COMPUTER NETWORKING STANDARDS

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MITCH M. ANDAYA

IMPORTANCE OF STANDARDS

- Many complex systems include hardware and software from many different vendors.

- It is therefore necessary to establish rules and conventions to facilitate communication among these devices.

IMPORTANCE OF STANDARDS

- These rules and conventions are referred to as ***standards*** or ***protocols***.

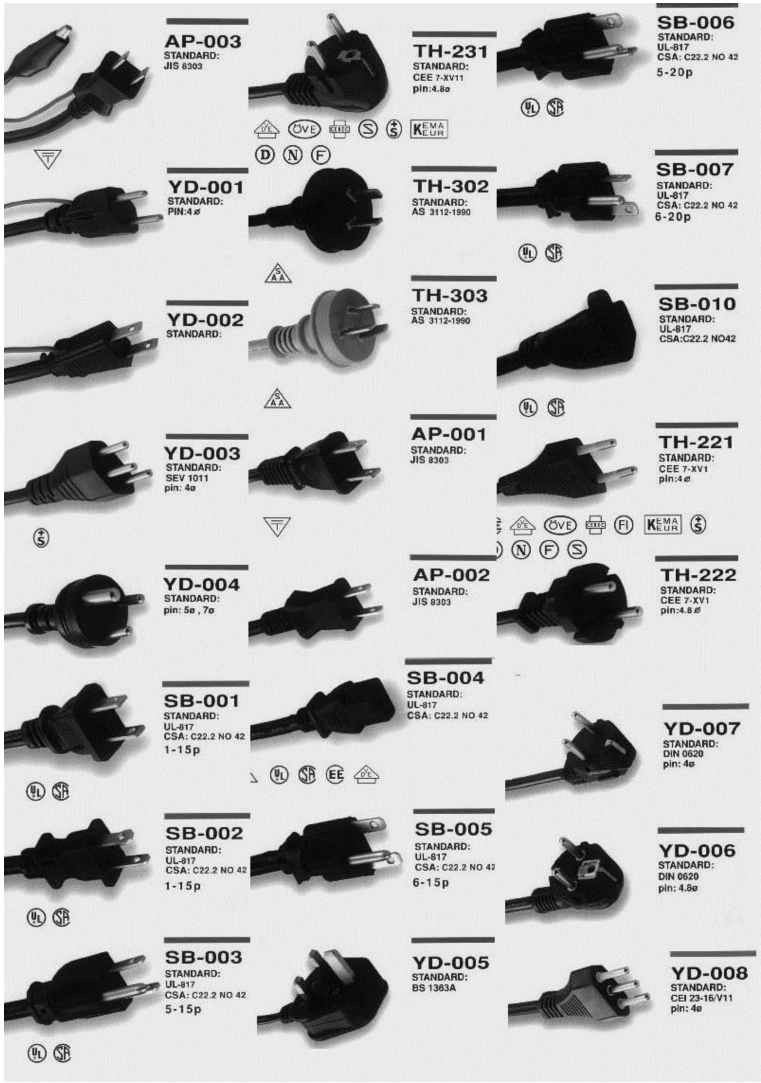
- Rules and standards help ensure upward compatibility.

IMPORTANCE OF STANDARDS

- However, there are multiple standards for the same thing.

- And a standard tends to freeze the technology.

  By the time a standard is developed, subject to review and compromise, and promulgated, more efficient techniques are possible.



IMPORTANCE OF STANDARDS

- In the world of computer networking, it has been a major headache of system integrators during the 70s to interoperate computer systems from different computer vendors.

- Because of standardization, ***open-systems*** have been encouraged.

  An open system is a system in which the components and protocols conform to standards independent of a particular supplier.

- Today, from software to hardware systems or component systems, integrators can mix and match. This can result to having the best possible solution with the least cost.

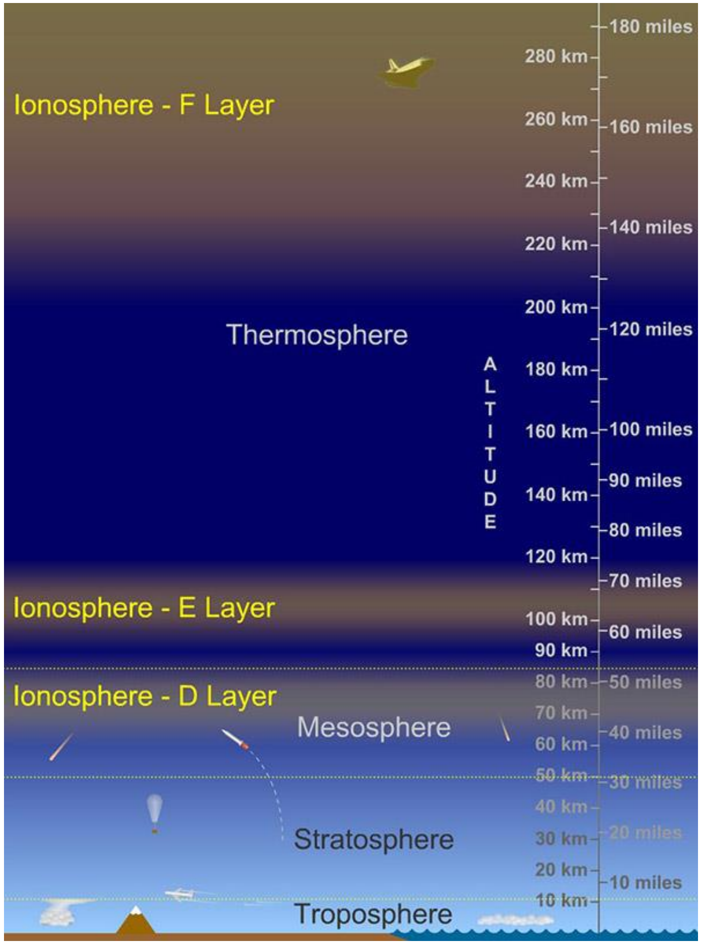
PROTOCOL LAYERING

- In data communication and networking, a ***protocol*** defines the rules that both the sender and receiver and all intermediate devices need to follow to be able to communicate effectively.

- When communication is simple, only one simple protocol is needed.

- When the communication is complex, there may be a need to divide the task between different layers, in which case a protocol (or a group of related protocols) at each layer is needed.

- This is called ***protocol layering***.



PROTOCOL LAYERING

- Analogy: Human Communications

Levels of Human Communication

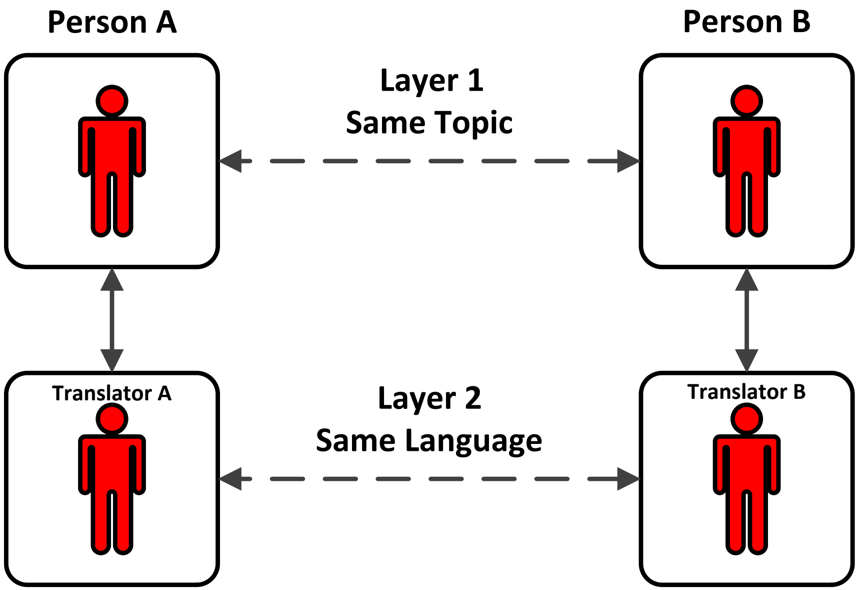
1. ***Cognitive Level*** - Both parties should understand the concept they are to discuss.

2. ***Language Level*** - Concerned with the words that convey the information -- not the information itself.

3. ***Transmission Level*** - Concerned with the physical means of conveying information between parties.

Note: Each of the three levels (or layers) is independent of the other.

PROTOCOL LAYERING

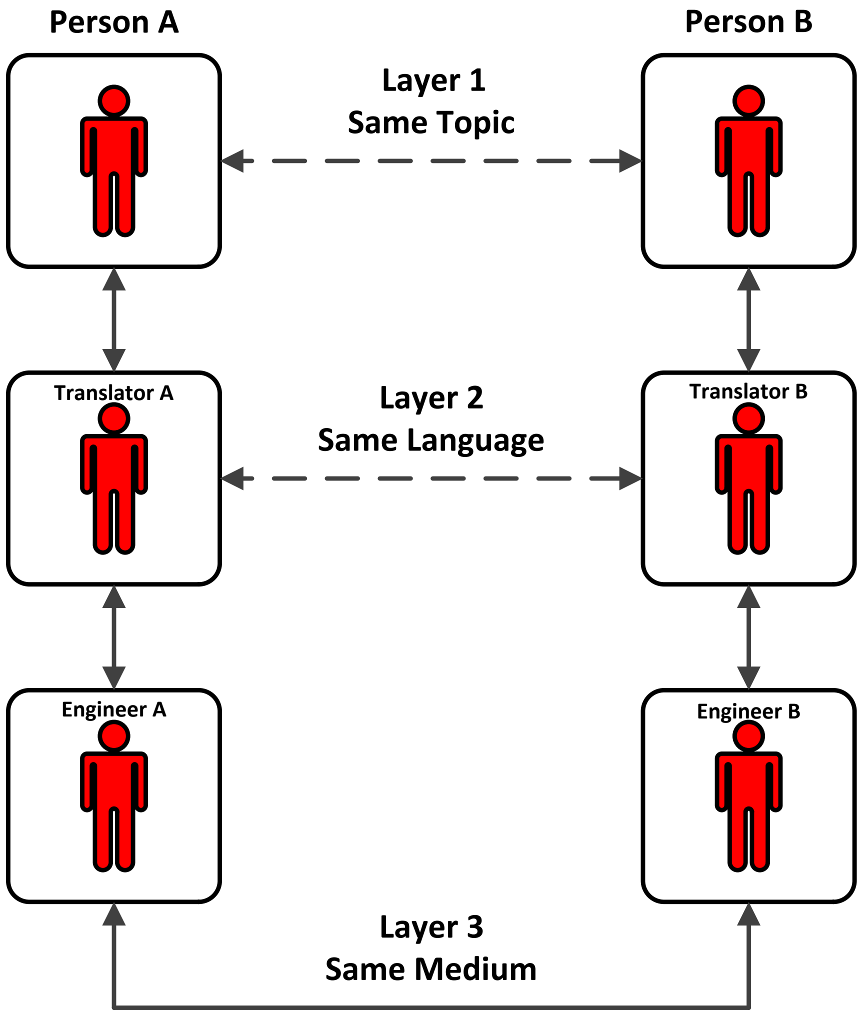


- Assume two persons would like to communicate.
- In order for communication to take place, they must coincide at the cognitive level (they must know or understand the topic of conversation).
- Assume further that the two persons are of different nationalities (no common language).

That would require the services of translators.

In order for the translators to understand each other, they must agree on the language level (they must have a common language).

PROTOCOL LAYERING



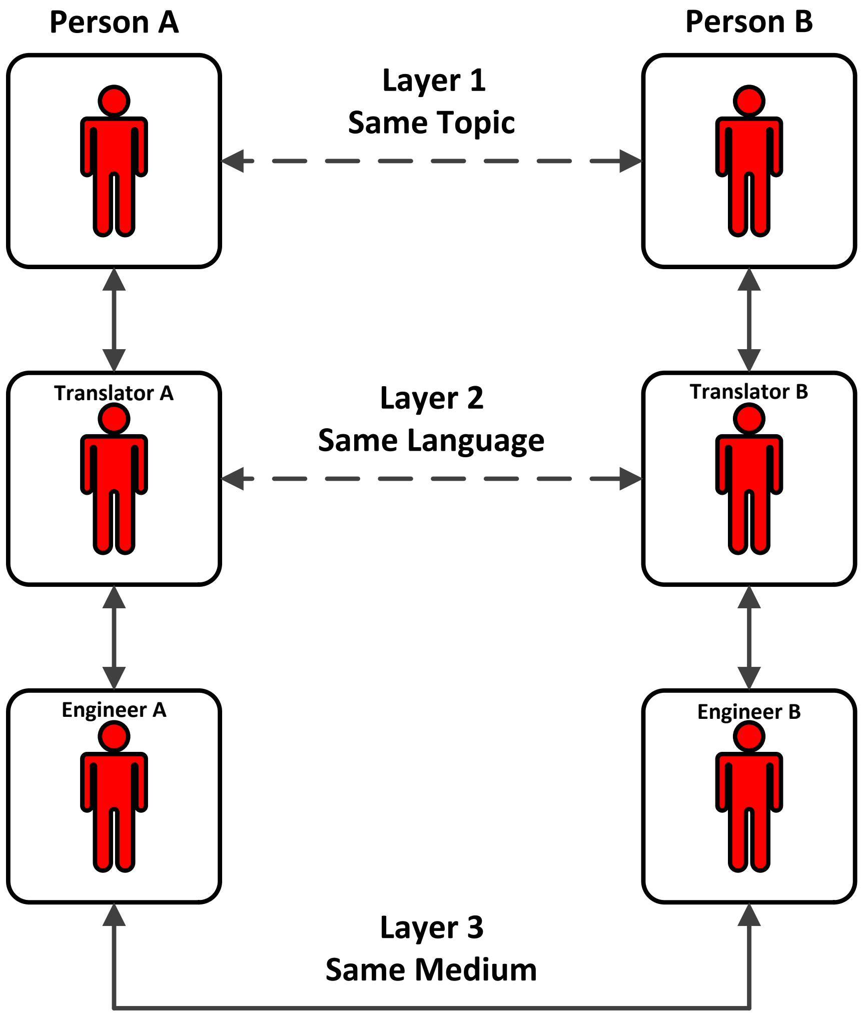
- Finally, assume that the two persons are located at different continents.

  Therefore, they need engineers to ensure that their messages are transmitted properly.

  In order for this to happen, the engineers must agree on the transmission level.

  In other words, they must use the same medium of transmission (telephone, video conferencing, email, etc.).

PROTOCOL LAYERING



- The advantage of the layered approach is the independence of the different layers.

  Technology or capability changes in one particular layer will not affect other layers above and below.

  For example, if the translators decided to change the language they use in communicating with one another, it will not affect how the persons communicating nor the engineers in the performance of their functions.

  This is referred to as ***modularity***. Modularity in this case means independent layers.

PRINCIPLES OF PROTOCOL LAYERING

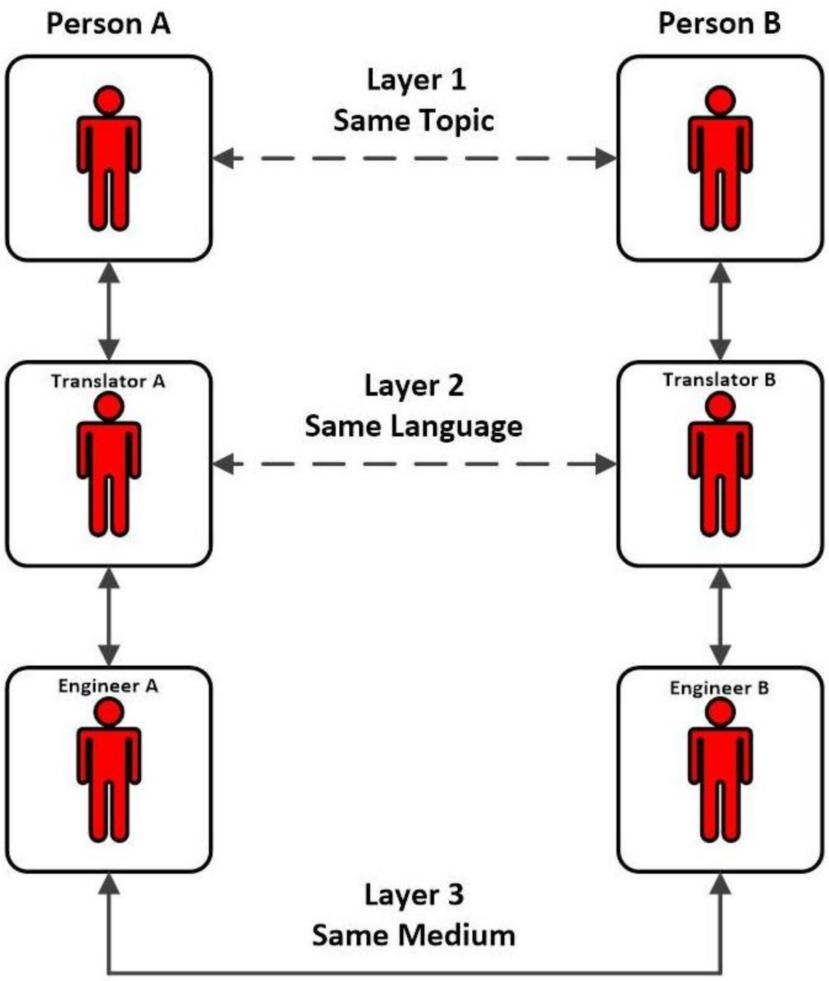
- First Principle

  The first principle of protocol layering dictates that if bidirectional communication is required, each layer must be able to perform two opposite tasks, one in each direction.

  For example, the task of Layer 1 is to listen (in one direction) and talk (in the other direction).

  Layer 2 should be able to convert to/from the native language of Person *A* or *B*.

  Layer 3 needs to transmit and receive data using the agreed-upon medium (e.g., transmit/receive email).



PRINCIPLES OF PROTOCOL LAYERING

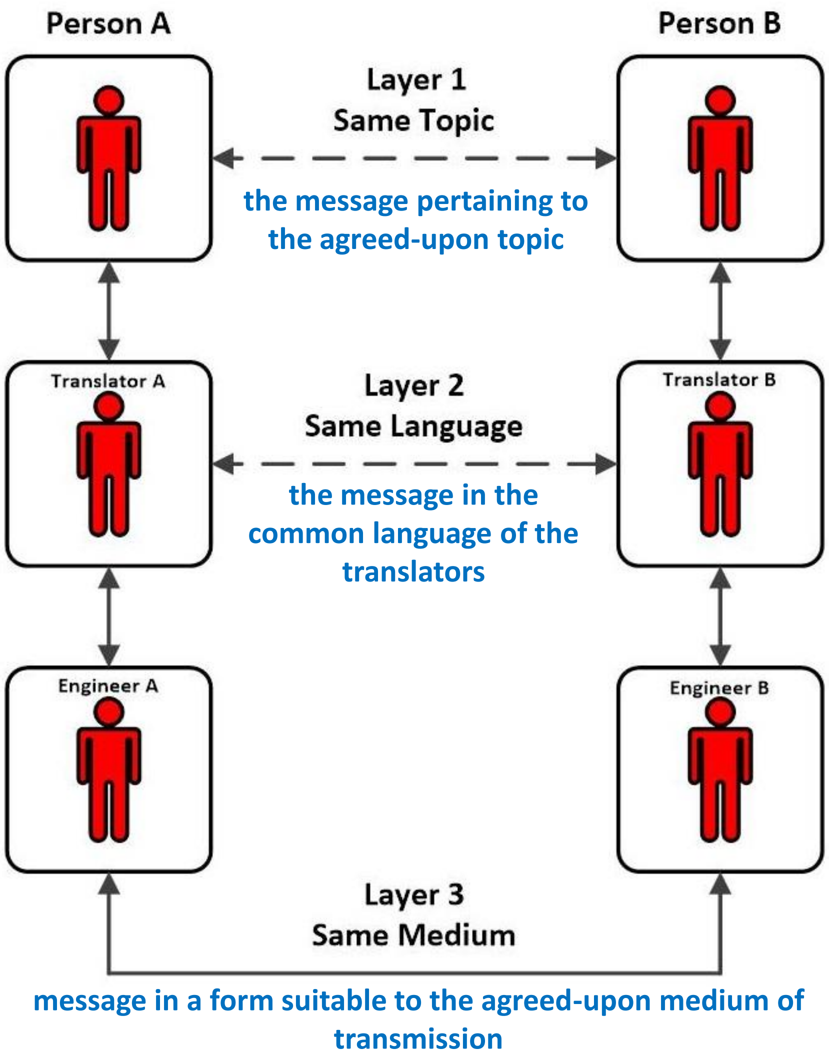
- Second Principle

The second principle to be followed in protocol layering is that the two objects under each layer at both sites should be identical.

For example, the object at Layer 1 at both sites should be the message pertaining to the agreed-upon topic.

The object at Layer 2 at both sides should be the message in the common language of the translators.

The object at Layer 3 should be message in a form suitable to the agreed-upon medium of transmission (e.g., email).

