

Computer Networks and Communications

Lecture (01):

Introduction

Computer Networks and Communications

Lecturer:

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About This Unit

- **Local Area Networks**
 - Ethernet and Token Passing Networks
- **Wide Area Networks**
 - ATM and ISDN
- **Wireless Networks**
 - Cellular Networks and Wireless LAN
- **Residential Area Networks**
 - ADSL, Cable TV
- **Basic Data Communications Theories**
 - Data transmission
 - Coding & Modulation
 - Multiplexing & Switching
 - Transmission Media

Schedule

PART I (weeks 1 to 6)

- **Basic data communications theories.**

PART II (weeks 6 to 12)

- **Real-world networks from LANs (local area networks) to WANs (wide area networks).**

Revision (week 13)

Lectures Schedule

Week 1	Introduction
Week 2	Data Transmission
Week 3	Transmission Media
Week 4	LAN Standards, Physical Connectivity, and Media Access
Week 5	Data Link Control
Week 6	Multiplexing
Week 7	Switching
Week 8	Connectivity Devices
Week 9	Network Security
Week 10	Cellular Wireless Networks
Week 11	LAN Design
Week 12	
Week 13	Revision

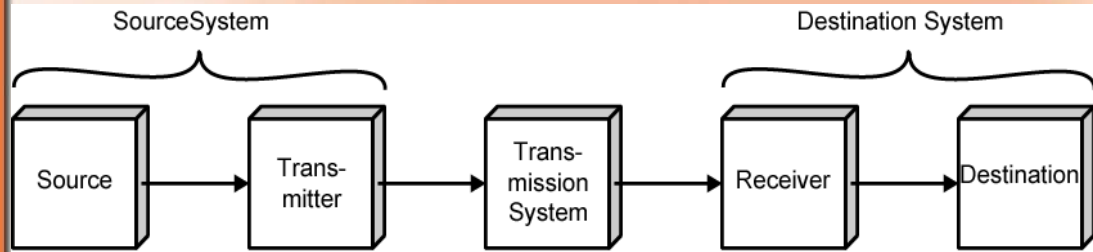
Textbook

**Data and Computer Communications,
10th Edition by William Stallings,
(c) Pearson Education - Prentice Hall, 2013**

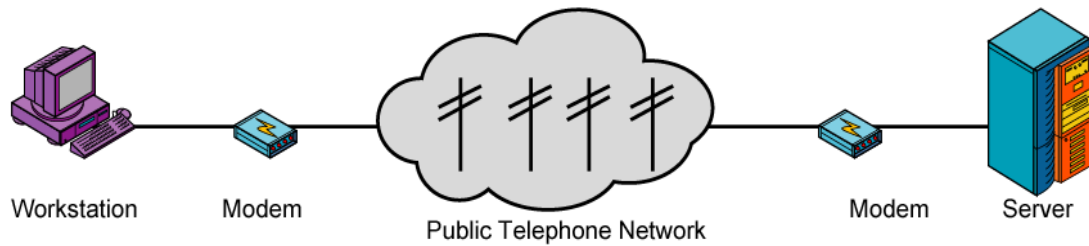
Other Materials

- **Lecture slides.**

A Communications Model



(a) General block diagram



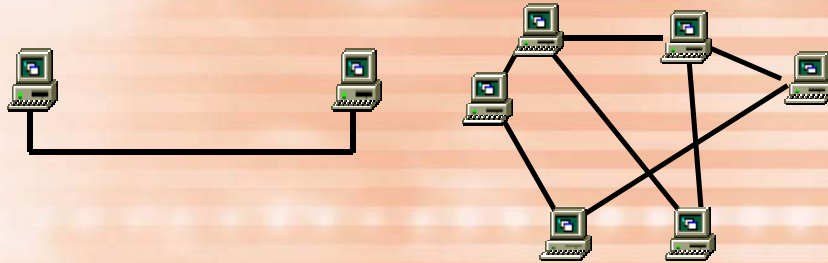
(b) Example

Key Communications Tasks

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

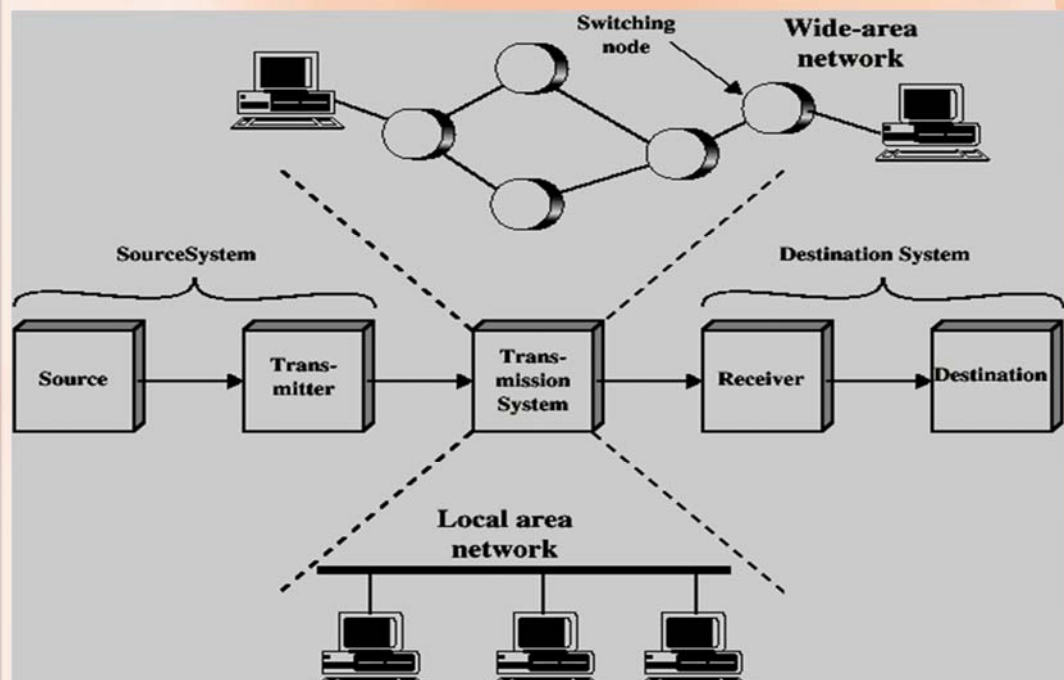
Computer Network?

