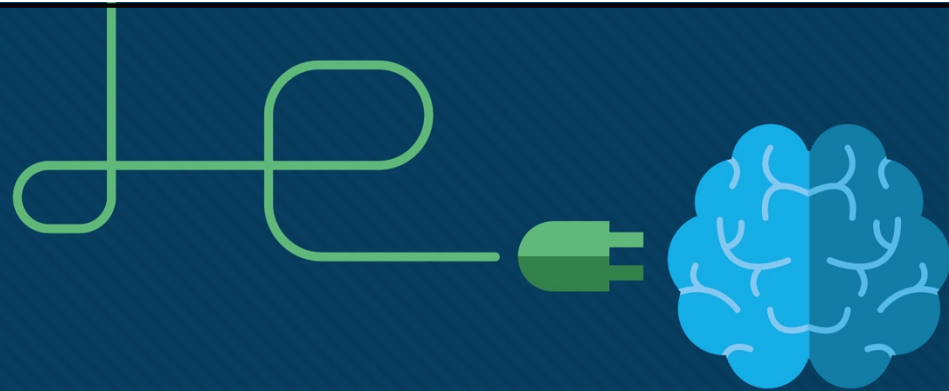# Lecture#2: Fundamentals

Network Architecture

Introduction to Networks (ITN) v7.0 Module: 3

2.1 The Rules

Communications Fundamentals

Networks can vary in size and complexity. It is not enough to have a connection, devices must agree on "how" to communicate.

There are three elements to any communication:

- There will be a source (sender).
- There will be a destination (receiver).
- There will be a channel (media) that provides for the path of communications to occur.

Communications Protocols

- All communications are governed by protocols.

- Protocols are the rules that communications will follow.

- These rules will vary depending on the protocol.
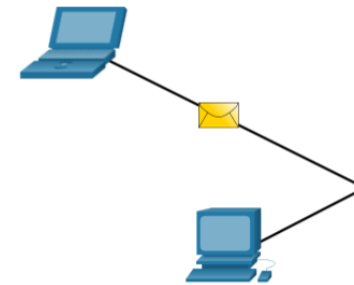
Rule Establishment

- Individuals must use established rules or agreements to govern the conversation.

- The first message is difficult to read because it is not formatted properly. The second shows the message properly formatted

```
humans communication between govern rules. It is verydifficult tounderstand messages that are not
correctly formatted and donot follow the established rules and protocols. A estrutura da
gramatica, da lingua, da pontuacao e do sentence faz a configuracao humana compreensivel por
muitos individuos diferentes.
```

```
Rules govern communication between humans. It is very difficult to understand messages that are
not correctly formatted and do not follow the established rules and protocols. The structure of
the grammar, the language, the punctuation and the sentence make the configuration humanly
understandable for many different individuals.
```

Rule Establishment (Cont.)

Protocols must account for the following requirements:

- An identified sender and receiver
- Common language and grammar
- Speed and timing of delivery
- Confirmation or acknowledgment requirements

Network Protocol Requirements

Protocols must account for the following requirements:

- An identified sender and receiver
- Common language and grammar
- Speed and timing of delivery
- Confirmation or acknowledgment requirements

Common computer protocols must be in agreement and include the following requirements:

- Message encoding
- Message formatting and encapsulation
- Message size
- Message timing
- Message delivery options

Message Encoding

- **Encoding** is the process of converting information into another acceptable form for transmission.

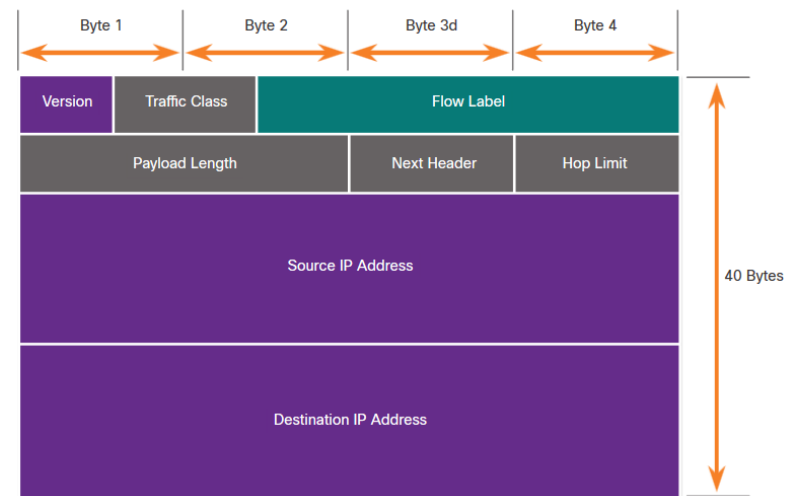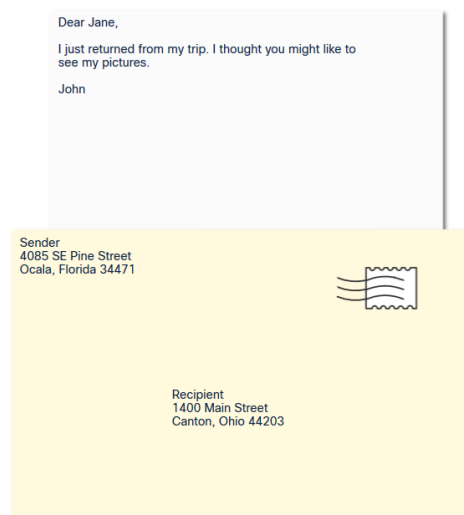- **Decoding** reverses this process to interpret the information.
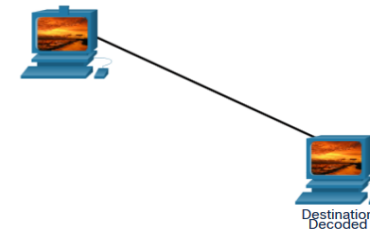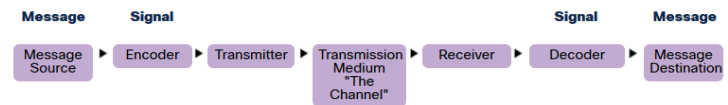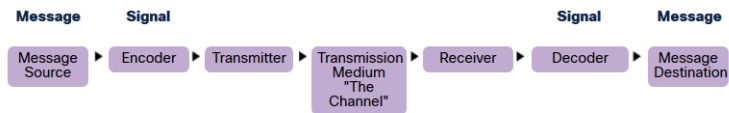
Message Formatting and Encapsulation

