Computer Networks

CMP2205

Lecture 1

Course information

- *Grading:*
- *2 mid-term tests: 40% and Final Exam: 60%*
- *Office: 3014*
- *References*
  - Andrew S. Tanenbaum1996. *Computer Networks*. Prentice Hall; 3rd Edition.ISBN-10: 0133499456, ISBN-13: 978-0133499452
  - James F. Kurose and Keith W, 2007.*Computer Networking: A Top-Down*. Addison Wesley; 4 Edition. ISBN-10: 0321497708, ISBN-13: 978-0321497703

Course Outline

- *Introduction*
  - *Basic concepts, terminology.*
  - *Protocols, layering, etc.*
- *Physical layer*
  - *Transmitting data.*
- *Data link layer*
  - *Reliable transmission.*
  - *Accessing the communication medium*
    - *Medium access control protocols.*
- *LANs*
  - *Ethernet, token ring, wireless LANs.*

Course Outline (cont'd)

- *Network layer*
  - *Types of network services.*
  - *Circuit- vs. packet switching.*
  - *Virtual circuits and datagrams.*
  - *Routing.*
  - *Addressing.*
  - *Unicast and multicast.*
- *Internetworking*
  - *IP.*
  - *The Internet.*
  - *IP Routing and Control.*

Course Outline (cont'd)

- *Transport layer*
  - *E2E communication..*
  - *Types of transport service.*
  - *Connectionless versus connection-oriented.*
  - *UDP.*
  - *TCP.*
- *Application layer*
  - *DNS, ssh, telnet, ftp, news, e-mail.*
  - *The Web.*
    - *HTTP.*
    - *HTML.*
    - *Search engines.*
    - *Proxy and caches*
  - *Peer-to-peer.*
  - *Security.*

What's a Computer network?

- A communication system for connecting computers/hosts.
  - A computer network is a number of computers (also known as nodes) connected by some communication lines.
  - Two computers connected to the network can communicate with each other through the other nodes if they are not directly connected.
  - Some of the nodes in the network may not be computers at all but they are network devices(Like switches, routers etc.) to facilitate the communication.

Why network?

- *Resource sharing!*
  - *Hardware: printers, disks, terminals, etc.*
  - *Software: text processors, compilers, etc.*
  - *Data.*
- *Robustness.*
  - *Fault tolerance through redundancy.*
- *Load balancing.*
  - *Processing and data can be distributed over the network.*
- *Location independence.*
  - *Users can access their files, etc. from anywhere in the network.*

Problems?

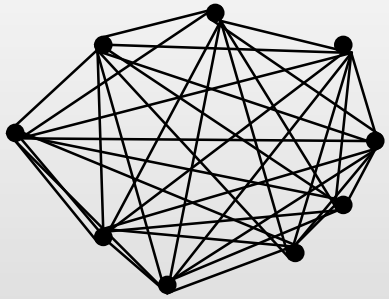
- *Security!*
  - *It's much easier to protect centralized resources than when they are distributed.*
  - *Network itself as the target..*

History

- *Before the internet*
  - *Postal network.*
    - *Delivers different types of objects (letters, packages, etc.) world-wide.*
    - *Relatively high delay but relatively cheap.*
    - *Sender and receiver identified by their postal address (name, number, street, city, etc.).*
  - *Telephone network.*
    - *Engineered to deliver real-time voice.*
    - *Also world-wide.*
    - *Low delay but more expensive.*
    - *Users identified by telephone number.*

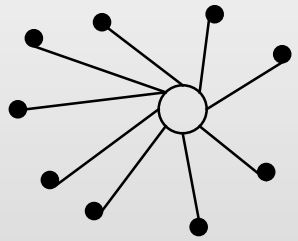
The Telephone Network

- *Telephone was patented by G. Bell in 1876.*
- *For one telephone to be able to talk with another telephone, a direct connection between the two telephones was needed.*
  - *Within one year, cities were covered with a wild jumble of wires!*



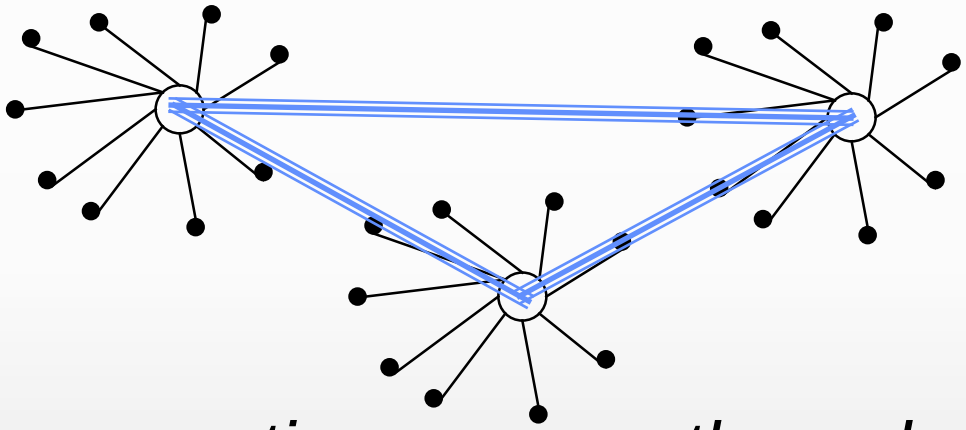
The Telephone Network (cont'd)

- *In 1878, the Bell Telephone company opened its first switching office (in New Haven, CT).*
- *Each user would connect to the local switching office.*
  - *When a user wanted to make a call, s/he rang to the office, and would be manually connected to the other end.*



The Telephone Network (cont'd)

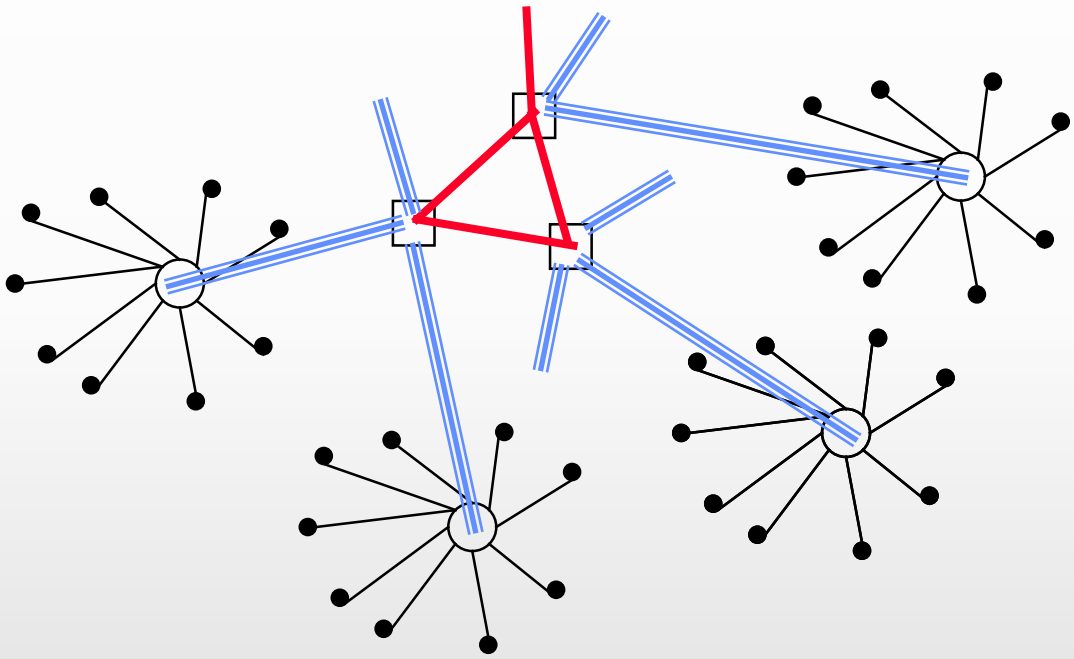
- *To allow for long-distance calls, switching offices (switches) were connected .*



- *Several connections can go through inter-switch trunks simultaneously.*
- *At some point, there were too many connections between switching offices!*

The Telephone Network (cont'd)

- *Thus, a second-level hierarchy was added.*



- *The current telephone system has at least five levels of hierarchy.*

Addressing

- *Uniquely identifies users.*
- *Examples:*
  - *Postal address, telephone number.*
- *Types of addresses:*
  - *Flat.*
  - *Hierarchical.*
  - *Are postal addresses flat or hierarchical?*
  - *And phone numbers?*

