According to New Credit System Syllabus

SPPU

Final Year (B.E.) Degree Course In

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

(Semester - VII)

CLOUD COMPUTING



Includes

- Model Question Papers For Practice
  (In Sem-30 Marks & End Sem-70 Marks)

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NIRALI® PRAKASHAN
ADVANCEMENT OF KNOWLEDGE

A TEXT BOOK OF

CLOUD COMPUTING

FOR
SEMESTER – VII

FINAL YEAR (B.E.) DEGREE COURSE IN ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Strictly According to New Credit System Syllabus of Savitribai Phule Pune University
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PREFACE

It gives us great pleasure to present the book '**Cloud Computing**' for the students of **Final Year (BE) Degree Course in Artificial Intelligence and Machine Learning** of Savitribai Phule Pune University. This book is strictly as per the **New Credit System Syllabus 2020 Pattern** effective from the Academic Year 2023-24.

As per the New Revised Examination Scheme, which has been implemented from the previous academic year, the In-semester examination allots 30 marks for the first two units and the End-Semester Examination allots 70 marks for the entire syllabus.

The theory subject will have 3 Credits.

In the book, all the basic concepts are explained in a simplified manner. Subject matter is presented in a conceptual manner rather than mathematical, as required by the new examination system. It is our objective to keep the presentation systematic, and clear through explanatory notes and figures.

Main feature of this book is, Complete Coverage of the New Credit System Syllabus with Exercises and Model Question Papers of In Sem. and End Sem. Exams.

We are sure that this book will cater to all needs of the students for this subject.

We also take this opportunity to express our sincere thanks to Shri. Dineshbhai Furia, Shri. Jignesh Furia, Mrs. Nirali Verma and entire team of Nirali Prakashan, namely Mrs. Deepali Lachake (Co-ordinator), who really have taken keen interest and untiring efforts in publishing this text.

We wish to make a special mention of the valuable contribution made by Late Shri M. P. Munde during the last two decades in reaching out to students, parents and teachers which eventually made **Nirali Prakashan, a brand of trust and quality in technical books**. Without his perseverance and zeal, successive editions would not have been possible.

The advice and suggestions of our esteemed readers to improve the text are most welcome and will be highly appreciated.

Pune **Authors**

SYLLABUS

Unit I: Fundamentals of Cloud Computing **(06 hrs)**

Understanding Cloud Computing: Origin and Influences-History, definitions, technology innovations; Cloud Computing terminologies, Applications, benefits and limitations, risk and challenges; Roles and Boundaries, Cloud characteristics, Cloud Delivery Models, Deployment Models.

Unit II: Common Enabling Technology **(06 hrs)**

Hardware and Infrastructure: Clients- mobile, thin, thick; Security- data leakage, offloading work, logging, forensics, development, auditing; Network-basic public Internet and accelerated Internet; Services- Identity, Integration, Mapping, Payments, Search.

Cloud Enabling Technology: Broadband Networks and Internet Architecture, Data Center Technology, Virtualization Technology, Web Technology, Multitenant Technology, Containerization.

Unit III: Cloud Services and Providers **(06 hrs)**

Cloud Service Types: Software as a Service, Platform as a Service, Infrastructure as a Service, Database as a Service, Monitoring as a Service, Communication as a service.

Cloud Service Providers: Google- Google App Engine, EMC- Technologies, VMware Acquisition, Microsoft Azure Services Platform; Amazon- Amazon Elastic Compute Cloud (EC2), Amazon Simple DB, Amazon Simple Storage Service (S3), Elastic Block Store; Salesforce.com- Force.com, Salesforce.com CRM, AppExchange.

Unit IV: Data Storage in Cloud **(06 hrs)**

Cloud File System: GFS and HDFS, BigTable, HBase and Dynamo Cloud data stores: Datastore and Simple DB Gautam Shrauf, Cloud Storage-Overview, Cloud Storage Providers. Creating Cloud Storage Systems, Virtual Storage Containers, Challenges.

Unit V: Cloud Security **(06 hrs)**

Cloud Security: Basic Terms and Concepts-Confidentiality, Integrity, Authenticity, availability, Threat, Vulnerability, Risk,

Security Control, Security Mechanisms, and Security Policies.

Cloud Security Mechanism: Encryption, Hashing, Digital Signature, Public Key Infrastructure (PKI), Identity and Access Management (IAM), Single Sign-On (SSO).

