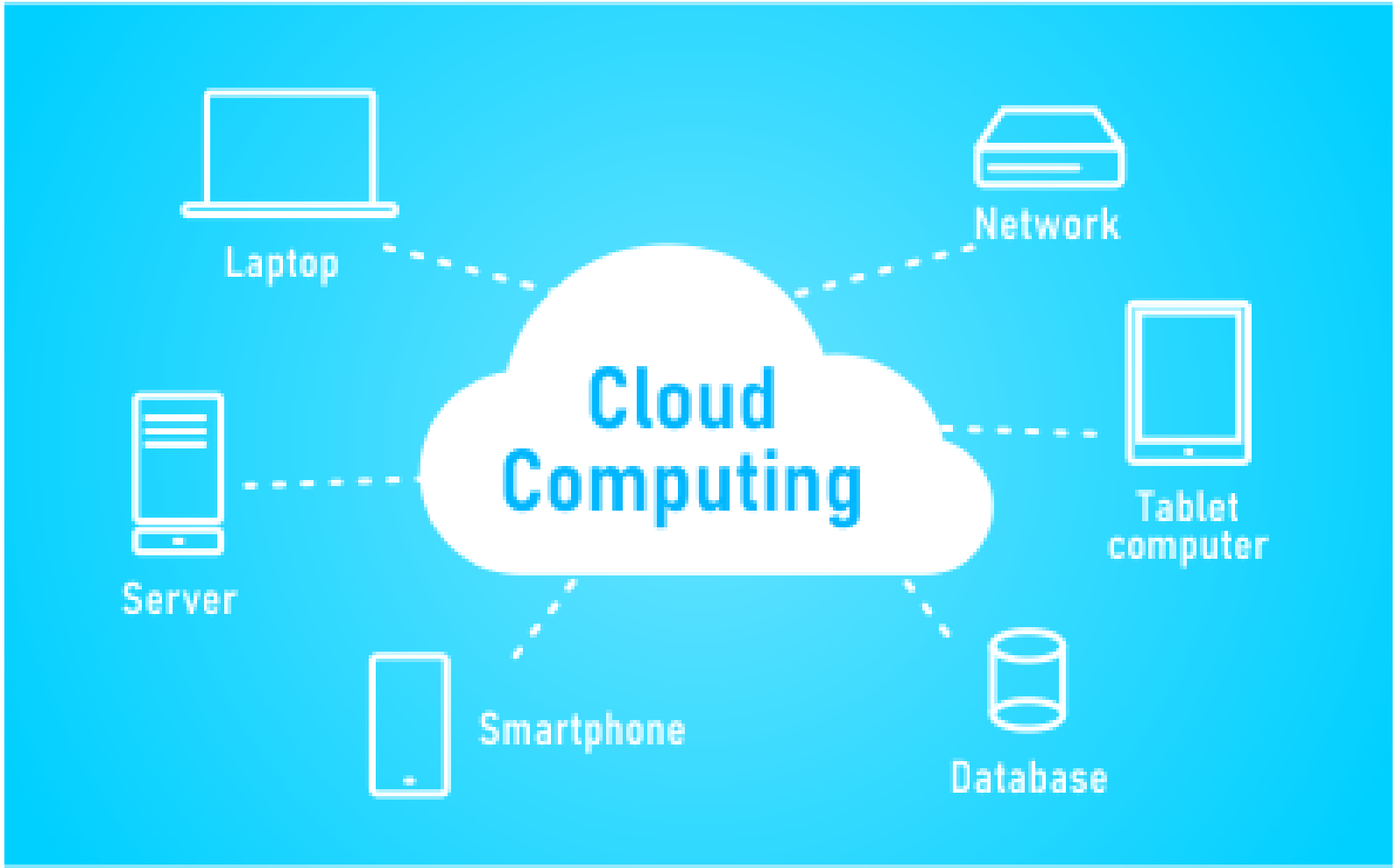
Subject Name: Cloud Computing
Subject Code: 20AIM71A
Semester: VII

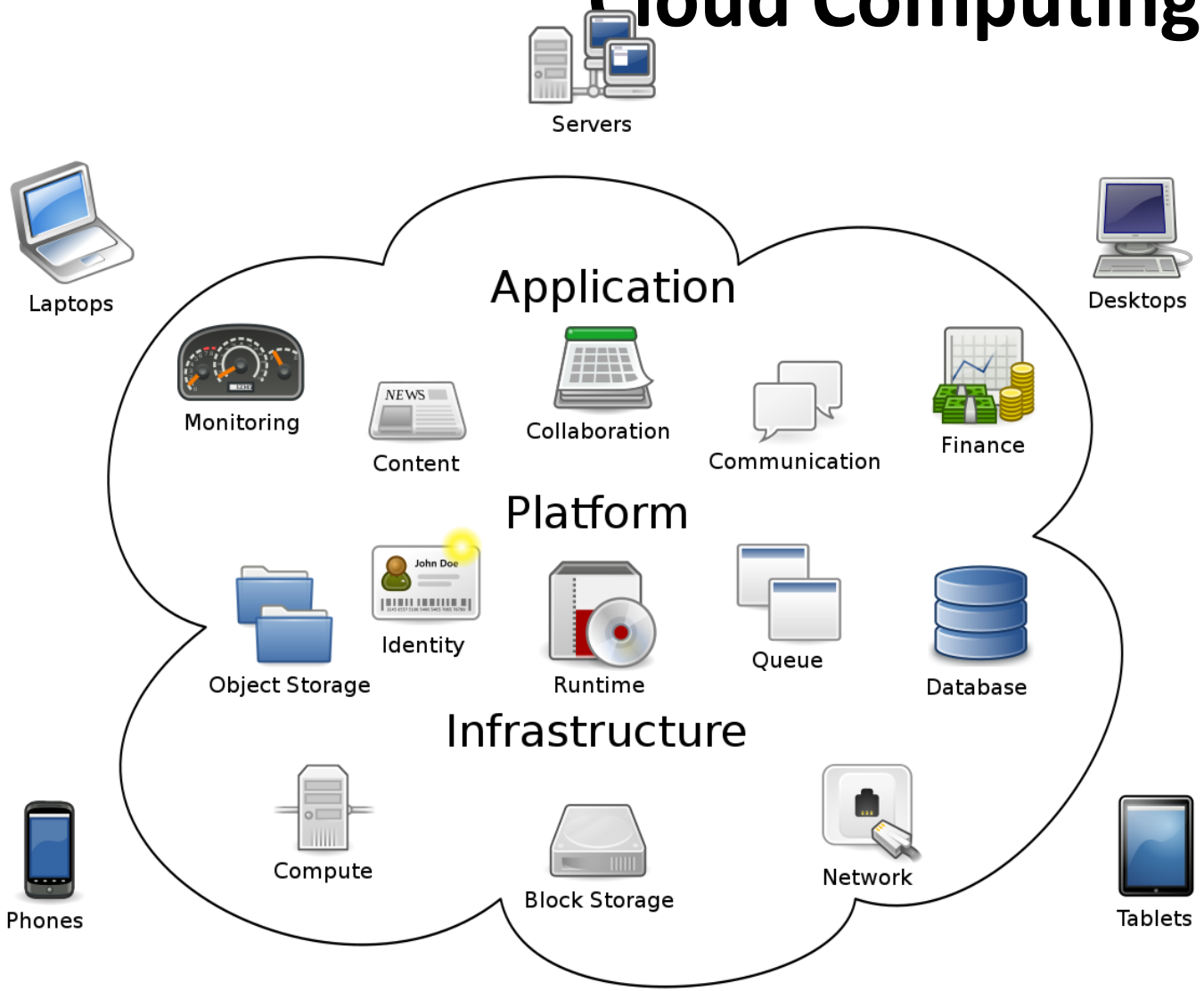
Module 1: Introduction

Module No.	Module Contents	Hours	COs
1	**Introduction** ,Cloud Computing at a Glance, The Vision of Cloud Computing, Defining a Cloud, A Closer Look, Cloud Computing Reference Model, Characteristics and Benefits, Distributed Systems, Virtualization, Web 2.0, Service-Oriented Computing, Utility-Oriented Computing, Building Cloud Computing Environments, Application Development, Infrastructure and System Development, Computing Platforms and Technologies, Amazon Web Services (AWS), Google AppEngine, Microsoft Azure, Hadoop, Force.com and Salesforce.com, Aneka.	9	CO1, CO2

