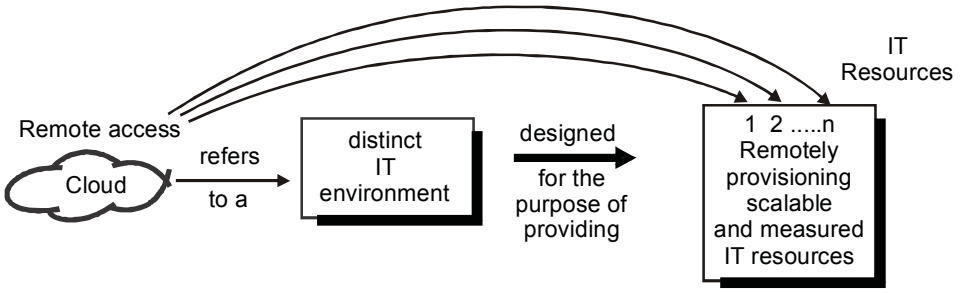


Figure 1.1: Definition of Cloud

Cloud is a metaphor to the Internet (a network of networks) providing remote access to a set of decentralised IT resources.

It is a general term for the delivery of hosted services over the Internet.

Existing customer is to be integrated with the right type of technology, and to develop them with modern ideal and cognitive approach.

Leading businesses are 5 times more likely to use **hybrid cloud** (one of the types of cloud) for cognitive capabilities. The first and foremost theory is to connect and use all relevant data to look for integration.

For this purpose, it is necessary to use proper technology ideas, plus environment, plus right type of people to get more from current environment.

Definition of Cloud Computing

Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources.

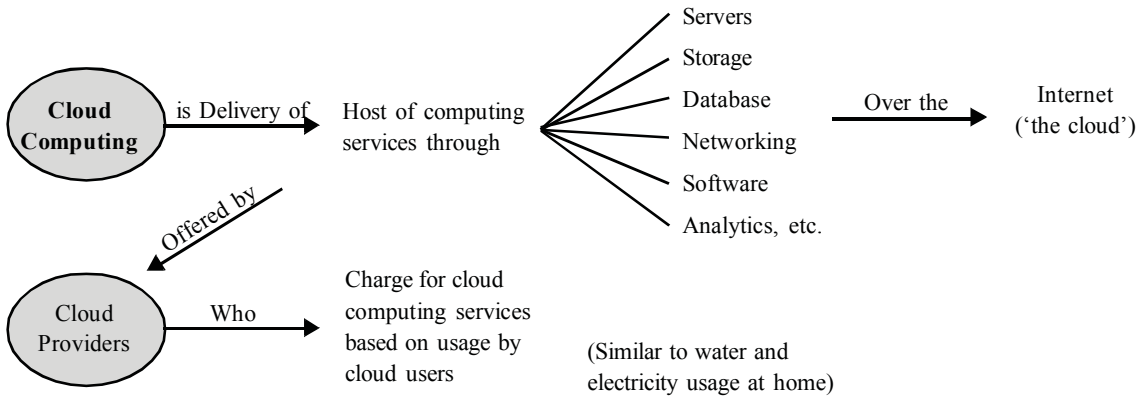


Figure 1.2: How Cloud Computing Works?

Cloud computing is the on-demand delivery of computer power, databases, storage, applications and other IT relevance through a cloud service, platform via the Internet with pay-as-you-go pricing.

Technologies that are driving the digital revolution and integration solutions address the challenges around security, governance, performance and scale. On the whole, **cloud computing** is now understood as commonly used to describe the delivery of software, infrastructure and storage services over the internet.

Existing customer is to be integrated with the right type of technology, and to develop them with modern ideal and cognitive approach.

Leading businesses are five times more likely to use **hybrid cloud** (one of the types of cloud) for cognitive capabilities. The first and foremost theory is to connect and use all relevant data to look for integration for this purpose.

It is necessary to use proper technology ideas, plus environment, plus right type of people to get more from current environment.

1.2 TYPES OF CLOUDS

In general, there are four types of clouds found from which any one can be selected and subscribed depending on one's needs. In general, it may be noted that the home user or a small business owner will use 'public cloud services'. The types of clouds are:

(a) Public Cloud, as already stated above, can be used by any subscriber who has an internet connection and access to the cloud space, services provided by third party vendors, multitenant or dedicated to you as a single company. (**Multitenant** means that your company shares the solution with other organisations. The data is kept separate and secure.)

(b) Private Cloud: This is generally established by a specific group or company which has a limited access and available only for that group/company. This is ideal for home users and small business owners.

(c) Community Cloud: As the name indicates, it is for a community, where cloud is shared among two or more organisations who are similar in nature and operate for more or less identical cloud requirements.

(d) Hybrid Cloud: This is essentially a combination of two clouds of different types (a), (b) and (c).

Private cloud services are delivered from a business data center to internal users. The model offers versatility and convenience while preserving the management control and security common to local data centers. Users who use internally may or may not be billed for services which depends on the agreement terms with the cloud provides.

In the **public cloud model**, a third-party provider delivers the cloud service over the internet. Public cloud services are sold on demand, typically by the minute or hour. Customer only pay for the CPU cycles, storage or band width they consume. Leading public cloud providers include Amazon Web Services (AWS), Microsoft Azure, IBM SoftLayer and Google Compute Engine.

Hybrid Cloud is a combination of public cloud services and on-premises private cloud, with orchestration and automation between the two. Companies can run mission-control workloadings or sensitive applications on the private cloud while using the public cloud for bursting workloadings that must scale on demand. The goal of hybrid cloud is to create an unified cloud, automated, scalable environment that takes advantage of all that of a public cloud infrastructure can provide, while still maintaining control over mission-critical data.

Hybrid cloud can be:

(i) Private + Community

(ii) Public + Community

(iii) Public + Private or

(iv) A combination of at least two or three clouds

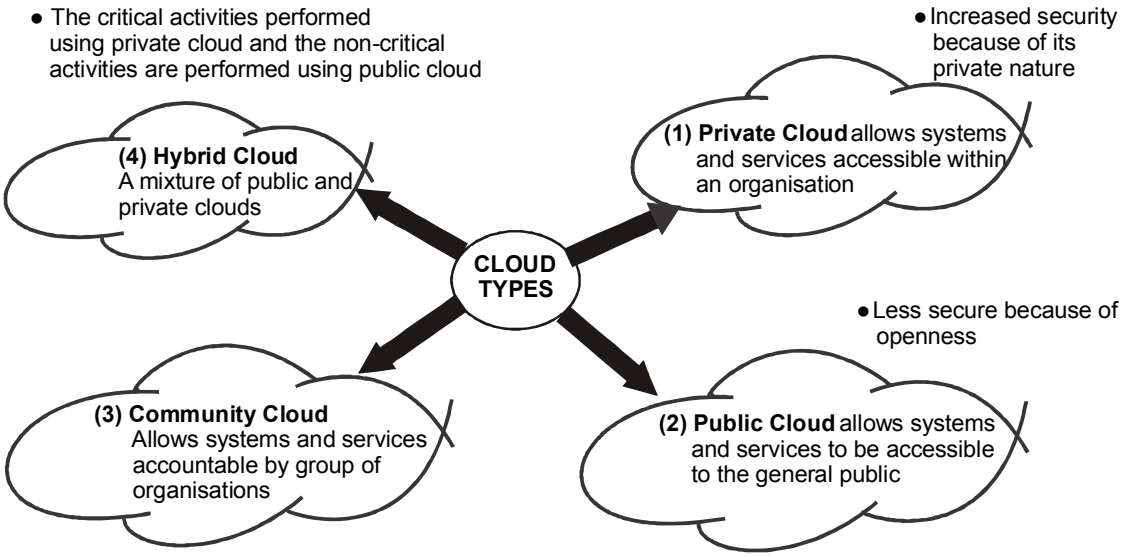


Figure 1.3: Types of Clouds and Activities/Safety Involved

The word **'Cloud computing'** is becoming very popular and receiving a great deal of attention in publications as well as among users from individuals as private as well as government.

Understanding of Different Types of Clouds and their Comparison

The different types of clouds have been already explained earlier in para 1.2. Firms which use the cloud have to choose to deploy the applications using any of the various types of clouds which suits them either public, private or hybrid type. **Cloud integrators** can play a vital part in determining the right cloud path for each organisation.

TABLE 1.1: COMPARISON OF CLOUDS

Public Cloud	*Private Cloud*	*Hybrid Cloud*
• These are owned and operated by third parties. • Deliver superior economies of scale to customers. • Infrastructure costs distributed among a mix of users, providing each individual client an attractive low cost. • Pay-as-you-go model • All customers share the same infrastructure pool with: — limited configuration — security protections — availability of variances. • Managed and supported by the cloud provider. • Advantage is: They may be larger than an enterprises cloud, thus providing the ability to scale seamlessly, on demand.	• Built exclusively for a single enterprise. • Address concerns on data security and offer greater control (lacking in a public cloud). • Two variations: On-premise private clouds or Internal clouds hosted from one's own data center. This model provides: — A more standardised process protection — Limited in aspects of size and scalability. • Best suited for applications which require complete control and configurability of the infrastructure and security (IT departments would also need to incur the capital and operational costs for the physical resources). • **Externally hosted private cloud** — Hosted externally with a cloud provider. Here, the provider facilitates an exchange cloud environment with full guarantee of privacy. This is best suited for those that does not prefer a public cloud due to sharing of physical resources.	• Combines both private and public cloud models. • Service providers can utilise a full or partly, capacities thus increase the flexibility of computing. • Capable of providing on demand, externally provisioned costs. • Cloud can be used to manage any unexpected surges in workload.

1.3 DIFFERENCE BETWEEN INTERNET AND CLOUD

TABLE 1.2: DIFFERENCE BETWEEN CLOUD AND INTERNET

Cloud	*Internet*
• A cloud has a finite boundary. • There are many individual clouds that are accessible to the Internet. • A cloud is typically privately operated. • Offers access to IT resources and measured. • IT resources provided are dedicated to supplying back end processing capabilities and user based access to these capabilities.	• Internet provides open access to many web-based information technology resources. • Dedicated to the access of content-based IT resources, published via www (world wide web). • Need not be web-based if they are commonly used on Internet protocols and techniques (protocols refer to standards and methods allowing computers to communicate with each other in a pre-defined and structured manner). • Can be based on any of the protocols that allow the remote access to the IT resources.

