NUMBER SYSTEMS

INTRODUCTION

Number Systems used in Computer & ICT:

- Binary (base 2)
- Octal (base 8)
- Hexadecimal (base 16)

BINARY NUMBER SYSTEM

- Refers to numbers with a base/radix of 2

- Given that digital logic and memory devices are based on two electrical states (on and off), it is natural to use a number system,

called the binary number system, which contains only two symbols, namely 0 and 1.

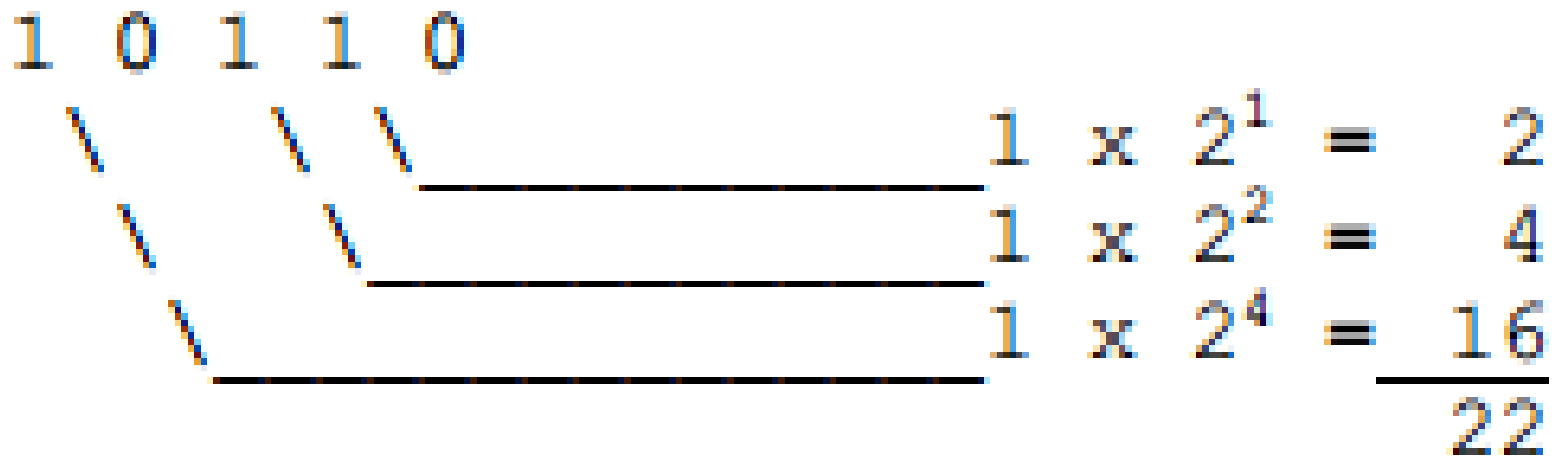
BINARY

- Each digit position in a binary number represents a power of two. So, when we write a binary number, each binary digit is multiplied by an appropriate power of 2 based on the position in the number:
- For example:

$$
\begin{aligned}
101101 &= 1 \times 2^5 + 0 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 \\
&= 1 \times 32 + 0 \times 16 + 1 \times 8 + 1 \times 4 + 0 \times 2 + 1 \times 1 \\
&= 32 + 8 + 4 + 1
\end{aligned}
$$

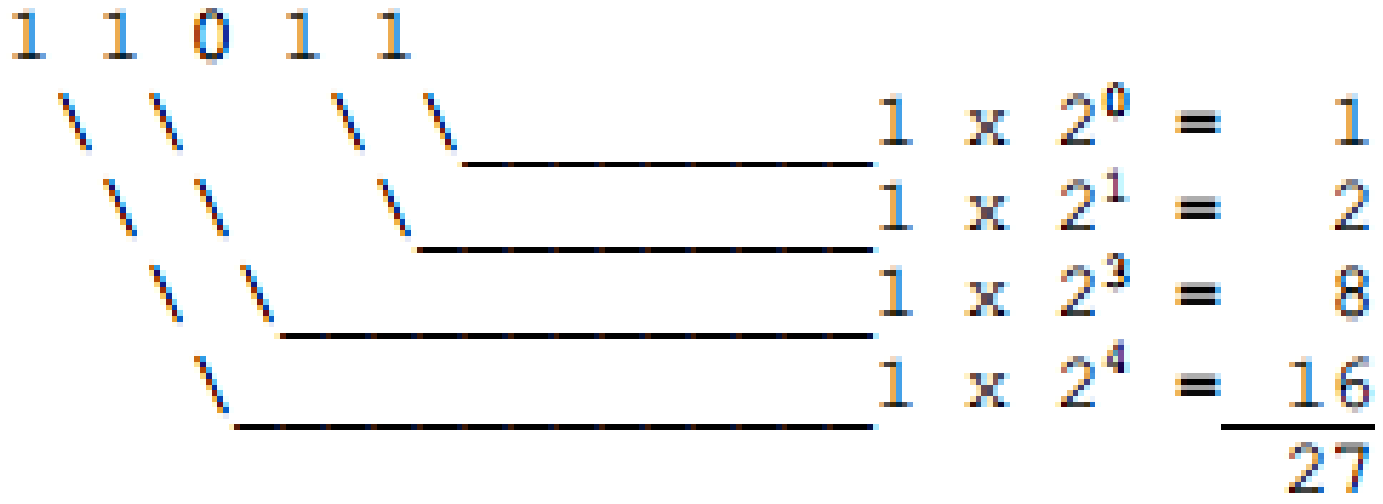
BINARY TO DECIMAL CONVERSION

For example: convert 10110_2 to decimal.



