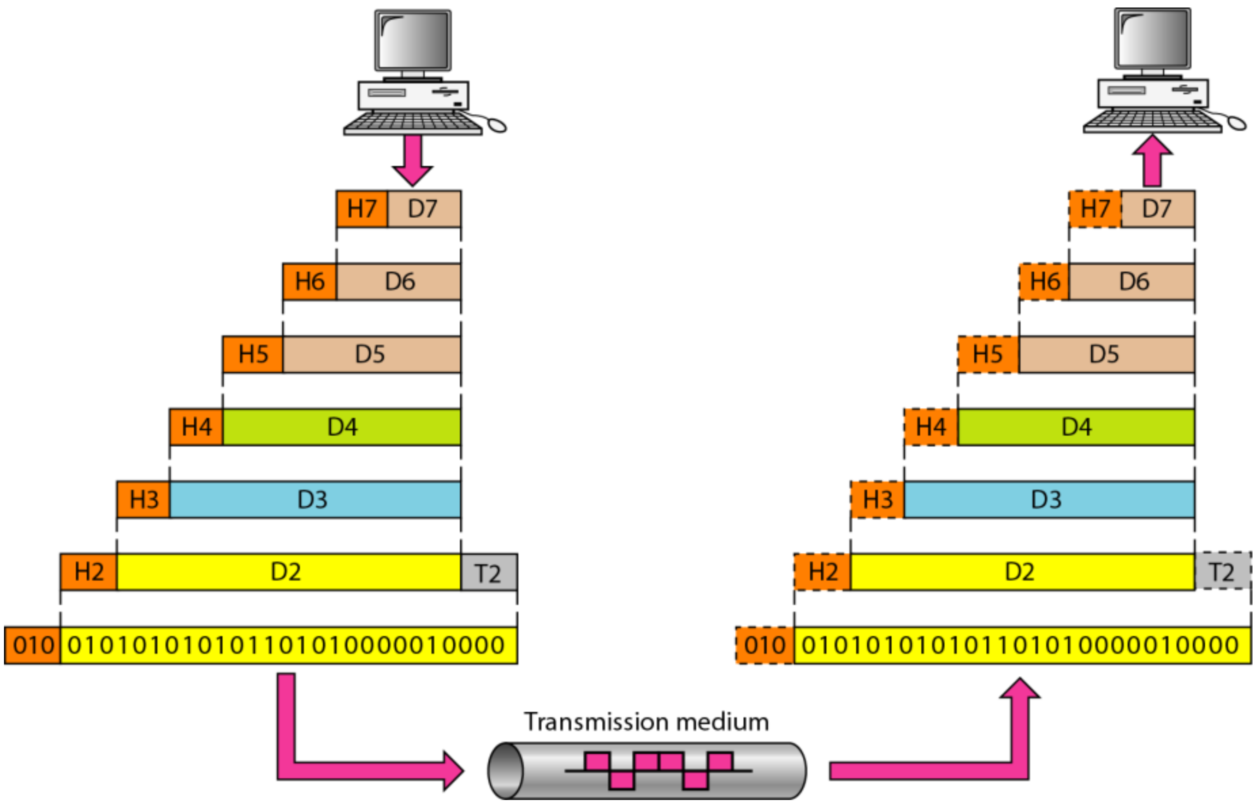
Network Standards and OSI Model



Network Criteria معايير الشبكات

A network must be able to meet a certain number of criteria. The most important of these are **performance, reliability, and security.**

يجب أن تكون الشبكة قادرة على تلبية عدد معين من المعايير. أهمها الأداء والموثوقية والأمان.

a) Performance can be measured in many ways, including transit time and response time. Transit time is the **amount of time** required for a message to travel from one device to another. Response time is the **elapsed time** between an inquiry and a response.

يمكن قياس الأداء بطرق عديدة ، بما في ذلك وقت الارسال ووقت الاستجابة.

وقت الارسال هو مقدار الوقت المطلوب للأرسال من جهاز إلى آخر. **وقت الاستجابة** هو الوقت المنقضي بين الطلب والرد.

The performance of a network depends on a number of factors:

1) Number of users.

2) Type of transmission medium.

3) Capabilities of the connected hardware.

4) Efficiency of the software.

Performance is often evaluated by two networking metrics: **throughput and delay**. We often need more throughput and less delay.

غالبًا ما يتم تقييم الأداء من خلال مقياسين للشبكة: الإنتاجية والتأخير. غالبًا ما نحتاج إلى إنتاجية أكبر وتأخير أقل.

b) Reliability الموثوقية network reliability is measured by the:

1) Accuracy of delivery.

2) Frequency of failure.

3) The time it takes a link to recover from a failure.

4) Network's robustness in a catastrophe.

c) Security الامنية Network security issues include:

1) Protecting data from unauthorized access

2) Protecting data from damage and change.

3) Implementing policies for recovery from data losses.

Protocols and Standards

A) Protocol

A protocol defines **what** is communicated, **how** it is communicated, and **when** it is communicated. The key elements of a protocol are **syntax, semantics, and timing**.

يحدد البروتوكول ما يتم توصيله ، وكيفية توصيله ، ومتى يتم توصيله. العناصر الرئيسية للبروتوكول هي بناء الجملة قواعدياً ، والمعنى ، والتوقيت.

Syntax It refers to the structure or format of the data, meaning the order in which they are presented.

For example, a simple protocol might expect the first 8 bits of data to be the address of the sender, the second 8 bits to be the address of the receiver, and the rest of the stream to be the message itself.

Semantics It refers to the meaning of each section of bits. How is a particular pattern to be interpreted, and what action is to be taken based on that interpretation?

For example, does an address identify the route to be taken or the final destination of the message?

Timing It refers to two characteristics: when data should be sent and how fast they can be sent.

For example, if a sender produces data at 100 Mbps but the receiver can process data at only 1 Mbps, the transmission will overload the receiver and some data will be lost.

B) Standards

Standards are essential in creating an open and competitive market for equipment manufacturers and in guaranteeing national and international telecommunications.

المعايير أو المقاييس ضرورية في إنشاء سوق مفتوحة وتنافسية لمصنعي المعدات ولضمان الاتصالات الوطنية والدولية.

Standards Creation Committees لجان وضع المعايير

Most data telecommunications rely primarily on the standards published by the following committees:

 International Organization for Standardization (ISO).

 American National Standards Institute (ANSI).

 Institute of Electrical and Electronics Engineers (IEEE).

 Electronic Industries Association (EIA).

Network Models

The layered model that dominated data communications and networking literature before 1990 was the **Open Systems Interconnection (OSI**) model. Everyone believed that the OSI model would become the ultimate standard for data communications, but this did not happen. The TCP/IP protocol suite became the dominant commercial architecture because it was used and tested extensively in the Internet; the OSI model was never fully implemented.

كان النموذج الطبقي الذي سيطر على اتصالات البيانات ووثائق الشبكات قبل عام 1990 هو نموذج ربط الأنظمة المفتوحة (OSI). اعتقد الجميع أن نموذج OSI سيصبح المعيار النهائي لاتصالات البيانات ، ولكن هذا لم يحدث. أصبحت مجموعة بروتوكولات TCP / IP هي البنية التجارية السائدة لأنه تم استخدامها واختبارها على نطاق واسع في الإنترنت ؛ لم يتم تنفيذ نموذج OSI بالكامل.

The Open Systems Interconnection (OSI) model is introduced in the late 1970s by the International Standards Organization (ISO).