Introduction

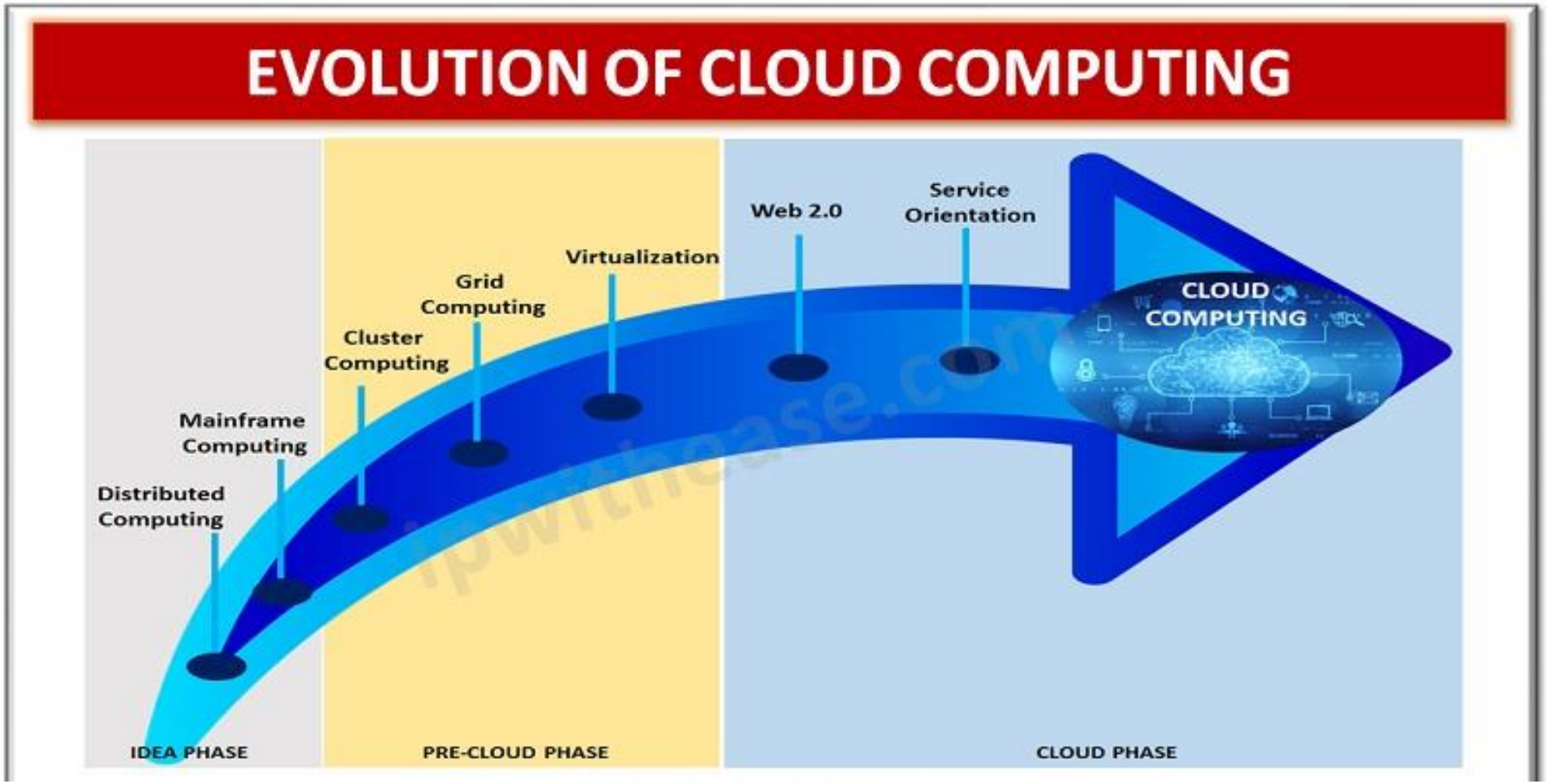


Cloud Computing at a Glance



Cloud computing is on-demand access, via the internet, to computing resources—applications, servers (physical servers and virtual servers), data storage, development tools, networking capabilities, and more—hosted at a remote data center managed by a cloud services provider (or CSP).

Cloud Computing at a Glance



The Vision of Cloud Computing

- Cloud computing provides the facility to provision virtual hardware, runtime environment and services to a person having money.
- These all things can be use as long as they are needed by the user
- The whole collection of computing system is transformed into a collection of utilities, which can be provisioned and composed together to deploy systems in hours rather than days, with no maintenance costs
- The long term vision of a cloud computing is that IT services are traded as utilities in an open market without technological and legal barriers

FIGURE 1.1

Cloud computing vision.

