INTRODUCTION TO DATA COMMUNICATIONS & COMPUTER NETWORKS - 2

ECE 422 - DATA COMMUNICATIONS & COMPUTER NETWORKS

Thursday, 19 January 2023

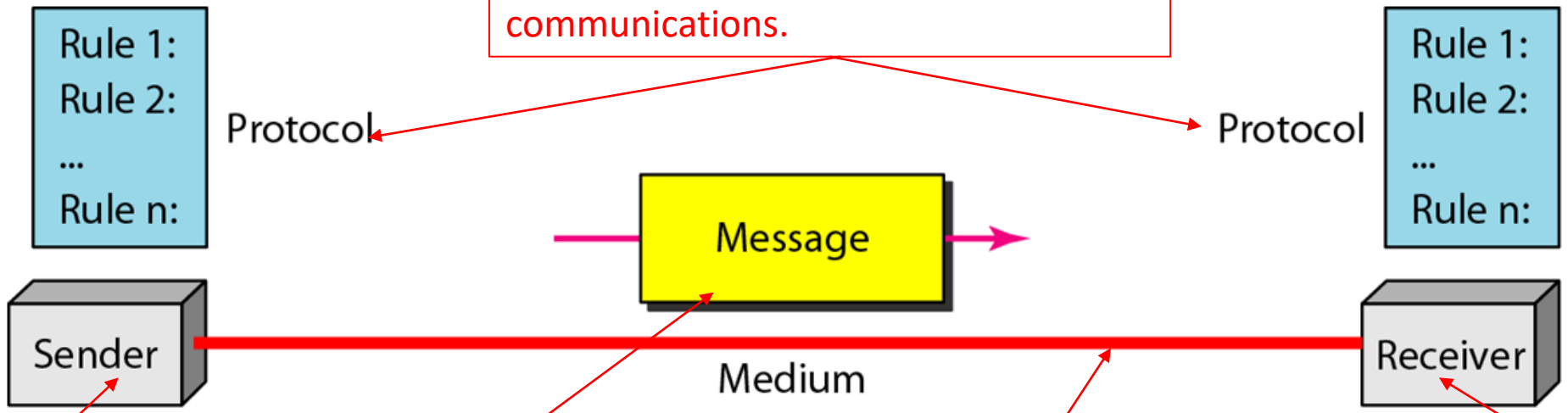
THE EFFECTIVENESS OF A DATA COMMUNICATION SYSTEM

The effectiveness of a data communication system depends on four parameters:

1. **Delivery:** The system must deliver data to the correct destination, i.e to the intended device or user.
2. **Accuracy:** The system must deliver the data accurately, i.e without alterations.
3. **Timeliness:** The system must deliver data in a timely manner. In the case of video and audio, timely delivery means delivering data as they are produced, in the same order that they are produced, and without significant delay. This kind of delivery is called *real-time* transmission.
4. **Jitter:** Jitter refers to the variation in the packet arrival time which results in uneven delay in the delivery of audio or video packets.

FIVE COMPONENTS OF A DATA COMMUNICATION SYSTEM

A data communication system has got 5 components as shown below.



5. Protocol
A set of rules that govern data communications.

1. Sender
originates the data message,
e.g. a computer, telephone handset, video camera.

2. Message
information or data to be communicated
Text, Numbers, Pictures, Audio, and Video.

3. Medium
The physical path by which a message travels from sender to receiver, i.e twisted-pair wire, coaxial cable, fiber-optic cable, and radio waves.

4. Receiver
The destination of the message, e.g. computer, telephone handset, television.

DATA REPRESENTATION - TEXT

1. In data communication, Text is represented as a bit pattern, a sequence of bits (0s or 1s).
2. Different sets of bit patterns have been designed to represent text symbols. Each set is called a code, and the process of representing symbols is called coding.
3. Today, the most prevalent coding system is called **Unicode**, which uses 32 bits to represent a symbol or character used in any language in the world.
4. The **American Standard Code for Information Interchange (ASCII),** constitutes the first 127 characters in Unicode and is also referred to as **Basic Latin**.

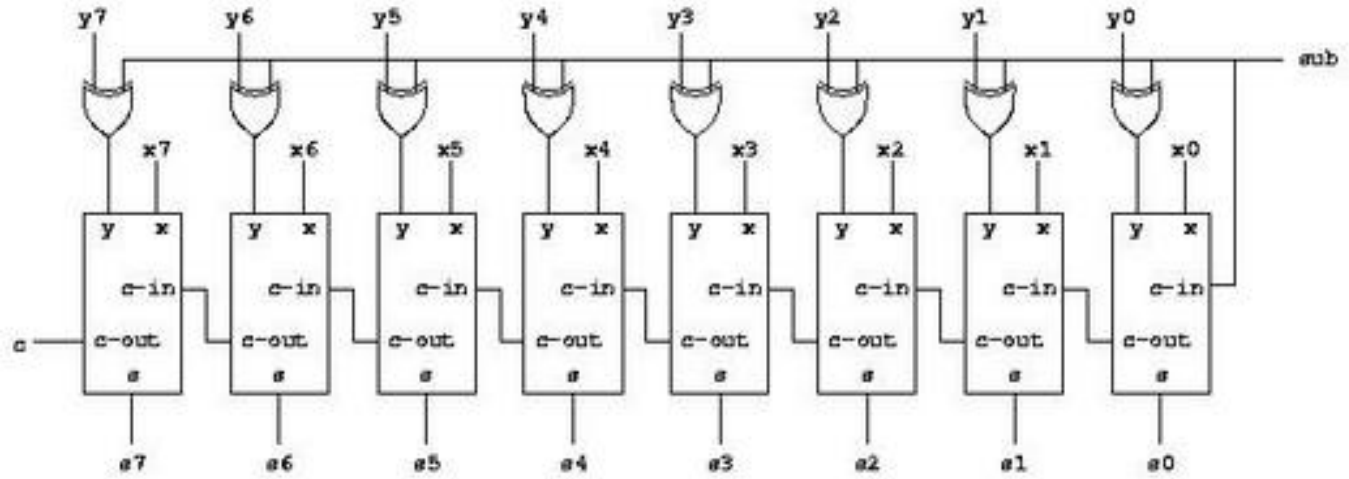
Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char
0	00	Null	32	20	Space	64	40	@	96	60	`
1	01	Start of heading	33	21	!	65	41	A	97	61	a
2	02	Start of text	34	22	"	66	42	B	98	62	b
3	03	End of text	35	23	#	67	43	C	99	63	c
4	04	End of transmit	36	24	$	68	44	D	100	64	d
5	05	Enquiry	37	25	%	69	45	E	101	65	e
6	06	Acknowledge	38	26	&	70	46	F	102	66	f
7	07	Audible bell	39	27	'	71	47	G	103	67	g
8	08	Backspace	40	28	(	72	48	H	104	68	h
9	09	Horizontal tab	41	29	)	73	49	I	105	69	i
10	0A	Line feed	42	2A	*	74	4A	J	106	6A	j
11	0B	Vertical tab	43	2B	+	75	4B	K	107	6B	k
12	0C	Form feed	44	2C	,	76	4C	L	108	6C	l
13	0D	Carriage return	45	2D	-	77	4D	M	109	6D	m
14	0E	Shift out	46	2E	.	78	4E	N	110	6E	n
15	0F	Shift in	47	2F	/	79	4F	O	111	6F	o
16	10	Data link escape	48	30	0	80	50	P	112	70	p
17	11	Device control 1	49	31	1	81	51	Q	113	71	q
18	12	Device control 2	50	32	2	82	52	R	114	72	r
19	13	Device control 3	51	33	3	83	53	S	115	73	s
20	14	Device control 4	52	34	4	84	54	T	116	74	t
21	15	Neg. acknowledge	53	35	5	85	55	U	117	75	u
22	16	Synchronous idle	54	36	6	86	56	V	118	76	v
23	17	End trans. block	55	37	7	87	57	W	119	77	w
24	18	Cancel	56	38	8	88	58	X	120	78	x
25	19	End of medium	57	39	9	89	59	Y	121	79	y
26	1A	Substitution	58	3A	:	90	5A	Z	122	7A	z
27	1B	Escape	59	3B	;	91	5B	[	123	7B	{
28	1C	File separator	60	3C	<	92	5C	\	124	7C	|
29	1D	Group separator	61	3D	=	93	5D	]	125	7D	}
30	1E	Record separator	62	3E	>	94	5E	^	126	7E	~
31	1F	Unit separator	63	3F	?	95	5F	_	127	7F	□

