Distributed Systems & Network Principles

Architecture

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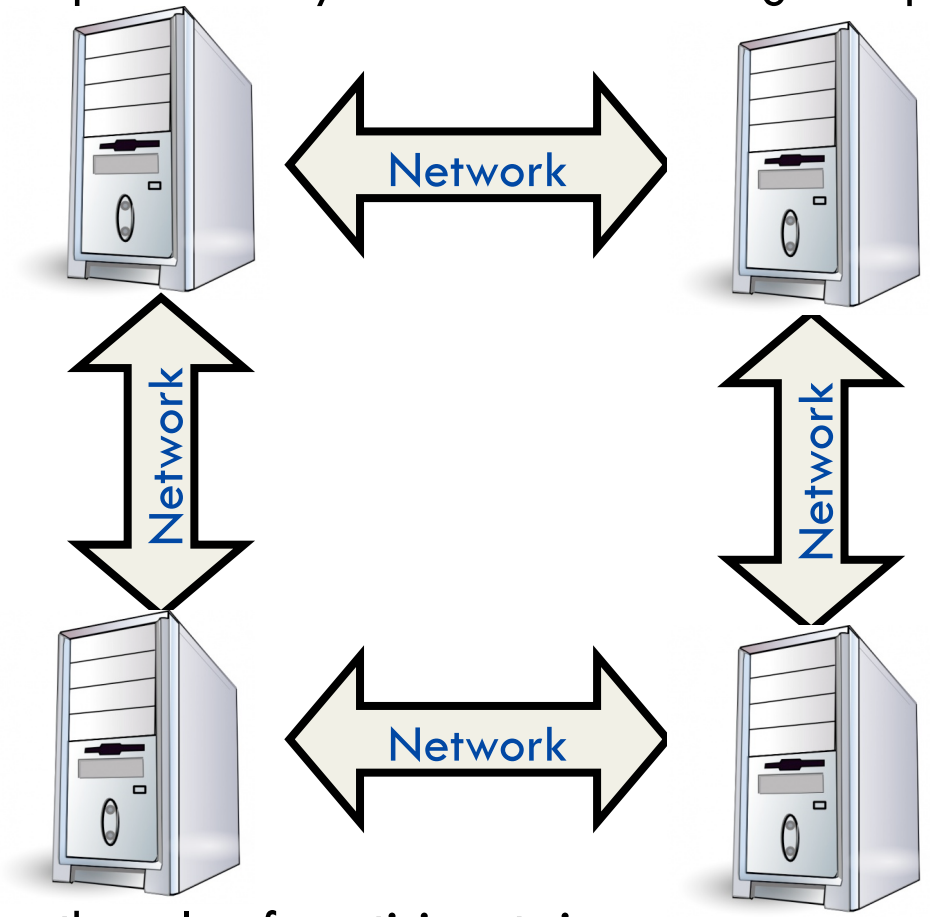
Introduction

Previously: diverse components may be involved in a single request



- Now: let's focus on the role of participants in a communication

Outline

- Software Architecture
- The Client-Server Model
- The Layered Organization
- The Peer-to-Peer Organization
- Distributed Operating Systems

Software Architecture

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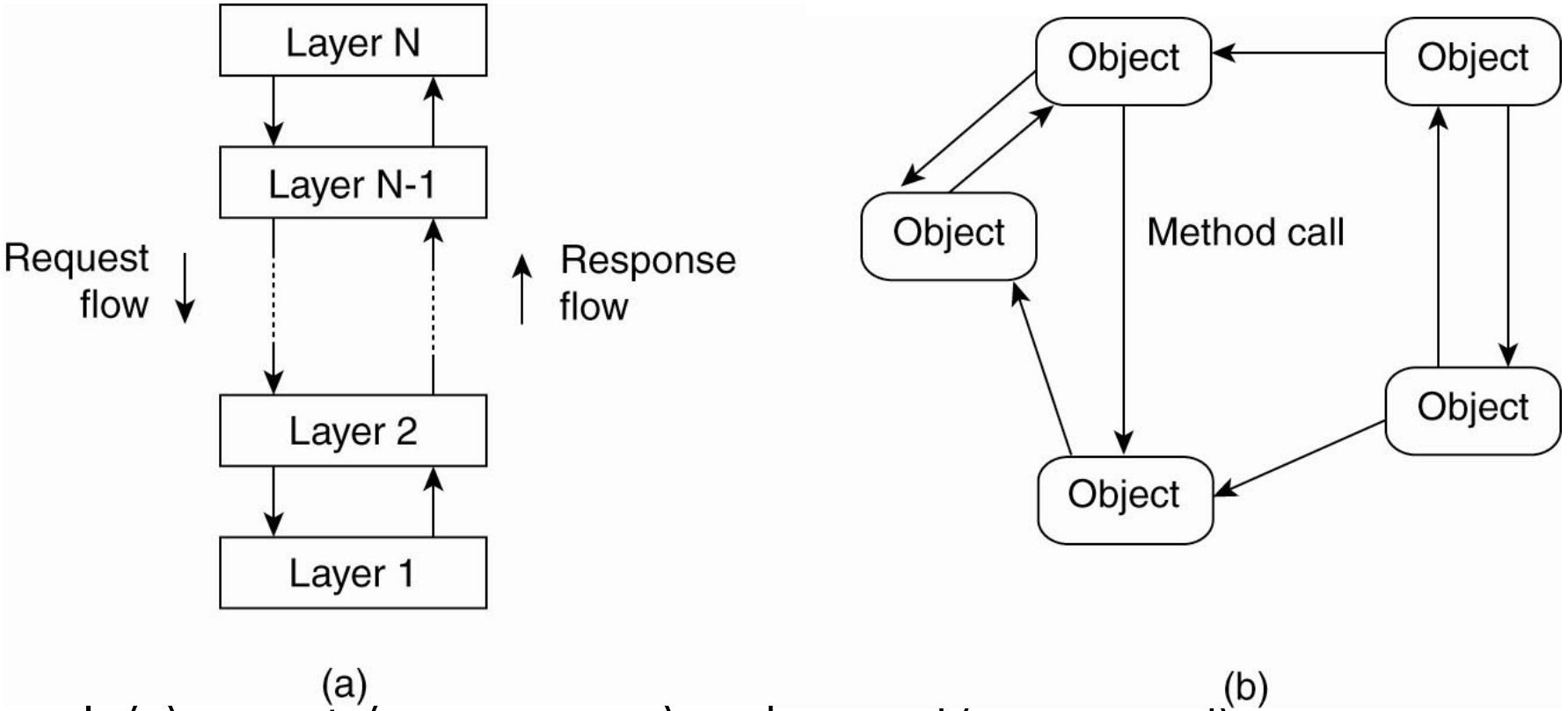
Component organization

