Lecture (04)
TCP/IP protocol Suite

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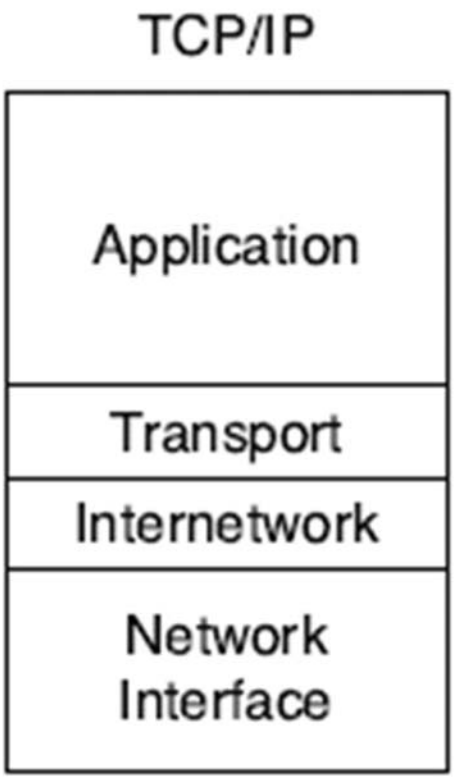
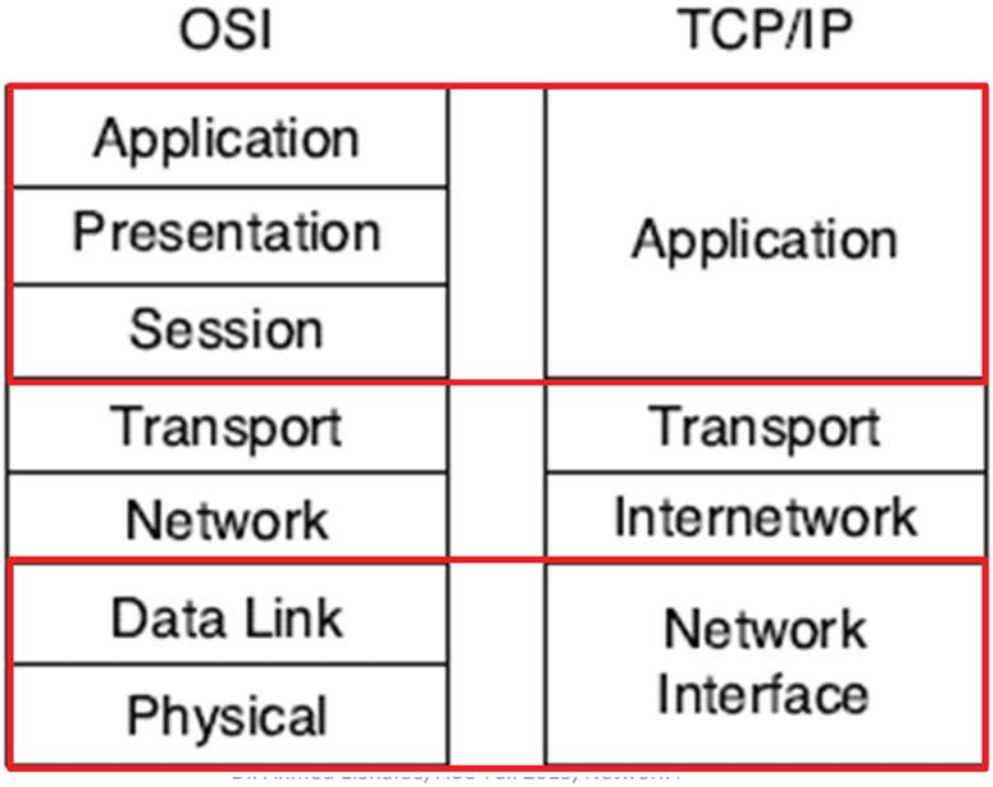
Agenda

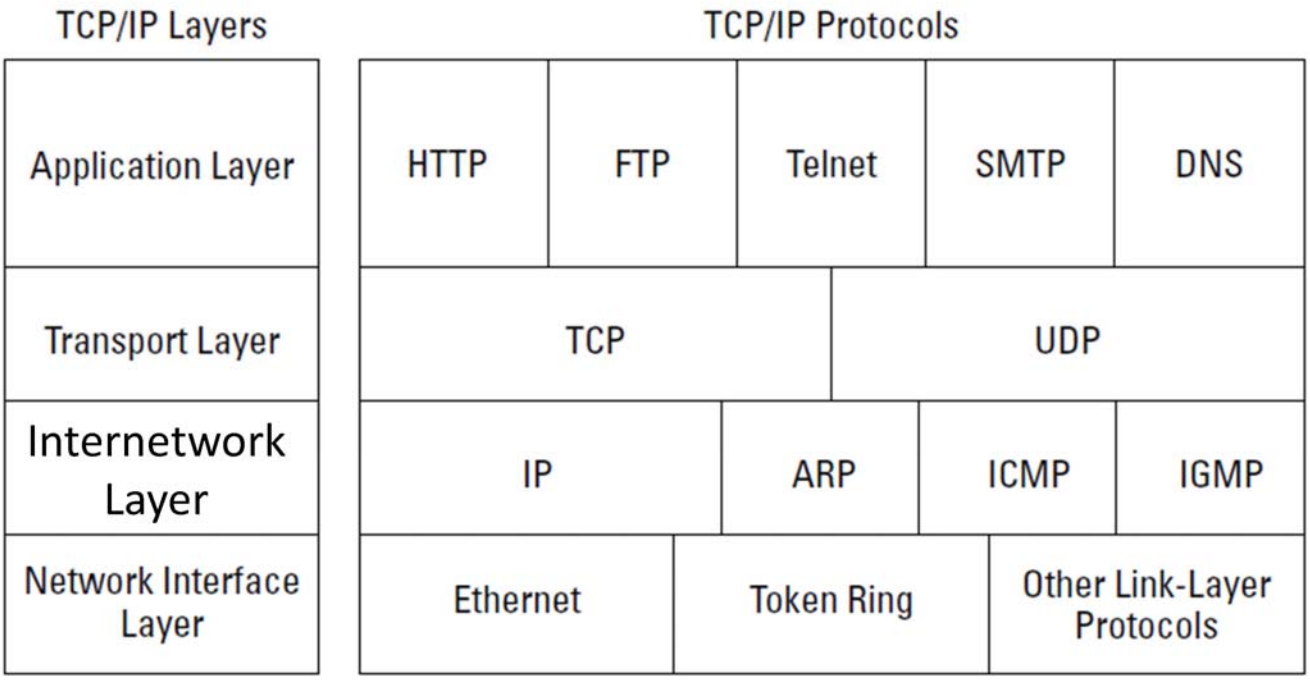
- TCP/IP Framework
- Internet
- Internetwork layer and IP Addresses
- Operation of TCP and IP
- TCP/IP Applications
- Classifying IP Addresses

TCP/IP Framework

- Like the seven-layer OSI Reference Model, TCP/IP protocols are based on a layered framework.
- TCP/IP has four layers



- 



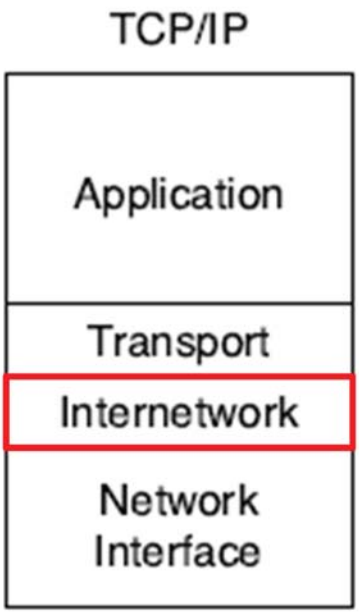
Network Interface layer

- The lowest level of the TCP/IP architecture is the Network Interface layer.
- It corresponds to the OSI Physical and Data Link layers.

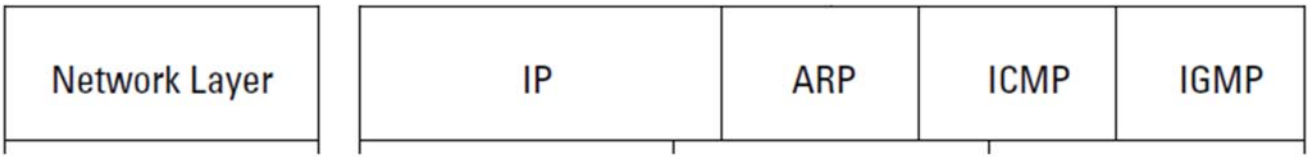
- You can use many different TCP/IP protocols at the Network Interface layer, including Ethernet and Token Ring for LANs and protocols such as X.25, Frame Relay, and ATM for wide area networks (WANs).
- The Network Interface layer is assumed to be unreliable.

