Distributed Systems

An operating system (OS) is basically a collection of software that manages computer hardware resources and provides common services for computer programs. Operating system is a crucial component of the system software in a computer system.

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Distributed Operating System is one of the important type of operating system.

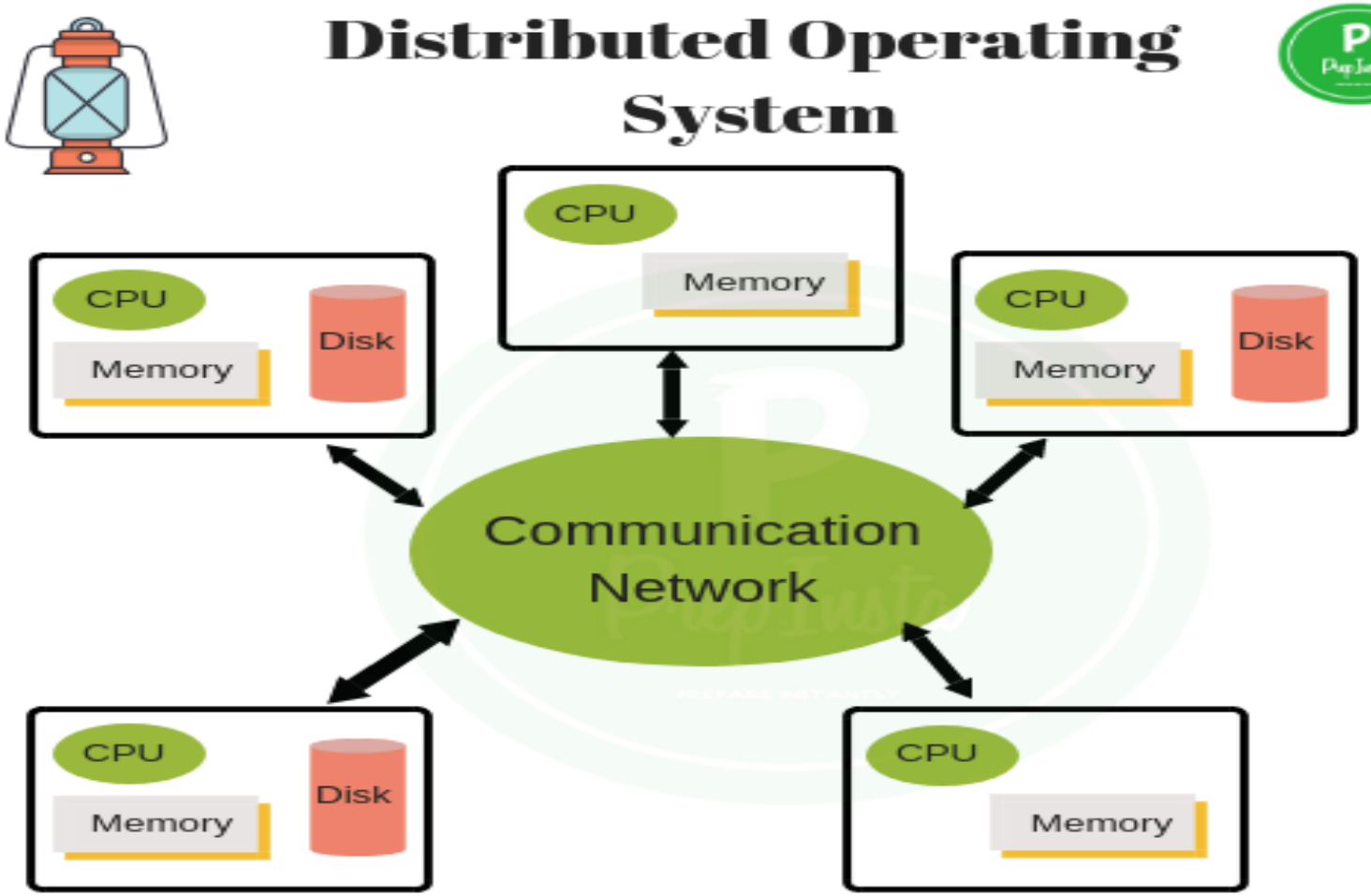
Definition:

Multiple central processors are used by Distributed systems to serve multiple real-time applications and multiple users. Accordingly, Data processing jobs are distributed among the processors.

Click to add text

Processors communicate with each other through various communication lines (like high-speed buses or telephone lines). These are known as loosely coupled systems or distributed systems. Processors in this system may vary in size and function. They are referred as sites, nodes, computers, and so on.

Architecture of Distributed OS:



Advantages of Distributed OS:

1] With resource sharing facility, a user at one site may be able to use the resources available at another.

2] Speedup the exchange of data with one another via electronic mail.

3] Failure of one site in a distributed system doesn't affect the others, the remaining sites can potentially continue operating.

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4] Better service to the customers.

5] Reduction of the load on the host computer.

6]Reduction of delays in data processing.

The Rise of Distributed Systems

- Computer hardware prices are falling and power increasing.
- Network connectivity is increasing.
  - Everyone is connected with fat pipes.
- It is *easy* to connect hardware together.
- Definition: a *distributed system* is
  - A collection of independent computers that appears to its users as a single coherent system.