DATA REPRESENTATION - NUMBERS

1. **Numbers** are represented by well-known bit patterns, i.e binary numbers

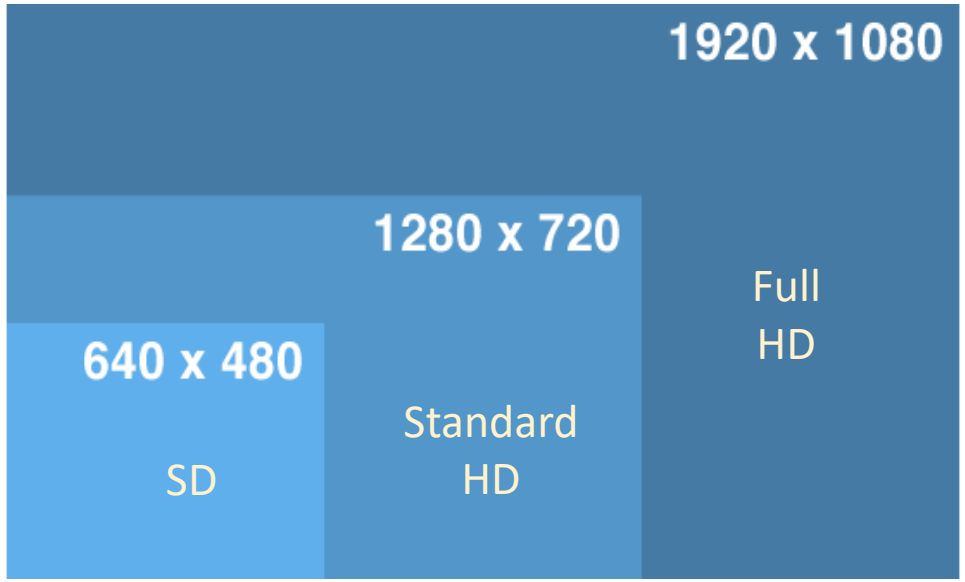
2. A code such as ASCII is usually not used to represent numbers.

3. **Numbers** are usually directly converted to binary form to simplify mathematical operations.



DATA REPRESENTATION - IMAGES

1. Images are also represented by bit patterns.
2. In its simplest form, an image is composed of a matrix of pixels (**pi**cture **el**ements), where each pixel is a small dot.
3. The size of the image depends on the *resolution.*
4. For example, an image can be divided into 640 x 480 pixels or 1280 x 720 pixels.
5. The 1280 x 720 pixel file has representation of the image (better resolution), but more memory is needed to store the image.



EXAMPLE - FOROUZAN PAGE 73

QUESTION

HDTV uses digital signals to broadcast high quality video signals. The HDTV Screen is normally a ratio of 16 : 9 (in contrast to 4 : 3 for regular TV), which means the screen is wider.

There are 1920 by 1080 pixels per screen, and the screen is renewed 30 times per second. Twenty-four bits represents one color pixel.

What is the bit rate?

ANSWER

Bit rate = 1920 x 1080 x 30 x 24

= 1,492,992,000 or 1.5 Gbps

The TV stations usually reduce this rate to 20 to 40 Mbps by using compression.

STANDARD CAMERA RESOLUTION

1. The more pixels on a target, then:
   a) The higher the resolution, and
   b) More likely recognition, and positive identification.

2. **Higher detail requires higher resolution camera** and **more bandwidth and memory**

CIF
Common Intermediate Format

VGA
Video Graphics Array

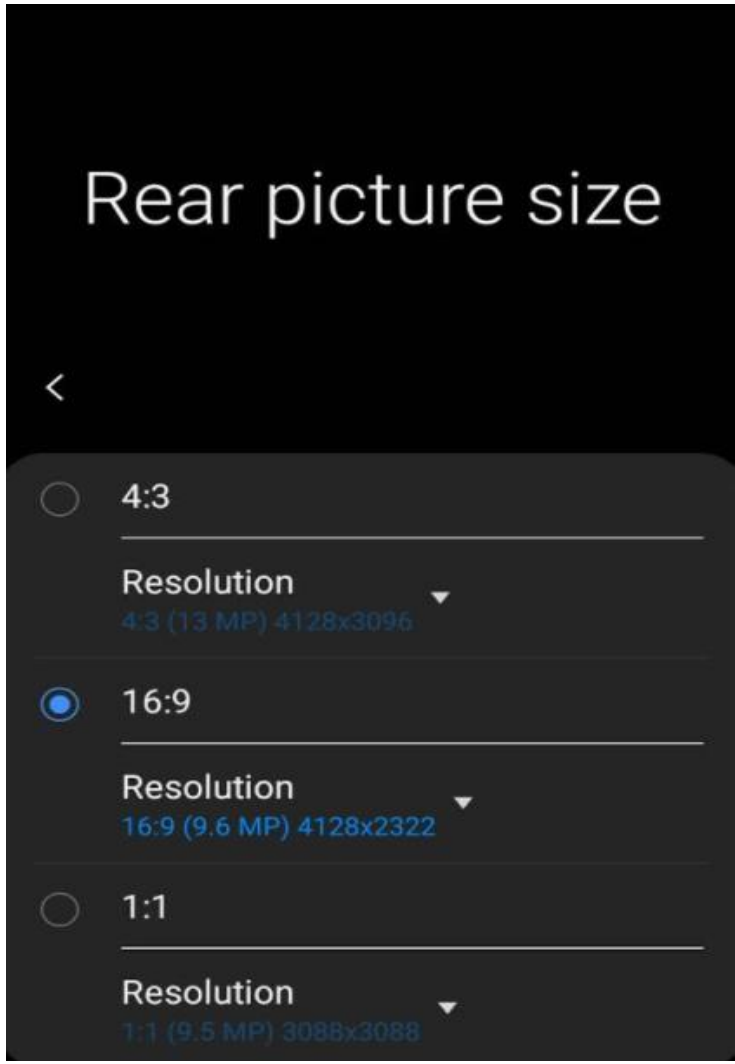
NAME	HORIZONTAL PIXELS	VERTICAL PIXELS	MEGAPIXEL RATING
CIF	320	240	0.1
VGA	640	480	0.3
WVGA	752	480	0.4
720P	1280	720	0.9
SXGA	1280	1024	1.3
UXGA	1600	1200	1.9
1080P	1920	1080	2.0
QXGA	2048	1536	3.1
QSXGA	2560	2048	5.2