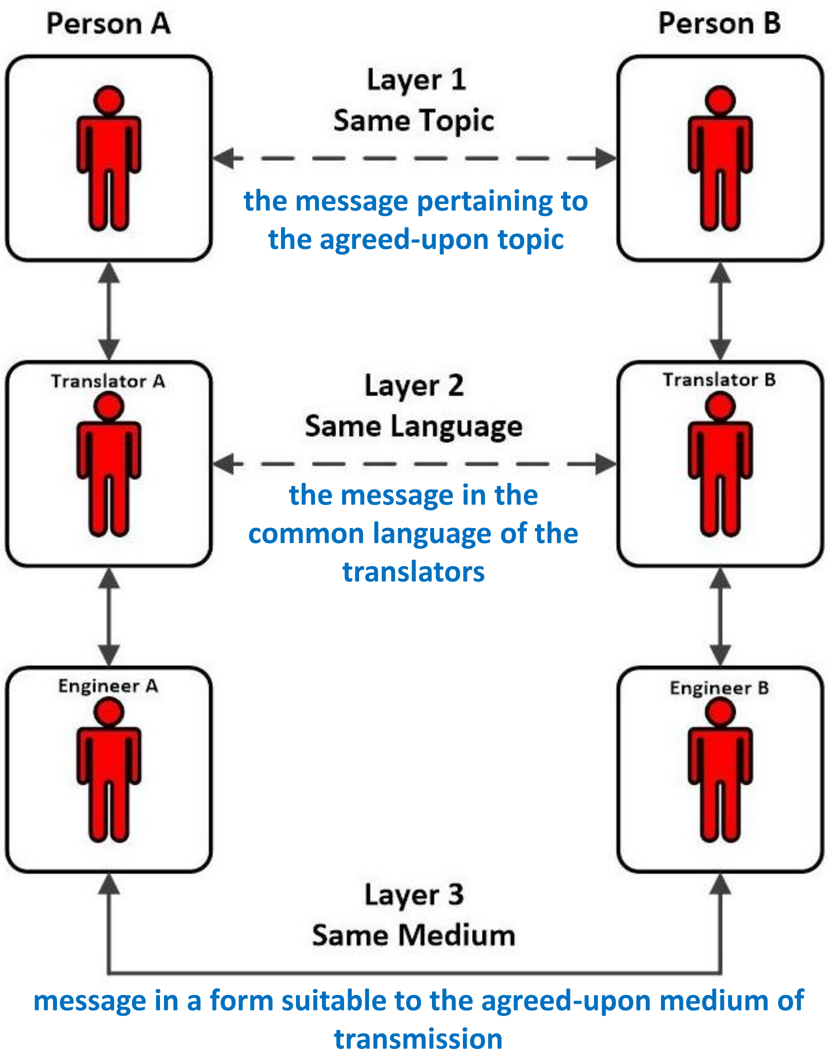

Person A
Person B
Layer 1
Same Topic
the message pertaining to the agreed-upon topic
Translator A
Translator B
Layer 2
Same Language
the message in the common language of the translators
Engineer A
Engineer B
Layer 3
Same Medium
message in a form suitable to the agreed-upon medium of transmission

PRINCIPLES OF PROTOCOL LAYERING

Take note that once a layer receives an object from the upper layer, the message may be changed so that the layer can perform its function.

For example, Layer 2 will change the message it receives from Layer 1 to the common language being used by Layer 2.

Layer 3 will change the message it receives from Layer 2 to a form necessary to transmit the message using the agreed-upon medium of transmission (e.g., bits if email is used).


Person A
Person B
Layer 1
Same Topic
the message pertaining to the agreed-upon topic
Translator A
Translator B
Layer 2
Same Language
the message in the common language of the translators
Engineer A
Engineer B
Layer 3
Same Medium
message in a form suitable to the agreed-upon medium of transmission

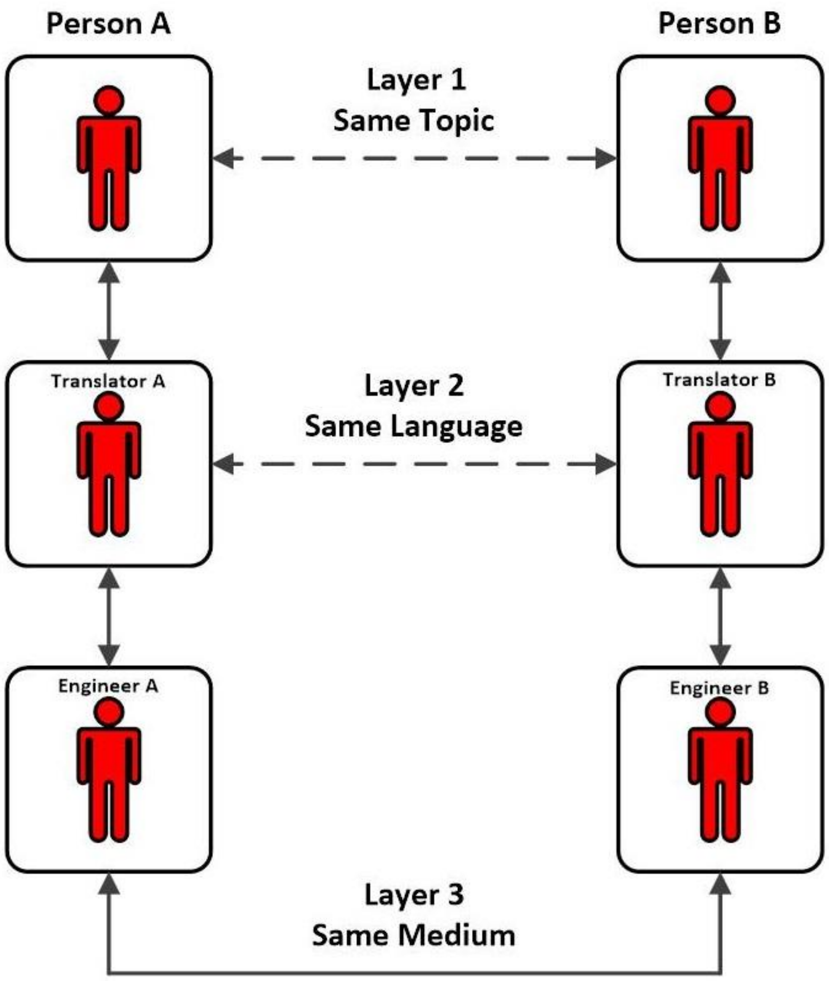
PRINCIPLES OF PROTOCOL LAYERING

- Third Principle

  The third principle in protocol layering is that the layers follow a hierarchy.

  So a ***protocol suite*** (a set of protocols organized in different layers) is made up of interactive modules, each of which provides a specific functionality, and is designed to be hierarchical.

  The term hierarchical means that each upper level protocol is supported by the services provided by one or more lower level protocols.

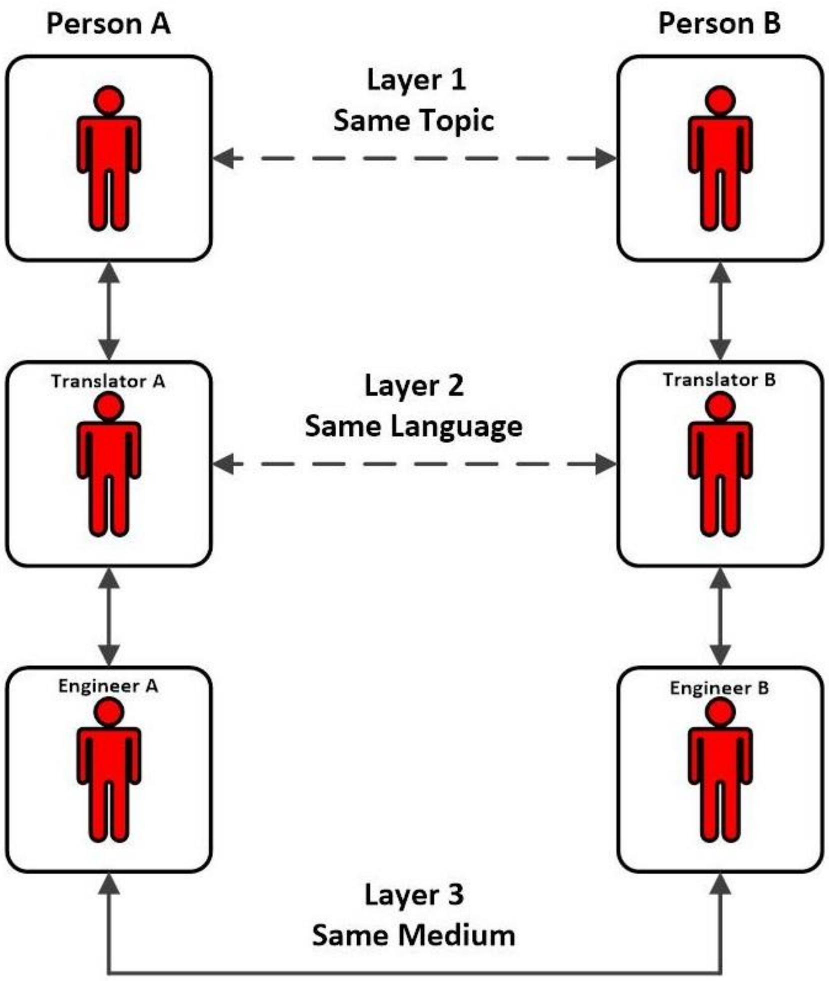


PRINCIPLES OF PROTOCOL LAYERING

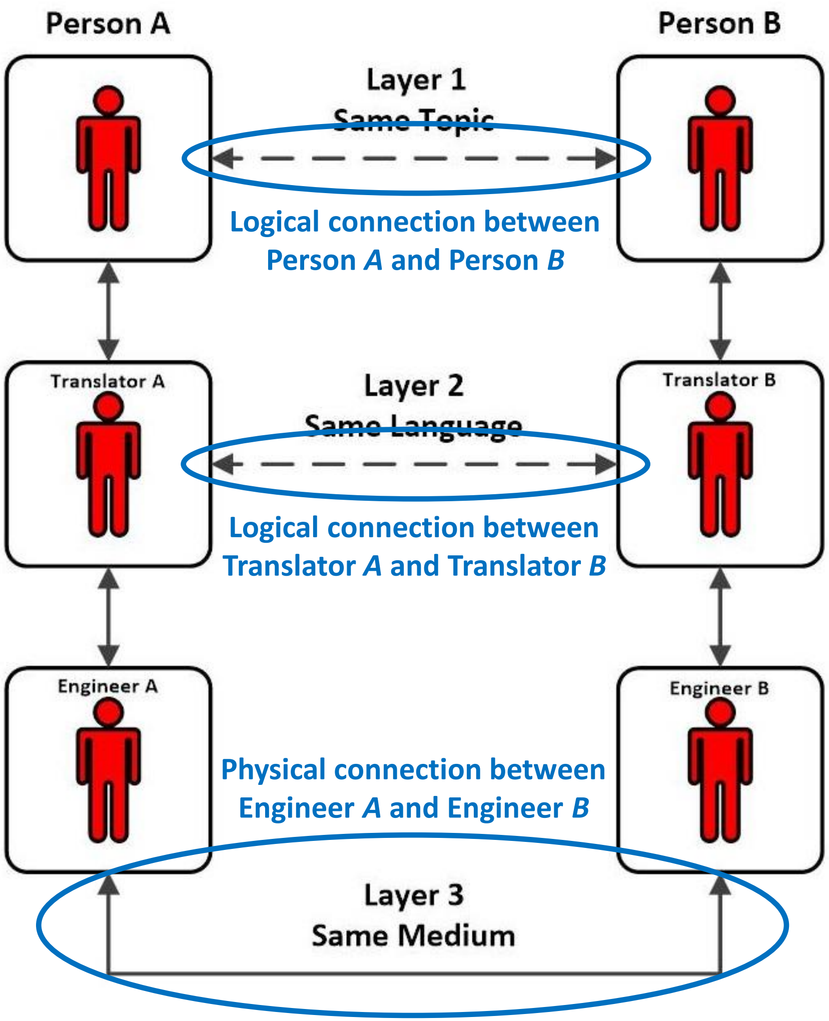
For example, Layer 2 exists to provide a service (language translation) to Layer 1. Layer 3 exists to provide a service (actual message transmission) to Layer 2.

Take note the lower layer shields the upper layer from the details of how the offered services are actually implemented (abstraction).

This makes it easier to change a protocol in one layer without affecting the protocols in other layers.



LOGICAL CONNECTIONS


Person A
Person B
Layer 1
Same Topic
Logical connection between Person *A* and Person *B*
Translator A
Translator B
Layer 2
Same Language
Logical connection between Translator *A* and Translator *B*
Engineer A
Engineer B
Physical connection between Engineer *A* and Engineer *B*
Layer 3
Same Medium

- After following the three principles, it is easy to think about ***logical connection*** between each layer.

  This means that there is a layer-to-layer communication.

  Person *A* and Person *B* can think that there is a logical (imaginary) connection at each layer through which they can send the object created from that layer.

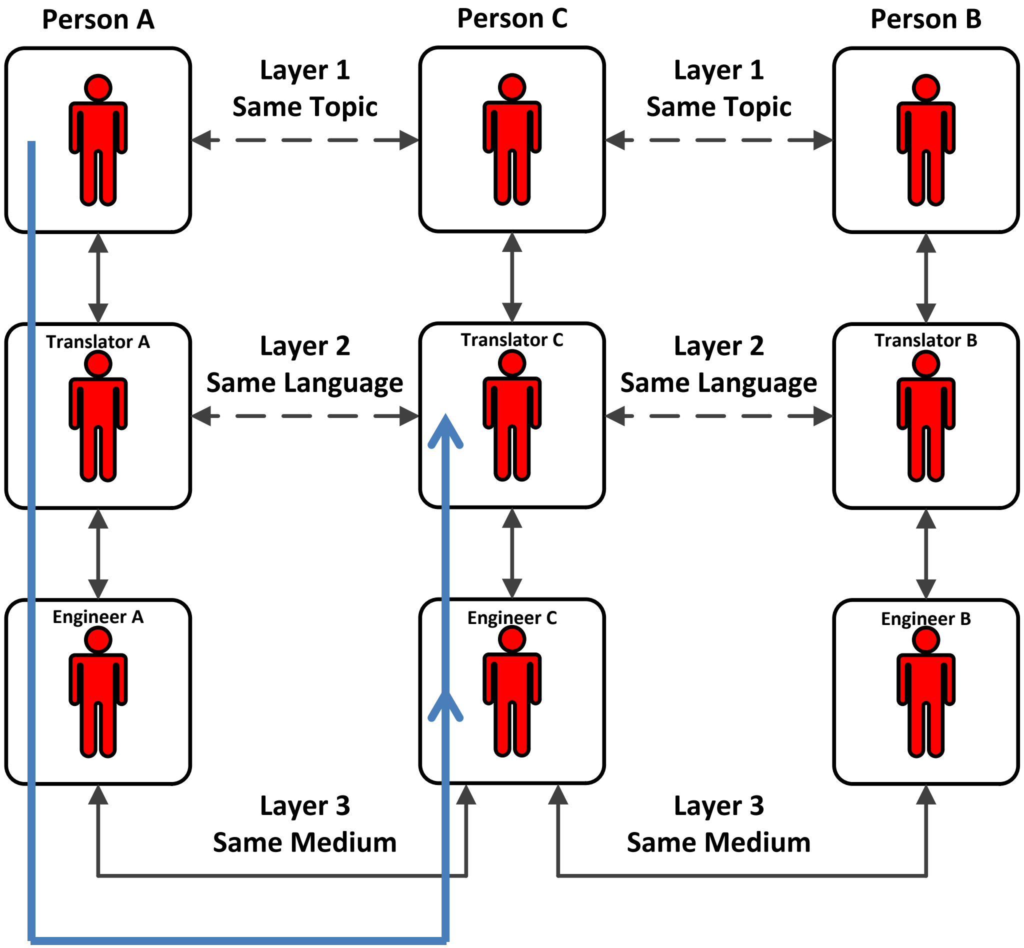
  The connection between the lowest layer of both sites is a ***physical connection*** (an actual connection).

INTERMEDIARY SYSTEMS

- Assume that the distance between Persons *A* and *B* is quite long that it has to pass through an intermediary site (the site where Person *C* resides).

- So Engineer *A* sends the message to Engineer *C*.

- Engineer *C* assumes the message is for Person *C* so he/she passes it to Translator *C*.

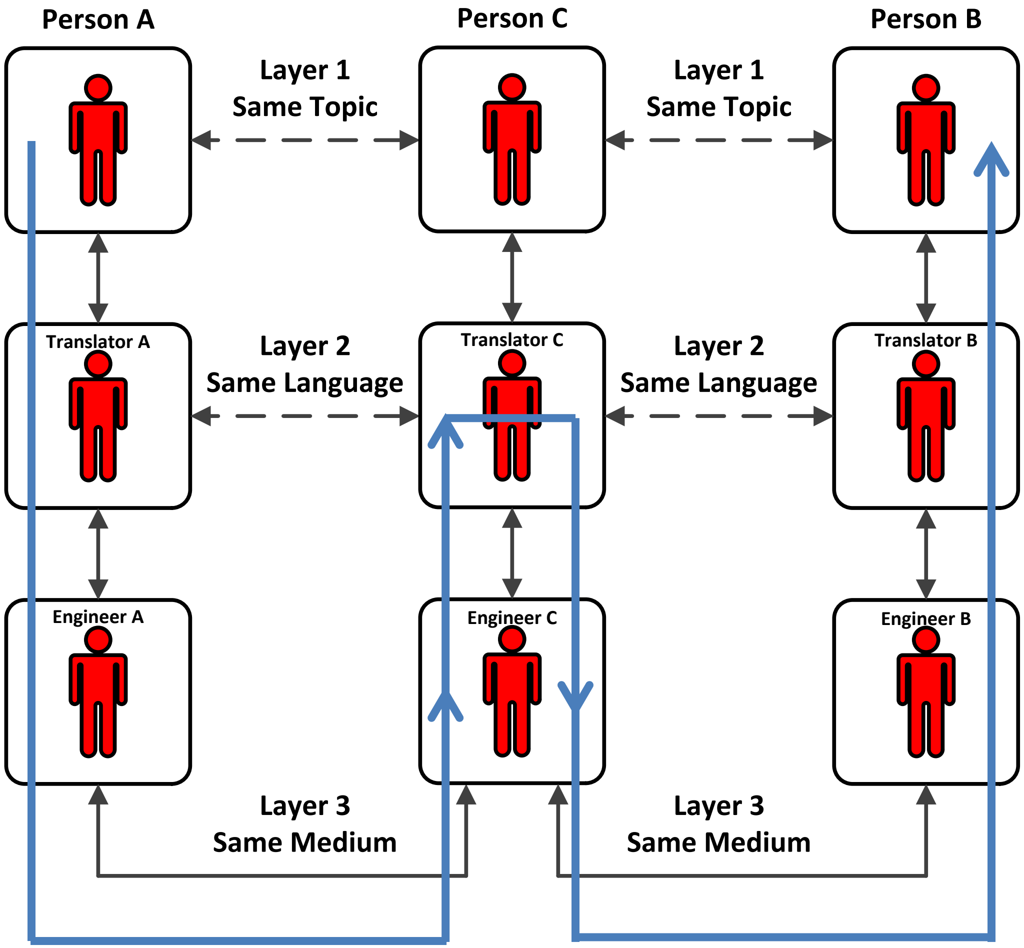


INTERMEDIARY SYSTEMS

- Upon reading the message, Translator *C* realizes that it is not for Person *C*. So he/she sends the message back to Engineer *C* with the instruction to send it to Person *B*.

- So Engineer *C* sends the message to Engineer *B* who then sends it up though the hierarchy.

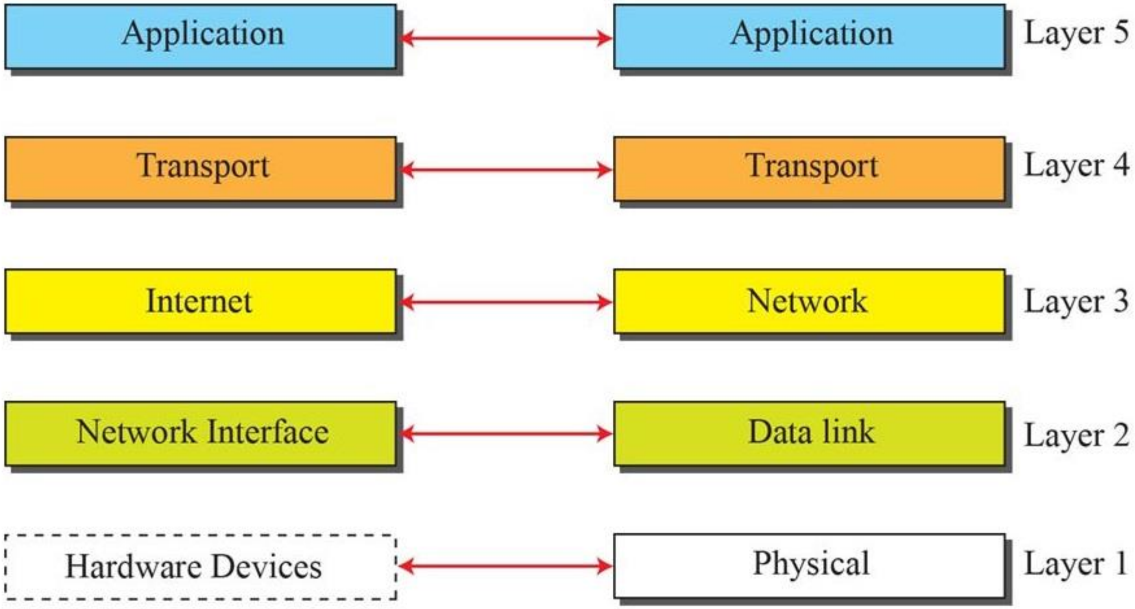
- So not all layers in a particular site will be involved in the communication process. It depends upon the situation.



TCP/IP PROTOCOL SUITE

- ***TCP/IP*** (***Transmission Control Protocol/Internet Protocol***) is the *protocol suite* used in the Internet today.

