CCNA Exploration Network Fundamentals

Chapter 02

Communicating Over The Network

The Elements of Communication

- Communication begins with a message, or information, that must be sent from one individual or device to another using many different communication methods.

- All of these methods have **3** elements in common:

  - message source, or sender

  - destination, or receiver

  - a channel, media or pathway

Communicating The Messages

- Data is divided into smaller parts during transmission - **Segmentation**

- The benefits of doing so:

  - Many **different conversations can be interleaved** on the network. The process used to interleave the pieces of separate conversations together on the network is called **multiplexing**.

  - **Increase the reliability** of network communications. The separate pieces of each message need not travel the same pathway across the network from source to destination

- Downside of segmentation and multiplexing

  - level of complexity is added (process of addressing, labeling, sending, receiving and etc are time consuming)

- Each segment of the message must go through a similar process to ensure that it gets to the correct destination and can be reassembled into the content of the original message

- Various types of devices throughout the network participate in ensuring that the pieces of the message arrive reliably at their destination

Components of the Network

- Devices (PCs, intermediary devices)
- Media (Cable or wireless)
- Services and processes (Software)
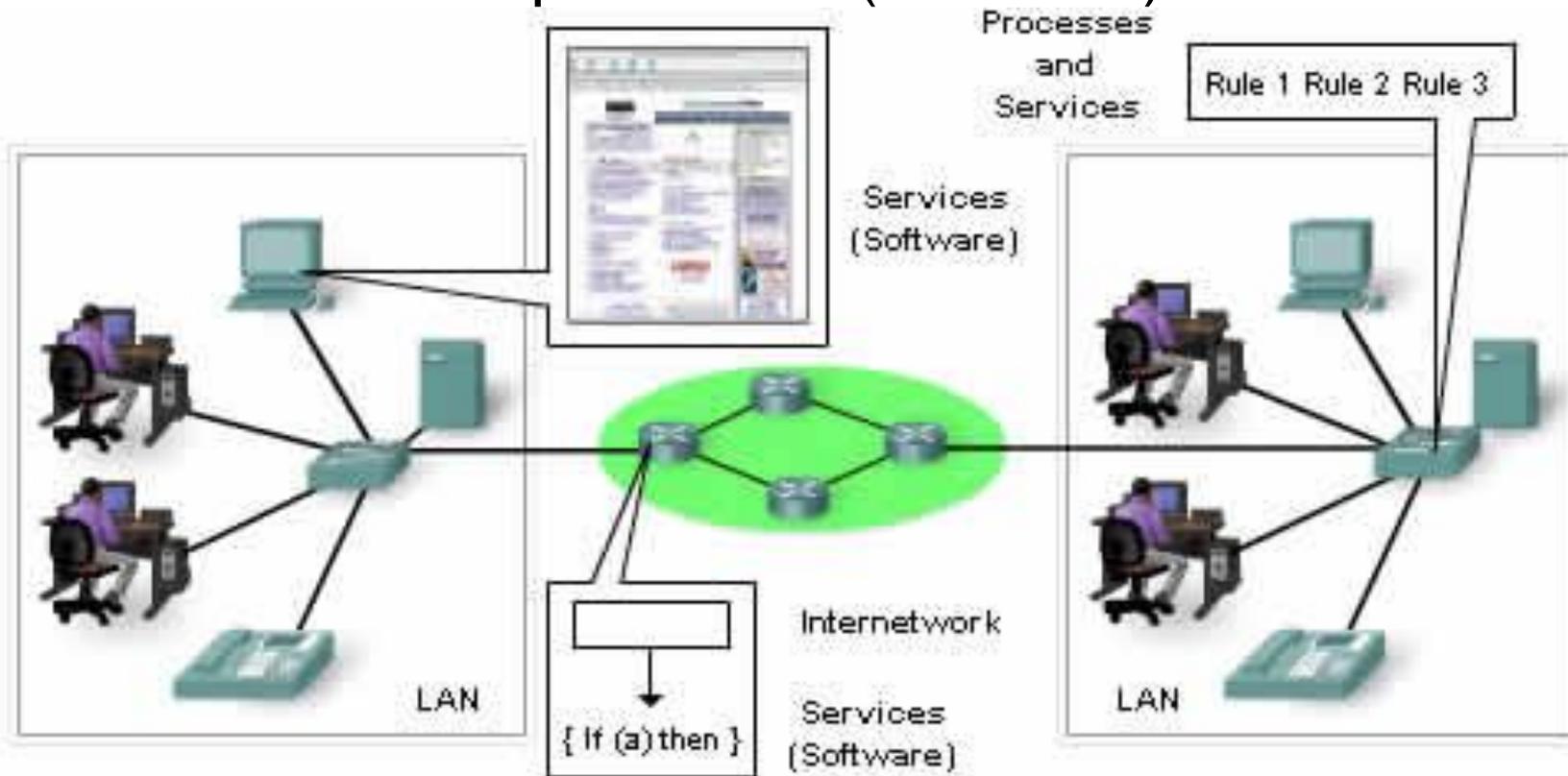
End Devices and Their Roles

- In the context of a network, **end devices** are referred to as **hosts**.

- A host device is either the sender or receiver

- To distinguish one host from another, each host on a network is identified by an address.

- A host (sender) uses the address of the destination host to specify where the message should be sent.