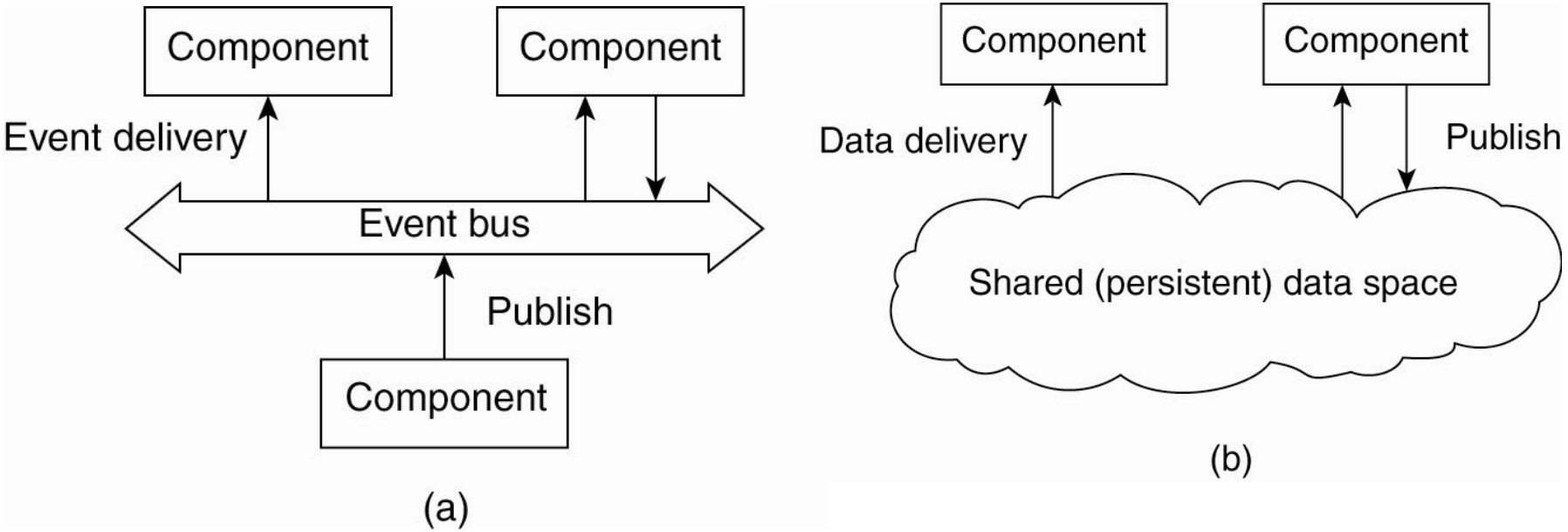
Layer-based architecture (a) vs. object-based architecture (b)



- In (a), requests (resp. responses) go downward (resp. upward)
- In (b), objects communicate through Remote Procedure Calls (RPCs)

Communication organization

Communication through events or shared repository



- (a) Event-based architecture: communication through events, that optionally carry data (subscribers get their desired events delivered)
- (b) Data-centered architecture: through a shared repository, that contains data (e.g., files in a distributed file system)

The Client-Server Model

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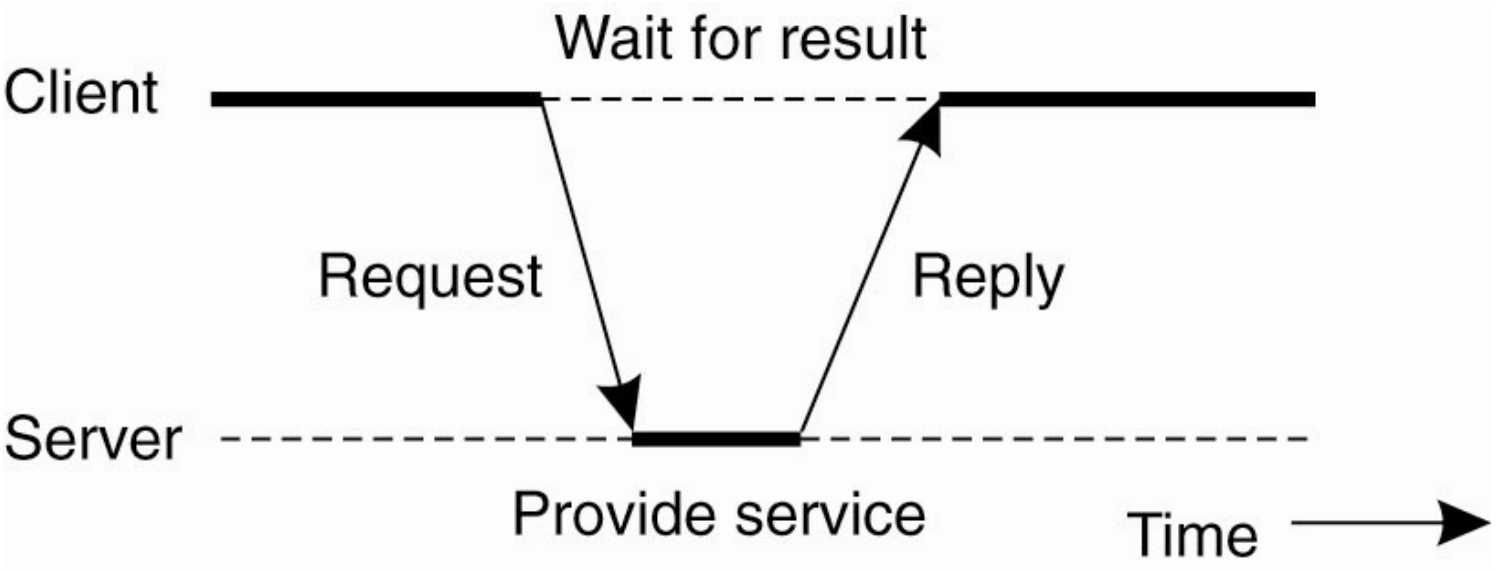
The client server model

The basic client-server model

- The client requests the service whereas the server provides the service
- The client and the server can be hosted on different machines.