- When a message is sent, it must use a **specific format** or structure.

- Message formats depend on the type of message and the channel that is used to deliver the message.

Dear Jane,

I just returned from my trip. I thought you might like to see my pictures.

John

Sender
4085 SE Pine Street
Ocala, Florida 34471

Recipient
1400 Main Street
Canton, Ohio 44203

Byte 1	Byte 2	Byte 3d	Byte 4

| Version	Traffic Class	Flow Label	
Payload Length		Next Header	Hop Limit
Source IP Address			
Destination IP Address			

40 Bytes

Message Size

Encoding between hosts must be in an appropriate format for the medium.

- Messages sent across the network are converted to bits
- The bits are encoded into a pattern of light, sound, or electrical impulses.
- The destination host must decode the signals to interpret the message.
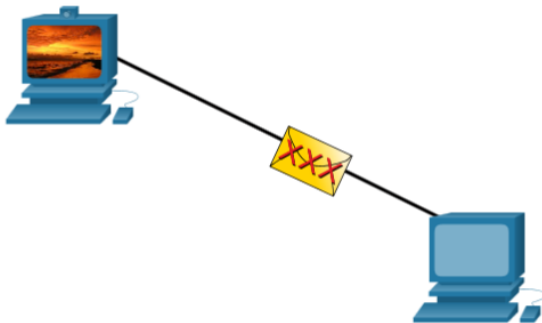
Message Timing

Message timing includes the following:

- **Flow Control –** Manages the rate of data transmission and defines how much information can be sent and the speed at which it can be delivered.

- **Response Timeout –** Manages how long a device waits when it does not hear a reply from the destination.

- **Access method -** Determines when someone can send a message.

  § There may be various rules governing issues like "collisions". This is when more than one device sends traffic at the same time and the messages become corrupt.

  § Some protocols are proactive and attempt to prevent collisions; other protocols are reactive and establish a recovery method after the collision occurs.
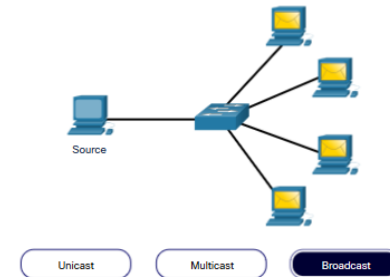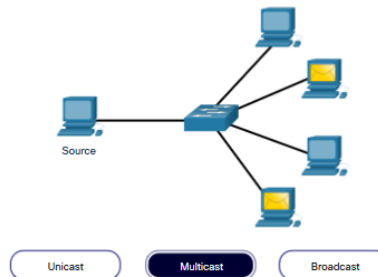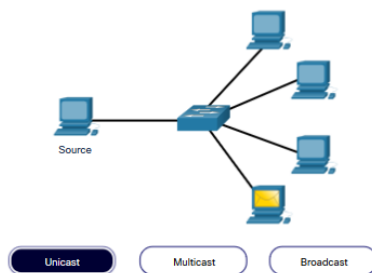
Message Delivery Options

Message delivery may one of the following methods:

- **Unicast –** one to one communication
- **Multicast –** one to many, typically not all
- **Broadcast** – one to all

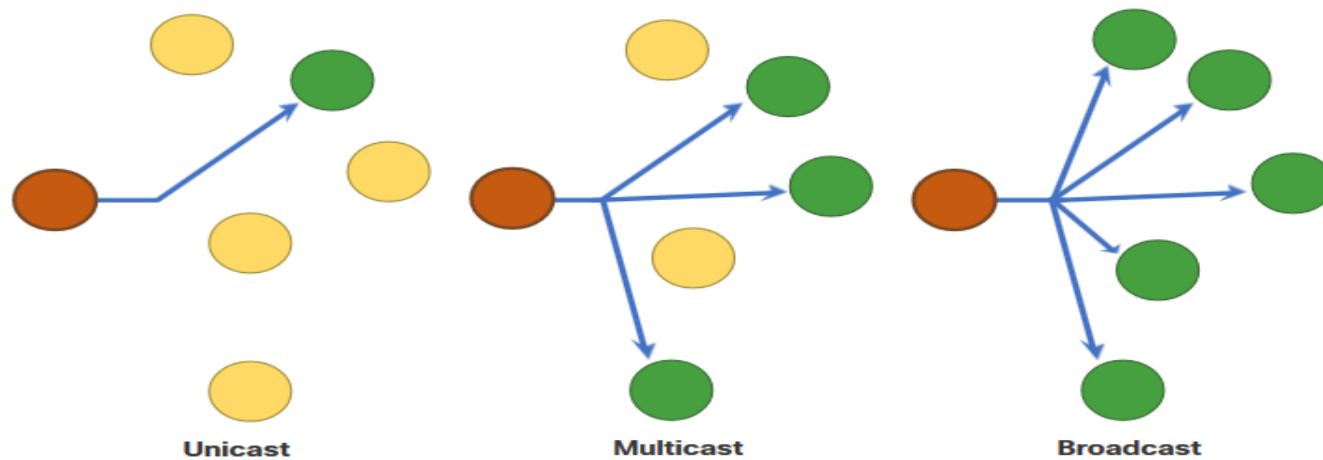**Note:** Broadcasts are used in IPv4 networks, but are not an option for IPv6. Later we will also see "Anycast" as an additional delivery option for IPv6.