- **Two or more computers to exchange information.**



- **Point to point communication often impractical.**
 - Devices are too far apart.
 - Large set of devices would need impractical number of connections.
- **Solution is a communications network.**

Simplified Network Model



Local Area Network (LAN)

- **Smaller scope.**
 - Building or small campus
- **Owned by same organization as attached devices.**
- **Data rates generally higher than WAN data rates.**
- **Broadcast, if devices connected via Hub**
- **Point-to-Point, if connected via Switch or ATM**
- **LAN Technologies:**
 - Ethernet
 - Token Ring
 - FDDI
 - Wireless LAN

Wide Area Networks

- **Large geographical area.**
- **A number of interconnected switching nodes.**
 - Provide path to move data from source to destination.
- **Implemented using,**
 - Circuit switching - Dedicated communication path (e.g. PSTN)
 - Packet switching - Data sent out in a sequence of packets (e.g. Frame Relay)
- **WAN Technologies:**
 - Frame Relay
 - ATM
 - ISDN and Broadband ISDN

Circuit Switching

- **uses a dedicated communications path established for duration of conversation**
- **comprising a sequence of physical links**
- **with a dedicated logical channel**
- **eg. 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**
- **Frame Relay provides higher speeds**
- **with most error control overhead removed**

Asynchronous Transfer Mode

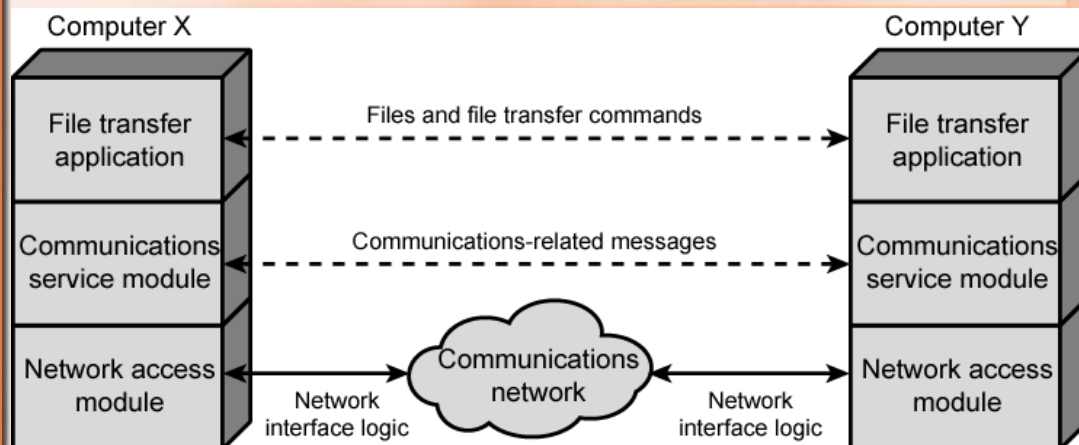
- **ATM**
- **evolution of frame relay**
- **fixed packet (called cell) length**
- **with little overhead for error control**
- **anything from 10Mbps to Gbps**
- **constant data rate using packet switching technique with multiple virtual circuits**

Protocols

- **Used for communications between entities in a system.**
 - Entities: User applications (e.g. e-mail) and terminals
 - Systems: Computer, Terminal and Remote sensor
- **Must speak the same language.**
- **Protocol is a set of rules and conventions.**
- **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

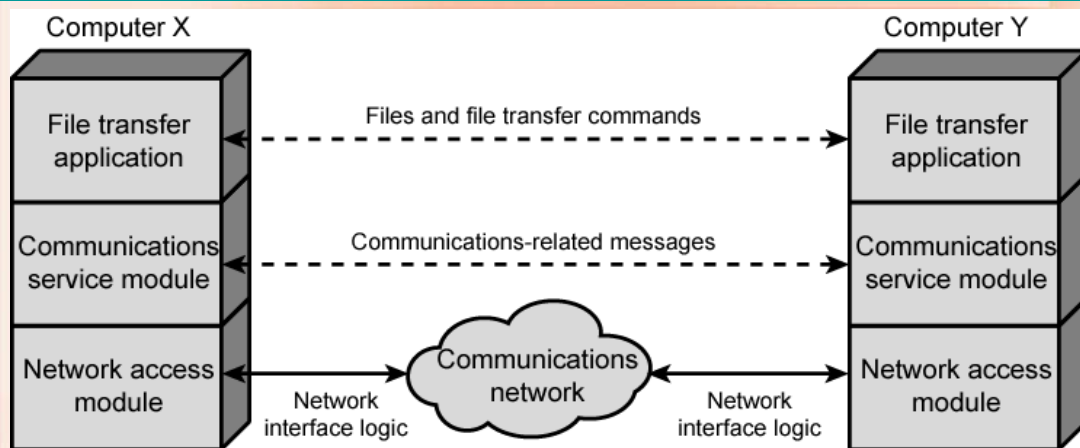


Protocol Architecture

▪ Layering:

- The general idea is that the services offered by the underlying hardware are modeled as the physical layer.
- Add a sequence of layers, each providing a higher level of service.
- Advantages:
 - simplify the task of building a network.
 - provide a modular design.

Simplified File Transfer Architecture



▪ A Three Layer Model

- Network Access Layer
- Transport Layer
- Application Layer

A Three Layer Model

▪ 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.