XGA
Extended Graphics Adaptor

SXGA
Super XGA

EXERCISE WITH YOUR PHONE

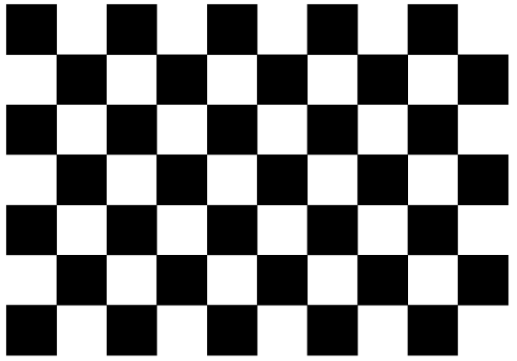
1. Select camera on your phone.
2. Go to camera settings and change the aspect ratio as follows:
   (a) 1:1
   (b) 3:4
   (c) 9: 16
3. Write down the resolution in pixels and megapixels for each of the aspect ratio.



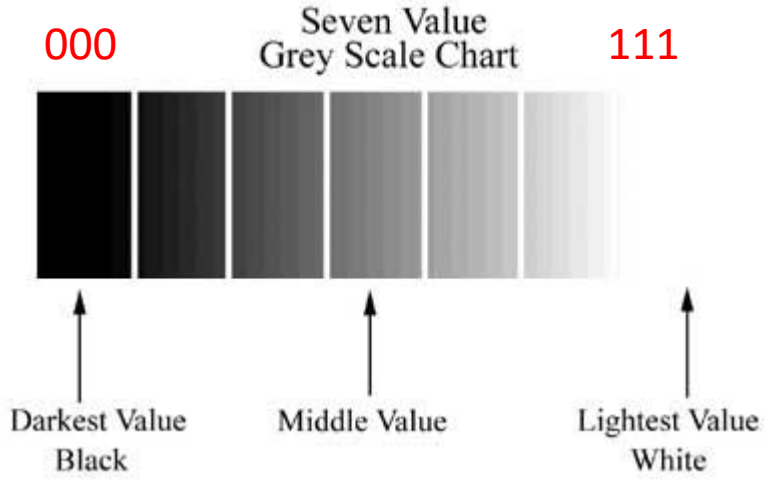
DATA REPRESENTATION – BLACK & WHITE IMAGES

1. The size and the value of the pattern depend on the image.
2. An image made of only black and-white dots (e.g., a chessboard), a 1-bit pattern is enough to represent a pixel.
3. However, if the image is made of many levels of brightness, the 1-bit pattern must be extended to include **grayscale**.
4. For example, to show eight levels of grey scale, you can use 3-bit patterns.

A black pixel can be represented by 000, a dark gray pixel by 001, a light gray pixel by 100, and a white pixel by 111.



Black and White Chess Board



GREYSCALE APPLICATIONS

1. A greyscale or image is one in which the value of each pixel is a single sample representing only an amount of light; that is, it carries only intensity information.
2. Greyscale is used in:
   a) black and white cameras
   b) black and white scanners
   c) Black and white TVs

DATA REPRESENTATION OF COLOUR IMAGES

1. There are several methods to represent colour images.

   a) **RGB** has colour made of a combination of three primary colours: Red, Green, and Blue.

   b) **YCM**, in which a colour is made of a combination of three other primary colours: Yellow, Cyan, and Magenta.

2. The intensity of each colour is measured, and a bit pattern is assigned to it.

Color Name	Color Palette	Color RGB	Color HEX
BlueViolet		138 43 226	#8A2BE2
Brown		165 42 42	#A52A2A
Brown1		255 64 64	#FF4040
Chartreuse		127 255 0	#7FFF00
Chartreuse1		118 238 0	#76EE00
Chartreuse2		102 205 0	#66CD00
Chartreuse3		69 139 0	#458B00
Chocolate		210 105 30	#D2691E
Chocolate1		255 127 36	#FF7F24

WORKED EXAMPLE

Assume the value (intensity) of red, green, and blue of a computer monitor can each take on 256 values (0 through 255) for a pixel.

(a) What are the RGB values for Red, Green, white and black pixels?

(b) What is the total number of colours?

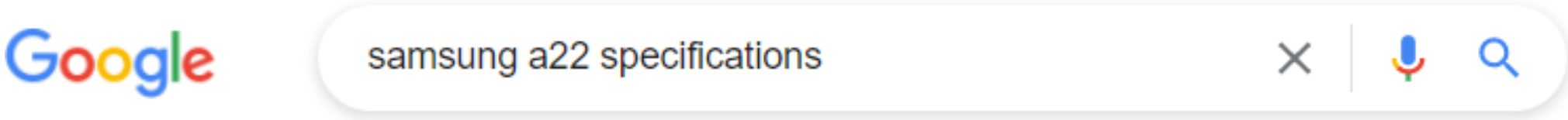
ANS

(a) (i) An RGB value of (255, 0, 0) would imply a red pixel,
(ii) An RGB value of (0, 255, 0) would be green,
(iii) An RGB value of (0, 0, 255) would be blue.
(iv) An RGB of (255, 255, 255) is white,
(v) An RGB of(0, 0, 0) is black.

(b) Varying the RGB value of the three colour elements causes the eye to perceive a wide range of colors. This would imply (3 colors) * (8 bits per color) = 24 bits to record the color for each pixel. The total range of colours at 24 bits per pixel (8 per RGB value) is 256 * 256 * 256 = 16,777,216 colors. In addition, many monitors store a value for opacity of the image requiring still more bits (typically 8 bits).

RESOLUTION OF YOUR PHONE

- User Google search to find out the resolution of your phone camera.



