Chapter 2

Grid Computing Basics

2.1 Introduction

Grid computing [1, 2] is a form of distributed computing that involves coordinating and sharing computers, applications, data, storage and network resources across dynamic and geographically dispersed organizations. The Grid aims to turn the global network of computers into one vast computational resource. Grid is in fact a sort of low-cost world-wide shared super-cluster, designed to deal with the increasing computational and storage load, far beyond a single institute or group computing capability.

Grid computing [7] can mean different things to different individuals. The grand vision is often presented as an analogy to power grids where users (or electrical appliances) get access to electricity through wall sockets with no care or consideration for where or how the electricity is actually generated. In this view of grid computing, computing becomes pervasive and individual users (or client applications) gain access to computing resources (processors, storage, data, applications, and so on) as needed with little or no knowledge of where those resources are
located or what the underlying technologies, hardware, operating system, and so on are.

2.2 A Grid Checklist

Ian Foster [8] suggests the definitions above can be captured in a simple checklist, according to which a Grid is a system that:

- Coordinates resources that are not subject to centralized control: A Grid combines and coordinates resources and their users those live within different control domains. For example, the user’s desktop versus central computing; different administrative units of the same or different companies; and addresses the issues of security, policy, payment, membership and so forth that arise in these settings. Otherwise, dealing with a local management system.

- Using standard, open, general-purpose protocols and interfaces: A Grid is built from multi-purpose protocols and interfaces that address such issues as authentication, authorization, resource discovery and resource access. It is important that these protocols and interfaces be standard and open.

- To deliver nontrivial qualities of service: A Grid allows its resources to be used in a coordinated fashion to deliver various qualities of service like response time, throughput, availability and security, and/or co-allocation of multiple resource types to meet complex user demands, so that the service of the combined system is greater than that of the sum of its parts.

Plaszczak/Wellner [15] defines grid technology as ”the technology that enables resource virtualization, on-demand provisioning, and service (resource) sharing between organizations.”
Many people consider the Grid [3] as a "vehicle for integrating and exchanging application data, much as the web integrated documents".

Grid provides a consistent way to balance the loads on a wider federation of resources. That applies to CPU, storage, and many other kinds of resources that may be available on a grid.

The use of grid computing is to run an existing application on other machine.

In most of organizations, there are many underutilized or unused computing resources. Most of desktop machines are busy less than 5% of its total time. In some organizations, server machines can also often be relatively idle. Grid computing provides a framework for exploiting these underutilized resources and thus has the possibility of significantly increasing the efficiency of resource usage [3].

The goal of Grid Computing [5] is to provide a service-oriented infrastructure that provides standardized protocols and services to enable access to coordinated sharing of geographically distributed h/w, s/w, and information resources.
2.3 Grid Computing operates on following technology principles

Grid Computing operates on following three technology principles [11].

1. **Standardization**: IT departments have greater interoperability and reduced their systems management overhead by standardizing on OS, servers, storage hardware, middleware components, and network components. It also helps to reduce operational complexity in the data centre by simplifying application deployment, configuration and integration.

2. **Virtualization**: Virtualizing IT resources means that applications are not tied to specific server, storage or network components and can use any of virtualized IT resource. It occurs through one sophisticated software layer (middle layer) that hides the complexity of IT resources and represents a simplified, coherent interface used by applications and other IT resources.

3. **Automation**: Because of the large number of components (both virtual and physical) grid computing demands major automation of IT operations. These Each component requires configuration management, on-demand provisioning, top-down monitoring, and other management related tasks. A grid management solution must make sure that infrastructure cost savings do not disappear as a result of hiring additional staff to manage the grid. IT administrators need a top-down view from the end-user or application level so they can in actual fact measure service levels and proactively resolve problems. Combines these capabilities into a single, automated, integrated solution for managing grids provides organizations a maximum return on their grid investment.
2.4 Types of Grid

2.4.1 Computational

A computational grid is paying attention on setting aside resources particularly for compute power. Most of the machines are high-performance servers in this type of grid.

2.4.2 Scavenging

This grid is used with large numbers of desktop machines. Machines are salvage for available CPU cycles and other resources. Owners of the desktop machines are usually given control of their resources, when their resources are available to contribute in the grid.

2.4.3 Data grid

This grid is responsible for housing and provides access to data across different organizations. Users of this grid are not concerned with where this data is situated as long as they have access to the data. E.g., you may have two universities those are conducting life science research, each with unique data [6].

