Introduction

Chapter 1

Book: Distributed Systems, Tanenbaum

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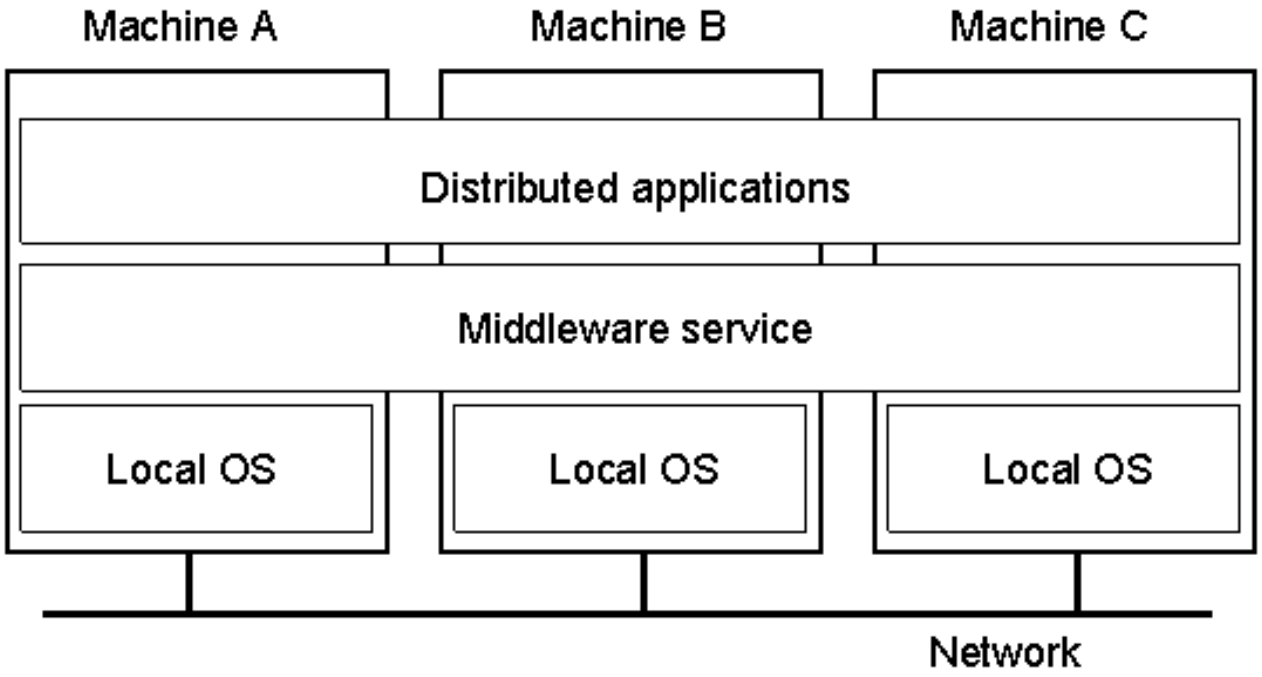
Definition of a Distributed System (1)

A distributed system is:

A collection of independent computers that appears to its users as a single coherent system.

Definition of a Distributed System (2)



- Note that the middleware layer extends over multiple machines.

- Middleware layer lies on top of OS layer to cover the heterogeneities and provide general-purpose services to the application programmers.

Features

- Extensibility and Openness
- Transparency
- Scalability

Extensibility

- The system is extensible by easily inserting new software/hardware components without the need to change much the available components (Minimum effort).
- The system is open (Not closed)

Transparency

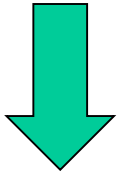
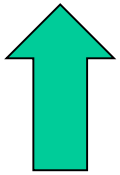
- Users see the system as a whole black box.
- The system hides the interior details from the view of users.

Transparency in a Distributed System

Transparency	Description
Access	Hide differences in data representation and how a resource is accessed
Location	Hide where a resource is located
Migration	Hide that a resource may move to another location
Relocation	Hide that a resource may be moved to another location while in use
Replication	Hide that a resource may replicated
Concurrency	Hide that a resource may be shared by several competitive users
Failure	Hide the failure and recovery of a resource

Different forms of transparency in a distributed system.

