CS-251: Parallel and Distributed Computing

Lecture 07 – Clusters- Latest Variation

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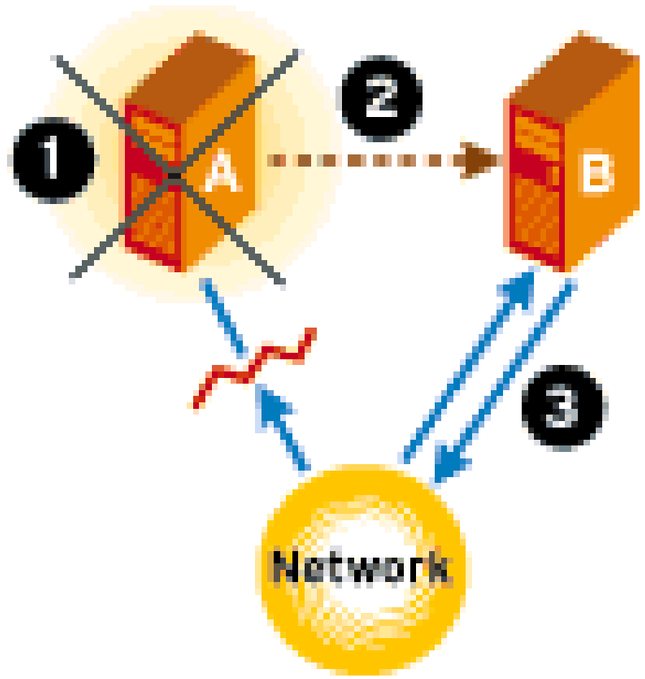
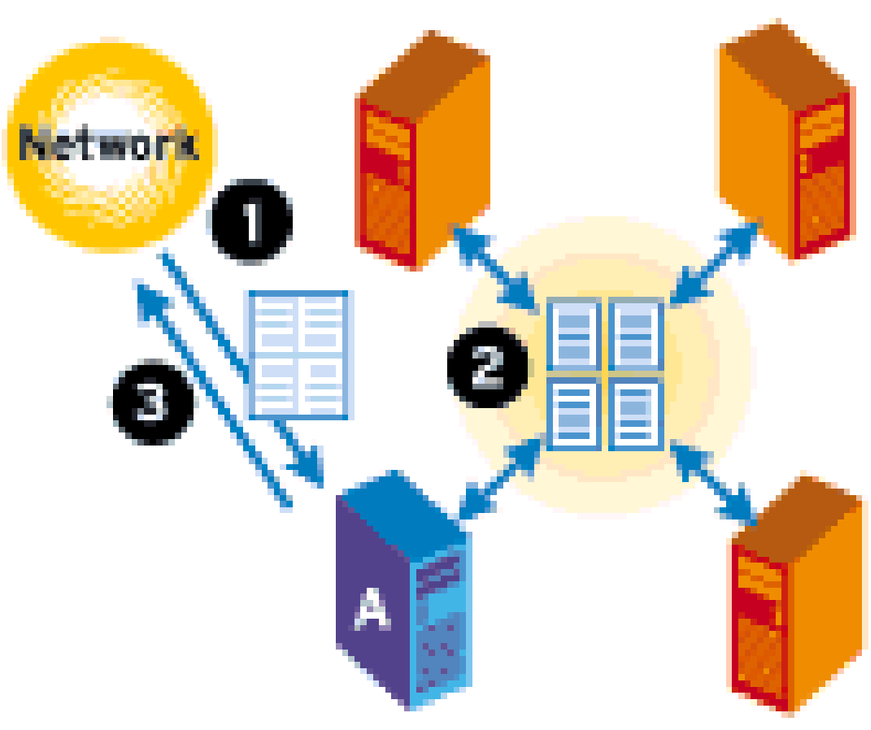
Clusters- Latest Variation

Agenda

- What is Cluster?
- Computer Clusters
- Configuration
- Applications of Clusters
- Components
- Classification
- Single Sysytem Image
- Cluster Middleware
- Benefits of Cluster , SSI & Middle





