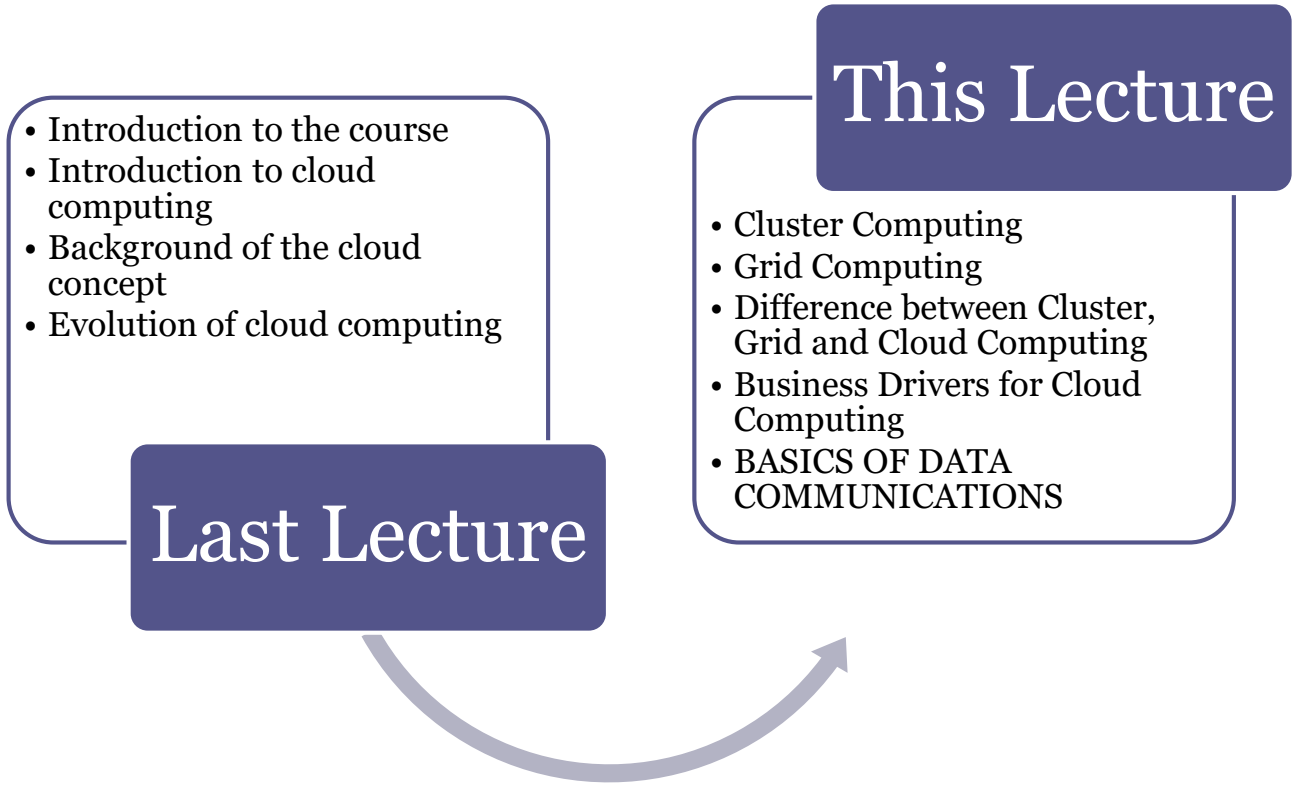
BSE-3502
Cloud Computing
Lecture

Department of Software Engineering
Mirpur University of Science and Technology (MUST)