Scalability

- Increasing Users  Decreases Efficiency
- Increasing Resources  Increases Efficiency

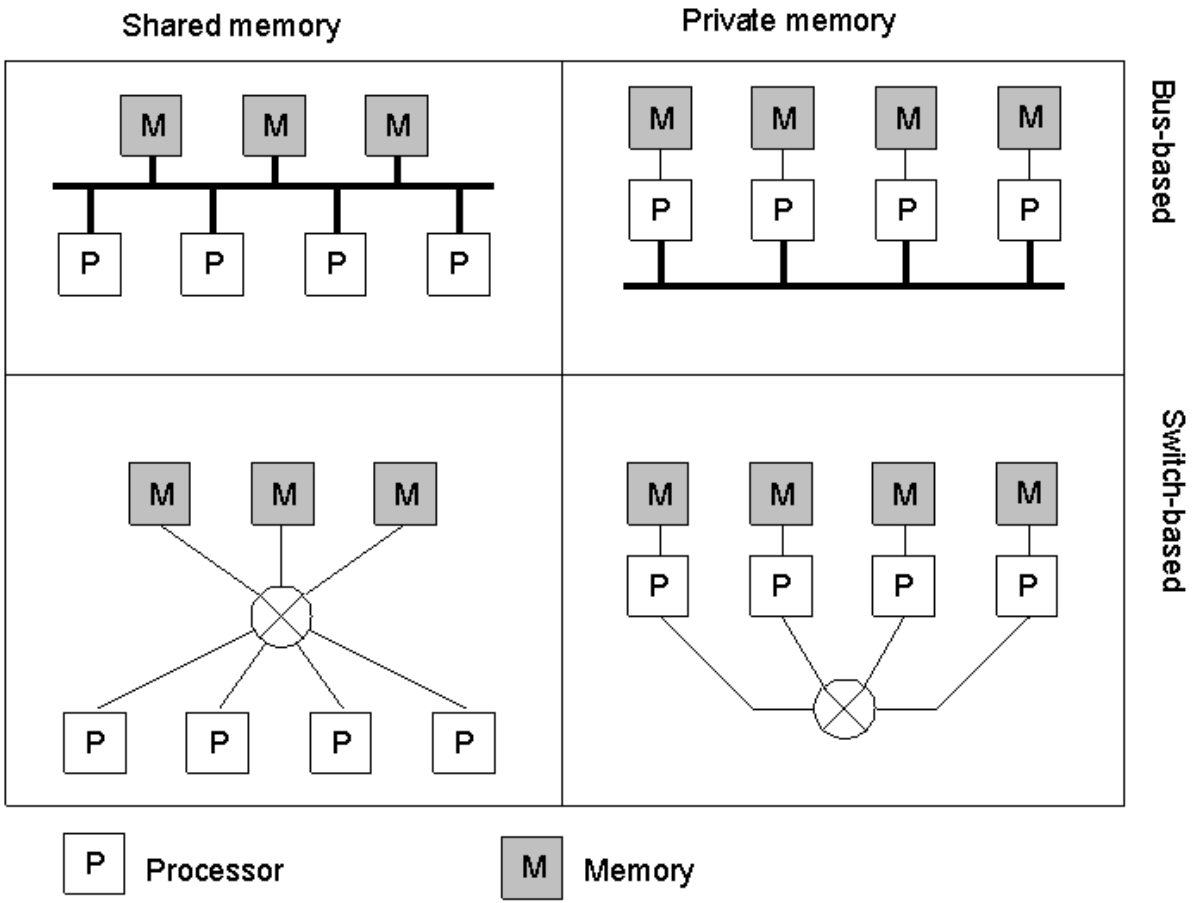
- **Definition**: A system is scalable if significantly increasing both the users and resources, could keep the efficiency fixed.