Samsung A22

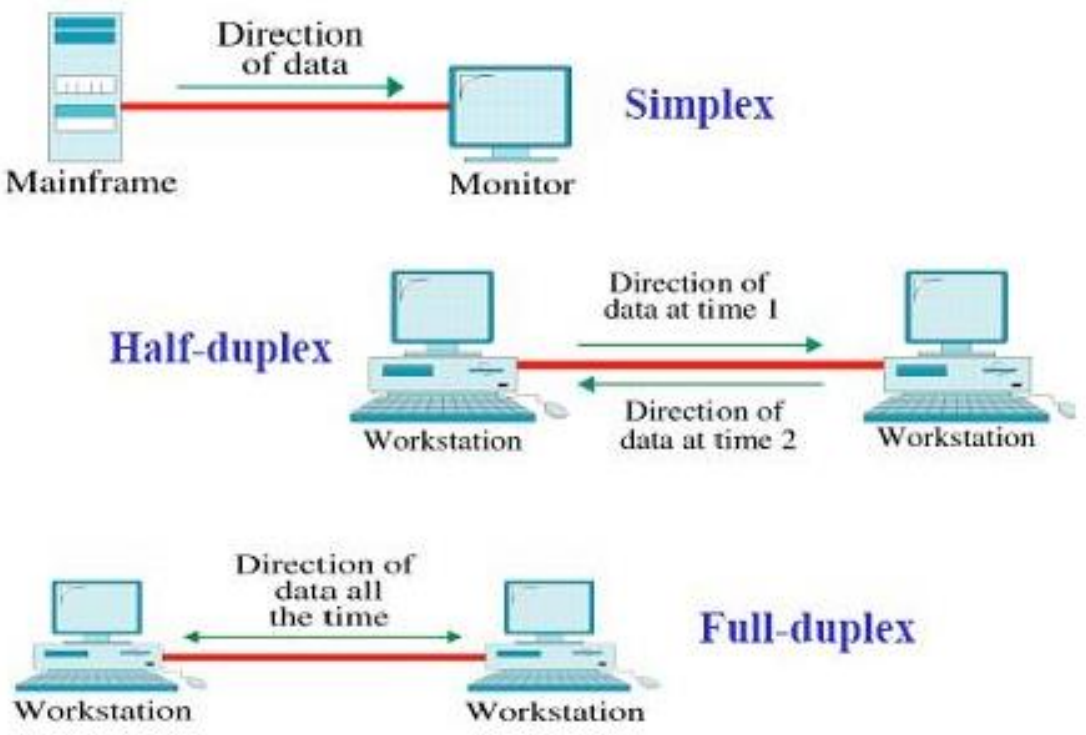
Display	
Display Type	Super AMOLED
Size	6.4 inches
Resolution	720 x 1600 pixels
Display Colors	16M
Pixel Density	274 PPI (pixels per inch)
Touch Screen	Yes

DATA FLOW: SIMPLEX, HALF DUPLEX, FULL DUPLEX

1. **Simplex mode**, the communication is unidirectional. Only one of the two devices on a link can transmit; the other can only receive.

2. **Half-duplex mode**, each station can both transmit and receive, but not at the same time. When one device is sending, the other can only receive, and vice versa.

3. **Full duplex mode**, both stations can transmit and receive simultaneously

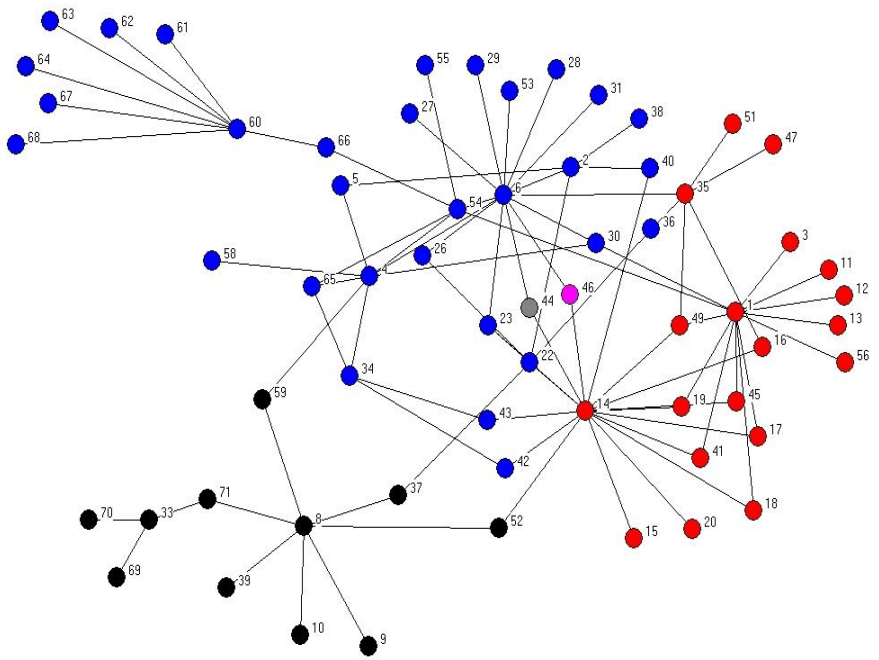


EXAMPLE OF FULL DUPLEX - TELEPHONE & FACSIMILE

DATA NETWORK

1. A **data network** is a set of devices (often referred to as *nodes)* connected by communication links.

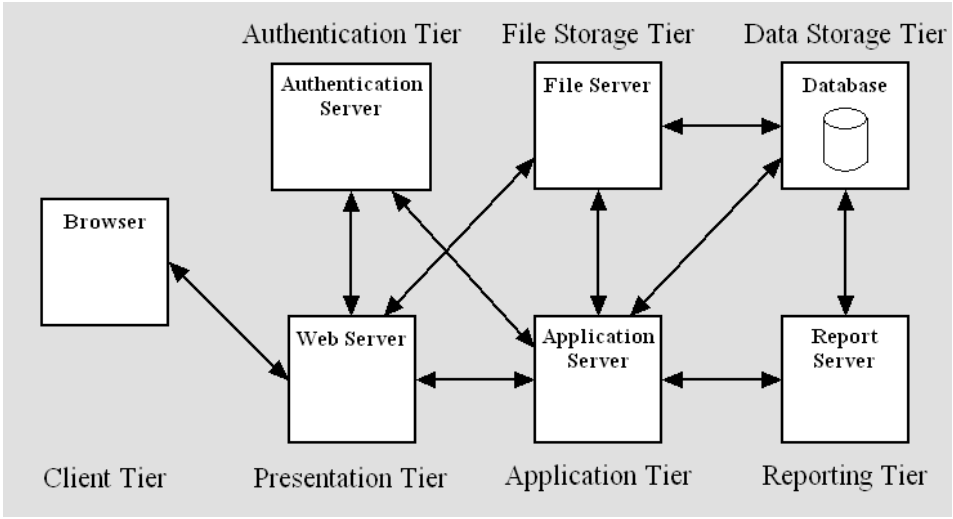
2. A node can be a computer, printer, or any other device capable of sending and/or receiving data generated by other nodes on the network.



