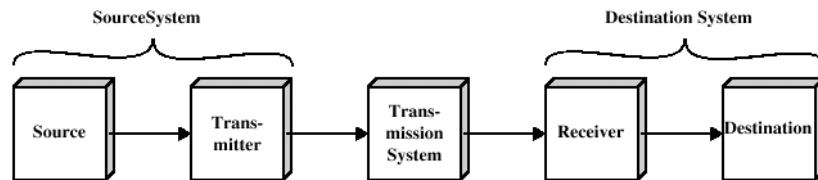# William Stallings
# Data and Computer Communications

Chapter 1
Introduction

A Communications Model

- 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

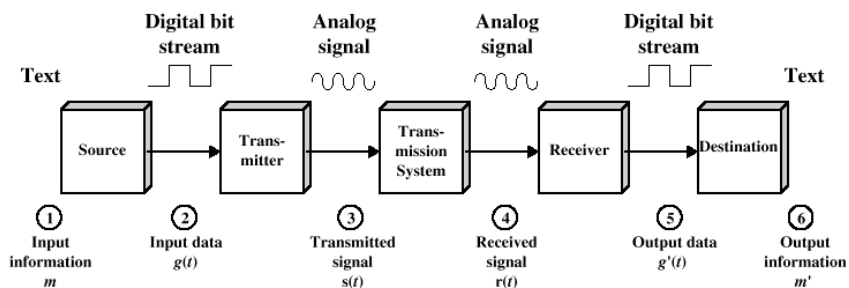# Simplified Communications Model - Diagram

(a) General block diagram
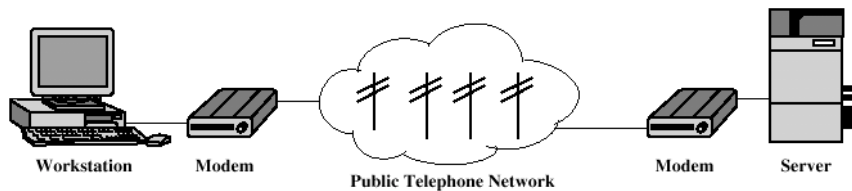
(b) Example

Key Communications Tasks

❚ Transmission System Utilization
❚ Interfacing
❚ Signal Generation
❚ Synchronization
❚ Exchange Management
❚ Error detection and correction
❚ Addressing and routing
❚ Recovery
❚ Message formatting
❚ Security
❚ Network Management

Simplified Data Communications Model

Digital bit stream	Analog signal	Analog signal	Digital bit stream

Text | Source → Trans-mitter → Trans-mission System → Receiver → Destination | Text

① Input information *m*
② Input data *g(t)*
③ Transmitted signal *s(t)*
④ Received signal *r(t)*
⑤ Output data *g'(t)*
⑥ Output information *m'*

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
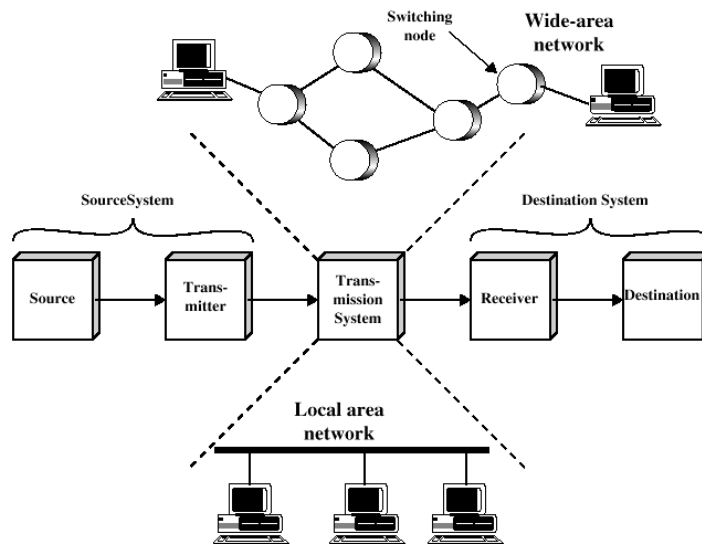
Wide Area Networks

