Fundamentals of Networking

Presented By
Anjalee Muraleedharan
Asst. Professor
Dept. Of Computer Science
Al-Ameen College, Edathala.

Introduction

1.1 Networks

1.2 The Internet

1.3 Protocols and Standards

Networks

- Network : A set of devices (nodes) connected by communication links
  - Node : computer, printer, …
  - Distributed Processing :
    - Most networks used it
    - Task is divided among multiple computers instead of one single large computer

Networks

- Network Criteria
  - Network must meet a certain number of criteria
  - The most important of the network criterions are:
    - Performance
    - Reliability
    - Security

Networks

- Performance
  - Transit time: A mount of time required for a message to travel from one device to another
  - Response time: Elapsed time between an inquiry and a response

Networks

- Performance
  - Performance depends on :

    1- Number of users: large number slow response time.

    2- Type of transmission medium: fiber-optic cabling faster than others cables.

    3- Capabilities of the connected hardware: affect both the speed and capacity of transmission.

    4- Efficiency of the software: process data at the sender and receiver and intermediate affects network performance.

Networks

- Performance
  - Performance is evaluated by two contradictory networking metrics:
    - Throughput (high): a measure of how fast we can actually send data through a network
    - Delay (low)

Networks

- Reliability
  - Reliability is measured by:
    1. Frequency of failure
    2. Recovery time of a network after a failure
    3. Network’s robustness in a catastrophe: protect by good back up network system

Networks

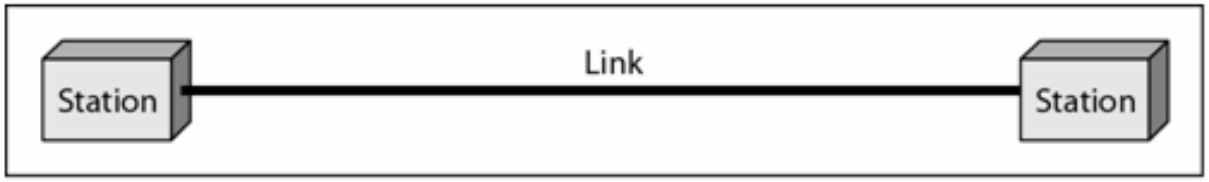
- Security
  - Protecting data from unauthorized access
  - Protecting data from damage and development
  - Implementing policies and procedures for recovery from breaches and data losses (Recovery plan)

Networks

- Physical Structures:
  - Type of connection
    - Network: Two or more devices connected through links
    - Link: Communication pathway that transfers data from one device two another
    - Two devices must be connected in some way to the same link at the same time. Two possible types:
      - Point-to-Point
      - Multipoint

Networks

- Point-to-Point
  - Dedicated link between two devices
  - Entire capacity of the link is reserved for transmission between those two devices
  - Use an actual length of wire or cable



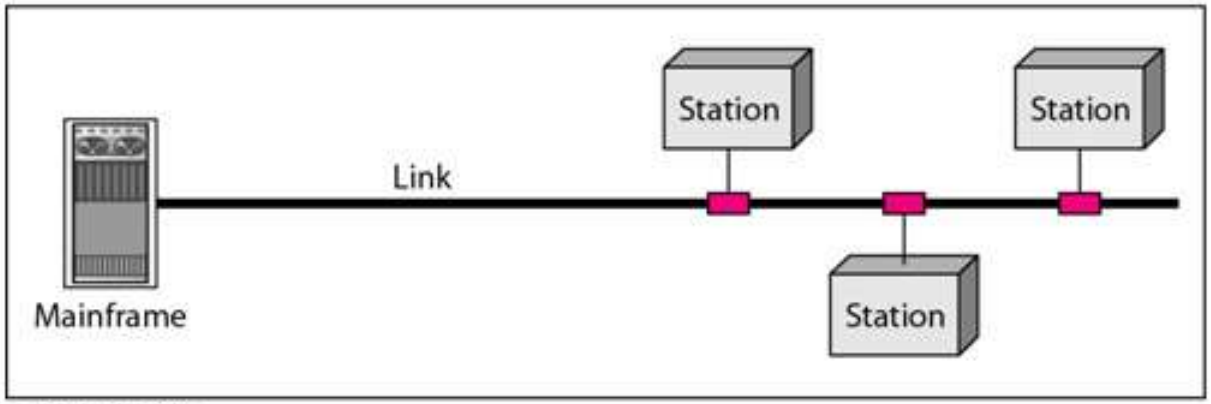
a. Point-to-point

Networks

- Point-to-Point
  - Other options, such as microwave or satellite is possible
  - Example: Television remote control

Networks

- Multipoint (multidrop)
  - More than two devices share a single link
  - Capacity is shared
  - Channel is shared either spatially or temporally
    - Spatially shared: if devices use link at same time
    - Timeshare: if users must take turns

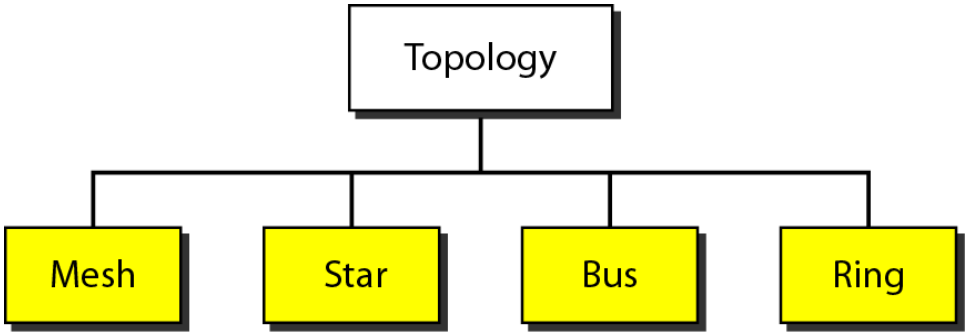


b. Multipoint

Networks

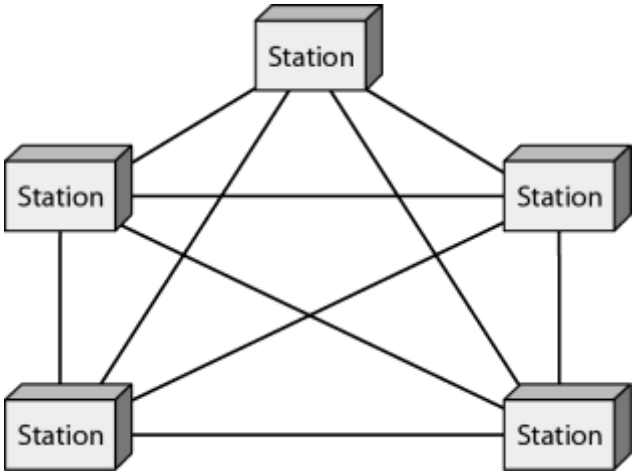
- Physical Topology
  - The way a network is laid out physically
  - Two or more links form a topology
  - The topology of a network is the geometric representation of the relationship of all the links and linking devices (nodes) to one another.
  - Four topologies : Mesh, Star, Bus, and Ring

