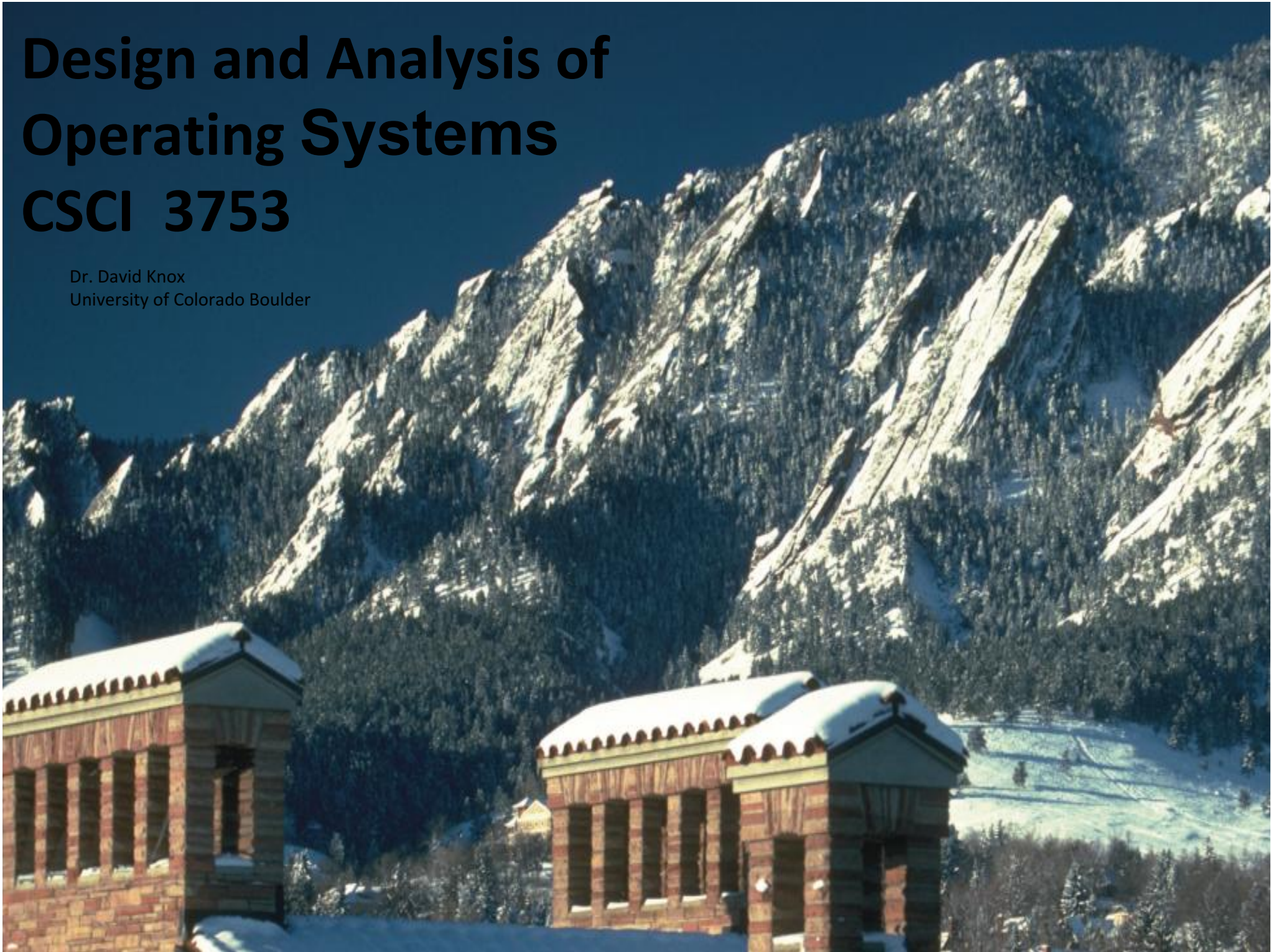# Design and Analysis of Operating Systems
CSCI 3753