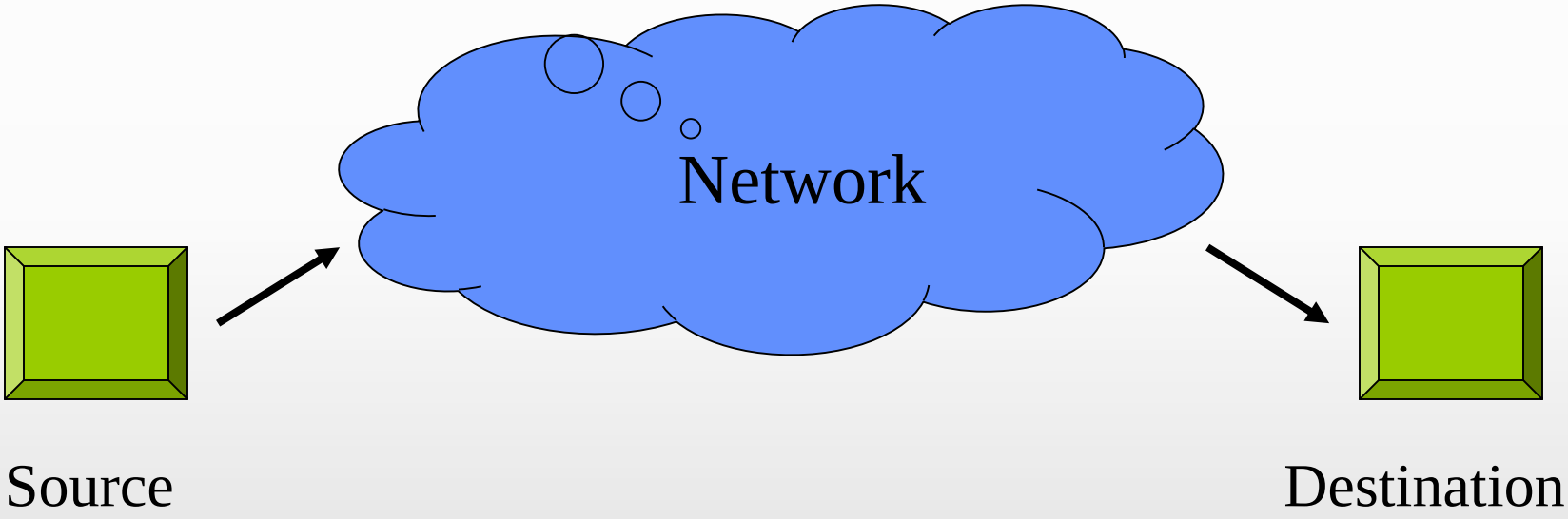
POTS or PSTN

- *For over 100 years, the **POTS** (Plain Old Telephone System) a.k.a. **PSTN** (Public Switched Telephone Network) handles **voice-band communications.***
- *The PSTN is well designed and engineered for the transmission and switching of **voice***
  - *Real-time.*
  - *Low latency.*
  - *High reliability.*
  - *Moderate fidelity.*

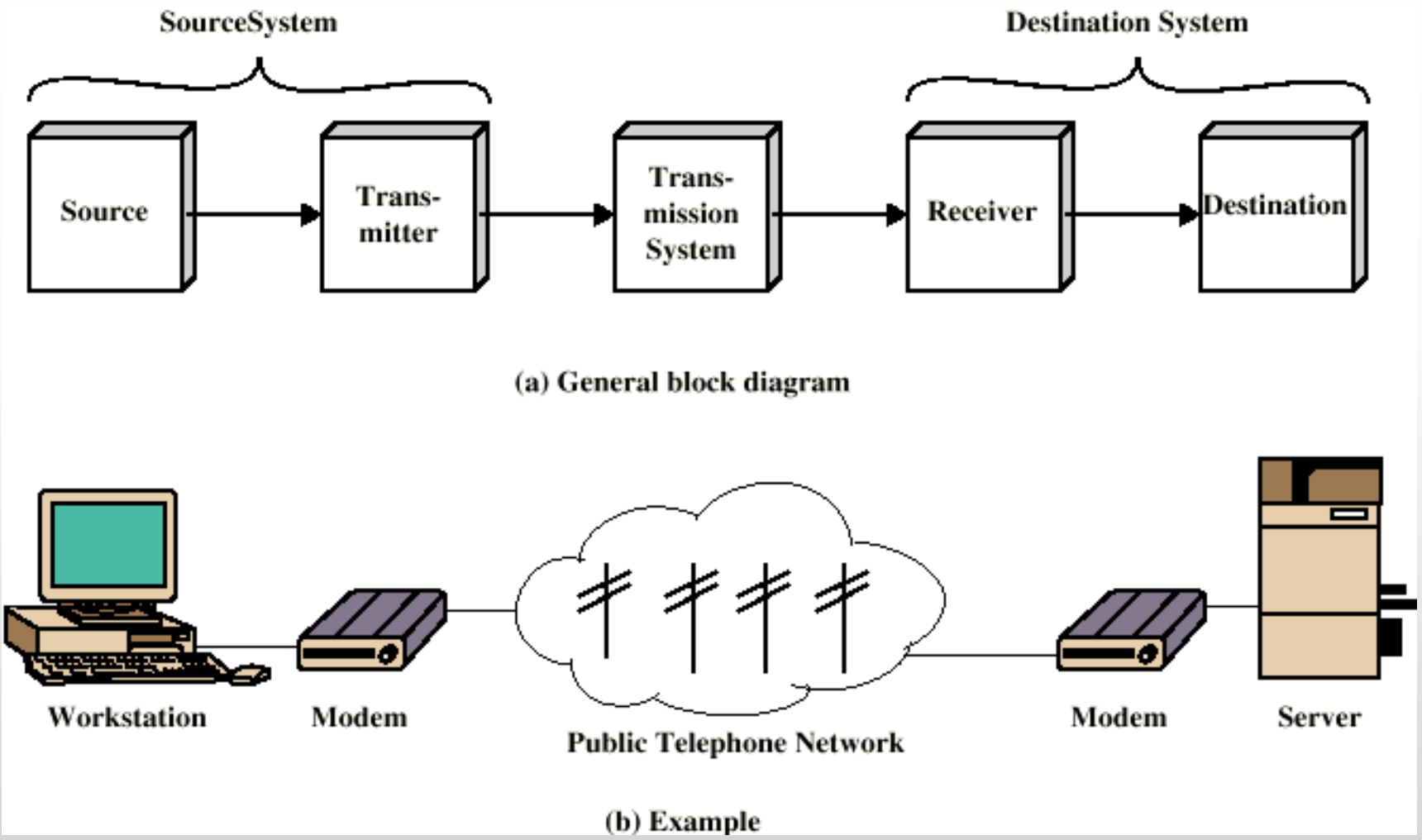
Evolution of Communications Networks

- *The second communications network was created with the goal of providing a better transport mechanism for* **data***.*
- *We will study the technology underpinning* ***data networks.***

Communication Model



Simplified Communication Model



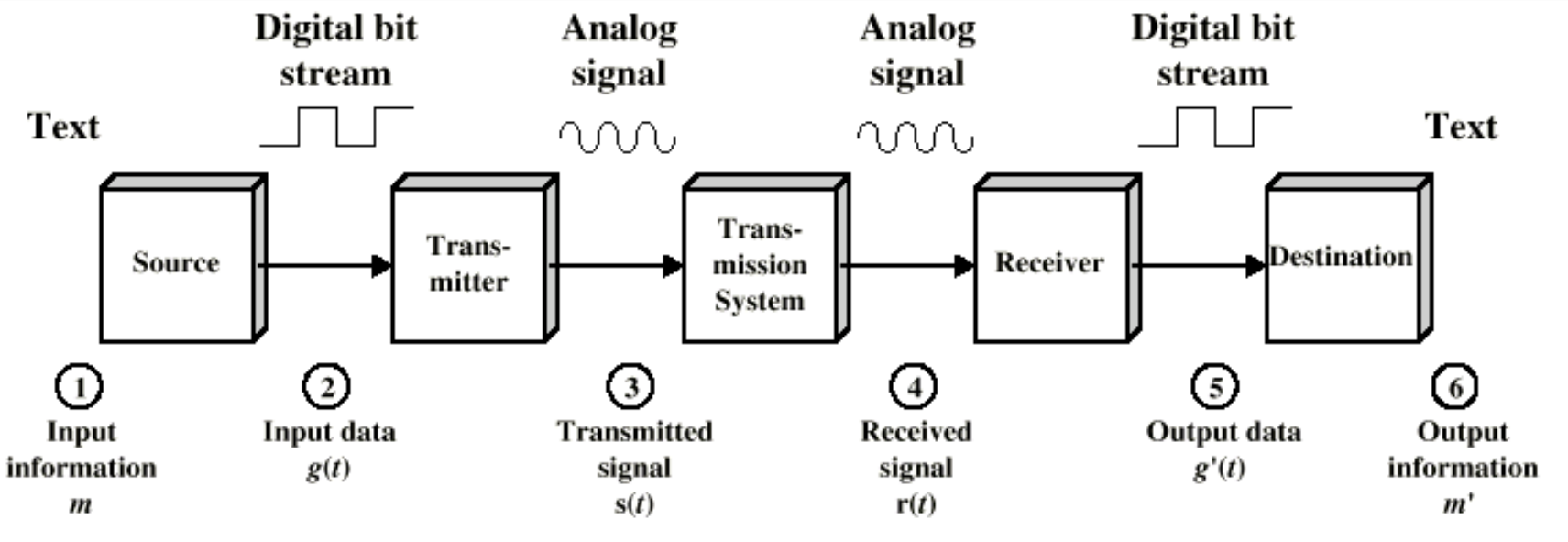
Components

- *End systems (or hosts),*
- *Routers/switches/bridges, and*
- *Links (twisted pair, coaxial cable, fiber, radio, etc.).*

Components (cont'd)

- *Source*
  - *generates data to be transmitted*
- *Transmitter*
  - *Converts data into transmittable signals*
- *Transmission System*
  - *Carries data*
- *Receiver*
  - *Converts received signal into data*
- *Destination*
  - *Takes incoming data*