Physical Topology



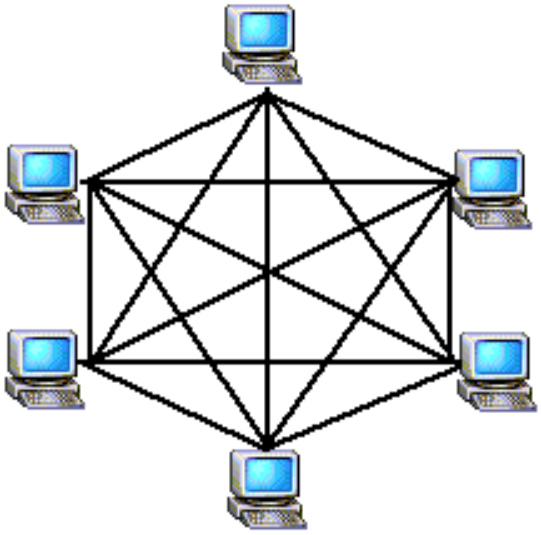
Physical Topology

- Mesh
  - Every link is dedicated point-to-point link
  - The term dedicated means that the link carries traffic only between the two devices it connects



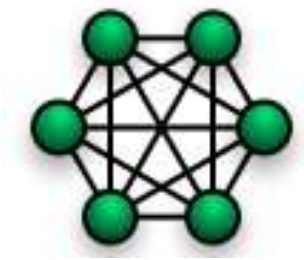
Physical Topology

- Mesh
  - To link ***n*** devices fully connected mesh has:
    n (n - 1) / 2 physical channels (Full-Duplex)
  - Every Device on the network must have
    n - 1 ports



Physical Topology

- Mesh
  - Example:



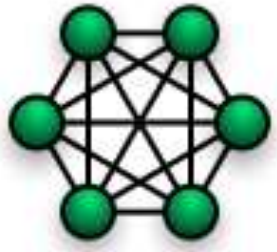
8 devices in mesh has links: n(n-1) / 2

number of links = 8 (8-1)/2 = **28**

number of ports per device = n – 1 = 8 –1 = **7**

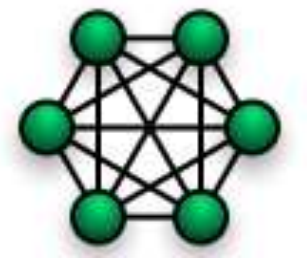
Physical Topology

- Mesh
  - Advantages
    - Each connection carry its own data load (no traffic problems)
    - A mesh topology is robust
    - Privacy or security
    - Fault identification and fault isolation



Physical Topology

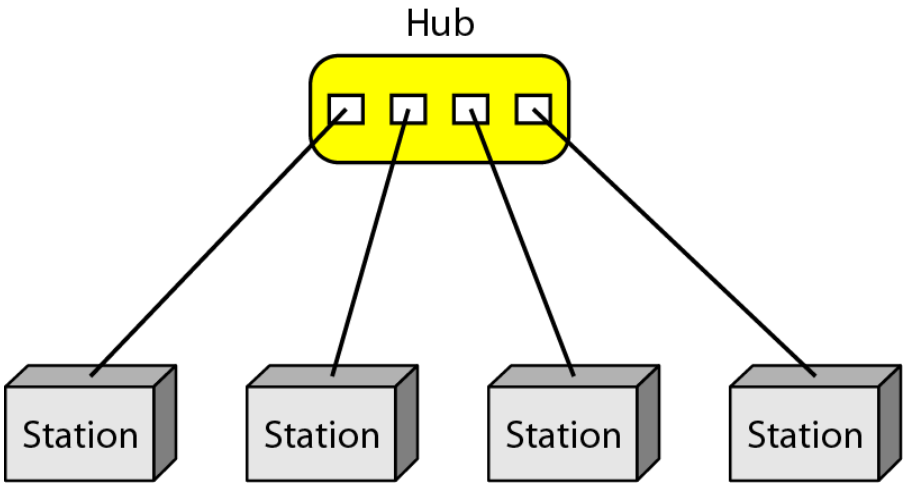
- Mesh:
  - Disadvantages
    - Big amount of cabling
    - Big number of I/O ports
    - Installation and reconnection are difficult
    - Sheer bulk of the wiring can be greater than the available space
    - Hardware connect to each I/O could be expensive



- Mesh topology is implemented in a limited fashion; e.g., as backbone of hybrid network

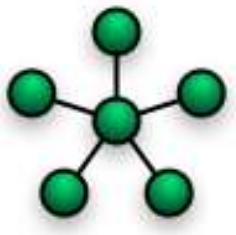
Physical Topology

- Star:
  - Dedicated point-to-point to a central controller (Hub)
  - No direct traffic between devices
  - The control acts as an exchange



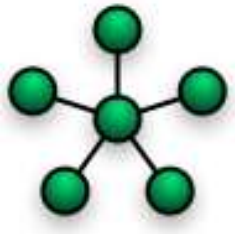
Physical Topology

- Star
  - Advantages
    - Less expensive than mesh (1 Link + 1 port per device)
    - Easy to install and reconfigure
    - Less cabling
    - Additions, moves, and deletions required one connection
    - Robustness : one fail does not affect others
    - Easy fault identification and fault isolation



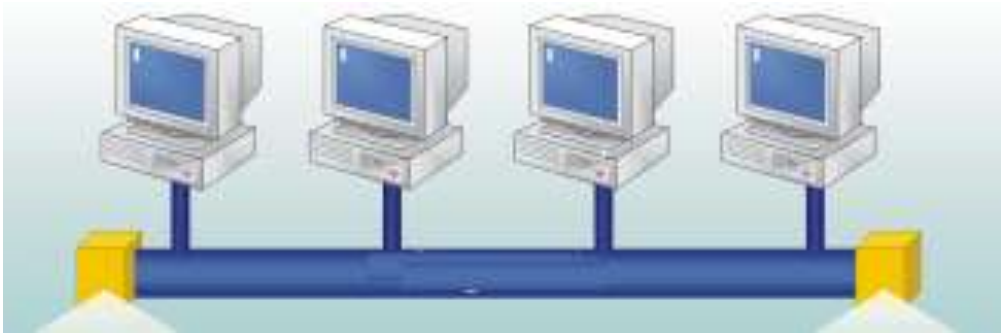
Physical Topology

- Star
  - Disadvantages
    - Dependency of the whole topology on one single point (hub)
    - More cabling than other topologies (ring or bus)
- Used in LAN