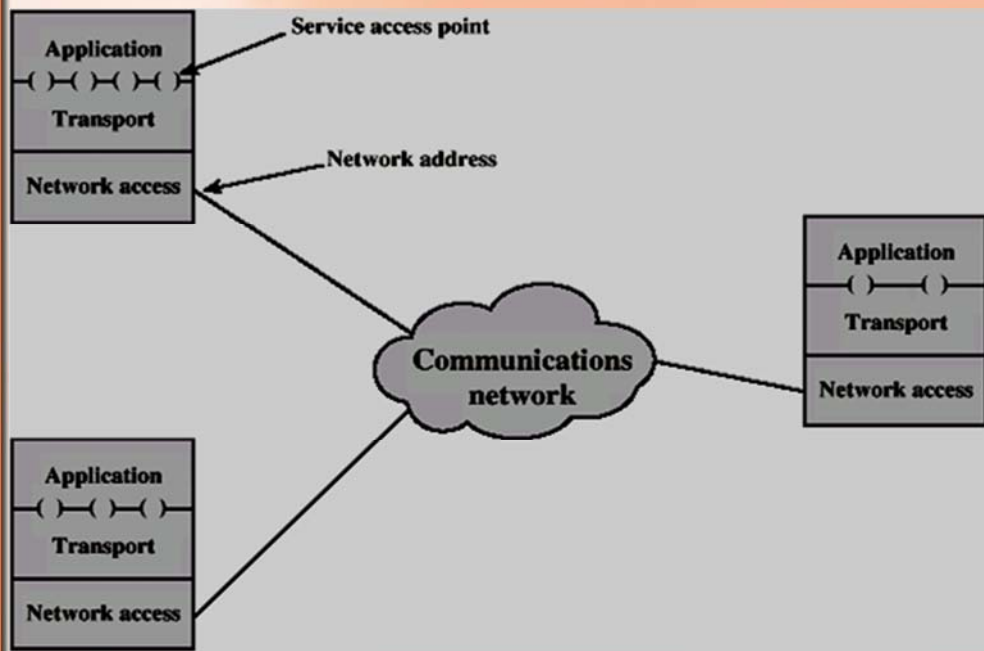
▪ Application Layer

- 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
 - Known as a port

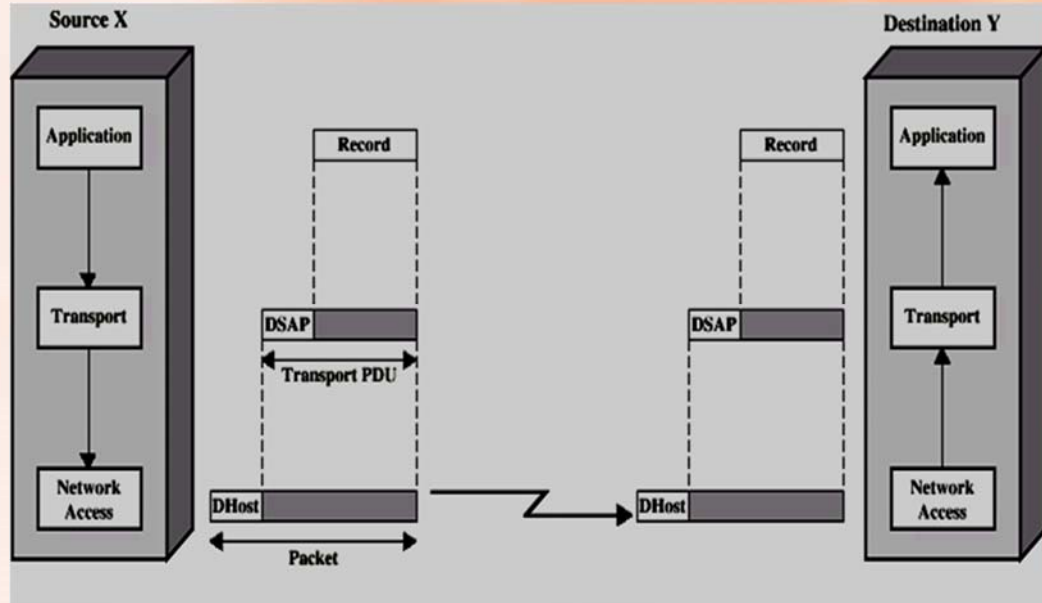
Addressing Requirements



Operation of a Protocol Architecture

- **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 (PDU).
- **Adds network header.**
 - network address for destination computer
 - Facilities requests

