

Computer Networks: Architecture & Concepts

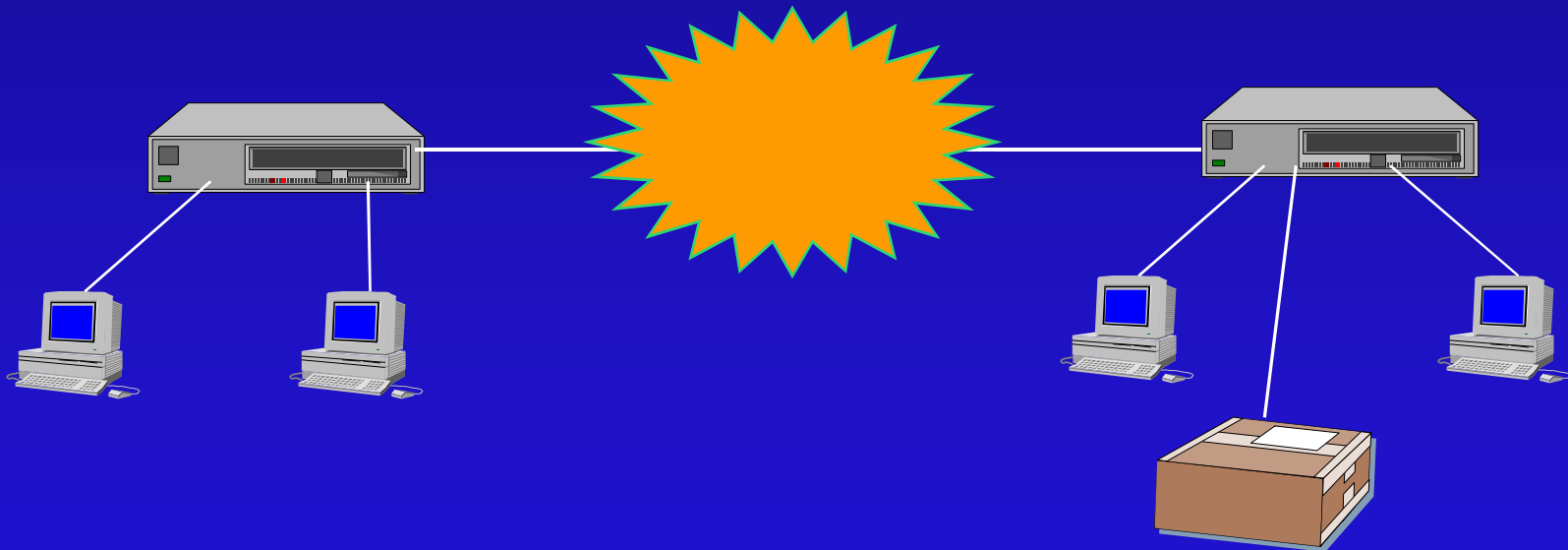
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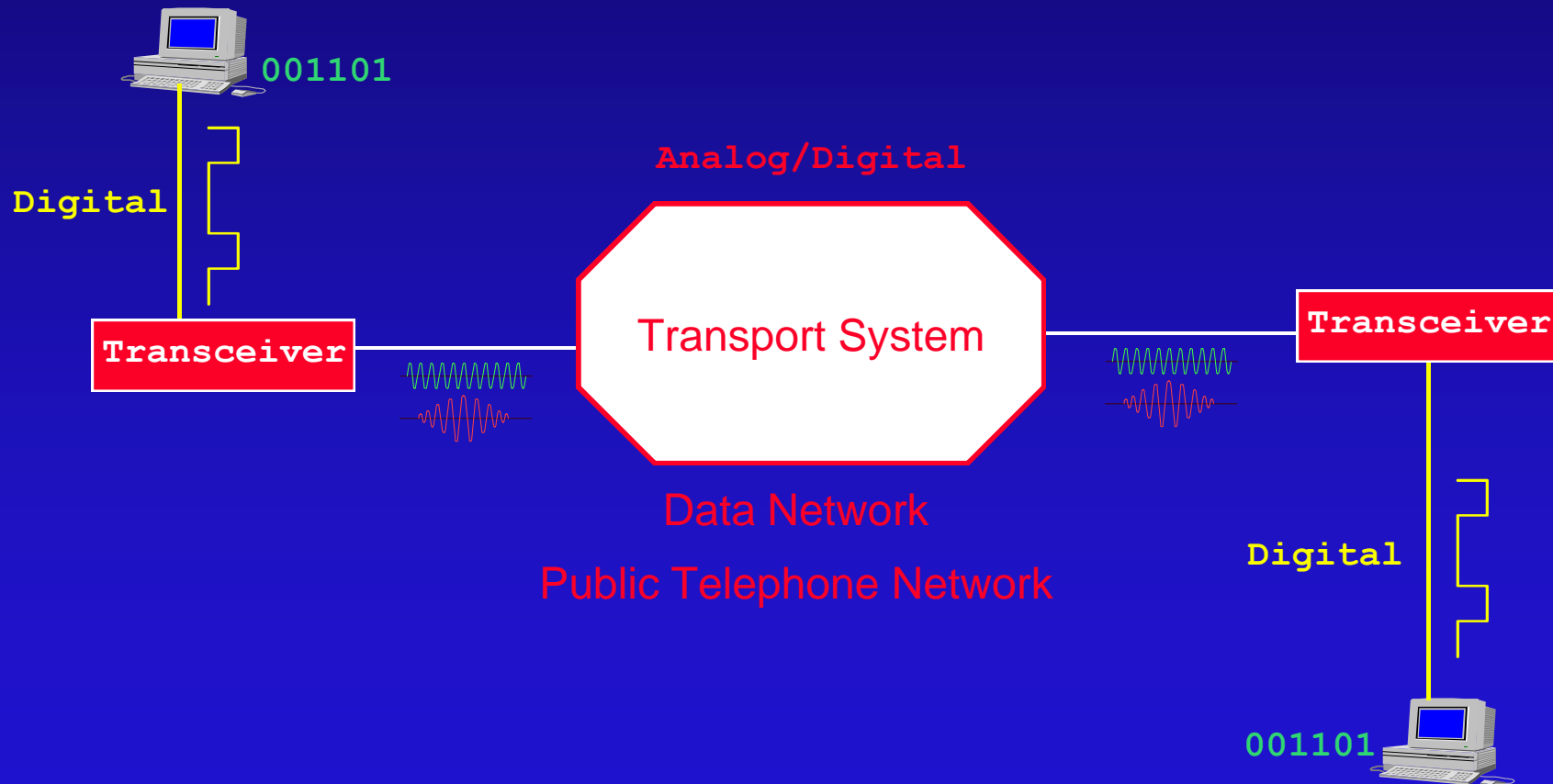
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Computer Network?

