Networking Overview

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Contents

1. Introduction to networking

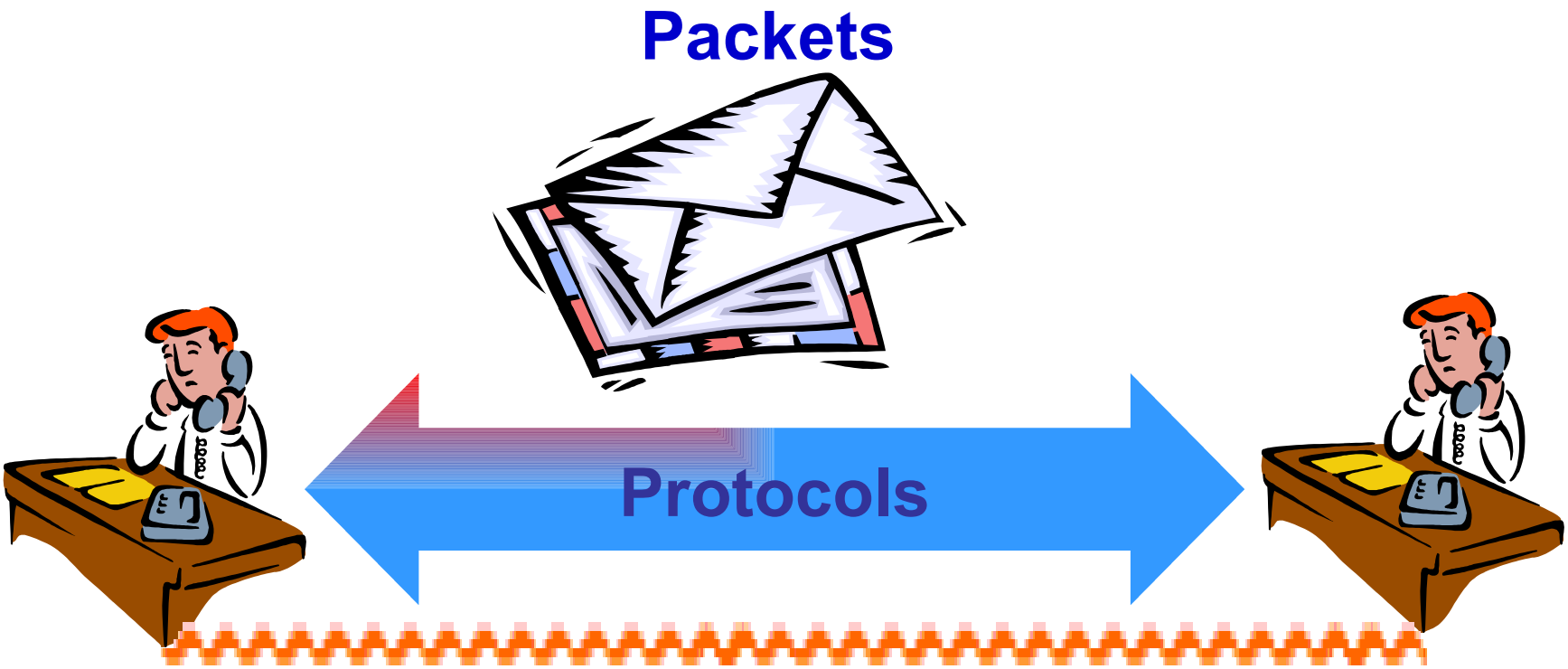
What is networking?

- In the world of computers, **networking** is the practice of linking two or more computing devices together for the purpose of sharing data. Networks are built with a mix of computer hardware and computer software.

What is a network?

- A network can consist of two computers connected together on a desk or it can consist of many smaller network connected together to form a bigger network across a continent.
- Networks can be categorized in several different ways
  - The geographic area it spans (LAN, WAN, …)
  - The protocol it uses (ATM, VPN, …)
- Backbone
  - The main wire that connects nodes. The term is often used to describe the main network connections

Communication Process



Communication Process (cont.)

- Addresses
  - Who are the source and the destination of a communication process?
  - Source Address, Destination Address
- Media
  - Where is the communication take place?
  - Cable, Fiber, Air
- Protocols
  - How to make the communication process effectively?
  - Format, Procedure

Evolution of networking standards

SNA

Standard

Interconnectio
n
Development
Simplification

TCP/IP

DECNET

2. OSI MODEL

OSI Model

- Researched and developed by the ISO - (International Organization for Standardizations) and **ITU-T** (International Telecommunication Union-Telecommunications Standards Sector).
- 1977: establish a subcommittee to develop a communications architecture.
- 1984: publish ISO-7498, the Open System Interconnection (OSI) reference model.

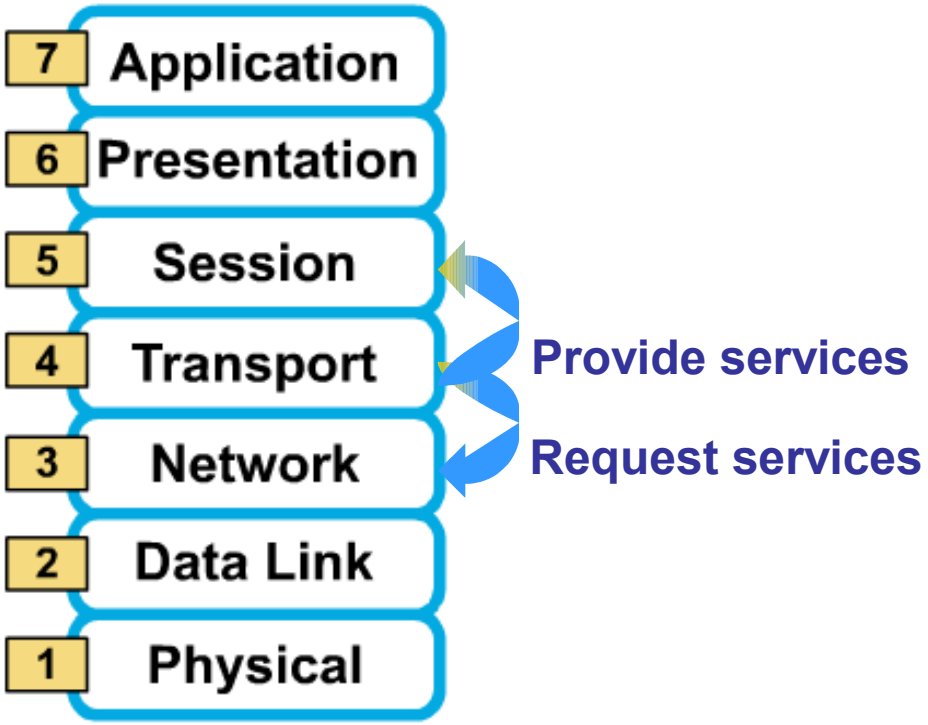
OSI model (cont.)

- A framework within which networking standards can be developed.
  - *It provided vendors with a set of standards that ensured greater compatibility and interoperability between the various types of network technologies that were produced by the many companies around the world.*

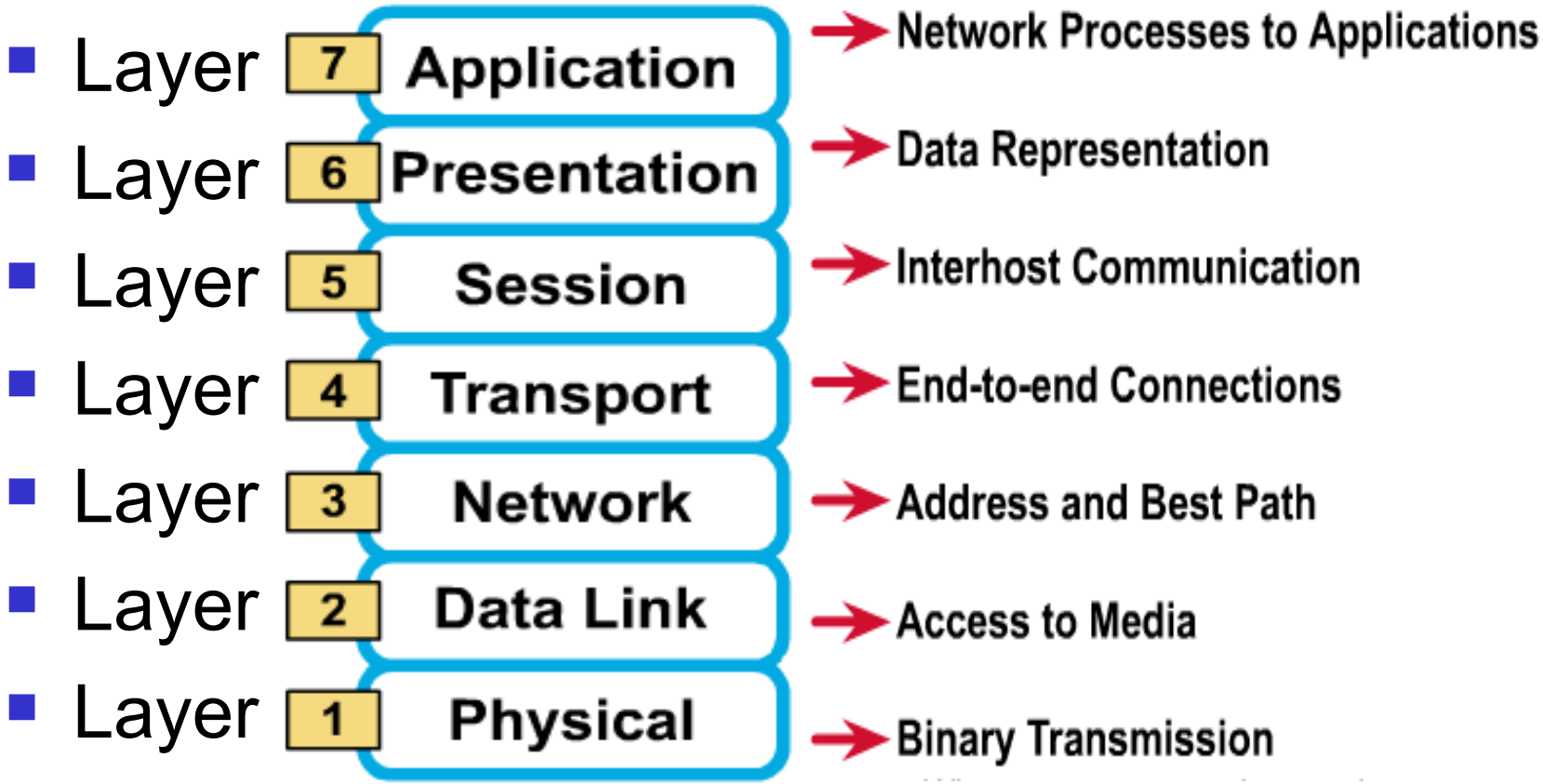
A layered model

- The communications functions are partitioned into a hierarchical set of layers
- Each layer performs a related subset of the functions required to communicate
- Each layer relies on the next lower layer to perform more primitive functions and provides services to the next higher layer

→ *The OSI Model define a set of layers and the services performed by each layer*



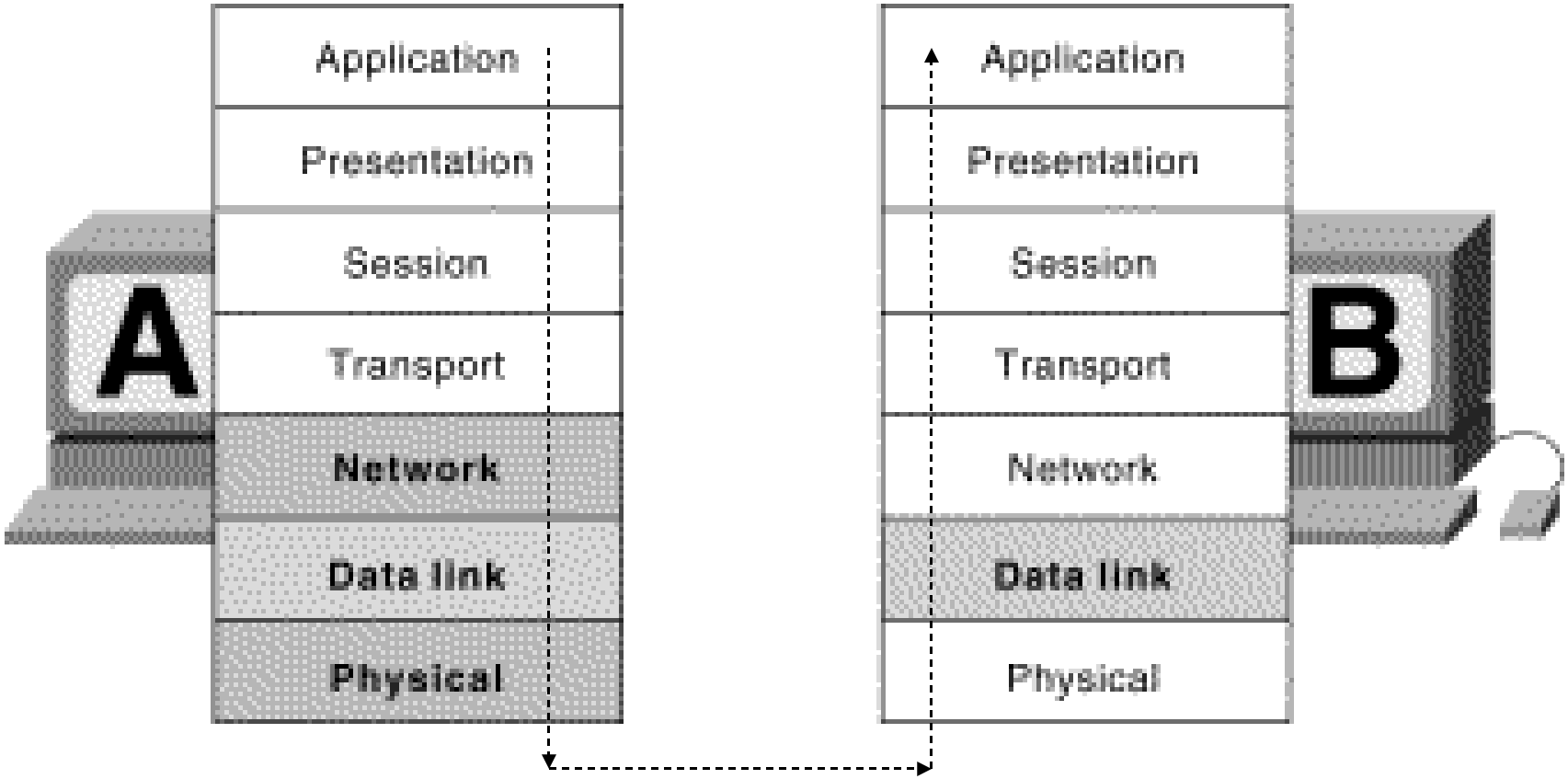
7 layers of the OSI reference model



Why a layered model?

- Reduces complexity.
- Standardizes interfaces.
- Facilitates modular engineering.
- Ensures interoperable technology.
- Accelerates evolution.
- Simplifies teaching and learning.