Network Interface Layer	Ethernet	Token Ring	Other Link-Layer Protocols

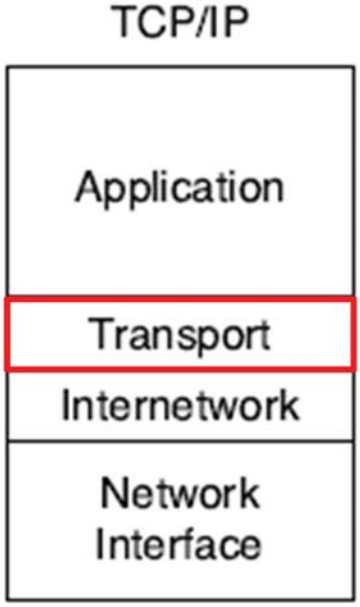
- **InterNetwork layer**
- The **InterNetwork** layer is where data is addressed, packaged, and routed among networks.
- Several important Internet protocols operate at the InterNetwork layer:
- **Internet Protocol (IP):** A routable protocol that uses IP addresses to deliver packets to network devices.
- IP is an intentionally unreliable protocol, so it doesn't guarantee delivery of information.



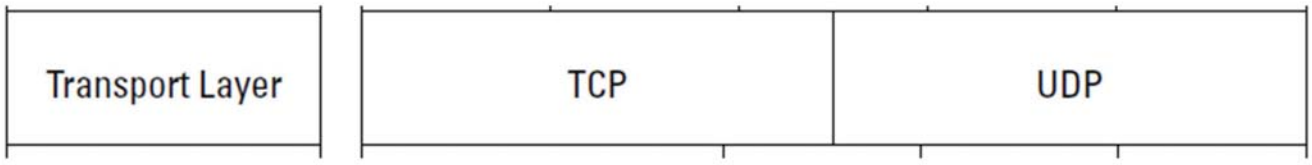
- **Address Resolution Protocol (ARP):** Resolves IP addresses to hardware MAC addresses, which uniquely identify hardware devices.
- **Internet Control Message Protocol (ICMP):** Sends and receives diagnostic messages. ICMP is the basis of the ubiquitous ping command.
- **Internet Group Management Protocol (IGMP):** Used to multicast messages to multiple IP addresses at once.



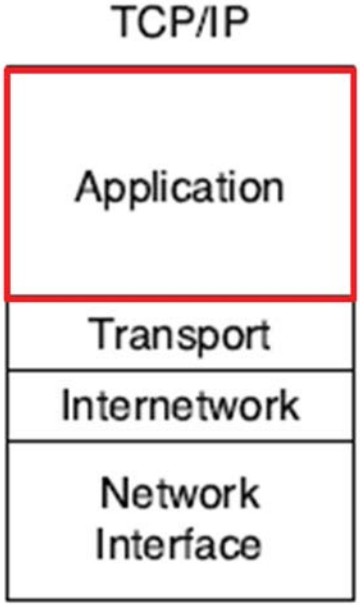
- **Transport layer**
- The Transport layer is where sessions are established and data packets are exchanged between hosts.
- Two core protocols are found at this layer:
- **Transmission Control Protocol (TCP):** Provides reliable connection oriented transmission between two hosts.
- TCP establishes a session between hosts, and then ensures delivery of packets between the hosts.



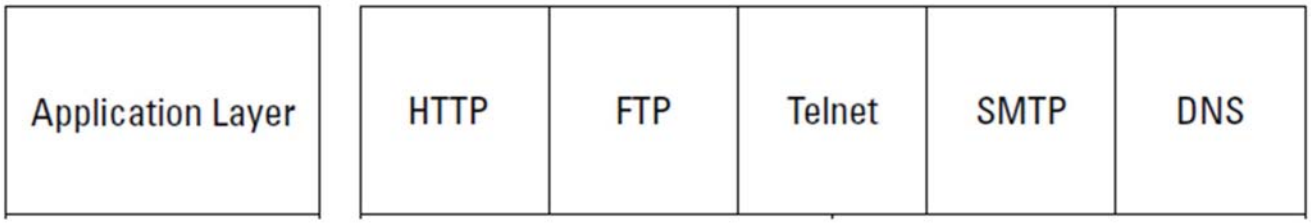
- **User Datagram Protocol (UDP):** Provides connectionless, unreliable, one-to-one or one-to-many delivery



- **Application layer**
- The Application layer of the TCP/IP model corresponds to the Session, Presentation, and Application layers of the OSI Reference Model.
- A few of the most popular Application layer protocols are
- **HyperText Transfer Protocol (HTTP):** The core protocol of the World Wide Web
- **File Transfer Protocol (FTP):** A protocol that enables a client to send and receive complete files from a server



- **Telnet:** The protocol that lets you connect to another computer on the Internet in a terminal emulation mode
- **Simple Mail Transfer Protocol (SMTP):** One of several key protocols that are used to provide e-mail services
- **Domain Name System (DNS):** The protocol that allows you to refer to other host computers by using names rather than numbers



Internet

- the Internet links hundreds of millions of computer users throughout the world.
- Strictly speaking, the Internet is a network of networks.
- It consists of tens of thousands of separate computer networks, all interlinked, so that a user on any of those networks can reach out and potentially touch a user on any of the other networks.

- The father of the internet is the ARPANET, which was built by the US Department of Defense in 1969 to link defense installations.
- In the 1970s, ARPANET was split into two networks: one for military use (renamed MILNET) and the original ARPANET
- The two networks were connected by a networking link called IP — the *Internet protocol*
- *Early IP was designed to allow 10 thousands of networks to be connected.*
- By the mid-1980s, ARPANET was beginning to reach the limits of what it could do.

- National Science Foundation (NSF), set up a nationwide network designed to connect huge *supercomputers,* used to discover new prime numbers and calculate the orbits of distant galaxies, In fact, NSFNET replaced ARPANET as the new backbone for the Internet.
- The Net began to grow so fast that even NSFNET couldn't keep up, so private commercial networks got into the game.
- The size of the Internet nearly doubled every year for most of the 1990s.
- After millennium, the growth rate slowed a bit.
- However, the Internet still seems to be growing at the phenomenal rate of about 30 to 50 percent per year,

Internetwork layer and IP Addresses

- **Introduction**
- An *IP address* is a number that uniquely identifies every host on an IP network.
- IP addresses operate at the interNetwork layer of the TCP/IP protocol stack, so they are independent of lower-level Data Link layer MAC addresses, such as Ethernet MAC addresses.
- IP addresses are 32-bit binary numbers, which means that theoretically, a maximum number of available hosts is about 4 billion unique host addresses can exist throughout the Internet (2^{32} = 4.3 E9)
- Many experts predict that we will run out of IP addresses soon.

- a standard for 128-bit IP addresses has been adopted, to overcome that problem

Networks and hosts

- a 32-bit IP address actually consists of two parts:
- **The network ID (or network address):** Identifies the network on which a host computer can be found
- **The host ID (or host address):** Identifies a specific device on the network indicated by the network ID

The dotted-decimal notation

- In dotted-decimal notation, each group of eight bits — an *octet* — is represented by its decimal equivalent. For example, consider the following binary IP address:

11000000101010001000100000011100

- To convert this value to dotted-decimal notation, first divide it into four octets, as follows:

11000000	10101000	10001000	10001000

- Then, convert each of the octets to its decimal equivalent:

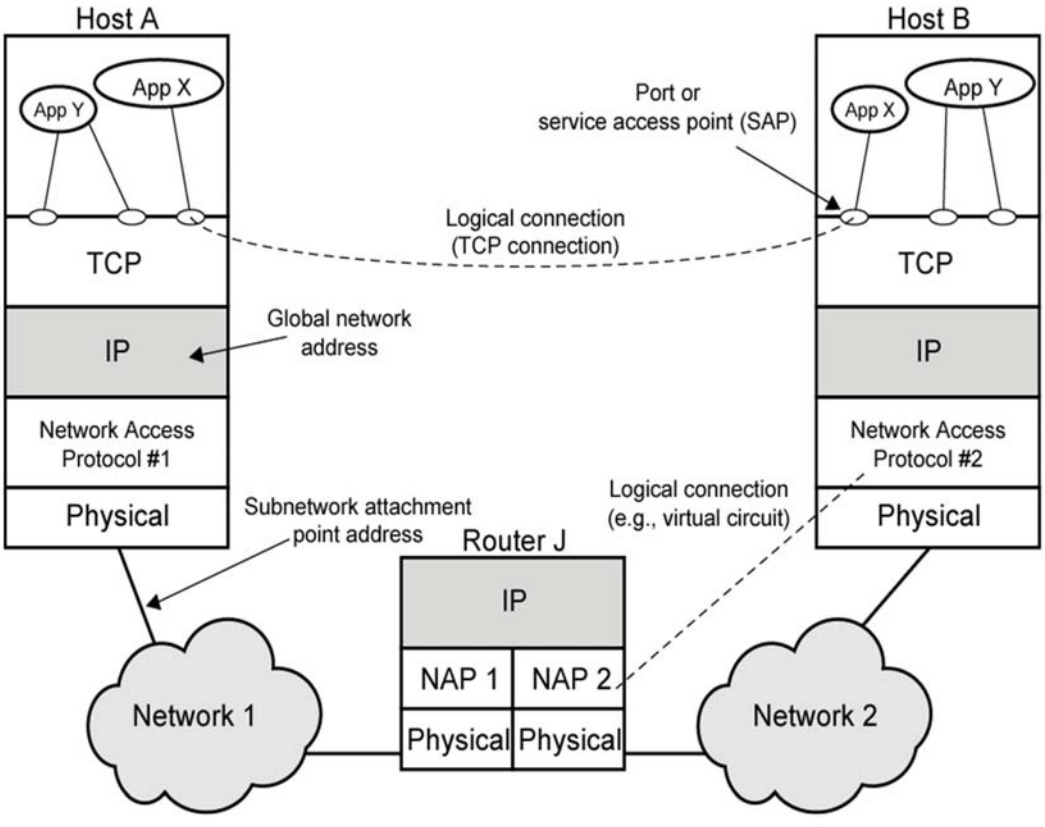
11000000	10101000	10001000	10001000
192	168	136	28

- Then, use periods or dots to separate the four decimal numbers, like this:

192.168.136.28

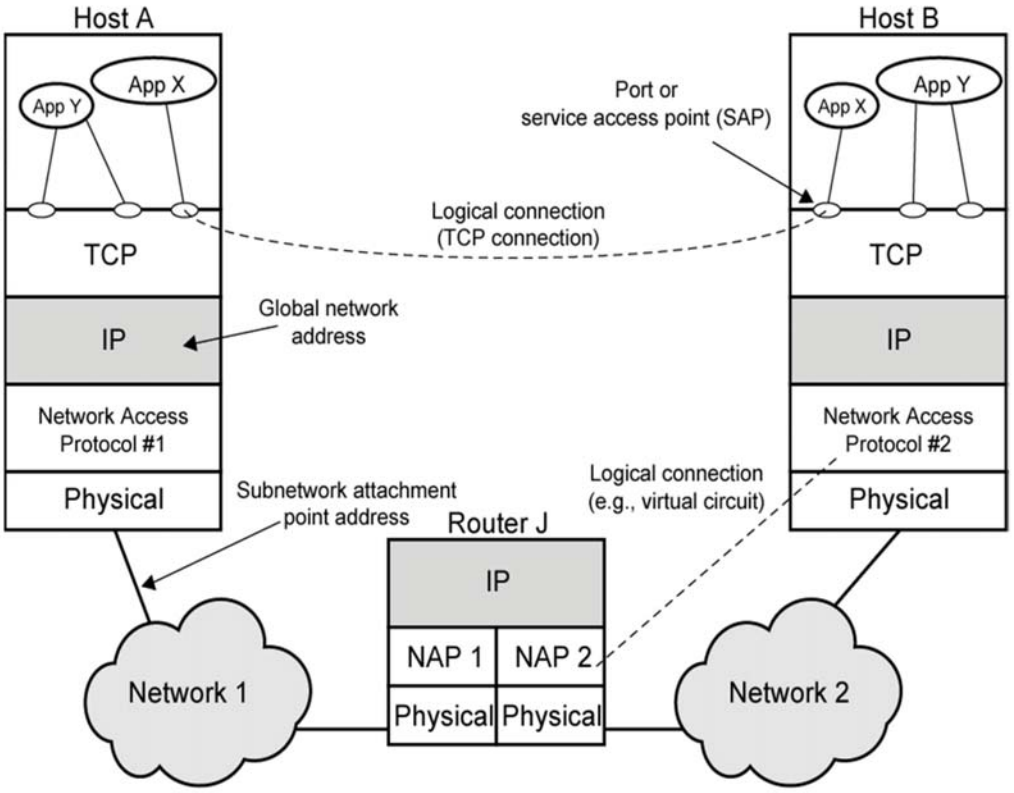
Operation of TCP and IP

- The total communications facility may consist of multiple networks, referred as subnetworks

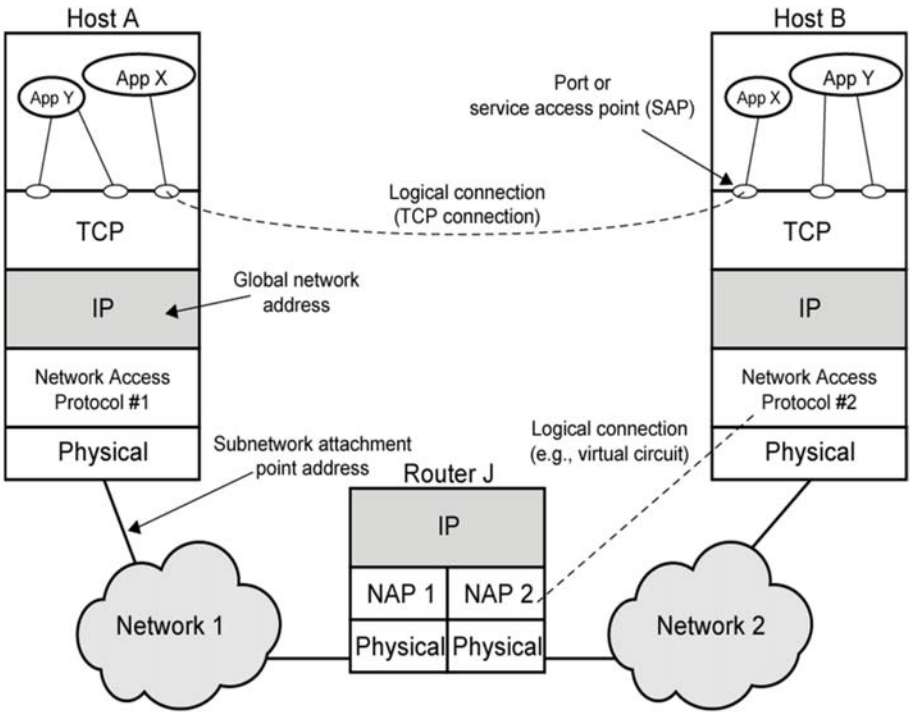


- Some sort of **network access** protocol, such as the Ethernet logic, is used to connect a computer to a subnetwork.
- This protocol enables the host to send data across the subnetwork to another host.
- if the target host is on another subnetwork, the router that will forward the data, using **IP** protocol.

- **IP** is implemented in all of the end systems and the routers, which acts as a relay to move a block of data from one host, through one or more routers, to another host.

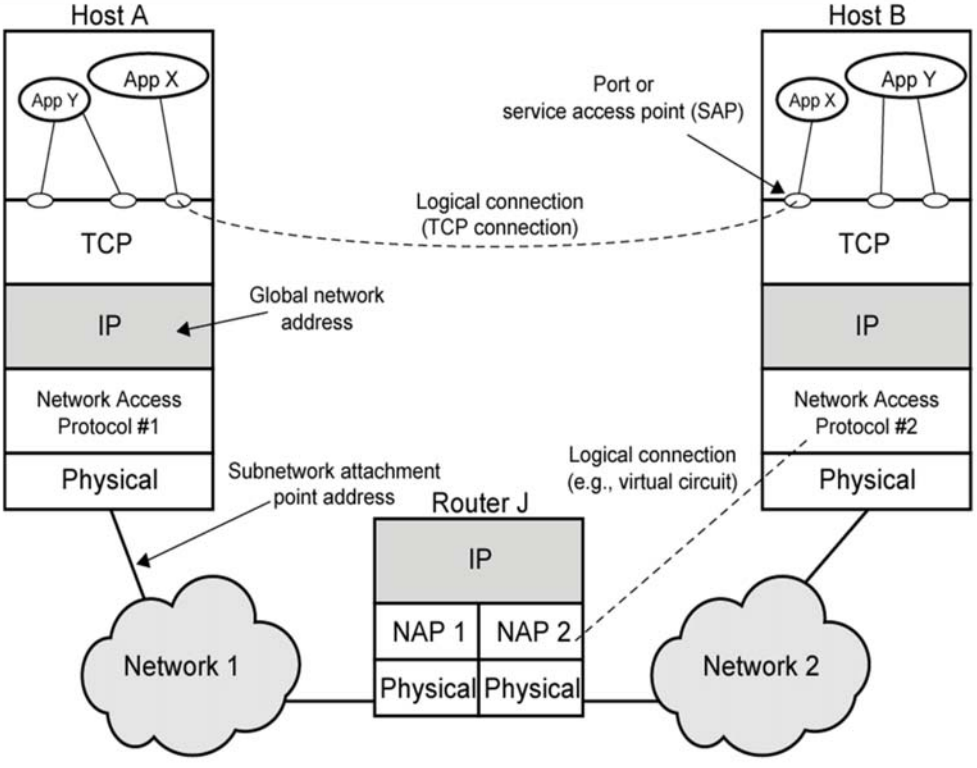


- TCP is implemented only in the end systems; it keeps track of the blocks of data to assure that all are delivered reliably to the appropriate application.