A Note About the Node Icon

- Documents may use the node icon , typically a circle, to represent all devices.

- The figure illustrates the use of the node icon for delivery options.

Unicast   **Multicast**   **Broadcast**

2.2 Protocols

Network Protocol Overview

Network protocols define a common set of rules.

- Can be implemented on devices in: Software, Hardware, or Both

- Protocols have their own: Function, Format, Rules

Protocol Type	Description
Network Communications	enable two or more devices to communicate over one or more networks
Network Security	secure data to provide authentication, data integrity, and data encryption
Routing	enable routers to exchange route information, compare path information, and select best path
Service Discovery	used for the automatic detection of devices or services

Network Protocol Functions

- Devices use agreed-upon protocols to communicate .

- Protocols may have may have one or functions.

IP	Data

I will send this message across the network using an IPv4 header.

I can forward this message because I understand the IPv4 header.

I can accept this message because I understand IPv4.
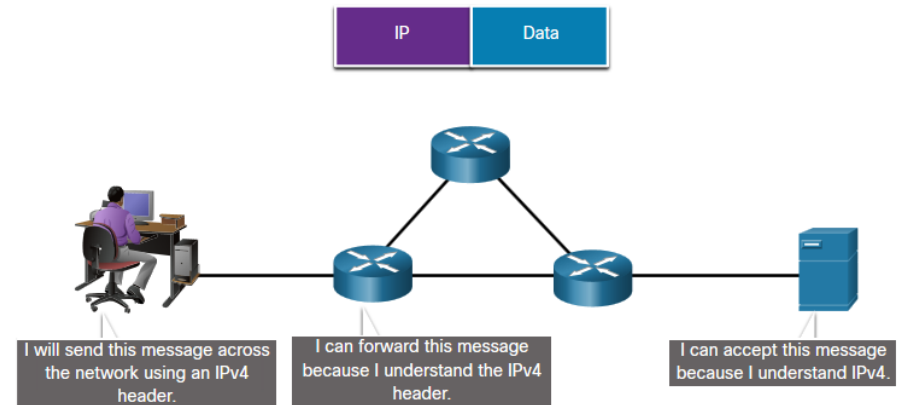
| Function	Description
Addressing	Identifies sender and receiver
Reliability	Provides guaranteed delivery
Flow Control	Ensures data flows at an efficient rate
Sequencing	Uniquely labels each transmitted segment of data
Error Detection	Determines if data became corrupted during transmission
Application Interface	Process-to-process communications between network applications

Protocol Interaction

- Networks require the use of several protocols.

- Each protocol has its own function and format.
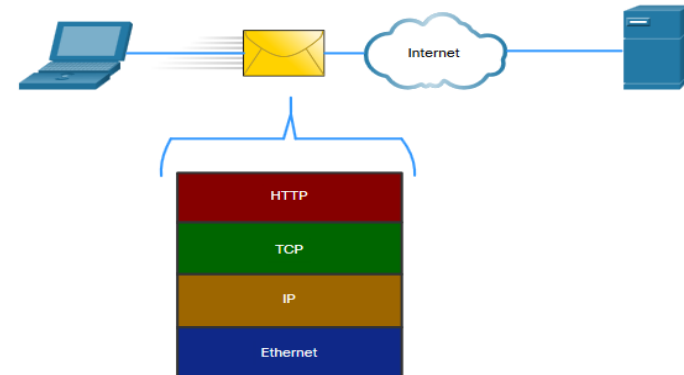
Protocol	Function
Hypertext Transfer Protocol (HTTP)	§ Governs the way a web server and a web client interact § Defines content and format
Transmission Control Protocol (TCP)	§ Manages the individual conversations § Provides guaranteed delivery § Manages flow control
Internet Protocol (IP)	Delivers messages globally from the sender to the receiver
Ethernet	Delivers messages from one NIC to another NIC on the same LAN

2.3 Protocol Suites
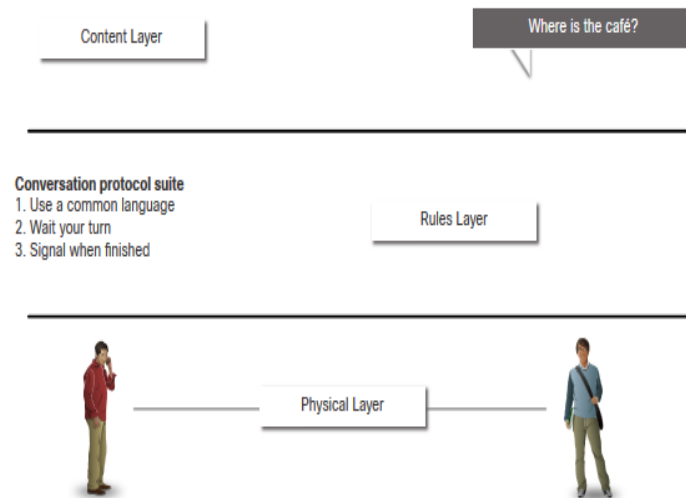
Network Protocol Suites

Protocols must be able to work with other protocols.