Clusters

- A group of the same or similar elements gathered or occurring closely together;
- a bunch
- a number of persons or things grouped together
- a number of things growing, fastened, or occurring close together

Computer Clusters

- “A computer cluster is a single logical unit consisting of multiple computers that are linked through a LAN and they can be worked as a single system.”
- The components of a cluster are usually connected to each other through fast local area networks ("LAN").
- The networked computers essentially act as a single, much more powerful machine

Computer Clusters(Cont…)

- Each system has its own CPU, memory, and I/O facilities
- Each system is known as a node of the cluster
  - generally 2 or more computers (nodes) connected together
  - in a single cabinet, or physically separated & connected via a LAN
  - appear as a single system to users and applications
  - provide a cost-effective way to gain features and benefits

Configuration Models

- ❑ **Shared nothing Model**
- ❑ **Shared Disk Model**

The detailed configuration models are:-

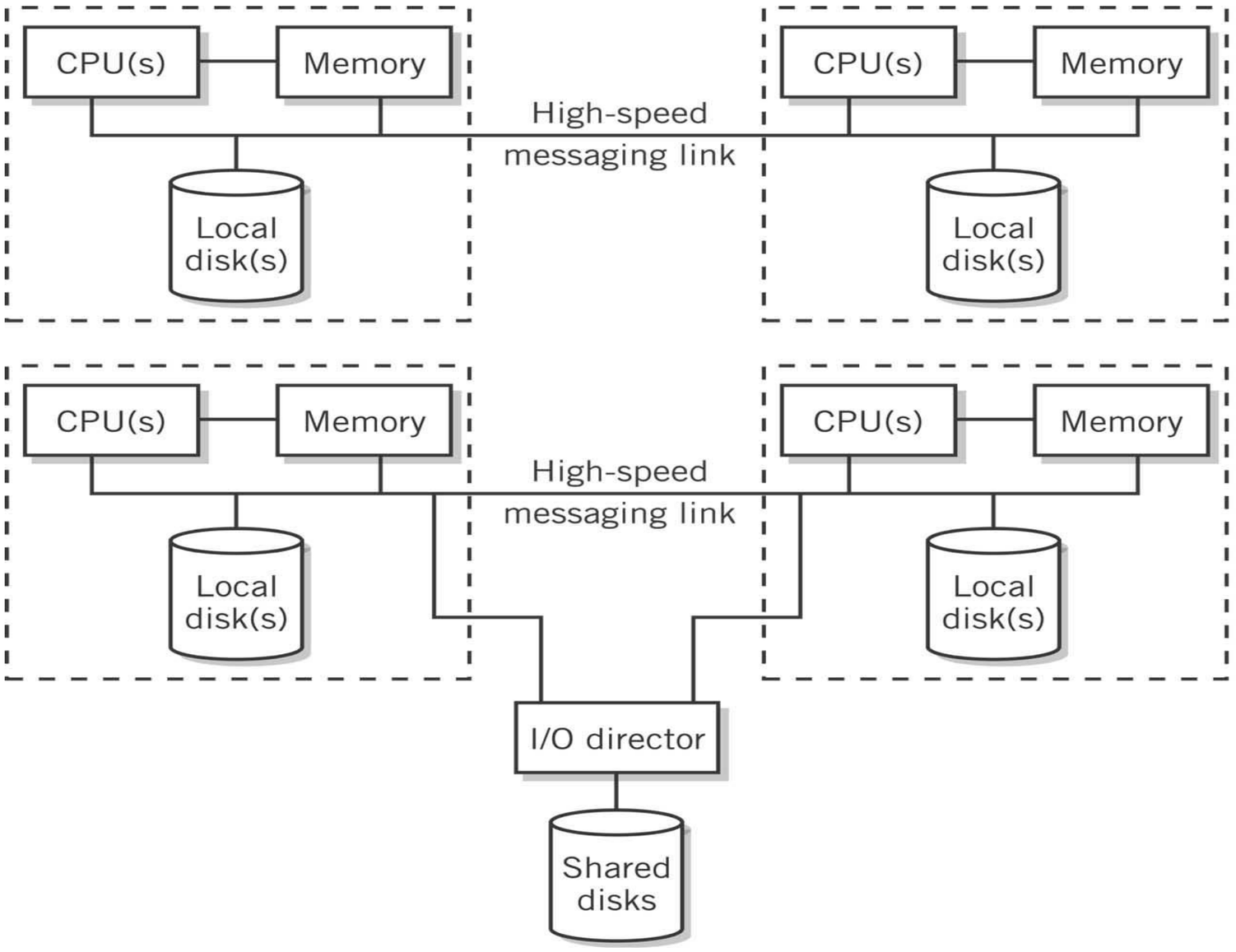