Scalability Problems

Centralization

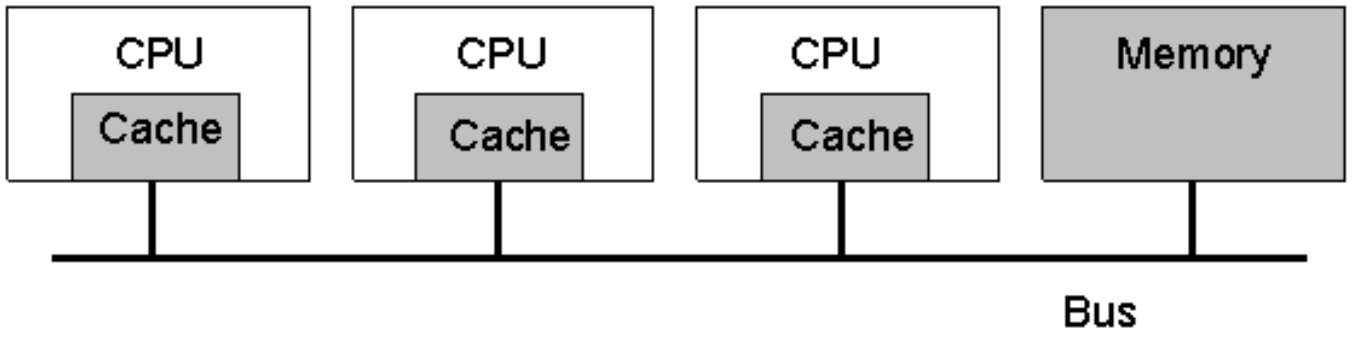
Concept	Example
Centralized services	A single server for all users
Centralized data	A single on-line telephone book
Centralized algorithms	Doing routing based on complete information

Hardware Concepts



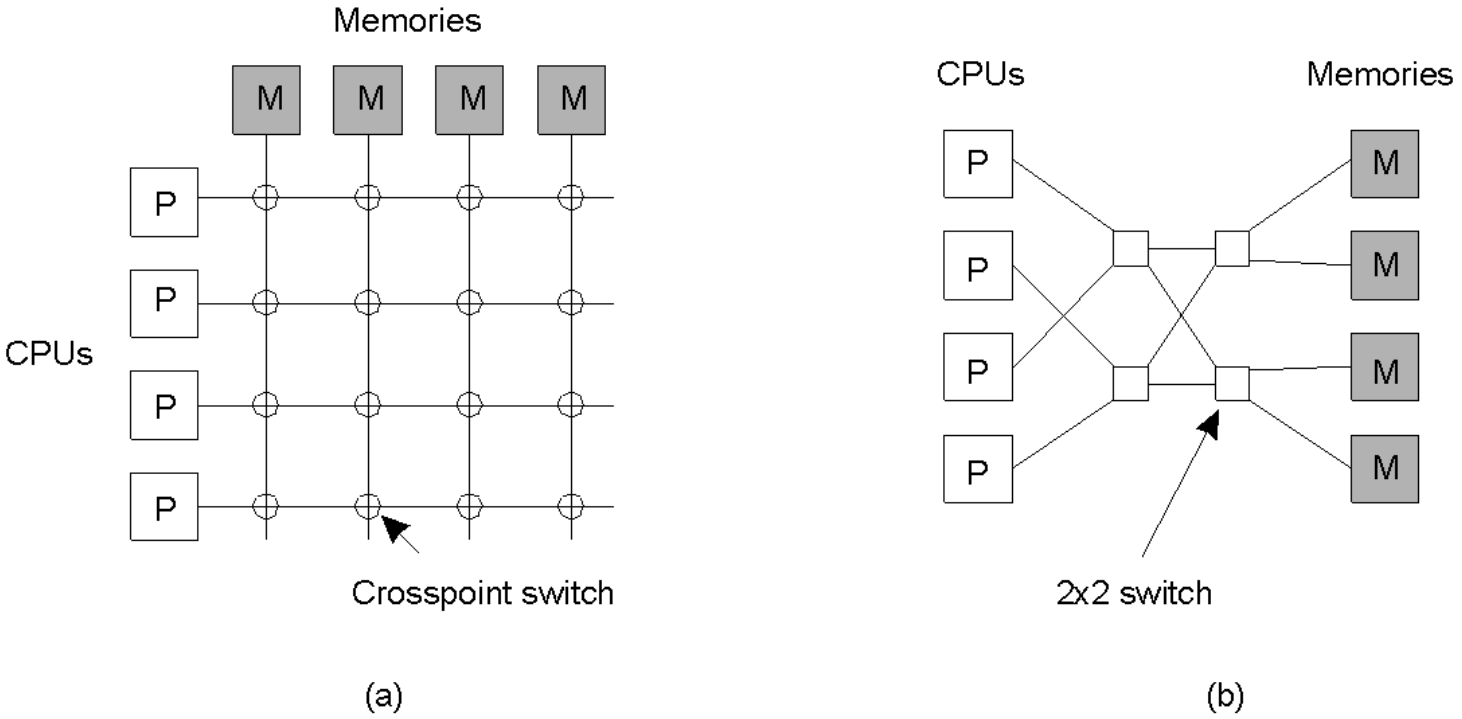
Different basic organizations and memories in distributed computer systems

