COMPUTER NETWORK

EGCO103 INFORMATION TECHNOLOGY IN THE DAILY LIFE

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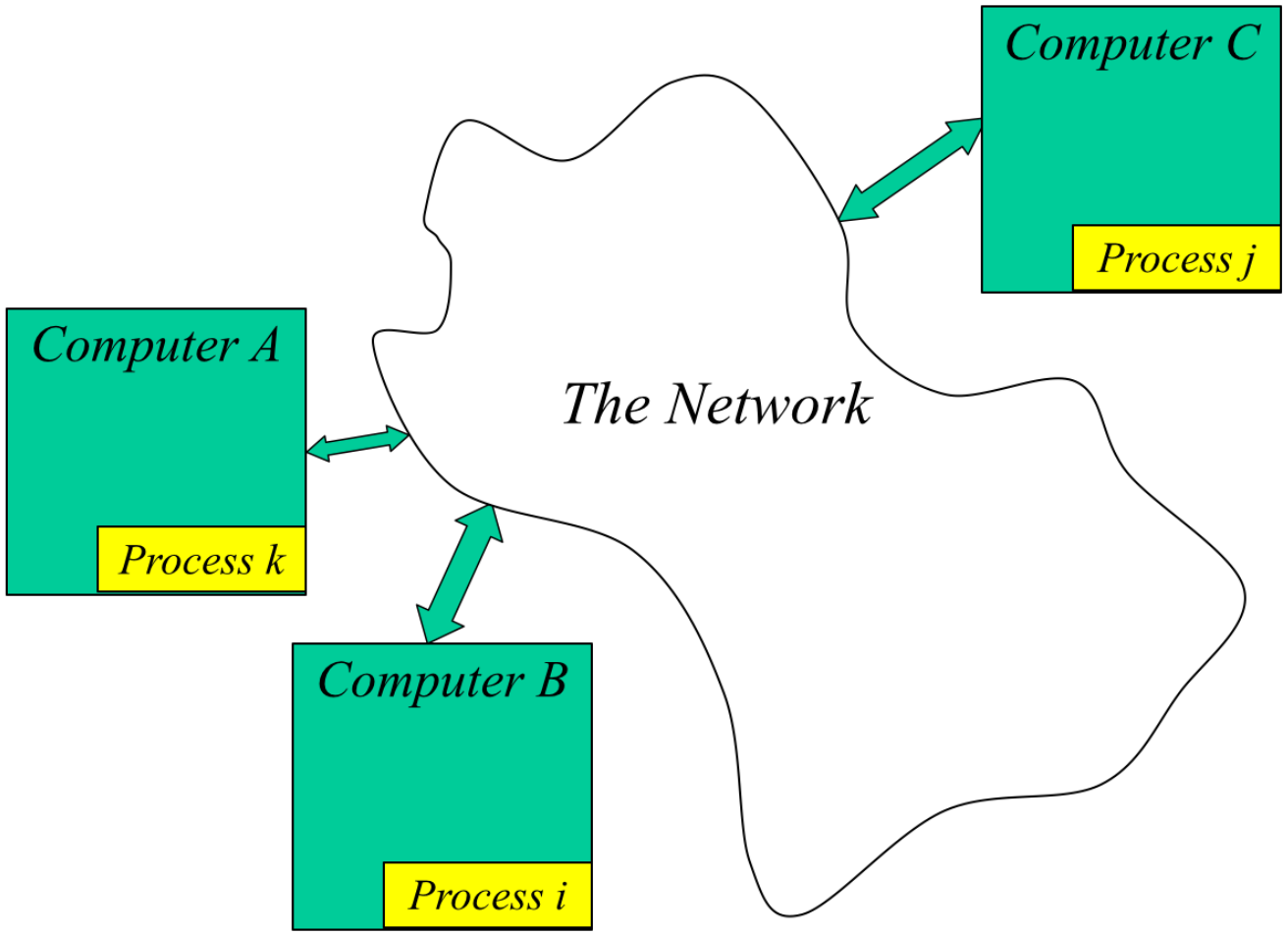
MOVING DATA

- We want to move data.
- Problems
  - Data too big to fit in one media (Flash Drive, DVD, etc.)
  - Destination computer is too far away.
  - Too many destination computers
  - Data has to be moved very frequently.

NETWORK DEFINITION



ADVANTAGES OF NETWORKING

- Connectivity and Communication
- Data Sharing
- Hardware Sharing
- Internet Access
- Internet Access Sharing
- Entertainment

DISADVANTAGES OF NETWORKING

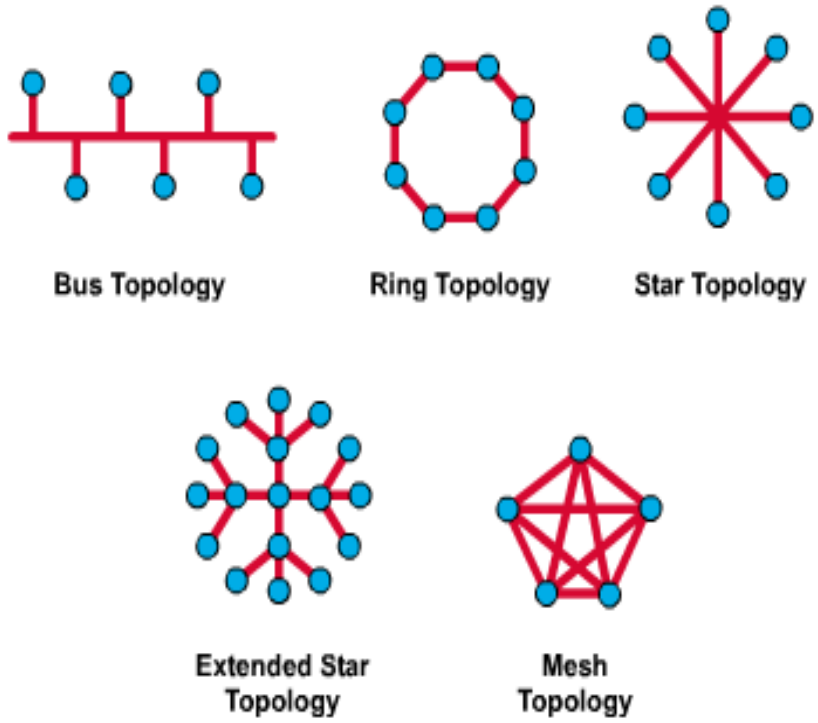
- Network Hardware, Software and Setup Costs
- Hardware and Software Management and Administration Costs
- Undesirable Sharing
- Illegal or Undesirable Behaviours
- Data Security Concerns

FUNDAMENTAL NETWORK CLASSIFICATIONS

- Local Area Networks (LANs):
  - A local area network (LAN) is a computer network covering a small geographic area, like a home, office, or group of buildings
- Wide Area Networks (WANs):
  - Wide Area Network (WAN) is a computer network that covers a broad area. Or, less formally, a network that uses routers and public communications links
  - The largest and most well-known example of a WAN is the Internet.

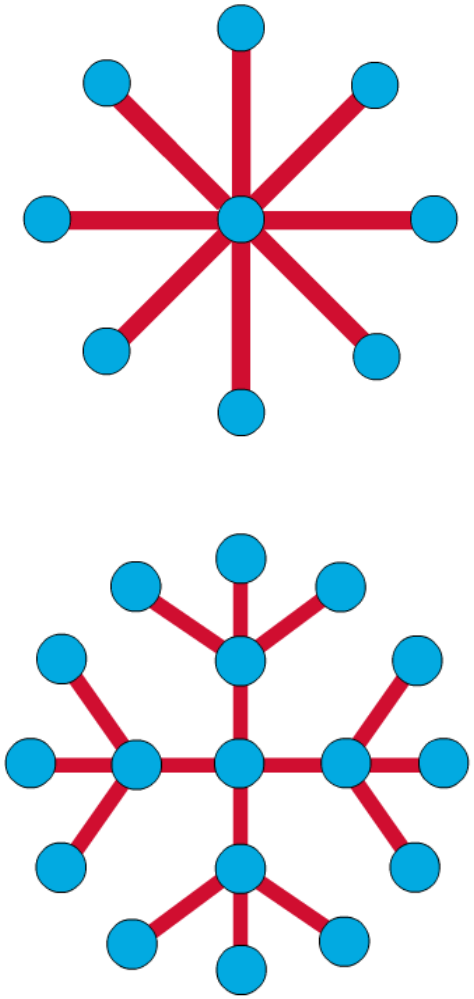
NETWORK TOPOLOGY

- The network topology defines the way in which computers, printers, and other devices are connected. A network topology describes the layout of the wire and devices as well as the paths used by data transmissions.



