

Networking

- introduction
 - network
 - connecting multiple devices together to share the information
 - group of machines/devices/IP addresses
 - devices
 - personal devices
 - smart car
 - Tesla
 - smart speaker
 - Amazon Echo: (Alexa)
 - Google: (Android assistant)
 - Apple HomePod: (Siri)
 - smart glass
 - google smart glass
 - tablets
 - Samsung/Xiomi: Android
 - Apple iPad: iPad OS
 - smart TV
 - LG: WebOS
 - Sony/Samsung: Android TV
 - smart watch
 - Apple Watch: watchOS
 - Samsung: Tizen
 - Sony/Asus/Xiomi/Moto: Android Wear
 - cell phone
 - feature phone
 - used to make/receive the phone call
 - used to send/receive SMS
 - e.g. nokia 3310, 3315 etc
 - smart phone
 - which has its own OS
 - e.g.
 - Android
 - Apple iOS
 - BlackBerry OS
 - Windows Phone OS
 - MeeMo
 - MeeGo
 - Tizen
 - Bada
 - Amazon FireOS
 - Mozilla Firefox OS
 - Ubuntu Mobile

- PalmOS
 - WebOS
 - Symbian
 - Embedded Linux
 - kitchen appliances
 - smart ovens
 - smart fridge
 - smart washing mashine
 - office equipments
 - smart printer
 - computer
- units
 - b: bit
 - B: byte
 - types
 - wired
 - medium: cable
 - cable types
 - co-axial: deprecated
 - cat cable
 - cat: category cable
 - also called as twisted pairs cable
 - transfers the data using electrical signals
 - types
 - stp: shielded twisted pairs
 - utp: unshielded twisted pairs
 - versions
 - cat1 : this was used only for telephony
 - cat2 : 1 mbps
 - cat3 : 10 mbps
 - cat4 : 16 mbps
 - cat5 : 100 mbps
 - cat5e: 125 mbps
 - cat6 : 1000 mbps ~ 1 gbps
 - cat7 : 10000 mbps ~ 10 gbps
 - cat8 : 25000 mbps ~ 25 gbps
 - fibre optics
 - transfers the data using light
 - min: 10000 mbps ~ 10 gbps
 - types
 - LAN

- Local Area Network
 - spans across a floors, building
 - e.g. office network, home network
 - MAN
 - Metropolitan Area Network
 - spans across the the cities
 - e.g. cable network
 - WAN
 - Wide Area Network
 - spans across cities, states, countries
 - internet: network of networks
 - e.g. multi-branch network
- wireless
 - medium: air (EM Waves)
- connectors
 - types
 - RJ11: telephony
 - RJ45: cat cable
 - T connector: co-axial
 - types
 - male connector
 - female connector
- topology
 - physical arrangement of computers
 - types
 - bus
 - ring
 - connected ring
 - star
 - mesh
- terminologies
 - sender
 - device which sends the data
 - is also known as a source
 - receiver
 - device which receives the data
 - is also known as a destination
- networking devices
 - hub

- physical layer (layer-1)
- a dumb device
- is used to build a LAN
- copies the data (signals) from the source port to all the other ports
- traffic increases
- collision increases
- decreases the performance / speed
- does the broadcasting every time
- switch
 - data link layer (layer-2) device
 - used to build a LAN
 - a smart device: has its own OS
 - understands the MAC address of the sender and receiver
 - manufactures
 - Cisco : IOS
 - Juniper : JunOS
 - does
 - unicasting : switch find the matching entry in the MAC address table
 - broadcasting: the MAC address table is empty
- router
 - works on network layer (layer-3 device)
 - used to build a WAN
 - used to connect multiple networks
- network interface card
 - also known as NIC
 - provides the connectivity
 - has an address burned/flash/written into the ROM (read only memory)
 - used to
 - convert the data to signals/light
 - convert the signals/light to the data
 - types
 - onboard (built-in on motherboard)
 - external
 - internal
 - external: USB
- casting
 - sending data from sender to receiver
 - types
 - broadcast: sending from one sender to all the devices in the network
 - unicast : sending from one sender to only one receiver
 - multicast: sending from one sender to multiple (not all) devices in the network