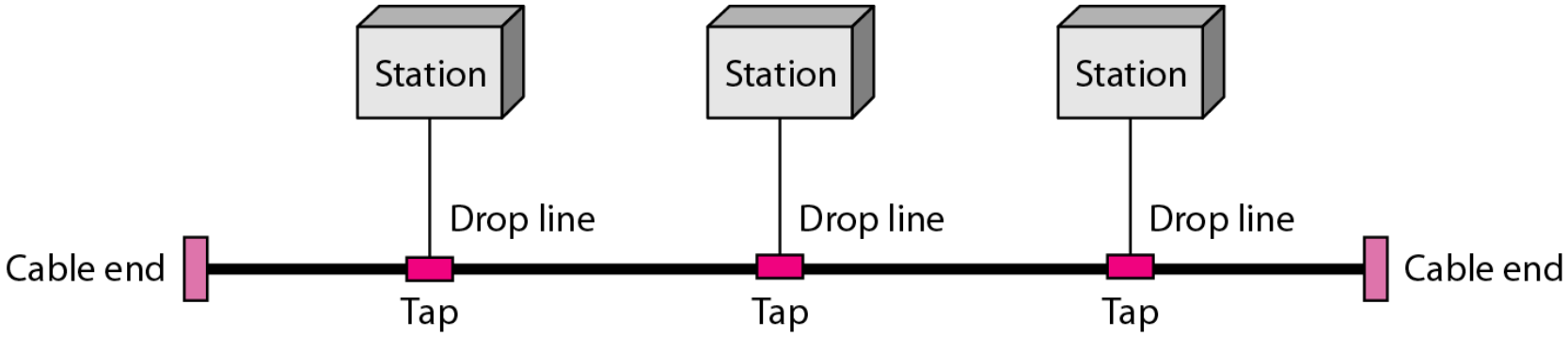
Physical Topology

- Bus
  - It is multipoint
  - One long cable acts as a backbone
  - Used in the design of early LANS, and Ethernet LANs



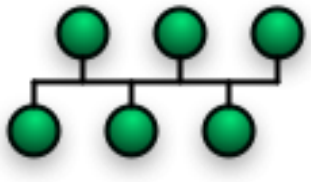
Physical Topology

- Bus
  - Nodes connect to cable by drop lines and taps
  - Signal travels along the backbone and some of its energy is transformed to heat
  - Limit of number of taps and the distance between taps



Physical Topology

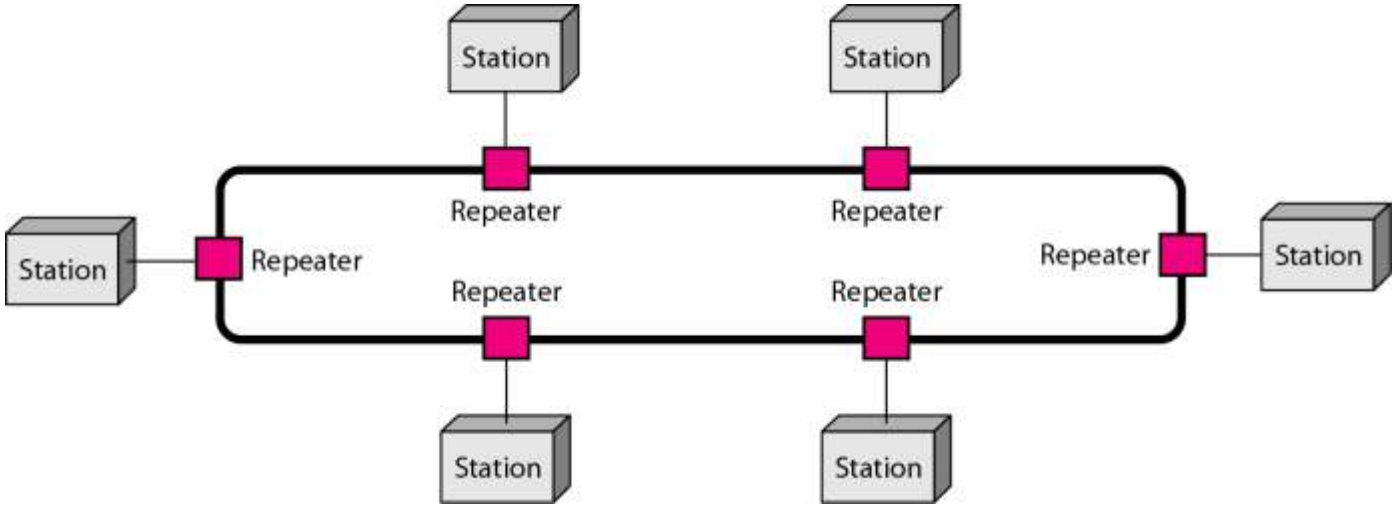
- Bus



  - Advantages
    - Ease of installation
    - Less cables than mesh, star topologies
  - Disadvantages
    - Difficult reconnection and fault isolation (limit of taps)
    - Adding new device requires modification of backbone
    - Fault or break stops all transmission
    - The damaged area reflects signals back in the direction of the origin, creating noise in both directions

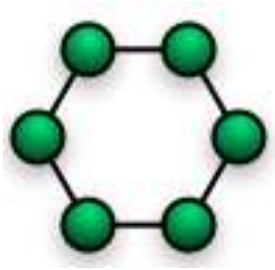
Physical Topology

- Ring
  - Each device has dedicated point-to-point connection with only the two devices on either side of it
  - A signal is passed along the ring in one direction from device to device until it reaches its destination
  - Each devices incorporates a Repeater



Physical Topology

- Ring
  - Advantages
    - Easy of install and reconfigure
    - Connect to immediate neighbors
    - Move two connections for any moving (Add/Delete)
    - Easy of fault isolation
  - Disadvantage
    - Unidirectional
    - One broken device can disable the entire network. This weakness can be solved by using a dual ring or a switch capable of closing off the break



Physical Topology

- Hybrid Topology
  - Example: having a main star topology with each branch connecting several stations in a bus topology