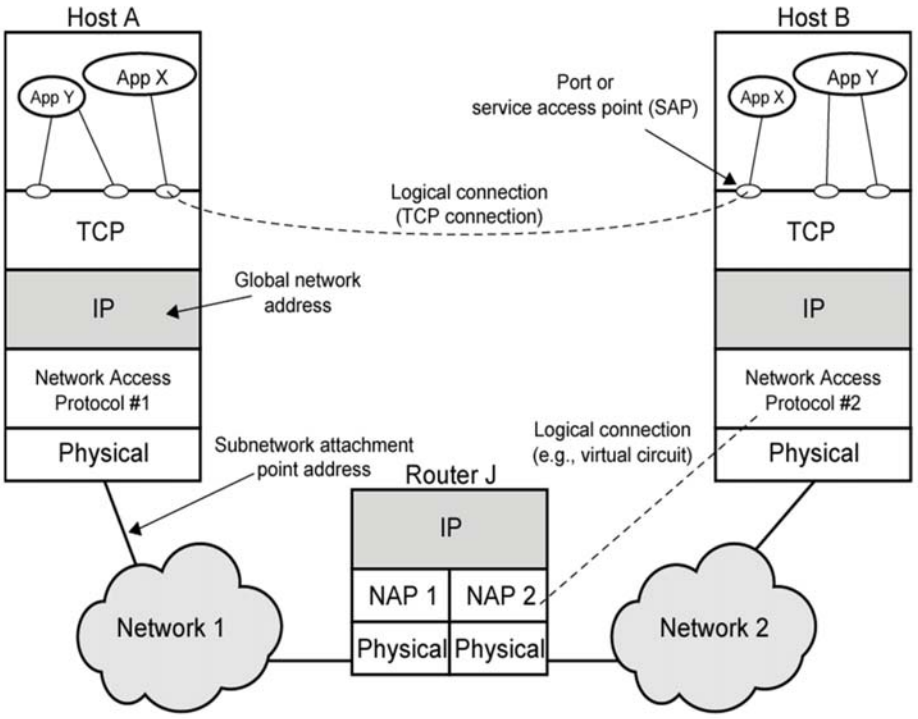


- Actually, there are two levels of addressing

1. Each host on a subnetwork must have a unique global internet address; this allows the data to be delivered to the proper host.



2. Each process with a host must have an address that is unique within the host; this allows the host-to-host protocol (TCP) to deliver data to the proper process. These latter addresses are known as ports.



Example:

- A process on host A, wishes to send a message to another process on host B.
- The process at A (**application layer**) hands the message down to TCP with instructions to send it to host B.

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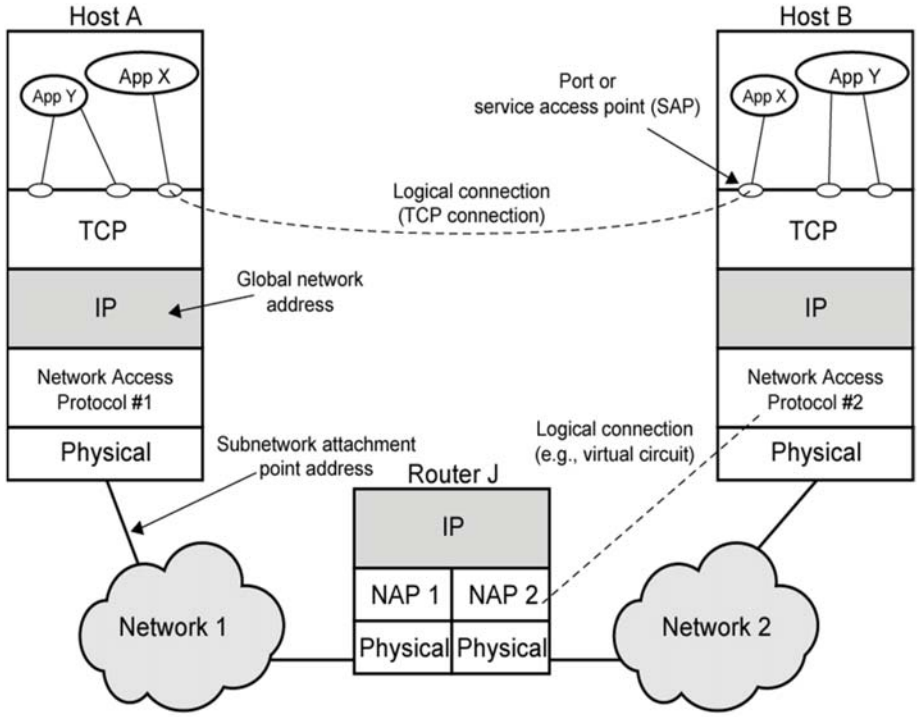

- The sending process generates a block of data containing control information and data than passes it to TCP.
- **TCP** hands the message down to IP with instructions to send it to host B.