1.4 USES OF CLOUD COMPUTING

It is said that **cloud computing** is a subscription-based service. From this, we can obtain (i) networked storage space and (ii) computer resources. It is something like experience with e-mail (Yahoo!, G-mail, Hotmail, etc.) which takes care of housing all the hardware and software necessary to support our personal e-mail account. At that time, we open our web browser, go to the e-mail account and login, *i.e.*, internet access. Our e-mail is not housed only on our physical computer but we can access it through internet connection anywhere, and at everywhere, even on a trip at work or on aeroplane, or at coffee house, friends house, independent of software installed in our computers such as a word processing program. When we create a document, this software (word processing software) document stays on the device, we used to make until it is physically moved elsewhere. **Cloud computing** also works like an e-mail client, but instead of e-mail, we can choose what all information we have to access available from and within the cloud.

1.5 INFORMATION FROM CLOUD *VIS-A-VIS* TRADITIONAL COMPUTERS

TABLE 1.3: INFORMATION FROM CLOUD VS. TRADITIONAL COMPUTERS

Details	*Using Cloud*	*Using Traditional Computers*
(i) Accessing of information	• Anywhere at anytime. • The cloud provider owns and house the hardware and software necessary to run home and business applications.	• Same location as your data storage and at that place you should be available. • Same physical location where your hardware exists where the data is stored.
(ii) Helpful for business (hardware and software space)	• Small businesses cannot afford the same amount of hardware and storage space as a big company, hence seeks cloud.	• Expensive and cumbersome to have such traditional methods.
(iii) Storing of information and amount of storage space	• Removes the cost of purchasing and storing memory devices.	• Expensive and cumbersome.
(iv) Amount of storage space	In the case of small businesses, the storage space required can be added as and when it is needed based on the business growth points (ii), (iii) and (iv) which are favourable to cloud for small businesses.	
(v) Internet connection	• Needed to access the cloud. To see any specific document you have housed in the cloud, first obtain an internet connection (wireless, or wired internet or a mobile broadband connection to obtain access from anywhere or through any device).	• Expensive and cumbersome to achieve and own all such connections.

Table (cont.)

(vi) Smooth functioning	• Devices could be a desktop, laptop, tablet or phone. • Yes (By connecting to the internet and cloud, we can work on documents, access software and store data). • Time and cost saving through exchange and cumbersome (No separate printing or uploading of any document).	

Table 1.3 provides a comparison from Cloud *vis-a-vis* Traditional Computers usage:

1.6 WHAT NEW THINGS COULD BE DONE WITH THE CLOUD?

Following are the uses of **cloud computing** which can benefit the cloud users. Behind the scenes, we can have plenty of cloud computing right now, even though we are not initially aware of those things, which we have not realised such online services as:

- Sending of e-mail
- Editing documents
- Watching movies on TV
- Listening to the music
- Playing games
- Storing pictures and other files, etc.

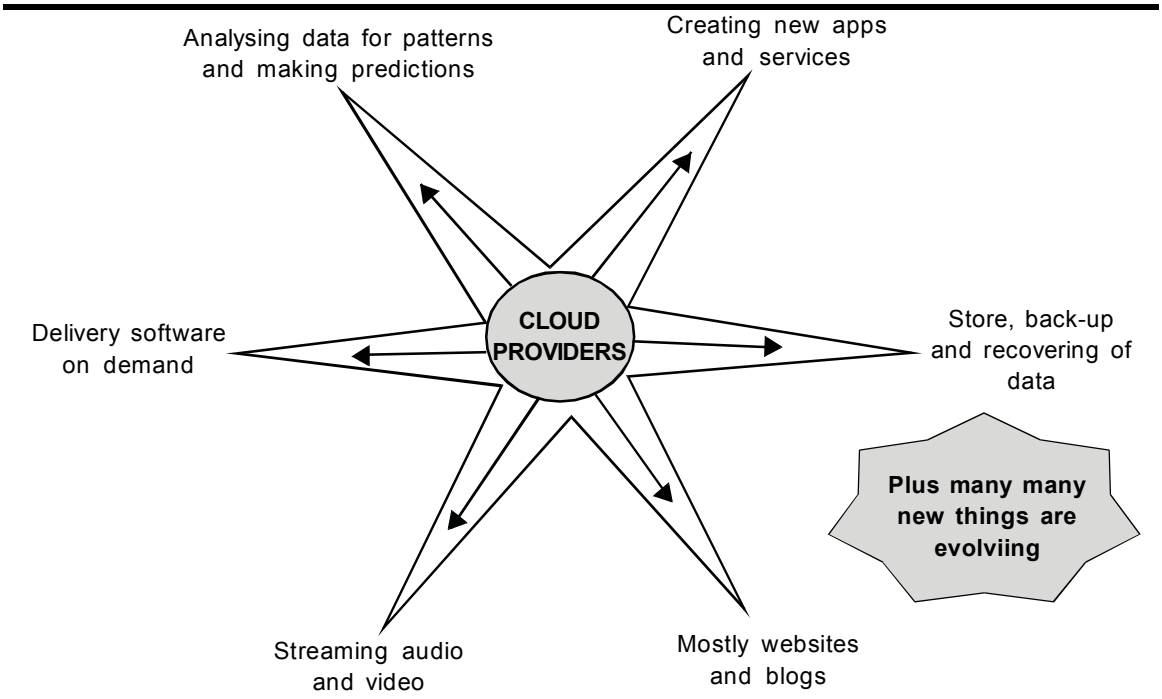


Figure 1.4: What Cloud Provides?

It is likely that **cloud computing** can be made use of in future for many things behind the scenes. The earlier cloud services are a decade old. Variety of organisations from tiny start-ups to big global corporations and government agencies to non-profitable organisations are involved in this technology. What we can do with the cloud are as shown in Fig. 1.4.

Advantages:

(i) It provides many options for the computer users throughout, irrespective of large and small businesses.

(ii) Opens up the world of computing to a broader range of uses and increases the ease of use through any internet connection access.

Disadvantages:

Increased use also come up with the following disadvantages:

(i) Less control over who have access to your information and little-to-no knowledge of the place it is stored. One should be aware of the security risks of having data stored on the cloud.

(ii) Malicious individuals take advantages as cloud is a big target for them and the information can be accessed through an unsecured internet connection.

Care to be Taken to Use the Cloud

(i) Be certain to identify what information you are putting on the cloud, who accesses to that information, what you will need to make sure if it is to be protected.

(ii) Make sure what type of cloud will optimise for your needs, type of provider useful to you and the reputation and responsibilities of the providers before entering into the contract with them and expert's advice needed.

1.7 VENDORS OF COMPUTER CLOUD SERVICES

The three big vendors who offer services to the cloud users ranging from big data in the cloud to serverless computing are as under:

- Microsoft Azure
- AWS
- Google

Bandwidth, Quality of Services and Data Units

- **Cloud computing** requires broadband of considerable speed, whilst many websites are usable on non-brand connections or slow broadband connections.
- Cloud based applications are often not usable.
- Connection speed in kilobytes per second (or MB/S and GB/S) is important for use of cloud computing services.

1.8 BENEFITS OF CLOUD COMPUTING

The main benefits of cloud computing are as indicated below in addition to other small benefits. The most important ones are:

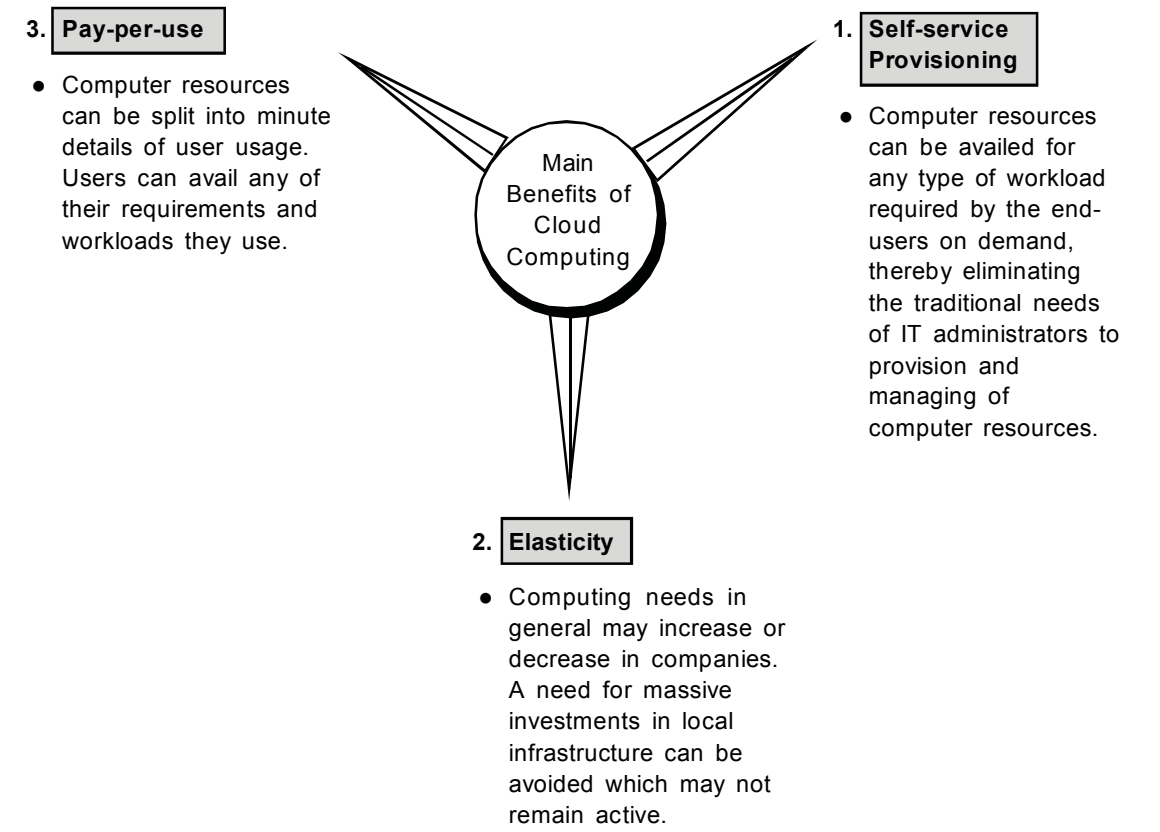


Figure 1.5: Main Benefits of Cloud Computing

The cloud users in the home or enterprises, who need to align their applications, in order to exploit fully the architecture models provided by the cloud computing providers are going to get the following benefits which can be categorised in this way are shown in the following pages 11 and 12).