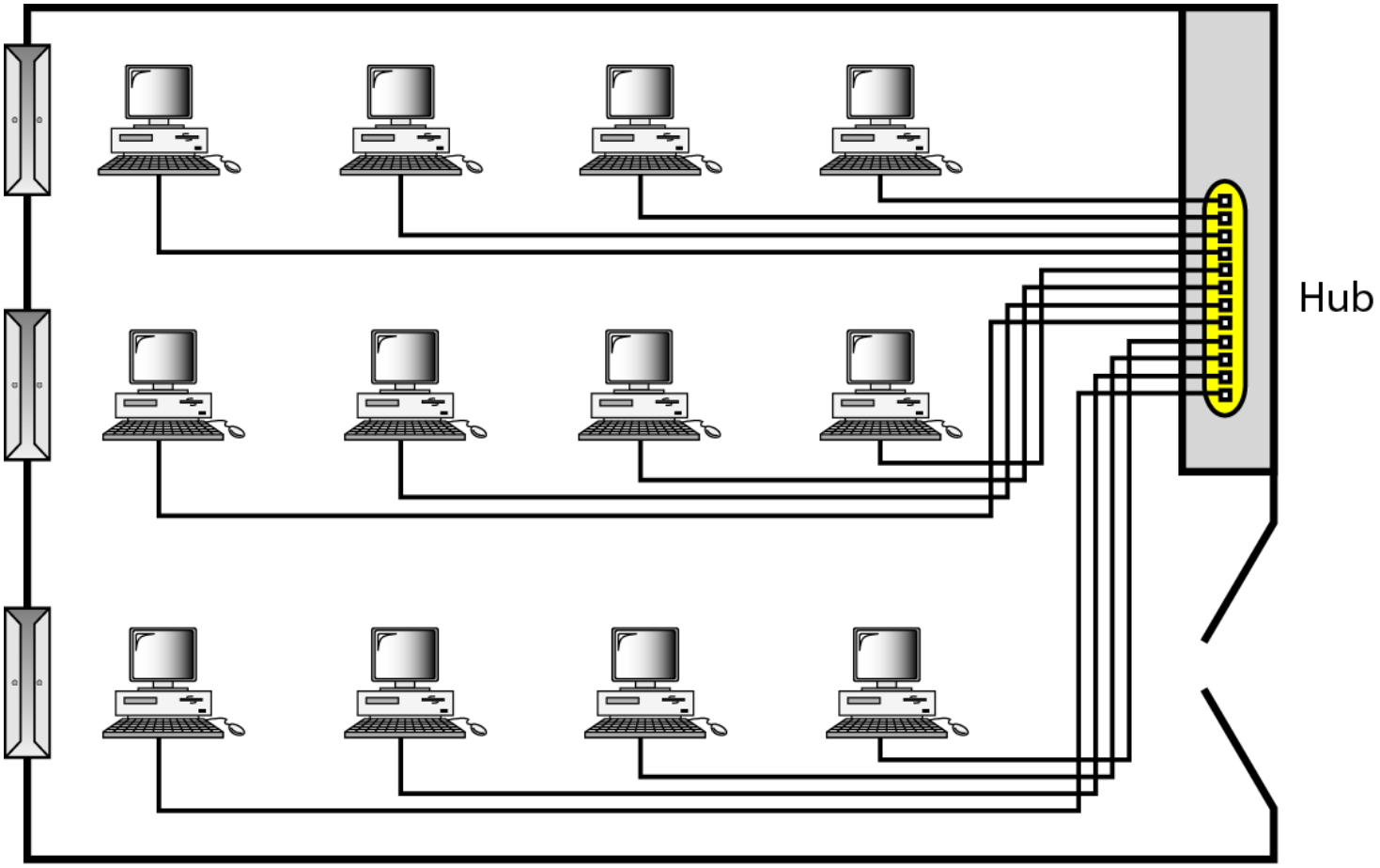
Categories of Networks

- Network Category depends on its size
- Two primary categories
  - **LAN**: Covers area < 2miles
  - **WAN**: Can be worldwide
  - **MAN**: Between LAN & WAN, span 10s of miles

Local Area Network (LAN)

- Privately owned
- Links devices in the same office, building, or campus
- Simple LAN: 2 PCs & 1 printer in home or office
- Size is limited to a few kilometers
- Allow resources to be shared (hardware, software, or data)

Local Area Network (LAN)

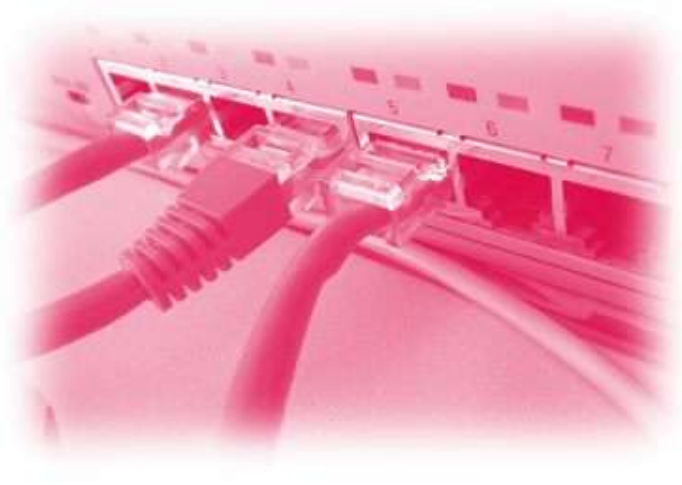


An isolated LAN connecting 12 computers to a hub in a closet

Local Area Network (LAN)

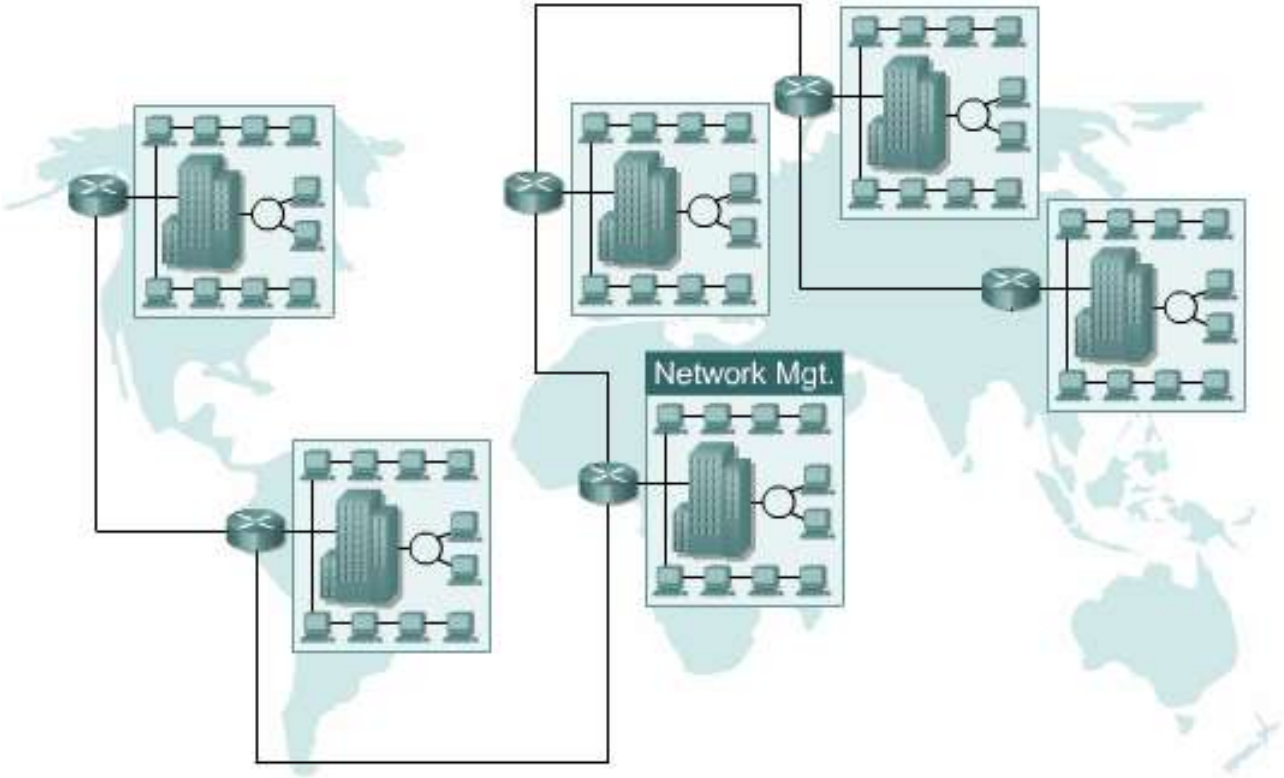
- LAN is distinguished by:
  - Size (# users of OS, or licensing restrictions)
  - Transmission medium (only one type)
  - Topology (bus, ring, star)

- Data Rates (speed):
  - Early: 4 to 16 Mbps
  - Today: 100 to 1000 Mbps



Wide Area Networks (WAN)

