

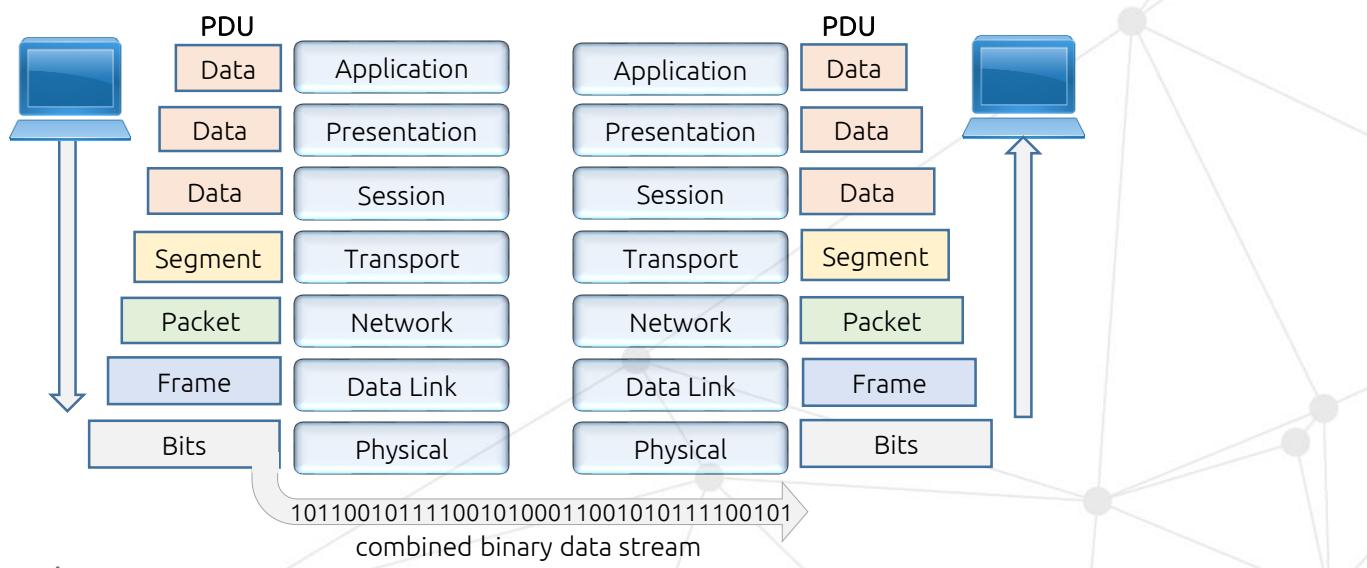
## A Comprehensive Breakdown

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The world of networking and computer to computer communication includes vast amounts of protocols, standards, hardware, software, and concepts. Given these inherent complexities we need a way to make this information easier to understand, discuss, and engage with. To accomplish this task the International Standards Organization (ISO) developed a conceptual model as a way to reference inter-computer communication processes. This 7-layer visual model was developed in 1984 and was named the Open Systems Interconnection (OSI) reference model. Let's go ahead and have a look at the OSI model layers. The layers begin at the end user process (Application, Layer 7) and work their way down through each layer until bits are put on the wire (Physical, Layer 1).

7	Application	Application services for end user processes such as file transfers, email, remote terminal access, domain name resolution, web transfer, network management etc. Protocols such as FTP & Telnet.
6	Presentation	Provides translation to/from the application layer. Performs data encryption, decryption, compression and decompression. Associated with file formats such as JPEG, MPEG etc.
5	Session	Coordinates, establishes, manages and tears down sessions between applications on either side of the connection. Maintains separate sessions for the different applications data streams.
4	Transport	Segments and reassembles data from upper layers and unites them into the same data stream. Provides flow control for data-loss prevention as well as reliable and unreliable transport methods.
3	Network	Provides logical network addressing and path determination/routing services. Responsible for packet delivery, fragmentation, and sequencing. This is the layer where Internet Protocol resides.
2	Data Link	LLC      Includes the Logical Link Control (LLC) sublayer which provides error detection and control. MAC      Delivers frames using unique hardware addressing via the Media Access Control (MAC) sublayer.
1	Physical	Turns raw bits into electrical signaling and defines physical network media such as copper cabling, fiber optics, and wireless transmission standards. Concerned with bit rates and transmission modes.