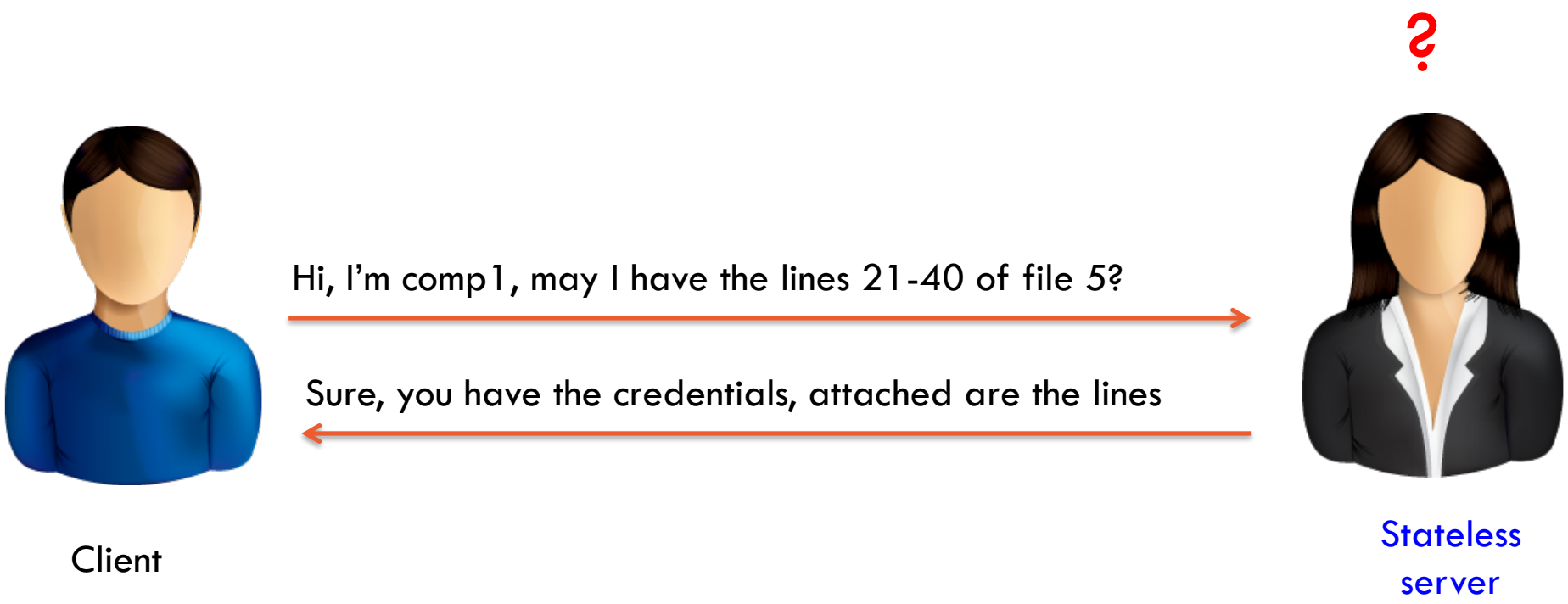


- The communication follows a request-reply model.

The client server model

Stateless vs stateful server

› Stateless server: does not record the state of its clients



The client server model

Stateless vs stateful server

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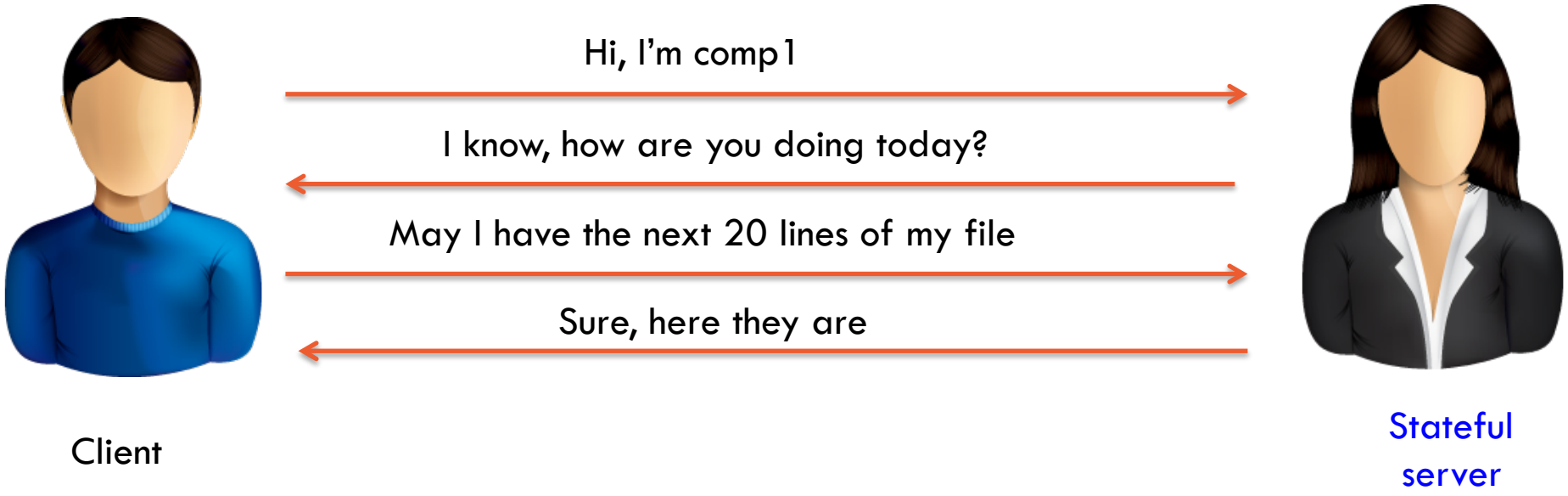
- Stateful server: maintains persistent information about its clients (client->file)



The client server model

Stateless vs stateful server

- Stateless server: does not record the state of its clients
- Stateful server: maintains persistent information about its clients (client->file)

	Stateless server	Stateful server
State	No info kept	Persistent info
Request	Self-contained	Can be split, generally faster
Upon failure	No recovery needed	State recovery needed (explicit deletion)
Example	Network file system (NFSv3)	Andrew file system (AFS)

