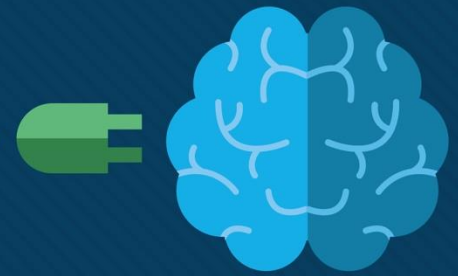
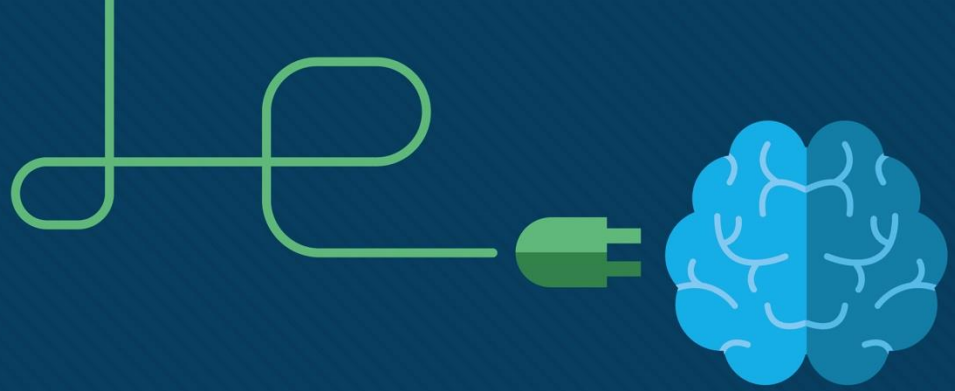


Module 3: Protocols and Models

Thomas Wyseur

Introduction to Networks v7.0 (ITN)



Module 3: Protocols and Models

Introduction to Networks 7.0 (ITN)

3.1 The Rules

Communications Fundamentals

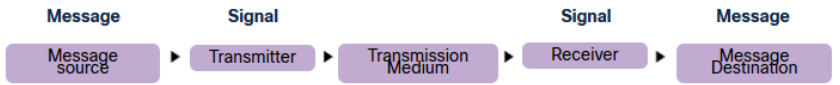
Networks can vary in size and complexity. It is not enough to have a connection, devices must agree on “how” to communicate.

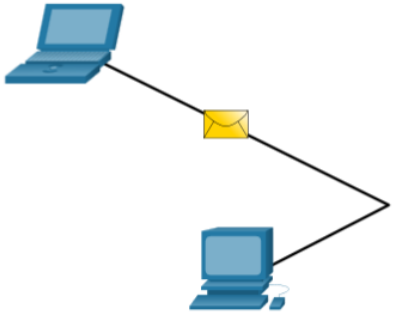
There are three elements to any communication:

- 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.
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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.
```
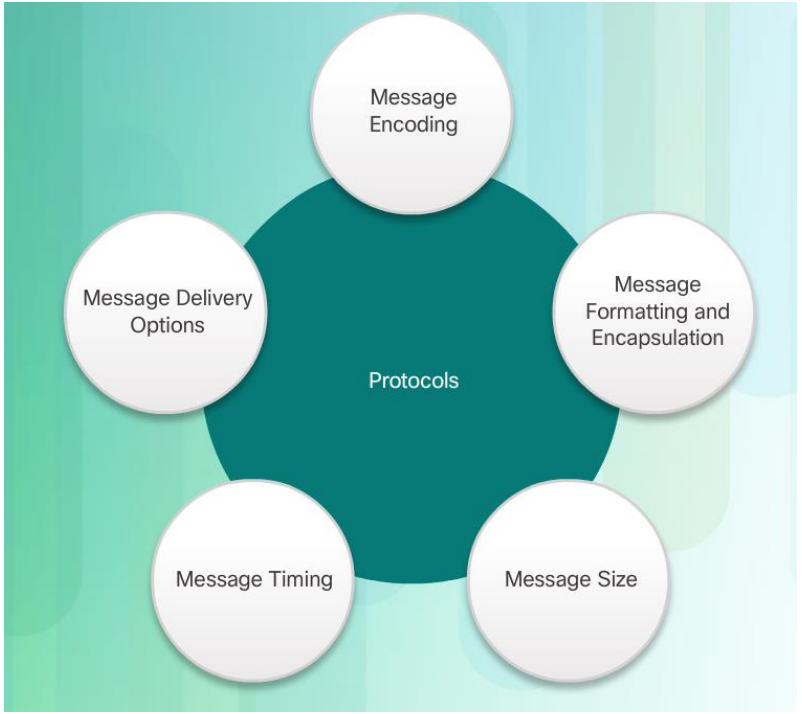
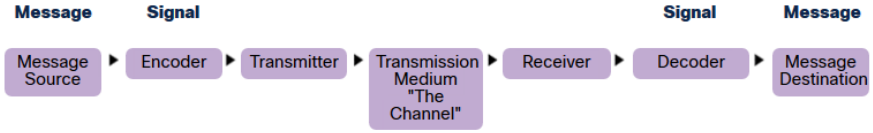

Rule Establishment

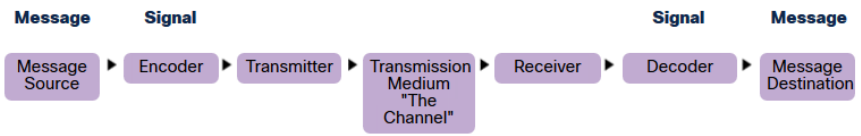
- Protocols are necessary for effective communication and include:
  - An identified sender and receiver
  - Common language and grammar
  - Speed and timing of delivery
  - Confirmation or acknowledgment requirements
- Protocols used in network communications also define:
  - Message encoding
  - Message delivery options
  - Message Formatting and Encapsulation
  - Message Timing
  - Message Size

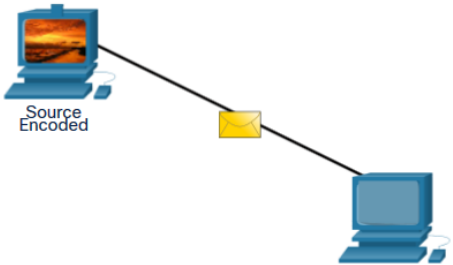


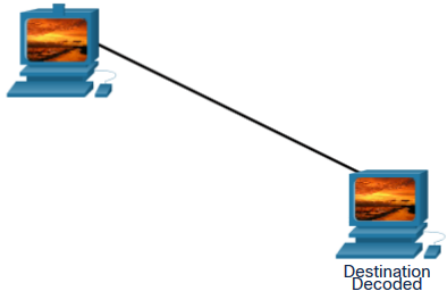
Message Encoding

- Encoding is the process of converting information into another acceptable form for transmission.
- Decoding reverses this process to interpret the information.



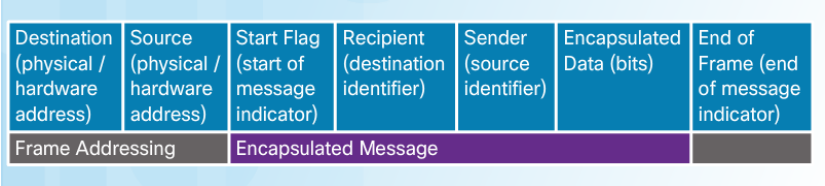






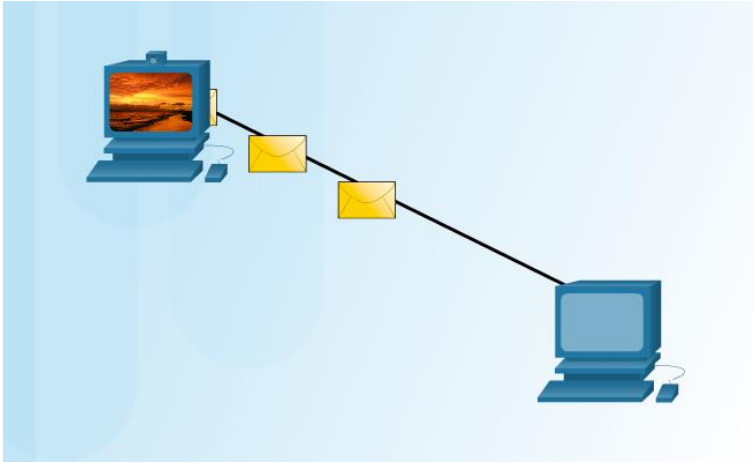
Message Formatting and Encapsulation

- There is an agreed format for letters and addressing letters which is required for proper delivery.
- Putting the letter into the addressed envelope is called encapsulation.
- Each computer message is encapsulated in a specific format, called a frame, before it is sent over the network.
- A frame acts like an envelope providing destination address and source address.



Message Size

- Humans break long messages into smaller parts or sentences.
- Long messages must also be broken into smaller pieces to travel across a network.
  - Each piece is sent in a separate frame.
  - Each frame has its own addressing information.
  - A receiving host will reconstruct multiple frames into the original message.

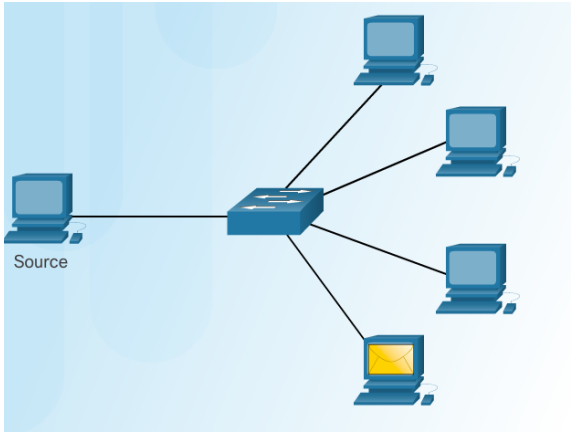


Message Timing

- Access Method
  - Hosts on a network need to know when to begin sending messages and how to respond when collisions occur.