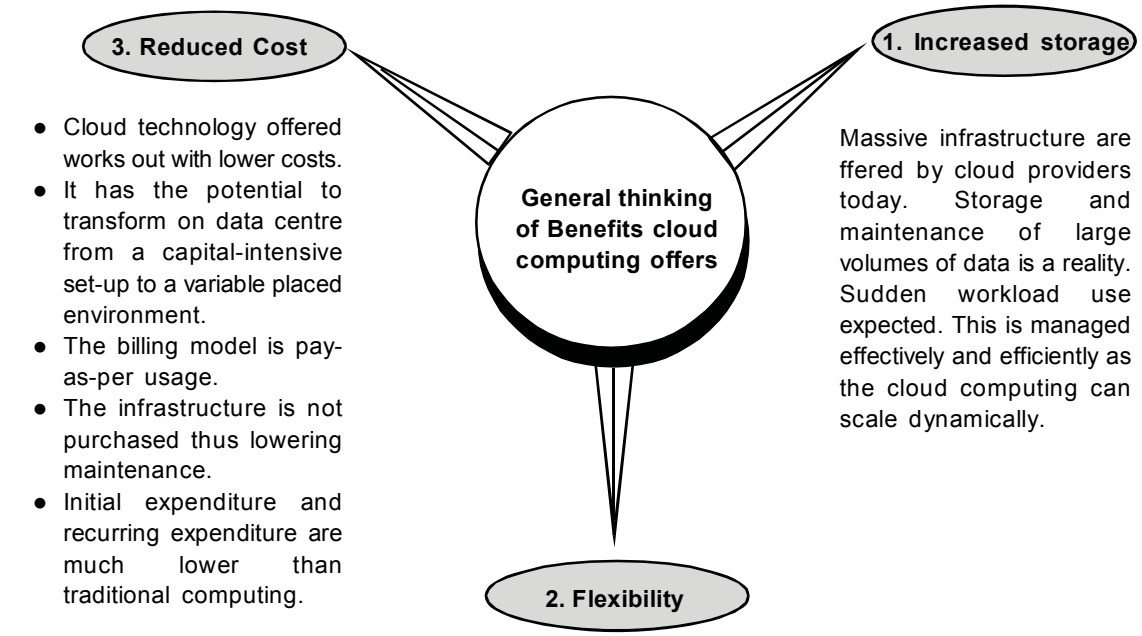


Figure 1.6: General Thinking of Benefits in Cloud Computing

Cloud Computing Benefits

The **benefits** achieved from cloud computing are many' as shown in figures 1.4, 1.5, 1.6.

Torry Harris in his abstract on **"Cloud Computing: An Overview"** paper says that resource sharing in a pure plug-and-play model that dramatically simplifies infrastructure planning is the promise of 'cloud computing'.The **two key benefits** of this model are:

- **Ease of use** and
- **Cost-effectiveness.**

Users of the cloud can benefit from other organisations delivering services associated with their data, software and other computing needs on their behalf without the need to own or run the usual physical hardware (such as server) and software (such as e-mail) themselves.

The **disadvantages** (questions on aspects) such as do exist which remains as questions are:

- Scarcity
- Vendor lock-in

However, the benefits are many. Understanding of the model *vis-a-vis* exploring options available for complementary technology and infrastructure needs a detailed study. The cloud computing models are dealt separately.

The **other benefits** would involve:

- Flexibility
- Disaster recovery
- Automatic software updates
- Increased collaboration
- Work from anywhere
- Capital expenditure (Capex) free
- Document control
- Security
- Competitiveness
- Environmental friendly

1.9 CLOUD COMPUTING SECURITY

There will be several cloud providers. The first theory we have to see in all of them regarding security with these cloud providers are the various security measures provided by them should meet the cloud users requirements. Under these security aspects, each provides varied types. The information housed on the cloud is often seen as valuable to individuals with malicious intent because there is a lot of personal information and potentially secure data that people store on their computers, and this information is now being transferred to the cloud. From this, the cloud provider can understand the security measures they have to provide has in place to meet the needs of each user and it is important for the provider to provide varied personal precautions to secure data needs to meet all the cases.

The user has to find out by studying each of the security measures, provided by the security providers already in place as they vary from provider to provider among the various types of clouds. Further, an in-depth study on the following questions will be helpful:

(i) What encryption methods provided?

(ii) Methods of protection do they have in place for the actual hardware for the data stored?

(iii) Any firewalls set up?

(iv) If you have community cloud, what barriers do they provide for your information with other companies?

Many cloud providers may have standard questions and answers for such readymade questions but the home user will not enter into a deep negotiation in their cloud contract may be due to his lack of knowledge or may not show much interest in the initial stages while discussing the concentration will be mainly on the terms of contract with the providers. Hence, the **questions on all aspects in detail are a must** before entering into a contract. Many questions can be asked, before choosing

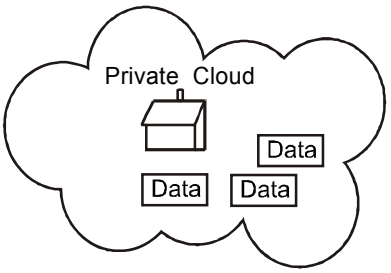
a cloud provider. The more questions asked and more clarifications sought will be better for the user.

In some cases, even though you ask intelligent questions careful about your personal data at the time of subscribing to the cloud, you may lose control to an external source at some point of time. This creates more space which is dangerous for a third party to access your information to his advantage.

1.10 DELIVERY OF CLOUD SERVICES

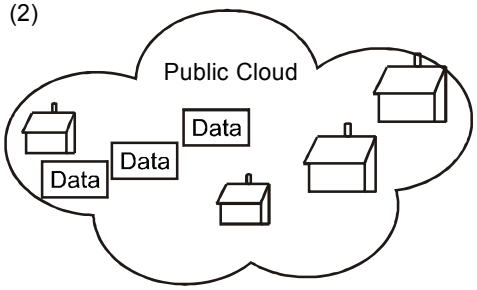
As already said in para 1.2, cloud computing services may be delivered over the following four types of cloud models:

(1)



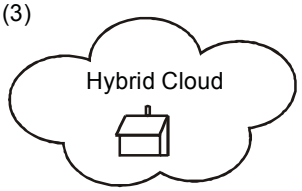
- Services owned and operated on-site by you and your company
- Data kept behind your firewall
- You have all control over security

(2)



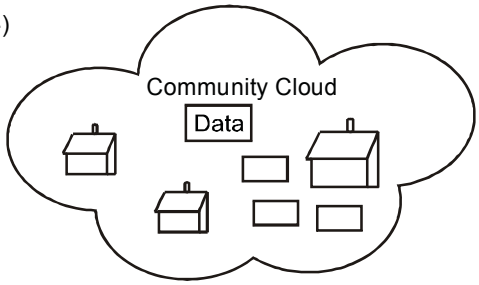
- Cloud services solution may be shared with other organisations, with data security provided by the cloud vendors
- Cloud services provider controls data security
- Benefits of scales and cost savings
- Large amounts of space available for expansion

(3)



- Services for a single organisation developed over
- Combined use of public and private clouds by your company, *e.g.*, CRM data stored in a public cloud accounts data stored in a private cloud
- Separate solutions connect with each other

(4)



- Shared public or private cloud by more than one organisation
- Shared by an industry group, government agency or other associations
- Allows sharing of similar in infrastructure set-up
- Cloud service provider secures and partitions data
- Cost-effective and unilaterally secured.

Figure 1.7: Cloud Computing Service Delivery Models

Cloud computing is a versatile technology that can support a broad spectrum of applications. The low cost of clouding and its dynamic selling provides an interest for small companies as it is an innovative driver to attract them particularly in developing world. Cloud embraces Enterprise Resource Planning (ERP) as well as Supply Change Management (SCM) and Customer Relationship Management (CRM) applications. Added to these, it attracts medical applications and mobile applications. Hence, it has potential to reach millions of users. Many concepts are involved in cloud computing. Our study in this book involves the study of clouds from technical and service aspects. It is quite interesting to know why this technology must succeed, examining various technical and service aspects.

1.11 CHARACTERISTICS OF CLOUD COMPUTING

The important characteristics involved in cloud computing are:

- **Services expected from cloud computing:** It should be **on-demand self-service;** requirements such as computing capabilities (server time, network storage, etc.) as needed automatically without human efforts from each service provider.
- **Access to network:** User expects broad network capabilities available to him through standard mechanisms that promote use by heterogenous thin/thick client platforms like laptops, personal digital assistants (PDAs) and mobile phones.
- **Cloud computing** provides pooled up resources.

1.12 COMPUTER HARDWARE VIRTUALISATION

Virtualisation is the creation of a virtual scenario of some theory or image, rather than actual. It is a version of something such as an operating system, a server, a storage or network. **Server virtualisation** is a virtualisation of **server**.

In computing, **virtualisation** means to create a virtual version of a device or resource as said above. This may be a server, storage, device, network or an operating system. Devices, applications and human users are able to interact with the virtual resource as if it has a real single logical resource.

It allows you to trick your operating systems into thinking that a group of servers is a single pool of computing resources. It allows you to run multiple operating systems simultaneously on a single machine.