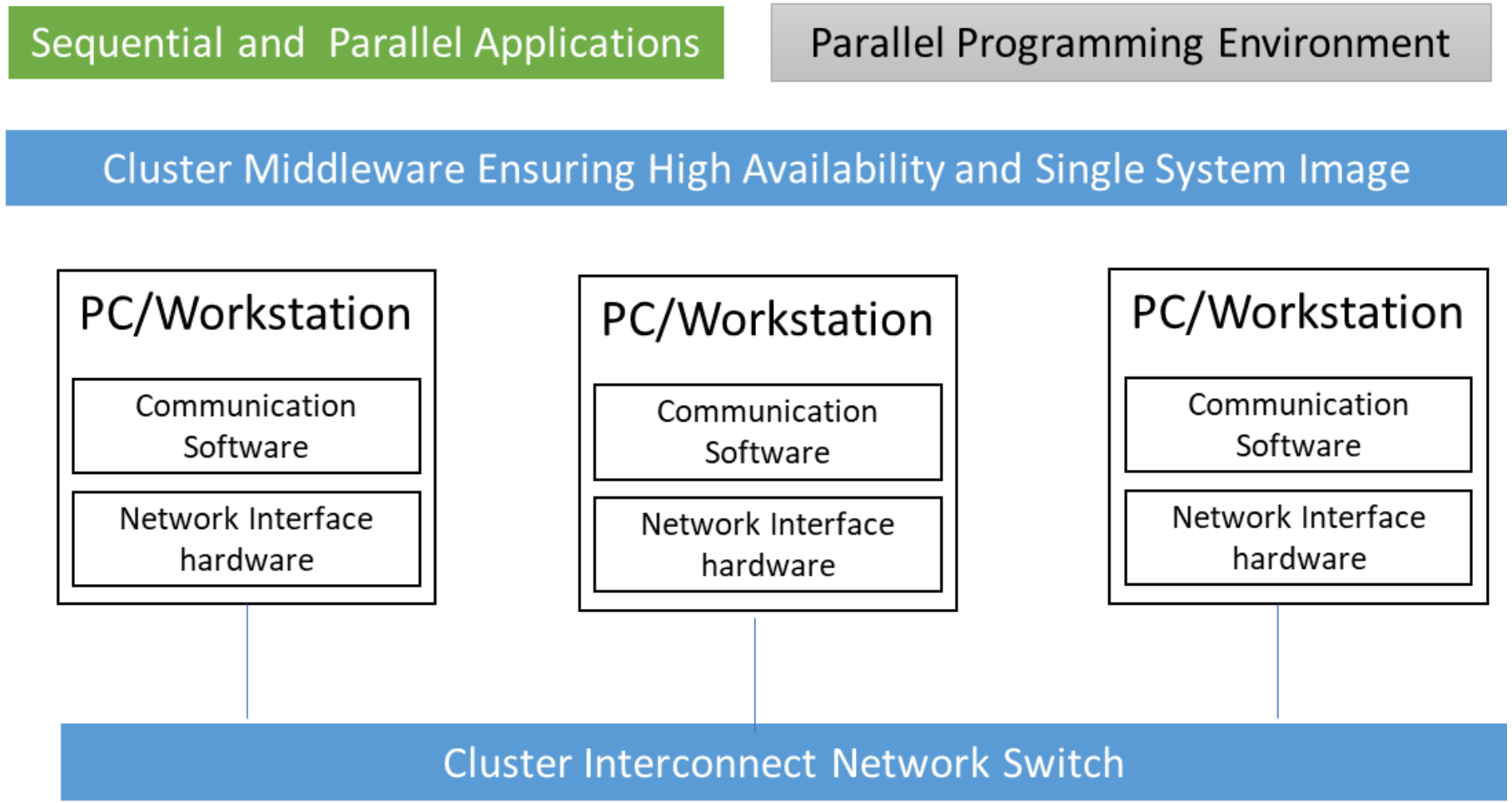
Lecture 02
Cluster, Grid and Cloud Computing



Overview of Cluster Computing

- A computer cluster is a collection of interconnected stand-alone computers which cooperate to work as a single resource pool of computing resources.
- Clusters became popular in 1990s when mainframes and traditional supercomputers were becoming less cost-effective for high performance computing (HPC).
- In 2010, out of top 500 supercomputers. 85% were computer clusters built with homogeneous nodes.
- Cluster computing has laid the foundation of modern day super computers, computational grids and cloud computing.
- Important Benefits of Cluster Computing:
  - Scalability
  - High availability and fault tolerance
  - Use of commodity computers