- Flow Control
  - Source and destination hosts use flow control to negotiate correct timing to avoid overwhelming the destination and ensure information is received.
- Response Timeout
  - Hosts on the network have rules that specify how long to wait for responses and what action to take if a response timeout occurs.

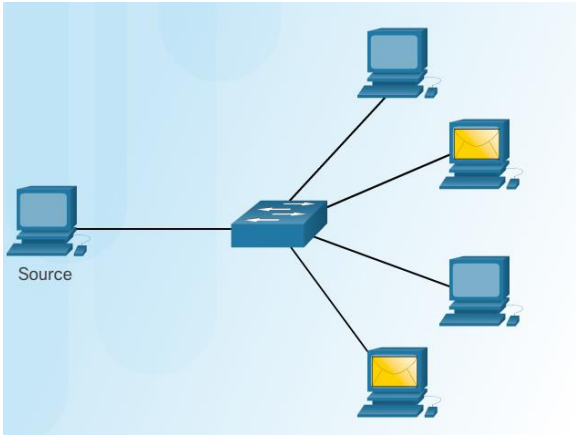
Message Delivery Options

Unicast Message



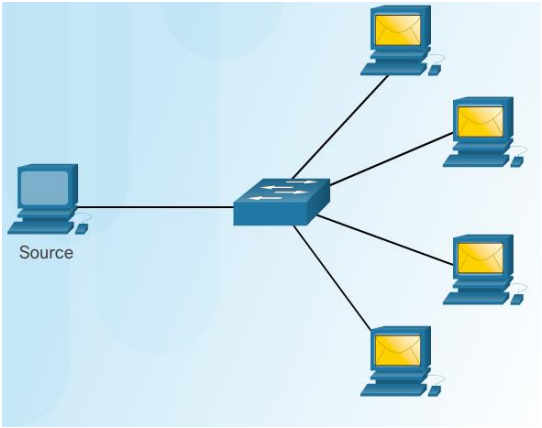
One-to-one delivery

Multicast Message



One-to-many delivery

Broadcast Message

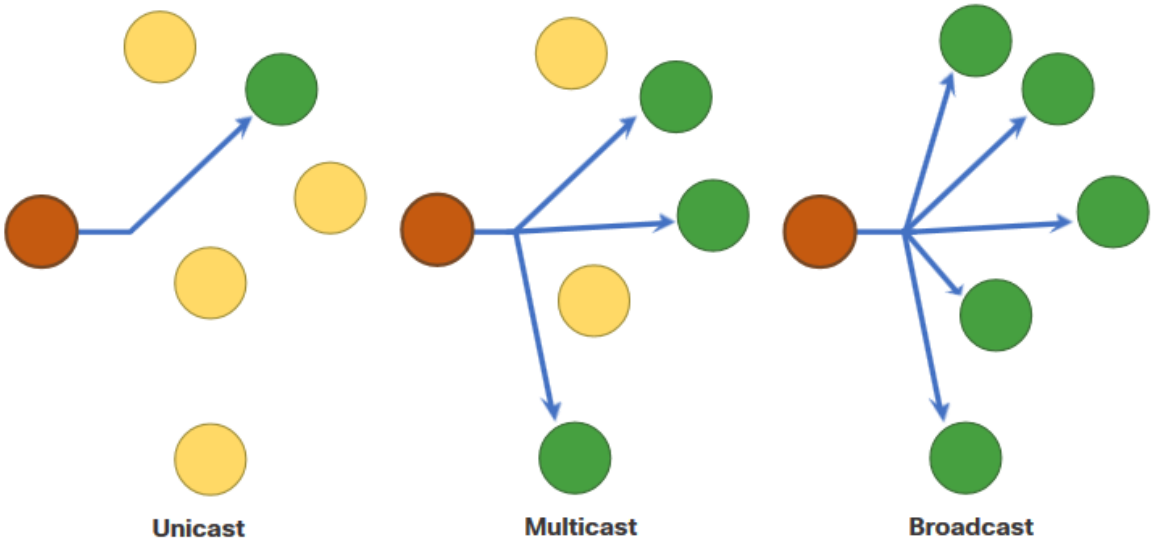


One-to-all delivery

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.



3.2 Protocols

Network Protocol Overview

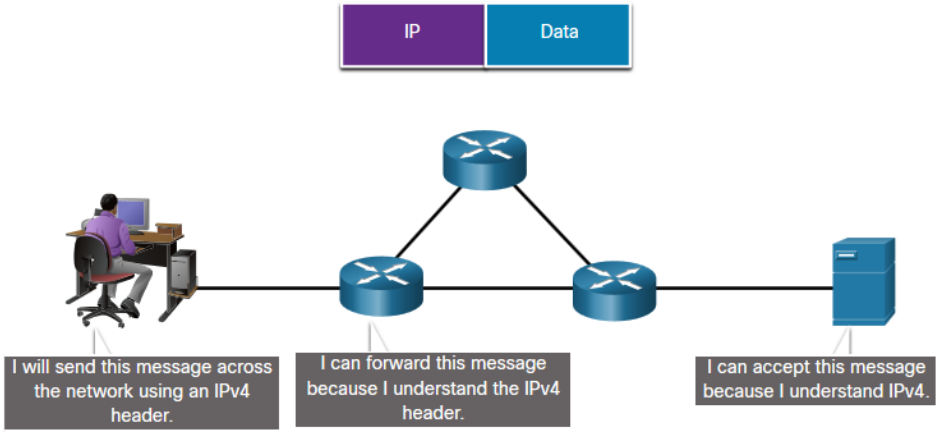
Network protocols define a common set of rules.

- Can be implemented on devices in:
  - Software
  - Hardware
  - 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

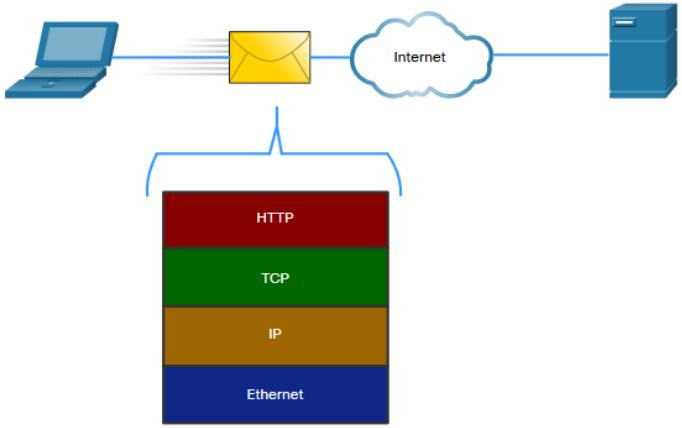
Network Protocol Functions

- Devices use agreed-upon protocols to communicate .
- Protocols may have may have one or functions.



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 Ethernet Local Area Network (LAN)

3.3 Protocol Suites

Network Protocol Suites

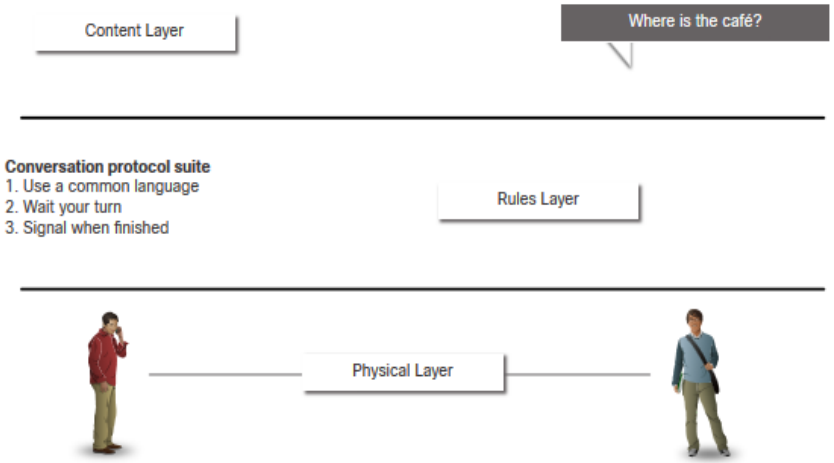
Protocols must be able to work with other protocols.