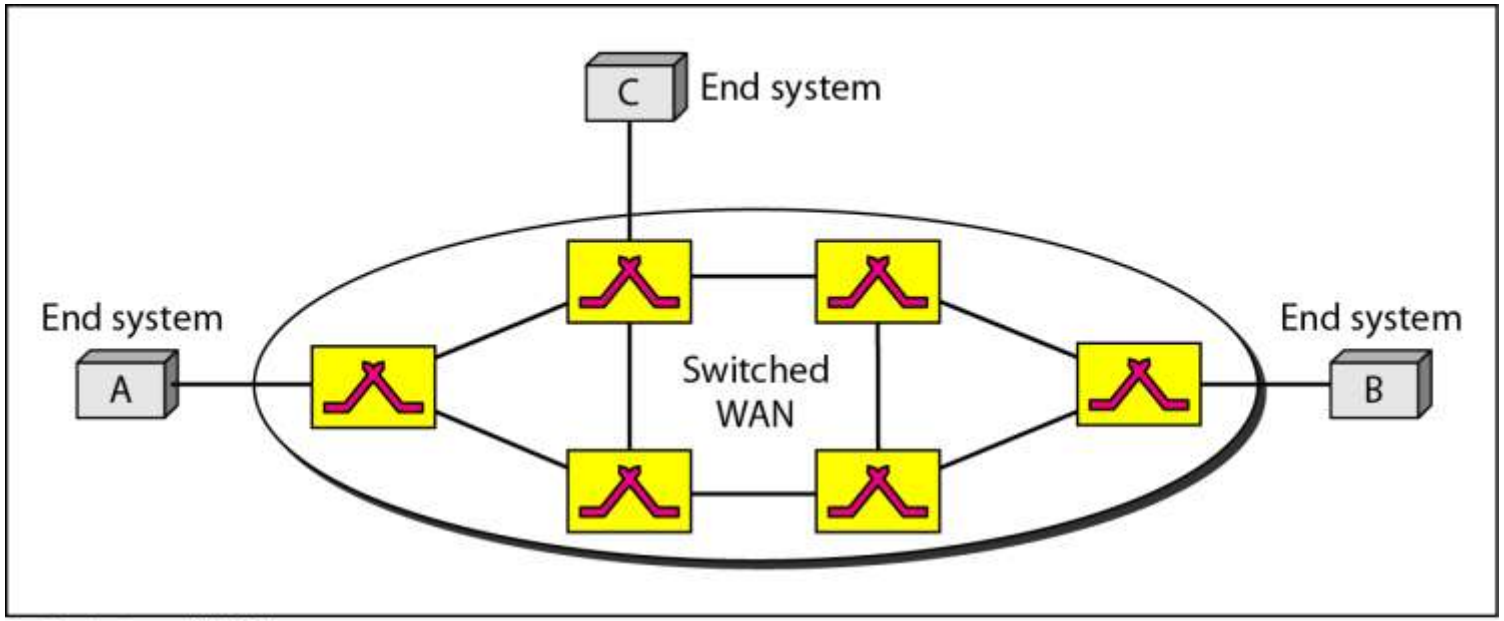
- Provides long-distance transmission of data over large geographic areas (country, continent, world)



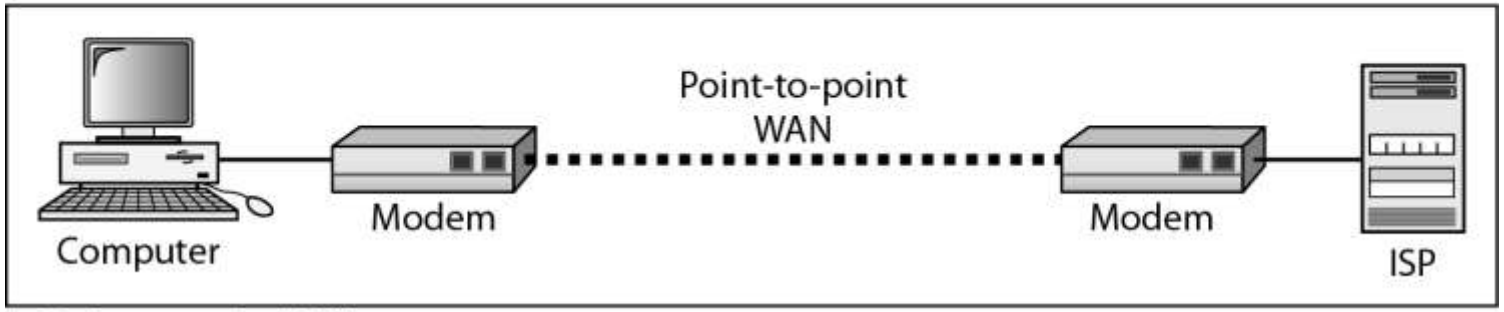
Wide Area Networks (WAN)

- Switched WAN
  - Backbone of the Internet
- Dialup line point-to-point WAN
  - Leased line from a telephone company

Wide Area Networks (WAN)