- Software determines the role of a host. A host can be a client, server or both

Intermediary Devices and Their Roles

- Examples:

  - Network Access Devices (Hubs, switches, and wireless access points)

  - Internetworking Devices (routers)

  - Communication Servers and Modems

  - Security Devices (firewalls)

- Processes running on the intermediary network devices perform these functions:

- Regenerate and retransmit data signals

- Maintain information about what pathways exist through the network and internetwork

- Notify other devices of errors and communication failures

- Direct data along alternate pathways when there is a link failure

- Classify and direct messages according to QoS priorities

- Permit or deny the flow of data, based on security settings

Network Media

- Communication across a network is carried on a medium


Copper

Fiber Optics

Wireless

• 3 types of Media:
- Metallic wires within cables
- Glass or plastic fibers (fiber optic cable)
- Wireless transmission

- The signal encoding is different for each media type.

- Metallic wires, the data is encoded into electrical impulses

- Fiber optic - pulses of light, within either infrared or visible light ranges.

- Wireless transmission, electromagnetic waves

- Criteria for choosing a network media are:

- The **distance** the media can successfully carry a signal.

- The **environment** in which the media is to be installed.

- The **amount** of data and the **speed** at which it must be transmitted.

- The **cost** of the media and installation

LAN, WAN, Internetworks

- **Local Area Network (LAN)** - An individual network usually spans a single geographical area, providing services and applications to people within a common organizational structure, such as a single business, campus or region

- **Wide Area Network (WAN)**- Individual organizations usually lease connections through a telecommunications service provider network. These networks that connect LANs in geographically separated locations are referred to as Wide Area Networks.
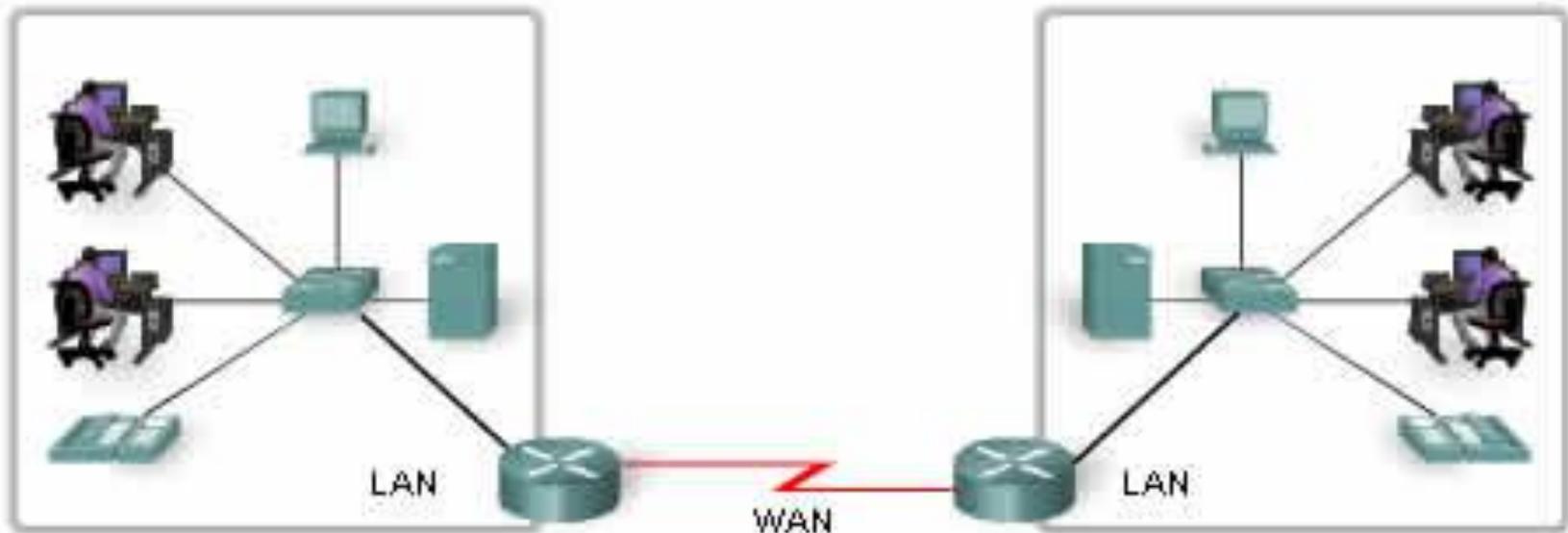
- Internetworks - A global mesh of interconnected networks for communication. Example: Internet
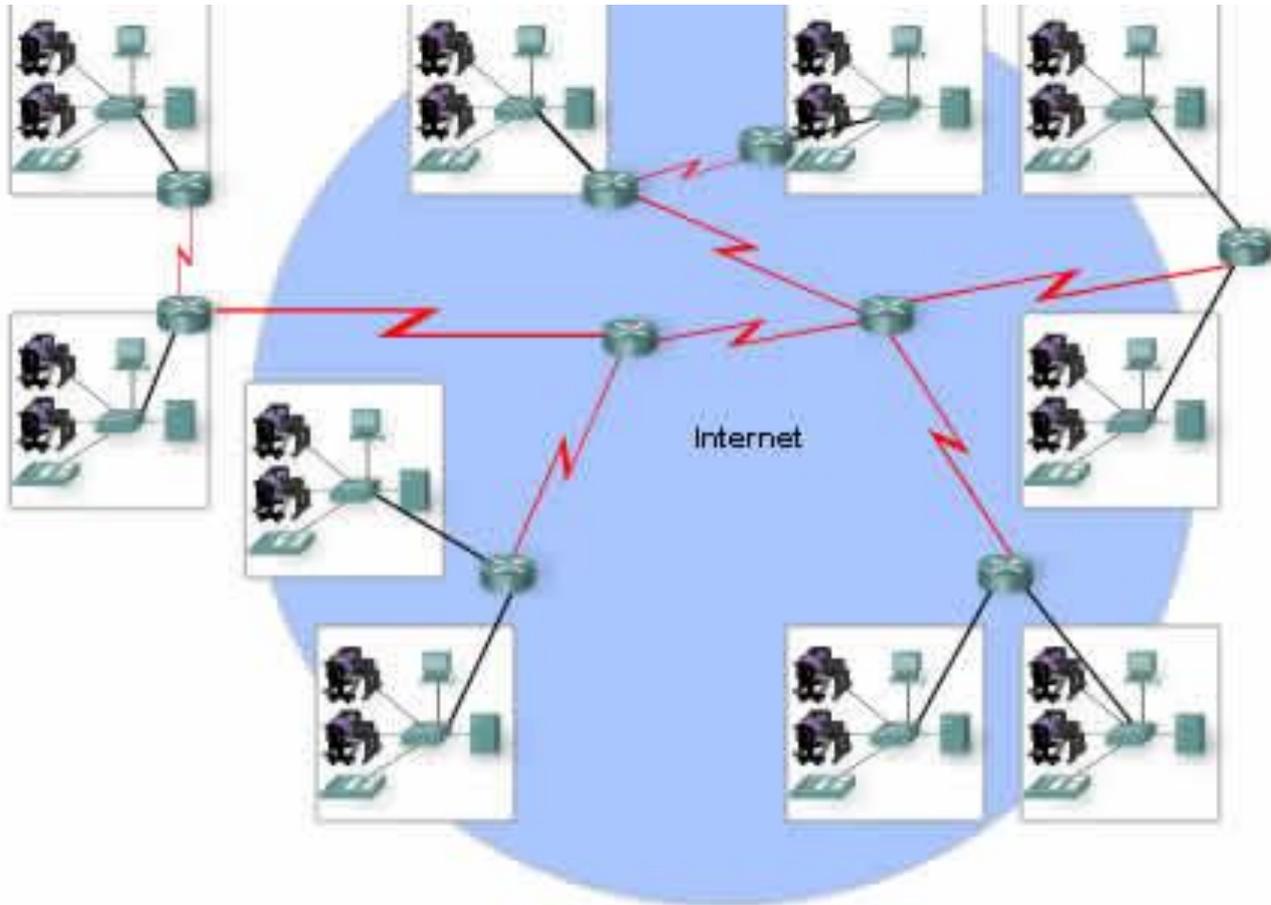
- The term **intranet** is often used to refer to a private connection of LANs and WANs that belongs to an organization, and is designed to be accessible only by the organization's members, employees, or others with authorization.

