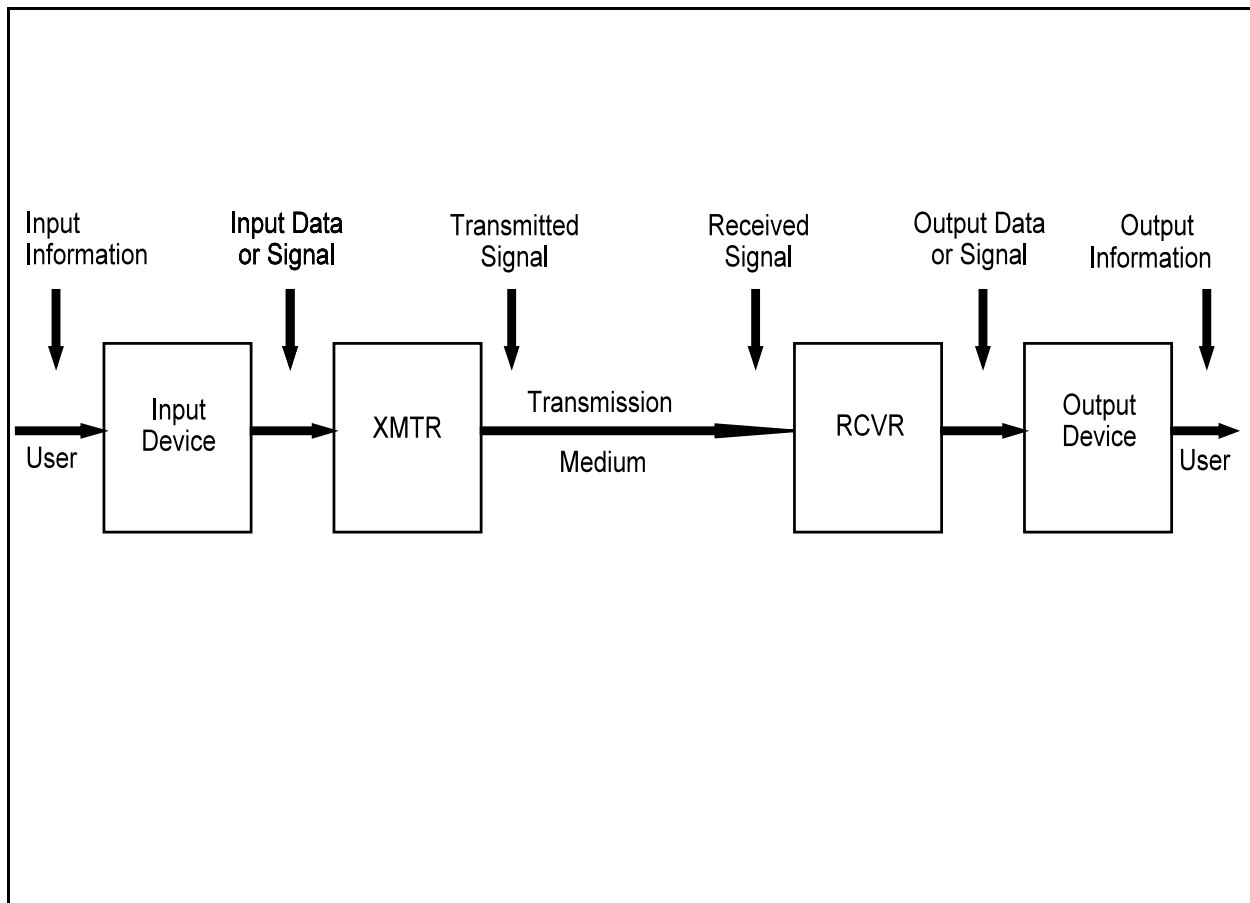


Introduction to Networking

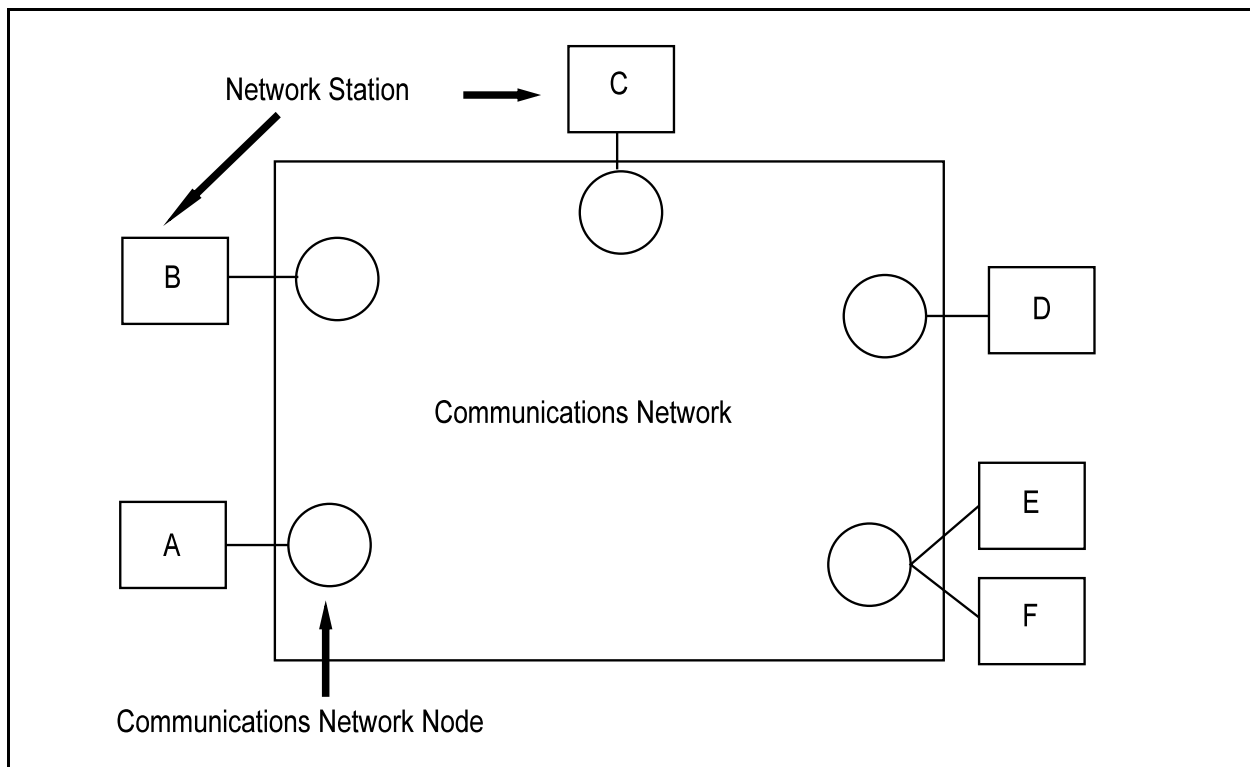
The fundamental purpose of data communications is to exchange information between user's computers, terminals and applications programs.