BINARY TO DECIMAL CONVERSION EX 2

Another example: convert 11011_2 to decimal



DECIMAL TO BINARY

An example of the process: convert 37_{10} to binary

```
37 / 2 = 18      remainder 1      (least significant digit)
18 / 2 = 9       remainder 0
9 / 2 = 4        remainder 1
4 / 2 = 2        remainder 0
2 / 2 = 1        remainder 0
1 / 2 = 0        remainder 1      (most significant digit)
```

The resulting binary number is: 100101

DECIMAL TO BINARY

- Convert 93_{10} to binary

DECIMAL TO BINARY

- The resulting binary number is: 1011101

HEXADECIMAL

- base 16.
- The following are the hexadecimal numerals:

0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

WHY HEXADECIMAL?

- The reason for the common use of hexadecimal numbers is the relationship between the numbers 2 and 16. Sixteen is a power of 2 (16 = 24). Because of this relationship, four digits in a binary number can be represented with a single hexadecimal digit. This makes conversion between binary and hexadecimal numbers very easy, and hexadecimal can be used to write large binary numbers with much fewer digits.
- Writing a 16 or 32 bit binary number would be quite tedious and error prone. By using hexadecimal, the numbers can be written with fewer digits and much less likelihood of error.

BINARY TO HEXADECIMAL

For example: Convert the binary number `10110101` to a hexadecimal number

Divide into groups for 4 digits	`1011 0101`
Convert each group to hex digit	`B 5`
	$B5_{16}$

BINARY TO HEX

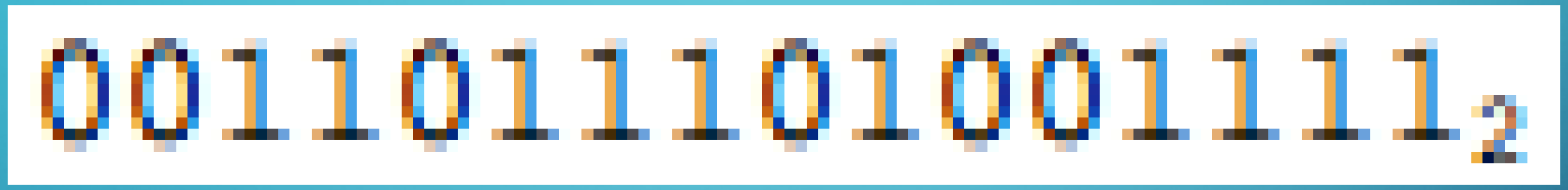
Another example: Convert the binary number 0110101110001100 to hexadecimal

Divide into groups of 4 digits
Convert each group to hex digit

0110 1011 1000 1100
6 B 8 C

$6B8C_{16}$

CONVERT TO HEX



HEX TO BINARY

- To convert a hexadecimal number to a binary number, convert each hexadecimal digit into a group of 4 binary digits.

Example: Convert the hex number 374F into binary

Convert the hex digits to binary

3	7	4	F
0011	0111	0100	1111

0011011101001111_2

HEX REPRESENTATION

- In the C and C++ languages, hexadecimal constants are represented with a ‘0x’ preceding the number, as in: 0x317F, or 0x1234, or 0xAF.
- In assembler programming languages that follow the Motorola style, hexadecimal constants begin with a ‘$’ character. So in this case: $371F or $FABC or $01 are valid hexadecimal constants

BINARY CODED DECIMAL

- numbers are represented in a decimal form, however each decimal digit is encoded using a four bit binary number.

For example: The decimal number 136 would be represented in BCD as follows:

```
136 = 0001 0011 0110
        1    3    6
```

BCD

01010110 10010011

This is converted to a decimal number as follows:

0101 0110 1001 0011

5 6 9 3

The value is 5693 decimal

BITS, BYTES AND WORDS

- Each binary digit is known as a bit.

- Given a fixed number of n bits, (a word), which the arithmetic unit of a computer is designed to handle, then there are 2^n separate binary numbers that can be accommodated. For example, in 8 bits, one can accommodate the binary numbers corresponding to decimal 0 to 255 (256 different numbers).
- Current computers have word lengths of 32 or 64 bits.

MEMORY HIERARCHY

- I bit = I binary digit (1 bit) =0 or 1
- I nibble = 4 bits
- 1 byte = 8 bits
- I Kilobyte(KB) = 2^{10} bytes
- 1 Megabyte (MB) = 2^{20} bytes
- 1 Gigabyte (GB) = 2^{30} bytes
- Terabyte >> Petabyte >> Exabyte >> Zettabyte >> Yottabyte

FURTHER READING

- Converting binary and decimal numbers with fractions
- Octal Numbering System
- Addition and Subtraction of Binary numbers