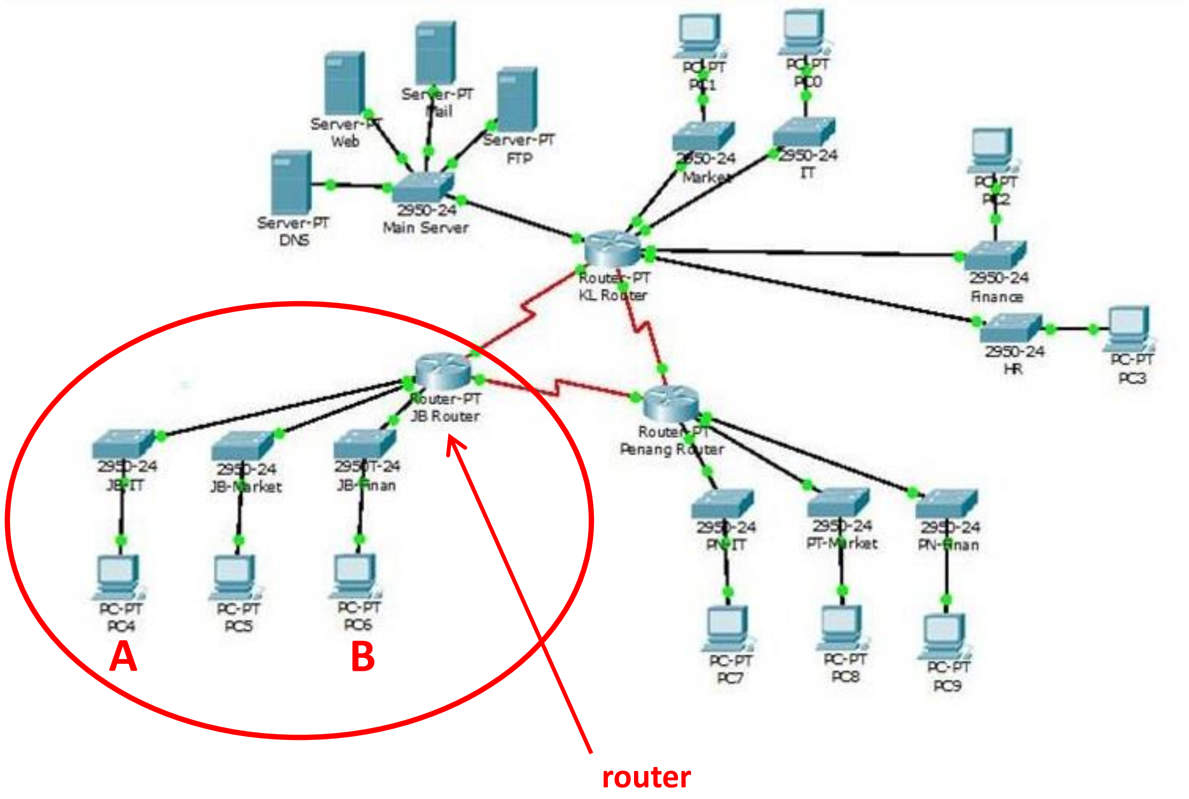
- The original TCP/IP protocol suite was defined as four software layers built upon the hardware.



- Today, TCP/IP is thought of as a five-layer model.

TCP/IP PROTOCOL SUITE

- Recall that a WAN interconnects LANs using interconnecting devices such as switches or routers.

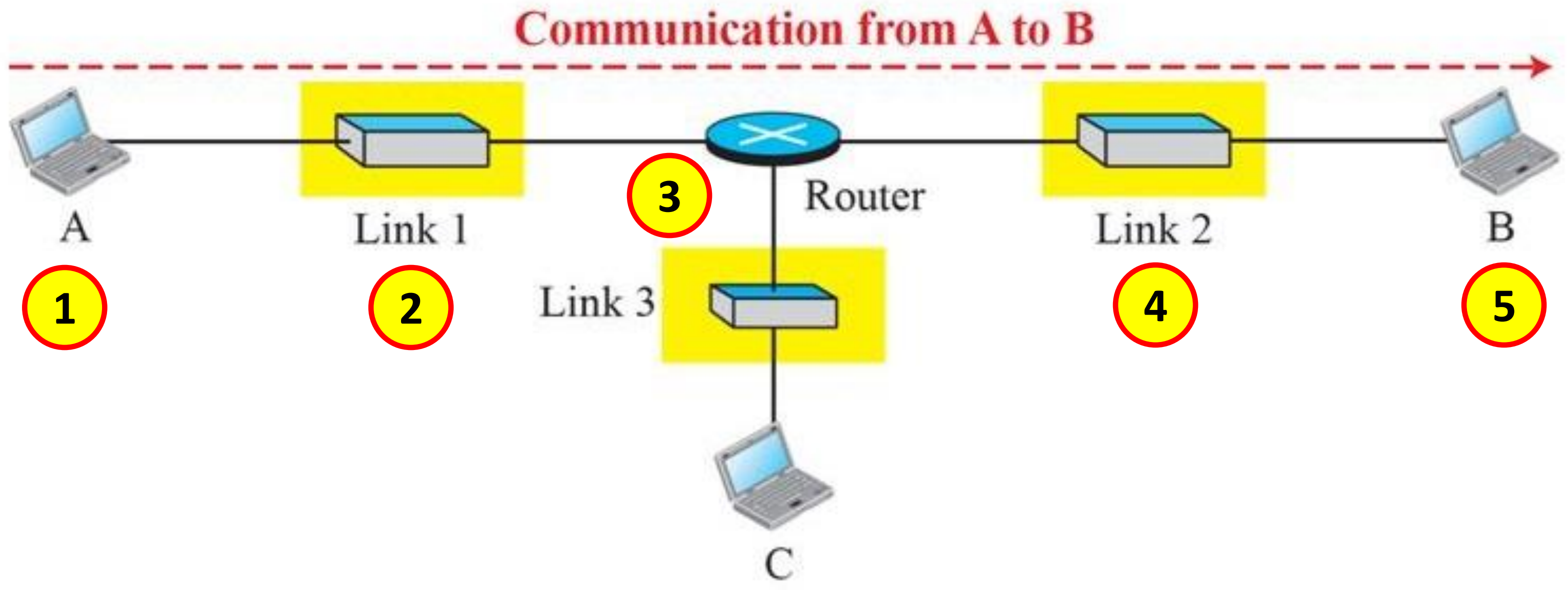


- To show how the layers in the TCP/IP protocol suite are involved in communication between two hosts, assume that the suite will be used in a small internet made up of three LANs (links), each with a switch.

Assume that computer *A* communicates with computer *B*.

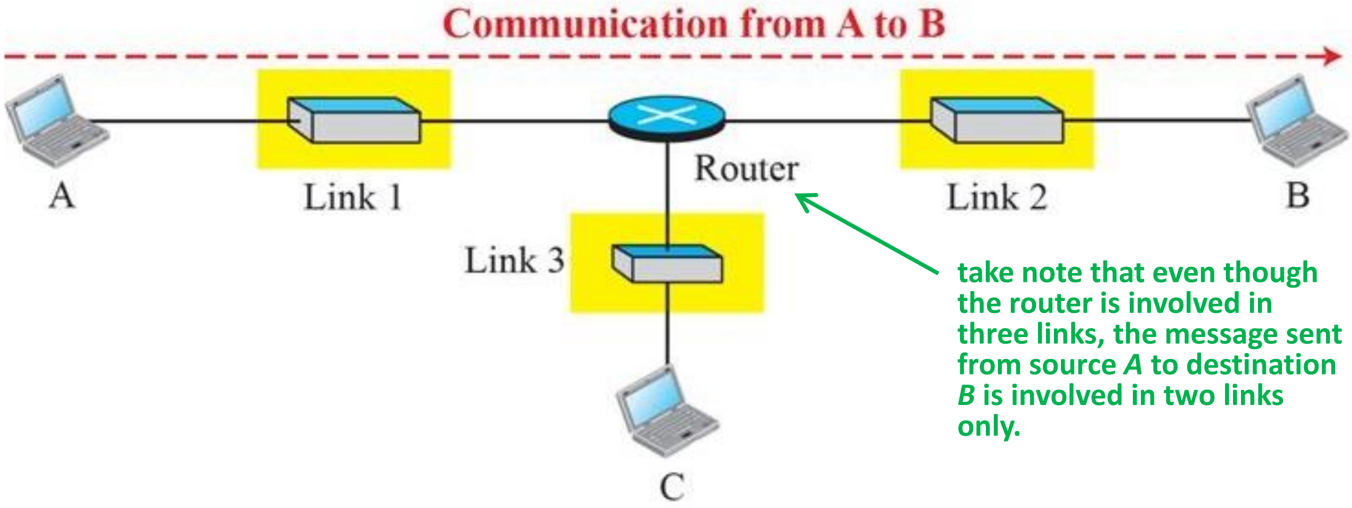
Assume also that the links are connected by one router.

TCP/IP PROTOCOL SUITE



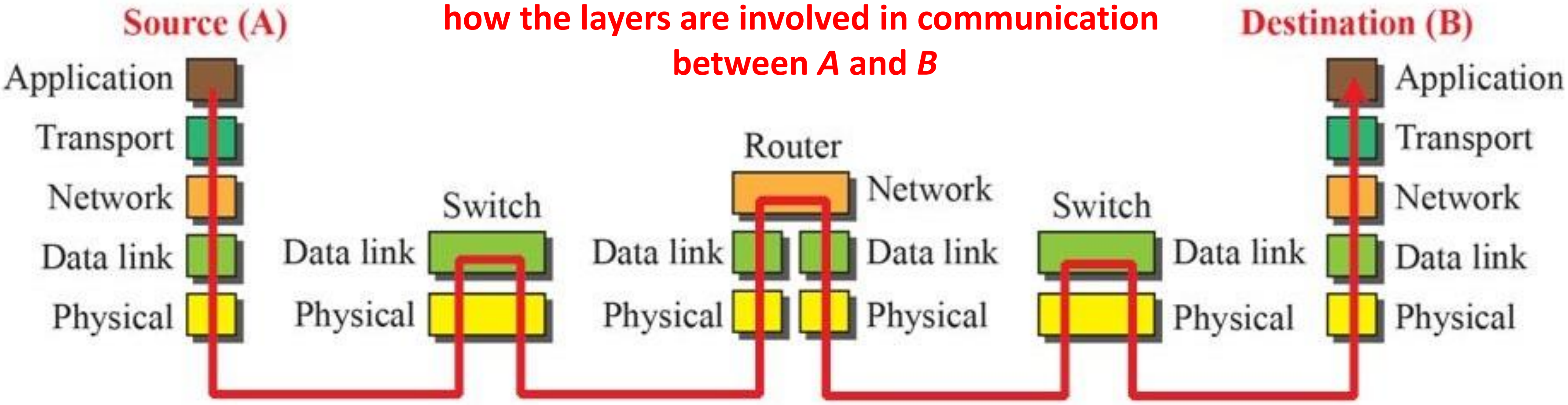
- There are five communicating devices in this communication: (1) source host (computer *A*), (2) the switch in link 1, (3) the router, (4) the switch in link 2, and (5) the destination host (computer *B*).

TCP/IP PROTOCOL SUITE



take note that even though the router is involved in three links, the message sent from source *A* to destination *B* is involved in two links only.

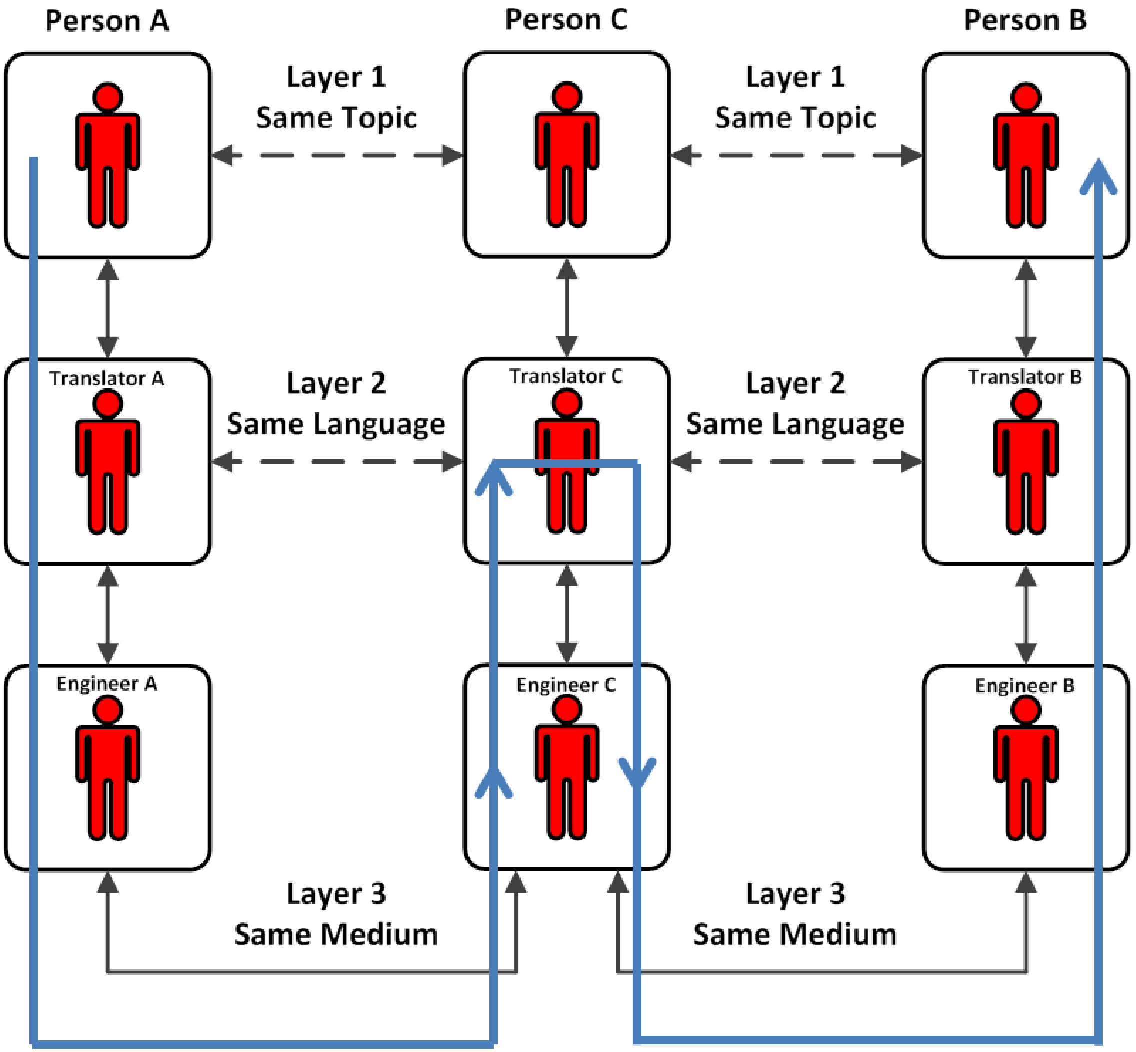
how the layers are involved in communication between *A* and *B*



TCP/IP PROTOCOL SUITE

Remember, not all layers in a particular site will be involved in the communication process.

It depends upon the situation.

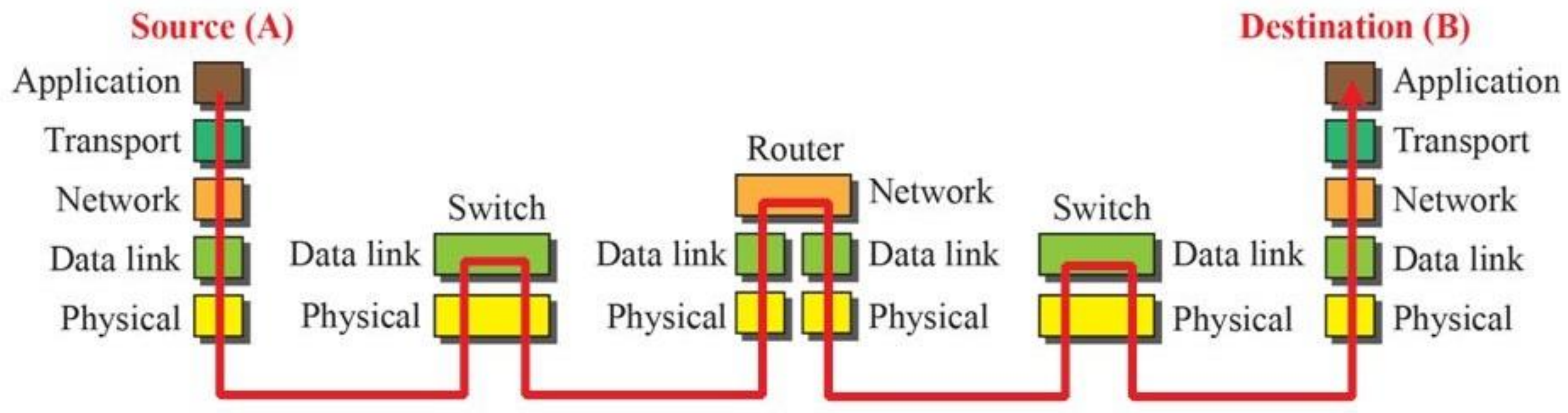


TCP/IP PROTOCOL SUITE

- Each device is involved with a set of layers depending on the role of the device in the internet.

- The two hosts (computers *A* and *B*) are involved in all five layers; the source host needs to create a message in the Application Layer and send it down the layers so that it is physically sent to the destination host.

  The destination host needs to receive the communication at the Physical Layer and then deliver it through the other layers to the Application Layer.

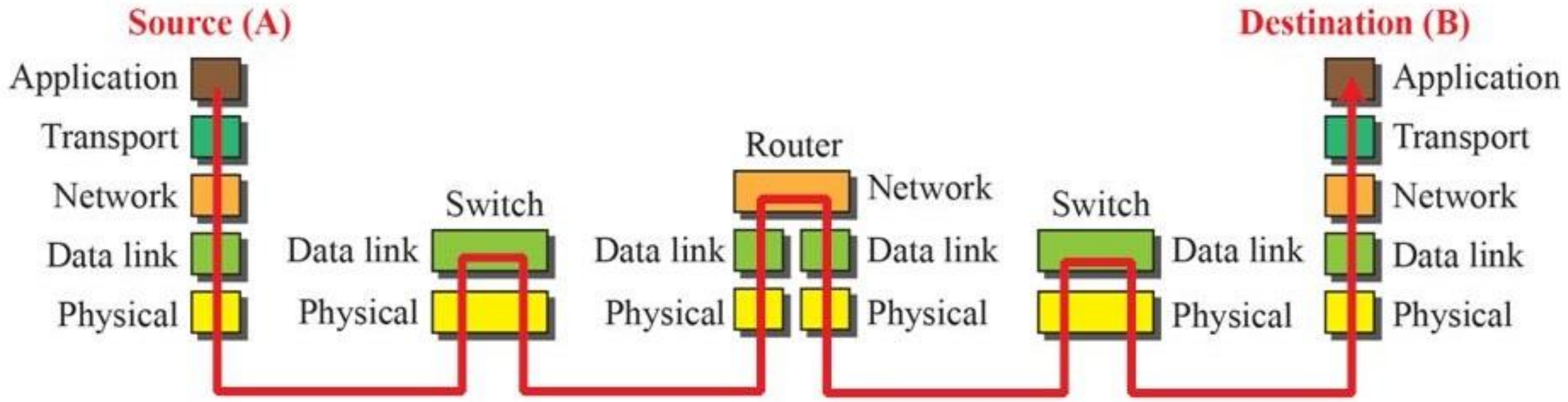


TCP/IP PROTOCOL SUITE

- The router is involved in only three layers; there is no Transport or Application Layer in a router as long as the router is used only for routing (finding the best path from *A* to *B*).

  Although a router is always involved in one Network Layer, it is involved in *n* combinations of Data Link and Physical Layer in which *n* is the number of links the router is connected to.

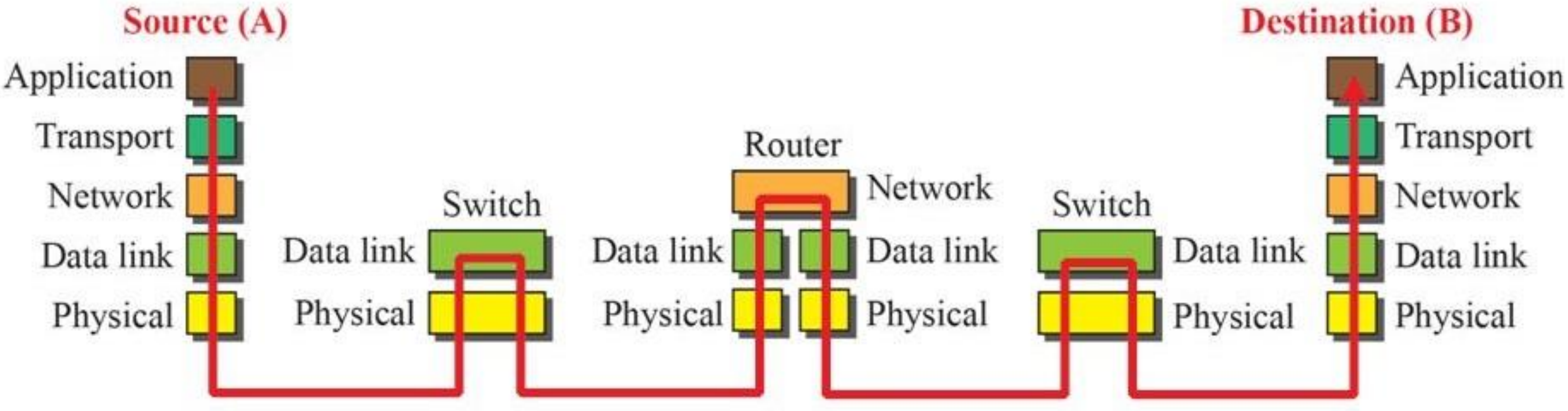
  Routers may interconnect dissimilar networks. The reason is that each link may use its own Data Link or Physical Layer protocol.



TCP/IP PROTOCOL SUITE

As mentioned earlier, the router is involved in three links, but the message sent from source *A* to destination *B* is involved in two links.

Each switch may be using different Data Link Layer and Physical Layer protocols; the router needs to receive data from switch 1 based on one pair of protocols and deliver it to switch 2 based on another pair of protocols.