OSI Model and Communication between Systems



The physical layer

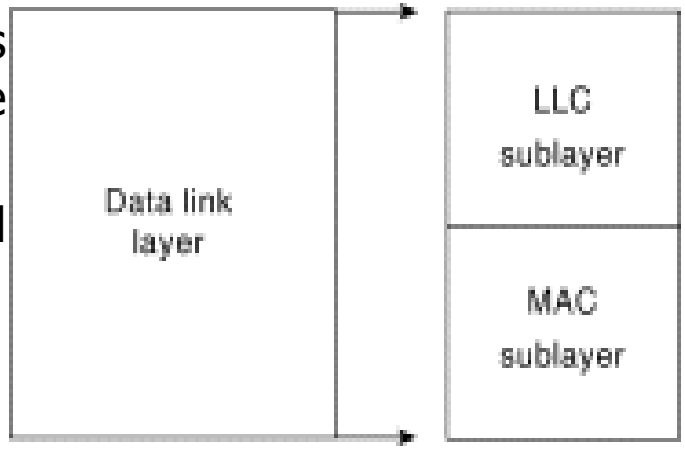
- The physical layer defines the electrical, mechanical, procedural, and functional specifications for activating, maintaining, and deactivating the physical link between communicating network systems
- Physical layer specifications define characteristics such as voltage levels, timing of voltage changes, physical data rates, maximum transmission distances, and physical connectors
  - Physical connector
    - Twisted Pair, Baseband Coaxial Cable, Broadband Coaxial Cable, Fiber Optical, Line-of-Sight Transmission, Communication Satellites.

The data-link layer

- The data link layer provides for the reliable transfer of data cross a physical link.
- Data link layer specifications define different network and protocol characteristics, including physical addressing, network topology, error notification, sequencing of frames, and flow control
  - **Framing**
    - Breaking the bit stream up into discrete frames, Character count
    - Starting and ending characters, with character stuffing (DLE STX, DLE ETX)
    - Starting and ending flags, with bit stuffing (01111110)
  - **Error control**
    - Alerts upper-layer that a transmission error has occurred and the sequencing of data frames reorders frames that are transmitted out of sequence
  - **Flow control**
    - Moderates the transmission of data so that the receiving device is not overwhelmed with more traffic than it can handle at one time
  - **Link management**
    - Manage the connections in case of connectionless services

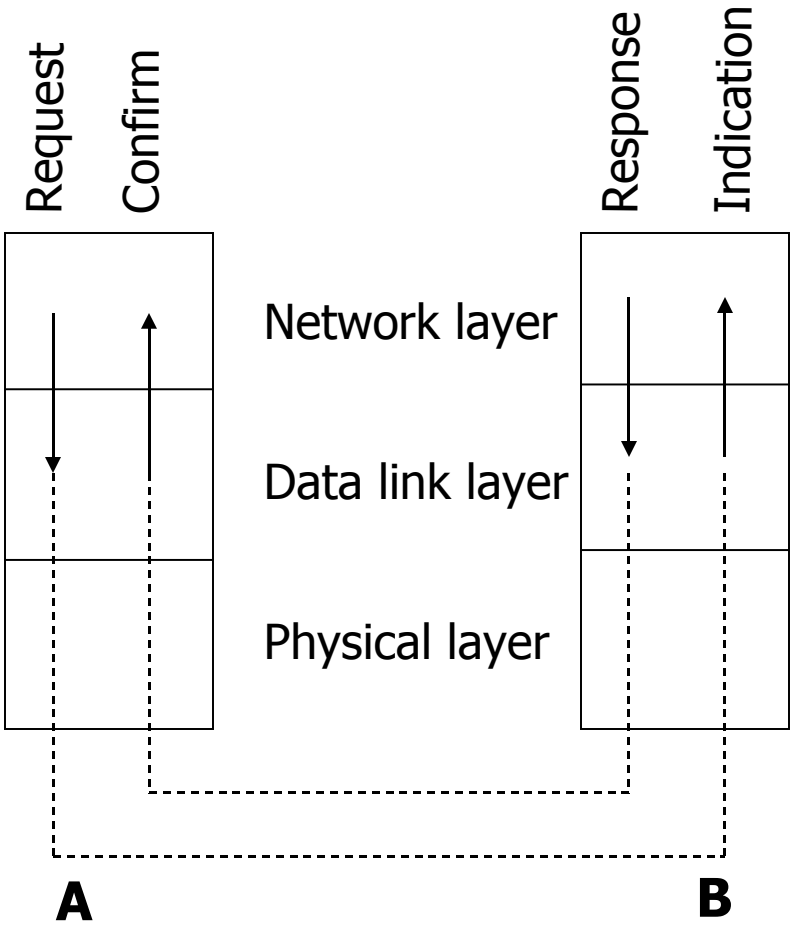
The data-link layer (cont.)

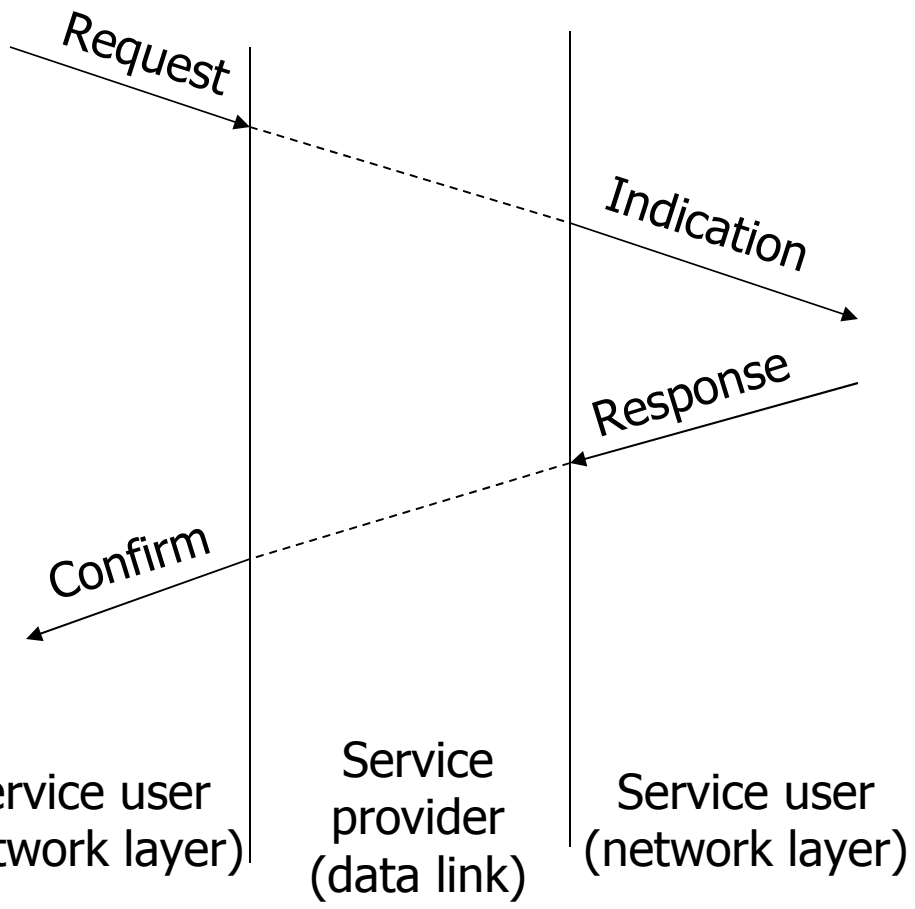
- Data link layer is subdivided into two sublayers
  - Logical Link Control (LLC) - manages communications between devices over a single link of a network
  - Media Access Control (MAC) - manages protocol access to the physical network medium
- Services Provided to the Network Layer
  - Unacknowledged connectionless service
  - Acknowledged connectionless service
  - Connection-oriented service
- Communication between the network layer and the data link layer
  - Request primitives
  - Indication primitives
  - Response primitives
  - Confirm primitives



The data-link layer (cont.)

- Two different representations of the service primitives





The network layer

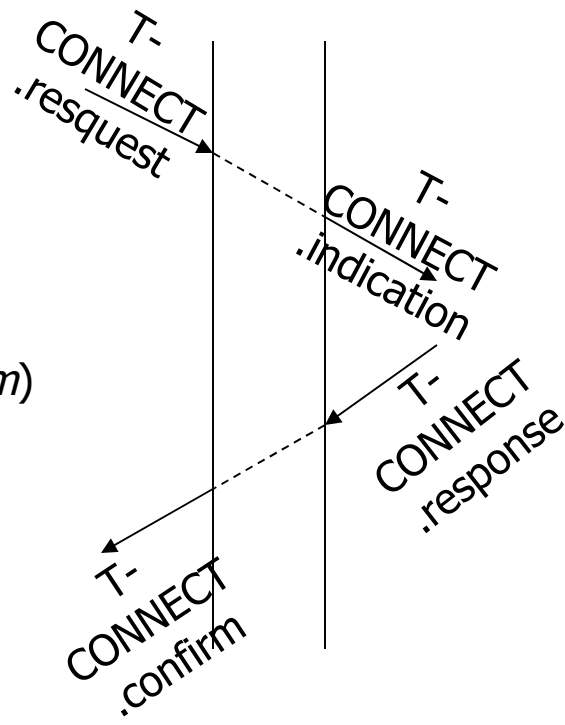
- Provides connectivity and path selection between two host systems that may be located on geographically separated networks.
  - Virtual circuits used for connection services
    - Inflexible, wastes resources
  - Datagram services - is used for connectionless services
    - Flexible, robust, but can suffer from congestion
  - Route, routing table, routing protocol
    - Shortest path routing, multipath routing, centralized routing, isolated routing, flooding, broadcast routing
  - Logical address - Network Service Access Point Addresses
- Communication between Network layer and Transport layer
  - N-CONNECT (*.request, .indication, .response, .confirm*)
  - N-DISCONNECT (*.request, .indication*)
  - N-DATA (*.request, .indication*)
  - N-RESET (*.request, .indication, .response, .confirm*)

The network layer (cont.)

- Two network layer protocols
  - **X.25** (Packet Layer Protocol)
    - Connection-oriented services: Virtual calls, Permanent virtual circuits
    - Packet format: *Call request format*, *Control packet format*, *Data packet format*
  - **IP** (Internet protocol)
    - Connectionless services
    - Datagram format (*Version, IHL, Type of service, Total length, Identification, DF, MF, Fragment offset, Time to live, Protocol, Header checksum, Source address, Destination address, Options*)

The transport layer

- The transport layer accepts data from the session layer and segments the data for transport across the network
- Provides reliable, transparent transfer of data over networks
  - End-to-end flow control
  - Error detection and recovery
  - Segmentation & reassembly
- Transport Layer Services
  - Quality of Service
  - Services Provided to the Session Layer
    - Connectionless and Connection-oriented services
    - T-CONNECT(.*request*, .*indication*, .*response*, .*confirm*)
    - T-DISCONNECT (.*request*, .*indication*)
    - T-DATA (.*request*, .*indication*)
    - T-EXPEDITED-DATA (.*request*, .*indication*)
    - T-UNITDATA (. *request*, .*indication*) – use the QoS
- Transport Layer protocol
  - TCP (*Transmission Control Protocol*)
  - UDP (*User Datagram Protocol*)



The session layer

- The session layer establishes, manages, and terminates sessions between two communicating hosts.
  - Sessions
  - Dialog management
    - Full duplex
    - Half-duplex
  - Data exchange
  - Synchronization
- Session service primitives
  - Connection establishment – S-CONNECT (*.request*,*.indication*,*.response*,*.confirm*)
  - Connection release – S-RELEASE (*.request*,*.indication*,*.response*,*.confirm*)
  - Synchronization – S-SYNC-MAJOR or S-SYNC-MINO (*.request*, *.indication*, *.response*, *.confirm*)
  - Data transfer – S-DATA or S-UNITDATA (connectionless) (. *request*,*.indication*)
- RPC (Remote procedure call)
  - Used in Client-Server Model
  - Error control based on the connectionless model

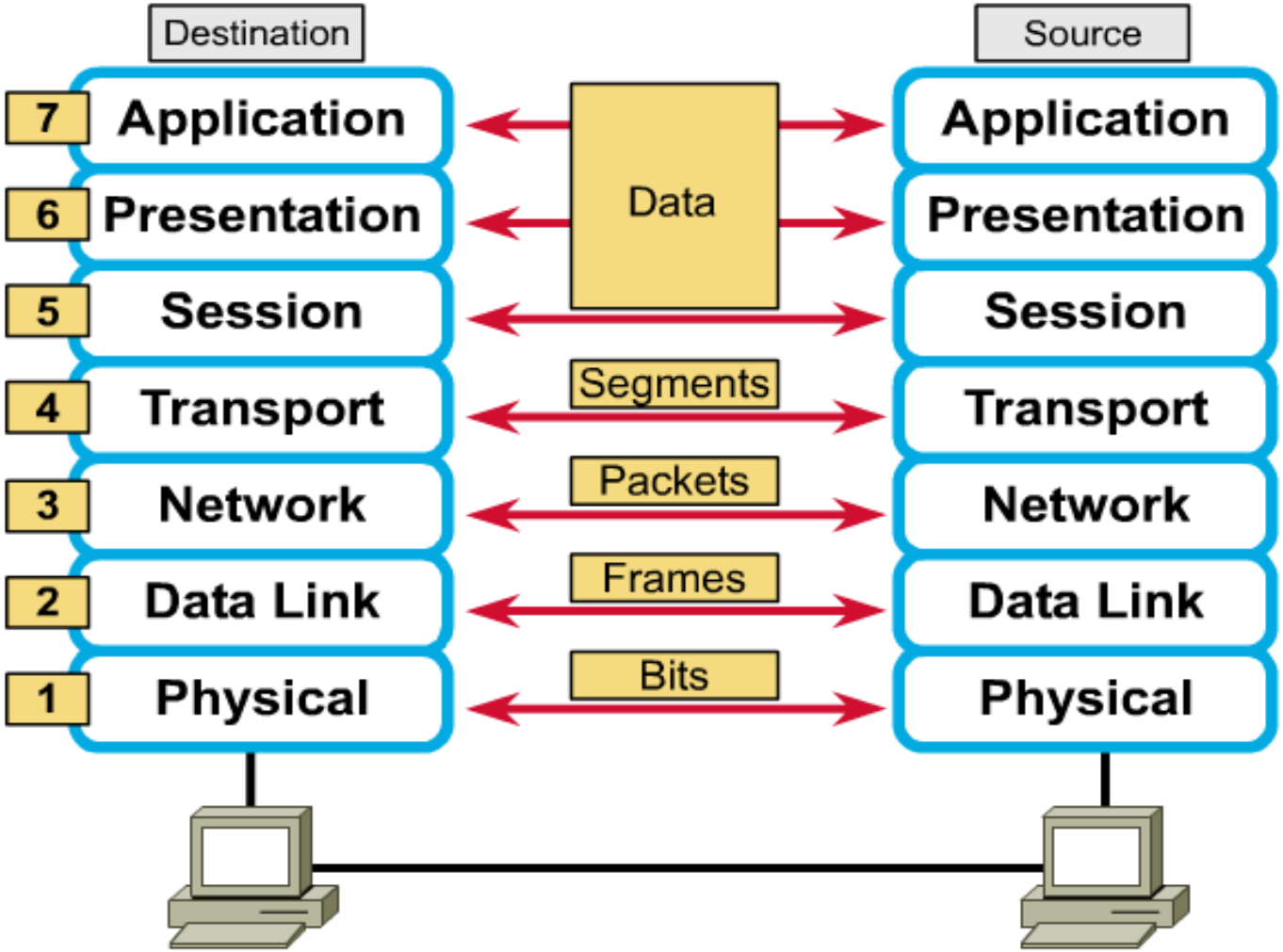
The presentation layer

- Ensures that information sent from the application layer of one system would be readable by the application layer of another system by using common data representation formats
  - Data structure – depending on the application
  - Format of data – define all the data structure types needed by each application in ASN.1 and package them together in a module
  - Data conversion
  - Data compression
  - Data encryption
- Presentation Service Primitives
  - Connection establishment – P-CONNECT (*.request*,*.indication*,*.response*,*.confirm*)
  - Connection release – P-RELEASE (*.request*,*.indication*,*.response*,*.confirm*)
  - Synchronization – P-SYNC-MAJOR or S-SYNC-MINO (*.request*, *.indication*, *.response*, *.confirm*)
  - Data transfer – P-DATA or P-UNITDATA (connectionless) (. *request*,*.indication*)
  - etc

