RAMAIAH
Institute of Technology

M. S. Ramaiah Institute of Technology
(Autonomous Institute, Affiliated to VTU)

Department of Computer Science and Engineering

Distributed Systems
CSE20

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Lesile Lamport

Leslie B. Lamport is an American computer scientist. Lamport is best known for his seminal work in distributed systems, and as the initial developer of the document preparation system LaTeX and the author of its first manual.

“A distributed system is one in which the failure of a computer you didn’t even know existed can render your own computer unusable”.

Why to design a system as a distributed system?

- Societal Importance

- Challenging: Node failures, Concurrency

  Eg: PASS developed by IBM in 1981 used in space shuttle.

- Failure of **one** node **does** not lead to the failure of the entire **distributed system**. Other nodes can still communicate with each other.

- An important goal of a **distributed system is** to make it easy for users (and applications) to access and share remote resources. Resources can be virtually anything.

Advantages of Distributed Systems

- All the nodes in the **distributed system** are connected to each other.
- More nodes can easily be added to the **distributed system** i.e. it can be scaled as required.
- Failure of one node does not lead to the failure of the entire **distributed system**.
- Resources like printers can be shared with multiple nodes rather than being restricted to just one.
- A distributed system enables you to do is **scale horizontally**. **Scaling horizontally** simply means adding more computers rather than upgrading the hardware of a single one.

Disadvantages of Distributed Systems

It is difficult to provide **adequate security** in distributed systems because **the nodes as well as the connections need to be secured**.

Some **messages and data can be lost in the network** while moving from one node to another.

The database connected to the distributed systems is quite **complicated and difficult to handle** as compared to a single user system.

Overloading may occur in the network if all the nodes of the distributed system try to send data at once.

Distributed Systems

- A **distributed system** is a **system** whose components are located on different networked **computers**, which communicate and coordinate their actions by passing messages to one another.

- **Distributed systems** allow breaking complex problems/data into smaller pieces and have multiple computers work on them in parallel, which can help cut down on the time needed to solve/compute those problems.

Introduction

- Autonomous processors communicating over a communication network

Some characteristics

- No common physical clock
- No shared memory
- Geographical separation
- Autonomy and heterogeneity