- An interconnected collection of autonomous computers and computer resources



Simple Data Communication Model

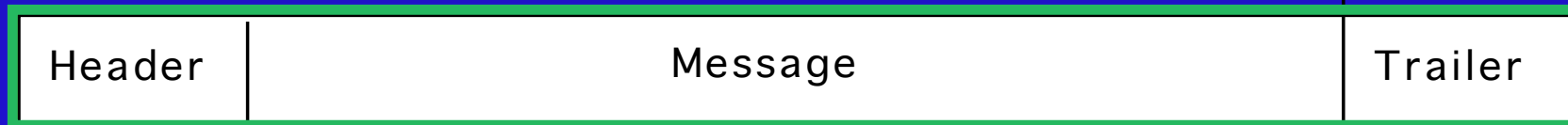


Communication Protocols

- To provide error-free and convenient information transfers, the network communication is regulated by a set of rules and conventions called network protocols.
- Protocols define connectors, cables, signals, data formats, error control techniques, and algorithms for message preparation, analysis and transfer.

Protocol Data Units (PDU)

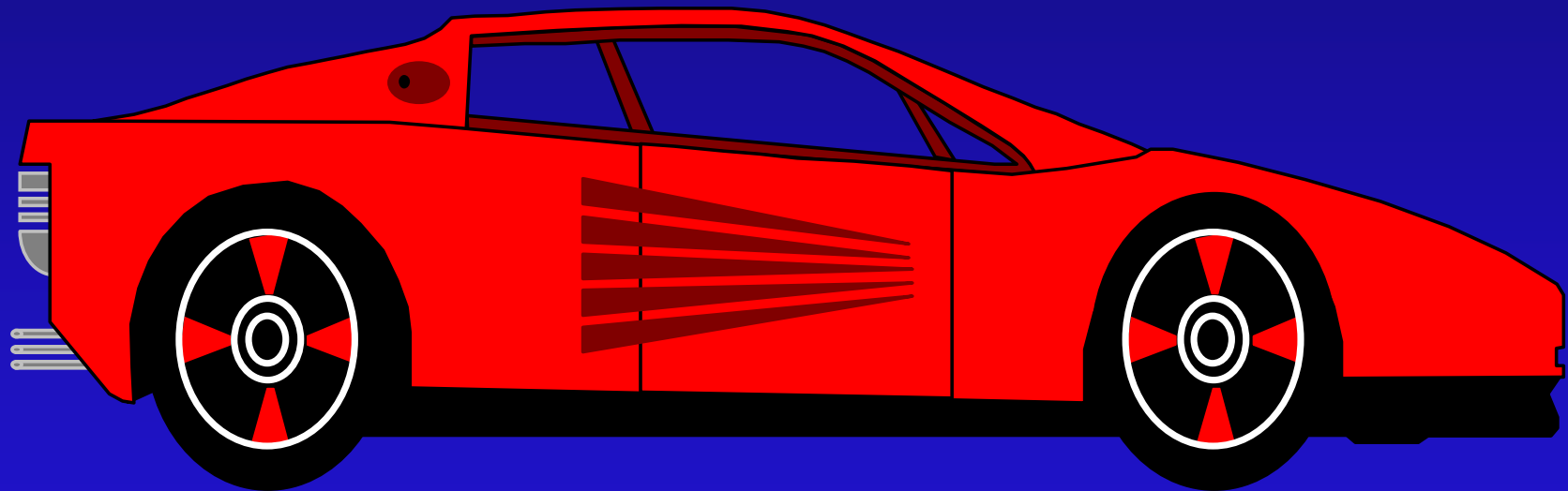
- Protocol entities exchange PDUs
 - » Each PDU must contain two major parts:
 - Header:
 - Identifies how the following parts are to be handled and routed.
 - Message:
 - This is the message body itself.
 - This is where the protocol is determined to be character oriented or bit oriented.



OSI Reference Model of ISO

- Architecture/structure that defines communication tasks and which would:
 - » Serve as a reference model for international standards
 - » would facilitate efficient internetworking among systems from different technologies, manufacturers, administrations, nationalities, and enterprises.