Unit VI: Common Standards in Cloud Computing **(06 hrs)**

Open Cloud Consortium- Open virtualization format, Standards for application developers- browsers, data and solution stack; Standards for messaging - SMTP, POP, IMAP, RSS, HTTP; Standards for security- Security (SAML OAuth, OpenID, SSL/TLS). Docker at a Glance: Process simplification, Broad support and adoption, Architecture, Getting the most from docker, The docker workflow.

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❋ ❋ ❋

UNIT I

FUNDAMENTALS OF CLOUD COMPUTING

1.1 UNDERSTANDING CLOUD COMPUTING

1. Origin and Influences

Cloud computing has emerged as a transformative force in the world of technology, revolutionizing the way businesses and individuals store, access, and manage data and applications. To truly grasp the significance of cloud computing, it's essential to delve into its origins and the various influences that have shaped its evolution into the ubiquitous technology we know today.

The Birth of Cloud Computing

- The concept of cloud computing can be traced back to the early days of computing when large mainframe computers were the primary means of processing data. In those times, users had to physically access these massive machines to perform computations or access data. This approach was highly inefficient and limited the accessibility of computing power to a select few.
- The term "Cloud Computing" began to gain prominence in the late 1990s and early 2000s. It was introduced as a way to describe a new paradigm in which computing resources, such as servers, storage, and software applications, could be delivered to users over the internet. The concept aimed to break free from the constraints of physical hardware and provide computing as a service, on-demand, and at scale.

2. Influences on Cloud Computing

Several key influences have played a pivotal role in shaping the evolution of cloud computing:

- **Virtualization:** The widespread adoption of virtualization technologies was a precursor to cloud computing. Virtualization allowed multiple virtual machines to run on a single physical server, optimizing resource utilization. This laid the foundation for the idea that computing resources could be abstracted from physical hardware.
- **Utility Computing:** Utility computing, a concept dating back to the 1960s, was a precursor to cloud computing's pay-as-you-go model. It involved charging users based on their actual usage of computing resources, similar to how cloud services are billed today.
- **Grid Computing:** Grid computing was a distributed computing model that aimed to harness the power of interconnected computers for complex scientific and engineering tasks. While not identical to cloud computing, it contributed to the development of distributed computing concepts.
- **Internet Expansion:** The exponential growth of the internet infrastructure and the availability of high-speed broadband connections made it feasible to deliver computing resources over the web. This expansion of internet connectivity was a critical enabler of cloud computing.
- **Economic Pressures:** The economic downturn of the early 2000s forced businesses to seek cost-effective ways to manage their IT infrastructure. Cloud computing offered a solution by shifting capital expenses to operational expenses and allowing businesses to scale resources up or down as needed.
- **Amazon Web Services (AWS):** AWS, launched by Amazon in 2006, is often credited with popularizing cloud computing. AWS introduced a wide range of cloud services, making it possible for businesses to access computing power, storage, and services on a massive scale. This laid the groundwork for the cloud's rapid adoption.
- **Open Source Software:** The open-source movement contributed significantly to cloud computing by providing a wealth of software tools and frameworks. Open-source technologies like Linux, OpenStack, and Kubernetes have played a crucial role in building and managing cloud infrastructures.
- **Security and Compliance:** As cloud computing matured, addressing security and compliance concerns became paramount. Innovations in encryption, access controls, and compliance frameworks have made cloud platforms more secure and trustworthy.

In conclusion, cloud computing's origin can be traced back to a culmination of technological advancements, economic pressures, and the relentless pursuit of efficiency in computing. It has evolved into a versatile and indispensable technology that powers everything from streaming services and social media to enterprise applications and scientific research. Understanding the origins and influences of cloud computing is key to appreciating its significance and continued impact on our digital world. As cloud computing continues to evolve, it promises even more innovation and transformative possibilities for the future.

1.2 ORIGINS AND INFLUENCES

1.2.1 A Brief History

- The term "cloud" in cloud computing has originated from utility computing, a concept being proposed by computer scientist John McCarthy in 1961: "If computers of the kind I have advocated become the computers of the future, then computing may someday be organized as a public utility just as the telephone system is a public utility. The computer utility could become the basis of a new and important industry".
- In the late 1990s, Salesforce.com brought remotely provisioning services into the enterprise. In 2002, Amazon.com launched its Amazon Web Services (AWS) platform, a suite of enterprise-oriented services that provide remotely provisioned storage, computing resources, and business functionality. A slightly different evocation of the term "Network Cloud" or "Cloud" was introduced in the early 1990s throughout the networking industry.
- It referred to an abstraction layer derived in the delivery methods of data across heterogeneous public and semi-public networks that were primarily packet-switched, although cellular networks used the "Cloud" term as well. The networking method at this point supported the transmission of data from one end-point (local network) to the "Cloud" (wide area network) and then further decomposed to another intended end-point.
- It wasn't until 2006 that the term "cloud computing" emerged in the commercial area. It was during this time that Amazon launched its Elastic Compute Cloud (EC2) services that enabled organizations to "lease" computing capacity and processing power to run their enterprise applications.