Multiprocessors (1)



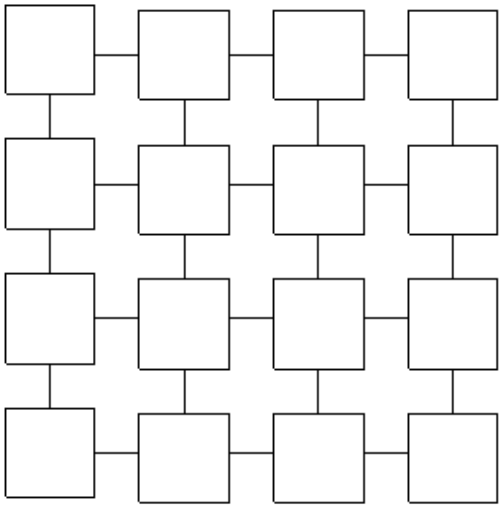
A bus-based multiprocessor.

Multiprocessors (2)

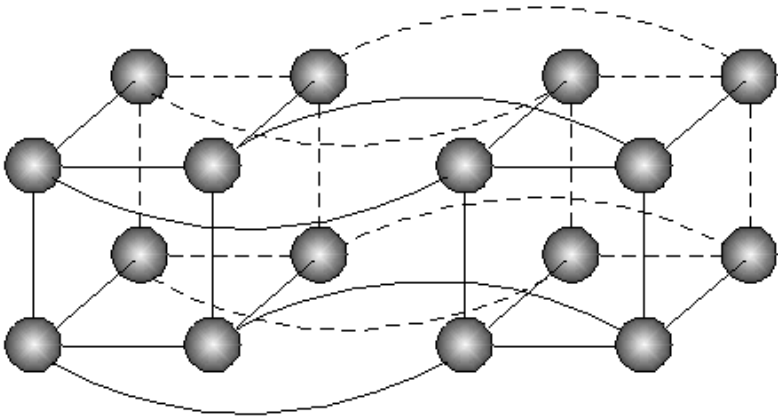


a) A crossbar switch
b) An omega switching network

Homogeneous Multicomputer Systems



(a)



(b)