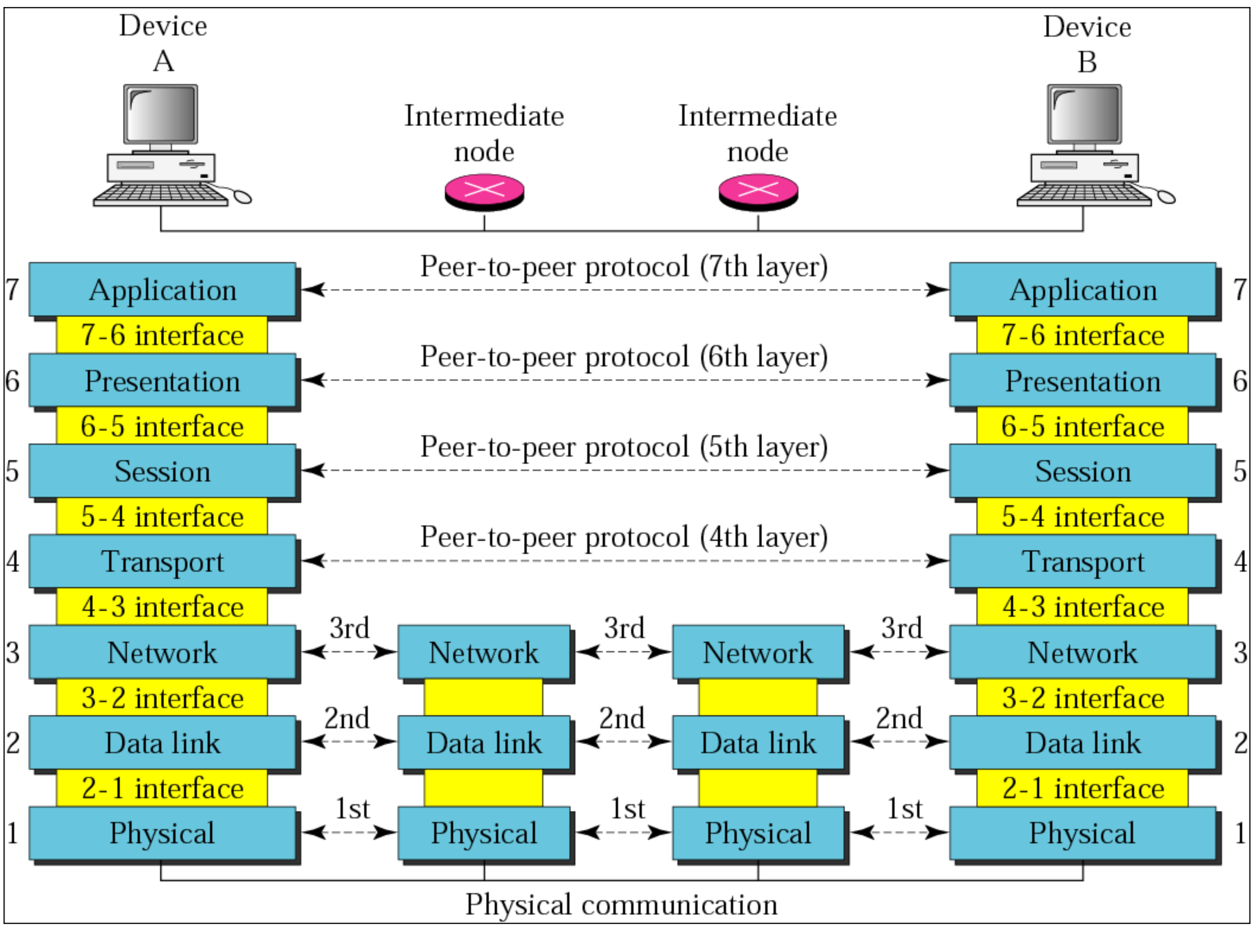
(Note: ISO is the organization. OSI is the model.)

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

إن نموذج OSI هو نموذج متعدد الطبقات لتصميم وفهم أنظمة الشبكة التي تسمح بالاتصال بين جميع أنواع أنظمة الكمبيوتر.

OSI consists of seven separate but related layers, each of which defines a part of the process of moving information across a network (see Figure 2.1). When a message is sent for example from device A to device B. As the message travels from A to B, it may pass through many intermediate nodes, called routers. These intermediate nodes usually involve only the first three layers of the OSI model.

يتكون OSI من سبع طبقات منفصلة ولكنها ذات صلة ، تحدد كل منها جزءًا من عملية نقل المعلومات عبر الشبكة (انظر الشكل 2.1). عندما يتم إرسال رسالة على سبيل المثال من الجهاز A إلى الجهاز B. أثناء انتقال الرسالة من A إلى B ، فقد تمر عبر العديد من العقد الوسطية ، تسمى الموجهات. عادةً ما تتضمن هذه العقد الوسطية الطبقات الثلاث الأولى فقط من نموذج OSI.



The interaction between layers in the OSI model

Each layer defines a family of functions distinct from those of the other layers. Each layer at the sending site uses the services of the layer immediately below it. The sender at the higher layer uses the services of the middle layer. The middle layer uses the services of the lower layer. The lower layer uses the services of the carrier. Layer 3, for example, uses the services provided by layer 2 and provides services for layer 4.

تحدد كل طبقة مجموعة من الوظائف تختلف عن تلك الخاصة بالطبقات الأخرى. تستخدم كل طبقة في موقع الإرسال خدمات الطبقة التي تحتها مباشرة. يستخدم المرسل في الطبقة العليا خدمات الطبقة الوسطى. تستخدم الطبقة الوسطى خدمات الطبقة السفلية. تستخدم الطبقة السفلية خدمات الناقل. فالطبقة 3 ، على سبيل المثال ، تستخدم الخدمات التي توفرها الطبقة 2 وتوفر الخدمات للطبقة 4.

The processes on each machine that communicate at a given layer are called peer-to-peer processes. Communication between machines is therefore a peer-to-peer process using the protocols appropriate to a given layer.

تسمى العمليات الموجودة على كل جهاز والتي تتواصل في طبقة معينة بعمليات نظير إلى نظير. وبالتالي ، يعد الاتصال بين الأجهزة عملية نظير إلى نظير باستخدام البروتوكولات المناسبة لطبقة معينة.

The interfaces between layers are to define the information and services that each layer must provide for the layer above it.

يجب أن تحدد الواجهات بين الطبقات المعلومات والخدمات التي يجب أن توفرها كل طبقة للطبقة الموجودة فوقها.

The seven layers are belonging to three subgroups. Layers 1, 2, and 3 are the network support layers; they deal with the physical aspects of moving data from one device to another (such as electrical specifications, physical connections, and physical addressing). Layers 5, 6, and 7 are the user support layers; they allow interoperability among unrelated software systems. Layer 4, the transport layer, links the two subgroups.

الطبقات السبع تنتمي إلى ثلاث مجموعات فرعية. الطبقات 1 و 2 و 3 هي طبقات دعم الشبكة ؛ تتعامل مع الجوانب المادية لنقل البيانات من جهاز إلى آخر (مثل المواصفات الكهربائية ، والتوصيلات المادية ، والعنونة المادية). الطبقات 5 و 6 و 7 هي طبقات دعم المستخدم ؛ أنها تسمح بالتشغيل البيني بين أنظمة البرامج غير ذات الصلة. الطبقة 4 ، طبقة النقل ، تربط المجموعتين الفرعيتين.