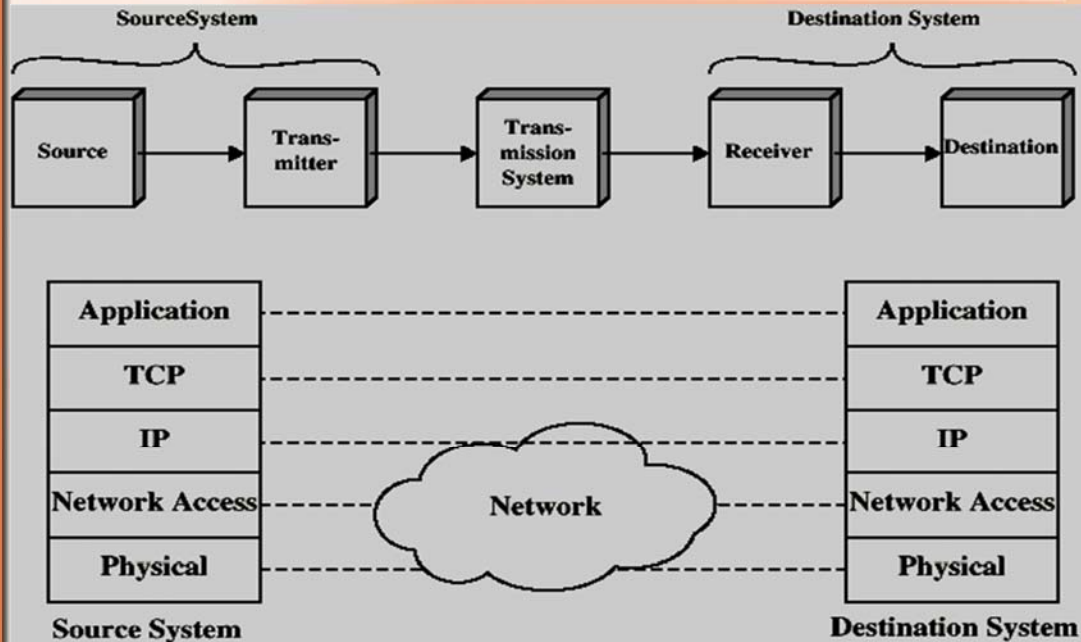
Operation of a Protocol Architecture



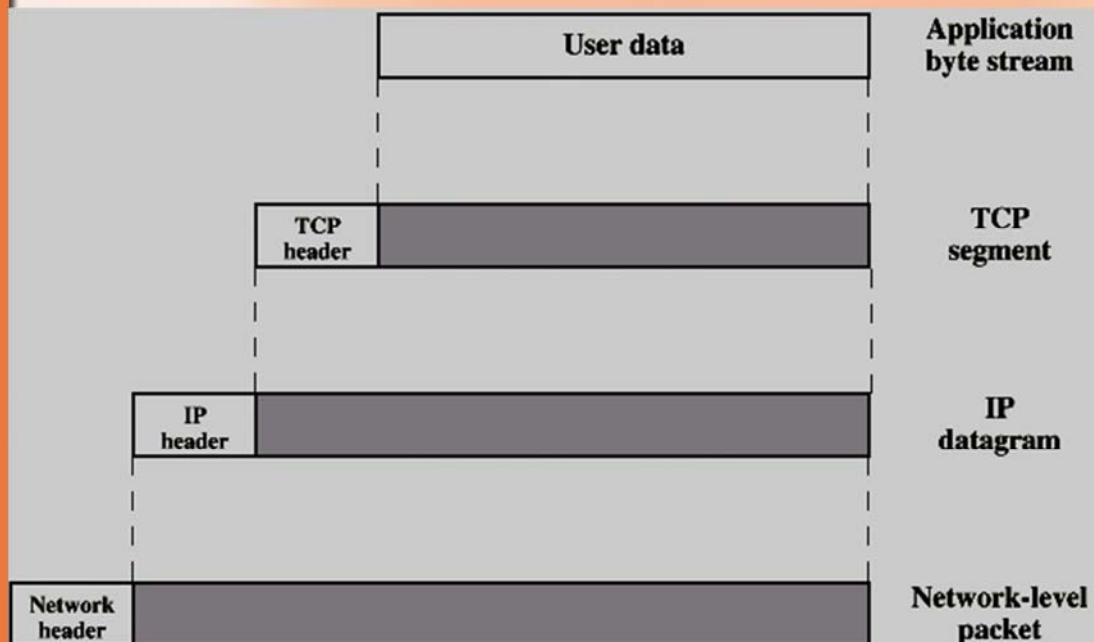
TCP/IP Protocol Architecture

- **Developed by the US Defense Advanced Research Project Agency (DARPA) for its packet switched network (ARPANET).**
- **Used by the global Internet.**
- **Dominant commercial protocol architecture.**
- **No official model but a working one.**
- **Five layers.**
 - Application layer
 - Host to host or transport layer
 - Internet layer
 - Network access layer
 - Physical layer

TCP/IP Protocol Architecture



PDU's in TCP/IP



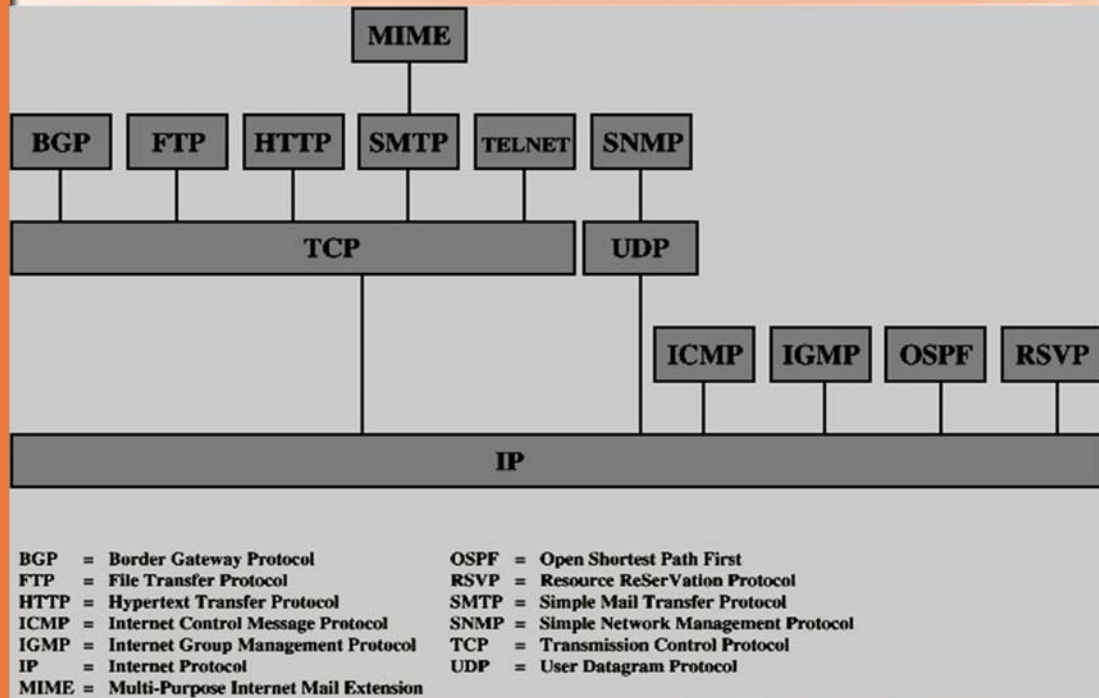
TCP/IP Protocol Architecture

- **Application layer**
 - Support for user applications.
 - e.g. HTTP, SMTP
- **Transport layer**
 - Reliable delivery of data.
 - Ordering of delivery.
- **Internet layer**
 - Systems may be attached to different networks.
 - Routing functions across multiple networks.
 - Implemented in end systems and routers.

TCP/IP Protocol Architecture

- **Network access layer**
 - Exchange of data between end system and network.
 - Destination address provision.
 - Invoking services like priority.
- **Physical layer**
 - Physical interface between data transmission device (e.g. computer) and transmission medium or network.
 - Characteristics of transmission medium.
 - Signal levels.
 - Data rates.

Some Protocols in TCP/IP Suite



Standards

- **Required to allow for interoperability.**
 - **Advantages:**
 - Ensures a large market for equipment and software.
 - Allows products from different vendors to communicate.
 - **Disadvantages**
 - Freeze technology.
 - May be multiple competing standards for the same thing.
 - **Standards Organizations**
 - Internet Society
 - ISO
 - ITU-T (formally CCITT)
 - ATM forum

Protocol Characteristics

▪ Direct or indirect

- Direct
 - Systems share a point to point link or a multi-point link.
 - Data can pass without intervening active agent.
- Indirect
 - Switched networks or internetworks or internets.
 - Data transfer depend on other entities.