Protocol suite:

- A group of inter-related protocols necessary to perform a communication function
- Sets of rules that work together to help solve a problem

The protocols are viewed in terms of layers:

- Higher Layers
- Lower Layers- concerned with moving data and provide services to upper layers

Content Layer

Where is the café?

Conversation protocol suite
1. Use a common language
2. Wait your turn
3. Signal when finished

Rules Layer

Physical Layer

Protocol suites are sets of rules that work together to help solve a problem.

Evolution of Protocol Suites
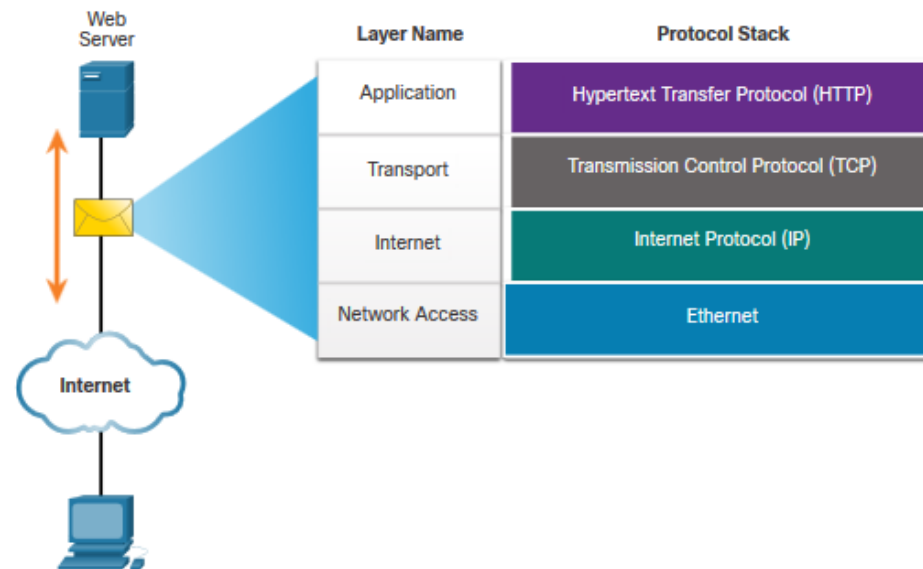
There are several protocol suites.

- **TCP/IP-** The most common protocol suite and maintained by the IETF.

- **OSI protocols-** Developed by the ISO and the ITU

- **AppleTalk-** Proprietary suite release by Apple Inc.

- **Novell NetWare-** Proprietary suite developed by Novell Inc.

TCP/IP Layer Name	TCP/IP	ISO	AppleTalk	Novell Netware
Application	HTTP DNS DHCP FTP	ACSE ROSE TRSE SESE	AFP	NDS
Transport	TCP UDP	TP0 TP1 TP2 TP3 TP4	ATP AEP NBP RTMP	SPX
Internet	IPv4 IPv6 ICMPv4 ICMPv6	CONP/CMNS CLNP/CLNS	AARP	IPX
Network Access	Ethernet ARP WLAN			

TCP/IP Protocol Example

- TCP/IP protocols operate at the application, transport, and internet layers.

- The most common network access layer LAN protocols are Ethernet and WLAN (wireless LAN).

| Layer Name	Protocol Stack
Application	Hypertext Transfer Protocol (HTTP)
Transport	Transmission Control Protocol (TCP)
Internet	Internet Protocol (IP)
Network Access	Ethernet

Web Server

Internet

TCP/IP Protocol Suite

- TCP/IP is the protocol suite used by the internet and includes many protocols.

  § An open standard protocol suite that is freely available to the public and can be used by any vendor

  § A standards-based protocol suite that is endorsed by the networking industry and approved by a standards organization to ensure interoperability
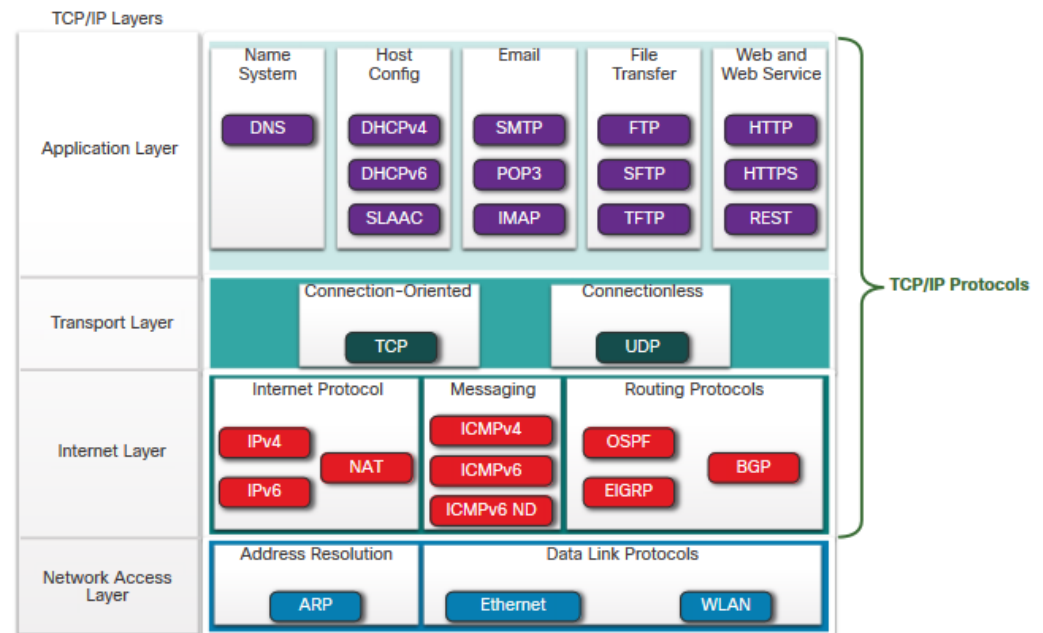
TCP/IP Communication Process