Defining a Cloud

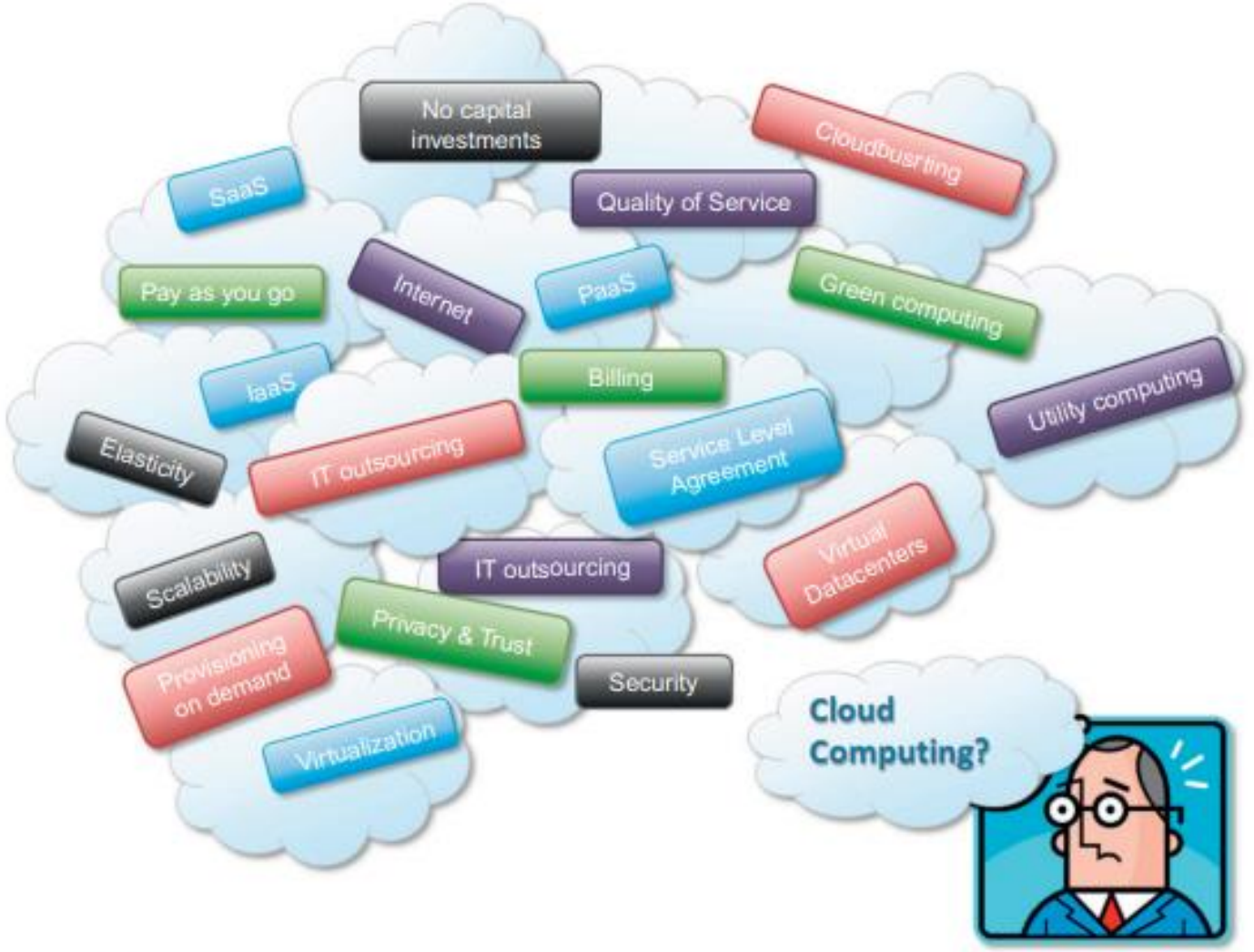


FIGURE 1.2

Cloud computing technologies, concepts, and ideas.

Cloud computing refers to both the applications delivered as services over the Internet and the hardware and system software in the datacenters that provide those services.

This definition describes cloud computing as a phenomenon touching on the entire stack: from the underlying hardware to the high-level software services and applications. It introduces the concept of everything as a service, mostly referred as XaaS (X as a Service) where the different components of a system—IT infrastructure, development platforms, databases, and so on—can be delivered, measured, and consequently priced as a service.

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.

Another important aspect of cloud computing is its utility-oriented approach.
A cloud is a type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements established through negotiation between the service provider and consumers.

Subscription - Oriented Cloud Services:
X{compute, apps, data, ..} as a Service (..aaS)

Manjrasoft

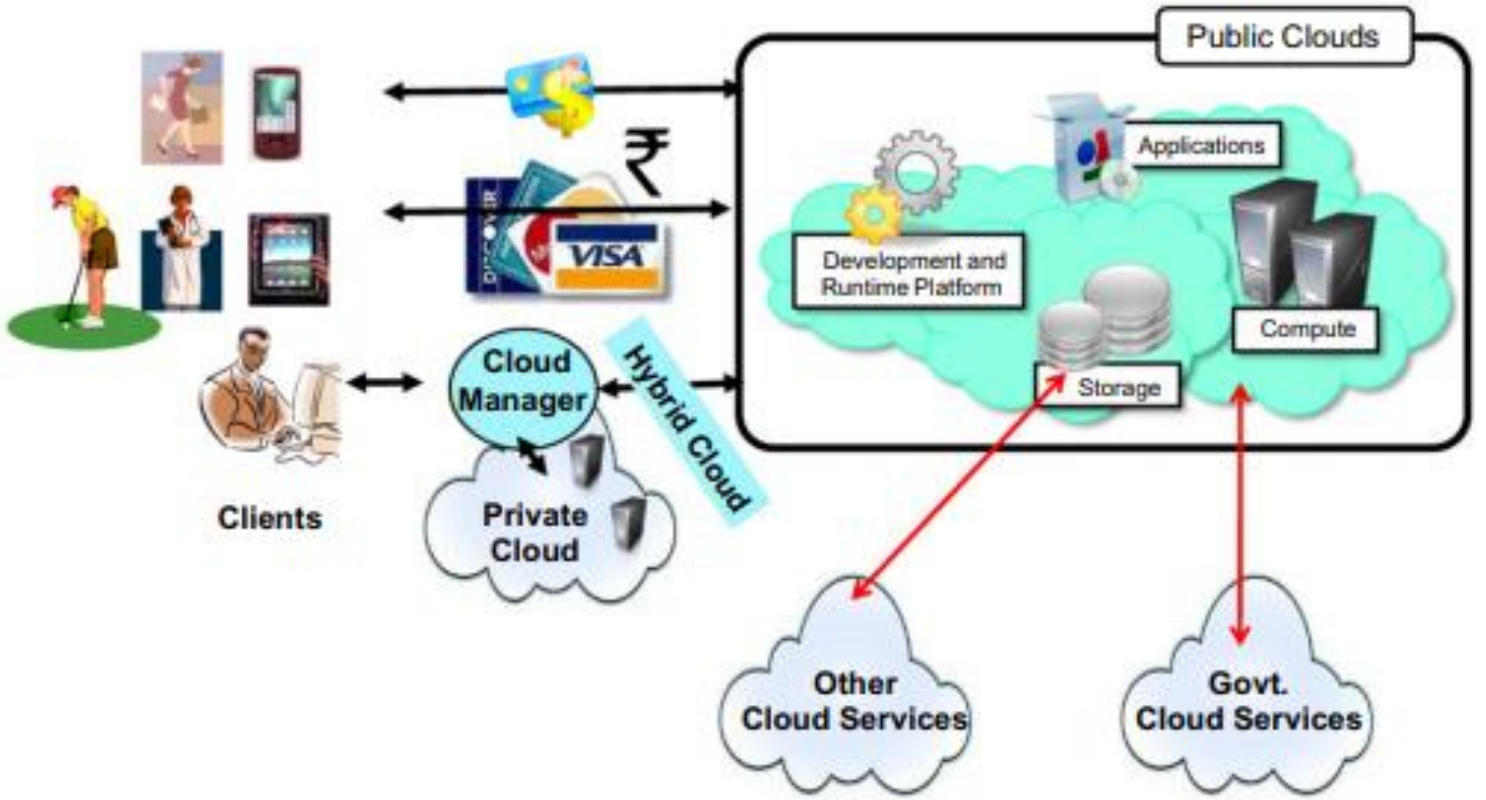


FIGURE 1.3

A bird's-eye view of cloud computing.

A Closer Look

1) Large enterprises can offload some of their activities to cloud-based systems.

2) Small enterprises and start-ups can afford to translate their ideas into business results more quickly, without excessive up-front costs.

3) System developers can concentrate on the business logic rather than dealing with the complexity of infrastructure management and scalability.

4) End users can have their documents accessible from everywhere and any device.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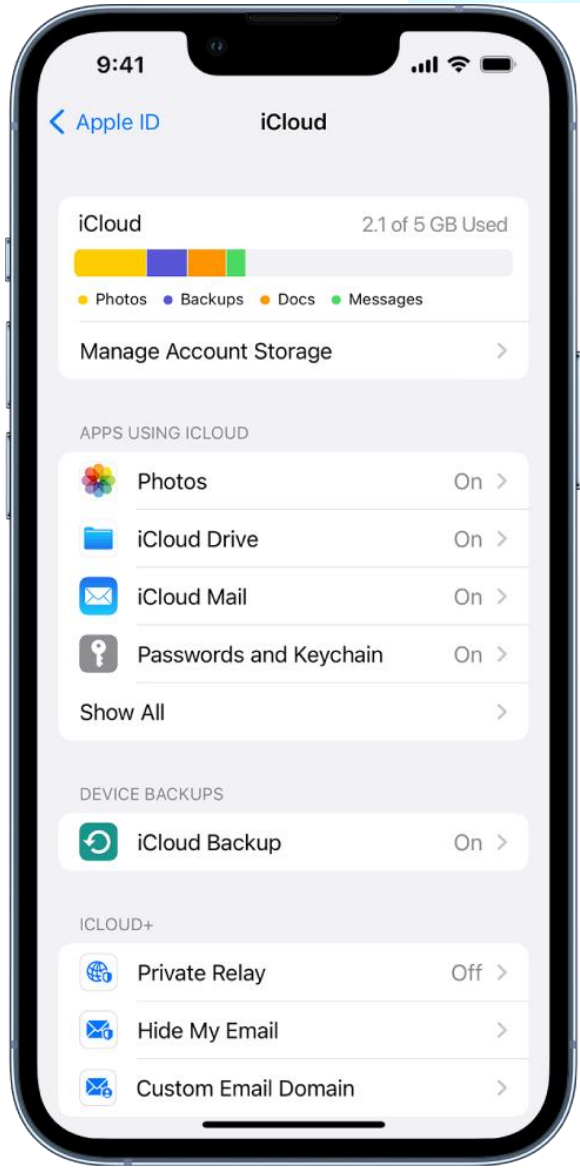