The Layered Organization

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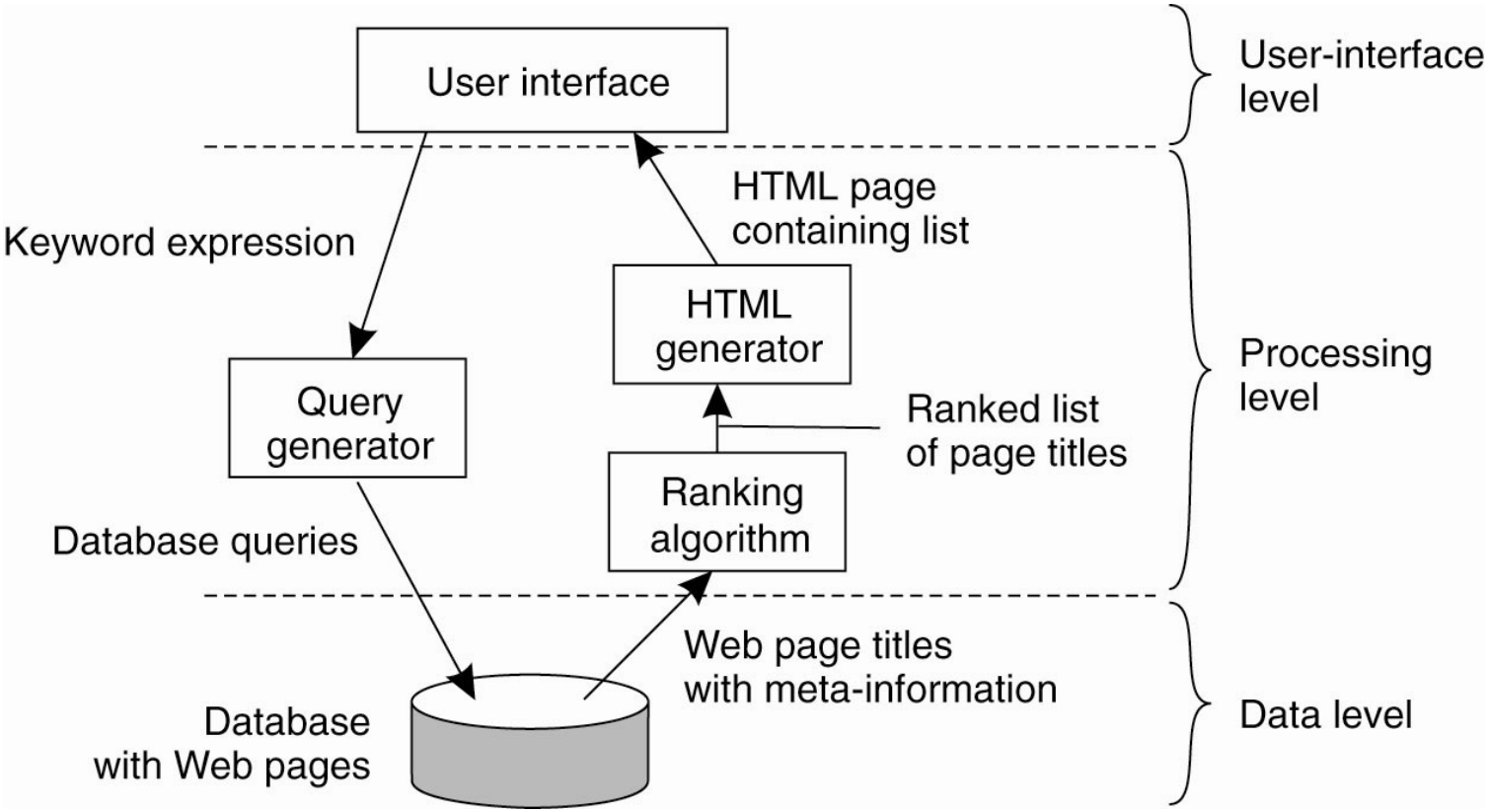
Application layering

Traditional three-layered view:

- The user interface layer: contains the feature to control the application
- The processing layer: contains the function of the application
- The data layer: contains the data of the application

Application layering (cont'd)

Example: a search engine request spanning the traditional three layers



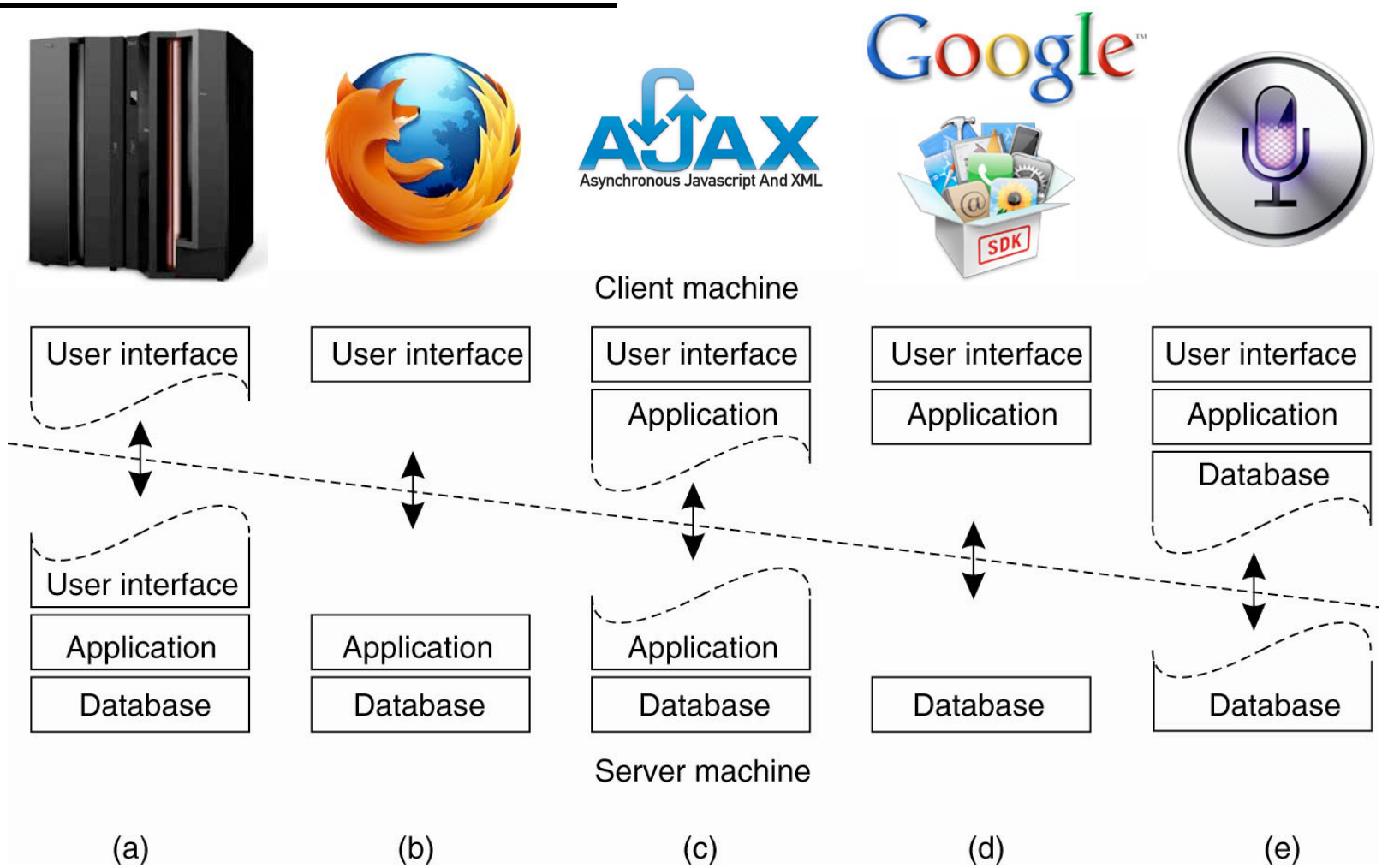
Application layering (cont'd)