The application layer

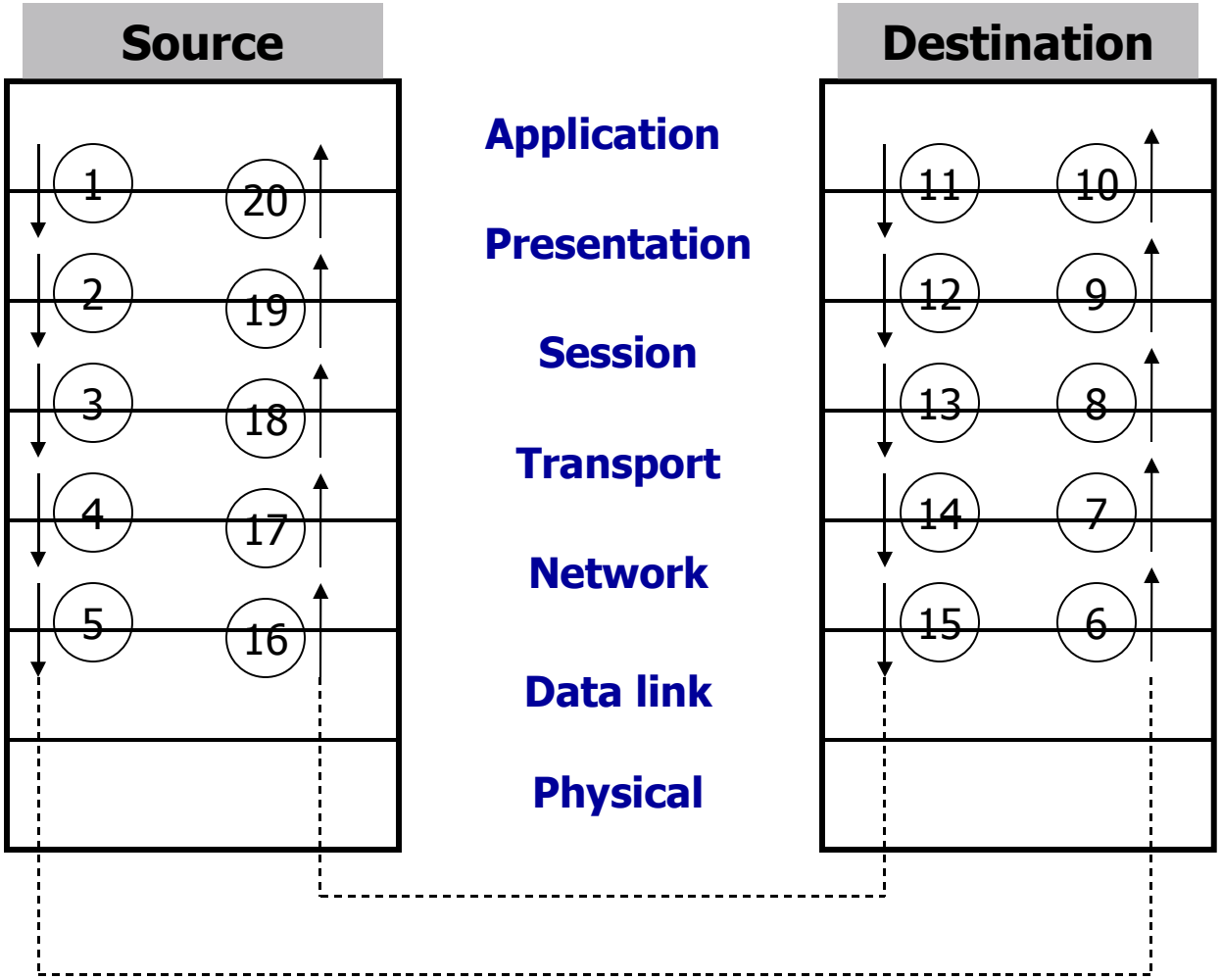
- Is the OSI layer that is closest to the end user; it provides network services to the user's applications.
  - File transfer
  - Electronic mail
  - Terminal access
  - Word processing
  - Intended communication partners

Peer-to-peer communications



Example

- File transfer



Example (cont.)

Establish the connection

1) P-CONNECT.request(caller-P-addr, called-P-addr, …)
2) S-CONNECT.request(caller-S-addrr, called-S-addr, …)
3) T-CONNECT.request(caller-T-addr, called-T-addr, …)
4) N-CONNECT.request(caller-N-addr, called-N-addr, …)
5) D-CONNECT.request(caller-MAC-addr, called-MAC-addr, …)
6) D-CONNECT.indication(caller-MAC-addr, called-MAC-addr, …)
7) N-CONNECT.indication (caller-N-addr, called-N-addr, …)
8) T-CONNECT.indication (caller-T-addr, called-T-addr, …)
9) S-CONNECT.indication(caller-S-addrr, called-S-addr, …)
10) P-CONNECT.indication(caller-P-addr, called-P-addr, …)
11) P-CONNECT.request(caller-P-addr, called-P-addr, …)
12) S-CONNECT.request(caller-S-addrr, called-S-addr, …)
13) T-CONNECT.request(caller-T-addr, called-T-addr, …)
14) N-CONNECT.request(caller-N-addr, called-N-addr, …)
15) D-CONNECT.request(caller-MAC-addr, called-MAC-addr, …)
16) D-CONNECT.indication(caller-MAC-addr, called-MAC-addr, …)
17) N-CONNECT.indication (caller-N-addr, called-N-addr, …)
18) T-CONNECT.indication (caller-T-addr, called-T-addr, …)
19) S-CONNECT.indication(caller-S-addrr, called-S-addr, …)
20) P-CONNECT.indication(caller-P-addr, called-P-addr, …)

Example (cont.)

- **Send data**

1) P-DATA.request(caller-P-addr, called-P-addr, data)
2) S-DATA.request(caller-S-addr, called-S-addr, data)
3) T-DATA.request(caller-T-addr, called-T-addr, data)
4) N-DATA.request(caller-N-addr, called-N-addr, data-segment)
5) ……
6) D-DATA.request(caller-MAC-addr, called-MAC-addr, data-packet)
7) ……..
8) D-DATA.indication(caller-MAC-addr, called-MAC-addr, data-packet)
9) N-DATA.indication (caller-N-addr, called-N-addr, data-segment)
10) T-DATA.indication (caller-T-addr, called-T-addr, data)
11) S-DATA.indication(caller-S-addr, called-S-addr, data)
12) P-DATA.indication(caller-P-addr, called-P-addr, data)

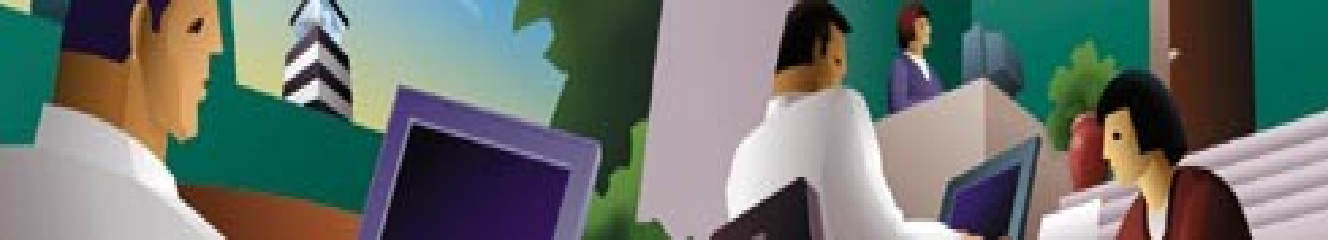
Example (cont.)

- **Release connection**

1) P-DISCONNECT.request(caller-P-addr, called-P-addr)
2) S-DISCONNECT.request(caller-S-addr, called-S-addr)
3) T-DISCONNECT.request(caller-S-addr, called-S-addr)
4) N-DISCONNECT.request(session)
5) D-DISCONNECT.request(connection)
6) D-DICONNECT.indication(connection)
7) N-DISCONNECT.indication (session)
8) T-DISCONNECT.indication (caller-T-addr, called-T-addr)
9) S-DISCONNECT.indication(caller-S-addr, called-S-addr)
10) P-DISCONNECT.indication(caller-P-addr, called-P-addr)

Protocols implemented in OSI model

- Protocol is a formal set of rules and conventions that governs how computers exchange information over a network medium.
- Protocol implements the functions of one or more of the OSI layers.
- A communication protocol is concerned with exchanging data between two peer layers.
- Protocols in
  - *Data link layer* – PPP, MLPPP, PAP (Password Authentication Protocol), L2F, L2TP, PPTP, SDCP (Serial Data Control Protocol), VLAN …
  - *Network layer* –BGP, IS-IS, OSPF, ICMP, RIP, MPLS, IP, IPSEC, VRPN, VoIP, ….
  - *Transport layer* – TCP, UDP, …
  - *Session layer* – ZIP, SCP, …
  - *Application layer* – File Transfer Protocol (FTP), and Simple Mail Transfer Protocol (SMTP), Telnet, SNMP, …



3. TCP/IP MODEL

TCP/IP Protocol

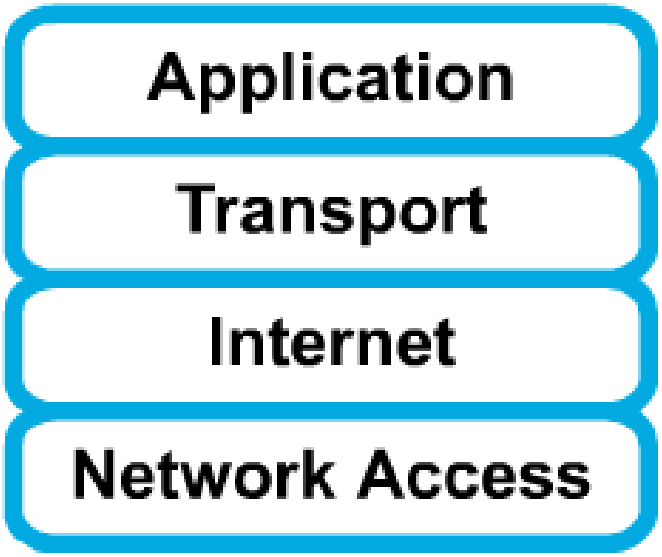
- ***T**ransmission **C**ontrol **P**rotocol/**I**nternet **P**rotocol*
- The suite of communication protocols used to connect hosts on the Internet
- *TCP/IP* uses several protocols, the two main ones being *TCP* and *IP*
- TCP (Transmission Control Protocol)
  - Enables two hosts to establish a connection and exchange streams of data
  - Guarantees delivery of data and also guarantees that packets will be delivered in the same order in which they were sent
- UDP (User Datagram Protocol)
  - Connectionless protocol
  - Used primarily for broadcasting messages over a network
- IP (Internet Protocol)
  - Specifies the format of packet and the addressing scheme

TCP/IP model development

- The late-60s The Defense Advance Research Projects Agency (DARPA) originally developed *TCP/IP* to interconnect various defense department computer networks.
- The Internet, an International Wide Area Network, uses TCP/IP to connect networks across the world.

4 layers of the TCP/IP model

- Layer 4: Application
- Layer 3: Transport
- Layer 2: Internet
- Layer 1: Network access



It is important to note that some of the layers in the TCP/IP model have the same name as layers in the OSI model. Do not confuse the layers of the two models.

The network access layer

- Concerned with all of the issues that an IP packet requires to actually make the physical link. All the details in the OSI physical and data link layers.
  - Electrical, mechanical, procedural and functional specifications.
  - Data rate, Distances, Physical connector.
  - Frames, physical addressing.
  - Synchronization, flow control, error control.

The internet layer

- Send source packets from any network on the internetwork and have them arrive at the destination independent of the path and networks they took to get there.
  - Packets, Logical addressing.
  - Internet Protocol (IP).
  - Route, routing table, routing protocol.

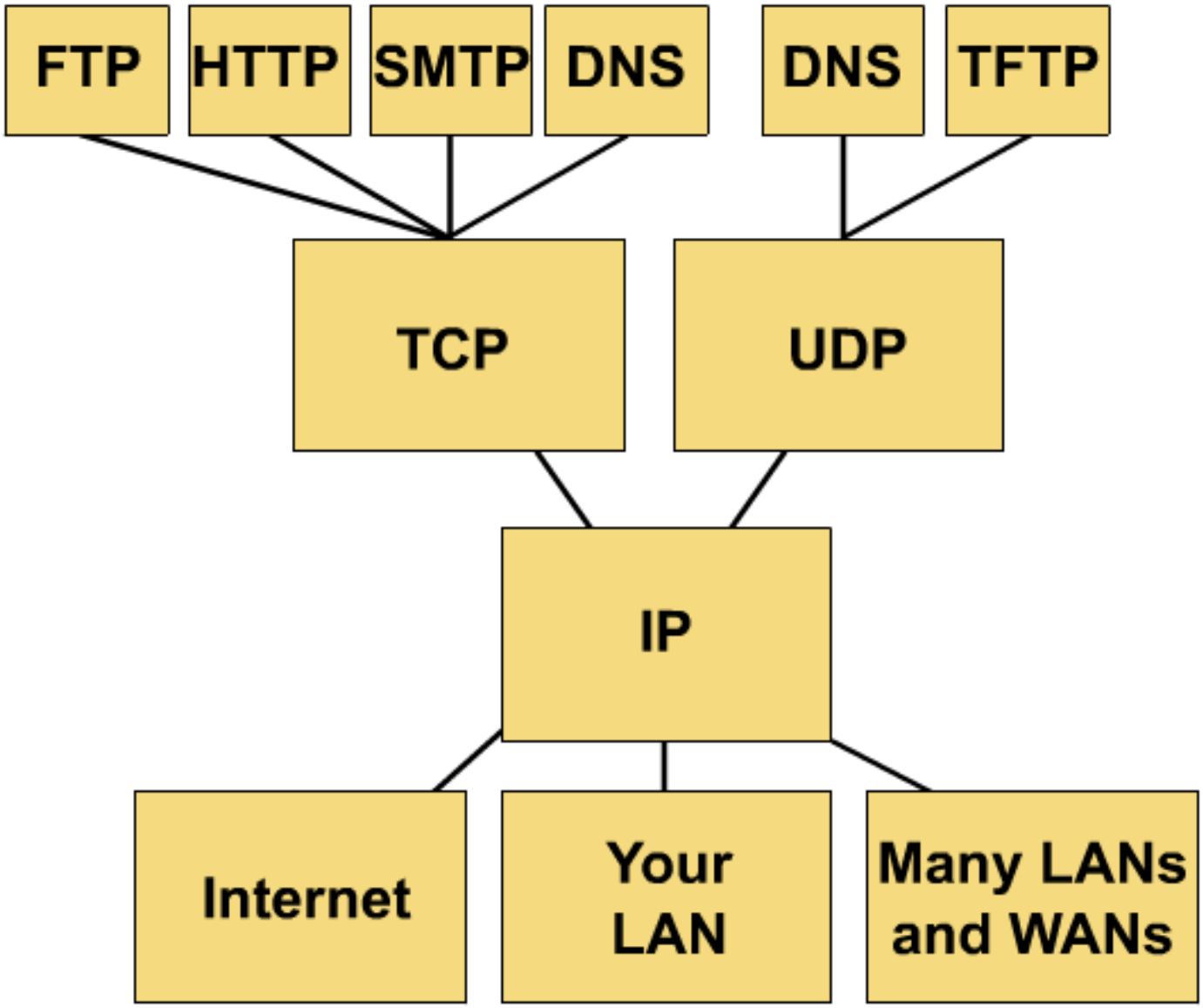
The transport layer

- The transport layer deals with the quality-of-service issues of reliability, flow control, and error correction.
  - Segments, data stream, datagram.
  - Connection oriented and connectionless.
  - Transmission control protocol (TCP).
  - User datagram protocol (UDP).
  - End-to-end flow control.
  - Error detection and recovery.

