CLOUD COMPUTING

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Features of

Learning Outcomes

After completing this chapter, students will be able to:

- comprehend online analytical processing (OLAP)
- explain performance monitoring tools
- list quality of service (QoS) issues in cloud computing
- describe sky computing
- understand various cloud computing platforms like Xen cloud platform
- discuss service-level agreement
- describe various computing platforms
- describe third-party technology
- explain MapReduce in cloud computing
- comprehend Hadoop

Learning Outcomes

Each chapter starts with 'Learning Outcomes' that describe the knowledge readers would acquire after going through that chapter's content.

Figures

All the chapters in the book include enough 'Illustrations' that support the text.

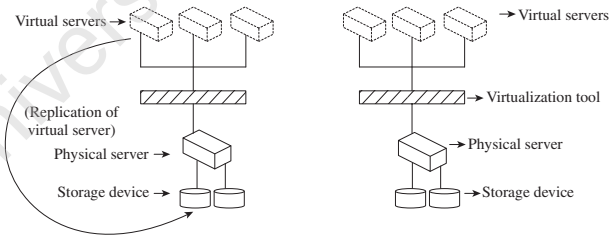


Fig. 12.4 Resource replication

Multiple-choice Questions

1. A file that keeps a log of virtual machine activities is/are called:
   (a) BIOS file
   (b) Log file
   (c) Virtual disk file
   (d) None of these
   (c) Hardware portability
   (d) All the above
7. The advantage of physical to virtual convertor is:
   (a) Reduction in set-up time
   (b) Enabling of migration (operating system)
   (c) Enabling migration (hardware)

Review Questions

1. What do you understand by compute virtualization?
2. What is a virtual machine?
3. What are the advantages of compute virtualization?
4. What are the various components of a hypervisor?
5. What do you understand by resource management? Explain the different tools available for it.
6. How is a physical machine converted into a virtual machine using hot and cold process?
7. What are the various steps to convert a traditional data center to a virtualized data center?
8. What is a hypervisor? Explain the various categories of hypervisors in detail.

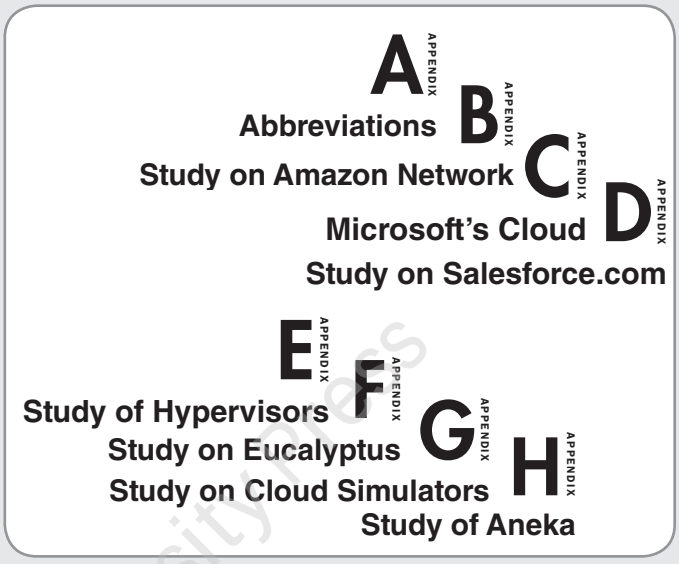
Exercises

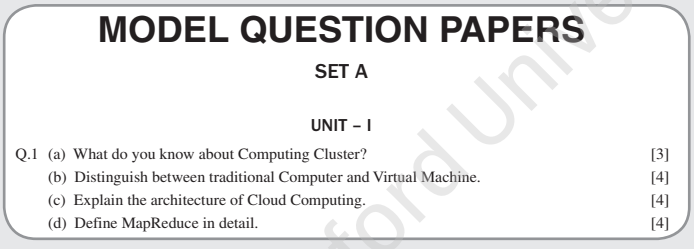
The 'Exercises' section in the book comprises Multiple-choice Questions and Review Questions for enhancing learning and for testing the knowledge of readers.

the Book

Appendices

The book comes with 'Appendices A-H' covering important topics such as study on Aneka, Amazon Network, Microsoft, etc.





MODEL QUESTION PAPERS

SET A

UNIT – I

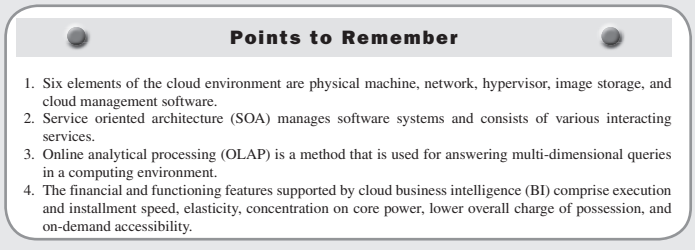
Q.1 (a) What do you know about Computing Cluster? [3]
(b) Distinguish between traditional Computer and Virtual Machine. [4]
(c) Explain the architecture of Cloud Computing. [4]
(d) Define MapReduce in detail. [4]

Model Question Papers

'Model Question Papers' are added at the end of this book for students to test their skills.

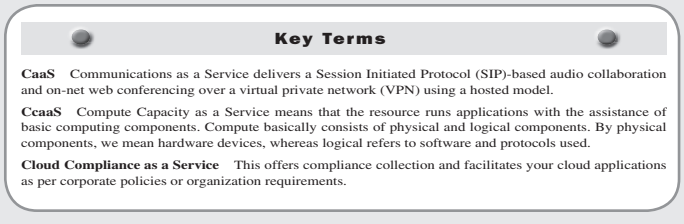
Points to Remember

Quick recapitulation of the topics discussed is provided as 'Points to Remember' at the end of each chapter.



Points to Remember

1. Six elements of the cloud environment are physical machine, network, hypervisor, image storage, and cloud management software.
2. Service oriented architecture (SOA) manages software systems and consists of various interacting services.
3. Online analytical processing (OLAP) is a method that is used for answering multi-dimensional queries in a computing environment.
4. The financial and functioning features supported by cloud business intelligence (BI) comprise execution and installment speed, elasticity, concentration on core power, lower overall charge of possession, and on-demand accessibility.



Key Terms

CaaS Communications as a Service delivers a Session Initiated Protocol (SIP)-based audio collaboration and on-net web conferencing over a virtual private network (VPN) using a hosted model.

CcaaS Compute Capacity as a Service means that the resource runs applications with the assistance of basic computing components. Compute basically consists of physical and logical components. By physical components, we mean hardware devices, whereas logical refers to software and protocols used.

Cloud Compliance as a Service This offers compliance collection and facilitates your cloud applications as per corporate policies or organization requirements.

Key Terms

Important 'Terms' used in each chapter are defined at the end of the chapter.

Preface

Cloud Computing is an emerging technology in today's world. It provides access to inexpensive software, infrastructure, and platform through very simple APIs that are based on a pay-per-use model, so that renting these resources is much cheaper then acquiring dedicated new ones. It is a practice that allows use of shared resources through a network of remote servers, which store and manage the data on the Internet. Of late, it has become very important for businesses as it provides services such as data security, scalability, easy accessibility and sharing of data, zero maintenance, and easy data recovery. Since the focus has shifted from PCs to data centers, and with growing competition, there are many cloud computing platforms and technologies available in the market.

ABOUT THE BOOK

This book on 'Cloud Computing' explains the fundamentals of cloud computing, migration services, virtualization as also the various cloud security issues faced. It discusses the principles followed by cloud service companies and platforms available in the market. Apart from the basics, various advanced technologies such as Big Table and IoT are also covered in this book.

The book follows a bottom-up approach with systematic flow of concepts covered in 12 chapters and 8 appendices. It is meant for the undergraduate computer science and information technology students of all Indian universities for an introductory course on the subject.

KEY FEATURES

- Student friendly and easy to understand
- Lucid, simple, and conversational language
- Focuses on the latest developments in cloud computing
- Discusses cloud computing models, cloud data center, virtualization technology both at the system and network level, and the architecture in detail
- Covers topics such as Cloud Platforms and Security, that are central to the subject, in separate chapters
- Provides a well-written points-to-remember section, review questions, key terms with explanation, and multiple-choice questions at the end of every chapter.
- Includes appendices with study of Amazon network, Microsoft, Salesforce.com, Eucalyptus, Aneka, and Hypervisors
- Comes with Model Question Papers from different universities

CONTENT AND COVERAGE

An attempt has been made to write this book in simple and lucid language with self-explanatory illustrations. The brief content of the book is as follows:

Chapter 1 provides an *Overview of Cloud Computing*. It starts with the history, need, and evolution of cloud computing, and then explains the benefits of this practice. It also discusses the limitations of cloud computing and throws some light on the vendors available in the market, elastic computing, enterprise cloud computing, etc.

Chapter 2 explains the *Factors Affecting Cloud Computing*. It highlights various cloud data center requirements and introduces architectural, technological, and operational influences on cloud computing. Topics such as issues in scalability of cloud architecture and applications, and influence of cloud computing on business companies are also discussed.

Chapter 3 on *Cloud Computing Architecture* discusses cloud computing architecture on the basis of load balancing, disk provisioning, storage management, hypervisor installed, migration, service relocation, cloud balancing, virtual switches of load balancing, and failure detection and recovery. Key design aspects of cloud architecture, similarities and differences between grid and cloud computing, and characteristics of cloud computing are also explained in this chapter.

Chapter 4 introduces the various *Models of Cloud Computing*. Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) are discussed in detail. This chapter also covers four cloud deployment models—public clouds, private clouds, community clouds, and hybrid clouds. Topics such as alternative deployment models, CloudStack, and cloud storage are also touched upon in this chapter.

Chapter 5 presents to its readers the *Traditional Data Center and Cloud Data Center*. It begins with the core elements of traditional data center and then discusses storage network technologies used. Important topics such as cloud backup, cloud and disaster recovery, replication technologies, and cloud analytics are also dealt with in this chapter. In the later part, traditional data center management is also discussed.

Chapter 6 on *Virtualization Technology (At Server)* covers virtualization reference model, types of virtualization, server/compute virtualization components, need of server/compute virtualization and its advantages, and techniques used. Hypervisor taxonomy, resource management tools, and conversion from physical machine to virtual machine (P2V) are also explained in this chapter.

Chapter 7 deals with *Virtualization Technology (At Network)*. It highlights tools used in network virtualization, its benefits, and components such as virtual switches and virtual LAN. Traffic management and its techniques, and virtual machine migration services are also covered.

Chapter 8 describes *Virtualization Technology (At Desktop and Application)*. It emphasizes on the drivers used in virtualization, the techniques used such as remote desktop services and virtual desktop infrastructure, and the components of desktop virtualization. Application virtualization, hardware virtual machine, and virtual machine provisioning are also discussed.