1.2.2 Definitions

The cloud computing can be defined as 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 (IaaS, PaaS and SaaS), and four deployment models (public, private, hybrid and community cloud).

Cloud computing is a specialized form of distributed computing that introduces utilization models for remotely provisioning scalable and measured resources. The cloud services are delivered by using internet technology on pay per use basis.

1.2.3 Business Drivers

Let's have a look on some of the motivations that has influenced the industry to adapt cloud computing.

Capacity Planning

Capacity planning is the process of determining and fulfilling future demands of an organization's IT resources, products, and services.

Within this context, capacity represents the maximum amount of work that an IT resource is capable of delivering in a given period of time. Capacity planning is focused on minimizing this discrepancy to achieve predictable efficiency and performance.

Cost Reduction

A direct alignment between IT costs and business performance can be difficult to maintain. The growth of IT environments often corresponds to the assessment of their maximum usage requirements.

This can make the support of new and expanded business automations an ever-increasing investment.

Two costs need to be accounted for:

- The cost of acquiring new infrastructure,
- The cost of its ongoing ownership.

Organizational Agility

Businesses need the ability to adapt and evolve to successfully face change caused by both internal and external factors. Organizational agility is the measure of an organization's responsiveness to change.

An IT enterprise often needs to respond to business change by scaling its IT resources beyond the scope of what was previously predicted or planned for. For example, infrastructure may be subject to limitations that prevent the organization from responding to usage fluctuations—even when anticipated if previous capacity planning efforts were restricted by inadequate budgets. In other cases, changing business needs and priorities may require IT resources to be more available and reliable than before.

1.2.4 Technology Innovations

Established technologies are often used as inspiration and, at times, the actual foundations upon which new technology innovations are derived and built. Following are the pre-existing technologies considered to be the primary influences on cloud computing.

Clustering

A cluster is a group of independent IT resources that are interconnected and work as a single system. System failure rates are reduced while availability and reliability are increased, since redundancy and failover features are inherent to the cluster. A general prerequisite of hardware clustering is that its component systems have reasonably identical hardware and operating systems to provide similar performance levels when one failed component is to be replaced by another.

Grid Computing

A computing grid provides a platform in which computing resources are organized into one or more logical pools. These pools are collectively coordinated to provide a high performance distributed grid, sometimes referred to as a "super virtual computer." Grid computing differs from clustering in that grid systems are much more loosely coupled and distributed. As a result, grid computing systems can involve computing resources that are heterogeneous and geographically dispersed, which is generally not possible with cluster computing-based systems.

Virtualization

Virtualization represents a technology platform used for the creation of virtual instances of IT resources. A layer of virtualization software allows physical IT resources to provide multiple virtual images of themselves so that their underlying processing capabilities can be shared by multiple users.

Technology Innovations vs. Enabling Technologies:

It is essential to highlight several other areas of technology that continue to contribute to modern-day cloud-based platforms. These are distinguished as cloud-enabling technologies:

- Broadband Networks and Internet Architecture
- Data Center Technology
- Virtualization Technology
- Web Technology
- Multitenant Technology
- Service Technology

Each of these cloud-enabling technologies existed in some form prior to the formal advent of cloud computing. Some were refined further, and on occasion even redefined, as a result of the subsequent evolution of cloud computing.

1.3 BASIC CONCEPTS AND TERMINOLOGY

Following are the set of basic terms that represent the fundamental concepts and aspects pertaining to the notion of a cloud and its most primitive artifacts.