DISTRIBUTED PROCESSING

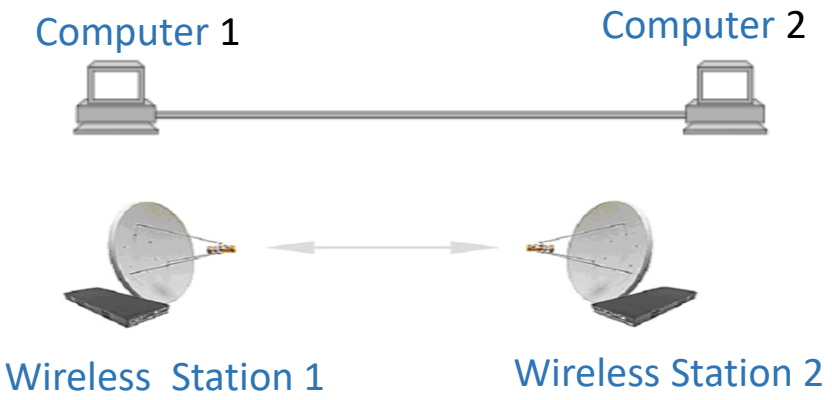
1. In distributed processing, a task is divided among multiple computers.

2. Instead of one single large machine being responsible for all aspects of a process, separate computers handle a subset of the whole process.

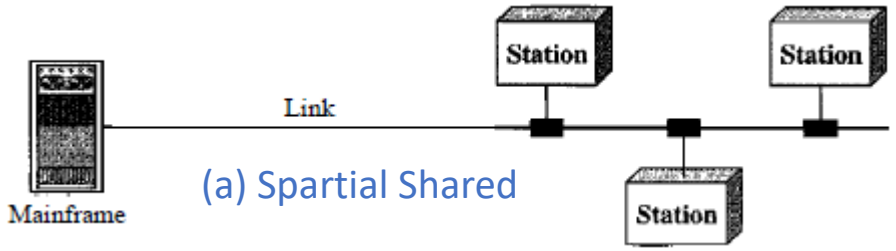


NETWORK CONNECTIONS

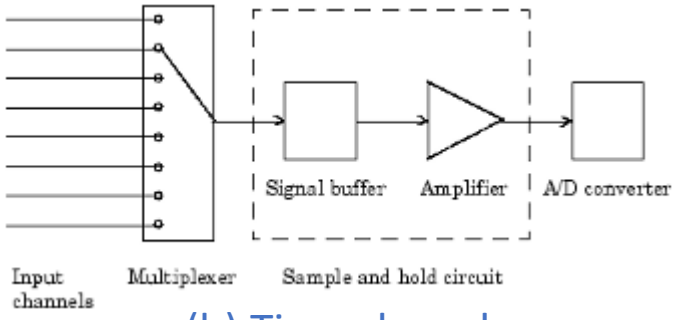
1. **Point-to-Point** - Provides a dedicated link between two devices.



2. **Multipoint** - connection is one in which more than two specific devices share a single link. Features of a multipoint connection are:
   a) The capacity of the channel is shared, either spatially or temporally.
      - **spatially shared connection** - several devices can use the link simultaneously.
      - **Timeshared connection** - users must take turns to use the link