Chapter 9 explains *Cloud Infrastructure Management and Migration*. Cloud suppliers including RightScale, Kaavo, Zeus, Scalr, and Morph are discussed in this chapter along with the components that constitute the framework of cloud infrastructure. It also discusses unified management software, processes involved in cloud service management, technique used to access cloud, and challenges in migration to and from the cloud.

Chapter 10 makes readers understand the various *Security Issues of Cloud Computing*. Security threats and vulnerabilities in cloud computing, cloud security design principles and objectives, and cloud security services are explained in detail. Cloud testing and its requirements, secure development practices, virtual machine security techniques, challenges faced, and legal issues involved in cloud computing are also dealt with.

Chapter 11 *Computing Platforms* such as XCP, T-Platform, Force.com and Salesforce.com, Apache VCL, Enomaly Elastic Computing Platform, MapReduce, Hadoop, OpenNebula, Nimbus, Google App Engine, Microsoft Hyper-V, Microsoft Azure, AJAX, EMC, and NETAPP, are discussed in this chapter. It also explains service level agreement, OLAP, ISVs, and Sky Computing.

Chapter 12 is devoted to *Advanced Technologies in Cloud Computing*. It covers cloud deployment tools, groupware clouds, mobile cloud computing, cloud descriptor language, green computing, third-party technology, Intercloud, Azure cloud services, BigTable, IoT, CometCloud, and T-Systems.

Appendix A lists the various acronyms and abbreviations used in the book.

Appendices B-H cover study on Amazon Network, Microsoft, Salesforce.com, Hypervisor Network, Eucalyptus, Cloud Simulators, and Aneka.

ONLINE RESOURCES

To aid teachers and students, the book is accompanied with online resources that are available at https://india.oup.com/orcs/9780199477388. The content for the online resources is as follows:

For Faculty
Chapter-wise PPTs

For Students
Additional MCQs with answers
Two Model Questions Papers

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I wish to express my deepest gratitude to Dr C. Thangaraj, Director, National Institute of Technical Teachers' Training and Research, Bhopal for his valuable guidance and support. Without his inspiration, effort, and advice, this book would not have been possible. I am very grateful to my source of inspiration, Prof. Sunil Kumar Gupta, Vice Chancellor Rajiv Gandhi Proudygiki, Vishwavidyalaya, Bhopal, India for his motivation. I am very grateful to Dr Sanjay Silakari, former I/C Director, UIT, RGPV, Dr Geetam Singh Tomar, Director, THDC-IHET Tehri, Uttarakhand, Dr Sanjiv Sharma, Head School of IT, RGPV, Bhopal and Dr Ravindra Patel, Head, MCA, RGPV, Bhopal for motivating me to write this book.

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All suggestions for the improvement of the book are welcome and can be sent to ssingh@nitttrbpl.ac.in

Shailendra Singh

Brief Contents

Contents

CHAPTER 1

Overview of Cloud Computing

Learning Outcomes

After completing this chapter, students will be able to:

- define cloud computing
- describe need of cloud computing
- describe history of cloud computing
- explain historical evolution of cloud computing
- describe benefits of cloud computing
- understand limitations of cloud computing
- explain elastic computing
- differentiate various vendors of cloud computing
- distinguish traditional data center and cloud data center

1.1 INTRODUCTION

Cloud computing is a technology which utilizes the Internet and central isolated servers in order to sustain applications and data. Users can access applications and data at any workstation through the Internet. This technology permits much more proficient computing by consolidating bandwidth, processing, and storage memory. Cloud offers robust memory administration, thus there is no necessity to sustain memory on a personal system. It alters the means by which the Internet and computer are used.

In this chapter, we will discuss the fundamental techniques and components in cloud computing, technologies from where cloud computing originated, and the various services provided by cloud computing to its users. Later in the chapter, the limitations of cloud computing and the important challenges, which prove to be obstacles in cloud computing, will be discussed. We will also discuss the difference between traditional data center and cloud data center.

1.2 ESSENTIALS OF CLOUD COMPUTING

Cloud computing is a type of computing that provides an off-premise computing facility like storing data on virtual resources using the Internet. The main component behind cloud computing is the data center. The data center refers to an on-premise hardware facility that is used for many purposes, for example, storing data on the local network.

The term 'cloud' is defined by NIST [10] as follows:

"Cloud computing is a model for enabling ubiquitous, 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. This cloud model is composed of five essential characteristics, three service models, and four deployment models."

Cloud computing offers services instead of a product, whereby shared software, information, and resources are supplied to computers and other tools efficiently over a network. Cloud users should not need to identify the site and other particulars such as infrastructure but cloud computing offers software applications, computation, storage resources, and data access and data administration facility.

End users access cloud-based applications via diverse interfaces such as a light-weight desktop, a web browser, or different mobile applications, whereas applications such as data and business software are saved on servers at an isolated site. Cloud application suppliers attempt to provide enhanced functioning and service than that provided if software programs were deployed locally on the end-user or on detached computers.

Cloud computing performs tasks at a faster rate to meet the demands of users. It permits the data center to allow enterprises to acquire applications and work on data quickly, and needs only simple administration and less upholding. Many unpredictable and uncertain company orders of IT resources, such as networking and servers, are effortlessly met with the cloud computing technology. The basic structure of cloud computing is shown in Fig. 1.1. As given in the figure, facilities and services are offered by cloud providers in a cloud computing environment and different users from various locations and devices can request for specific services that are offered.

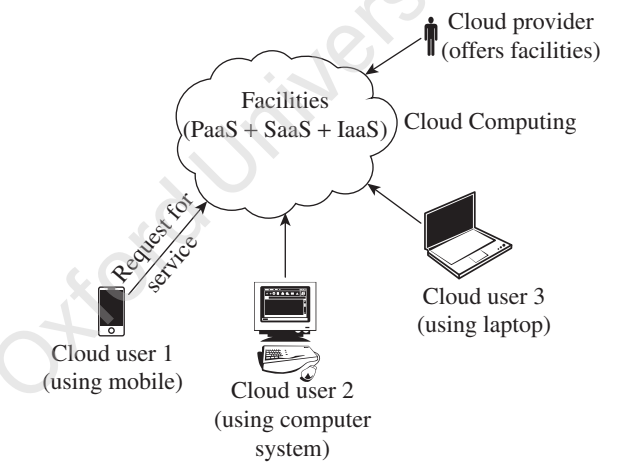

Fig. 1.1 Basic structure of cloud computing

As cloud computing is a recent technology, different people have different views about it. Cloud computing actually meets the overall software and hardware demand of an organization, user, or company.

Cloud computing is a novel approach and an important innovation in how we operate applications and save information. On the cloud, everything is hosted effortlessly. This is easier than managing data and programs on a personal desktop computer. You can access every application and any record from anywhere on the globe.

Associates working towards a similar goal may team up, irrespective of the positions they hold, and work in parallel. Cloud computing works to lessen the capital expenses involved in storing data. The IT division can concentrate on the actual coding and technical problems, rather than on maintaining

the data center. It reduces the total investment in hardware and software charges of a corporation. Some of the benefits of cloud computing are given here:

1. It improves parallelism and allocation of resources for fast accessing
2. One may acquire software services, networked storage space, computer resources, and various other services at a single place
3. An additional company hosts a set of applications, get software renewals (with no charge), and so on
4. It improves monetary burden such as operational expenses, renewing charge, and capital expenses

Hotmail, Gmail, Yahoo email, etc., are all simple illustrations of cloud computing. You do not need a server or software for using them. Customers would just require an Internet connection and then begin functioning with cloud services. The email administration software and server are on the cloud and are completely controlled by the cloud service suppliers, Google and Yahoo, among many others. The customer may use modernized software and have the advantages of cloud computing. Cloud computing is an array of network, hardware, storage, interfaces, and services which facilitate the various services. We can also say that the term 'cloud' is a set of hardware, network, storage, services, and interfaces that facilitate the service.

In cloud architecture, there are generally five main components of cloud infrastructure.

- Front-end interface for users for simple access and for using cloud resources
- Management for handling networking resources
- Storage for virtual machine
- Constant storage tool that may be organized within working virtual machines
- Monitoring tools for initiating virtual machines on the cloud

There are two types of a cloud environment:

1. The end user who has no idea about cloud complexity
2. The cloud service provider who has the liability of controlling the complete cloud environment and offer services to the consumer. One of the jobs of the supplier is safety, and it assures the consumers the degree to which their data is protected. The cloud service supplier is also accountable for IT resources, uploading, and other services offered to the user. Various services and resources are provided to users by the cloud provider, as suggested and managed by the cloud administrator, in the cloud environment, as shown in Fig. 1.2.

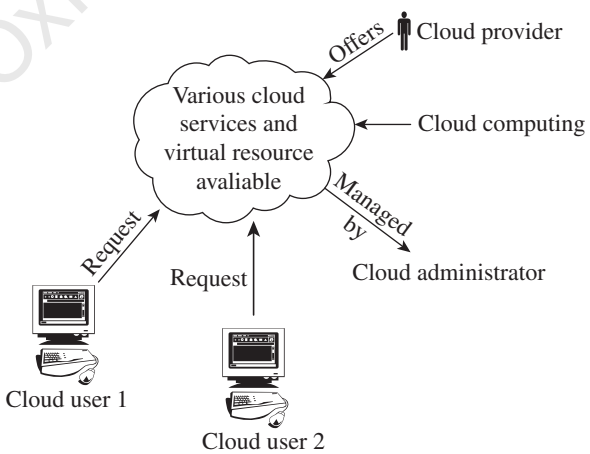

Fig. 1.2 Cloud resource management

Cloud computing gives users the option of accessing information from any place at any point of time. To access the conventional computer system, you should be in a similar physical position as your data

storage tool. The cloud eradicates this barrier. Suppliers of clouds offer you the obligatory software and hardware for operating your company or home applications.

It is required to pay for storage space, hardware, and software for a business or corporation if they are using cloud resources provided by cloud providers. Small corporations as well may save their information on the cloud, which will lessen the price of buying hardware and memory tools. They only need to purchase a specific volume of storage space, as per the requirement.

You require an Internet connection to access the cloud. The benefit of this is that you can access that record from anywhere, by any tool that can access the Internet. Workers at distinct sites can access similar data on the cloud and any tool may be used (e.g., a laptop, desktop, mobile phone, or tablet). Cloud computing involves a cloud consumer, cloud provider, cloud auditor, cloud broker, and cloud carrier, as shown in Table 1.1.

Table 1.1 Terminology used in cloud computing

Cloud consumer	An individual person or organization that sustains a business relationship with cloud providers and avails the services offered by the provider
Cloud provider	An individual person or organization who offers a service and is liable for the services of cloud computing to the parties that demand it
Cloud auditor	A party that conducts evaluation of cloud services, such as performance, operation on various systems, and security, among others
Cloud broker	The management between cloud providers and cloud consumers, like presentation and delivery of various services
Cloud carrier	The mediator responsible for connectivity and transport of cloud services from service providers to cloud consumers

1.3 NEED OF CLOUD COMPUTING

Every corporation desires to provide workers with a comfortable platform for working. In a corporation, there are top-level professionals who are always in the pursuit of more elasticity, heavier workload at lower fees, and the use of information as a competitive benefit to recognize the most appropriate information and data for decision-making. IT corporations need to react to these changes by converting IT into a domain with better business agility.