COMPUTER COMMUNICATIONS AND NETWORKS

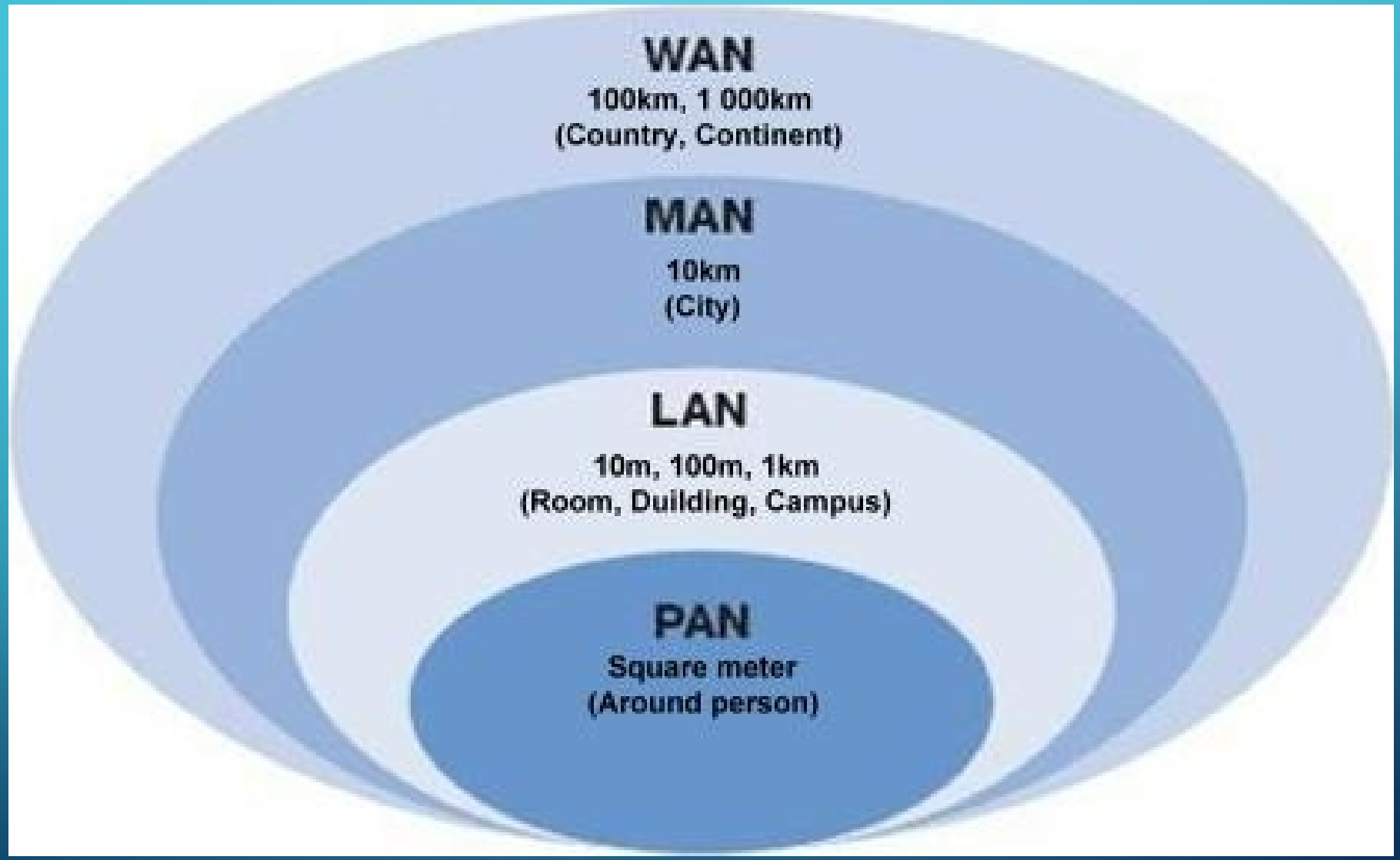
- A **computer network** or data **network** is a telecommunications **network** that allows **computers** to exchange data. In **computer networks**, networked computing devices pass data to each other along data connections. Data is transferred in the form of packets.
- Networking devices may include gateways, routers, network bridges, modems, wireless access points, networking cables, line drivers, switches, hubs, and repeaters; and may also include hybrid network devices such as multilayer switches, protocol converters, bridge routers, proxy servers, firewalls, network address translators, multiplexers, network interface controllers, wireless network interface controllers, ISDN terminal adapters and other related hardware.

