Distributed Systems

课程群

- **Textbook**

  Andrew S. Tanenbaum and Maarten van Steen, *Distributed Systems: Principles and Paradigms, 2nd edition*, Prentice Hall, 2007.

- **Reference**

  George Coulouris etc., *Distributed Systems: Concepts and Design, 4th edition*, Addison-Wesley, 2005.

- **Scores**

  Final Exam (70%) + Projects (30%)

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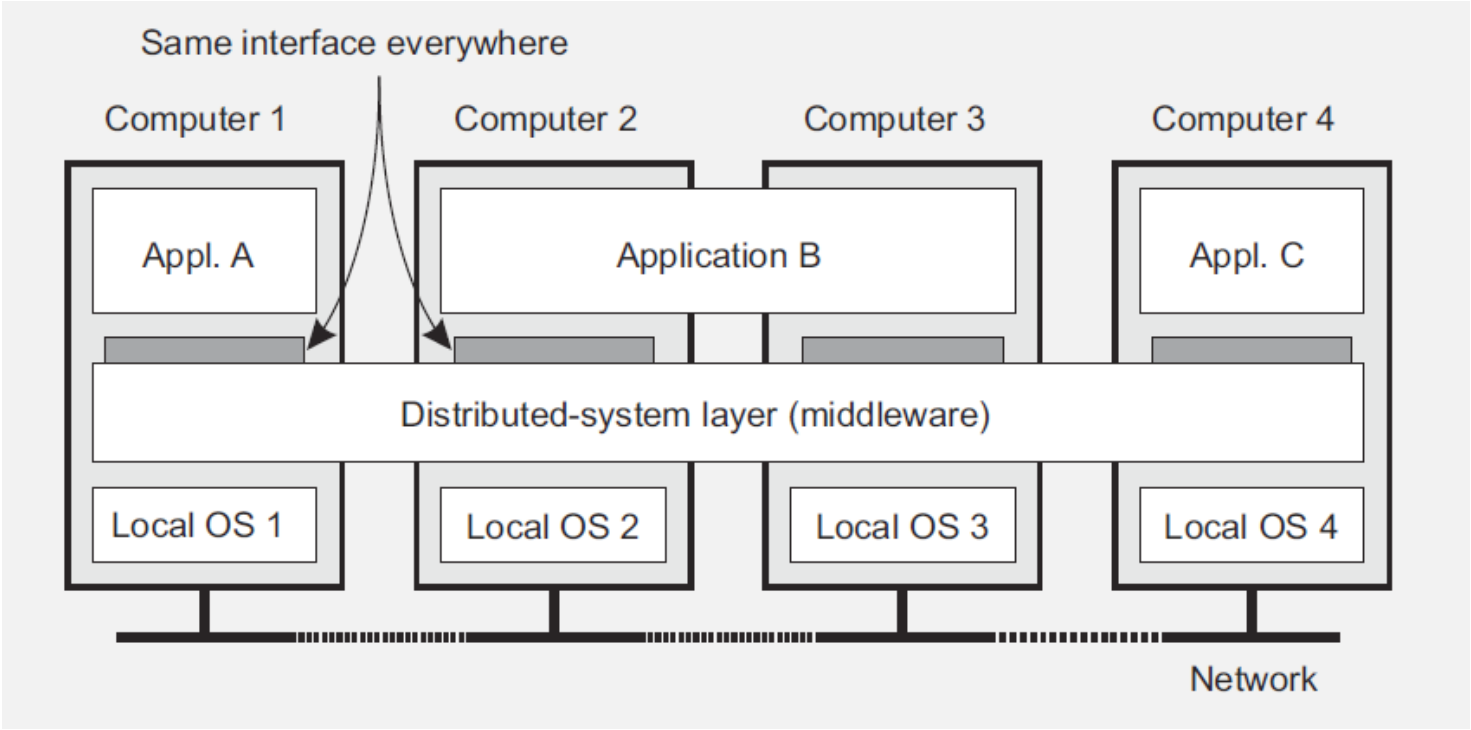
- Research: distributed system, networking
  - Cloud-edge computing/intelligence
  - Next generation networking and distributed system
  - Distributed learning

Introduction

Distributed Systems [1]

Distributed Systems: Definition

- A distributed system is a collection of *autonomous computing elements* that appears to its users as a *single coherent system*.