Simplified Communications System Block Diagram

Data Communications Networking

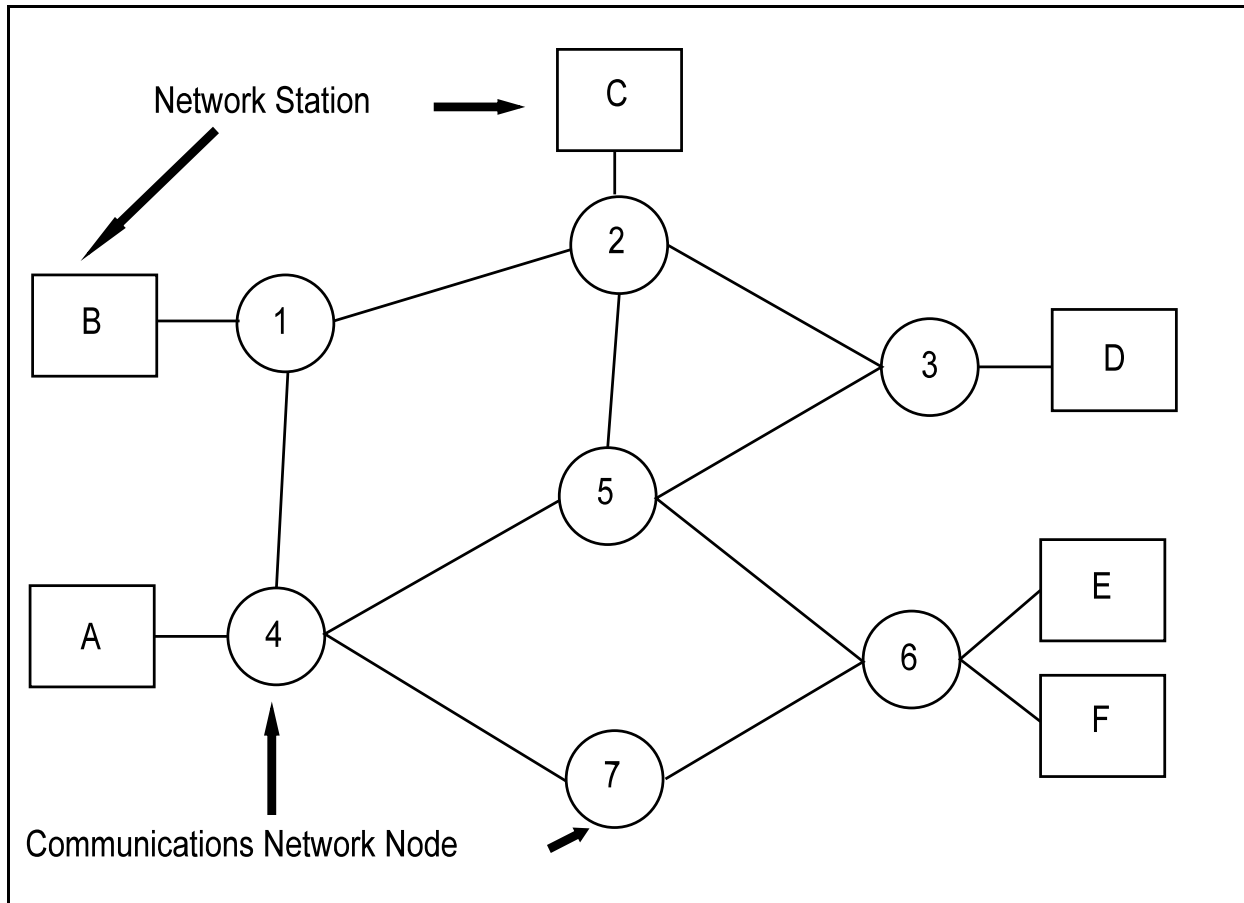
- In its simplest form data communications takes place between two devices that are directly connected by some form of point-to-point transmission medium.
- Often it is impractical for two devices to be directly connected:
 - a) The devices are far apart,
 - b) There is a large set of devices to be interconnected.
- The solution is to connect each device to a **COMMUNICATIONS NETWORK**.



Interconnection via a Communications Network

Switched Communications Networks

Communications between stations is accomplished via transmission and switching.



A Generic Switched Communications Network

- Common Switching Methods:
 - Circuit Switching
 - Message Switching
 - Packet Switching

Switching Methods

1. Circuit Switching:

- Prior to the start of data transmission, an end-to-end (station-to-station) physical path must be established.
- During data transmission, all channels in the path are used simultaneously.
- The entire path remains dedicated to the pair of communicating stations until circuit release.
- Three phased operation:
 - Circuit Establishment (Allocation of Resources)
 - Data Transfer (Use of Resources)
 - Circuit Termination (Deallocation of Resources)

2. Message Switching:

- A MESSAGE represents a logical unit of information that one station wishes to send to another station.
- No dedicated path is established prior to data transfer. Instead, the message will travel over one channel at a time.
- A message travels (hops) through the network from node-to-node, in a store-and-forward fashion, until it reaches its final destination.

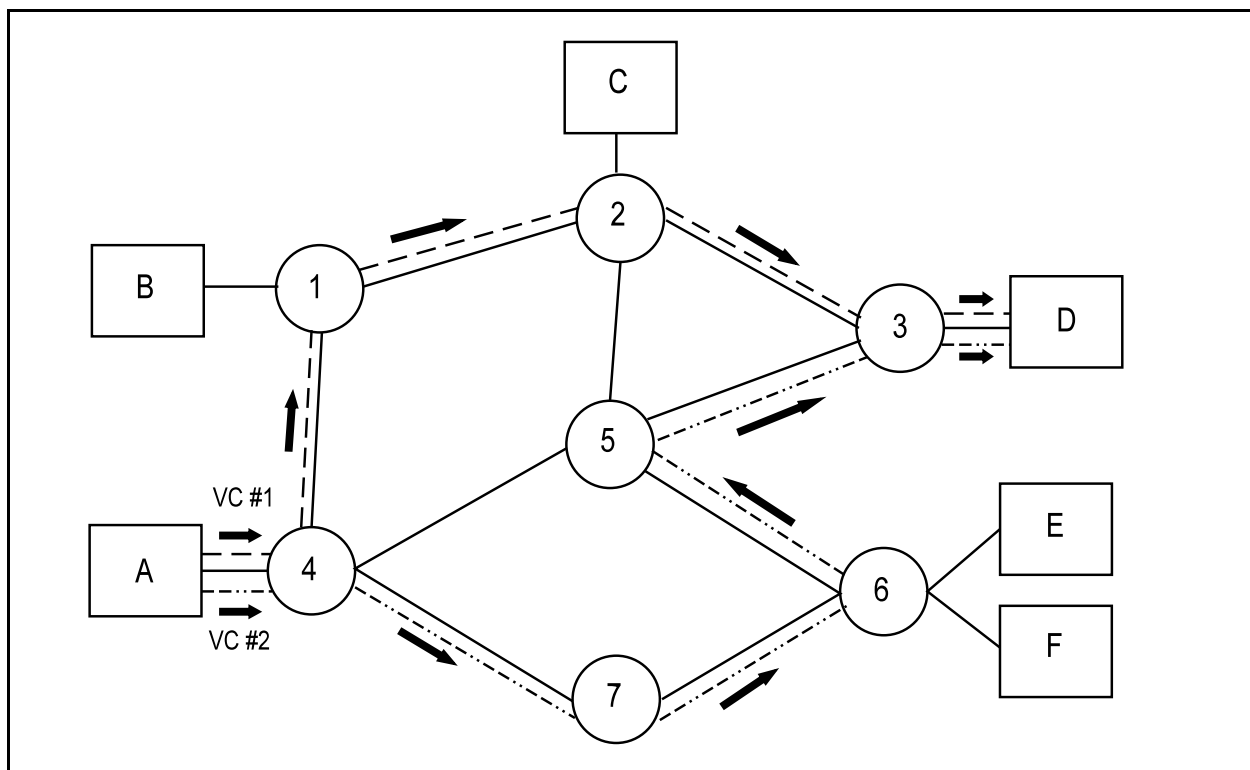
3. Packet Switching:

- Messages are decomposed into smaller units of data called **PACKETS** and then sent out packet-by-packet.
- Many packets of the same message can be in transit at the same time.
- Reassembly of the original message is required at the destination.

Packet Switching Alternatives

A. Virtual Circuit Packet Switching:

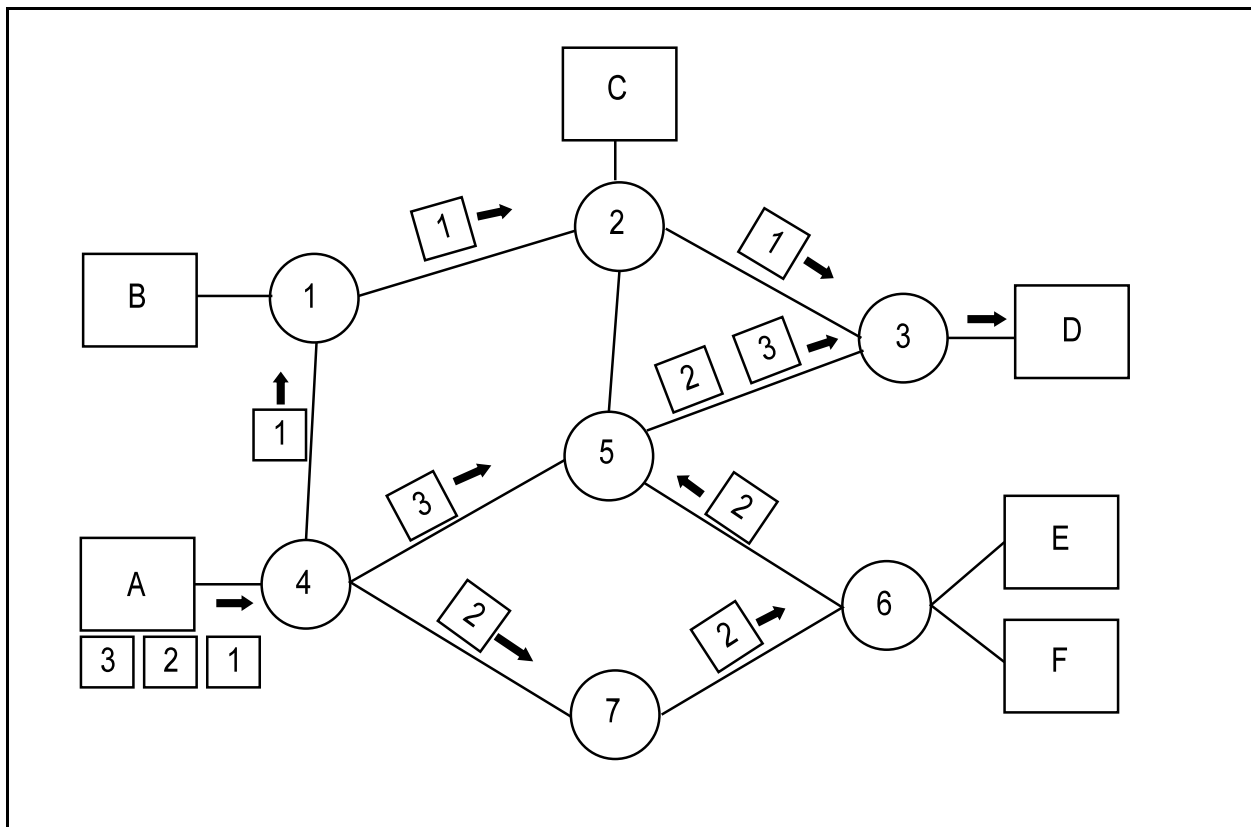
- A LOGICAL CONNECTION (virtual circuit) is established between communicating stations prior to the transmission of data packets.
- The logical connection establishes the route over which all data packets will travel between stations.
- Packet delivery across the virtual circuit will be in sequential order.
- Connection-Oriented Operation:
 - Connection Establishment Phase
 - Data Transfer Phase
 - Connection Termination Phase