4. Apple iCloud

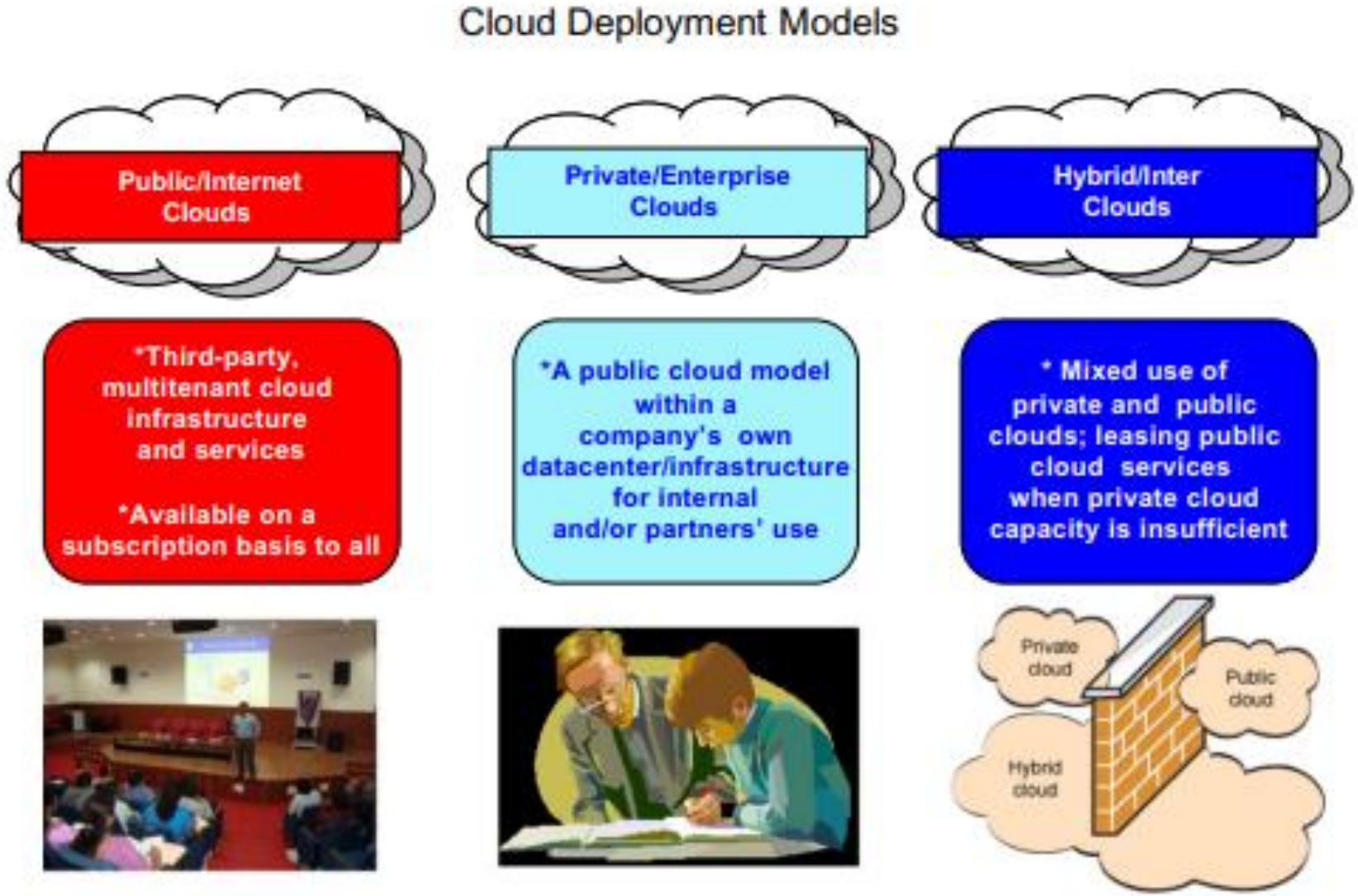
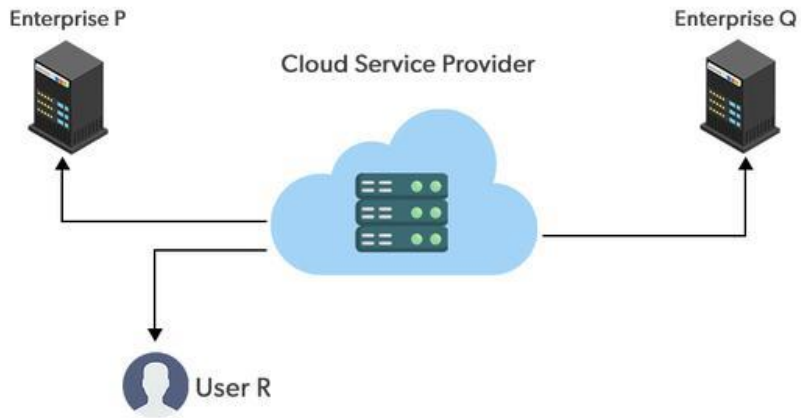


FIGURE 1.4

Major deployment models for cloud computing.