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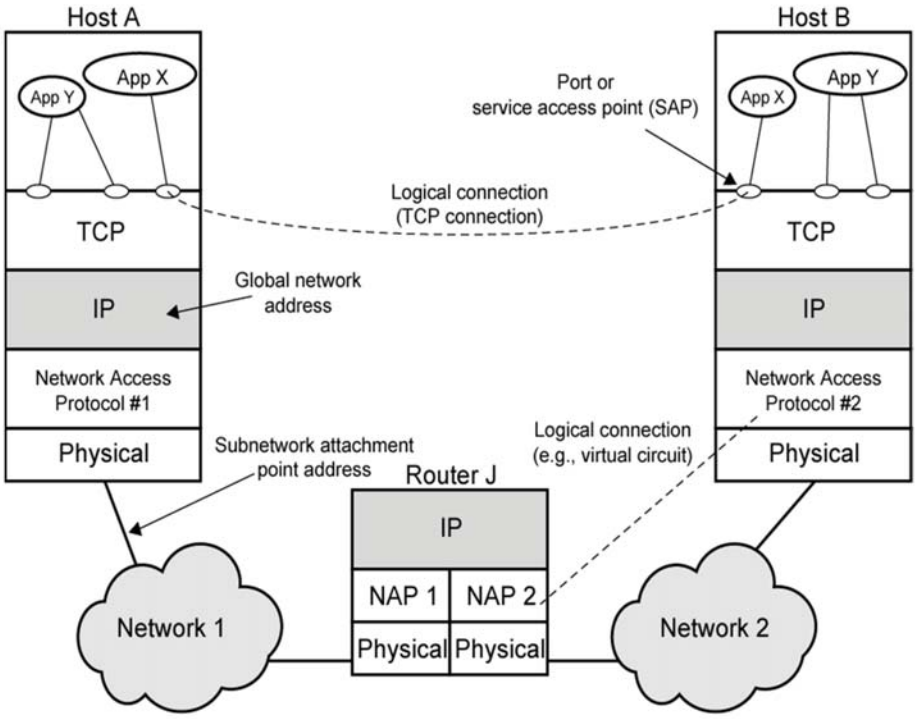
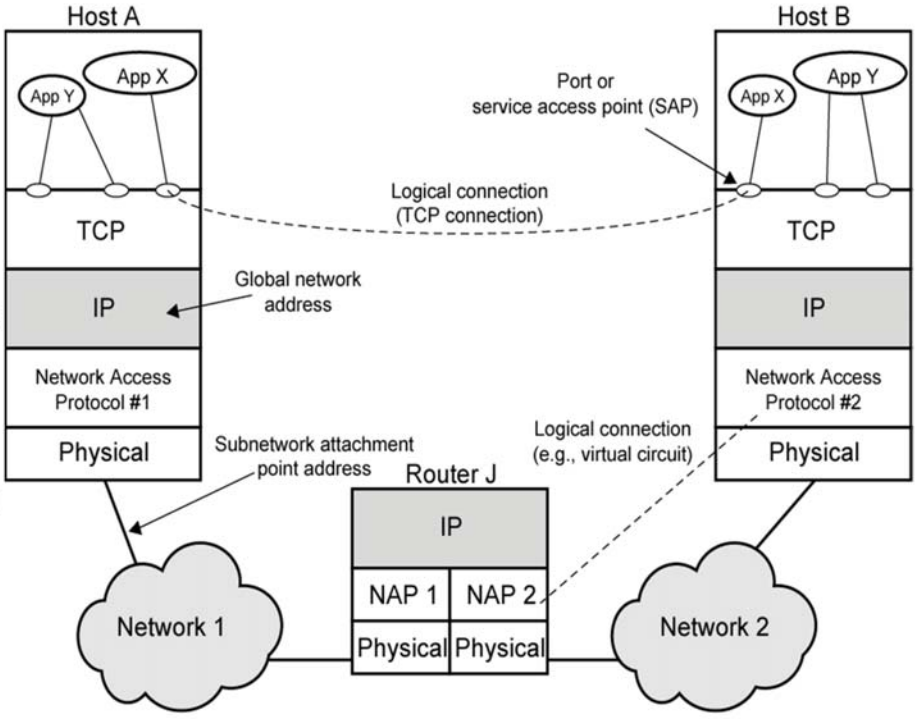
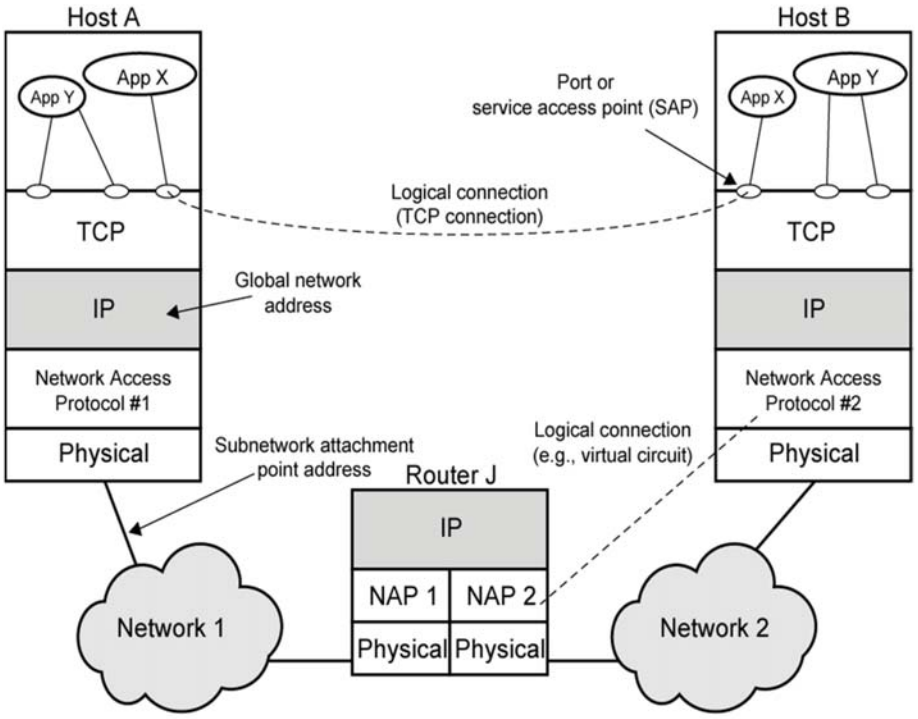


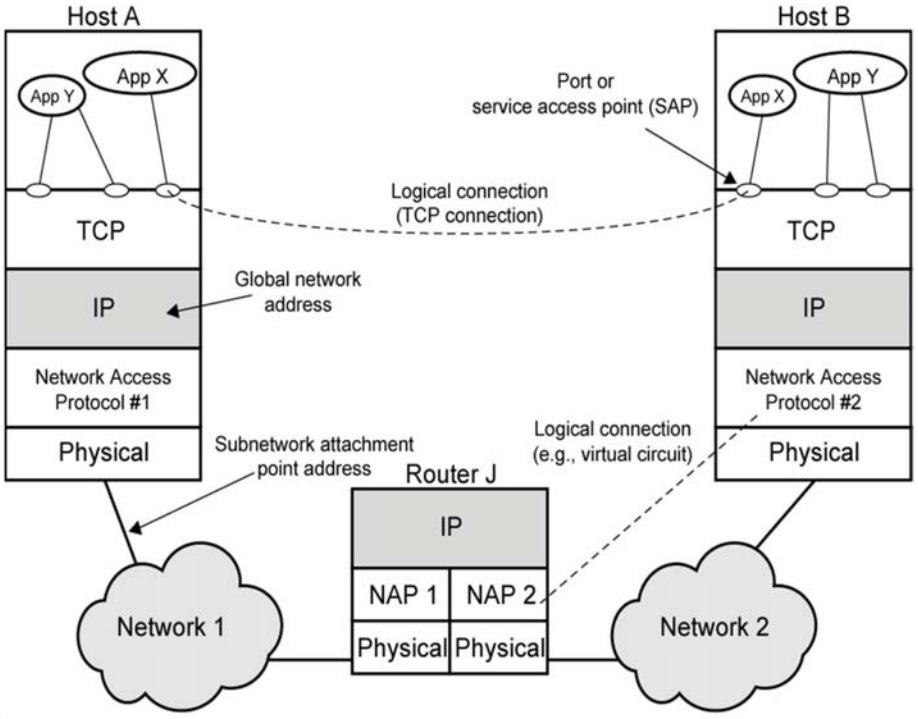
- TCP may break this block into smaller pieces to make it more manageable.
- To each of these pieces, TCP appends control information known as the TCP header, formatting a TCP segment.
- Note that IP need not be told the identity of the destination port.

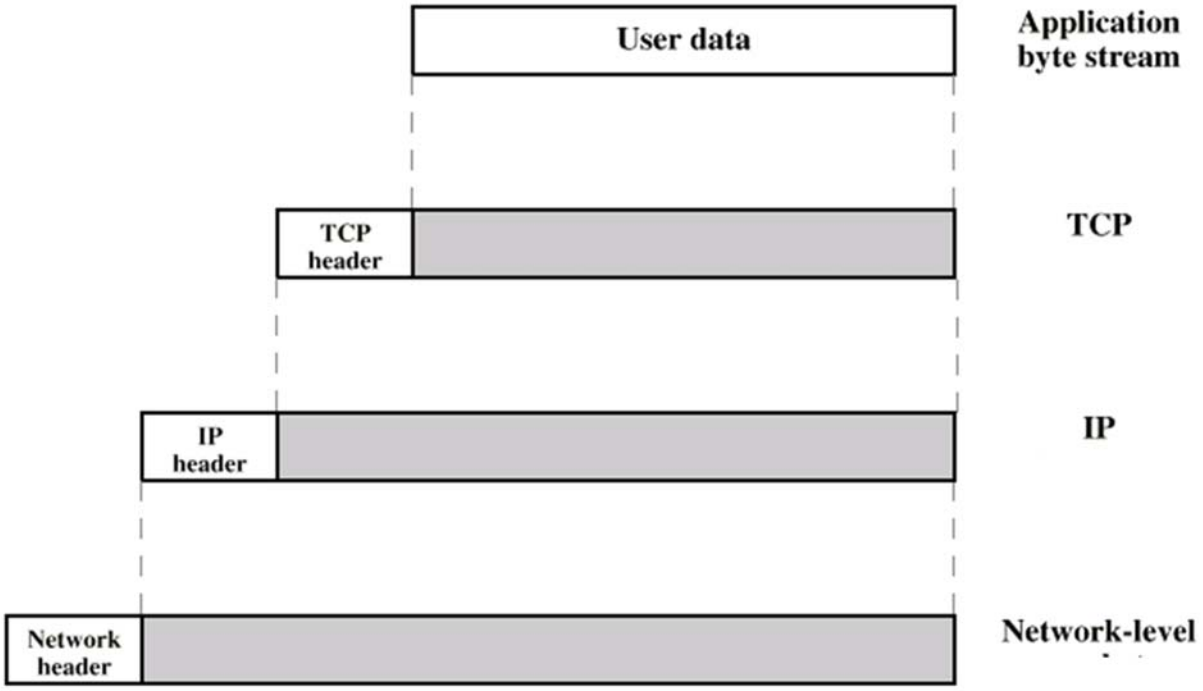


- **IP** appends a header of control information to each segment to form an IP packets.
- These segments must be transmitted across one or more subnetworks and relayed through one or more intermediate routers.



- **IP** hands the message down to the **network access layer** (e.g., Ethernet logic) with instructions to send it to router J (the first hop on the way to B).
- Network access layer appends its own header, creating a packet, or frame.