Reference Model



Important Standards Organizations

- **ITU-T**: International Telecommunication Union (a United Nations specialized agency, was created on March 1, 1993)
- **ISO**: International Organization for Standardization (an international voluntary, nontreaty organization, founded in 1946)
- **IETF**: Internet Engineering Task Force (responsible for publishing RFCs (Requests For Comments))
- **IEEE**: Institute of Electrical and Electronic Engineers

(**ATM Forum**: This organization is not a standard organization. After ITU defined the ATM concept in Nov 1990, ATM Forum was initiated in October 1991 to accelerate the deployment of ATM products and services. ATM Forum develops implementation agreements and publishes them as "specifications" on its web site: www.atmforum.com)

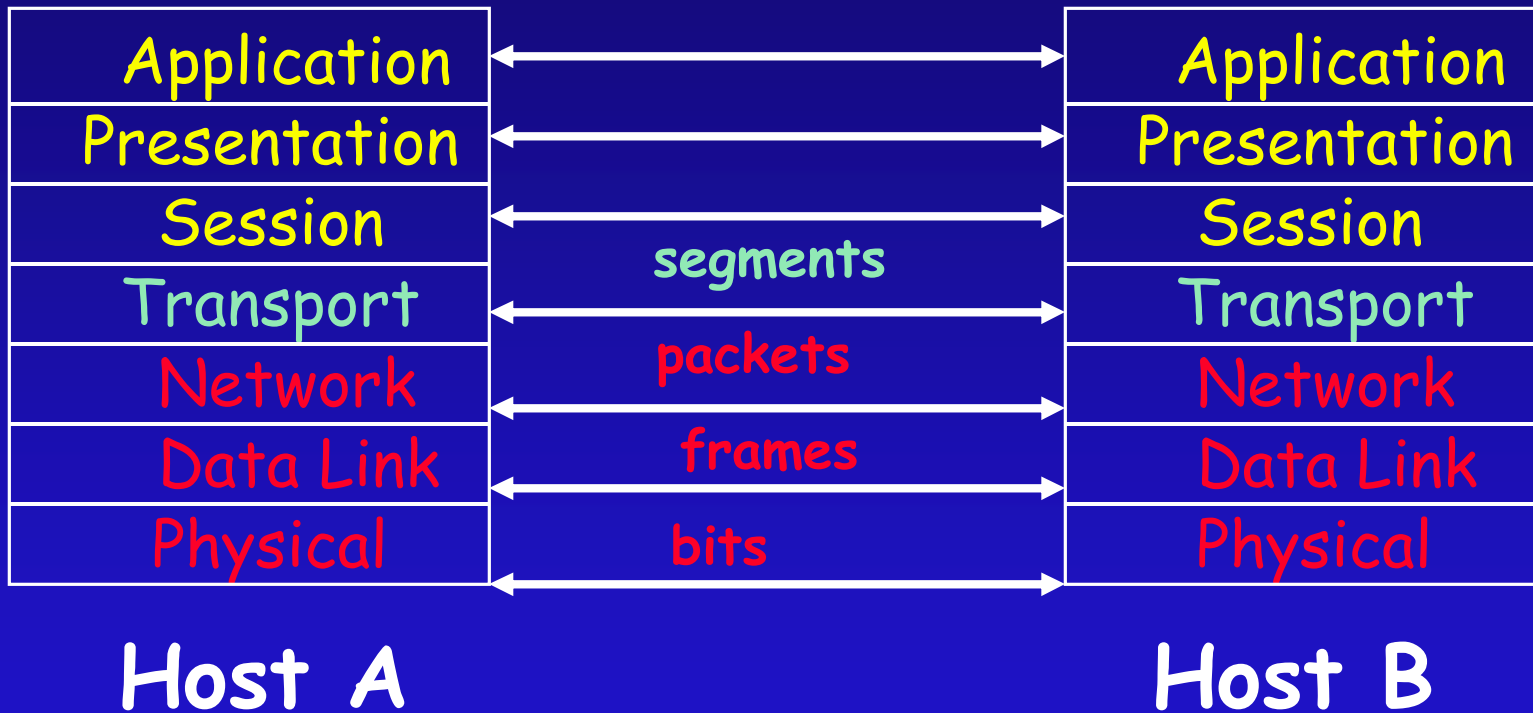
ISO OSI Reference Architecture

- The architecture is layered to reduce complexity.
 - » Each layer offers certain services to the layer immediately above it.
 - » Each layer shields the higher layer from the details of implementation of how the services are offered.
 - » Layer "n" on one station carries on a conversation with layer "n" on another network station.