1. Shared nothing Model

- High speed link between nodes
- No sharing of resources
- Partitioning of work through division of data
- **Advantage:**
  - Reduced communication between nodes
- **Disadvantage:**
  - Can result in inefficient division of work

Shared-Disk Model

- High speed link between nodes
- Disk drives are shared between nodes
- **Advantage:**
  - Better load balancing
- **Disadvantage:**
  - Complex software required for transactional processing

Cluster Models



(a) Shared-nothing model

(b) Shared-disk model

Computer Clusters

Computer Clusters

Technicians working on a large Linux cluster at University of Technology, Germany.

Sun Microsystems Cluster

Clusters Classifications

Clusters are classified into many categories based on various factors as indicated below.

- Application Target
- Node Ownership
- Node Hardware
- Node Operating System
- Node Configuration

Clusters Classification (I)

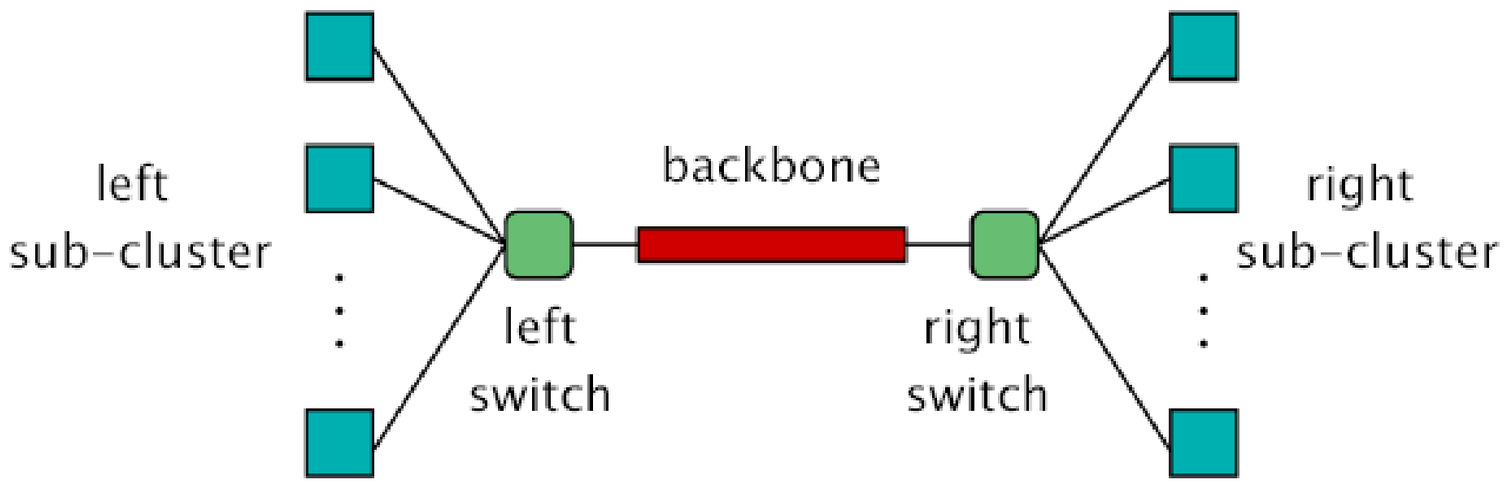
- **Application Target**
  - –High Performance (HP) Clusters
    - Grand Challenging Applications
  - –High Availability (HA) Clusters
    - Mission Critical applications