▪ Monolithic or Structured

- Communications is a complex task, too complex for single unit.
- Structured design breaks down problem into smaller units (Layered structure).

▪ Symmetric or Asymmetric

- Symmetric: Communication between peer entities.
- Asymmetric: Client/server

Protocol Characteristics

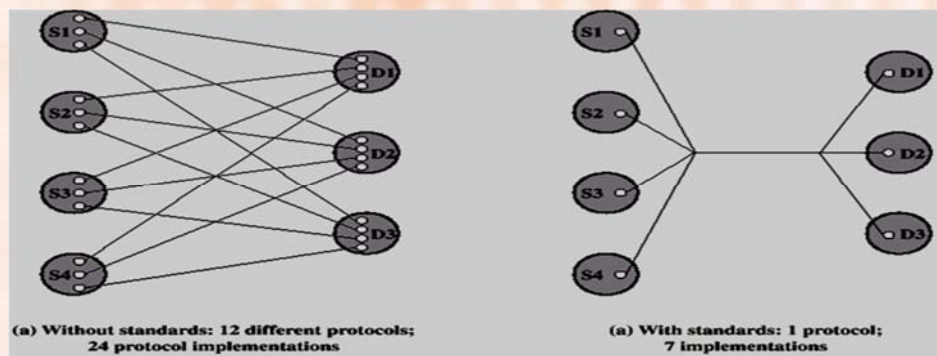
▪ Standard or Nonstandard

Nonstandard:

- Nonstandard protocols built for specific computers and tasks.
- K sources and L receivers leads to $K \cdot L$ protocols and $2 \cdot K \cdot L$ implementations.

Standard:

- If common protocol used, $K + L$ implementations needed.



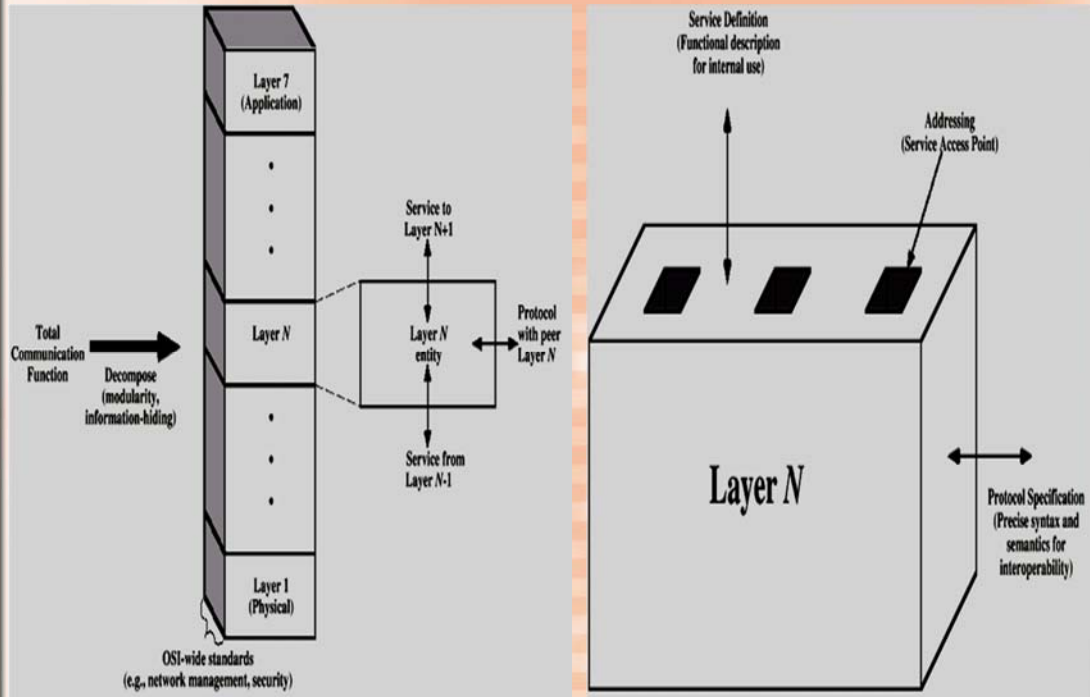
Protocol Functions

- **Encapsulation**
- **Segmentation and reassembly**
- **Connection control**
- **Ordered delivery**
- **Flow control**
- **Error control**
- **Addressing**
- **Multiplexing**
- **Transmission services**

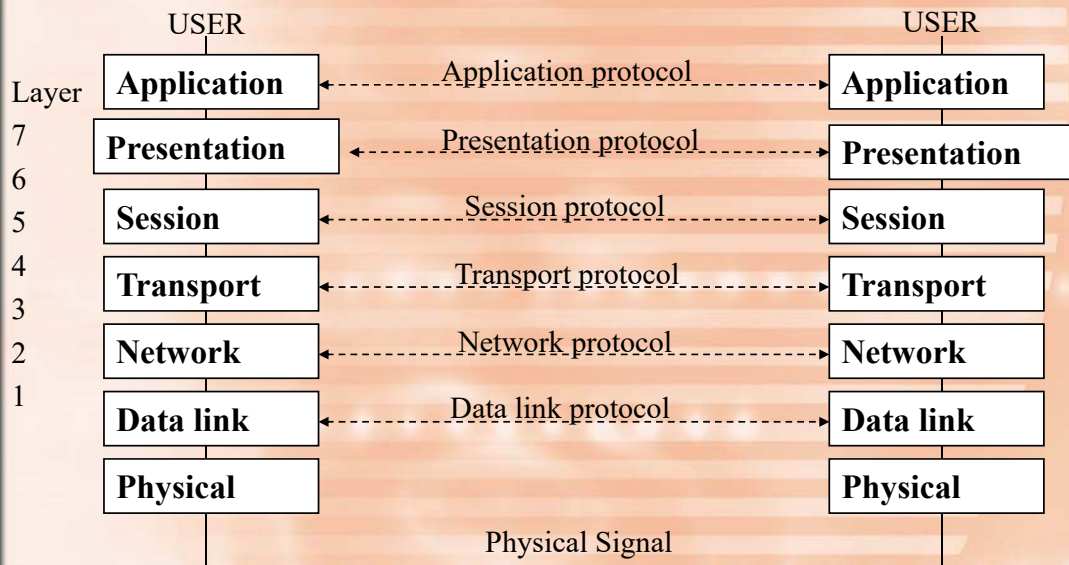
OSI Model

- **Open Systems Interconnection (OSI).**
- **Developed by the International Organization for Standardization (ISO).**
- **Developed too late! (TCP/IP de facto standard).**
- **A seven layer model.**
 - **Application** - **Presentation** - **Session** - **Transport**
 - **Network** - **Data Link** - **Physical**
- **Each layer:**
 - Performs a subset of the required communication functions.
 - Relies on the next lower layer to perform more primitive functions.
 - Provides services to the next higher layer.
 - Independent of changes in other layers.