Forms of Transparency in a Distributed System

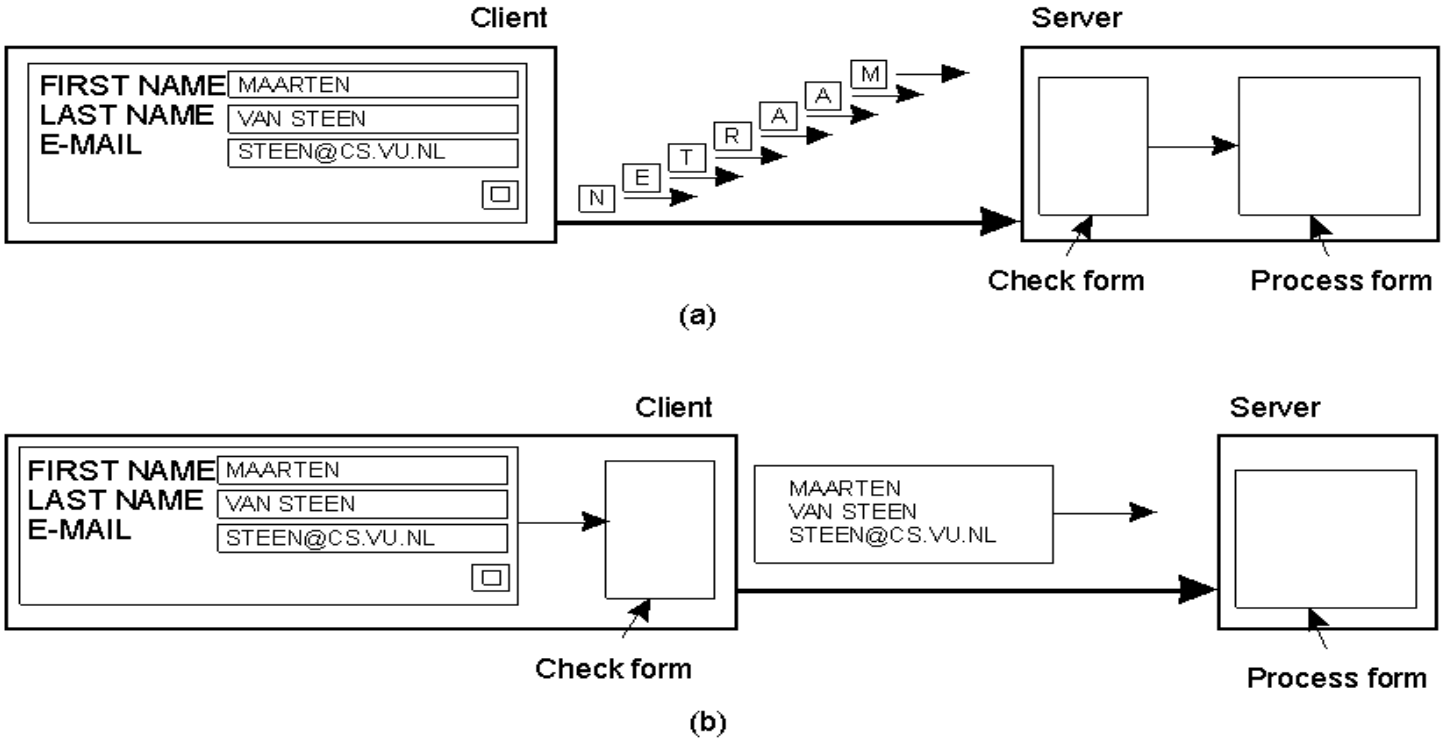
Transparency	Description
Access	Hide differences in data representation and how a resource is accessed
Location	Hide where a resource is located
Migration	Hide that a resource may move to another location
Relocation	Hide that a resource may be moved to another location while in use
Replication	Hide that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

Scalability Problems

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

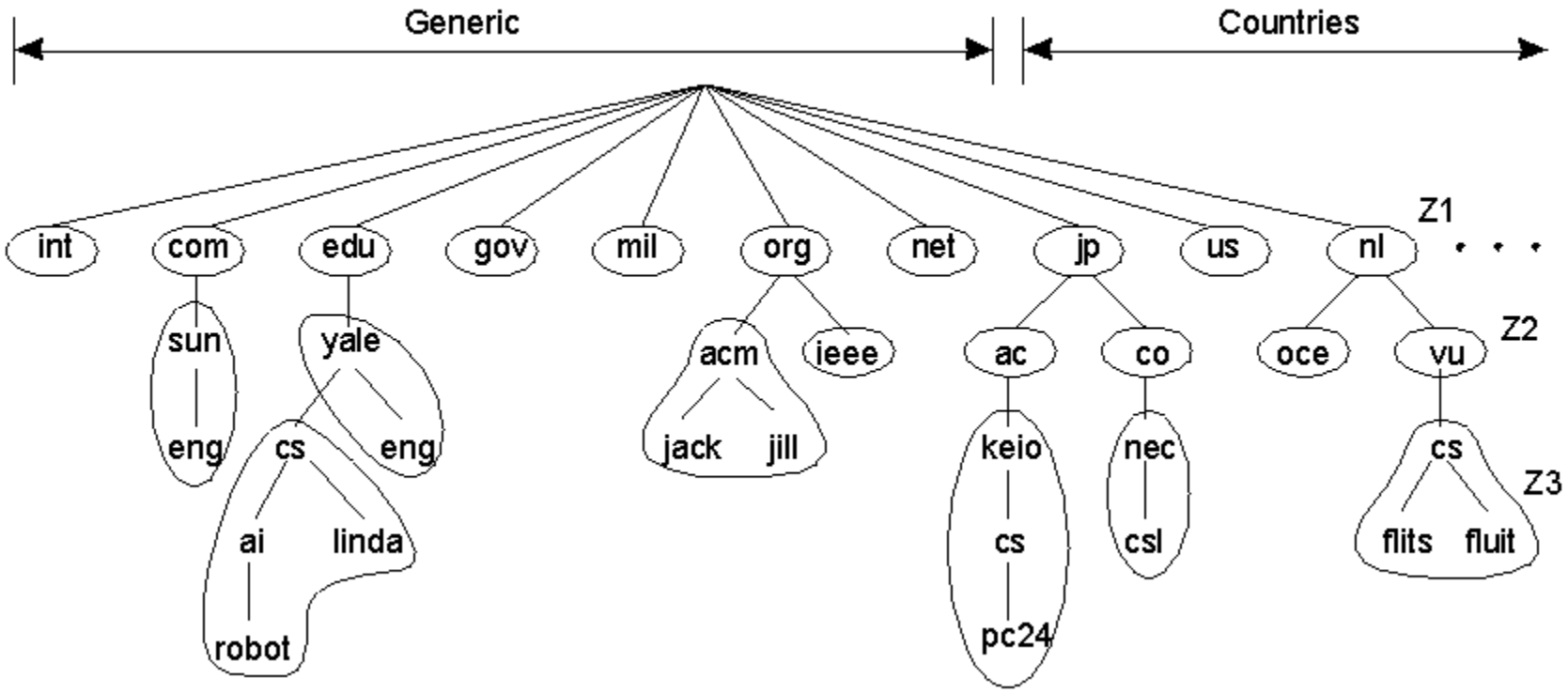
- As distributed systems grow, centralized solutions are limited.