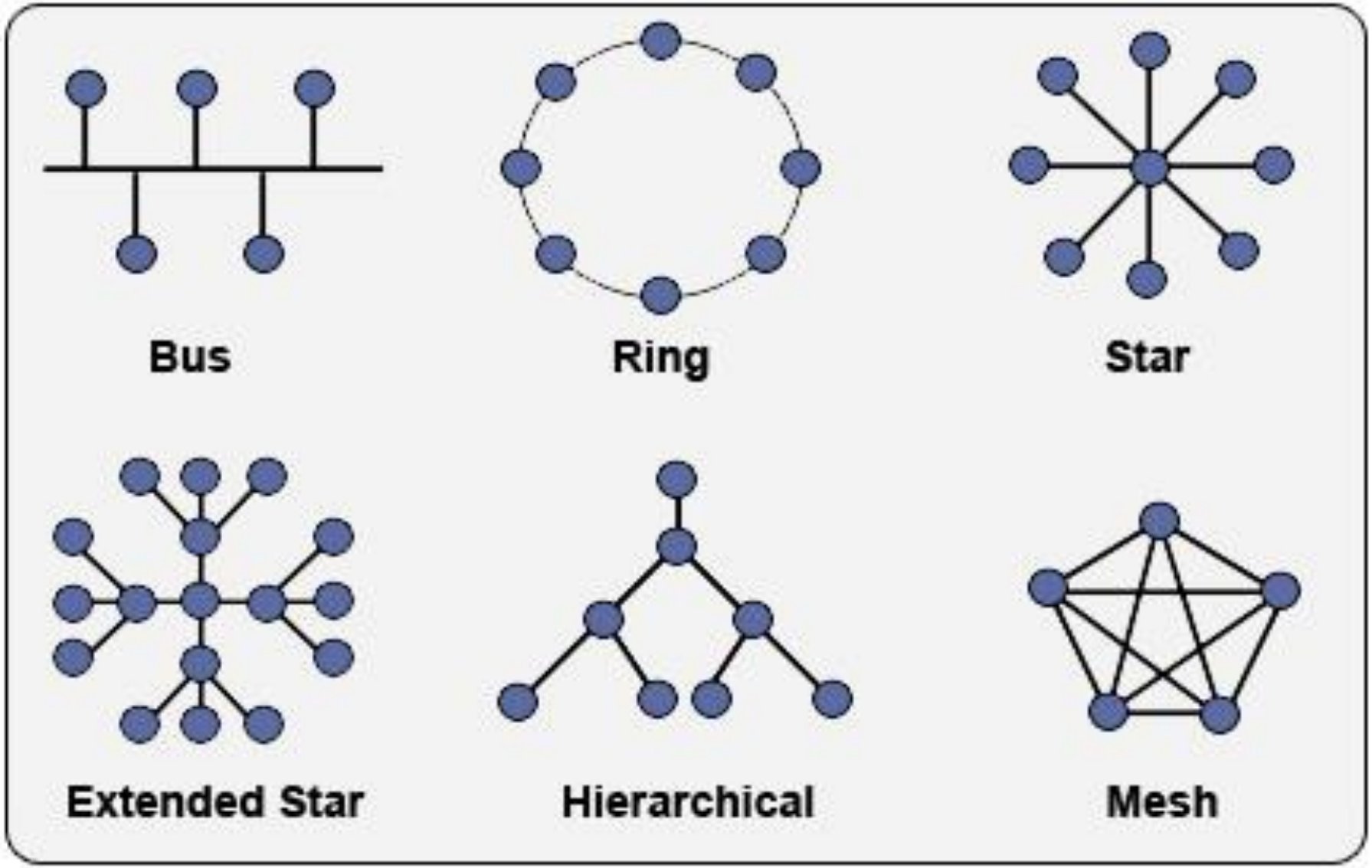


(a) Spartial Shared



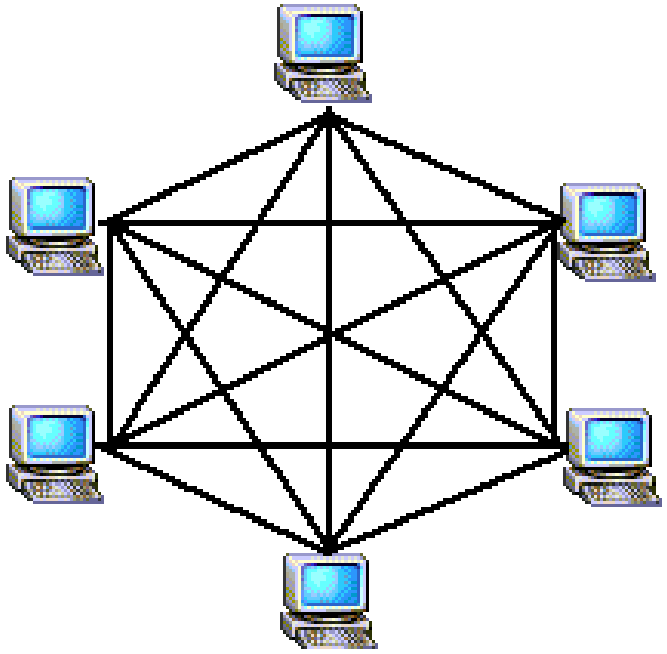
(b) Time shared

BASIC NETWOK TOPOLOGIES



MESH TOPOLOGY

1. **Mesh Topology:** Every device has a dedicated point-to-point link to every other device.
   a) Requires $\frac{n(n-1)}{2}$ $links$
   b) Each node has n-1 input/output ports.
2. Advantages:
   a) Dedicated links guarantees that each connection can carry its own data load.
   b) Robustness, i.e if one link becomes unusable, it does not incapacitate the entire system.
   c) Higher privacy or security.
   d) Easy fault identification and isolation.
3. Disadvantages:
   a) Large amount of cabling
   b) Large amount of hardware (input/output ports)

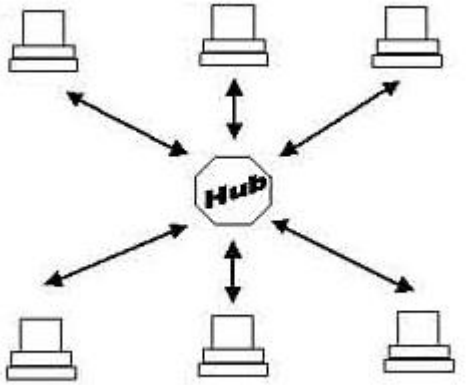


- Links = $\frac{n(n-1)}{2} = \frac{6\times5}{2} = 15$
- Each Node has 5 I/O ports

STAR TOPOLOGY

1. **Star Topology:** Each device has a dedicated point-to-point link only to a central controller, usually called a hub.
   a) The devices are not directly linked to one another.
   b) If one device wants to send data to another, it sends the data to the hub (controller), which then relays the data to the other connected Device.
2. **Advantages**
   a) Less expensive than the mesh since it requires less links and input/output ports.
   b) Easy to install and reconfigure.
   c) Robustness - if one link fails, only that link is affected.
   d) Can be easily configured into hierarchical topology.

3. **Disadvantages:**
   a) Single point failure - If the hub goes down, the whole system is dead.
   b) Requires more cable than a ring or bus