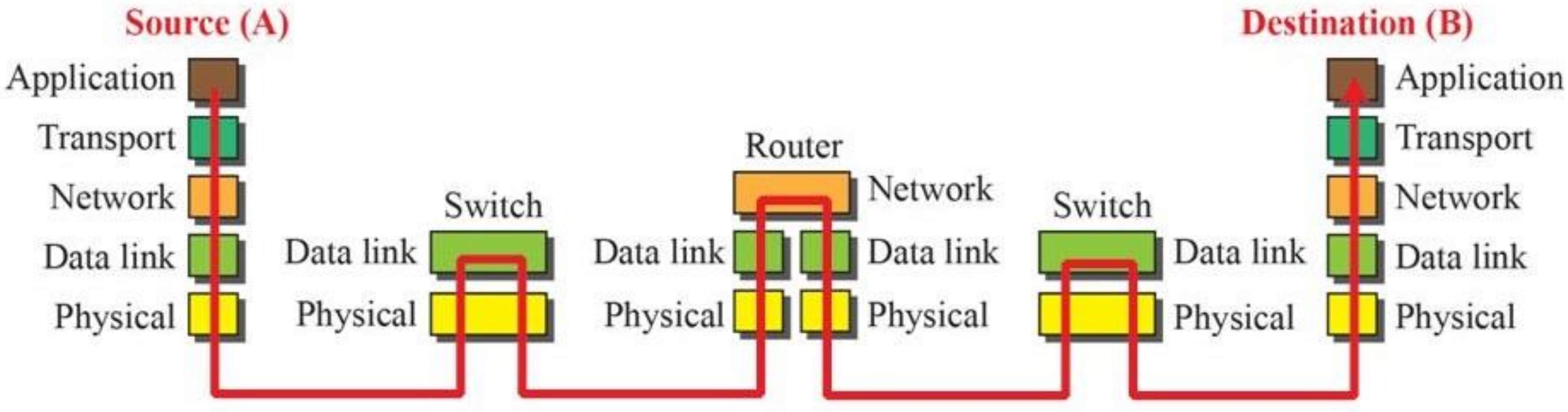


TCP/IP PROTOCOL SUITE

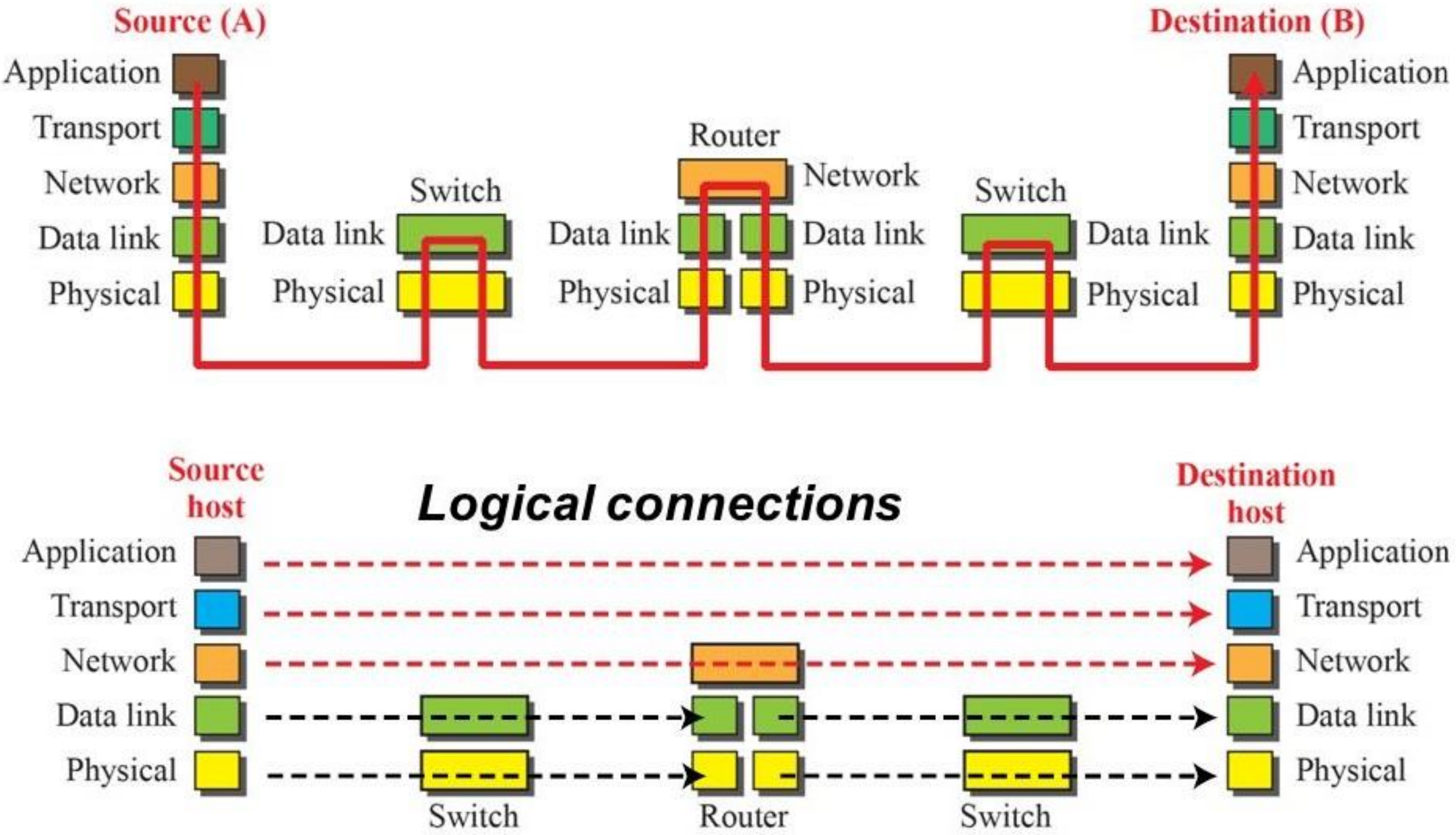
- A switch in a link, however, is involved only in two layers, Data Link and Physical.

  Although each switch has two different connections, the connections are in the same link, which uses only one set of protocols (switches are usually used to connect similar LANs).

  This means that, unlike a router, a switch is involved only in one Data Link and one Physical Layer.

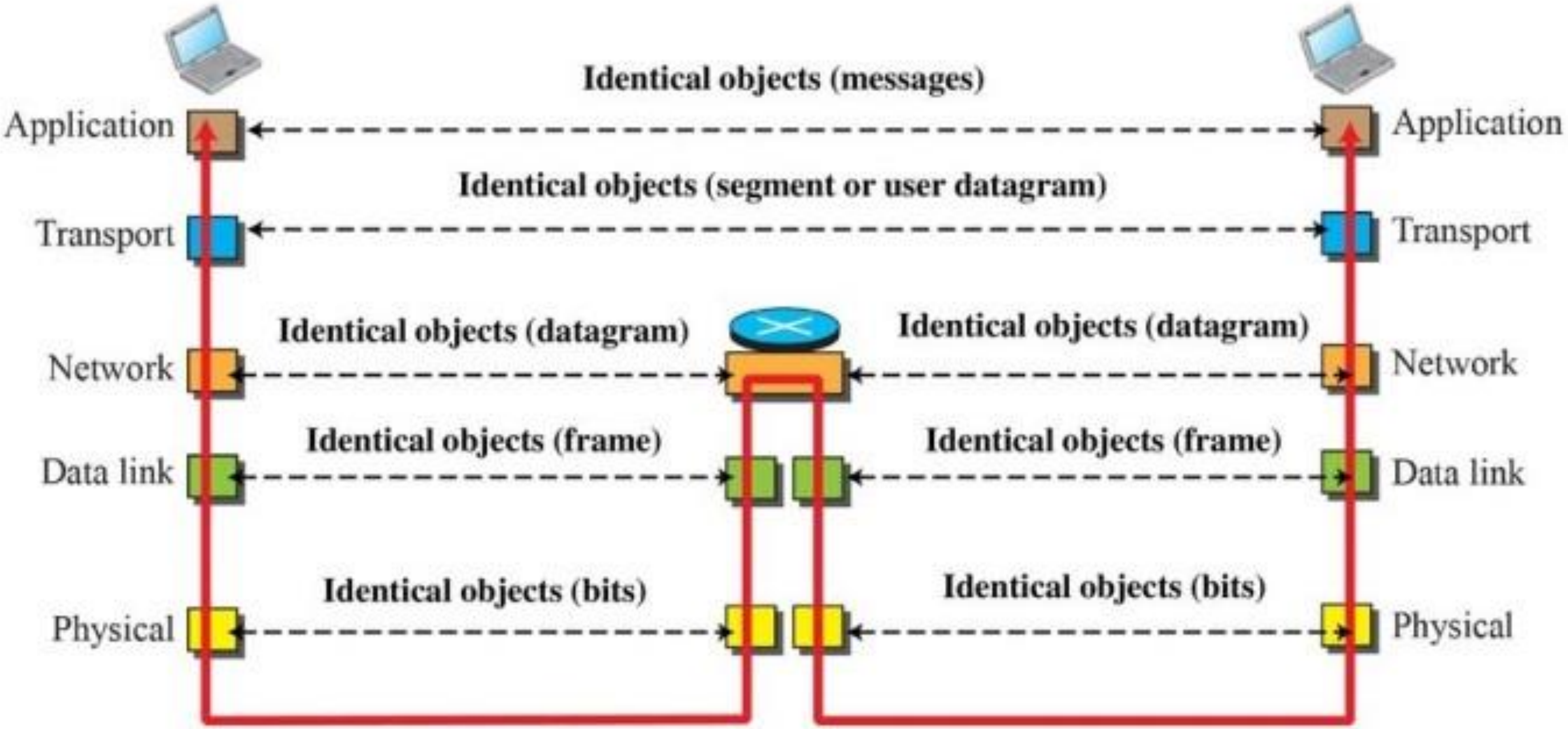


LOGICAL CONNECTIONS IN THE TCP/IP PROTOCOL SUITE



LOGICAL CONNECTIONS IN THE TCP/IP PROTOCOL SUITE

Identical Objects in the TCP/IP Protocol Suite

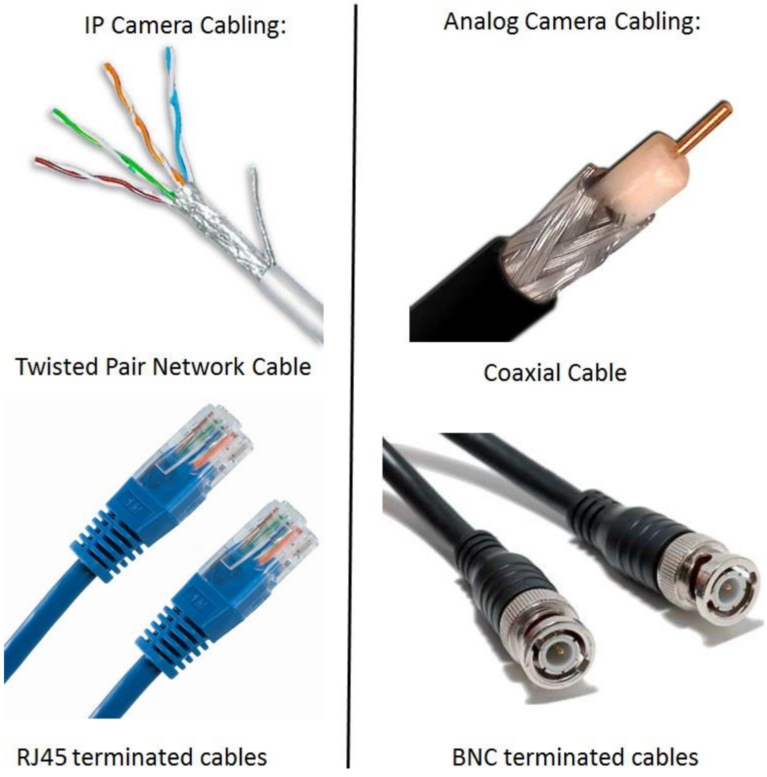

Identical objects (messages)
Application
Application
Identical objects (segment or user datagram)
Transport
Transport
Identical objects (datagram)
Identical objects (datagram)
Network
Network
Identical objects (frame)
Identical objects (frame)
Data link
Data link
Identical objects (bits)
Identical objects (bits)
Physical
Physical

THE PHYSICAL LAYER

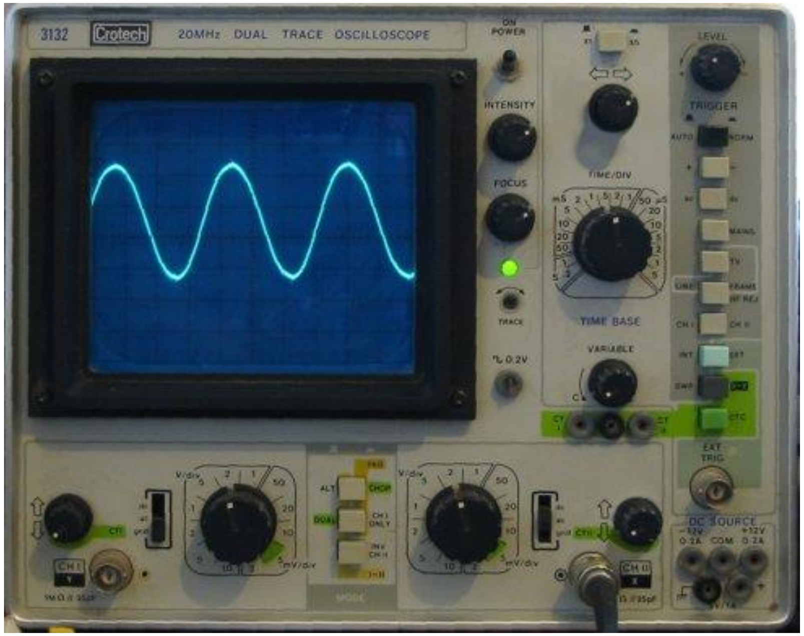
- The ***Physical Layer*** is responsible for transmitting the individual bits of the frame received from the Data Link Layer across the transmission medium (cable or air).

- Factors covered by the layer are the mechanical details and electrical/optical signaling.

- Mechanical details include how information should be transferred such as connector specifications - how many pins, dimensions, cabling and topology, etc.



THE PHYSICAL LAYER

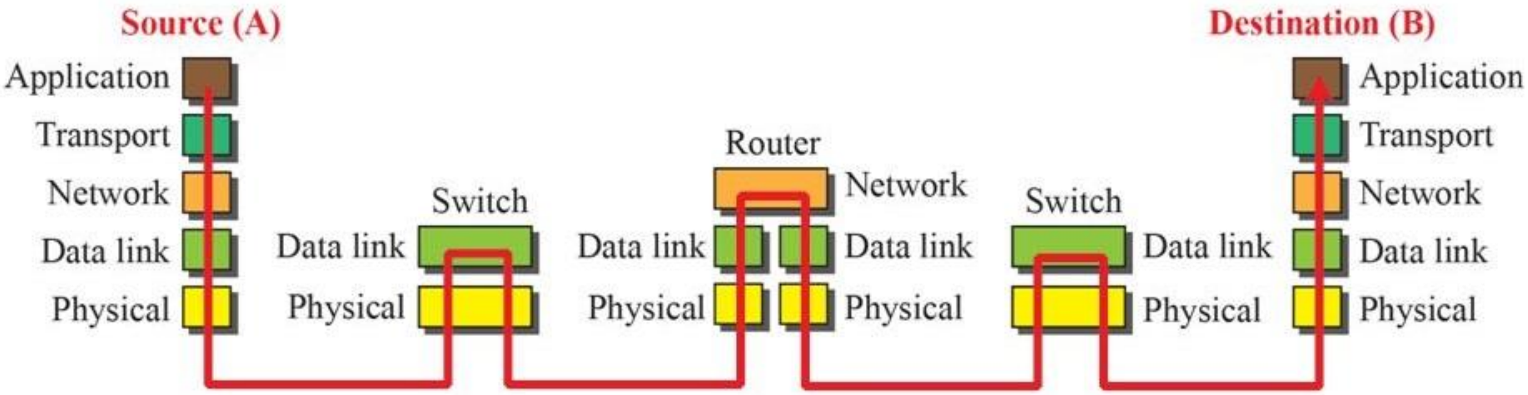


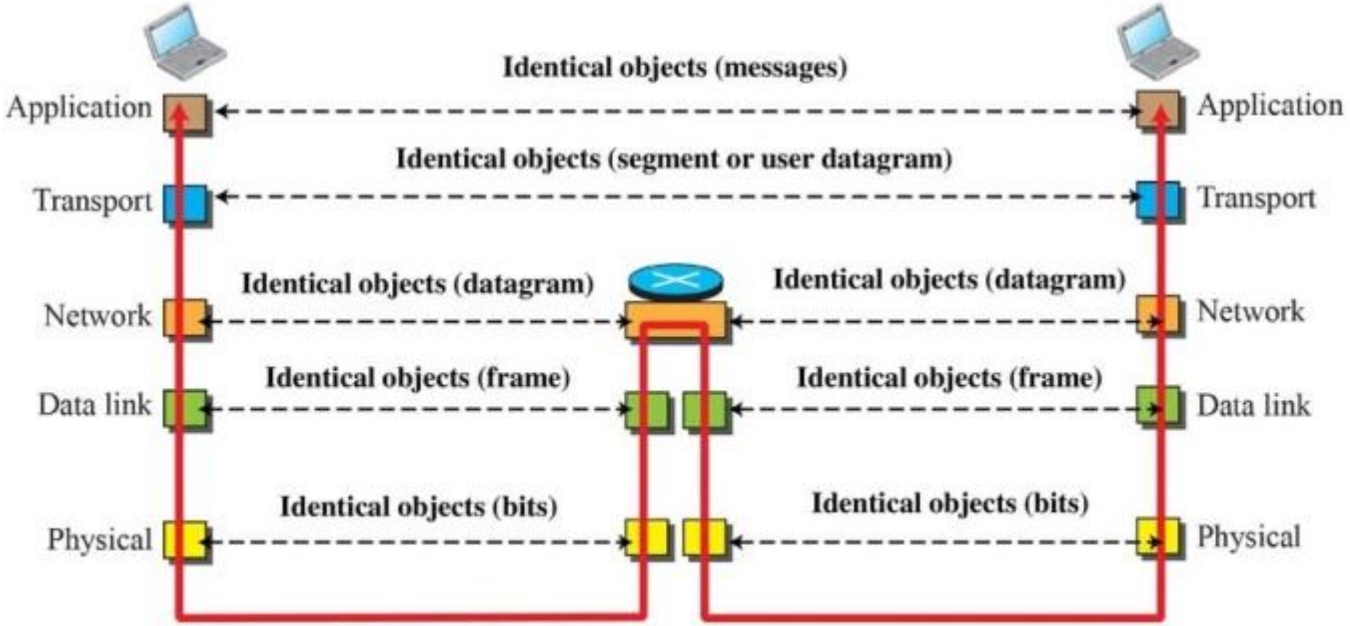
- Electrical/Optical signaling includes how information are electrically encoded, how device synchronization is achieved, how fast signal are transmitted from one device to another.

- Transfer rates are measured in the number of bits per second (bps).

- This is referred to as ***information capacity*** or ***bandwidth***.

THE PHYSICAL LAYER




Identical objects (messages)
Application
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Network
Network
Identical objects (frame)
Identical objects (frame)
Data link
Data link
Identical objects (bits)
Identical objects (bits)
Physical
Physical

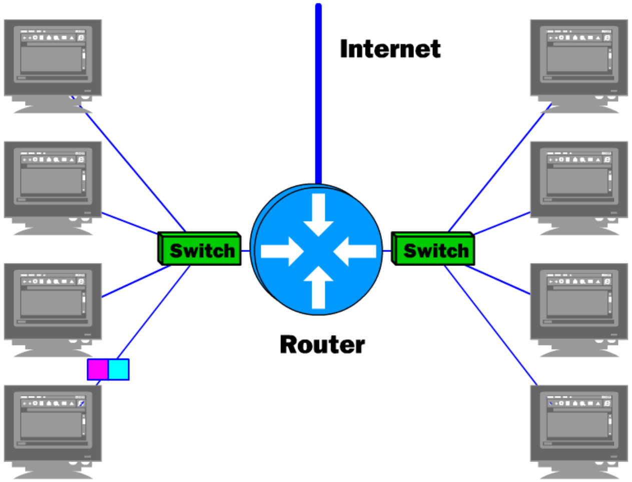
THE DATA LINK LAYER

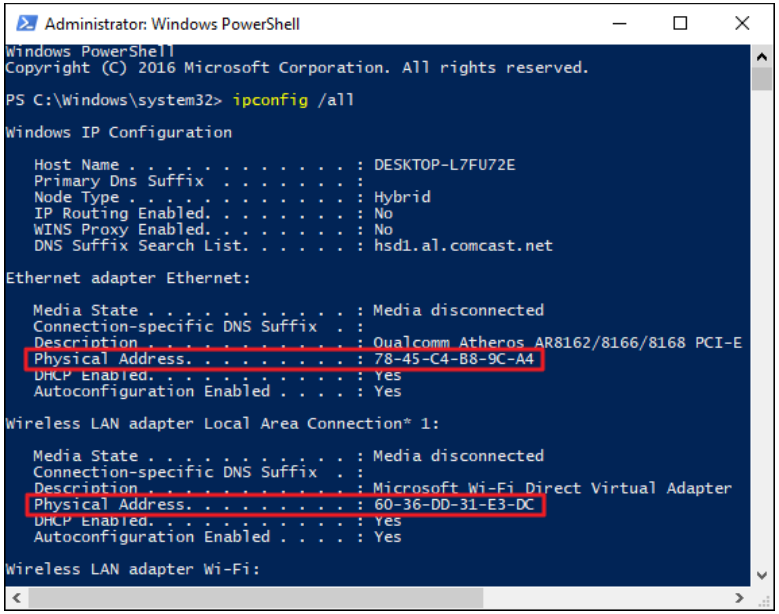
- This ***Data Link Layer*** controls how a device in a network can gain access to the transmission medium and get permission to transmit data.

  This is called ***Media Access Control*** (MAC).

  When transmitting data, this layer adds a header containing the source and destination MAC addresses to the datagram received from the Network Layer (layer 3) thus forming a Data Link Layer frame.

  The frame it creates will then be forwarded to the Physical Layer.