Hiding Communication Latency



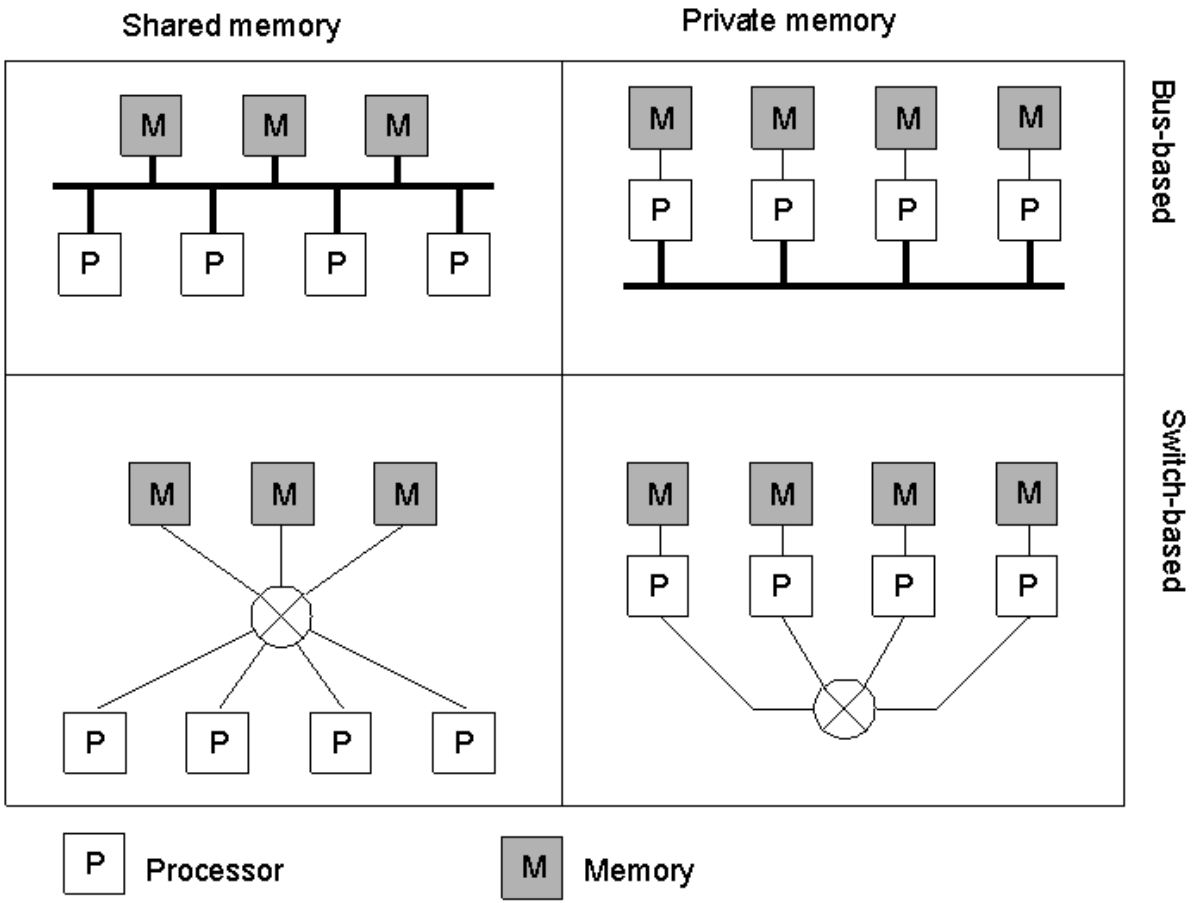
- This is especially important for interactive applications
- If possible, system can do *asynchronous communication*.
- The system can hide latencies.

Dividing the DNS name space into zones



Hardware Concepts

Basic organizations and memories in distributed computer systems



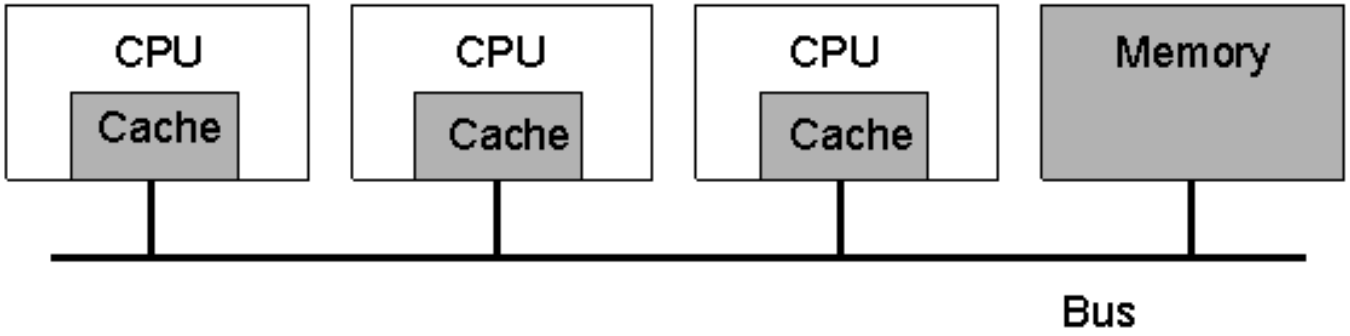
Hardware Considerations

- General Classification:
  - Multiprocessor – a single address space among the processors
  - Multicomputer – each machine has its own private memory.
- OS can be developed for either type of environment.

Multiprocessor Organizations

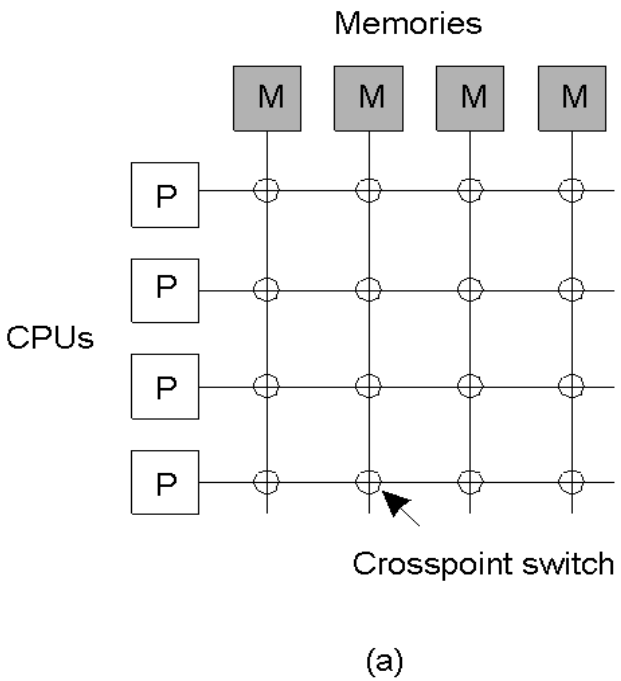
- ***Uniform Memory Access* [UMA]**
  - Caching is vital for reasonable performance (e.g., caches on a shared memory multiprocessor).
  - Want to maintain cache coherency
    - **Write-through cache ::** any changes to cache are written through to memory.

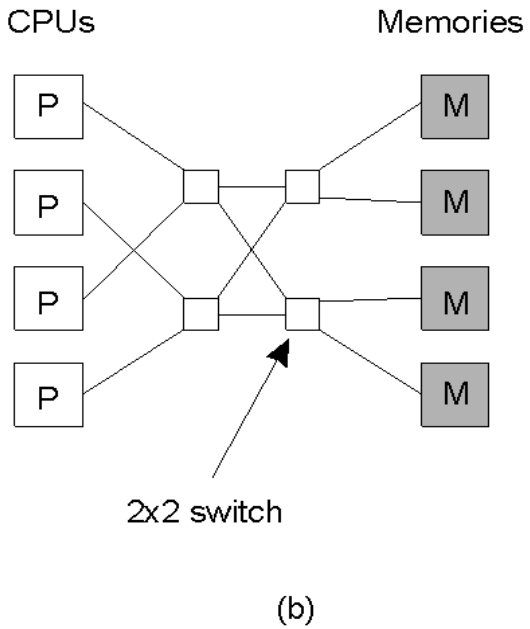
Multiprocessors



A bus-based multiprocessor.

Multiprocessors





A crossbar switch

An omega switching network

Multiprocessor Organizations

- ***Non-Uniform Memory Access*** **[NUMA]**
  - A hierarchy where CPUs have their own memory (not the same as a cache).
  - Access costs to memory is non-uniform.