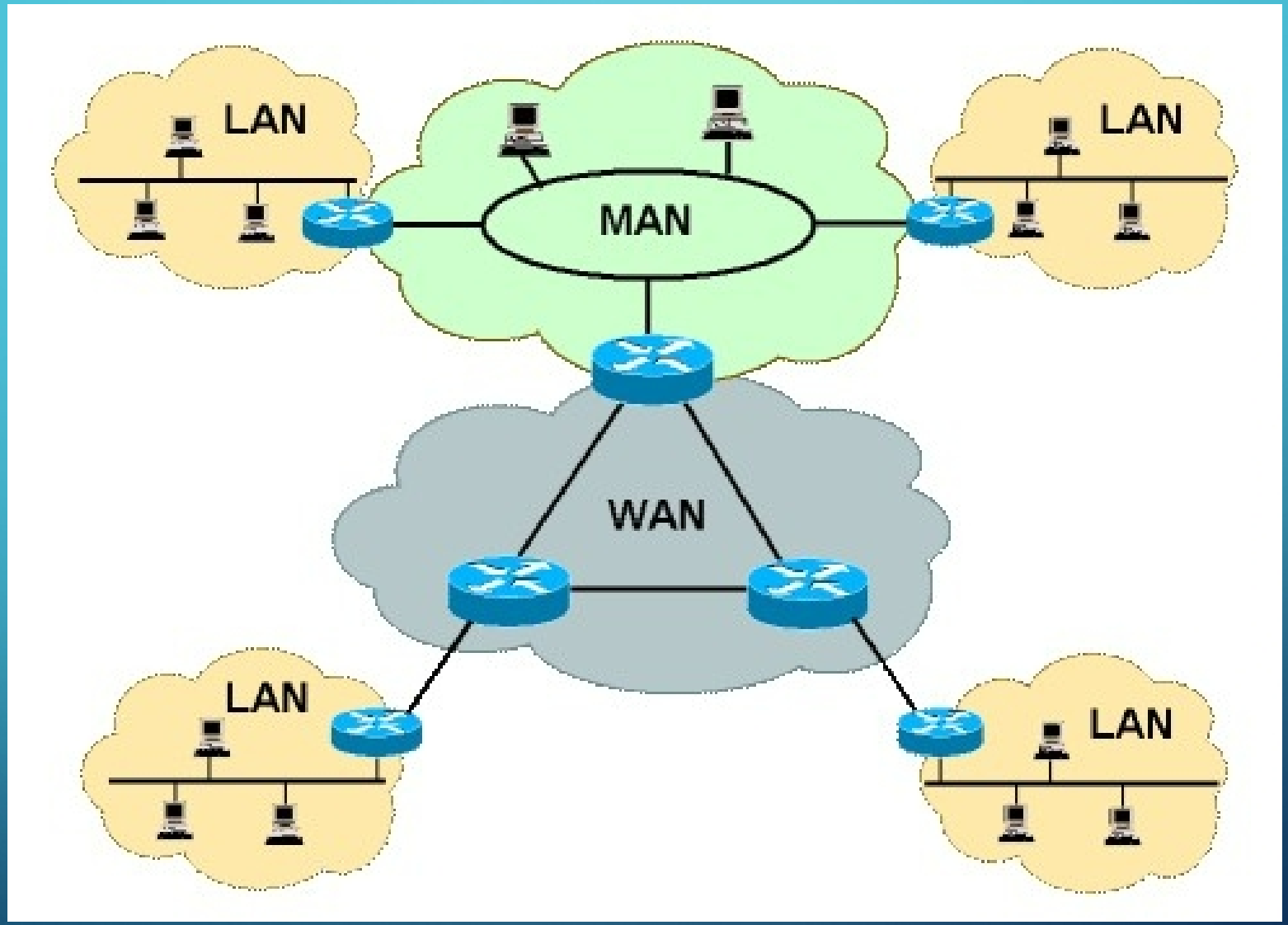
CLASSIFICATION OF NETWORKS

- Point- to –Point
- Broadcast
  - Broadcast(all)
  - Multicast(some)
  - Unicast(one)

CLASSIFICATION ACCORDING TO EXTENT

- Personal Area Network (PAN)
- Local Area Network (LAN)
- Metropolitan Area Network
- Wide Area Network(WAN)


WAN
100km, 1 000km
(Country, Continent)
MAN
10km
(City)
LAN
10m, 100m, 1km
(Room, Building, Campus)
PAN
Square meter
(Around person)