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

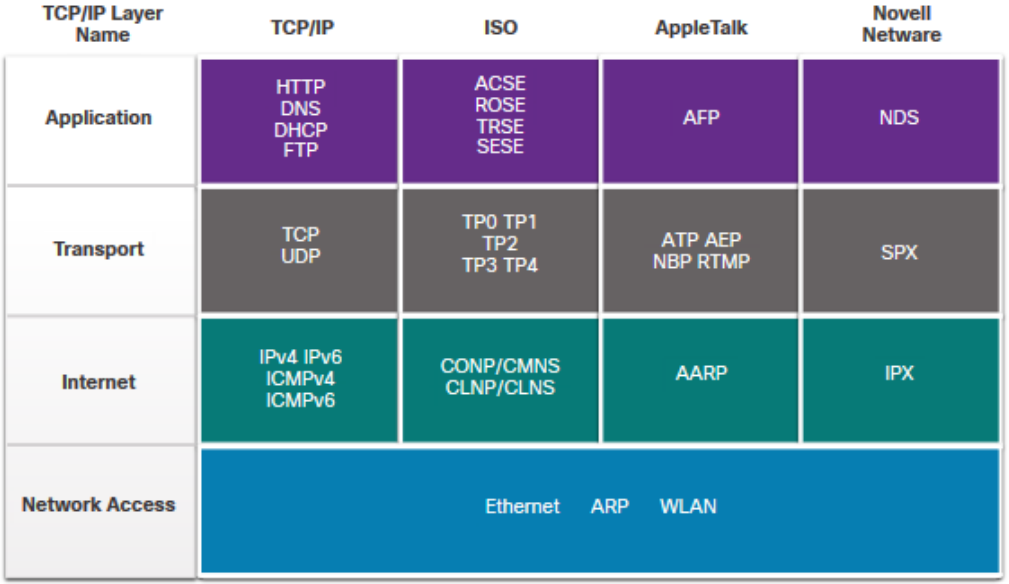


Protocol suites are sets of rules that work together to help solve a problem.

Evolution of Protocol Suites

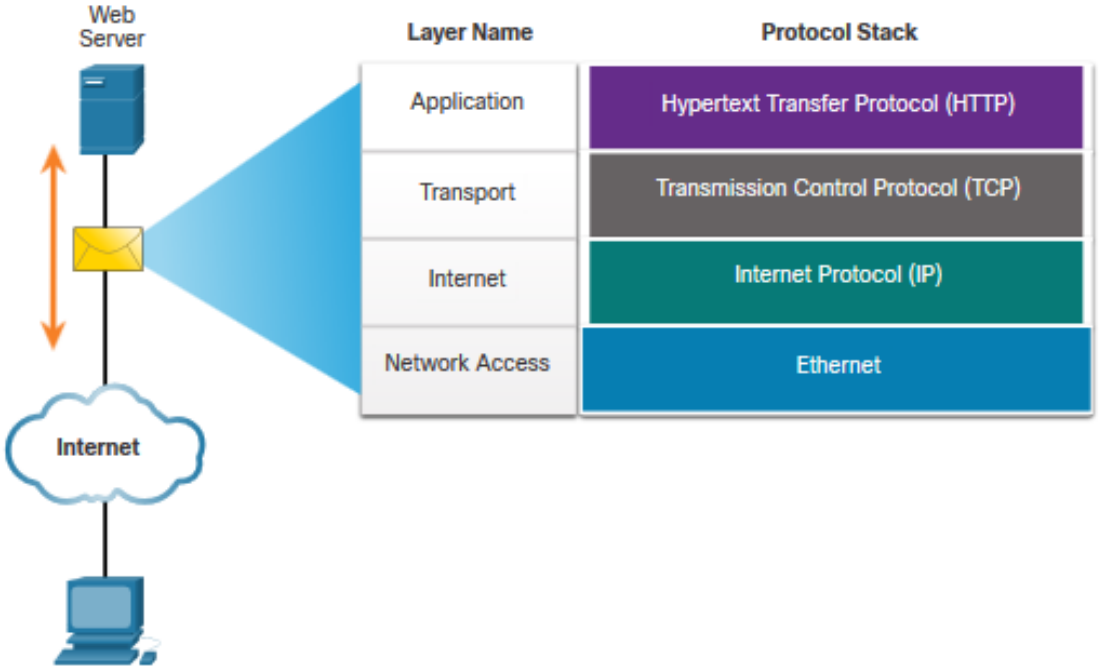
There are several protocol suites.

- **Internet Protocol Suite or TCP/IP-** The most common protocol suite and maintained by the Internet Engineering Task Force (IETF)
- **Open Systems Interconnection (OSI) protocols-** Developed by the International Organization for Standardization (ISO) and the International Telecommunications Union (ITU)
- **AppleTalk-** Proprietary suite release by Apple Inc.
- **Novell NetWare-** Proprietary suite developed by Novell Inc.



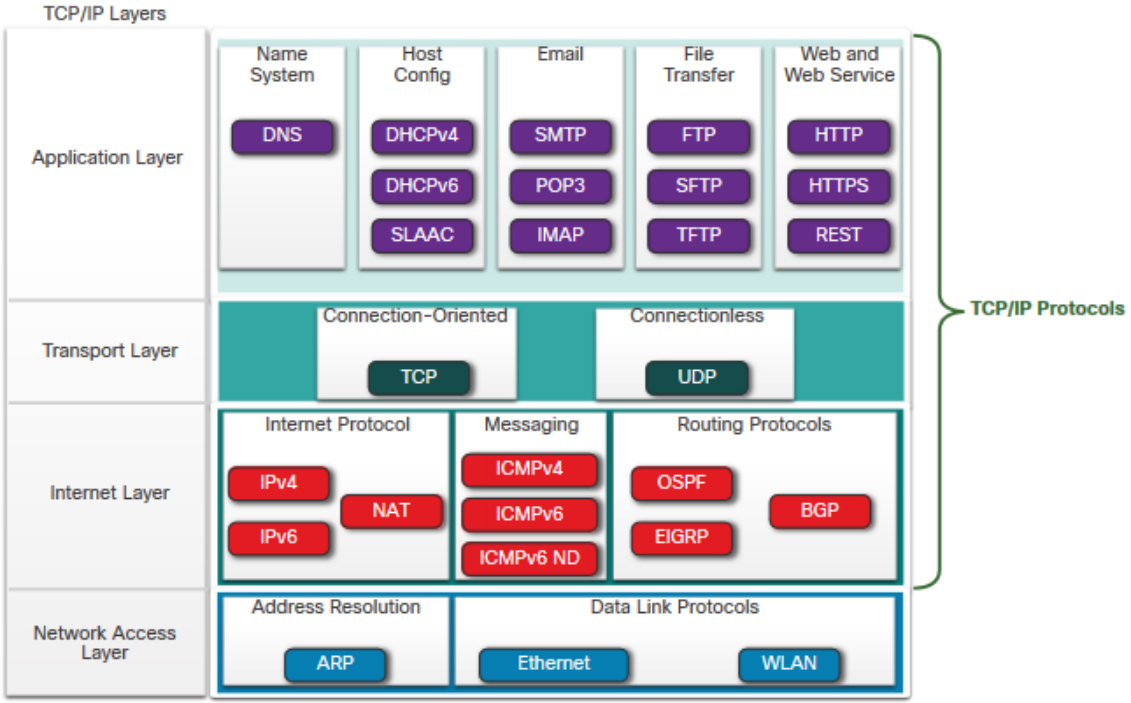
TCP/IP Protocol Example

- 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).



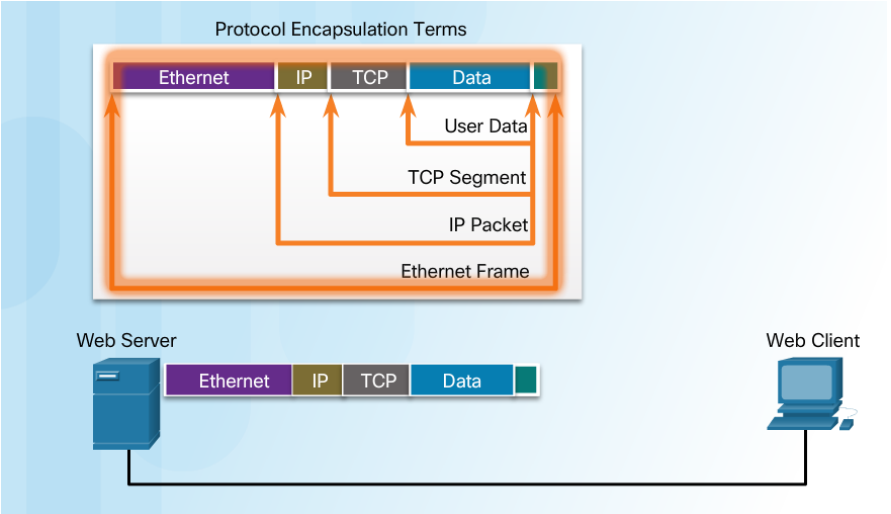
TCP/IP Protocol Suite

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

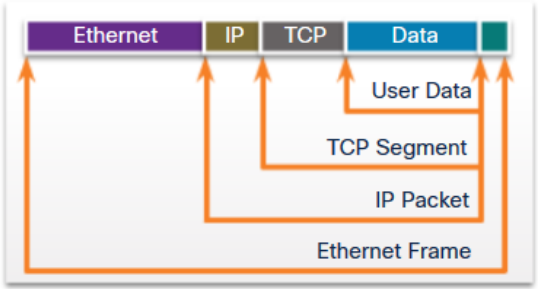
- When sending data from a web server to a client the encapsulation procedure would be as follows:
  - The webserver prepares the Hypertext Markup Language (HTML) page. The HTTP application layer protocol sends the data to the transport layer.
  - The transport layer breaks the data into segments and identifies each.
  - Next the IP source and destination addresses are added, creating an IP Packet.
  - The Ethernet information is then added creating the Ethernet Frame, or data link frame.

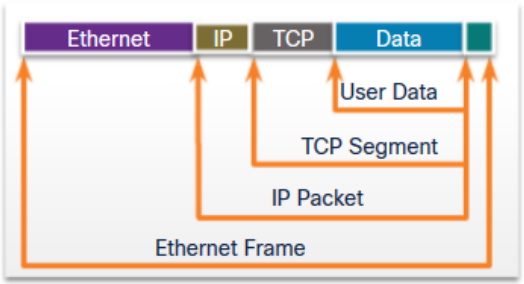


- This frame is delivered to the nearest router along the path towards the web client. Each router adds new data link information before forwarding the packet.