Simplified Data Communications Model



Key Tasks

- *Transmission.*
- *Signal Generation.*
- *Synchronization.*

- *Error detection and correction.*

- *Addressing and routing*

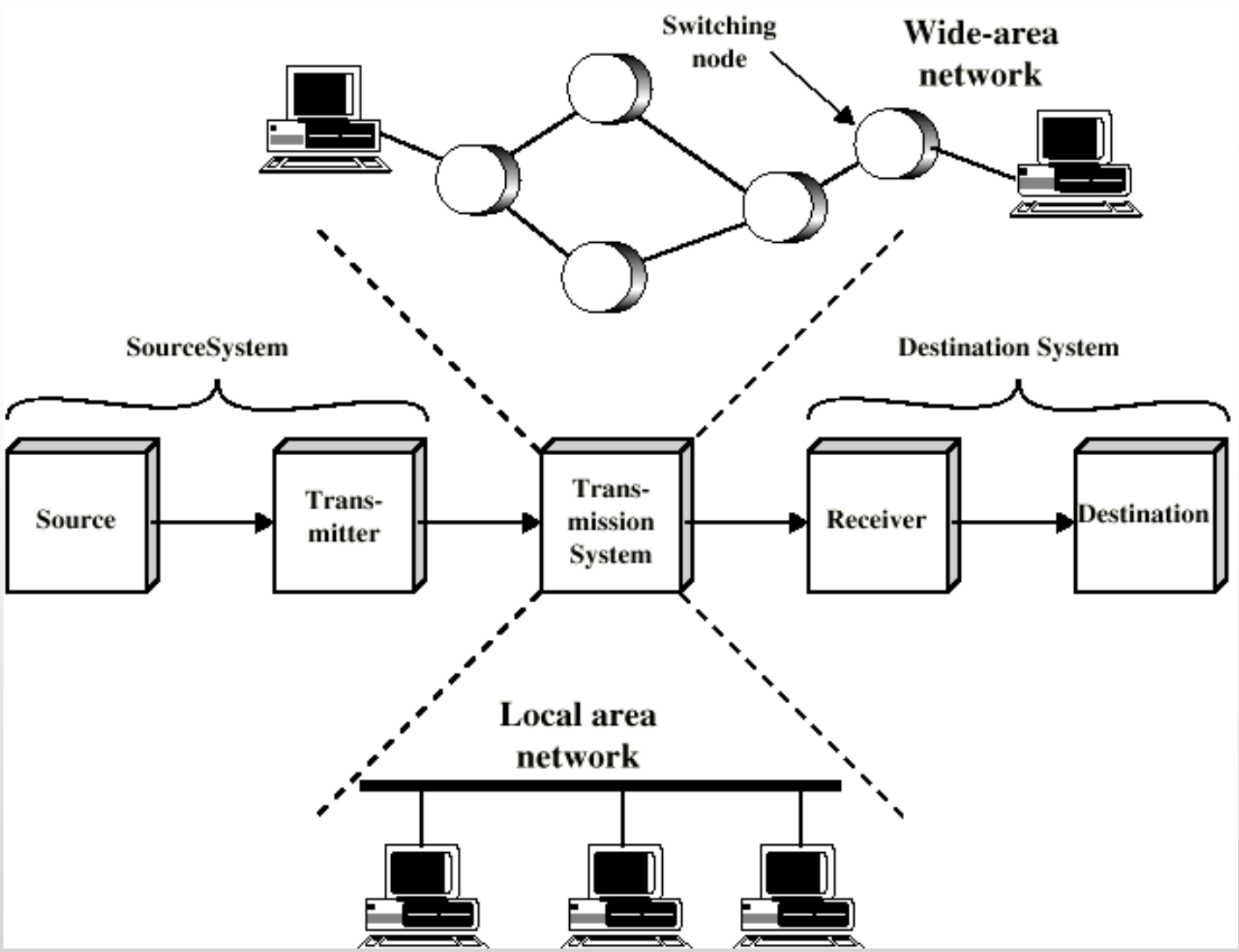
- *End-to-end Recovery.*

- *Security.*

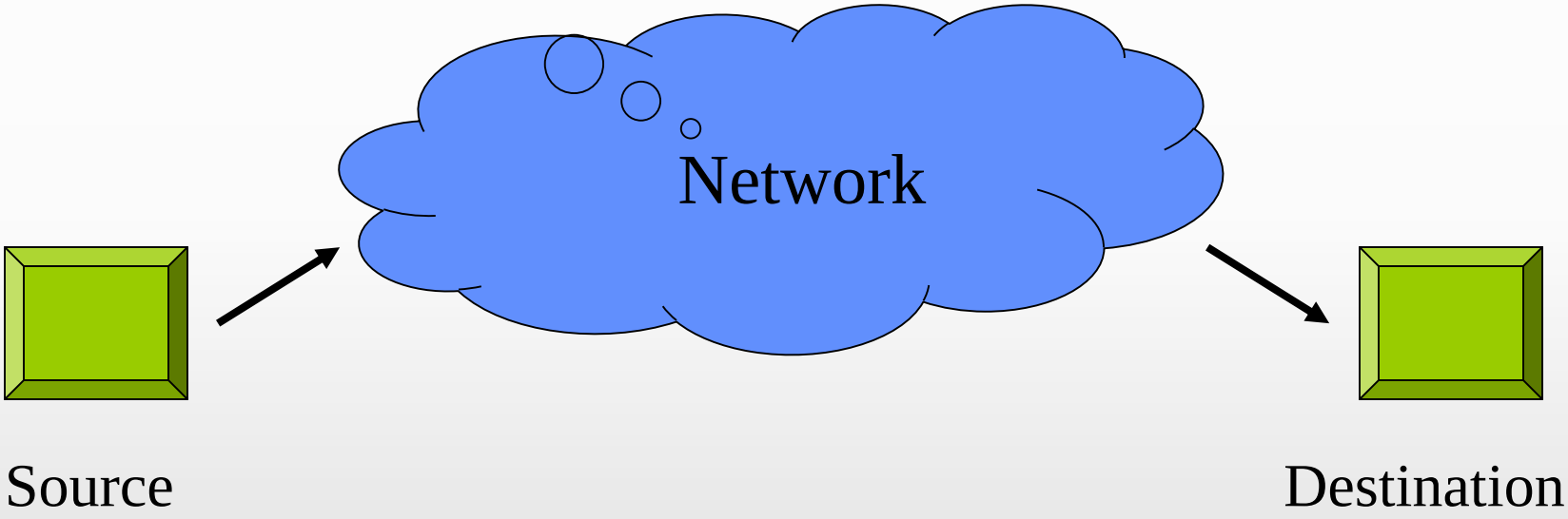
Networking

- *Point to point communication not usually practical*
  - *Devices are too far apart.*
  - *Large set of devices would need impractical number of connections.*
- *Solution is a communications network.*