While it is important to understand the function of each layer we should also consider how a message is treated when sent from one host to another. In the next example we will see that additional information is added to the data as it passes down through the layers. On the receiving side of the connection that same information is read at each layer as it passes back up the model. The term Protocol Data Unit (PDU) is used to describe the data as it moves through each layer.



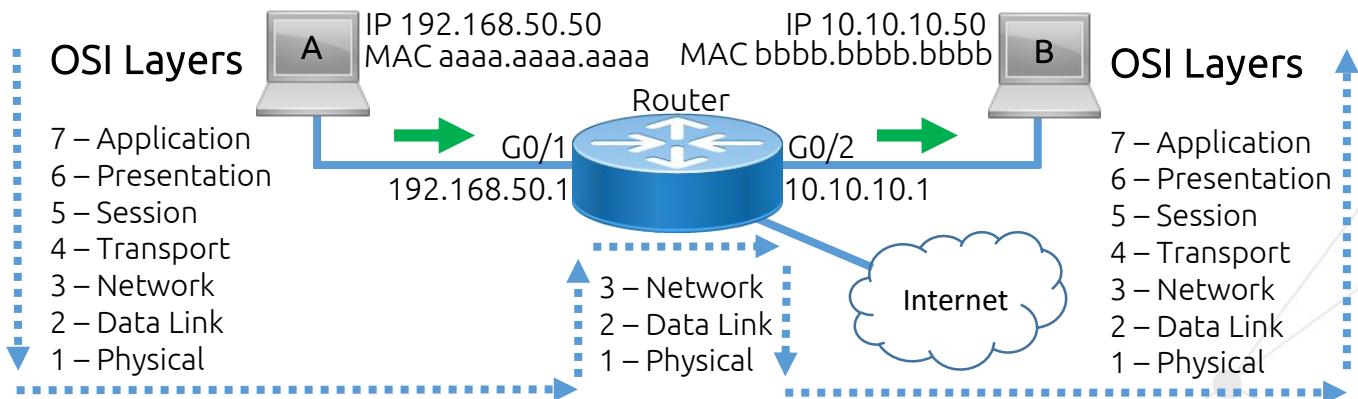
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As we saw in the previous example a computer actually works at all 7 layers of the OSI model. This is true because it deals with everything from human to computer interaction all the way down to putting information on the wire. However, there are hardware devices that work at just a few of the layers and other devices that even work at just a single layer. It is important to note that if a device works at any specific layer then it also works at all the layers below it. For example, routers work at layer 3, so they will also work at layers 2 and 1. Layer 2 switches work at layers 2 and 1, while hubs and repeaters work only at the Physical layer and so function at just a single layer.

The purpose of networking hardware such as routers and switches is to connect multiple devices together and make decisions on how and where to send their data. To understand the general function of network devices in relation to OSI let's use an example of two hosts that are on different IP networks. In order to have traffic move from one network to another we need a device that is capable of reading layer 3 Packet headers and making routing decisions based on the layer 3 destination. This is where a Router comes into play. As shown in the example below the router is looking at the data up to layer 3, making a routing decision and then placing that data back on the wire addressed to its final layer 3 destination.