- addressing
 - MAC address
 - used on data link layer
 - burned into the ROM part of the NIC
 - used to identify every NIC uniquely
 - also known as
 - ethernet address
 - physical address
 - read-only address
 - to find the MAC address of NIC
 - windows: ipconfig /all
 - linux/macOS: ifconfig
 - e.g. 78:4f:43:90:13:d0
 - size: 6 bytes => $8 \times 6 = 48$ bits
 - significance
 - group of first 3 bytes
 - represent a manufacturer's Id
 - e.g. 78:4f:43 -> Apple
 - group of last 3 bytes
 - represent the unique number for the NIC
 - e.g. 90:13:d0 -> unique NIC address
 - IP address
 - also known as logical address
 - given by / configured on OS
 - can be changed
 - one machine may have multiple IP addresses
 - versions
 - IPv4: 32 bit
 - IPv6: 128 bit
 - types
 - private IP address
 - used within a LAN
 - public IP address
 - used only when the device needs to get connected to internet
 - to get the IP address
 - windows: ipconfig
 - linux/macOS: ifconfig
 - e.g.
 - decimal: 192.168.2.101
 - binary : 11000000.10101000.00000010.01100101
 - size: 4 bytes = $4 \times 8 = 32$ bits
 - minimum: 00000000.00000000.00000000.00000000
 - maximum: 11111111.11111111.11111111.11111111
 - address space: $2^{32} = 4.2b$

- assignment
 - manual: static ip address
 - dynamic: use DHCP
- classes
 - class A
 - 0.0.0.0 to 127.255.255.255
 - private range: 10.0.0.0 to 10.255.255.255
 - network mask: 255.0.0.0 [11111111.00000000.00000000.00000000]
 - #networks: [$2^{(8-1)}$]: 0 is already reserved] $2^7 = 128$
 - #hosts : $2^{24} = 16m$
 - reserved
 - 0.0.0.0 : invalid ip address
 - 127.x.x.x : reserved for loopback address
 - 127.0.0.1 :
 - loopback address of localhost (same machine)
 - used to refer the same machine
 - ping localhost
 - command can be used to check the network settings of localhost
 - first address: reserved as network address
 - last address : reserved as broadcast address
 - class B
 - 128.0.0.0 to 191.255.255.255
 - private range: 172.16.0.0 to 172.31.255.255
 - network mask: 255.255.0.0 [11111111.11111111.00000000.00000000]
 - #networks: [$2^{(16-2)}$]: 10 is already reserved] $2^{14} = 16384$
 - #hosts : $2^{16} = 65536$
 - reserved:
 - first address: reserved as network address
 - last address : reserved as broadcast address
 - class C
 - 192.0.0.0 to 223.255.255.255
 - private range: 192.168.x.x
 - network mask: 255.255.255.0 [11111111.11111111.11111111.00000000]
 - #networks: [$2^{(24-3)}$]: 110 is already reserved] $2^{21} = 2m$
 - #hosts : $2^8 = 256$
 - reserved
 - first address: reserved as network address
 - last address : reserved as broadcast address
 - class D
 - 224.0.0.0 to 239.255.255.255
 - reserved for multicasting
 - class E
 - 240.0.0.0 to 255.255.255.255
 - reserved for R&D

- IP addressing

- process of selecting the IP address range for a network
- types

- classfull

- selecting the entire class

- e.g.

machine 1: 192.168.10.10 / 255.255.255.0 -> 192.168.10.0 machine 2:
192.168.10.200 / 255.255.255.0 -> 192.168.10.0

- classless

- also known as variable length subnet mask (VLSM)

- uses subnetting

- e.g.