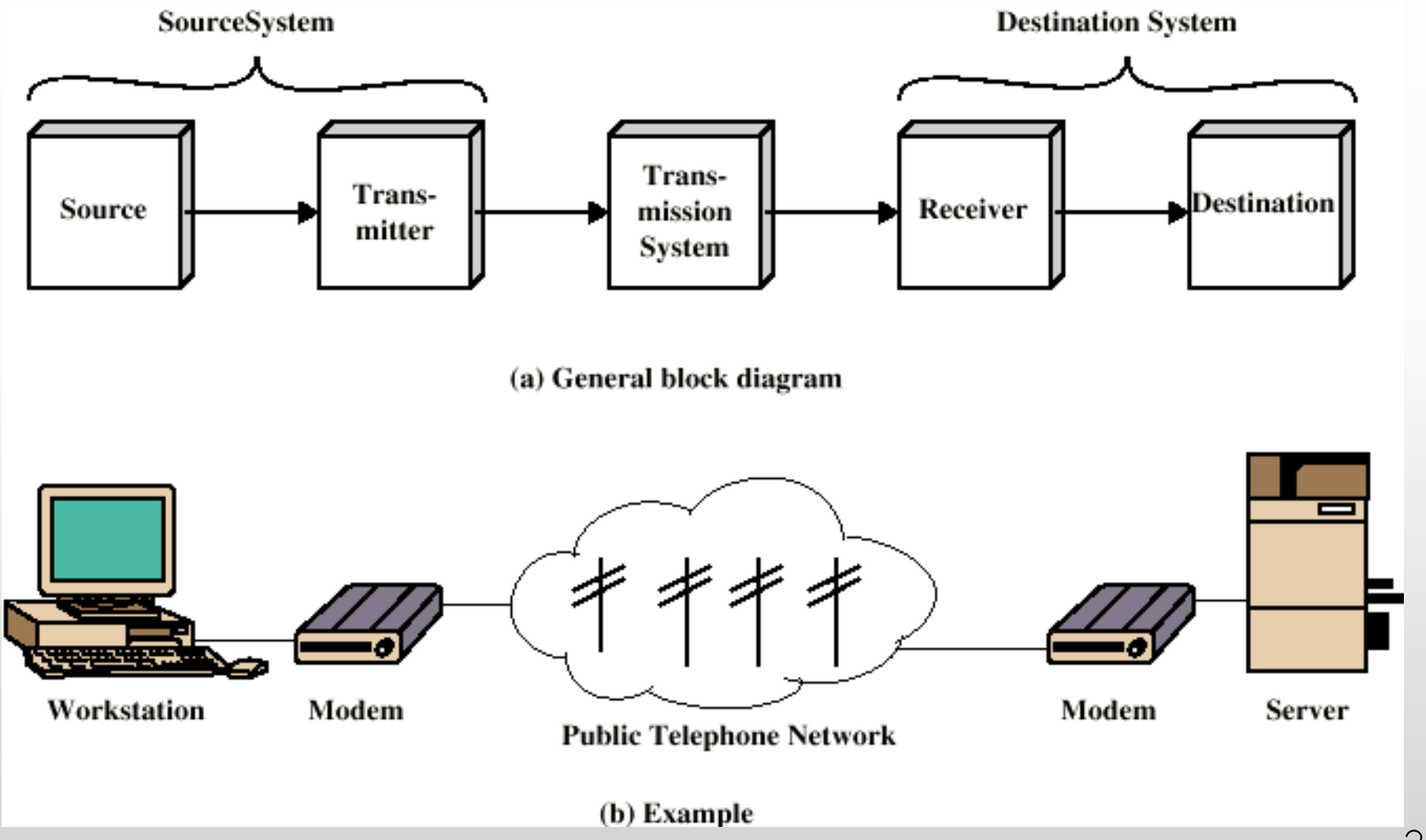
Simplified Network Model



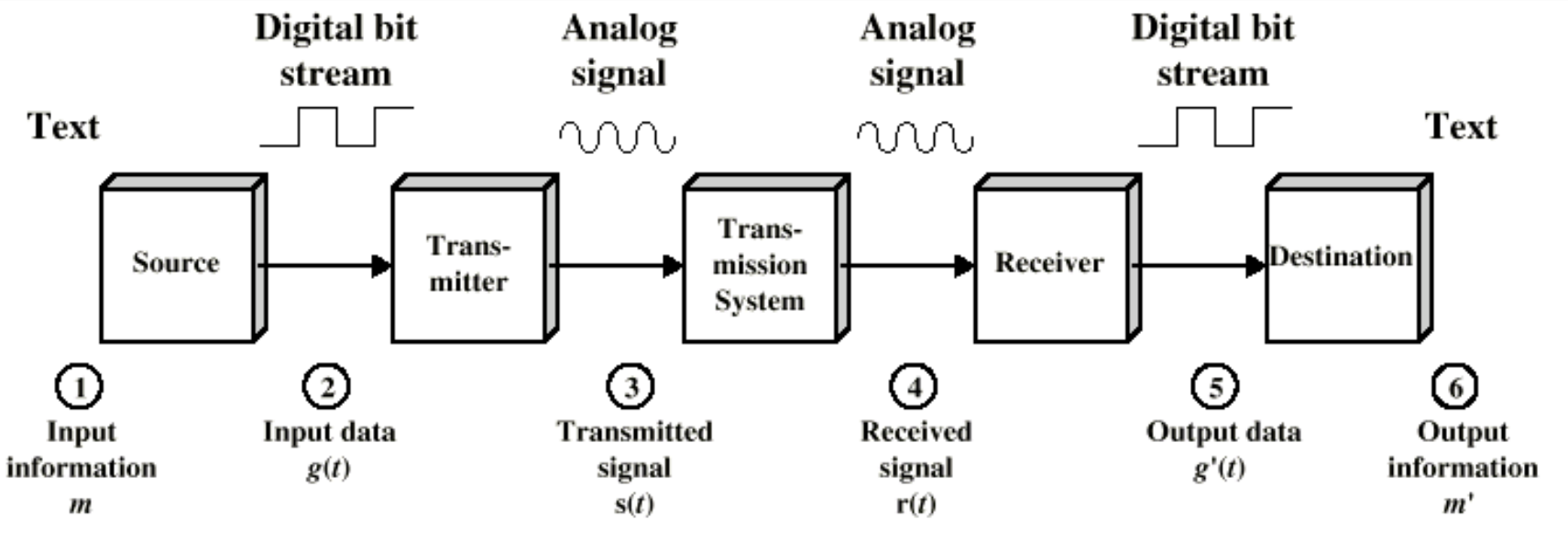
Data Communication Model



Simplified Communication Model



Simplified Data Communications Model



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Key Tasks

- *Transmission.*
- *Signal Generation.*
- *Synchronization.*

Physical Layer

- *Error detection and correction.*

Data Link Layer

- *Addressing and routing*

Network Layer

- *End-to-end Recovery.*

Transport Layer

- *Security.*

Application Layer

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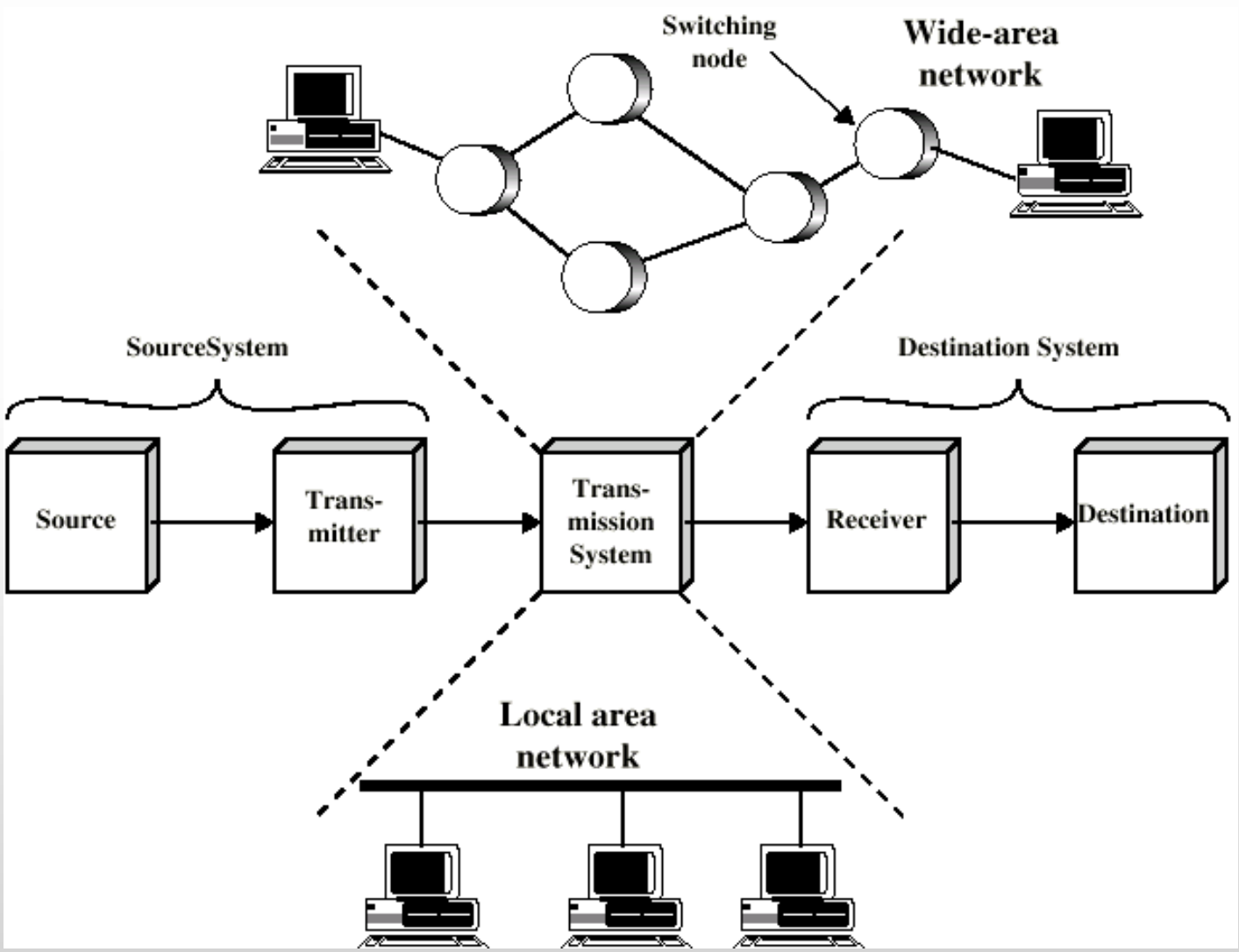
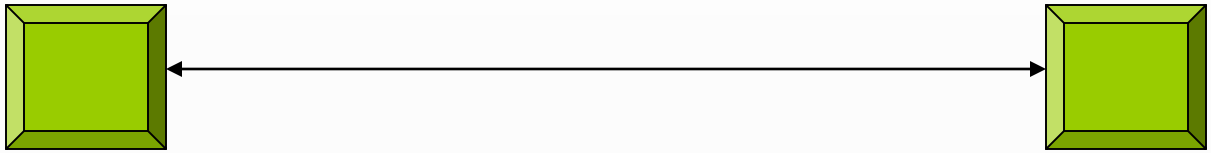
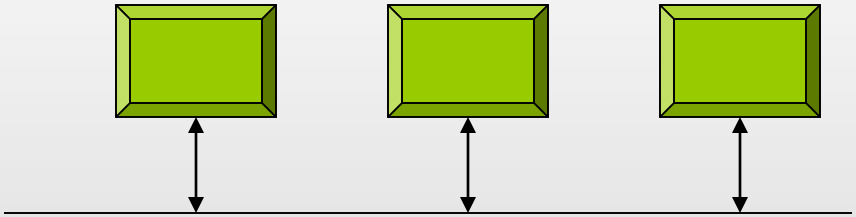
Simplified Network Model