Network Representations

Desktop Computer

Laptop

Server

IP Phone

LAN Media

Wireless Media

LAN Switch

Firewall

Router

Wireless Router

Cloud

WAN Media

- **Network Interface Card** - A NIC, or LAN adapter, provides the physical connection to the network at the PC or other host device. The media connecting the PC to the networking device plugs directly into the NIC.

- **Physical Port** - A connector or outlet on a networking device where the media is connected to a host or other networking device.

- **Interface** - Specialized ports on an internetworking device that connect to individual networks. Because routers are used to interconnect networks, the ports on a router are referred to network interfaces.
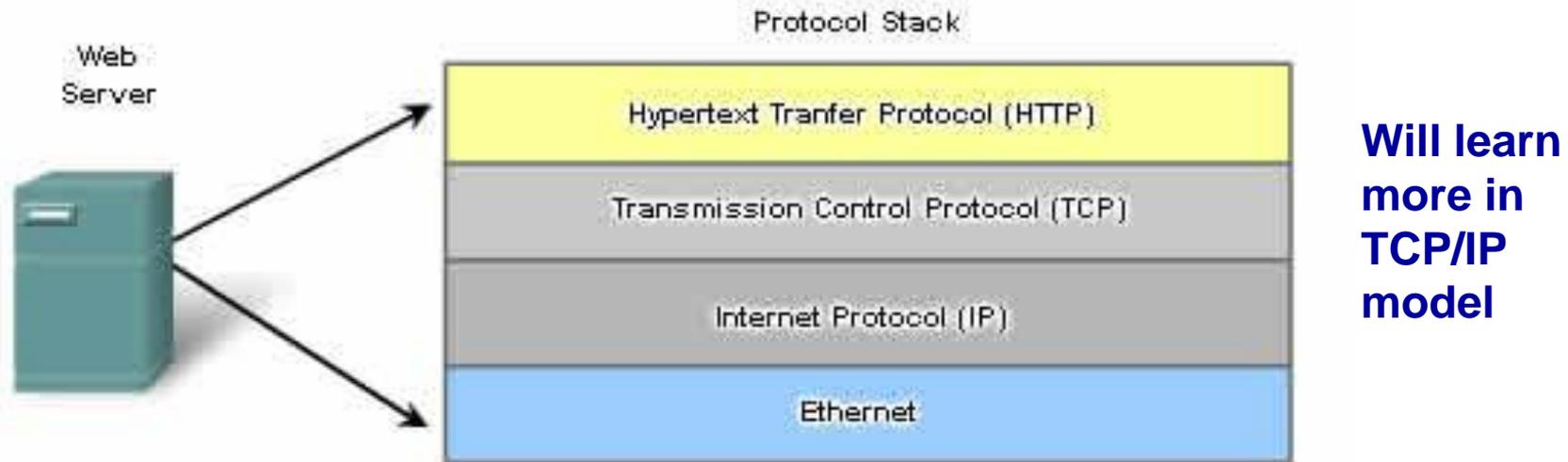
Rules that Govern Communications

- Communication in networks is governed by pre-defined rules called protocols.