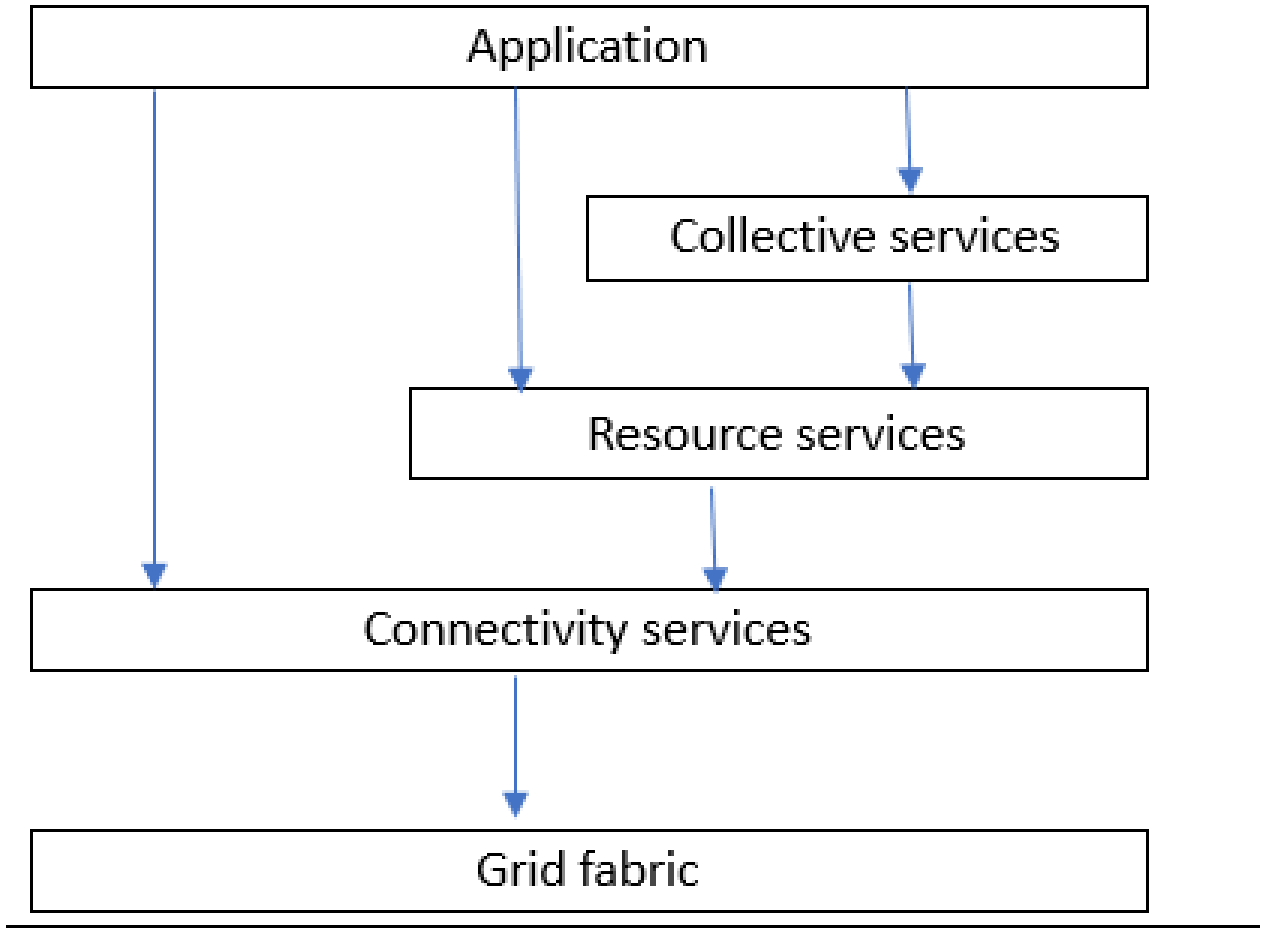
Cluster Architecture (basic)



Overview of Grid Computing

- The grid is an integrated computing infrastructure for bringing together *computers* to create a large collection of compute, storage, and network resources.
- Grid is used to solve large-scale computation problems or to enable fast information retrieval by registered users or user groups.
- *Computers* include PCs, workstations, server clusters, supercomputers, laptops, notebooks, mobile computers, PDAs, etc.
- Building virtual grid through *CPU scavenging*: Creating a grid by using unutilized CPU cycles in a network of computers at night or periods of inactivity.
  - This is done on voluntary basis. The grid hosts donate some RAM, disk space and network bandwidth as well.
  - The most famous example is the SETI@Home which applied over 3 million computers to achieve 23.37 TFlpos as of Sept. 2001.