Examples

- A network of workstations allocated to users
- A pool of processors in the machine room allocated dynamically
- A single file system (all users access files with the same path name)
- User command executed in the best place (user workstation, a workstation belonging to someone else, or on an unassigned processor in the machine room)

Technology advances

- Networking
- Processors
- Memory
- Storage
- Protocol

Why Distributed?

Economics	Microprocessors offer a better price/ performance than mainframes
Speed	A distributed system may have more total computing power than a mainframe
Inherent distribution	Some applications involve spatially separated machines
Reliability	If one machine crashes, the system as a whole can still survive
Incremental growth	Computing power can be added in small increments

People are distributed

Goals of Distributed Systems

- Making resources available
- Distribution transparency
- Openness
- Scalability

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

Distribution transparency is a nice goal, but achieving it is a different story.

Degree of Transparency

- Aiming at full distribution transparency may be too much:
  - Users may be located in different continents
  - Completely hiding failures of networks and nodes is (theoretically and practically) impossible
    - You cannot distinguish a slow computer from a failing one
    - You can never be sure that a server actually performed an operation before a crash
  - Full transparency will cost performance, exposing distribution of the system
    - Keeping Web caches exactly up-to-date with the master
    - Immediately flushing write operations to disk for fault tolerance

Openness of Distributed Systems

- Be able to interact with services from other open systems, irrespective of the underlying environment:
  - Systems should conform to well-defined interfaces
  - Systems should support portability of applications
  - Systems should easily interoperate

- At least make the distributed system independent from heterogeneity of the underlying environment.

Policies Versus Mechanisms (策略与机制)

- Requires support for different policies:
  - What level of consistency do we require for client-cached data?
  - Which operations do we allow downloaded code to perform?
  - Which QoS requirements do we adjust in the face of varying bandwidth?
  - What level of secrecy do we require for communication?
- Ideally, a distributed system provides only mechanisms:
  - Allow (dynamic) setting of caching policies
  - Support different levels of trust for mobile code
  - Provide adjustable QoS parameters per data stream
  - Offer different encryption algorithms

Scalability

- At least three components:
  - Number of users and/or processes (size scalability)
  - Maximum distance between nodes (geographical scalability)
  - Number of administrative domains (administrative scalability)

- Most systems account only, to a certain extent, for size scalability. The (non)solution: powerful servers. Today, the challenge lies in **geographical** and **administrative** scalability.