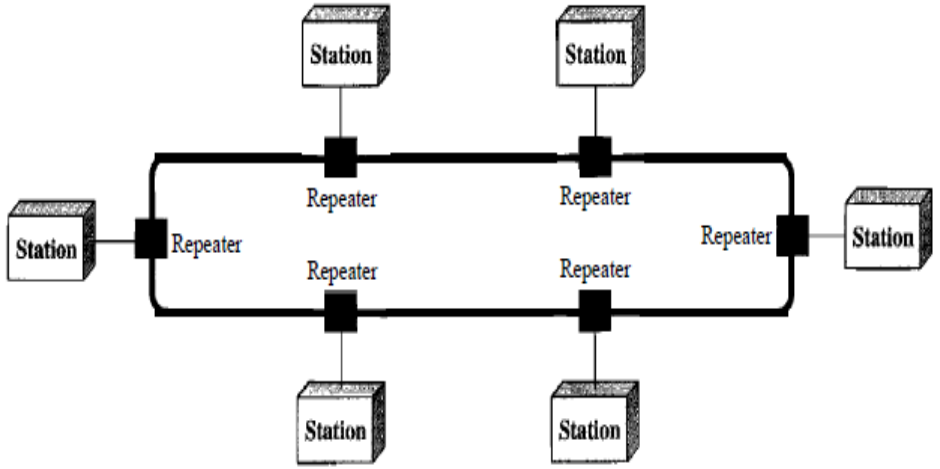


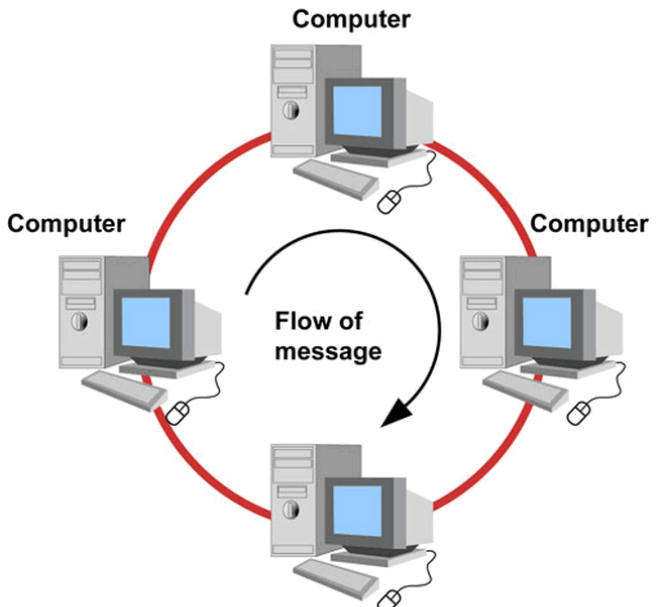
(a) Basic Star Topology

- Links = $n = 6$
- Each Node has one I/O port

RING TOPOLOGY

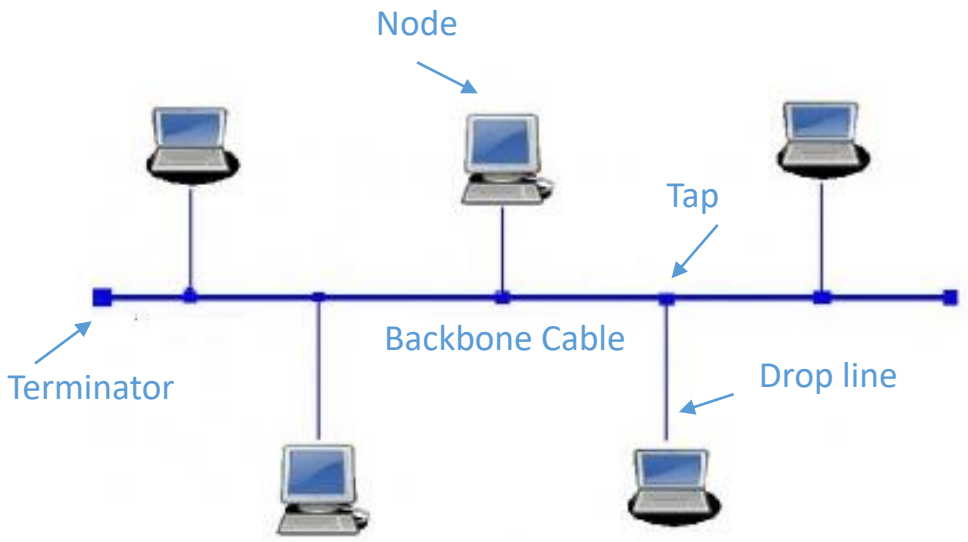
1. **Ring Topology:** Each device has a dedicated point-to-point connection with only the two devices on either side of it.
   a) Each device in the ring incorporates a repeater.
   b) When a device receives a signal intended for another device, its repeater regenerates the bits and passes them along.
2. Advantages:
   a) A ring is relatively easy to install and reconfigure.
   b) To add or delete a device requires changing only two connections.
3. Disadvantage:
   a) A break in the ring (such as a disabled station) can disable the entire network.





BUS TOPOLOGY

1. **Bus Topology:** A multipoint topology in which one long cable acts as a backbone to link all the devices in a network.
   a) Nodes are connected to the bus cable by drop lines and taps.
   b) A drop line is a connection running between the device and the main cable.
   c) A tap is a connector that either splices into the main cable or punctures the sheathing of a cable to create a contact with the metallic core.
2. Advantages
   a) Uses less cable than a mesh or star
   b) Easy to install
3. Disadvantages
   a) Difficult to identify and isolate faults.
   b) Difficult to add new devices.
   c) Signal reflection at the taps can cause degradation in quality.
   d) A fault or break in the bus cable stops all transmission, even between devices on the same side of the problem as the damaged area reflects signals back in the direction of origin, creating noise in both directions.



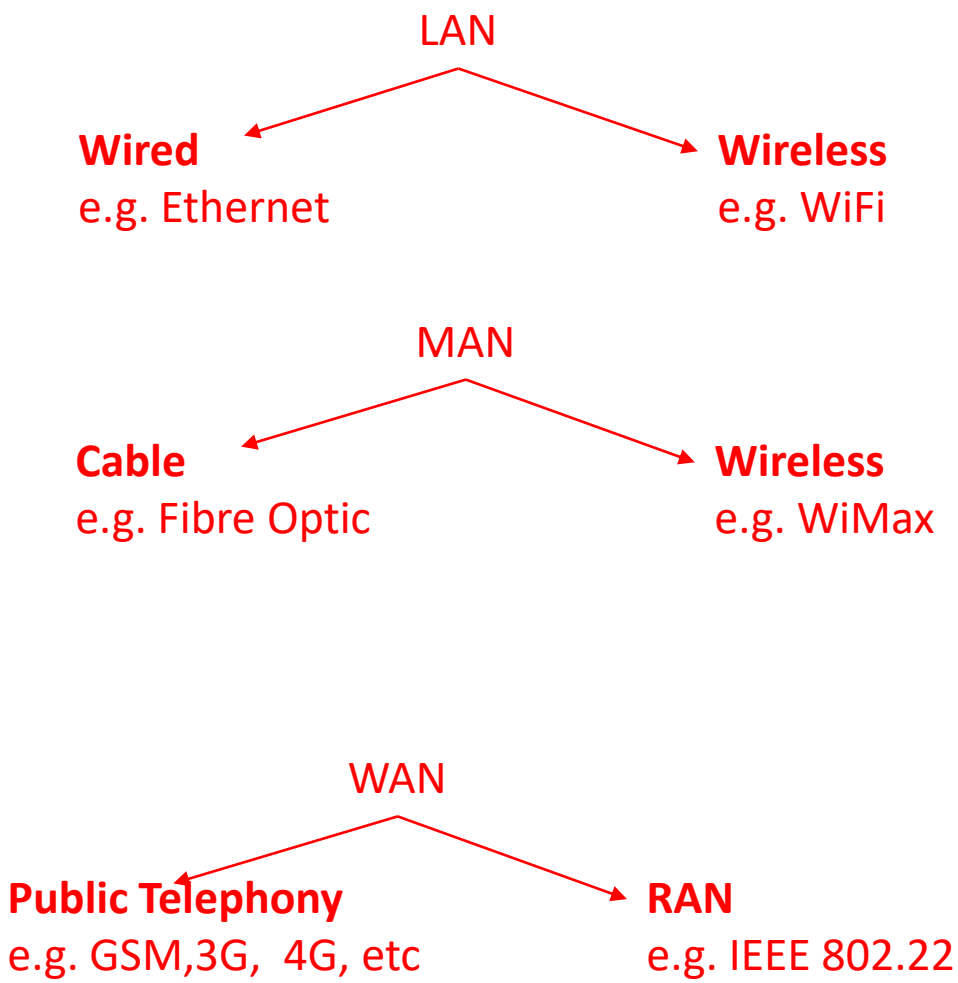
CATEGORIES OF NETWORKS

1. **Personal area network(PAN):** A computer network that enables communication between computer devices near a person. PANs can be wired, such as USB or FireWire, or they can be wireless, such as infrared, ZigBee, Bluetooth and ultrawideband(UWB).

