CLOUD COMPUTING
(PROFESSIONAL ELECTIVE – IV)

	L	T	P	C
B.Tech. IV Year I Sem.	**L**	**T**	**P**	**C**
Course Code: CS742PE	**3**	**0**	**0**	**3**

Prerequisites:

- A course on "Computer Networks".
- A course on "Operating Systems".
- A course on "Distributed Systems".

Course Objectives:

- This course provides an insight into cloud computing
- Topics covered include- distributed system models, different cloud service models, service-oriented architectures, cloud programming and software environments, resource management.

Course Outcomes:

- Ability to understand various service delivery models of a cloud computing architecture.
- Ability to understand the ways in which the cloud can be programmed and deployed.
- Understanding cloud service providers.

UNIT - I

Computing Paradigms: High-Performance Computing, Parallel Computing, Distributed Computing, Cluster Computing, Grid Computing, Cloud Computing, Bio computing, Mobile Computing, Quantum Computing, Optical Computing, Nano computing.

UNIT-1

1. Computing Paradigms

1.1 High-Performance Computing

In high-performance computing systems, a pool of processors (processor machines or central processing units [CPUs]) connected (networked) with other resources like memory, storage, and input and output devices, and the deployed software is enabled to run in the entire system of connected components.

1.2 Parallel Computing

Parallel computing is also one of the facets of HPC. Here, a set of processors work cooperatively to solve a computational problem. These processor machines or CPUs are mostly of homogeneous type. Therefore, this definition is *the same* as that of HPC and is broad enough to include supercomputers that have hundreds or thousands of processors interconnected with other resources. One can distinguish between *conventional* (also known as serial or sequential or Von Neumann) computers and parallel computers in the way the applications are executed.

In serial or sequential computers, the following apply:

- It runs on a single computer/processor machine having a single CPU.
- A problem is broken down into a discrete series of instructions.
- Instructions are executed one after another.

In parallel computing, since there is simultaneous use of multiple processor machines, the following apply:

- It is run using multiple processors (multiple CPUs).
- A problem is broken down into discrete parts that can be solved concurrently.
- Each part is further broken down into a series of instructions.

  - Instructions from each part are executed simultaneously on different processors.
  - An overall control/coordination mechanism is employed.

1.3 Distributed Computing

Distributed computing is also a computing system that consists of multiple computers or processor machines connected through a network, which can be homogeneous or heterogeneous, but run as a single system. The connectivity can be such that the CPUs in a distributed system can be physically close together and connected by a local network, or they can be geographically distant and connected by a wide area network. The heterogeneity in a distributed system supports any number of possible configurations in the processor machines, such as mainframes, PCs, workstations, and minicomputers. The goal of distributed computing is to make such a network work as a single computer.

Distributed computing systems are advantageous over centralized systems, because there is a support for the following characteristic features:

1. Scalability: It is the ability of the system to be easily expanded by adding more machines as needed, and vice versa, without affecting the existing setup.
2. Redundancy or replication: Here, several machines can provide the same services, so that even if one is unavailable (or failed), work does not stop because other similar computing supports will be available.

1.4 Cluster Computing

A cluster computing system consists of a set of the same or similar type of processor machines connected using a dedicated network infrastructure. All processor machines share resources such as a common home directory and have a software such as a message passing interface (MPI) implementation installed to allow programs to be run across all nodes simultaneously. This is also a kind of HPC category. The individual computers in a cluster can be referred to as *nodes*. The reason to realize a cluster as HPC is due to the fact that the individual nodes can work together to solve a problem larger than any computer can easily solve. And, the nodes need to communicate with one another in order to work cooperatively and meaningfully together to solve the problem in hand.

If we have processor machines of heterogeneous types in a cluster, this kind of clusters become a subtype and still mostly are in the experimental or research stage.

1.5 Grid Computing

The computing resources in most of the organizations are underutilized but are necessary for certain operations. The idea of grid computing is to make use of such nonutilized computing power by the needy organizations, and thereby the return on investment (ROI) on computing investments can be increased.

Thus, grid computing is a network of computing or processor machines managed with a kind of software such as middleware, in order to access and use the resources remotely. The managing activity of grid resources through the middleware is called *grid services*. Grid services provide access control, security, access to data including digital libraries and databases, and access to large-scale interactive and long-term storage facilities.