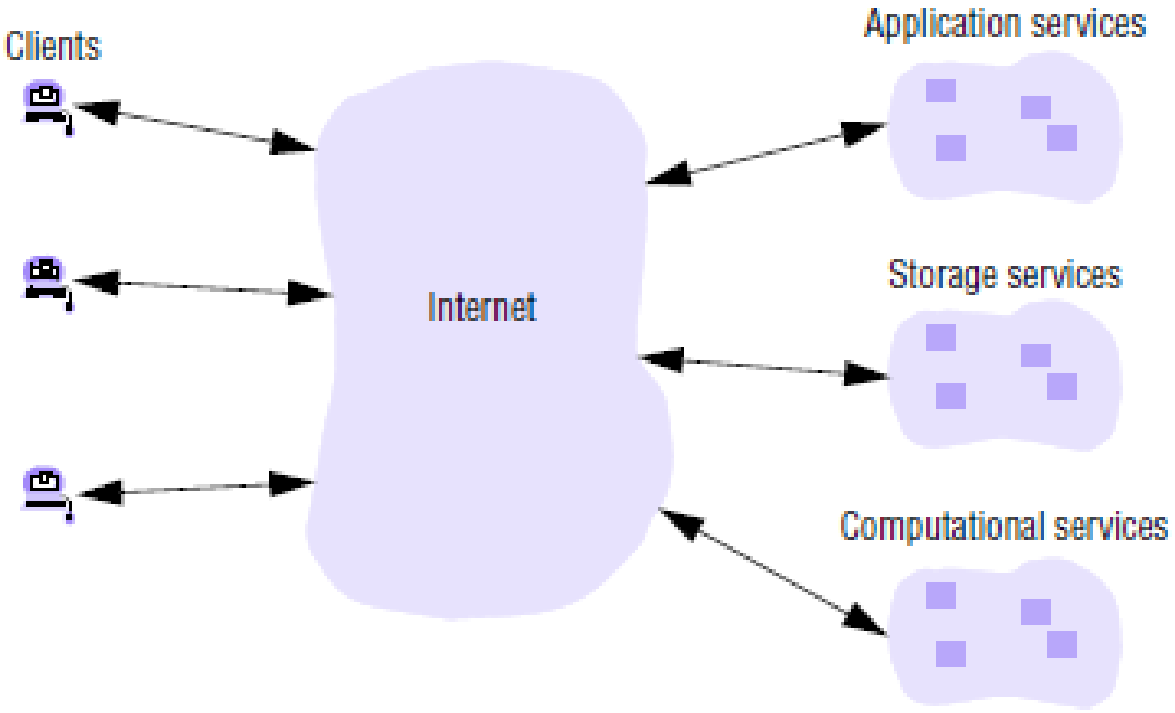
Types of Distributed Systems

- Distributed computing systems
- Distributed information systems
- Distributed pervasive systems