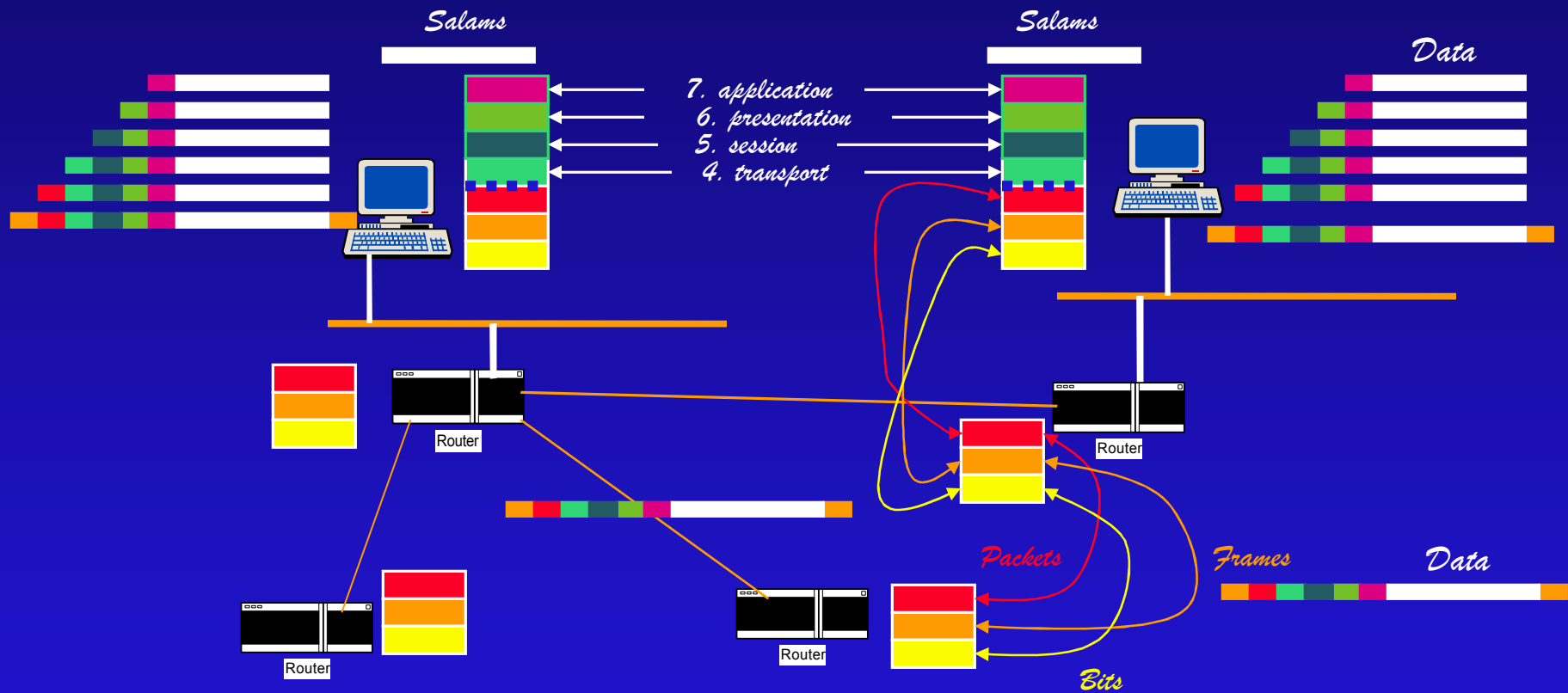
Layer Functions

7	Application	ftp, telnet, email, www, etc.
6	Presentation	Data representation
5	Session	Negotiation and connection
4	Transport	End-to-end delivery
3	Network	Addresses and best path (routing)
2	Data Link	Access to media (transfer of frames)
1	Physical	Binary transmission and cabling

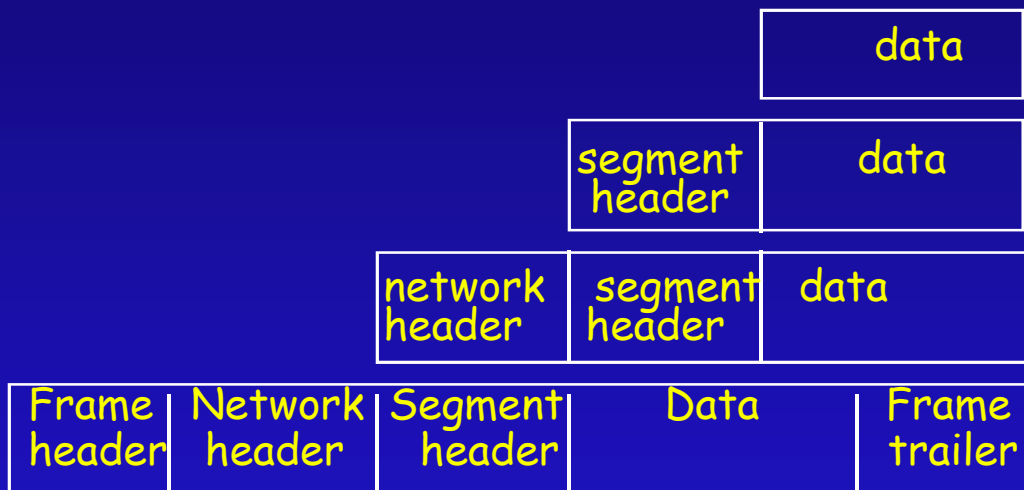
Layer Functions



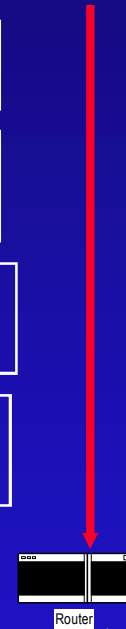
Data Encapsulation



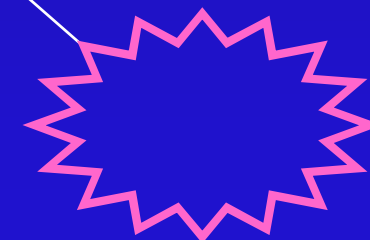
Data Encapsulation Example



0111111010101101000100100010110101



Data
Segment
Packet
Frame
Bits



Summary

- Internetworking evolved to support current and future applications
- The OSI reference model organizes network functions into seven layers
- Data flows from upper-level user applications to lower-level bits transmitted over network media
- Peer-to-peer functions use encapsulation and de-encapsulation at layer interfaces
- Most network manager tasks configure the lower three layers

Application, Presentation, and Session Layers

Application Layer

Computer Applications

- Word Processing
- Presentation Graphics
- Spreadsheet
- Database
- Design/Manufacturing
- Project Planning
- Others

Network Applications

- Electronic mail
- File Transfer
- Remote Access
- Client/Server Process
- Information Location
- Network Management
- Others

Application Layer (cont.)