machine 1: 192.168.10.10 / 255.255.255.128 ->
192.168.10.0 10 -> 00001010 128 -> 10000000

0 -> 00000000

machine 2: 192.168.10.200 / 255.255.255.128 ->
192.168.10.128 200 -> 11001000 128 -> 10000000

128 -> 10000000

- uses CIDR

- Classless Inter Domain Routing

- notion to write the subnet mask

- #ones

- 11111111.11111111.11111000.00000000 -> 255.255.248.0 -> /21

- 11111111.11111111.11111100.00000000 -> 255.255.252.0 -> /22

- 11111111.11111111.11111110.00000000 -> 255.255.254.0 -> /23

- /20 -> 11111111.11111111.11110000.00000000 -> 255.255.240.0

- possible numbers in network/subnet mask

- 00000000: 0
 - 10000000: 128
 - 11000000: 192
 - 11100000: 224
 - 11110000: 240
 - 11111000: 248
 - 11111100: 252
 - 11111110: 254
 - 11111111: 255

- network address
 - also known as network id
 - used to identify a network uniquely
- port number
 - number which identifies a program (process) uniquely
 - types
 - reserved ports: 1-1024
 - ephemeral: > 1024 and < 65536
- protocol
 - set of instructions
- OSI model
 - application
 - top most layer in OSI
 - provides application to connect the other machines
 - e.g.
 - browser: chrome, firefox, safari, IE
 - mail client: Apple Mail, Mozilla thunderbird
 - ftp clients: FileZilla
 - protocols
 - http (80) : hypertext transfer protocol
 - https (443) : secure hypertext transfer protocol
 - ftp (20/21) : file transfer protocol
 - smtp (25) : simple mail transfer protocol
 - pop3 : post office protocol
 - ssh (22) : secure shell
 - telnet (23) :
 - presentation
 - translation (encoding and decoding): ASCII to EBCDIC [Extended Binary Coded Decimal Interchange Code] and EBCDIC to ASCII
 - encryption (on sender side) and decryption (on receiver side): RSA, SHA
 - compression (on sender side) and decompression (on receiver side)
 - data presentation
 - represents the data in common file format
 - images: image/png, image/jpg, image/jpeg
 - audio: audio/mp3, audio/wav
 - video: video/mp4, video/flv
 - text: text/plain, text/html, text/xml
 - application: application/json
 - session

- used for session management
- establishing/breaking/restarting session
- protocols
 - sip: session initiation protocol
 - NetBIOS: Network Basic Input Output Service
 - RPC: Remote Procedure Call
- transport
 - core part / heart of OSI
 - responsible for end-to-end delivery
 - segment
 - data (part or chunk of session layer PDU)
 - sequence number: used to re-order the segments on the receiver side
 - checksum: used to check if the segment is damaged
 - responsible for
 - segmentation: process of dividing the session layer PDU into smaller segments
 - flow control: manage the speed of communication
 - error checking: used to check if the segment is damaged
 - protocols
 - TCP
 - transmission control protocol
 - connection oriented protocol (connection will be kept live till the data transmission is under progress)
 - provides error checking, flow control
 - slower than UDP
 - e.g. ssh, http, https
 - UDP
 - user datagram protocol
 - connectionless protocol
 - does not provide error checking, flow control
 - faster than TCP
 - e.g. online games, video/audio streaming
- network
 - packet
 - data (part or chunk of segment)
 - source IP address
 - destination IP address
 - responsible for
 - packeting: process of splitting the segment into smaller packets
 - routing: sending the data across the networks
 - protocols
 - IP: internet protocol
 - IPx: Internetwork Packet Exchange
 - ICMP: Internet Control Messaging Protocol
 - NAT: Network Address Protocol