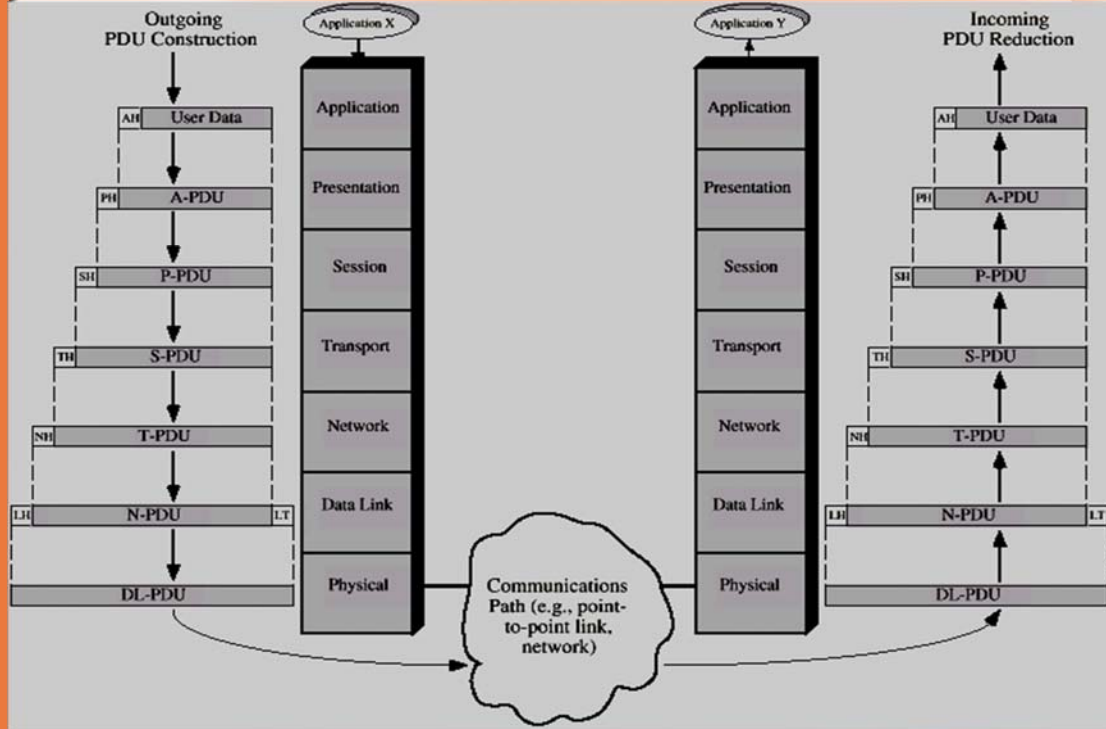
OSI Model



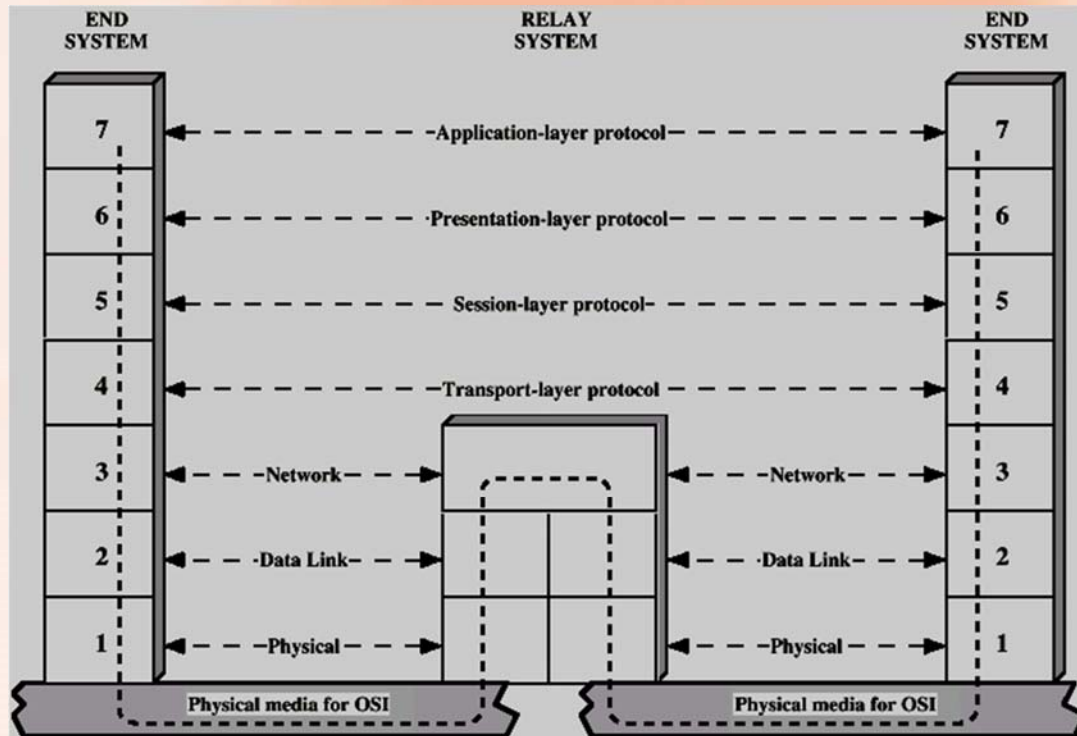
OSI Model



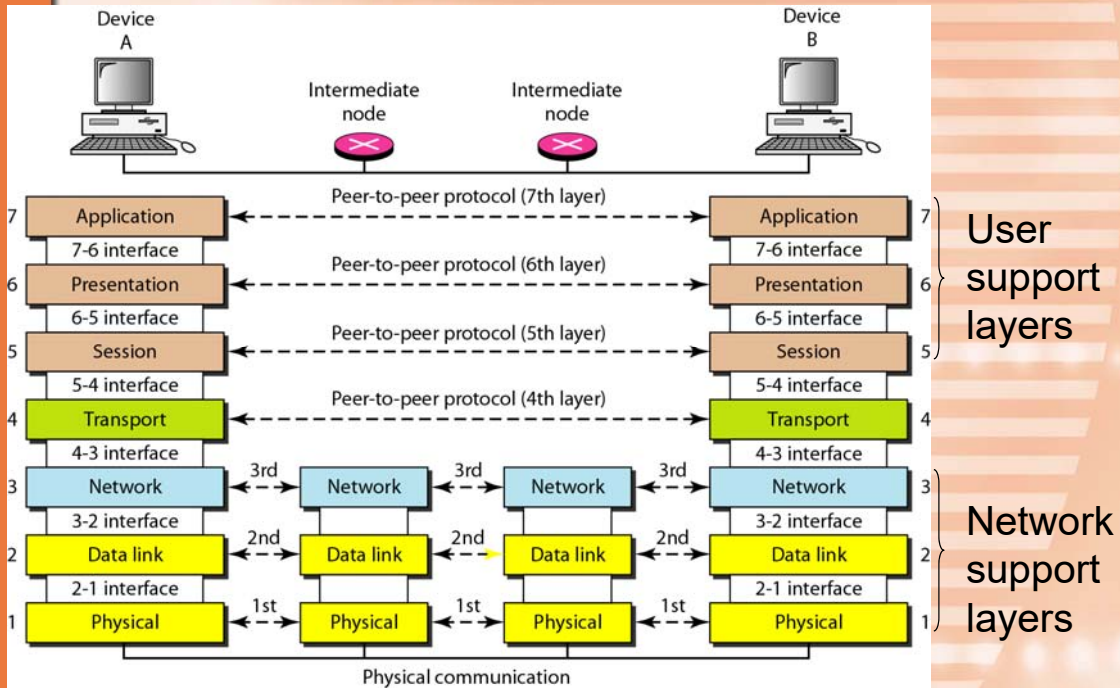