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Windows PowerShell
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PS C:\Windows\system32> ipconfig /all

Windows IP Configuration

   Host Name . . . . . . . . . . . . : DESKTOP-L7FU72E
   Primary Dns Suffix  . . . . . . . :
   Node Type . . . . . . . . . . . . : Hybrid
   IP Routing Enabled. . . . . . . . : No
   WINS Proxy Enabled. . . . . . . . : No
   DNS Suffix Search List. . . . . . : hsd1.al.comcast.net

Ethernet adapter Ethernet:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . :
   Description . . . . . . . . . . . : Qualcomm Atheros AR8162/8166/8168 PCI-E
   Physical Address. . . . . . . . . : 78-45-C4-B8-9C-A4
   DHCP Enabled. . . . . . . . . . . : Yes
   Autoconfiguration Enabled . . . . : Yes

Wireless LAN adapter Local Area Connection* 1:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . :
   Description . . . . . . . . . . . : Microsoft Wi-Fi Direct Virtual Adapter
   Physical Address. . . . . . . . . : 60-36-DD-31-E3-DC
   DHCP Enabled. . . . . . . . . . . : Yes
   Autoconfiguration Enabled . . . . : Yes

Wireless LAN adapter Wi-Fi:
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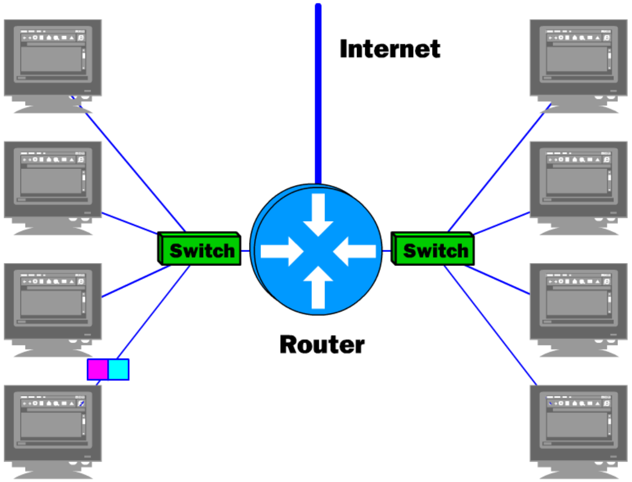
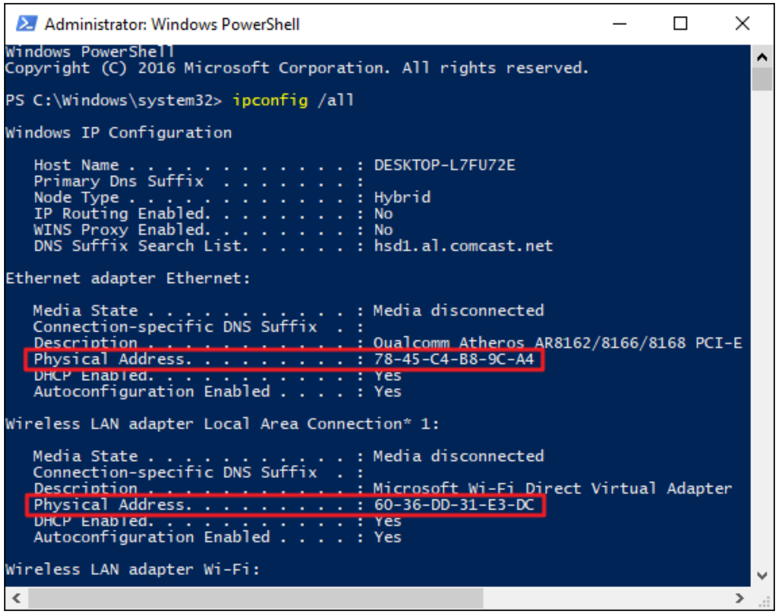
THE DATA LINK LAYER



The source and destination MAC address of a frame tells the receiving Data Link Layer whether it is the designated recipient of the frame and where the frame came from.

When receiving data, this layer is used to determine if the frame received by the host contains the host's MAC address.

If it does, the data is forwarded up to the Network layer.



```
Windows PowerShell
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PS C:\Windows\system32> ipconfig /all

Windows IP Configuration

   Host Name . . . . . . . . . . . . : DESKTOP-L7FU72E
   Primary Dns Suffix  . . . . . . . :
   Node Type . . . . . . . . . . . . : Hybrid
   IP Routing Enabled. . . . . . . . : No
   WINS Proxy Enabled. . . . . . . . : No
   DNS Suffix Search List. . . . . . : hsd1.al.comcast.net

Ethernet adapter Ethernet:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . :
   Description . . . . . . . . . . . : Qualcomm Atheros AR8162/8166/8168 PCI-E
   Physical Address. . . . . . . . . : 78-45-C4-B8-9C-A4
   DHCP Enabled. . . . . . . . . . . : Yes
   Autoconfiguration Enabled . . . . : Yes

Wireless LAN adapter Local Area Connection* 1:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . :
   Description . . . . . . . . . . . : Microsoft Wi-Fi Direct Virtual Adapter
   Physical Address. . . . . . . . . : 60-36-DD-31-E3-DC
   DHCP Enabled. . . . . . . . . . . : Yes
   Autoconfiguration Enabled . . . . : Yes

Wireless LAN adapter Wi-Fi:
```

THE DATA LINK LAYER

- The Data Link Layer also contains the protocols for error-control.

  Error control can vary from *Detection-only* to *Detection and Correction*.

  This allows for having an alert mechanism whether physically the data bits received are erroneous or not.

  Errors are detected by including a block of data (or set of bits) which is correlated with the original data.

  This block of data is called the ***checksum***.

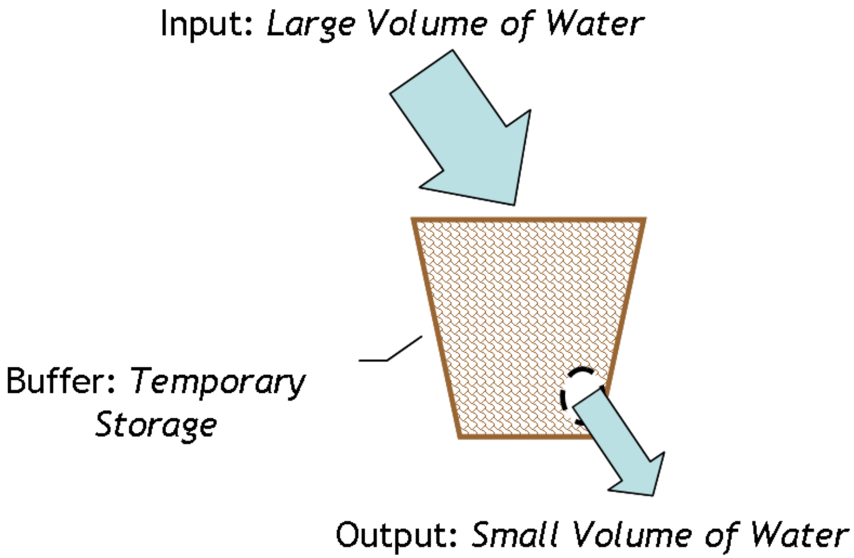
THE DATA LINK LAYER

- Aside from error-control, the data-link layer also provides for ***flow-control***.

  This ensures that data are transferred to the adjacent device at the correct rate (amount of info at a time).

  If data are sent too fast than what a receiver can handle, there will be the possibility of overflow at the receiver end resulting to discarded data.

THE DATA LINK LAYER


Input: *Large Volume of Water*
Buffer: *Temporary Storage*
Output: *Small Volume of Water*

Receiver hardware are designed to temporarily hold information until the actual decoder can process the received information.

However, if the faster sender hardware continues to send more information, eventually the temporary storage space will run out.

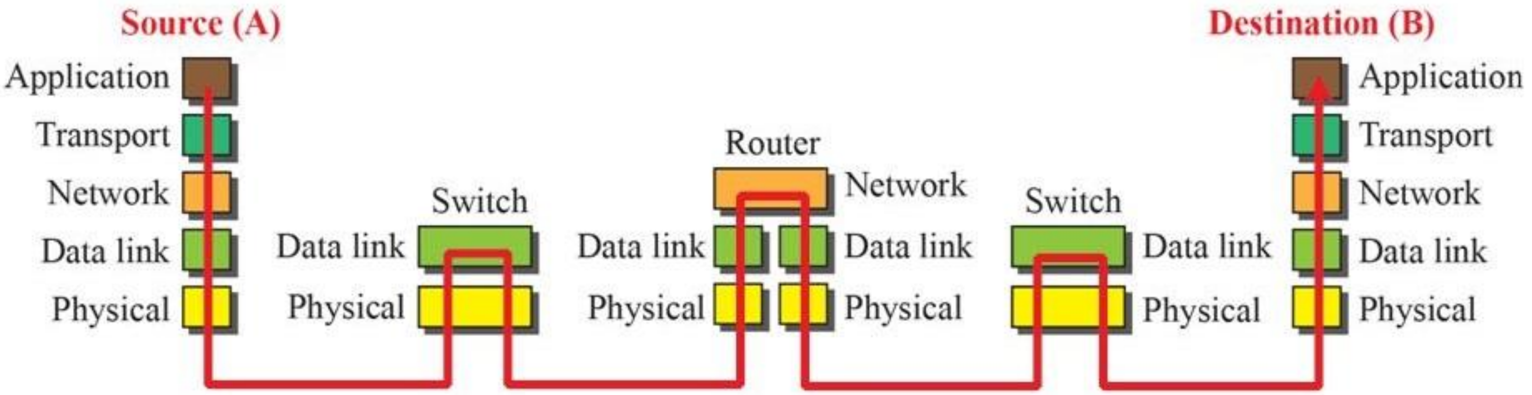
THE DATA LINK LAYER

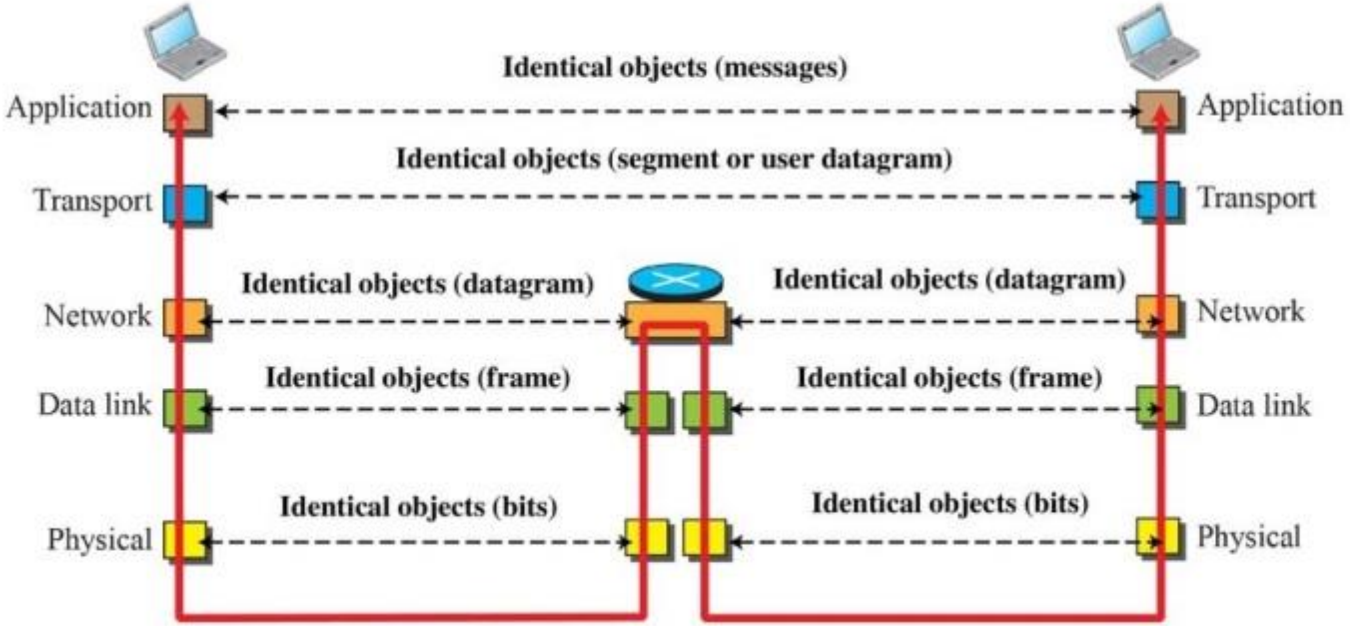
- It is then important for both sender and receiver devices to perform ***handshakes*** to negotiate an optimal rate at which they should transfer information.

  So if a 56kbps modem connects to a 28.8kbps modem across the telephone network, both agree to use a rate both devices can handle.

  It is easier for the 56kbps modem to downshift its rate than for the 28.8kbps modem to increase its throughput.

THE DATA LINK LAYER

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Identical objects (segment or user datagram)
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Network
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Identical objects (frame)
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Data link
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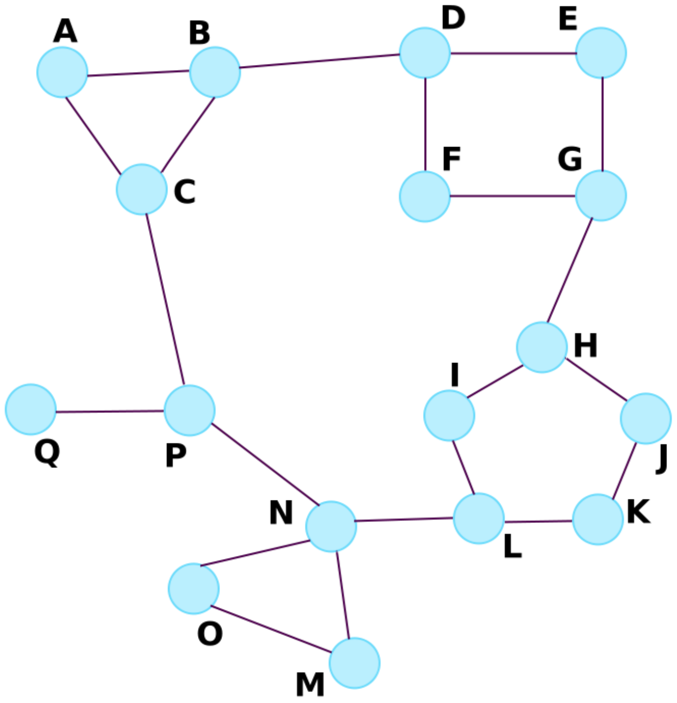
Identical objects (bits)
Physical
Physical

THE NETWORK LAYER



- The ***Network Layer*** takes care of packet forwarding (or datagram forwarding). In doing so, it has to decide which network path or route is to be taken by the packets.

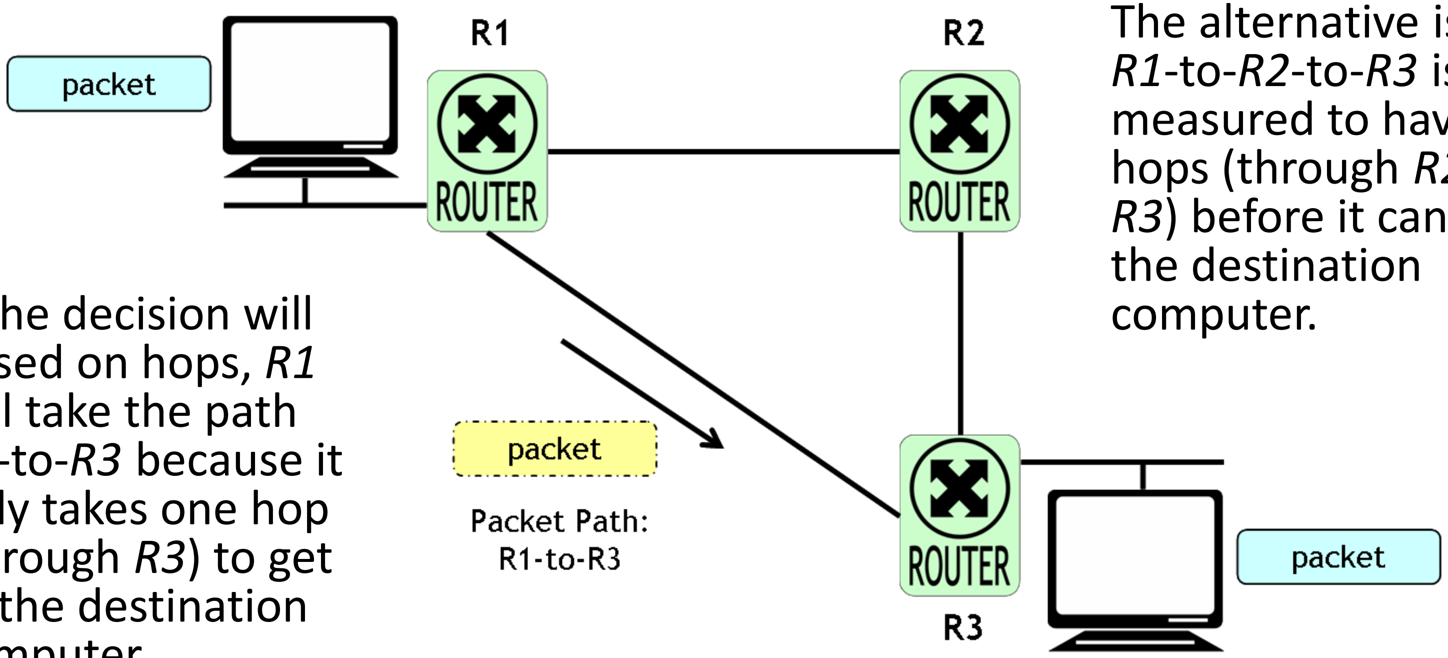
- Routers decide based on the routing criteria set, referred to as ***routing metrics***.

Metrics can be the number of routers along the path, the physical link bandwidth, the link load or just about any parameter significant to computer networks.

As an example, the *hop metric* refers to the number of routers the packet must traverse before getting to the destination device.

THE NETWORK LAYER

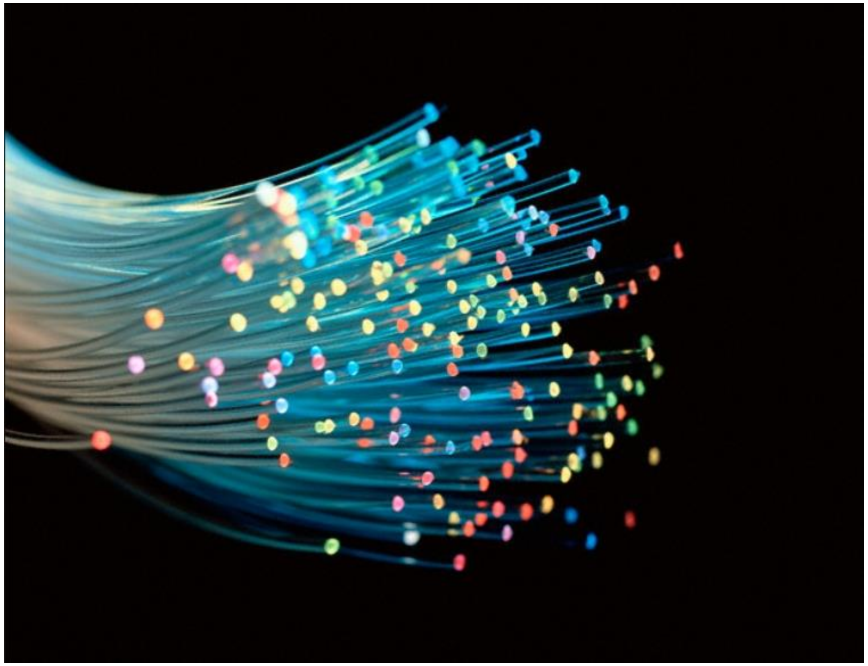
- Router *R1* has two paths to decide on – either to take *R1*-to-*R3* or *R1*-to-*R2*-to-*R3*.



The alternative is path *R1*-to-*R2*-to-*R3* is measured to have two hops (through *R2* then *R3*) before it can get to the destination computer.

If the decision will based on hops, *R1* will take the path *R1*-to-*R3* because it only takes one hop (through *R3*) to get to the destination computer.

THE NETWORK LAYER

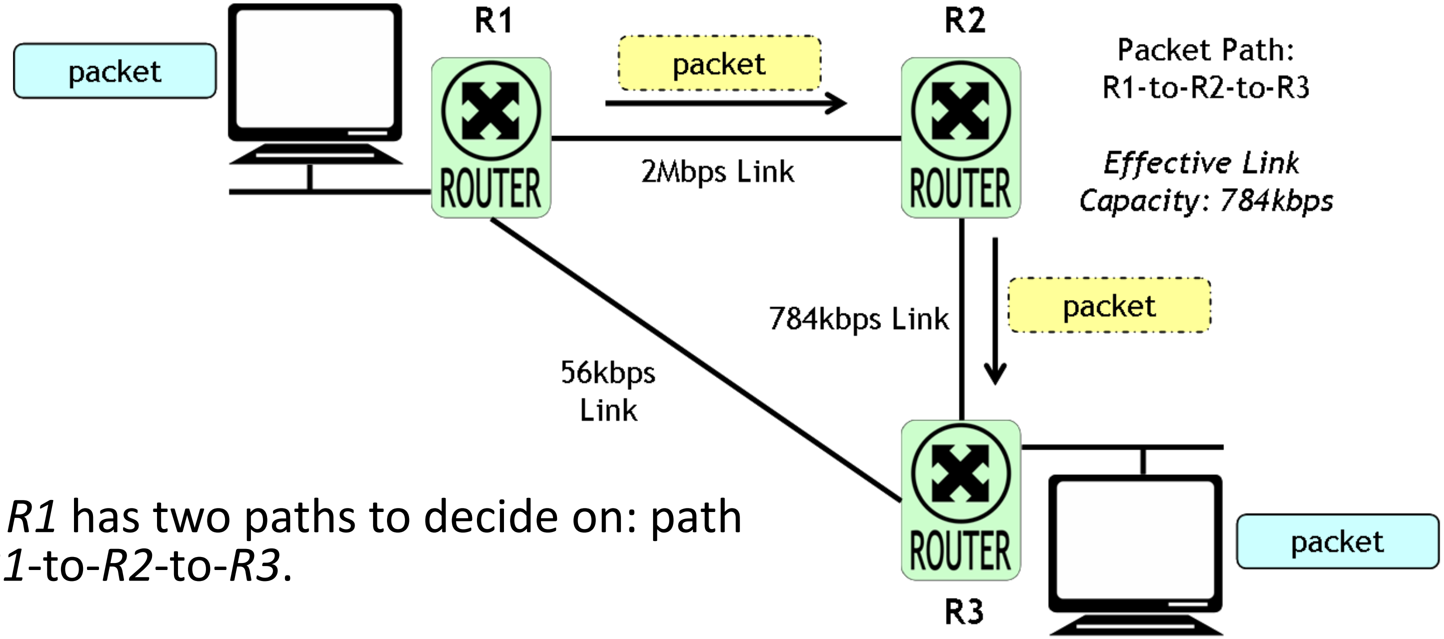


- Alternately, path selection can be based on overall physical link capacity, or bandwidth.

