Veri Haberleşmesi ve Bilgisayar Ağları
"IP Adresleme"

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Computer Networking

An interconnection of computers and other devices including:

- Client computers (Uç Bilgisayar): Client computers are user computers that receive services from server computers on a network. Access permissions for client computers are determined by the server.

- A server computer is a computer that provides services, resources, or data to other computers (called clients) over a network. A server computer waits for requests and responds to them.

- Host Computer (Ana Bilgisayar): A host is a computer or other computer-controlled device connected to a network. A host can function as a server, providing information resources, services, and applications to users or other hosts on the network.

- Servers (computers): Servers that store and retain information may have a specific purpose.

- Network Devices:
  - ✓ NIC
  - ✓ Hub (LAN) has a single communication medium
  - ✓ Switch has switched multiple communication environments
  - ✓ Router – Gateway: (WAN)
  - ✓ A router is a network device that connects different networks and directs data packets between them. A router decides where data should go next so it reaches the correct destination.
  - ✓ What does a router do? A router connects local network to the Internet, chooses the best path for data, assigns local IP addresses (via DHCP), protects the network using firewall & NAT.
  - ✓ Firewall: Security hardware and software equipment.
  - ✓ Modem

TCP/IP

- TCP/IP: Transmission Control Protocol / Internet Protocol
- TCP enables data transfer using packet switching.
- IP is the network layer.
  - IP provides data packets delivery services (host-to-host).
  - IP translates between different data link protocols.
- IP ensures the connectionless, unreliable delivery of data packets.
  - Connectless: each data packet is independent of the others.
  - Unreliable: There is no guarantee that data packets will be delivered correctly or even at all.

Ethernet Media Types

- **1. Twisted Pair Copper Cable (most common)**
  - Examples: **Cat5e, Cat6, Cat6a; UTP, STP**
  - Medium: **copper wire**
  - Signal: **electrical**
  - Distance: up to **100 meters**
  - Used in homes, offices, labs
- **2. Fiber Optic Cable**
  - Medium: **glass or plastic fiber**
  - Signal: **light**
  - Distance: **kilometers**
  - Very high speed, immune to interference
  - Used in data centers, ISPs
- **3. Coaxial Cable (historical)**
  - Used in **early Ethernet**
  - Rare today
- 4. Wireless Access

Wireless Media Used in Ethernet-like Networks

Medium: Air
Signal type: Electromagnetic radio waves
Range: 10–100 meters
Speed: Up to several Gbps

1️⃣ Radio Waves (Primary Wireless Ethernet Medium)

Wi-Fi transmits data using **radio frequency (RF) waves** through the air.

Common Wi-Fi Standards

IEEE Standard	Common Name	Frequency Band
802.11b	Wi-Fi	2.4 GHz
802.11g	Wi-Fi	2.4 GHz
802.11n	Wi-Fi 4	2.4 / 5 GHz
802.11ac	Wi-Fi 5	5 GHz
802.11ax	Wi-Fi 6 / 6E	2.4 / 5 / 6 GHz

Important properties of an Ethernet medium

- Bandwidth (speed)

- Maximum distance

- Noise resistance

- Cost

Ethernet Protocol – CSMA/CD

- An Ethernet medium is the physical path (copper or fiber) that Ethernet signals use to travel between network devices.

- Data Link Layer protocol

- Ethernet (IEEE 802.3) is widely used.

- Supported by a variety of physical layer implementations.

- Multi-access (shared medium).

CSMA/CD: *Carrier Sense Multiple Access with Collision Detection*

- *In only an internet environment, each (Client or computer) device has an equal right to send own packets. Therefore, collisions occur when packets are sent simultaneously. Because each computer is unaware of other's status.*

- *Carrier Sense* : can tell when another host is transmitting: If there is a data packet present in the environment, all devices will sense it.

- *Multiple Access* : Each computer has right access

- *Collision Detection* : can tell when another host transmits at the same time. Every computer sense collision.

An Ethernet Packet Frame

Preamble	Destination Address	Source Address	Len	DATA	CRC
8 bytes	6	6	2	0-1500	4

- If the package is very large, it is divided into smaller parts and sent separately. The packages arrive at their destinations at different times, so each package is numbered to ensure they are neatly arranged.

- The preamble is a sequence of alternating 1s and 0s (How can be understanded when data packet start) used for synchronization. Every computer sense this is packet.

- CRC is Cyclic Redundancy Check. A message is sent to check whether the bits are even or odd.

MAC Adresi

- MAC (Media Access Control): It is the hardware address of the computer's Network Interface Card (NIC). Every wired or wireless network card that can be assigned an IP address has a 48-bit MAC address. Each MAC address is unique.

  Örn: 00-23-C3-45-00-B3

  - The broadcast address is all 1's.
  - Addresses are assigned to vendors by a central authority.

- Frames used in network communication actually transmit using these MAC addresses.

- IP addresses are at OSI Layer 3, MAC addresses are at OSI Layer 2.

- Each interface looks at each frame and examines the destination address. If the address does not match the interface's hardware address (or broadcast address), the frame is discarded.

IP Addressing

- Every computer connected to the Internet is assigned an IP address by its Internet Service Provider, and other computers on the Internet reach this computer using this address.