Replication

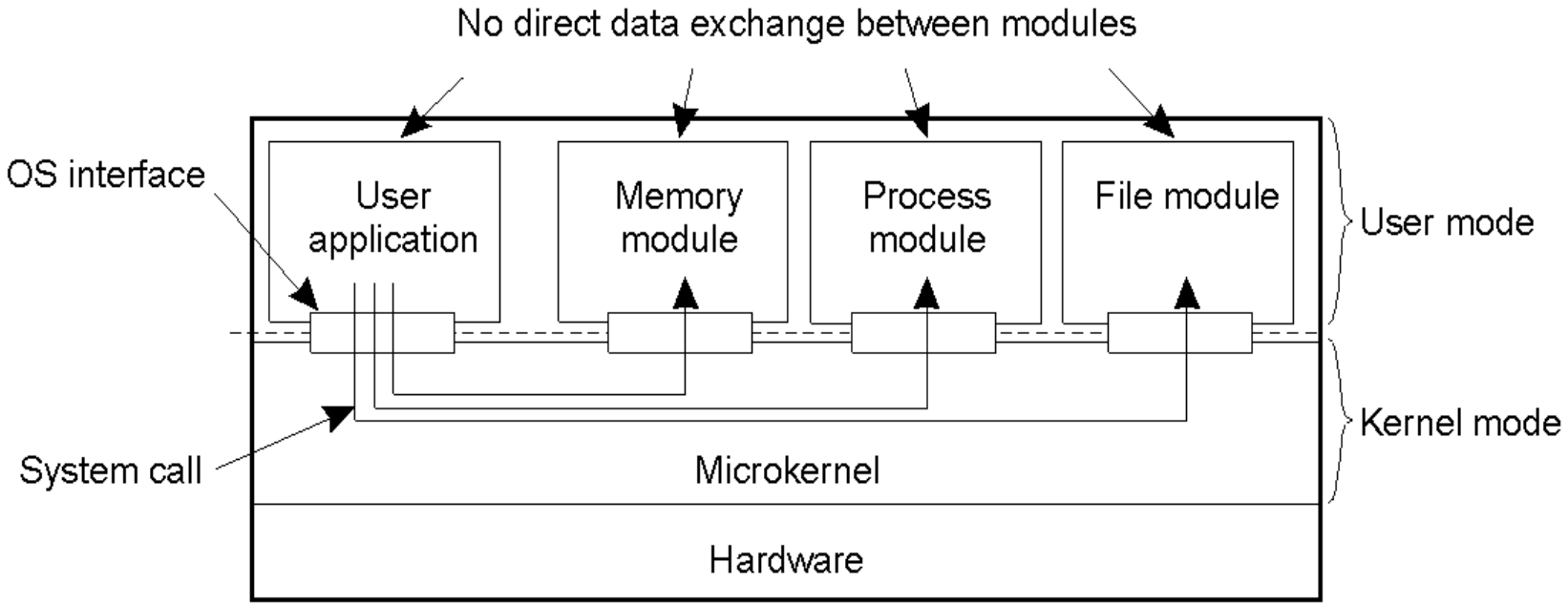
- Make a copy of information to increase availability and decrease centralized load.
  - Example: P2P networks (Gnutella +) distribute copies uniformly or in proportion to use.
  - Example: CDNs (Akamai)
  - Example: Caching is a replication decision made by client.
- Issue: Consistency of replicated information
  - Example: Web Browser cache

Software Concepts

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

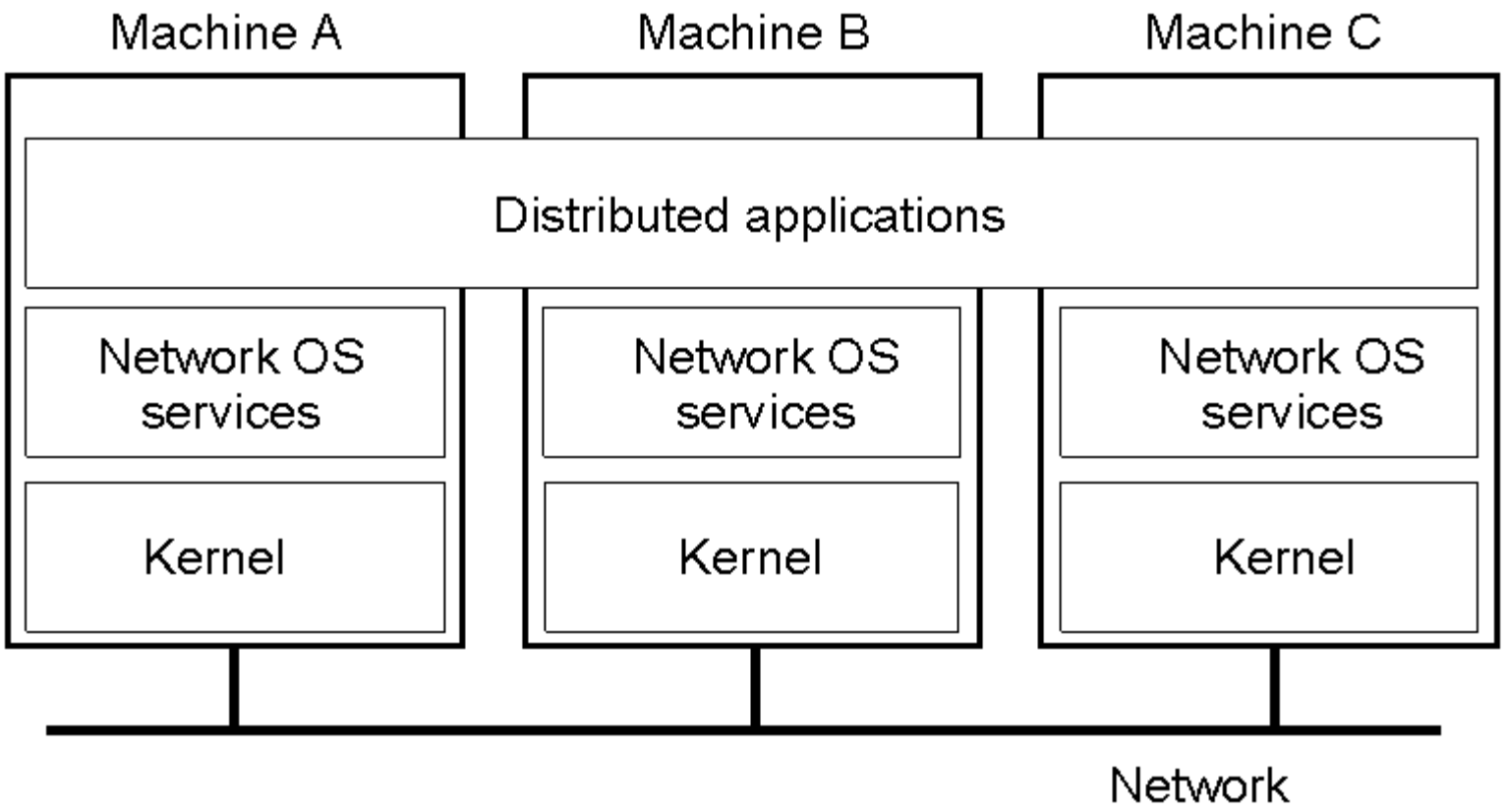
System	Description	Main Goal
DOS	Tightly-coupled operating system for multi-processors and homogeneous multicomputers	Hide and manage hardware resources
NOS	Loosely-coupled operating system for heterogeneous multicomputers (LAN and WAN)	Offer local services to remote clients
Middleware	Additional layer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