STAR AND TREE TOPOLOGY

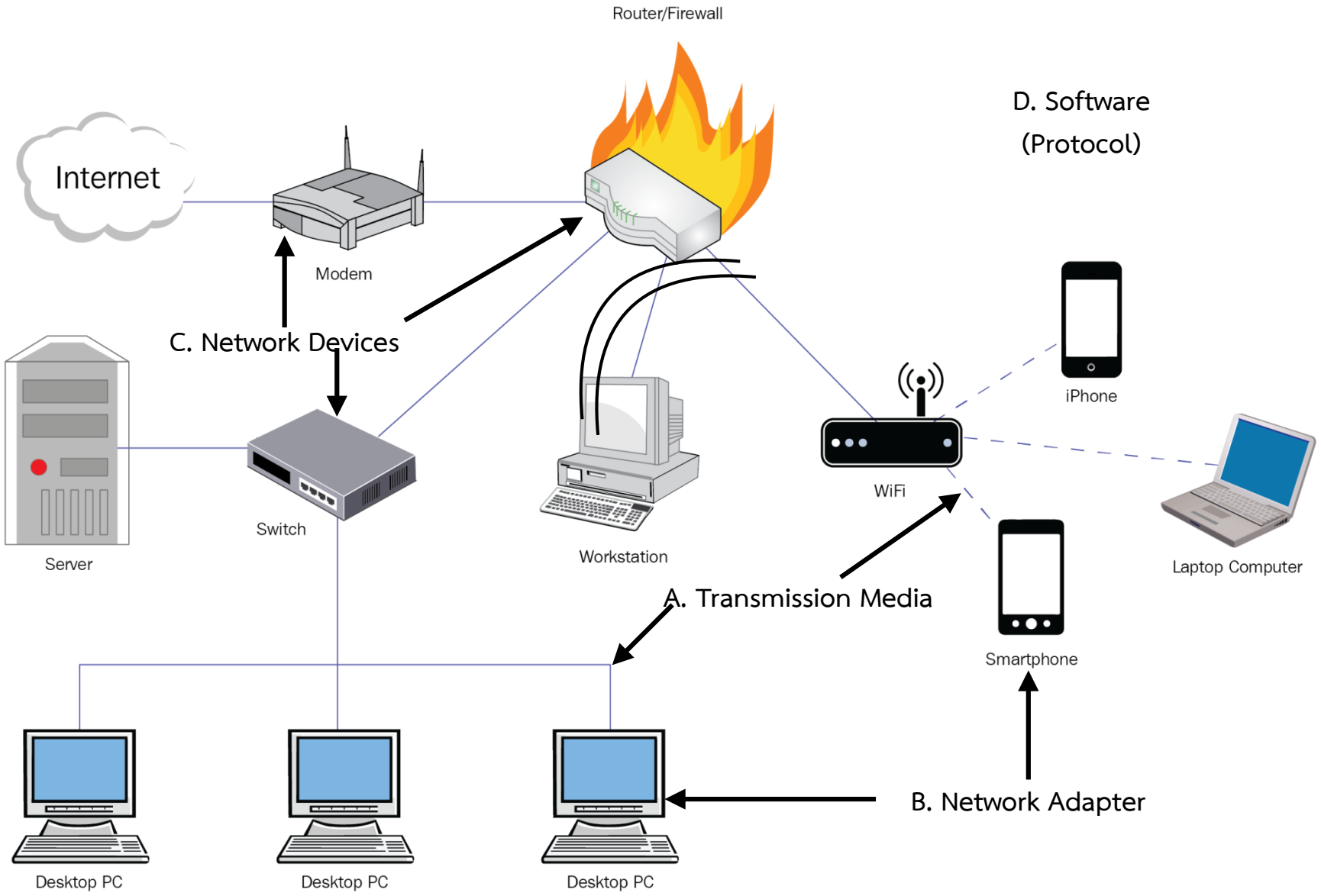
- The star topology is the most commonly used architecture in Ethernet LANs.
- Larger networks use the extended star topology also called tree topology. When used with network devices that filter frames or packets, like bridges, switches, and routers, this topology significantly reduces the traffic on the wires by sending packets only to the wires of the destination host.



NETWORK COMPONENTS (1)

- All networks must include:
  - Means of connecting nodes to network (cables or wireless)
  - Network devices that allow nodes to communicate with each other
  - Software that allows network to run

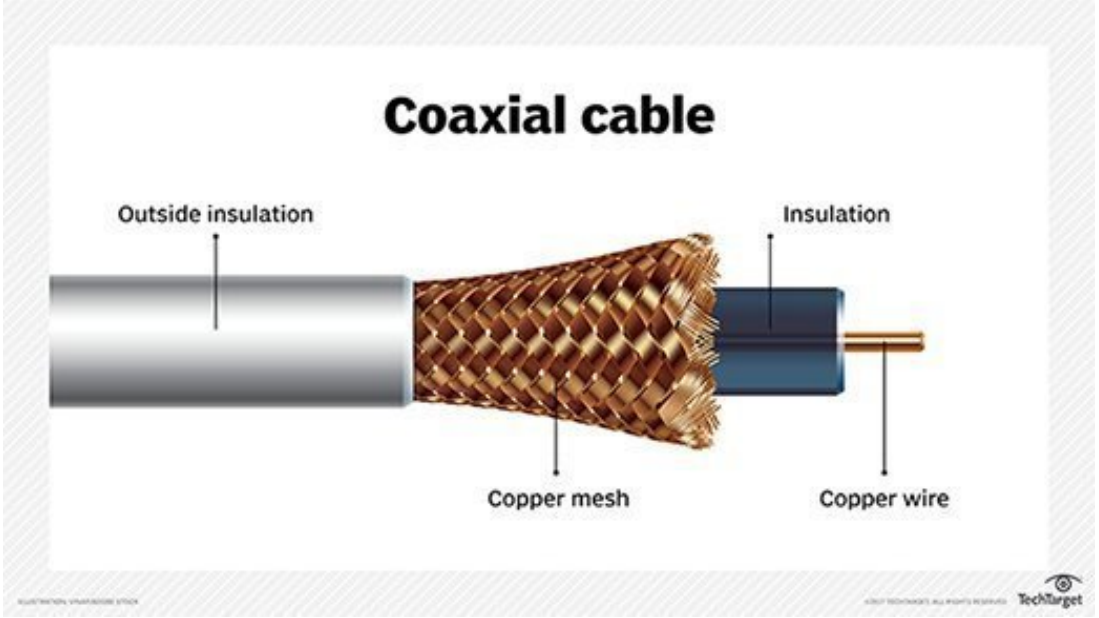
NETWORK COMPONENTS (2)



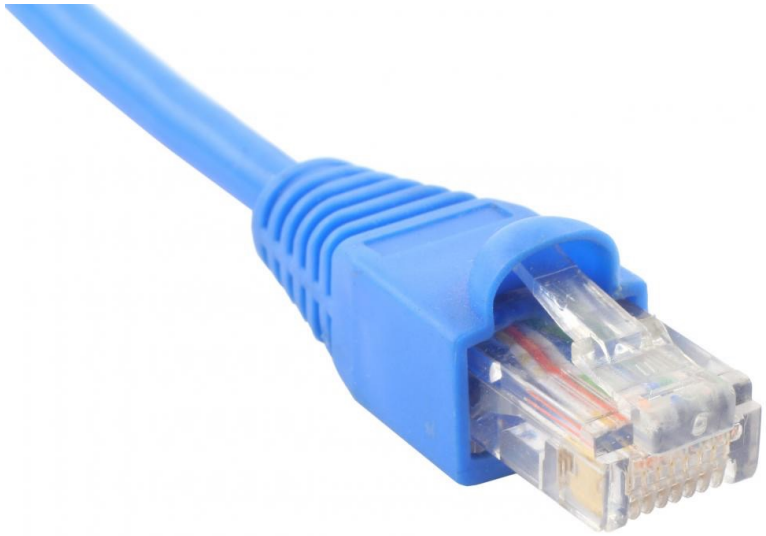
TRANSMISSION MEDIA

- Establish a communications channel between nodes on network
  - Wired networks use cables to connect nodes
    - Coaxial cable
    - Twisted-pair cable
    - Fiber-optic cable
  - Wireless networks use radio waves