Dr. David Knox
University of Colorado Boulder

Department of Computer Science
UNIVERSITY OF COLORADO BOULDER

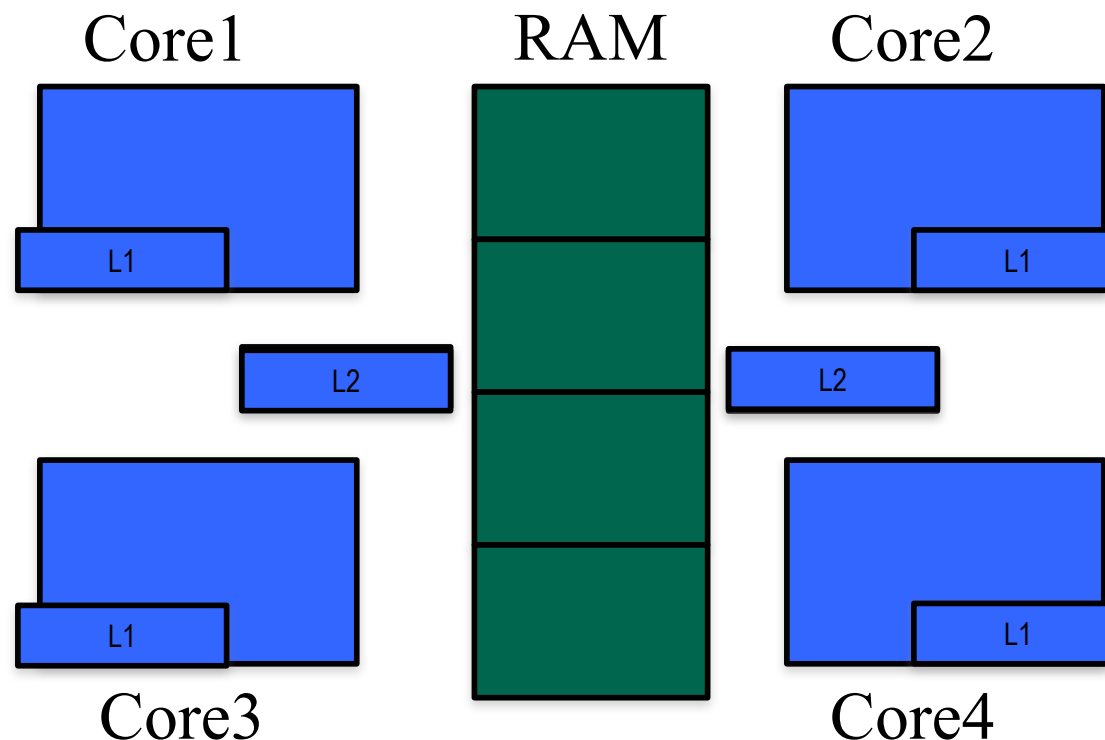# Design and Analysis of Operating Systems
CSCI 3753