Grid Middle ware Layered Architecture (deployed on participant computers)



Overview of Grid Computing

- **Application:** The top layer consisting of user applications to be run on grid.
- **Collective Services:** Focus on interaction among the resources. implements functions such as resource discovery, scheduling, brokering etc.
- **Resource service:** Deals with the aggregated computing resources (software and hardware) available for user applications in collective operations.
- **Connectivity Layer:** Provides the core networking among the computational resources of fabric layer through physical or virtual networking.
- **Grid fabric:** Consists of all the computational resources such as storage systems, catalogs, network resources, servers and their network connections.

Difference between Cluster, Grid and Cloud Computing

- The purpose of *Grid Computing* is to solve large scale computational problems.
- Just like *Clusters*, except that
  - The Grids make use of computational resources are spread across the nation or the globe.
  - These computational resources are owned by different organizations and are shared (as grid resources) by multiple users.
  - Grids heavily depend upon WAN/LAN resources.
  - Virtual Supercomputer term is derived from Grid Computing whereby multiple computers collaborate over network to create an illusion of a single big computer.

Difference between Cluster, Grid and Cloud Computing

- As compared to cloud:
  - The resources do not join or leave the grid dynamically.
  - Majority of the resources are not provisioned from data centers.
- Several organizations may unite to form a grid in the shape of a virtual organization (VO). For example multiple hospitals and research centers may collaborate in a VO to find a cure for cancer.

Difference between Cluster, Grid

Feature	**Cluster Computing**	**Grid Computing**	**Cloud Computing**
Location	Same location (local network)	Geographically distributed	Accessed via Internet
Ownership	Single organization	Multiple organizations	Cloud service provider
Hardware Type	Homogeneous	Heterogeneous	Virtualized resources
Goal	High performance	Resource sharing	On-demand services
Scalability	Limited	Moderate	Highly scalable
Management	Centralized	Decentralized	Managed by provider
Cost Model	Fixed infrastructure	Shared volunteer resources	Pay-per-use

Business Drivers for Cloud Computing

- when an organization wants to install or upgrade software, it also needs to **upgrade its hardware** (computers, servers, storage, etc.).
  This can be **very expensive**, and if the organization cannot afford it, their **business operations may stop** or **competitors may move ahead**.
- However, **Cloud Computing** removes this problem — because in the cloud, you **don't buy or maintain hardware**.
  You simply **pay for what you use** — like electricity or water.
- There are several **business drivers** (reasons) that attract organizations to use cloud computing, including:
- **IT Capacity Planning** – easily adjust resources as business grows.
- **Cost Reduction** – no need for heavy investment in IT infrastructure.
- **Organizational Agility** – ability to adapt quickly to market changes.

Business Drivers for Cloud Computing

- IT Capacity Planning:
  - It is the estimation and fulfillment of future IT requirements of an organization.
  - The over provisioning of IT happens when acquired equipment is more than the estimated requirements. Resulting in over expenditure.
  - The under provisioning occurs when the equipment turns out to be inadequate to fulfill the IT requirements of the future.
  - IT Capacity planning is a difficult job as it should cover the fluctuating load.
- Usually the companies adopt any of the following strategies:
  - Lead Strategy: Adding new IT capacity in anticipation of future needs.
  - Lag Strategy: Adding new IT capacity when the IT resources reach the full utilization
  - Match Strategy: Adding IT capacity in small increments.
- The capacity planning may lead to adopting the option of Cloud Computing and then planning for future needs of Cloud resources rental instead of purchasing the IT equipment.

Business Drivers for Cloud Computing

- Cost Reduction: The costs include
  - Cost of acquiring the IT infrastructure
  - Operational overheads such as technical personnel salaries, upgrades, utility bills, security, accounts and administrative staff salaries
  - Why not choose the Cloud instead ?
- Organizational Agility: It is the responsiveness to the change. We consider the *change* in IT for this topic.

BASICS OF DATA COMMUNICATIONS

- Data Communication: Exchange of data over some transmission medium between two devices.
- The following factors are essential for data communication:
  - Data must be delivered to correct destination.
  - There must be timely delivery of the data.
  - There must not be uneven delay among the packet arrival time during audio or video transmission.