a) Grid
b) Hypercube

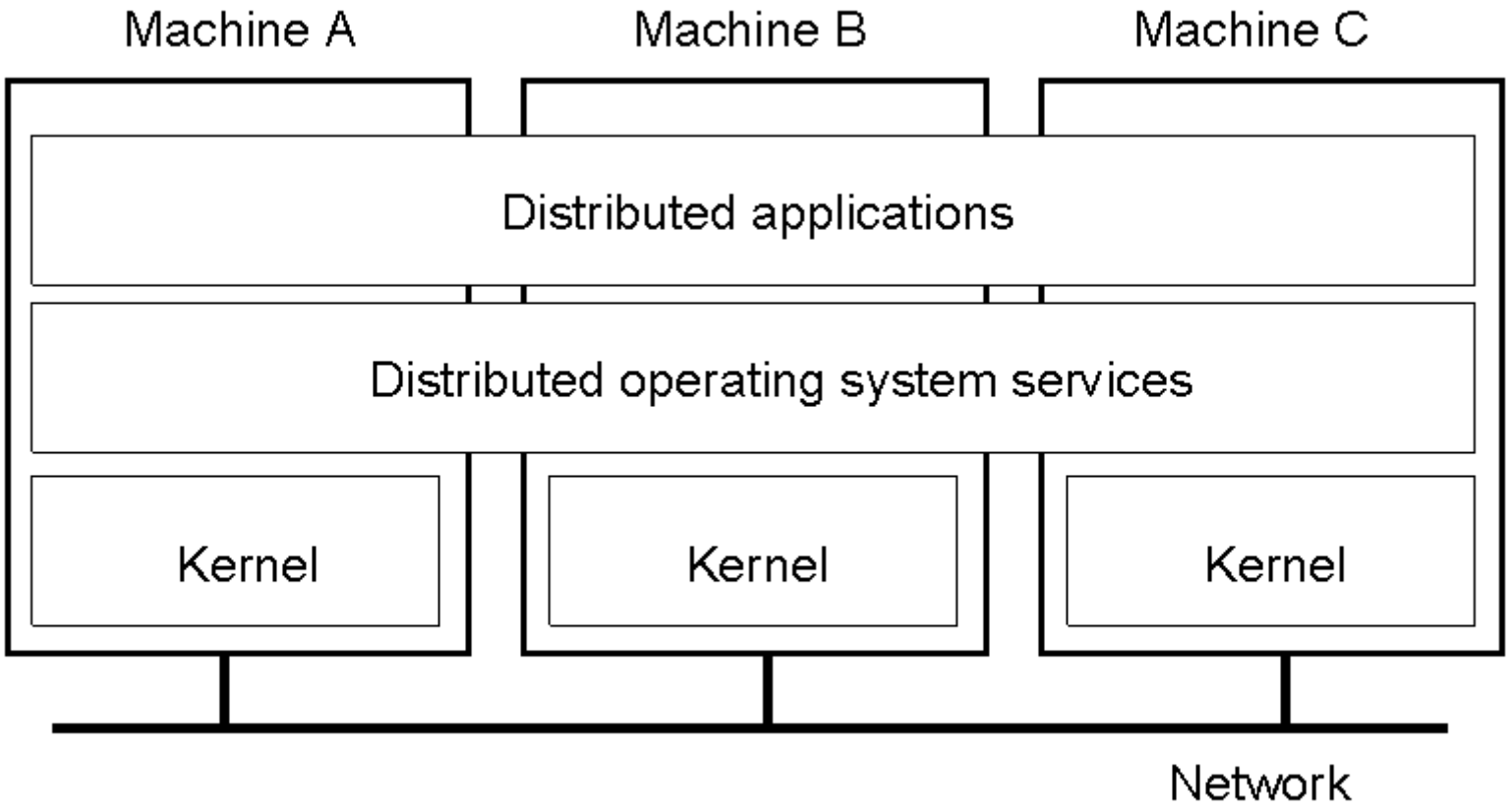
Software Concepts

System	Description	Main Goal
DOS	Tightly-coupled operating system for multi-processors and homogeneous multicomputers	Hide and manage hardware resources
NOS	Loosely-coupled operating system for heterogeneous multicomputers (LAN and WAN)	Offer local services to remote clients
Middleware	Additional layer atop of NOS implementing general-purpose services	Provide distribution transparency