Virtual Circuit Packet Switching

B. Datagram Packet Switching:

- Each data packet is treated independently from one another.
- Each packet finds its own route through the network.
- Packets may arrive at the destination out of sequential order.
- Connectionless Operation:
 - Data Transfer Phase



Datagram Packet Switching

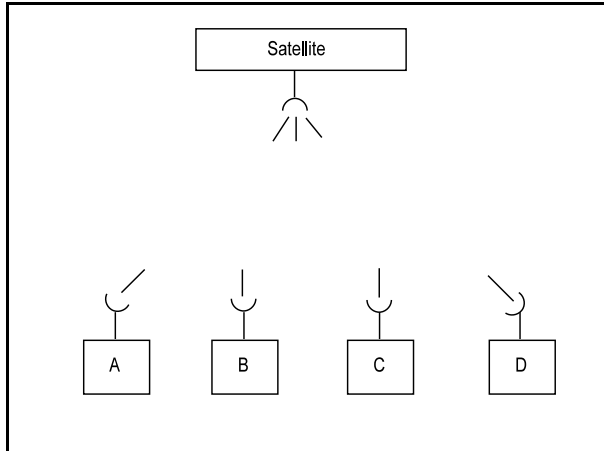
Broadcast Communications Networks

A transmission from one station can be received by all other station within the network.

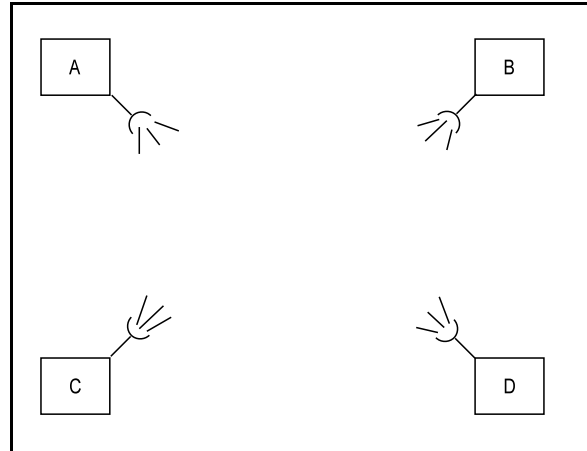
Sample Networks:

- Satellite Networks
- Radio Networks
- Local Area Networks

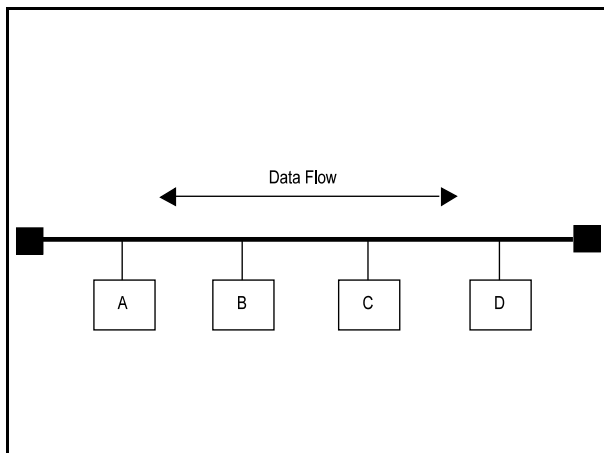
Sample Broadcast Network Topologies



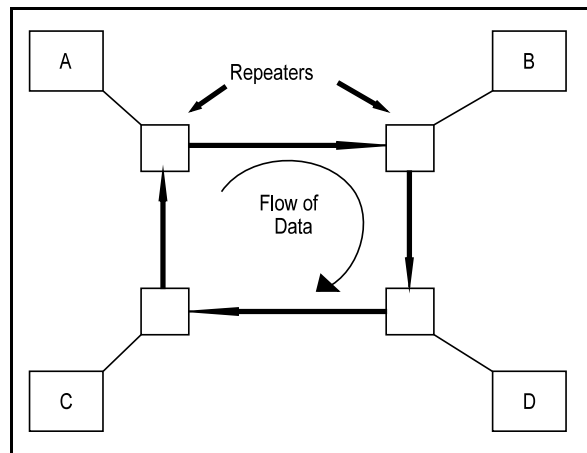
Satellite Network Topology



Radio Network Topology



Bus Topology



Ring Topology

- Common Access Methods:
 - Contention (e.g., CSMA/CD, etc.)
 - Reservation
 - Token Passing

Type of Networks

Local Area Network (LAN):

A Local Area Network is a communications network that provides interconnection of a variety of data communicating devices within a small area. (Ethernet, Token Ring, 10BaseT, 100BaseT, ...)

Typical Characteristics

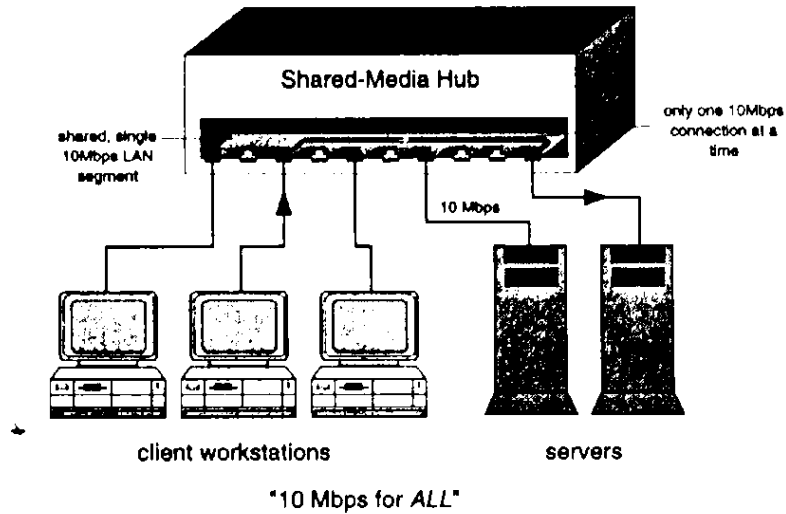
- High Data Rates (0.1 to 1000 Mbps)
- Short Distances (0.1 to 25 km)
- Low Error Rate (10^{-8} to 10^{-11})

Wide Area Network (WAN):