Example of data being routed between two hosts on different networks

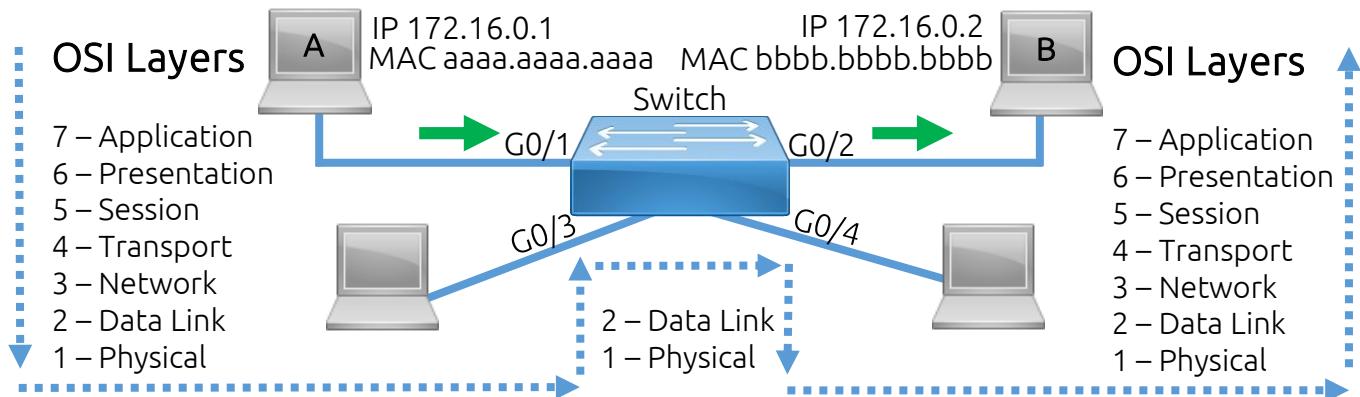


The example above shows that routers are necessary when hosts are on different networks, however when hosts communicate within the same network there is no need for a router. Hubs and switches are used to connect devices that are within the same network. Switches are much more efficient than hubs and provide intelligent packet switching between hosts. Switches keep tables of all the layer 2 (MAC) addresses seen on each individual port and are able to switch data received on one port directly out of another port based on the destination MAC address. This is a huge improvement over using a hub because hubs simply forward any traffic received back out all their connected ports. As more and more devices are added to a hub the communication between devices becomes increasingly inefficient and slows down the network dramatically when there are too many devices. In the next two examples we will look more closely at switches and hubs and how the traffic passing through them looks in reference to the OSI model.

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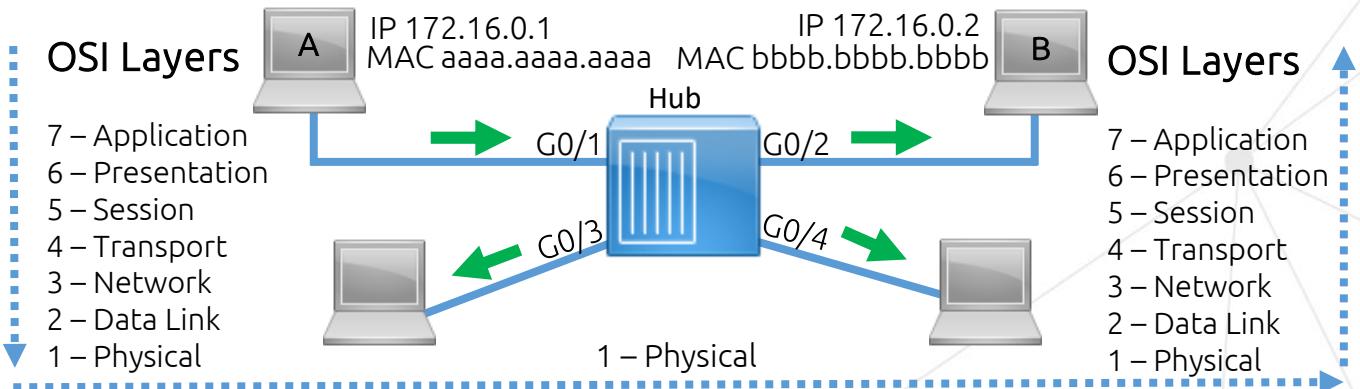
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Example of Frames being switched between two hosts on the same network



Switches build a table of MAC addresses and know the port each MAC address is connected to. In the example above you can see that host A is sending a message to Host B. The switch receives the information and looks at the OSI Layer 2 header which is the MAC header on the Ethernet Frame. Once the switch identifies the destination MAC address it is able to switch the Frame out of the destination port that connects to Host B. In this way the switch is making intelligent decisions and increasing the efficiency of communication across the network. This efficiency is maintained even as more and more devices are connected to the switch.