Cloud computing offers services to users for storing software and files distantly, instead of on a server or a hard drive at their workplace. Every corporation must possess its own personal cloud that may be adapted according to the users' demands. Examples include video sites such as Facebook and YouTube, web-based email such as Hotmail and Gmail, conversation support tools like Skype, and many others. Certain cloud computing applications comprise Software as a Service (SaaS), file storage, and file back-up, file synchronization, and consumer relationship management. There are many benefits of using cloud computing for worldwide corporations. One of the key reasons is the elasticity provided by it.

Through the Internet, employees may access information from home, on the way, from a customer's office, or from a smartphone such as an iPhone or a BlackBerry. Employees may also jointly work on documents and files, even when they are not physically all together. Everyone can work mutually even if they are physically far from each other. Concurrently, documents can be seen and proofread even though they are in remote areas.

Cloud computing may be extremely fast and simple to operate. Since downloading and deploying of software needs time, clouds maintain everything up to date. Cloud computing is cheaper as well. There is no requirement of purchasing and deploying costly software as it is already deployed online and you

operate it from there. Cloud computing provides agility and it may be easily and swiftly scaled up and down as per the requirement.

One of the chief benefits of using cloud computing for various corporations is that it provides nearly infinite storage, in contrast to a server, and takes into consideration the limits of a hard drive as it is online. There is no requirement to pay for enormous disk space and devices. There are many challenges associated with a conventional infrastructure:

Software licensing and support For every application and data center, licensing is needed. However, in cloud computing, for allocated data centers, only a single licence is needed for the application.

Scalability Conventional infrastructure cannot extend easily at a particular instance of time, and scalability requires variation with time. It has to regularly improve in order to face the challenges.

Accountability The application in conventional infrastructure never has vital liability and power.

Modifiability When alteration is needed, the application constantly needs and sustains extra charge.

Physical security It is tough to uphold security, and therefore, security is still a serious issues related to cloud computing.

Cost-effective management To make the application significantly accessible, the replication of data is required from time to time, which is very cost effective for a organization.

After many years of data center augmentation and development of IT, various companies are left with overgrown, complex computing platforms. Cloud computing is a new trend in computing due to its many benefits, which are discussed in the following sections in detail:

1.3.1 Reduced Costs

Cloud technique is rewarded incrementally, thus helping in the reduction of expenditure to an organization. With the help of cloud computing, IT expenses can be minimized. For example, if you are offered a business application over the Internet, you need not deploy and set up any resource at your own risk or cost.

Cloud computing services can minimize the updating requirement of software and hardware because expenses of maintenance and upgradation are handled by the cloud provider.

Though outsourcing IT trade requires extra concentration, the cloud provider handles complexity of technical proficiency, permitting users to concentrate on their main business. IT cloud computing follows a pay-as-you-go approach, where only a low preliminary investment is needed. The main cause of companies to use cloud computing is to save funds. The technology behind the cloud eliminates the servers' cost, maintenance fees, data center space, software licences, etc. Hence, asset expenses are minimized and substituted by scalable and convenient operating costs.

Another aspect that should be taken into account while selecting the cloud is that customer organizational support and maintenance expenses are minimized drastically as these costs are shifted to the cloud supplier, comprising 24/7 support. The requirement for extremely trained and costly IT recruits is minimized as well. In cloud computing, resources are used more effectively, resulting in considerable support and saving of energy expenses.

In practice, it has been discovered that companies spend almost double on server energy expenses than on hardware. An option has been provided by cloud computing for these costs. With cloud computing, corporations need not purchase and deploy costly platforms and software in order to host the software. Apart from many cloud computing applications being provided cost-free, end users are just needed to subscribe to services desired by them, rather than purchasing necessary software. According to requirements, you may scale up or down.

1.3.2 Scalability

With cloud technology, more information can be saved, when compared to personal computer systems by companies. Some of the important advantages of scalability are as follows:

1. One of the biggest advantages of cloud computing is that a business pays only for the services it avails. In a conventional infrastructure and technology, businesses should invest in advanced storage tools and servers which normally occurs at fixed prices. Cloud computing is exclusively scalable and flexible, functioning on the basis of usefulness and permitting businesses to pay as per work and the resources they use.
2. Since cloud computing is based on virtualized technology, RAM space, storage, etc., are simple and swift to use and append. The requirements of a business can be accomplished in hours rather than days.
3. In a cloud environment, scalability is a benefit. With the expansion of the business, further resources are included already to support the progress of the business. In association with SaaS, businesses have to pay according to their demand, that is, pay more for more demand and less for less demand.
4. As business requirements go up and down, instead of buying and making costly advances by yourself, your cloud service supplier may deal with it for you. As this service frees up your time, you may focus more on the functioning of your company.

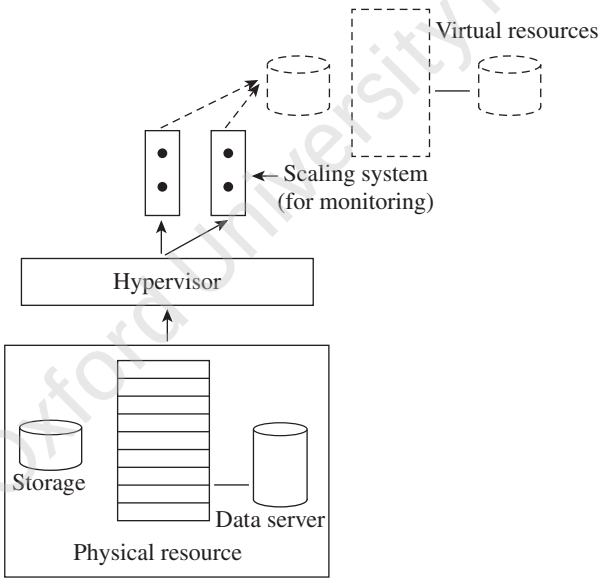

Fig. 1.3 Scaling management in cloud computing

As shown in Fig. 1.3, the scaling system in a cloud environment will maintain a record of the virtual resource requirements of cloud users, and resources' requirement can be kept up to date.

1.3.3 Remote Access

Through cloud computing, it becomes very easy to synchronize data access between international offices. Once data is virtually stored, it can be shared effortlessly between offices that are far from each other through isolated access. The advantages of isolated access are that any tool can be used, any time and at any place.

Anytime, access to Viewpoint V6 Software is offered by Viewpoint Cloud Computing and it is the top incorporated comprehension software solution of the industry that can be accessible from any place with an Internet connection.

Regardless of place, users would have access to their software, attributing the newest information and data on any venture. Users can do the following:

1. Access project reports and data, alter orders, etc.
2. Sense the 'always on' benefit of being capable of giving up one zone and carry on even on your smart cell phone.
3. Expand your trade and support your cell phone sales strength as everybody has 24 × 7 access to the cloud any time, from any mobile tool or desktop.

The advantages of cloud computing and web-based business cooperation applications all emphasize on the advantages of isolated access. Cooperating on shared records expands the speed upon which people may complete complex jobs collectively. Accessing private files from any isolated desktop connection signifies that a person is certainly not coupled to a machine or site in order to use software and files that are vital to them, whether for personal or business use. Web and cloud computing are as good as the extent to which they facilitate people to share and access; isolated access is the chief advantage of these technologies.

Isolated access functions in three fundamental methods. The first is the streaming of data from one machine to another; this occurs when a person online listens to a radio station or watches a movie. The second one is when web applications exhibit an interface which permits the web user to interact with an application such as an online store or a search engine. The third one is when files are made comprehensible on an isolated desktop computer through desktop sharing and isolated control software, and are cloned to the PC of the end user to be controlled and cloned back to the initial site. For the third use, users download isolated PC access software, a petite yet precious piece of software for small ventures and also for large- and middle-sized businesses.

1.3.4 Disaster Relief

Natural calamities such as earthquakes, floods, internal troubles, and wars might result not only in the loss of data of e-governance applications but also in unavailability of services. In a different geographical locality, multiple set-ups along with total backup and retrieval explanations should survive. Disaster recovery control measures should be put in place and exercised from time to time. Data and applications should be surplus and must be accessible at short notice to switch from one data center to another. Cloud virtualization techniques permit restoration and backup. As compared to a conventional data center, it provides flawless migration of applications.

1.3.5 Ease of Implementation

Over the last several years, cloud computing has become very popular, as now-a-days, workplaces and homes have access to broadband Internet. Cloud computing has many benefits over other conventional ways of hosting and networking. These benefits are particularly noticeable for small ventures which require the strength of business services, but the finances are unavailable for purchasing computers, paying workers, and executing the technology.

For those who do not have the knowledge of modern technology, executing cloud computing services might tend to be a little inconvenient on home networks. However, this can be accomplished easily with an Internet connection and a cloud computing host. With this benefit, it becomes easy for small-scale company owners to set up services even if they are unaware of the execution of modern technology.

With the help of these benefits, anybody can get started on cloud computing. The benefits are particularly useful for small enterprises; nevertheless big corporations may also benefit from cloud computing. Cloud applications do not need to be upgraded, fixed, or downloaded. It is easy to learn and use applications and several of these are accessible at a cost-free trial, to check if it suits some small enterprises or not. For small enterprises, various cloud-based software and applications are offered, which are beneficial for smooth running of businesses.

1.3.6 Skilled Vendors

Cloud computing business models need suppliers to appoint, teach, and maintain highly talented workers to maintain the quality of service. Cloud computing suppliers maintain a professional's requirements at their end.

1.3.7 Response Time

Cloud computing achieves an improved response, compared to other types of computing. The response time, is faster when compared to normal hardware and server.

At present, cloud computing is growing in a totally new manner, as businesses of every range and form are getting used to this recent technology. Cloud computing is used for data storage services and software applications which are sent in real time over networks, generally, the Internet. These services principally comprise everything you may perform on a PC—data storage, email, and productivity and conversion applications. The advantages of cloud computing can comprise improved cooperation, cheaper rates, and better mobility.

Cloud computing has significantly lower costs than the equivalent user licences and desktop software. The subscription services provide the best features and priority consumer support although they are paid as per usage.

Possessing such kind of productivity applications and storage 'in the cloud' facilitates access to your files anywhere and anytime. It makes it easier to work on projects regardless of locality and time zones.

Industrial cloud service suppliers must have very strong data backup systems. Through cloud computing, it is improbable that your data will be lost since service suppliers will usually have data retrieval systems in place. Nevertheless, accessibility is a more common drawback. Round-the-clock access is one of the assurances of cloud computing, but the truth is that it is not possible every time. Even chief suppliers own services that can go offline owing to system maintenance or failures from time to time. You would require steady Internet access at your end so as to ascertain your access to the existing services.