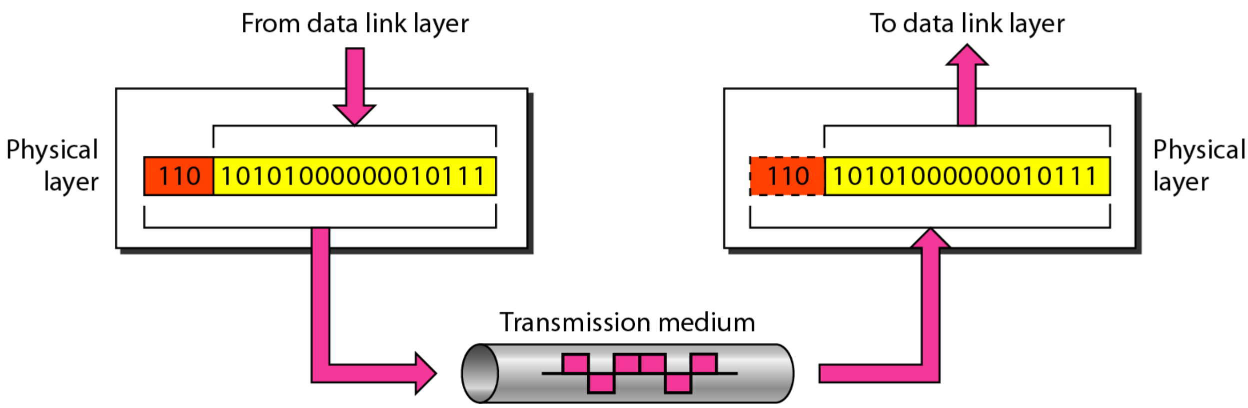
Layers in the OSI Model

In the following we describe the functions of each layer in the OSI model.

1. Physical Layer

The physical layer coordinates the functions required to carry a bit stream over a physical medium.

تنسق الطبقة المادية (الفيزيائية) الوظائف المطلوبة لحمل سيل من ال Bits على وسط مادي.



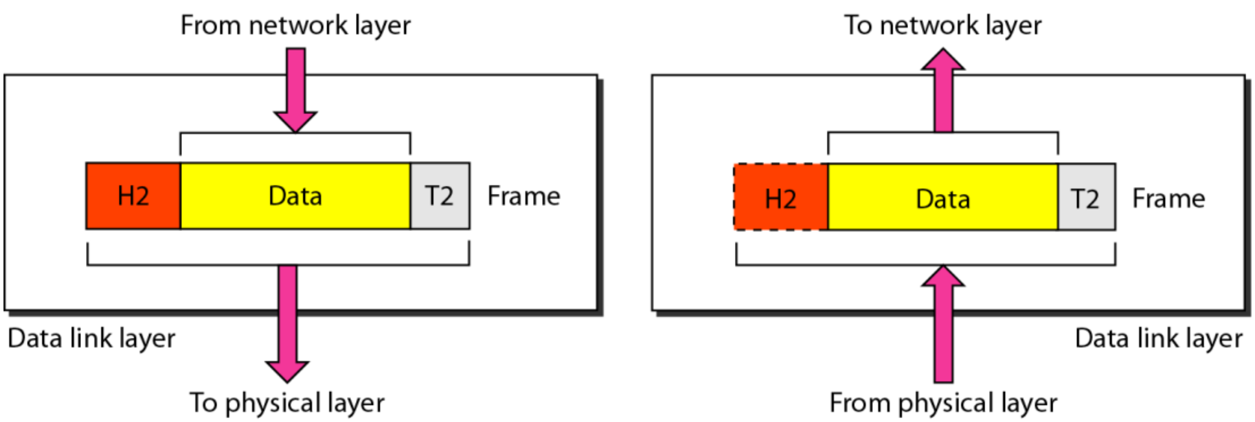
The physical layer is concerned with the following:

- Physical characteristics of interfaces and medium.
- Representation of bits (sequence of 0s or 1s) with defining the type of encoding (how 0s and 1s are changed to signals).
- Data rate or the transmission rate (the number of bits sent each second)
- Synchronization of bits. The sender and receiver not only must use the same bit rate but also must be synchronized at the bit level.
- Line configuration (point-to-point or multipoint configuration).
- Physical topology (mesh, star, bus, etc.).
- Transmission mode (simplex, half-duplex, or full-duplex).

2. Data Link Layer

The data link layer makes the physical layer appear error-free to the upper layer (network layer). The figure shows the relationship of the data link layer to the network and physical layers.

تجعل طبقة ارتباط البيانات الطبقة المادية (الفيزيائية) خالية من الأخطاء للطبقة العليا (طبقة الشبكة). يوضح الشكل علاقة طبقة ارتباط البيانات بالشبكة والطبقات المادية.



The data link layer is responsible for moving frames from one hop (node) to the next. Other responsibilities of the data link layer include the following:

- Framing. The data link layer divides the stream of bits received from the network layer into manageable data units called **frames**.
- Physical addressing. The data link layer adds a header to the frame to define the sender and/or receiver devices of the frame. The devises are defined by the physical address (or MAC address).
- Flow control. The data link layer ensures the rate at which data are produced in the sender and arrived in the receiver.
- Error control. The data link layer adds mechanisms to detect and retransmit damaged or lost frames. Error control is normally achieved through a **trailer** added to the end of the frame (see the **T2** in Figure).
- Access control. The data link layer controls the access to the link when two or more devices are connected to the same link.

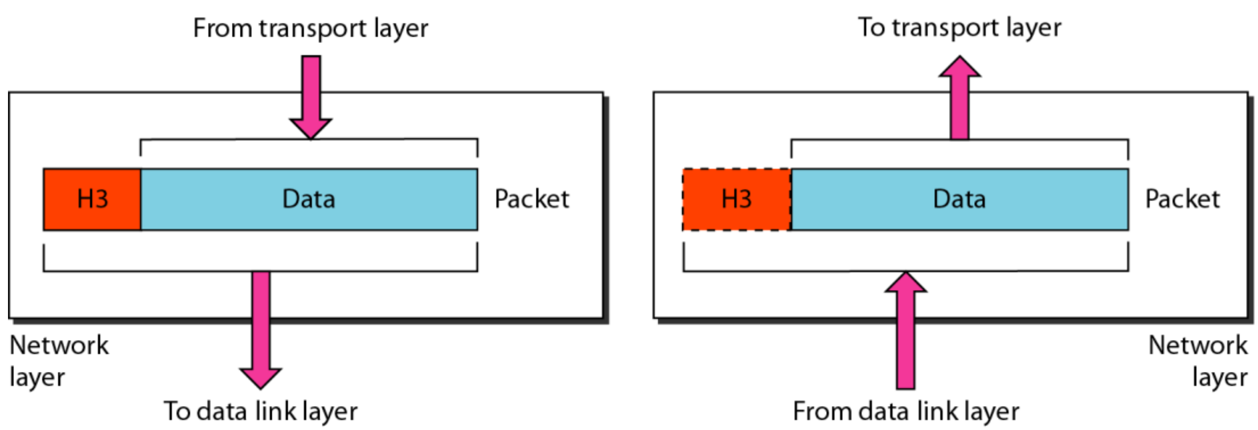
3. Network Layer

The network layer is responsible for the source-to-destination delivery of a packet (see Figure), possibly across multiple networks (links). Whereas the data link layer oversees the delivery of the packet between two systems on the same network (links).

طبقة الشبكة مسؤولة عن تسليم الحزمة من المصدر إلى الوجهة (انظر الشكل) ، ربما عبر عدة شبكات متعددة. بينما تشرف طبقة وصلة البيانات (data link layer) على تسليم الحزمة بين نظامين على نفس الشبكة (الروابط).