- Even if two different devices with IP addresses (Different LAN) are not on the same network, they can communicate with each other via routers (routers or gateways).

- IP addresses are currently 32 bits for IPv4, which is widely used, and are represented by four 8-bit numbers separated by dots. For example: 192.168.10.5

- Both Network ID and Host ID are used for routing.

- A single network interface is assigned a single IP address, also called a host address.

- A host can have multiple interfaces (clients) and therefore multiple host addresses.

- All hosts sharing a network have the same IP network address (network ID).

- An IP address that has the same host or router ID is called a network address and represents the entire network.

IP Address Configuration

- To communicate with other computers on your network, you need to configure your IP address correctly:

  - IP Address (of your computer)

  - Subnet Mask (of your computer)

  - DNS Server information (ISP)

- To communicate with computers outside your network, you need to configure your IP address correctly with Default Gateway IP Address

Dynamic IP and static IP addressing

- What does DHCP mean?
- DHCP stands for Dynamic Host Configuration Protocol. DHCP automatically assigns an IP address to a specific workstation client.
- Specify the difference between dynamic and static IP addressing?
- In dynamic IP addresses, the IP address is provided by the DHCP server, while in static IP addresses, it is assigned manually.
- You can also use static IP addresses for machines like printers, servers, routers, and scanners.

Default Gateway IP Addressing

- Default Gateways IP addressing enables communication between different LAN networks.

- Typically, the IP address of a router device is designated as the gateway for accessing the Internet from a LAN.

IP v4 - IPv&6

IP: Internet Protocol

- IP, the Internet Protocol standard, is a unique protocol used by end devices on a network to recognize each other, communicate with each other, and exchange data.

- Every device with an internet connection must have an IP address.

- An IP address ensures that information is sent to the correct address, or data is received from the correct address.

- There are currently two types of Internet Protocol in use and being tested: IPv4 and IPv6.

IPv4 Protocol

- IPv4 is the standard Internet protocol currently in use and consists of 32 bits, or 4 bytes. Each group ranges from 0 to 255 in the decimal number system.

- An address in the IPv4 protocol can be any number between 1.0.0.0 and 255.255.255.255. More than 4 billion addresses can be generated using this protocol. An example IPv4 address: Dotted decimal notation, 4 bytes = 32 bits

Example: 123.45.67.89 Convert the IPv4 address to binary.

- 01111011.00101101.01000011.01011001

Example: Convert the IPv4 address given below to dotted decimal.

- 01011110.01100010.10011011.00010000

- 94.98.155.16

10010001	00001010	00100010	00000011
145	10	34	3

145.10.34.3
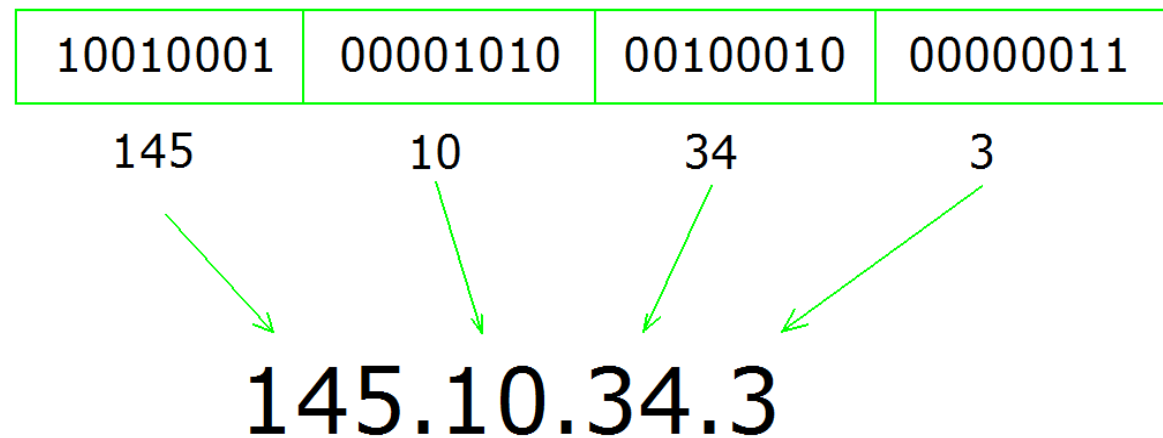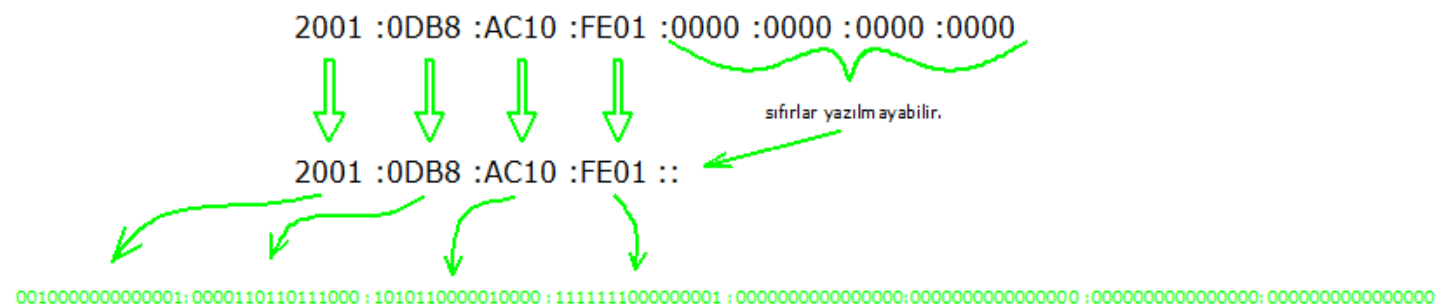
Bir IPv4 adresi (noktalı decimal)