Virtualisation is a great way of simplifying your IT solution as well as licences, antiviruses and operating system upgrades are done on one machine instead of performing each one on every machine within your network. This not only saves time and energy, but cash as well. The virtualisation of your IT solution is very often the first step in a cloud computing solution.

1.13 THE BUILDING BLOCKS INVOLVED IN CLOUD COMPUTING

Any layman can understand the terms involved in cloud computing if it is explained in a simple way. You need not know everything about cloud and cloud computing right in the beginning, the important ones occurring are to be understood and the different ways in which a cloud computing solution can be implemented.

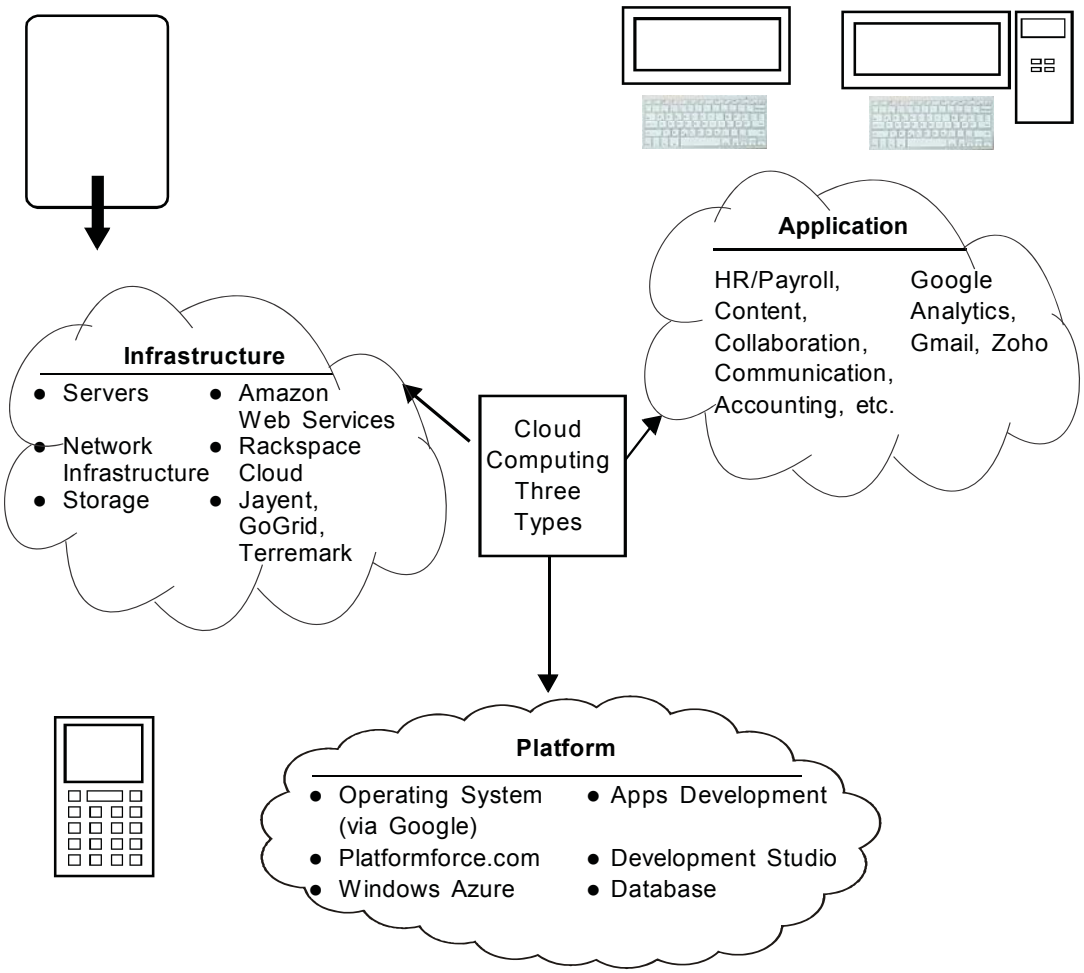


Figure 1.8: Clouding Types: Applications, Platform and Infrastructure as a Service

1.14 SECOND STAGE IN THE EVOLUTION OF THE INTERNET IS CLOUD COMPUTING

Cloud computing enables companies to utilise a computer resource such as a virtual machine, storage or an application as an utility, just like electricity, instead of building and maintaining computer infrastructures in-house.

1.15 CLOUD COMPUTING STAGES

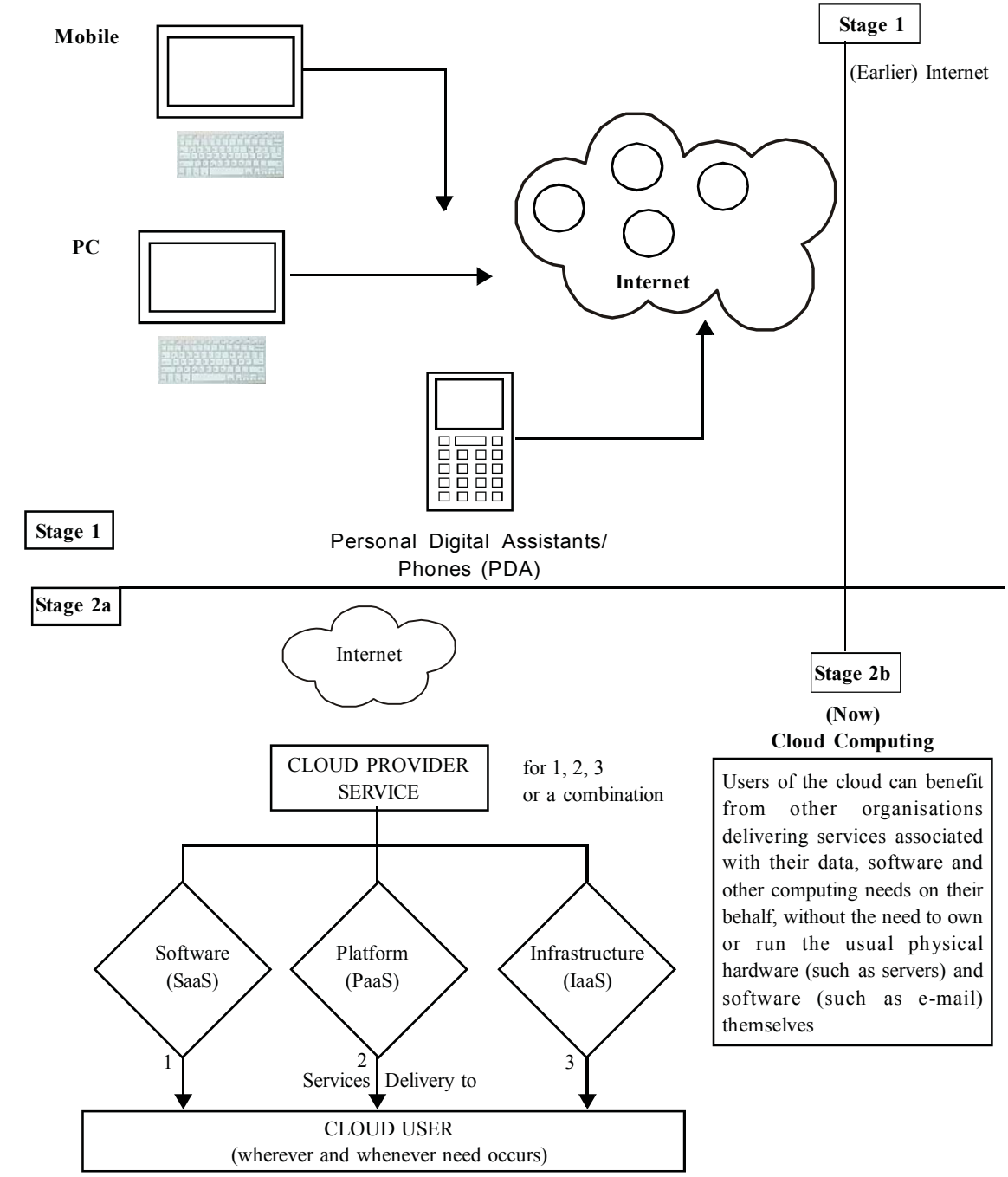


Figure 1.9: Cloud Computing Stages
(1) SaaS (SoftwaRe as a Service), (2) Platform as a Service (3), Infrastructure as a Service

1.16 THE CONCEPTUAL VIEWS OF CLOUD COMPUTING

Forrester defines cloud computing as under: "cloud computing is a pool of abstracted, highly scalable, and managed computer infrastructure capable of hosting end-customer applications and billed by consumption."

Cloud computing is a practical approach to experience direct cost benefits.

1.17 MAJOR CLOUD COMPUTING VENDORS

TABLE 1.4: CLOUD COMPUTING VENDORS

Vendors	*IaaS*	*PaaS*
Amazon	EC Elastic Cloud Compute	Amazon Web Services
Google	App Engine	Google App Engine (Python, Java, GO)
HP	Enterprise Services Cloud Compute	Cloud Application Delivery
IBM	Smart Cloud Enterprise	Smart Cloud Application Service

Major Cloud Computing Vendors — IT Manager Daily

People also search for Salesforce.com, VMware and IBM Google.

- Amazon Web Services (AWS) (Highly scalable, complete cloud platform)
- Microsoft Azure (Cost-effective tools for business operational, high scalability and availability)

IaaS and PaaS computing for development, deployment and management as per Founder and CEO, Phedeax.

Made for enterprise clients familiar with Microsoft products, robust development and deployment.

Others are DigitalOcean, redhat, Oracle Cloud, CloudSigma, Hyve, Krizen Cloud, Ubiquity Hosting, Toggle Box, Atlantic, Met, Vulture, Navistic, Googlenet, E24 ElasticHosts, VEXXHOST, etc.