- ARP: Address Resolution Protocol (get MAC address from IP address)
 - devices: router
- data link
 - frame
 - data (part or chunk of packet)
 - source MAC address
 - destination MAC address
 - divided into
 - logical link control (LLC)
 - responsible for creating frames from packet
 - error control
 - flow control
 - media access control (MAC)
 - identifies every NIC uniquely by using MAC address
 - devices: switch (H/W) and bridge (S/W)
- physical
 - translating the data into signals/light
 - devices: hub, cables, connectors, ports etc
 - standards: IrDA, ITU, DSL
- TCP/IP model
- IP header
 - version
 - contains the internet protocol version
 - IPv4 or IPv6
 - IHL
 - internet header length
 - header length (does not include the length of data field)
 - TOS
 - type of service
 - contains the description of type of service
 - e.g.
 - minize delay
 - normal service
 - total length
 - total length of the packet = length(header) + length(data)
 - maximum size: $2^{16} = 65536$
 - identification
 - used to check if the fragmentation is enabled
 - flags
 - also known as control flags
 - e.g.
 - 0: reserved

- DF
 - do not fragment
 - e.g. 0: allow fragmentation, 1: do not allow fragmentation
- MF
 - more fragment
 - e.g.
 - 0: this is the last fragment of the packet
 - 1: there are more fragments to come
- fragment offset
 - offset of every fragment (like sequence number / counter)
- time to live
 - used to expire the packet after certain time
- protocol
 - used to identify the protocol
 - e.g.
 - 0 : reserved
 - 1 : Internet Control Message Protocol (ICMP)
 - 2 : Internet Group Management Protocol (IGMP)
 - 4 : IP
 - 6 : Transmission Control Protocol (TCP)
 - 17: User Datagram Protocol (UDP)
- checksum
 - used to check if the received packet is damaged/corrupted or intact
- source ip address
 - ip address of sender
- destination ip address
 - ip address of receiver
- options
 - used for adding some additional options (if required)
- type of questions
 - find invalid ip address
 - 192.58.67.46
 - 340.45.26.67 : invalid (min value: 0 and max value: 255)
 - 172.5.7.7
 - what is the class of a given IP address
 - 172.15.6.8 : class B
 - 10.34.67.89: class A
 - 192.168.3.7: class C
 - what is the type of IP address
 - 172.15.6.8 : public address
 - 10.34.67.89: private address
 - 192.168.3.7: private address

- what is the network id of an ip address
 - 5.4.3.2
 - class : A
 - ip address : 5.4.3.2 -> 00000101.00000100.00000011.00000010
 - network mask : 255.0.0.0 -> 11111111.00000000.00000000.00000000

 - network address : 5.0.0.0 -> 00000101.00000000.00000000.00000000
 - 192.168.74.10
 - class : C
 - ip address : 192.168.74.10
 - network mask : 255.255.255.0
 - network id : 192.168.74.0
 - 172.16.78.199 : 172.16.0.0
- which class/IP address can be used for a network with ___ hosts
 - 100 : class C
 - 512 : class B
 - 60000 : class B
 - 100000 : class A
- ___ subnet mask can be used to get 300 devices
 - $2^9 = 512$
 - #zeros = 9
 - #ones = $32 - 9 = 23$
 - 11111111.11111111.11111110.00000000
 - 255.255.254.0
- ___ subnet mask can be use to get 600 devices
 - $2^8 = 256 < 600$
 - $2^9 = 512 < 600$
 - $2^{10} = 1024 > 600$
 - #zeros = 10
 - #ones = 22
 - 11111111.11111111.11111100.00000000
 - 255.255.252.0
- ___ subnet mask can be use to get 2000 devices
 - $2^8 = 256 < 2000$
 - $2^9 = 512 < 2000$
 - $2^{10} = 1024 > 2000$
 - $2^{11} = 2048 > 2000$
 - #zeros = 11

- #ones = 20
- 11111111.11111111.11111000.00000000
- 255.255.248.0
- /18 means __
 - 11111111.11111111.11000000.00000000 -> 255.255.192.0