Network Applications

(For enterprise
communication)

- Electronic mail
- File Transfer
- Remote Access
- Client/Server Process
- Information Location
- Network Management
- Others

Internetwork Applications

(Extend beyond the enterprise)

- Electronic Data Interchange
- World Wide Web
- E-mail Gateways
- Special-Interest Bulletin Boards
- Financial Transaction Services
- Internet Navigation Utilities
- Conferencing (Video, Voice, Data)

Presentation Layer

- Text
- Data
 - » ASCII
 - » EBCDIC
 - » Encrypted
- Sound
- Video
 - » MIDI (Musical Instrument Digital Interface)
 - » MPEG (Motion Picture Experts Group)
 - » QuickTime

Presentation Layer

- Graphics
- Visual Images
 - » PICT(format to transfer QuickDraw graphics between Macintosh or PowerPC programs)
 - » TIFF (Tagged Image File Format)
 - » JPEG (Joint Photographic Experts Group)
 - » GIF
- Provides code formatting and conversion for applications

Session Layer

- Coordinates applications as they interact on different hosts



Session Layer (contd.)

- Network File System (NFS)
 - Allows transparent access to remote network resources
- Structured Query Language (SQL)
- Remote-Procedure Call (RPC)
 - RPC procedures are built on clients and executed on servers
- X Window System
 - Allows intelligent terminals to communicate with remote UNIX machines
- AppleTalk Session Protocol (ASP)
 - Establishes and maintains sessions between an AppleTalk client and server
- DNA Session Control Protocol (SCP)

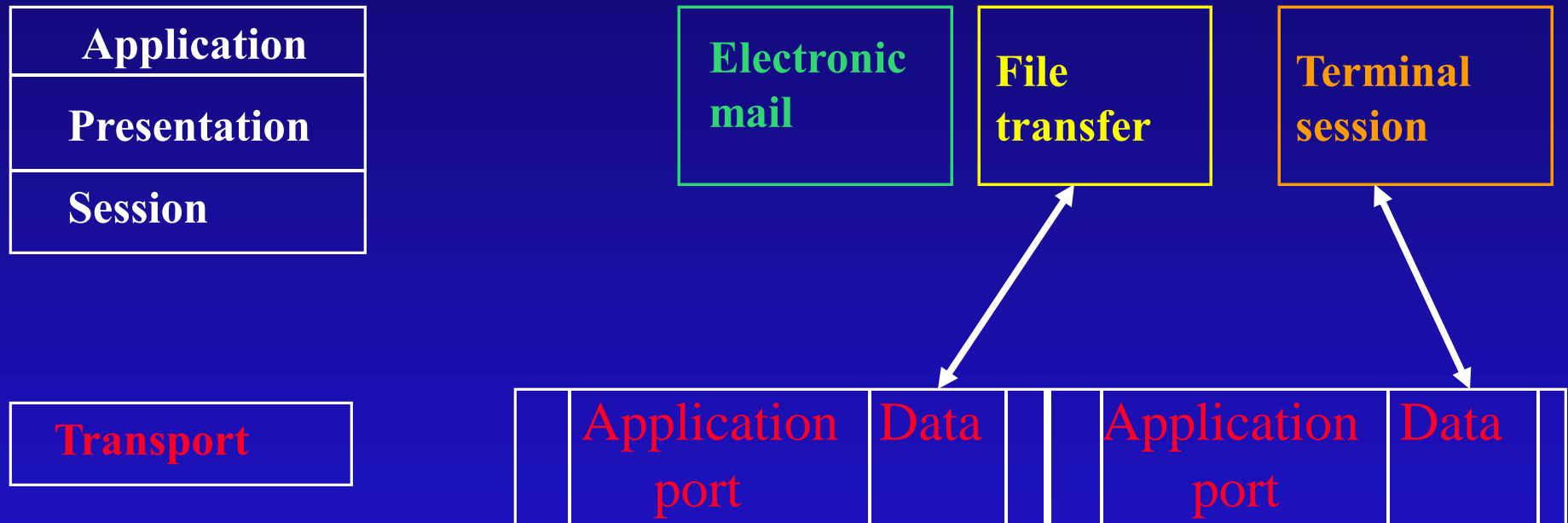
Transport Layer

Transport Layer Overview

- Segments upper-layer applications
- Establishes an end-to-end connection
- Sends segments from one end host to another
- Ensures end-to-end data reliability