- A web server encapsulating and sending a web page to a client.

- A client de-encapsulating the web page for the web browser
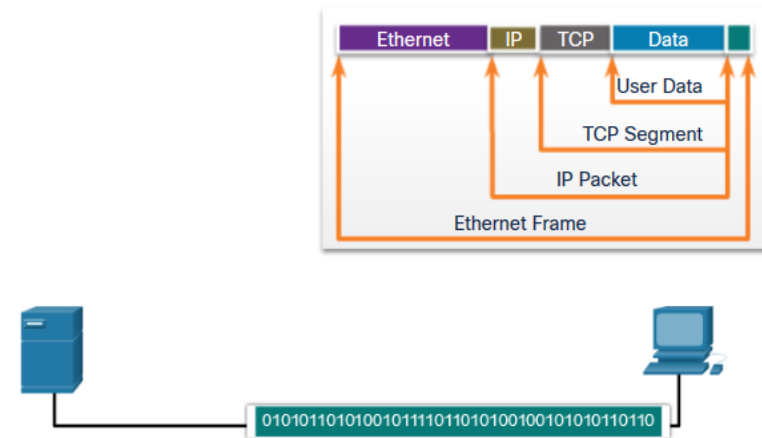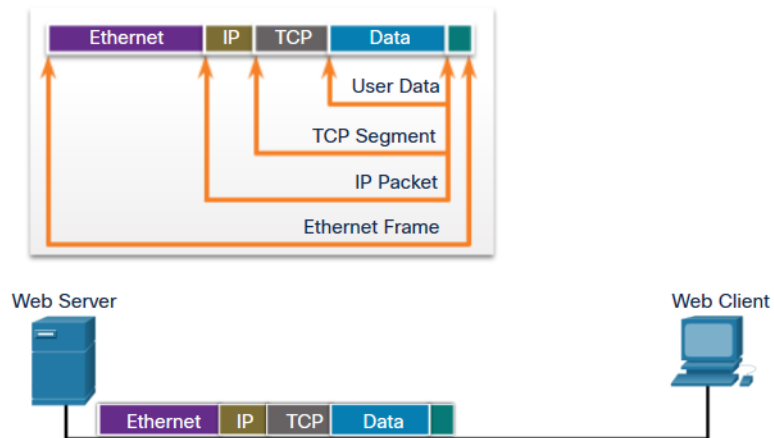
2.4 Standards Organizations

Open Standards

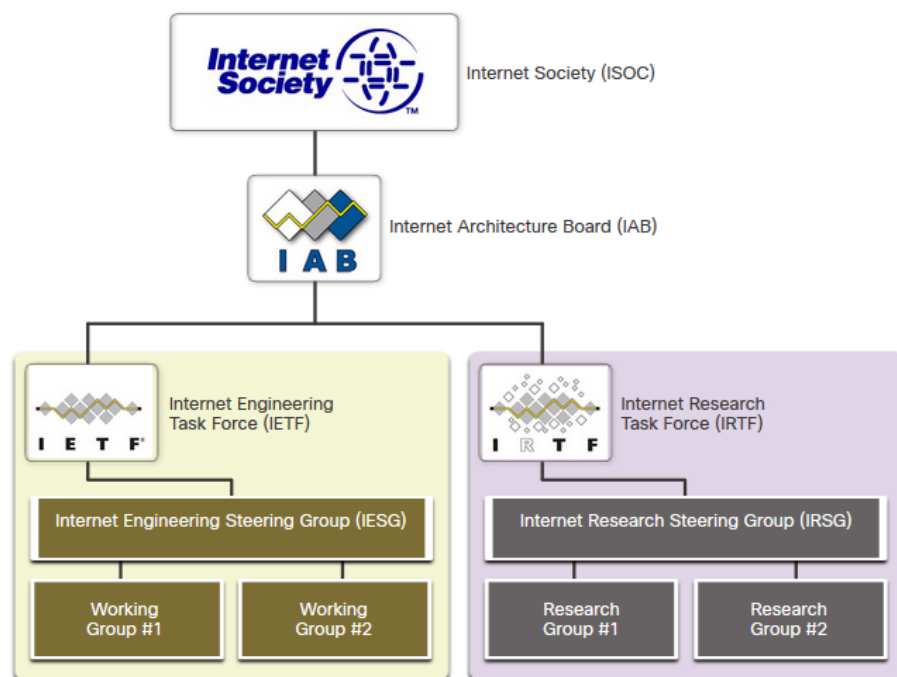Open standards encourage:

- interoperability

- competition

- innovation

Standards organizations are:

- vendor-neutral

- non-profit organizations

- established to develop and promote the concept of open standards.