Box.net is an online workspace service meant for file grouping and sharing, and QuickBooks Online is a multi-user accounting software.

1.3.8 Easy to Customize

Customization may be possible for easy access of resources to some degree, as per our need. Physical servers or virtual servers may be customized to distinct schemes via a control panel.

Other than these, there are various other benefits of cloud hosting over isolated hosting:

1. Pre-configured operating system—A variety of famous Linux allocations (Debian, Red Hat, Ubuntu, Arch, Fedora Enterprise Linux, and several editions of Windows-based servers)
2. Committed IP addresses for cloud servers
3. Conversion amid servers in the similar cloud, free of conversion expenses and at high speed
4. Allocation or replication over many remote sites

1.3.9 Virtual Provisioning

A novel technology used in storage is the fact that storage space is allocated on demand to various devices on the virtual storage network. There is a virtualized environment for controlling, monitoring, and maintaining a physical disk storage that is connected with virtual machines.

Thin provisioning is another term used for virtual provisioning. Virtual provisioning is mainly used in a virtual environment, whereas thin provisioning is generally used in a physical computing environment. Virtual provisioning does not ensure the assigning of a higher storage capacity to VMs. It offers physical storage to each unit of virtual memory, based on the demands of the user.

1.3.10 Fully Automated Storage Tiering—FAST

Fully automated storage tiering (FAST) mechanically shifts active data to storage tiers with high-performance computing and stationary data to different storage spaces at low cost. It is useful to increase the performance of the applications, compared to other traditional technologies like Serial Advanced Technology Attachment (SATA). It is difficult to do the same optimization in data storage with a manual system. By continuously monitoring FAST, one can easily identify active or inactive data. On the basis of set principles, the administrator can control and manage systems automatically. It is an optimized method that does not add any extra expenditure and burden on the system.

1.4 HISTORY OF CLOUD COMPUTING

Cloud computing is an Internet-based service that has evolved after going through a number of phases, for example, grid and utility computing, SaaS, etc.

In 1999, Salesforce.com came into the market. This was a pioneer of cloud computing. After that, Amazon Web Services was launched in 2002, which provided customized cloud-based services including storage, computation, etc., to the cloud users. Another big invention in cloud computing was in 2009, as Web 2.0 and Google services, through Google Apps.

The following sections show the historical evolution of computing.

1.4.1 Client-Server Technology

Client-Server is the technology behind cloud computing. Client-Server technology is shown in Fig. 1.4. In this, multiple computers perform collectively to augment computing power.

The server is the prime regulator wherein software applications and data are kept for access. If a user requires to operate a program or access precise data, he/she needs to connect to the server, to get suitable access and to perform various operations whilst renting the data or program from the server.

The client may request to be associated to the server, to which the server replies appropriately. This is known as dumb terminal as it does not have high processing power, storage space, or memory. The client is simply a tool which is associated with the user for facilitation.

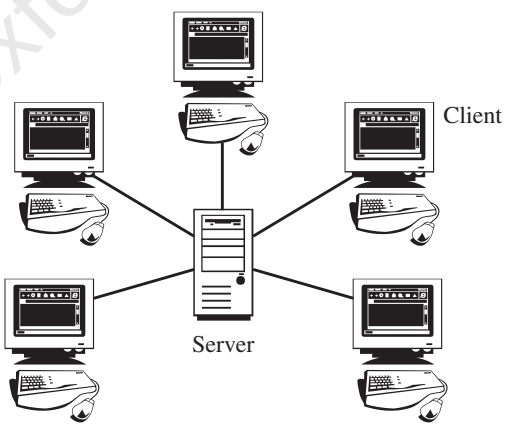

Fig. 1.4 Client-Server technology

The user needs to obtain consent until and unless it does not get approval to access the processor. Due to inadequate processing power, IT employees neither acquire instant access nor can two users access similar data concurrently in client–server technology.

You are required to wait for your number, in case lots of populace is sharing a single computer, even though that computer is an enormous processor. Thus, in a client server, instant access is not probable all the time. Thus, the client server also has a centralized storage, divergent from cloud computing in which it does not have a user-centric converge. Thin clients and fat clients are also used at times, which is a little different from client–server technology.

Fat clients refer to a computer in a client–server technology that is independent of the central server for performing various computations. Fat clients make periodic connections with the server, for performing large functions. Without synchronous connections, it easily performs computations, when compared to thin clients.

A thin client is a computer that is used to create a virtual environment. It depends on the server for performing computation. It shares a desktop, data, and file storage. The advantage of using thin clients for hardware optimal utilization is to reduce software maintenance cost and maintain security of data.

Advantages of Client–Server Networks

Centralized control There is a centralized power used in the client-server model. Servers assist in controlling the complete system. Access acceptance of distinct users and resource allotment is made by servers.

Administration managed File administration turns out to be trouble-free since every file is saved at a single place.

Replication for backup Since complete data is saved on the server, it is easy to create a back-up of it. During the time of recovering the missing data, it performs a vital role.

Easy updating possible Variations may be made simply by mere advancement of the server.

Remote service Access of distant server is possible to accomplish the needs of consumers and support distinct network.

Secure and safe For any computing, safety is a vital feature. Safety convention and access privileges may be termed at the time of association of server.

Disadvantages of Client–Server Networks

1. If the server is unable to tackle countless requests from the consumers, it might lead to congestion with data getting missed.
2. In case you are downloading a file from the server and if, because of some fault, it gets discarded, download too discontinues.
3. Administration and deployment is extremely costly for such computing.
4. Expert IT populaces are forever required for maintaining servers and other technological particulars of the network. It needs unique guidance for the upholding of server.

1.4.2 Peer-to-Peer Approach

Peer-to-Peer (P2P) is a decentralized approach and it encompasses no principal server. It is a design in which every computer has equal responsibilities and facilities.

In client–server technology, the consumer is the entire time strike server for diverse requests. In conventional design of a client server, one or more computers are devoted to serving the others. In a P2P setting, there is no master (boss) and slave. P2P facilitates straight swap of services and resources. No one lingers on for others to react since all are masters (boss) and there is no need for a principal server as any of the computers may perform in that capability, when called on to do so. This kind of network is not simple to manage.

Disadvantages of Peer-to-Peer Networks

1. It is not easy to administer this type of network.
2. Safety matters are forever on this network and it cannot be tackled appropriately.
3. Backup or data revival is not simple. Every computer must have its personal imitation system.

1.4.3 Distributed Computing

To amplify the throughput and for the utmost exploitation of the computing power of a system in a network, we may utilize distributed computing. A system is not completely busy all the time; several systems remain idle many times, so if the idle time of various systems is integrated and used for computation, which functions for the highest consumption, it is known as distributed computing. Distributed computing utilizes those idle resources that are not utilized for some reason or the other. Figure 1.5 shows distributed computing.

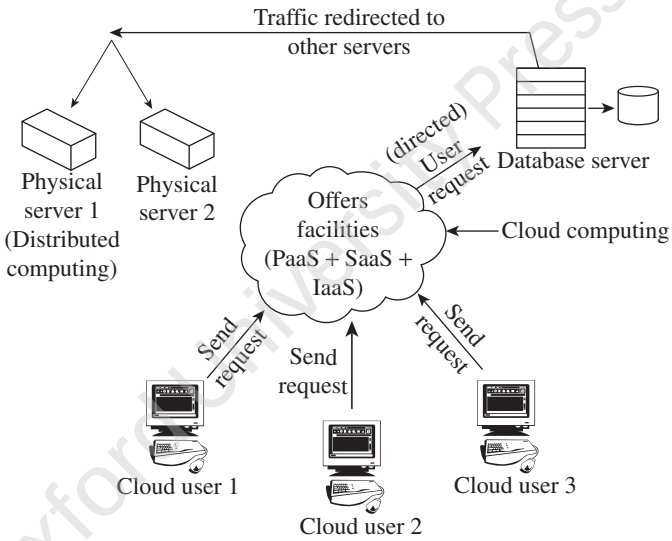

Fig. 1.5 Distributed computing

For highest consumption, free-time dispensation is occasionally uploaded in order to allocate a computing network and to unite with other PCs in the project. If sufficient computers are involved in the computing process, it replicates the dispensation power of bigger supercomputers and processors.

Disadvantages of Distributed Computing

There are several problems regarding transfer and allocation of IT resources. They are as follows:

1. Growing computing power at every data center
2. Growing storage facility
3. Under-consumption of the resources in various scattered data centers
4. Rise in maintenance expenses of data centers

1.4.4 Evolution of Cloud Computing from Grid Computing

Grid computing utilizes a network or group of computers for making computing resources like super computers, and performs large or complex operations and tasks over it. It is not necessary to have a

network of computers at one geographical location. Unused computing powers of many computers are used to perform complex scientific problems using grid computing.

When computers are united mutually for an application, they may be tightly coupled or loosely coupled. Tightly coupled systems via a system bus or some further speedy short-space network normally share memory and other system resources, along with the processors. A geographic discrete system is utilized in grid computing. Associates of grid computing communicate via networks; it does not matter where the computers are actually placed. Grid applications are frequently intended to acquire the benefits of unused CPU cycles accessible on every computer component. Grid computing is fairly distinct from cloud computing. It uses the resources of various computers in a network to perform.

Grid computing is attractive for several reasons:

1. Computer resources are not appropriately utilized; as a result it is profitable to employ a known sum of computer resources.
2. It accomplishes the need of high computing power.
3. The resources of various computers can be shared with an understanding, not requiring a single computer to have to organize it further.

Grid computing is accountable for cloud commencement up to a certain extent. There is a system of parent and child procedures in grids or any distributed computing system. For a specific assignment, an initial evaluation, to ascertain if it can be broken into assignments of a smaller range, is conducted. If it is feasible, distributed computing performs similar tasks and transfers the pieces of job into an additional computer for completion of the assignment.

It is also beneficial for appropriate consumption of resources which remain unused. Figure 1.6 shows the typical forms of cluster grids where servers are connected with each other in an organization

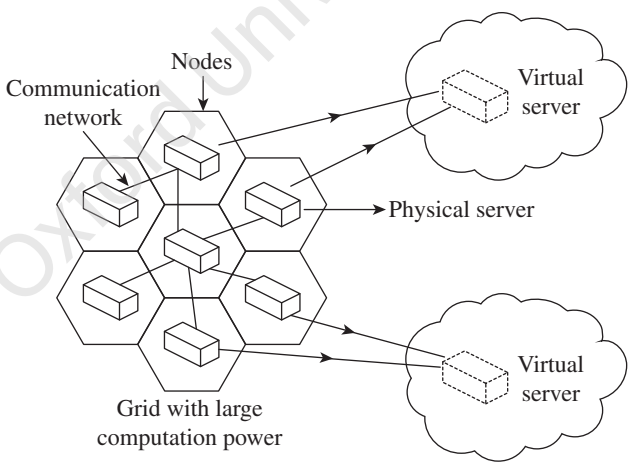

Fig. 1.6 Typical forms of cluster grids

network; there is one administrator to control the servers and so, services are accessed by the clients on the network.