Clusters Classification (II)

- **<u>Node Ownership</u>**
  - –Dedicated Clusters
  - –Non-dedicated clusters
- Adaptive parallel computing

Clusters Classification (III)

- **Node Hardware**
  - –Clusters of PCs (CoPs)
  - –Clusters of Workstations (COWs)



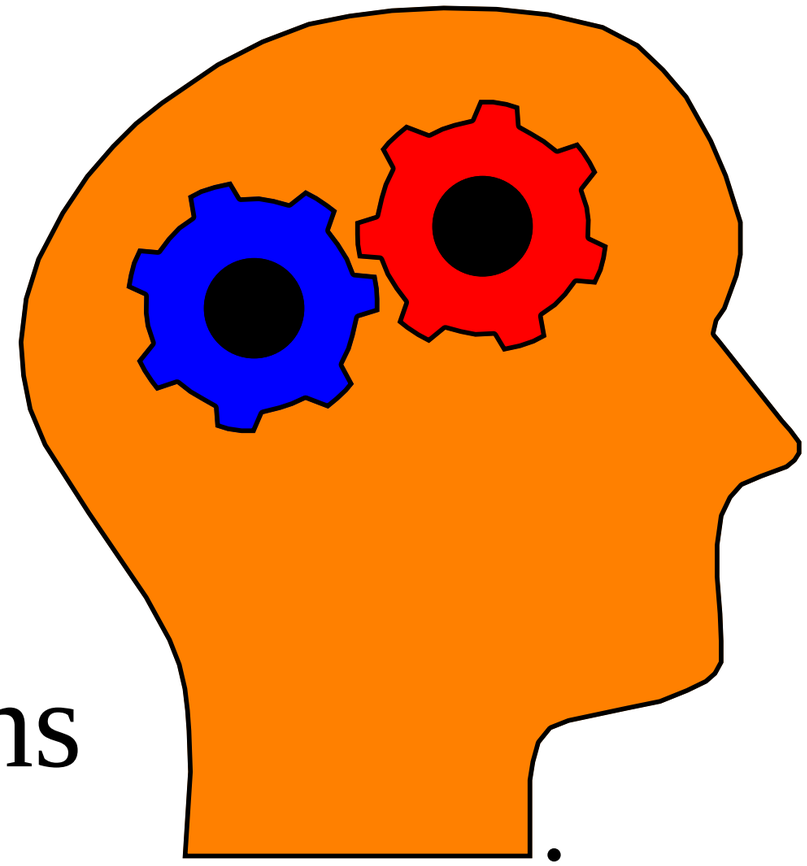
Clusters Classification (V)

- **<u>Node Configuration</u>**
  - –Homogeneous Clusters
    - All nodes will have similar architectures and run the same OSs
  - –Heterogeneous Clusters
    - All nodes will have different architectures and run different OSs

Commodity Components For Clusters

- Processors
- Memory and Cache
- Disk and I/O
- System Bus

Motivating Factors



← Aggregated speed with which complex calculations carried out by millions of neurons in human brain is amazing! although individual neurons response is slow (milli sec.)