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





3.4 Standards Organizations

Open Standards

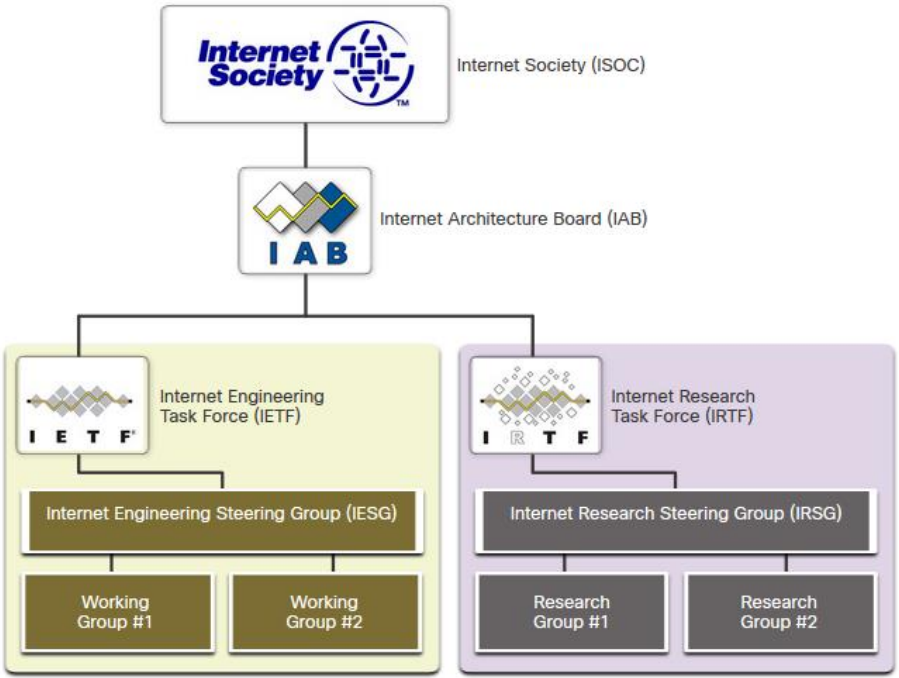
Open standards encourage:

- interoperability
- competition
- innovation

Standards organizations are:

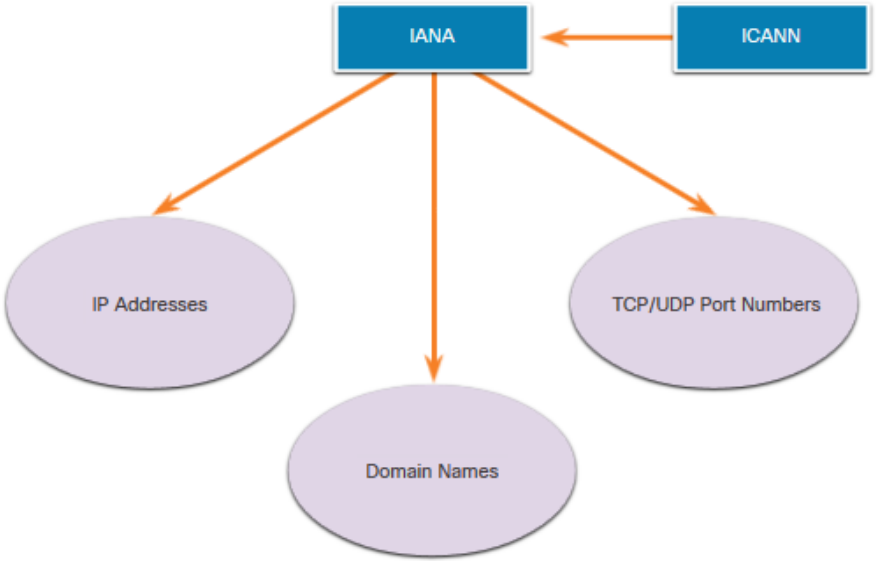
- vendor-neutral
- non-profit organizations
- established to develop and promote the concept of open standards.

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

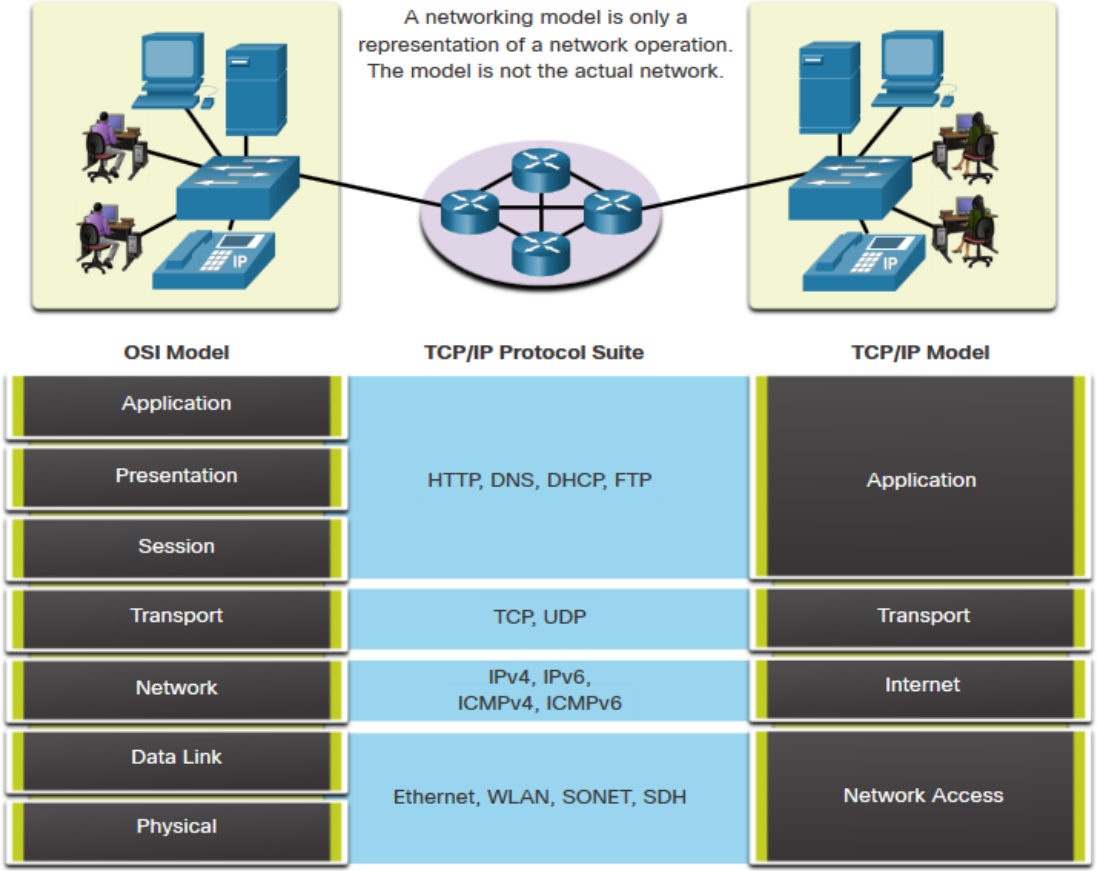
- **Internet Corporation for Assigned Names and Numbers (ICANN)** - Coordinates IP address allocation, the management of domain names, and assignment of other information
- **Internet Assigned Numbers Authority (IANA)** - Oversees and manages IP address allocation, domain name management, and protocol identifiers for ICANN

Electronics and Communications Standard Organizations

- **Institute of Electrical and Electronics Engineers** (**IEEE**) - dedicated to advancing technological innovation and creating standards in a wide area of industries including networking.
- **Electronic Industries Alliance (EIA)** - standards related to electrical wiring, connectors, and network racks.
- **Telecommunications Industry Association (TIA)** standards for radio equipment, cellular towers, Voice over IP (VoIP) devices, and satellite communications.
- **International Telecommunications Union-Telecommunication Standardization Sector (ITU-T**) standards for video compression, Internet Protocol Television (IPTV), and broadband communications.

3.5 Reference Models

The Benefits of Using a Layered Model



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

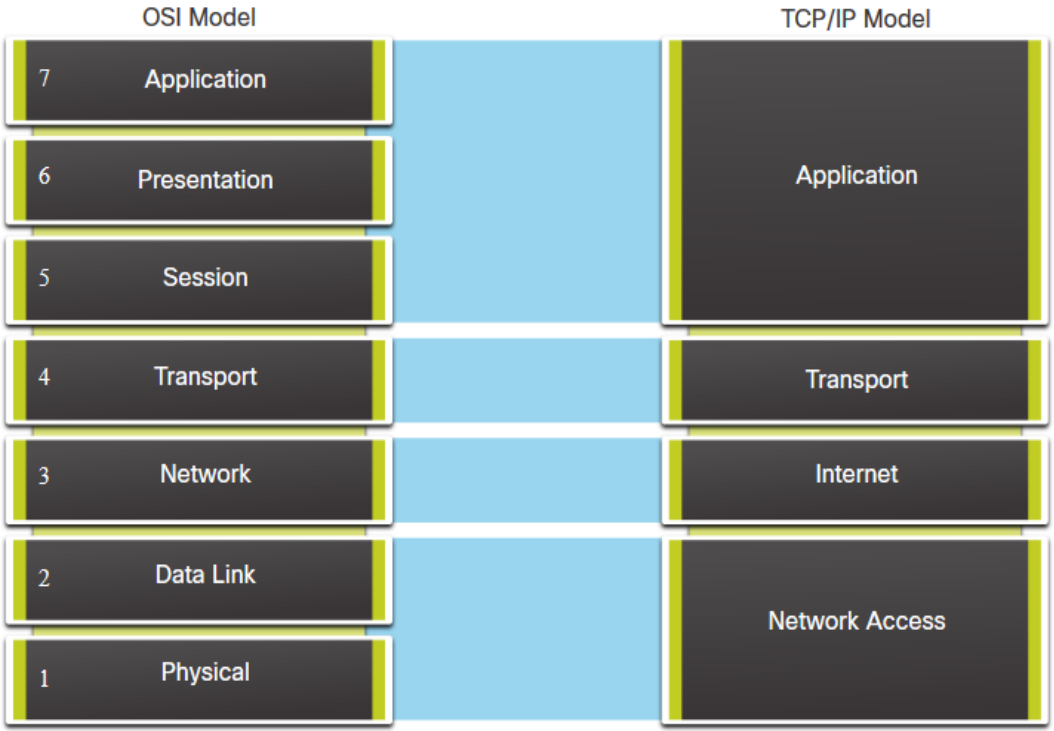
The OSI Reference Model

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.