Hosting different layers on different machines

- Three-tiered architecture:
  - each layer on separate machine
- Two-tiered architecture:
  - client
  - single server configuration
- Single-tiered architecture:
  - dumb terminal
  - mainframe configuration

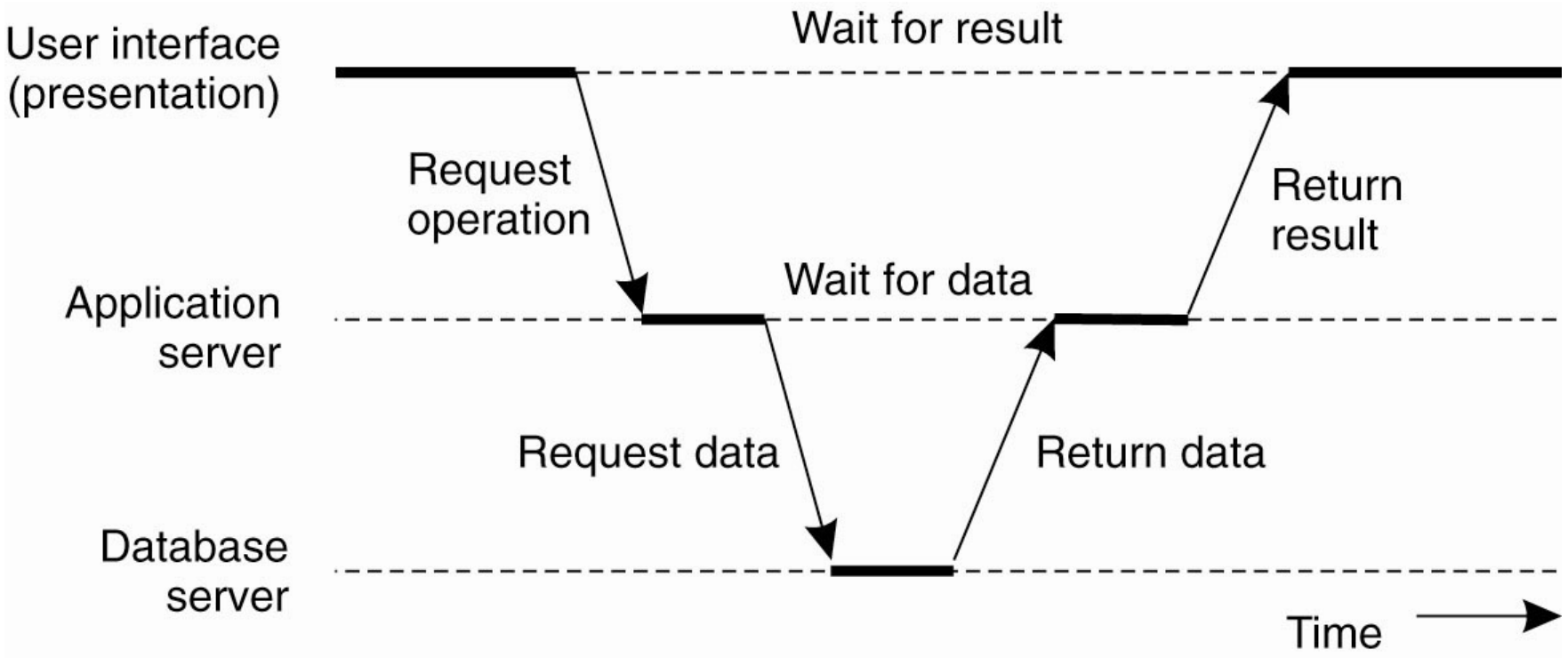
Multi-tiered architectures

Physical two-tiered architecture



Multi-tiered architectures (cont'd)

A single machine can act both as a client and a server



Multi-tiered architectures (cont'd)