a. Switched WAN



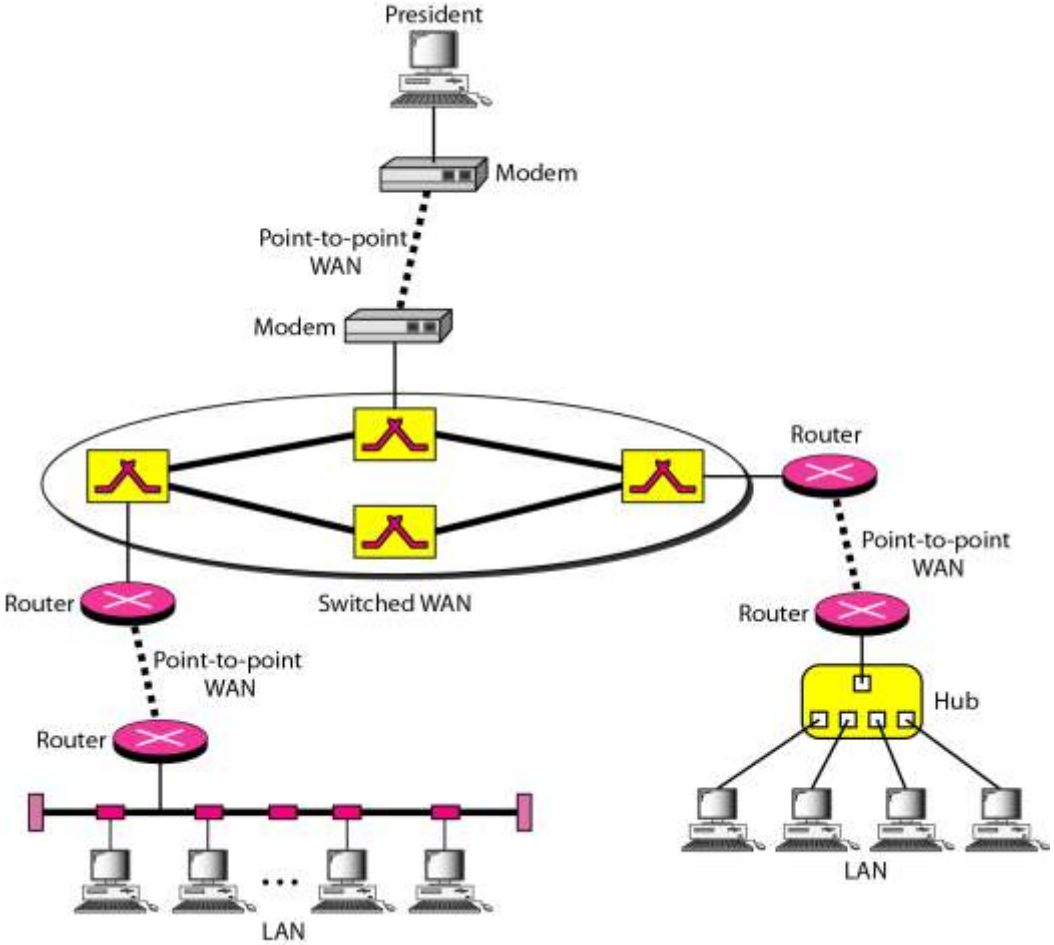
b. Point-to-point WAN

Metropolitan Area Networks (MAN)

- Size between LAN and WAN
- Inside a town or a city
- Example: the part of the telephone company network that can provide a high-speed DSL to the customer

Interconnection of Networks: Internetworks

- Two or more networks connected together



The Internet

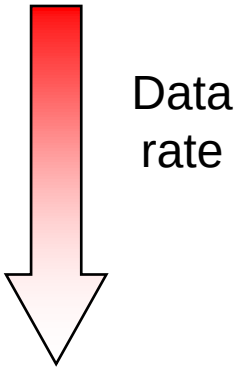
- Internet has revolutionized many aspects of our daily lives.
- It has affected the way we do business as well as the way we spend our leisure time.
- Internet is a communication system that has brought a wealth of information to our fingertips and organized it for our use
- An internet is 2 or more networks that can communicate with each other
- The Internet is a collaboration of more than hundreds of thousands of interconnected networks

The Internet

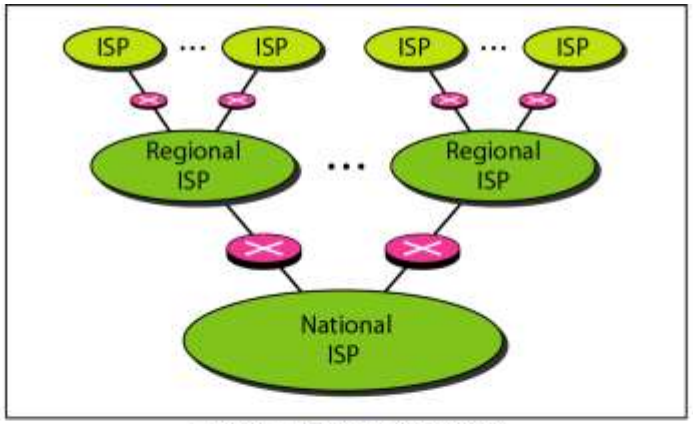
- An internet (small i) is two or more networks
- Notable internet is called the Internet (hundreds of thousands interconnected networks)
  - Private individuals + government agencies + school + research facilities + Corporations + libraries in more than 100 countries
- This communication system came in 1969
- Mid-1960 (ARPA) Advanced Research Projects Agency in (DOD) was interested to connect mainframes in research organizations
- 1967, ARPA presented its ideas for ARPANET
  - Host computer connecting to (IMP) interface message processor.
  - Each IMP communicate with other IMP
- 1969, four nodes (universities) connected via IMPs to form a network
  - Software (NCP) Network Control Protocol provided communication between the hosts.
- 1972, Vint Cerf and Bob Kahn invented (TCP) Transmission Control Protocol
- Later TCP was split to (TCP) Transmission Control Protocol and (IP) Internetworking Protocol

The Internet

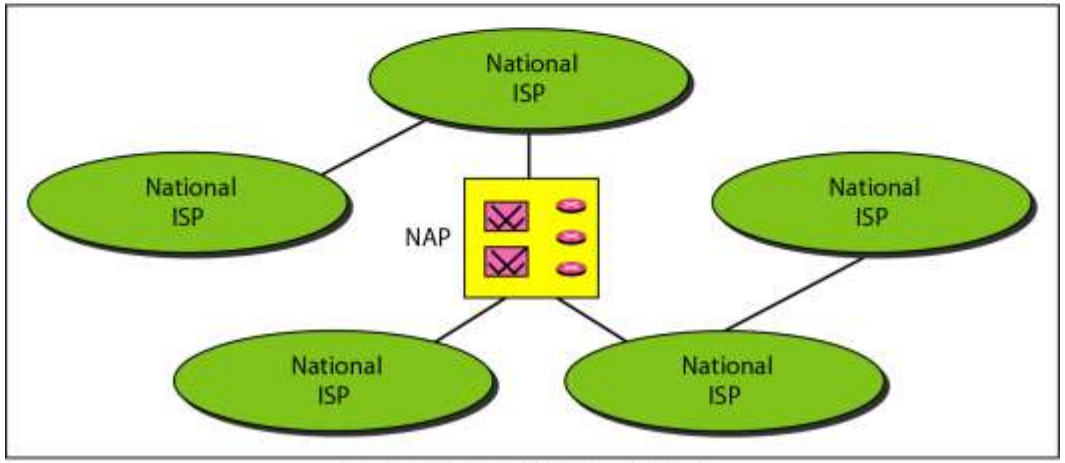
- Internet Today
  - Made of many LANs and WANs
  - Every day new networks area added and removed
  - Internet services Providers (ISPs) offer services to the end users
    - International service providers
    - National service providers
    - Regional service providers
    - Local service providers



The Internet



a. Structure of a national ISP



b. Interconnection of national ISPs

Hierarchical organization of the Internet

Protocols and Standards

- Protocol synonymous with rule
- Standards: agreed-upon rules

- Protocols
  - A protocol is a set of rules that govern data communications
  - Defines What, How, and When it is communicated

Protocols and Standards

- Elements of a protocol:
  - ***Syntax:*** structure or format of data
    - Example: 8-bits address of sender, 8-bits address of receiver
  - ***Semantics:*** meaning of each section of bits
    - Example: Does the address is a route to be taken or the final destination of the message
  - ***Timing:*** when data should be sent and how fast they can be sent
    - Example: sender produces data at 100 Mbps but the receiver can process data at only 1 Mbps $\Rightarrow$ overload and data loose

Standards

- Essential in creating and maintaining an open and competitive market for equipment manufactures
- Guaranteeing national and international interoperability of data and telecommunication technology and processes
- Providing guidelines to manufacturers, vendors, government agencies, and other service providers to ensure the kind of interconnectivity necessary in today's marketplace and in international communications

Standards

- Two categories
  - De facto: not approved by an organized body but adopted as standards through widespread use
  - De jure: Legislated by an officially recognized body

Standards

- Standards are developed through the cooperation of:
  - Standards Creation Committees
    - ISO, ITU-T, CCITT, ANSI, IEEE, EIA
  - Forums
    - Created by special-interest groups
    - Present their conclusions to the standards bodies
  - Regulatory Agencies
    - Ministry of Telecommunication and Information Technology (KSA)
    - Purpose: Protecting the public by regulating radio, television, and communication

Standards

- Internet standards
  - Tested thoroughly tested specification that is useful to be adhered to by those who work with the Internet
  - Formalized regulation that must be followed
  - Specification become Internet standard
    - Begins as Internet draft for 6 months
    - Upon recommendation from the Internet authorities draft published as Request for Comment (RFC)
    - RFC is edited, assigned a number, and made available to all interested parties

Network Layer: Logical Addressing

TOPICS

- Logical Addressing
- IPV4 Address
  - Address Space Notation,
  - Network Address Translation.
- IPV6 address
  - Structure
  - address space
  - advantages
- Tunneling
- Address mapping.

