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(شبكات واتصالات - محاضرات النظري)

محاضرة رقم (3)

Data communication and Networks

Lecture 3: TCP/IP Protocol Suite and addressing

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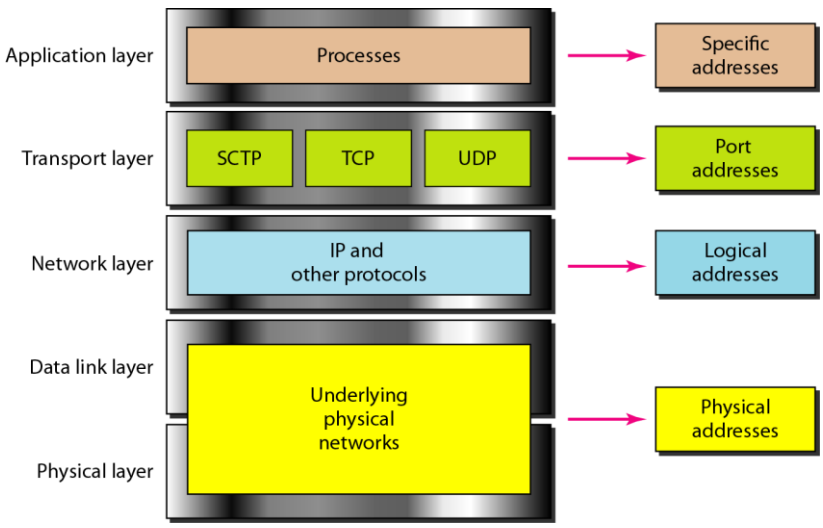


صفحة فارغة

3.1 TCP/IP Protocol Suite

The TCP/IP protocol suite is made of five layers: physical, data link, network, 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 (see Figure 3.1). The three topmost layers in the OSI model, however, are represented in TCP/IP by a single layer called the *application layer*.

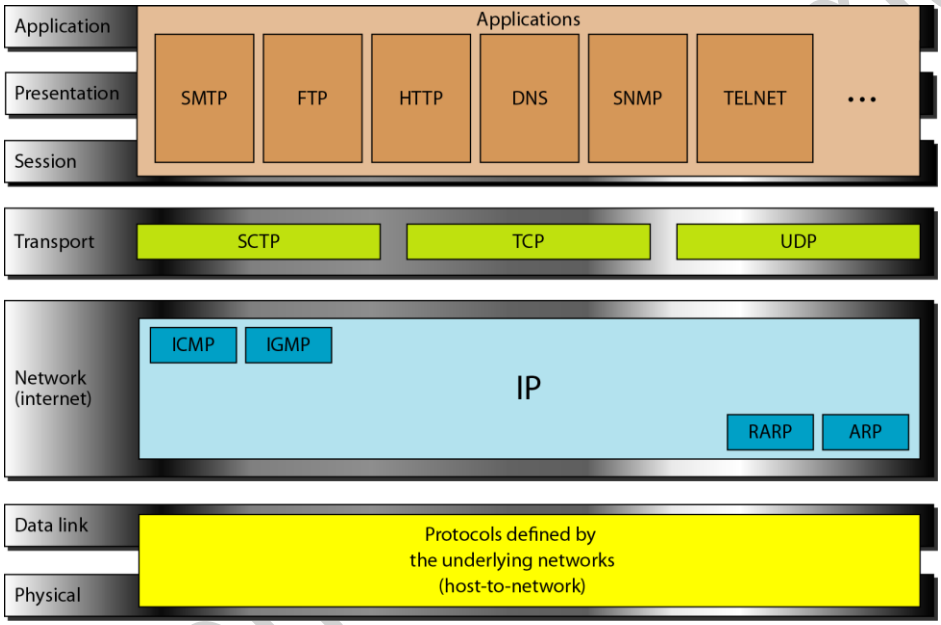


Figure 3.1 TCP/IP and OSI Model

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.

3.2 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** (see Figure 3.2).