❚ Large geographical area
❚ Crossing public rights of way
❚ Rely in part on common carrier circuits
❚ Alternative technologies
  ❚ Circuit switching
  ❚ Packet switching
  ❚ Frame relay
  ❚ Asynchronous Transfer Mode (ATM)

Circuit Switching

▌ Dedicated communications path established for the duration of the conversation

▌ e.g. telephone network

Packet Switching

▌ Data sent out of sequence

▌ Small chunks (packets) of data at a time

▌ Packets passed from node to node between source and destination

▌ Used for terminal to computer and computer to computer communications

Frame Relay

- Packet switching systems have large overheads to compensate for errors
- Modern systems are more reliable
- Errors can be caught in end system
- Most overhead for error control is stripped out

Asynchronous Transfer Mode

- ATM
- Evolution of frame relay
- Little overhead for error control
- Fixed packet (called cell) length
- Anything from 10Mbps to Gbps
- Constant data rate using packet switching technique

Integrated Services Digital Network

❚ ISDN
❚ Designed to replace public telecom system
❚ Wide variety of services
❚ Entirely digital domain

Local Area Networks

❚ Smaller scope
  ❚ Building or small campus
❚ Usually owned by same organization as attached devices
❚ Data rates much higher
❚ Usually broadcast systems
❚ Now some switched systems and ATM are being introduced

Protocols

▮ Used for communications between entities in a system
▮ Must speak the same language
▮ Entities
  ▮ User applications
  ▮ e-mail facilities
  ▮ terminals
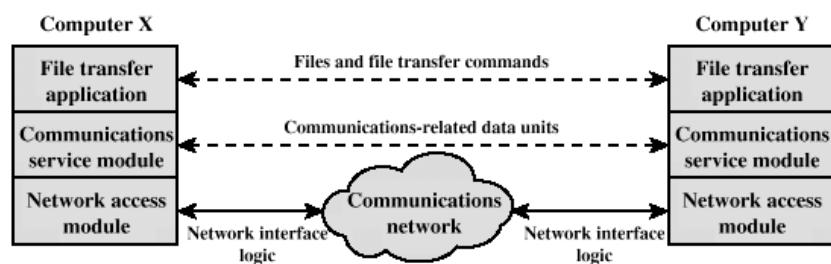▮ Systems
  ▮ Computer
  ▮ Terminal
  ▮ Remote sensor

Key Elements of a Protocol

▮ Syntax
  ▮ Data formats
  ▮ Signal levels
▮ Semantics
  ▮ Control information
  ▮ Error handling
▮ Timing
  ▮ Speed matching
  ▮ Sequencing

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

Computer X | Computer Y

File transfer application — Files and file transfer commands — File transfer application

Communications service module — Communications-related data units — Communications service module

Network access module — Network interface logic — Communications network — Network interface logic — Network access module

A Three Layer Model

❚ Network Access Layer
❚ Transport Layer
❚ Application 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
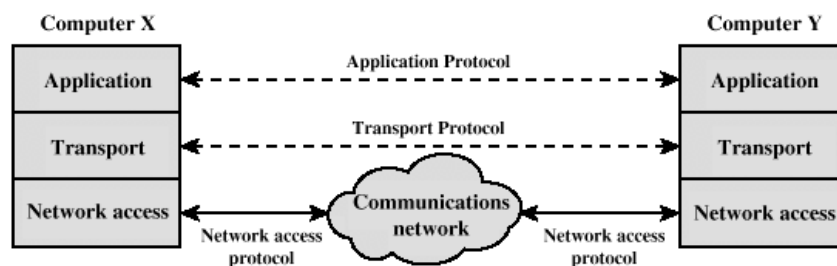∎ e.g. e-mail, file transfer