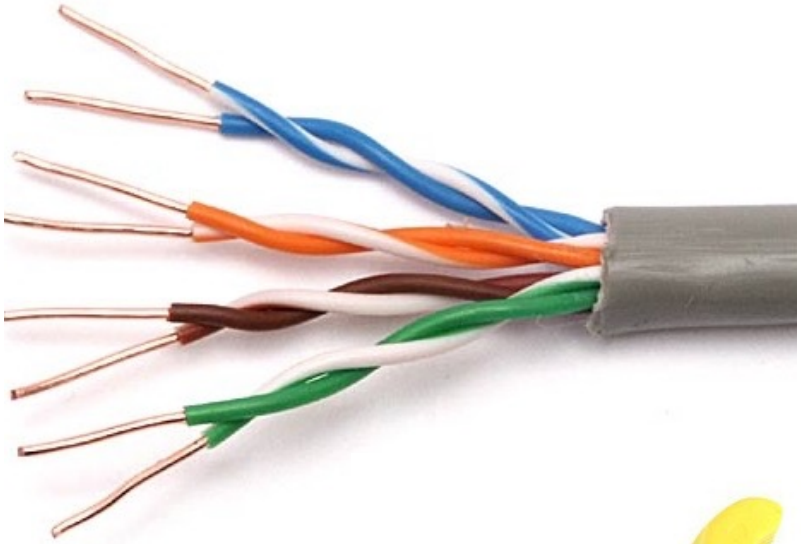
COAXIAL CABLE



UNSHIELDED TWISTED PAIR (UTP)



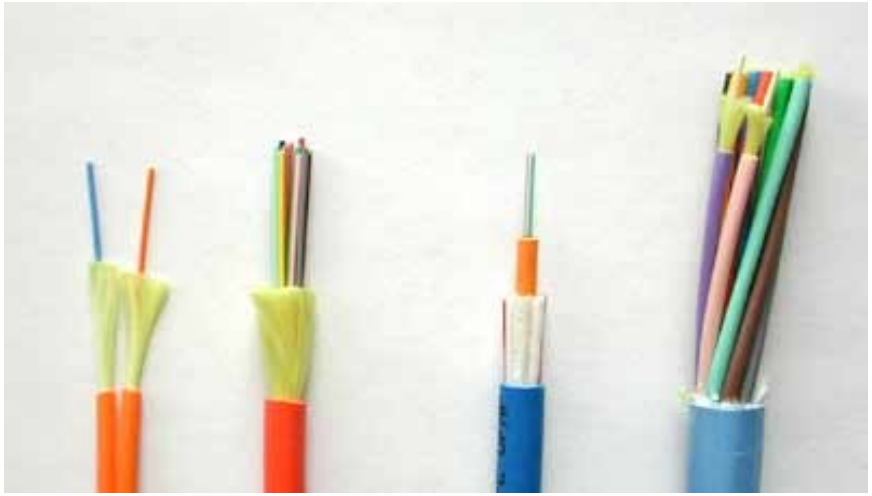
RJ-45

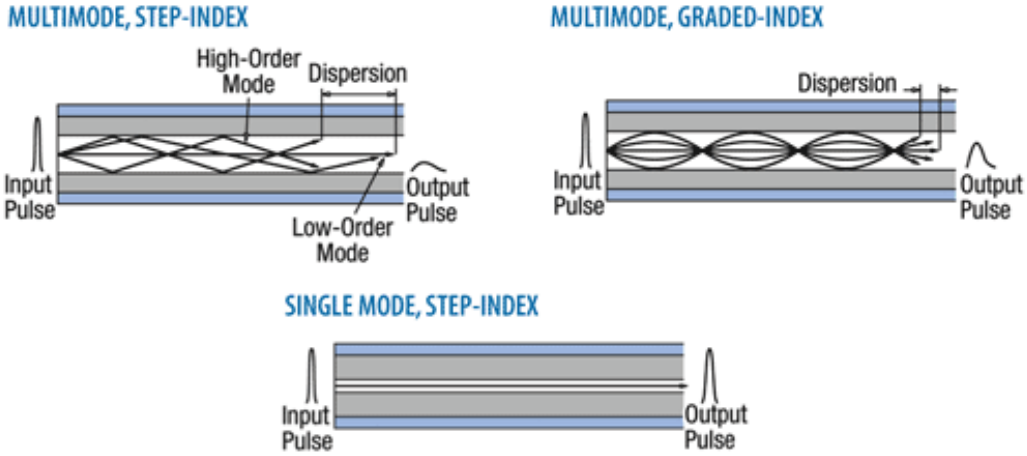


- CAT 5/5e (100/1,000 Mbps)
- CAT 6 (10 Gbps)
- CAT 6a, 7, 7a (UTP/FTP)
- CAT 8.1, 8.2 (40 Gbps)

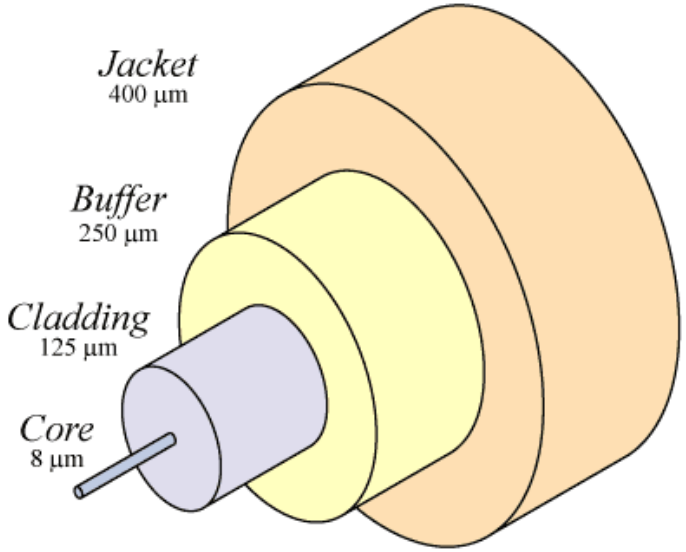
UTP Cable Clamp

FIBER OPTIC



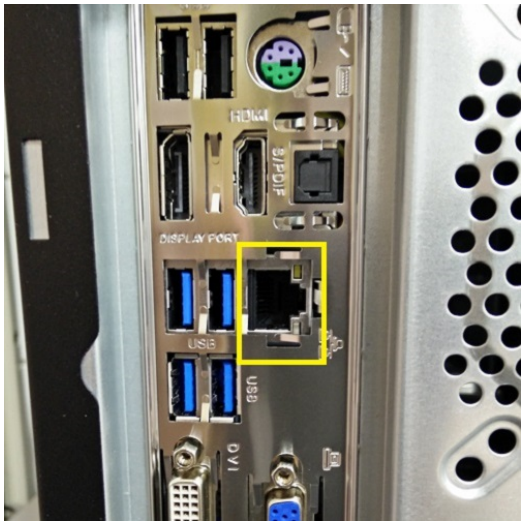


- Fiber Optic Cable
  - Mutimode
    - Step-Index
    - Graded-Index
  - Singlemode

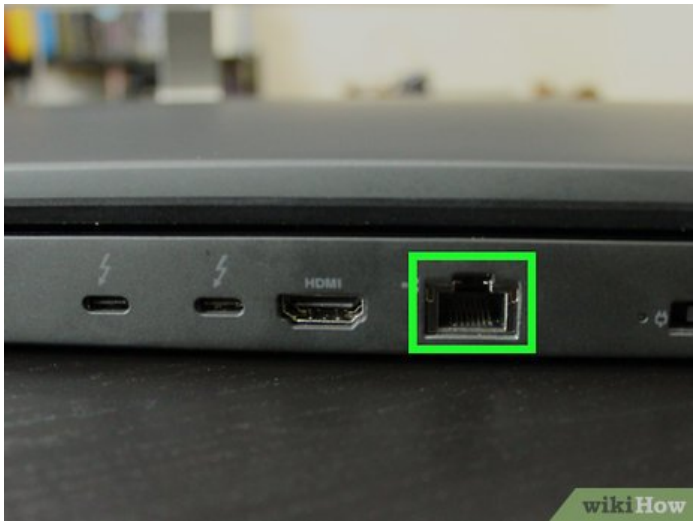


NETWORK ADAPTERS

- Devices connected to or installed in network nodes
- Enable nodes to communicate with each other and access the network
- Desktop computers sold today contain network adaptors



Desktop



Notebook

Network Adapter

NETWORK NAVIGATION DEVICES (1)

- Control the flow of data through a network
- Data sent in bundles called packets
- Router
  - Transfers packets between two or more networks
- Hub/Switch
  - Receives data packets and sends them to intended nodes on same network

NETWORK NAVIGATION DEVICES (2)