Connecting End Systems

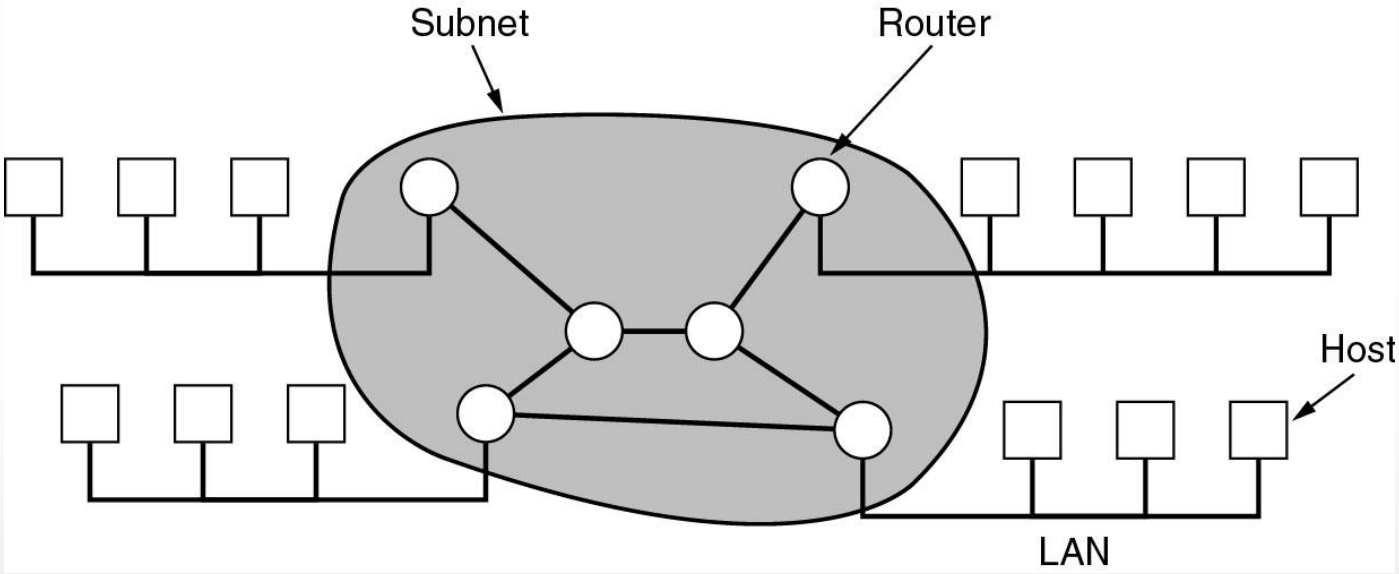


Dedicated link

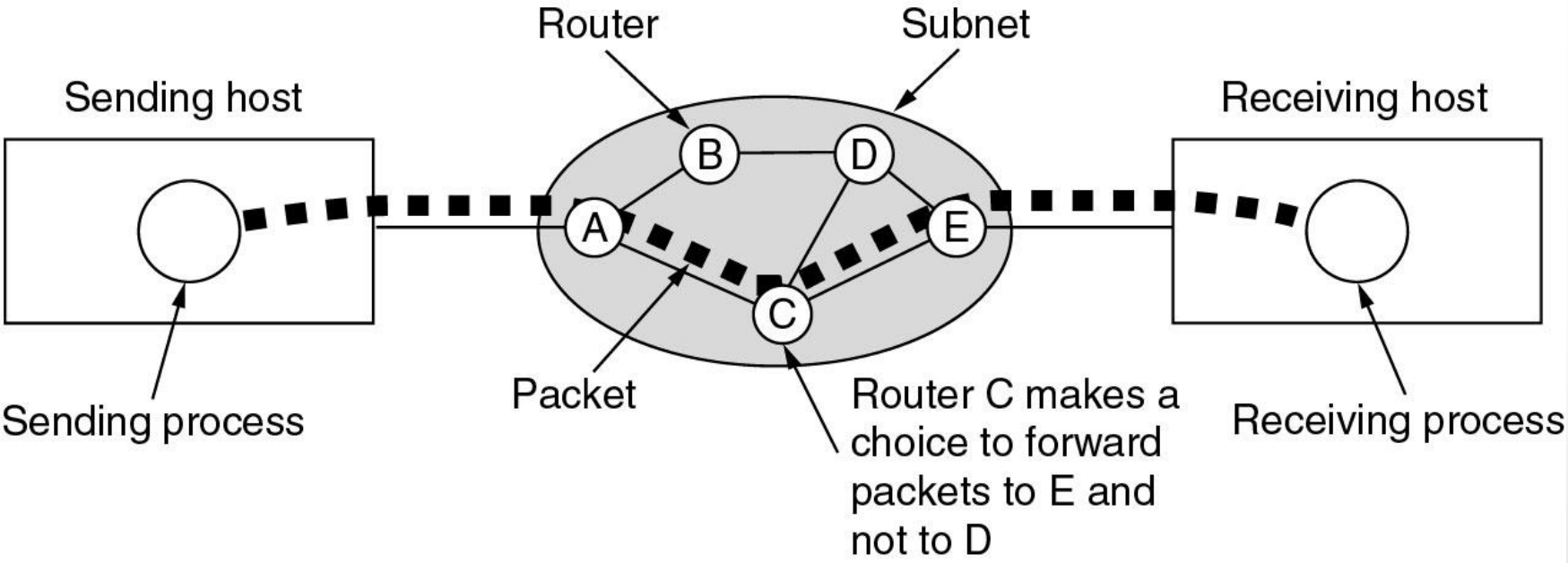


Multiple access / shared medium

Connecting End Systems (cont'd)



Shared Communication Infrastructure

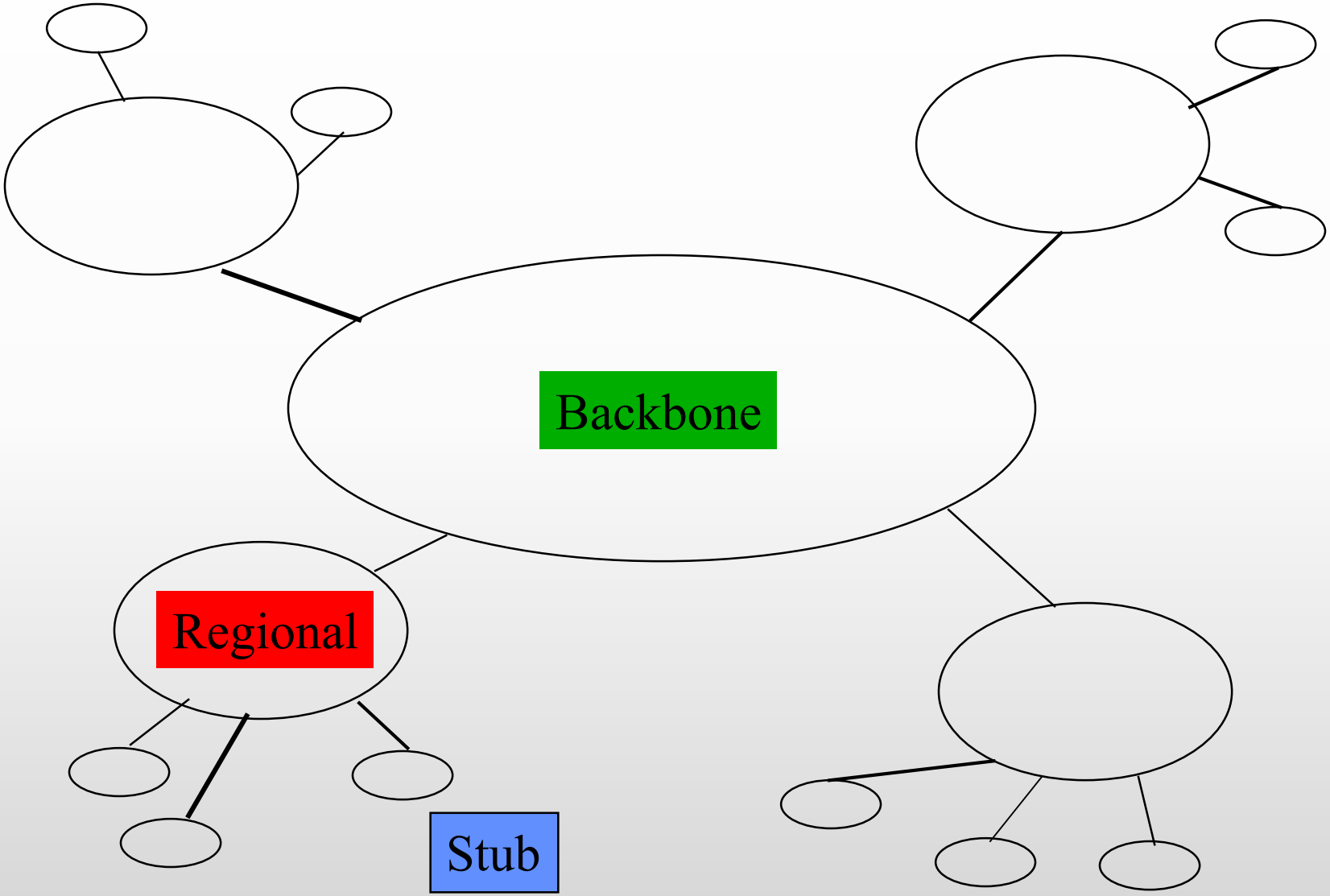


A stream of packets from sender to receiver.