An overview of

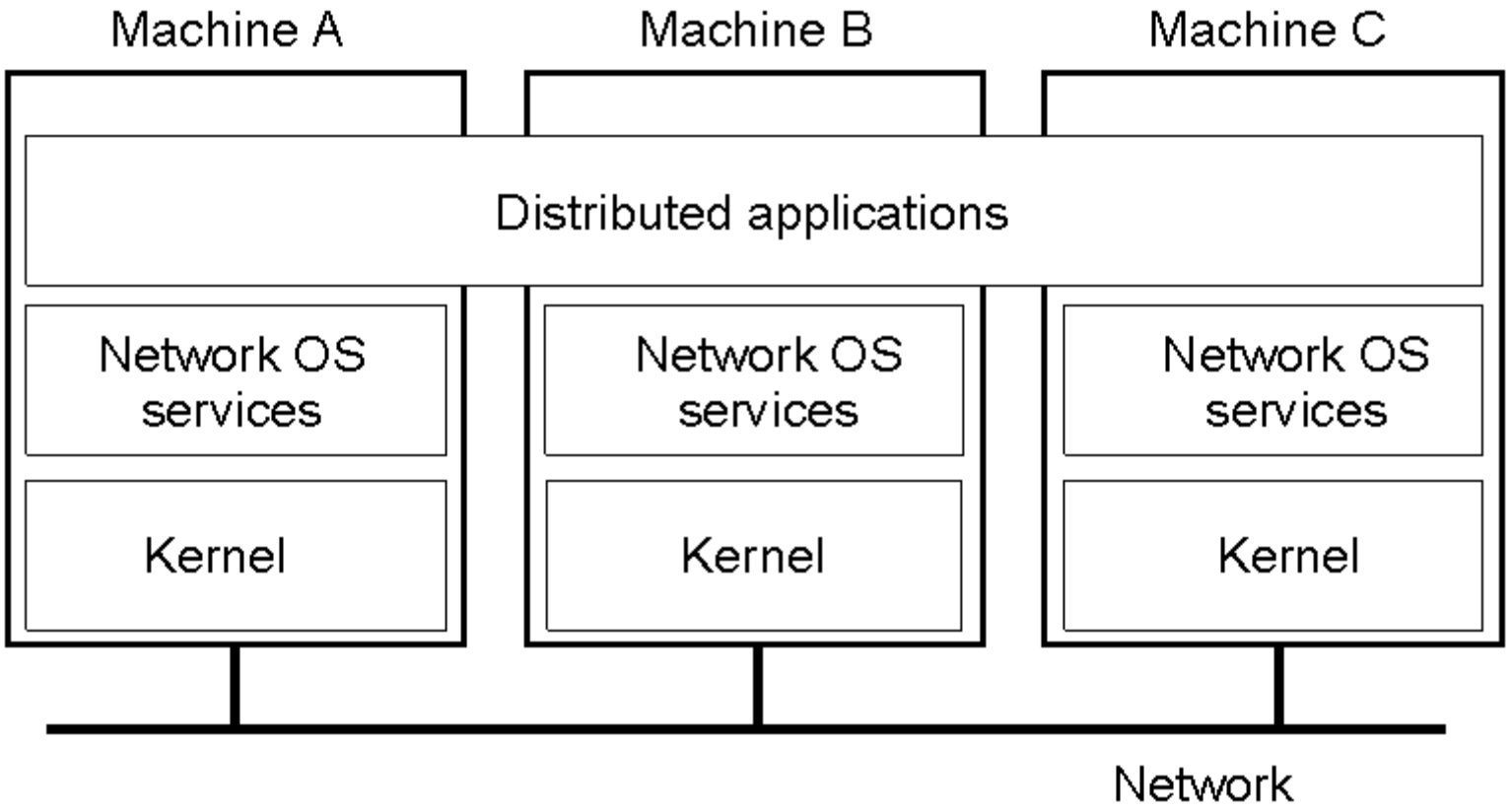
- DOS (Distributed Operating Systems)
- NOS (Network Operating Systems)
- Middleware

Multicomputer Operating Systems (1)