172 . 16 . 254 . 1

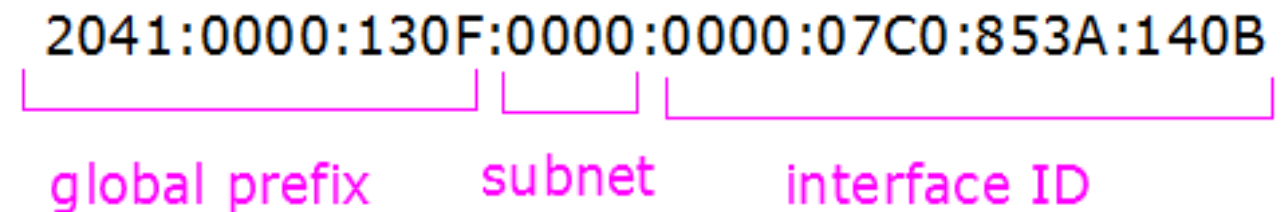10101100 . 00010000 . 11111110 . 000000001

IPv6

- Due to the increasing number of network users, a larger IP address is needed.
- IPv6 was born from this need.
- Unlike IPv4, IPv6 is 128 bits wide,
- which means 2^{128} unique addresses, or in other words, 3×10^{38} unique addresses.
- It consists of 8 four-digit hexadecimal numbers. (::) is used to shorten the address where there are 0s.
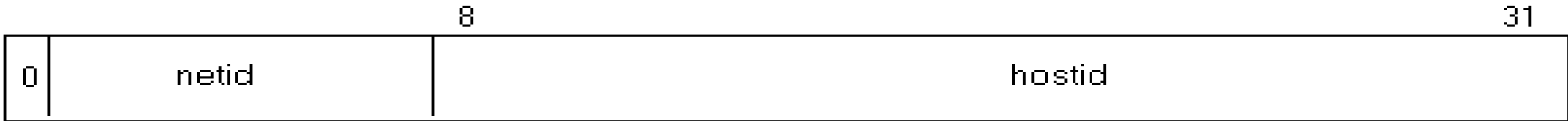
Örnek bir IPv6 adresi   (hexadecimal)

2001 :0DB8 :AC10 :FE01 :0000 :0000 :0000 :0000

sıfırlar yazılmayabilir.

2001 :0DB8 :AC10 :FE01 ::

0010000000000001: 0000110110111000 : 1010110000010000 : 1111111000000001 : 0000000000000000: 0000000000000000 :0000000000000000: 0000000000000000

IPv6 adresleme biçimi

2041:0000:130F:0000:0000:07C0:853A:140B

global prefix   subnet   interface ID

IP Addressing

IP Address Format

Five forms of IP Addresses

	8		31

0	netid	hostid

Class A

1	0	netid	hostid

Class B

1	1	0	netid	hostid

Class C

1	1	1	0	multicast address

Class D

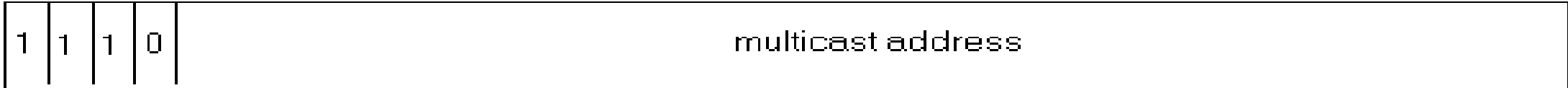| 1	1	1	1	0	reserved for future use
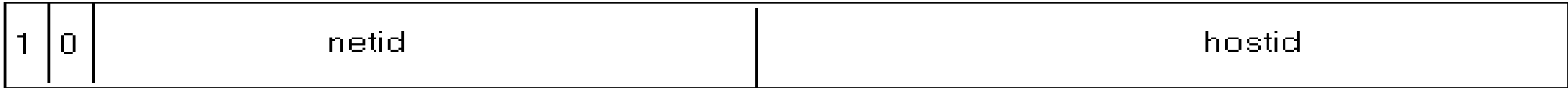
Class E

IP Address Classes

- IP addresses consist of two parts: network number (Net ID) and computer number (Host ID).

- Network IDs are unique. Host IDs, on the other hand, each range of address from 0 to 255.

- The "Net ID" specifies the network the computer is on, while the "Host ID" contains values that distinguish computers from each other within the network.

Converting IPv4 addresses to binary

- Convert the IPv4 address 142.45.67.89 to binary. Each decimal value is written as the sum of 2'n's.