OSI Model



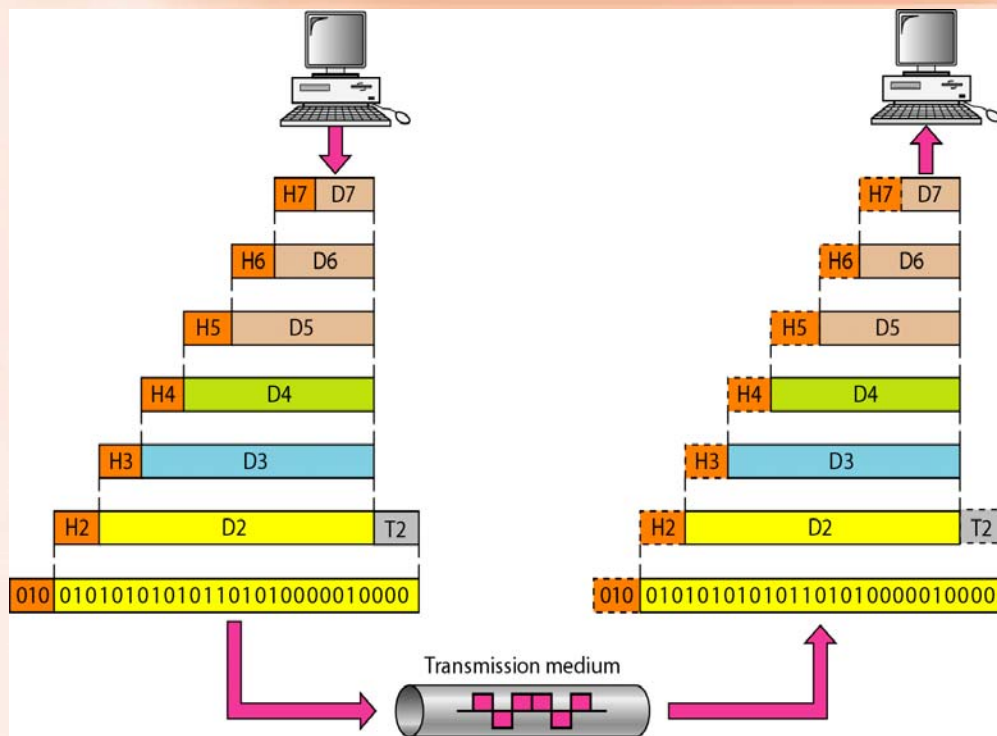
OSI Model



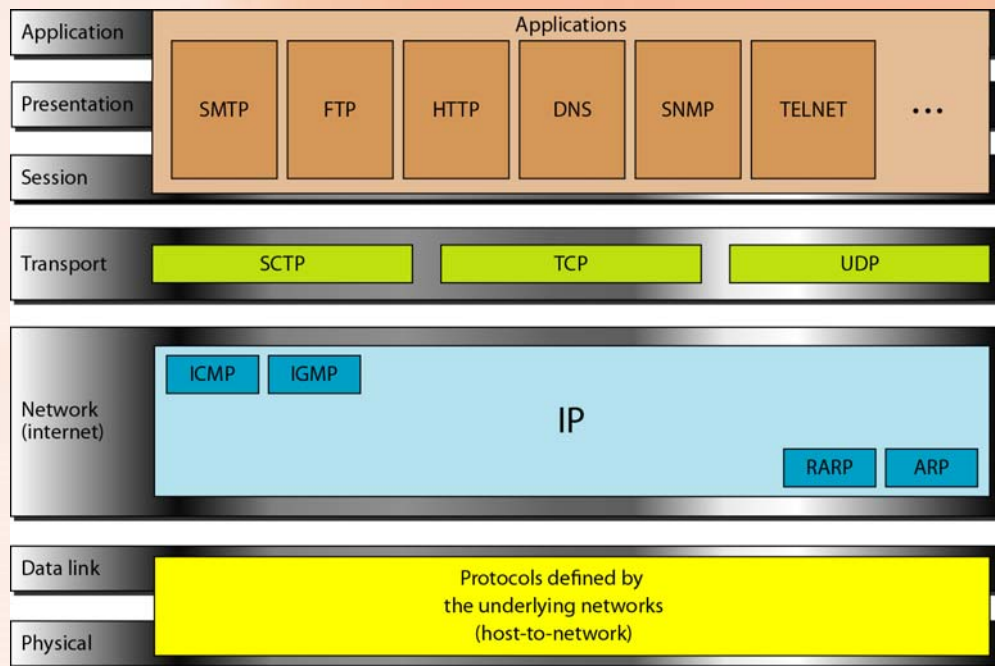
The interaction between layers in the OSI model