Addressing Requirements

❙ Two levels of addressing required
❙ Each computer needs unique network address
❙ Each application on a (multi-tasking) computer needs a unique address within the computer
  ❙ The service access point or SAP

Protocol Architectures and Networks
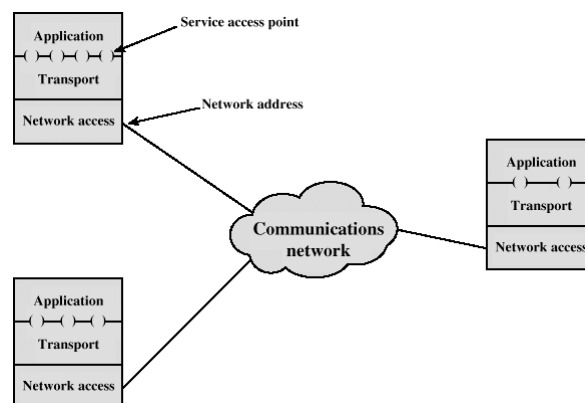
Protocols in Simplified Architecture

Protocol Data Units (PDU)

❚ At each layer, protocols are used to communicate
❚ Control information is added to user data at each layer
❚ Transport layer may fragment user data
❚ Each fragment has a transport header added
  ❚ Destination SAP
  ❚ Sequence number
  ❚ Error detection code
❚ This gives a transport protocol data unit

Network PDU

∎ Adds network header
  ∎ network address for destination computer
  ∎ Facilities requests

Operation of a Protocol Architecture
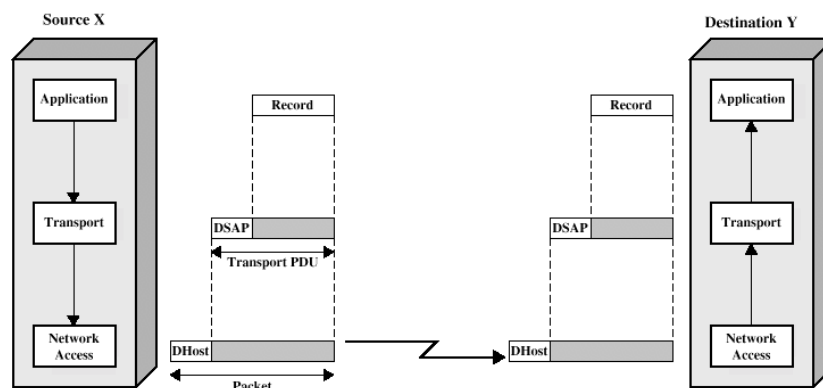
TCP/IP Protocol Architecture

❚ Developed by the US Defense Advanced Research Project Agency (DARPA) for its packet switched network (ARPANET)

❚ Used by the global Internet

❚ No official model but a working one.

  ❚ Application layer
  ❚ Host to host or transport layer
  ❚ Internet layer
  ❚ Network access layer
  ❚ Physical layer

Physical Layer

❚ Physical interface between data transmission device (e.g. computer) and transmission medium or network

❚ Characteristics of transmission medium

❚ Signal levels

❚ Data rates

❚ etc.

Network Access Layer

∎ Exchange of data between end system and network

∎ Destination address provision

∎ Invoking services like priority

Internet Layer (IP)