- Note: Indexing is done in 8-bit format; 1 is written for those that are present, and 0 for those that are not. For example, $(142)d=128+8+4+2=2^7+2^3+2^2+2^1$

- Index: 7 6 5 4 3 2 1 0 if $(142)d=(1000\ 1110)b$

IP Addressing Classes

Class A - 0nnnnnnn.hhhhhhhh.hhhhhhhh.hhhhhhhh
Initial byte = 0-127 (7 bits)
1.0.0.0 – 127.255.255.255

Class B - 10nnnnnn.nnnnnnnn.hhhhhhhh.hhhhhhhh
Initial byte = 128-191 (14 bits)
128.0.0.0 – 191.255.255.255

Class C - 110nnnnn.nnnnnnnn.nnnnnnnn.hhhhhhhh
Initial byte = 192-223 (21 bits)
192.0.0.0 – 223.255.255.255

n = network ID, h = host ID
Host: client or computers

- IPv4: Network & Host portion
  - A:1-126   N.H.H.H
  - B:128-191   N.N.H.H
  - C:192-223   N.N.N.H
  - D:224-239
  - E:240-255

IPV4 Find the class of the following addresses

158.223.1.108

227.13.14.88

- 158.223.1.108

1st byte = 158 (128<158<191) class B

- 227.13.14.88

1st byte = 227 (224<227<239) class D

Given the network address 132.21.0.0, find the class, the block, and the range of the addresses

The 1st byte is between 128 and 191.
Hence, Class B
The block has a netid of 132.21.
The addresses range from
132.21.0.0 to 132.21.255.255.
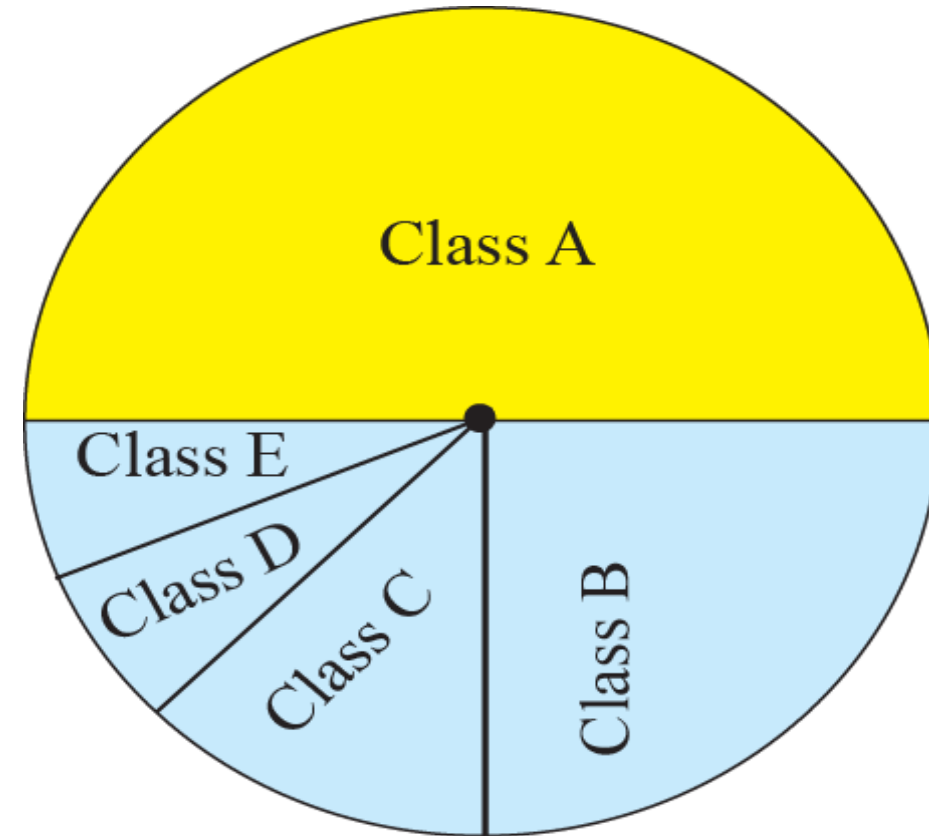NetID: 132.21, Host ID: 0.0 − 255.255

What is range: NetID is uniqe
HostID: 0.0 to 255.255

Example

- IP address is: 194.68.90.56

- What is the class? Class C

- (194)d= (1100 0000)

- Net ID: 194.68.90

- HostID: 56

- What is the range? NetID is uniqe, HostID: 0 to 255

IP address format

- İlk dört bit (x:0/1)
- 0 xxxx : A (%50)
- 10 xxxx : B (%25)
- 110 xxxx : C (%12.5)
- 1110 xxxx : D (%6.125)
- 11110 xxxx : E (%6.125)

Not: LAN'a bağlanan bilgisayarlar HOST. LAN'a ait Gateway IP adresi NetID dir.

Router IP Addressing

- Generally used in LAN-WAN and LAN-LAN connections. It has separate ports for LAN and WAN. It collects and routes data packets.

- The router or gateway connects to another WAN or LAN via a modem. Two connections are important here: the connection port to the communication medium (fiber, satellite, 2 or 4 wires). Ethernet port.

- A router is a network device that connects two or more network segments. Routers are used to transfer information (data packets) from source to destination.

- Routers send information in the form of data packets, and when these data packets are transmitted from one router to another, the router reads the network address in the packets and identifies the destination network.

- Modems are used in communication media between LAN and WAN

- Multiple LAN switches can be connected to a single router.