  This is more commonly used in the Internet as packets get to the destination sooner if a wider bandwidth link is chosen.

  A hop metric does not guarantee faster delivery since a path may take only one hop but the link bandwidth is a dial-up connection (very slow).

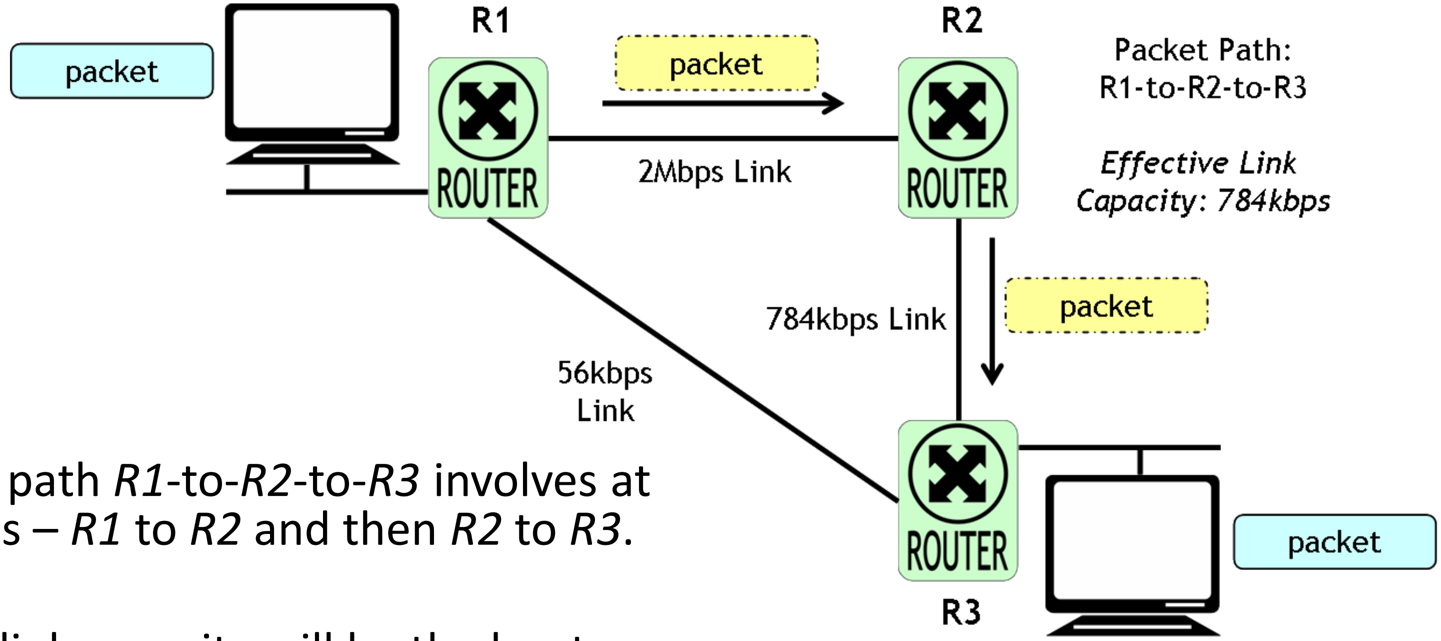
THE NETWORK LAYER



Again, router *R1* has two paths to decide on: path *R1*-to-*R3* or *R1*-to-*R2*-to-*R3*.

If link capacity will be the basis, it is important for *R1* to determine the effective link capacity to the destination for every path option. In path *R1*-to-*R3*, since this is just a single hop path the effective link capacity will be that of the link – 56kbps.

THE NETWORK LAYER



However, the path *R1*-to-*R2*-to-*R3* involves at least two hops – *R1* to *R2* and then *R2* to *R3*.

The effective link capacity will be the least capacity among the series of links. In this case, the effective link capacity is 784kbps.

Having this information, *R1* can then decide which path has more link capacity. The choice then is path *R1*-to-*R2*-to-*R3*.

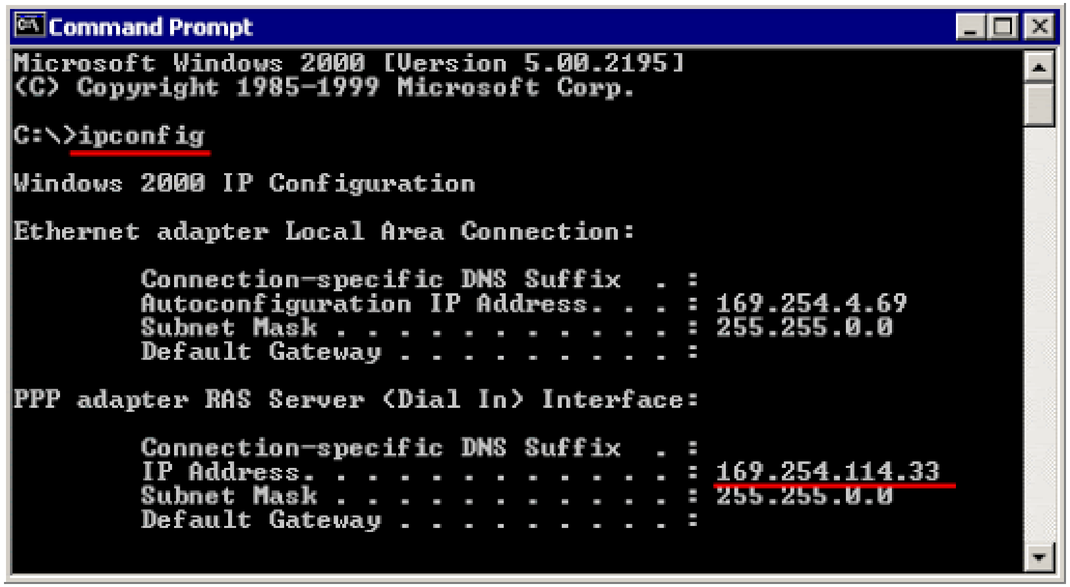
THE NETWORK LAYER

- In the Internet, the ***Internet Protocol*** (IP) is the Network Layer protocol of TCP/IP in which data is sent from one computer to another on the Internet.

  It uses unique addresses for the different devices connected.

  Such an address is called an ***IP Address*** and it is a unique identifier for every machine using the internet.