Uniprocessor Operating Systems



- Separating applications from operating system code through a microkernel
  - Can extend to multiple computers

Network Operating System

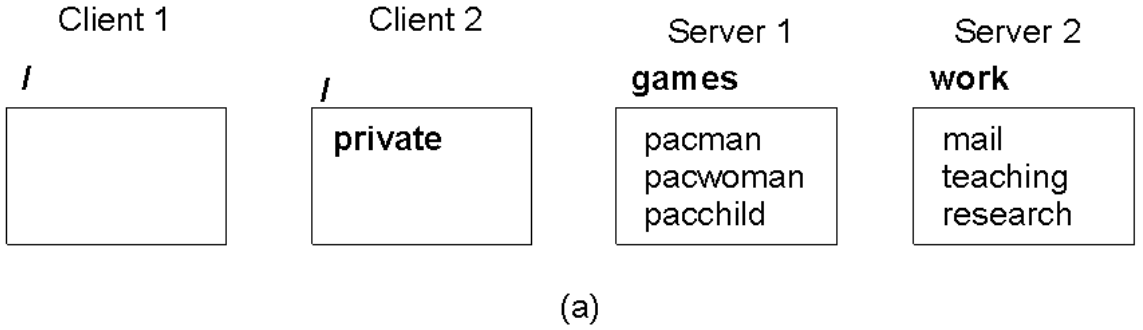


- OSes can be different (Windows or Linux)
- Typical services: rlogin, rcp
  - Fairly primitive way to share files

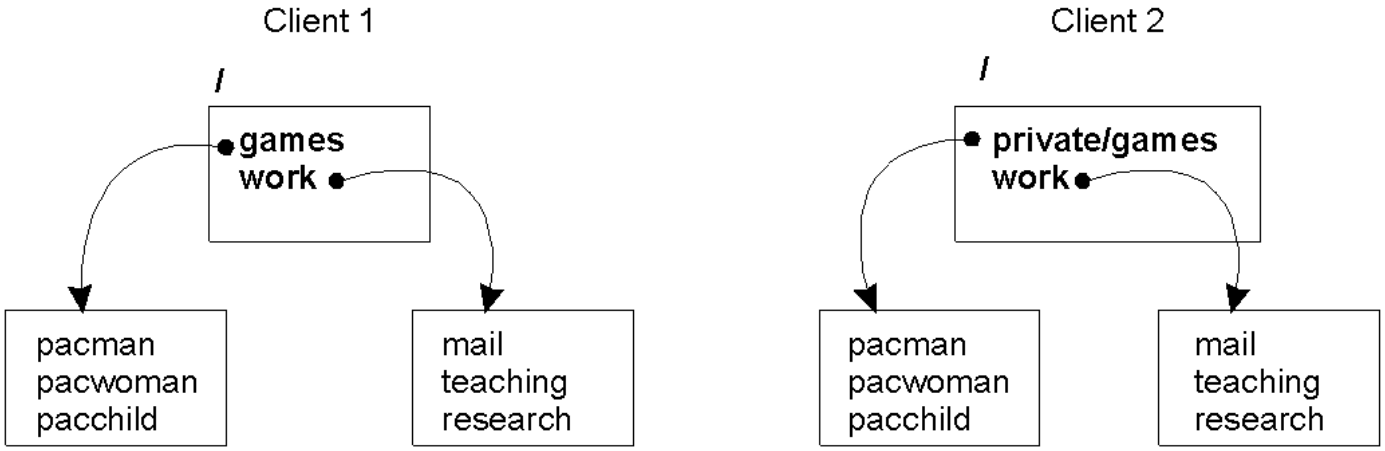
Network Operating System

- Can have one computer provide files transparently for others (NFS)
  - (try a "`df`" on the WPI hosts to see. Similar to a "mount network drive" in Windows)

Network Operating System



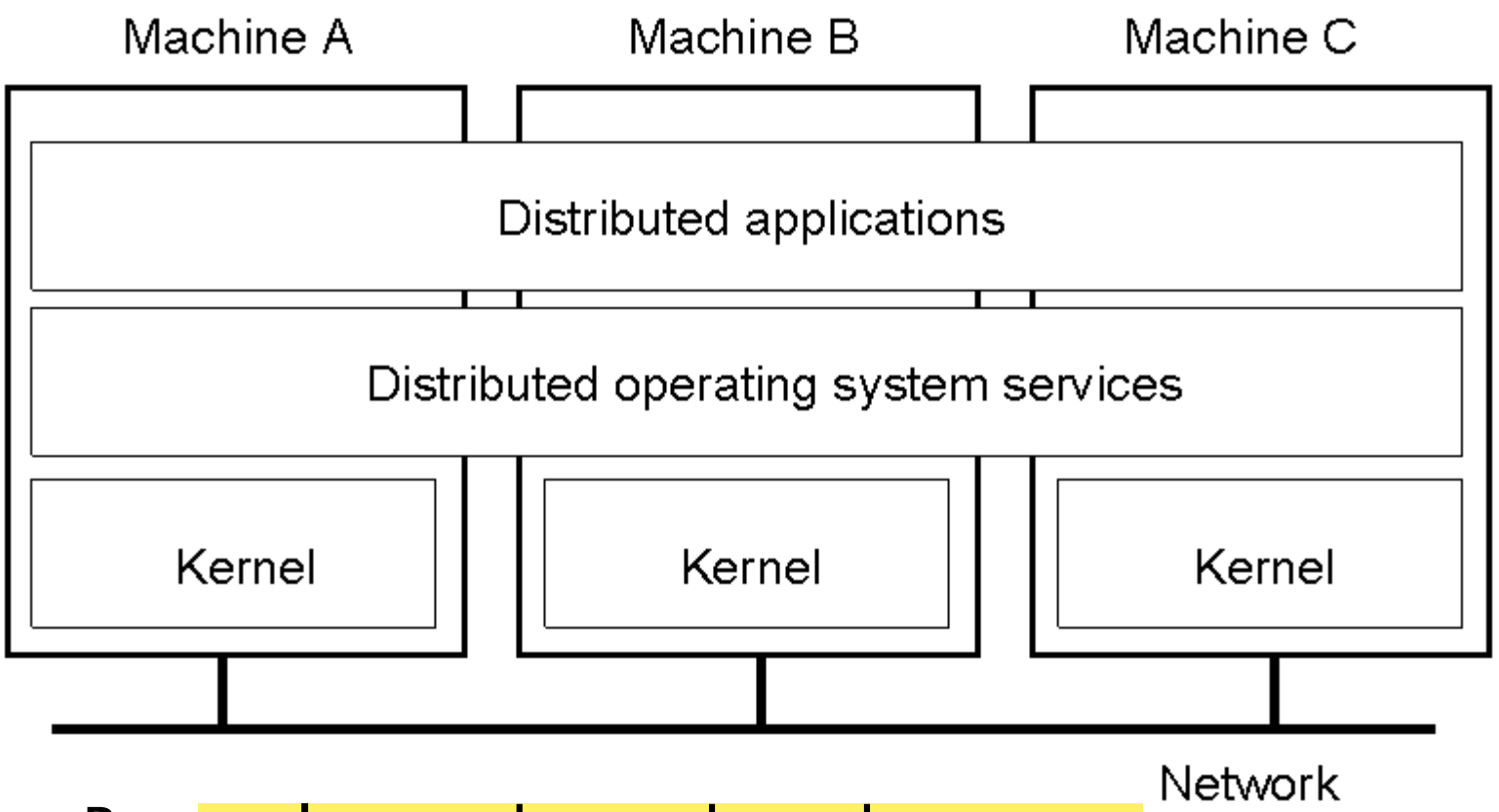
(a)