LAN
MAN
LAN
WAN
LAN
LAN

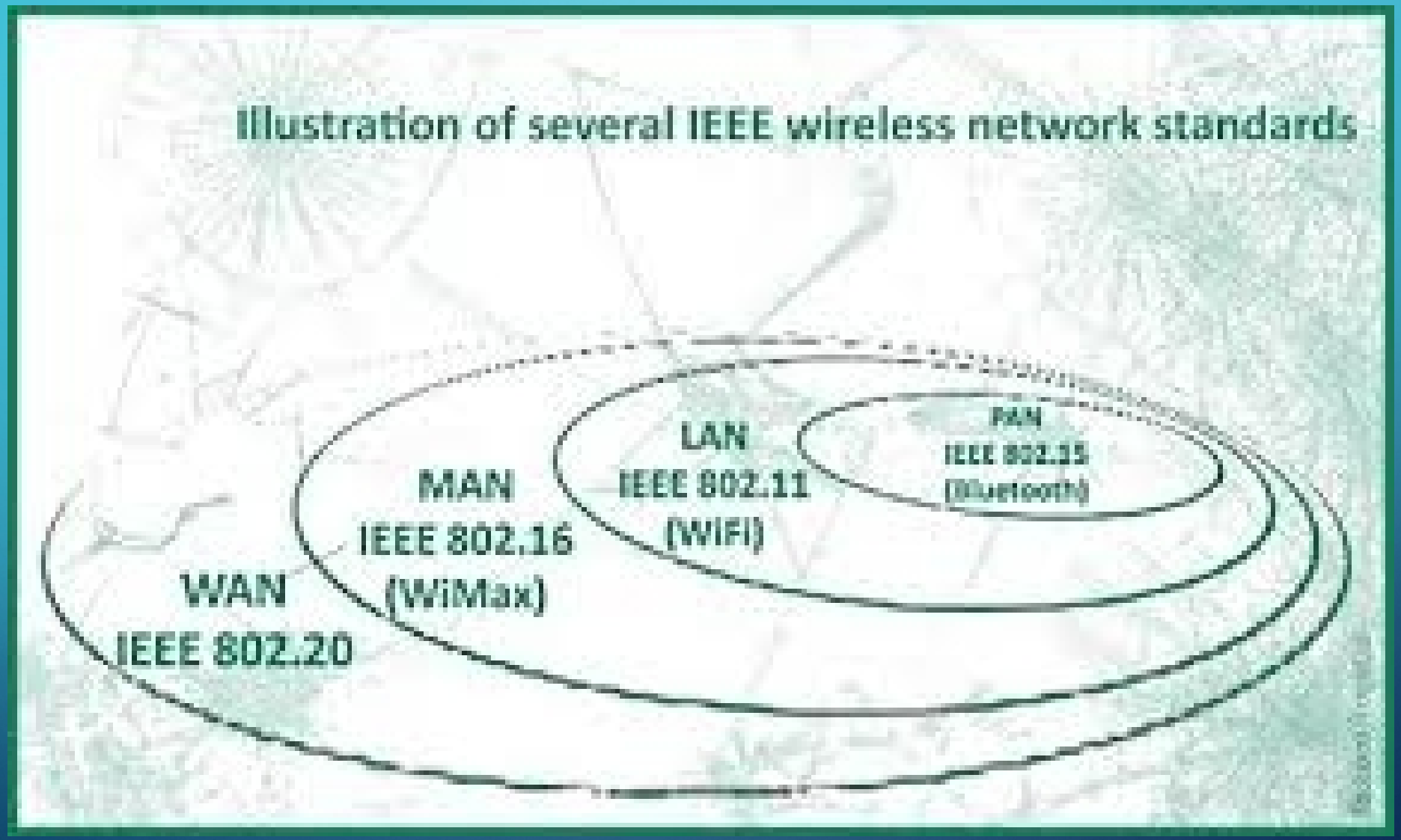
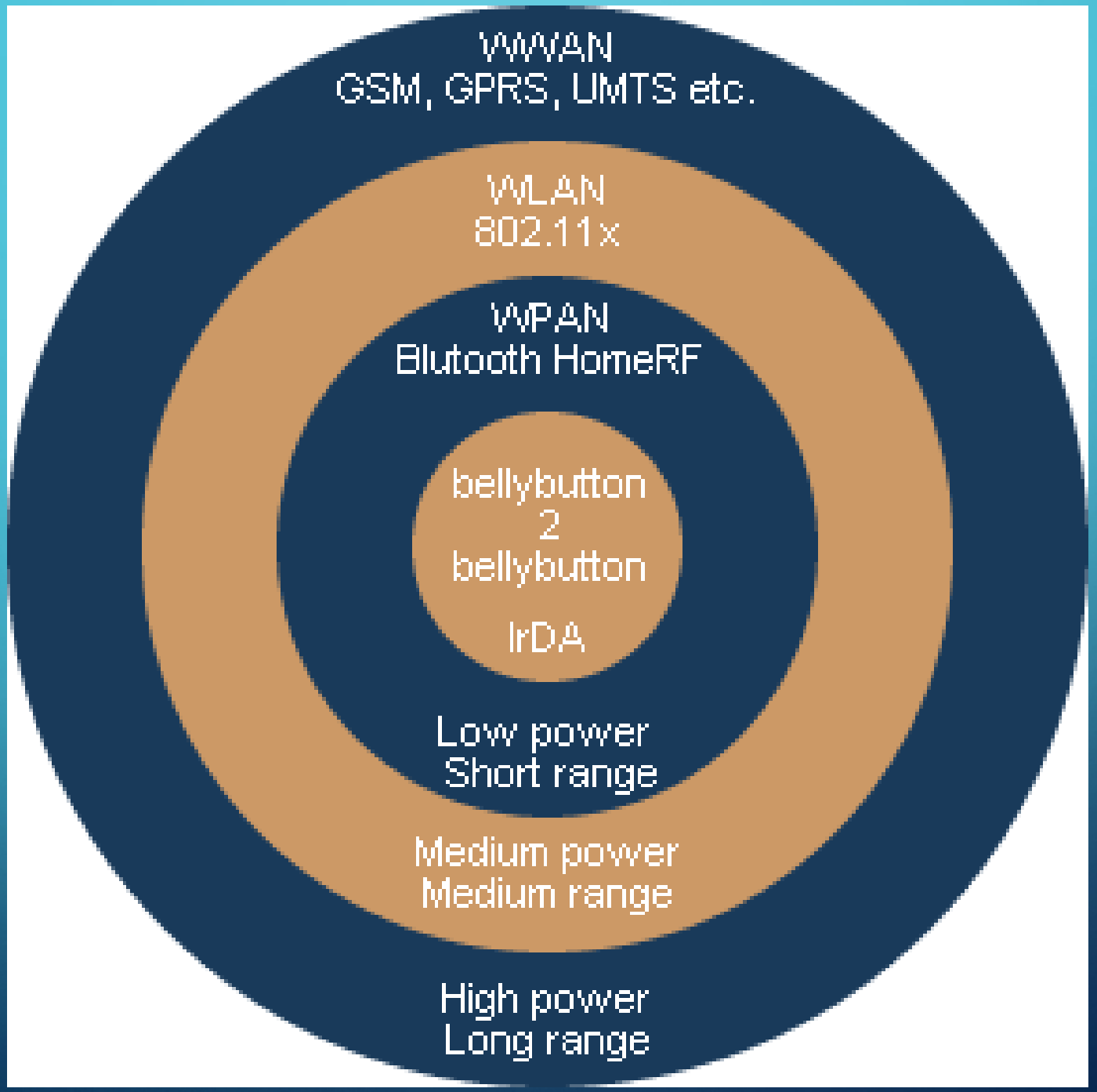


Illustration of several IEEE wireless network standards
WAN
IEEE 802.20
MAN
IEEE 802.16
(WiMax)
LAN
IEEE 802.11
(WIFI)
PAN
IEEE 802.15
(Bluetooth)