Distributed Systems

Dr. David Knox

University of
Colorado Boulder

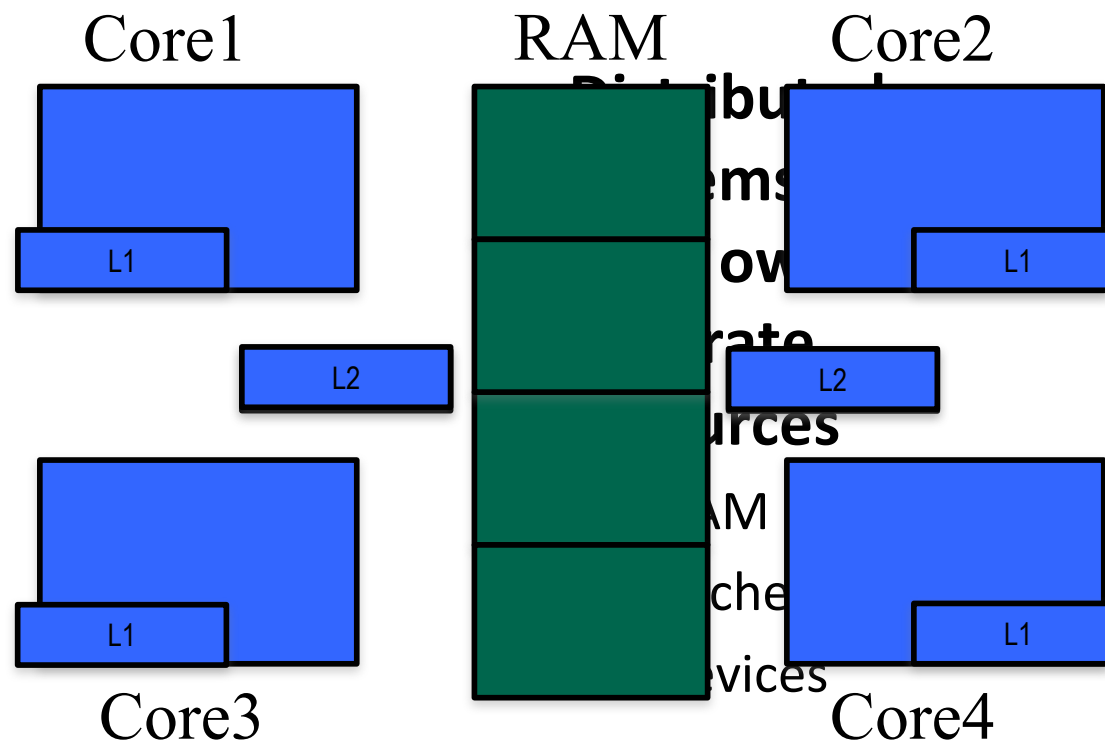# Distributed Systems

Multicore vs Distributed

- **Multi-core systems have access to shared resources**
  - RAM
  - cache
  - devices

Multicore vs Distributed

Core1

RAM

Distributed
systems

Core2

L1

L1

L2

L2

Core3

L1

Core4

L1

Multicore vs Distributed

Node1

L1

L2

Node2

L1

L2

Node3

L2

L1

Node4

L2

L1

Network

- Distributed Systems have their own separate resources
  - RAM
  - cache
  - devices

A collection of loosely coupled processors interconnected by a communications network