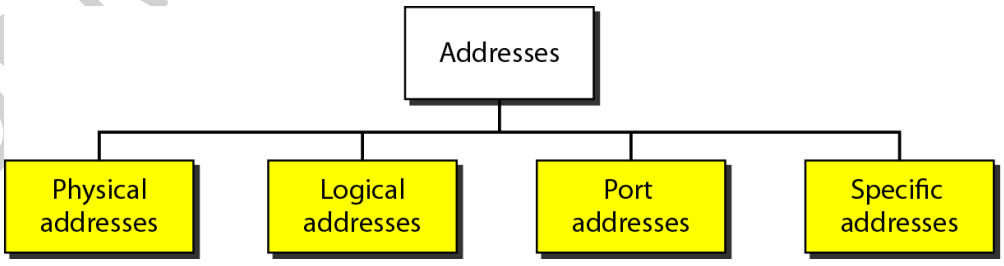


Figure 3.2 Addressing in TCP/IP

Each address is related to a specific layer in the TCPIIP architecture, as shown in Figure 3.3.

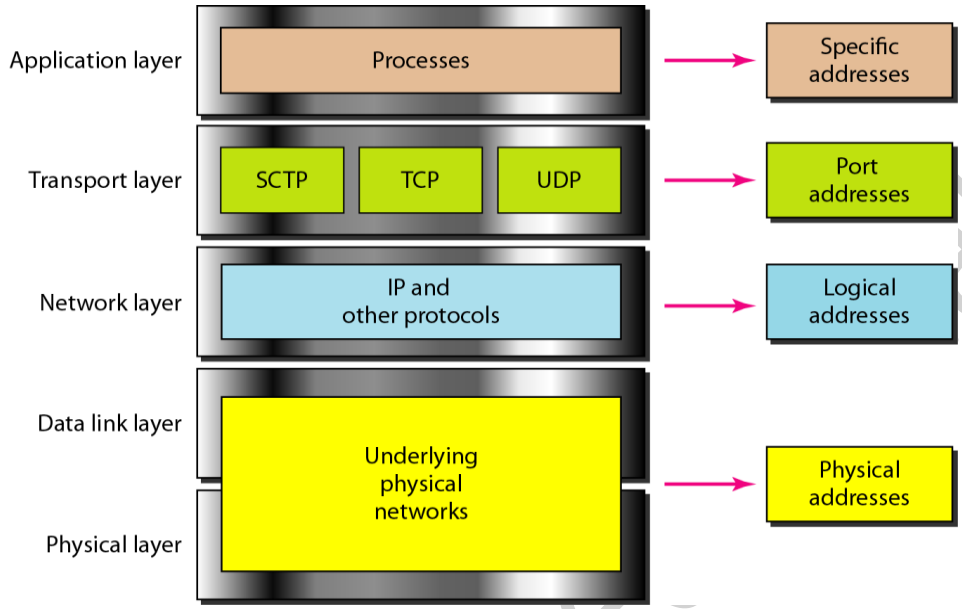


Figure 3.3 Relationship of layers and addresses in TCP/IP

3.2.1 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.

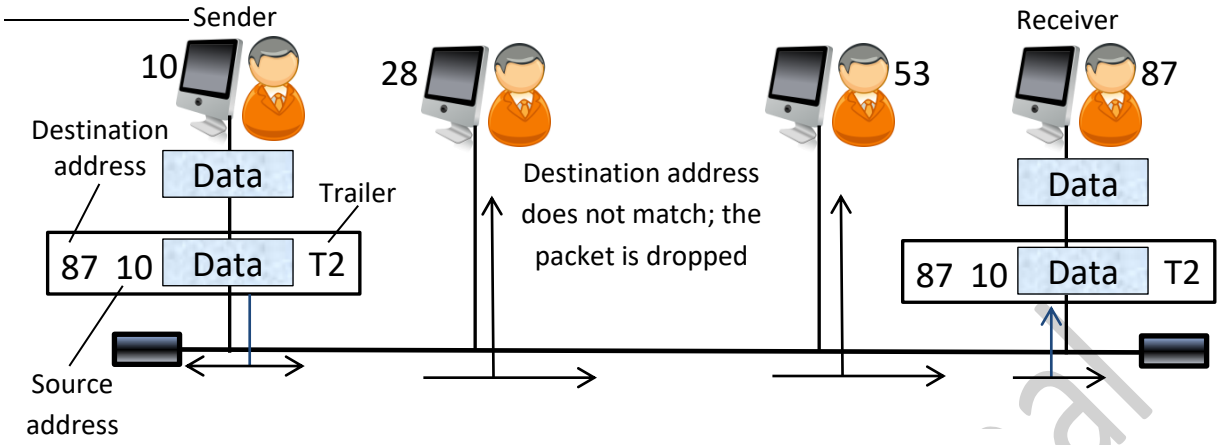


Figure 3.4(a) Example of physical addresses

Example 2

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 of Figure 3.4(b) and can be displayed on any computer as shown in the right.