Segment Upper-Layer Applications



- **Transport segments share traffic stream**

E S



sender



receiver

synchronize



Negotiate connection



synchronize



Acknowledge

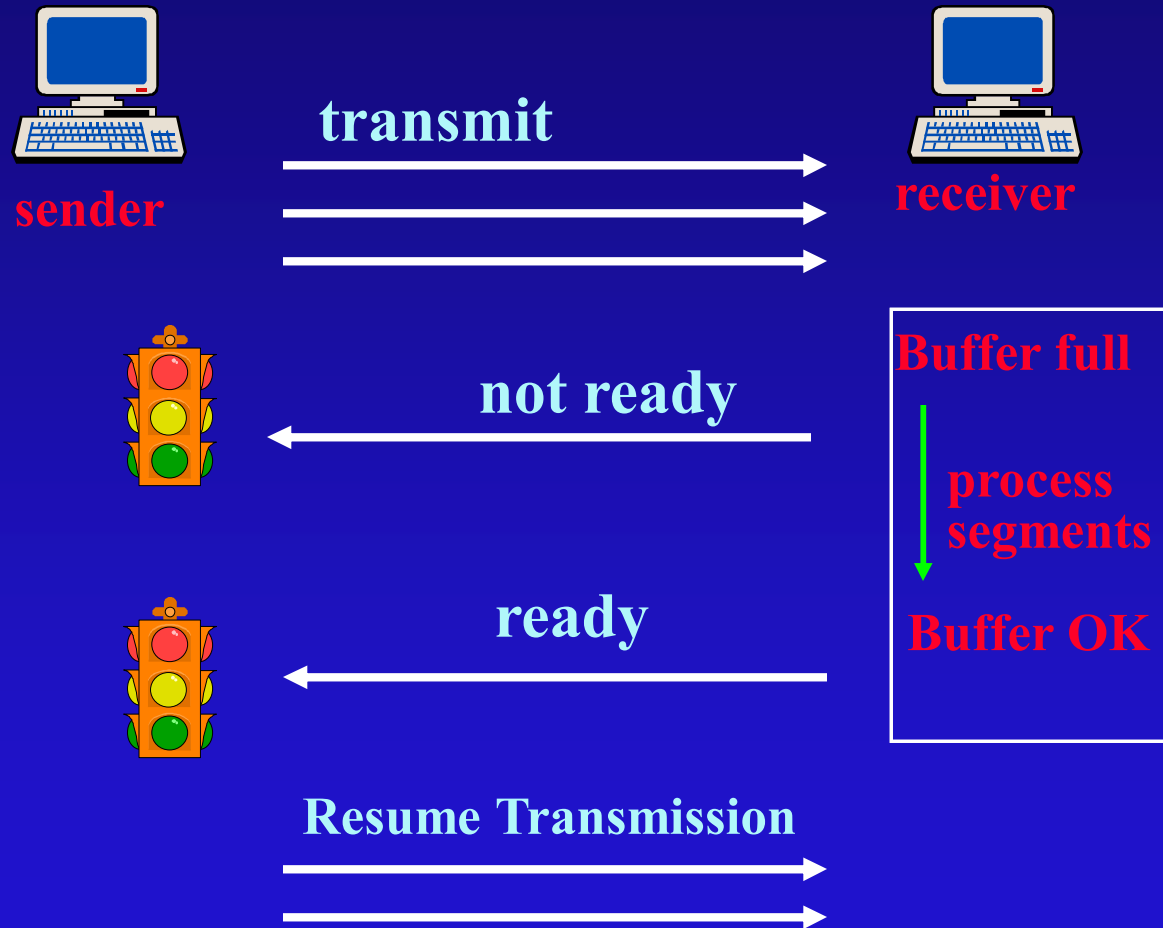


Connection established

Data transfer (send segments)



Establishes Connection



Reliability with Windowing

- In the most basic form of reliable connection-oriented transfer, data segments must be delivered to the recipient in the same sequence that they were transmitted.
- **Windowing** is a method to control the amount of information transferred end-to-end. Some protocols measure information in terms of number of packets