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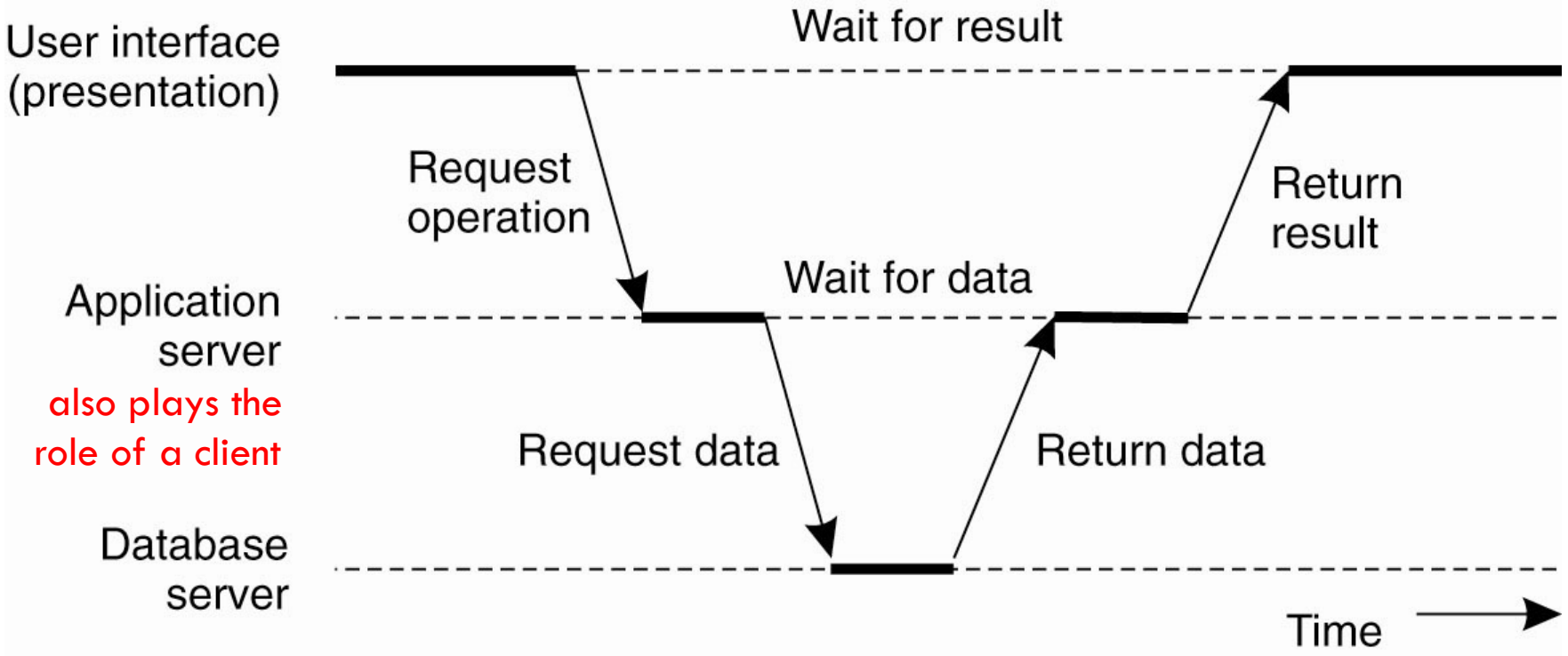

Multi-tiered architectures (cont'd)

Example: Cloud computing

amazon.com

- *Cloud computing*: the delivery of computation or storage as a service to end-users.

Multi-tiered architectures (cont'd)

Example: Cloud computing

amazon.com

- The client hosts the user interface to launch the computation and prints the results
- The servers handle most of the computation upon request and sends back the results to the client
  - One server asks data to another server
  - Another does the computation

The Peer-to-Peer Organization

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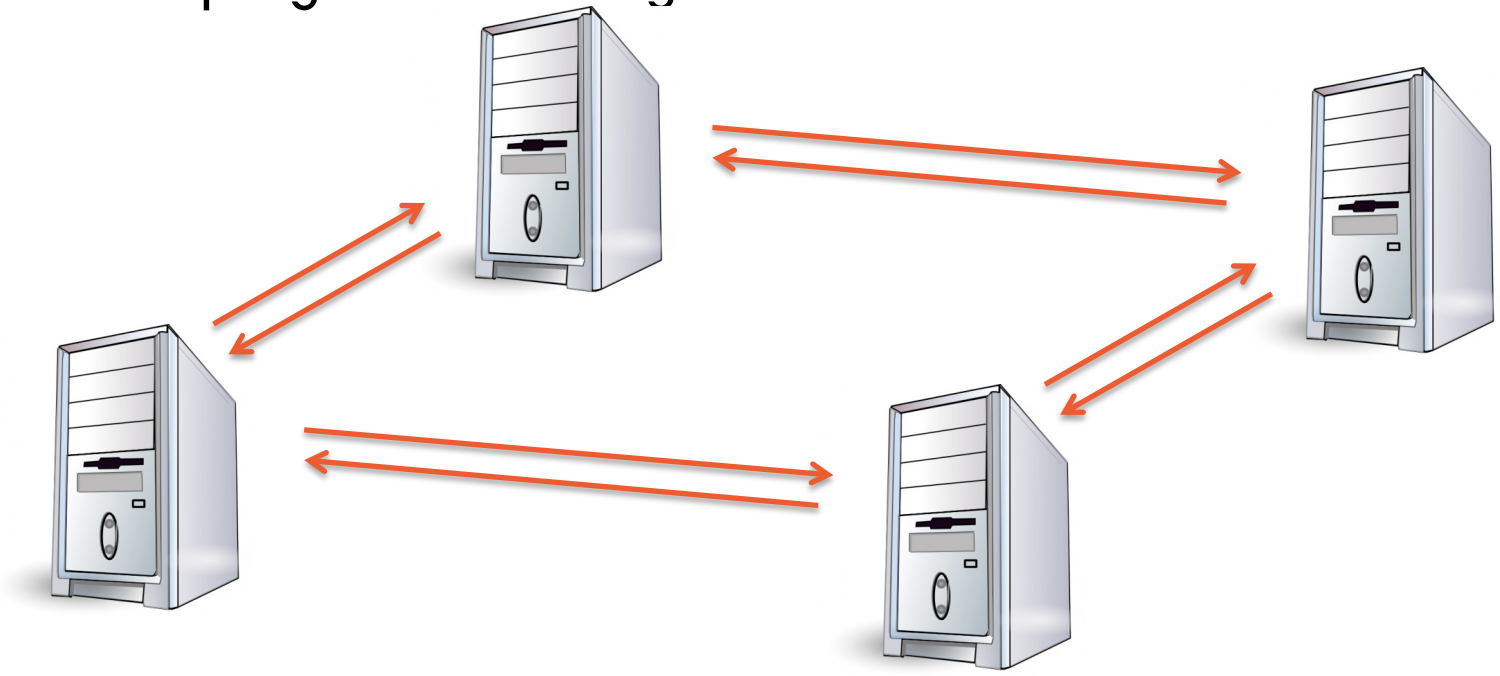
The peer-to-peer model

Every machine acts similarly

- Every machine is both a client and a server
- No centralized control: the responsibility is distributed evenly
- Even the program executing on each machine is similar