  It is used to route traffic to the desired destination host.



```
Microsoft Windows 2000 [Version 5.00.2195]
(C) Copyright 1985-1999 Microsoft Corp.

C:\>ipconfig

Windows 2000 IP Configuration

Ethernet adapter Local Area Connection:

        Connection-specific DNS Suffix  . :
        Autoconfiguration IP Address. . . : 169.254.4.69
        Subnet Mask . . . . . . . . . . . : 255.255.0.0
        Default Gateway . . . . . . . . . :

PPP adapter RAS Server (Dial In) Interface:

        Connection-specific DNS Suffix  . :
        IP Address. . . . . . . . . . . . : 169.254.114.33
        Subnet Mask . . . . . . . . . . . : 255.255.0.0
        Default Gateway . . . . . . . . . :
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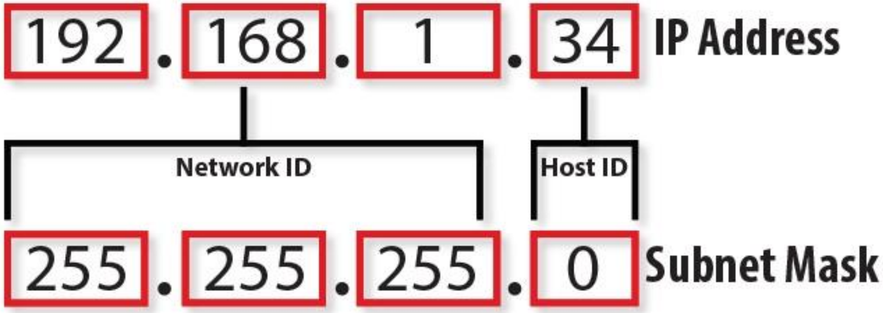
The Internet Protocol defines the format and the structure of addresses used in this layer.

Sample IP Address: 169.254.114.33

THE NETWORK LAYER



- A MAC address is a physical address while the IP address is a logical address.

  A MAC address is fixed and never changes while an IP address may change.

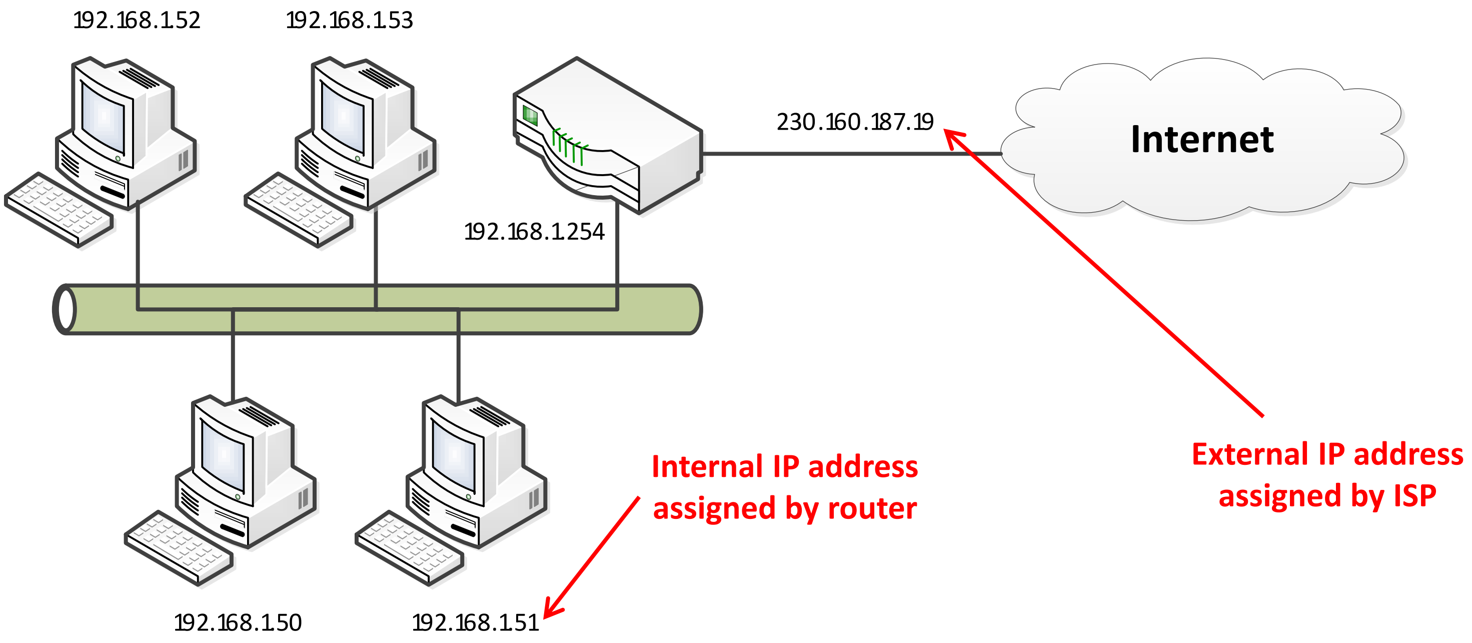
  MAC addresses cannot be used for routing. They are just a unique number, but they provide no help to figure out how to get to that computer.

  IP addresses are actually composed of network IDs and host IDs that can be used to locate a computer in the entire Internet.

THE NETWORK LAYER

- Every device in a network has a unique IP address (***internal IP address***). A device in a local network can be directly reached from other devices at this number.

- For external Internet access, however, all devices generally use the IP address of the router (***external IP address***).

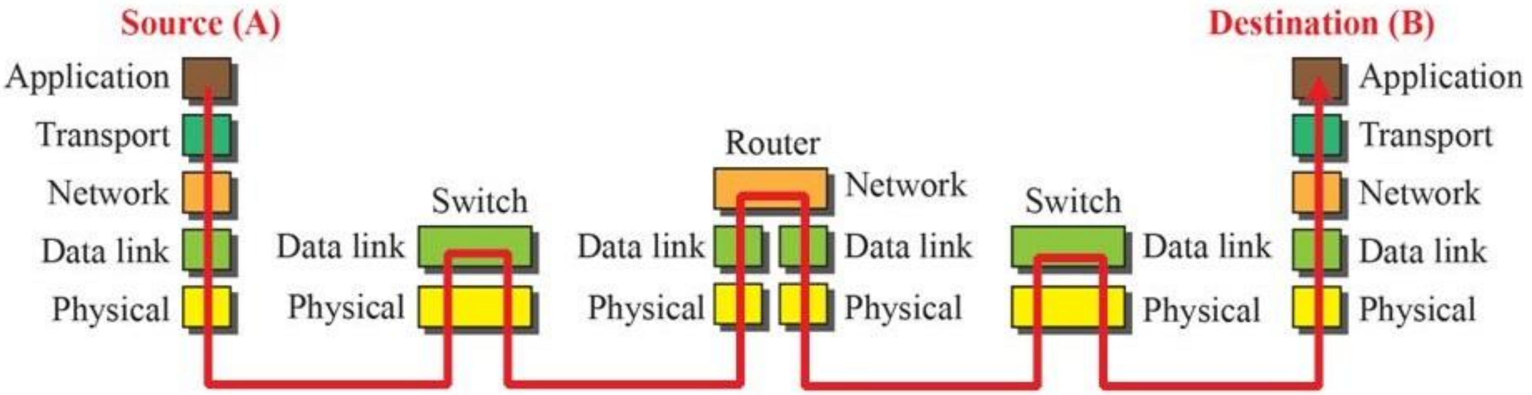


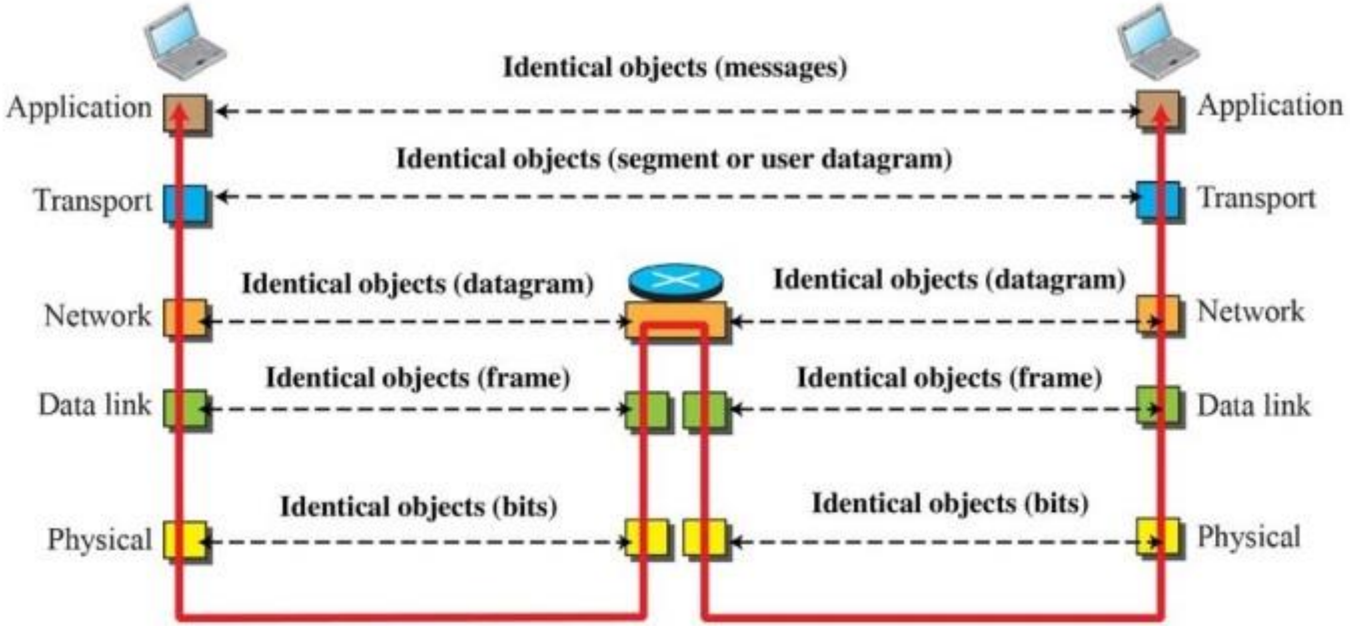
Internal IP address assigned by router

External IP address assigned by ISP

THE NETWORK LAYER

THE NETWORK LAYER

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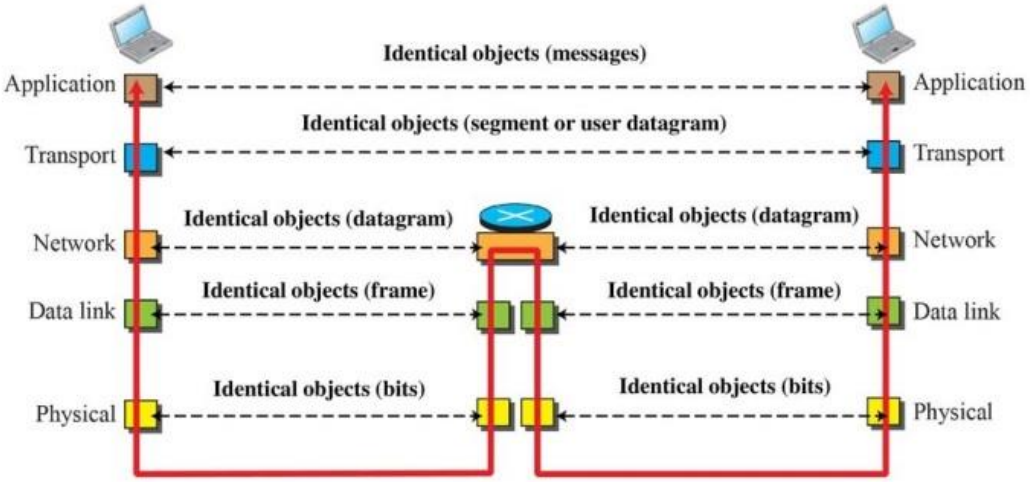
THE TRANSPORT LAYER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Identical objects (bits)
Physical
Physical

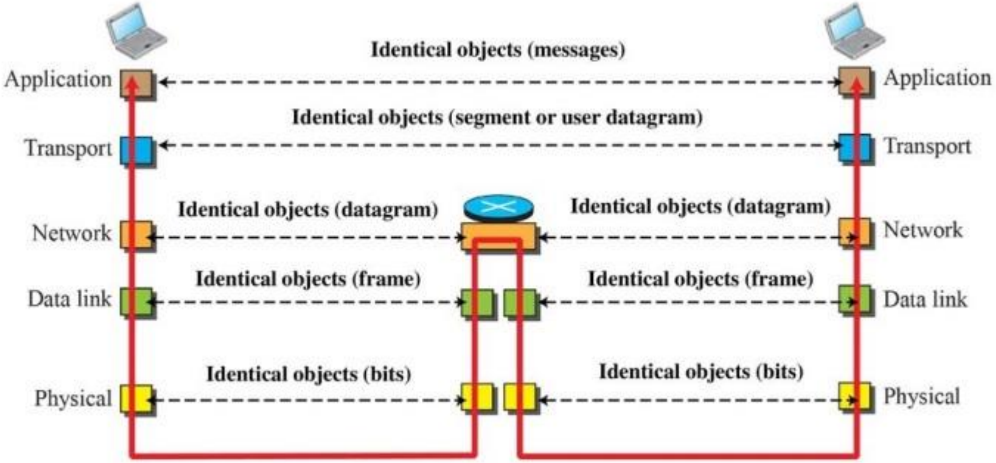
- The ***Transport Layer*** contains the protocols that ensure that the transmitted data gets to the other device (data integrity).

- In other words, the Transport Layer provides a reliable mechanism for the exchange of data between processes in different systems.

THE TRANSPORT LAYER

- The Transport Layer at the source host:

1. gets the message from the Application Layer,
2. breaks it up into manageable chunks or packets (called ***segments*** or ***user datagrams***)
3. labels them with numbers so they can be reassembled in the correct order
4. and sends them, through the logical (imaginary) connection, to the Transport Layer at the destination host.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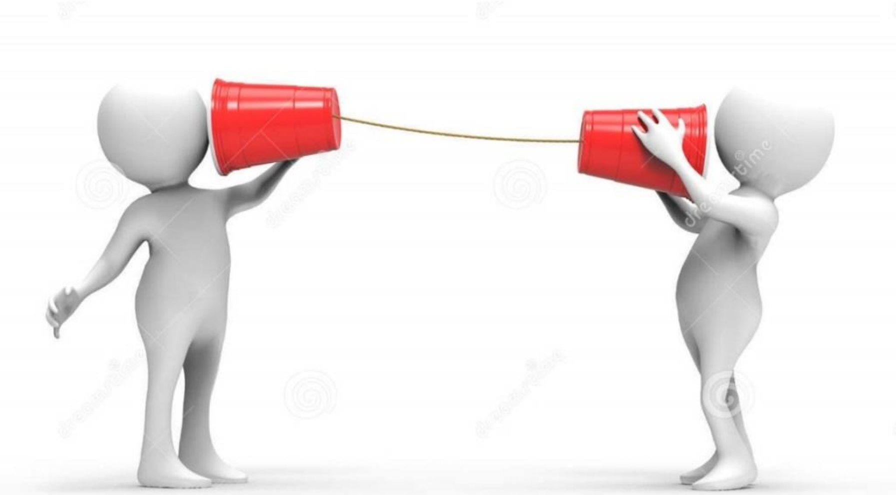
Physical
Physical

- It ensures that the packets are delivered error-free, in sequence, with no losses or duplication.

THE TRANSPORT LAYER

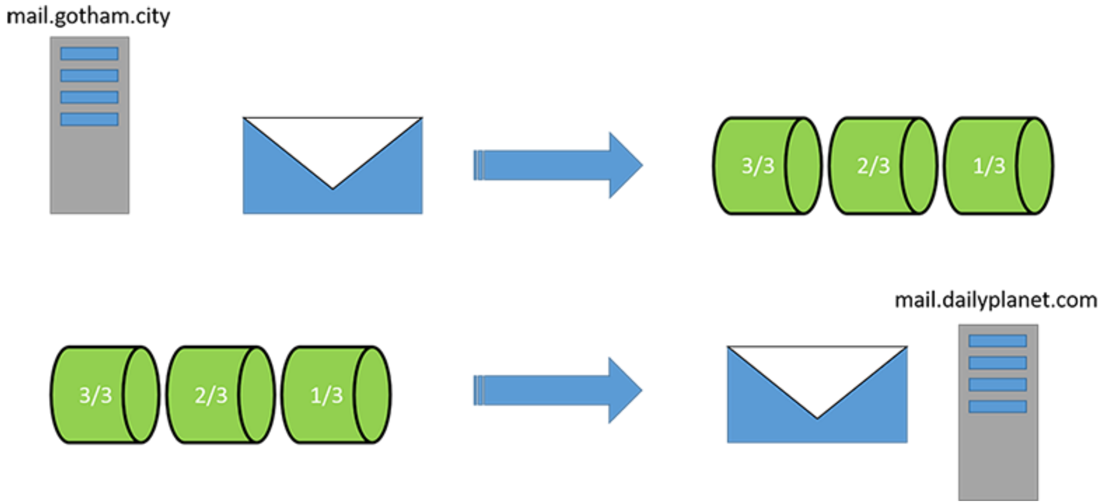


- In the Internet, the ***Transmission Control Protocol*** (IP) is a Transport Layer protocol that is a ***connection-oriented protocol*** that first establishes a logical (imaginary) connection between Transport Layers at two hosts before transferring data.

  It is a connection-oriented protocol because it ensures that packets are always in the proper order before giving the message to the receiving Application Layer (it's like having a physical connection between transmitter and receiver like a telephone connection).

THE TRANSPORT LAYER

- In computer networks, the Transport Layer breaks the message (from the Application Layer) into data packets.
- These packets are labelled chronologically so that when packets get to the receiving end not in the right order the Transport Layer of the receiving end can put them together to the original order and hence, back to the original block.
- The label also allows the receiver to detect missing packets.

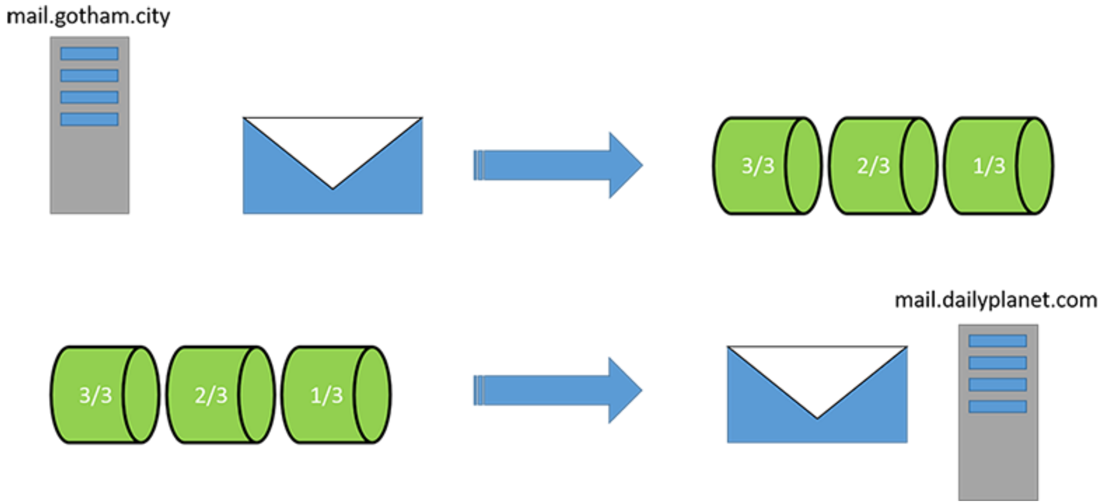


THE TRANSPORT LAYER

- Sometimes Transport Layer protocols are also provisioned to ***time-out*** and ask for a retransmission if a packet does not get to the receiver on time.

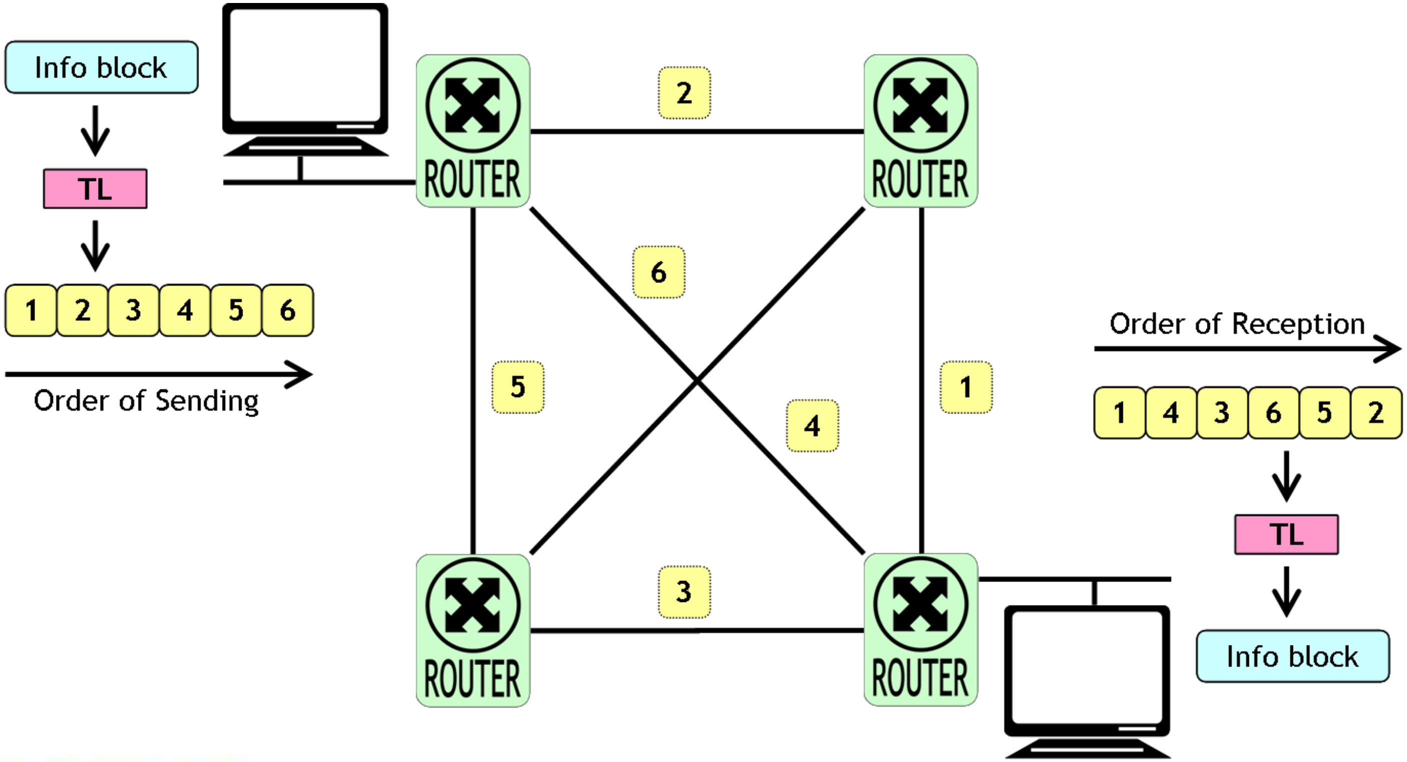
- If the original packet is just late in arriving, the request for retransmission may result to a second packet to be sent to the receiver again.

- This can cause the receiver to have two copies of the same packet – a duplicate packet.



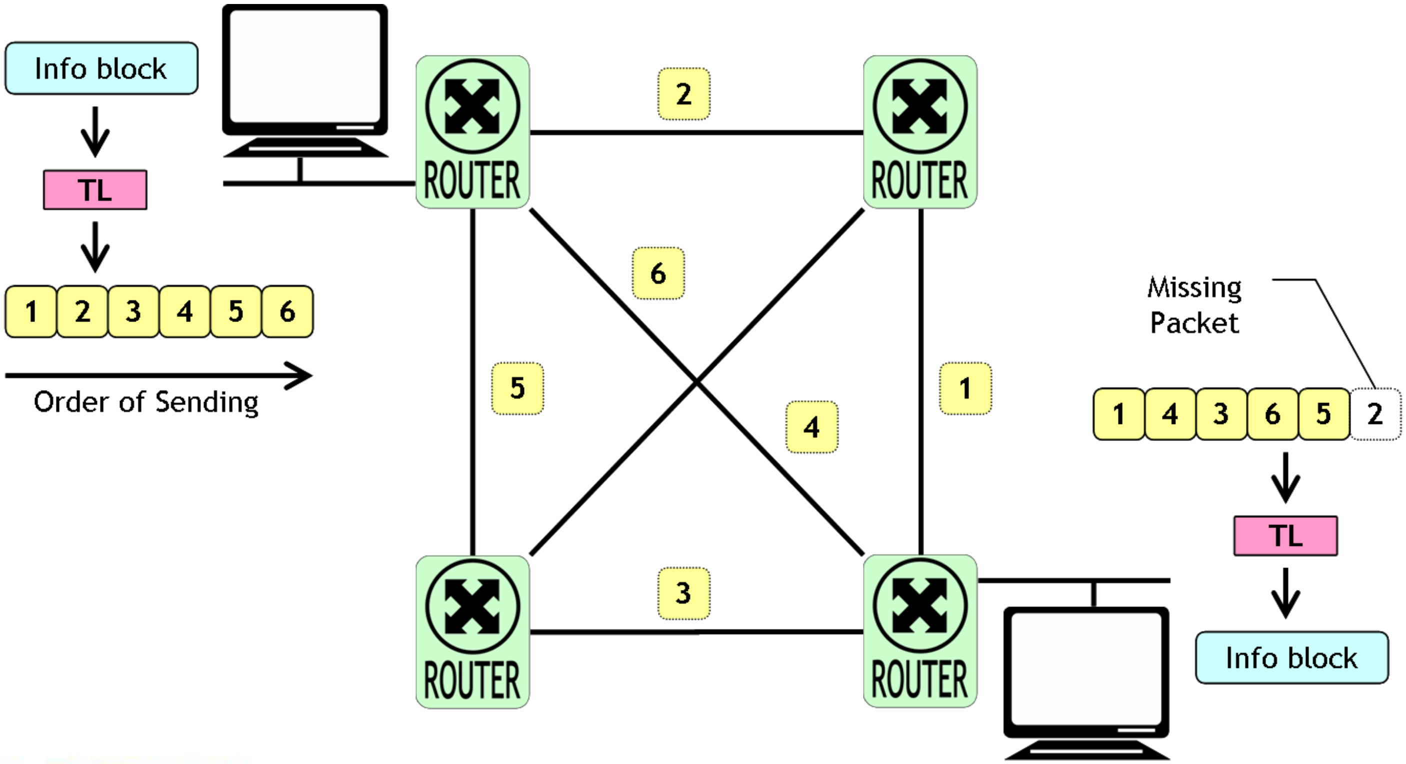
THE TRANSPORT LAYER

- In the case when packets reach the destination not in the right order, the Transport Layer (TL) assumes responsibility of putting these packets in the right order to produce the correct information block.



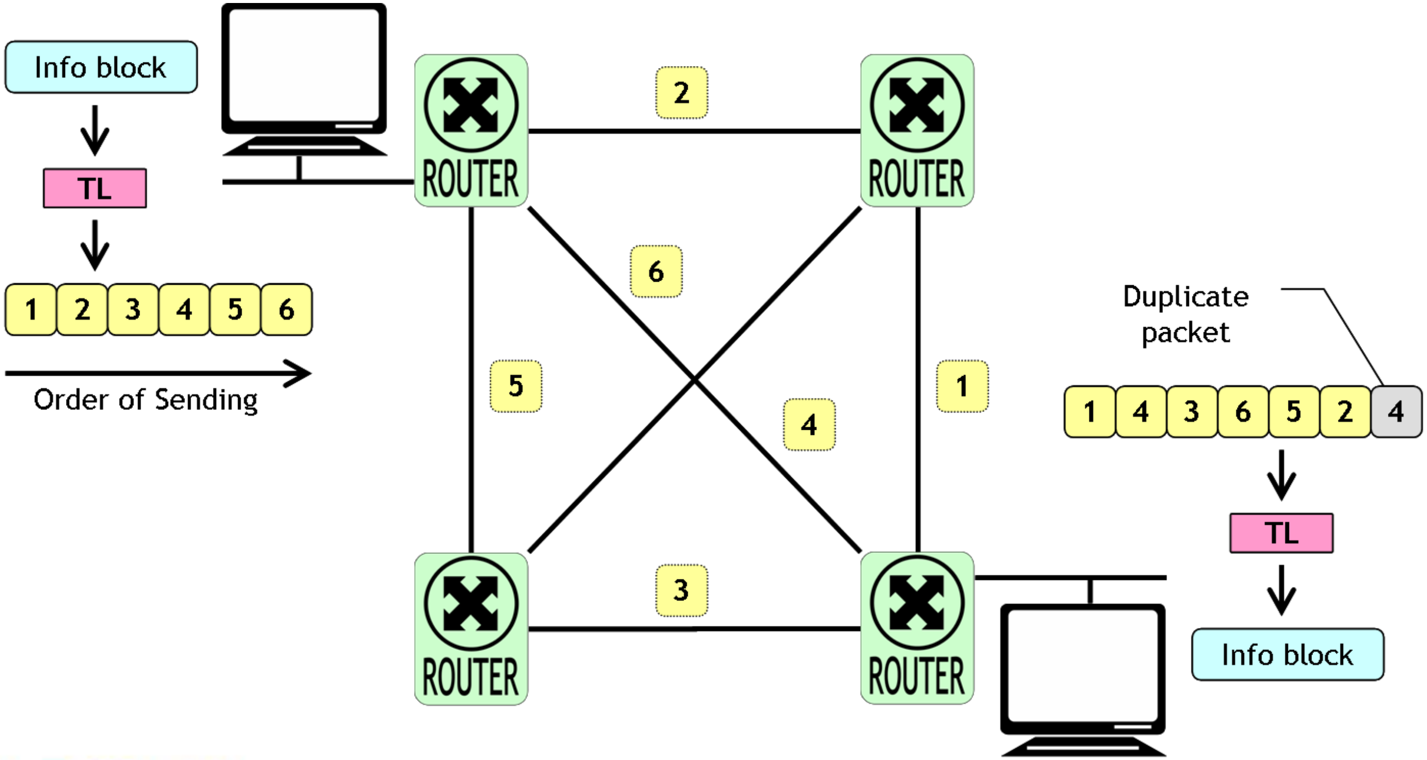
THE TRANSPORT LAYER

- In the case when a missing packet is detected at the receiver, it is the TL that initiates for the receiver to request for retransmission



THE TRANSPORT LAYER

In the case of duplicate, or even triplicate, packets getting to the receiver, the Transport Layer takes care of discarding the redundant packet.

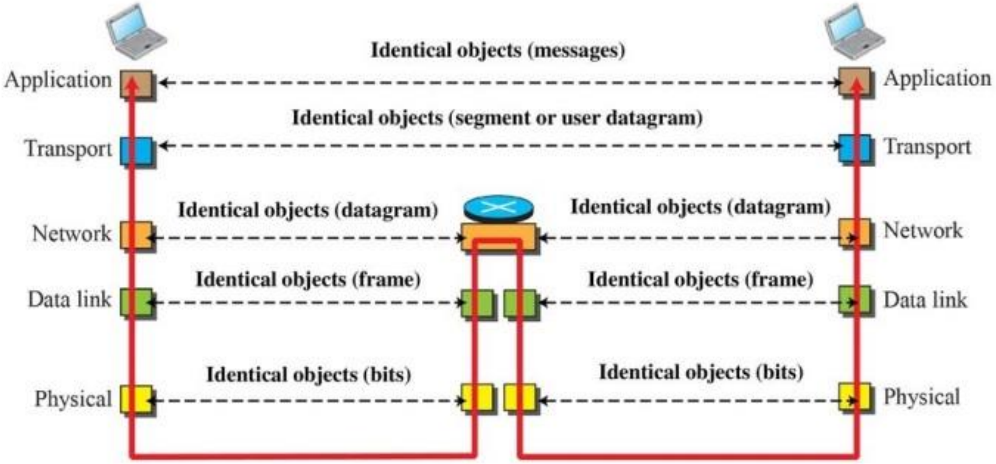


THE TRANSPORT LAYER

- The Transport Layer also performs end-to-end error control.

  Error control is an issue that occurs at the Data Link Layer and Transport Layer as well.

  The errors checked for at the Data Link Layer are errors in transmission from one link to its next link. Did the receiving link get the same data sent out from the sending link?



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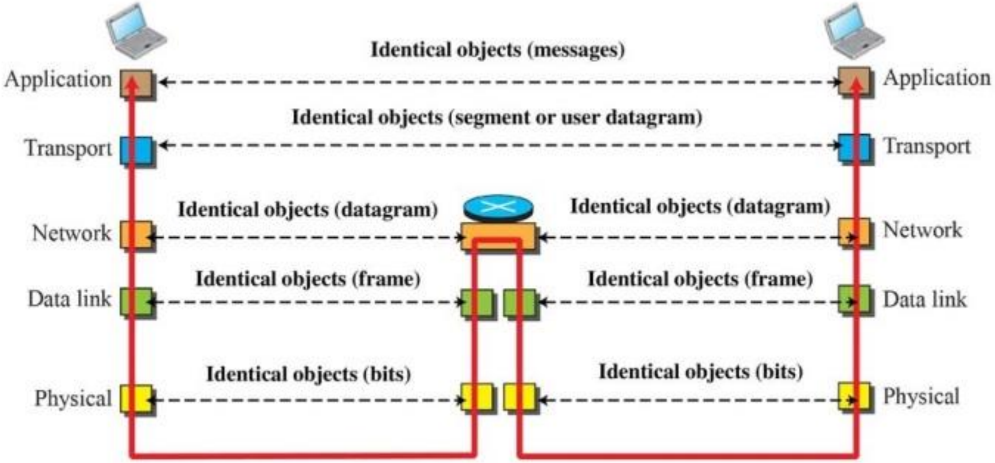
Data link
Data link
Identical objects (bits)
Identical objects (bits)
Physical
Physical

THE TRANSPORT LAYER

Between the sending and receiving side could be a lot of intermediate routers. During that transit there could be problems as:

1. One or more packets get lost.
2. Packets lose their original order.
3. Duplicate packets.
4. One or more frames are discarded.
5. A malfunctioning router modifies the data in a packet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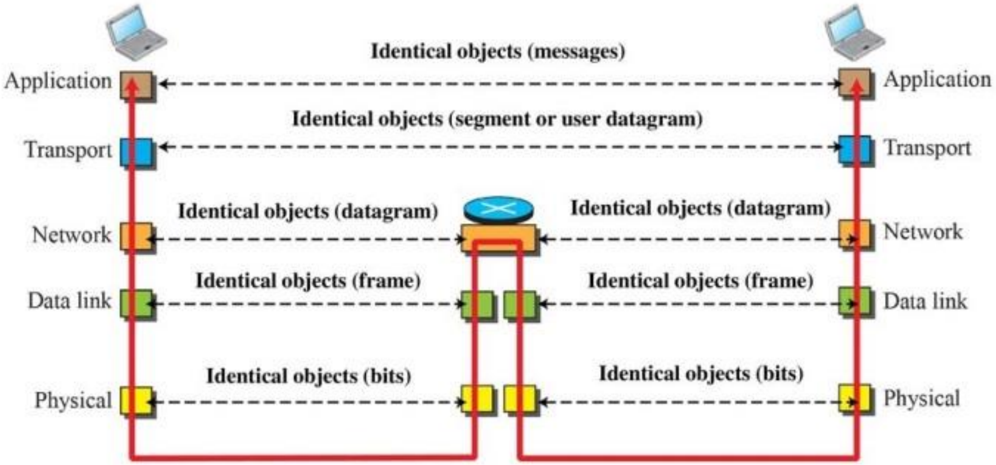
THE TRANSPORT LAYER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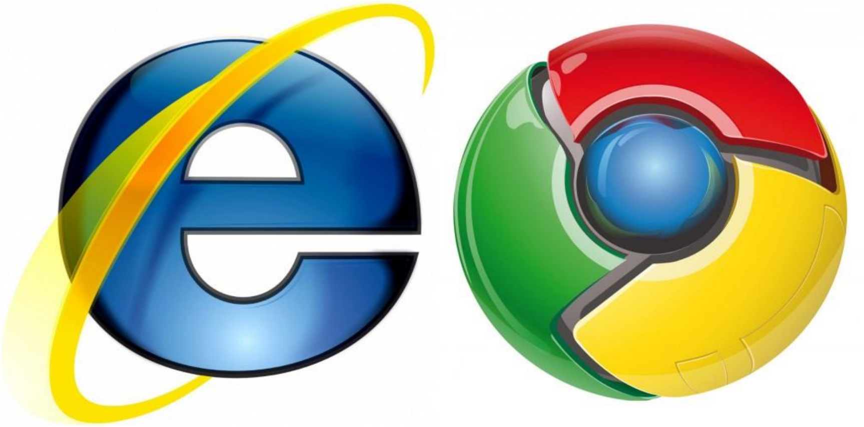
Data link
Identical objects (bits)
Identical objects (bits)
Physical
Physical

- The Transport Layer also performs end-to-end flow control

  Flow control in Data Link Layer is for controlling hop to hop transmission where we want to make sure that routers are not flooding the next hop.

  Flow control at Transport Layer applies to end to end transmission where the source shouldn't be pushing more data than the receiver can process.

THE APPLICATION LAYER



- The ***Application Layer*** contains the protocols that provides the services for an application program (such as email programs, browsers, etc.) to ensure that effective communication with another application program in a network is possible.