19-1 IPv4 ADDRESSES

An IPv4 address is a 32-bit address that uniquely and universally defines the connection of a device (for example, a computer or a router) to the Internet.

Topics discussed in this section:

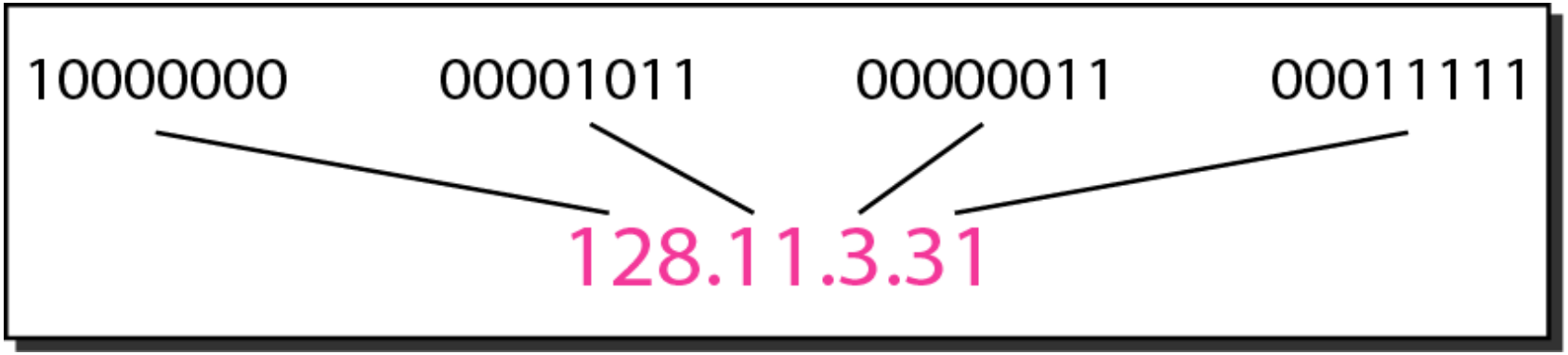
Address Space
Notations
Classful Addressing
Classless Addressing
Network Address Translation (NAT)

Address Space

- An IPv4 address is 32 bits long.
- The IPv4 addresses are unique and universal.
- The address space of IPv4 is 2^{32} or 4,294,967,296.

Notations

- ✓ *Dotted-decimal notation*
- ✓ *Binary notation*



Example 19.1

Change the following IPv4 addresses from binary notation to dotted-decimal notation.

a. 10000001 00001011 00001011 11101111

b. 11000001 10000011 00011011 11111111

Solution

We replace each group of 8 bits with its equivalent decimal number (see Appendix B) and add dots for separation.

a. 129.11.11.239

b. 193.131.27.255

Example 19.2

Change the following IPv4 addresses from dotted-decimal notation to binary notation.

a. 111.56.45.78

b. 221.34.7.82

Solution

We replace each decimal number with its binary equivalent (see Appendix B).

a. 01101111 00111000 00101101 01001110

b. 11011101 00100010 00000111 01010010

Example 19.3

Find the error, if any, in the following IPv4 addresses.

a. 111.56.045.78

b. 221.34.7.8.20

c. 75.45.301.14

d. 11100010.23.14.67

Solution

a. There must be no leading zero (045).

b. There can be no more than four numbers.

c. Each number needs to be less than or equal to 255.

d. A mixture of binary notation and dotted-decimal notation is not allowed.

Classful Addressing, Classless Addressing

- In classful addressing, the address space is divided into five classes: A, B, C, D, and E.

	First byte	Second byte	Third byte	Fourth byte
Class A	0			
Class B	10			
Class C	110			
Class D	1110			
Class E	1111			

a. Binary notation

	First byte	Second byte	Third byte	Fourth byte
Class A	0–127			
Class B	128–191			
Class C	192–223			
Class D	224–239			
Class E	240–255			

b. Dotted-decimal notation

Example 19.4

Find the class of each address.

a. 00000001 00001011 00001011 11101111

b. 11000001 10000011 00011011 11111111

c. 14.23.120.8

d. 252.5.15.111

Solution

a. The first bit is 0. This is a class A address.

b. The first 2 bits are 1; the third bit is 0. This is a class C address.

c. The first byte is 14; the class is A.

d. The first byte is 252; the class is E.

Note

In classful addressing, a large part of the available addresses were wasted.

Classful addressing, which is almost obsolete, is replaced with classless addressing.

Classless Addressing

In IPv4 addressing, a block of addresses can be defined as

x.y.z.t /*n*

in which x.y.z.t defines one of the addresses and the /*n* defines the mask.

Note

The first address in the block can be found by setting the rightmost
$32 - n$ bits to 0s.

Example 19.6

A block of addresses is granted to a small organization. We know that one of the addresses is 205.16.37.39/28. What is the first address in the block?

Solution

The binary representation of the given address is

11001101 00010000 00100101 00100111

If we set 32−28 rightmost bits to 0, we get

11001101 00010000 00100101 0010000

or

205.16.37.32.

This is actually the block shown in Figure 19.3.

Note

The last address in the block can be found by setting the rightmost
32 − n bits to 1s.

Example 19.7

Find the last address for the block in Example 19.6.

Solution

The binary representation of the given address is

11001101 00010000 00100101 00100111

If we set 32 − 28 rightmost bits to 1, we get

11001101 00010000 00100101 00101111

or

205.16.37.47

This is actually the block shown in Figure 19.3.