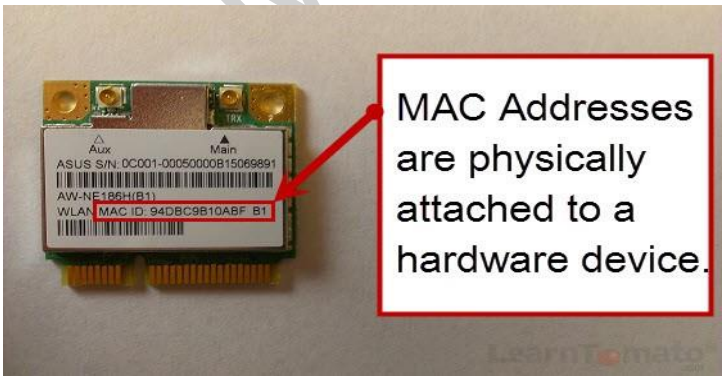
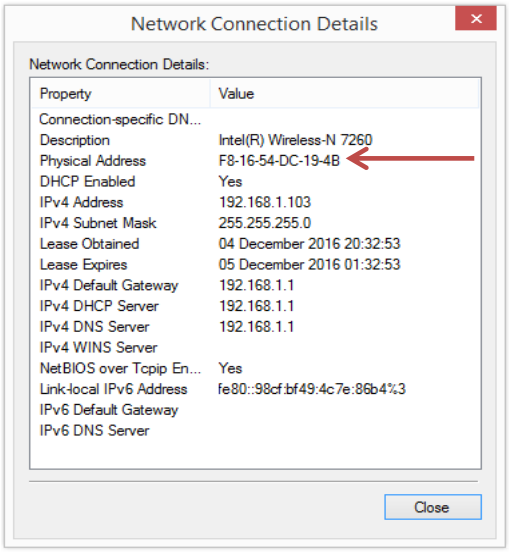


Figure 3.4(b) Network interface card (NIC)



A screenshot that shows a physical address and other connection details

3.2.2 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 3.5 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).