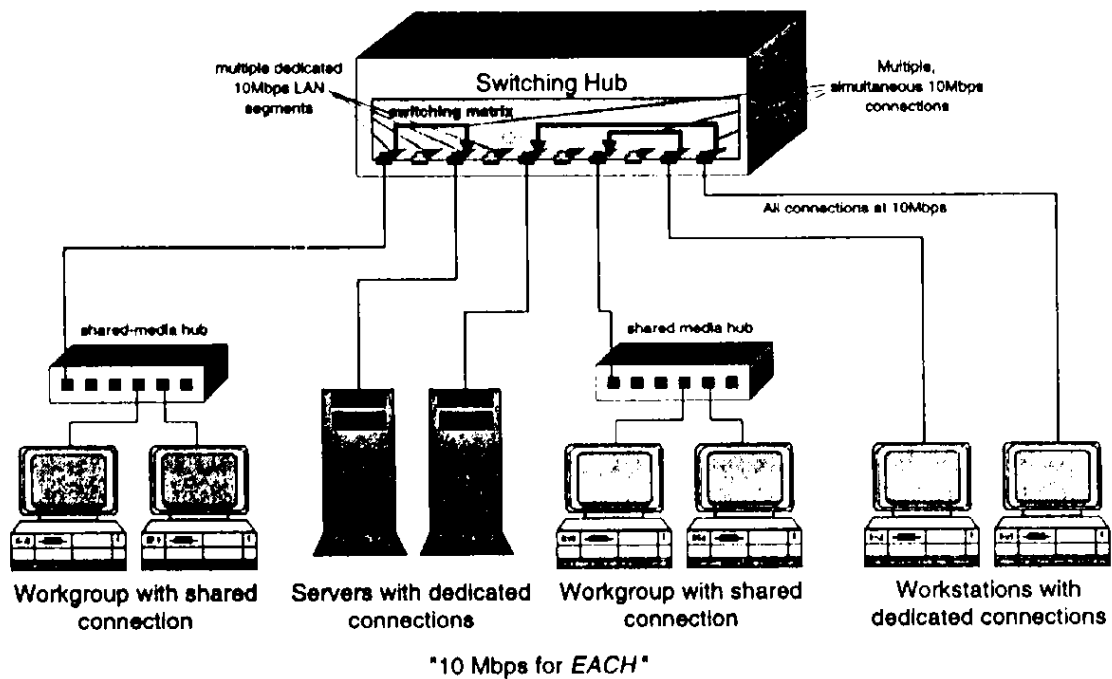
A Wide Area Network is a communications network that provides interconnection of a variety of data communicating devices over long distances.

Shared Media vs. Switching LAN Architectures

Shared-Media LAN Architecture



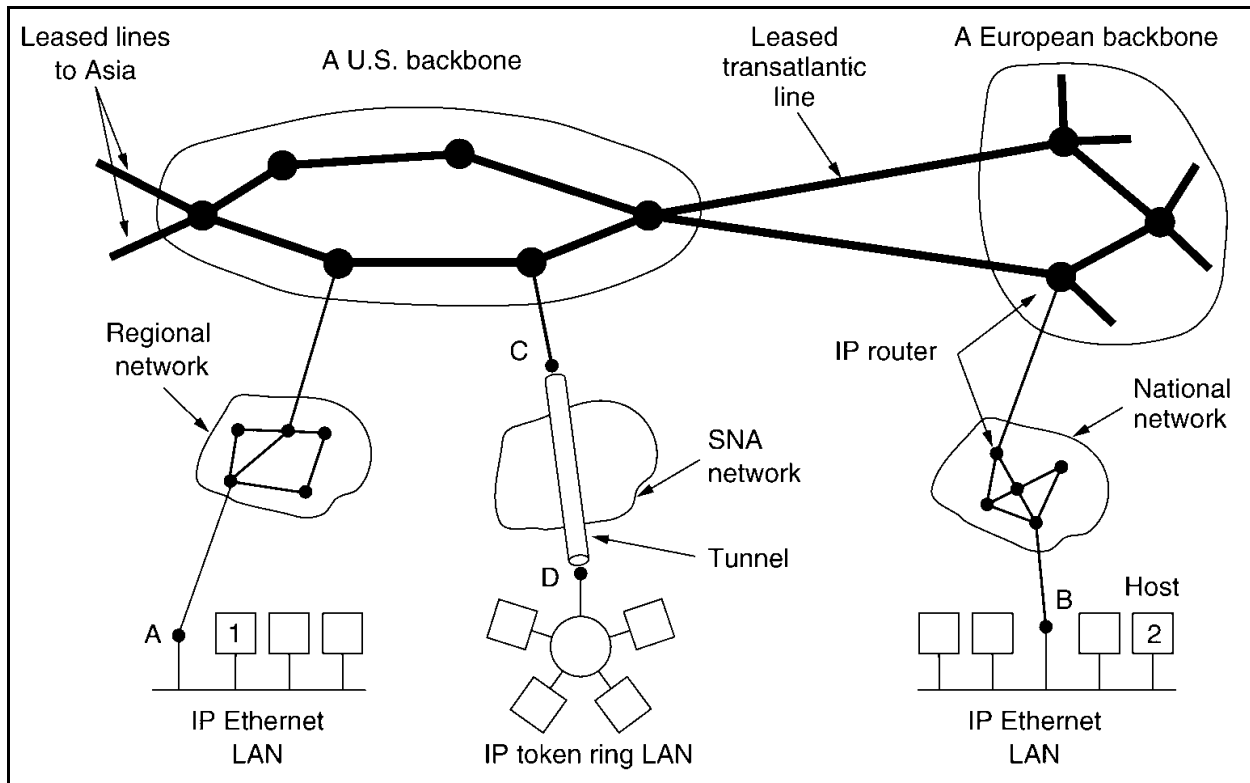
Switch-Based LAN Architecture



Switched LAN Architectures Versus Media-Sharing LAN Architectures Wiring Center Functionality

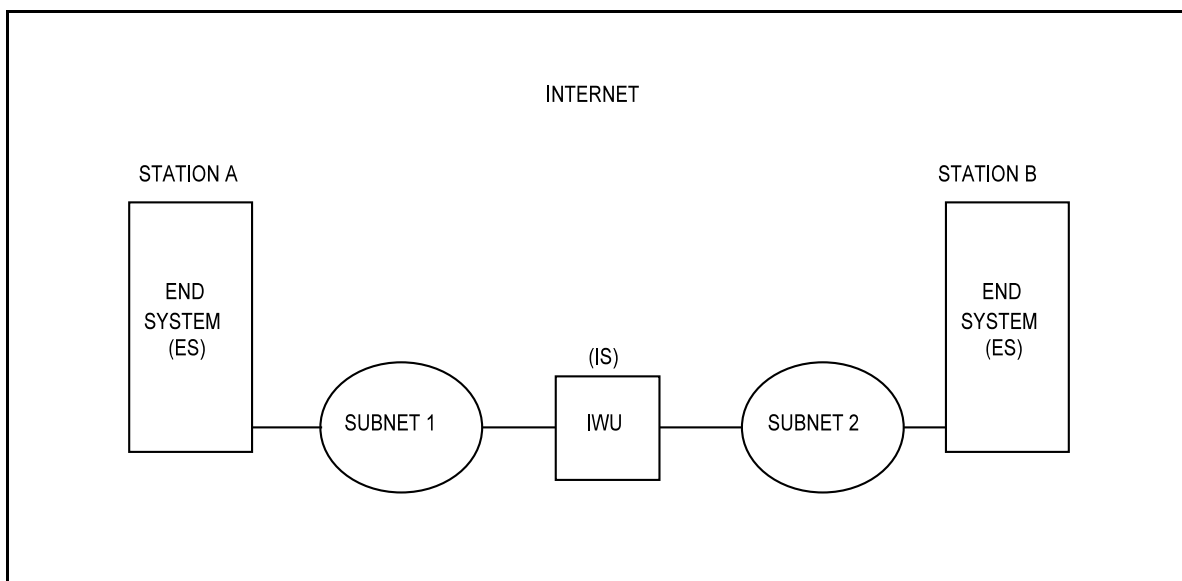
The Internet

The Internet is an interconnected collection of networks.



Internetworking

- **Communications Network:**
A facility that provides a data transfer service among stations attached to the network.
- **Internet:**
A collection of interconnected communications networks.
- **Subnetwork:**
A constituent network of an internet.
- **Intermediate System (IS) or Interworking Unit (IWU):**
A device used to interconnect two subnetworks and permit communications between end systems attached to different subnetworks. (e.g., Router, Bridge, ...)
- **Communications Protocol:**
A set of rules used for regulating communications between entities on different systems.



