

# EEC-484/584 Computer Networks

## Lecture 2

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(Lecture notes are based on materials supplied by  
Dr. Louise Moser at UCSB and Prentice-Hall)



## Outline

- Definition of computer networks
- Network Hardware
  - Type of computer networks
- Network Software
  - Protocols etc.
- Reference models
- Network standardization



## Misc.

- Interested in research?
  - Secure and Dependable Web Services
  - Randomized Service Migration
  - Byzantine Fault Tolerant Database Systems
  - Secure and Dependable Voice over IP Systems
  - Reliable multicast in wireless networks
- Textbook online:
  - <http://proquest.safaribooksonline.com/0130661023>



## Definition of Computer Network

- Computer Network: Interconnected collection of autonomous computers
  - **Interconnected** - able to exchange info via copper wire, fiber, microwaves, satellites, etc.
  - **Autonomous** - act independently
- Single network vs. network of networks
  - A single network uses a single technology



## Why Computer Networks?

- Business applications
  - Share resource, conduct business
- Home applications
  - Entertainment, shopping
- Mobile users

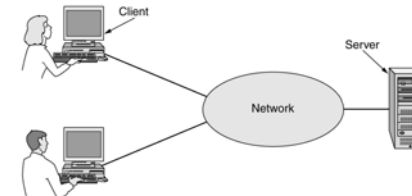
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## Computer Networks Enable Resource Sharing

- Resource sharing
  - Equipment, software programs, data



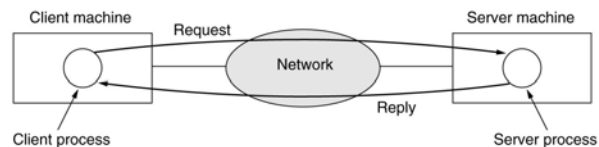
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## Client-Server Model

- The client-server model involves requests and replies



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## Type of Computer Networks

- No generally accepted taxonomy. Two dimensions
  - Transmission technology
  - Scale
- Transmission technology
  - Broadcast links
  - Point-to-point links (unicasting)

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## Classification by Scale

Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	Local area network
100 m	Building	
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	
10,000 km	Planet	

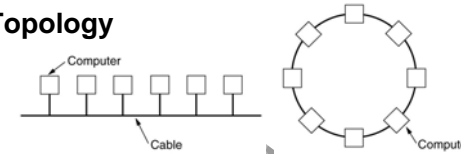
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## Local Area Networks

- LANs are distinguished from other kinds of networks by three characteristics
  - Size** – typically spans a room, a building or a campus
  - Transmission technology** – typically using broadcast
  - Topology**



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## Wide Area Networks

- Spans a large geographical area, often a country or continent
- Network structure in WAN
  - Hosts** or end systems
    - Collection of machines that run user (application) programs
  - Communication Subnet** – connects hosts
    - Carry messages from host to host, just as the telephone system carries words from speaker to listener

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## Wide Area Networks

- Separation of the pure communication aspects of the network (the subnet) from the application aspects (the hosts), greatly simplifies the complete network design

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## Communication Subnet

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- Two distinct components
  - **Transmission lines** – move bits (circuits, channels, trunks)
  - **Routers or switching elements** that connect three or more transmission lines
- Two types of designs
  - Point-to-point channels <= dominating
  - Broadcast channels

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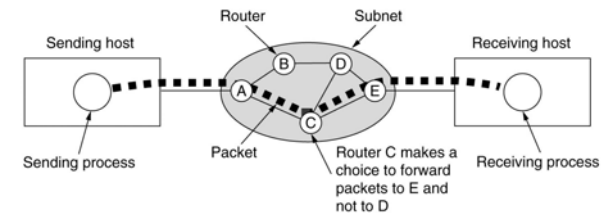
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## Wide Area Networks

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- Relation between hosts on LANs & subnet



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## Network Software

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- Terminologies
- Design issues for the layers
- Connection-oriented and connectionless services
- The relationship of services to protocols

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## Terminologies

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- A protocol is a set of rules governing the format and meaning of the messages that are exchanged by the peer entities within a layer
- Protocol hierarchies are organized into layers or levels with different protocols at each layer
  - Each layer offers certain services to higher layers, hiding the details of implementation of those services

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## Terminologies

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- Interface between adjacent layers defines operations and services offered by lower layer to upper layer
- A service is a set of primitives (operations) that a layer provides to the layer above it
  - Defines what operations the layer is prepared to perform on behalf of its users
  - How service is implemented is not revealed
  - Relates to an interface between two layers, with lower layer being the service provider and the upper layer being service user