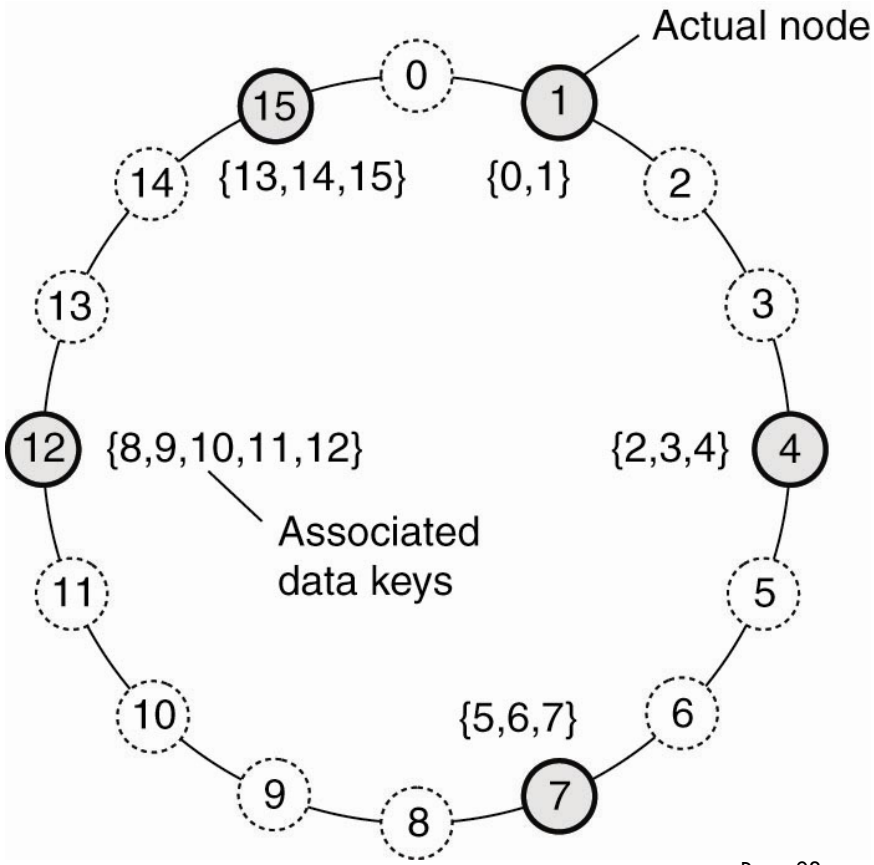


The peer-to-peer model (cont'd)

Example 1: Chord is an example of a Distributed Hash Table (DHT)

As a node:

- I have a successor peer
- I have a predecessor peer
- I have some shortcuts to other nodes to speedup delivery of requests
- I am responsible of a subset of the system data items (based on my unique identifier)

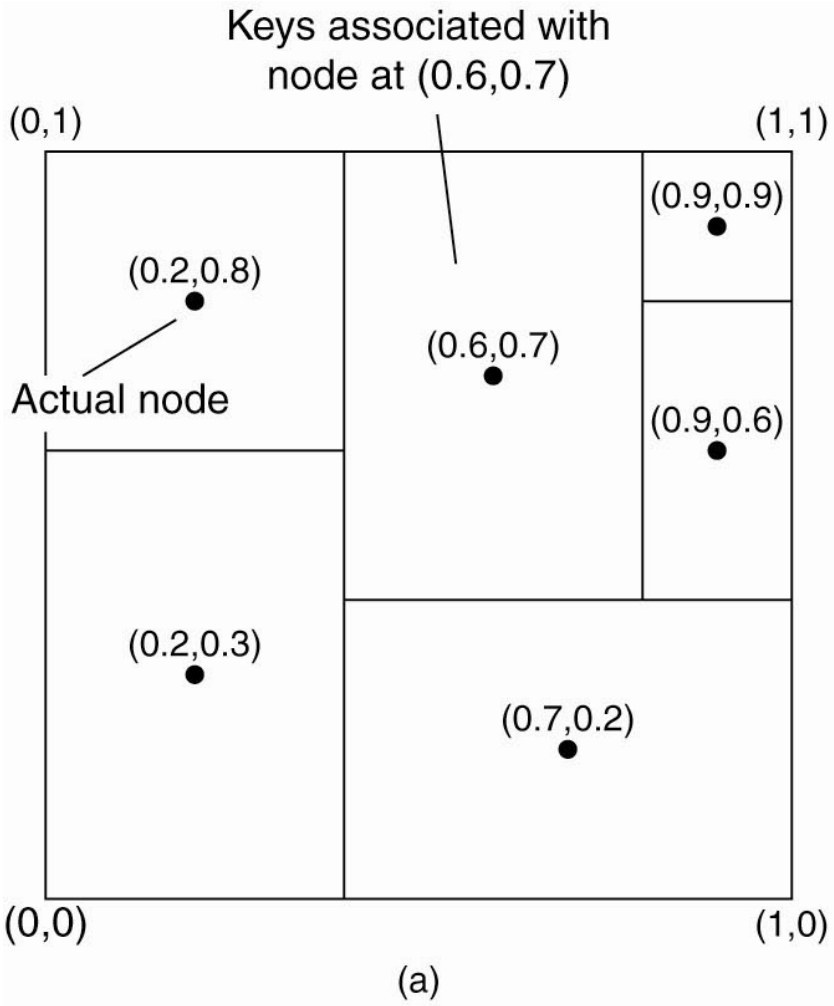


The peer-to-peer model (cont'd)

Example 2: CAN (Content Adressable Network), another DHT

As a node:

- I am responsible of a region of the system (based on my unique identifier)
- I have few neighbors, the nodes with adjacent regions, with which I can communicate



The peer-to-peer model (cont'd)

Example 3: BitTorrent, a file sharing application

- 20% of European internet traffic in 2012.
- Used for Linux distribution, software patches, distributing r
- Goal: quickly replicate large files to large number of clients

- Web server hosts a .torrent file (w/ file length, hash, tracker's URL…)
- A tracker (server or a DHT) tracks downloaders/owners of a file
- Files are divided into chunks (256kb-1MB)
- Downloaders download chunks from themselves (and owners)
- Tit-for-tat: the more one shares (server), the faster it can download (client)