Standards Organizations
Internet Standards

- **Internet Society (ISOC)** - Promotes the open development and evolution of internet

- **Internet Architecture Board (IAB)** - Responsible for management and development of internet standards

- **Internet Engineering Task Force (IETF)** - Develops, updates, and maintains internet and TCP/IP technologies

- **Internet Research Task Force (IRTF)** - Focused on long-term research related to internet and TCP/IP protocols

Internet Standards (Cont.)

Standards organizations involved with the development and support of TCP/IP

- **Internet Corporation for Assigned Names and Numbers (ICANN)** - Coordinates IP address allocation, the management of domain names, and assignment of other information

- **Internet Assigned Numbers Authority (IANA)** - Oversees and manages IP address allocation, domain name management, and protocol identifiers for ICANN
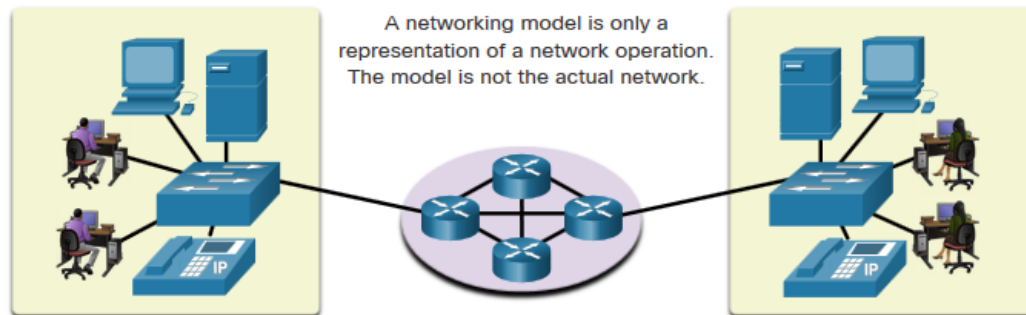
Electronic and Communications Standards

- **Institute of Electrical and Electronics Engineers** (**IEEE**, pronounced "I-triple-E") - dedicated to creating standards in power and energy, healthcare, telecommunications, and networking

- **Electronic Industries Alliance (EIA)** - develops standards relating to electrical wiring, connectors, and the 19-inch racks used to mount networking equipment

- **Telecommunications Industry Association (TIA)** - develops communication standards in radio equipment, cellular towers, Voice over IP (VoIP) devices, satellite communications, and more

- **International Telecommunications Union-Telecommunication Standardization Sector (ITU-T**) - defines standards for video compression, Internet Protocol Television (IPTV), and broadband communications, such as a digital subscriber line (DSL)

2.5 Reference Models

The Benefits of Using a Layered Model

A networking model is only a representation of a network operation. The model is not the actual network.

OSI Model	TCP/IP Protocol Suite	TCP/IP Model
Application	HTTP, DNS, DHCP, FTP	Application
Presentation		
Session		
Transport	TCP, UDP	Transport
Network	IPv4, IPv6, ICMPv4, ICMPv6	Internet
Data Link	Ethernet, WLAN, SONET, SDH	Network Access
Physical		

Complex concepts such as how a network operates can be difficult to explain and understand. For this reason, a layered model is used.

Two layered models describe network operations:

- Open System Interconnection (OSI) Reference Model

- TCP/IP Reference Model

The Benefits of Using a Layered Model (Cont.)

These are the benefits of using a layered model:

- Assist 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

- Foster competition because products from different vendors can work together

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

- Provide a common language to describe networking functions and capabilities

The OSI Reference Model

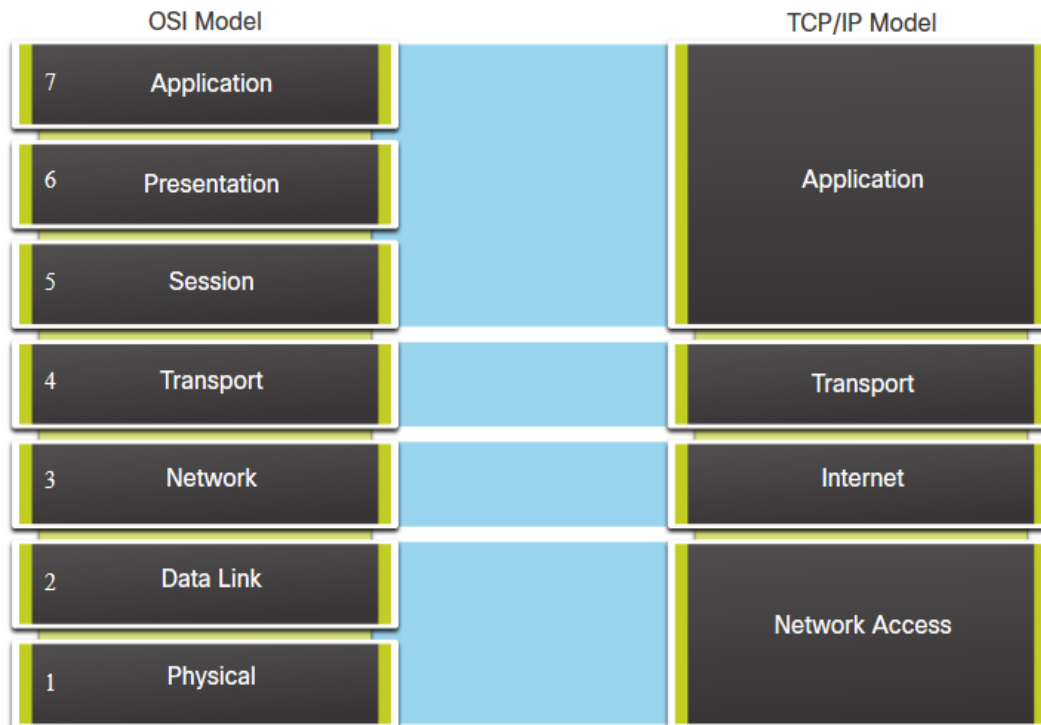| OSI Model Layer	Description
7 - Application	Contains protocols used for process-to-process communications.
6 - Presentation	Provides for common representation of the data transferred between application layer services.
5 - Session	Provides services to the presentation layer and to manage data exchange.
4 - Transport	Defines services to segment, transfer, and reassemble the data for individual communications.
3 - Network	Provides services to exchange the individual pieces of data over the network.
2 - Data Link	Describes methods for exchanging data frames over a common media.
1 - Physical	Describes the means to activate, maintain, and de-activate physical connections.