Distributed System Model

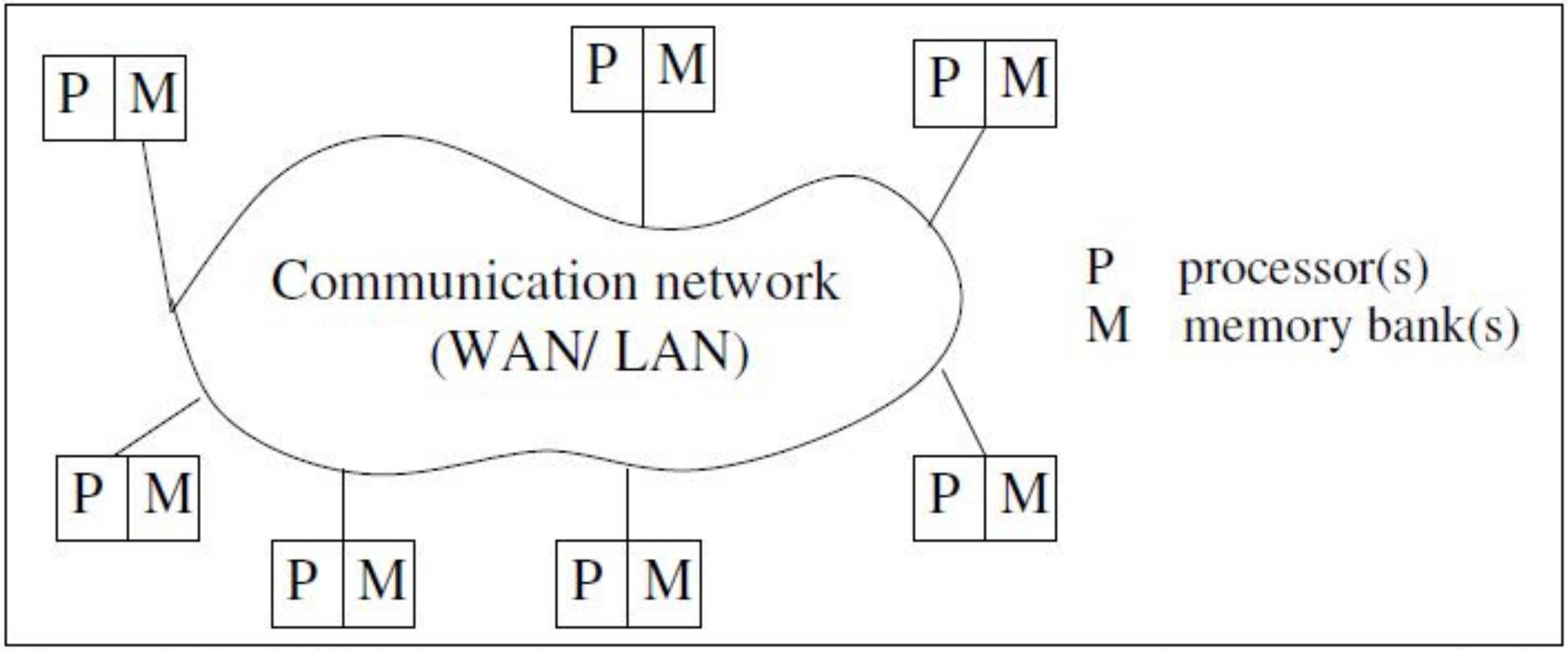


Figure 1.1: A distributed system connects processors by a communication network.

Relation between Software Components

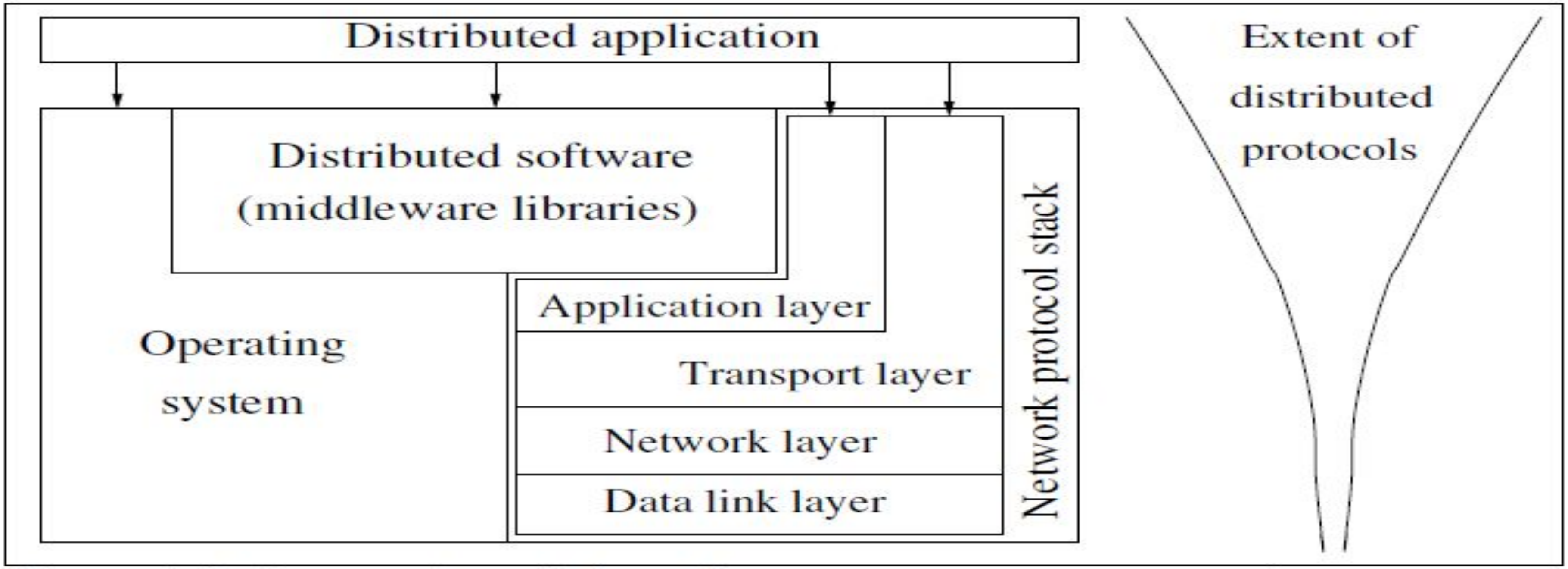


Figure 1.2: Interaction of the software components at each process.