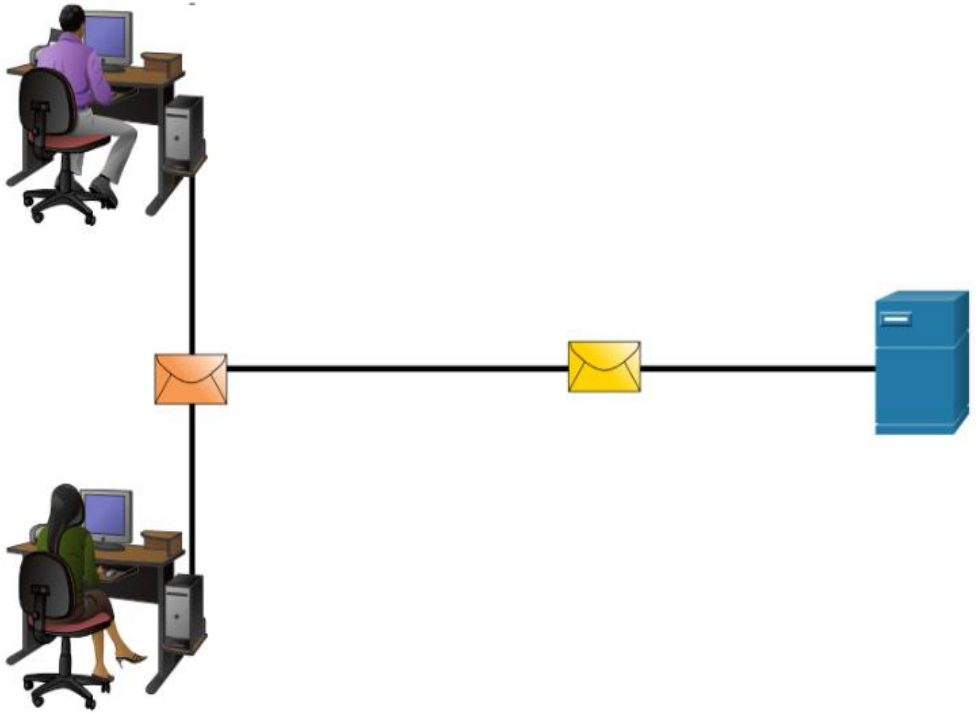
OSI and TCP/IP Model Comparison



- 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.

3.6 Data Encapsulation

Segmenting Messages

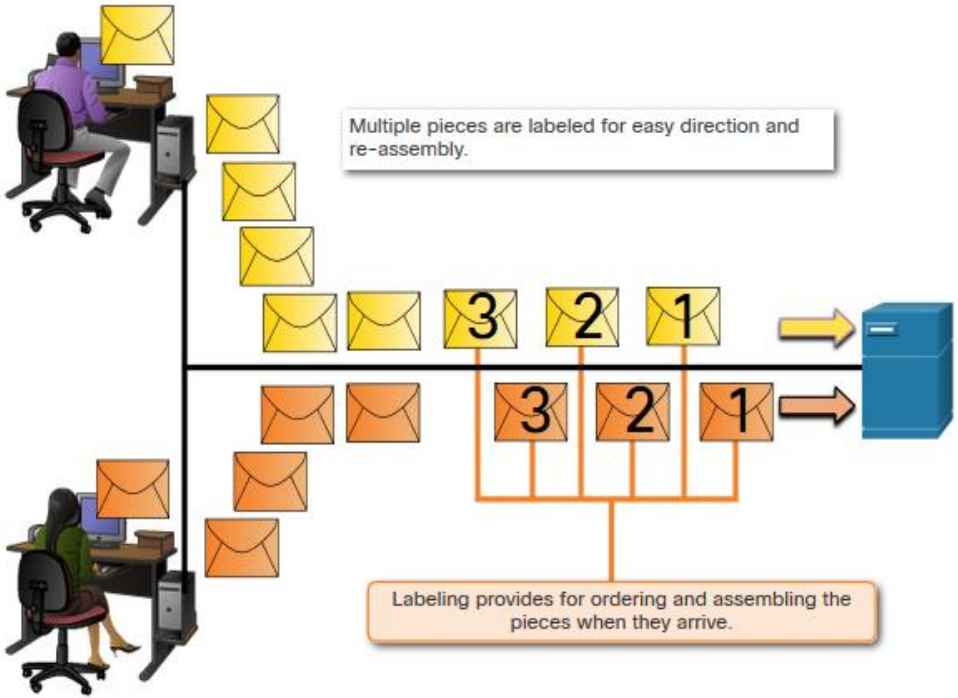


Segmenting is the process of breaking up messages into smaller units. Multiplexing is the processes of taking multiple streams of segmented data and interleaving them together.

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.

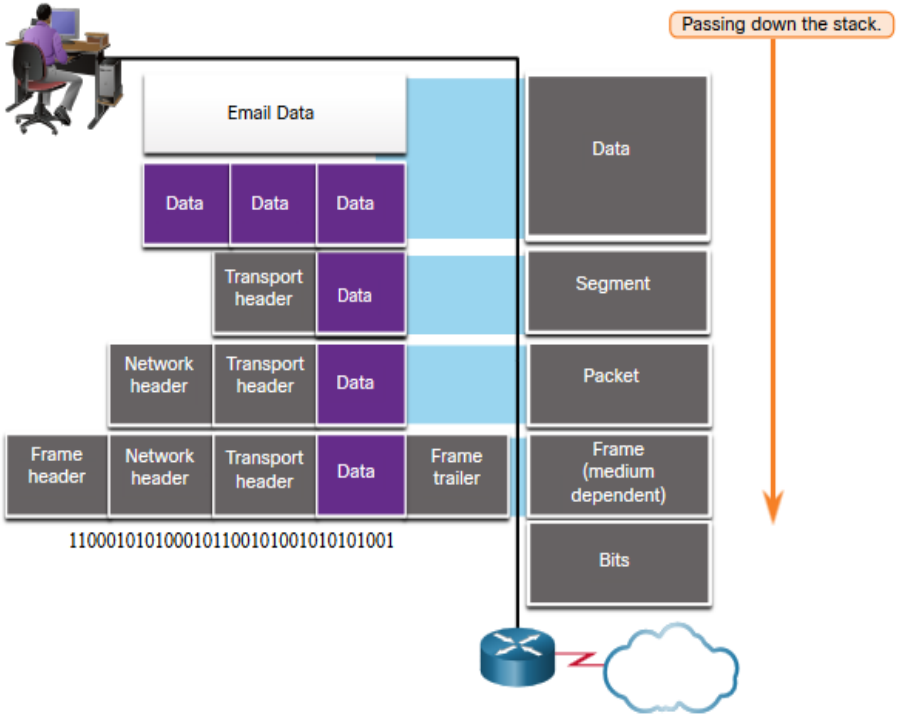
Sequencing



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

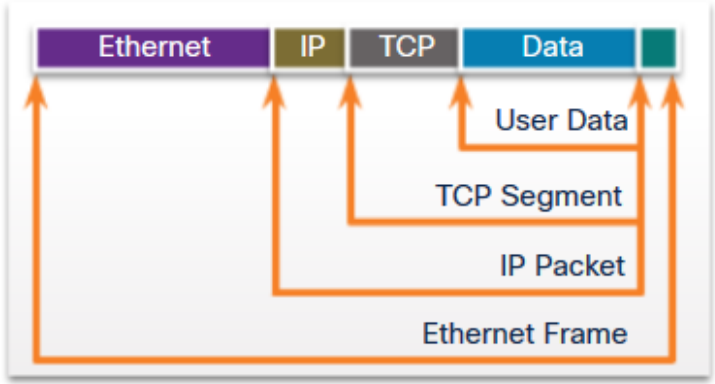


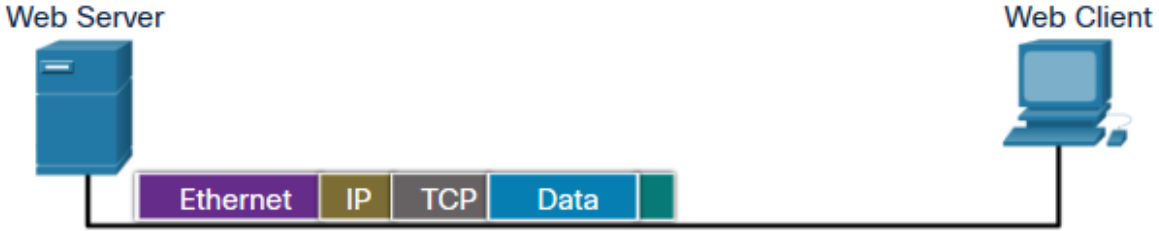
Encapsulation is the process where protocols add their information to the data.