Distributed System

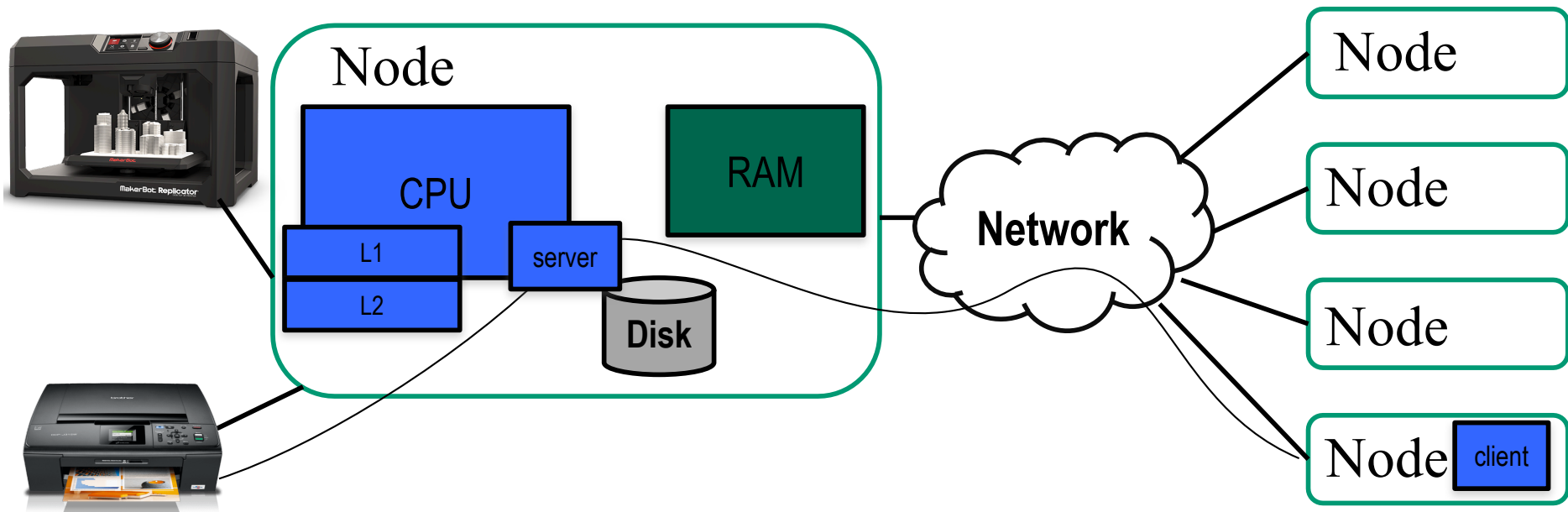- **A collection of loosely coupled processors interconnected by a communications network**

- **Processors variously called *nodes, computers, machines, hosts***
  - Network is used to communicate between machines
  - Generally a ***server*** has a resource a ***client*** node at a different site wants to use

Distributed System

- **Reasons for a Distributed System**

  - Resource sharing

  - Computational speed up (load balancing)

  - Reliability (thru redundancy)

  - Remote connections thru communications
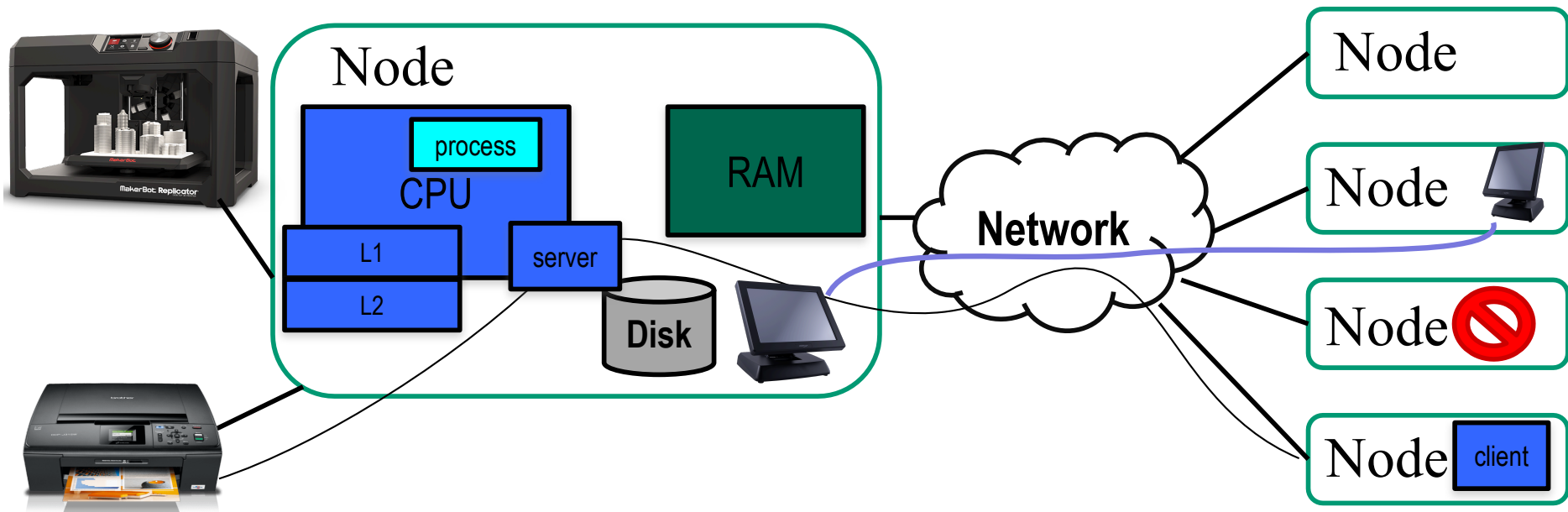
Network-Operating Systems