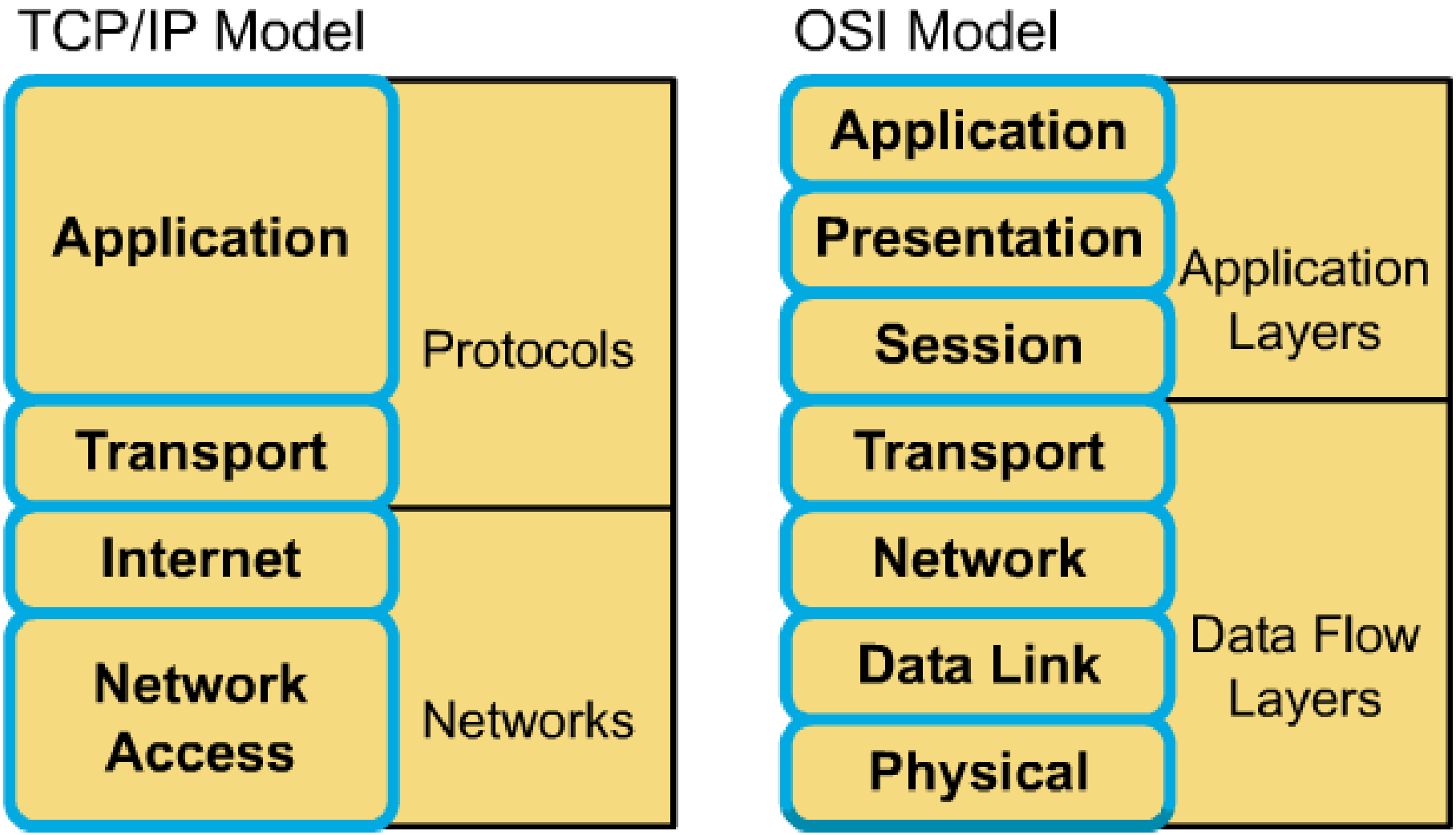
The application layer

- Handles high-level protocols, issues of representation, encoding, and dialog control.
- The TCP/IP combines all application-related issues into one layer, and assures this data is properly packaged for the next layer.
  - FTP, HTTP, SMNP, DNS ...
  - Format of data, data structure, encode …
  - Dialog control, session management …

TCP/IP protocol stack



Mapping TCP/IP into OSI model



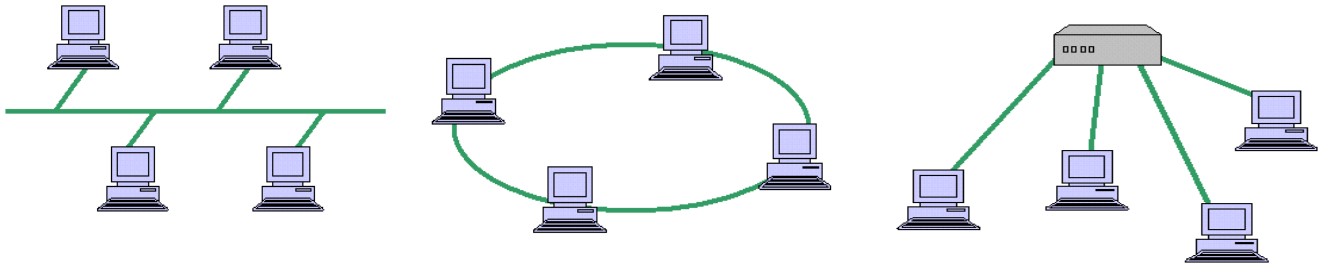
4. Local Area Networks

What is a LAN?

- A *LAN* is a high-speed data network that covers a relatively small geographic area
- It connects workstations, personal computers, printers, and other devices
- LANs offers computer users
  - Shared access to devices and applications
  - File exchange between connected users
  - Communication between users via electronic mail and other applications

Topologies

- LAN topologies define the manner in which network devices are organized.
- Four common LAN topologies : *bus, ring, star,* and *tree.*
- These topologies are logical architectures, but the actual devices need not be physically organized in these configurations.



Access method

- The set of rules that enable data from one workstation to successfully reach its destination
- LAN protocols typically use one of two methods to access the physical network medium
  - CSMA/CD (Carrier-Sense Multiple Access with Collision Detection)
  - CSMA/CA (Carrier-Sense Multiple Access with Collision Avoidance)
  - Token passing
  - Switch-based, connection-oriented

LAN Transmission Methods

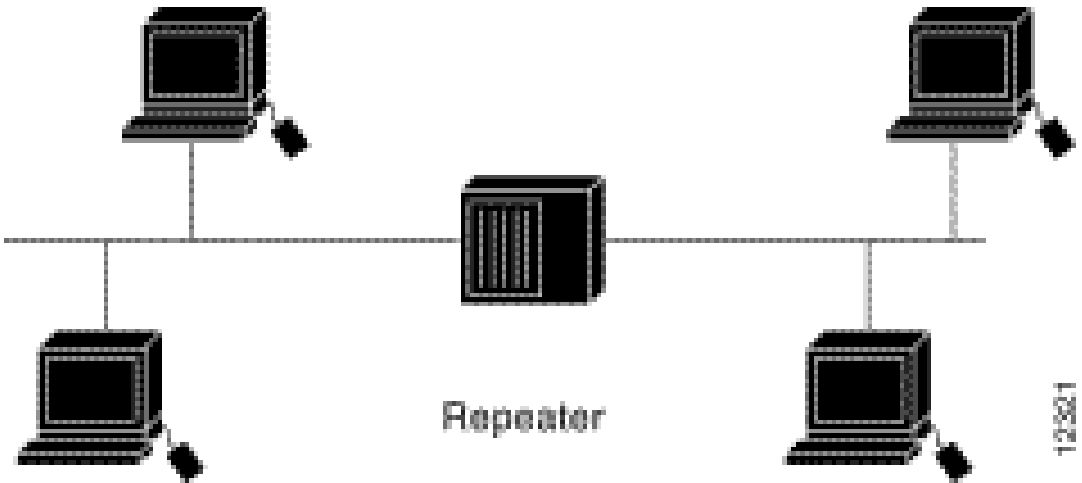
- LAN data transmissions fall into three classifications:
  - **Unicast**: a single packet is sent from the source to a destination on a network
  - **Multicast**: a single data packet that is copied and sent to a specific group of nodes on the network.
  - **Broadcast**: a single data packet that is copied and sent to all nodes on the network.
- In each type of transmission, a single packet is sent to one or more nodes.

LAN Devices

- *Repeaters*
- *LAN extenders*
- *Bridges*
- *LAN switches*
- *Routers*
- *Gateway*

LAN Devices (cont)

- A ***repeater*** is a *physical layer* device used to interconnect the media segments of an extended network or enlarge the LAN networks
- Repeater is restricted to linking similar LANs (Ethernet, Fast Ethernet or Token ring)
- Repeaters receive signals from one network segment and amplify, retime, and retransmit those signals to another network segment.

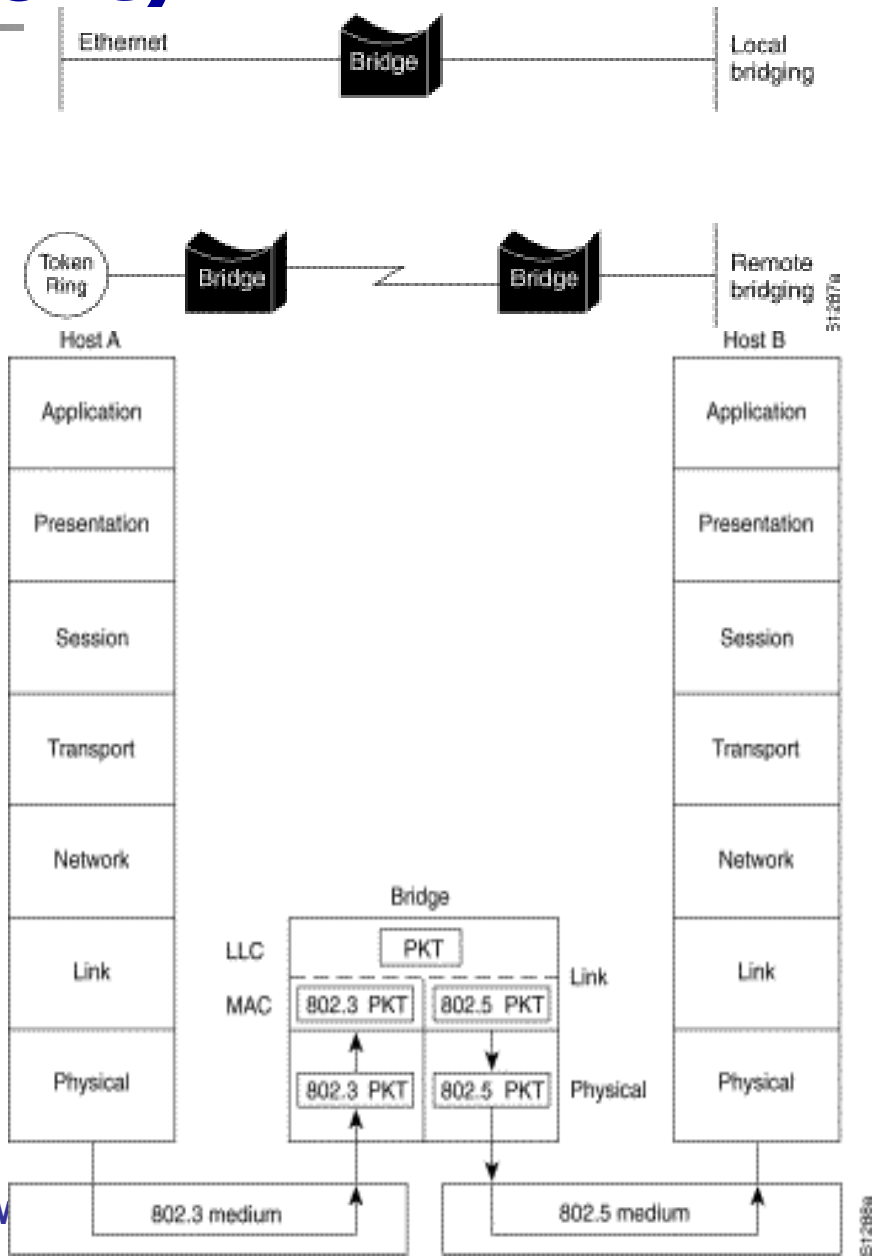


LAN Devices (cont)

- ***Bridges*** are data communications devices at link layer
- Bridges can connect similar or dissimilar LANs
- Types of Bridges
  - Transparent bridge

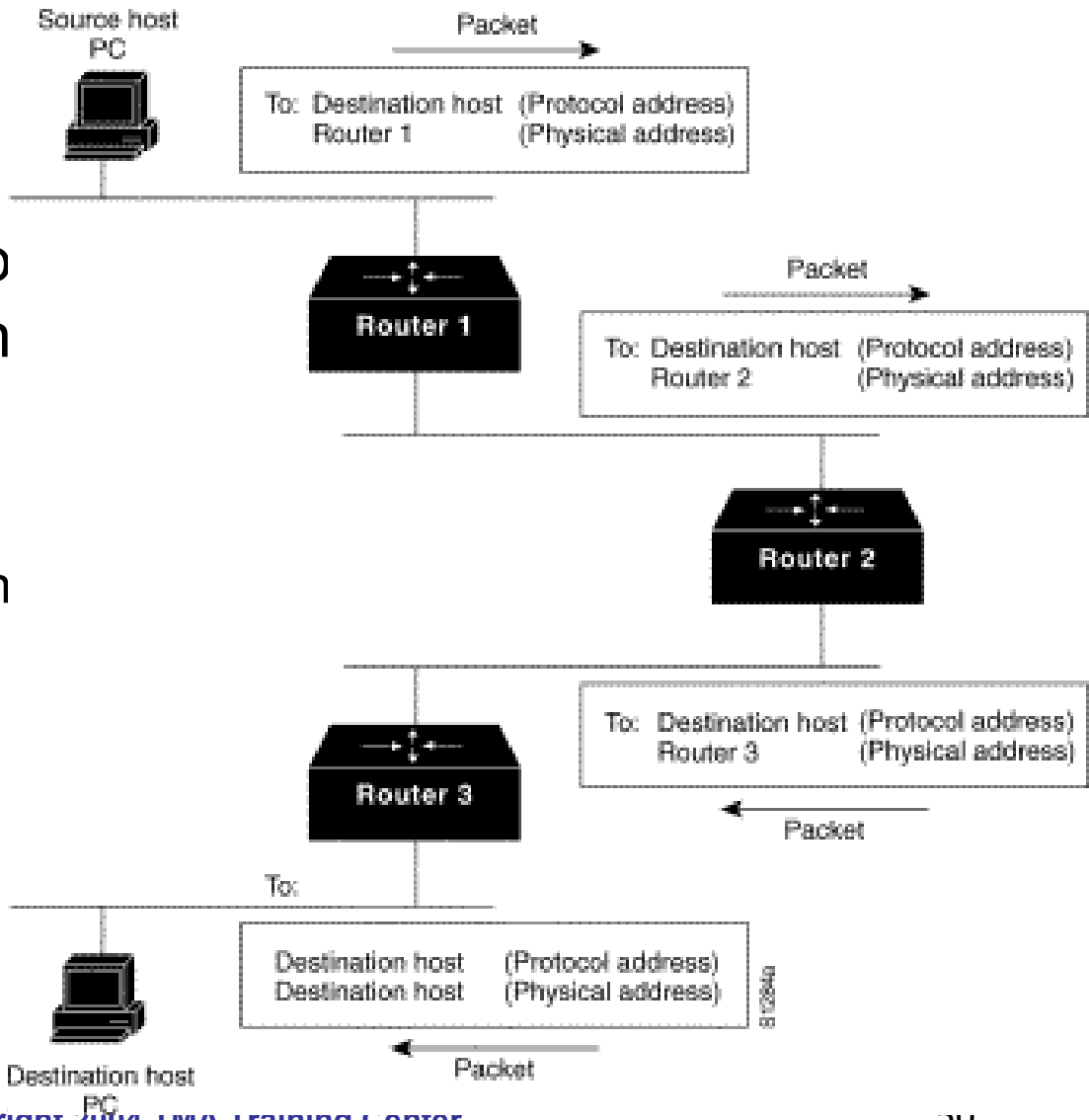
    Provides a connection between two LANs that employ the same protocol at the data link layer
  - Translating bridge