(b) (c)

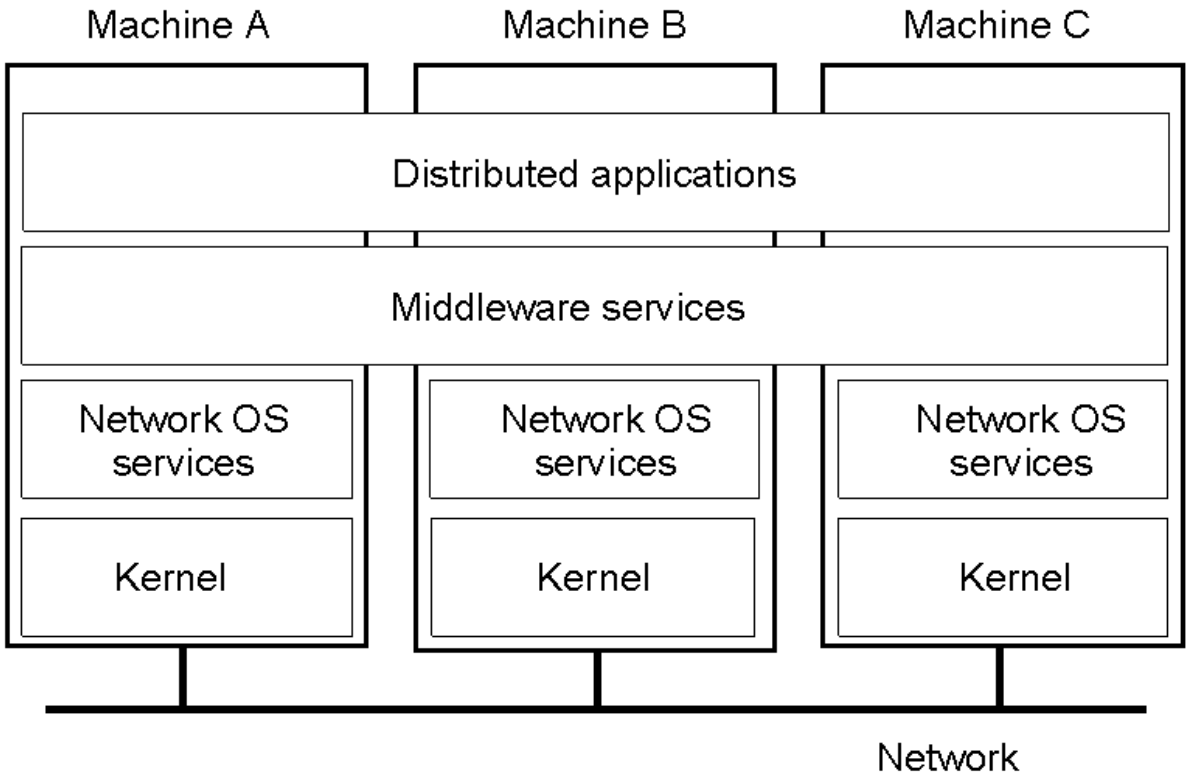
- Different clients may mount the servers in different places
- Inconsistencies in view make NOS's harder, in general for users than DOS's.
  - But easier to scale by adding computers

Distributed Operating Systems



- But no longer have shared memory
  - Provide *message passing*
  - Can try to provide *distributed shared memory*
    - But tough to get acceptable performance

Distributed System as Middleware



Positioning Middleware

- Network OS's are not transparent.
- Distributed OS's are not independent of computers.
- Middleware can help.

Middleware Models

- View everything as a file - *Plan 9.*
- Less strict – *distributed file systems.*
- Make all procedure calls appear to be local – *Remote Procedure Calls (RPC).*
- *Distributed objects (oo model).*
- The Web – *distributed documents.*

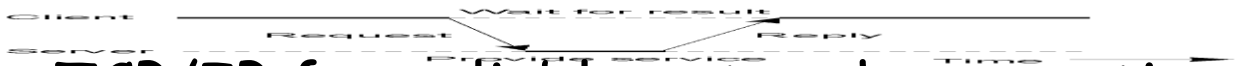
Middleware and Openness

- 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.
  - If different, there will be compatibility issues
  - If incomplete, then users will build their own or use lower-layer services (frowned upon)