Other responsibilities of the network layer include the following:

- Logical addressing. The network layer adds a header to the packet coming from the upper layer that, among other things, includes the logical addresses (IP address) of the sender and receiver.
- Routing. When independent networks or links are connected to create internetworks, the connecting devices (called routers or switches) route or switch the packets to their final destination. One of the functions of the network layer is to provide this mechanism.



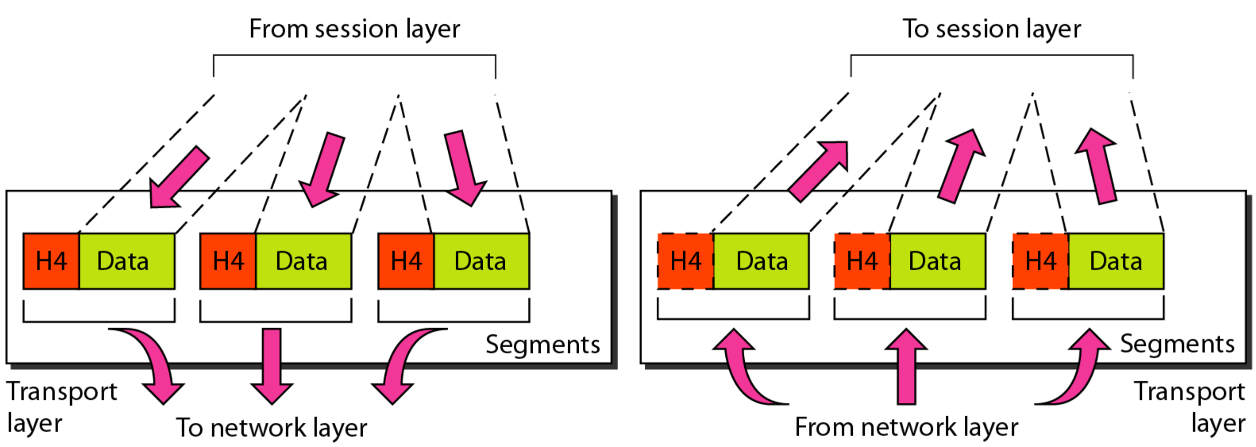
4. Transport Layer

The transport layer is responsible for process-to-process delivery of the entire message. A process is an application program running on a host. Whereas the network layer oversees source-to-destination delivery of individual packets.

طبقة النقل مسؤولة عن تسليم الرسالة بأكملها من عملية إلى عملية. العملية عبارة عن برنامج تطبيق يعمل على مضيف. بينما تشرف طبقة الشبكة على تسليم الحزم الفردية من المصدر إلى الوجهة.

Other responsibilities of the transport layer include the following:

- Service-point addressing. Computers often run several programs at the same time. The transport layer header includes a type of address called a service-point address (or port address) in order to deliver the entire message to the correct process on that computer.
- Segmentation and reassembly. A message is divided into transmittable segments, with each segment containing a sequence number. These numbers enable the transport layer to reassemble the message correctly at the destination.
- Flow control. Like the data link layer, the transport layer is responsible for flow control. However, flow control at this layer is performed end to end rather than across a single link.
- Error control. Like the data link layer, the transport layer is responsible for error control. However, error control at this layer is performed process-to-process rather than across a single link.



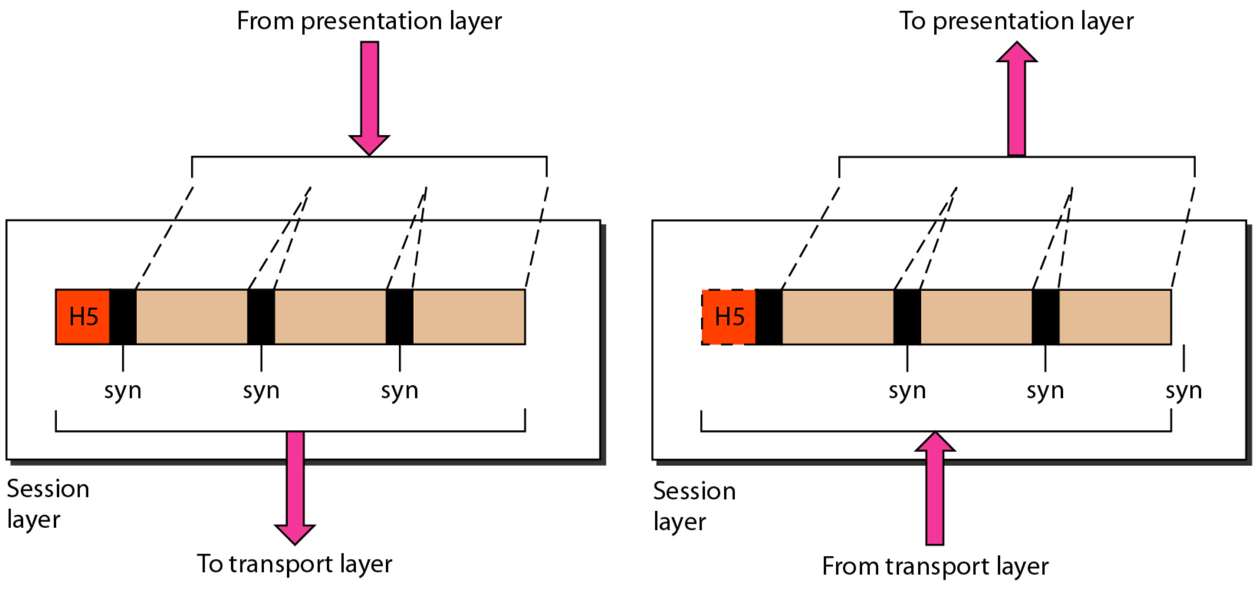
5. Session Layer

The services provided by the first three layers (physical, data link, and network) are not sufficient for some processes. The session layer is responsible for dialog control and synchronization.

الخدمات التي تقدمها الطبقات الثلاث الأولى (المادية ، وصلة البيانات ، والشبكة) ليست كافية لبعض العمليات. طبقة الجلسة مسؤولة عن التحكم في الحوار والمزامنة.

Specific responsibilities of the session layer include the following:

- Dialog control. The session layer allows the communication between two processes to take place in either half-duplex (one way at a time) or full-duplex (two ways at a time) mode.
- Synchronization. The session layer allows a process to add checkpoints, or synchronization points, to a stream of data (see Figure). For example, if a system is sending a file of 2000 pages, it is advisable to insert checkpoints after every 100 pages.



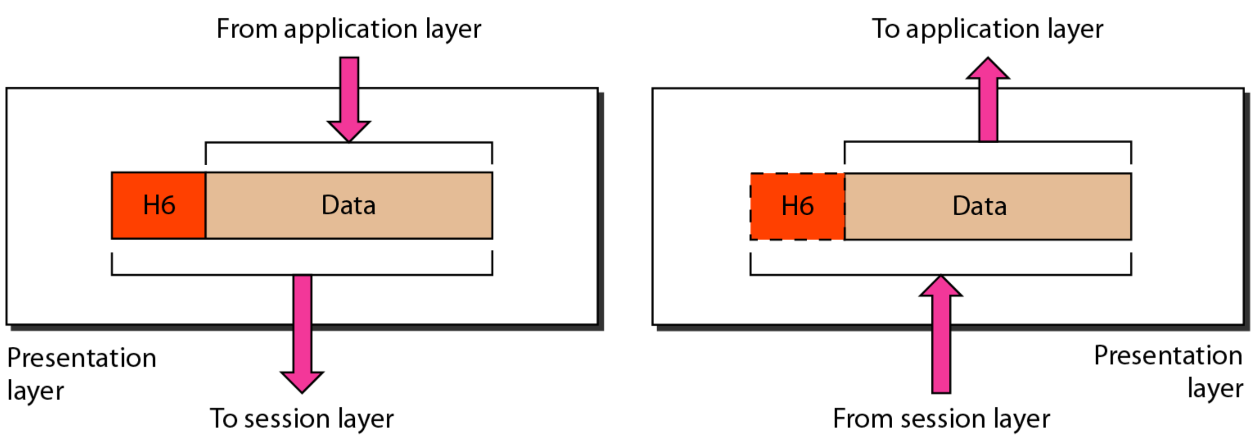
6. Presentation Layer

The presentation layer is concerned with the syntax and semantics of the information exchanged between two systems.