Reliability with Windowing



sender

Send 1

Window size 1

Receive 1

ACK 2

Send 2

Receive 2

ACK 3



receiver



sender

Send 1

Window size 3

Receive 1

Send 2

Receive 2

Send 3

Receive 3

ACK 4

Send 4

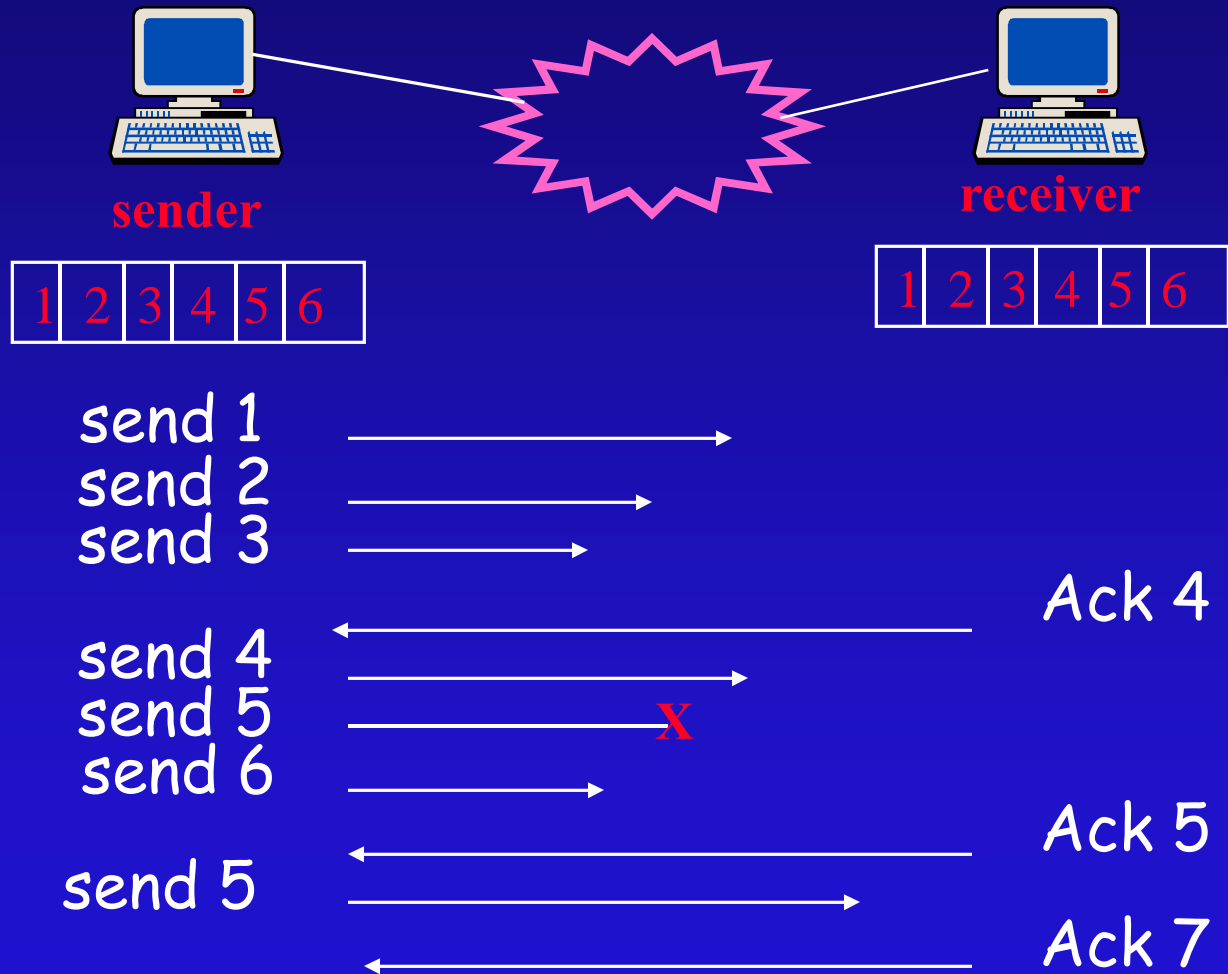


receiver

PAR Technique

- Reliable delivery guarantees that a stream of data sent from one machine will be delivered through a functioning data link to another machine without duplication or data loss. Positive acknowledgement with retransmission is one technique that guarantees reliable delivery of data streams.
- The sender keeps the record of each segment it sends and waits for an acknowledgement.
- The sender also starts a timer when it sends a segment, and it retransmits a segment if the timer expires before an acknowledgement arrives.

PAR Technique (contd.)



Summary

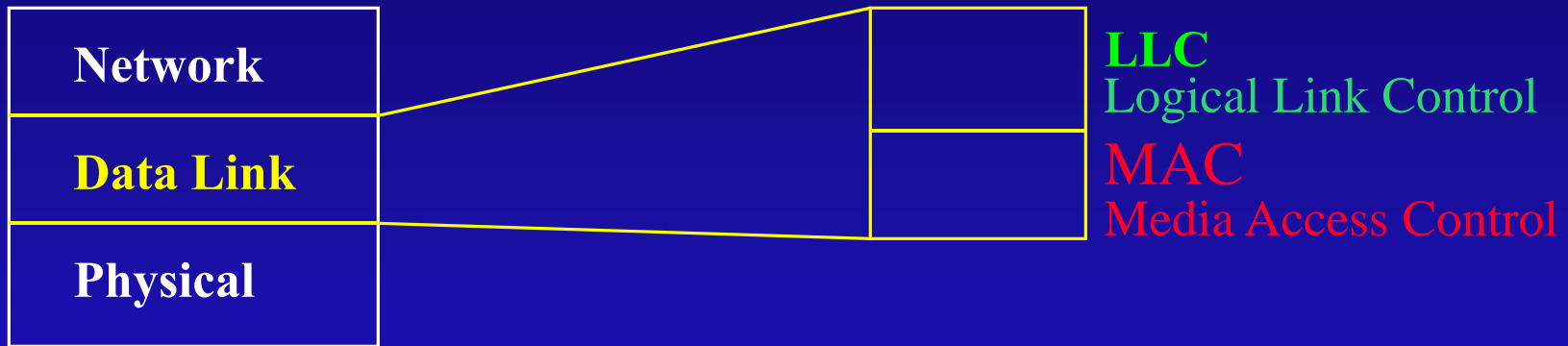
- Presentation layer formats and converts network application data to represent text, graphics, images, video, and audio.
- Session-layer functions coordinate communication interactions between applications.
- Reliable transport-layer functions include
 - » Multiplexing
 - » Connection synchronization
 - » Flow control
 - » Error recovery
 - » Reliability through windowing

Physical and Data Link Layers

Physical and Data-Link Standards

- The data link layer provides data transport across a physical link. To do so, the data link layer handles physical addressing, network topology, line discipline, error notification, orderly delivery of frames, and optional flow control.
- The physical layer specifies the electrical, mechanical, procedural, and functional requirements for activating, maintaining, and deactivating the physical link between end systems.
- These requirements and characteristics are codified into standards.