Note

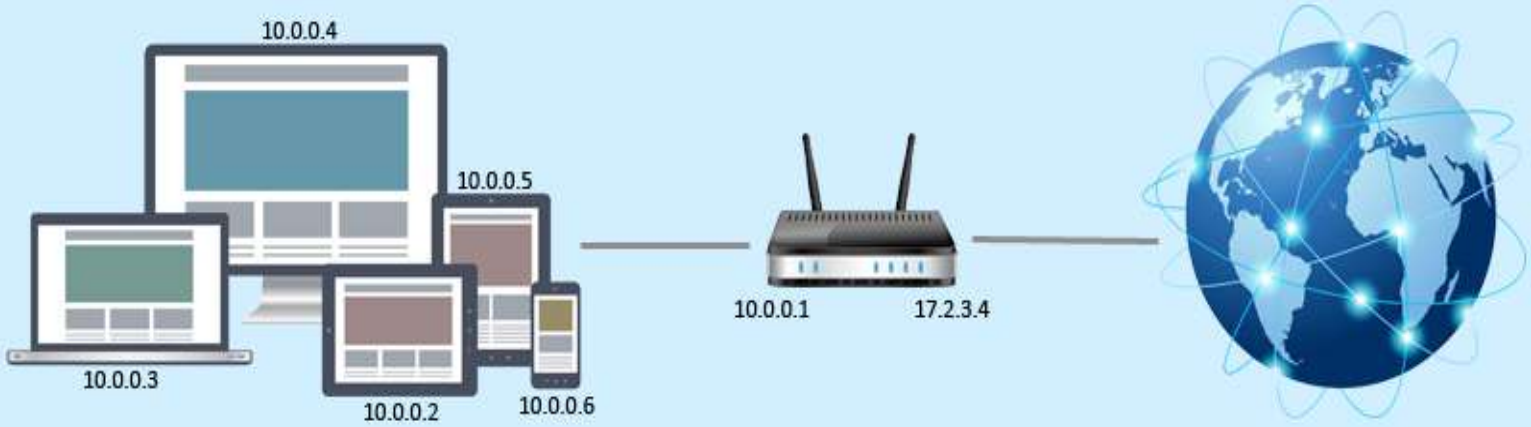
The number of addresses in the block can be found by using the formula

2^{32-n}.

NAT

- Stands for “Network Address Translation”.
- NAT translates the IP addresses of computers in a local network to a single IP address.
- This address is often used by the router that connects the computers to the Internet.
- The router can be connected to a DSL modem, cable modem, T1 line, or even a dial-up modem.
- When other computers on the Internet attempt to access computers within the local network, they only see the IP address of the router.
- This adds an extra level of security, since the router can be configured as a firewall, only allowing authorized systems to access the computers within the network.

Network Address Translation



19-2 IPv6 ADDRESSES

Despite all short-term solutions, address depletion is still a long-term problem for the Internet. This and other problems in the IP protocol itself have been the motivation for IPv6.

Topics discussed in this section:

Structure
Address Space

Structure

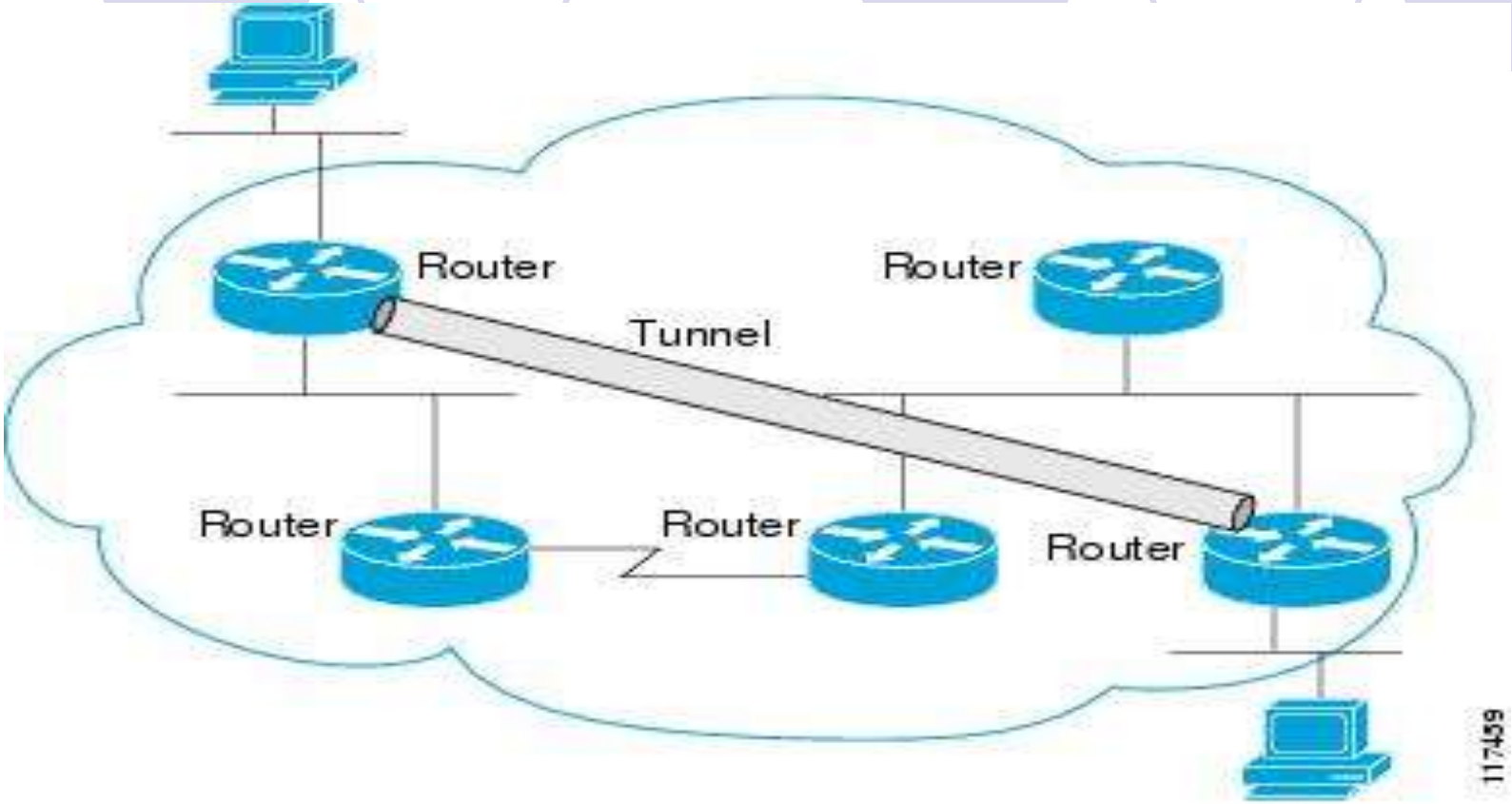
- In IPv6 the IP address size is increased from 32 bits to 128 bits
- IPv6 supports a greater number of addressable nodes
- IPv6 provides more levels of addressing hierarchy
- IPv6 offers simpler auto-configuration of addresses
- Ipv6 also supports simplified header format

Address Space

- The **address space** therefore has
- 2^{128} or approximately 3.4×10^{38} **addresses** (340,282,366,920,938,463,463,374,607,431,768,211,456,
- which is approximately 340 undecillion, or 340 billion billion billion billion, **addresses**

Tunneling

- Tunneling is a protocol that allows for the secure movement of data from one network to another.
- Tunneling involves allowing private network communications to be sent across a public network, such as the Internet, through a process called encapsulation.
- The encapsulation process allows for data packets to appear as though they are of a public nature to a public network when they are actually private data packets, allowing them to pass through unnoticed.
- Tunneling is also known as port forwarding.



If the path between two computers has more than 15 hops, the computers cannot communicate with each other, but it is possible to hide some of the hops inside the network using a tunnel.

Address Mapping

- The deliver delivery of a packet to a host or a router requires two levels of addressing addressing: logical and physical.
- We need to be able to map a logical logical address address to its corresponding physical address address and vice versa.
- This can be done by using either static or dynamic dynamic mapping