    Provides a connection capability between two LANs that employ different protocols at the data link layer



LAN Devices (cont)

- ***Routers*** operate at the Network Layer
- Purpose of a router is to connect nodes across an Internetwork
- Advantages of use
  - Multiple path transmission and routing control
  - Flow control
  - Frame fragmentation

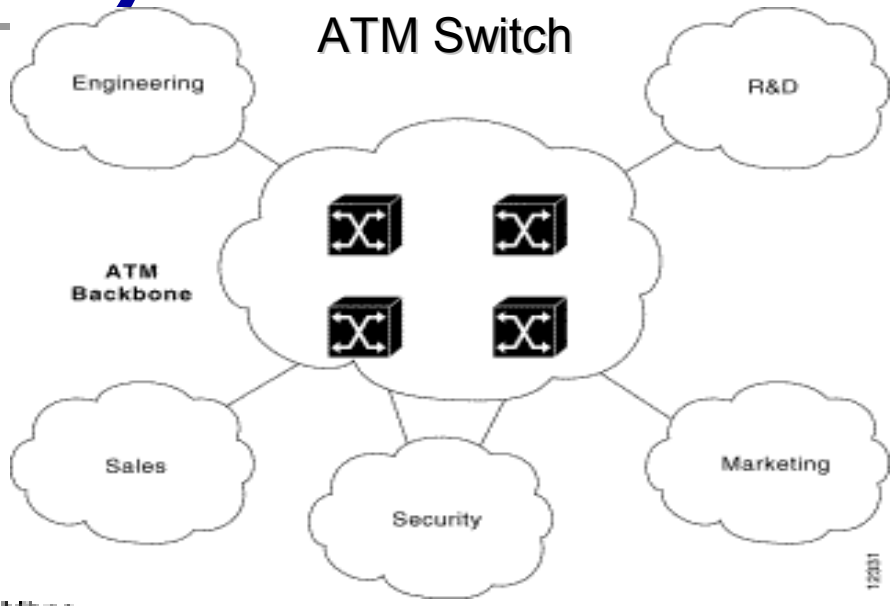


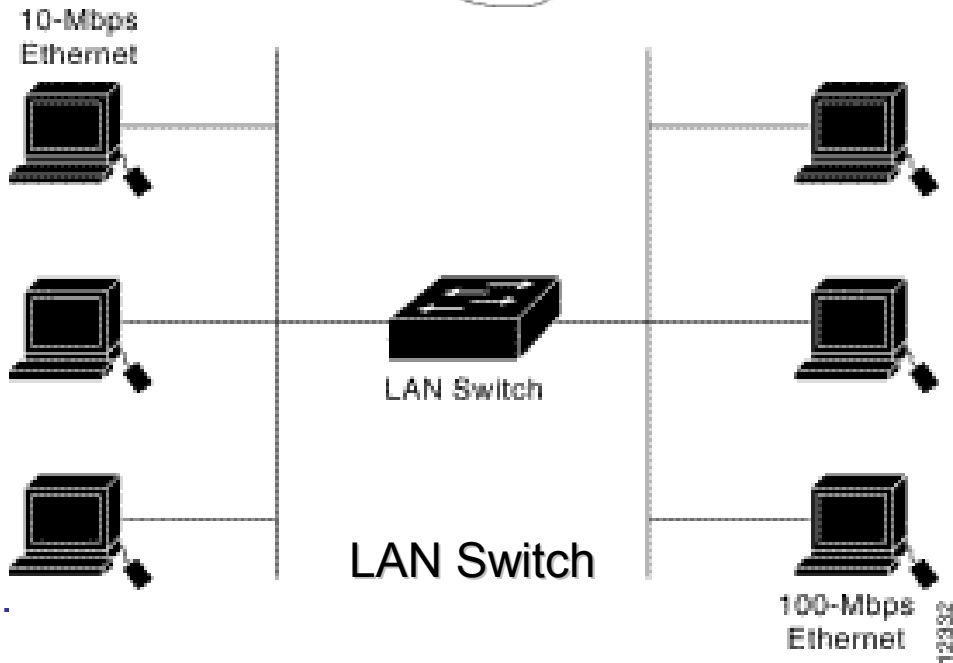
LAN Devices (cont)

- A ***gateway*** operates at all seven layers of OSI model
- Store and forward packets between dissimilar networks
- Translating each source layer protocol into the appropriate destination layer protocol
- Connection-Oriented Gateways
  - Table space required in the gateways for each open connection
- Connectionless Gateways
  - Potential for congestion
- Gateway software
  - Manages the packet queue

LAN Devices (cont)

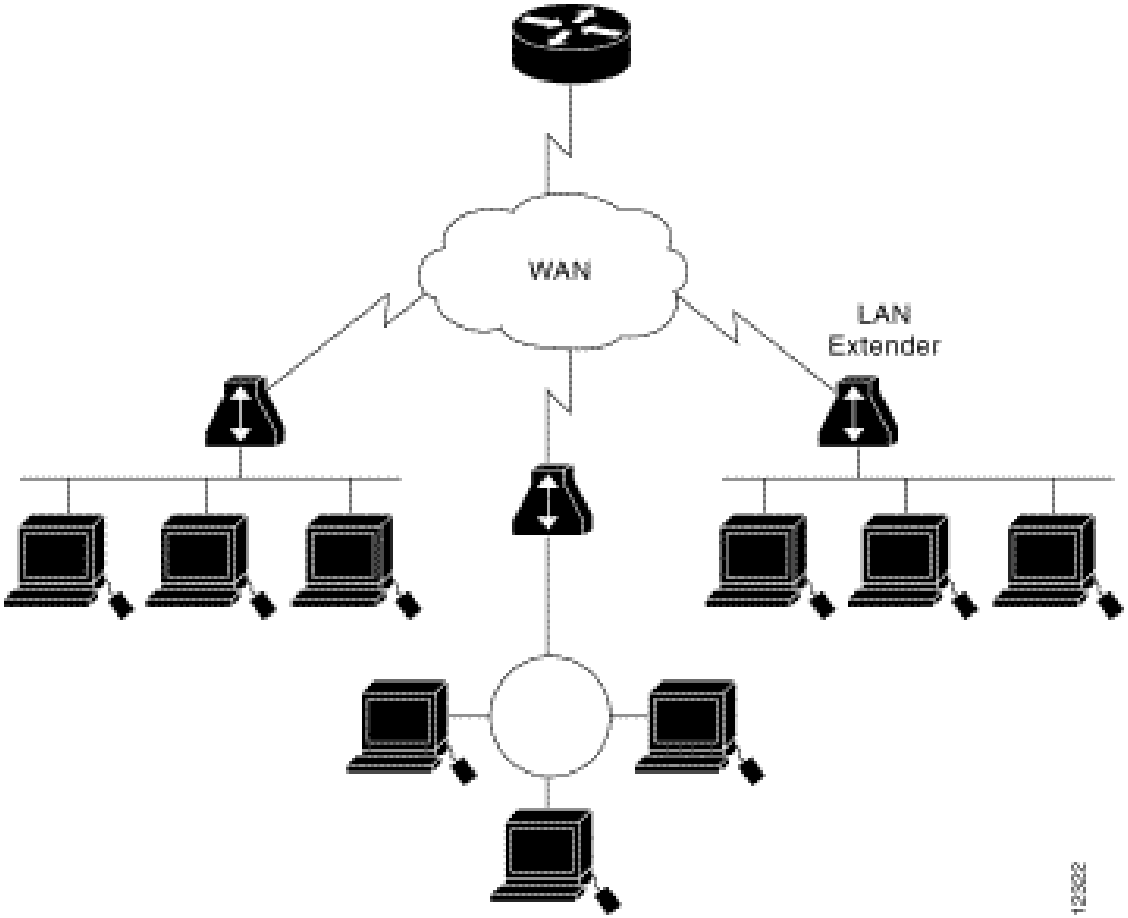
- ***Switches*** are used in the higher operating rate switches
- Advantages of use
  - Parallel switching
  - Higher bandwidth
- Types of Switches
  - Cross-point switching – the switch uses the destination from a look-up table as soon as the destination address in the frame is read
  - Store-and-forward – the switch first stores an entire frame in memory, then operating on the data fields within the frame to check the error and last one is switching occur.





LAN Devices (cont)

- A LAN ***extender*** is a remote-access multilayer switch that connects to a host router.



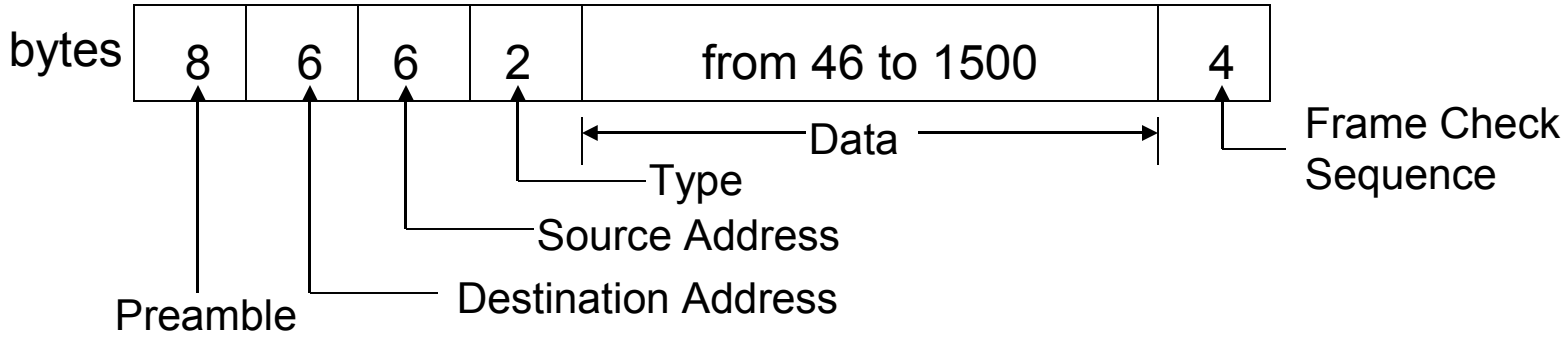
Popular Types of LANs

- Ethernet
- Fast Ethernet
- FDDI

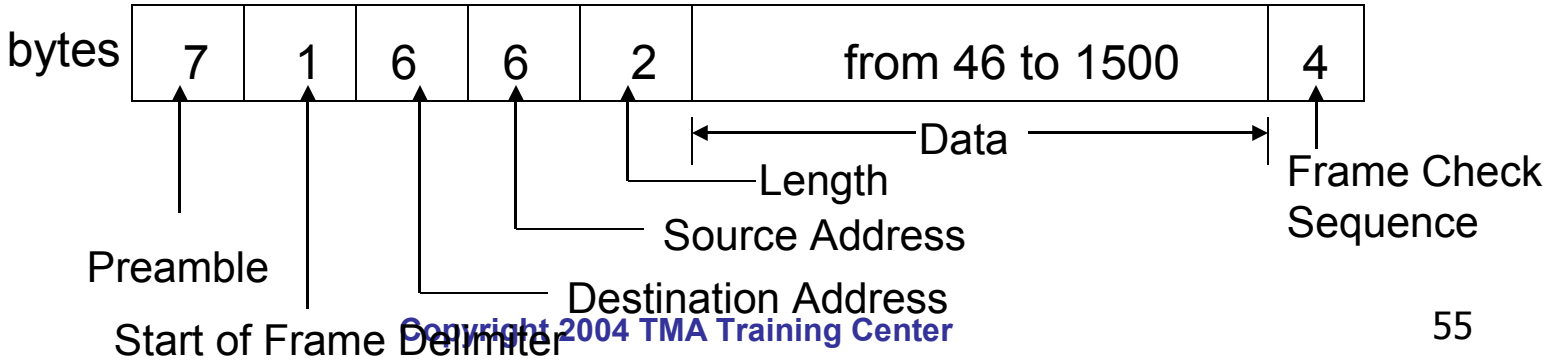
Ethernet LAN

- Uses the CSMA/CD access protocol on a bus structure

Ethernet frame format



IEEE 802.3 frame format



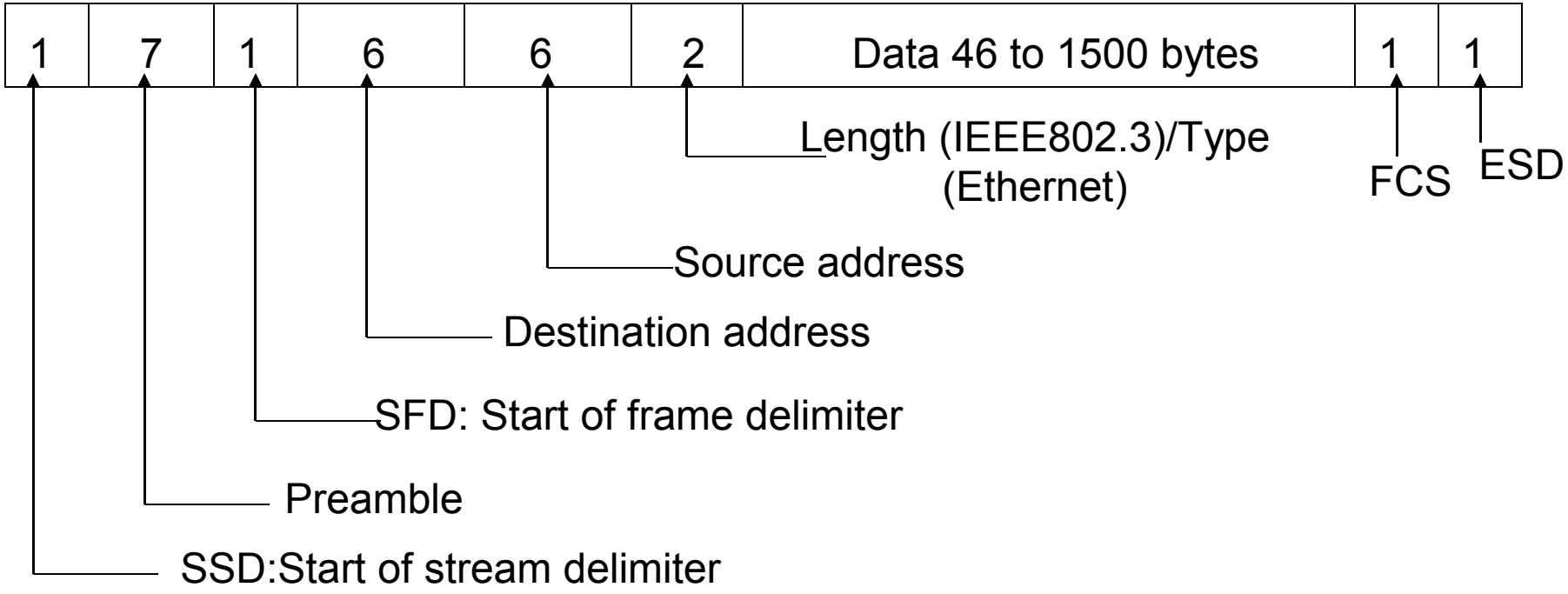
Ethernet LAN (cont.)