Types of Data Networks

- *Several ways to classify data networks.*
- *For example, according to "coverage".*
  - **Local Area Networks (LANs)** *typically provide networking capabilities within a building, campus.*
    - *Typically within 5-mile radius.*
  - **Wide-Area Networks (WANs)** *span greater geographic distances (e.g., world-wide).*
  - **Metropolitan Area Networks (MANs)** *span more restricted distances, e.g., geographic regions (e.g., Los Nettos network in Southern California, etc.)*

The Internet



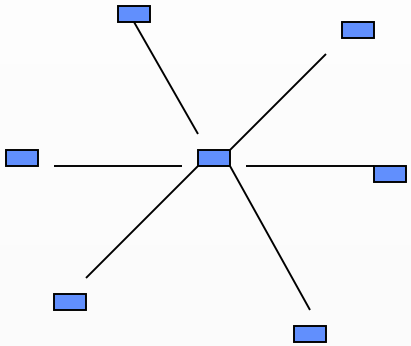
Types of Networks (cont'd)

- *Classification according to type of connection.*
  - *Dedicated link.*
  - *Shared medium (multiple access).*
  - *Switched point-to-point.*

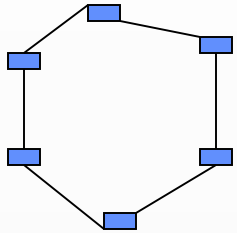
Types of Networks (cont'd)

- *Classification according to topology…*
- *What is network topology?*
  - *The way network elements are interconnected.*

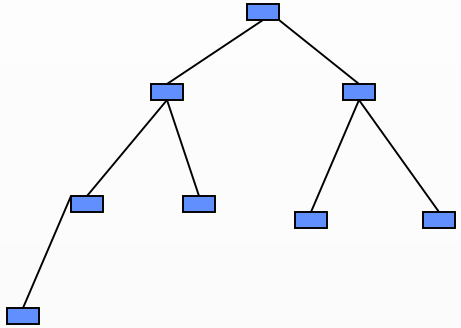
Network Topologies: Examples



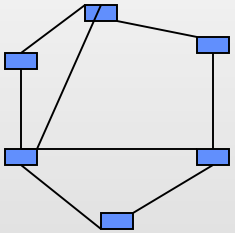
Star



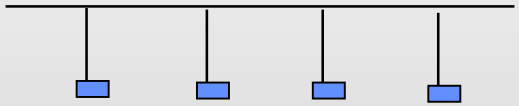
Ring



Tree



Irregular



Bus

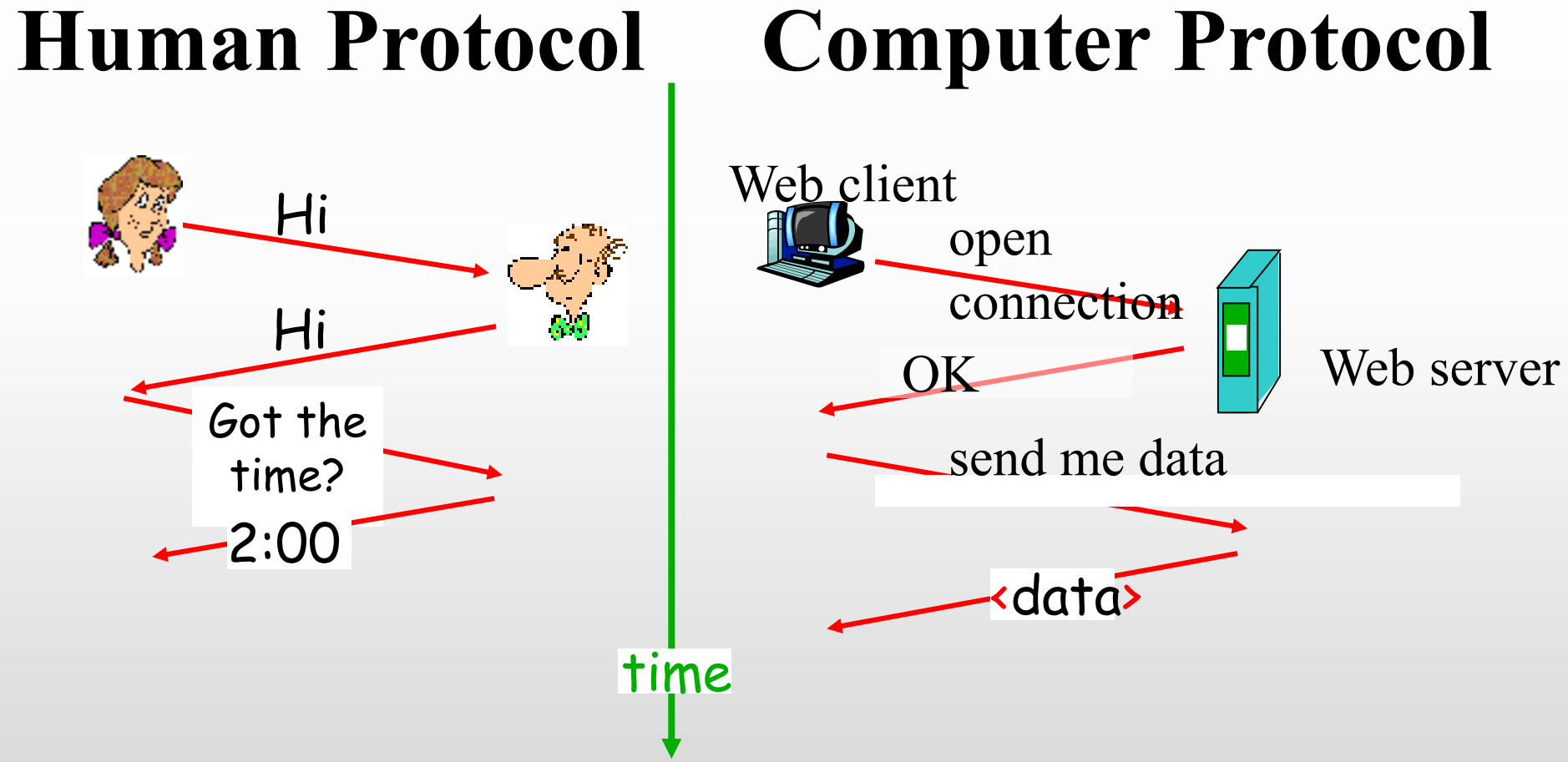
More Concepts…

- *Network protocols.*
- *Layering.*
- *Network/protocol architecture.*

Network Protocols

- *Diplomats use rules, called **protocols**, as guides for formal interactions.*
- *A **communication protocol** is a set of rules that specify the format and meaning of messages exchanged between computers across a network.*
- *A set of related protocols that are designed for compatibility are called **protocol suite.***