Distributed Operating Systems

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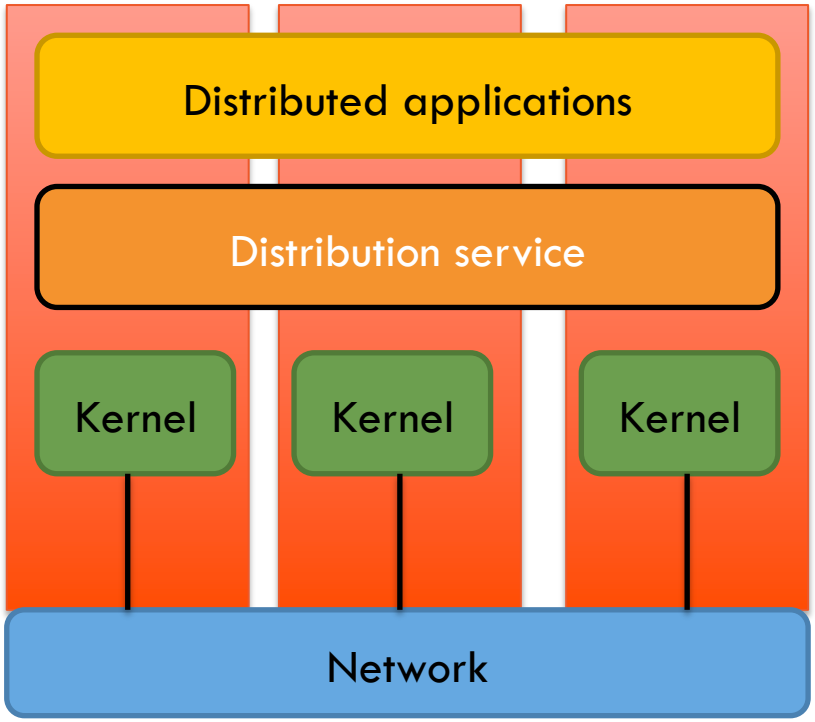
Distributed operating systems

Distributed operating system

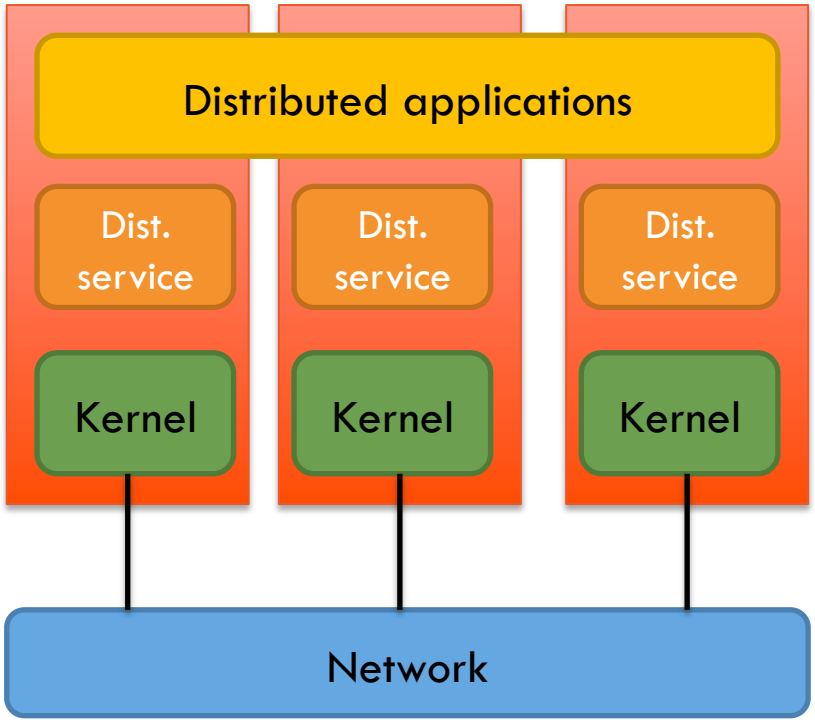
- This is a single system image, the system maintains a single copy of the resources



Distributed operating systems (con't)

Network operating system

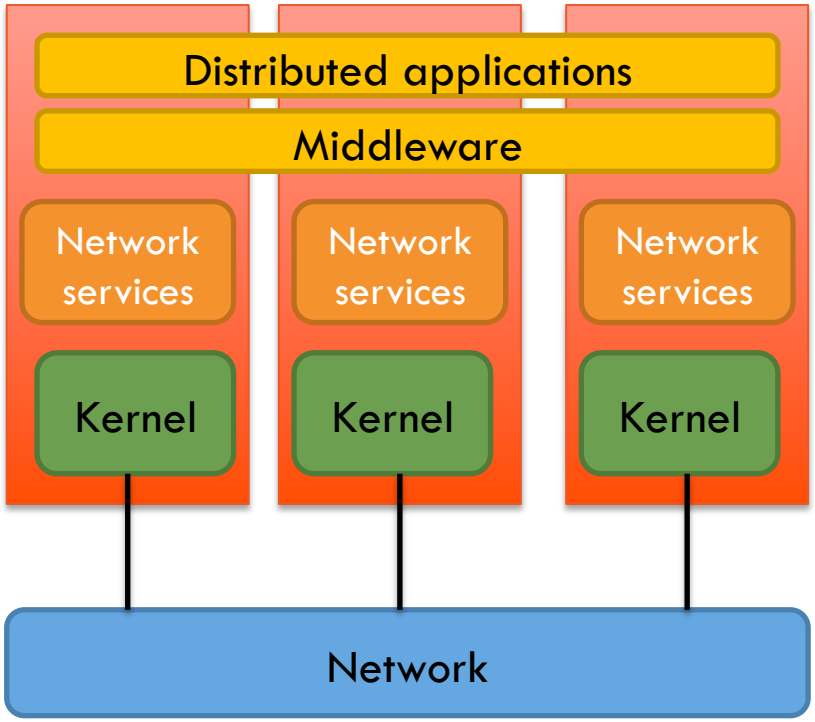
- Machines provide resources to other machines (e.g., UNIX rlogin)
- The OS can vary from one machine to another, essentially file sharing



Distributed operating systems (con't)

Middleware

- A layer over the network services providing general services to applications in a very transparent manner (systems can differ)



Conclusion

- Client and server are used to identify the role of communication participant

- Client and server roles may run on:
  - The same machine
  - Distinct machines with very different resources
  - Distinct machines with similar resources

- In operating systems, applications may run on top of a single distributed operating system, of network operating systems (multiple OSes), or a middleware (multiple OSes looking like a single OS).