- A group of inter-related protocols that are necessary to perform a communication function is called a protocol suite. These protocols are implemented in software and hardware that is loaded on each host and network device

- Networking protocols suites describe processes such as:

  - The format or structure of the message

  - The process by which networking devices share information about pathways with other networks

  - How and when error and system messages are passed between devices

  - The setup and termination of data transfer sessions

- Individual protocols in a protocol suite may be vendor-specific and proprietary.

Protocol Suites & Industry Standard

- Many of the protocols that comprise a protocol suite reference other widely utilized protocols or industry standards

- Institute of Electrical and Electronics Engineers (IEEE) or the Internet Engineering Task Force (IETF)

- The use of standards in developing and implementing protocols ensures that products from different manufacturers can work together for efficient communications

The Interaction of Protocols

Protocol Stack

Web Server

Hypertext Tranfer Protocol (HTTP)
Transmission Control Protocol (TCP)
Internet Protocol (IP)
Ethernet

Will learn more in TCP/IP model

- Application protocol – HTTP. HTTP defines the content and formatting of the requests and responses exchanged between the client and server
- Transport Protocol – TCP. TCP divides the HTTP messages into smaller segments. It is also responsible for controlling the size and rate of message exchange.
- Internetwork Protocol – IP. It encapsulating segments into packets, assigning the appropriate addresses, and selecting the best path to the destination host.
- Network Access Protocol – Protocols for data link management and the physical transmission of data on the media.

Using Layer Models

- To visualize the interaction between various protocols, it is common to use a layered model.

- Benefits of using layered model:

  - Assists in protocol design, because protocols that operate at a specific layer have defined information that they act upon and a defined interface to the layers above and below.

  - Fosters competition because products from different vendors can work together.

  - Prevents technology or capability changes in one layer from affecting other layers above and below.

  - Provides a common language to describe networking functions and capabilities.

Protocol & Reference Model

- 2 types of networking models

- A **protocol model** provides a model that closely matches the structure of a particular protocol suite. The hierarchical set of related protocols in a suite typically represents all the functionality required to interface the human network with the data network. Example: TCP/IP model

- A **reference model** provides a <u>common reference</u> for maintaining consistency within all types of network protocols and services. A reference model is <u>not intended to be an implementation specification</u> or to provide a sufficient level of detail to define precisely the services of the network architecture. The primary purpose of a reference model is to aid in clearer understanding of the functions and process involved