The TCP/IP Reference Model

TCP/IP Model Layer	Description
Application	Represents data to the user, plus encoding and dialog control.
Transport	Supports communication between various 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.

OSI and TCP/IP Model Comparison

OSI Model

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

TCP/IP Model

| Application |
| Transport |
| Internet |
| Network Access |

- The OSI model divides the network access layer and the application layer of the TCP/IP model into multiple layers.

- The TCP/IP protocol suite does not specify which protocols to use when transmitting over a physical medium.

- OSI Layers 1 and 2 discuss the necessary procedures to access the media and the physical means to send data over a network.

Lab Activity

Packet Tracer - Investigate the TCP/IP and OSI Models in Action
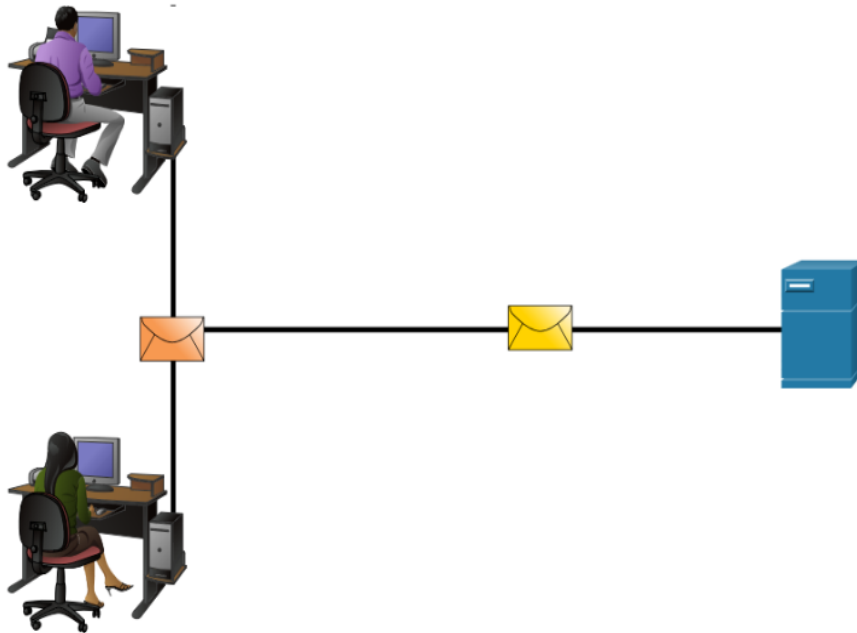
Task#1 : Examine HTTP Web Traffic.

Task#2 : Display Elements of the TCP/IP Protocol Suite.

2.6 Data Encapsulation
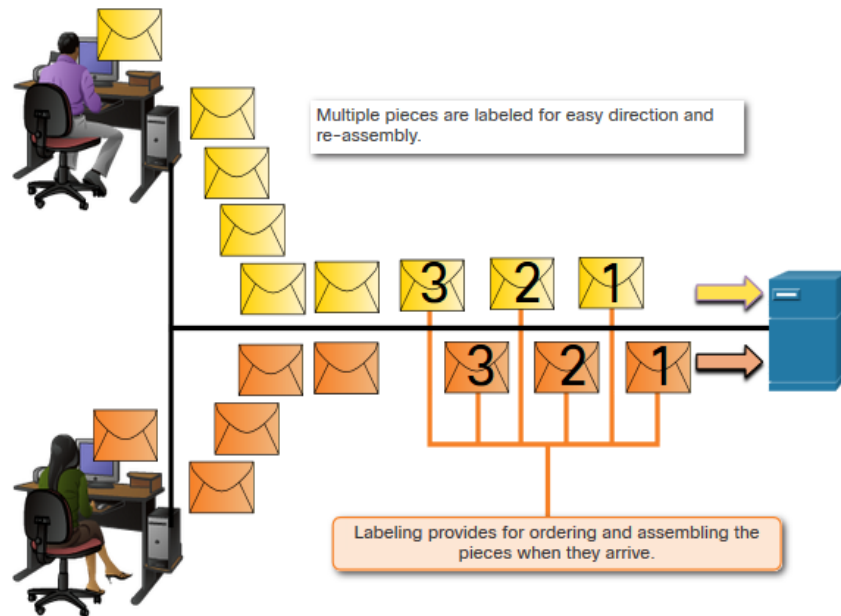
Segmenting Messages

Segmenting is the process of breaking up messages into smaller units. Multiplexing is the processes of taking multiple streams of segmented data and interleaving them together.