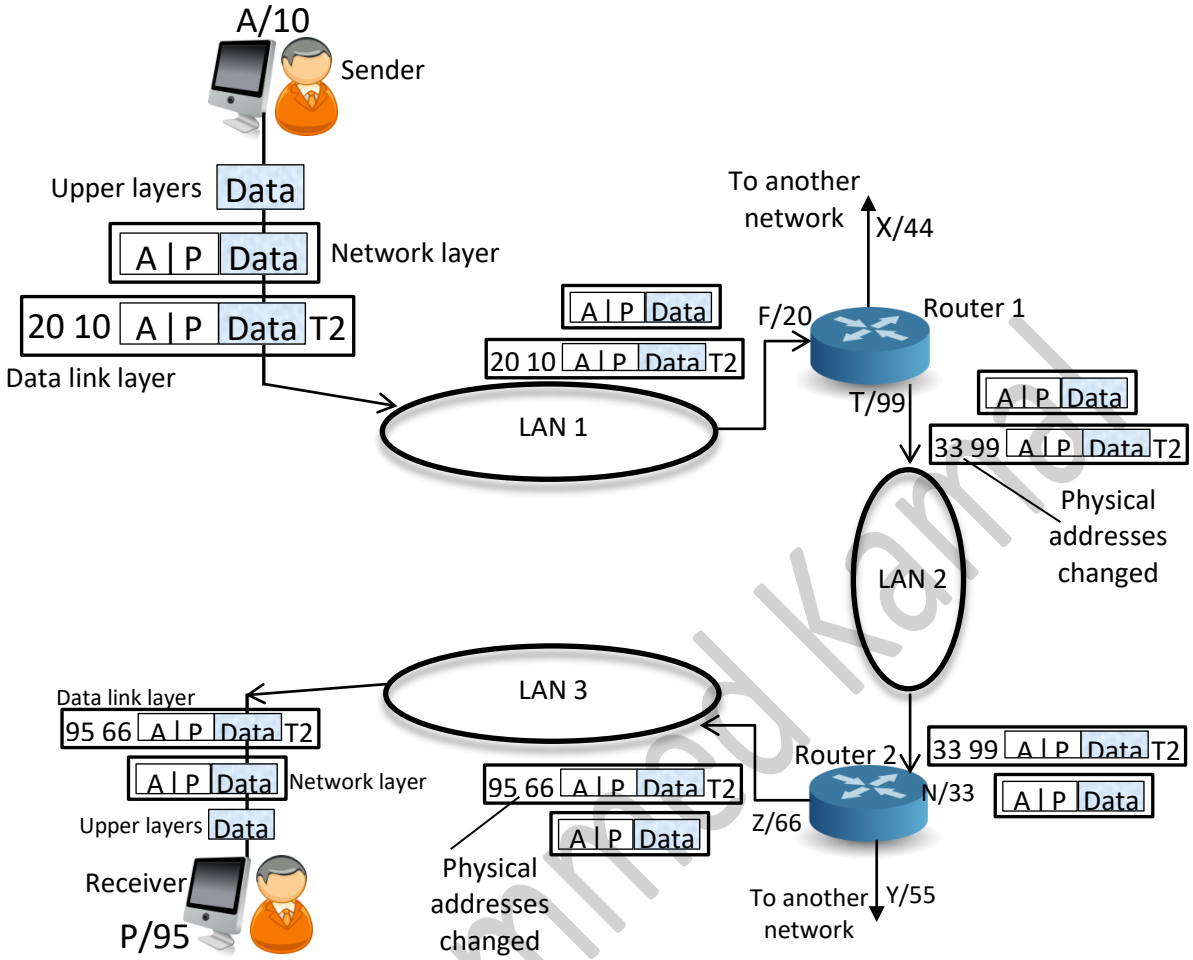


Figure 3.5 Example of logical (IP) addresses

3.2.3 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 3.6 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).