The top 20 Infrastructure as a Service (IaaS) vendors are:

Amazon Web service — EC_2, QT & T, Bluelock, Ca technologies, cloud scaling, Data pipe, ENKI, enomaly. Eucalyptus systems, Go grid, hp, toyent, layered tech, logic works, Napsite, OP source, rock space, sav vis, terremark, verizon

These **twenty cloud infrastructure vendors** that are making the infrastructure game their own and altering the way IT is combined.

Top ten best PaaS (Platform as a Service) providers are (in 2018)

- Microsoft Azure • IBM — Blue Mix • Red Hat — Open Shift
- Amazon Web Services — Elastic Beanstock • Sales Force • VMware — Pivotal
- Sales Force • VMWare — Proposal CF • Software AG — Long Jump
- Google — App Engine

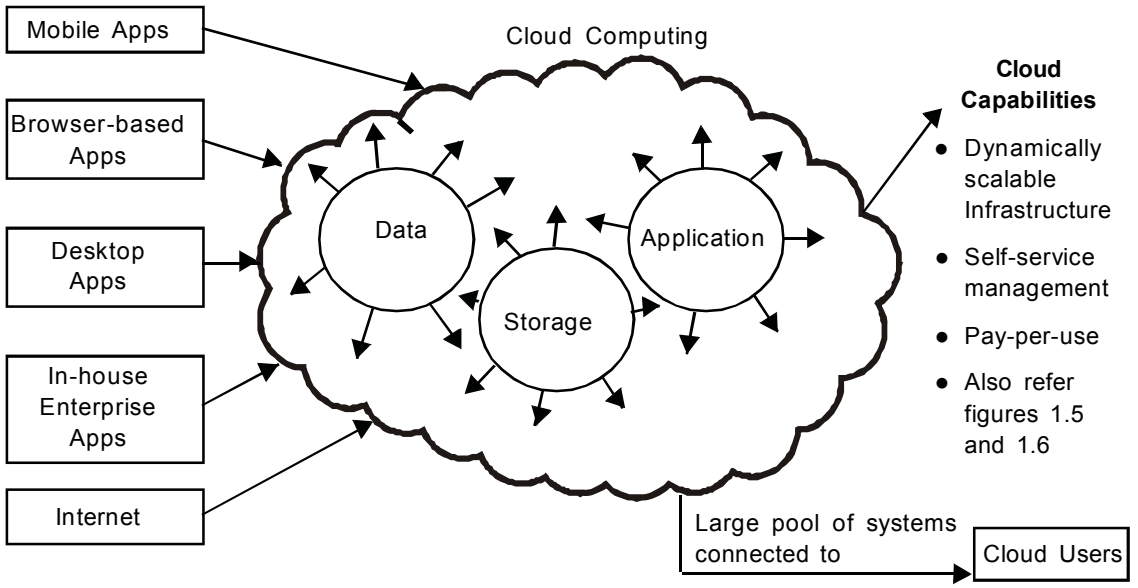


Figure 1.10: The Conceptual View of Cloud Computing

1.18 IDEA OF CLOUD COMPUTING

It is based on a very fundamental principle of "Reusability of IT Capabilities."

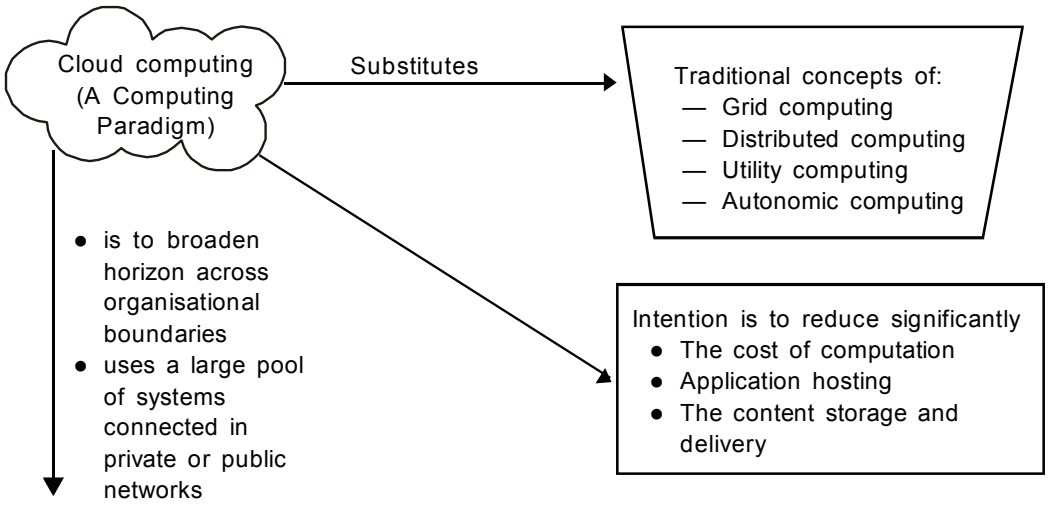


Figure 1.11: Cloud Computing

The figure is self-explanatory (also refer Fig. 1.2).

Different types of computing are:

— Grid computing
— Cloud computing
— Utility computing
— Cluster computing
— Distributed computing
— Autonomic computing

1.19 WHAT IS GRID COMPUTING?

Grid computing is the collection of computer resources from multiple locations to read a common goal. The grid can be considered as a **distributed system** with non-interactive workloads that involve a large number of files.

(1) How grid computing works?

A **grid computing** system requires:

- Atleast one computer usually a server, which handles all the administrative duties for the system.
- A network of computers running special grid computing network software.
- A collection of computer software called middleware

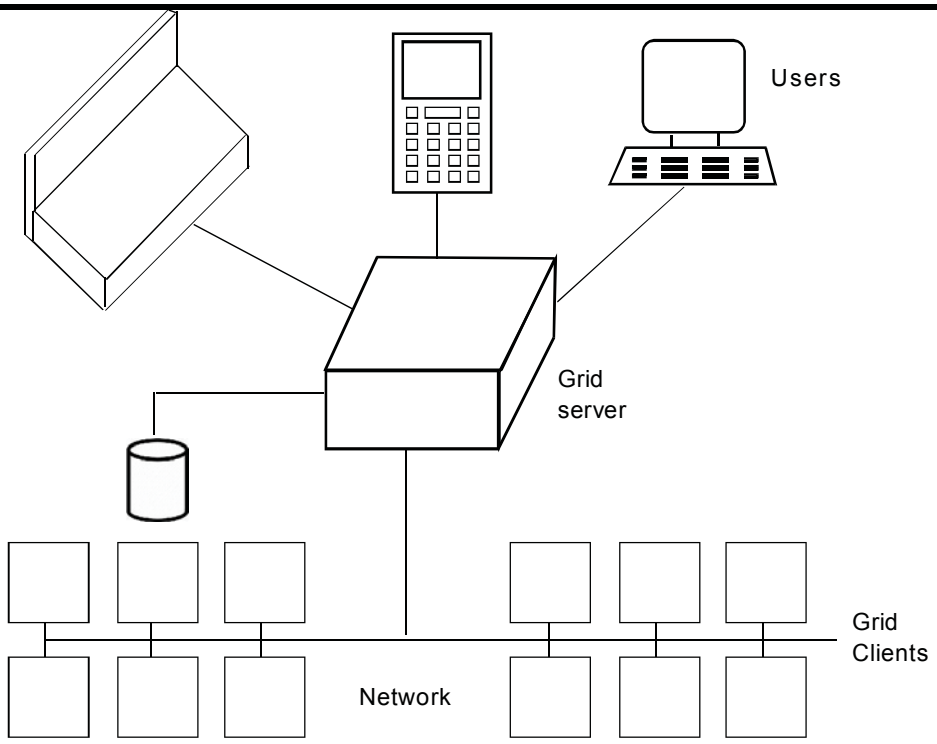


Figure 1.12: Grid Computing

(2) Cloud computing: This is already explained earlier.

(3) Utility Computing or **the computer utility** is a service provisioning model in which a service provider makes computing resources and infrastructure management available to the customer as needed, and changes them for specific usage rather than a flat rate. IBM, HP and Microsoft were early leaders in the new field of utility computing. Google, Amazon and others started to take the lead in 2008, as they established their own utility services for computing, storage and applications.

Utility computing can support grid computing which has the characteristic of very large computations or sudden peaks on demand which are supported via a large number of computers. It has envisioned some form of virtualisation so that the amount of storage or computing power available is considerably larger than that of a single time sharing computer. This computing merely means **'pay and use'** with regards to computing power, having a long history.

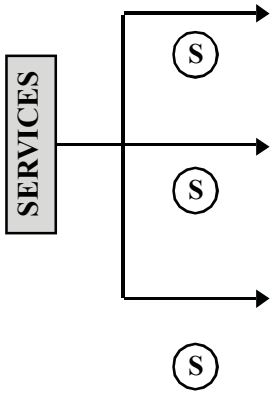
(4) A cluster computing is a set of loosely or tightly connected computers that work together so that, in many respects, they can be viewed as a single system. Unlike grid computers, these have each node set to perform the same task, controlled and scheduled by software.

(5) Distributed computing is a field of computer science that studies distribution systems. It is a model in which components located on networked computers communicate and coordinate their actions by passing messages. The components interact with each other in order to achieve a common goal. It is a collection of independent computers, interconnected via a network, capable of collaborating on a task.

(6) Autonomic computing (AC) refers to the self-managing characteristics of distributed computing resources, adapting to unpredictable changes while hiding intrinsic complexity to operators and users. This is initiated by IBM in 2001.

1.20 CLOUD COMPUTING MODELS OR CLOUD DELIVERY MODELS

There are three major types of services which are provided by cloud providers to the cloud users:



Software as a Service (SaaS): Allows to provide software application as a service for the end-users. It refers to a software that is deployed on a hosted service and is accessible via Internet.

Platform as a Service (PaaS): PaaS offers the runtime environment for applications. It also offers development and deployment tools, required to develop applications. It has a feature of point and click tools that enables non-developers to create web applications.

Infrastructure as a Service (IaaS): This provides access to fundamental resources such as physical machines, virtual machines, virtual storage, etc. Apart from these resources, IaaS also offers other things. All the resources are made available to end-user via server virtualisation. These resources are accessed by the customers as if they own them.