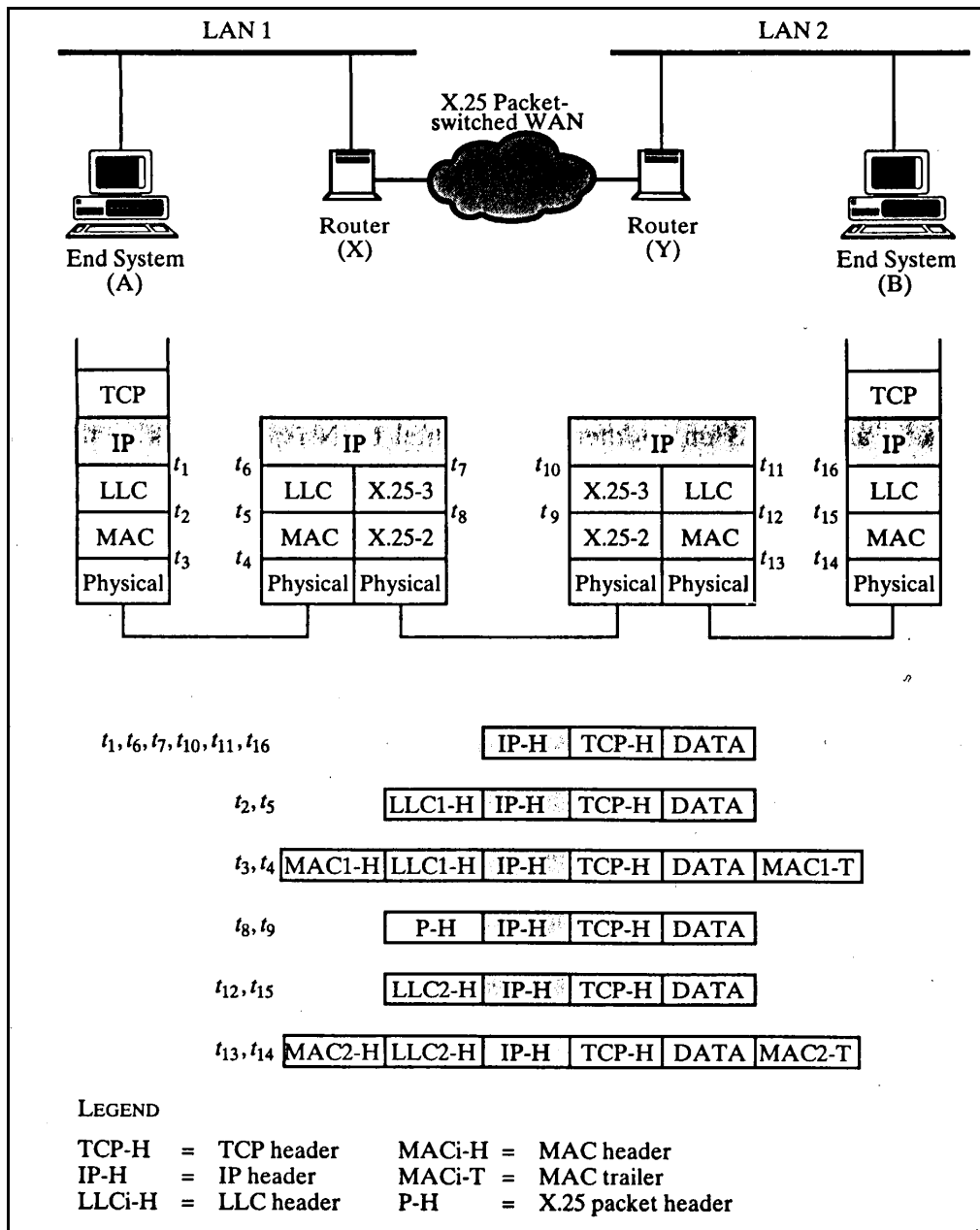
Requirements for Internetworking

- Provide a link between networks.
- Provide for routing and delivery of data between processes on different networks.
- Provide an accounting service that keeps track of the use and status of the various networks and IWUs.
- Accommodate differences among networks:
 - network service
 - addressing
 - routing
 - quality of service
 - maximum packet size
 - flow and congestion control
 - error reporting

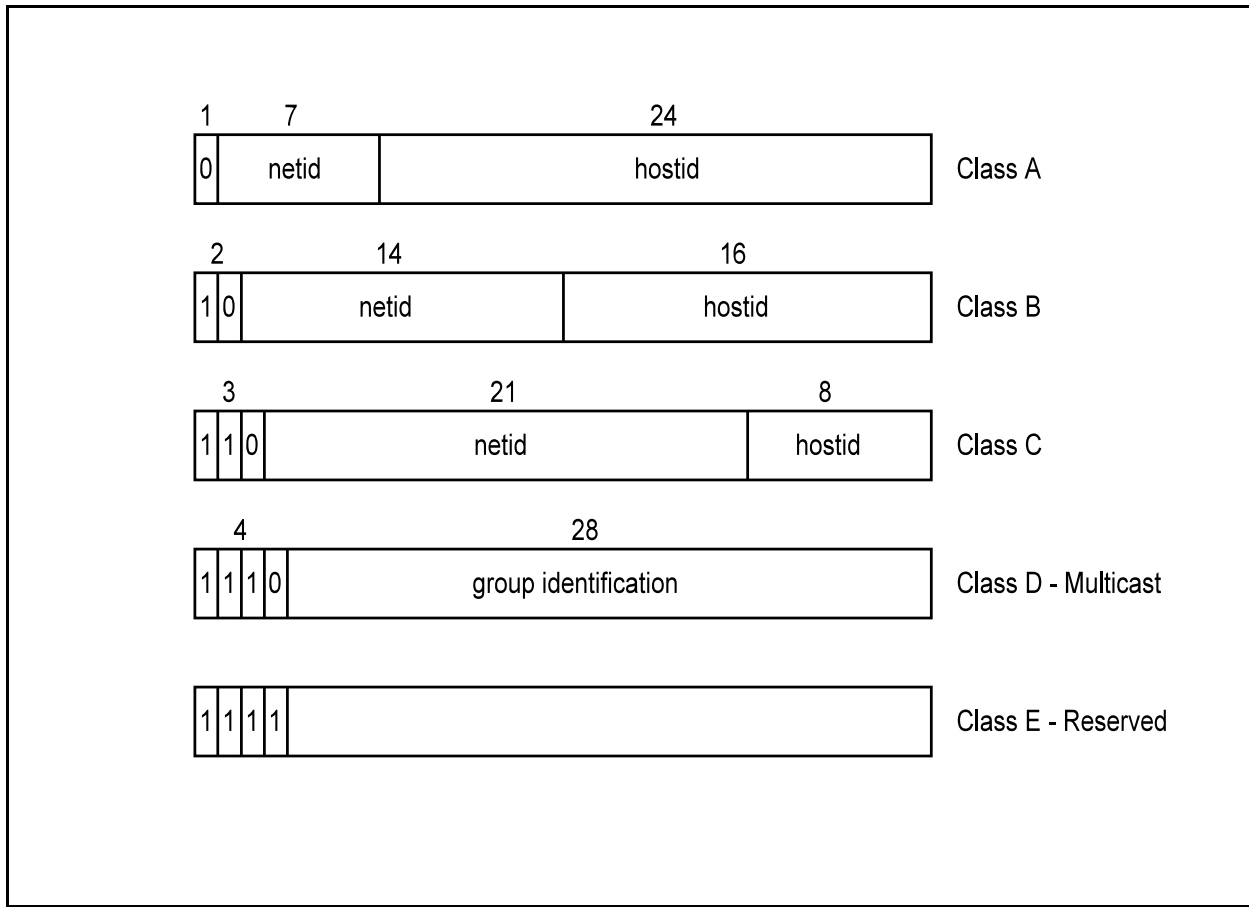
Connectionless Internetworking - The IP Approach

The Internet Protocol (IP) is a DoD standard. It provides connectionless service between stations.

A connectionless internet facility is flexible in that it requires very little of its constituent networks.



IP Address Structure



- IP addresses are communicated as four bytes using **dotted decimal** notation. e.g.,

00001010 00000000 00000000 00000000 = 10.0.0.0
 (Class A netid= 10 (ARPANET))

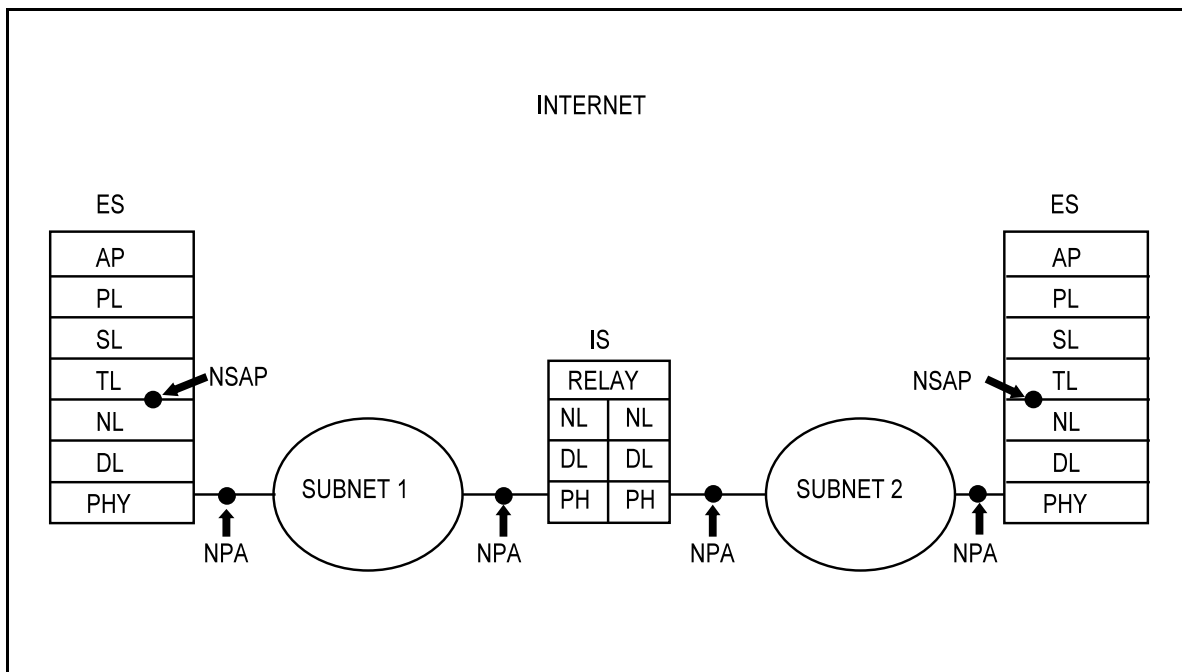
10000000 00000011 00000010 00000011 =
 128.3.2.3 (Class B netid= 128.3 hostid= 2.3)