LAN Data-Link Sublayers



LAN Data-Link Sublayers

- LLC refers upward to higher-layer software functions.
- MAC refers downward to lower-layer hardware functions.
- LAN protocols occupy the bottom two layers of OSI reference model: the physical layer and data link layer.

LAN Data-Link Sublayers

- The IEEE 802 committee subdivided the data link layer into two sublayers:
 - » The logical link control (LLC) sublayer
 - » The media access control (MAC) sublayer
- The LLC sublayer provides for environments that need connectionless or connection-oriented services and the data link layer.
- The MAC sublayer provides access to the LAN medium in an orderly manner.

LLC Sublayer Functions

- Enable upper layers to gain independence over LAN media access.
- Allow service access points (SAPs) from interface sublayers to upper-layer functions.
- Provide optional connection, flow control, and sequencing services.

Client-Server Model

Client Server Model

- Client-Server paradigm is the primary pattern of interactions among cooperating applications.
- This model constitutes the foundation on which distributed algorithms are built.

What is the Client-Server Paradigm?

- The paradigm divides communicating applications into 2 broad categories, depending on whether the application waits for communication or initiates it.
 - » An application that initiates a communication is called a client.
 - » End users usually invoke a client software when they use a network service.

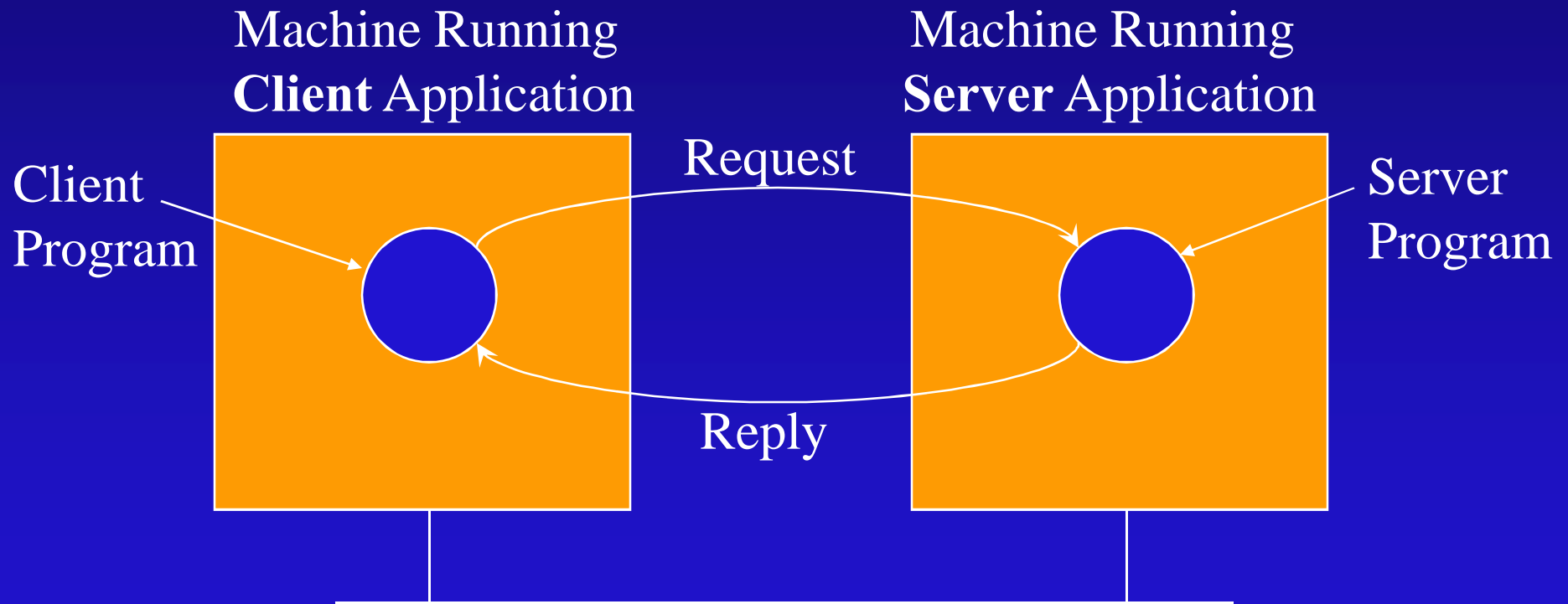
Client Server Model (cont.)

- **Server:** Any program that offers a service reachable over the network
 - » If a machine's primary purpose is to support a particular server program, the term server is usually applied to both, the machine and the server program
- **Client:** An executing program becomes a client when it sends a request to a server and waits for a response

Client Server Model (cont.)

- A server is any program that waits for incoming communication requests from a client.
 - » Each time a client application needs to contact a server, it sends a request and awaits a response.
 - » The server receives a client's request, performs the necessary computation, and returns the result to the client.
 - » When the response arrives at the client, the client continues processing.

Client Server Model (cont.)



Client Server Model (cont.)

- A Misconception:

- » Technically, a **server** is a program and not a piece of hardware.
- » However, computer users frequently (mis)apply the term to the computer responsible for running a particular server program.
 - For example, **Web Server**, is usually a computer running the **http** server program.

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- Peer-to-peer functions use encapsulation and de-encapsulation at layer interfaces.
- Client-Server paradigm constitutes the foundation on which distributed algorithms are built.