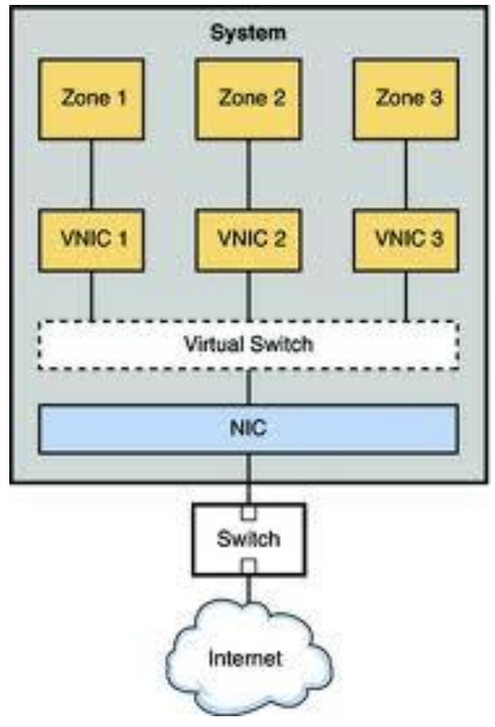
Single System Image (SSI)

- The Single System Image (SSI) represents the view of a distributed system as a single unified computing resource
- This provides better usability for the users as it hides the complexities of the underlying distributed and heterogeneous nature of clusters from them
- A single system image is the illusion, created by software or hardware, that presents a collection of resources as one, more powerful resource.
- SSI makes the cluster appear like a single machine to the user, to applications, and to the network.
- A cluster without a SSI is not a cluster

Desired SSI Services

- Single entry point
  - telnet cluster.my_institute.edu
  - telnet node1.cluster.my_institute.edu
- Single file hierarchy
- Single control point: manage from single GUI
- Single virtual networking
- Single memory space - DSM
- Single job management
- Single user interface

Single System Image (SSI)



Single System Image

- **Problem**
  - each nodes has a certain amount of resources that can only be used from that node
  - This restriction limits the power of a cluster
- **Solution**
  - implementing a middle-ware layer that glues all operating systems on all nodes
  - offer a unified access to system resources

Benefits of Single System Image

- Usage of system resources transparently
- Transparent process migration and load balancing across nodes.
- Improved reliability and higher availability
- Improved system response time and performance
- Simplified system management
- Reduction in the risk of operator errors
- User need not be aware of the underlying system architecture to use these machines effectively

Resource Management System

- A cluster resource management system (RMS) acts as a cluster middleware that implements the SSI for a cluster of machines

- It enables users to execute jobs on the cluster without the need to understand the complexities of the underlying cluster architecture

- A RMS manages the cluster through four major branches, namely: resource management, job queuing, job scheduling, and job management