There are numerous reasons as to why you could decide to perform an application on a grid instead of a high performance computing (HPC). Additional savings or money, and data accessibility—both kinds of resolution need enormous sums of computing strength.

Evolution of cloud computing from grid computing is shown in Table 1.2.

Table 1.2 Evolution of cloud computing from grid computing

Grid computing	Utility computing	Software as a Service	Cloud computing
Big crisis could be resolved with equivalent computing	Provided computing resources as metered services (disburses as per usage)	Beneficial in usage based payments to applications.	An Internet based computing offering services such as IaaS, PaaS, and SaaS.

Grid technology supports application-oriented inter domain business, so the purpose of grid security infrastructure is to protect shared resources from unintended users and also support fundamental feature of security like authentication and authorization. Authentication means that the entity has to prove that it is really what it claims to be and authorization means access permission of shared resources under different conditions given to different users.

Authentication Infrastructure

The generally used authentication infrastructure is public key infrastructure, which is based on public key cryptography. A third-party mediator is involved for this authentication process, that issues certificate to users as grid identity that allows users to use shared resource in the grid infrastructure. Another user authentication is done through Kerberos. Session key is issued to the users by the authentication servers for accessing resources in the grid. Security key means special token issued to the users.

A different method, Athens, is also used, which maintains separate user account for each resource they want to access and users' accounts are managed centrally by an account server. One level authentication technique is used, which is based on user name and password.

Authorization Infrastructure

Akeni authorization infrastructure method issues users' certificate to access a shared resource under different condition. A trusted entity is defined to gain access of shared resource. Use condition on resource is also defined for every stake holder, for keeping data safe and unreached from each other. Another method is privilege and role management, in which for accessing resource, users have to present role-based certificate that defines user role and attribute. One of the important methods is virtual organization membership service that maintains all information about users centrally through a virtual organization administrator. Certificate needs to be present for accessing a shared resource, and only after checking the validity of certificate users are allowed to access resources.

Other method of access control of user identity is grid map files. A distinguished list is prepared for shared resources used by particular user accounts and the list is shared on each resource. Generally, user mechanisms of security in grid computing are authentication and authorization and these are termed as hard security, whereas other method, trust management based system, is called as soft security.

Trust between two parties is a bidirectional relationship, which decides extent up to which one party depends or relies on the other. Trust management consists of a trustor and a trustee. Mutual trust relationship is of the following types:

1. Provision trust—It describes a user's trust on a service provider or service.
2. Access trust—It describes service provider trust in the user access on provided resource.
3. Identity trust—It describes trust on identity claimed by the user.
4. Delegation trust—It describes trust on someone which acts and makes decision on behalf of some other.

Goal of trust model is to support decision making for various interactions. Trust values are calculated for prediction of future possibilities. Depending upon application trust value, trust model is of three types:

1. Fuzzy logic model
2. Probability theory model
3. Mathematical method model

Fuzzy logic uses linguistic terms for calculating trust value that explains its believe on the other entity. In probability based model, trust is calculated on the basis of previous experience that determines future actions. In mathematical method, calculated index value determines the level of belief on the other entity.

1.4.5 Autonomic Computing

This is a system that supports computing to perform and work without any outer control or intervention. The phrase is on the basis of the autonomic nervous system of the human body that manages heart functioning, breathing, and many other functions. The aim of autonomic computing is to have the computer carry out versatile and critical functions without any interference by a user. Each task may be programmed, with orders given according to necessity, and evading user interference as per the need.

1.4.6 Platform Virtualization

Virtualization is a base for clouds, irrespective of whether you are heading towards constructing a mini-cloud in a prevailing data center or want to place your applications on a complete cloud.

A virtual picture offers an undefined number of hardware resources for strengthening the accessibility and functioning of an application; the choice on which resources to virtualize is normally handled down to a query of the resources previously being utilized on a variety of accessible servers. Each user acquires a service according to the requisites in virtualization.

The unused time of a server is involved in waiting for output or input, or is devoted to an assignment, working for lesser consumption of CPU and rotating its computational power for new assignment to be completed. Virtualization is a proficiency which conceals physical resources and emerges as virtual resources for users. Organizations have to carry out many steps in order to accept cloud computing. In a conventional data center, resources are devoted for every business application or entities. IBMS/360-67 supports up to four processors. It, in fact, supports dynamic address translation (DAT) to perform with competent paging.

Virtualization makes physical resources look like virtual resources in front of users. Virtualization is founded on the perception of a virtual machine working on a physical computing platform. Virtualization is managed by a Virtual Machine Monitor (VMM), called a hypervisor. An open-source hypervisor, Xen, is broadly utilized for cloud computing.

1.4.7 Service Oriented Architecture—SOA

A software allocation and installation module is that in which applications are offered to consumers as a service. The applications may work on the computing systems of users or the web servers of suppliers. A variety of software is easily accessible on the cloud and instantaneously accessed by several users.

An array of services can communicate with one another. Cloud computing is Internet-based computing, where mutual information, software, and resources are offered to consumers on-need, for example, a public utility.

In cloud computing, service level agreements (SLAs) are mandatory to manage the usage of resources. In the negotiation process, a joint decision is made between the parties, service provider, and service consumer in the context of cloud computing. Quality of service (QoS) is the ability to offer various priorities to dependents based on applications and consumers, and guarantees a certain level of performance. QoS norms are rich and are extremely dependent on the application.

The general service arrangement is as follows:
1. Loss—Chance that a flow's data is missing
2. Delay—Time it acquires a package's flow in order to find it from source to target
3. Bandwidth—Greatest speed at which the source may transmit data

Service condition in the cloud relies on the SLAs which represent a contract made between the customer and the service provided as well as non-functional necessities of the service, in particular, QoS. SLA considers its responsibility, service charge, and fine in case of violations of the agreement.

1.4.8 Utility Computing

Utility computing disburses resources as a metered service when required. The aim is to utilize services resourcefully and efficiently, which lessens related expenses as well. The expression 'utility' is used to evaluate such a computing resource consumption and imbursement to utilities such as natural gas suppliers or electricity suppliers for appropriate consumption of resources.

Utility computing is the procedure of offering computing services via an on-demand, pay-per-use invoicing system. It is a computing enterprise module where the supplier possesses, works, and controls the computing resources and infrastructure, and is accessed by subscribers as and when needed on a metered and leasing basis.

Utility computing is one among the most famous IT services' modules, basically due to the economy and elasticity offered by it. This module is based on the one used by traditional utilities such as gas, electricity, and telephonic services. The customer has access to a virtually infinite delivery of computing resolutions over the virtual private network or the Internet that may be sourced; supply is managed by the service providers. Utility computing may offer virtual software, virtual storage, virtual servers, and other IT resolutions. Managed IT services, grid computing, and cloud computing are based on the idea of utility computing. Like other kinds of on-demand computing, for example, grid computing, the utility module looks to raise the effective use of resources or/and reduce related prices.

The word utility is used to create a likeness to other services like electrical power, which looks at meeting the changeable demands of consumers, and to pay for the resources based on usage. This approach is becoming even more usual in business computing and is occasionally used for the customer market, for website access, Internet services, and other applications.

1.4.9 Web 2.0

Web 2.0 represents a change in technology in the world of the World Wide Web. It is usually designed to increase data security and customization of application as per the requirement with improved functionality.

Web-based service hosting, main social networking, sharing videos, etc., are important provisions provided by Web 2.0. In Web 2.0, the world wide web (WWW) puts stress to generate content by the user, and easy access and other operations on the content.

The important features of Web 2.0 are as follows:
1. Easy to access
2. User interaction and participation
3. Rich customization features
4. Easy communication through video chatting, instant messaging facilities, etc.
5. User-friendly writing tools and applications
6. Data management and analysis
7. Multimedia supporting tools
8. Web application and hosting

1.4.10 Parallel Computing

Parallel computing supports a type of computation which is helpful for carrying out computation of a program simultaneously. It is based on the principle that a single large problem is divided into small parts and parallely runs different parts on different machines. Distributed or grid computing is also a special type of parallel computing in which computers are connected on a network. Geographically dispersed computer resources are used for a common purpose. Different parts of the same problem run in parallel for faster and easy processing. It is cost effective to run a program on a super computer. Grid infrastructure supports different parts of the same problem to be run on multiple machines at the same time. This is also helpful in removing complications related with many instances of the same program sharing memory and space at the same time.

Parallel computing simultaneously uses various computing resources for solving a computational problem:

1. Discrete parts of a broken problem can be solved in parallel
2. Further, every part is broken down into a series of instructions
3. Different processors are used to execute the instructions in parallel
4. Coordination method works behind parallel computing

Parallel computing supports applications that require processing of a large problem in a sophisticated way. Some of the examples are:

- Big data problem
- Data mining
- Search engines
- Medical diagnosis
- Virtual reality
- Multimedia

1.5 BUSINESS AND INFORMATION TECHNOLOGY PERSPECTIVE

Cloud computing technology is valuable to both end users and developers. Cloud computing offers the developer an augmented quantity of storage and added strength. It is simple for them to operate the application. It is a creative method for accessing information, and for processing and evaluating data. It unites resources and people from any place. Users are no more constrained by physical restrictions.

Cloud computing proposes various advantages to the user. An individual using a web-based application is not physically compelled to one PC, network, or location. Users can record and applications can be accessed from anywhere, at any time. There is no problem of losing data in case a computer collapses. Records hosted on the cloud remain forever, so there is no issue even if something happens to the machine of the user. If the machine of a user collapses, even then, the user may log in with an additional machine and data can be accessed and stored. After that, there is the advantage of pool partnership. Users from all around may group resources on similar projects, applications, and records, in actual time.

Cloud computing proposes amenities at the lowest rate, since the cloud allows more competent resource sharing than that of conventional network computing. Users do not have to be worried about software or hardware installation or updating, as it is for the cloud provider. With cloud computing, the hardware needs to be physically adjacent to an office of the data center or company. Cloud computing infrastructure may be situated at any place. As extra cloud resources are forever ready, corporations need not buy resources for irregular and rigorous computing assignments. Cloud resources are available on a charge basis.

Cloud service providers propose a number of advantages over and above those provided by remote hosting:

1. Accessibility of data all over
2. Physical servers or virtual servers
3. Servers' interaction within similar clouds
4. Allocation or imitation of resources at numerous physical regions
5. Strength offered by different cloud storage capacities

Other services provided by cloud computing are discussed in the following sections.

1.5.1 Electronic Faxing

Secure faxes are transmitted to specific telephone number and are directed to an e-mail address as PDF attachments. Outgoing messages are transmitted through e-mail and conveyed to fax machines all around the world.

1.5.2 Voice on Clouds

Cloud-founded Google Voice can deal with calls, in case the call is made by an user on a published phone number. The call can be acknowledged from any telephone number associated to Google voice.