TABLE 1.1

Electrical Power Grid and Grid Computing

Electrical Power Grid	Grid Computing
Never worry about where the electricity that we are using comes from; that is, whether it is from coal in Australia, from wind power in the United States, or from a nuclear plant in France, one can simply plug the electrical appliance into the wall-mounted socket and it will get the electrical power that we need to operate the appliance.	*Never worry* about where the computer power that we are using comes from; that is, whether it is from a supercomputer in Germany, a computer farm in India, or a laptop in New Zealand, one can simply plug in the computer and the Internet and it will get the application execution done.
The infrastructure that makes this possible is called *the power grid*. It links together many different kinds of power plants with our home, through transmission stations, power stations, transformers, power lines, and so forth.	*The infrastructure* that makes this possible is called *the computing grid*. It links together computing resources, such as PCs, workstations, servers, and storage elements, and provides the mechanism needed to access them via the Internet.
The power grid is *pervasive*: electricity is available essentially everywhere, and one can simply access it through a standard wall-mounted socket.	The grid is also *pervasive* in the sense that the remote computing resources would be accessible from different platforms, including laptops and mobile phones, and one can simply access the grid computing power through the web browser.
The power grid is a *utility*: we ask for electricity and we get it. We also pay for what we get.	The grid computing is also a *utility*: we ask for computing power or storage capacity and we get it. We also pay for what we get.

Grid computing is more popular due to the following reasons:

- Its ability to make use of unused computing power, and thus, it is a cost-effective solution (reducing investments, only recurring costs)
- As a way to solve problems in line with any HPC-based application
- Enables heterogeneous resources of computers to work cooperatively and collaboratively to solve a scientific problem

Researchers associate the term *grid* to the way electricity is distributed in municipal areas for the common man. In this context, the difference between electrical power grid and grid computing is worth noting (Table 1.1).

1.6 Cloud Computing

The computing trend moved toward cloud from the concept of grid computing, particularly when large computing resources are required to solve a single problem, using the ideas of computing power as a *utility* and other allied concepts. However, the potential difference between grid and cloud is that grid computing supports leveraging several computers in parallel to solve a particular application, while cloud computing supports leveraging multiple resources, including computing resources, to deliver a unified *service* to the end user.

In cloud computing, the IT and business resources, such as servers, storage, network, applications, and processes, can be dynamically provisioned to the user needs and workload. In addition, while a cloud can provision and support a grid, a cloud can also support nongrid environments, such as a three-tier web architecture running on traditional or Web 2.0 applications.

1.7 Biocomputing

Biocomputing systems use the concepts of biologically derived or simulated molecules (or models) that perform computational processes in order to solve a problem. The biologically derived models aid in structuring the computer programs that become part of the application.

Biocomputing provides the theoretical background and practical tools for scientists to explore proteins and DNA. DNA and proteins are nature's building blocks, but these building blocks are not exactly used as *bricks*; the function of the final molecule rather strongly depends on the *order* of these blocks. Thus, the biocomputing scientist works on inventing the *order* suitable for various applications mimicking biology. Biocomputing shall, therefore, lead to a better understanding of life and the molecular causes of certain diseases.

1.8 Mobile Computing

In mobile computing, the processing (or computing) elements are small (i.e., handheld devices) and the communication between various resources is taking place using wireless media.

Mobile communication for voice applications (e.g., cellular phone) is widely established throughout the world and witnesses a very rapid growth in all its dimensions including the increase in the number of subscribers of various cellular networks. An extension of this technology is the ability to send and receive data across various cellular networks using small devices such as smartphones. There can be numerous applications based on this technology; for example, video call or conferencing is one of the important applications that people prefer to use in place of existing voice (only) communications on mobile phones.

Mobile computing–based applications are becoming very important and rapidly evolving with various technological advancements as it allows users to transmit data from remote locations to other remote or fixed locations.

1.9 Quantum Computing

Manufacturers of computing systems say that there is a limit for cramming more and more transistors into smaller and smaller spaces of integrated circuits (ICs) and thereby doubling the processing power about every 18 months. This problem will have to be overcome by a new *quantum computing*–based solution, wherein the dependence is on quantum information, the rules that govern the subatomic world. Quantum computers are millions of times faster than even our most powerful supercomputers today. Since quantum computing works differently on the most fundamental level than the current technology, and although there are working prototypes, these systems have not so far proved to be alternatives to today's silicon-based machines.

1.10 Optical Computing

Optical computing system uses the photons in visible light or infrared beams, rather than electric current, to perform digital computations. An electric current flows at only about 10% of the speed of light. This limits the rate at which data can be exchanged over long distances and is one of the factors that led to the evolution of optical fiber. By applying some of the advantages of visible and/or IR networks at the device and component scale, a computer can be developed that can perform operations 10 or more times faster than a conventional electronic computer.

1.11 Nanocomputing

Nanocomputing refers to computing systems that are constructed from nanoscale components. The silicon transistors in traditional computers may be replaced by transistors based on carbon nanotubes.

The successful realization of nanocomputers relates to the scale and integration of these nanotubes or components. The issues of scale relate to the dimensions of the components; they are, at most, a few nanometers in at least two dimensions. The issues of integration of the components are twofold: first, the manufacture of complex arbitrary patterns may be economically infeasible, and second, nanocomputers may include massive quantities of devices. Researchers are working on all these issues to bring nanocomputing a reality.