- 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:
  1. Data (Data Stream)
  2. Segment
  3. Packet
  4. Frame
  5. 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.

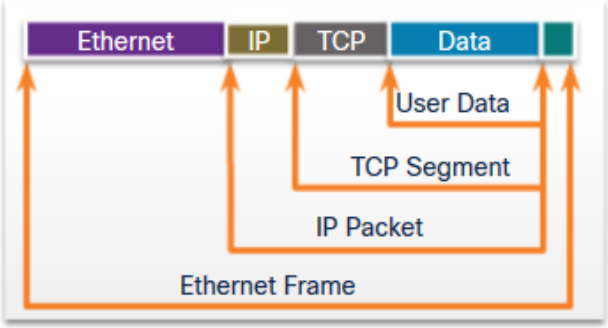




De-encapsulation Example

- Data is de-encapsulated as it moves up the stack.
- When a layer completes its process, that layer strips off its header and passes it up to the next level to be processed. This is repeated at each layer until it is a data stream that the application can process.

1. Received as Bits (Bit Stream)
2. Frame
3. Packet
4. Segment
5. Data (Data Stream)



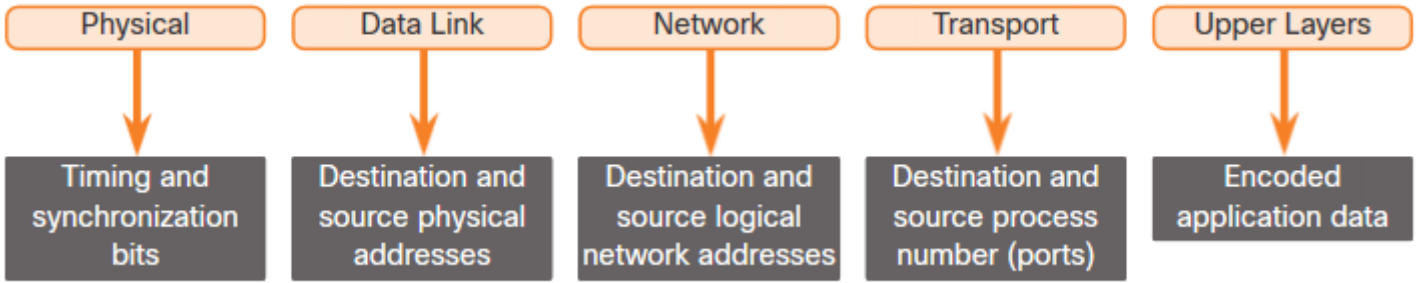
3.7 Data Access

Addresses

Both the data link and network layers use addressing to deliver data from source to destination.

Network layer source and destination addresses - Responsible for delivering the IP packet from original source to the final destination.

Data link layer source and destination addresses – Responsible for delivering the data link frame from one network interface card (NIC) to another NIC on the same network.

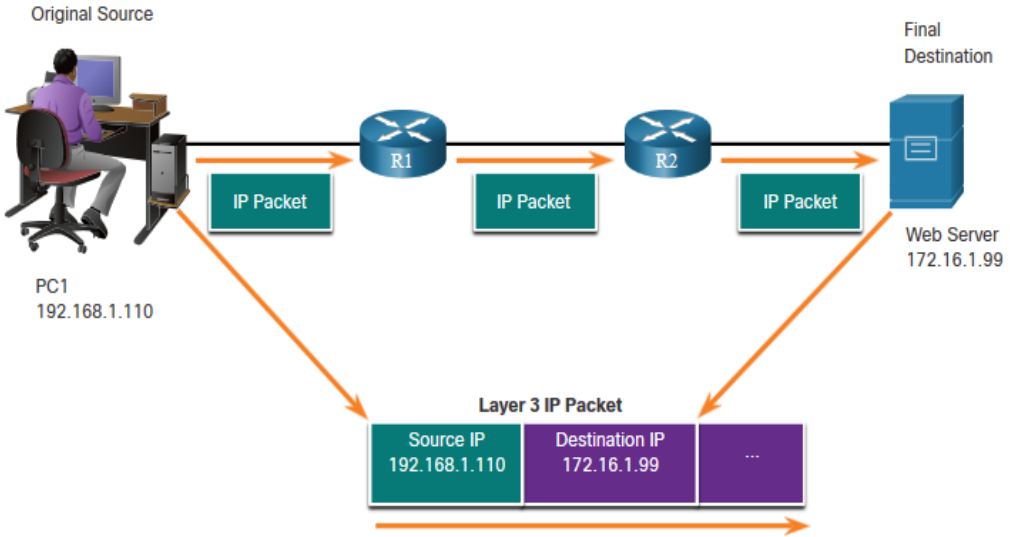


Layer 3 Logical Address

The IP packet contains two IP addresses:

- **Source IP address** - The IP address of the sending device, original source of the packet.
- **Destination IP address** - The IP address of the receiving device, final destination of the packet.

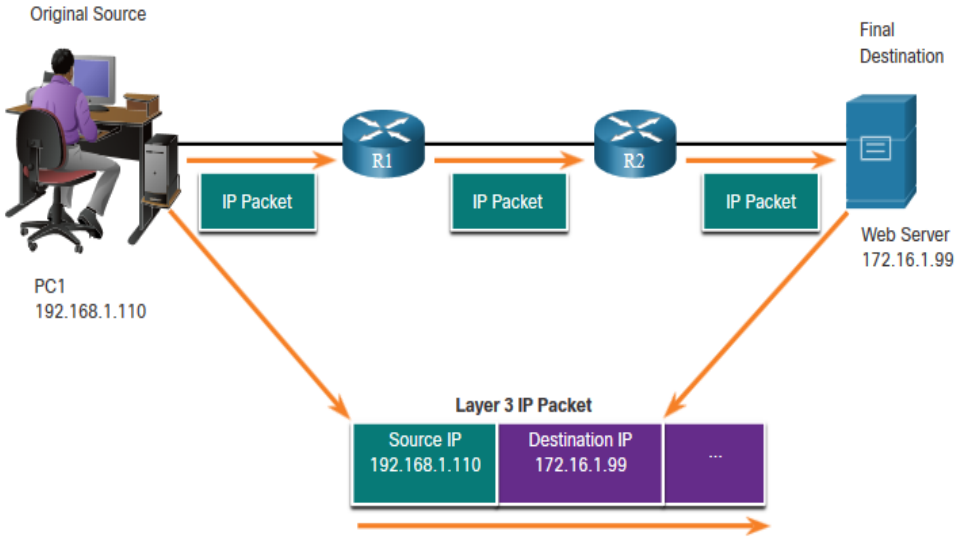
These addresses may be on the same link or remote.



Layer 3 Logical Address (Cont.)

An IP address contains two parts:

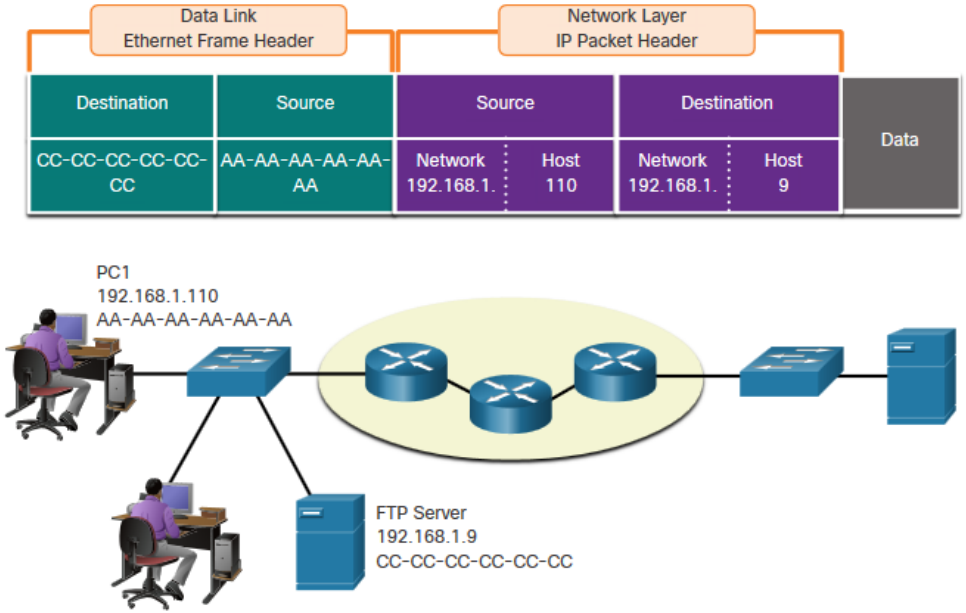
- **Network portion (IPv4) or Prefix (IPv6)**
  - The left-most part of the address indicates the network group which the IP address is a member.
  - Each LAN or WAN will have the same network portion.
- **Host portion (IPv4) or Interface ID (IPv6)**
  - The remaining part of the address identifies a specific device within the group.
  - This portion is unique for each device on the network.



Devices on the Same Network

When devices are on the same network the source and destination will have the same number in network portion of the address.