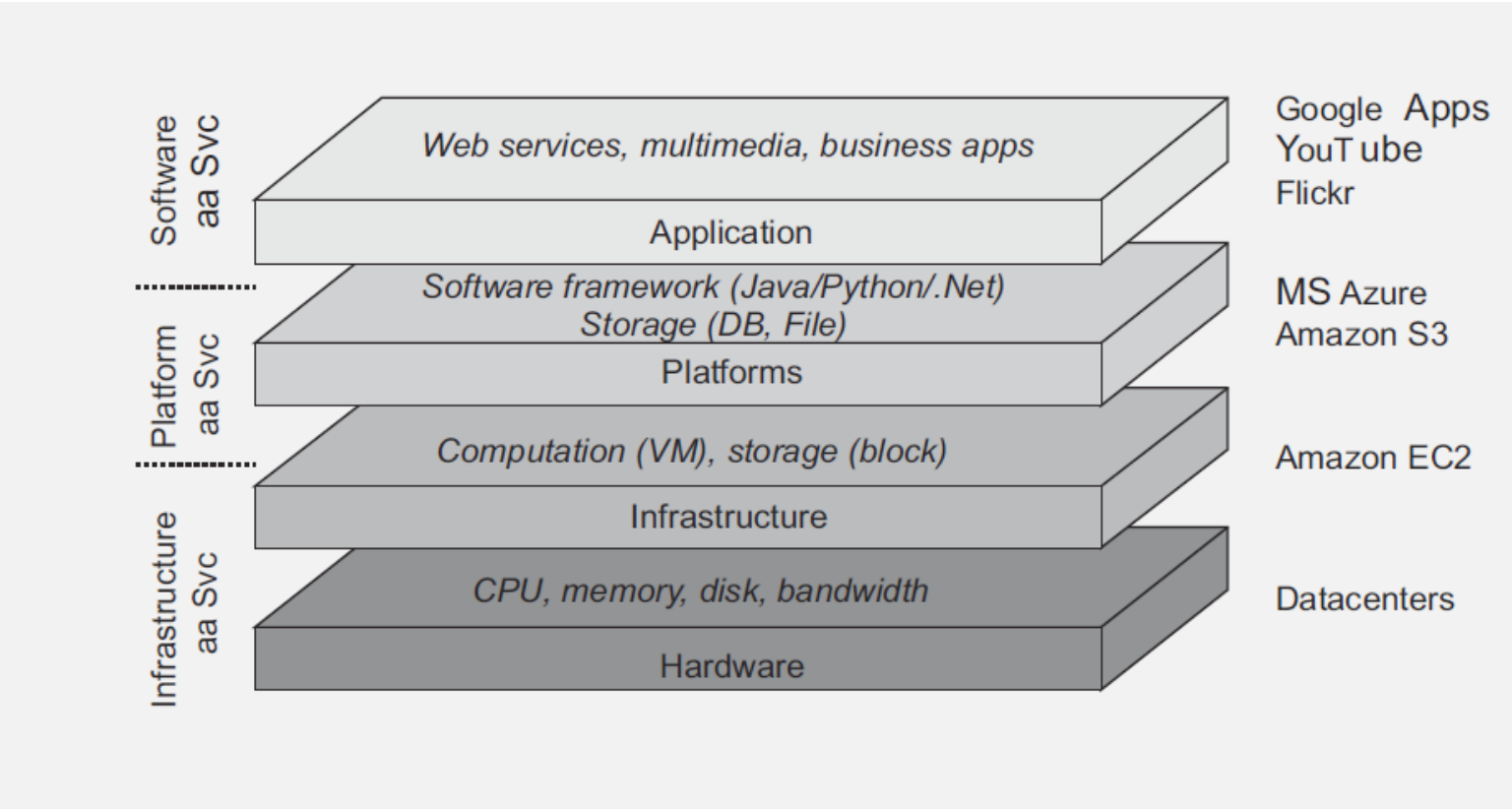
Distributed Computing Systems

- **Cluster Computing**
  - Essentially a group of high-end systems connected through a LAN:
    - Homogeneous: same OS, near-identical hardware
    - Single managing node
- **Grid Computing**
  - The next step: lots of nodes from everywhere:
    - Heterogeneous
    - Dispersed across several organizations
    - Can easily span a wide-area network