Comparison between Systems

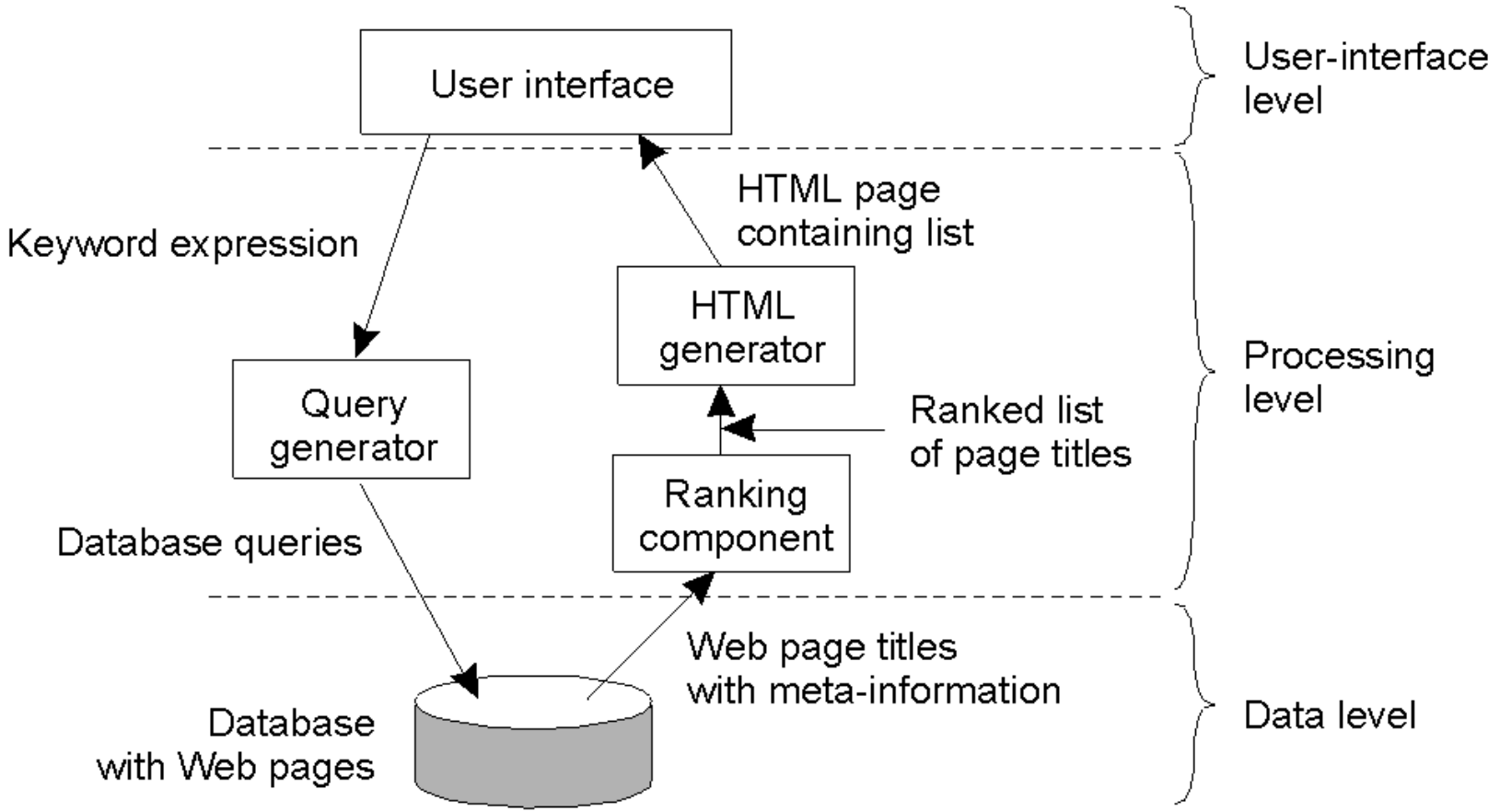
Item	Distributed OS		Network OS	Middleware -based OS
	Multiproc.	Multicomp.		
Degree of transparency	Very High	High	Low	High
Same OS on all nodes	Yes	Yes	No	No
Number of copies of OS	1	N	N	N
Basis for communication	Shared memory	Messages	Files	Model specific
Resource management	Global, central	Global,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

Client-Server Model

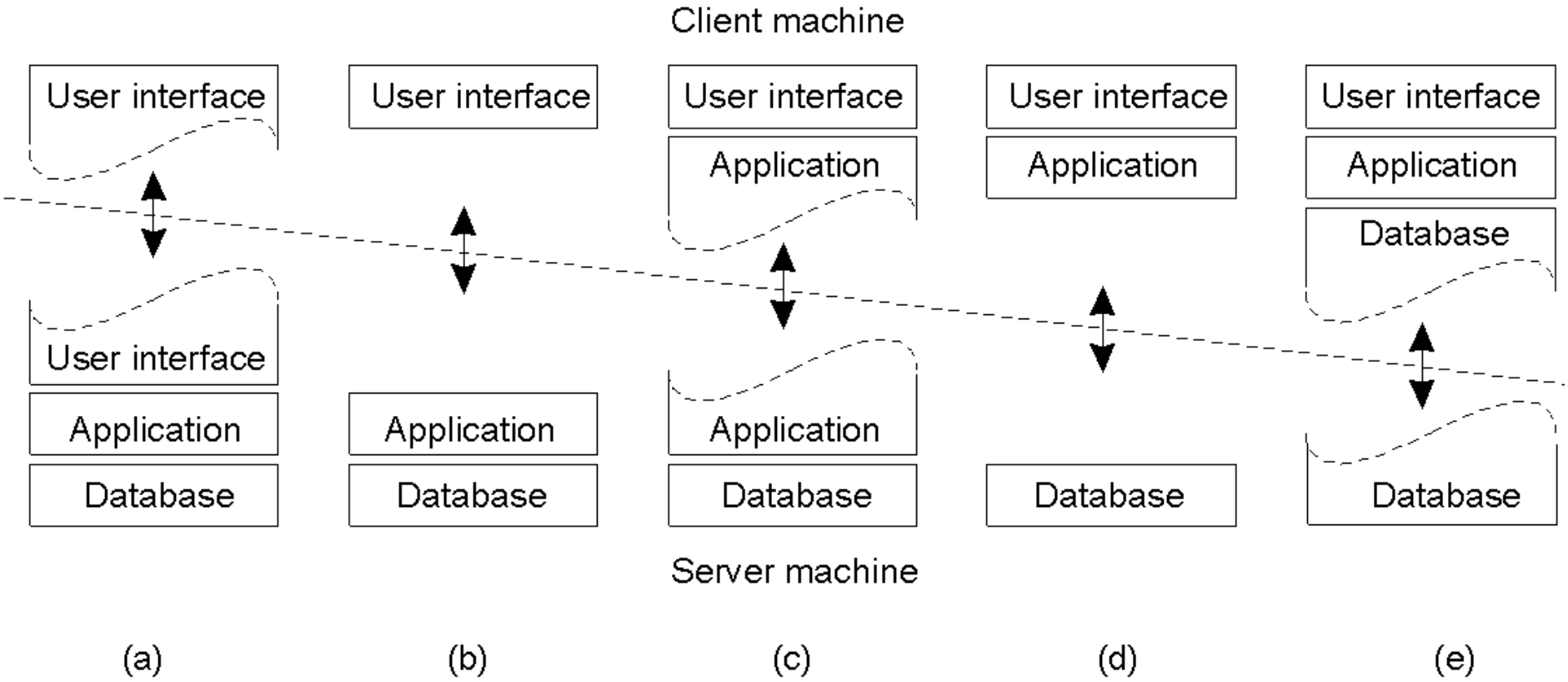


- Use TCP/IP for reliable network connection.
  - This implies the client must establish a connection before sending the first request.