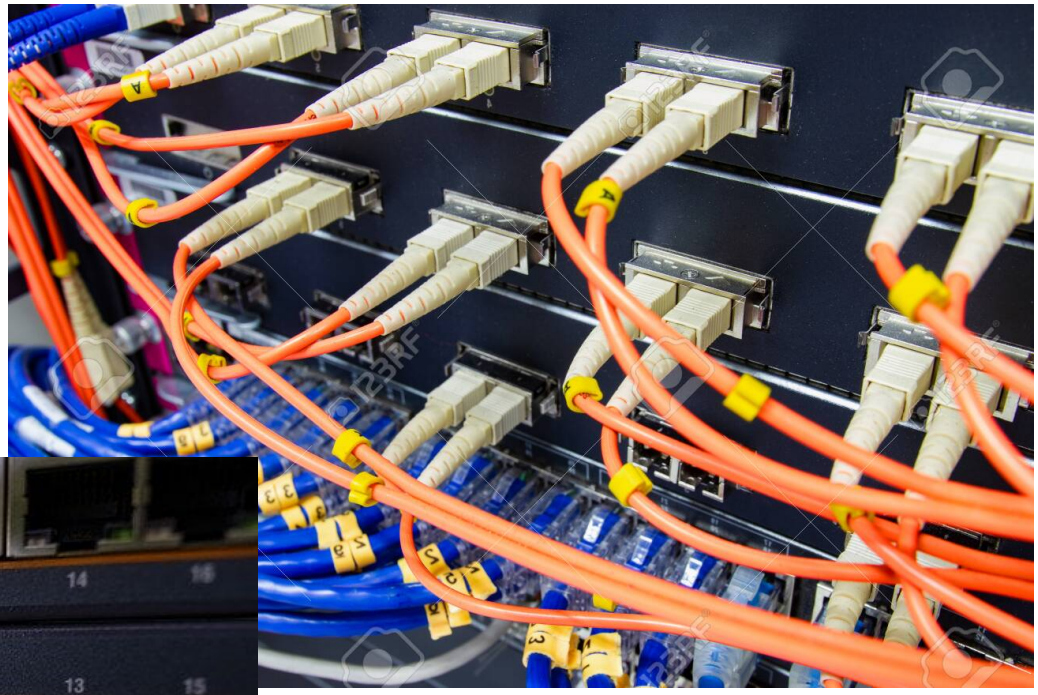
Hub

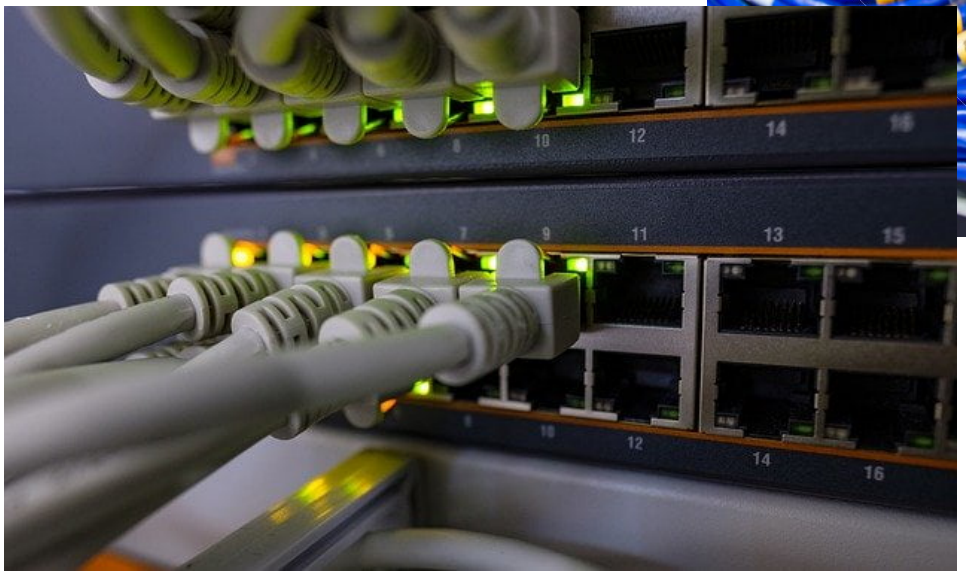
Switch

Router

FIBER OPTIC & UTP

Fiber Optic





UTP

WIRELESS SIGNALS

- Might have decreased throughput
  - Interference from magnetic and electrical sources
  - Interference with other wireless networks
  - Building materials and metal
  - Distance from networking equipment

WIRELESS LAN

- A wireless local area network (LAN) is a flexible data communications system implemented as an extension to, or as an alternative for, a wired LAN.
  - Using radio frequency (RF) technology, wireless LANs transmit and receive data over the air, minimizing the need for wired connections.
  - Thus, combining data connectivity with user mobility.
- Wireless LAN Standard
  - IEEE 802.11a (5 GHz)
  - IEEE 802.11b/g (2.4 GHz)
  - IEEE 802.11n (2.4/5 GHz)

ADVANTAGES OF WIRELESS LAN

- Productivity, convenience, and cost advantages
  - Installation speed and simplicity.
  - Installation flexibility.
  - Reduced cost-of-ownership.
  - Mobility.
  - Scalability.

DISADVANTAGES OF WIRELESS LAN

- Cost
  - Wireless network cards cost 4 times more than wired network cards.
  - The access points are more expensive than hubs and wires.
- Signal Bleed Over
  - Access points pick up the signals of adjacent access points or overpower their signal.

BASIC HARDWARE OF A WIRELESS LAN

- Access points (AP) / Wireless Router (Network Navigation Devices)
- Network Adapter
- Directional Antenna
- Extension Points (EP)
- Wired Network