- **Users are aware of multiplicity of machines**

- **Access to resources of various machines is done explicitly by:**
  - Remote logging into the appropriate remote machine (telnet, ssh)
  - Remote Desktop (Microsoft Windows)
  - Transferring data from remote machines to local machines, via the File Transfer Protocol (FTP) mechanism

- **Users must change paradigms**
  - establish a **session**
  - give network-based commands
  - More difficult for users

Distributed-Operating Systems

- **Users not aware of multiplicity of machines**
  - Access to remote resources similar to access to local resources

- **Data Migration**
  - transfer data by transferring entire file
  - or transferring only those portions of the file necessary for the immediate task

- **Computation Migration**
  - Transfer the computation, rather than the data, across the system
  - Via remote procedure calls (RPCs)
  - or via messaging system

Distributed-Operating Systems (Cont.)

- **Process Migration**

    - **Execute** an entire process, or parts of it, at different sites

    - **Load balancing** – distribute processes across network to even the workload

    - **Computation speedup** – subprocesses can run concurrently on different sites

    - **Hardware preference** – process execution may require specialized processor

    - **Software preference** – required software may be available at only a particular site

    - **Data access** – run process remotely, rather than transfer all data locally

Network Structure

- **Local-Area Network (LAN)**

    - Designed to cover small geographical area

    - Multiple topologies like star or ring

    - Speeds from 1Mb per second (Appletalk, bluetooth)

        40 Gbps for Ethernet over twisted pair copper or optical fibre

    - Consists of multiple computers (mainframes through mobile devices), peripherals (printers, storage arrays), routers (specialized network communication processors) providing access to other networks