تهتم طبقة العرض التقديمي بالقواعد ودلالات المعنى للمعلومات المتبادلة بين نظامين.

Specific responsibilities of the presentation layer include the following:

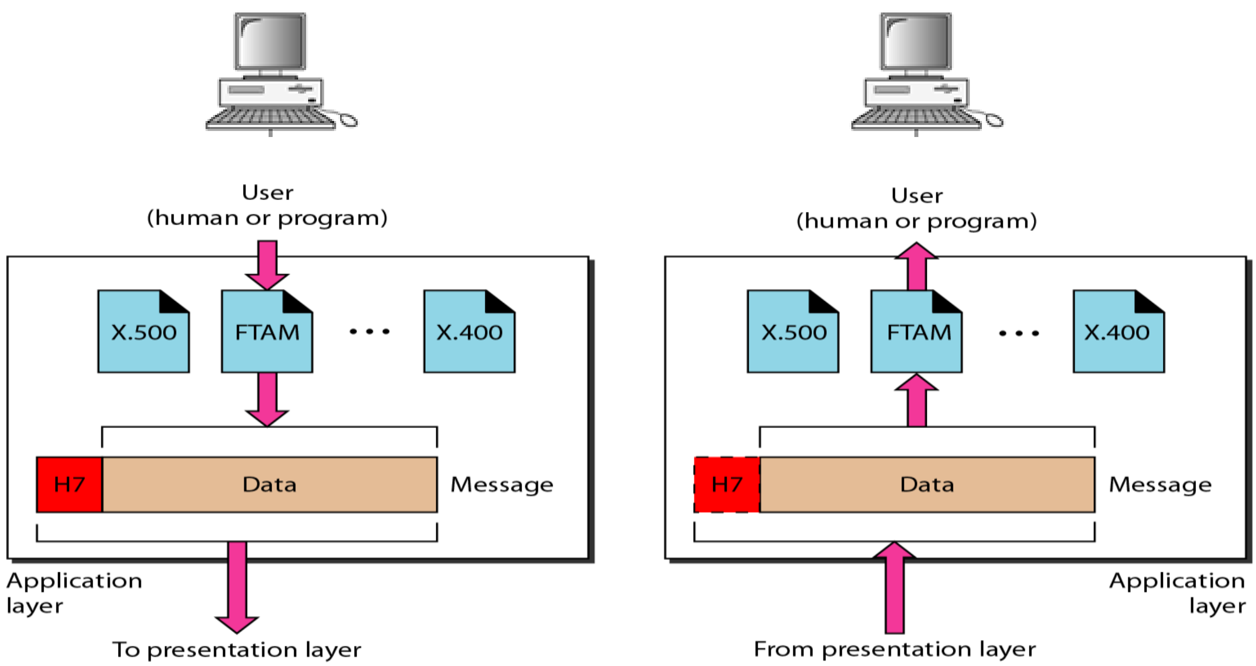
- Translation. Because different computers use different encoding systems, the presentation layer is responsible for interoperability between these different encoding methods.
- Encryption. To carry sensitive information, a system must be able to ensure privacy.
- Compression. Data compression reduces the number of bits contained in the information. Data compression becomes particularly important in the data transmission.

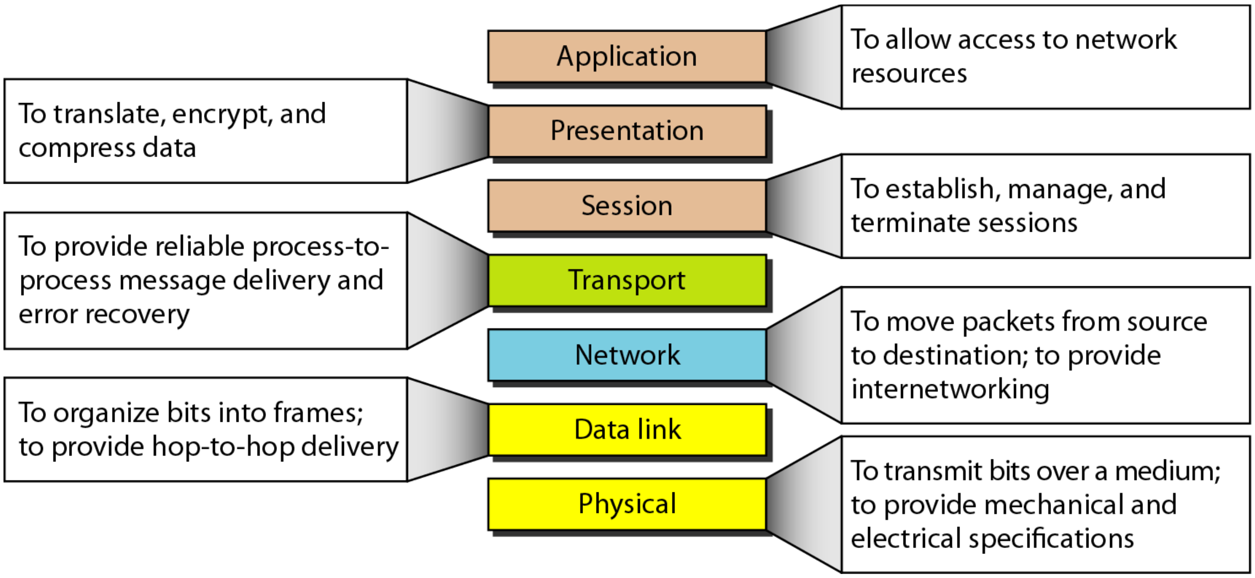


7. Application Layer

The application layer is responsible for providing services to the user. It enables the user, whether human or software, to access the network. It provides user interfaces and support for services such as electronic mail, remote file access and transfer, and other types of distributed information services.

طبقة التطبيق مسؤولة عن تقديم الخدمات للمستخدم. إنها تمكن المستخدم ، سواء كان الإنسان أو البرمجيات ، من الوصول إلى الشبكة. يوفر (واجهات المستخدم) و(الدعم) لخدمات مثل البريد الإلكتروني ، والوصول إلى الملفات عن بعد ونقلها ، وأنواع أخرى من خدمات المعلومات الموزعة.