1.3.1 Cloud

A cloud refers to a distinct IT environment that is designed for the purpose of remotely provisioning scalable and measured IT resources. The term originated as a metaphor for the Internet which is, in essence, a network of networks providing remote access to a set of decentralized IT resources. Prior to cloud computing becoming its own formalized IT industry segment, the symbol of a cloud was commonly used to represent the Internet in a variety of specifications and mainstream documentation of Web-based architectures. This same symbol is now used to specifically represent the boundary of a cloud environment, as shown in Fig. 1.1:



Fig. 1.1: Symbol of boundary of a cloud environment

It is important to distinguish the term "cloud" and the cloud symbol from the Internet. As a specific environment used to remotely provision IT resources, a cloud has a finite boundary. There are many individual clouds that are accessible via the Internet.

Whereas the Internet provides open access to many Web-based IT resources, a cloud is typically privately owned and offers access to IT resources that is metered. Much of the Internet is dedicated to the access of content-based IT resources published via the World Wide Web.

1.3.2 IT Resource

An IT resource is a physical or virtual IT-related artifact that can be either software based, such as a virtual server or a custom software program, or hardware-based, such as a physical server or a network device (Fig. 1.2).

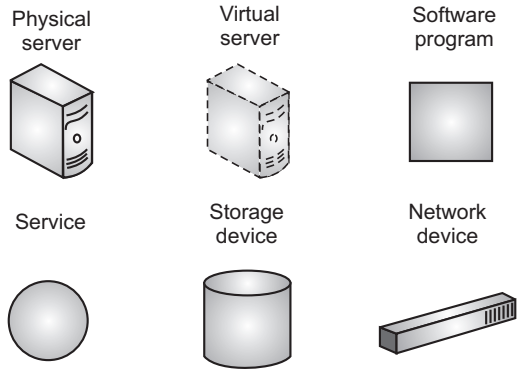


Fig. 1.2: Examples of common IT resources and their corresponding symbols

Fig. 1.3 illustrates how the cloud symbol can be used to define a boundary for a cloud-based environment that hosts and provisions a set of IT resources. The displayed IT resources are consequently considered to be cloud-based IT resources. A cloud is hosting eight IT resources: three virtual servers, two cloud services, and three storage devices.

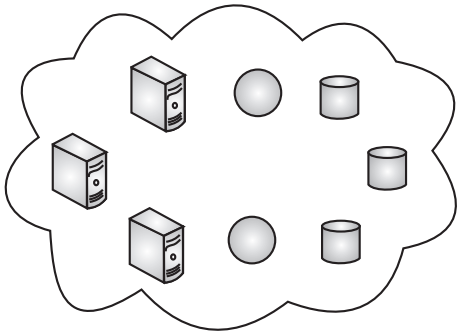


Fig. 1.3: Cloud symbol

1.3.3 On-Premise

As a distinct and remotely accessible environment, a cloud represents an option for the deployment of IT resources. An IT resource that is hosted in a conventional IT enterprise within an organizational boundary (that does not specifically represent a cloud) is considered to be located on the premises of the IT enterprise, or on-premise for short.

In other words, the term "on-premise" is another way of stating "on the premises of a controlled IT environment that is not cloud-based". This term is used to qualify an IT resource as an alternative to "cloud-based". An IT resource that is on-premise cannot be cloud-based, and vice-versa.

1.3.4 Cloud Consumers and Cloud Providers

The party that provides cloud-based IT resources is the cloud provider. The party that uses cloud-based IT resources is the cloud consumer. These terms represent roles usually assumed by organizations in relation to clouds and corresponding cloud provisioning contracts.

1.3.5 Scaling

Scaling, from an IT resource perspective, represents the ability of the IT resource to handle increased or decreased usage demands.

The following are two types of scaling:

- **Horizontal Scaling :** Scaling out and scaling in.
- **Vertical Scaling :** Scaling up and scaling down.

1. Horizontal Scaling

The allocating or releasing of IT resources that are of the same type is referred to as horizontal scaling (Fig. 1.4). The horizontal allocation of resources is referred to as scaling out and the horizontal releasing of resources is referred to as scaling in. Horizontal scaling is a common form of scaling within cloud environments. Fig. 1.4 shows an IT resource (Virtual Server A) is scaled out by adding more of the same IT resources (Virtual Servers B and C).