1.5.3 Commerce on Clouds

Businesses can be tackled via clouds, for example, the sale and purchase of items. A few books are accessible for sale as downloadable e-books on websites. The numerous sites interrelate flawlessly. Online buying, screening of items, and entire transactions may be handled effortlessly.

1.5.4 Distributed Hosting on Clouds

Godaddy.com is faultlessly hosted and provides services in this context. You might have utilized Rack space, Amazon, and many other websites for availing services.

1.5.5 Accounting and Online Banking

The online banking system offers convenient banking, encompassing numerous characteristics such as amount transfer and balance enquiry, among others. You might have applied on CapitalOne bank instead of Quickbooks; or NetSuite Small Business or other new excellent cloud-based alternatives. Consecutively, the web-based, bill-paying application of banks is dealt by a different cloud-based dealer which interfaces with the cloud-based Automated Clearing House (ACH) system for delivering and disbursing dues.

The cloud provides complete safety of data in the bank. The complete SaaS application is accessible to banks for invoice imbursement and similar services. Similarly, in many organizations, salaries are is also accepted electronically as direct deposit payments. Cloud computing may be used not only for business-to-personal communication, but also for business-to-business communication.

1.6 NEWS ON CLOUDS

Some of the news available on the cloud are as follows:

1. A mobile phone can be used to access services related to news.
2. Google Apps or Gmail is capable of seeking information via e-mail, rapidly from any tool. We can talk and work with partners or consumers without any language barrier.
3. Distribution and editing of data with trouble-free collaboration using Google items Docs and Sites. TripIt is a private travel that assists in arranging tours. Data is gathered from consumers and colleagues by using Google types. There is joint work on a general venture.

4. Through Force.com, you may construct a scalable business application on the cloud platform. Both Google's cloud and salesforce.com computing platforms are employed to generate business and web applications.
5. Using online patterns for presentations, spreadsheets, and records
6. Functioning steady, safe, and quick Web apps
7. Easily and firmly distributing video in apps through Youtube for Google apps

1.7 BENEFITS OF CLOUD COMPUTING

Cloud computing technology offers various benefits to both cloud service consumers and cloud service providers. The main advantage of cloud computing systems and technologies is increased economical return due to reduced maintenance costs related to infrastructure and IT software. Capital costs are costs associated with assets that need to be paid in advance to start the business. Before the advent of cloud computing, software and IT infrastructure generated capital cost, since they were paid upfront to afford computing infrastructure and software for enabling the business activities of an organization. The revenue of the business is then utilized to compensate over time for these costs. In case of hardware, it is always associated with depreciable values. To make profit, the organizations have to also compensate this depreciation created by time, thus reducing the net gain obtained from the revenue. In this way, cloud computing technology transforms IT infrastructure and software into utilities. Cloud computing offers the following benefits:

Pay as per use On demand access to pay-as-you-go computing resources on a short-term basis and ability to release these computing resources when they are no longer needed.

Reduced investment and proportional costs The product wholesaler purchases goods in bulk at a low price. Public cloud providers base their business model on the mass acquisition of IT resources that are then made available to cloud consumers via attractive prices. This opens the door for organizations to gain access to powerful infrastructure without having to purchase it themselves.

The investment in cloud-based IT resources is in the reduction or outright elimination of up-front IT investments, namely hardware and software purchases, and ownership costs. The cloud measures operational expenditures (directly related to business performance) to replace anticipated capital expenditures. This is also referred to as proportional costs. The same rationale applies to operating systems, middleware or platform software, and application software.

Accessibility from anywhere Resources can be accessed from anywhere, irrespective of location and device. This feature facilitates business continuity around the clock.

Increased scalability The business load can be handled with scalability of the respective resources without much effort, time, and cost.

Increased availability and reliability Resources provided as services are available all the time. Even if there is a failure in any of the components of a service, the provider immediately identifies, isolates, and replaces the failed components without any performance degradations.

Dynamic provisioning It is the perception of having unlimited computing resources that are available on demand, thereby reducing the need to prepare for provisioning.

1.8 LIMITATIONS OF CLOUD COMPUTING

Cloud computing is broadly acknowledged as a revolutionary IT concept and along with customized assistance may suit the requirements of varied consumers, scaling from big ventures and small-

beginners to end-users. Many cloud-based applications like Gmail have become very successful; however, in the information technology departments of organizations and corporations, the decision makers continue to refuse to use the cloud. Currently, companies mainly just contract applications which comprise less confidential data. The ones which become ready to move to the cloud still insist on third-party risk appraisal or enquire with cloud suppliers on the following:

1. By whom the applications and data will be accessed and how will that be scrutinized?
2. What security methods are used for storage and transmission of data?
3. How data and applications from diverse consumers are reserved separately?
4. Where will the data be stored in terms of geographical sites? Will the selection of the site influence us?
5. Can these details and channels be specified in a service-level contract?

Each of these consumer worries are the chief obstacles to the implementation and development of cloud computing. Some of the limitations of cloud computing are discussed next.

1.8.1 Availability of Services

Consumer administration interfaces of public clouds are only possible through the Internet. As services are a primary concern of consumers, they sometimes need to discard all the data from the cloud environment provided to them, while sometimes they may want to recover all the data. There is an augmented risk of disaster in this when compared to conventional services, as there are more ways to access the application or information over cloud computing.

1.8.2 Data Lock-in

SaaS permits the services to be interoperable on every cloud. However, shifting of data and applications from one platform to another is a challenge to the cloud provider for a big organization handling high volumes of data. Google is the single cloud supplier to attain a more typical environment and they also have a scheme, known as Data Liberation Front, to support user shifting applications and data in and out of their platform.

1.8.3 Data Segregation

It is not simple to isolate cloud users from each other. A straight effect of the multitenant control mode, where virtual machines of distinct consumers are co-located on a single server or data on single hard disks, is the main concern related to privacy. This set of risks comprises matters regarding the breakdown of mechanisms to separate memory or storage among distinct users.

Amazon EC2 service measured this as a real threat and rectified this attack by effectively overcoming the following:

1. Finding out where a particular virtual machine command is positioned in the cloud infrastructure
2. To determine whether two instances are resident in a similar physical machine
3. The secrecy of the data should be guaranteed, whether or not it is in transit. It should be required to offer a closed box implementation environment where the secrecy and reliability of the data must be confirmed by its possessor.
4. In a majority of circumstances, data should be encrypted at a certain time when it is within the cloud. Several procedures are unfeasible to perform with encoded data, and moreover performing computation with the encoded data must utilize more computing resources.
5. The user encodes the data earlier to upload it to the cloud. When specific data is needed, the token creator is used by the user to produce a token as well as decryption key. The token is transmitted to the cloud, the chosen encoded file(s) are downloaded, and after that these files are confirmed locally and decrypted using the key. Sharing is facilitated by transmitting the decryption key and token to the other user with whom you wish to cooperate.

1.8.4 Privilege Neglect

Companies sometimes take advantage of the liberty given to them. They disclose sensitive data of their company to others for some benefits. The threat of a malicious insider with access to confidential data is a concern for any outsourced computation model. Miscreants might affect and harm the consumer's fame and brand or openly harm the consumer. Mistreatment of opportunity not only spoils brand name, but may also place protected data in the hand of competitive attackers. It must be observed that similar kinds of attacks may be taken out by in-house workers in a conventional infrastructure too.

1.8.5 Scaling Resources

A web application designer who hosts its service on a cloud can view how the reply time gradually increases when usage of the application rises since the cloud does not scale up resources rapidly enough. The capability of scaling resources up and down to meet workload is one of the chief benefits of cloud computing. Resource pooling through multitenancy is also an important element that is managed by the cloud provider.

Separate storage devices are provided to every client on the cloud network, called a single tenant; and in a multi-tenant environment, a single storage device is shared by more than one cloud user as shown in Fig. 1.8. In the figure, there are two consumers 1 and 2, who are sharing a single shared storage for storing data, so there is the risk of interchanging or risk related to mismatch of data if proper arrangement is not carried out.

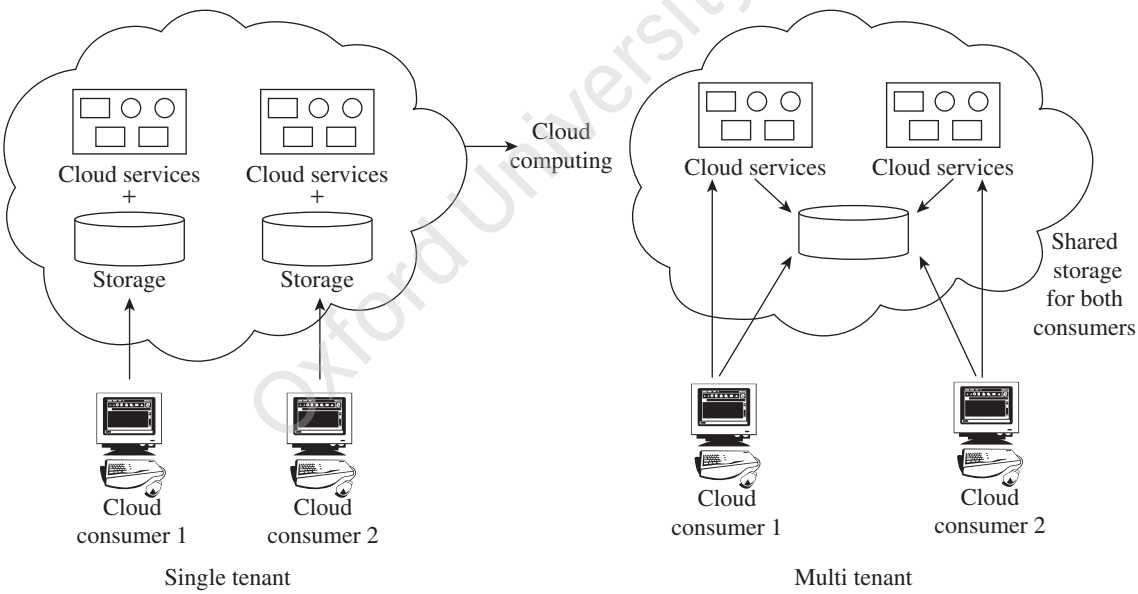

Fig. 1.8 Multi-tenancy in cloud computing

1.8.6 Data Location

The geographical site of the data also counts as a challenge. Being aware of the geographical site of data is essential to protect it, since there could be significant differences amid rigid strategies in various countries. The route followed by the data is also important. It may be difficult for an application operator to install applications at the smallest 'distance' from the users.

At present, there are cloud suppliers who leave the alternative of the data center site to the user. For example, Amazon proposes one site in Europe and two in other countries. It is expected that other

suppliers will follow Amazon's region option proposal as the site of data is a rising and significant requirement of promising consumers.

1.8.7 Deletion of Data

Public cloud users might need their data to be removed, that is, totally erased from the cloud.