IEEE 802.3 specifications

Feature	10BASE-5	10BASE-2	10BROAD-36	1BASE-5	10BASE-T
Medium	Thick 50 Ω coaxial	Thin coaxial cable	CATV coaxial cable	Twisted pair wire cable	Twisted pair wire
Topology	Bus	Bus	Bus	Star	Star
Segment distance	500m	200m	3.6km	500m	100m
Data rate	10Mbps	10Mbps	10Mbps	1Mbps	10Mbps

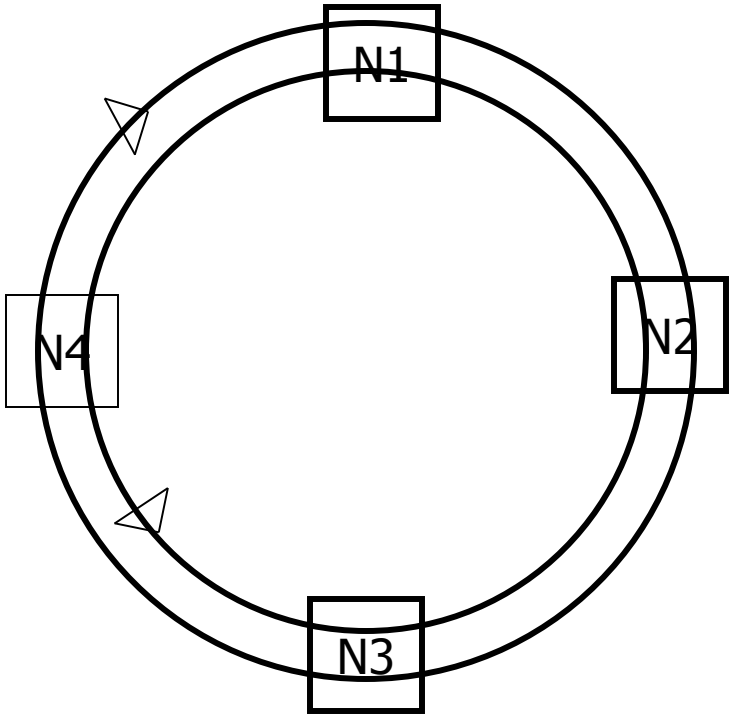
Fast Ethernet

- A term commonly used to reference a series of three 100 Mbps physical layer LAN specifications



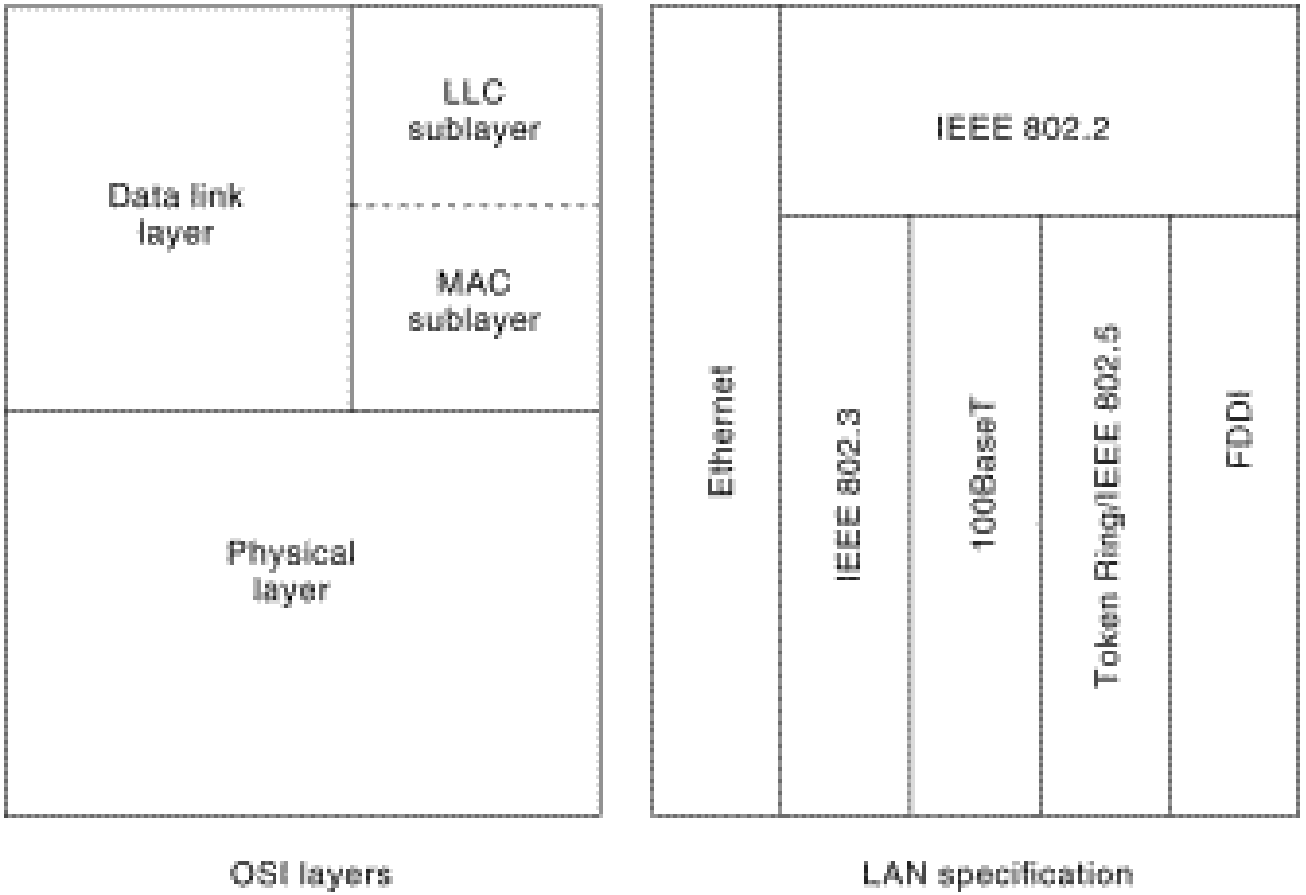
FDDI

- Fiber Distributed Data Interface (FDDI) is a local networking standard which provides a 100 Mbps operating rate.
- FDDI incorporate counter-rotating rings
- Advantages
  - Operating rate
  - Reliability



LAN protocols and the OSI model

- LAN protocols function at the lowest two layers of the OSI reference model



LAN Protocols

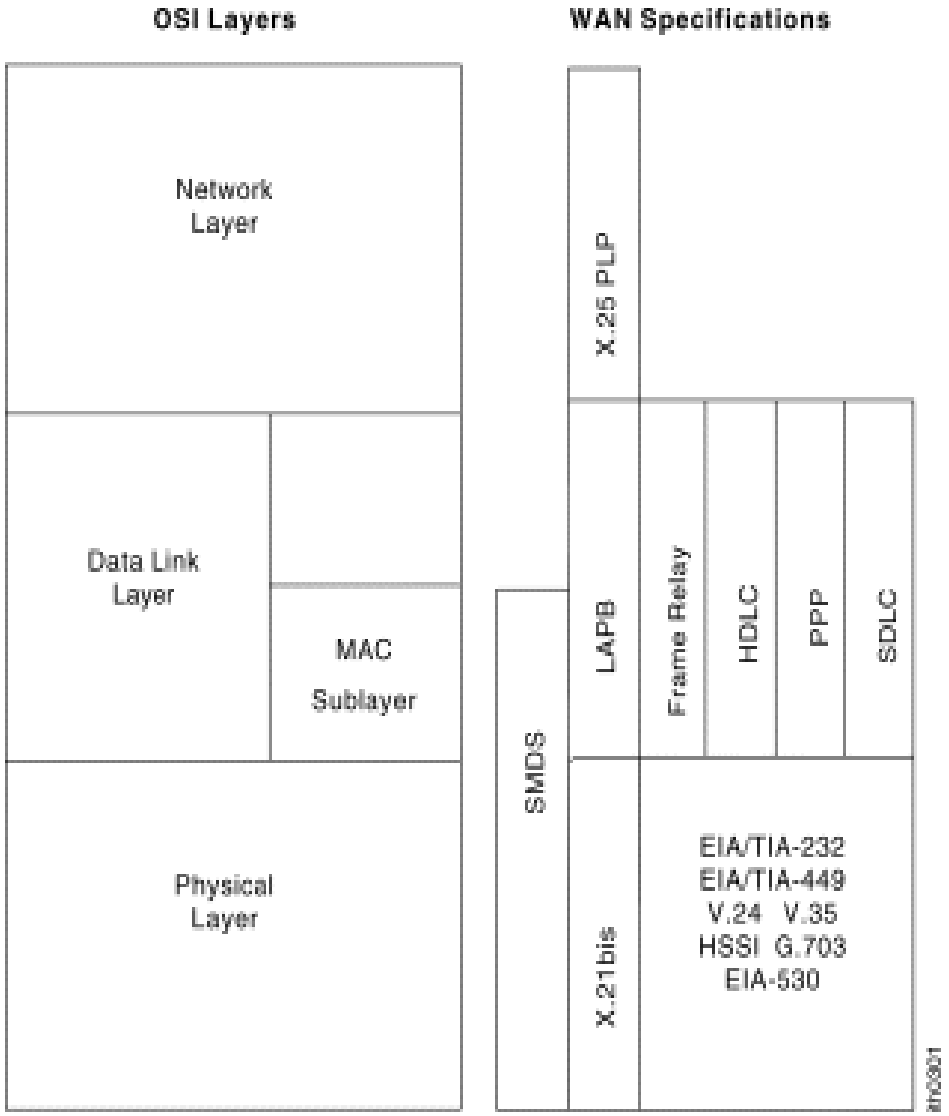
- PPP
  - The Point-to-Point Protocol (PPP) originally emerged as an encapsulation protocol for transporting IP traffic over point-to-point links
- PPPoE
  - The Point-to-Point Protocol over Ethernet (PPPoE) is a specification for connecting multiple computer users on an Ethernet local area network to a remote site through common customer premises equipment

5. Wide Area Networks

What is a WAN?

- A WAN is a data communications network that covers a relatively broad geographic area.
- WAN technologies operate at the lowest levels of the OSI model : the physical layer, the data link layer, and the network layer.
- Respect to the flow of information on a transmission, WANs can be grouped into three basic types:
  - Circuit switching
  - Packet switching
  - Leased line

WAN Technologies-OSI Model



Point-to-Point Links

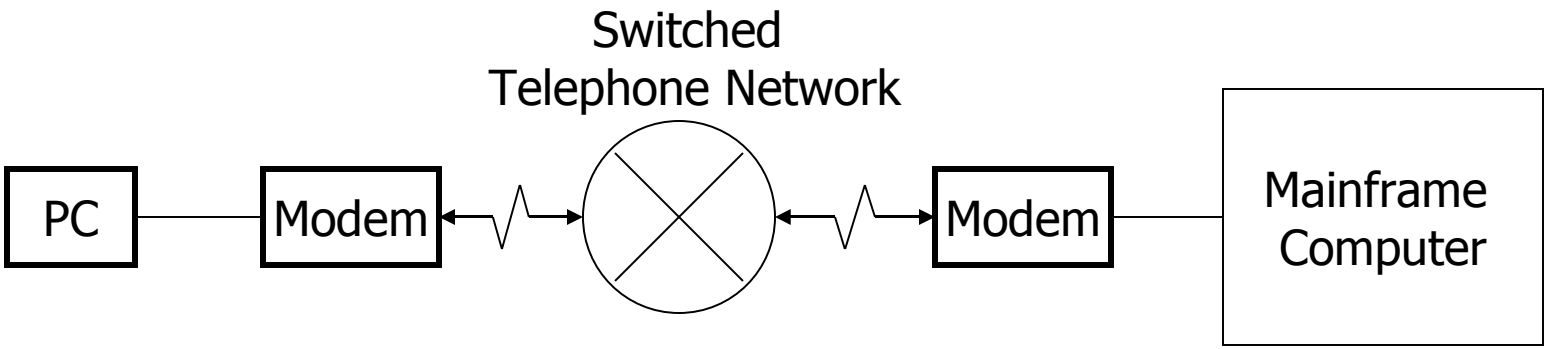
- A point-to-point link provides a single, pre-established WAN communications path from the customer premises through a carrier network
- It is also known as a leased line
- These links accommodate two types of transmissions: datagram transmissions and data-stream transmissions

Circuit Switching

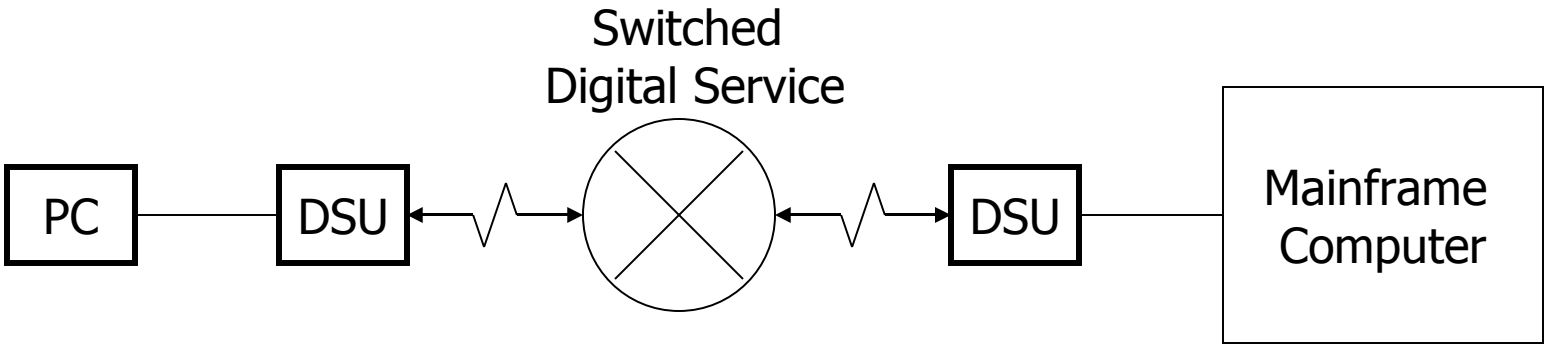
- Circuit switching is a WAN switching method in which a dedicated physical circuit (path) is established, maintained, and terminated through a carrier network for each communication session
- This connection in which a call is established by switching equipment over a temporary path is known as a switched virtual call (SVC)
- Circuit switching accommodates two types of transmissions
  - Data-stream transmissions (analog)
    - Used in telephone network, requires the use of modems
    - Used by DSL, ADSL technologies
  - Datagram transmissions (digital)
    - Requires DSU (Data Service Unit) in place of a modem
    - Used by ISDN technology

Circuit Switching (cont.)