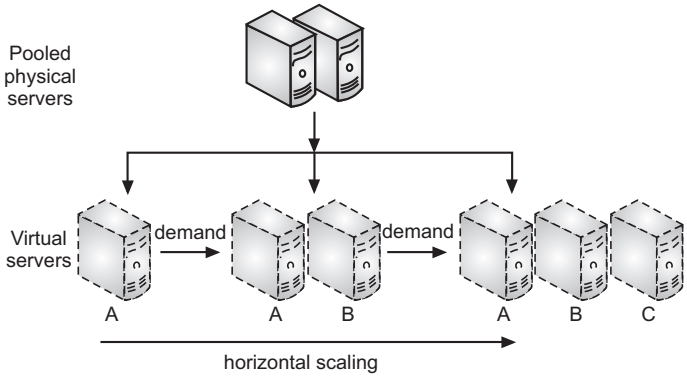


Fig. 1.4: Horizontal scaling

2. Vertical Scaling

When an existing IT resource is replaced by another with higher or lower capacity, vertical scaling is considered to have occurred (Fig. 1.5). Specifically, the replacing of an IT resource with another that has a higher capacity is referred to as scaling up and the replacing an IT resource with another that has a lower capacity is considered scaling

down. Vertical scaling is less common in cloud environments due to the downtime required while the replacement is taking place. Fig. 1.5 shows an IT resource (a virtual server with two CPUs) is scaled up by replacing it with a more powerful IT resource with increased capacity for data storage (a physical server with four CPUs).

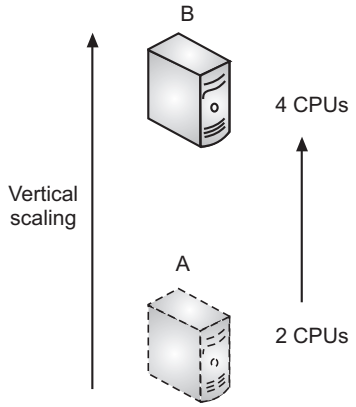


Fig. 1.5: Vertical scaling

Table 1.1 provides a brief overview of common advantages and disadvantages associated with horizontal and vertical scaling.

Table 1.1: A Comparison of Horizontal and Vertical Scaling

Sr. No.	Horizontal Scaling	Vertical Scaling
1.	Less expensive (through commodity hardware components).	More expensive (specialized servers).
2.	IT resources instantly available.	IT resources normally instantly available.
3.	Resource replication and automated scaling.	Additional setup is normally needed.
4.	Additional IT resources needed.	No additional IT resources needed.
5.	Not limited by hardware capacity.	Limited by maximum hardware capacity.

1.3.6 Cloud Service

- Although a cloud is a remotely accessible environment, not all IT resources residing within a cloud can be made available for remote access. For example, a database or a physical server deployed within a cloud may only be accessible by other IT resources that are within the same cloud.
- A software program with a published API may be deployed specifically to enable access by remote clients unlike other IT fields that fall under the service technology umbrella such as service- oriented architecture the term "service" within the context of cloud computing is especially broad.
- A cloud service can exist as a simple web-based software program with a technical interface invoked via the use of a messaging protocol, or as a remote access point for administrative tools or larger environments and other IT resources.
- In Fig. 1.6, the circle symbol is used to represent the cloud service as a simple Web-based software program. A different IT resource symbol may be used in the latter case, depending on the nature of the access that is provided by the cloud service.

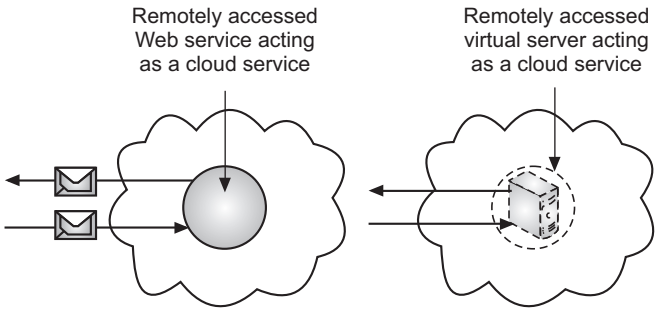


Fig. 1.6

- A cloud service with a published technical interface is being accessed by a consumer outside of the cloud (left). A cloud service that exists as a virtual server is also being accessed from outside of the cloud's boundary (right).
- The cloud service on the left is likely being invoked by a consumer program that was designed to access the cloud service's published technical interface. The cloud service on the right may be accessed by a human user that has remotely logged on to the virtual server.
- The driving motivation behind cloud computing is to provide IT resources as services that encapsulate other IT resources, while offering functions for clients to use and leverage remotely.
- A multitude of models for generic types of cloud services have emerged, most of which are labeled with the "as-a-service" suffix.

1.3.7 Cloud Service Consumer

- The cloud service consumer is a temporary runtime role assumed by a software program when it accesses a cloud service.