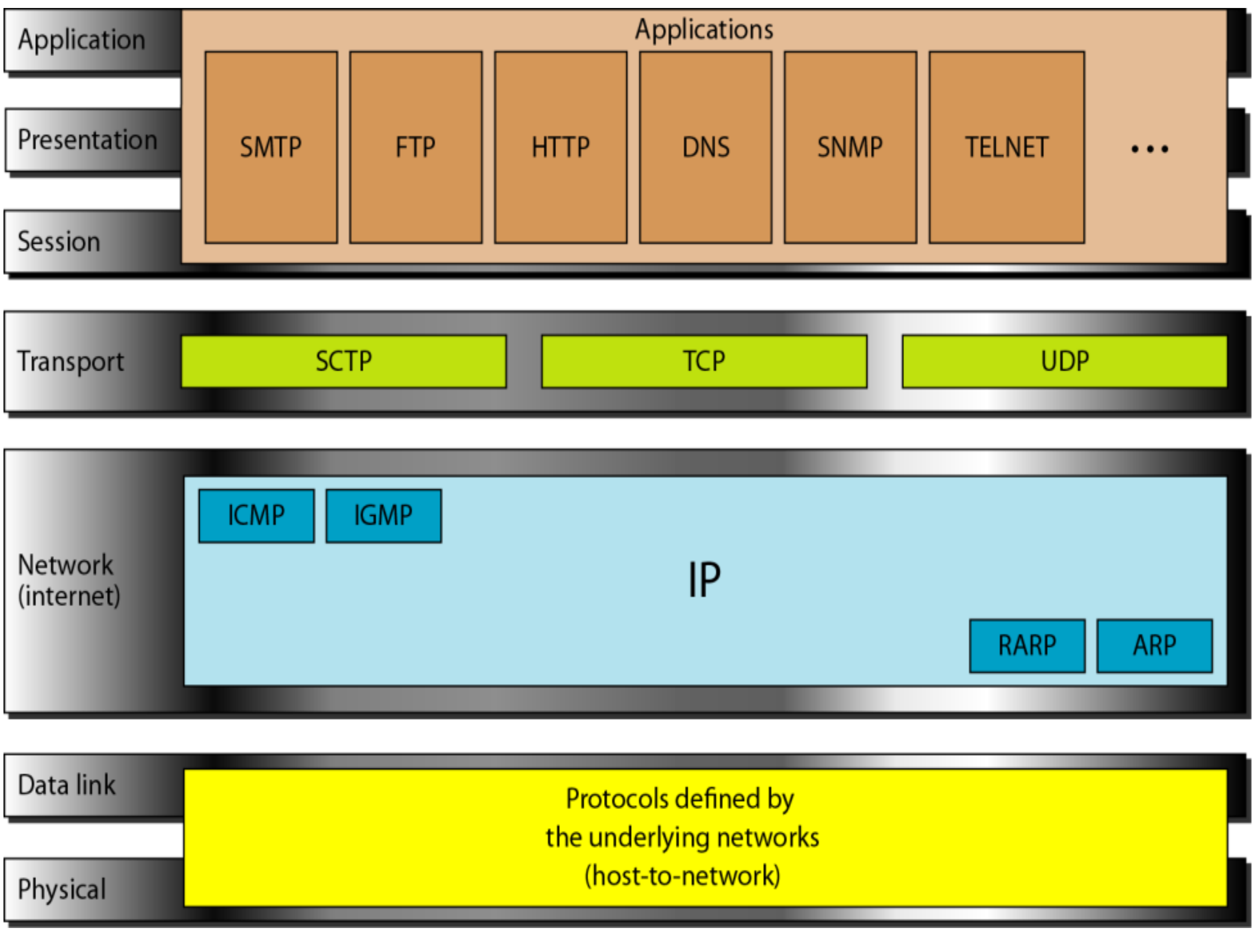
Summary of OSI layers

TCP/IP Protocol Suite and addressing

TCP/IP Protocol Suite

The TCP/IP protocol suite is made of four layers: physical & data link which called link layer, network (or Internet layer), transport, and application. The first four layers provide physical standards, network interfaces, internetworking, and transport functions that correspond to the first four layers of the OSI model.

The three topmost layers in the OSI model, however, are represented in TCP/IP by a single layer called the application layer.



TCP/IP and OSI Model

1. Physical and Data Link Layers

At the physical and data link layers, TCP/IP does not define any specific protocol. It supports all the standard and proprietary protocols. A network in a TCP/IP internetwork can be a local area network or a wide-area network.

2. Network Layer

At the network layer (or the internetwork layer), TCP/IP supports the Internetworking Protocol (IP). IP uses four supporting protocols: ARP, RARP, ICMP, and IGMP as described in the following:

The Internetworking Protocol (IP) is the transmission mechanism used by the TCP/IP protocols. IP transports data in packets called datagrams, each of which is transported separately. Datagrams can travel along different routes and can arrive out of sequence or be duplicated.

The Address Resolution Protocol (ARP) is used to associate a logical address with a physical address. ARP is used to find the physical address of the node when its Internet address is known.

The Reverse Address Resolution Protocol (RARP) allows a host to discover its Internet address when it knows only its physical address. It is used when a computer is connected to a network for the first time.

The Internet Control Message Protocol (ICMP) is a mechanism used by hosts and gateways to send notification of datagram problems back to the sender.

The Internet Group Message Protocol (IGMP) is used to facilitate the simultaneous transmission of a message to a group of recipients.

3. Transport Layer

The main protocols in transport layer are the TCP and UDP. IP protocol in network layer is a source-to-destination protocol, meaning that it can deliver a packet from one physical device to another. Weather, UDP and TCP are transport level protocols responsible for delivery of a message from a process (running program) to another process (process-to-process protocols).

The User Datagram Protocol (UDP) is the simpler of the two standard TCP/IP transport protocols. It is a process-to-process protocol that adds only port addresses, checksum error control, and length information to the data from the upper layer.

The Transmission Control Protocol (TCP) is a reliable stream transport protocol. The term stream, in this context, means connection-oriented: A connection must be established between both ends of a transmission before either can transmit data.

At the sending end of each transmission, TCP divides a stream of data into smaller units called segments. Each segment includes a sequence number for reordering after receipt. At the receiving end, TCP collects each datagram as it comes in and reorders the transmission based on sequence numbers.

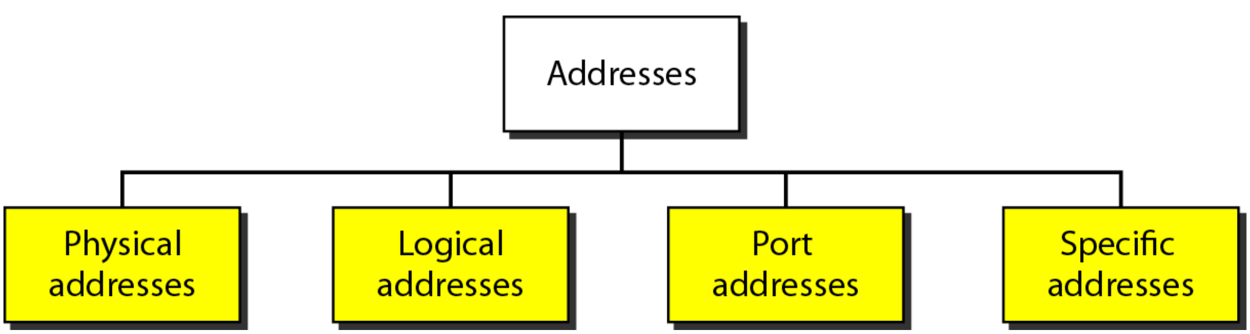
The Stream Control Transmission Protocol (SCTP) provides support for newer applications such as voice over the Internet.

4. Application Layer

The application layer in TCP/IP is **equivalent** to the combined **session, presentation, and application** layers in the OSI model. Many protocols are defined at this layer.