2.5 Grid Components

Following capabilities in grid computing environments play a significant role in enabling a variety of scientific, engineering, and business applications [9]:

- Remote storage and/or replication of data sets
• Publication of datasets using global logical name and attributes in the catalogue

• Security - access authorisation and uniform authentication

• Uniform access to remote resources (data and computational resources)

• Publication of services and access cost

• Composition of distributed applications using diverse software components including legacy programs.

• Discovery of suitable datasets by their global logical names or attributes

• Discovery of suitable computational resources

• Mapping and Scheduling of jobs (Aggregation of distributed services)

• Submission, monitoring, steering of jobs execution

• Movement of code/data between the user desktop machines and distributed resources

• Metering and Accounting of resource usage

• Enforcement of quality of service requirements

2.6 Features and Objectives of Grid Computing

Grid computing aims to achieve the following goals [25, 64, 68]:

• The sharing of distributed and heterogeneous computing resources belonging to different organizations. Grid computing is the sharing, selection and aggregation of a group of resources such as supercomputers, mainframes,
storage systems, data sources and management systems that behave like networks of computation [66, 67]. It promotes the sharing of distributed resources that may be heterogeneous in nature. The primary benefit of grid computing is the ability to coordinate and share distributed and heterogeneous resources such as Sharing Infrastructure and REsources iN Europe (SIEREN) [65].

SIEREN is a cooperative association between twelve European countries whose purpose is to share their infrastructure and resources.

- The exploitation of underutilised resources.

In most organisations and companies there are huge numbers of underutilised computing resources. Most of these resources are only busy less than 5% of the time. In most organisations these resources are relatively idle. Grid computing is designed to exploit these underutilised resources and increase the efficiency of resource usage. Users can also rent the resources that reside on the grid for executing their computationally intensive applications, instead of purchasing their own dedicated (and expensive) resources.

- The enablement and simplification of collaboration among different organisations.

Another capability of grid computing is the provision of an environment for collaboration between organisations. Grid computing enables very heterogeneous and distributed systems to work together, thereby simplifying collaboration between different organisations by providing direct access to computers, software and data storage.

- The provision of a single login service with secure access to grid resources while protecting security for both users and remote sites.
Grids provide a single login service to all users over all distributed resources using grid authentication mechanisms. They also provide secure access to any information anywhere over any type of network. This is achieved by providing access control mechanisms that govern these resources.

- The provision of resource management, information services, monitoring and secure data transportation.

The shared resources and networks involved in grid computing are difficult to manage and monitor, but grid computing is able to meet these challenges because of its architecture and protocols.

- The solution of large scale problems.

Grids are designed to exploit underutilised resources, meaning that they can employ a large number of them to solve a large scale problem; it promising solution for problems like storage and processing of massive amounts of data that even mainframe computers can not handle such as weather forecasting. These resources may be high capability devices such as high capacity disk storage and high performance computing.

- The provision of fast results, delivered more efficiently.

Grid computing obtains results quickly and more efficiently, because it enables parallel processing; it may also have high capability devices. With grid computing, businesses can efficiently utilise computing and data resources and combine them for large capacity workloads.

2.7 Grid Architecture and Components

Components that are necessary to form a Grid (shown in Figure 2.2) are as follows [13]:

2.7.1 Grid fabric

It consists of all the globally distributed resources, accessible from anywhere on the Internet. These could be computers (such as PCs or Symmetric Multi-Processors) running a variety of operating systems, storage devices, databases, and special scientific instruments such as a radio telescope or particular heat sensor.

2.7.2 Core Grid middleware

It offers main services like co-allocation of resources, storage access, information registration and discovery, remote process management, security, and aspects of Quality of Service (Quos) such as trading and resource reservation.

2.7.3 User-level Grid middleware

It includes application development environments, programming tools and resource brokers to managing resources and scheduling application jobs for execution on shared global resources.

2.7.4 Grid applications and portals

Grid applications are developed using Grid-enabled languages and utilities like MPI or HPC++. For Example, parameter simulation or a grand-challenge problem, would require computational power, access to remote data sets, and may need to interrelate with scientific instruments. Grid portals offer Web-enabled application services, where users can submit and collect results for their tasks on remote resources through the Web.
2.8 Globus: A Toolkit for Grid Computing

The open source Globus [10, 14] Toolkit is used for building Grid systems and applications. It is developed by Globus Alliance that includes some institutes, companies and Universities. Many Research institutes and companies are using Globus Toolkit to develop relative Grid projects. It is a set of software services that can solve general problems when creating distributed system services.