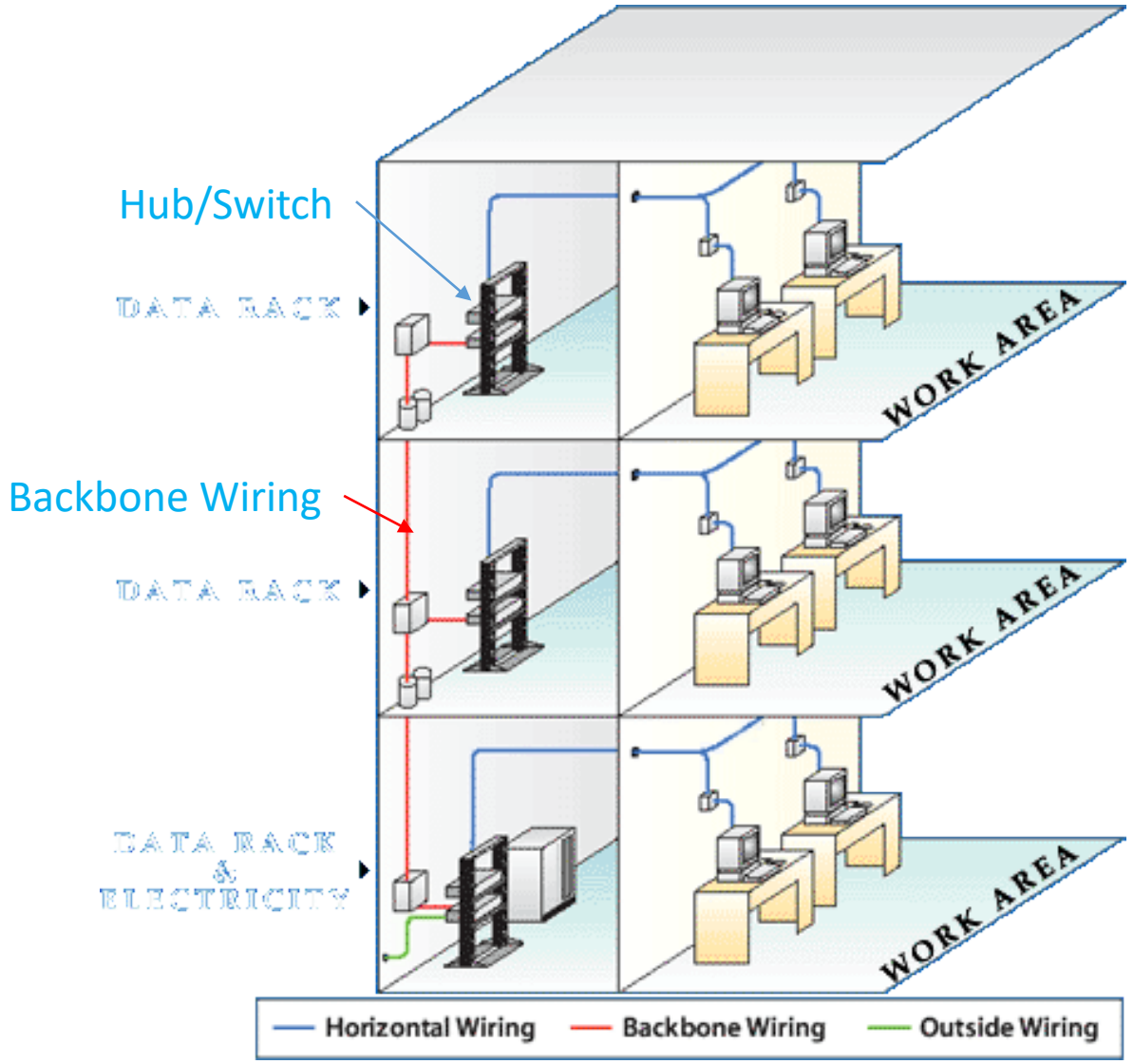
2. **Local Area Network(LAN):** A computer network that interconnects computers within a limited area such as a home, school, computer laboratory, or office building.

3. **Metropolitan Area Network (MAN):** A large computer network that spans a metropolitan area or campus. Its size falls between a WAN and LAN. MANs provide Internet connectivity for and connect them to wider area networks like the Internet.

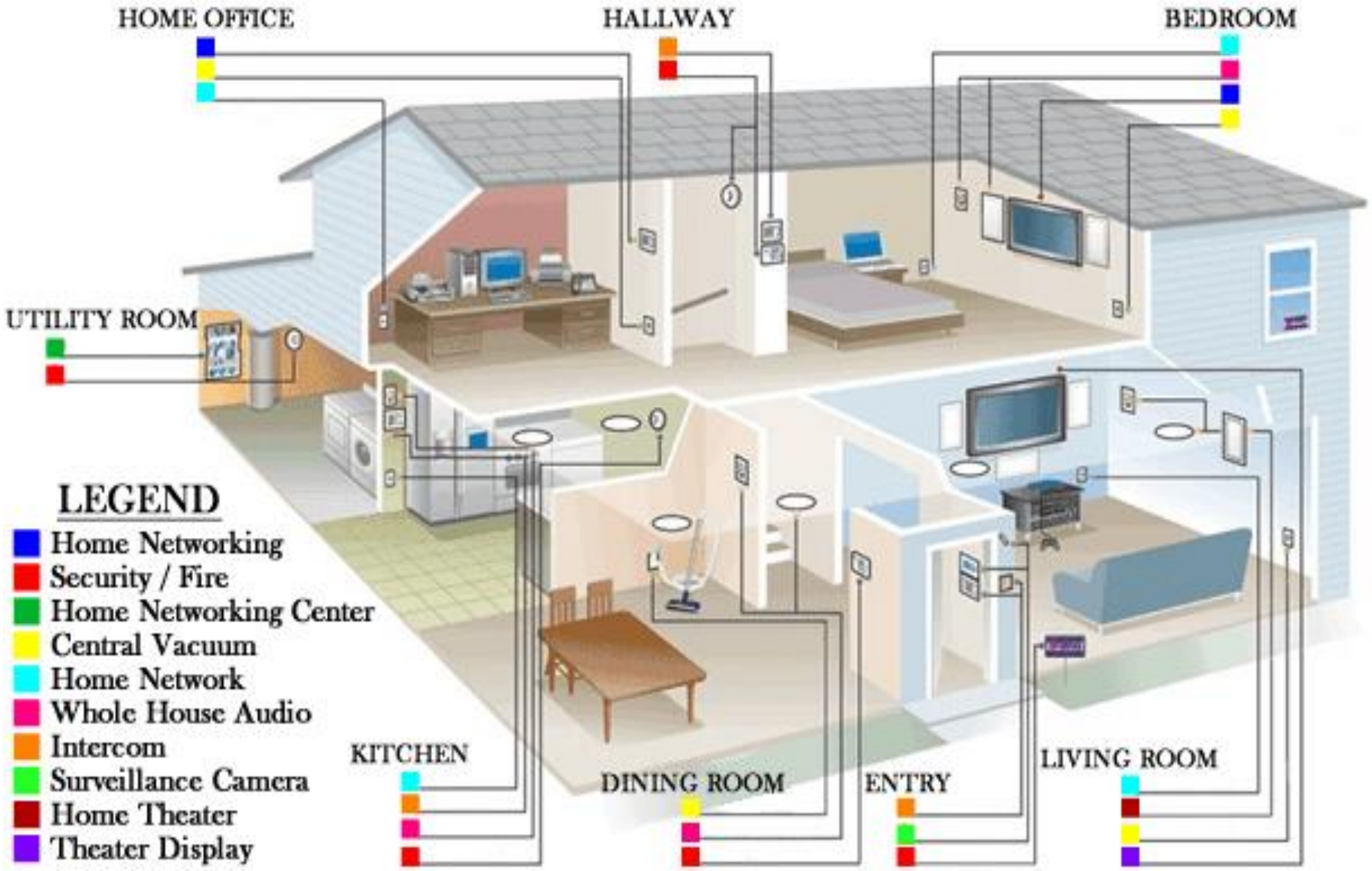
4. **Wide Area Networks(WAN):** A network that covers a broad area using public or leased telecommunication lines, e.g a corporate network, government network or the Internet.



LOCAL AREA NETWORK FOR COMMERCIAL PREMISES



LOCAL AREA NETWORK FOR RESIDENTIAL PREMISES



EXAMPLE: SECURITY SYSTEM IN A MODERN HOUSE