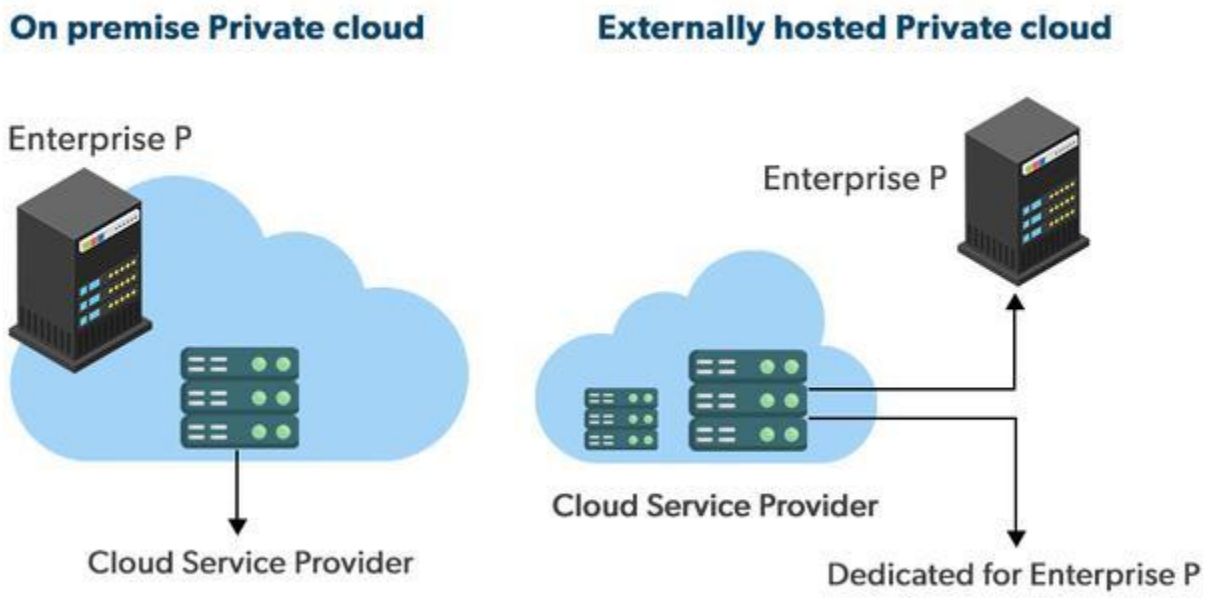
1) Public Cloud

- Necessary IT infrastructure is established by a third party service provider that makes it available to any consumer on a subscription basis
- The infrastructure in this cloud model is owned by the entity that delivers the cloud services, not by the consumer.
- It is a type of cloud hosting that allows customers and users to easily access systems and services.
- Eg: Google Engine
- **Advantages-** Minimal Investment, No setup cost, Infrastructure Management is not required, No maintenance, dynamic stability
- **Disadvantages**-Less secure, Low customization



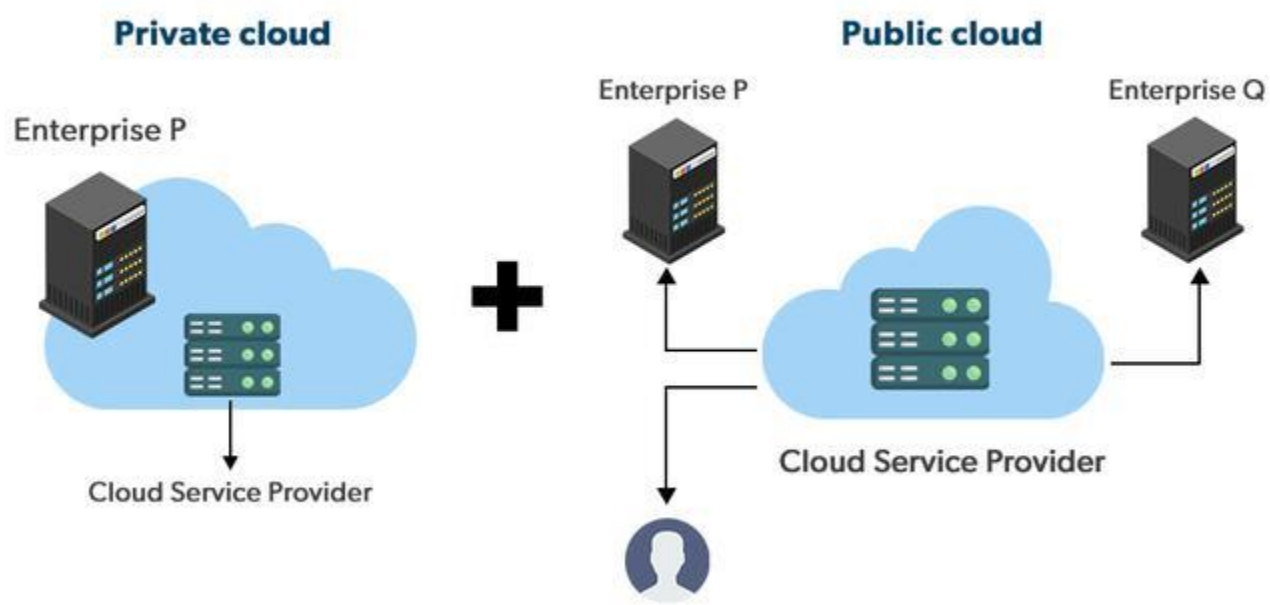
2) Private Cloud

- It's a one-on-one environment for a single user (customer).
- There is no need to share your hardware with anyone else.
- It is also called the "internal cloud" & it refers to the ability to access systems and services within a given border or organization.
- **Advantages-** Better Control, Data security and privacy, supports legacy systems, customization
- **Disadvantages**-Less scalable, costly



3) Hybrid Cloud

- Combination private and public cloud-partially composed of public cloud resources and privately owned infrastructures, are created to serve the organization's needs.
- **Advantages-** Flexibility and control, cost, security
- **Disadvantages**-Difficult to manage, slow data transmission



The Cloud Computing Reference Model

Cloud computing services offerings into three major categories:

1) Infrastructure-as-a-Service (IaaS)
2) Platform-as-a-Service (PaaS)
3) Software-as-a-Service (SaaS)

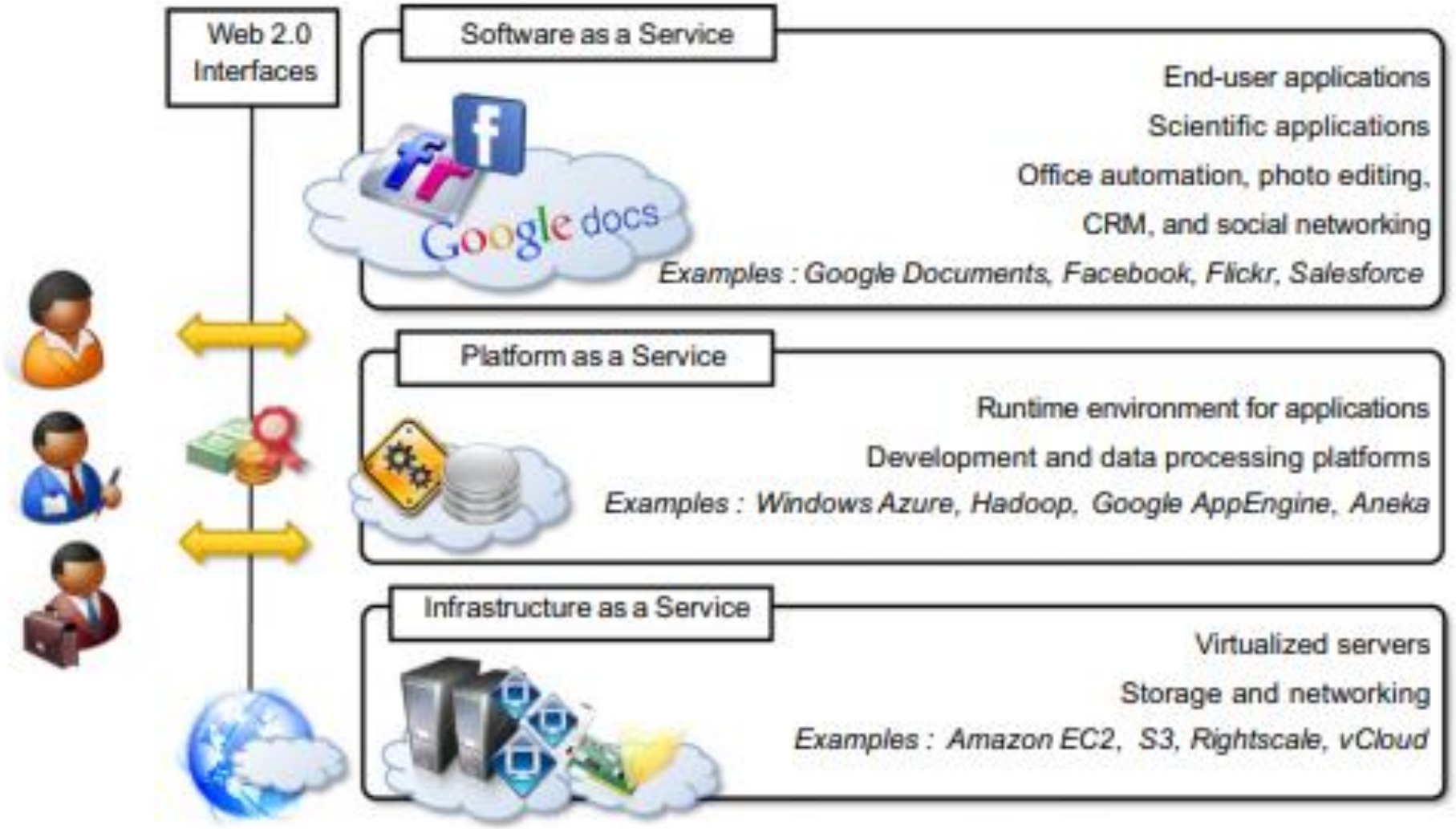


FIGURE 1.5

The Cloud Computing Reference Model.