- Example: OSI model

TCP/IP Model

TCP/IP Model

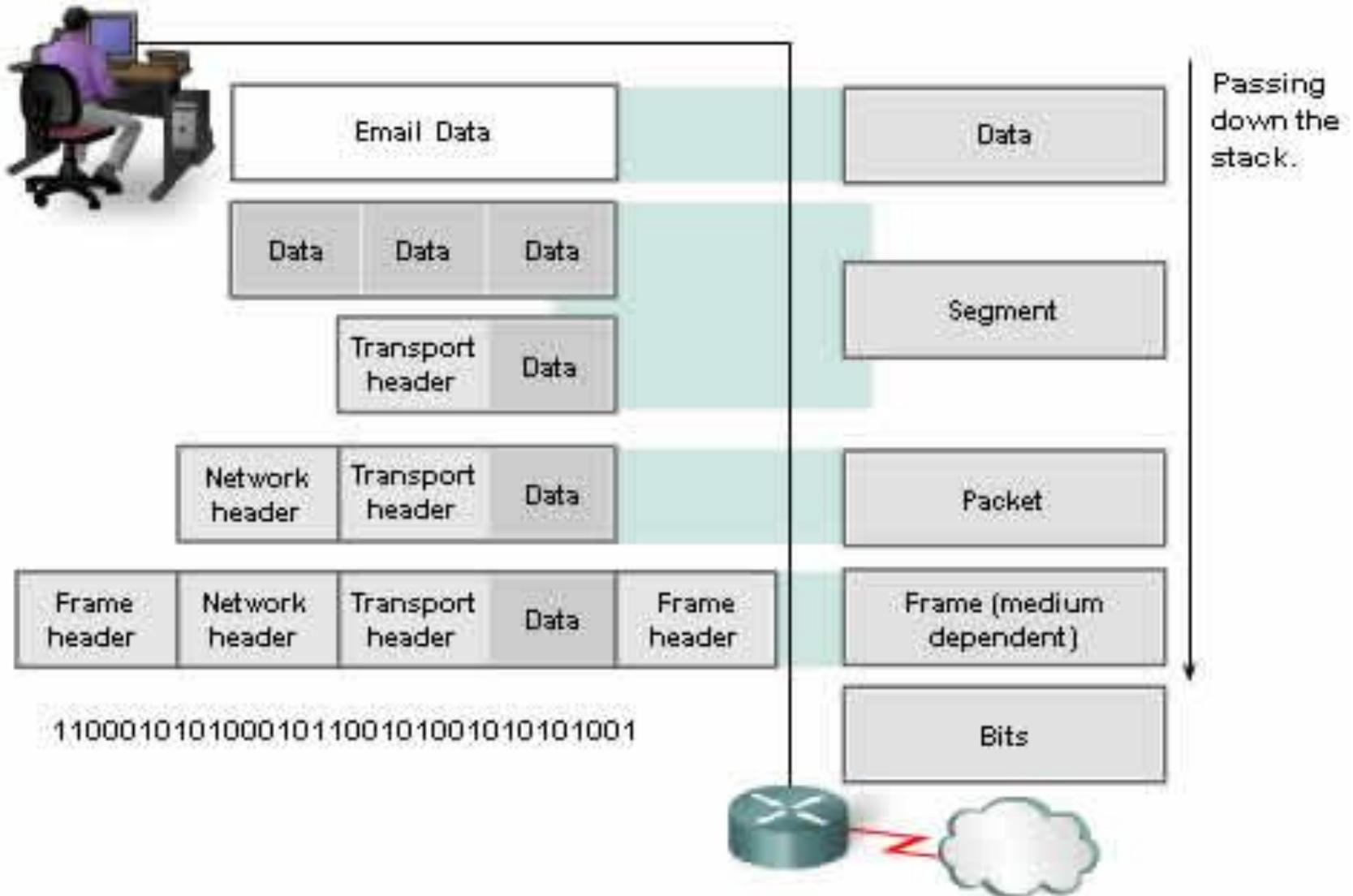|	
Application	Represents data to the user plus encoding and dialog control.
Transport	Supports communication between diverse devices across diverse networks.
Internet	Determines the best path through the network.
Network Access	Controls the hardware devices and media that make up the network.
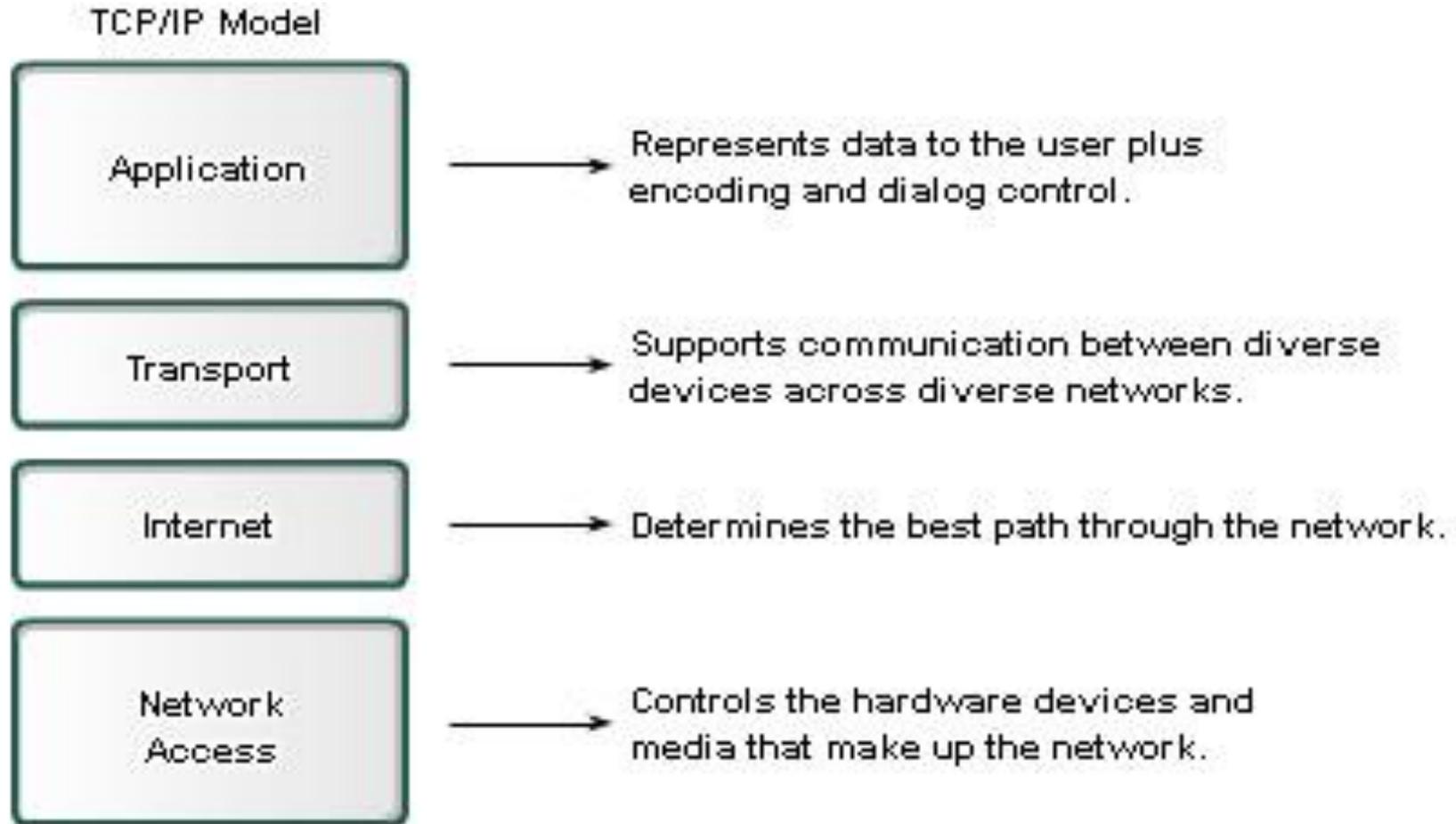
Communication Process