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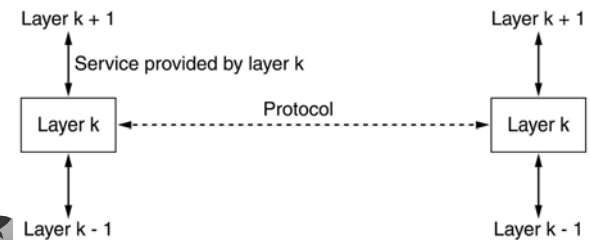
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## Terminologies

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- Entities use protocols to implement their service definitions
  - Different protocol could be used to provide the same service



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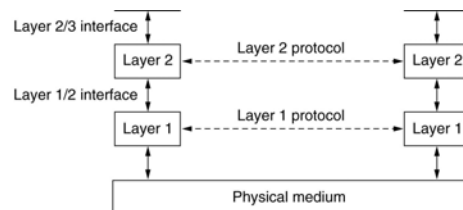
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## Terminologies

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- **Protocol Stack** - A list of protocols used by a certain system, one protocol per layer



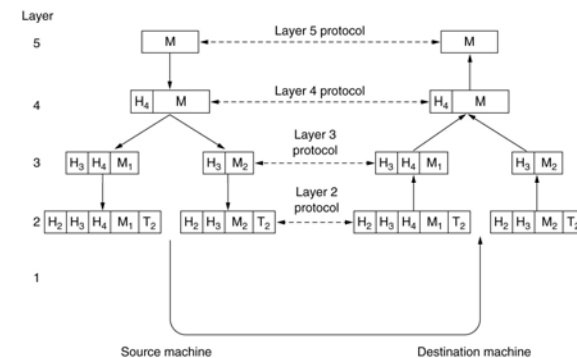
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## Multilayer Communication Example

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## Design Issues for the Layers

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- Mechanisms for
  - Connection establishment and addressing
  - Connection termination or release
- Rules for data transfer
  - Simplex – one direction
  - Half duplex – either direction, but not simultaneously
  - Full duplex – both directions simultaneously
  - Number of logical channels and their priority

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## Design Issues for the Layers

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- Error control
  - Error detecting and correcting codes
  - Positive and negative acknowledgement
  - Re-sequencing packets that arrives out of order
- Flow control
  - Need to keep a fast sender from swamping a slow receiver
  - Use feedback from receiver to sender

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## Design Issues for the Layers

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- Finite buffers
  - Use mechanisms for disassembling, transmitting, reassembling large messages
- Multiplexing
  - Several unrelated conversations between pair of communicating processes
- Routing
  - Which route to use if there are several

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## Connection-Oriented Services

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- Modeled after telephone system – establish connection before communication
- Some service allow a **negotiation** among sender, receiver and subnet regarding the parameters to be used, such as max message size, etc.

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## Connectionless Services

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- Modeled after postal system – a message carries full destination address, and each one is routed through the system independent of all the others
- Ordering of messages are not guaranteed

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## Quality of Services

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- **Quality of service** - characterize each service
- **Reliable service** - it does not lose data
  - Implemented by having the receiver acknowledge the receipt of each message
  - Possible for both connection-oriented and connectionless services
- Connection-oriented service is not necessarily a reliable service!

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## Connection-Oriented and Connectionless Services

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	Service	Example
Connection-oriented	Reliable message stream	Sequence of pages
	Reliable byte stream	Remote login
	Unreliable connection	Digitized voice
Connection-less	Unreliable datagram	Electronic junk mail
	Acknowledged datagram	Registered mail
	Request-reply	Database query

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## Switching

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- Circuit switching
- Packet switching

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## Circuit Switching

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- Circuit switching - physical path set up from source to destination before any data transmitted, e.g., phone system
  - Adv: no congestion problem, only delay is propagation time
  - Disadv: unused bandwidth on allocated circuit is wasted

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## Packet Switching

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- Packet switching - store-and-forward, one hop at a time, uses pipelining, each packet has limited size
  - Adv: low overhead - no setup required, high utilization
  - Disadv: packets may be received out of order, packets may be lost due to buffer overflow