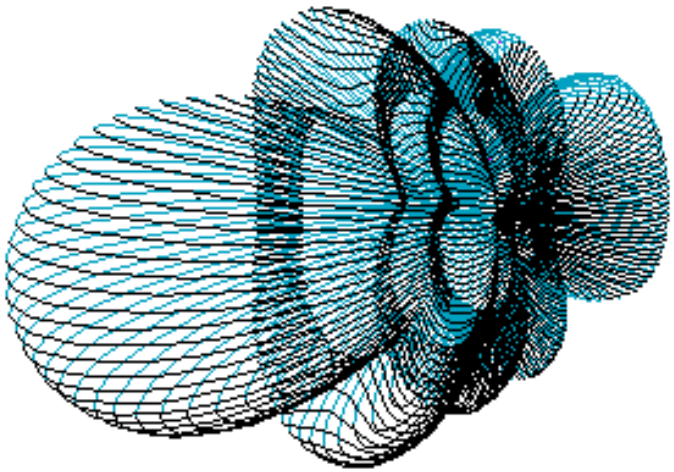
ACCESS POINT & WIFI ROUTER

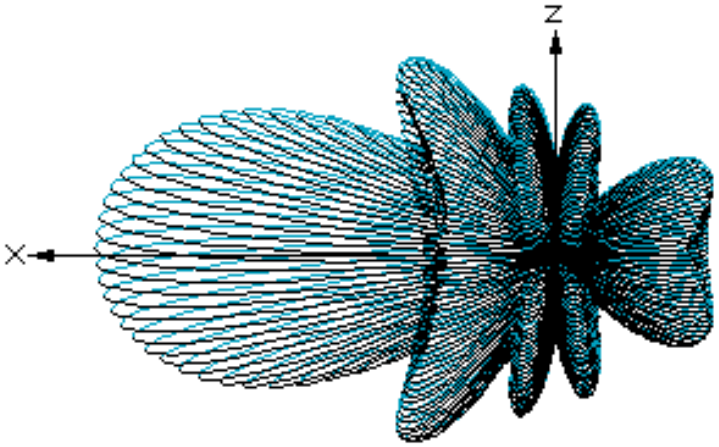
Access Point (AP) = Hub

WiFi Router = Router

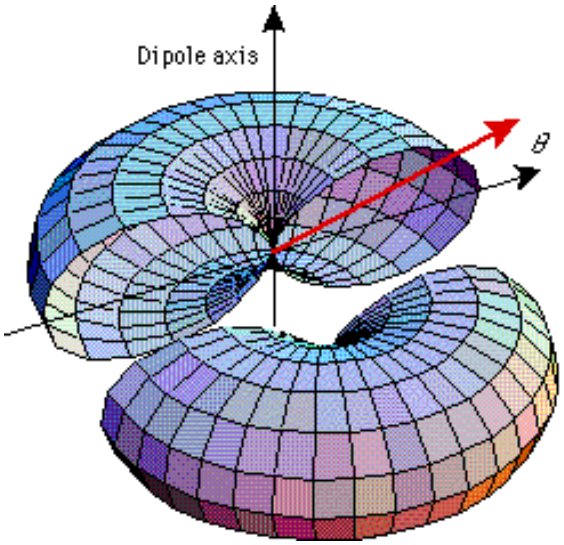
NETWORK ADAPTERS

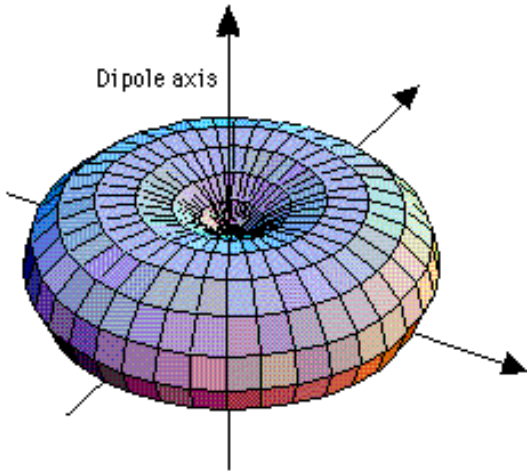
DIRECTIONAL ANTENNA

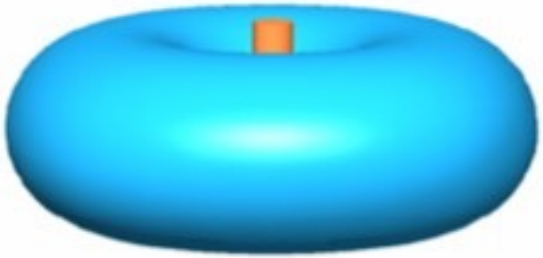




ANTENNA PATTERN

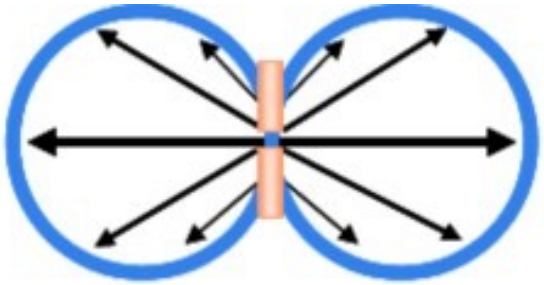






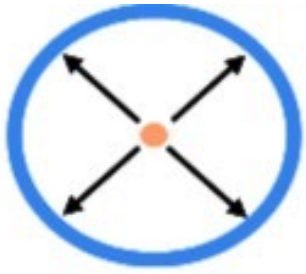
3-D Raidation Pattern

Figure 3.1a



Vertical Plane

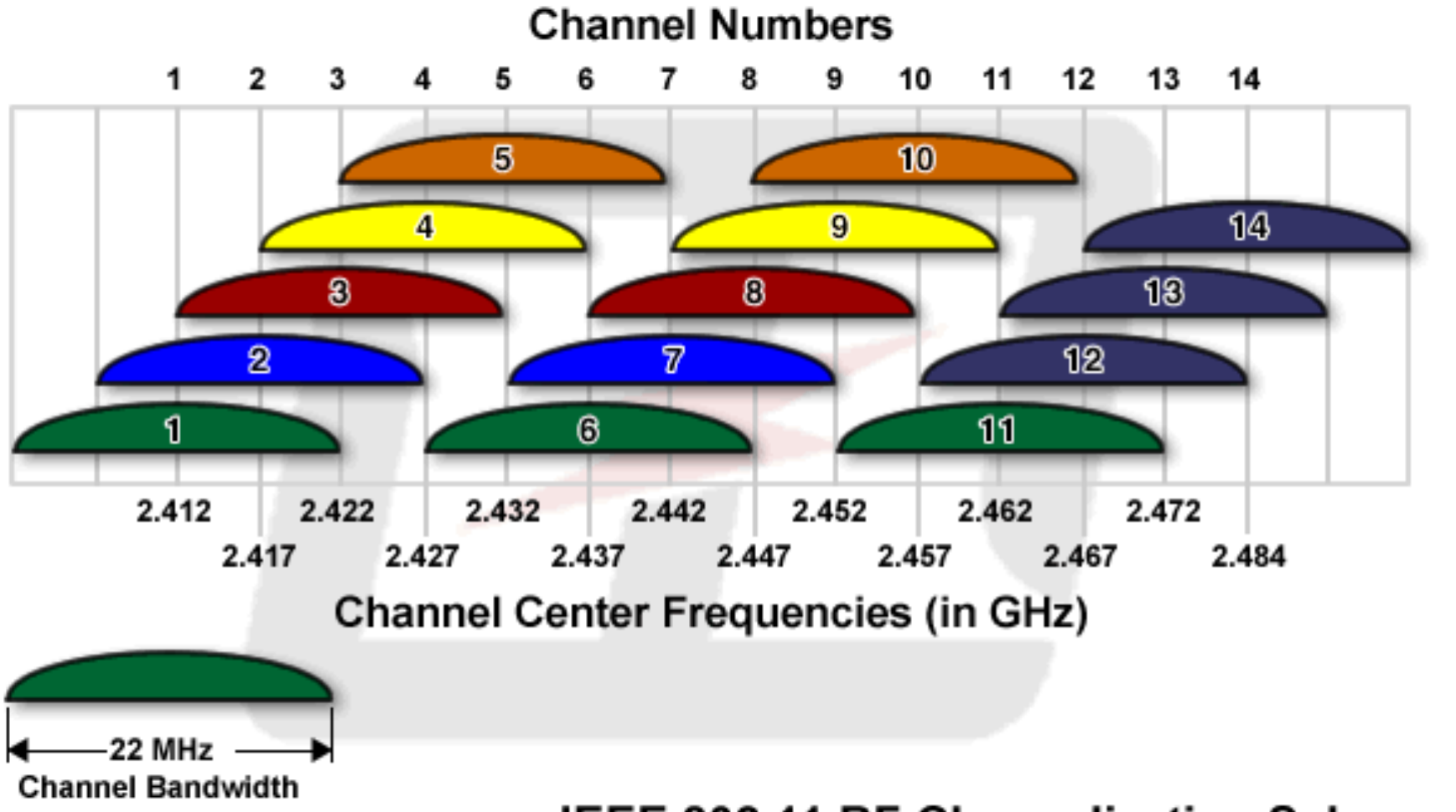
Figure 3.1b



Horizontal Plane

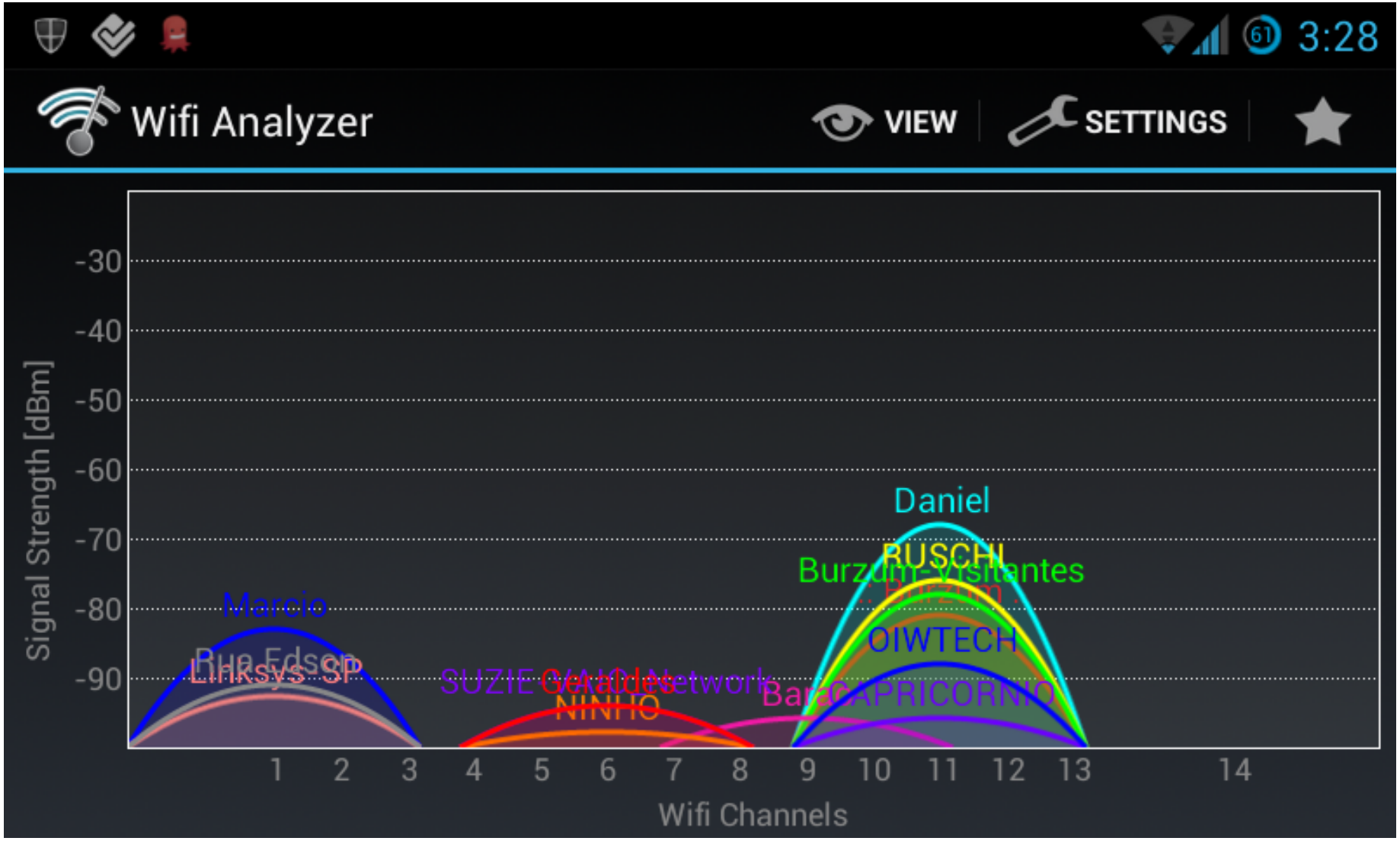
Figure 3.1c

WIFI CHANNEL (1)