At the base of the stack, ***Infrastructure-as-a-Service*** solutions deliver infrastructure on demand in the form of

1) ***virtual Hardware***-is utilized to provide compute on demand in the form of virtual machine instances. These are created at users' request on the provider's infrastructure, and users are given tools and interfaces to configure the software stack installed in the virtual machine.
2) ***Virtual Storage***-is delivered in the form of raw disk space or object store. The former complements a virtual hardware offering that requires persistent storage.
3) ***Virtual Networking***-identifies the collection of services that manage the networking among virtual instances and their connectivity to the Internet or private networks.

Platform-as-a-Service solutions are the next step in the stack.

- They deliver scalable and elastic runtime environments on demand and host the execution of applications.
- These services are backed by a core middleware platform that is responsible for creating the abstract environment where applications are deployed and executed.
- It is the responsibility of the service provider to provide scalability and to manage fault tolerance, while users are requested to focus on the logic of the application developed by leveraging the provider's APIs and libraries

At the top of the stack, ***Software-as-a-Service*** solutions provide applications and services on demand.

- Most of the common functionalities of desktop applications—such as office automation, document management, photo editing, and customer relationship management (CRM) software—are replicated on the provider's infrastructure and made more scalable and accessible through a browser on demand.
- These applications are shared across multiple users whose interaction is isolated from the other users.
- The SaaS layer is also the area of social networking Websites, which leverage cloud-based infrastructures to sustain the load generated by their popularity.

Characteristics and Benefits

Cloud computing has some interesting characteristics that bring benefits to both cloud service consumers (CSCs) and cloud service providers (CSPs). These characteristics are:

- No up-front commitments
- On-demand access
- Nice pricing
- Simplified application acceleration and scalability
- Efficient resource allocation
- Energy efficiency
- Seamless creation and use of third-party services

Historical Developments

1) Distributed Systems
2) Virtualization
3) Web 2.0
4) Service Oriented Computing
5) Utility Oriented Computing

1) Distributed Systems

- A distributed system is a collection of independent computers that appears to its users as a single coherent system
- the fact that it is composed of multiple independent components and that these components are perceived as a single entity by users
- The primary purpose of distributed systems is to share resources and utilize them better.
- Distributed systems often exhibit other properties such as heterogeneity, openness, scalability, transparency, concurrency, continuous availability, and independent failures
- Three major milestones have led to cloud computing: mainframe computing, cluster computing, and grid computing.