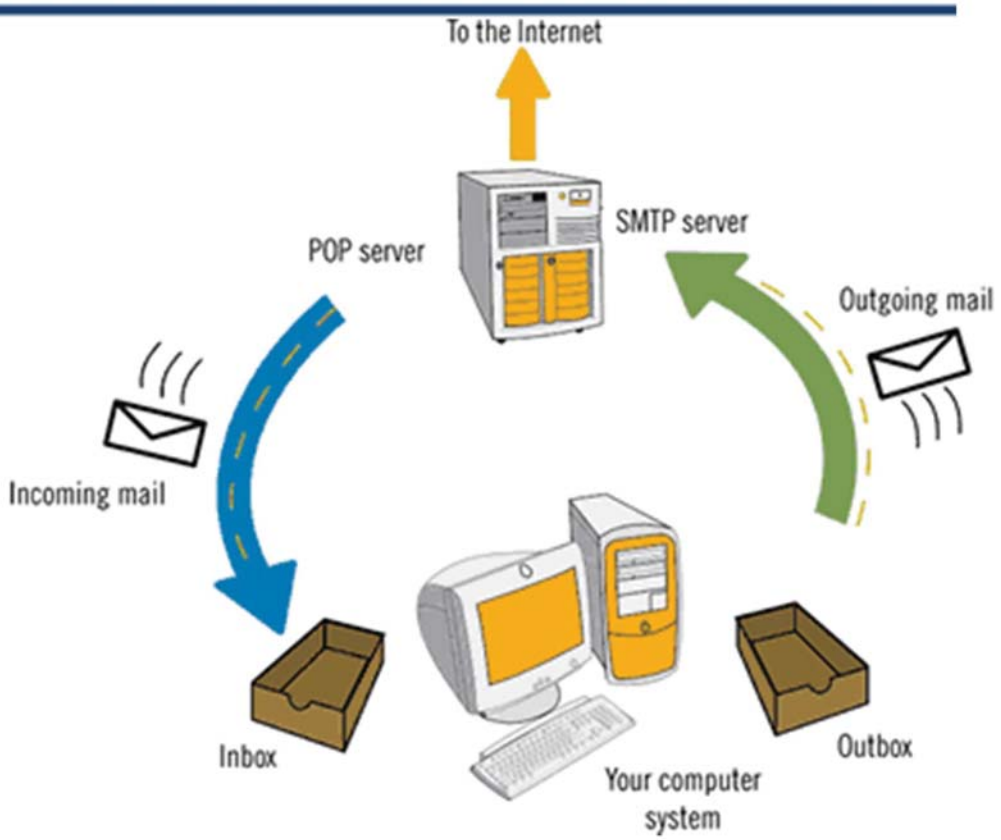
TCP/IP Applications

Hyper text transfer protocol (http)

- is used to transfer web pages from a Web Server to Web Client (Browser)
- Web Pages are arranged in a directory structure in the Web Server
- HTTP supports Virtual Hosting (Hosting multiple sites on the same server)
- Popular Web Servers
  - Apache
  - Windows IIS

Email

- Simple Mail Transfer Protocol (SMTP) is used to transfer mail between Mail Servers over Internet



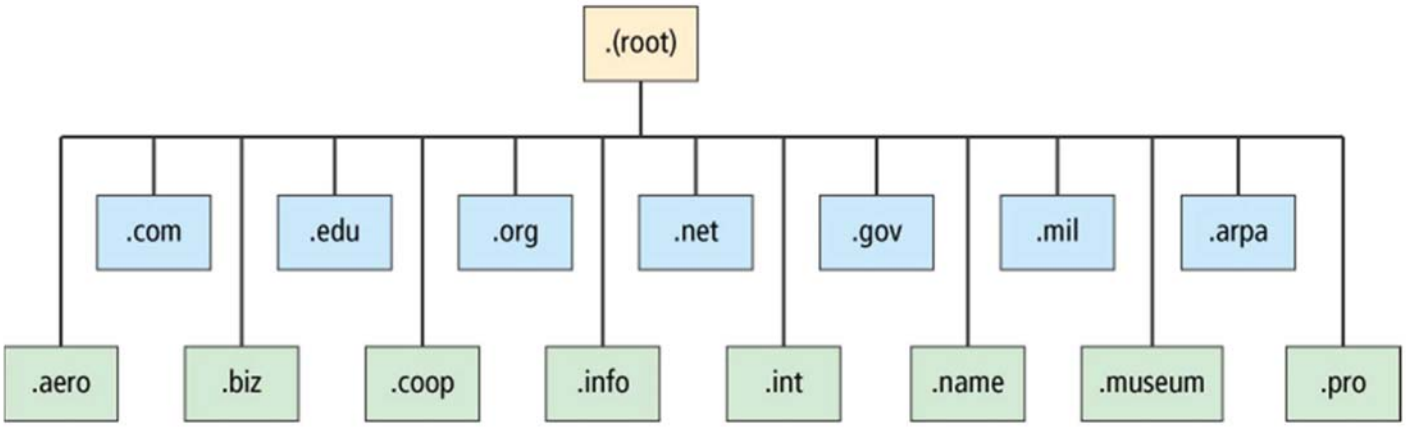
- Post Office Protocol (PoP) and Interactive Mail Access Protocol (IMAP) is used between Client and Mail Server to retrieve mails
- The mail server of a domain is identified by the MX record of that domain
- Popular Mail Servers
  - Microsoft Exchange Server
  - IBM Lotus

Webmail

- Webmail (or web-based email) is any email client implemented as a web application accessed via a web browser.
- Examples of webmail providers include AOL Mail Gmail, Outlook.com and Yahoo! Mail.
- Practically every webmail provider offers email access using a webmail client, and many of them also offer email access by a desktop email client using standard email protocols,

DNS

- A DNS server maintains the name to IP address mapping of the domain for which it is the name server.
- The DNS server for a domain is registered with the domain registrar and the entry is maintained by the **Internet Root-Servers** or **Country Level Root-Servers**.
- Whenever a server is queried, if doesn't have the answer, the root servers are contacted.
- The **Internet root servers** refer to the DNS server for that domain (in case the domain is a top level domain) or the **Country Root Server** (in case the domain is country level domain).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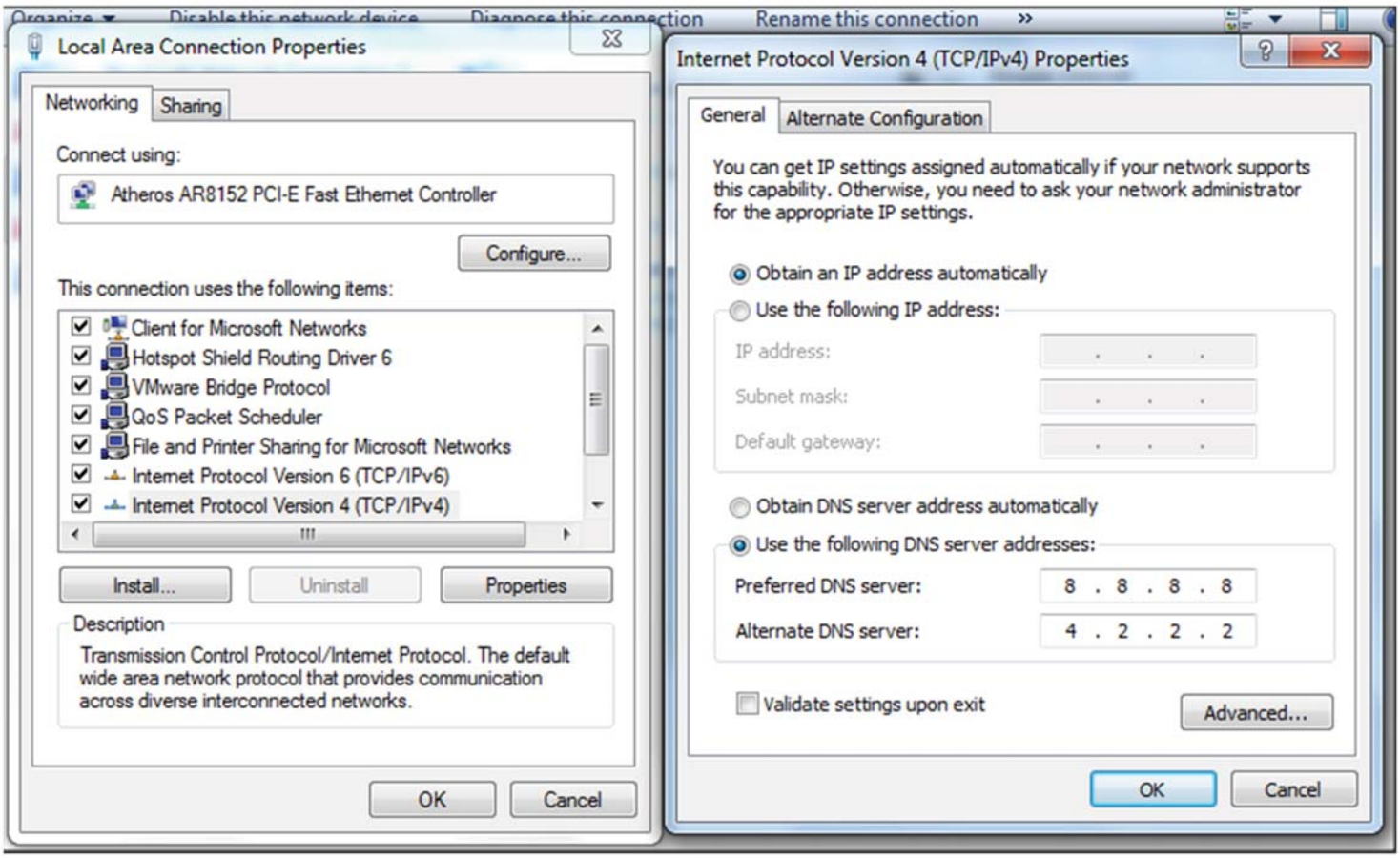