- The distributed system uses a layered architecture to break down the complexity of system design.

A ***distributed execution****(computation)* is the execution of processes across the distributed system to collaboratively achieve a common goal.

✓ **The remote procedure call (RPC) mechanism.**

✓ Middleware such as CORBA, DCOM (distributed component object model), Java, and RMI(remote method invocation) technologies and the message-passing interface (MPI).

UMA vs. NUMA Models

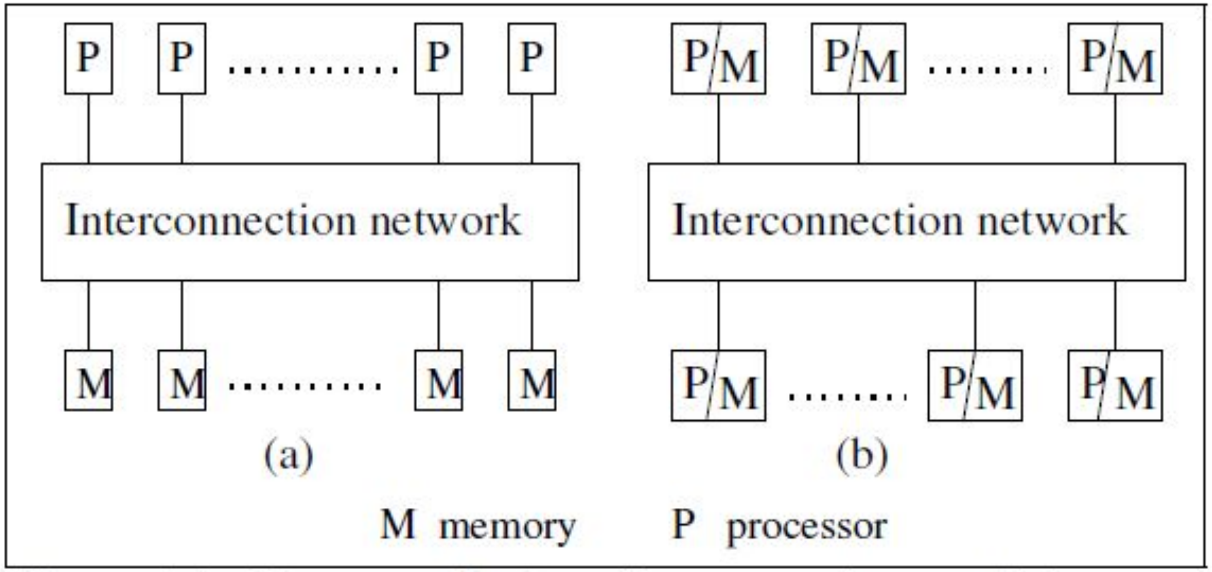


Figure 1.3: Two standard architectures for parallel systems. (a) Uniform memory access (UMA) multiprocessor system. (b) Non-uniform memory access (NUMA) multiprocessor. In both architectures, the processors may locally cache data from memory.

Interconnection Networks

- Common Highway or interconnection network for processors in parallel to communicate.
- Based on a topology interconnection network is built
- Topology can be
  - Fixed
  - Reconfigurable(multistage interconnection network)

Omega Network

- Multistage switching network has self routing property.
- Multistage omega network used as connectors between CPUs and their shared memory, in order to decrease the probability of CPU-to –memory connection bottleneck.
- Outputs of each stages are connected to inputs of next stage using a perfect shuffle connection system.
- This class of networks has been built into the Illinois Cedar Multiprocessor, into the IBM RP3, and into the NYU Ultracomputer.