    - Ethernet most common way to construct LANs

        - Multiaccess bus-based

        - Defined by standard IEEE 802.3

    - Wireless spectrum (**WiFi**) increasingly used for networking

   - I.e. IEEE 802.11g standard implemented at 54 Mbps

Local-area Network
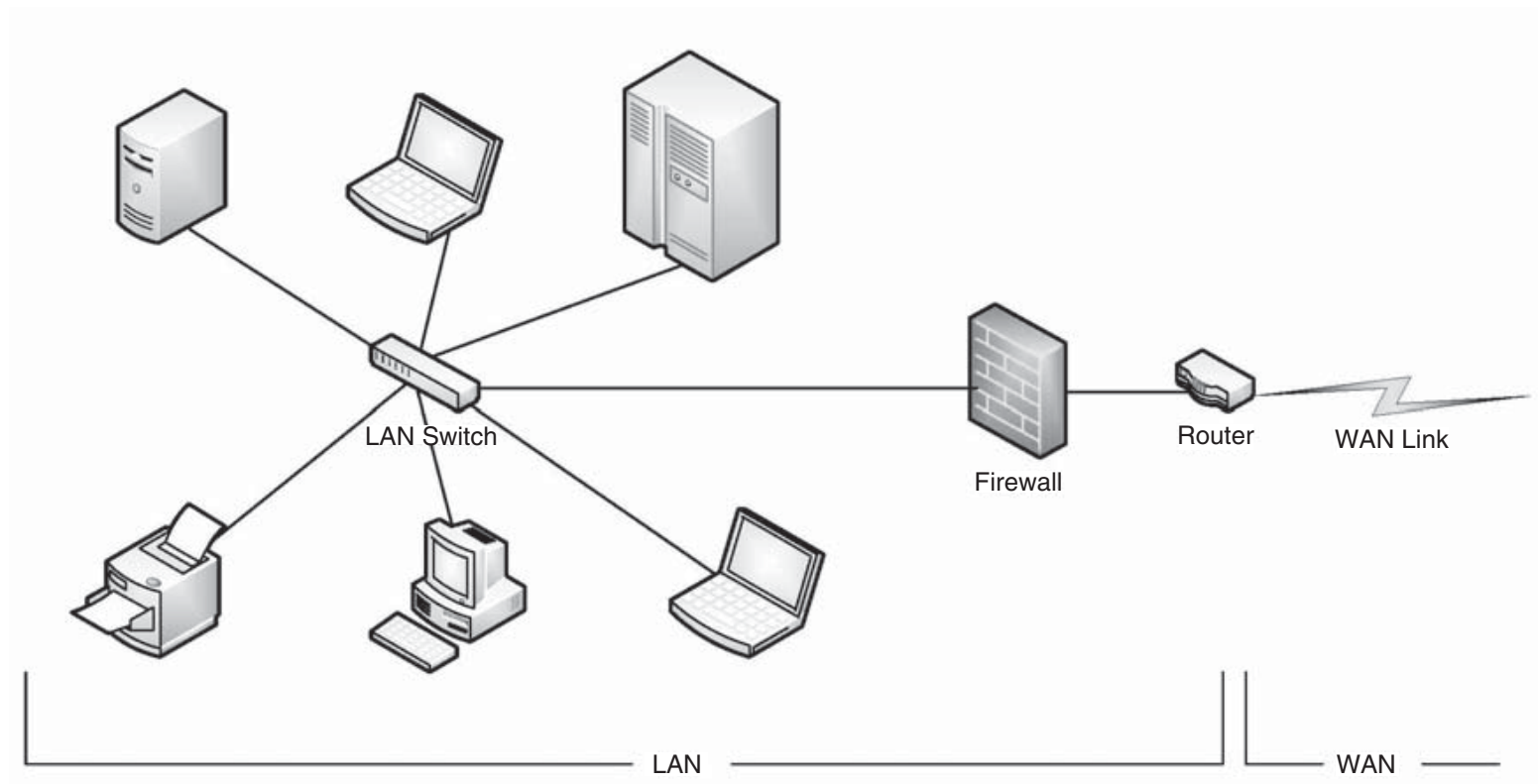
Network Types (Cont.)

- **Wide-Area Network (WAN) – links geographically separated sites**
  - Point-to-point connections over long-haul lines (often leased from a phone company)
    - Implemented via **connection processors** known as **routers**

  - Internet WAN enables hosts world wide to communicate
    - Hosts differ in all dimensions but WAN allows communications

  - Speeds
    - T1 link is 1.544 Megabits per second
    - T3 is 28 x T1s = 45 Mbps
    - OC-12 is 622 Mbps

  - WANs and LANs interconnect, similar to cell phone network:
    - Cell phones use radio waves to cell towers
    - Towers connect to other towers and hubs