Sometimes, one company migrates its data to another cloud provider. In that case, they want complete deletion of the data or complete migration of data; if this is not done, the benefit of the data might be used by the malicious user later. Various security agencies have been advised to use cipher text form of data for high security.

1.8.8 Recovery and Backup

For safety purpose, keeping the data of a consumer safe at different locations, for easy recovery and backup, if there is any failure, is a big challenge. A proposal of data backup must be proposed to cloud suppliers in of the event of a disaster. This can be achieved by the replication of data diagonally on various sites and the proposal should be referred in the service level contract.

1.8.9 Offline Clouds

For several users who require an application to be accessible the whole time through, becoming entirely dependent on the Internet could prove to be highly risky or unfeasible. This generates greater trouble in case the user is shuffling and there is a change in the connection quality. Thus in several cases, trusting the Internet service supplier is not an alternative. At present, a web browser is a widely used software application and all applications can be easily accessed through the interactive web browser. Locally, it is not necessary to maintain a hard disk with a strong processor because customized services are available on the cloud.

Google launched Gears, a free-of-cost add-on for the browser, which allows data to be saved locally in a complete searchable database while surfing the Internet. Gears resolved the 'offline problem' permitting web applications to resume their working while offline and subsequently coordinating when the link was accessible again. The latest edition of the HTML protocol tackles the offline matters with a pair of constituents—database and AppCache.

1. Canavas—Offers an influential and clear-cut meaning to depict arbitrary graphics on a web page using Javascript
2. Video—Aims to assemble a simple video on a web page as it is to establish images nowadays
3. Web workers—A novel method to take on gear jobs which should hold up the web browser

1.8.10 Unpredictable Performance

The cloud-end consumer would not even know the number of physical machines on which their application was functioning. The single source of information which the user has regarding these servers is the hardware specification offered by the cloud supplier for every kind of service. Further, these metrics do not have a similar significance in the cloud server as they had in a conventional server, since in the cloud server, some users can share I/O resources and compute on a specified case of a physical processor. A similar performance at similar financial levels has been expected by the user, but this might not be simply accurate, since the performance depends on several aspects and the end user has no control over many of them.

1.9 HOW TO DEVELOP CLOUD INFRASTRUCTURE

Infrastructure should meet the following vital features for assisting users to access data proficiently and efficiently at any occasion:

Accessibility It is the major responsibility of every central origin that data is accessible, on order, to users.

Functioning Optimal service and functioning should be offered by the data center.

Supple High-priority business needs may be under the control of the prevailing infrastructure, without any disruption of accessibility and with the least charge and least variation.

Safety Data must be protected from illegal and malevolent users.

Manageability Corporations try to reduce IT expenses on the data center and increase the consumption of prevailing resources.

In today's competitive world, a corporation should be flexible and capable of reacting quickly, and this should be achieved with the least investments in costs. Cloud computing is a completely automatic request accomplishment procedure which is dedicated to flexibility, quicker access, and cost savings.

For the development of cloud infrastructure, the following are needed:

1. Understanding the prevailing conventional data center
2. Computing resources that will be virtualized
3. Installing service administration devices

An infrastructure must accomplish the necessary uniqueness to support cloud services. It may be assembled by using a shared group of computing resources such as network, storage, and compute so as to accomplish cloud services. The infrastructure must be flexible for meeting the numerous demands of its customers. It also permits them to provision resources on order over a network. Cloud services facilitate optimization by managing and scrutinizing resource usage and by preservation of energy.

Along with the virtualization feature in cloud computing, it is possible to offer flexible physical infrastructure to cloud users. Largely, virtualizations offer us the ability to give continuous services to consumers. Cloud infrastructure may be built in several stages:

1. The first starts with thoroughly recognizing the prevailing physical infrastructure with its procedures and constituents.
2. The next step is to concentrate on accumulating the prevailing infrastructure resources by using virtualization technologies. Therefore, the accessible resource allows centralized administration of resources and permits quicker resource provisioning.
3. Then comes the step to install service administration devices, which allow mechanization of procedures and administration to reduce human interference. Service administration devices comprise purposeful services as well as those that permit utilization-based metering so that customers have to pay for just what is utilized by them. Through service administration, on-order provisioning of IT resources turns out to be livelier and permits IT to be sent as a service.

Core Components of Traditional Data Centers

A conventional data center is the prevailing infrastructure which processes data using IT resources. The core components of a traditional data center are as follows:

Application Program employed to carry out numerous computing functions. It may be an operating system, DBMS, and many more.

DBMS It is an administration system which offers the ability to save or get data from rationally prepared tables.

Compute Resources which work numerous applications using various elements

Storage This is used to save data for often use

Network It is the ability to communicate among systems. It assists us to share data and resources.

All the core elements of a traditional data center work together, to complete a task.

1.10 VENDORS OF CLOUD COMPUTING

With the migration of various organizations to the cloud-based technology, there are many vendors who have come into existence with incredible facilities, that not only easily offer customization as per user requirements but also have distinct features. Some of them are explained here:

1.10.1 Amazon Web Services—IaaS

The cloud computing corporation of Amazon.com—Amazon Web Service (AWS)—offers Infrastructure as a Service (IaaS) on the cloud for associations needing computing storage, power, and further services.

Elastic Compute Cloud Elastic Compute Cloud (EC2) is a web service which permits resizable computing ability on the cloud. The consumers may generate virtual machines (VMs), that is, server cases known as Amazon Machine Image (AMI), on which the consumer may put in any software of his/her preference. A pay-by-the hour system is followed.

Simple Storage Service (S3) S3 offers a web service interface which may be used to regain and store an infinite quantity of data, from any place, at any time, via the Internet.

Amazon SimpleDB is integrated for providing AWS services such as Amazon S3 and EC2, which provide the infrastructure for creating various web applications.

1.10.2 Google—SaaS, PaaS

Google App Engine is Google's Platform as a Service (Paas) that provides hosting and produces web applications on the Google Infrastructure. Presently, Java and Python are the supported programming languages. Up to a specific level, the resource-used App Engine is without any charge. Payment is charged for further bandwidth, CPU cycles, and storage needed by the application. Software as a Service (SaaS) provides business agreements and email. It is similar to conventional office suits, comprising Sites, Talk, Docs, Calendar, and Gmail.

In fact, the Google cloud is something which will entirely alter how people access data they look for. The Google Cloud is powered by thousands, possibly millions of unique services and servers which accommodate a surprising quantity of information. These are situated at various sites on the globe and maintain many clones of the information which are available on the Internet. Relevant information of the users is replicated on various servers.

Basically, Google Cloud is a 'reference' to the information which has been stored and made clear by Google. Services of cloud computing may be used from any site to access information which has been saved by Google. Services are provided by Search Docs, Google Maps, etc.

1.10.3 Microsoft Azure Service Platform—PaaS

Azure Service Platform is the proposal of Microsoft PaaS, an operating system known as Windows Azure, which performs as a runtime for the application and offers a set of services such as SQL Services, Live Services, and NET Services.

Windows Azure is a Microsoft Cloud computing platform used to develop, launch, and control applications via a universal network of Microsoft-controlled data centers. Windows Azure permits applications to be developed using various distinct languages, frameworks, or devices and makes it potential for designers to amalgamate communal cloud applications within their accessible IT environment. Windows Azure offers both IaaS and PaaS services and is categorized as the 'public cloud' in cloud computing policy of Microsoft, with its SaaS offering, Microsoft Online Services.

The following new characteristics were released by Windows Azure:

1. Websites permit designers to develop sites using PHP, Node.js, or ASP.NET and may be installed using TFS, FTP, etc.
2. Virtual machines permit designers to drift infrastructure and applications without altering the existing code and may operate both Linux virtual machines and the Windows Server.
3. Cloud services is a platform of Microsoft as a Service environment which is used to generate scalable services and applications. Supports automated installations and multi-tier states.
4. Data management, an SQL database once recognized as SQL Azure Database, performs to generate, scale, and expand applications into the cloud by using Microsoft SQL Server techniques. It amalgamates with System Center and Active Directory.
5. Media service is a PaaS-based service that may be used for content security, encoding, analytics and/or streaming.

The Windows Azure platform, which became available in the market in 2010, offers an API developed on XML, REST, and HTTP, which facilitates a designer to interrelate with the services offered by Windows Azure. Microsoft also offers a consumer-side operated class library which summarizes and customizes interrelating services as per user requirement. It also amalgamates with Eclipse, GIT, and Microsoft Visual Studio as it may be used as the integrated development environment (IDE) to build and print Azure-hosted applications.

1.10.4 Rackspace—Cloud Hosting

Rackspace is the service head in Cloud Computing and an initiator of OpenStack, an open source cloud platform. The San Antonio-based vendor, which operates around more than thousand enterprises, offers dedicated support to its consumers, athwart a variety of IT services, comprising cloud computing and managed hosting. Their exclusive consumer service policy has benefited them in getting the faith of their customers. Rackspace has been identified by Bloomberg Business Week as a 'Top Hundred Functioning Technology Corporations' and was highlighted in the list of Fortune. The corporation was also placed in the Leaders for Cloud Infrastructure under Service and Web Hosting.

1.10.5 Salesforce.com—SaaS, PaaS

Salesforce is a supplier of SaaS-based goods, along with having a PaaS offering, Force.com. It is a universal venture software corporation with headquarters in San Francisco, United States, California. Salesforce is best identified for its consumer relationship management (CRM). It was in graded position in Fortune's 100 Best Corporations.

1.11 ELASTIC COMPUTING

Elastic computing is offered by cloud computing where computing resources may be scaled up and down by the cloud service supplier. Elastic computing is the capability of a cloud service supplier to provision flexible computing strength when and where required. The elasticity of such resources may be in terms of bandwidth, storage, processing power, etc. Cloud computing pertains to provisioning on-demand computing

resources at the click of a mouse. The quantity of resources that may be sourced via cloud computing integrates nearly all the aspects of computing from basic processing power to enormous storage space.

On a small scale, it can be done manually but for huge deployments, there is automatic scaling. For instance, a better supplier of online videos might set up a system so that the number of web servers online are scaled all through peak performance hours.

In cloud computing, elasticity is described as the level to which a system is capable of adapting to workload variation by offering and taking back resources the autonomic way; at every point in time the accessible resources meet the present need. It is a vital feature, which distinguishes it from earlier computing paradigms, like grid computing. This dynamic difference, so as to meet an unreliable workload, is known as elastic computing.

1.12 SOCIAL NETWORKING

The Internet-based social media programs are used to build connections with family, friends, classmates, clients, and customers. Social networking may be done for business purposes, social purposes, or both. The programs show the connections among people and ease the ability of new links. Examples of social networking include LinkedIn, Facebook, etc. A social networking website is an online podium which permits customers to build a public profile and interact with other users on the website. Generally, social networking websites have a new record of people with whom they share a link and then permit the people in the record to verify or reject the link. After the establishment, the new customers may explore the networks of their links for making further links.