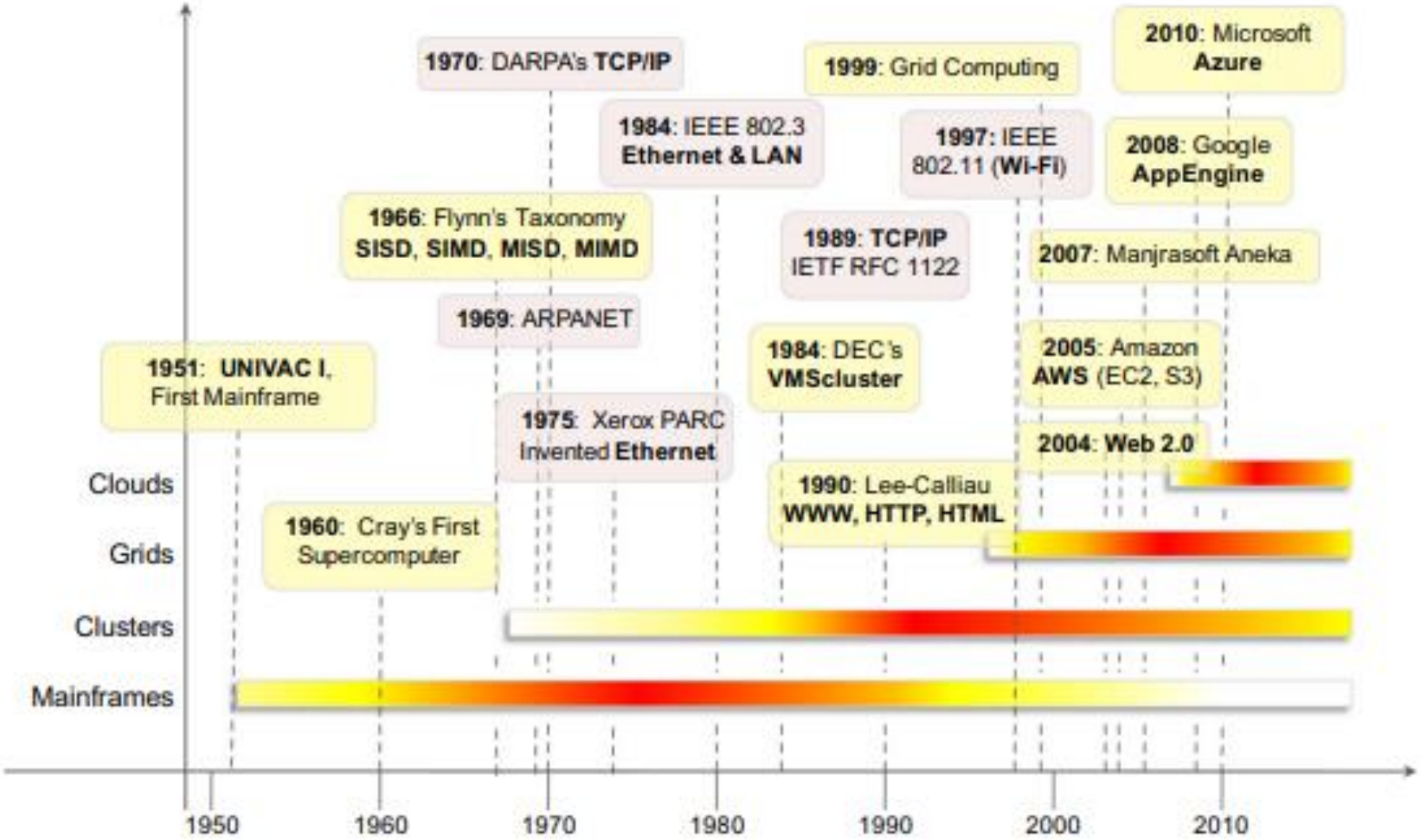


FIGURE 1.6

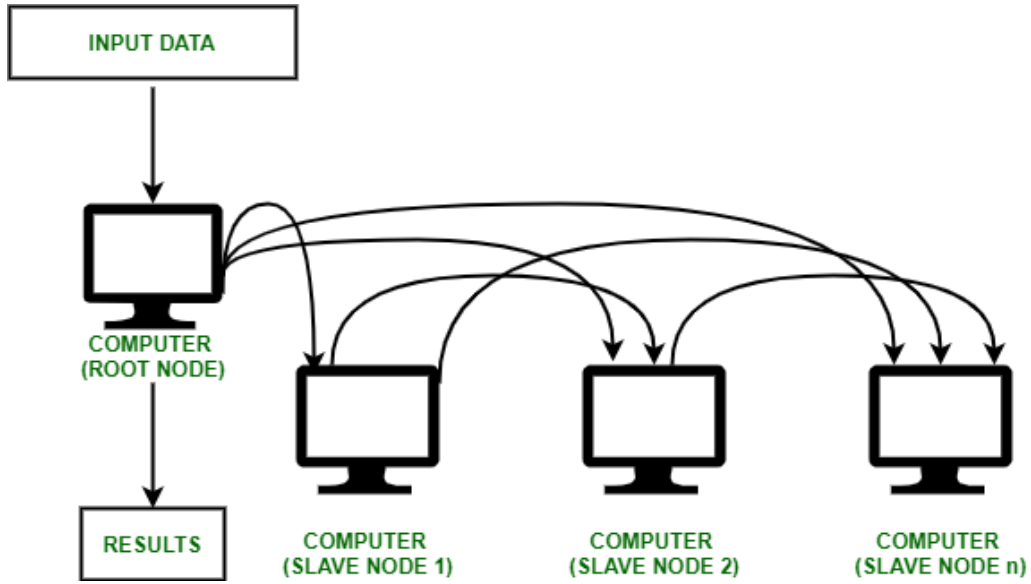
The evolution of distributed computing technologies, 1950s–2010s.

Mainframes

- These were the first examples of large computational facilities leveraging multiple processing units.
- Even though mainframes cannot be considered distributed systems, they offered large computational power by using multiple processors, which were presented as a single entity to users.
- One of the most attractive features of mainframes was the ability to be highly reliable computers that were “always on” and capable of tolerating failures transparently.
- No system shutdown was required to replace failed components, and the system could work without interruption.
- Batch processing was the main application of mainframes.
- Now their popularity and deployments have reduced, but evolved versions of such systems are still in use for transaction processing (such as online banking, airline ticket booking, supermarket and telcos, and government services).

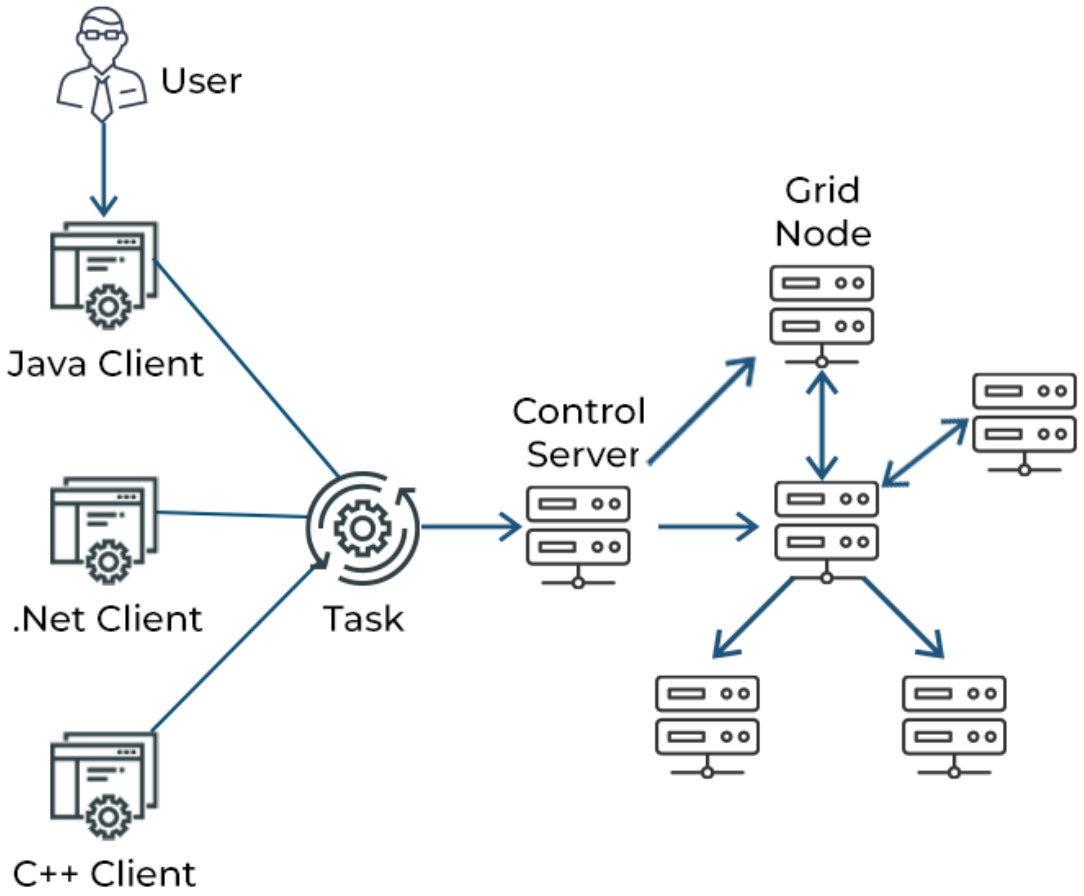
Clusters

- Cluster computing started as a low-cost alternative to the use of mainframes and supercomputers.
- Starting in the 1980s, clusters become the standard technology for parallel and high-performance computing.
- Built by commodity machines, they were cheaper than mainframes and made high-performance computing available to a large number of groups, including universities and small research labs
- Advantage-computational power
- Limitation-clusters become common resources, underutilized, new problems require computational power beyond the capability of single clusters



Grids

- Grid computing appeared in the early 1990s as an evolution of cluster computing.
- grid computing proposed a new approach to access large computational power, huge storage facilities, and a variety of services.
- Grids serve as a multitude of users across the world



2) Virtualization

- Virtualization is another core technology for cloud computing. It encompasses a collection of solutions allowing the abstraction of some of the fundamental elements for computing, such as hardware, runtime environments, storage, and networking
- Virtualization confers that degree of customization and control that makes cloud computing appealing for users and, at the same time, sustainable for cloud services providers
- Hardware virtualization technology allows simulating the hardware interface expected by an operating system.
- Hardware virtualization allows the coexistence of different software stacks on top of the same hardware.
- Virtualization technologies are also used to replicate runtime environments for programs. Applications in the case of process virtual machines (which include the foundation of technologies such as Java or .NET), instead of being executed by the operating system, are run by a specific program called a virtual machine.

3) Web 2.0

- The Web is the primary interface through which cloud computing delivers its services
- At present, the Web encompasses a set of technologies and services that facilitate interactive information sharing, collaboration, user-centered design, and application composition. This evolution has transformed the Web into a rich platform for application development and is known as Web 2.0
- Web 2.0 brings interactivity and flexibility into Web pages, providing enhanced user experience by gaining Web-based access to all the functions that are normally found in desktop applications
- Examples of Web 2.0 applications are Google Documents, Google Maps, Flickr, Facebook, Twitter, YouTube, de.li.cious, Blogger, and Wikipedia.