Figure 1.13: Cloud Computing Models

1.21 WHO COINED THE TITLE OF CLOUD COMPUTING? (ORIGIN OF CLOUD COMPUTING)

It is quite interesting to know that who is the original person, when thought about cloud computing concept. According to **Antono Regaldo** in his article on 31st October 2011 in the 'Business Report' in America has said that this thinking is one of the hottest buzzwords in technology. He says it appeared 48 million times by 2011 on the Internet, the questions as under:

There is one question about cloud computing that has never answered, "Who said it first."

Some of the people have said that large organisations like **Google** and **Amazon** started using **'Cloud Computing Concept'** to describe the new paradigms in which people were increasingly using the following:

- Software
- Computer power
- Files over the web (instead of on their desktops)

VIEWS ON CLOUD COMPUTING

- **Technology Review**, another magazine, tracked the coinage of the term back ten years earlier **in late 1996** and to an office part outside Houston. At that time, it was found that:
  - — **Netscape's Web Browser** was the technology to be excited and, Yankees were playing Atlanta in the world series.
  - — Included the offices of Compaq Computers where a small group of executives were plotting the future of the Internet Business and calling it **'Cloud Computing'**. Their vision was detailed and prescient. Not only would all business software move to the Web, but what they termed it as **"cloud computing enabled applications"** as consumer file storage would become emanate.

  For two men in the room, a Compaq marketing executive named George Favaloro and a young technologist named **Sean O'Sullivan**, cloud computing would have dramatically different outcomes:
  - — For Compaq, it was the start of a $2-billion-a-year business selling servers to Internet providers.
  - — For O'Sullivan's start-up venture, it was a step toward disenchantment and insolvency.
- Oxford English Dictionary does not talk about **"cloud computing."** But today, its use is spreading rapidly. Whether they know the subject in detail, or not, because it captures a historic shift in the IT industry with the following:
  - — More computer memory
  - — More processing power
  - — Apps are hosted in remote data centres or the 'Cloud'.
- **In 2008, Dell** drew outrage from programmes after attempting to win a trademark on **"Cloud Computing".**
- Other technology vendors, such as IBM and Oracle, were accused of **"Cloud Washing"** or misusing the phrase to describe older product lines. This aspect however is not known.
- Like **"Web 2.0"**, cloud computing has become a **universal jargon** that many technical executives find annoying. "I hated it, but I finally gave in" says **Carl Bass**, President of Autodesk whose company inspected a **cloud computing campaign** in September later. I did not think the term **'cloud computing'** has conveyed anything to people who did not already know about that.

- The **US Government** has also had trouble with the term. After the country's former IT chat, **Vivek Kundra,** pushed agencies to move to **cheaper cloud services**, procurement officials faced the question of what exactly, counted as **'cloud computing'**. The Government also requested to National Institute of Standards and Technology to come with a **suitable definition for 'cloud computing'**. In the final draft, the US agencies cautioned that 'cloud computing' can and mean different things to different people.

'The cloud is a metaphor for the Internet!'
'It is a rebranding of the Internet.'
} said Reuven Coehen, Co-founder of Cloud Computing in his programmer's course

which was not accepted by many. There was a raging debate on this. "By virtue of being a metaphor, it is open to different interpretations, when finally added **'It is worth money'",** said **Reuven Cohen, Co-founder of Cloud Computers** in his programmer's course.

- Regarding who should get credit for inventing the idea was finally debated. The notion of **network based computing** started **in 1960**. Many believed the first use of 'cloud computing' in its modern extent occurred on **9th August 2006**. (Google Ere Schmidt introduced this term in an industry conference.)
- The term of cloud computing began to see wider. We in the following years when Amazon, Microsoft and IBM were also involved in the effort.
- **New York Times Report** carried the headline "**IBM to push cloud computing** after describing vague plans for **"Internet super computing"**.
- Sam Johnston, director of Cloud and IT services at **'Equinix'** says cloud computing took hold among techies, because it described something important. A number of trends that have been observing such as the consumerisation and commodisation of IT, we now have a common opinion.

  Johnson had a close watch on the person who covered this term. As an editor of the **Wikipedia** entry for cloud computing, he raised alarms about Dell's trademark application saying a Professor at Emory has coined the phrase in **1990s**.

  Johnson says "There have been many attempts to co-opt the term, as well as various claims of invention."
- In **May 1957**, a trademark application at the offices of **Net Centric** in Cambridge, **Massachusetts** in 1990s was there from a defunct company called **'Net Centric'**. The trademark application was for educational services (classes and Seminars) and was never approved. When this matter was in question, **'Technical Review'** tracked down Net Centric founder, **O'Sullivan**, he agreed to help dig up of earlier paper copies of 15-year-old business plans from **Net Centric and Compaq**. The documents, written in **late 1996**, used the phrase **'Cloud computing'** and also described in accurate terms many of the ideas sweeping the Internet today.
- **O'Sullivan** started negotiating with **Favaloro of Compaq** who was in the Internet Services Group. O'Sullivan located a daily planner dated 29th October 1996, in which he jolted down the phrase "**Cloud computing**: **The cloud has no Border,**" following a meeting with **Favaloro**. That handwritten note and the Compaq business plan separated by two weeks.
- **Security and compliance controls:** One platform enabling policy driven over all of year developing processes, application workloads and infrastructure utilisation provide safe, self-service access to the resources your teams need.
- **Cloud computing** of this type provides **development environment as a service.** The consumer can use the middleman's equipment (providers) to develop his own program and deliver it to the users through Internet and Servers. The consumer controls the applications that run in the environment, but does not control the operating system, hardware or network infrastructure on which they are

running. The platform is typically an application work. The earliest references to the phrase 'cloud computing' was that Technology Review was located.

- "There are only two people who could have come up with the term: me, at **NetCentric**, or **George Favaloro**, at Compaq … or both of us together, brainstorming," says O'Sullivan.
- Both agree that **'Cloud computing' was born as a marketing term**. At that time, Telecom networks were already referred to as the cloud. In emergency drawings, a cloud represented the network.
- In Jan. 1997, Compaq press release draft version was considered. They announced the deal as part of 'a strategic initiative' to provide **'cloud computing to businesses.'** That phrase was designed to be the ages ahead of its time.
- **Compaq** eventually dropped the firm name at plans for Internet software entering plans for Internet software. Compaq later on merged with HP and what became a huge business selling servers to early Internet providers and webpage losters, like UUNet.

1.22 WHY ONE SHOULD USE CLOUD COMPUTING?

- Reduce **capex** cost and improve the predictability of ongoing operating expenses **(capex is capital expenditure)**. These are funds used by a company to acquire or upgrade physical assets such as property, industrial buildings or equipment. It is often used to undertake new projects or investments by the firm)
- Enable your employees to work from anywhere.
- Access your data, any time, anywhere, without risks associated with physical storage as it is managed by cloud providers.
- Avoid complex **Disaster Recovery Planning** (DRP). Cloud vendors will take care of this. (DRP is a documented process or set of procedures to recover and protect a business IT infrastructure in the event of a disaster.)
- Access the same class of technology as your bigger, more established competitors.
- Cloud computing vendors, do your server maintenance, for you for more important tasks and expenses reduced.
- Improvement of your document control, with all your files at one central location, everyone to work from one central document.

1.23 CLOUD COMPUTING: CHALLENGES AND ISSUES

Cloud computing is influencing a lot on the users, but cloud computing still remains as a challenge to the users. No doubt, many prefer to use and take blames. In our opinion, the benefits outweigh the drawbacks and the model may be worth exploring. The most common challenges are with regard to:

- Under **data protection,** the entrepreneurs fear losing data to competition and the data confidentiality of consumers. The actual data storage location is not disclosed in many cases. This adds on to the security concerns of enterprises. In the existing models, firewalls across data centres, owned by enterprises may protect this sensitive information. In the cloud model, server providers are responsible for maintaining data security, and enterprises would have to heavily rely on them.

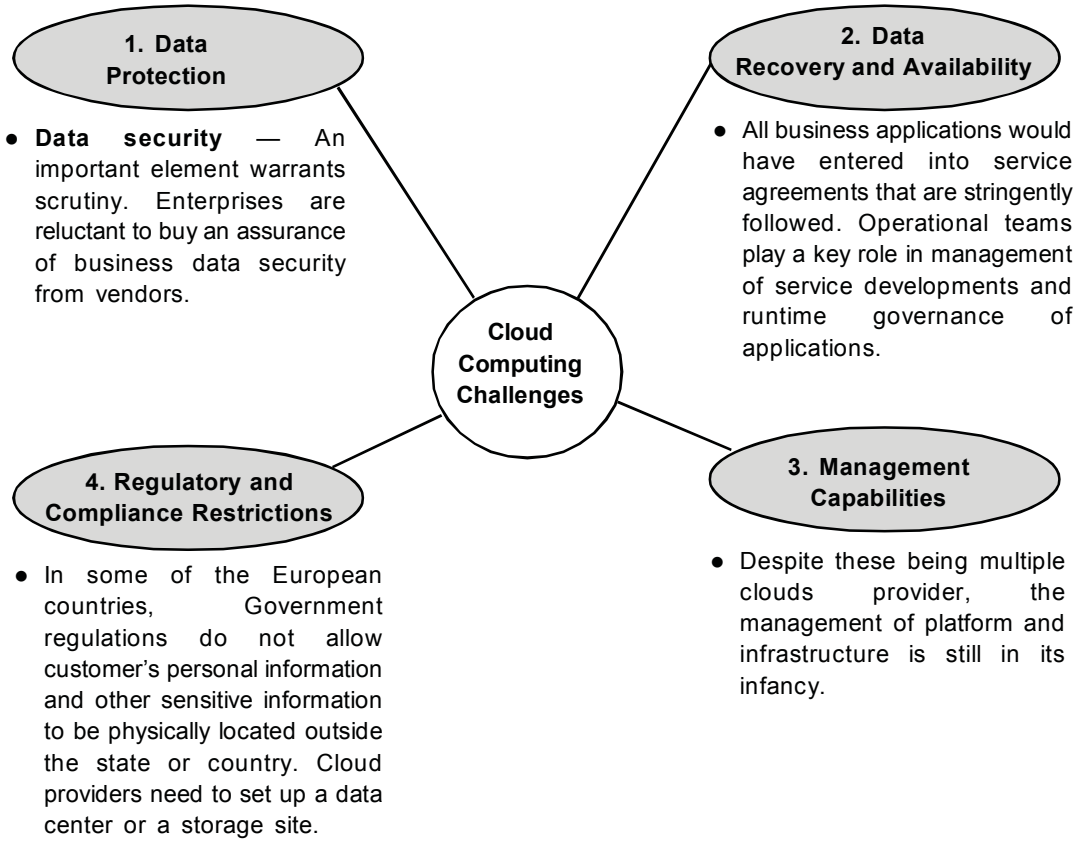


Figure 1.14: Cloud Computing Technologies

- In **data recovery and availability:** Operational teams support production environments in the following:
  - — Appropriate clustering and fall over
  - — Data replication
  - — System monitoring (Transactions monitoring and loss monitoring, etc.)
  - — Maintenance (Runtime Governance)
  - — Disaster recovery capacity and performance management
  - — Capacity and performance management