- A complete communication process includes these steps:

1. Creation of data at the application layer of the originating source end device

2. Segmentation and encapsulation of data as it passes down the protocol stack in the source end device

3. Generation of the data onto the media at the network access layer of the stack

4. Transportation of the data through the internetwork, which consists of media and any intermediary devices

5. Reception of the data at the network access layer of the destination end device

6. Decapsulation and reassembly of the data as it passes up the stack in the destination device

7. Passing this data to the destination application at the Application layer of the destination end device

Protocol Data Units and Data Encapsulation

		Email Data				Data
	Data	Data	Data			Segment
		Transport header	Data			
	Network header	Transport header	Data			Packet
Frame header	Network header	Transport header	Data	Frame header		Frame (medium dependent)

1100010101000101100101001010101001

Bits

Passing down the stack.

Protocol Data Units and Data Encapsulation

- As application data is passed down the protocol stack on its way to be transmitted across the network media, various protocols add information to it at each level.

- This is commonly known as the encapsulation process.

- The form that a piece of data takes at any layer is called a Protocol Data Unit (PDU).

- During encapsulation, each succeeding layer encapsulates the PDU that it receives from the layer above in accordance with the protocol being used.

Protocol Data Units and Data Encapsulation

- TCP/IP protocol suite PDUs:

  Data – Application Layer PDU

  Segment - Transport Layer PDU

  Packet - Internetwork Layer PDU

  Frame - Network Access Layer PDU

  Bits - PDU used when physically transmitting data over the medium

Sending and Receiving Process

- When sending messages on a network, the protocol stack on a host operates from top to bottom.

- This process is reversed at the receiving host. The data is decapsulated as it moves up the stack toward the end user application.

Protocol Operation of Sending and Receiving a Message
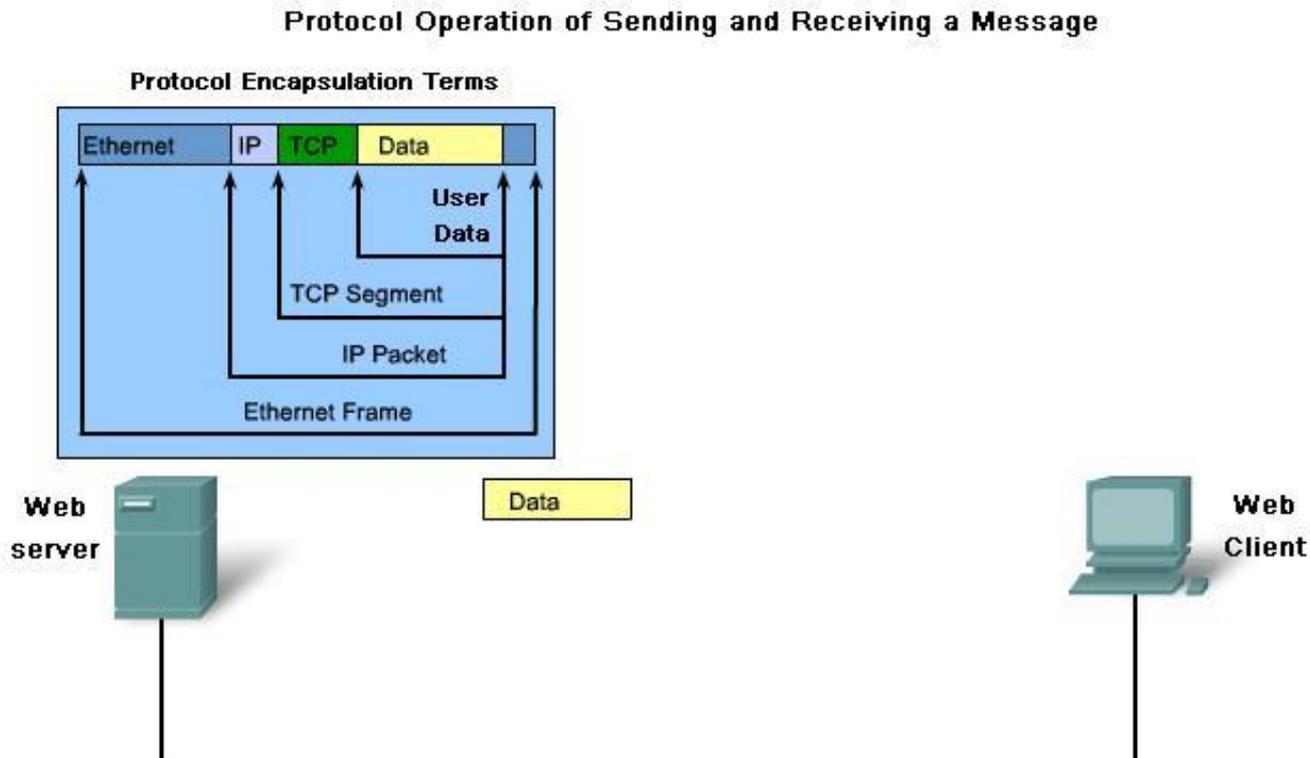
OSI – The Application Layer

- Performs services for the applications used by end users.