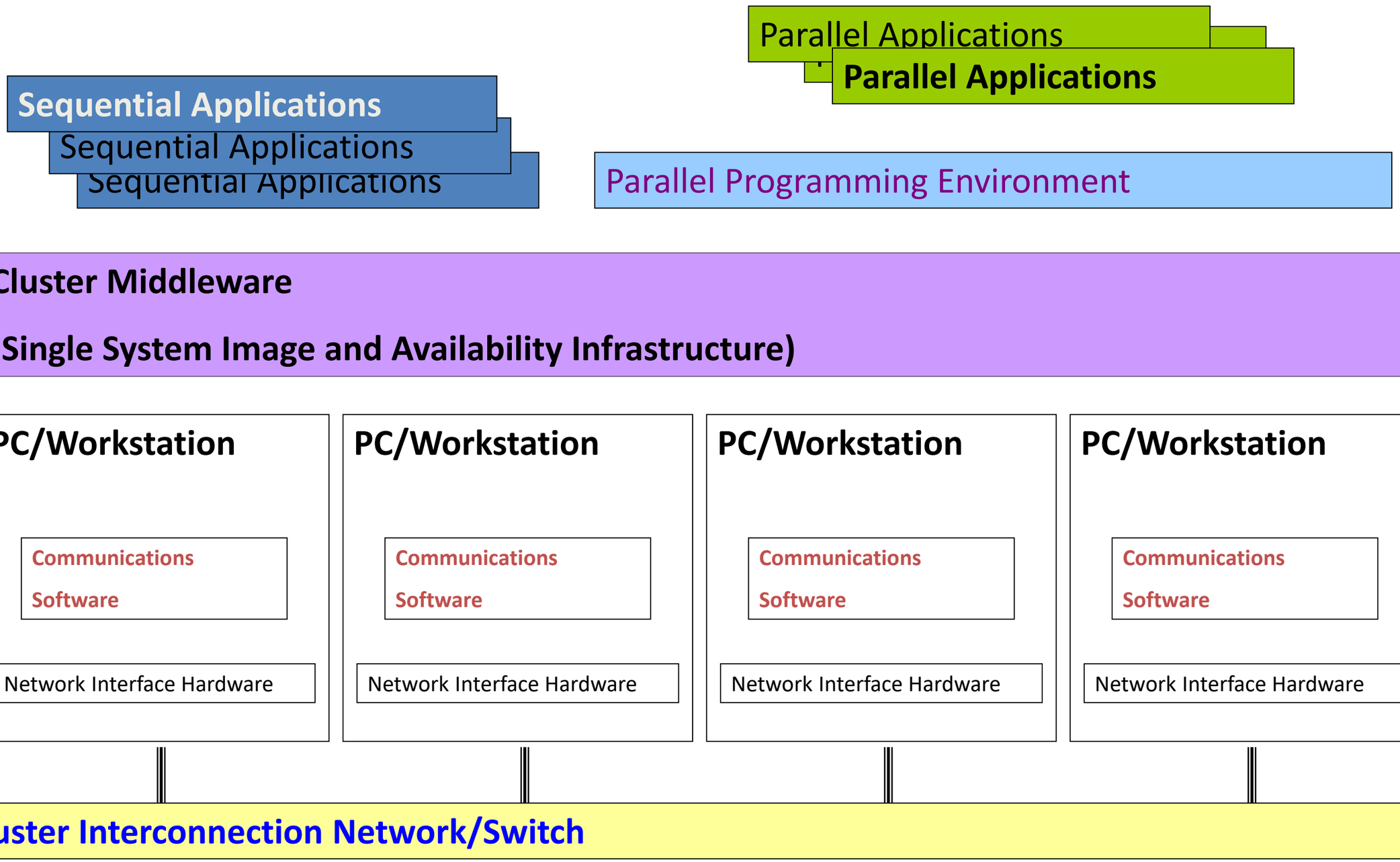
What is Cluster Middleware ?

- An interface between between use applications and cluster hardware and OS platform.
- Middleware packages support each other at the management, programming, and implementation levels.
- Programming
  - enable applications, reduce programming effort, distributed object/component models?
- Middleware Layers:
  - SSI Layer
  - Availability Layer: It enables the cluster services of
    - Checkpointing, Automatic Failover, recovery from failure,
    - fault-tolerant operating among all cluster nodes.

Middleware Design Goals

- Complete Transparency (Manageability)
  - Lets the see a single cluster system..
    - Single entry point
- Scalable Performance
  - Easy growth of cluster
    - no change of API & automatic load distribution.
- Enhanced Availability
  - Automatic Recovery from failures
    - Employ checkpointing & fault tolerant technologies
  - Handle consistency of data when replicated..

Cluster Architecture



Key Benefits of Clusters

- High performance: running cluster enabled programs
- Scalability: adding servers to the cluster or by adding more clusters to the network as the need arises or CPU to SMP(Symmetric Multiprocessors)
- High throughput: (cycle)
- System availability (HA): offer inherent high system availability due to the redundancy of hardware, operating systems, and applications
- Cost-effectively

Cluster Applications

- Numerous Scientific & engineering Apps.
- Business Applications:
  - Database Applications (Oracle on clusters).
- Internet Applications
- Mission Critical Applications:
  - banks, nuclear reactor control

Conclusion

The conclusion of this chapter is that although solutions to the resource management and Meta computing problems do exist, none of the solutions is directly applicable to the case in which a user does not have a great deal of knowledge about the system they are using.

Cont…

- Clusters are promising and fun
  - Offer incremental growth and match with funding pattern
  - New trends in hardware and software technologies are likely to make clusters more promising
  - Cluster-based HP and HA systems can be seen everywhere!