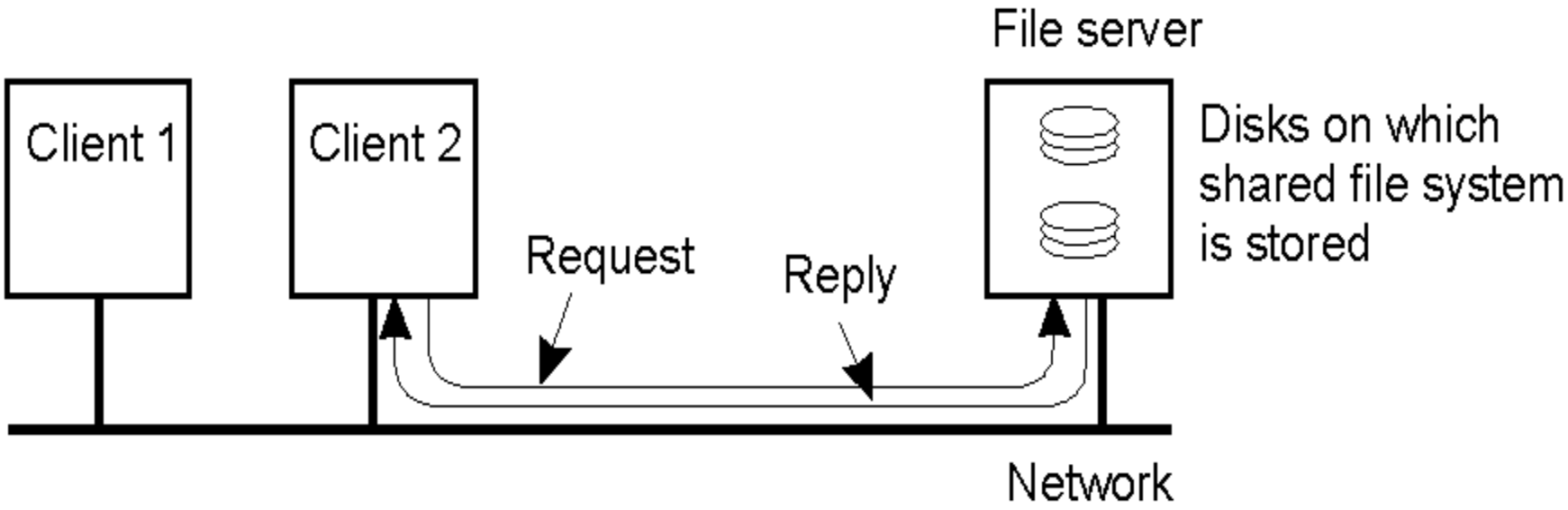
General structure of a multicomputer operating system

Network Operating System (1)



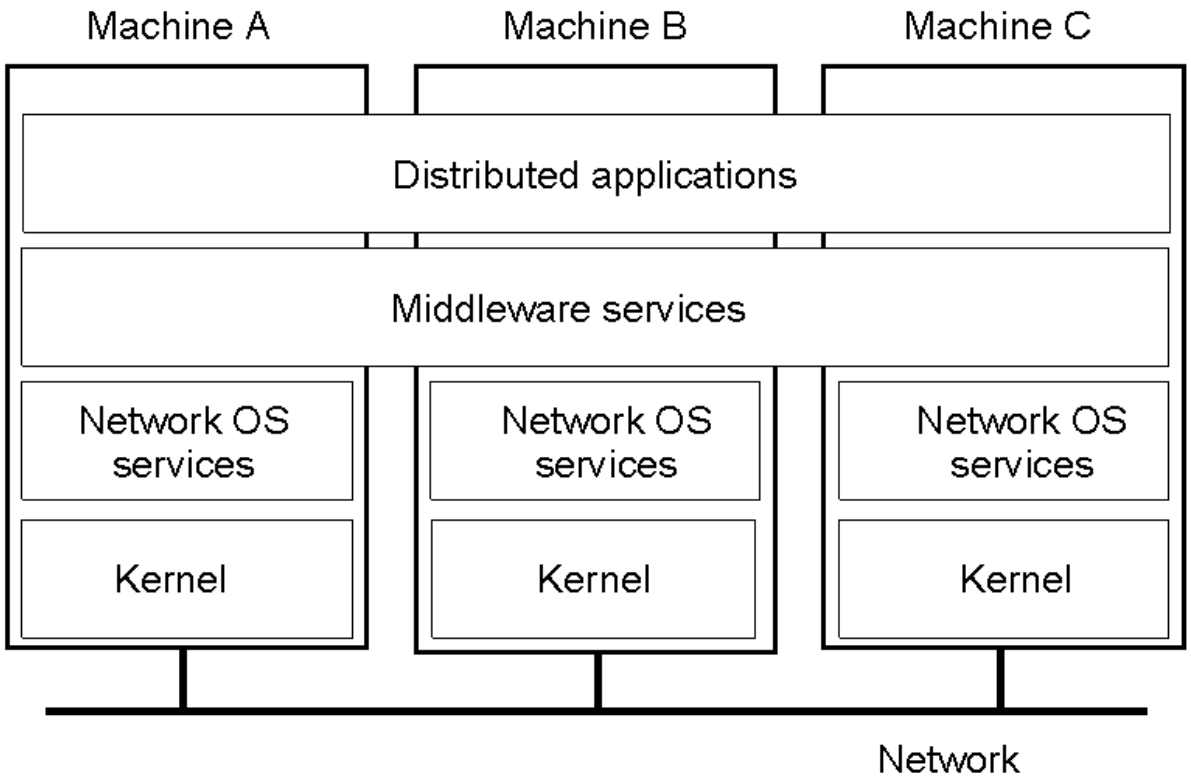
General structure of a network operating system.