7. Application

6. Presentation

5. Session

4. Transport

3. Network

2. Data Link

1. Physical

Application

The Application layer provides the means for end-to-end connectivity between individuals in the human network using data networks.

OSI – The Presentation Layer

- Provides data format information to the application. For example, the presentation tells the application layer whether there is encryption or whether it is a .jpg picture.

7. Application

6. Presentation

5. Session

4. Transport

3. Network

2. Data Link

1. Physical

Presentation

The Presentation Layer provides for common representation of the data transferred between Application layer services.

OSI – The Session Layer

- Manages sessions between users.

7. Application	
6. Presentation	
5. Session	**Session**
4. Transport	The Session layer provides services to the Presentation layer to organize its dialogue and to manage data exchange.
3. Network	
2. Data Link	
1. Physical	

OSI – The Transport Layer

- Defines data segments and numbers them at the source, transfers the data, and reassembles the data at the destination.

7. Application

6. Presentation

5. Session

4. Transport

3. Network

2. Data Link

1. Physical

Transport

The Transport layer defines services to segment, transfer, and reassemble the data for individual communications between the end devices.

OSI – The Network Layer

- Creates and addresses packets for end-to-end delivery through intermediary devices in other networks.

7. Application

6. Presentation

5. Session

4. Transport

3. Network

2. Data Link

1. Physical

Network

The Network layer provides services to exchange the individual pieces of data over the network between identified end devices.

OSI – The Data Link Layer

- Creates and addresses frames for host-to-host delivery on the local LANs and between WAN devices.

7. Application

6. Presentation

5. Session

4. Transport

3. Network

2. Data Link

1. Physical

Data Link

The Data Link layer protocols describe methods for exchanging data frames between devices over a common media.
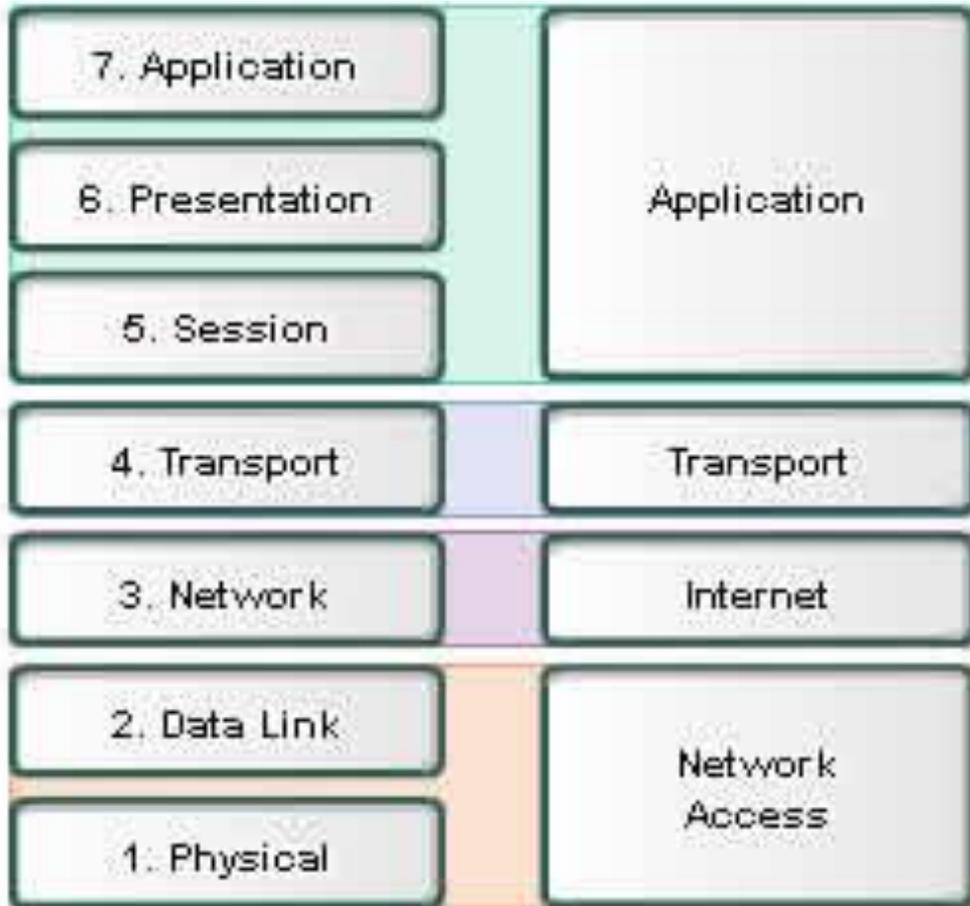
OSI – The Physical Layer

- Transmits binary data over the media between devices. Physical layer protocols define media specifications.