BASICS OF DATA COMMUNICATIONS

- Components:
  - Message: The data to be sent. Can be text, numbers, pictures, audio and video.
  - Sender
  - Receiver
  - Transmission medium: The physical path through which a message travels from sender to receiver.
  - Protocol: The set of agreed-upon communication-rules between sender and receiver devices. Two devices can be connected but not communicating without a protocol.

BASICS OF DATA COMMUNICATIONS

- Data Representation:
  - Text: Represented by bit pattern called code e.g.; Unicode and American Standard Code for Information Interchange (ASCII).
  - Numbers: Directly converted binary of the number. ASCII is not used to represent numbers.
  - Images: Sent as binary patterns. Image is represented by a matrix of pixels. *Pixel* is a small dot. Each pixel is assigned a bit pattern on the basis of color.
  - Audio: A continuous stream of data. Different from text, numbers and images.
  - Video: Can be a continuous stream or a sequence of image combinations.

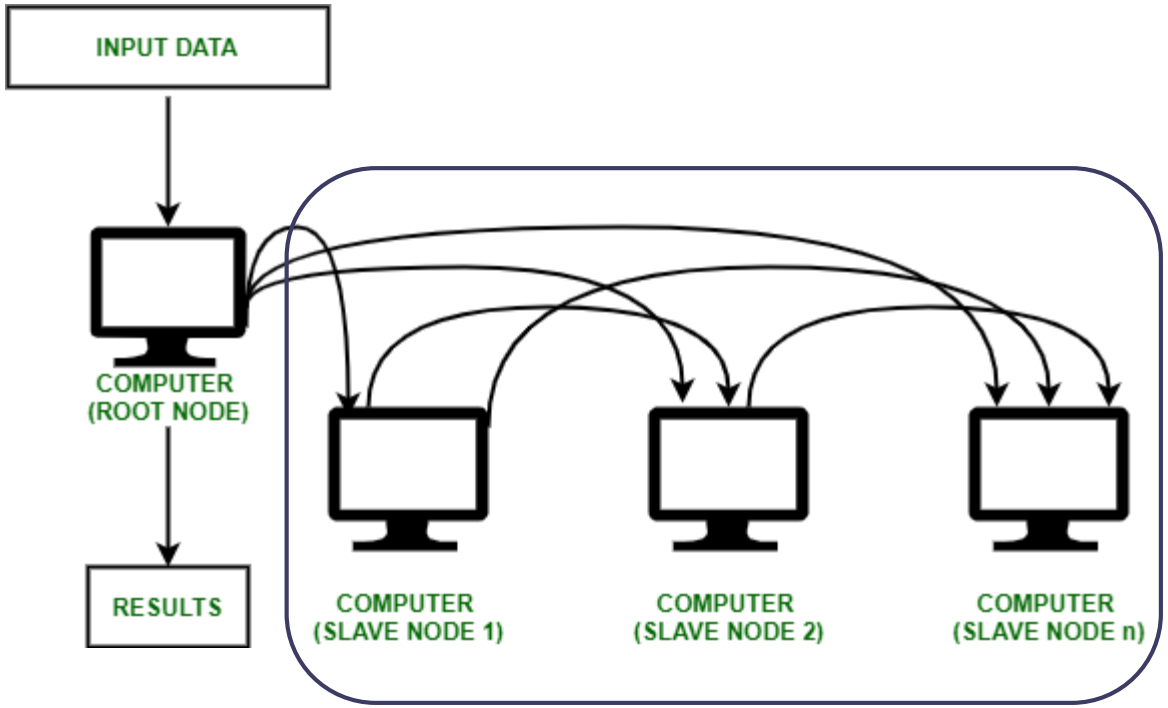
BASICS OF DATA COMMUNICATIONS

- Data Flow:
  - Simplex: Unidirectional communication in which either one of the sender or receiver device can transmit. For example: key board, monitor etc.
  - Half Duplex: Both devices can communicate but one at a time. The entire capacity of the transmission medium is available to the transmitting device. For example: walkie-talkies.
  - Full Duplex: Both devices can send and receive at the same time. The transmission medium should provide separate paths (channels) for the transmission of each device. For example telephone conversation is full duplex.