Distributed Computing Systems: Clouds



Cloud Platform

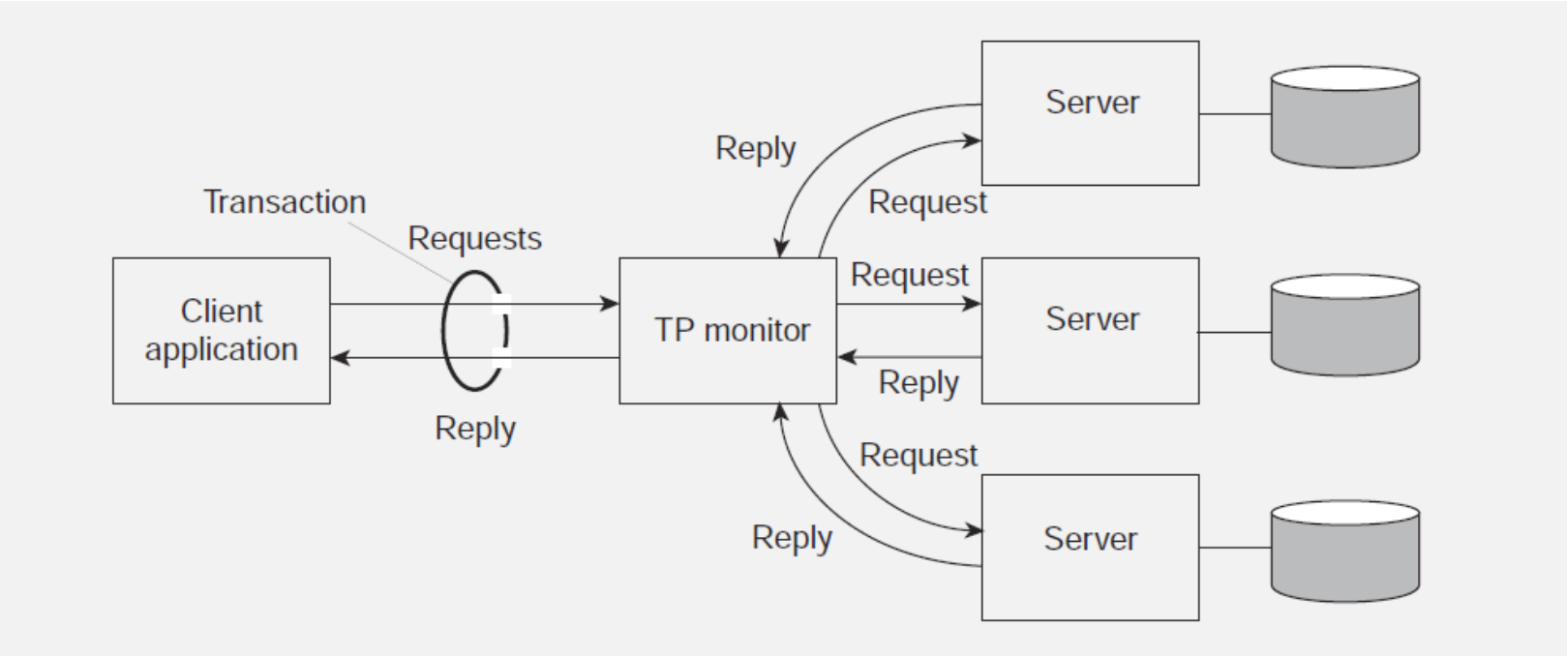


Distributed Information Systems

- The vast amount of distributed systems in use today are forms of traditional information systems, that now integrate legacy systems.
  - Example: Transaction processing systems.
- A transaction is a collection of operations on the state of an object (database, object composition, etc.) that satisfies the following properties (ACID)
  - Atomicity
  - Consistency
  - Isolation
  - Durability

Transaction Processing Monitor

- In many cases, the data involved in a transaction is distributed across several servers. A TP Monitor is responsible for coordinating the execution of a transaction.