Router IP addressing

- IP addresses are defined as X.Y.Z.T.
- First, the IP addresses of the routers or mainframes are defined.
- The IP address must be defined in the format N.N.N.H. Broadband router: 192.168.1.1
- Wireless router IP address: 192.168.1.2; what IP range is assigned to wired client computers?
- 192.168.1.3/255. In this case, data packets coming from the wireless router and wired client computers access the internet through the broadband router.
- The wireless router uses wireless switching. Wireless client computers connect to the internet first through the wireless router and then through the broadband router.

Internet

X=3 ... 255

Wired Clients
192.168.1.x

Switch

Broadband Router
192.168.1.1

192.168.1.2

Wireless Router
192.168.2.1

Wireless Clients
192.168.2.x
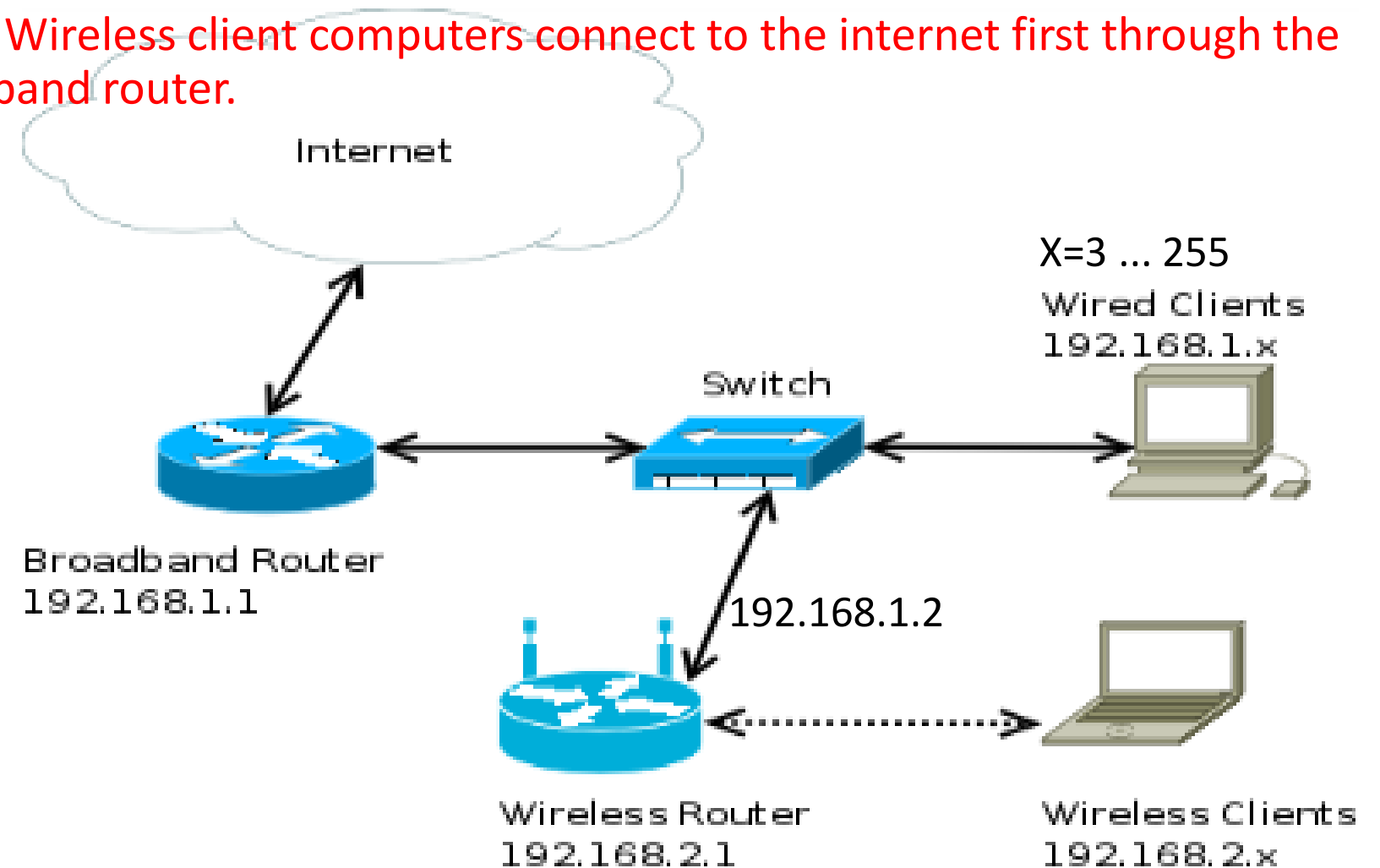
Class D and Class E

- The number of addresses in a class C block is smaller than the needs of most organizations.

- Class D addresses are used for multicasting; there is only one block in this class.

- Class E addresses are reserved for special purposes; most of the block is wasted.