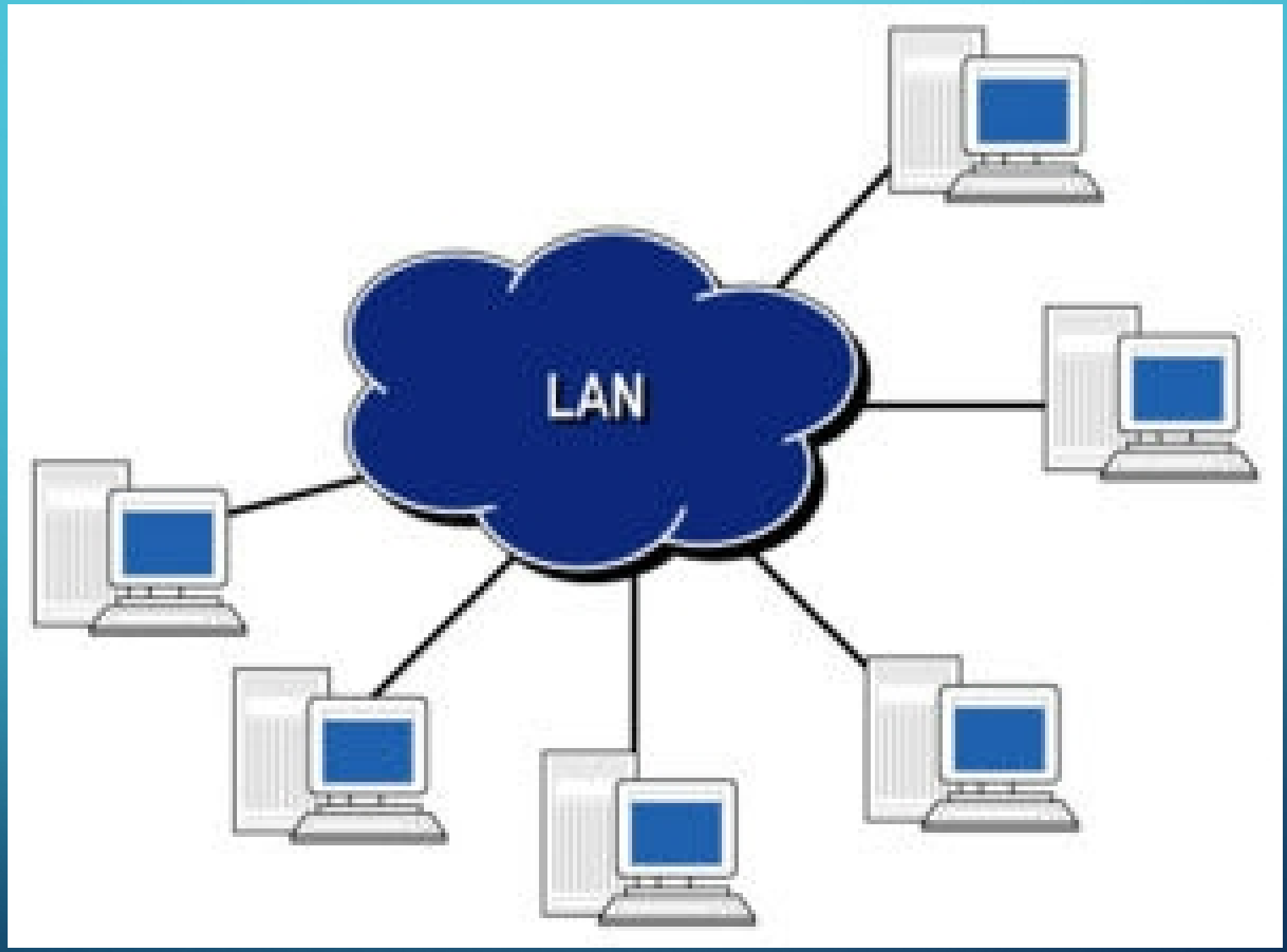

WWAN
GSM, GPRS, UMTS etc.
WLAN
802.11x
WPAN
Blutooth HomeRF
bellybutton
2
bellybutton
IrDA
Low power
Short range
Medium power
Medium range
High power
Long range