  If any of the above mentioned services is underserviced by a cloud provider, the damage and impact could be severe.
- Under **management capabilities:** Feature like **'Autoscaling'** as an example are a crucial requirement for most of the enterprises (Refer 'Autoscaling' explanation below).

— **Autoscaling:** Amazon EC_2 helps to maintain application availability and allows you to dynamically scale your Amazon EC_2 capacity up or down automatically according to conditions you define. (Also refer details of 'Autoscaling' on page 28.)

- Under **regulatory and compliance restrictions:** Cloud providers need to set up a data centre exclusively within the country to comply with regulations. Having such an infrastructure may not always be feasible and is a big challenge for cloud providers.

In this para, let us analyse the challenges and issues, cloud computing will normally face. Lot of economics is tied to this field and hence it will be better to take up the matter seriously as the issues are to be resolved as early as possible from the minds of the cloud user as well as from the minds of the cloud server. Matter below shows the summary of the survey conducted by some of the experts on the basic issues of the cloud computing. The client's primary concern will take this into the account. The following are the issues that a cloud computing environment has to still resolve. The concerns are more about security, performance, availability, cost regulatory requirements, band width, quality of service and data limits which are more. The issues pertaining to these are yet to be resolved. Let us analyse the same in the order of importance.

(i) Security: In order to utilise cloud based services, the cloud user is entrusting the data to a cloud based service supplier for storage and security. The user has to rely completely on the cloud provider to the cloud based company who will protect and secure their data. (Cloud computing presents specific challenges to privacy and security, back it up, check for data errors and defend against security breaches) if the needed party or acquiring party is using their services from cloud provider, if they are using their services at a very low cost? or often for free? Once data is entrusted to a cloud based service, which third parties do they share the information with, is also a question and about their reliability?

Cloud sourcing involves the use of many services, and many cloud used sources provide services to each other. There may be a leakage of several issues at several points and hence the security of those are to be suspected. Thus, cloud based products may have to share your information with third parties, if they are involved in processing or transforming your information. This may have to be shared and cautioned even with advertisers as well. Security presents a severe threat to the cloud. Sometimes, even without your knowledge, it might happen (sometimes from the cloud providers side).

As per the survey indicated in the ISSN: 2178-1021 International Journal of Advanced Research in Computer and Communication Engineering, Vol. I, Issue 5th July, 2012, one of the survey made by involving a study 4 or 5 people as depicted shows that security is a major issue or drawback and it is a challenge for the cloud (scaling about 75% by the raters).

(ii) Performance: The next danger involved in cloud computing is, it may suffer from severe performance issues. The cloud provider must ensure that the performance of the service provided should remain the same at the same level and with the same interest all through. There may be peak time breakdowns, internal flaws, and technical stags might arise. Load balancer, data replicators, high-end servers must be installed when needed. There should be a guarantee from the provider for the dedicated and constant supply of the services throughout (scaling about 63% by the raters surveyed).

(iii) Service availability: Cloud promises also like an Internet 24 × 7 × 365 service. **Cloud outages** occur sometimes. **Cloud outage** is a period of time during which cloud services are unavailable. **Cloud outage** due to a cyber incident at US resulted in total losses up to $ 19 billion in 3 to 6 days. Such things may be scheduled or unscheduled and the cloud outages will have a lot of **economy impact** on the users and it would **cost heavily**. One of the studies conducted and as reported in ISSN: 2278-1021 shows that the economy impact works out from a minimum of US $ 89,000 to a maximum of millions of dollars from various cloud companies for 5 years during 2001 to 2012. This shows that economic impact cloud outages will be heavy due to downtown hours. The various service providers are Microsoft, Amazon, Google, Twitter, Yahoo!, PayPal, Facebook, Hostway, Blackberry, ServerBeach, Amadeus, NaviSite, OVA, etc.

In the survey conducted on these firms by some of the eminent organisations, it was found that the economic impact of cloud outages of various cloud providers during 2007-12 worked out to a total of US $ 71 million for a total hours of 568 hours (scaling 63% by the raters surveyed).

(iv) Cost: Cloud costing works out to be costly due to:

(i) Having requirements for an 'always on' connection

(ii) Using large amounts of data back in-house (scaling 50% by the raters surveyed).

(v) Regulatory requirements: Like Internet, the information stored by cloud services is subject to the legal, regulatory and policy environments of the country of domicile of the cloud service, as well as the country in which the server infrastructure is based. This question is hard to ascertain due to the decentralised and global structure of the internet as well as cloud computing. This is still complicated by the fact that some data in transit may also be regulated (scaling 49% by the raters surveyed).

(vi) Band width, quality of service and data limits: Cloud computing requires "broadband of considerable speed". Many websites are usable on non-broad band of considerable speed". Many websites are usable on non-broadband connections or slow brandband connection. Cloud based applications are not usable. Connection speed in kilobyte per second (or MB/s and GBs) is important for use of cloud computing service. Another important aspect is Quality of Service (QOS), indicators for which include the amount of time the connections are dropped, response time (ping) and the extent of delays in processing of network data (latency) and loss of data (packet loss).

Autoscaling (automatic scaling also) is a method used in **cloud computing**, whereby the amount of computational resources in a server farm, typically measured in terms of the number of active servers, scales automatically based on the load on the farm. It is closely related to, and build, upon the idea of local balancing. (Also refer page 24 and 25).

Advantages

- For companies running on their own web server infrastructure, autoscaling typically means allowing some servers to go to sleep during times of low load, saving on electrical costs (as well as costs of water being used to cool the machines).
- For companies using infrastructure hosted in the cloud, autoscaling can mean lower bills, because most cloud provides change based on total usage rather than maximum capacity.

- Even for companies that cannot reduce the total compute capacity, they run or pay for at any given time. Autoscaling can help by allowing the company to run less time-sensitive workloads on machines that get freed up by autoscaling during times of low traffic.
- Autoscaling solutions, such as the one offered by AWS, can also take care of replacing unhealthy instances and therefore protecting somewhat against hardware, network and application failures.
- Autoscaling can offer greater uptime and non-availability in cases where production workloads are variable and unpredictable.
- Autoscaling differs from having a fixed daily, weekly, or yearly cycle of server use in that it is responsive to actual usage patterns and thus reduces the potential downside of having too few or too many servers for the traffic load. For instance, if traffic is usually lower at midnight, then a static scaling solution might schedule some senses to sleep at night, but this might result in downtime on a night when people happen to use the internet more. (For instance, due to a viral news event, Autoscaling, on the other hand, can handle unexpected traffic spikes.)

Amazon scaling is now an integral confront of Amazon EC2 offering autoscaling on Amazon Web Services through the web browser or the command line tool.

1.24 OPPORTUNITIES IN THE CLOUD COMPUTING DELIVERY

The cloud computing field offers in the three service levels (SaaS, PaaS, IaaS) concerning with the delivery of IT capabilities by providing interfaces at all the above three levels. It addresses different types of customers such as end consumers, business developers and independent software vendors.

1.25 CLOUD COMPUTING CUSTOMERS

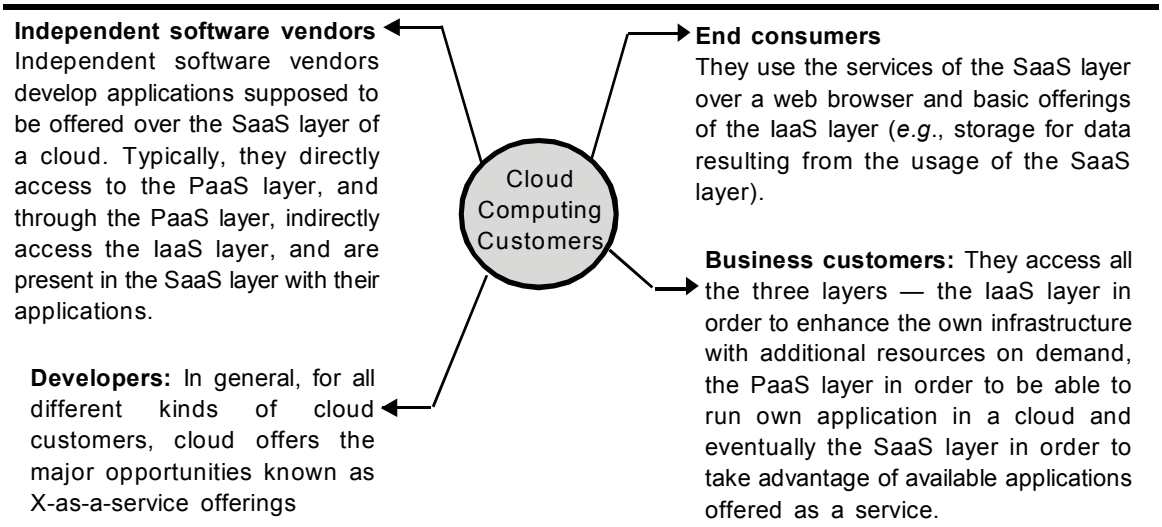


Figure 1.15: Cloud Computing Customers

1.26 AUTOSCALING

As already explained in pages 25 to 27, it helps us to ensure that one can have the correct number of instances available to handle the load for their application. First, work out collections of instances called Autoscaling groups. Then specify the minimum number of instances in each Autoscaling Group. Autoscaling ensures that the group never goes above this size. It also ensures that the group has many instances. If the scaling policies are made, then Auto Scaling can launch or terminate instances as demand on your application increases or decreases.