IEEE 802.11 RF Channelization Scheme

WIFI CHANNEL (2)



ETHERNET HOME NETWORKS

- Uses Ethernet protocol as standard for network communication
- Current standards
  - Wired 802.3
  - Wireless 802.11
    - 802.11ax features fastest data transfer rate
  - Devices using older 802.11 standards will still work with networks but will operate with slower data transfer rates

PROTOCOL

- Formal set of rules that govern the formats, contents, and meanings of messages from computer to computer, process to process, etc.
- Must be agreed to by all parties to a communication
- May be defined in terms of other protocols

THERE ARE MANY, MANY PROTOCOLS

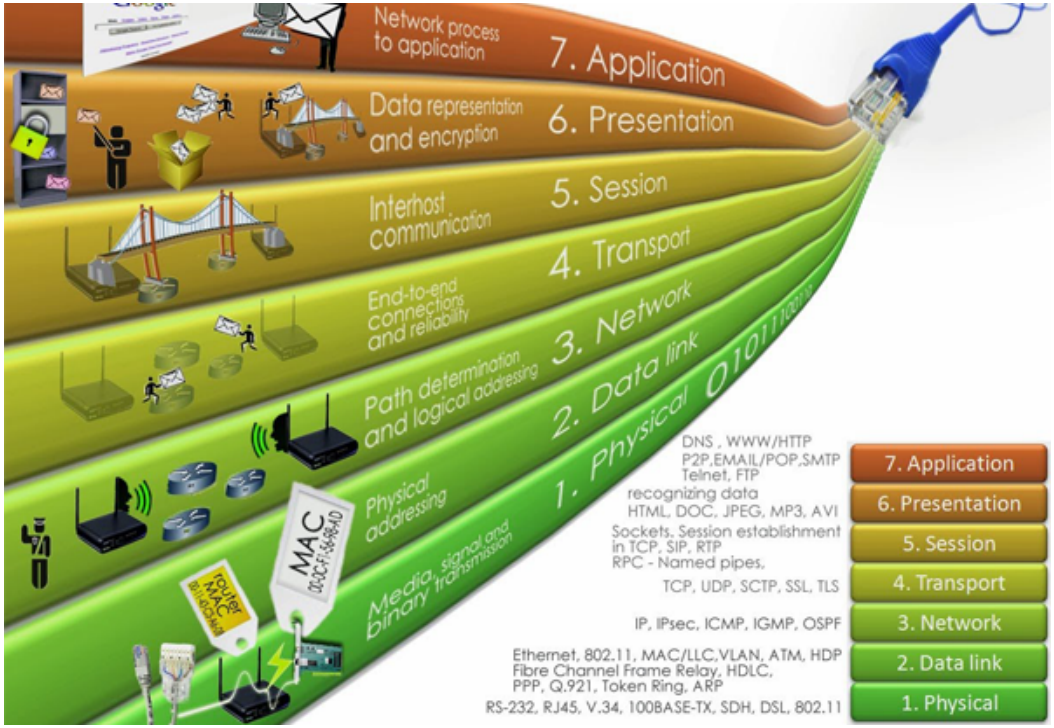
- TCP, UDP, IP, NCP, SMTP, SNNP, NNTP, FTP, TFTP, POP, IMAP, HTTP, VMRL, …
- Appletalk, Netware, …
- Remote Procedure Call, NFS, …
- CORBA, GLOBE, JINI, …
- Network Streaming, …
- Etc.

How to make sense out of all of them?

NETWORK STACK

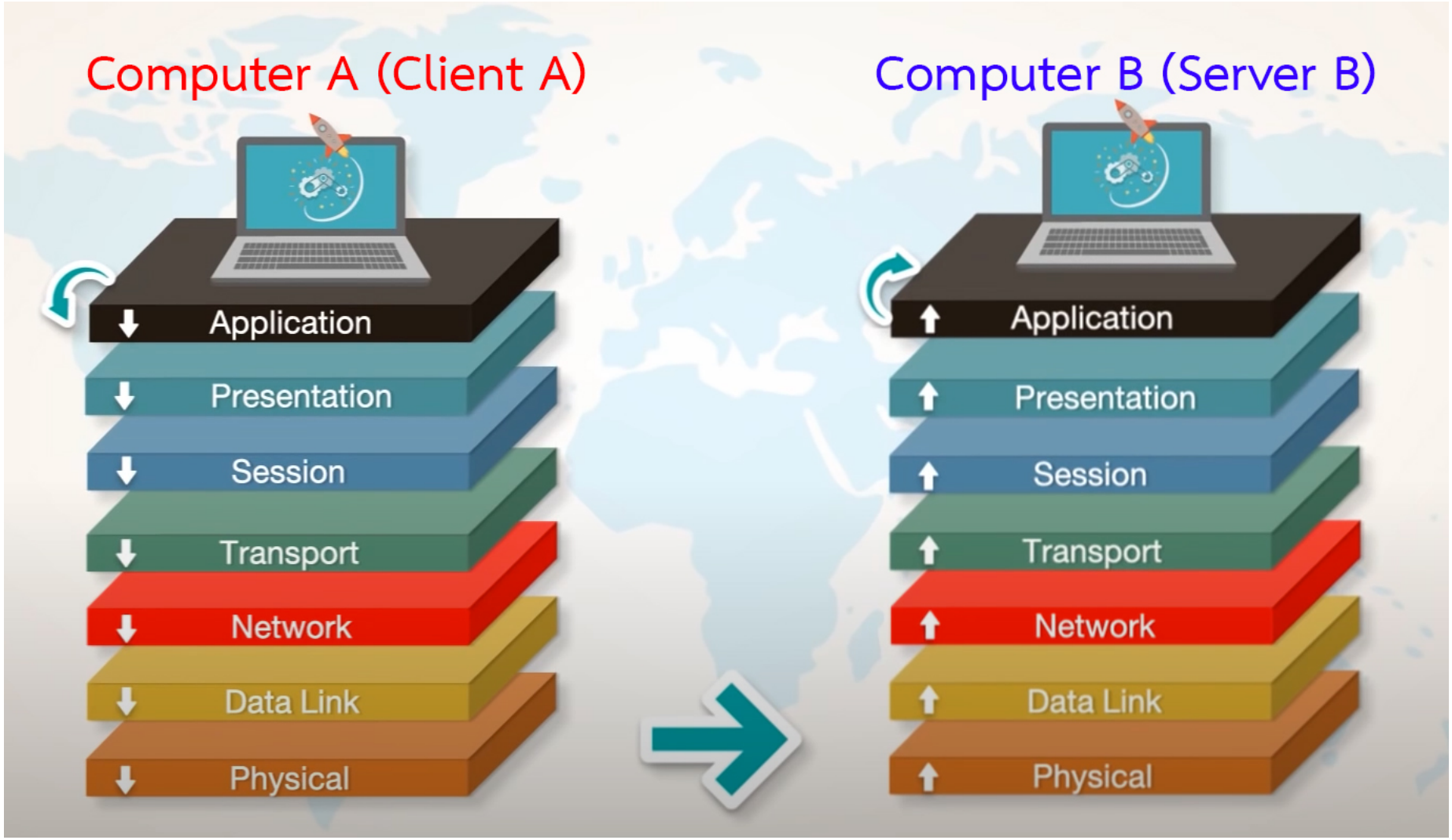
- 1983 – Open System Interconnection (OSI) 7 layer Reference Model
  - Working group of the International Standards Organization (ISO)
  - Defines seven layers
  - Describe how applications communicate with each other
  - Via network-aware devices
  - Most day-to-day protocols

OSI 7-LAYER MODEL (1)



7. APPLICATION	SERVICES LAYER
6. PRESENTATION	
5. SESSION	MIDDLEWARE LAYER
4. TRANSPORT	
3. NETWORK	OPERATING SYSTEM LAYER
2. DATA-LINK	
1. PHYSICAL	HARDWARE LAYER

OSI 7-LAYER MODEL (2)



TCP/IP

- TCP/IP (Transmission Control Protocol/Internet Protocol) is the basic communication language or protocol of the Internet.
- Many Internet users are familiar with the even higher layer application protocols that use TCP/IP to get to the Internet.
- These include the World Wide Web's Hypertext Transfer Protocol (HTTP), the File Transfer Protocol (FTP), Telnet (Telnet) which lets you logon to remote computers, and the Simple Mail Transfer Protocol (SMTP).
- These and other protocols are often packaged together with TCP/IP as a "suite."