- PC1 – 192.168.1.110
- FTP Server – 192.168.1.9

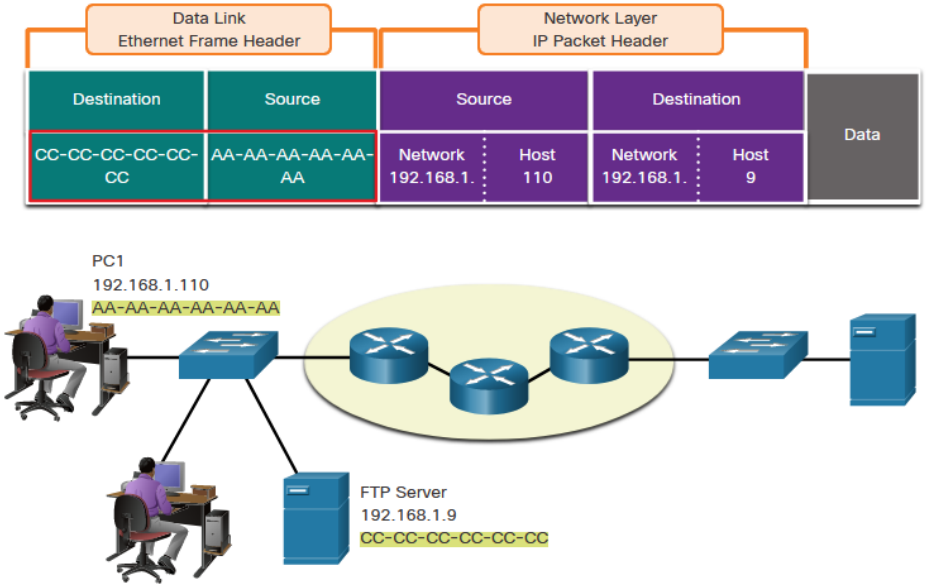


Role of the Data Link Layer Addresses: Same IP Network

When devices are on the same Ethernet network the data link frame will use the actual MAC address of the destination NIC.

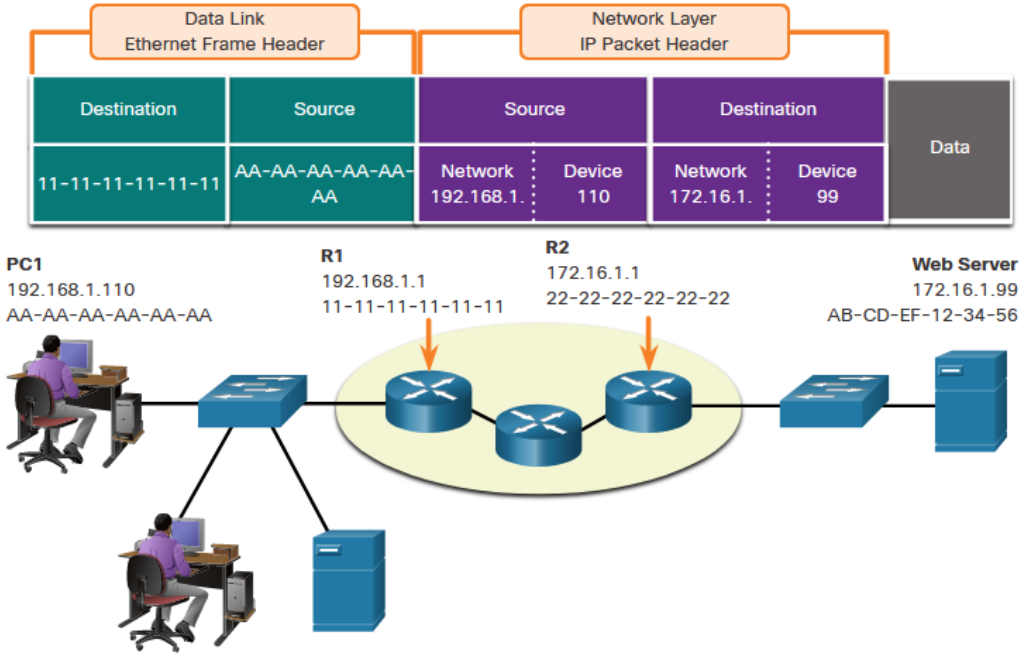
MAC addresses are physically embedded into the Ethernet NIC and are local addressing.

- The Source MAC address will be that of the originator on the link.
- The Destination MAC address will always be on the same link as the source, even if the ultimate destination is remote.



Devices on a Remote Network

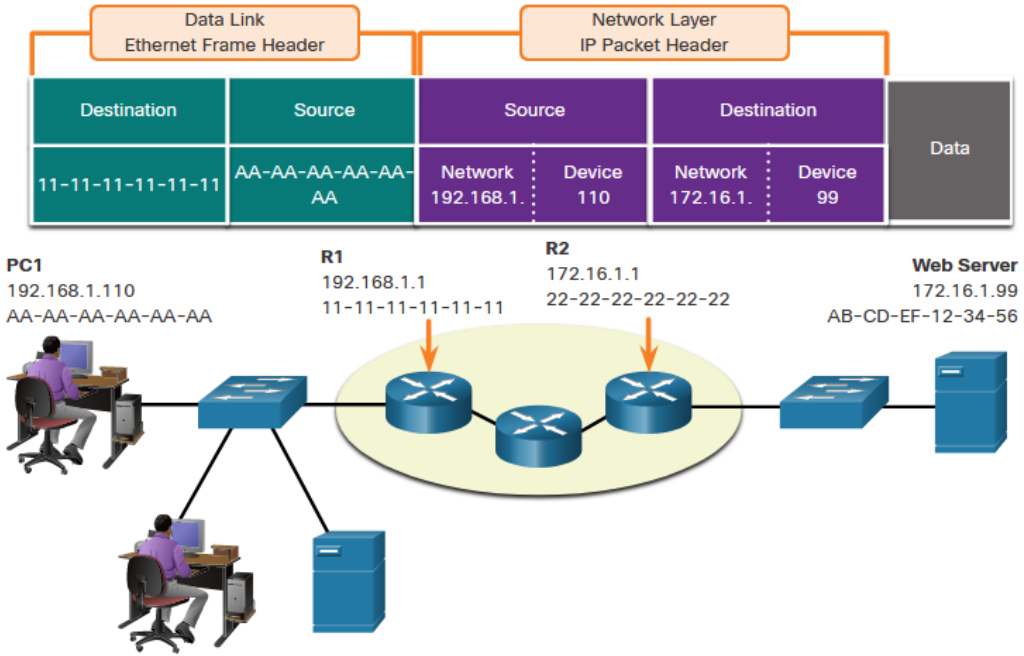
- What happens when the actual (ultimate) destination is not on the same LAN and is remote?
- What happens when PC1 tries to reach the Web Server?
- Does this impact the network and data link layers?



Role of the Network Layer Addresses

When the source and destination have a different network portion, this means they are on different networks.

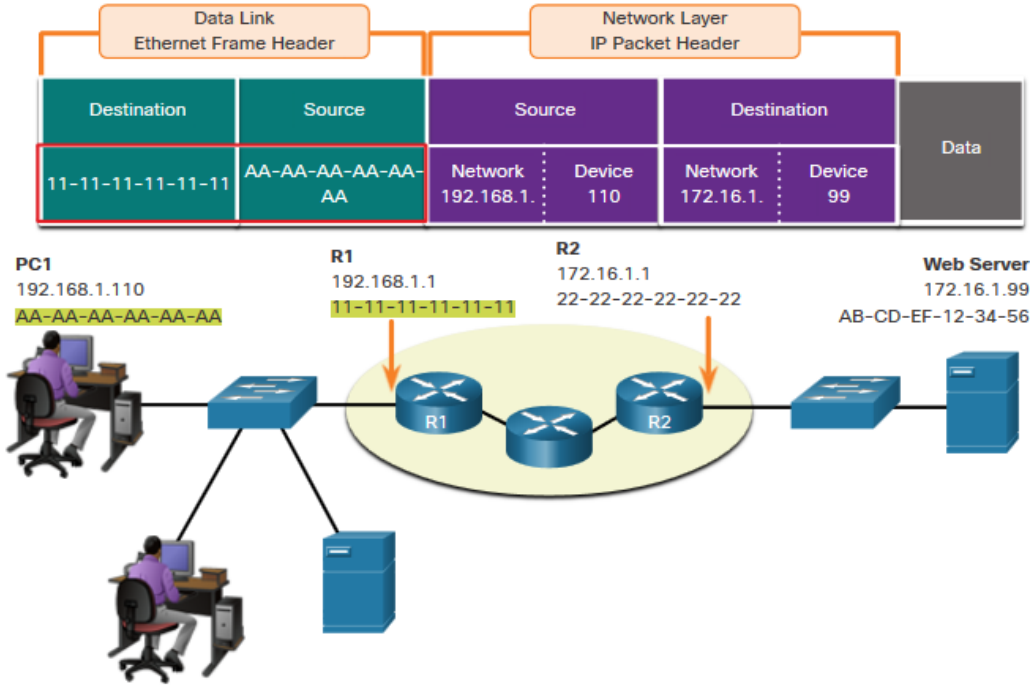
- PC1 – 192.168.1
- Web Server – 172.16.1



Role of the Data Link Layer Addresses: Different IP Networks

When the final destination is remote, Layer 3 will provide Layer 2 with the local default gateway IP address, also known as the router address.