11000000 00000000 00000001 11111111 =
 192.0.1.255 (Class C netid= 192.0.1 all hosts
 broadcast)

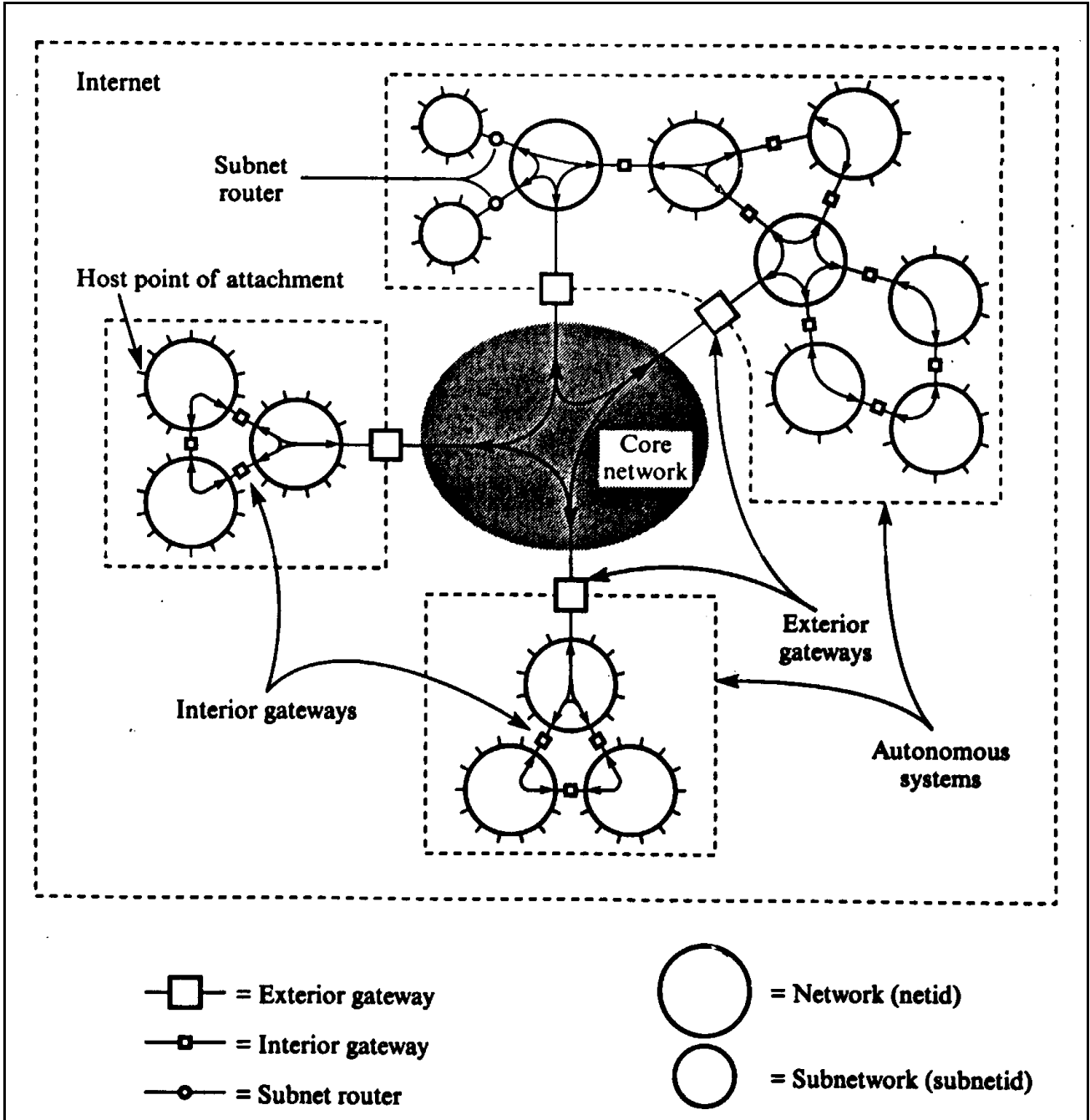
(BC - IP Address: 146.245.XXX.YYY)

Addressing

- **Network Service Access Point (NSAP):**
 - Uniquely identifies a station within the internet (**global internet address**).
 - A station may have more than one NSAP.
 - Usually has the form (**network, host**).
- **Subnetwork Attachment Point Address (Network Point of Attachment):**
 - Each subnetwork must maintain a unique address for each station attached to that subnetwork.
 - One must assume that the subnetwork attachment point address has significance only within a particular subnet.
 - The interworking facility must translate between the global address and the locally significant address.



Internet Routing Example



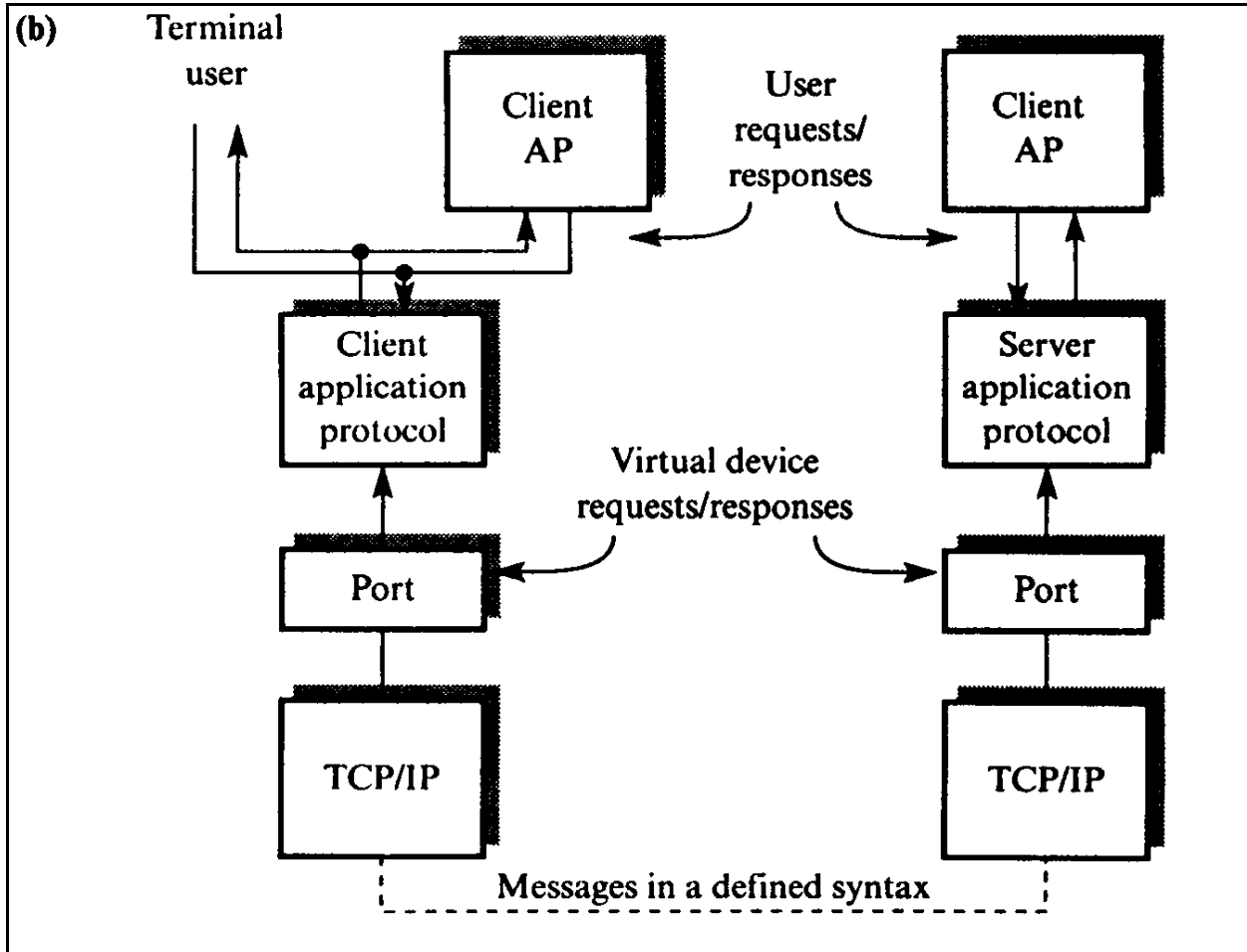
Transport Protocols

- Transmission Control Protocol (TCP)
Connection-Oriented
- User Datagram Protocol (UDP)
Connectionless
- **TCP Services:**
 - Provides reliable communications across reliable and unreliable networks and internets.
 - Designed specifically and exclusively to work with IP.
- **UDP Services:**
 - Provides a transport-level, unreliable, datagram service.
 - Delivery and duplicate detection are not guaranteed.