PAN

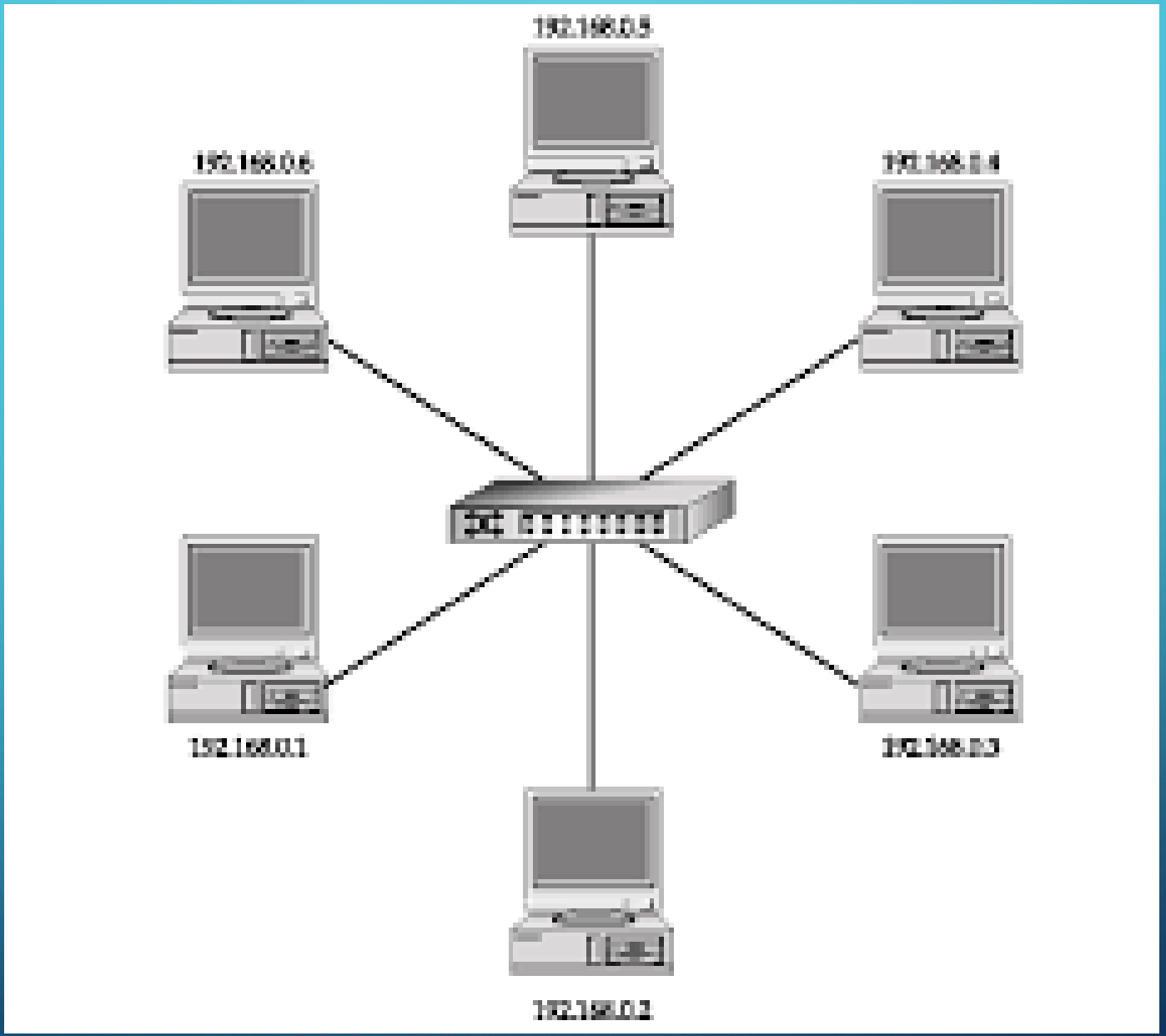
- Handsets, PDA, Mobile Phone
- Bluetooth, Infrared, NFC,USB

LAN

- Computers connected over Ethernet cables.
- Network coordinated by a switch and hubs
- An Ethernet hub, active hub, network hub, repeater hub, multiport repeater or hub is a device for connecting multiple Ethernet devices together and making them act as a single network segment.