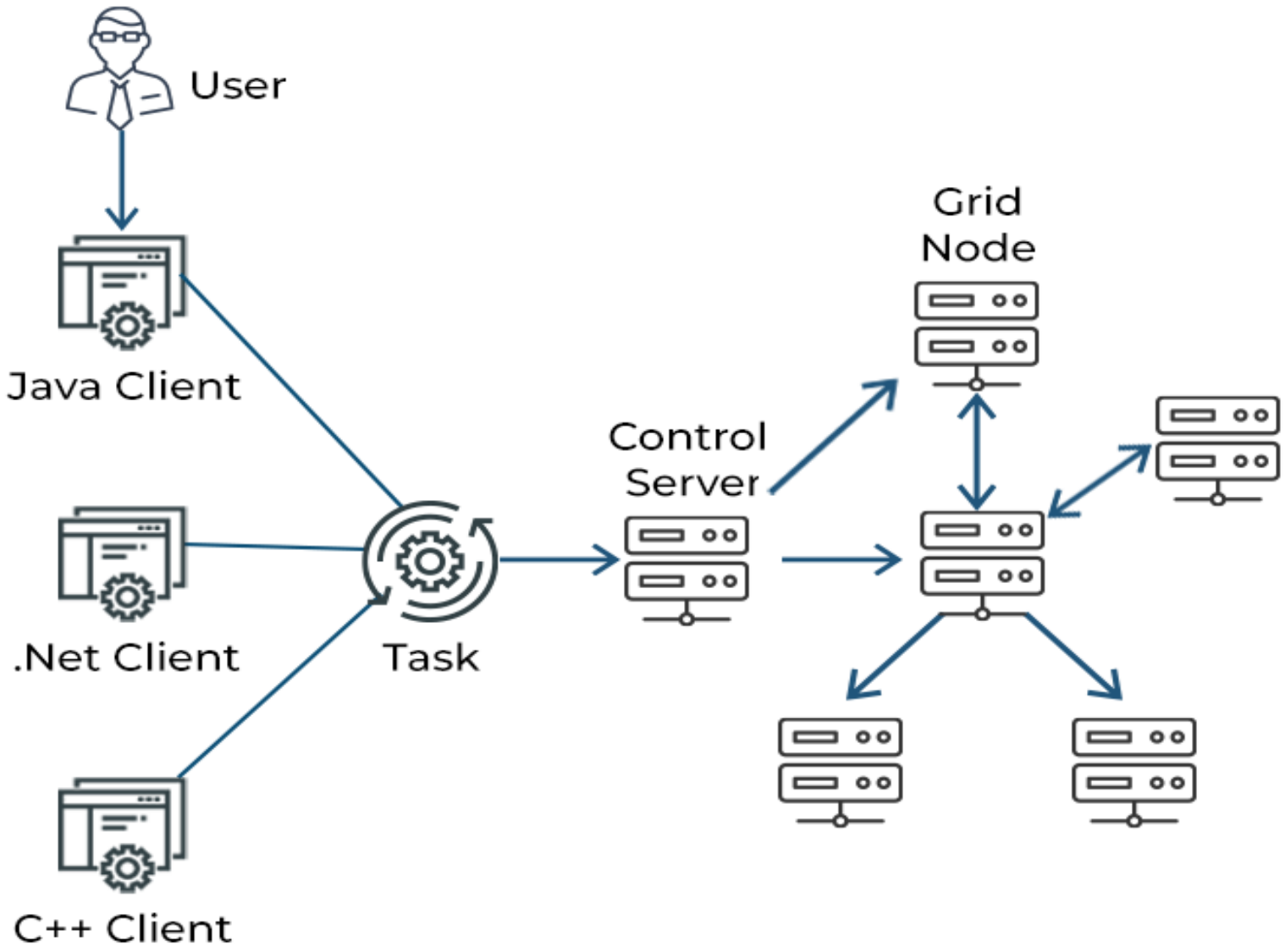
Class Activity

- Show the following diagrammatically
  - Grid Computing
  - Cluster Computing
  - Cloud Computing

Cluster Computing



Grid Computing



Cloud Computing