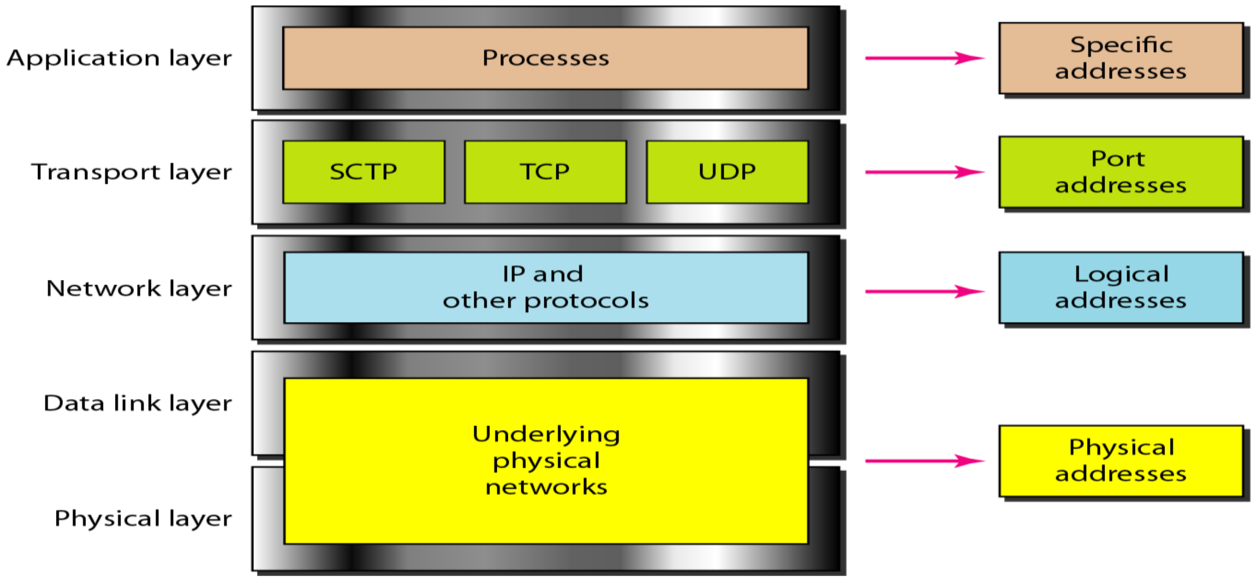
Addressing

Four levels of addresses are used in an internet employing the TCP/IP protocols: **physical (link) addresses**, **logical (IP) addresses**, **port addresses**, and **specific addresses.**



Addressing in TCP/IP

Each address is related to a specific layer in the TCP/IP architecture, as shown in Figure:



Relationship of layers and addresses in TCP/IP

1. Physical Addresses

The physical address, also known as the link address, is the address of a node as defined by its LAN or WAN. It is included in the frame used by the data link layer. It is the lowest-level address.

Example 1

In Figure 3.4 a node with physical address 10 sends a frame to a node with physical address 87. The two nodes are connected by a link (bus topology LAN). At the data link layer, this frame contains physical (link) addresses in the header. These are the only addresses needed. The data link layer at the sender receives data from an upper layer. It encapsulates the data in a frame, adding a header and a trailer.

Encapsulation means that a packet (header, data and maybe trailer) at a specific level is encapsulated in one whole packet.

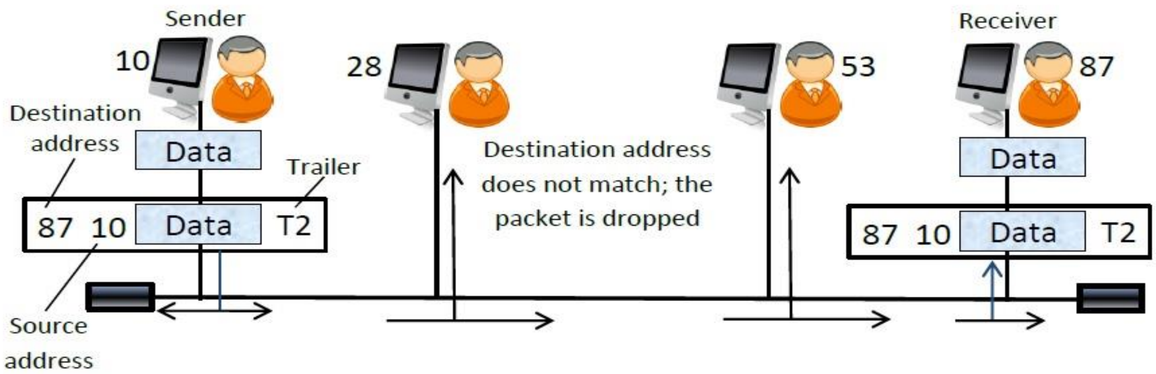


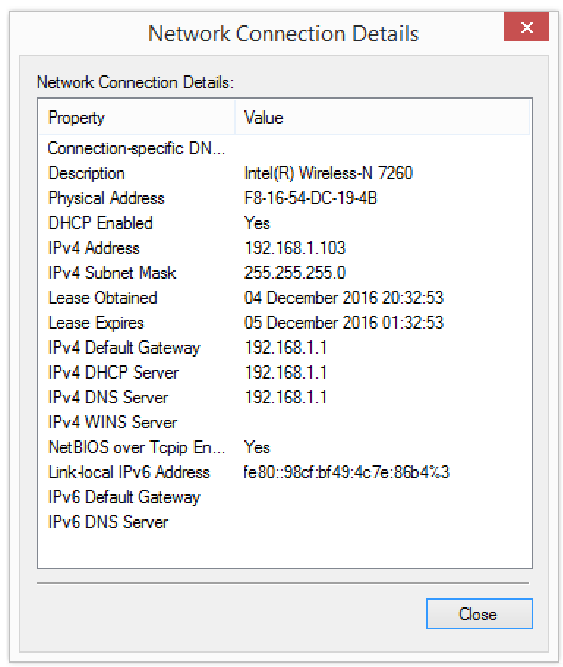
Figure 3.4 Example of physical addresses

Most local-area networks use a **48-bit (6-byte)** physical address written as **12 hexadecimal digits**; every byte (2 hexadecimal digits) is separated by a colon, as shown below:

07:01:02:01:2C:4B

A 6-byte (12 hexadecimal digits) physical address

The physical address is imprinted on the network interface card (NIC) as shown in the left picture and can be displayed on any computer as shown in the right screenshot.



2. Logical Addresses

Physical addresses are not enough in an internetwork environment. A universal (or logical) addressing system is needed in which each host can be identified uniquely, regardless of the underlying physical network.

A logical address in the Internet is currently a 32-bit address that can uniquely define a host connected to the Internet. No two publicly addressed hosts on the Internet can have the same IP address.

192.168.1.100

IP (or logical) address, Version 4, Class C

Example 2

Figure 3.6 shows a part of an internet with two routers connecting three LANs. Each device (computer or router) has a pair of addresses (logical and physical). The computer with logical address A and physical address 10 needs to send a packet to the computer with logical address P and physical address 95.

The sender encapsulates its data in a packet at the network layer and adds two logical addresses (A and P). The network layer, however, needs to find the physical address of the next hop before the packet can be delivered. The network layer consults its routing table and finds the logical address of the next hop (router 1) to be F. The ARP finds the physical address of router 1 that corresponds to the logical address of 20. Now the network layer passes this address to the data link layer, which in turn encapsulates the packet with physical destination address 20 and physical source address 10.