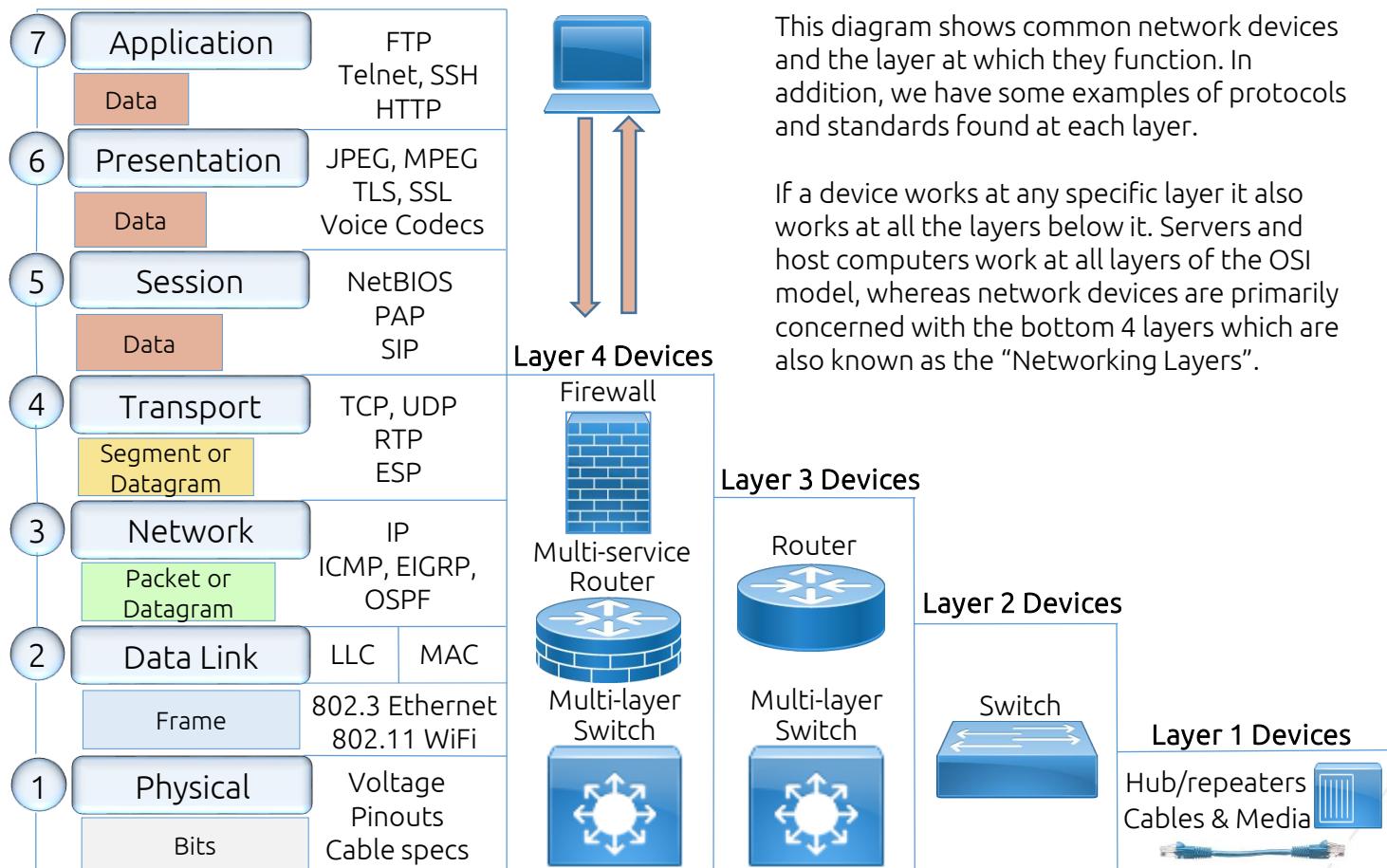
Example of network traffic passing through a hub from Host A to Host B



Hubs are not intelligent devices and simply forward all received traffic out of all connected ports. As you can see in the above diagram a hub only works at OSI layer 1 which is the Physical layer. When compared with switches, hubs increase the amount of traffic on the network and the amount of information each host must process because they flood received traffic out all connected ports. As more and more devices are added to a hub the network becomes less and less efficient.

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You can use the model below to help remember each layer from top to bottom and bottom to top!