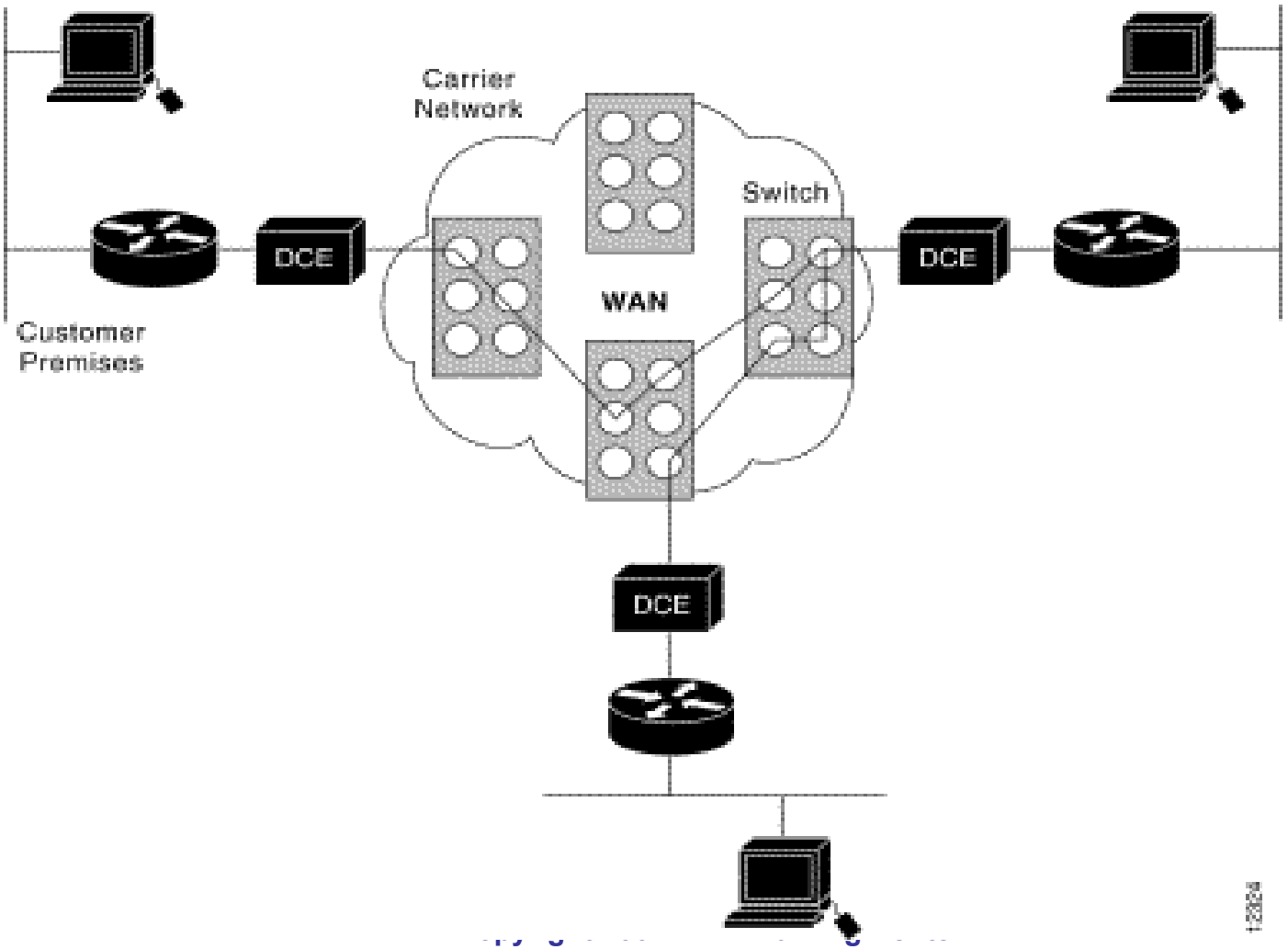
- **Datagram transmissions (analog)**



- **Data-stream transmissions (digital)**



A circuit-switching WAN



WAN Virtual Circuits

- A virtual circuit is a logical circuit created to ensure reliable communication between two network devices
- There are two types:
  - SVCs (*switched virtual circuits)*
  - PVCs (*permanent virtual circuits)*

SVCs

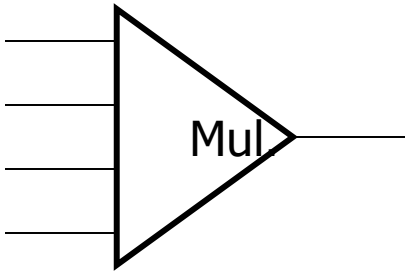
- SVCs are virtual circuits that are dynamically established on demand and terminated when transmission is complete
- Communication over an SVC consists of three phases
  - circuit establishment
  - data transfer
  - circuit termination
- SVCs are used in situations in which data transmission between devices is sporadic, largely

PVCs

- PVC is a permanently established virtual circuit that consists of one mode: data transfer
- PVCs are used in situations in which data transfer between devices is constant

Leased line networks

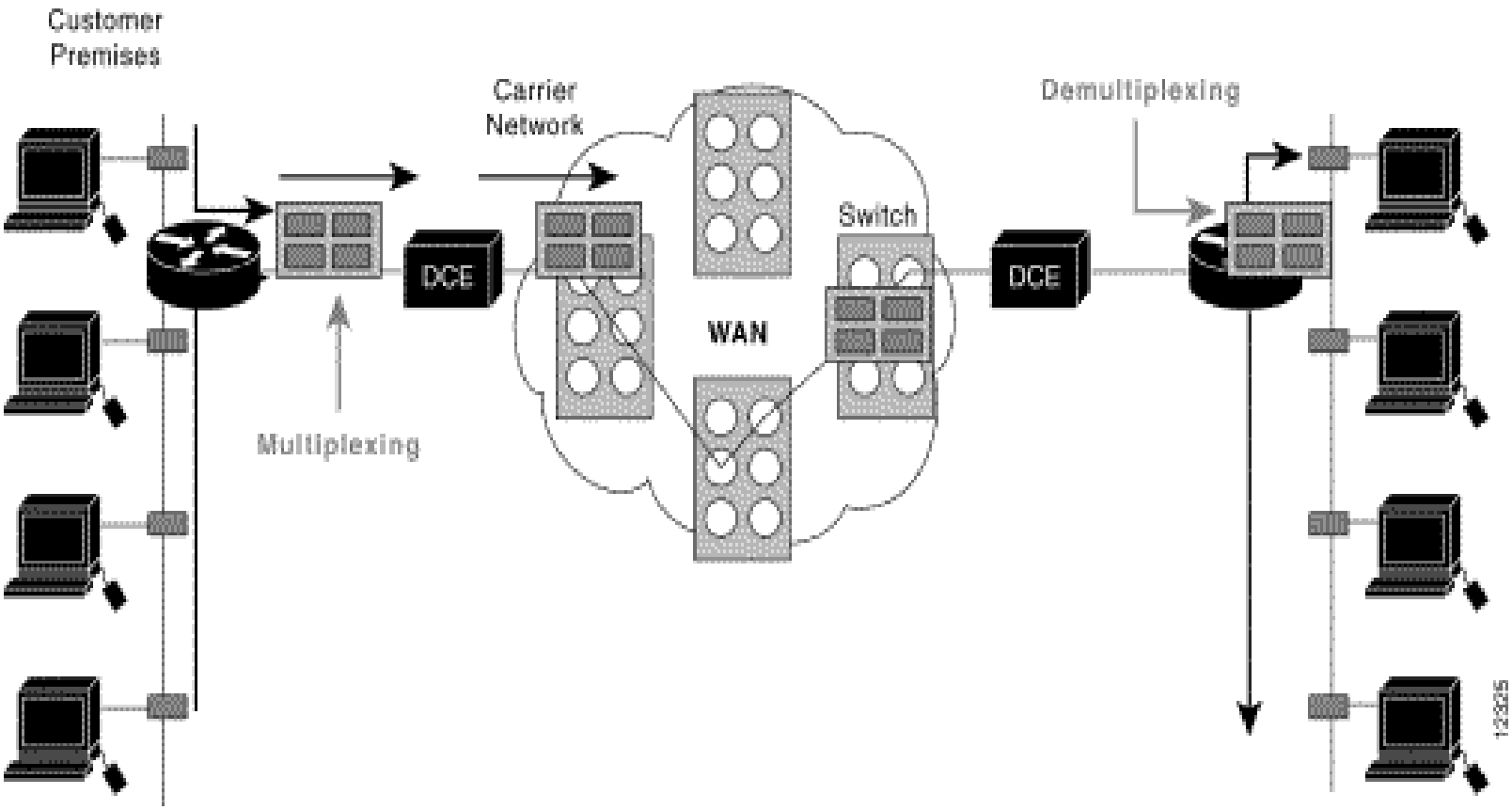
- Leased line is used to reduce the number of physical lines required to connect telephone company offices to one another, communications carriers implemented a technique called multiplexing
- A physical line can be shared for many users at time. However, information in the form of voice or data uses the reserved slot for the duration of the voice call or data transmission session
- Two types of multiplexing
  - Frequency division multiplexing (FDM)
    - Uses a communication circuit that has a relatively wide bandwidth. This bandwidth is then divided into subchannels by frequency
    - Used for analog leased lines
      - Need the multiplexer and demultiplexer
  - Time division multiplexing (TDM)
    - Used for digital leased lines



Packet Switching

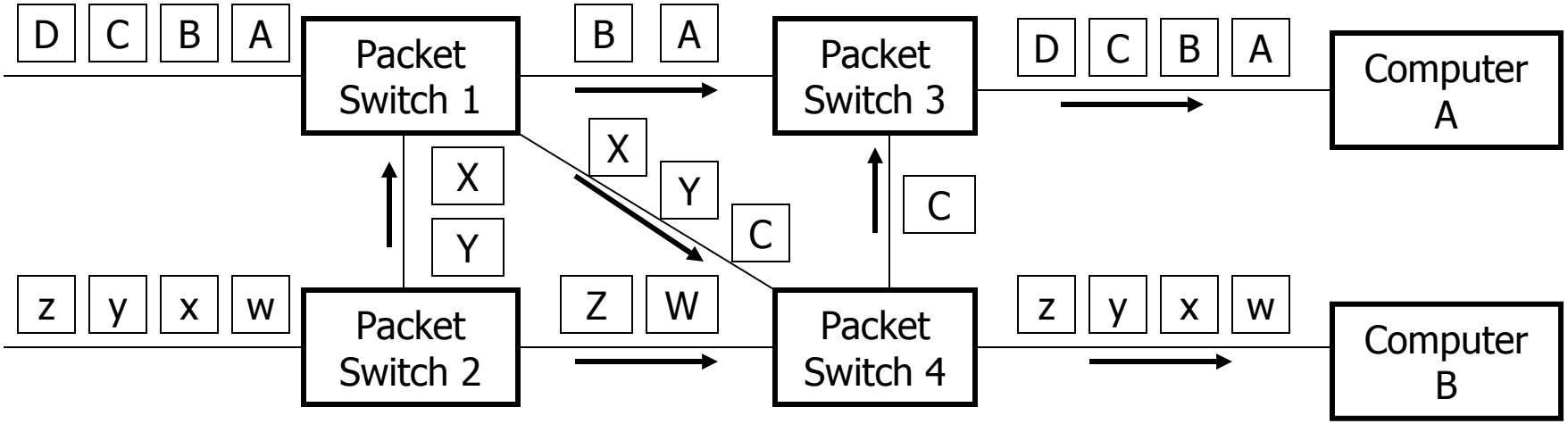
- Packet switching is a WAN switching method in which network devices share a single point-to-point link to transport packets from a source to a destination across a carrier network
- Transmitted data is divided into the packets, that have addressing, sequencing, and error control information
- The flow of packets between nodes in a packet network is intermixed with respect to the originator and destination of packets => many users can share large portions of the transmission facilities
- The network using the packet switching technique is called as packet network
  - Datagram packet networks - each packet is transmitted independently of other packets
  - Virtual circuit packet networks – a fixed path is established from the data originator to the recipient at the time a call is established

Packet switching (cont.)

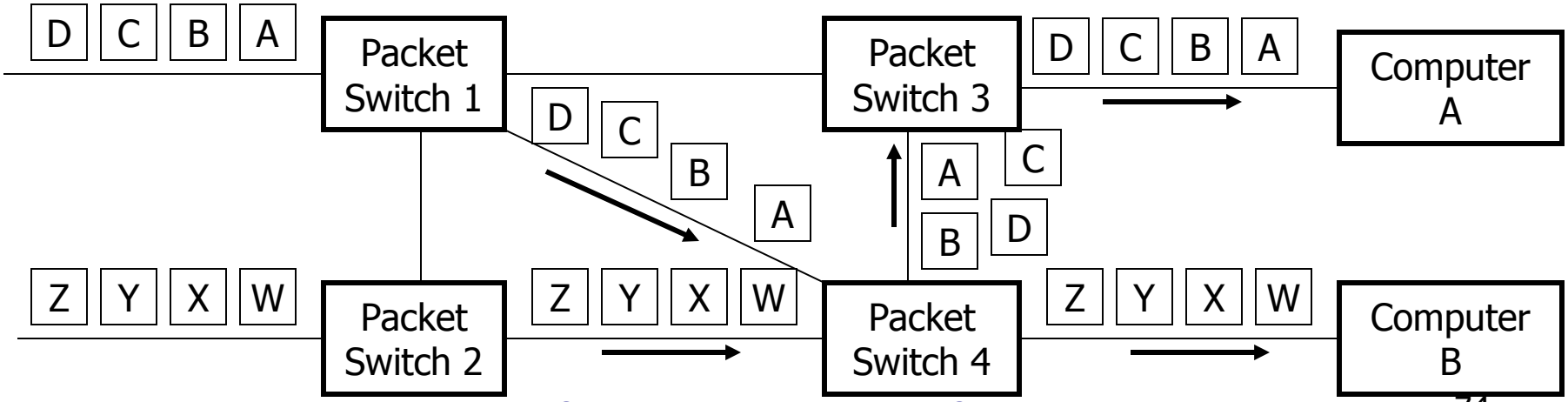


Packet Switching (cont.)