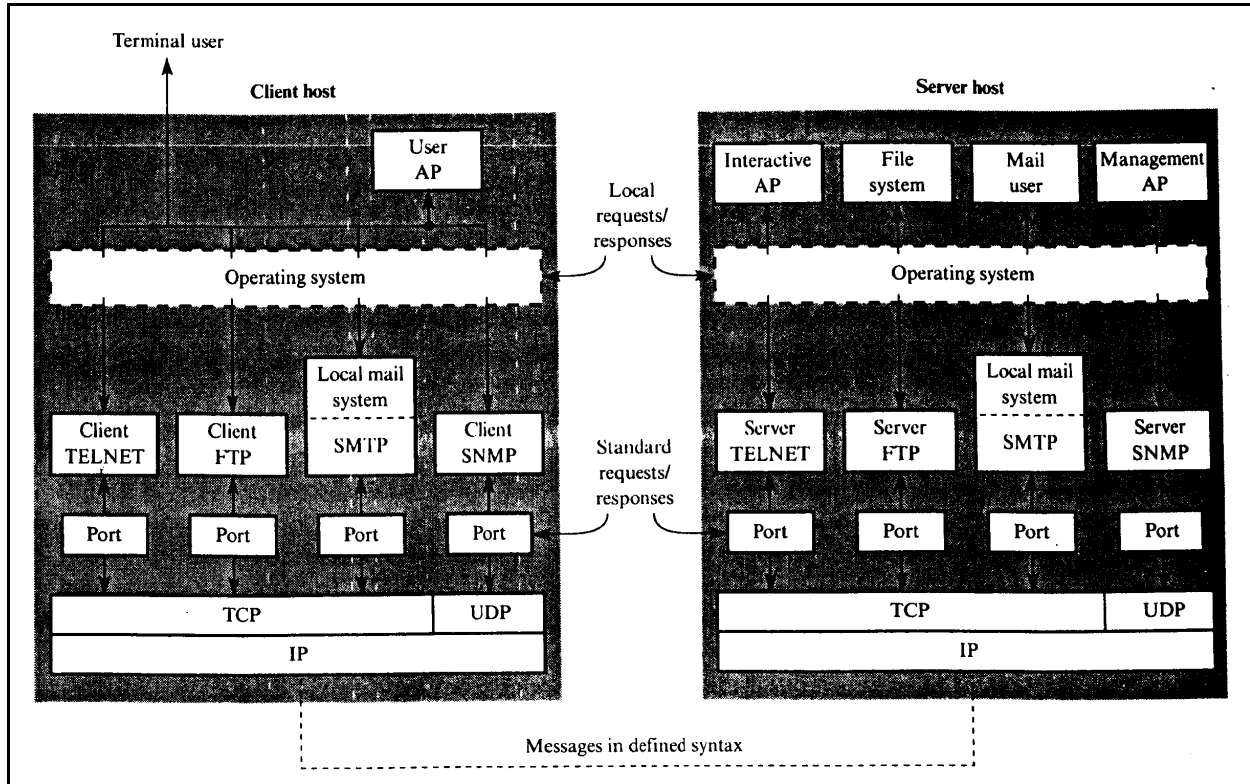
Client-Server Model for Applications

- Client-Server Model defines a paradigm for communications between two programs called the client and the server.
 - Server:
 - Any application that provides a service to a network user.
 - File Server
 - Print Server
 - Communications Server
 - Telephony Server
 - Fax Server
 - Web Server
- Client:
 - Any program that makes a request to the server.