Human and Computer Protocols

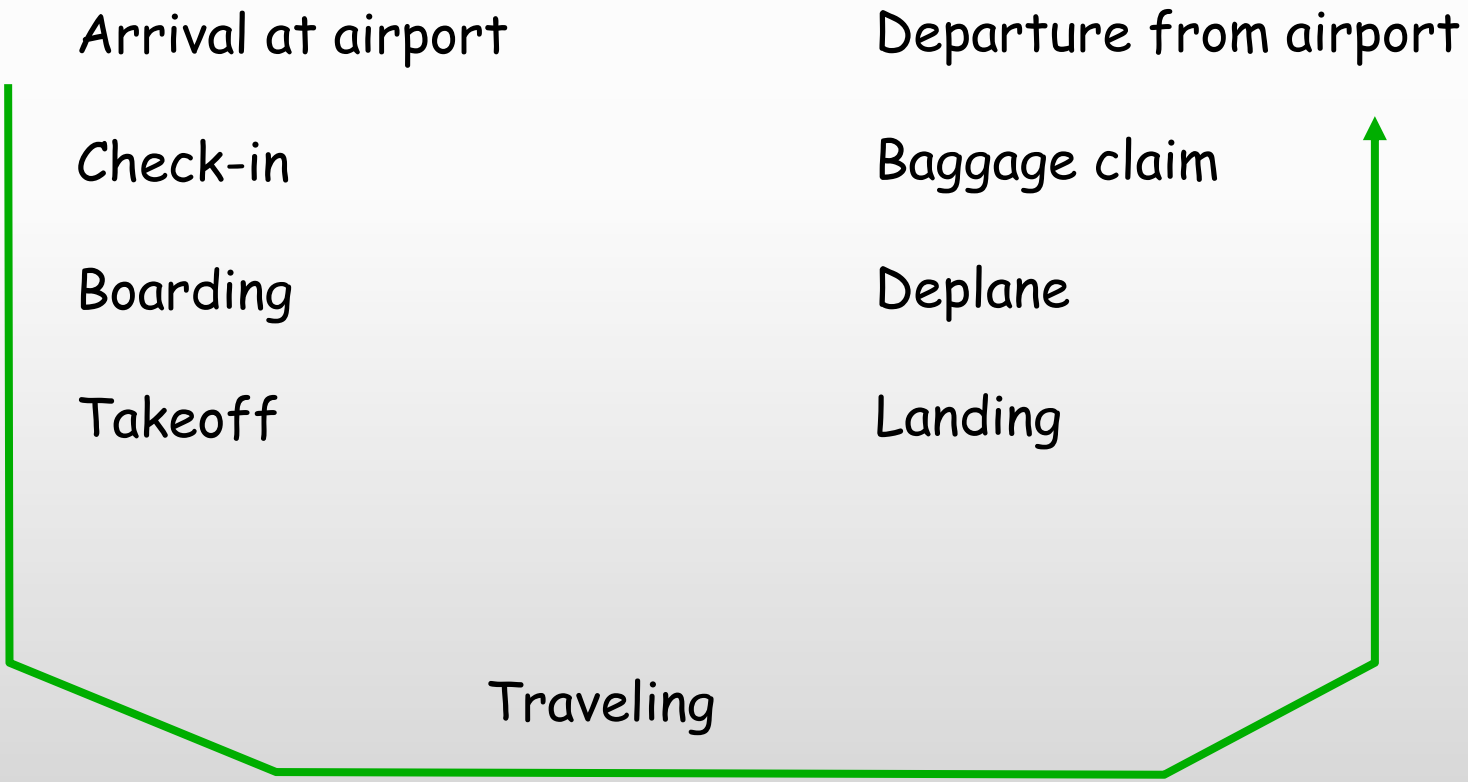


Layering

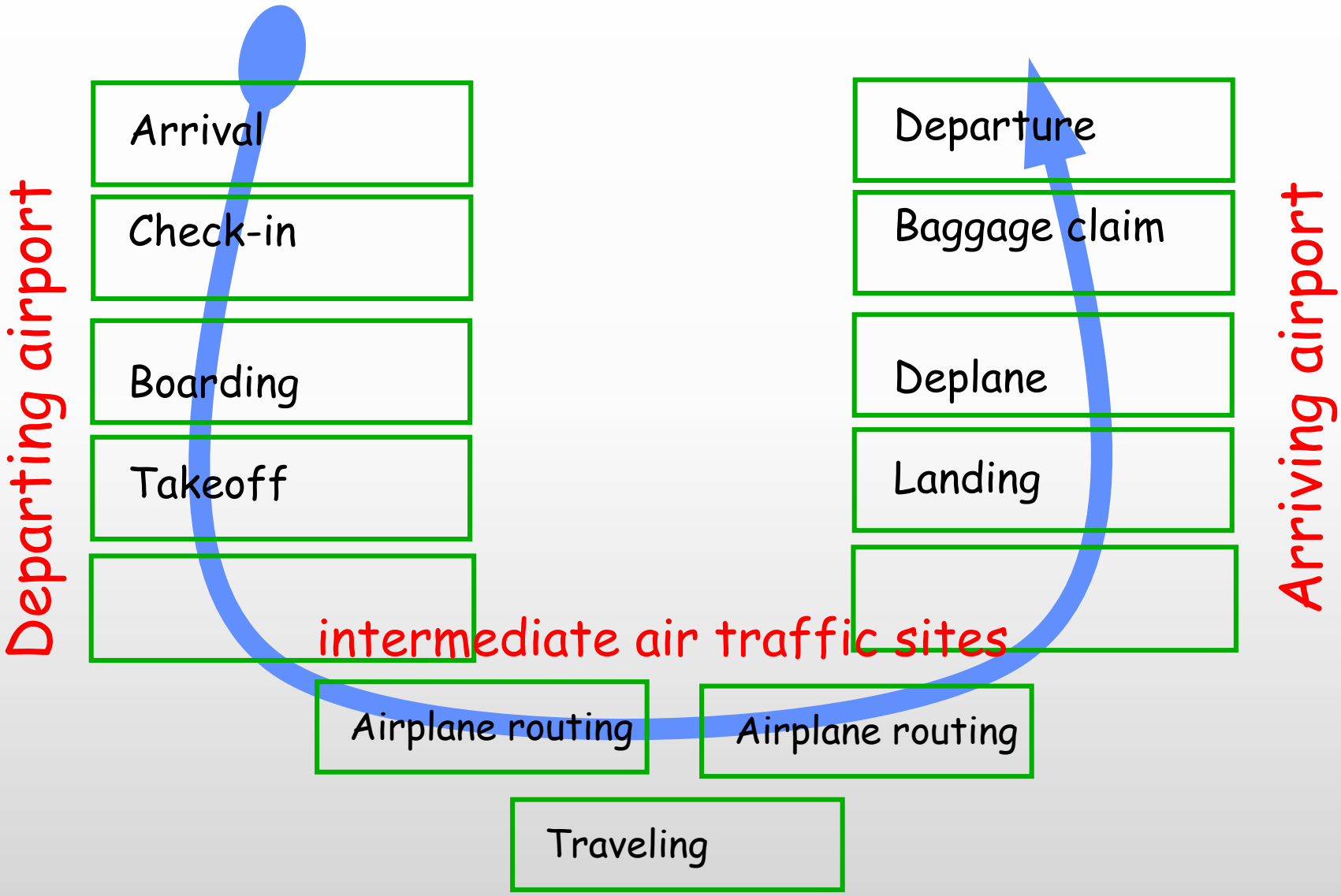
- *What is it?*
- **Building complex systems is hard!**
  - **Approach: "Divide and conquer".**
  - **Split job into smaller jobs, or layers.**
- *Analogy to other fields.*
  - *Building a house: digging, foundation, framing, etc.*
  - *Car assembly line…*
- *Basic idea: each step dependent on the previous step but does not need to be aware of how the previous step was done.*

Analogy: Air Travel

- *The problem: air travel.*
- *Decomposed into series of steps:*



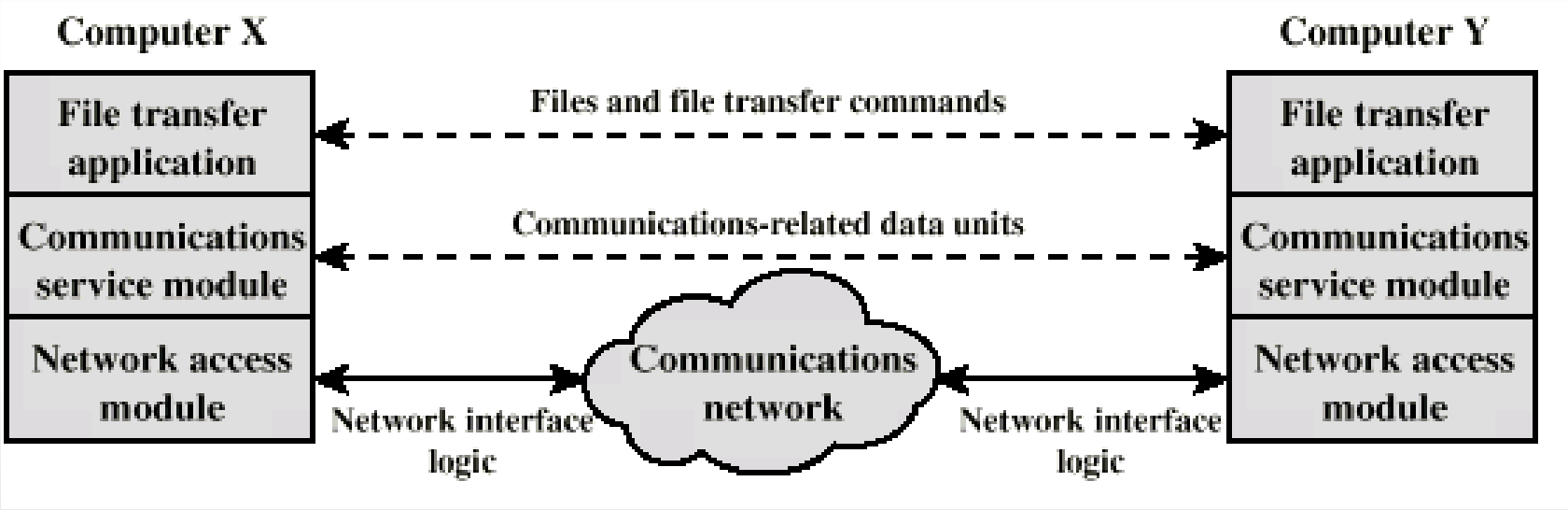
More on the air travel analogy…



Protocol Architecture

- *Task of communication broken up into modules*
- *For example file transfer could use three modules*
  - *File transfer application*
  - *Communication service module*
  - *Network access module*

Simplified File Transfer Architecture



A Three Layer Model

- *Application Layer*
- *Transport Layer*
- *Network Access Layer*

Network Access Layer

- *Exchange of data between the computer and the network*
- *Sending computer provides address of destination*
- *May invoke levels of service*
- *Dependent on type of network used (LAN, packet switched etc.)*

Transport Layer

- *Reliable data exchange*
- *Independent of network being used*
- *Independent of application*

Application Layer

- *Support for different user applications*
- *e.g. e-mail, file transfer*

Layered Protocol Design

- ***Layering model*** *is a solution to the problem of complexity in network protocols*
- *The model divides the network protocols into* ***layers****, each of which solves part of the network communication problem*
  - *Each layer has its own protocol!*
- *Each layer implements a* ***service*** *to the layer above*
  - *Relying on services provided by the layers below.*

Layers

- *Layers are the different components that need to be designed/implemented when designing/implementing networks.*
- *Each layer responsible for a set of functions.*
- *Top layer relies on services provided by bottom layer.*
- *Layer makes it service available to higher layer through an* **interface***.*