- **Datagram packet networks**



- **Virtual circuit packet networks**

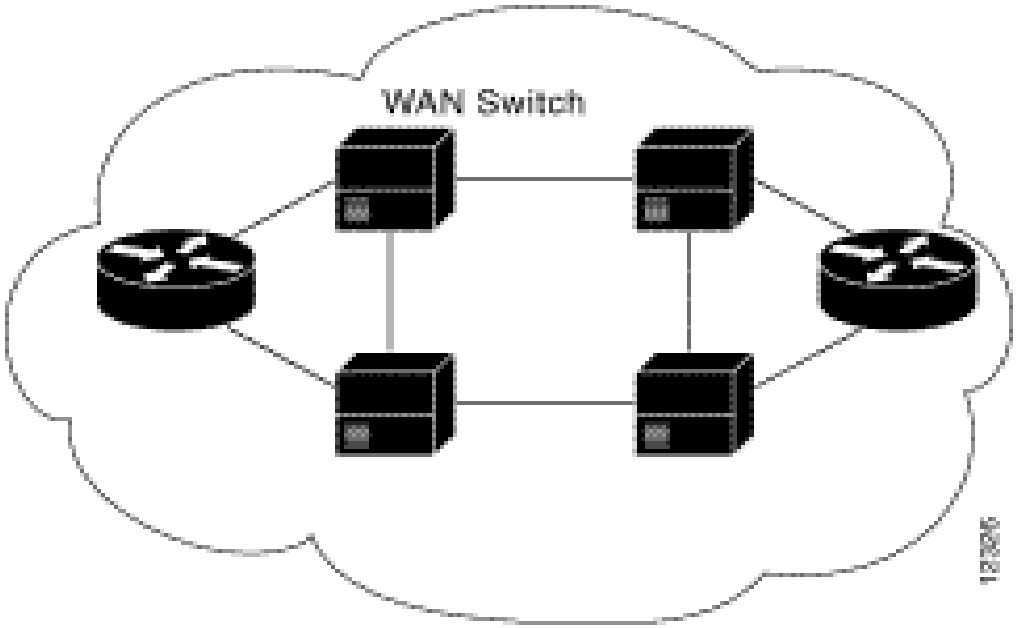


WAN Devices

- WANs use many types of devices :
  - WAN switches
  - Access servers
  - Modems
  - CSU/DSUs
  - ISDN terminal adapters

WAN Switch

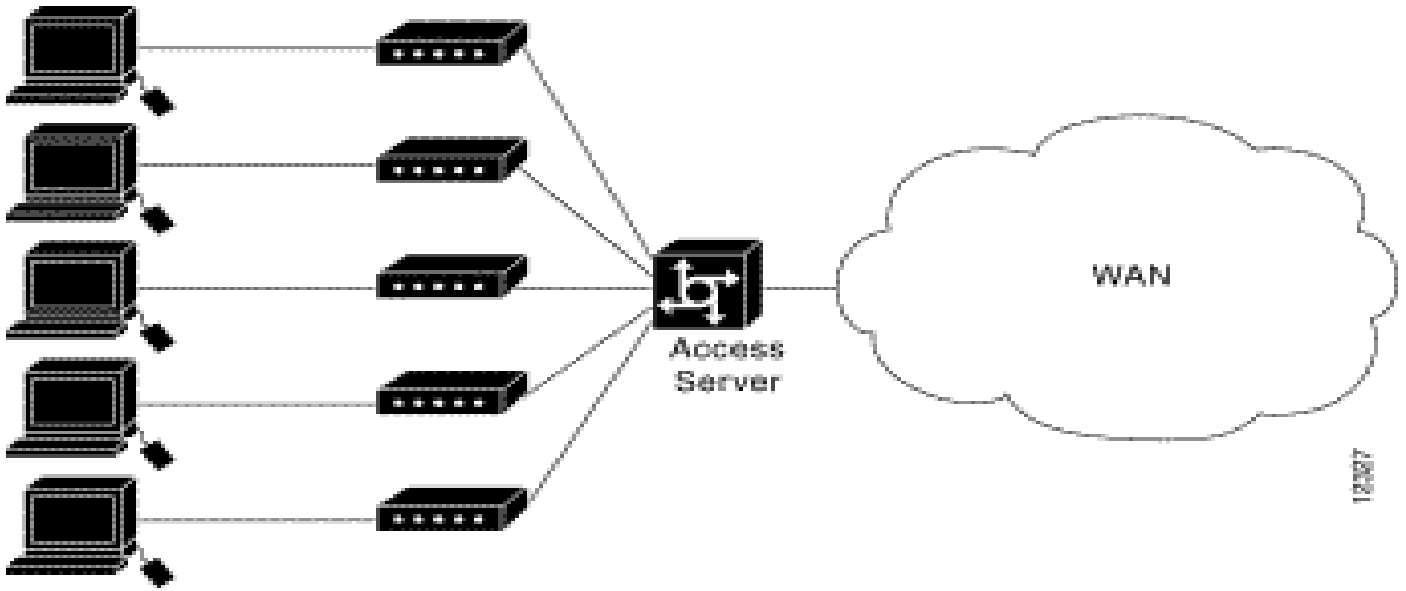
- A WAN switch is a multiport internetworking device used in carrier networks: Frame Relay, X.25,…
- A switch operates at the data link layer of the OSI model
- It is used to establish a physical path for the duration of a call



Two routers of a WAN are connected by WAN switches

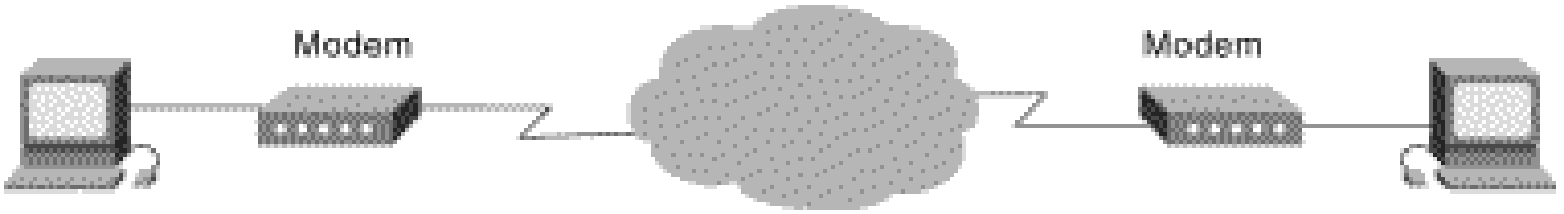
Access Server

- An access server acts as a concentration point for dial-in and dial-out connections
- An access server concentrates dial-out connections into a WAN



Modem

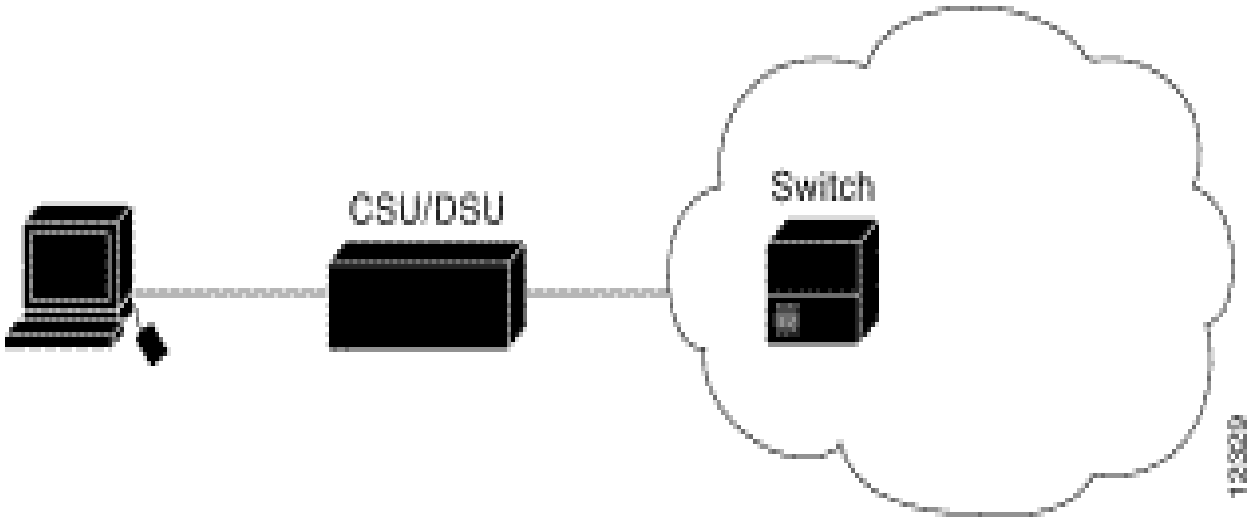
- A modem is a device that interprets digital and analog signals



A Modem Connection Through a WAN Handles Analog and Digital Signals

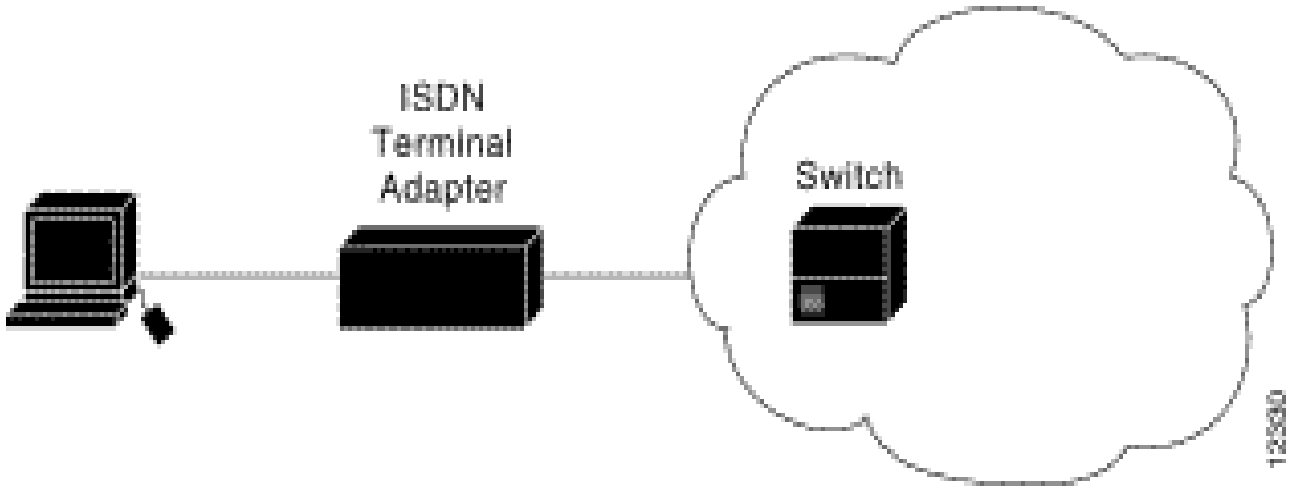
CSU/DSU-channel service unit/digital service unit

- CSU/DSU is a digital-interface device (or sometimes two separate digital devices) that adapts the physical interface on a data terminal equipment (DTE) device (such as a terminal) to the interface of a data circuit-terminating (DCE) device (such as a switch) in a switched-carrier network
- CSU/DSU is sometimes referred to as a digital modem as it converts unipolar digital signals produced by computers into bipolar digital signals suitable for transmission over a switched digital network



ISDN Terminal Adapter

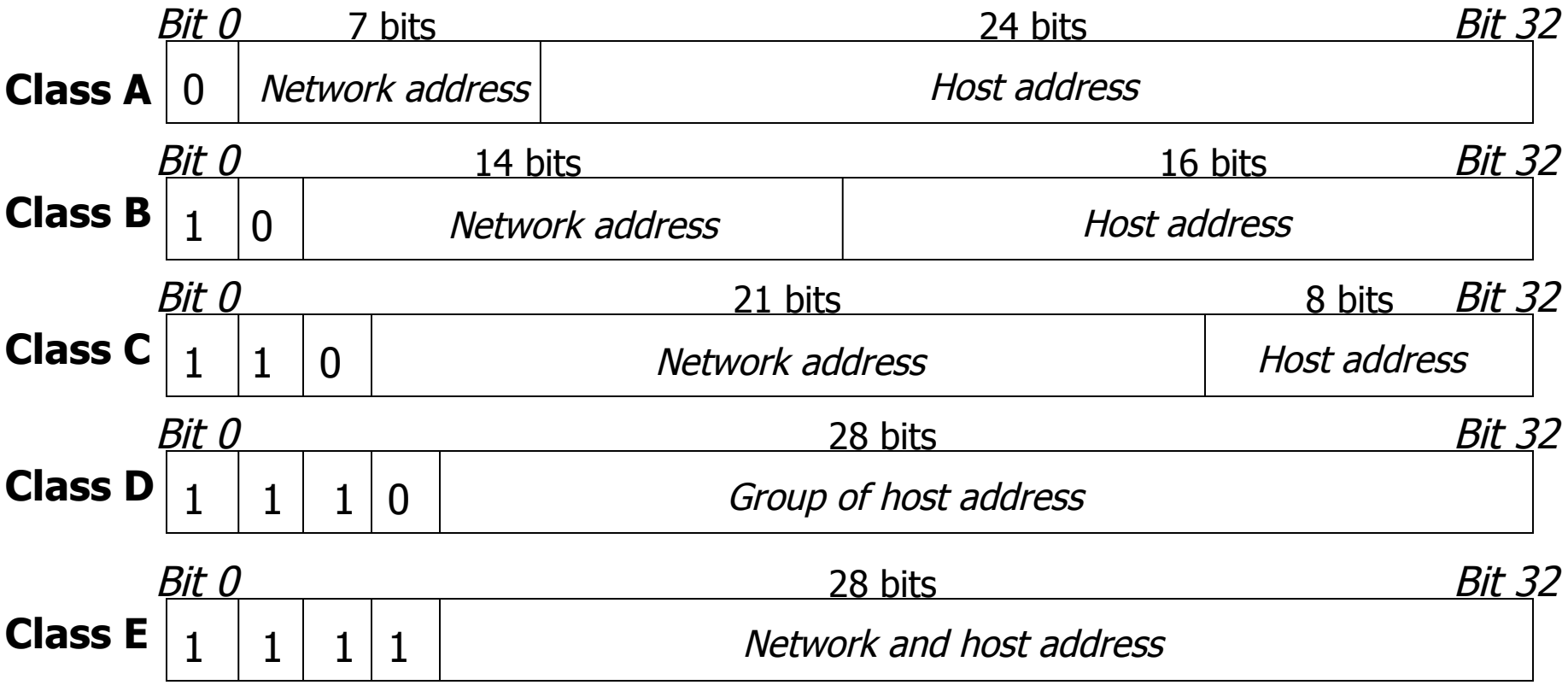
- is a device used to connect ISDN Basic Rate Interface (BRI) connections to other interfaces
- The terminal adapter connects to other interfaces



6. Other Concepts

IP Addresses

- Identifies the location to where the packet can be sent
- Uses a 32 bit address which is divided into an assigned network number and a host number
- The ranges of IP addresses



Subnet Mask

- Subnets is used to separate groups of hosts for security reasons, for traffic control purposes, or other reasons
- A subnet mask is an IP address feature that serves as a sort of template to indicate which bits in the IP address define the network and which bits define the host
- All devices on the same IP network must use the same subnet mask.
- The standard subnet masks used for the class A, B, and C networks are
  - Class A 255.0.0.0 – 11111111 00000000 00000000 00000000
  - Class B 255.255.0.0 – 11111111 11111111 00000000 00000000
  - Class C 255.255.255.0 – 11111111 11111111 11111111 00000000

Subnet Mask (ex.)

- Consider a network in class B with the network address 192.168.x.x, we can separate the groups of host into 4 groups by adding 2 bits in host address into subnet mask

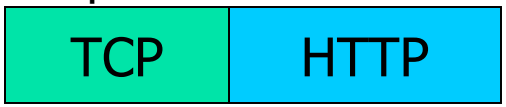
18 leftmost bits are the network address

  - 192.168.0.0/18 11000000.10101000.00000000.00000000
  - 192.168.32.0/18 11000000.10101000.01000000.00000000
  - 192.168.64.0/18 11000000.10101000.10000000.00000000
  - 192.168.96.0/18 11000000.10101000.11000000.00000000
- The subnet groups
  - Subnet 0 – 192.168.0.1 through 192.168.63.254
  - Subnet 64 – 192.168.64.1 through 192.168.127.254
  - Subnet 128 – 192.168.128.1 through 192.168.191.254
  - Subnet 192 – 192.168.192.1 through 192.168.255.2540

Encapsulation

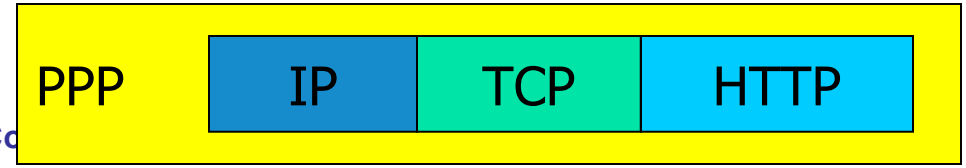
- Enclosing data using one protocol within messages of another protocol
- Example
  - The HTTP is used to construct a message requesting a page

  - TCP is used to provide the connection management and reliable delivery that HTTP requires



  - Using IP for relaying a message from one machine to another in order to reach its destination

  - Using PPP to transmit the message from one machine to the next



Tunneling

- Tunneling is the transmission of data intended for use only within a private, usually corporate network through a public network in such a way that the routing nodes in the public network are unaware that the transmission is part of private network
- Tunneling is generally done by encapsulating the private network data and protocol information within the public network transmission units so that the private network protocol information appears to the public network as data
- Example
  - Microsoft's PPTP technology enables organizations to use the Internet to transmit data across a VPN. It does this by embedding its own network protocol within the TCP/IP packets carried by the Internet.

Q&A