8x8 Omega Network (logical left shift)

000->000->000->000

001->010->100->001

010->100->001->010

011->110->101->011

100->001->010->100

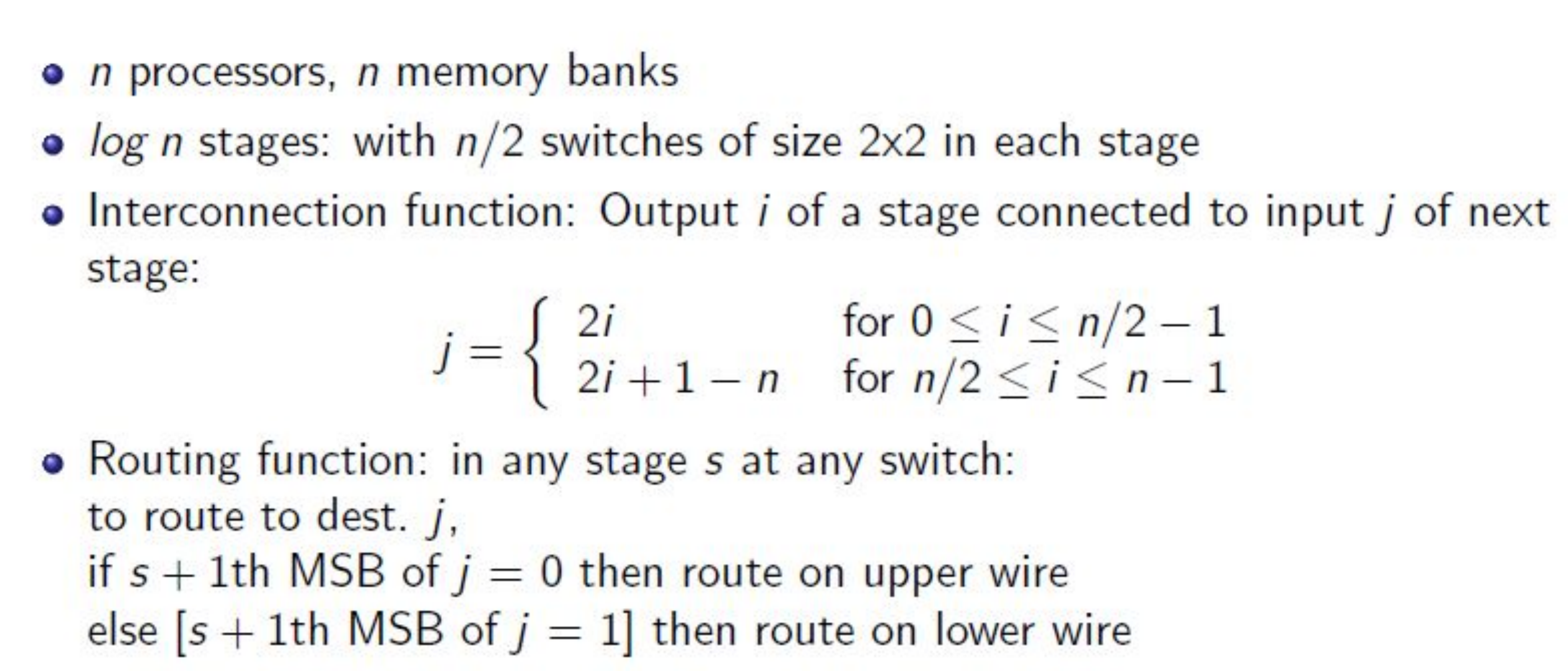
101->011->110->101

110->101->011->110

111->111->111->111

Input	Output
0	0
1	2
2	4
3	6
4	1
5	3
6	5
7	7

Omega Network



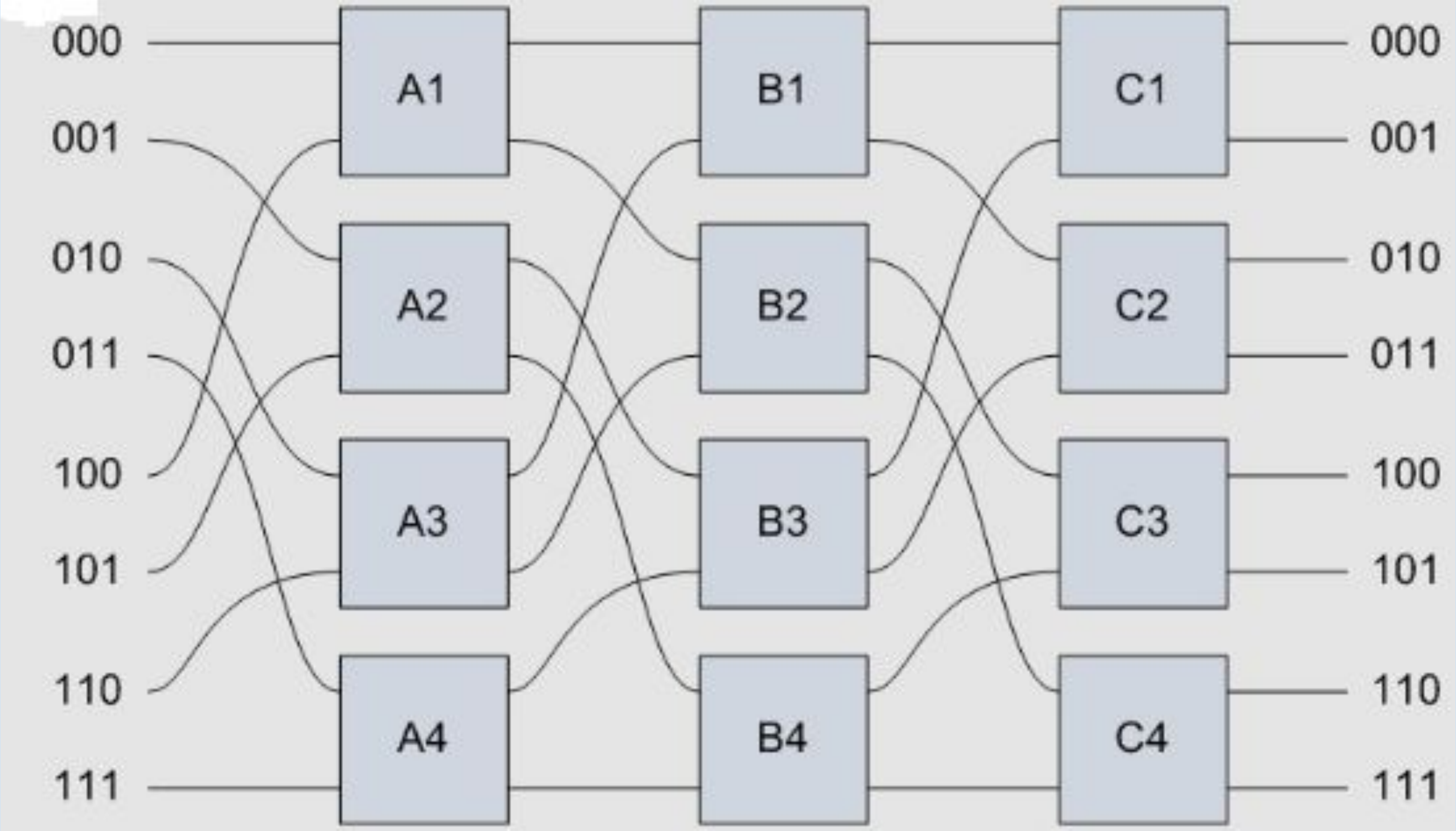
- n processors, n memory banks
- $\log n$ stages: with $n/2$ switches of size 2x2 in each stage
- Interconnection function: Output i of a stage connected to input j of next stage:

$$j = \begin{cases} 2i & \text{for } 0 \leq i \leq n/2 - 1 \\ 2i + 1 - n & \text{for } n/2 \leq i \leq n - 1 \end{cases}$$

- Routing function: in any stage s at any switch:
  to route to dest. j,
  if $s + 1$th MSB of $j = 0$ then route on upper wire
  else [$s + 1$th MSB of $j = 1$] then route on lower wire

Omega Network using Routing function

Building 8X8 Omega Network using Routing Function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