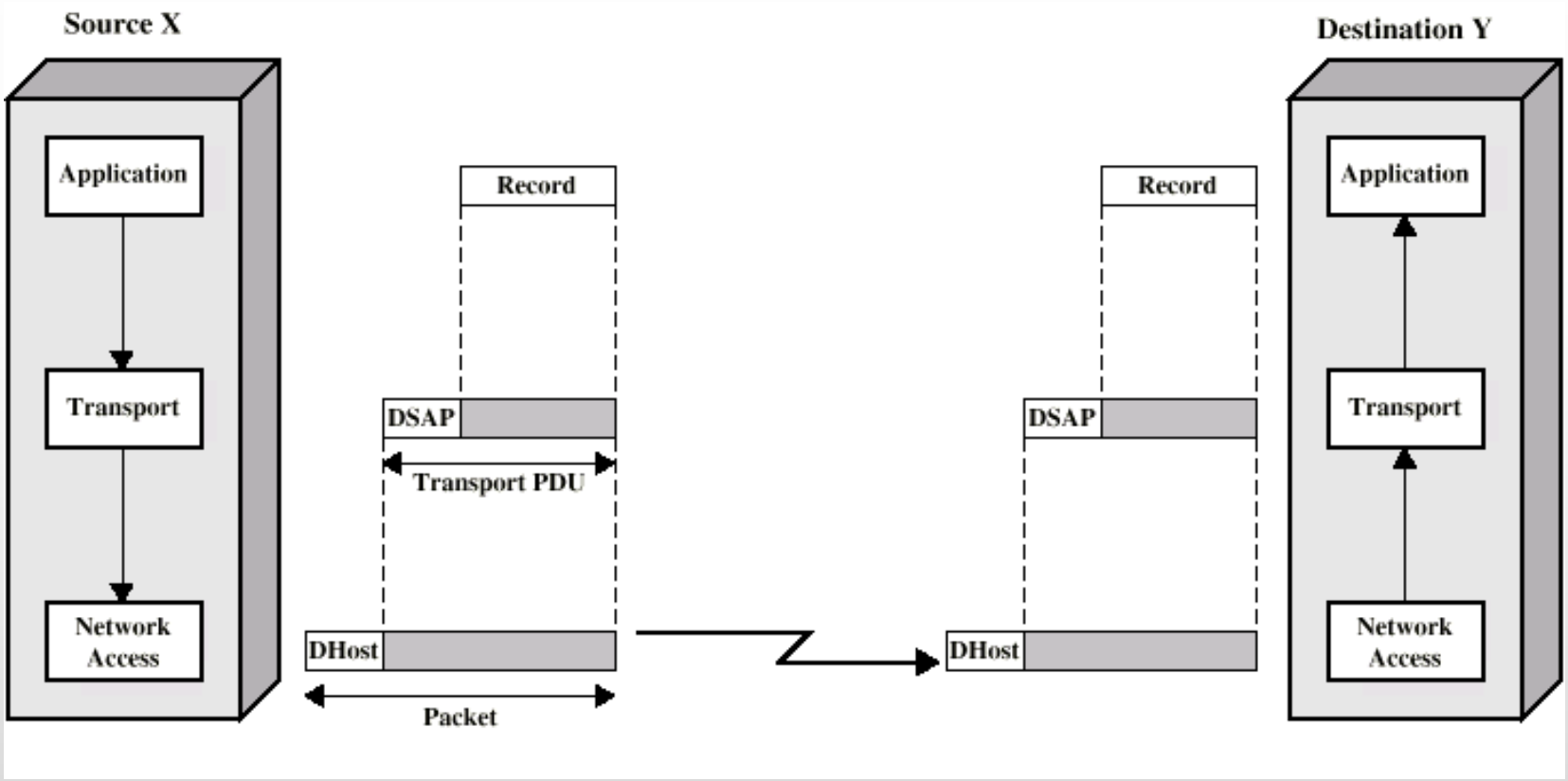
Network/Protocol Architecture

- *Set of layers, what their functions are, the services each of them provide, and the interfaces between them.*
- *A.k.a, protocol architecture or protocol stack.*
- *Examples:*
  - *ISO-OSI 7 layer architecture.*
  - *TCP-IP architecture (Internet).*

Protocol Data Units (PDU)

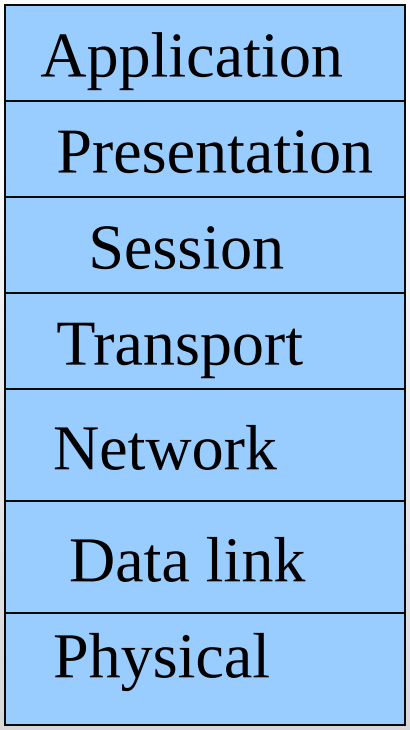
- *At each layer, protocols are used to communicate.*
- *At the source, control information is added to user data at each layer, a.k.a., encapsulation.*
- *At the receiver, control information is stripped off at each layer going up the stack, a.k.a., decapsulation.*

Operation of a Protocol Architecture



Example 1: ISO OSI Architecture

- *ISO: International Standards Organization*
- *OSI: Open Systems Interconnection.*

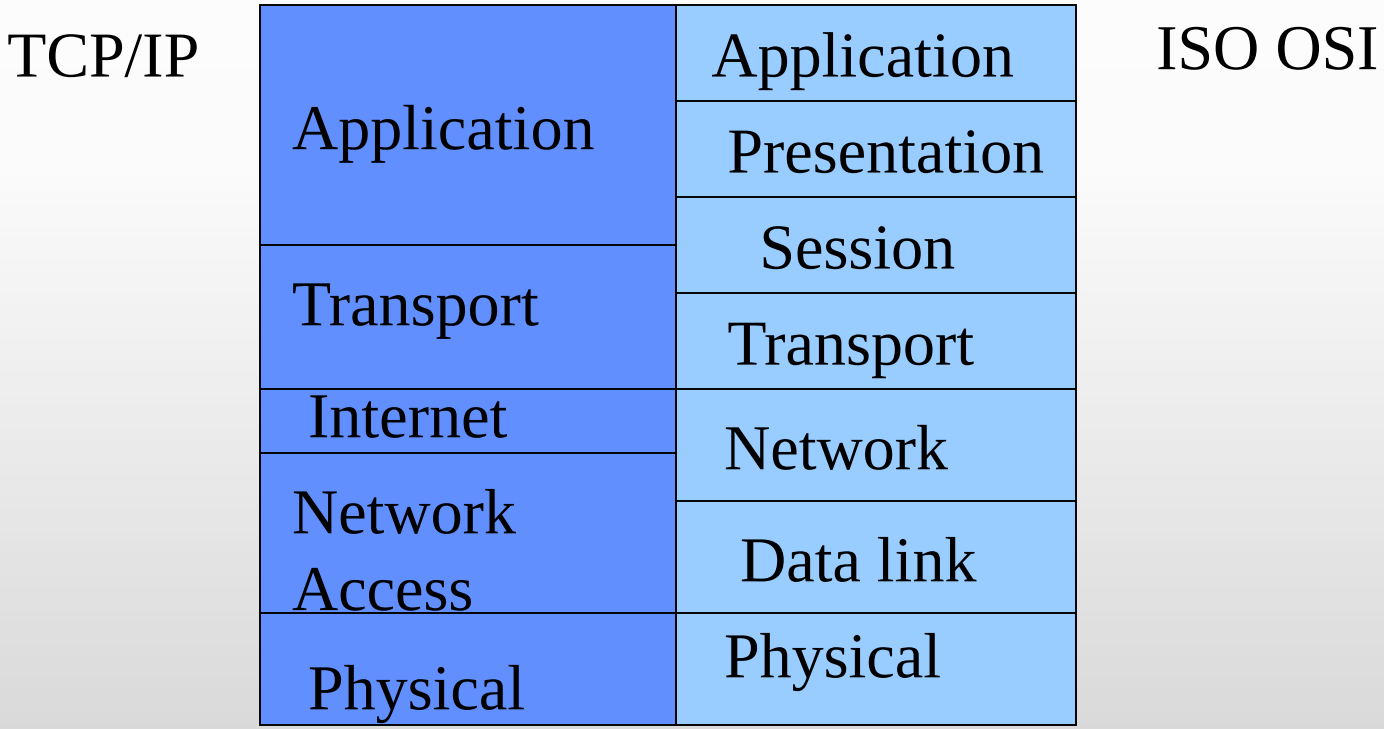


Layers of Interest in ISO Model

- *Layer 7:* ***Application***
  - *Application-specific protocols (e.g. ftp, http, smtp)*
- *Layer 4:* ***Transport***
  - *Delivery of data between computers (end-to-end).*
- *Layer 3:* ***Network***
  - *Data routing across a network.*
- *Layer 2:* ***Data Link***
  - *Reliable transmission over physical medium.*
- *Layer 1:* ***Physical***
  - *Transmission of bits between two nodes.*

Example 2: TCP/IP Architecture

- *Model employed by the Internet.*



TCP/IP Protocol Architecture