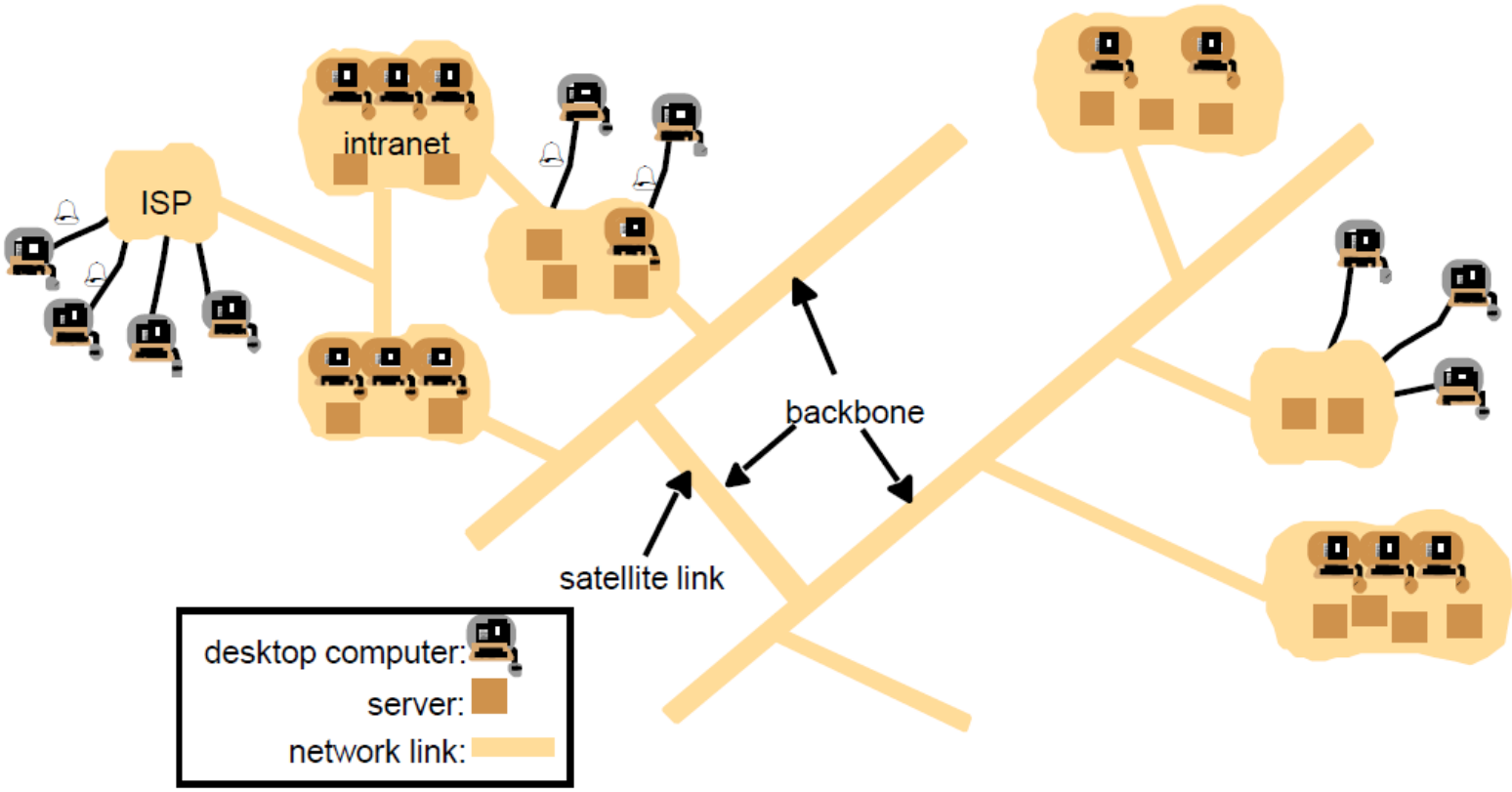
Distributed Pervasive Systems

- Emerging next-generation of distributed systems in which nodes are small, mobile, and often embedded in a larger system, characterized by the fact that the system naturally blends into the user's environment.
  - Ubiquitous computing systems
  - Mobile computing systems
  - Sensor (and actuator) networks