Social networking sites have various rules for setting links, but they frequently permit customers to examine the links of a confirmed link and even advise further links on the basis of an established network of a person. Some social networking websites like LinkedIn are used for creating professional links, whereas sites such as Facebook are on both sides of the line (i.e., professional and private). There are also networks that are created for a particular customer base, like political or cultural groups within a specified region or even dealers in economic markets.

1.13 ENTERPRISE CLOUD COMPUTING

Enterprise cloud computing is the process of using cloud computing for saving cost and for business innovation by getting extraordinary speed and agility, and improved collaboration among customers and business partners. Enterprise cloud computing is important because:

1. Cost of accessing data can be reduced to a great extent by linking it directly with the usage. Customers are charged on a pay-per-use basis.
2. Start-ups can test out new business ideas risk-free and at low cost, due to enormous scalability. Since there is no upfront capital expense involved, in case a new project takes off, it can be scaled up instantly, and vice versa.
3. Enterprise cloud computing allows a company to create a shared workspace in order to collaborate with its trading partners and work together as a 'virtual enterprise network'. In this way, they can share the information and communication resources, without actually owning it all. This also helps in lowering costs.

As shown in Fig. 1.9, an enterprise with *n* numbers of hosts can connect through cloud services and different types of services supported by cloud network such as database, servers, and various applications.

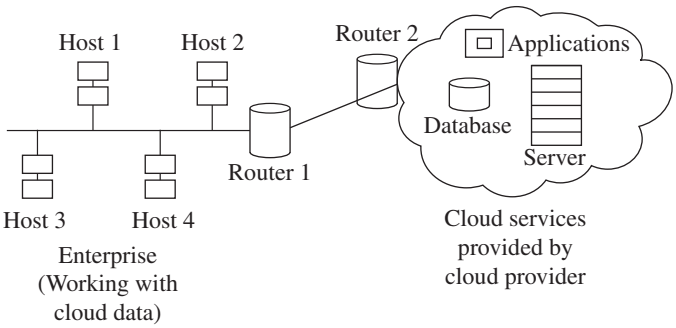

Fig. 1.9 Enterprise cloud computing

Points to Remember

1. Cloud computing is a technology which uses the Internet and central remote servers (data center) to maintain data, software, storage, and applications. It offers the following:
   (a) On-demand self-sufficient services
   (b) Omnipresent network access
   (c) Location-independent resource (access from anywhere)
   (d) Speedy elasticity
2. Cloud application doesn't need software or a server to use it and does not call for software updation.
3. Cloud computing allows users to use any application without installation and access their files at any computer with Internet access any time.
4. Cloud computing is becoming a progressively more attractive alternative for many organizations.
5. Cloud computing promises to reduce operational and capital costs.
6. Peer-to-peer is a decentralized approach having no center server.
7. Cloud computing is essential as it helps in reducing costs; offers scalability, remote access, disaster relief, ease of implementation, and better response time; and provides a virtual environment.
8. Grid is the application of multiple computers working on a single problem at the same time.
9. In utility computing, computing resources are disbursed as per usage.
10. Software as a Service is beneficial in usage based payments to applications.
11. Virtualization means the logical partitioning of physical computing resources into multiple execution environments, including servers, applications, and operating systems.
12. Building the cloud infrastructure involves the following:
    (a) Understanding the existing traditional data center
    (b) Virtualizing the computing resources
    (c) Deploying service management tools
13. Cloud computing has the ability to increase the usage level of the infrastructure through multi-tenancy.
14. Windows Azure is a Microsoft Cloud computing platform used to build, deploy, and manage applications through a global network of Microsoft-managed data centers.
15. Major challenges with traditional infrastructure software licensing and support, scalability, accountability, modifiability, physical security, and cost management.
16. The limitations of cloud computing are availability of service, data lock-in, data segregation, privilege neglect, scaling resources, data location, deletion of data, recovery and backup, offline cloud, and unpredictable performance.

Key Terms

Canavas It offers an influential and clear-cut means to depict arbitrary graphics on a web page using Javascript.

Cloud computing Cloud computing is the dynamic delivery of information technology resources and capabilities as a service over the Internet. Cloud computing is dynamically scalable and often transmits virtualized resources over the Internet. It provides services such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS).

DBMS A type of system of managing databases for providing facilities like storing or retrieving information from organized tables.

Distributed computing A distributed system consists of multiple computers that communicate through a computer network to achieve a common goal.

Grid computing The application of the processing power of multiple networked computing resources to solve a specific problem.

Hyper text markup language (HTML) A language mainly used for static web page designing

IP addresses A unique address provided to each computer in a network

Lock in Cloud vendor lock-in is a problem without a villain, according to Tom Hughes-Croucher, a technical evangelist at Yahoo. It makes a customer dependent on a vendor for products and services, unable to use another vendor without substantial switching costs.

Media services A PaaS offering that can be used for encoding, content protection, streaming, etc.

Network It is a facility to communicate between systems.

Peer-to-peer A different type of architecture in which each computer in the network has equivalent capabilities and responsibilities. It is not a centralized approach.

Remote access A distinct technology that allows logging into a system as an authentic user into a remote location without being physically present at the system. This technology is commonly used on corporate sectors but can also be utilized on home networks.

Replication Creation of different copies at various locations.

Scalability Change as per the demands.

Service level agreement (SLA) It is a type of agreement or contract between the cloud provider and cloud users for availing services from the cloud system.

Service oriented architectures (SOA) A set of services that communicate with each other, whose interfaces are known and described, whose functions are loosely coupled, and whose use can be incorporated by multiple organizations.

Service provider Those who are responsible for IT assets and maintenance services provided to users

Software as a Service (SaaS) Among the various services of a cloud, SaaS is a deployment model in which applications are provided to customers as a service.

Structured query language (SQL) SQL is a special-purpose programming language designed for managing and handling data in a relational database management system (RDBMS).

Trojans A Trojan is a non-self-replicating type of malware which performs an enviable function but instead facilitates unauthorized access to the user's computer system.

Utility computing The packaging and delivery of computing resources to a customer who pays for the resources as a metered-based service when needed. Customers have to pay on the basis of how much they have used.

Web workers A novel method to take on gear jobs which should hold up the web browser

Multiple-choice Questions

1. Which of the following is an example of a cloud computing application?
   (a) Facebook
   (b) Twitter
   (c) Skype
   (d) Salesforce.com and Googleapp
   (e) All the above
2. The logical partitioning of physical computing resources into multiple execution environments is called:
   (a) Grid computing
   (b) Platform virtualization
   (c) Distributed computing
   (d) None of these
3. The term used to describe a hypervisor running multiple operating systems simultaneously is:
   (a) Full virtualization
   (b) Para virtualization
   (c) Partial virtualization
   (d) Nested virtualization
4. Which among these best describes the difference between SOA and cloud computing?
   (a) Metered service
   (b) Shared resources
   (c) SOA existing within a firewall
   (d) Leveraging IT resource on demand
5. Cloud is a set of _____ that provide the service.
   (a) Hardware
   (b) Networks
   (c) Storage and services interfaces
   (d) All the above
6. The participants in cloud computing are _____.
   (a) The end user
   (b) The business management which has the responsibility of managing the overall cloud governance and provide services to the customer
   (c) The cloud service provider who are responsible for IT assets and maintenance
   (d) All the above
7. The core elements of a traditional data center is/are_____.
   (a) DBMS
   (b) Compute
   (c) Network
   (d) All the above
8. Peer-to-peer is a _____.
   (a) Decentralized approach
   (b) Centralized approach
   (c) Distributed approach
   (d) None of these
9. The advantages of client server networks is/are_____.
   (a) Centralization
   (b) Proper management
   (c) Backup and recovery possible
   (d) All the above
10. The objective of autonomic computing is to have the computer perform _____.
    (a) Critical and complex functions
    (b) Virtualization
    (c) On-demand services
    (d) None of these
11. Security is enhanced by which services in the cloud infrastructure?
    (a) Intrusion prevention
    (b) Hardware (intelligent switch)
    (c) Isolation of virtual network
    (d) File providing different permissions
    (e) DHCP used to track the IP address
12. What is cloud computing replacing?
    (a) Expenses of computer hardware
    (b) Software upgrades expenses
    (c) Data centers
    (d) All the above

13. What is the prime concern about cloud computing?
    (a) Security concerns
    (b) Too many platforms
    (c) Accessibility
    (d) Too expensive
14. Which of these is not the leader of cloud computing?
    (a) Google
    (b) Amazon
    (c) Blackboard
    (d) Microsoft
15. Which of the following is not a major cloud computing platform?
    (a) Google 101
    (b) IBM Deep blue
    (c) Microsoft
    (d) Azure
16. What represents the 'cloud' in cloud computing?
    (a) Wireless
    (b) Wireless LAN
    (c) Crowd of people
    (d) The Internet
17. Which of these should a company consider before implementing cloud computing technology?
    (a) Employee satisfaction
    (b) Cost reduction
    (c) Sensitivity of information
    (d) All the above
18. The challenges with traditional infrastructure include:
    (a) Software licensing and support
    (b) Scalability
    (c) Accountability and modifiability
    (d) All the above
19. The advantage of cloud over remote hosting is _____.
    (a) Virtual servers or physical servers that can be customized to different plans through a control panel
    (b) Dedicated IP addresses for cloud servers
    (c) Replication or distribution over various distant locations
    (d) All the above
20. Which of these are the challenges of cloud computing?
    (a) Safeguarding data security
    (b) Managing the contractual relationship
    (c) Managing the cloud
    (d) All the above

Review Questions

1. What is cloud computing and how is it different from the Internet?
2. What is the need of cloud computing?
3. Explain the different elements responsible for the origination of cloud computing.
4. What are the core elements of a traditional data center?
5. What is virtualization? What are its various benefits?
6. What is distributed computing? Explain.
7. What is grid computing? How is it different from cloud computing?
8. How is a traditional data center different from a cloud data center?
9. What are the various services provided by cloud computing?
10. What are the advantages of peer-to-peer networking?
11. What are the various challenges of cloud computing?
12. How is cloud computing beneficial?
13. How can you say that security is one of the major challenges for cloud users?
14. Why is data segregation a limitation for cloud users?
15. What do you understand by remote access?
16. How can you say that interoperability and portability are the challenges of cloud computing?
17. What are the various vendors of cloud computing?
18. How can we use Windows Azure in the application platform of a public cloud?

19. What do you understand by customization? How can we use it in cloud computing?
20. What are the applications of utility computing with reference to cloud computing?
21. What is the need of elastic computing?

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Answers to Multiple-choice Questions

1. (e)	5. (d)	9. (d)	13. (a)	17. (d)
2. (b)	6. (d)	10. (a)	14. (c)	18. (d)
3. (d)	7. (d)	11. (a) and (c)	15. (b)	19. (d)
4. (d)	8. (a)	12. (d)	16. (d)	20. (d)