Computer Communication and Networking

Data Communications and Networking by Behrouz A. Forouzan

Network → Interconnection of two or more devices through a medium where they can share resources(hardware/software).

A network should have good performance, reliability and security.

NAP → Network Access Point

Data Communications → Exchange of data between two or more devices through a medium. Effectiveness depends on 4 things:

1. Delivery
2. Accuracy
3. Timeliness
4. Jitter

Distributed Processing → Task is divided.

Networking Organizations

Cisco → Biggest Networking Organization

- **ISO** → International Organization for Standardization
- **ITU-T** → International Telecommunication Union - Telecommunications
- **ANSI** → American National Standards Institute
- **IEEE** → Institute of Electrical and Electronics Engineers
- **EIA** → Electronic Industries Association
- **FCC** → Federal Communications Commission

Data Signals

Analog Signals → Continuous Signals
Digital Signals → Discrete Signals

Periodic Signal → Signals that complete a cycle in same amount of time period.
Non-Periodic Signal → Signals which change their shape *OR* Do not complete a cycle in fixed time period.

Sine Wave → A periodic waveform that is defined by y=sinx

- **Simple Signal** → A signal composed of a single Sine Wave.
- **Composite Signal** → A signal composed of multiple Sine Waves.
    - **Fourier Analysis** → Used to separate the composite signals.

Bandwidth → Range of Frequencies in a composite signal.

Properties of Analog Signals

Frequency → Number of cycles that can be completed in 1 sec.
Period → Time taken to complete 1 cycle. Opposite of Frequency.
Peak Amplitude → Highest/Lowest point on a wave.
Wavelength → Distance one cycle occupies.
Phase → Position of Wavelength relative to Time-0.

Properties of Digital Signals

Bit Rate → Number of bits sent in 1 sec.
Bit Length → Distance one bit occupies.
Bit Duration →

Transmission of Data

Baseband Transmission → Sending a digital signal without converting to analog first.
    Low Pass Channel → Only allows low-frequency signals to pass through.
Broadband Transmission → Sending a digital signal after converting to analog first.
    Band Pass Channel → Only allows selected frequency signals to pass through.

Decibel → Unit to measure the difference between two signals.
Amplification → Increase in Energy.
Attenuation → Loss of Energy.

Data Flow

Simplex → One-Directional Communication.
(Full) Duplex → Two-Directional Communication where they can send/receive simultaneously.
Half-Duplex → Two-Directional Communication where they can either send or receive at a time.

Components of Communication

1. **Sender**
2. **Reciever**
3. **Medium** → Path/Way to send information.
4. **Message** → Information to be communicated.
5. **Protocol** → Set of rules that govern the data communication.
    - Wired Protocol → Ethernet
    - Wireless Protocol → Wifi

Point-to-Point Communication → A dedicated link between two devices.
Point-to-Multipoint Communication → A shared link between multiple devices.

- **Spatially Shared** → If multiple devices can use the link at the same time.
- **Timely Shared** → If multiple devices have to take turns to use the link.

Area Networks

- **LAN** → Local Area Network. An area of a few kilometers.
    - **WLAN** → Wireless Local Area Network.
- **MAN** → Metropolitan Area Network. An area comprising a town/city.
- **WAN** → Wide Area Network. An area comprising of an entire country, continent or the world.

Data Representation

Data is represented in different forms.

- Text
- Number
- Picture
- Video
- Audio

Network Topology

Logical Topology → The shape of the network based on how communication flows.
Physical Topology → The physical layout or arrangement of devices in the network.

- **Bus** → Every device has a multi-point link to a Backbone cable. Can be used in LAN.
- **Ring** → Every device has a dedicated point-to-point link to the two devices on it's sides. Can be used in LAN.
- **Star** → Every device has a dedicated point-to-point link to a Central Hub. Can be used in LAN.
- **Mesh** → Every device has a dedicated point-to-point link to every other device. Can be used for LAN, MAN or WAN.
  n(n-1)/2 two-way links required for a Mesh Topology. n is the number of devices.
- **Tree** → Combination of multiple LANs in a tree structure. There is one central node and multiple branches. Can be used in MAN/WAN.
- **Hybrid** → Combination of the other Networks. Can be used in MAN/WAN.

Cloud Computing

Accessing computing services on the internet.

- Software as a Service (SaaS) → **Software**
- Platform as a Service (PaaS) → **Runtime Environment**
- Infrastructure as a Service (IaaS) → **Operating System**
    - **Test Beds** → Processor + Hardware + Storage

Internet

Combination of Networks → **inter**connected **net**work. (lowercase i)

Switch → To connect two or more devices/nodes.
Router → To connect two or more networks.

History of the Internet (uppercase i)

- **ARPA** (1967) → Advanced Research Projects Agency
- **ARPAnet** (1969) First network but it had only 4 devices(called Mini PCs).
- **IMP** → Interface Message Processor
    - A special purpose minicomputer initiated by the Department of Defense (DoD US) for their own communication.
    - **NCP** → (Network Control Protocol) provided communication.
- **NSF** → National Science Foundation
    - ARPAnet was private and NSF introduced a public internet network.

Hierarchy of the Internet

International ISP → National ISP → Regional ISP → Local ISP

Protocols

Elements of Protocols
Syntax → What order to show data in?
Semantics → How is it shown?
Timing → What to send and how fast?