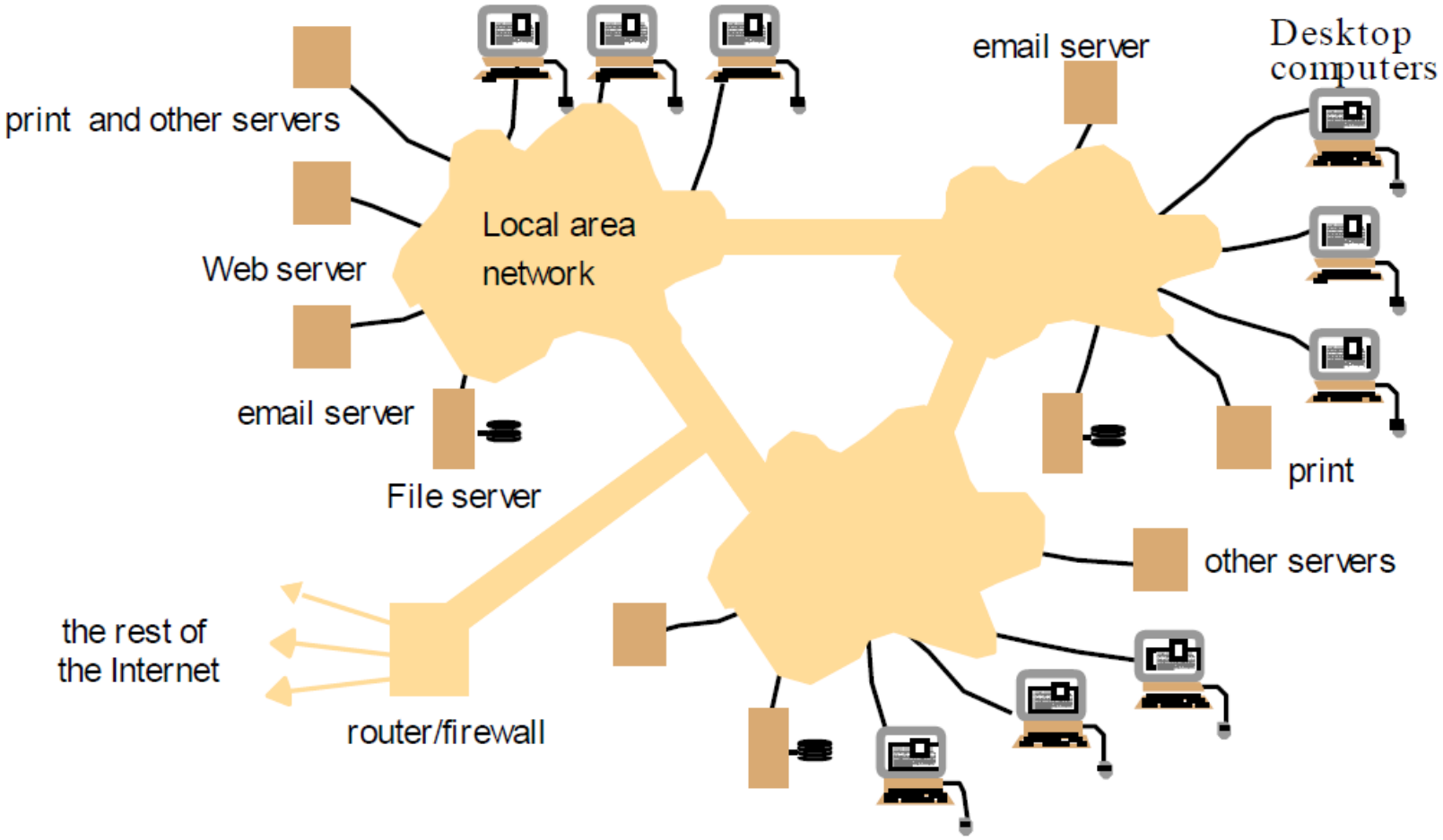
Some Typical Examples

- Internet
- Intranet
- Mobile environment
- Web

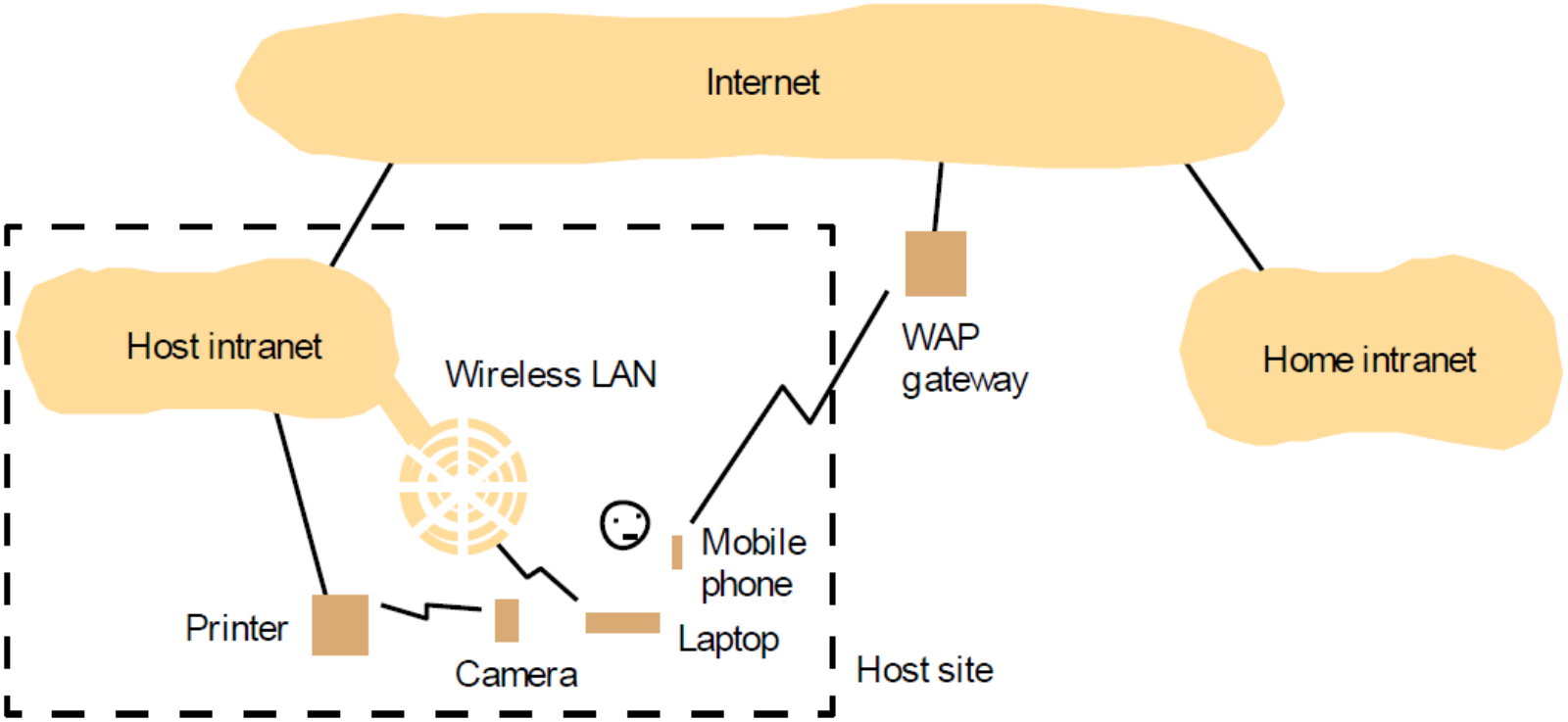
Internet


intranet
ISP
backbone
satellite link
desktop computer:
server:
network link:

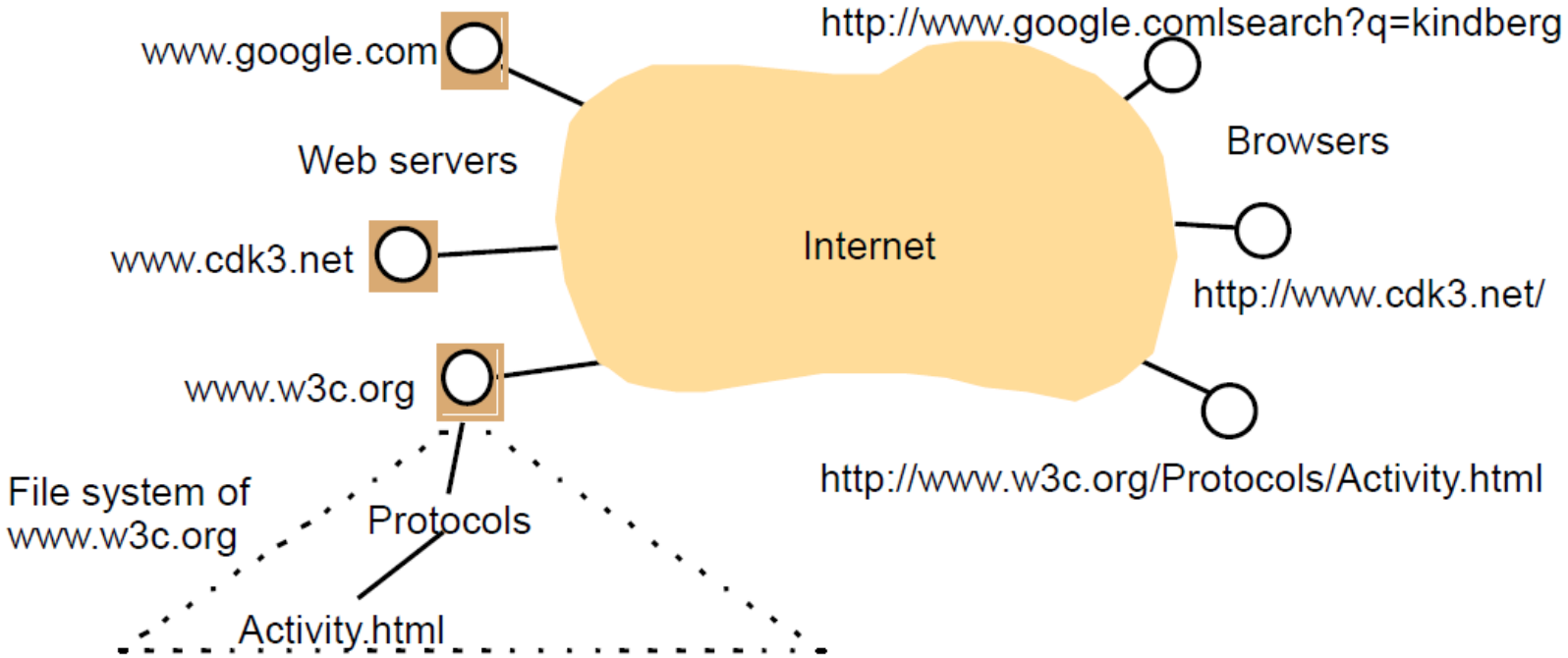
Intranet


print and other servers
Web server
email server
File server
Local area network
email server
Desktop computers
print
other servers
the rest of the Internet
router/firewall

Mobile Environment



Web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