- Take note that the Application Layer does not refer to the application programs. The Application Layer contains the protocols used by the application programs to communicate with other application programs.

THE APPLICATION LAYER

- As an example: a web browser serves as the user interface for accessing a website.

  Take note the browser itself does not function at the Application Layer.

  Instead, the web browser invokes the ***Hyper Text Transfer Protocol*** (HTTP), which is an Application Layer protocol, to interface with the remote web server, which is why http:// precedes every web address.

THE APPLICATION LAYER

- HTTP is a set of standards that allow users of the World Wide Web to exchange information found on web pages.

- As soon as a web user opens their web browser, the user is indirectly making use of HTTP.

THE APPLICATION LAYER

- HTTP functions as a request–response protocol in the client–server computing model.

- A web browser, for example, may be the client and an application running on a computer hosting a website may be the server.

THE APPLICATION LAYER

- The client submits an HTTP request message to the server.

- The server, which provides resources such as HTML files and other content, or performs other functions on behalf of the client, returns a response message to the client.

- The response contains completion status information about the request and may also contain requested content in its message body.

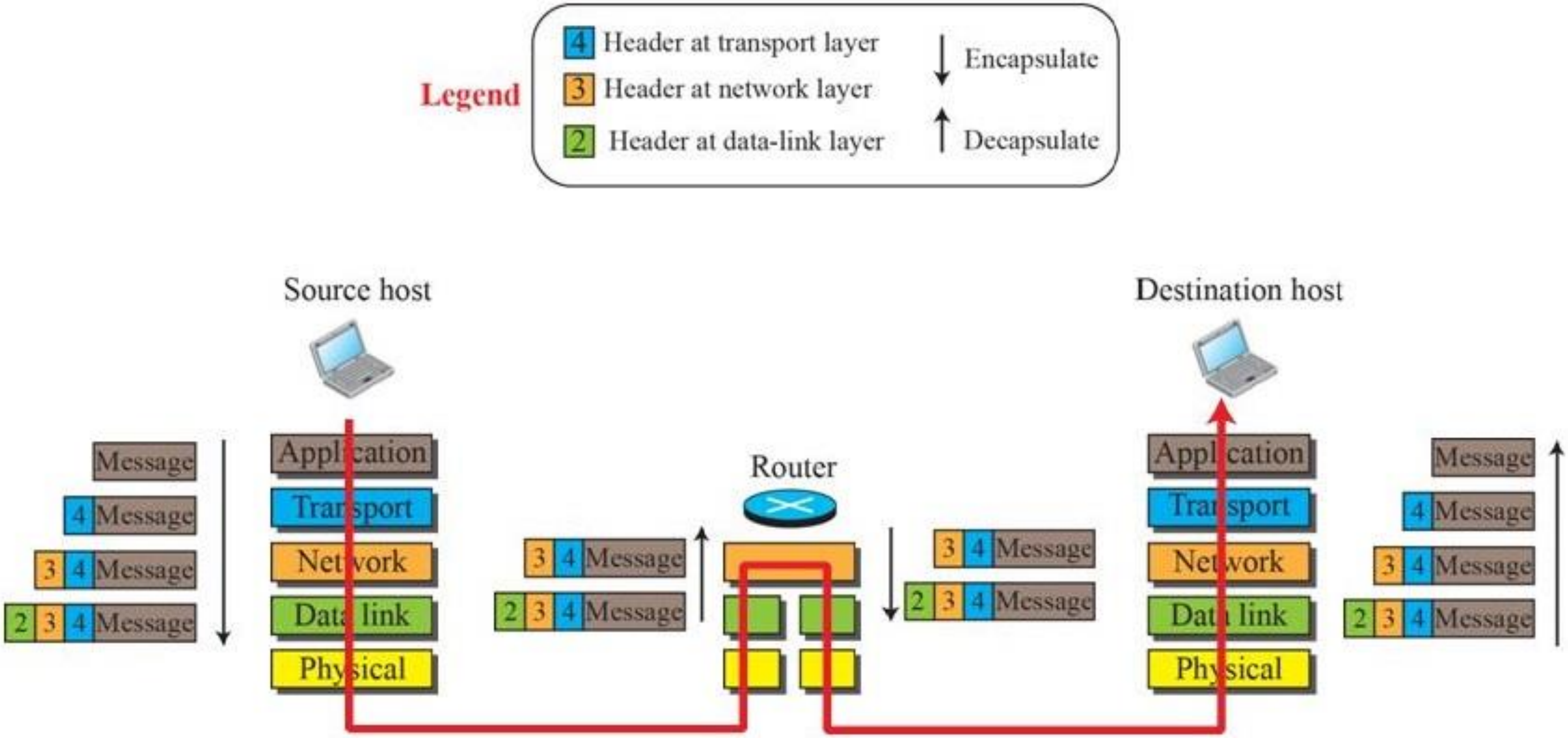
THE APPLICATION LAYER

- Other examples of application layer protocols are:

  1. SMTP (Simple Mail Transfer Protocol)
  2. POP3 (Post Office Protocol 3)
  3. IMAP (Internet Message Access Protocol)
  4. Telnet (Remote Terminal Access)
  5. FTP (File Transfer Protocol).

ENCAPSULATION/DECAPSULATION

- One of the important concepts in protocol layering in the Internet is encapsulation/decapsulation.



ENCAPSULATION/DECAPSULATION

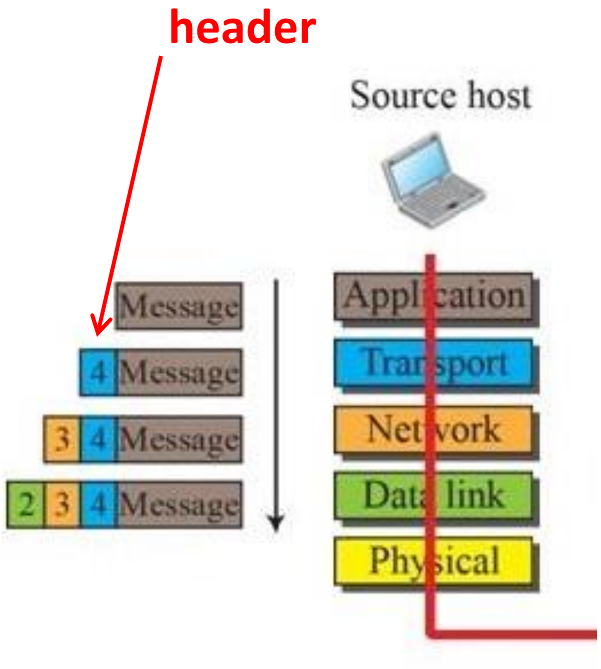
- When data moves from upper layer to lower level of TCP/IP protocol stack (outgoing transmission) each layer includes a bundle of relevant information called a ***header*** along with the actual data.

  The data package containing the header and the data from the upper layer then becomes the data that is repackaged at the next lower level with lower layer's header.

  A header is the supplemental data placed at the beginning of a block of data when it is transmitted.

  This supplemental data is used at the receiving side to extract the data from the encapsulated data packet.

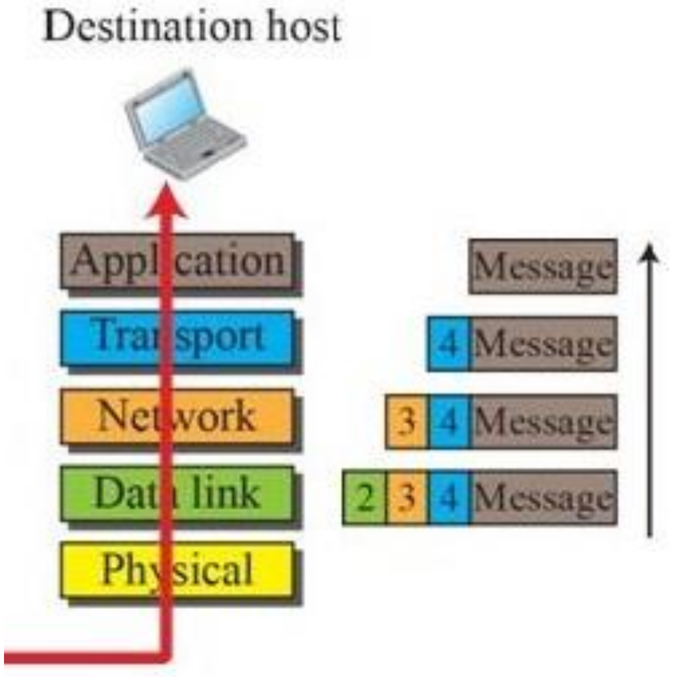
  This packing of data at each layer is known as ***data encapsulation***.



ENCAPSULATION/DECAPSULATION

- The reverse process of encapsulation (or ***decapsulation***) occurs when data is received on the destination computer.

  As the data moves up from the lower layer to the upper layer of TCP/IP protocol stack (incoming transmission), each layer unpacks the corresponding header and uses the information contained in the header to deliver the packet to the exact network application waiting for the data.



OPEN SYSTEM INTERCONNECT (OSI) MODEL

- Although, when speaking of the Internet, everyone talks about the TCP/IP protocol suite, this suite is not the only suite of protocols defined.

- Established in 1947, the International Organization for Standardization (ISO) is a multinational body dedicated to worldwide agreement on international standards.

- Almost three-fourths of the countries in the world are represented in the ISO. An ISO standard that covers all aspects of network communications is the Open Systems Interconnection (OSI) model.

- It was first introduced in the late 1970s.

ISO
International
Organization for
Standardization

- The ***American National Standards Institute*** (ANSI), for example, represents the United States.

- The Philippines is represented by the ***Bureau of Product Standards*** (under the DTI).

OPEN SYSTEM INTERCONNECT (OSI) MODEL

- An open system is a set of protocols that allows any two different systems to communicate regardless of their underlying architecture.

- The purpose of the OSI model is to show how to facilitate communication between different systems without requiring changes to the logic of the underlying hardware and software.

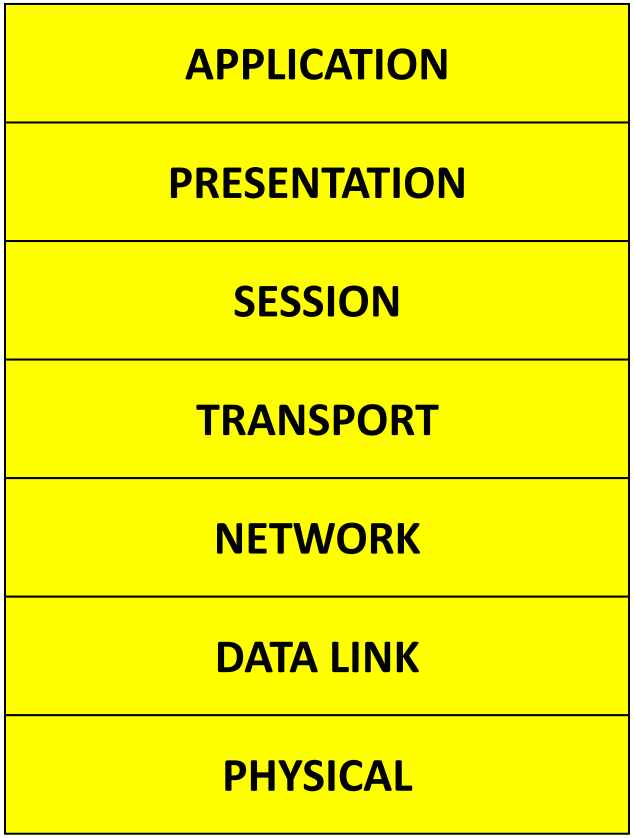
- The OSI model is not a protocol; it is a model for understanding and designing a network architecture that is flexible, robust, and interoperable.

- The OSI model was intended to be the basis for the creation of the protocols in the OSI stack.

OPEN SYSTEM INTERCONNECT (OSI) MODEL

- The OSI model is a layered framework for the design of network systems that allows communication between all types of computer systems.

- It consists of seven separate but related layers, each of which defines a part of the process of moving information across a network.

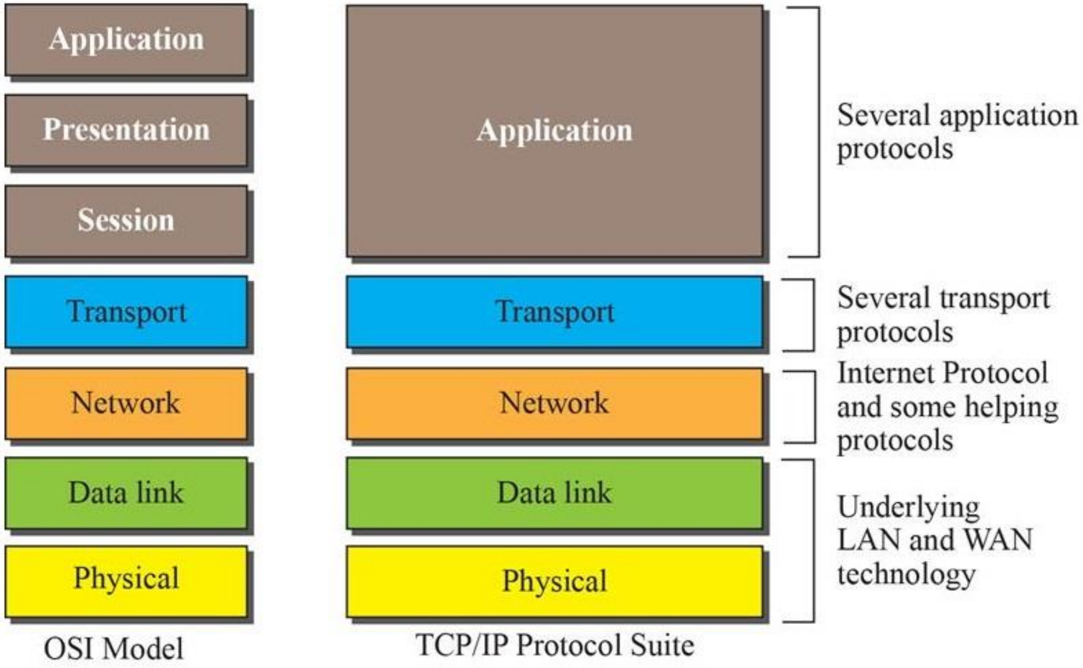

APPLICATION
PRESENTATION
SESSION
TRANSPORT
NETWORK
DATA LINK
PHYSICAL

OSI VERSUS TCP/IP

- In comparing the two models, it can be noticed that two layers, Session and Presentation, are missing from the TCP/IP protocol suite.

  These two layers were not added to the TCP/IP protocol suite after the publication of the OSI model.

  The Application Layer in the suite is usually considered to be the combination of three layers in the OSI model.

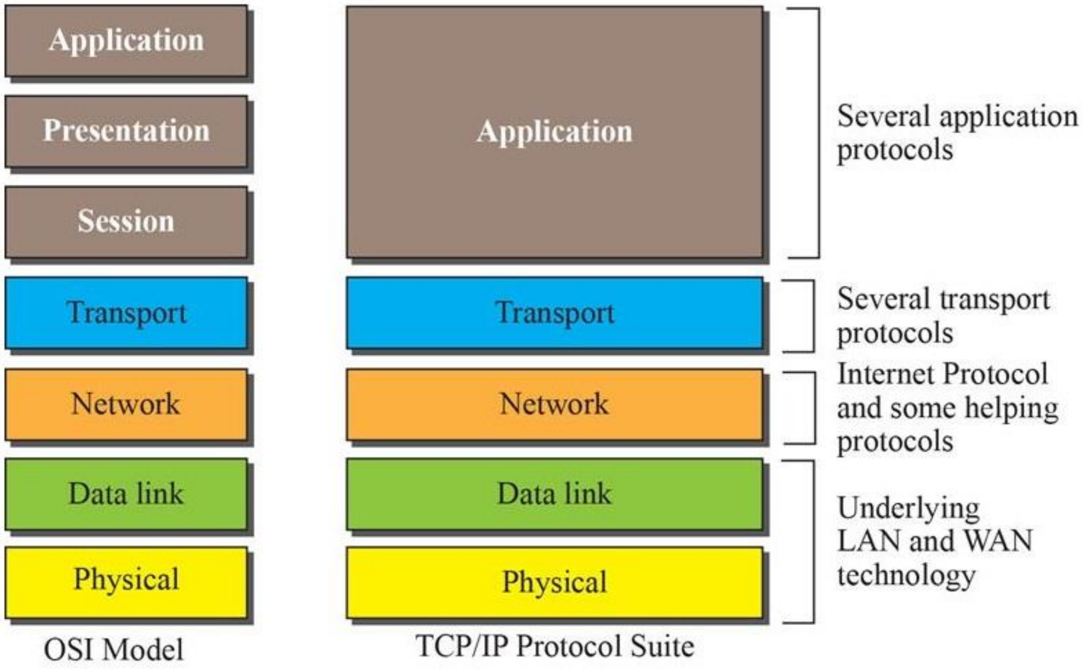


OSI VERSUS TCP/IP

- Two reasons were mentioned for this decision.

  1. First, TCP/IP has more than one Transport-Layer protocol.

     Some of the functionalities of the Session Layer are available in some of the Transport-Layer protocols.

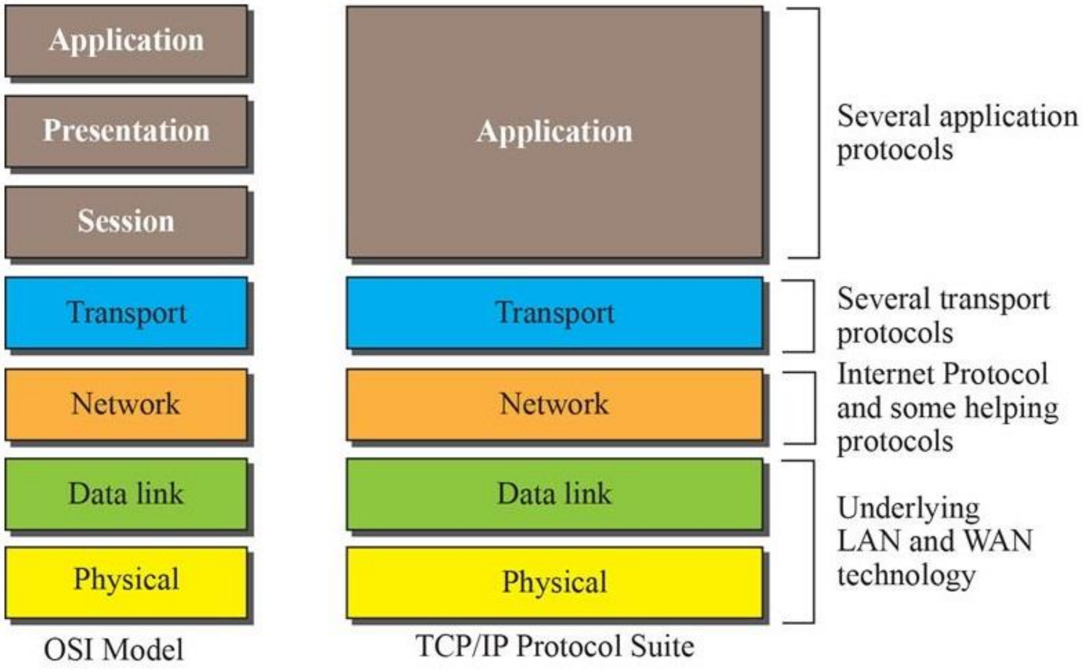


OSI VERSUS TCP/IP

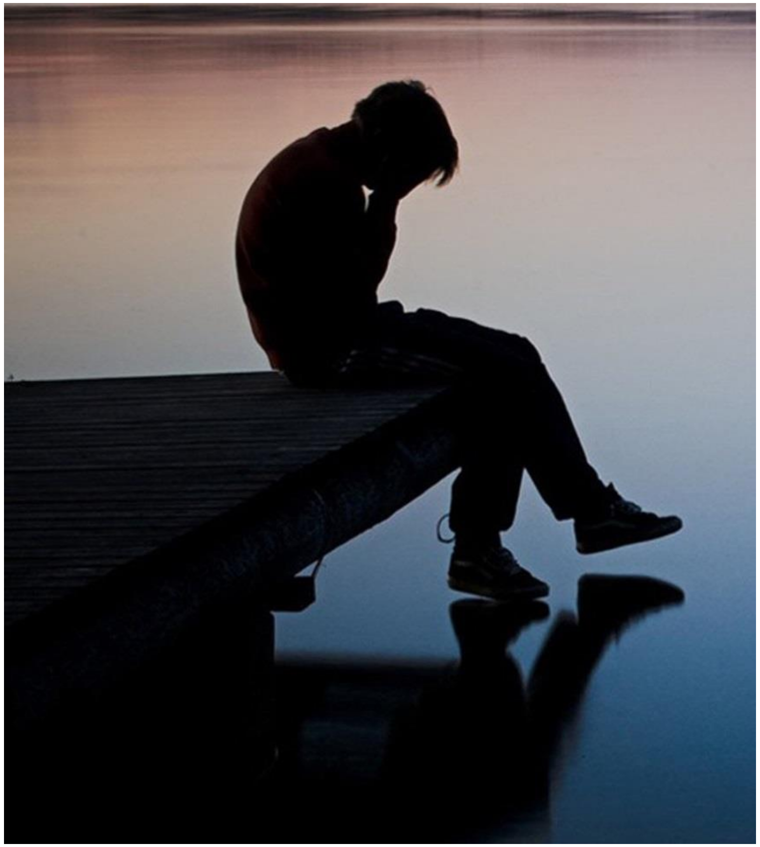
2. Second, the Application Layer is not only one piece of software.

   Many applications can be developed at this layer.

   If some of the functionalities mentioned in the Session and Presentation Layers are needed for a particular application, they can be included in the development of that piece of software.



LACK OF OSI MODEL'S SUCCESS



- The OSI model appeared after the TCP/IP protocol suite. Most experts were at first excited and thought that the TCP/IP protocol would be fully replaced by the OSI model.

- This did not happen for two main reasons:

1. OSI was completed when TCP/IP was fully in place and a lot of time and money had been spent on the suite; changing it would cost a lot.

2. Some layers in the OSI model were never fully defined. For example, although the services provided by the Presentation and the Session Layers were listed in the document, actual protocols for these two layers were not fully defined, nor were they fully described, and the corresponding software was not fully developed.