7. Application

6. Presentation

5. Session

4. Transport

3. Network

2. Data Link

1. Physical

Physical

The Physical layer protocols describe the mechanical, electrical, functional, and procedural means to activate, maintain, and de-activate physical-connections for bit transmission to and from a network device.
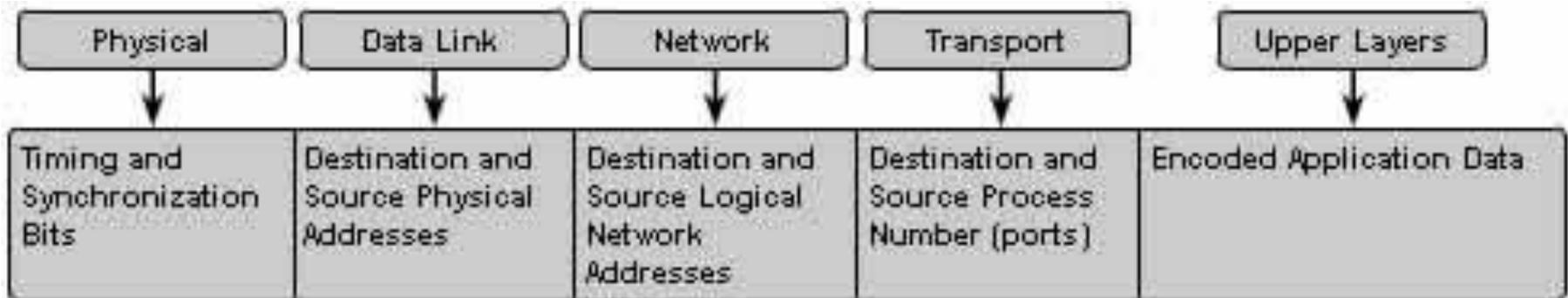
Comparing OSI model with TCP/IP Model

7. Application	
6. Presentation	Application
5. Session	
4. Transport	Transport
3. Network	Internet
2. Data Link	Network Access
1. Physical	

The key parallels are in the Transport and Network layers.

--Both have application layers, though they include very different services

--Both have comparable transport and network (Internet) layers

--TCP/IP combines the presentation and session layer issues into its application layer

--TCP/IP combines the OSI data link and physical layers into one layer

--TCP/IP appears simpler because it has fewer layers

Addressing in the Network

- There are various types of addresses that must be included to successfully deliver the data from a source application running on one host to the correct destination application running on another
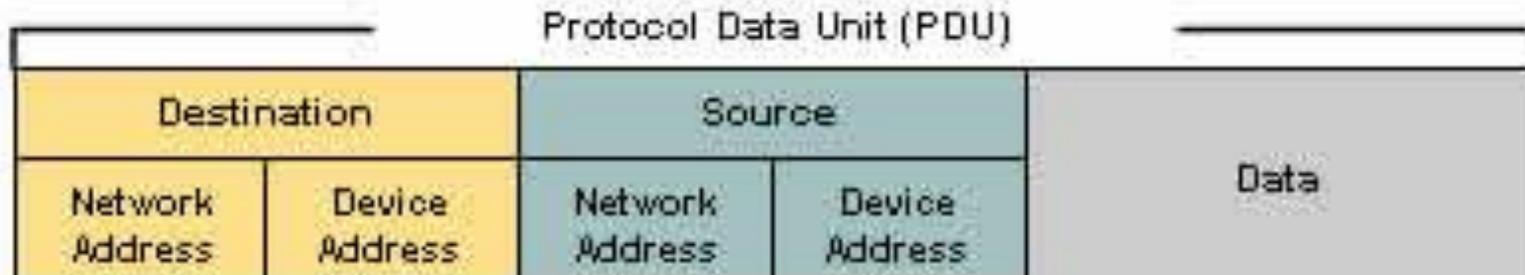
Physical	Data Link	Network	Transport	Upper Layers
Timing and Synchronization Bits	Destination and Source Physical Addresses	Destination and Source Logical Network Addresses	Destination and Source Process Number (ports)	Encoded Application Data

Getting Data to the End Device

- The host physical address, is contained in the header of the Layer 2 PDU, called a **frame.**

- Layer 2 is concerned with the delivery of messages on a **single local network**.

- The Layer 2 address is **unique** on the local network and represents the address of the end device on the physical media.

- In a LAN using Ethernet, this address is called the **Media Access Control (MAC) address**.

- When two end devices communicate on the local Ethernet network, the frames that are exchanged between them **contain the destination and source MAC addresses**.

- Once a frame is successfully received by the destination host, the Layer 2 address information is removed as the data is decapsulated and moved up the protocol stack to Layer 3.

Getting the Data Through the Internetwork

- Layer 3 protocols are primarily designed to move data **from one local network to another local network** within an internetwork.

- Layer 3 addresses **must include identifiers** that enable intermediary network devices to locate hosts on different networks

- At the boundary of each local network, an intermediary network device, usually a **router**, decapsulates the frame to read the destination host address contained in the **header of the packet**, the Layer 3 PDU

- Routers use the network identifier portion of this address to **determine which path to use** to reach the destination host.

Protocol Data Unit (PDU)				
Destination		Source		Data
Network Address	Device Address	Network Address	Device Address	

Getting Data to the Right Application

- At Layer 4, information contained in the PDU header identify the specific process or service running on the destination host device that will act on the data being delivered.

- Hosts, whether they are clients or servers on the Internet, can run multiple network applications simultaneously.

- Each application or service is represented at Layer 4 by a port number.

- A unique dialogue between devices is identified with a pair of Layer 4 source and destination port numbers that are representative of the two communicating applications.