An exchange using the OSI model



TCP/IP and OSI model



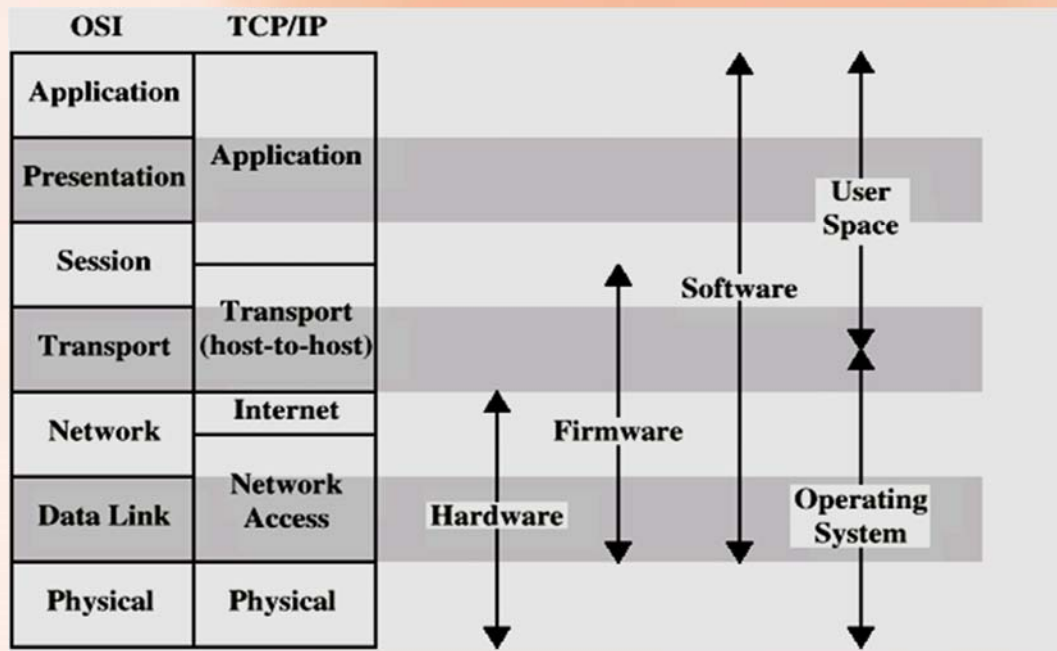
OSI Layers

- **Physical**
 - Physical interface between devices.
 - Mechanical, Electrical, Functional and Procedural
- **Data Link**
 - Means of activating, maintaining and deactivating a reliable link.
 - Error detection and control.
 - Higher layers may assume error free transmission.
- **Network**
 - Transport of information.
 - Higher layers do not need to know about underlying technology.
 - Not needed on direct links.

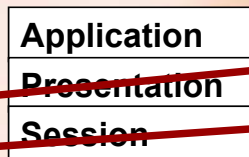
OSI Layers

- **Transport**
 - Exchange of data between end systems.
 - Error free, In sequence, No losses, No duplicates.
 - Quality of service.
- **Session**
 - Control of dialogues between applications.
 - Dialogue discipline, Grouping, Recovery.
- **Presentation**
 - Data formats and coding.
 - Data compression & Encryption.
- **Application**
 - Means for applications to access OSI environment

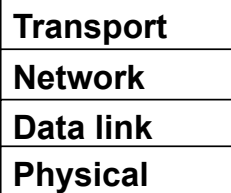
OSI and TCP/IP



OSI model

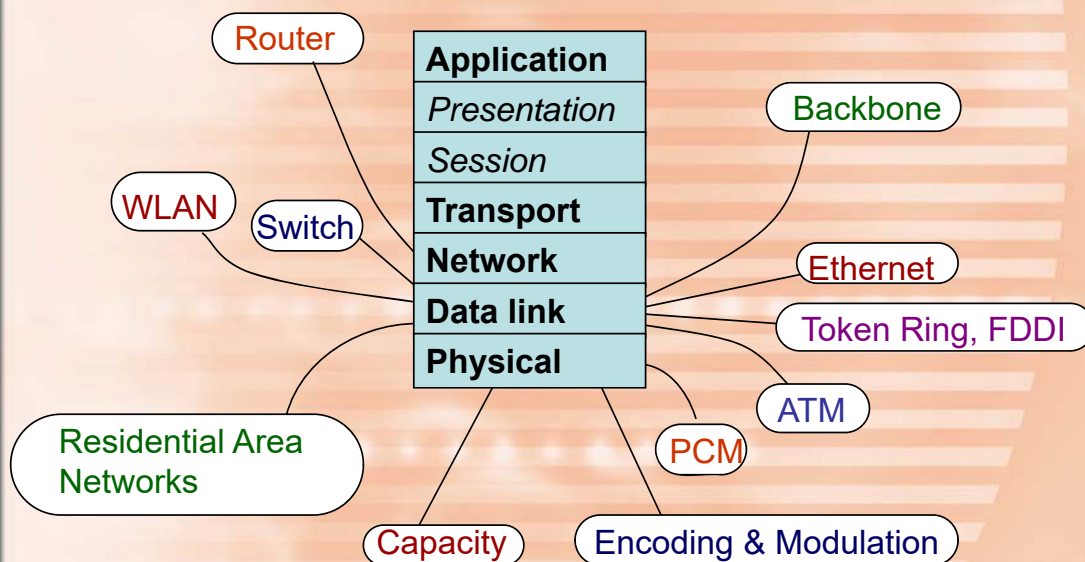


How information from users can be transported using the provided connection.



How bits can be transported reliably and economically through a computer network.

Computer Networks



Required Reading

**Data and Computer Communications,
10th Edition by William Stallings,
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>> Chapter 1 and 2