- Class E: reserved for future use. This is an IP class with the first octet between 240-255. It is reserved for scientific research and is not used on the internet. (241.0.0.0 - 248.0.0.0)
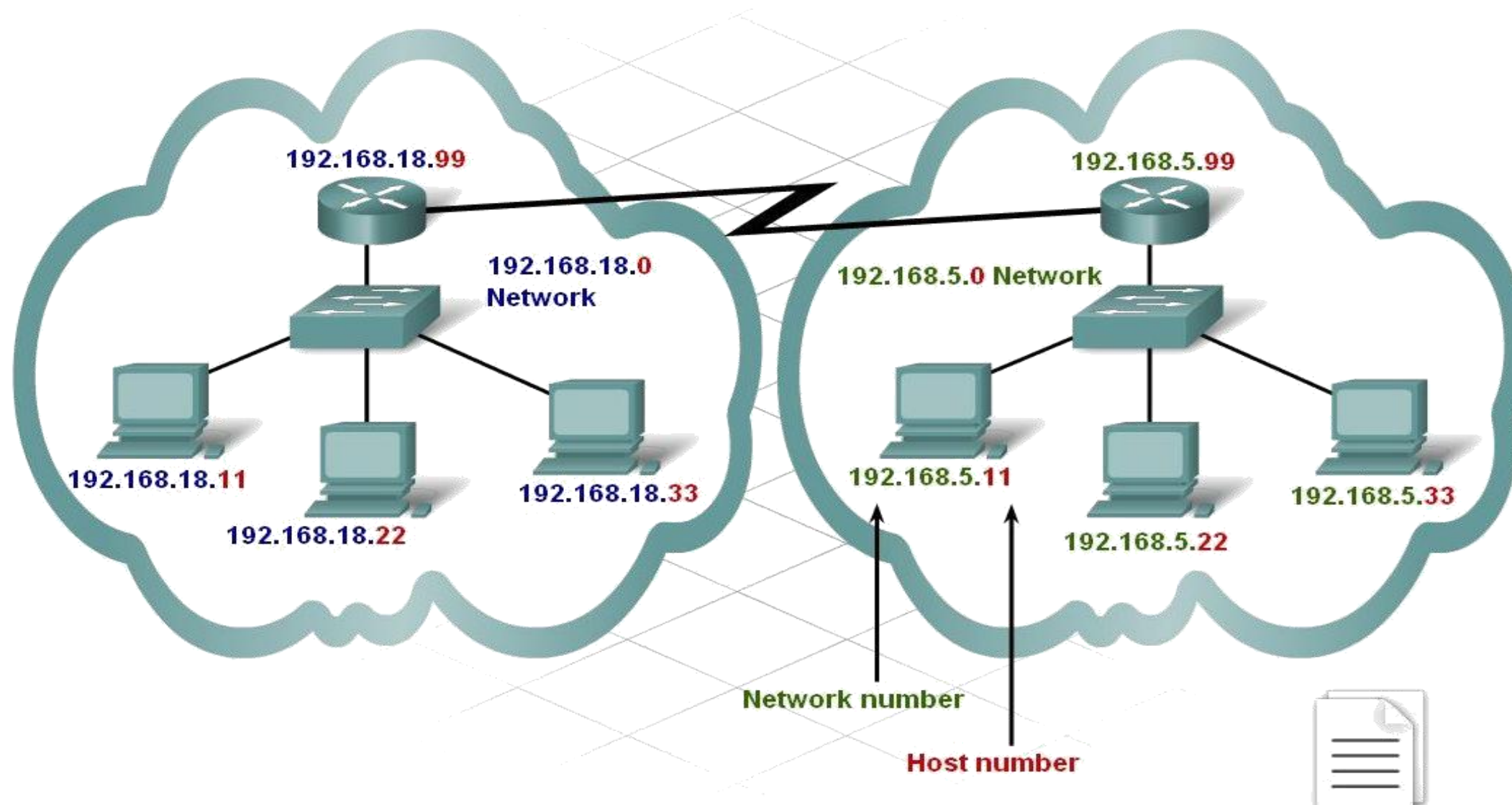
Example

187.67.90.55

- 187=2^7+2^5+2^4+2^3+2^1+2^0
- 187-128=59
- 59-32=27
- 27-16=11
- 11-8=3

- 7 6 5 4 3 2 1 0
- 1 0 1 1 1 0 1 1 B Class,
- NetID: 187.67
- Host ID:90.55; 0.0 – 255.255

Example

192.67.90.55

- 192=2^7+2^6
- 192-128=64
- 64-64=0

- 7 6 5 4 3 2 1 0
- 1 1 0 0 0 0 0 0 : C Class,
- NetID: 192.67.90
- Host ID:55; 0 - 255

192.168.18.99

192.168.5.99

192.168.18.0 Network

192.168.5.0 Network

192.168.18.11

192.168.18.22

192.168.18.33

192.168.5.11

192.168.5.22

192.168.5.33

Network number

Host number

Public and Private IP Addresses

Class A: Large networks
Class B: Medium Networks
Class C: Home or Office

Example: Public and Private IP Addresses

6. Public vs Private IP addresses

Private IP ranges (not routable on Internet):

Range	Usage
10.0.0.0/8	Large networks
172.16.0.0 – 172.31.255.255	Medium
192.168.0.0/16	Home/office

Example

- IP address is: 194.68.90.56
- What is the class type
- C- Class: Home or Office

Subnet Mask

What is a subnet?

- A "subnet" is a general term used for a section of a larger network that is separated, usually by a bridge or router. It also works for the network's broadcast domains, manages traffic flow, and helps improve network performance. Uses of subnets in a network include:
  - Relieving network congestion
  - Reassigning IP addresses
  - Improving network security

Subnet Mask

Determines the way an IP address is split into network and hosts portions
Network ID: replace with 255. HostID replace 0.