Internet Search Engine

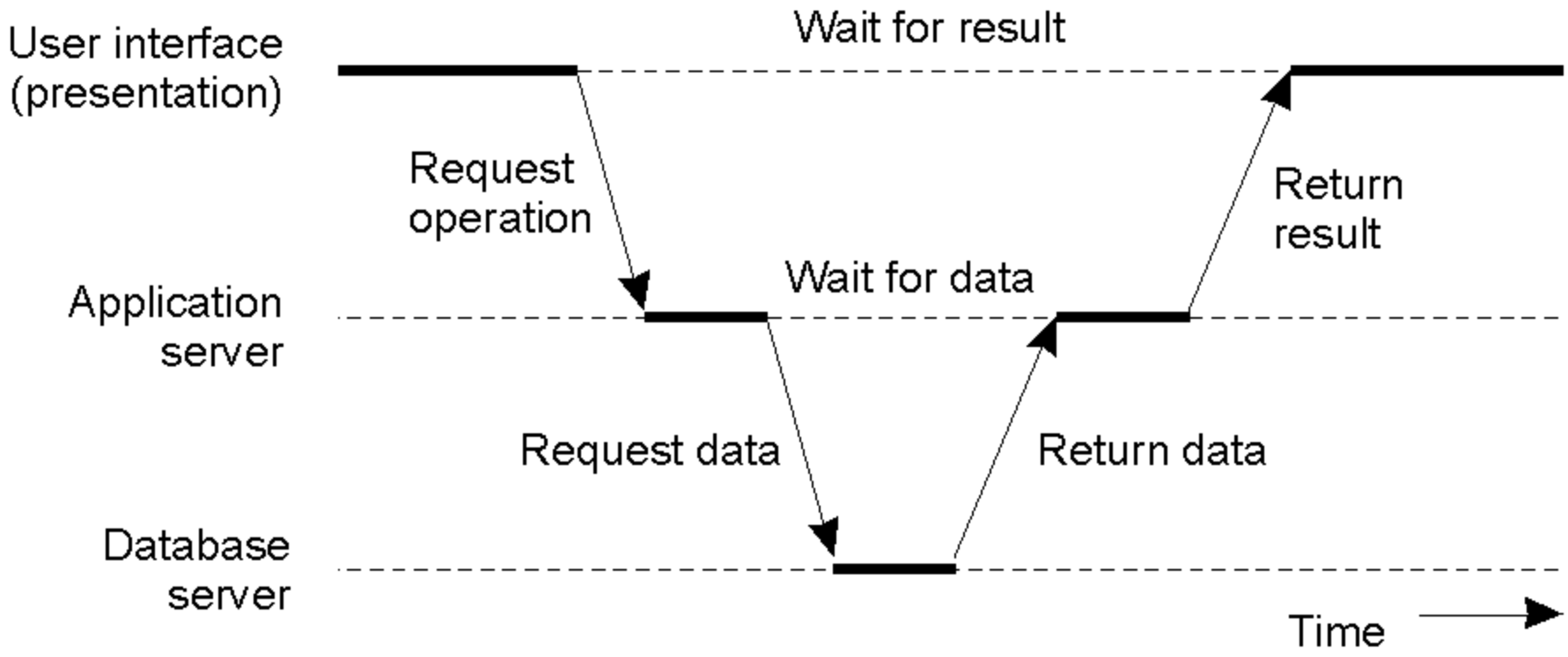


Multitiered Architectures



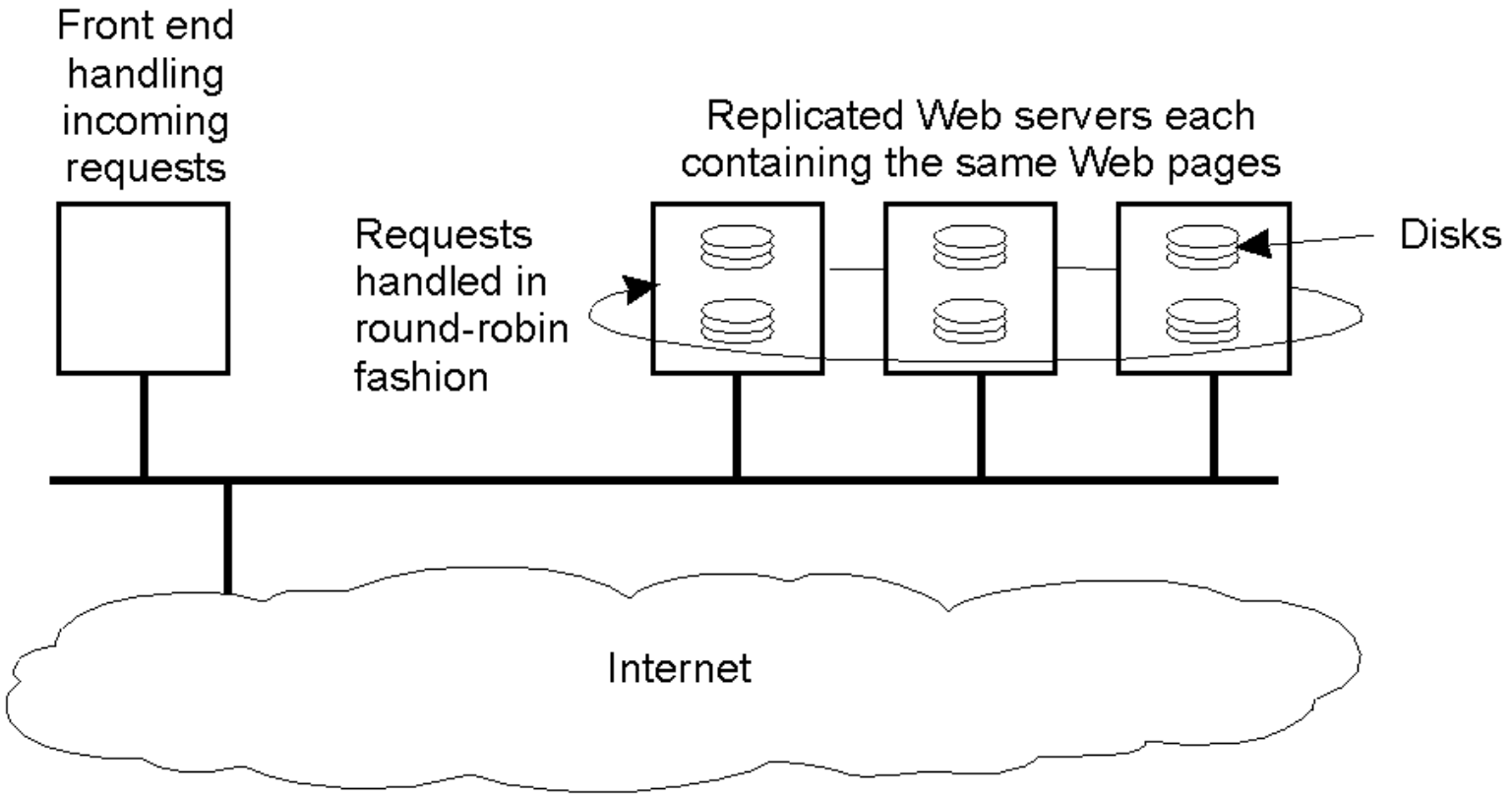
- Thin client (a) to Fat client (e)
  - (d) and (e) popular for NOS environments

Multitiered Architectures: 3 tiers



- Server may act as a client
  - Example would be transaction monitor across multiple databases

Horizontal Distribution



- Distribute servers across nodes
  - E.g., Web server "farm" for load balancing
- Distribute clients in peer-to-peer systems.