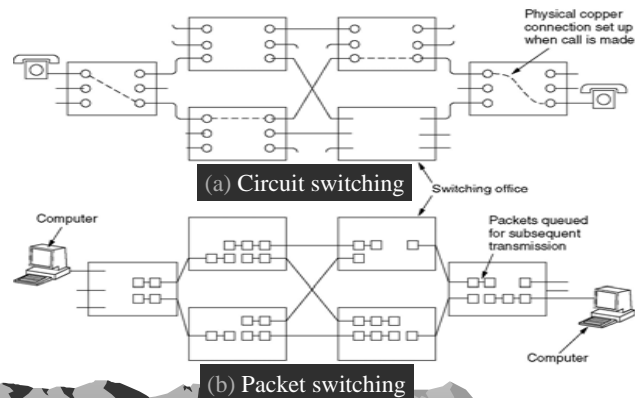
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## Circuit Switching and Packet Switching

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## Reference Models

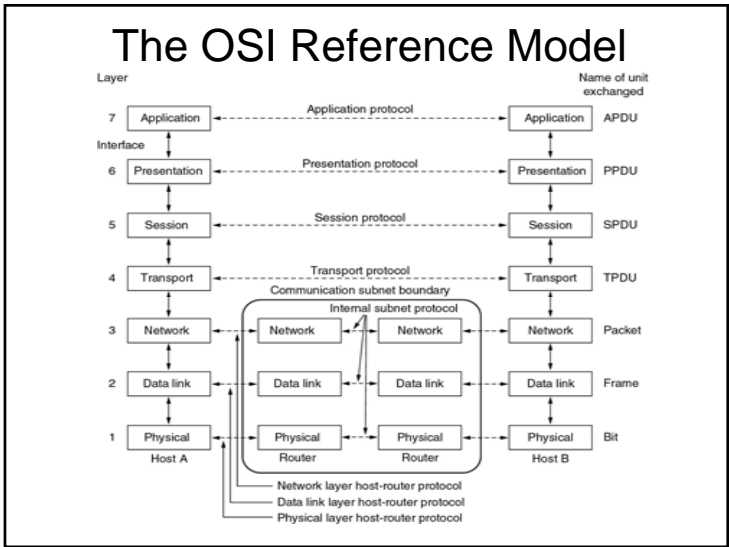
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- The OSI Reference Model
  - ISO - International Standards Organization
  - OSI - Open Systems Interconnection
    - Open: open for communication with other systems
- The TCP/IP Reference Model

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### Principles Applied in Deriving Layers

- A layer should be created where a different level of abstraction is needed
- Each layer should perform a well-defined function
- The layer boundaries should be chosen to minimize info flow across interfaces
- The number of layers should be
  - large enough to separate distinct functions
  - small enough to have a manageable architecture

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### TCP/IP Reference Model

- TCP – Transmission Control Protocol
- IP – Internet Protocol
- Used in Internet and its predecessor ARPANET
- TCP/IP invented by Cerf and Kahn in 1974, became official protocol of ARPANET in 1983

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### TCP/IP Reference Model

OSI	TCP/IP
7 Application	Application
6 Presentation	Not present in the model
5 Session	Not present in the model
4 Transport	Transport
3 Network	Internet
2 Data link	Host-to-network
1 Physical	

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## TCP/IP Reference Model

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- Internet Layer
  - Connectionless (packet switched)
  - Injects packets into the network; delivers them to the destination
  - May be delivered out-of-order
  - Packet routing and congestion control are key issues
  - Uses IP

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## TCP/IP Reference Model

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- Transport layer, two protocols
- TCP – Transmission Control Protocol
  - Point-to-point
  - Connection-oriented
  - Reliable (no message loss or corruption)
  - Source ordered (sequenced)
  - Flow control
  - Byte stream, does not maintain message boundary

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## TCP/IP Reference Model

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- UDP – User Datagram Protocol
  - Point-to-point
  - Connectionless
  - Unreliable
  - Not source ordered
  - No flow control
  - Preserve message boundary

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## TCP/IP Reference Model

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- Application Layer - contains higher-level protocols
  - DNS - Domain Name Service
    - Maps host names onto their network addresses
  - HTTP - HyperText Transfer Protocol
    - Fetches pages on the World Wide Web
  - FTP - File Transfer Protocol
    - Allows user to transfer files efficiently from one machine to another

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## TCP/IP Reference Model

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- Host-to-Network Layer
  - Host has to connect to the network using some protocol so it can send IP packets to it
  - No protocol is defined

## Network Standardization

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- Why standard?
  - Only way to achieve interoperability
  - Standards also increase the market for products adhering to them
  - Two kinds of standards
    - De facto – from the fact (standards that just happened)
    - De jure – by law (formal, legal standards adopted by authorized organization)