IP → Internetting Protocol
TCP → Transmission Control Protocol

Addressing

- **Physical Address** → Link Address, address of the node, 48-bit for Ethernet.
- **Logical Address** → IP Address, 32-bits
- **Port Address** → Process Labels, 16 bits

IP Address (Internet Protocol)

Logical Addresses that universally and uniquely identifies each device on a network.

- **Public IP** → Used outside the network. Assigned by the ISP.
- **Private IP** → Used inside the network. Assigned by the Router.

Notation

- **Binary Notation** → 01110101 10010101 00011101 00000010
- **Dotted-Decimal Notation** → 117.149.29.2

Classful Addressing

An IPv4 addressing scheme which divides addresses into 5-groups.

Class	Blocks	Block Size	Used For	Default Subnet	Network/Host	Range
A	128	16.777M	Unicast	255.0.0.0	N.H.H.H	0-127
B	16k	65,536	Unicast	255.255.0.0	N.N.H.H	128-191
C	2.097M	256	Unicast	255.255.255.0	N.N.H.H	192-223
D	1	268.435M	Multicast	-	-	224-239
E	1	268.435M	Reserved	-	-	240-255

Subnet Mask → It is used to identify network and host part.

Address Space → Total number of addresses supported by the address scheme.

- **Size of IPv4** → 2^32 addresses
- **Size of IPv6** → 2^128 addresses

Address Depletion → Biggest problem with Classful Addressing.

Classless Addressing

Addresses are allocated as consecutive addresses. The addresses are not divided into classes.

Address Blocks → Blocks (of power of 2) of Addresses given based on the size.

- The addresses must be consecutive.
- The number of addresses be a power of 2.
- First Address must be divisible by number of Addresses.

Subnetting → Dividing larger networks into smaller networks.
Supernetting → Combining many smaller network into a larger network.

Classless Subnet Mask → Address/ 32 - log(exponent of the block size)

16.0.0.10 → 16.0.0.10/32 - log(2^4) → 16.0.0.10/28

First convert the mask and given address to Binary then:

- To find the first address, **AND** the given address with it's mask.
- To find the last address, **OR** the given address with it's mask.
- To find the number of addresses, Take the **complement** of the mask.

First Address of a Network is the Network Identifier Address.
Last Address of a Network is the Broadcasting Address.

MAC Address → 12-digit Physical Address used to identify Network Interfaces.
DNS → Domain Name System translates human readable domain names (for example, www.amazon.com) to machine readable IP addresses (for example, 192.0.2.44).

Router

Applications

1. **Internetworking** → Connecting multiple networks together.
2. **Routing** → Process of identifying route for delivering packets from source to destination.
    a. **Static Routing** → Already decided route by the network admin.
    b. **DHCP Routing**→ Dynamic Hosting Configuration Protocol, Assigning routes dynamically.
3. **NATing** → Network Address Translation. Used to translate Private IPs to Public IPs.
4. **PATing** → Port Address Translation. Used to translate Private IPs to Public IPs.

Modes of Router

These give increasing amounts of access.

- User Mode
- Privilleged Mode
- Global Config Mode
- Interface Mode
- Console Mode

Symbols in CLI (Router Configuration)

1. User Mode → router>
2. Privileged Mode → router#
3. Global Mode → router(config)#
4. Interface Mode → router(config-if)#

Open System Interconnect (OSI) Model

A layered framework for the design of network systems that allows communication between all types of computer systems. Created by the ISO.

Layers

There are 7 ordered layers.

No.	Layer	About	Example
1	*Physical*	Interface between the devices and the transmission medium.	Type of Medium
2	*Data Link*	Node-to-Node/Hop-to-Hop L2 Switch, Bridge	MAC Address
3	*Network*	Host-to-Host L3 Switch, Router, Brouter	IP Address
4	*Transport*	Process-to-Process Firewall	Port Number
5	*Session*	Maintains and Terminates logical connections.	Network Dialog Controller
6	*Presentation*	Performs compression/translation of data.	Encryptor
7	*Application*	Provides services to end-users	Services

Blue are the **Network-Support** Layers.
Green are the **User-Support** Layers.
Red connects the two.

- **Header** → Each layer appends some extra information. This information is used by the peer of that layer at the receiver. This allows **Encapsulation**.
- **Translation** → Converting data from User-dependent format to common format.
- **TCP/IP Protocols**

1. User-Support layers → HTTPS, DNS, Telnet, SMTP etc.
2. Transport layer → UDP, TCP, SCTP
3. Network layer → IP

Hardware

There are three types of Cables

1. **Coaxial**
2. **Twisted Pair**
3. **Fiber-Optic**

Cable Configurations

Straight-Through Cable
To connect different devices to each other. From ISP to Router
Have both sides be either 568-A or 568-B.

Crossover Cable
To connect same devices to each other. From My Laptop to Arif's Laptop
Have one side be 568-A and the other 568-B.

Rollover Cable (Console Cable)
To connect a router to PC. From Router to My Laptop
Have one side be 568-A or 568-B and then reverse the order on the other side.

Color Coding

Given by EIA for Twisted Pair cables.

568-A
WhiteGreen→Green→WhiteOrange→Blue→WhiteBlue→Orange→WhiteBrown→Brown

568-B
WhiteOrange→Orange→WhiteGreen→Blue→WhiteBlue→Green→WhiteBrown→Brown