Principles of cloud computing
Fourth Class
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Computing Paradigms

1.1   Introduction

The term paradigm conveys that there is a set of practices to be followed to accomplish a task. In the domain of computing, there are many different standard practices being followed based on inventions and technological advancements. In this chapter, we look into the various computing paradigms: namely

1. High-Performance Computing
2. Parallel Computing
3. Distributed Computing
4. Cluster Computing
5. Grid Computing
6. Biocomputing
7. Mobile Computing
8. Quantum Computing
9. Optical Computing
10. Nanocomputing
11. Network Computing

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

The processor machines can be of homogeneous or heterogeneous type. The legacy meaning of high-performance computing (HPC) is the supercomputers; however, it is not true in present-day computing scenarios. Therefore, HPC can also be attributed to mean the other computing paradigms that are discussed in the forthcoming sections, as it is a common name for all these computing systems.

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Thus, examples of HPC include a small cluster of desktop computers or personal computers (PCs) to the fastest supercomputers. HPC systems are normally found in those applications where it is required to use or solve scientific problems. Most of the time, the challenge in working with these kinds of problems is to perform suitable simulation study, and this can be accomplished by HPC without any difficulty.

Scientific examples such as protein folding in molecular biology and studies on developing models and applications based on nuclear fusion are worth noting as potential applications for HPC.

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.

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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.

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.

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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 non utilized computing power by the needy organizations, and there by 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.

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.

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.