∎ Systems may be attached to different networks

∎ Routing functions across multiple networks

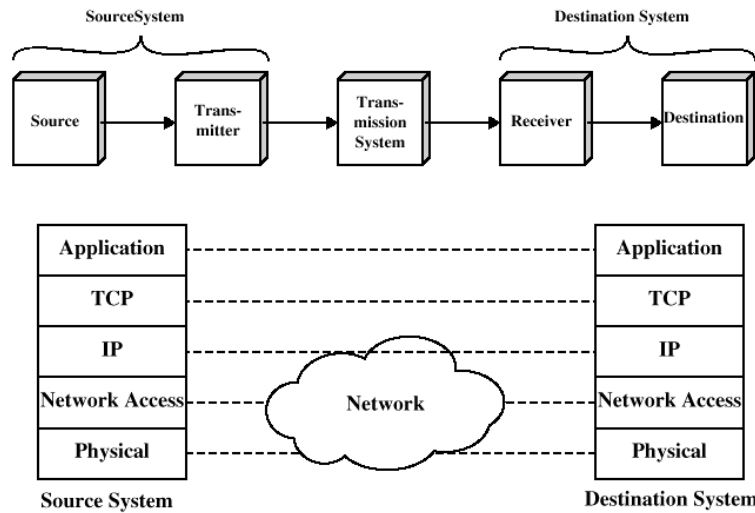∎ Implemented in end systems and routers

Transport Layer (TCP)

❚ Reliable delivery of data
❚ Ordering of delivery

Application Layer

❚ Support for user applications
❚ e.g. http, SMPT

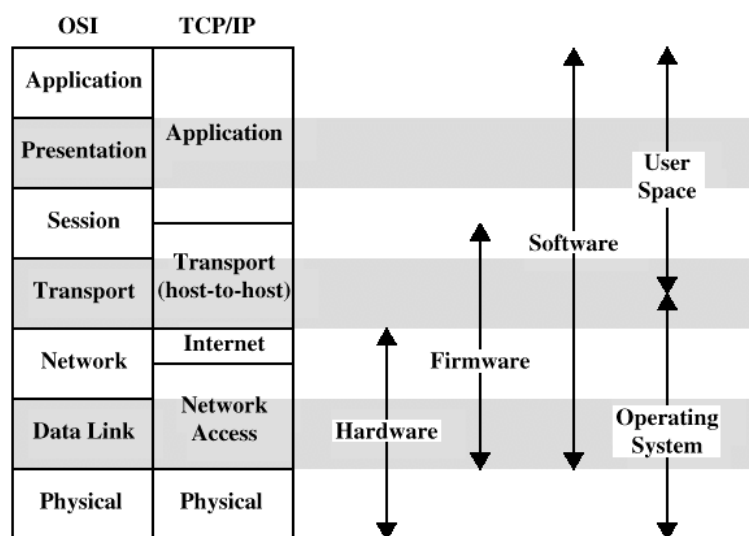# TCP/IP Protocol Architecture Model

OSI Model

- Open Systems Interconnection
- Developed by the International Organization for Standardization (ISO)
- Seven layers
- A theoretical system delivered too late!
- TCP/IP is the de facto standard

OSI Layers

∎ Application
∎ Presentation
∎ Session
∎ Transport
∎ Network
∎ Data Link
∎ Physical

OSI v TCP/IP

OSI	TCP/IP				
Application	Application				
Presentation				User Space	
Session			Software		
Transport	Transport (host-to-host)				
Network	Internet		Firmware		
Data Link	Network Access	Hardware		Operating System	
Physical	Physical				

Standards

❚ Required to allow for interoperability between equipment

❚ Advantages

  ❚ Ensures a large market for equipment and software

  ❚ Allows products from different vendors to communicate

❚ Disadvantages

  ❚ Freeze technology

  ❚ May be multiple standards for the same thing

Standards Organizations

❚ Internet Society

❚ ISO

❚ ITU-T (formally CCITT)

❚ ATM forum

Further Reading

- ❚ Stallings, W. Data and Computer Communications (6th edition), Prentice Hall 1999 chapter 1
- ❚ Web site for Stallings book
  - ❚ www.shore.net/~ws/DCC6e.html
- ❚ Web sites for IETF, IEEE, ITU-T, ISO
- ❚ Internet Requests for Comment (RFCs)
- ❚ Usenet News groups
  - ❚ comp.dcom.*
  - ❚ comp.protocols.tcp-ip