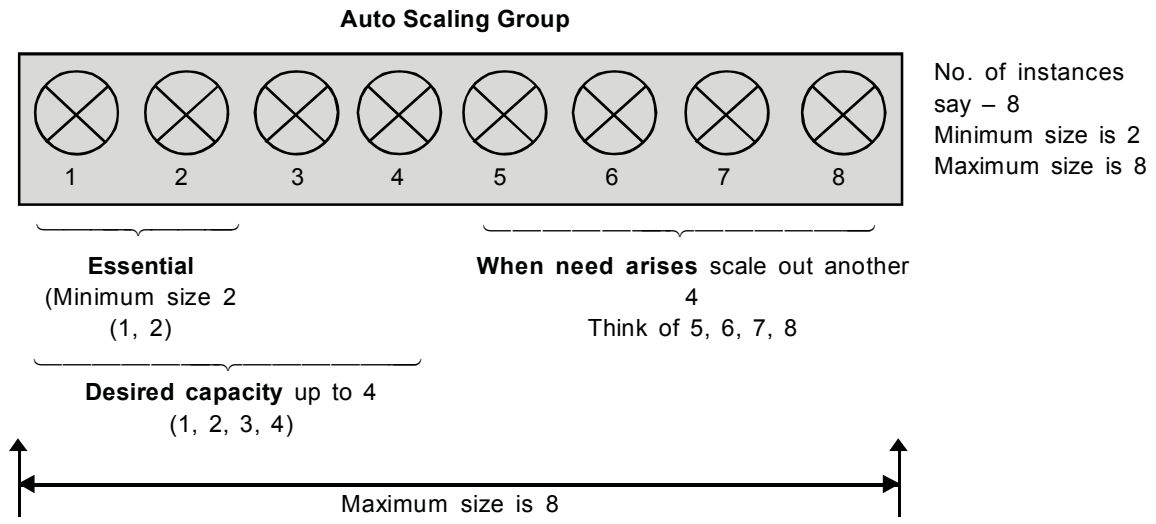


Figure 1.16: Auto Scaling

1.27 SUMMARY (with Additions)

Cloud computing definition issued by the NIST (National Institute of Standards and Technology) in Sept. 2011 is as follows:

Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (*e.g.*, network servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service **provider** interaction.

Providers can use the markets in order to perform **effective capacity planning**. A provider is equipped with a price setting mechanism which sets the current price for the resource based on market conditions, user demand, and current level of the utilisation of the resource.

Cloud computing is a special technology considered as disruptive with profound implications not only on the Internet services but also for the IT sector as a whole. Its emergence promises several things, out of which streamlining the on-demand provisioning of hardware, software and data as a service, achieving economies of scale in IT solutions deployment and operation.

Further, enterprises are beginning to increasingly rely on cloud computing systems for hosting their applications. Users of many enterprise applications, *e.g.*, web servers, require fast responses to their requests which are not provided to users satisfaction. Improvements are still awaited. The enterprise subscriber of the cloud service (SP) is responsible for provisioning resources such that their applications performance objectives are met. **Enterprise applications** are being increasingly deployed in cloud infrastructures. **A cloud service provider** (SP) enables entering into a **Service Level Agreement. (SLA)** with a cloud subscriber, which specifies requirements for the subscriber's applications. An SP needs **systematic Service Level Planning (SLP) tools** that can help estimate the resources needed and hence to cut costs incurred to satisfy their customers.

With the significant advances in **Information and Communications Technology (ICT)**, from 50 years, there is an increasingly perceived vision that computing will one day be the **5th utility after water, electricity, gas and telephony**. The architecture creating clouds with market-oriented resource allocation by leveraging technologies such as virtual machines (VMs). The market-based resource management strategies that encompass both customer-driven service management and computational risk management to sustain **Service Level Agreement (SLA) oriented resource allocation** has been discussed. The chapter also reveals early thoughts of interconnecting various cloud services for dynamically creating global cloud exchanges and markets. Representative **cloud platforms** especially developed in industries to realise market-oriented resource allocation of clouds has been explained.

Providers such as **Amazon, Google, Salesforce, IBM, Microsoft** and **Sun Microsystems** have begun to establish new data centers for hosting Cloud computing applications in various locations around the world to provide redundancy and ensure reliability in case of site failures.

Enterprise service consumers with global operations require faster response time and thus save time by distributing workload requests to multiple clouds in various locations at the same time. A need for establishing a computing atmosphere for dynamically interconnecting and provisioning clouds from multiple domains within and across enterprises, exists. Many challenges are also involved in creating such Clouds and Cloud interconnections.

NIST definition of cloud computing lists five essential characteristics of cloud computing.

- On-demand self-service, Broad network access, Resource pooling, Rapid elasticity and Measured service.

Missing any one of these essential characteristics means a service or computing capability cannot be considered as cloud computing.

Cloud computing makes it easy to tap into **virtually endless choices of hosted tools and services**. We still have to consider business goals and needs, current infrastructures, security issues and the overall costs associated with doing business in the cloud.

Facts and Statistics of 2017 shows the changing landscape of cloud computing and how service providers and customers are keeping up with the changing trends.

— Depending on business needs and security concerns, a business can choose between private, public or hybrid cloud deployment. **Hybrid** will be the most common usage of the cloud,

but this will require **public cloud** to be the part of the overall strategy. Technology providers will increasingly be able to assure that their customers will be able to ensure cloud capabilities.

— Among software vendors, the top end of the market is represented by corporations such as Salesforce.com, Microsoft and Adobe.

Salesforce.com Resources	2016	US $ 6.2 bn from the sales of subscription and support service
Microsoft	2015	11%
Commercial revenue predicted to increase	By 2018	30%

— A corporate 'no cloud' policy will be as rare as a "no-internet" policy is today. Cloud is treated first and even cloud is replacing the defensive no cloud stance that dominated many large providers in recent years. Today, most provider **technology innovation is cloud-centric**, with the stated intent of retrofitting the technology to on-premises.

Enterprise Integration Platform as a Service (iPaaS)

The speciality of iPaaS is:

No hardware or software to manage, automatic upgrades, secure, and saleable. Dell Bhoomi is faster and smarter with the #1 integration cloud. It allows the automation of business processes, integration of systems and services, and the secure sharing of data across numeric applications. Overcoming integration challenges allows organisations to create systems internally and externally. Business Process Integration (BPI) allows for:

- The automation of management
- Operational and supporting processes
- Giving businesses edge over competitors (spend less time concerned about the challenges of integration and more time and energy in getting new businesses).

1.28 KEY TERMS

- Cloud
- Cloud Computing
- Business Process Integration (BPI)
- Cloud Provider
- Public Cloud
- Service Level Agreement
- Private Cloud
- Community
- Enterprise Integration Platform as a Service (iPaaS)
- Hybrid Cloud
- Virtualisation
- Cloud Computing
  - — Benefits — Evolution — Ideas — Customers — Benefits
  - — Security — Stages — Usage — Budding Blocks
  - — Characteristics — Major Vendors — Opportunities — Working — Disadvantages
- Grid Computing
- Utility Computing
- Cluster Computing
- Distributed Computing

- Autonomic Computing
- Cloud Delivery Models
- Platform as a Service (PaaS)
- Eneless choice of hosted tools and services
- Cloud Computing Models
- Software as a Service (SaaS)
- Infrastructure as a Service (IaaS)

1.29 QUESTIONS

1. What is cloud?
2. What is cloud computing?
3. Mention the different types of clouds.
4. What is a private cloud?
5. What is a public cloud?
6. What is a hybrid cloud?
7. Define a cloud.
8. What is a community cloud?
9. Mention the activities of different types of activities involved and safety involved.
10. Compare and contrast different types of cloud.
11. What is the difference between cloud and Internet?
12. What are the uses of cloud computing?
13. Describe how cloud computing works?
14. What new things could be done with cloud computing as compared to traditional computing?
15. Mention the advantages and disadvantages of cloud computing.
16. Mention the cloud computing benefits.
17. What type of securities are provided by cloud providers?
18. Discuss on the subject of delivery of cloud services.
19. Which applications of information technology are supported by cloud computing technology?
20. Mention the characteristics of cloud computing.
21. What is virtualisation?
22. Discuss on computer hardware virtualisation? What is server virtualisation?
23. Discuss on the building blocks involved in cloud computing.
24. What are the advantages and disadvantages of cloud computing?
25. Who are the big vendors of computer cloud services?
26. Discuss on the bandwidths, quality of services and data limits of cloud capacity.
27. What is the general thinking of benefits by cloud computing users and by providers?
28. Explain the conceptual view of cloud computing with a status.
29. What is the fundamental principle of cloud computing?

30. Explain the following terms of computing:
    — Grid computing
    — Distributed computing
    — Utility computing
    — Autonomic computing
31. Explain the cloud computing models.
32. What do you mean by cloud computing models based on service? Explain each one of them.
33. Explain in detail about Software as a Service (SaaS) computing model.
34. Explain in detail about Platform as a Service (PaaS) Model of cloud computing.
35. Explain in detail about Infrastructure as a Service (IaaS) model.
36. Explain the characteristics of SaaS model.
37. Explain the characteristics of PaaS model.
38. Who found the word 'cloud computing'?
39. Explain the challenges and issues of cloud computing.
40. What is Autoscaling? Mention its advantages.
41. Who are the cloud computing customers?