IP ADDRESS

- Responsible for end to end transmission.
- Sends data in individual packets
- Four bytes
  - e.g. 163.1.125.98
  - Each device normally gets one (or more)
  - In theory there are about 4 billion available

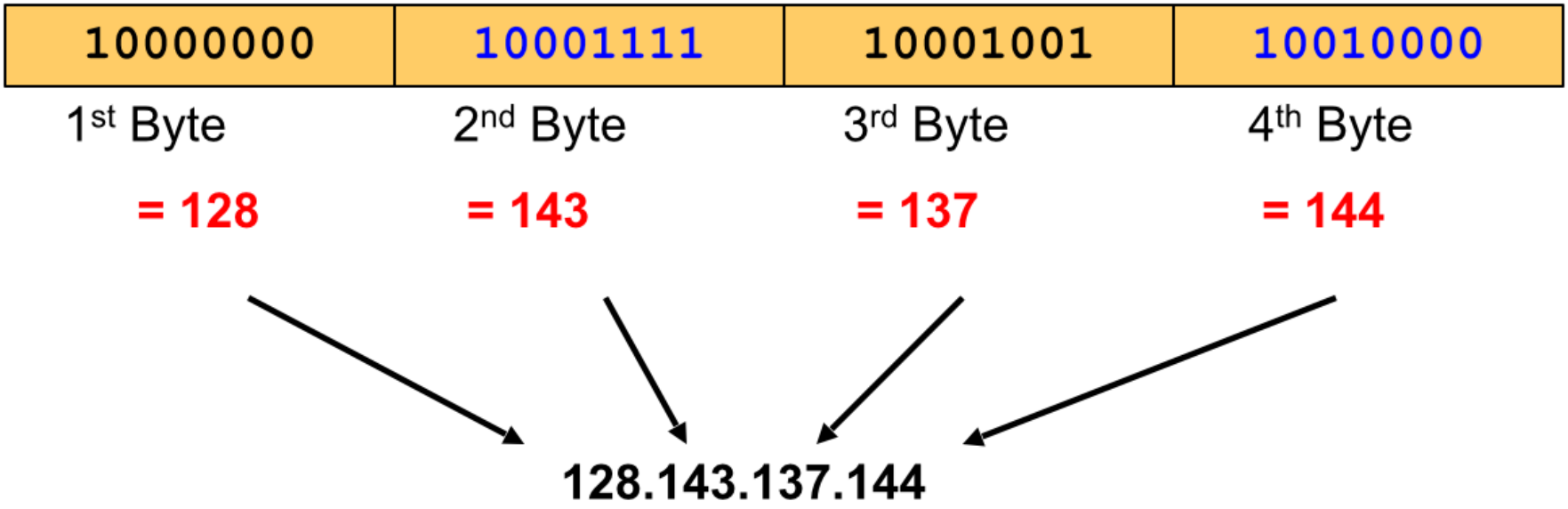
MAC ADDRESS

- A media access control address (MAC address) is a unique identifier assigned to network interfaces for communications on the physical network segment. MAC addresses are used as a network address for most IEEE 802 network technologies, including Ethernet and WiFi.

DOTTED DECIMAL NOTATION

- IP addresses are written in a so-called dotted decimal notation
- Each byte is identified by a decimal number in the range [0..255]:

- Example:



NETWORK PREFIX AND HOST NUMBER

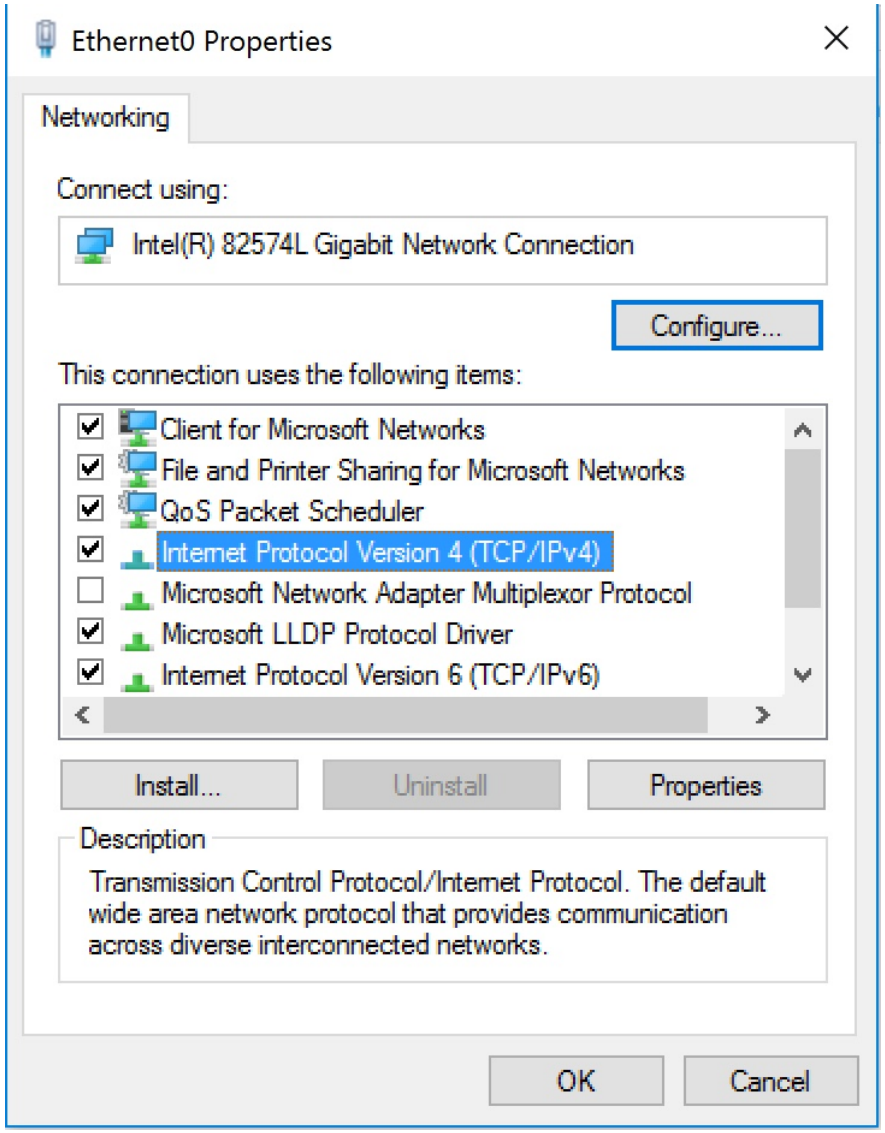
- The network prefix identifies a network and the host number identifies a specific host (actually, interface on the network).

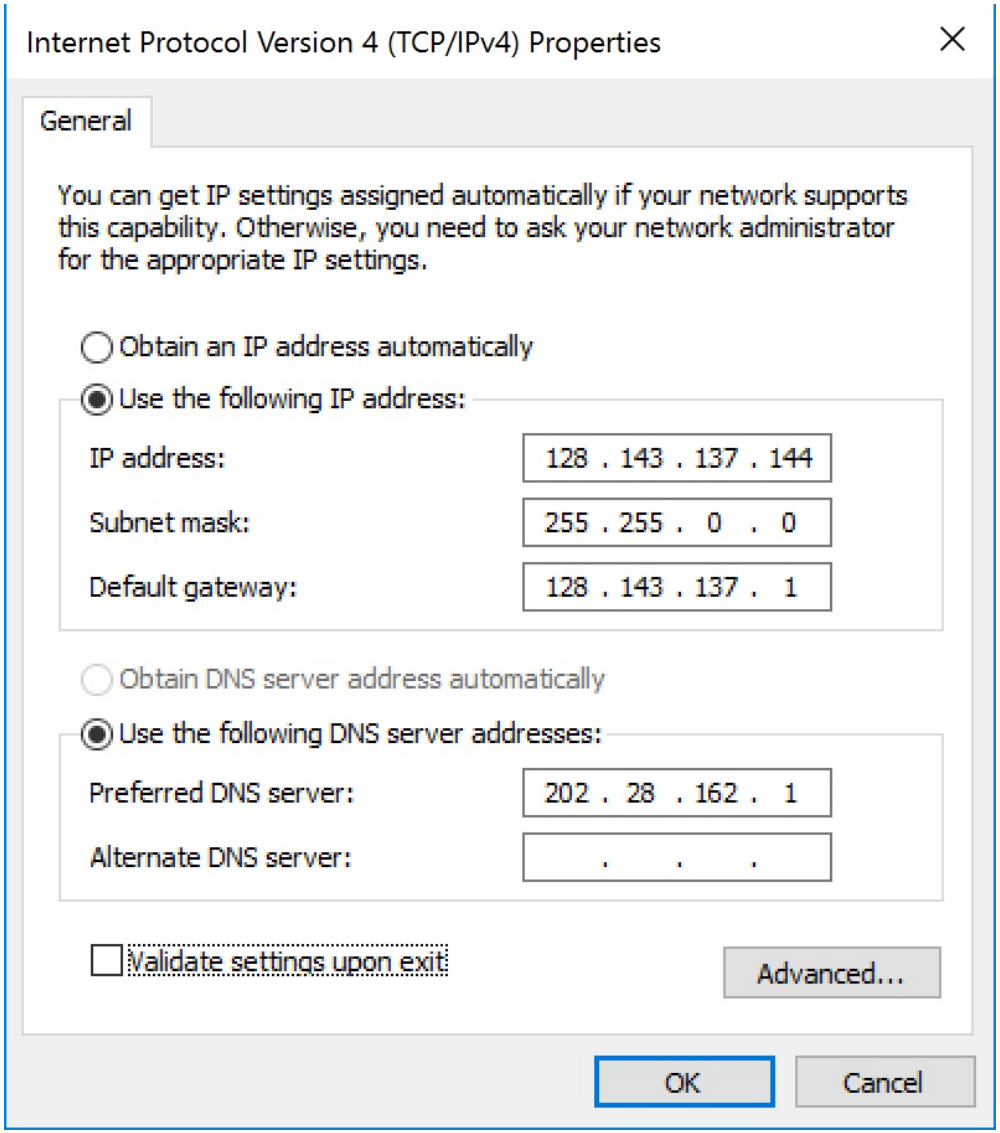
EXAMPLE (1)