LAN

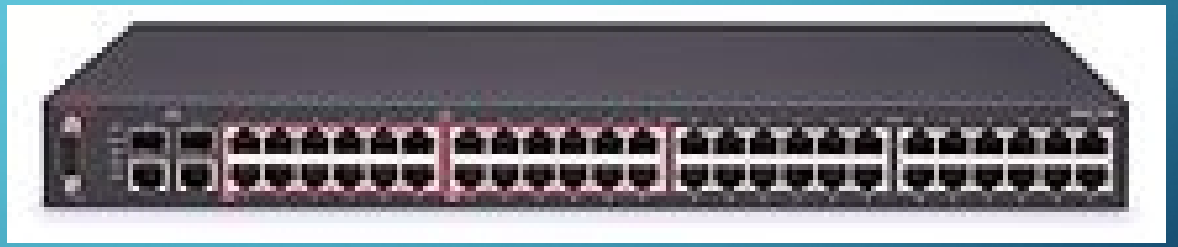
NETWORK HUB


192.168.0.5
192.168.0.6
192.168.0.4
192.168.0.1
192.168.0.3
192.168.0.2

NETWORK SWITCH

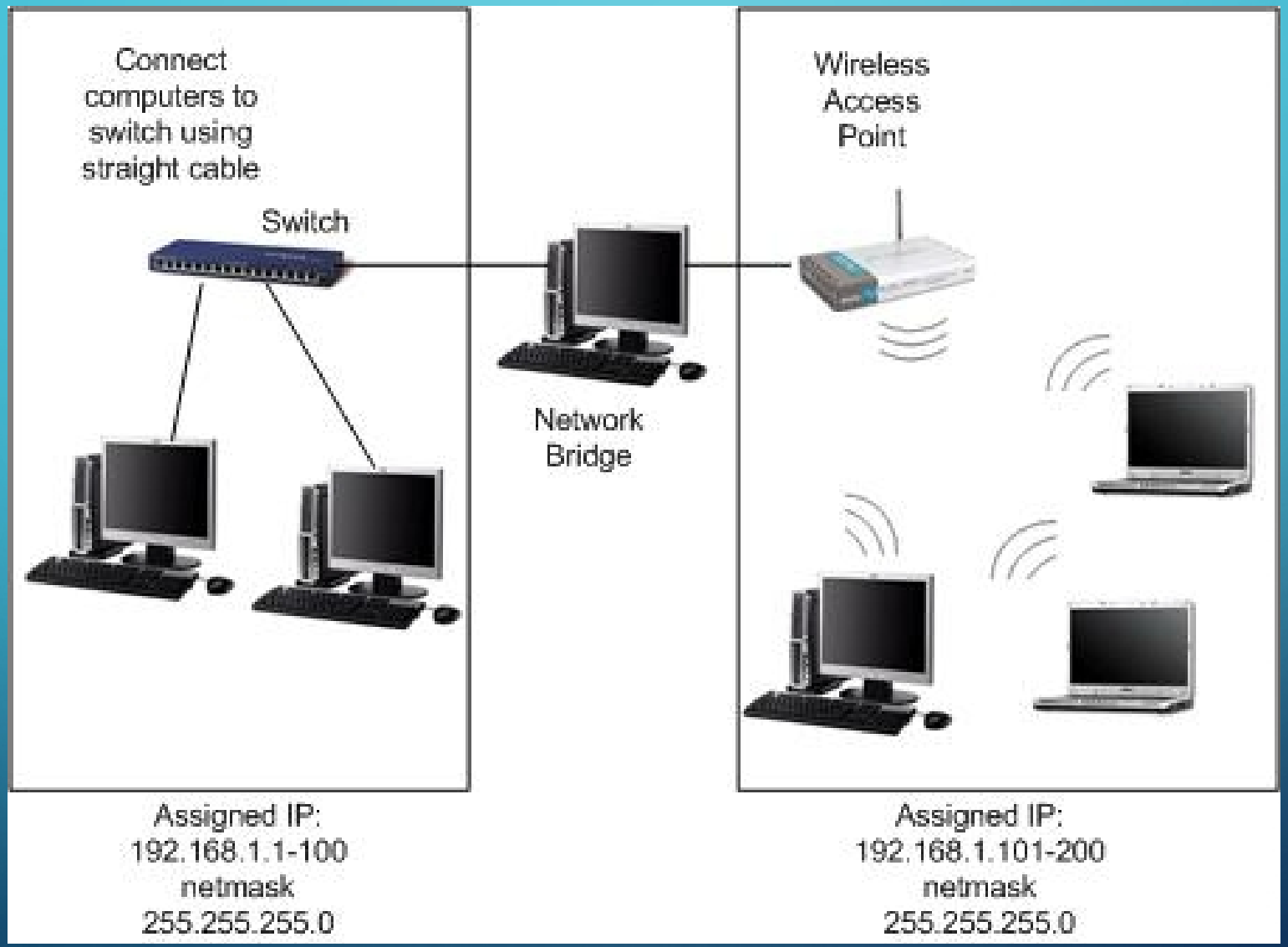
- A network switch (sometimes known as a switching hub) is a computer networking device that is used to connect devices together on a computer network, by using a form of packet switching to forward data to the destination device. A network switch is considered more advanced than a hub because a switch will only forward a message to one or multiple devices that need to receive it, rather than broadcasting the same message out of each of its ports

NETWORK SWITCH



NETWORK BRIDGE

- A network bridge is a network device that connects multiple network segments.
- A network bridge is software or hardware that connects two or more networks so that they can communicate.
- People with home or small office networks generally use a bridge when they have different types of networks but they want to exchange information or share files among all of the computers on those networks.
- Here's an example. Let's say you have two networks: in one, the computers are connected with cables; and in the other, the computers are connected using wireless technology. The wired computers can only communicate with other wired computers, and the wireless computers can only communicate with other wireless computers. With a network bridge, all of the computers can communicate with each other.


Connect computers to switch using straight cable
Switch
Network Bridge
Wireless Access Point
Assigned IP: 192.168.1.1-100 netmask 255.255.255.0
Assigned IP: 192.168.1.101-200 netmask 255.255.255.0

ROUTER

- A router connects two or more different networks &forwards data packets btn them.
- They forward packets from one router to another through an internetwork until it reaches its destination node. Forwarded from one line by a routing table or policy based on the network address information.
- Home & small office routers connects to Internet via an ISP. Enterprise routers, connect large business or ISP networks to fast optical fibres (Internet backbone)
- A router may integrate a firewall, VPN handling, and other security functions.

GATEWAY

- Network node equipped for interfacing with another network that uses different communication protocols.
- May have two different hardware interfaces e.g. Wireless LAN and Ethernet (LAN)
- Cloud gateway - translates cloud storage APIs such as SOAP or REST (public cloud) to block-based storage protocols (private cloud) – data protection.
- IoT (modular/embedded) gateway – bridges gap between nodes (factory, home, etc.); the Cloud (data collection, storage &manipulation); and the local or offline (field) processing equipment (smartphones, tablets etc.)

CABLES

Media	Bandwidth	Distance
Coaxial (thick/thinnet)	10 Mbps	(185, 500)
Cat 3 -UTP	10 Mbps	100m
Cat 5 - UTP	100 Mbps	100m
Cat 5e/6/7	1 Gbps	100m
SMF/MMF	1-10bps	0.2-40km

CABLES

	Copper Twisted Pair		Multimode Fiber	Single-mode Fiber	Wireless
	Cat 5e	Cat 6			
					
Bandwidth	Up to 10 Gbps 100 Mhz	Up to 10 Gbps 200 Mhz	Up to 10 Gbps	Up to 10 Gbps or Higher	Up to 54 Mbps
Distance	Up to 100 m	Up to 100 m	Up to 2 km (Fast E) Up to 550 m (Gi E) Up to 300 m (10 Gi E)	Up to 80 km (Fast E) Up to 100 m (Gi E) Up to 80 km (10 Gi E)	Up to 500m @ 1 Mbps
Price	Inexpensive	Inexpensive	Moderate	Moderate to Expensive	Moderate

ROUTER

- Read about SDN, Routers, Switches
- Read about details of categories of Ethernet cables