Class A - 0nnnnnnn.hhhhhhhh.hhhhhhhh.hhhhhhhh
Subnet Mask = 255.0.0.0   IP Address /8

Class B - 10nnnnnn.nnnnnnnn.hhhhhhhh.hhhhhhhh
Subnet Mask = 255.255.0.0   IP Address /16

Class C - 100nnnnn.nnnnnnnn.nnnnnnnn.hhhhhhhh
Subnet Mask = 255.255.255.0   IP Address /24

Network – Broadcast - Host

IP address: 192.168.10.25

Subnet mask: 255.255.255.0

- Network: 192.168.10.0

- Broadcast: 192.168.10.255

- Usable hosts: 192.168.10.1 – 192.168.10.254

Network – Broadcast - Host

- IP address: 194.68.90.56
- Class-c
- NetID: 194.68.90
- Host ID: 56
- Subnet Mask: 255.255.255.0   Not:255 inserts for NetID, 0 insert for HostID
- What is network IP address? NetID remains the same. Host ID: 0

  194.68.90.0
- What is network Broadcast IP address? NetID remains the same. Host ID: 255

  194.68.90.255
- What is usable hosts IP address? NetID remains the same. Host ID: 1 to 254

  194.68.90.1 to 194.68.90.254

IP adressing

- IP address: 192.168.10.25, Class C
- Subnet mask: 255.255.255.0

What is network IP address?
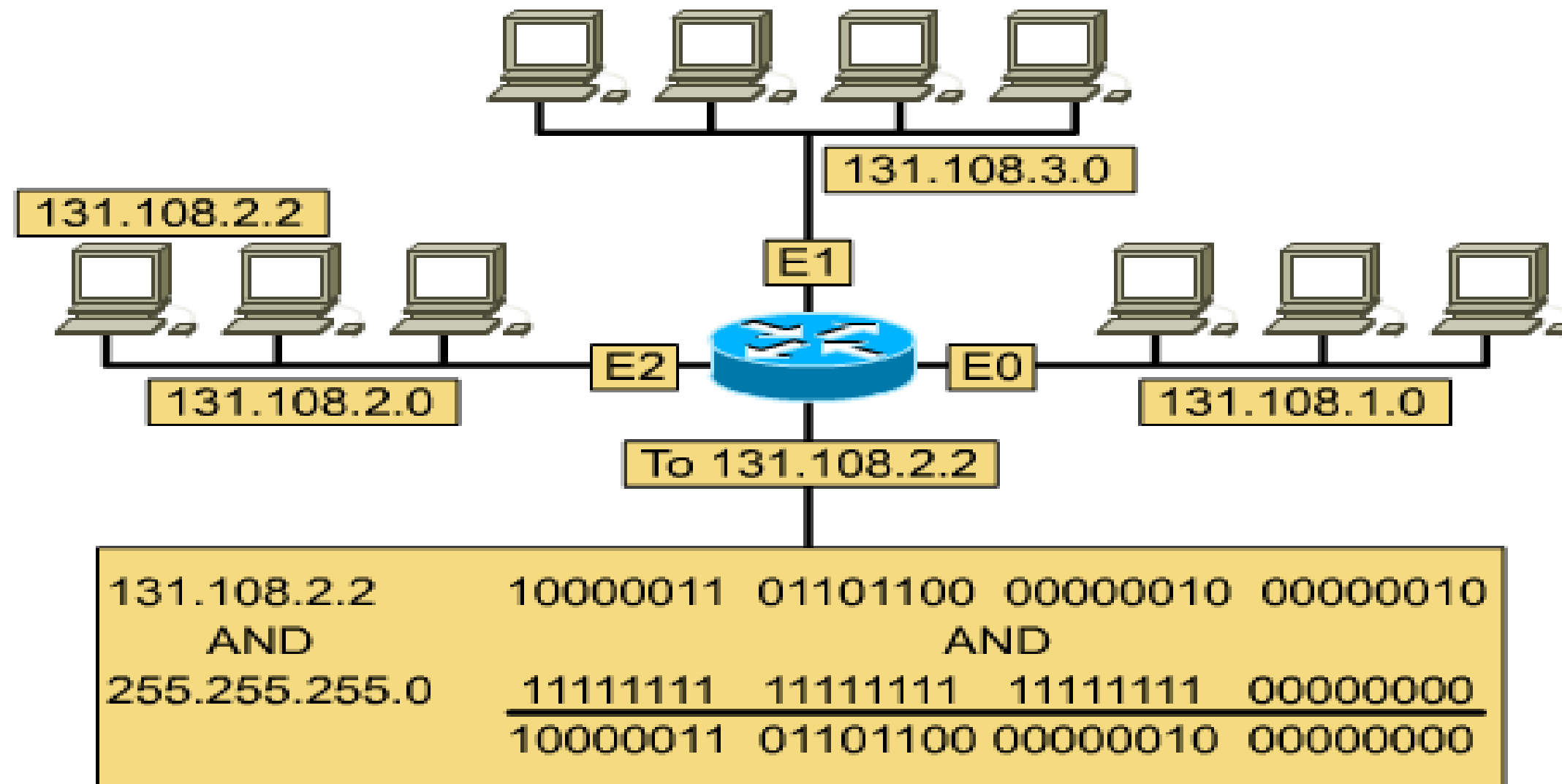
- Network: 192.168.10.0

What is network Broadcast IP address?