- Example: IP = 128.143.137.144

- Network id is: 128.143.0.0
- Host number is: 137.144
- Network mask is: 255.255.0.0 or ffff0000
- Prefix notation: 128.143.137.144/16
- Network prefix is 16 bits long

EXAMPLE (2)


Ethernet0 Properties
Networking
Connect using:
Intel(R) 82574L Gigabit Network Connection
Configure...
This connection uses the following items:
Client for Microsoft Networks
File and Printer Sharing for Microsoft Networks
QoS Packet Scheduler
Internet Protocol Version 4 (TCP/IPv4)
Microsoft Network Adapter Multiplexor Protocol
Microsoft LLDP Protocol Driver
Internet Protocol Version 6 (TCP/IPv6)
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
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: 128 . 143 . 137 . 144
Subnet mask: 255 . 255 . 0 . 0
Default gateway: 128 . 143 . 137 . 1
Obtain DNS server address automatically
Use the following DNS server addresses:
Preferred DNS server: 202 . 28 . 162 . 1
Alternate DNS server:
Validate settings upon exit
Advanced...
OK
Cancel

CLASSFUL IP ADDRESSING

- When Internet addresses were standardized (early 1980s), the Internet address space was divided up into classes:
  - Class A: Network prefix is 8 bits long
  - Class B: Network prefix is 16 bits long
  - Class C: Network prefix is 24 bits long

Class A Subnet Mask	Netwok	Host	Host	Host
	255	0	0	0
Class B Subnet Mask	Netwok	Network	Host	Host
	255	255	0	0
Class C Subnet Mask	Netwok	Network	Network	Host
	255	255	255	0

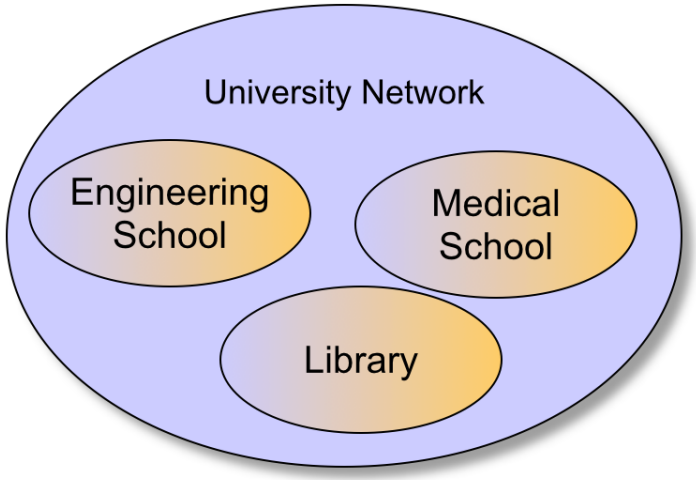
PRIVATE IP NUMBERS

- Private IP networks are "organizationally scoped" IP nets which the university uses internally but are not routed outside the institution.

Prefix	First Address	Last Address	Number of Addresses
10.0.0.0/8	10.0.0.0	10.255.255.255	16,777,216
172.16.0.0/12	172.16.0.0	172.31.255.255	1,048,576
192.168.0.0/16	192.168.0.0	192.168.255.255	65,536

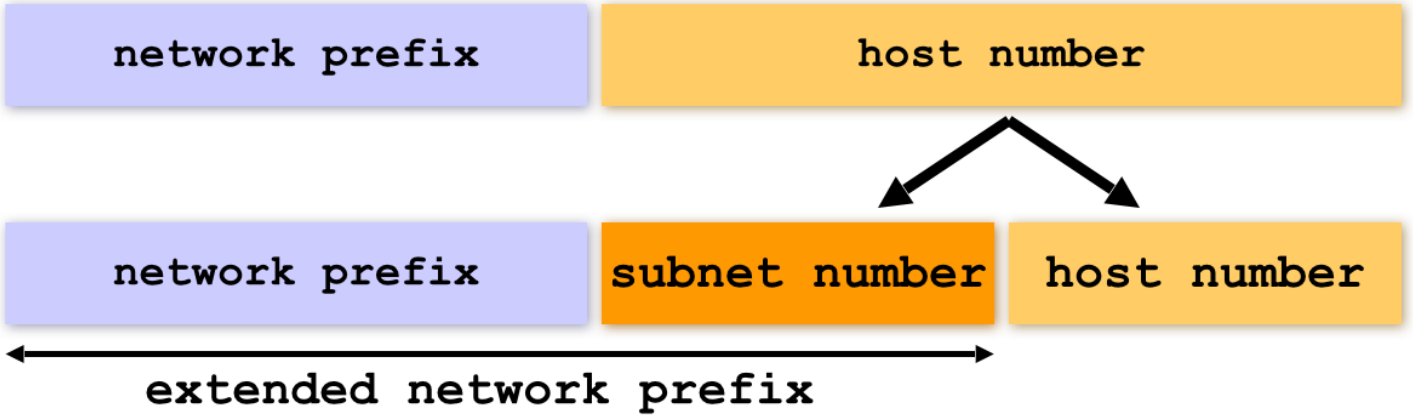
SUBNETTING

- Problem: Organizations have multiple networks which are independently managed
  - Solution 1: Allocate one or more addresses for each network
    - Difficult to manage
    - From the outside of the organization, each network must be addressable.
  - Solution 2: Add another level of hierarchy to the IP addressing structure



BASIC IDEA OF SUBNETTING

- Split the host number portion of an IP address into a subnet number and a (smaller) host number.
- Result is a 3-layer hierarchy



- Subnets can be freely assigned within the organization
- Internally, subnets are treated as separate networks
- Subnet structure is not visible outside the organization

IPV6 - IP VERSION 6

- IP Version 6
  - Is the successor to the currently used IPv4
  - Specification completed in 1994
  - Makes improvements to IPv4 (no revolutionary changes)
- One (not the only !) feature of IPv6 is a significant increase in size of the IP address to 128 bits (16 bytes)
  - IPv6 will solve – for the foreseeable future – the problems with IP addressing

IPV6 VS. IPV4: ADDRESS COMPARISON

- IPv4 has a maximum of
  - 232 ≈ 4 billion addresses
- IPv6 has a maximum of
  - 2128 = (232)4 ≈ 4 billion x 4 billion x 4 billion x 4 billion addresses

CONNECTING TO THE INTERNET

- Main reason for home network is to share an Internet connection
- Must purchase Internet access from Internet Service Providers (ISPs)
  - Specialized providers
  - Companies that provide other services
- Connection choices
  - Broadband uses high-speed data access
  - Dial-up uses conventional phone lines

BROADBAND CONNECTIONS

- Broadband is often referred to as high-speed Internet with data transmission rate of 256 Kbps or greater
  - Digital subscriber line (DSL) uses same types of wiring as standard phone lines
  - Cable uses television's cable service provider
  - Fiber-optic service uses plastic or glass cables
  - Satellite broadband used in rural and mountain areas

CONNECTING AWAY FROM HOME

- Use a WiFi hotspot
  - WiFi is standard for wireless transmissions using radio waves
  - Notebooks, smartphones, game systems, and PMPs have wireless capability built in
- Sign up for 3G or 4G access with cell phone provider
  - Many devices such as iPads and notebooks are available with 3G or 4G capabilities

ASSIGNMENT 3

- Answer the following questions:
  - How did you find the MAC address of your phone ?
  - What is the IP of the computer you are using? How did you find out?
  - What is NAT ? Do you need one and why ?