GT (Globus Toolkit) [14] software services address the basic issues relating to resource management, workflow management, file management, security and communication, and so on. To develop applications and web services, those software
services are packaged and can use either independently or together. They are deployed to support the development of many Globus deployments, such as TeraGrid, EUGrid, APgrid, China Grid, etc.

2.9 Grid Computing Users

Grid Computing can be used by following users [17].

**Biologists** use grids to simulate thousands of molecular drug candidates on their computer in order to find a molecule capable of blocking specific disease proteins.

**Earth scientists** use grids to track ozone levels using satellites, download hundreds of gigabytes of data each day (the equivalent of about 150 CDs a day!)

**High energy physicists** use grids in their search for a better understanding of the universe, based on a network of tens of thousands of jobs to store and analyze 10 petabytes of data (the equivalent data on approximately 20 million CD!) produced by the Large Hadron Collider each year. Thousands of physicists in dozens of universities around the world want to analyze these data.

**Engineers** use grids to study alternative fuels, such as fusion energy.

**Artists** use grids to create complex animations for feature films (see Kung Fu Panda for example).

**Social scientists** use grids to study the social life of bees, the composition of our society, the secrets of history.

And Many More
2.10 Other Distributed Object Technology

Enterprise development technologies such as DCOM, Enterprise Java Beans (EJB), Java 2 Enterprise Edition (J2EE), CORBA, Remote Method Invocation (RMI), Peer to Peer and Jini are all systems designed to enable the construction of distributed applications.

2.11 Grid Computing Applicability

Grid Computing can be apply in following area [19].

- Financial Organization
- Scientific Research
- Online multiplayer game
- Government organization
- Natural Disaster Management
- Weather forecasting
- Animation of Movies

2.12 Advantages and Disadvantage of Grid Computing

Following are the advantages and disadvantages of Grid Computing [1, 7, 11, 12, 18].
2.12.1 Advantages

- **Responding Quickly to Volatile Business Needs:** Today, businesses operate in an unpredictable, global environment. Staying on top of business demands, supply chain risks, competitive threats and regulatory requirements is increasingly challenging. Businesses expect their IT groups to “turn on a dime” and be able to, for example, change a pricing model to beat a participant, change the order management process to accommodate new regulatory requirements, and integrate acquired companies. With a fundamental grid infrastructure, IT has the capability to react quickly to these types of changing business needs.

- **Responding to Dynamic Workloads in Real Time:** Most of today’s applications are tied to specific s/w and h/w silos, limiting their capability to adapt to changing workloads. This costly and inefficient use of resources means that IT departments must abundance their h/w so that each application can handle peak or worst-case workload scenarios. Grid computing provides IT professionals dynamically allocate and deallocate IT resources as needed, providing much better responsiveness to workloads that change on a global scale.

- **Providing Predictable Service Levels:** Through the use of service-level agreements (SLAs), organizations can tie business requirements to IT architecture to get comprehensible metrics and proactive monitoring and maintenance. This process encourages a shared-service-bureau approach to IT, with the focus on measuring and meeting higher service levels and better aligning IT and business goals. Grid based architecture removes single sources of failure and gives powerful, high availability capabilities throughout the entire
software stack, guard for valuable information assets, and business stability. It allows IT groups to eliminate costly systems administration overhead, costly integration projects, and runaway budgets.

- **Reducing Costs with Improved Efficiency and Smarter Capacity Planning:** Grid computing practices goal on operational efficiency and predictability. Easy grid workload management and resource availability require more power in the hands of the IT staff, allow them maintain current recruitment levels even as computing demands skyrocket. New generation of server virtualization and clustering, IT departments no longer have to abundance to meet worst-case scenarios during peak periods. Because computing resources can be applied incrementally when needed, organizations enjoy higher computing and storage capacity utilization at a lowest cost.

- **Virtual resources and virtual organizations for collaboration:** Grid computing provides an environment for collaboration among a wider audience. In the past, distributed computing promised this collaboration and achieved it to some extent. Grid computing can take these capabilities to an even wider audience, while offering important standards that enable very heterogeneous systems to work together to form the image of a large virtual computing system offering a variety of resources, as illustrated in Figure 2.3. The users of the grid can be organized dynamically into a number of virtual organizations, each with different policy requirements. These virtual organizations can share their resources collectively as a larger grid.

- Easier to collaborate with other organizations

- Make better use of existing hardware and Access to additional resources

- Resource balancing

- Reliability
Can solve larger, more complex problems in a shorter time

2.12.2 Disadvantages

- Grid software and standards are still evolving
- Learning curve to get started
- Non-interactive job submission