4) Service-Oriented Computing

- Service orientation is the core reference model for cloud computing systems. This approach adopts the concept of services as the main building blocks of application and system development.
- Service-oriented computing (SOC) supports the development of rapid, low-cost, flexible, interoperable, and evolvable applications and systems
- A service is supposed to be loosely coupled, reusable, programming language independent, and location transparent
- One of the most popular expressions of service orientation is represented by Web Services (WS). These introduce the concepts of SOC into the World Wide Web, by making it consumable by applications and not only humans
- Web services are software components that expose functionalities accessible using a method invocation pattern that goes over the HyperText Transfer Protocol (HTTP).
- The interface of a Web service can be programmatically inferred by metadata expressed through the Web Service Description Language (WSDL)
- The interaction with Web services happens through Simple Object Access Protocol (SOAP)

4) Service-Oriented Computing

- Service-oriented computing introduces and diffuses two important concepts, which are also fundamental to cloud computing: quality of service (QoS) and Software-as-a-Service (SaaS).
- Quality of service (QoS) identifies a set of functional and nonfunctional attributes that can be used to evaluate the behavior of a service from different perspectives. These could be performance metrics such as response time, or security attributes, transactional integrity, reliability, scalability, and availability. QoS requirements are established between the client and the provider via an SLA that identifies the minimum values (or an acceptable range) for the QoS attributes that need to be satisfied upon the service call.
- The term Software-as-a-service has been inherited from the world of application service providers (ASPs), which deliver software services-based solutions across the wide area network from a central datacenter and make them available on a subscription or rental basis. The SaaS approach reaches its full development with service-oriented computing (SOC), where loosely coupled software components can be exposed and priced singularly, rather than entire applications

5) Utility-Oriented Computing

- Utility computing is a vision of computing that defines a service-provisioning model for compute services in which resources such as storage, compute power, applications, and infrastructure are packaged and offered on a pay-per-use basis.
- The idea of providing computing as a utility like natural gas, water, power, and telephone connection has a long history but has become a reality today with the advent of cloud computing
- The first traces of this service-provisioning model can be found in the mainframe era.
- IBM and other mainframe providers offered mainframe power to organizations such as banks and government agencies throughout their datacenters.
- The business model introduced with utility computing brought new requirements and led to improvements in mainframe technology: additional features such as operating systems, process control, and user-metering facilities.

Building Cloud Computing Environments

1) Application Development
2) Infrastructure and System Development

1) Application Development

- Applications that leverage cloud computing benefit from its capability to dynamically scale on demand.
- One class of applications that takes the biggest advantage of this feature is that of Web applications.
- Another class of applications that can potentially gain considerable advantage by leveraging cloud computing is represented by resource-intensive applications. These can be either data intensive or compute-intensive applications.
- In both cases, considerable amounts of resources are required to complete execution in a reasonable timeframe. For example, scientific applications can require huge computing capacity to perform large-scale experiments once in a while, so it is not feasible to buy the infrastructure supporting them.

1) Application Development

- Cloud computing provides a solution for on-demand and dynamic scaling across the entire stack of computing. This is achieved by

(a) providing methods for renting compute power, storage, and networking;
(b) offering runtime environments designed for scalability and dynamic sizing; and
(c) providing application services that mimic the behavior of desktop applications but that are completely hosted and managed on the provider side.

2) Infrastructure and System Development

- Distributed computing, virtualization, service orientation, and Web 2.0 form the core technologies enabling the provisioning of cloud services from anywhere on the globe.
- Developing applications and systems that leverage the cloud requires knowledge across all these technologies.

Computing Platforms and Technologies

1) Amazon Web Services(AWS)
2) Google AppEngine
3) Microsoft Azure
4) Force.com and Salesforce.com
5) Manjrasoft Aneka

1) Amazon Web Services (AWS)

- AWS offers comprehensive cloud IaaS services ranging from virtual compute, storage, and networking to complete computing stacks
- Types of services: Amazon EC2(Elastic compute cloud), Amazon RDS(Relational Database services), Amazon S3(simple storage services), Amazon Lambda etc
- EC2 provides users with customizable virtual hardware that can be used as the base infrastructure for deploying computing systems on the cloud.
- EC2 instances are deployed either by using the AWS console, which is a comprehensive Web portal for accessing AWS services, or by using the Web services API available for several programming languages.
- EC2 also provides the capability to save a specific running instance as an image, thus allowing users to create their own templates for deploying systems.
- These templates are stored into S3 that delivers persistent storage on demand.
- S3 is organized into buckets; these are containers of objects that are stored in binary form and can be enriched with attributes.
- Users can store objects of any size, from simple files to entire disk images, and have them accessible from everywhere.

2) Google AppEngine

- Google App Engine (GAE) is a platform-as-a-service product that provides web app developers and enterprises with access to Google's scalable hosting and tier 1 internet service.
- AppEngine provides both a secure execution environment and a collection of services that simplify the development of scalable and high-performance Web applications.
- These services include in-memory caching, scalable data store, job queues, messaging, and cron tasks.
- Developers can build and test applications on their own machines using the AppEngine software development kit (SDK), which replicates the production runtime environment and helps test and profile applications.
- Once development is complete, developers can easily migrate their application to AppEngine, set quotas to contain the costs generated, and make the application available to the world.
- The languages currently supported are Python, Java, and Go.

3) Microsoft Azure

- Microsoft Azure is a cloud operating system and a platform for developing applications in the cloud.
- It provides a scalable runtime environment for Web applications and distributed applications in general.
- Applications in Azure are organized around the concept of roles, which identify a distribution unit for applications and embody the application's logic.
- Currently, there are three types of role: Web role, worker role, and virtual machine role.
- The Web role is designed to host a Web application, the worker role is a more generic container of applications and can be used to perform workload processing, and the virtual machine role provides a virtual environment in which the computing stack can be fully customized, including the operating systems.
- Besides roles, Azure provides a set of additional services that complement application execution, such as support for storage (relational data and blobs), networking, caching, content delivery, and others

4) Hadoop

- Apache Hadoop is an open-source framework that is suited for processing large data sets on commodity hardware.
- Hadoop is an implementation of MapReduce, an application programming model developed by Google, which provides two fundamental operations for data processing: map and reduce.
- The former transforms and synthesizes the input data provided by the user; the latter aggregates the output obtained by the map operations.
- Hadoop provides the runtime environment, and developers need only provide the input data and specify the map and reduce functions that need to be executed.
- Yahoo!, the sponsor of the Apache Hadoop project, has put considerable effort into transforming the project into an enterprise-ready cloud computing platform for data processing.
- Hadoop is an integral part of the Yahoo! cloud infrastructure and supports several business processes of the company.
- Currently, Yahoo! manages the largest Hadoop cluster in the world, which is also available to academic institutions

5) Force.com and Salesforce.com

- Force.com is a cloud computing platform for developing social enterprise applications.
- The platform is the basis for SalesForce.com, a Software-as-a-Service solution for customer relationship management.
- Force.com allows developers to create applications by composing ready-to-use blocks; a complete set of components supporting all the activities of an enterprise are available.
- It is also possible to develop your own components or integrate those available in AppExchange into your applications. The platform provides complete support for developing applications, from design of the data layout to the definition of business rules and workflows and the definition of the user interface.
- The Force.com platform is completely hosted on the cloud and provides complete access to its functionalities and those implemented in the hosted applications through Web services technologies.

6) Manjrasoft Aneka

- Manjrasoft Aneka is a cloud application platform for rapid creation of scalable applications and their deployment on various types of clouds in a seamless and elastic manner.
- It supports a collection of programming abstractions for developing applications and a distributed runtime environment that can be deployed on heterogeneous hardware (clusters, networked desktop computers, and cloud resources).
- Developers can choose different abstractions to design their application: tasks, distributed threads, and map-reduce.
- These applications are then executed on the distributed service-oriented runtime environment, which can dynamically integrate additional resource on demand.
- The service-oriented architecture of the runtime has a great degree of flexibility and simplifies the integration of new features, such as abstraction of a new programming model and associated execution management environment.
- Services manage most of the activities happening at runtime: scheduling, execution, accounting, billing, storage, and quality of service
- These platforms are key examples of technologies available for cloud computing. They mostly fall into the three major market segments identified in the reference model: Infrastructure-as-a-Service, Platform-as-a-Service, and Software-as-a-Service.