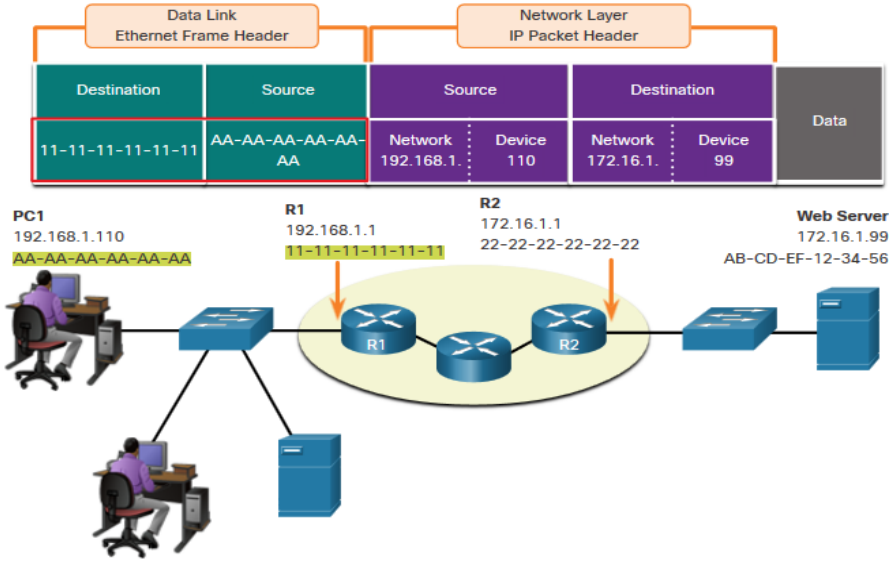
- The default gateway (DGW) is the router interface IP address that is part of this LAN and will be the “door” or “gateway” to all other remote locations.
- All devices on the LAN must be told about this address or their traffic will be confined to the LAN only.
- Once Layer 2 on PC1 forwards to the default gateway (Router), the router then can start the routing process of getting the information to actual destination.



Role of the Data Link Layer Addresses: Different IP Networks (Cont.)

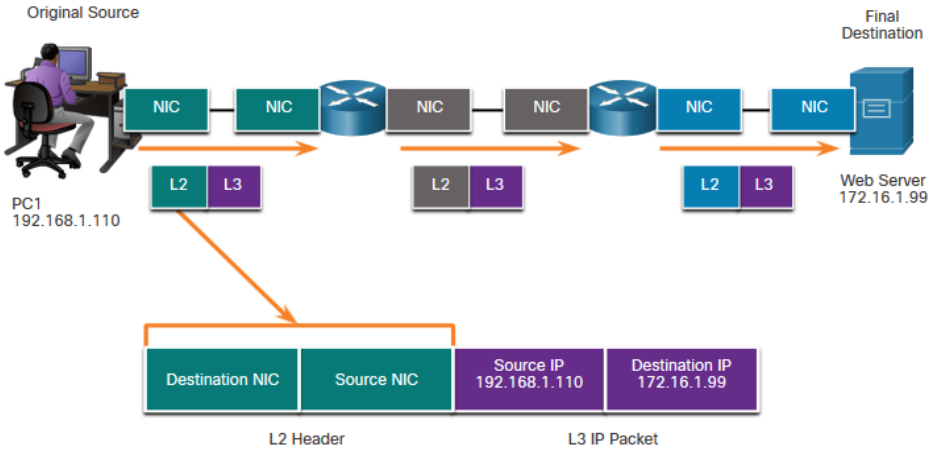
- The data link addressing is local addressing so it will have a source and destination for each link.
- The MAC addressing for the first segment is :
  - Source – AA-AA-AA-AA-AA-AA (PC1) Sends the frame.
  - Destination – 11-11-11-11-11-11 (R1-Default Gateway MAC) Receives the frame.

Note: While the L2 local addressing will change from link to link or hop to hop, the L3 addressing remains the same.



Data Link Addresses

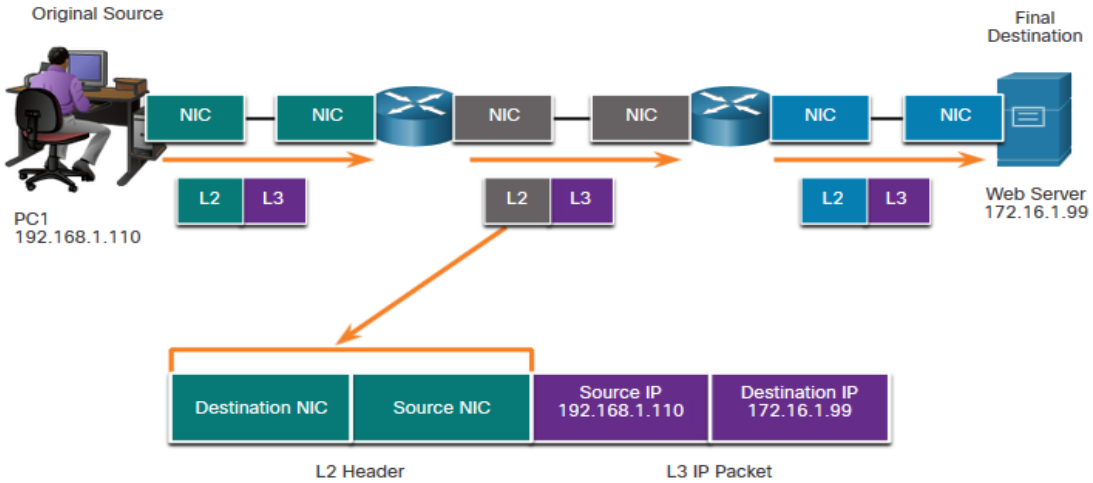
- Since data link addressing is local addressing, it will have a source and destination for each segment or hop of the journey to the destination.
- The MAC addressing for the first segment is:
  - Source – (PC1 NIC) sends frame
  - Destination – (First Router- DGW interface) receives frame



Data Link Addresses (Cont.)

The MAC addressing for the second hop is:

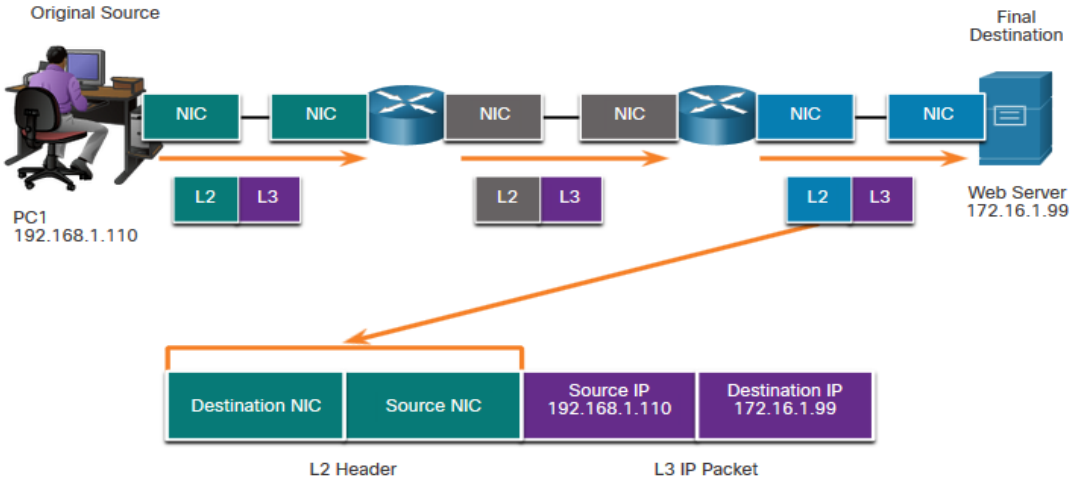
- Source – (First Router- exit interface) sends frame
- Destination – (Second Router) receives frame



Data Link Addresses (Cont.)

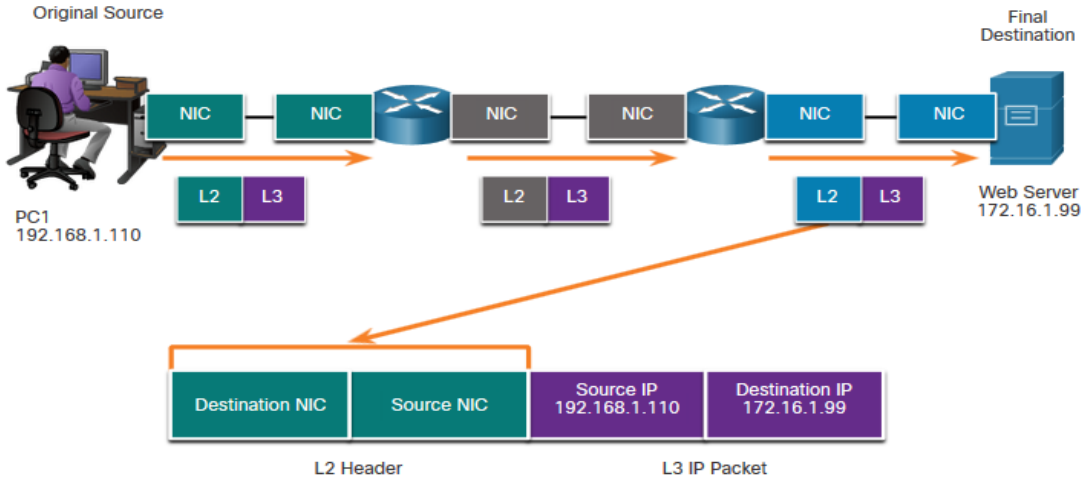
The MAC addressing for the last segment is:

- Source – (Second Router- exit interface) sends frame
- Destination – (Web Server NIC) receives frame



Data Link Addresses (Cont.)

- Notice that the packet is not modified, but the frame is changed, therefore the L3 IP addressing does not change from segment to segment like the L2 MAC addressing.
- The L3 addressing remains the same since it is global and the ultimate destination is still the Web Server.

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