Organize
Disable this network device
Diagnose this connection
Rename this connection
Local Area Connection Properties
Networking
Sharing
Connect using:
Atheros AR8152 PCI-E Fast Ethernet Controller
Configure...
This connection uses the following items:
Client for Microsoft Networks
Hotspot Shield Routing Driver 6
VMware Bridge Protocol
QoS Packet Scheduler
File and Printer Sharing for Microsoft Networks
Internet Protocol Version 6 (TCP/IPv6)
Internet Protocol Version 4 (TCP/IPv4)
Install...
Uninstall
Properties
Description
Transmission Control Protocol/Internet Protocol. The default wide area network protocol that provides communication across diverse interconnected networks.
OK
Cancel
Internet Protocol Version 4 (TCP/IPv4) Properties
General
Alternate Configuration
You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.
Obtain an IP address automatically
Use the following IP address:
IP address:
Subnet mask:
Default gateway:
Obtain DNS server address automatically
Use the following DNS server addresses:
Preferred DNS server: 8 . 8 . 8 . 8
Alternate DNS server: 4 . 2 . 2 . 2
Validate settings upon exit
Advanced...
OK
Cancel

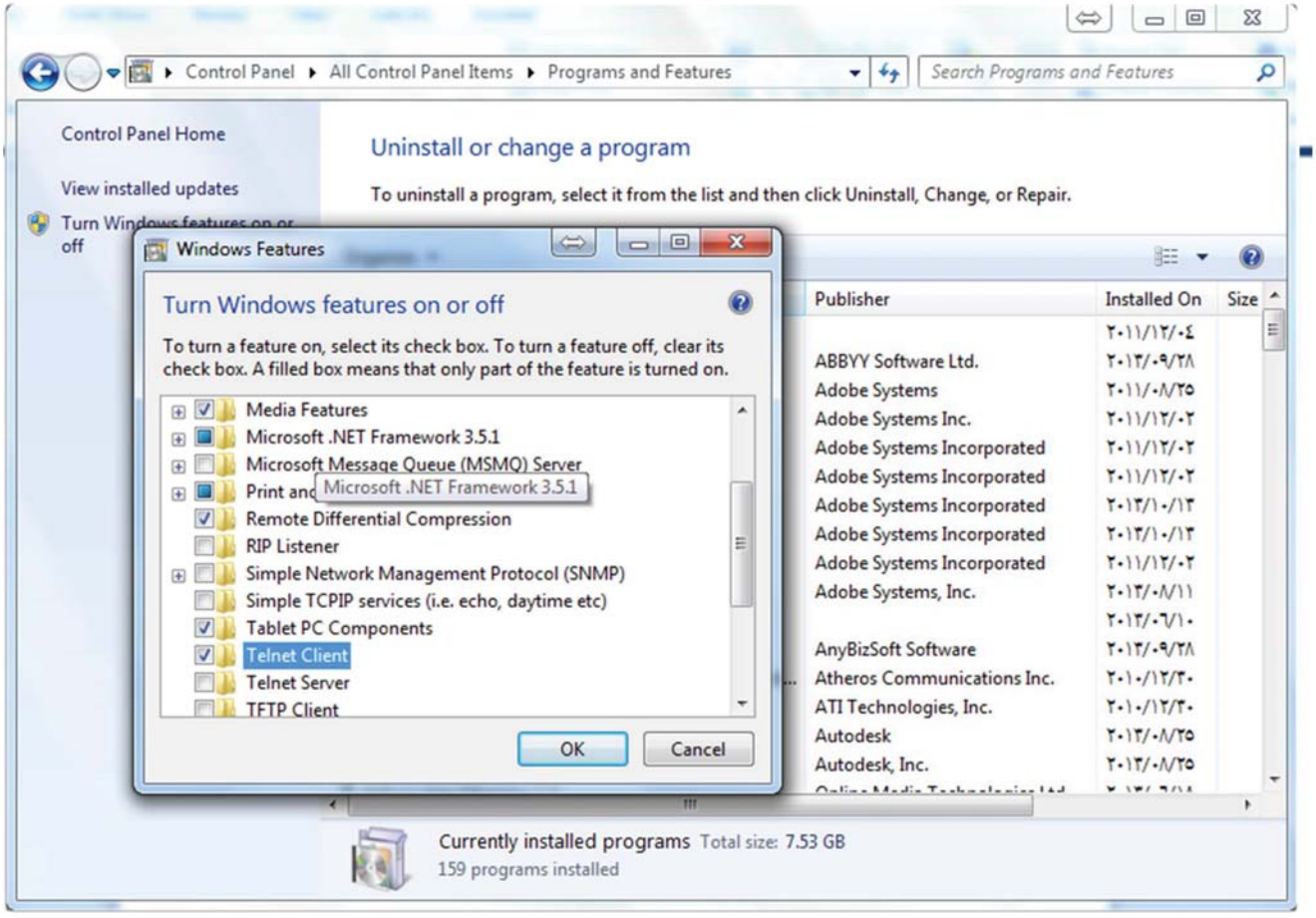
The File Transfer Protocol (FTP)

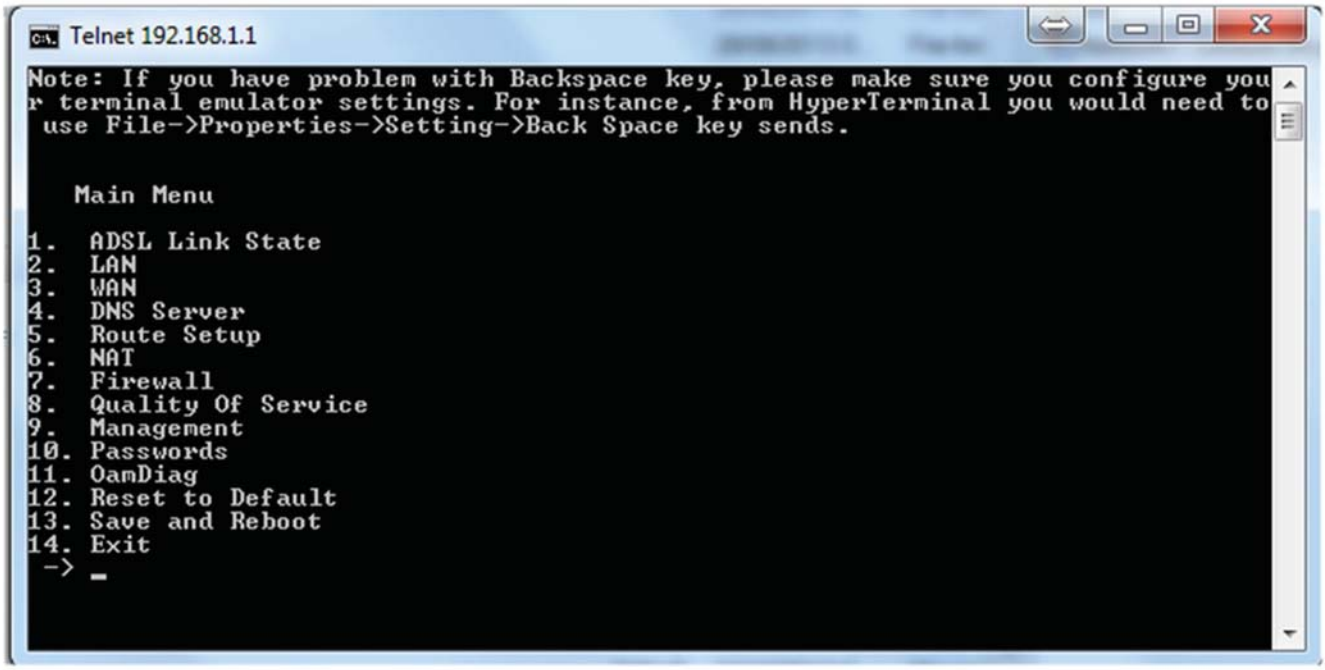
- Is used to send files from one system to another under user command.
- Both text and binary files are accommodated.
- FTP sets up a TCP connection to the target system for the exchange of control messages.
- Once a file transfer is approved, a second TCP data connection is set up for the data transfer.