Communication Processors in a Wide-Area Network
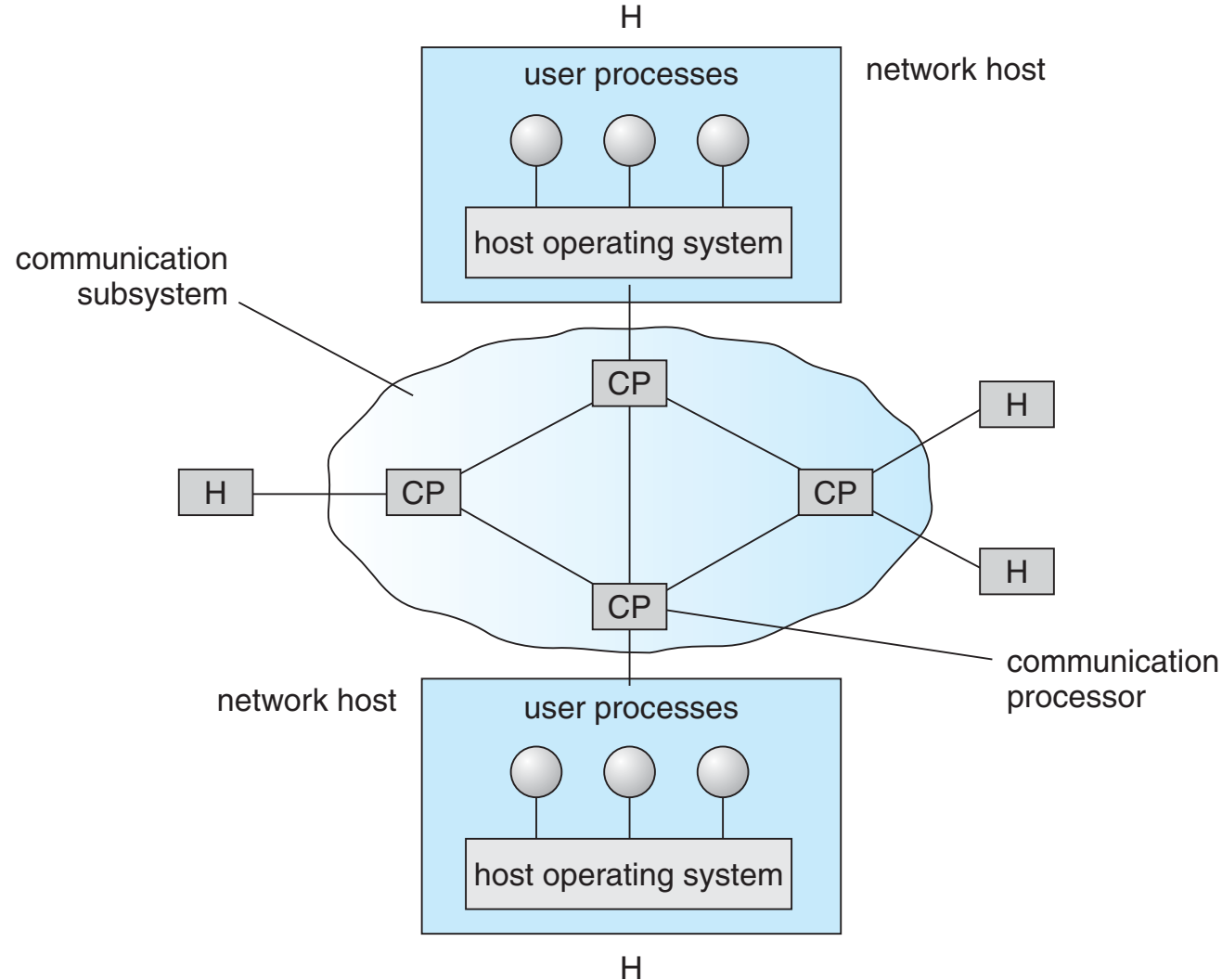
Communication Structure

Design of a communication network must address four basic issues:

- **Naming and name resolution**

  - How do two processes locate each other to communicate?
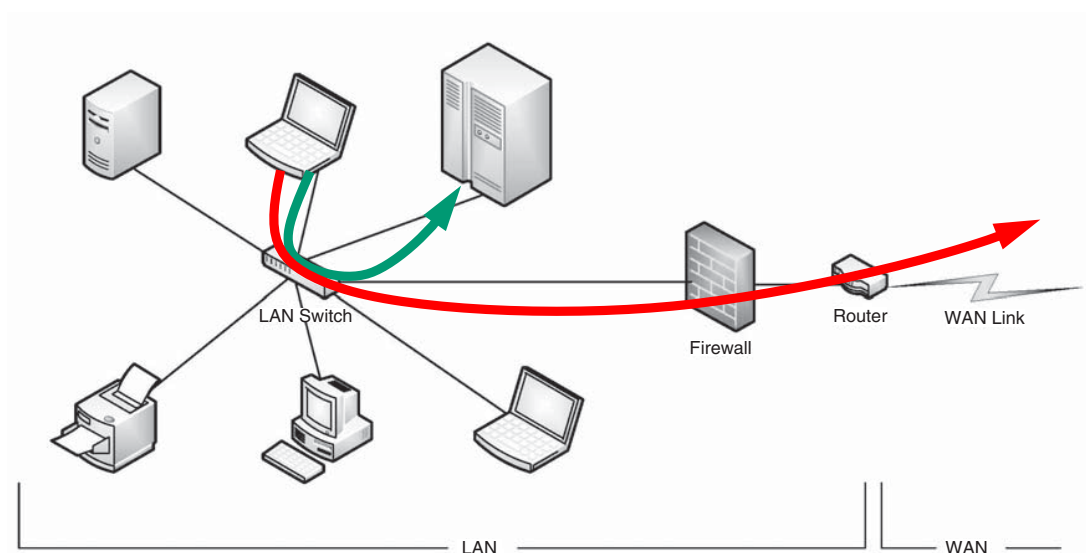
- **Routing strategies**

  - How are messages sent through the network?

- **Connection strategies**

  - How do two processes send a sequence of messages?

- **Contention**

  - The network is a shared resource, so how do we resolve conflicting demands for its use?

LAN Switch

Firewall

Router

WAN Link

LAN

WAN

Naming and Name Resolution

- **Name systems in the network**

- **Address messages with the process-id**

- **Identify processes on remote systems by**

    <host-name, identifier> pair

- **Domain name system (DNS)**

    - specifies the naming structure of the hosts, as well as name to address **resolution** (Internet)

Routing Strategies

- **Fixed routing - A path from *A* to *B* is specified in advance; path changes only if a hardware failure disables it**

  - Since the shortest path is usually chosen, communication costs are minimized

  - Fixed routing cannot adapt to load changes

  - Ensures that messages will be delivered in the order in which they were sent

- **Virtual routing- A path from *A* to *B* is fixed for the duration of one session. Different sessions involving messages from *A* to *B* may have different paths**

  - Partial remedy to adapting to load changes

  - Ensures that messages will be delivered in the order in which they were sent

Routing Strategies (Cont.)

- **Dynamic routing**

    - Path used to send a message form site *A* to site *B* is chosen only when a message is sent

    - Usually a site sends a message to another site on the link least used at that particular time

    - Adapts to load changes by avoiding routing messages on heavily used path

    - Messages may arrive out of order

        - This problem can be remedied by appending a sequence number to each message

    - Most complex method to set up

- **Tradeoffs mean all methods are used**

    - UNIX provides ability to mix fixed and dynamic

    - Hosts may have fixed routes and **gateways** connecting networks together may have dynamic routes

Routing Strategies (Cont.)

- **Router is communications processor responsible for routing messages**

- **Must have at least 2 network connections**

- **Maybe special purpose or just function running on host**

- **Checks its tables to determine where destination host is, where to send messages**
  - Static routing – table only changed manually
  - Dynamic routing – table changed via **routing protocol**

Routing Strategies (Cont.)

- **More recently, routing managed by intelligent software more intelligently than routing protocols**

- **Messages vary in length**
  - simplified design breaks them into **packets** (or **frames**, or **datagrams**)

- **Connectionless message is just one packet**
  - Otherwise need a connection to get a multi-packet message from source to destination

Design and Analysis of Operating Systems
CSCI 3753

Dr. David Knox

University of
Colorado Boulder

Material adapted from: Operating Systems: A Modern Perspective : Copyright © 2004 Pearson Education, Inc.