Segmenting messages has two primary benefits:

- **Increases speed** - Large amounts of data can be sent over the network without tying up a communications link.

- **Increases efficiency** - Only segments which fail to reach the destination need to be retransmitted, not the entire data stream.
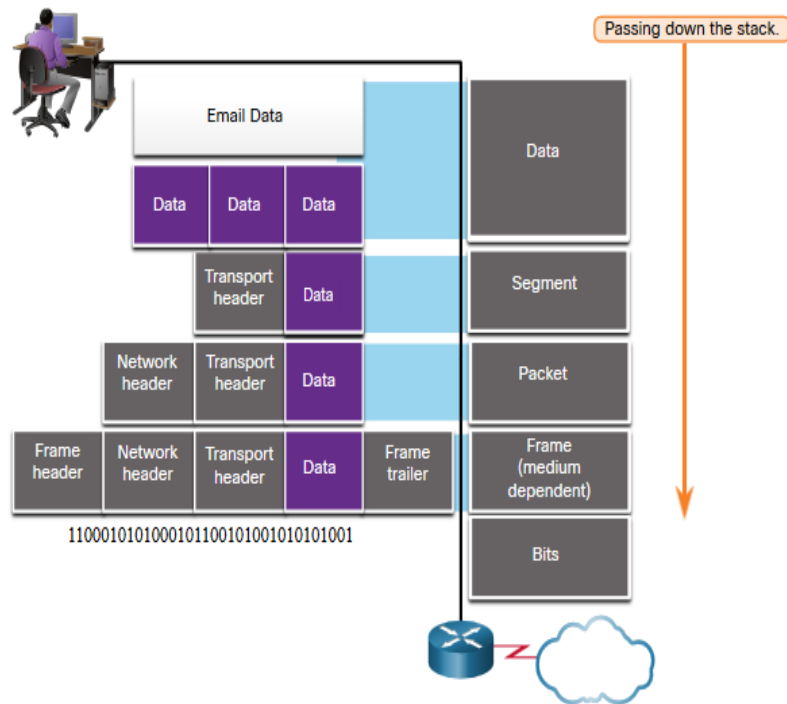
Sequencing

Multiple pieces are labeled for easy direction and re-assembly.

Labeling provides for ordering and assembling the pieces when they arrive.

Sequencing messages is the process of numbering the segments so that the message may be reassembled at the destination.

TCP is responsible for sequencing the individual segments.

Protocol Data Units

Passing down the stack.

Email Data

Data | Data | Data

Transport header | Data

Network header | Transport header | Data

Frame header | Network header | Transport header | Data | Frame trailer

1100010101000101100101001010101001

Data
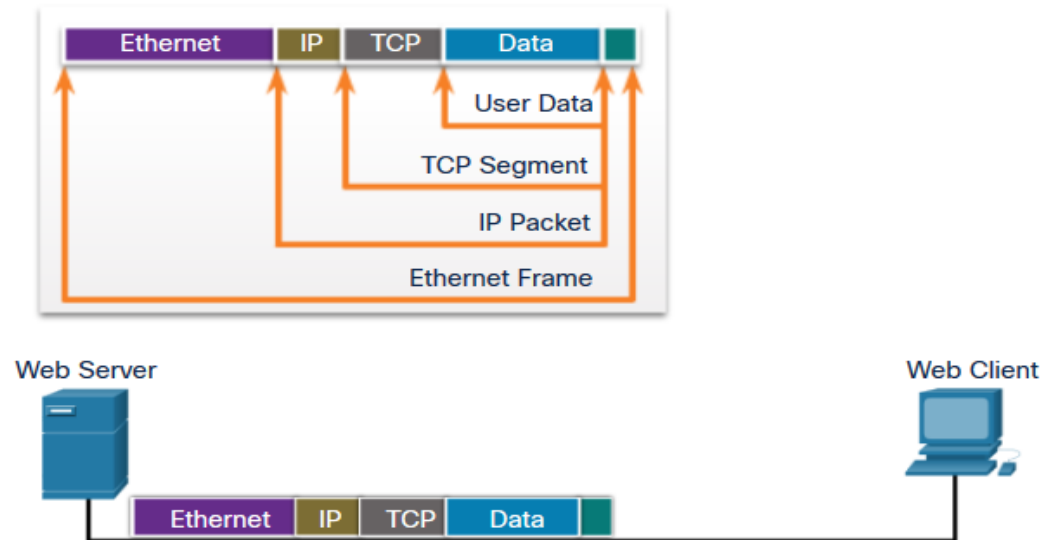
Segment

Packet

Frame (medium dependent)

Bits

Encapsulation is the process where protocols add their information to the data.

- At each stage of the process, a PDU has a different name to reflect its new functions.

- There is no universal naming convention for PDUs, in this course, the PDUs are named according to the protocols of the TCP/IP suite.

- PDUs passing down the stack are as follows:

  ⁻ Data (Data Stream)

  ⁻ Segment

  ⁻ Packet

  ⁻ Frame

  ⁻ Bits (Bit Stream)

Encapsulation Example

- Encapsulation is a top down process.

- The level above does its process and then passes it down to the next level of the model. This process is repeated by each layer until it is sent out as a bit stream.

Ethernet	IP	TCP	Data	

User Data

TCP Segment

IP Packet

Ethernet Frame

Web Server

Web Client

Ethernet	IP	TCP	Data	