- Data is being sent without the overhead of any headers or control information at the application level.
- When the transfer is complete, the control connection is used to signal the completion and to accept new file transfer commands.

TELNET

- Provides a remote logon capability, which enables a user at a terminal or personal computer to logon to a remote computer and function as if directly connected to that computer.
- The protocol was designed to work with simple scroll-mode terminals.
- Terminal traffic between User and Server TELNET is carried on a TCP connection.





Classifying IP Addresses

- In IP addressing scheme, some arbitrary number of bits for it is assigned an for network ID, The remaining bits then be used for the host ID.
- suppose that half of the address (16 bits) would be used for the network, the remaining 16 bits used for the host ID. result of that scheme would be 65,536 networks, each of those networks could have 65,536 hosts.
- Suppose that a network of 1,000 computers joins the Internet and is assigned one of these hypothetical network IDs, that network then wast 64,000 IP addresses for hosts.

- Solution, is IP address classes
- The IP protocol defines five different address classes: A, B, C, D, and E.
- of the first three classes, A–C, uses a different size for the network ID and host ID portion of the address.
- Class D is for a special type of address called a *multicast address.*
- Class E is an experimental address class that isn't used.

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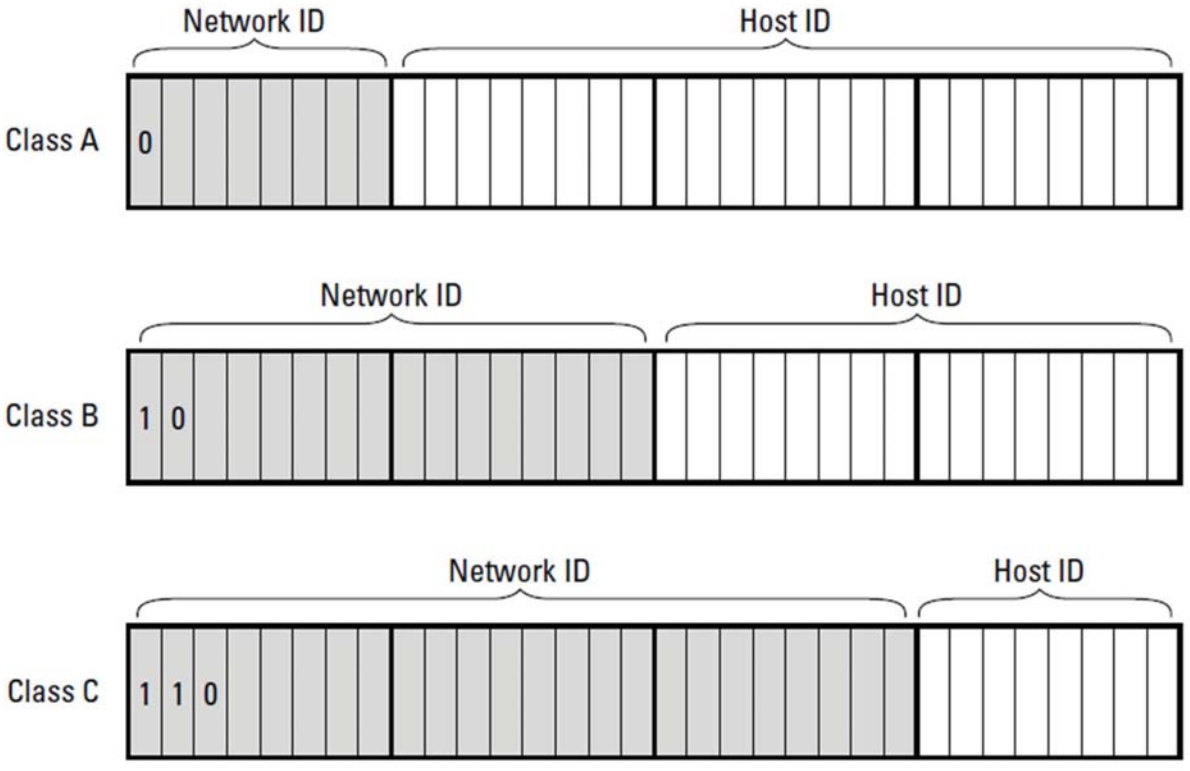

- The first four bits of the IP address are used to determine into which class a particular address fits, as follows:
- **If the first bit is zero,** the address is a Class A address "0xxx"
- **If the first bit is one and if the second bit is zero,** the address is a Class B address. "10xx"
- **If the first two bits are both one and if the third bit is zero,** the address is a Class C address. "110x"
- **If the first three bits are all one and if the fourth bit is zero,** the address is a Class D address "1100"
- **If the first four bits are all one,** the address is a Class E address. "1111"

IP Address Classes

Class	*Address Number Range*	*Starting Bits*	*Length of Network ID*	*Number of Networks*	*Hosts*
A	1–126.*x.y.z*	0	8	126	16,777,214
B	128–191.*x.y.z*	10	16	16,384	65,534
C	192–223.*x.y.z*	110	24	2,097,152	254

- **Class A addresses**
- Class A addresses are designed for very large networks, as only eight bits are allocated to the network, first of these bits is used to indicate that the address is a Class A, only 126 Class A networks can exist in the entire Internet.
- The last 3 octets are used for hosts, so each network can

IP Address Classes

Class	*Address Number Range*	*Starting Bits*	*Length of Network ID*	*Number of Networks*	*Hosts*
A	1–126.x.y.z	0	8	126	16,777,214

- Only about 40 Class A addresses are actually assigned to companies or organizations, The rest are either reserved by Internet Assigned Numbers Authority (IANA)

Some Well-Known Class A Networks

Net	*Description*	*Net*	*Description*
3	General Electric Company	32	Norsk Informasjonsteknology
4	Bolt Beranek and Newman Inc.	33	DLA Systems Automation Center
6	Army Information Systems Center	35	MERIT Computer Network
8	Bolt Beranek and Newman Inc.	38	Performance Systems International
9	IBM	40	Eli Lilly and Company
11	DoD Intel Information Systems	43	Japan Inet
12	AT&T Bell Laboratories	44	Amateur Radio Digital Communications
13	Xerox Corporation	45	Interop Show Network
15	Hewlett-Packard Company	46	Bolt Beranek and Newman Inc.
16	Digital Equipment Corporation	47	Bell-Northern Research

Some Well-Known Class A Networks

Net	Description	Net	Description
17	Apple Computer Inc.	48	Prudential Securities Inc.
18	MIT	51	Department of Social Security of UK
19	Ford Motor Company	52	E.I. duPont de Nemours and Co., Inc.
20	Computer Sciences Corporation	53	Cap Debis CCS (Germany)
22	Defense Information Systems Agency	54	Merck and Co., Inc.
25	Royal Signals and Radar Establishment	55	Boeing Computer Services
26	Defense Information Systems Agency	56	U.S. Postal Service
28	Decision Sciences Institute (North)	57	SITA
29–30	Defense Information Systems Agency		

- **Class B addresses**
- the first two octets of the IP address are used as the network ID, and the second two octets are used as the host ID.
- in order to indicate that the address is Class B the first two bits of the first octet are required to be 10, As a result, a total of 16,384 Class B networks can exist.

IP Address Classes

Class	Address Number Range	Starting Bits	Length of Network ID	Number of Networks	Hosts
B	128–191.x.y.z	10	16	16,384	65,534

- Each Class B network can accommodate more than 65,000 hosts.

- The problem with Class B networks is that even though they are much smaller than Class A networks, they still allocate far too many host IDs.

- **Note:**
- Class A addresses end with126.*x.y.z*, and Class B addresses begin with 128.*x.y.z*.
- What happened to 127.*x.y.z*? This special range of addresses is reserved for loopback testing, so these addresses aren't assigned to public networks.

Class C addresses

- the first three octets are used for the network ID, and the fourth octet is used for the host ID.
- with 24 network ID bits, Class C addresses allow for more than 2 million networks, each Class C network can accommodate only 254 hosts

IP Address Classes

Class	Address Number Range	Starting Bits	Length of Network ID	Number of Networks	Hosts
C	192–223.x.y.z	110	24	2,097,152	254

- The problem with Class C networks is that they're too small.

Thanks,..

See you next week (ISA),…