Since the logical destination address does not match the router's logical address, the router 1 knows that the packet needs to be forwarded to router 2. When the frame reaches the destination, the packet is de-capsulated. The destination logical address P matches the logical address of the computer. The data are de-capsulated from the packet and delivered to the upper layer.

Note: Although physical addresses will change from hop to hop, logical addresses remain the same from the source to destination (but there are some exceptions to this rule).

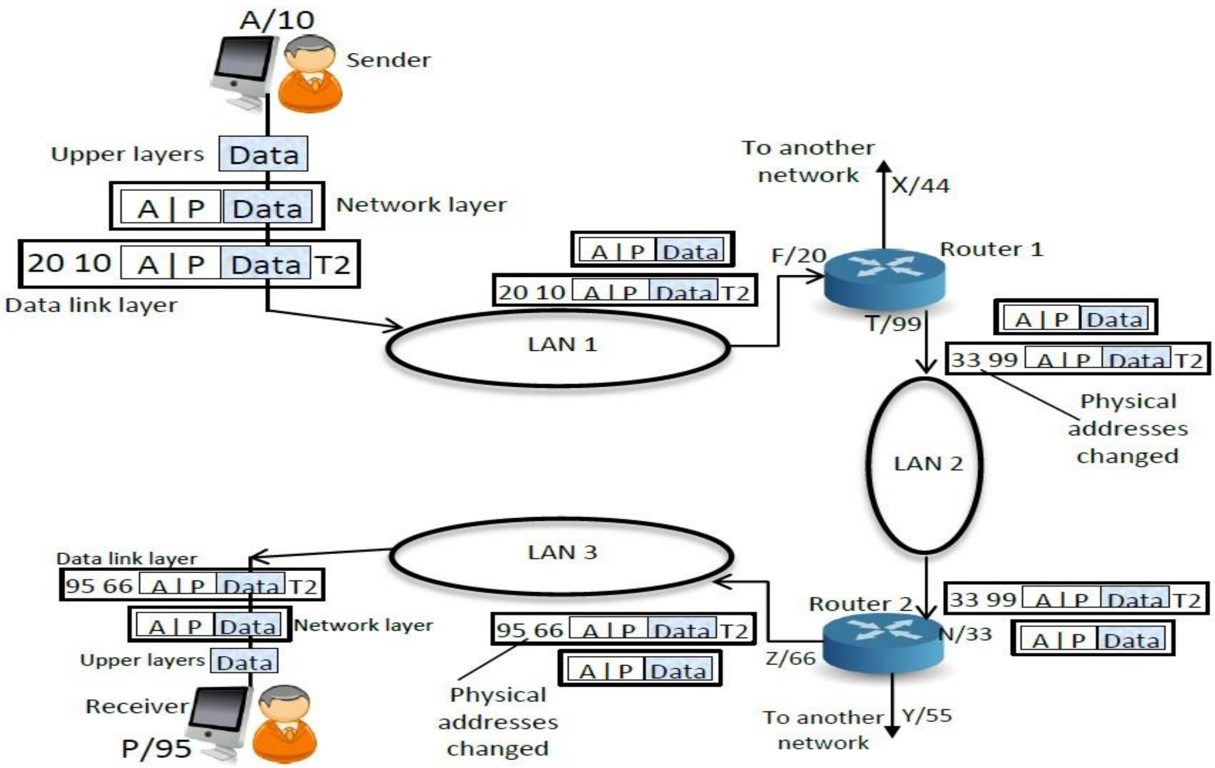


Figure 3.6 Example of logical (IP) addresses

3. Port Addresses

Today, computers are devices that can run multiple processes at the same time. The end objective of Internet communication is a process communicating with another process. Therefore, we need a method to label the different processes. In the TCP/IP architecture, the label assigned to a process is called a port address. A port address in TCP/IP is 16 bits in length.

Example 3

Figure 3.7 shows two computers communicating via the Internet. The sending computer is running three processes at this time with port addresses (a), (b), and (c). The receiving computer is running two processes at this time with port addresses (j) and (k). Process (a) in the sending computer needs to communicate with process (j) in the receiving computer.

Note that although both computers are using the same application, FTP, for example, the port addresses are different **because** one is a **client program** and the other is a **server program.**

Note: Although **physical addresses** change from hop to hop, **logical and port addresses** remain the same from the source to destination (there are some exceptions to this rule).

4. Specific Addresses

Some applications have user-friendly addresses that are designed for that specific address, for example:

- The e-mail address (for example, someone@gmail.com) that defines the recipient of an e-mail.
- Universal Resource Locator (URL) (for example, www.google.com) that is used to find a document on the World Wide Web (WWW).

The e-mail and URL addresses are changed automatically to the corresponding port and logical addresses by the sending computer (by using the DNS: Domain Name System).

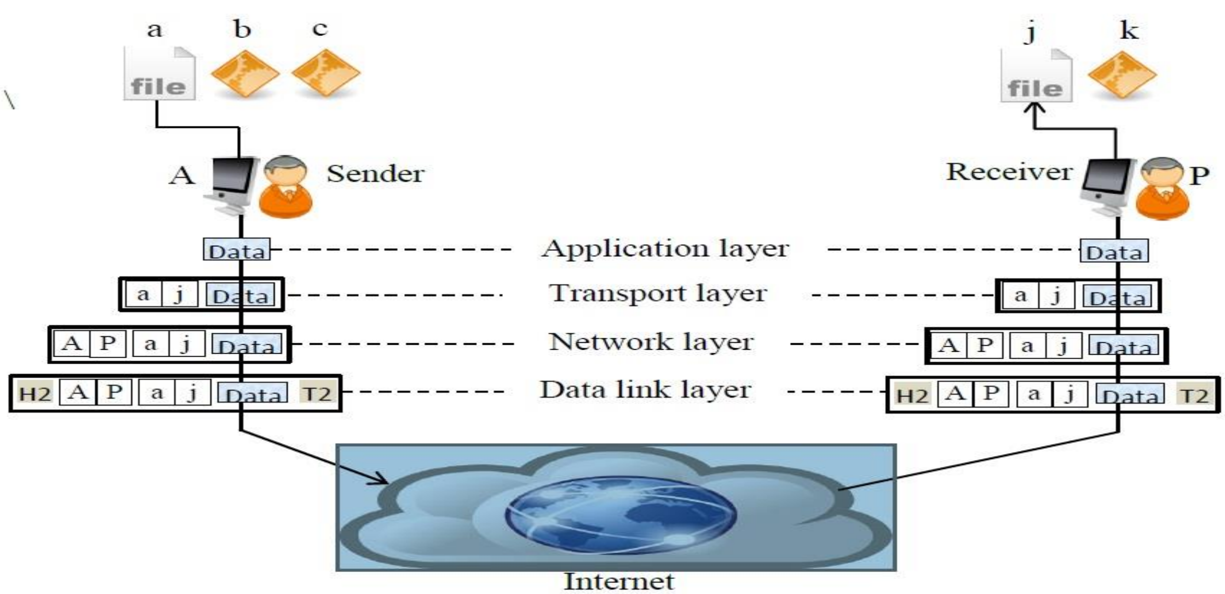


Figure 3.7 Example of port addresses

According to the function of each layer, **the encapsulation operation** of the above figure is included the following:

- The transport layer **encapsulates** data from the application layer in a **packet** and adds two port addresses (a) and (j), source and destination.
- The packet from the transport layer is then **encapsulated** in another **packet** at the network layer with logical source and destination addresses (A and P).
- Finally, the packet is **encapsulated** in a **frame** with the physical source and destination addresses of the next hop.