- Broadcast: 192.168.10.255

What is usable hosts IP address

- Usable hosts: 192.168.10.1 – 192.168.10.254

Performing the AND Function to find Network ID

Common mistakes in IP addressing

- Duplicate IP addresses
- Wrong subnet mask
- Using public IP internally
- Misconfigured gateway

Q68. What is ipconfig?

- Ans. 'ipconfig' is an acronym for Internet Protocol Configuration. We use ipconfig on Microsoft Windows to view and configure the network interface. It displays all TCP/IP network summary information available on a network and helps to modify the DHCP protocol and DNS settings.

- Q69. What is ifconfig?
- Ans. It is an acronym for Interface Configuration and is used on Linux, Mac, and UNIX operating systems. 'ifconfig' configures and controls the TCP/IP network interface parameters from Command Line Interface while allowing the user to check the IP addresses of these network interfaces.

QoS - Performance Improvement
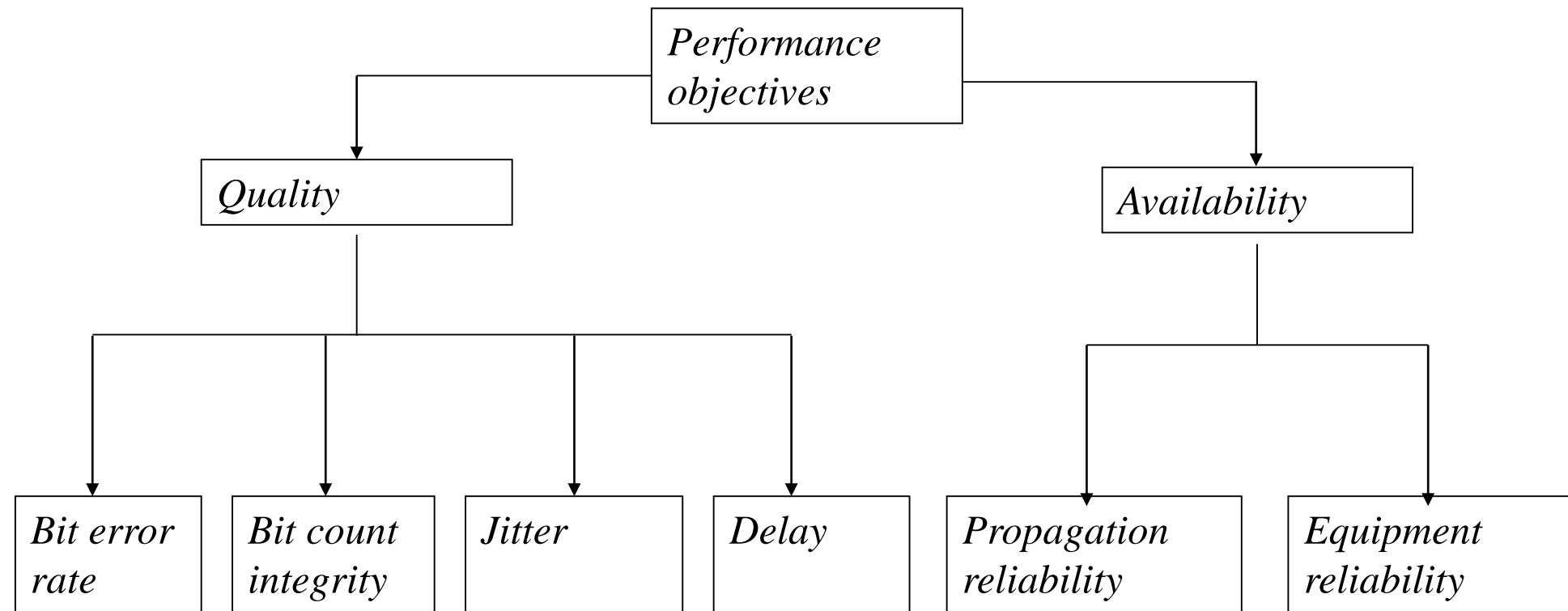
- Availability: The quality of being usable or valid.

- Reliability: Reliability, durability.

- Jitter: In electronics and telecommunications, jitter is the deviation from the true periodicity of a possibly periodic signal, possibly based on a reference clock pulse signal. Integrity: Integration

QoS

- QoS: Prioritizing data packets that carry both real-time voice and data.

- Network Communication Quality of Service (QoS) is a network service protocol that aims to reduce downtime by prioritizing applications on a network.

- It refers to various techniques that prioritize a type of traffic or program running over a network connection.

Improving LAN performance

- As networks become increasingly heavily utilized, LAN performance becomes a critical issue.

- LAN performance is measured by throughput, which is the total amount of user data transmitted within a given period.

- LAN performance can be improved by identifying and eliminating bottlenecks, which are points where network congestion occurs because network technologies cannot meet all the demand.

- Cost is a crucial factor in performance improvement.

Kaynaklar

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- https://www.ics.uci.edu/

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