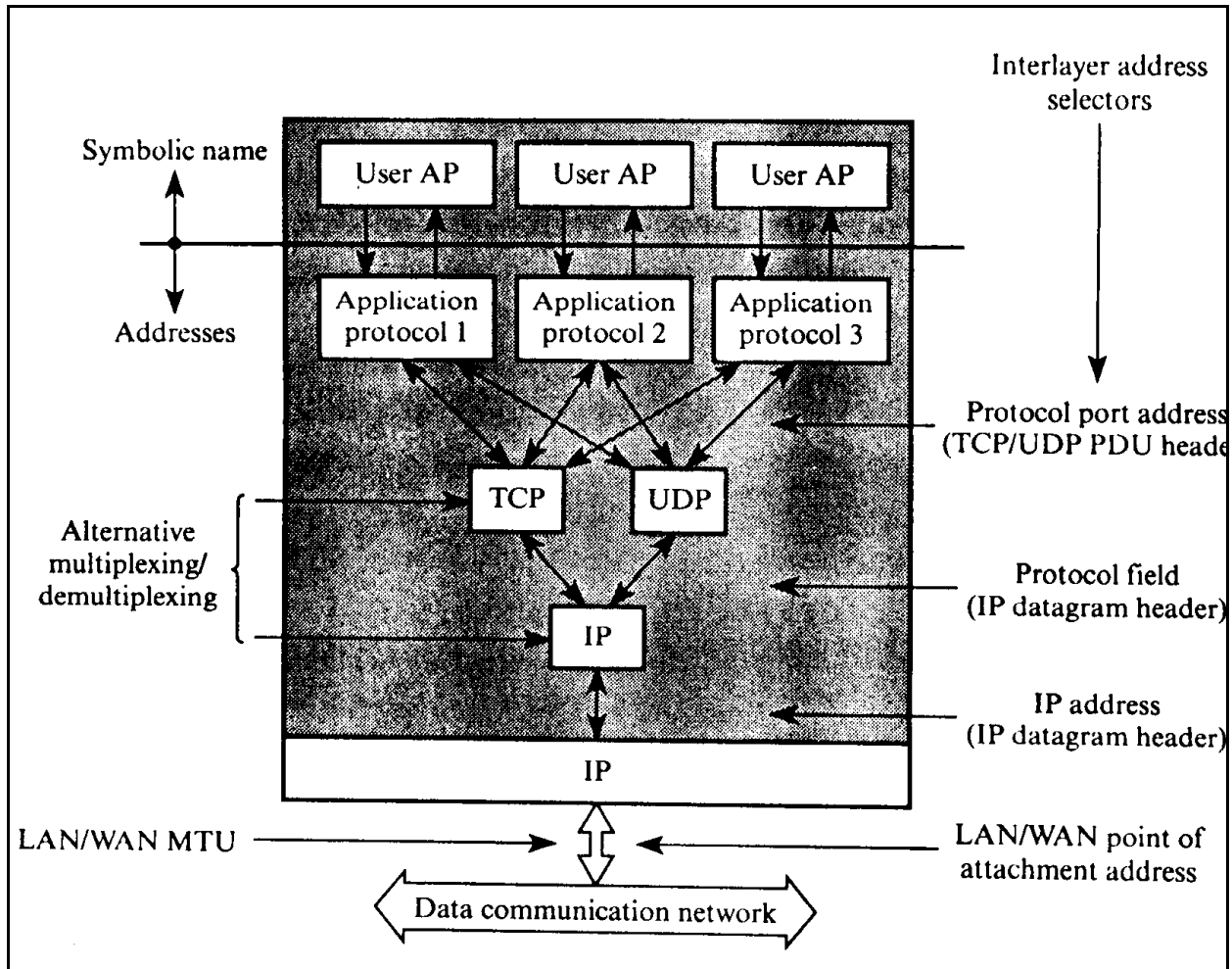
TCP/IP Application Layer Schematic



TCP/IP Application Protocols



Directory Services - Address Resolution Service

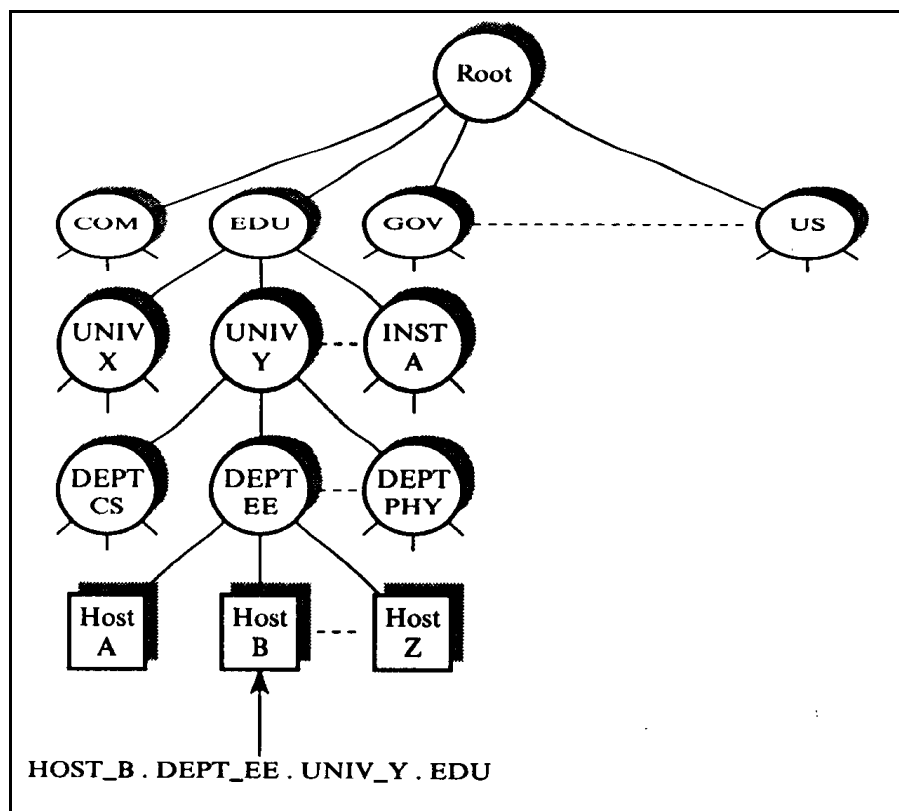


TCP/IP Address Composition

- Within real system environments users (people and APs) are known by **symbolic names**.
- Directory Services are used to find the addresses of a named destination user.
- Addresses can consist of:
 - Network Point-of-Attachment (physical address)
 - IP address
 - TCP/UDP port number

TCP/IP Domain Name System (DNS)

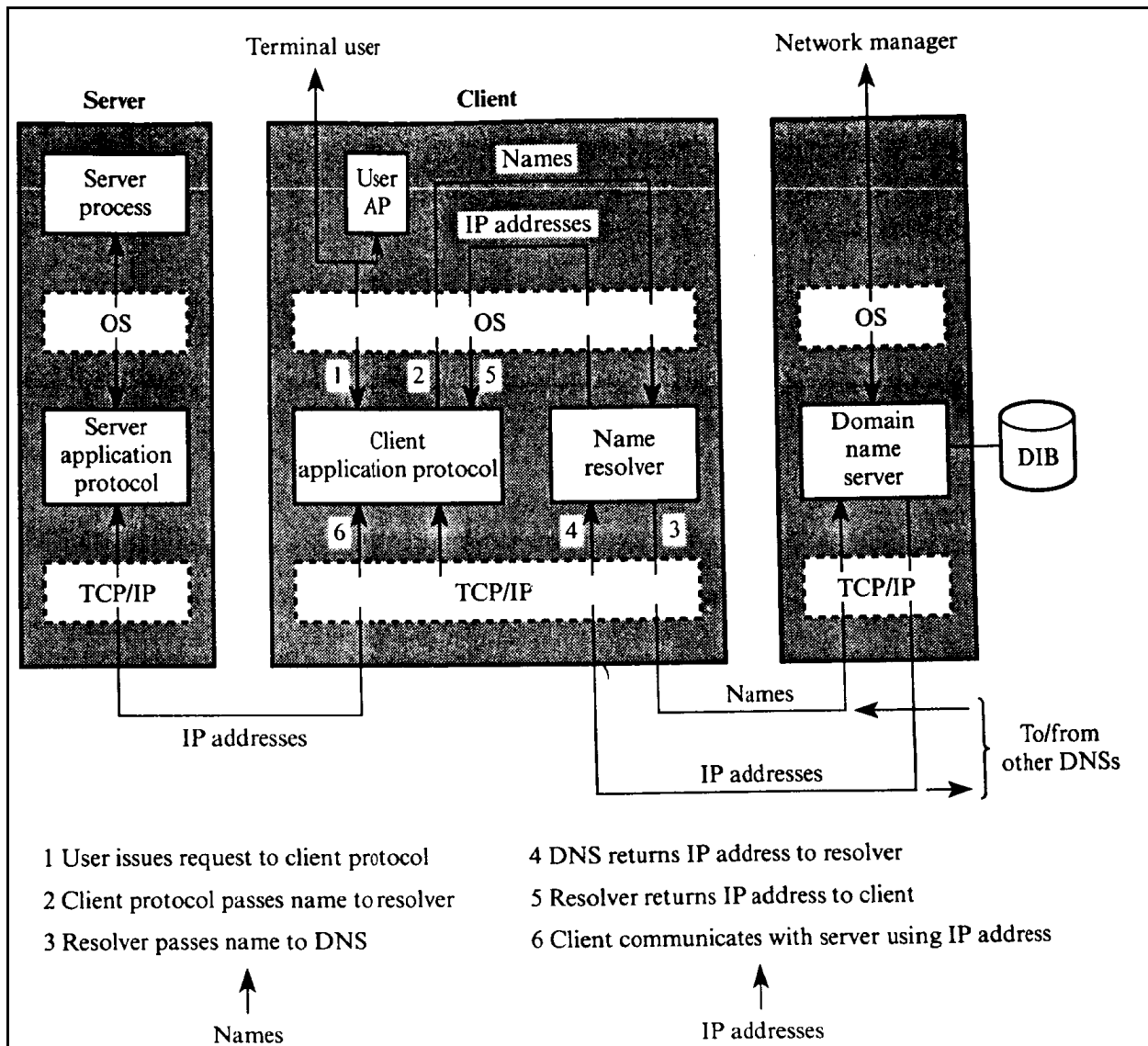
- The total directory system in a TCP/IP suite is known as the **Domain Name System (DNS)**.
- It uses a **hierarchical structure** for naming entities.
- The Internet uses a partition of **Domains** at the highest level of its hierarchy:
 - COM commercial organizations
 - EDU educational institutions
 - GOV government institutions
 - MIL military groups
 - NET (Internet) network support centers
 - ORG other organizations
 - country code (e.g., .us, .ca, .uk, .il)
 - etc.



Sample Domain Name Hierarchy

The Domain Name Server

- Associated with each institution network is a host that runs an AP known as the **Domain Name Server**.
- Associated with the DNS server is a **Directory Information Base (DIB)** which contains all the directory related information for that institution.
- Each host has a client process known as the **Name Resolver** which communicates the DNS server.



Name-to-Address Resolution Protocols and Sequence

Uniform Resource Locators (URL)

- A Uniform Resource Locator (URL) is a compact representation of the location and access method for a resource available via the Internet.
- General form of a URL:
 $\langle \text{scheme} \rangle : \langle \text{scheme-specific-part} \rangle$
- URL Schemes:

Uniform resource locator (URL) schemes.		
Scheme	Default Port	Syntax
ftp	21	ftp://<user>:<password>@<host>:<port>/<cwd1>/<cwd2>/.../<cwdN>/<name>; type=<typecode>
http	80	http://<host>:<port>/<path>?<searchpart>
gopher	70	gopher://<host>:<port>/<selector> or gopher://<host>:<port>/<selector>%09<search> or gopher://<host>:<port>/<selector>%09<search>%09<gopher+ _string>
mailto	—	mailto:<rfc822-addr-spec>
news	—	news:<newsgroup-name> or news:<message-id>
nntp	119	nntp://<host>:<port>/<newsgroup-name>/<article-number>
telnet	23	telnet://<user>:<password>@<host>:<port>
wais	210	wais://<host>:<port>/<database> or wais://<host>:<port>/<database>?<search> or wais://<host>:<port>/<database>/<wtype>/<wpath> or
file	—	file://<host>/<path>
prospero	1525	prospero://<host>:<port>/<hsoname>;<field>=<value>

<http://www.brooklyn.cuny.edu/index.html>

<http://acc6.its.brooklyn.cuny.edu/~core51/>

<ftp://myhost.sci.brooklyn.cuny.edu/ziegler/myfile.txt>

<mailto:webmaster@brooklyn.cuny.edu>