Network Operating System (2)



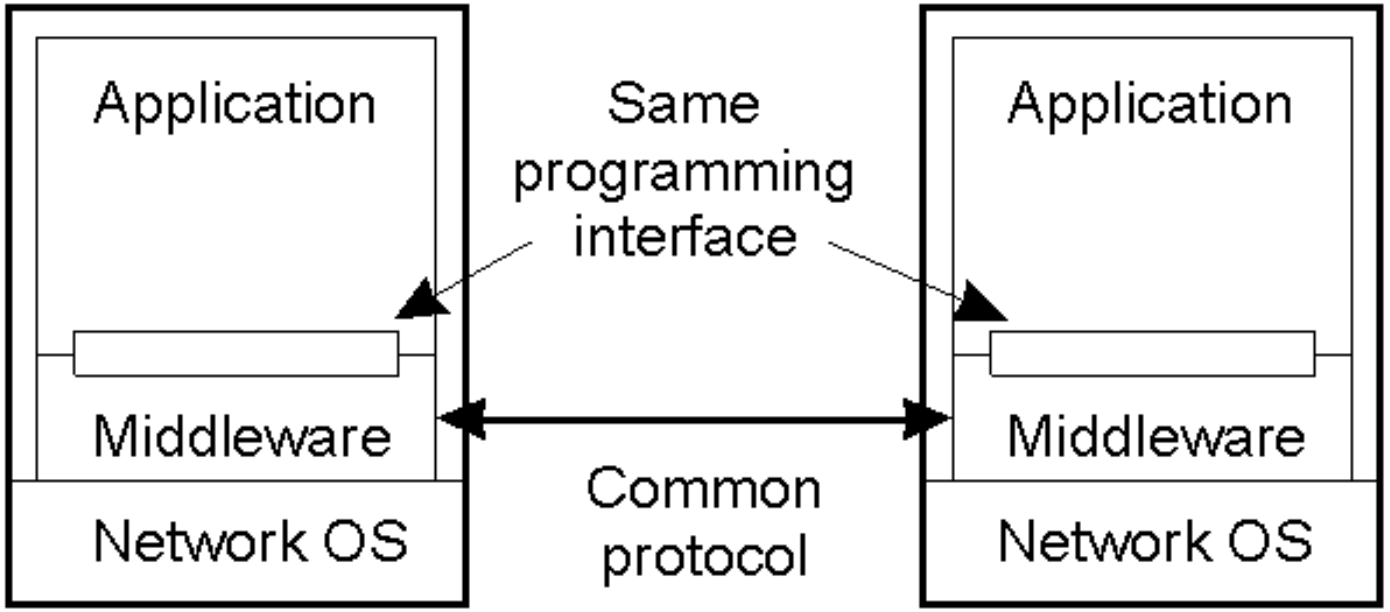
Two clients and a server in a network operating system.

Positioning Middleware



General structure of a distributed system as middleware.

Middleware and Openness



In an open middleware-based distributed system, the protocols used by each middleware layer should be the same, as well as the interfaces they offer to applications.

Comparison between Systems

Item	Distributed OS		Network OS	Middleware-based OS
	Multiproc.	Multicomp.		
Degree of transparency	Very High	High	Low	High
Same OS on all nodes	Yes	Yes	No	No
Number of copies of OS	1	N	N	N
Basis for communication	Shared memory	Messages	Files	Model specific
Resource management	Global, central	Global, distributed	Per node	Per node
Scalability	No	Moderately	Yes	Varies
Openness	Closed	Closed	Open	Open

A comparison between multiprocessor operating systems, multicomputer operating systems, network operating systems, and middleware based distributed systems.