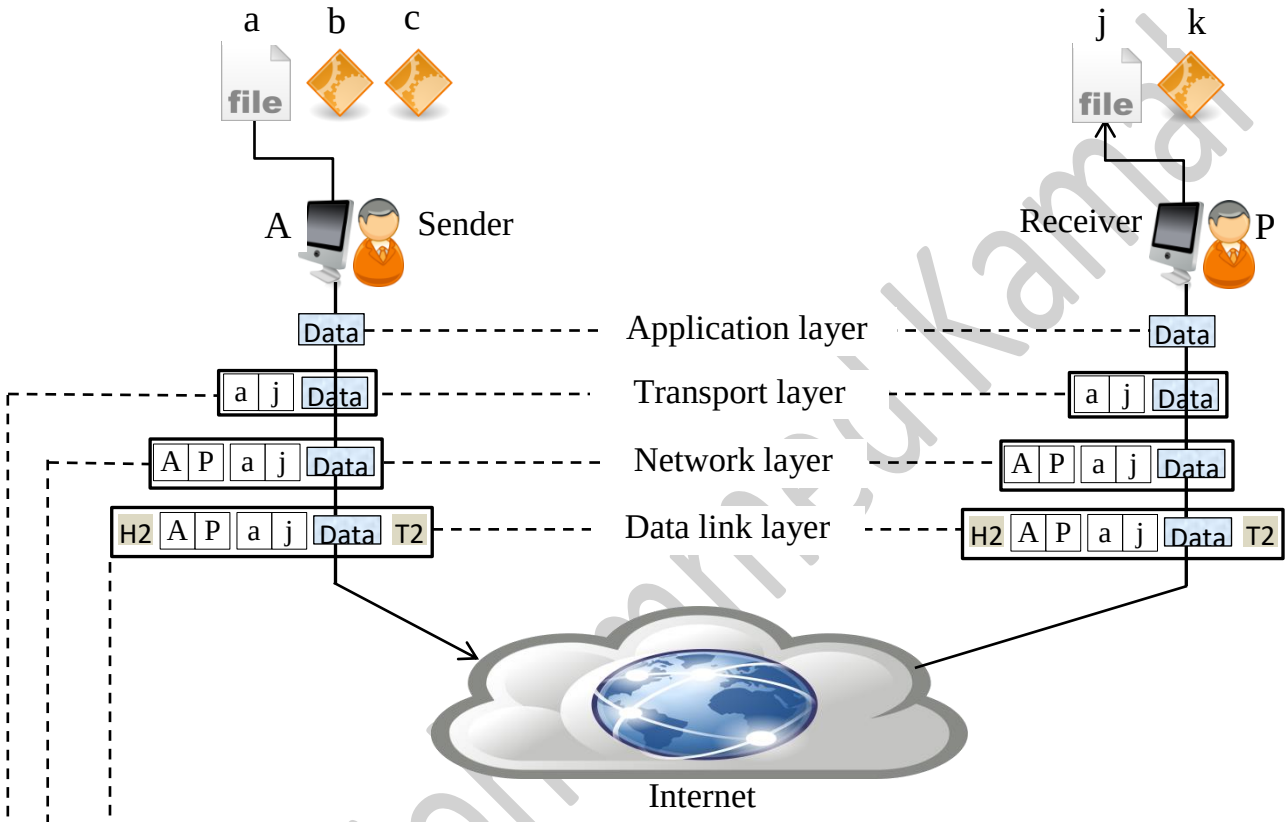


Figure 3.6 Example of port addresses

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.

3.2.4 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*).

For example, Figure 3.7 shows a screenshot of the command prompt window in which the 172.217.17.196 is the logical address of the URL address: www.google.com.

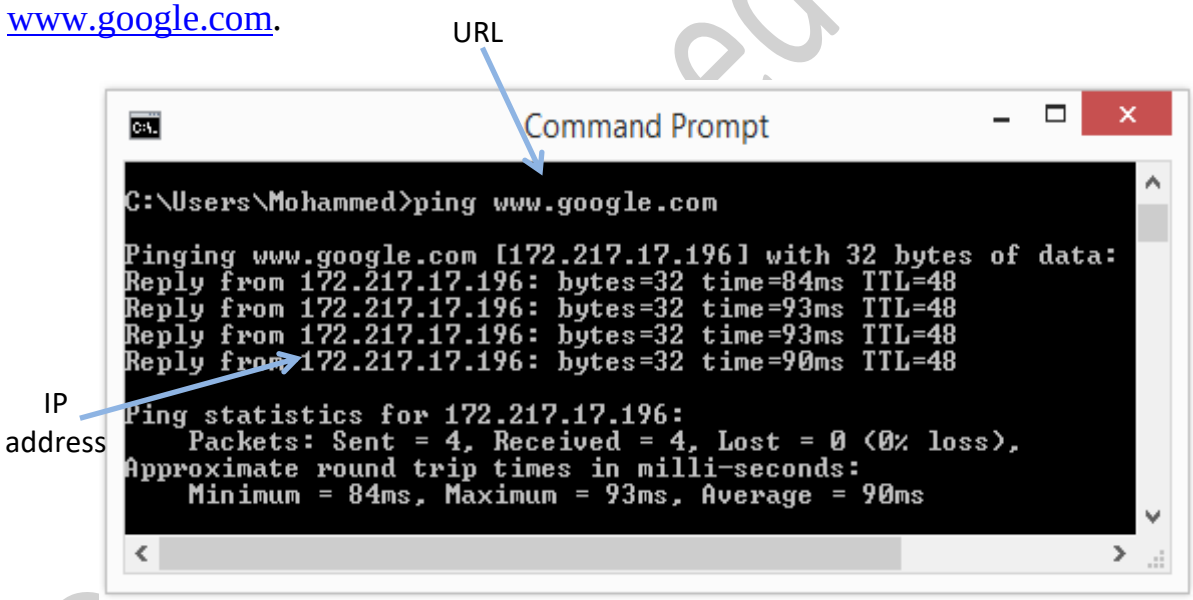


Figure 3.7 Using **ping** instruction to know the corresponding IP address of www.google.com