Every Byte Speaks the Glory of God

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Computer Networks

(IEE2072 & IBDA2022 – Jaringan Komputer)

Lecture #01 – Data Comm. & Networking

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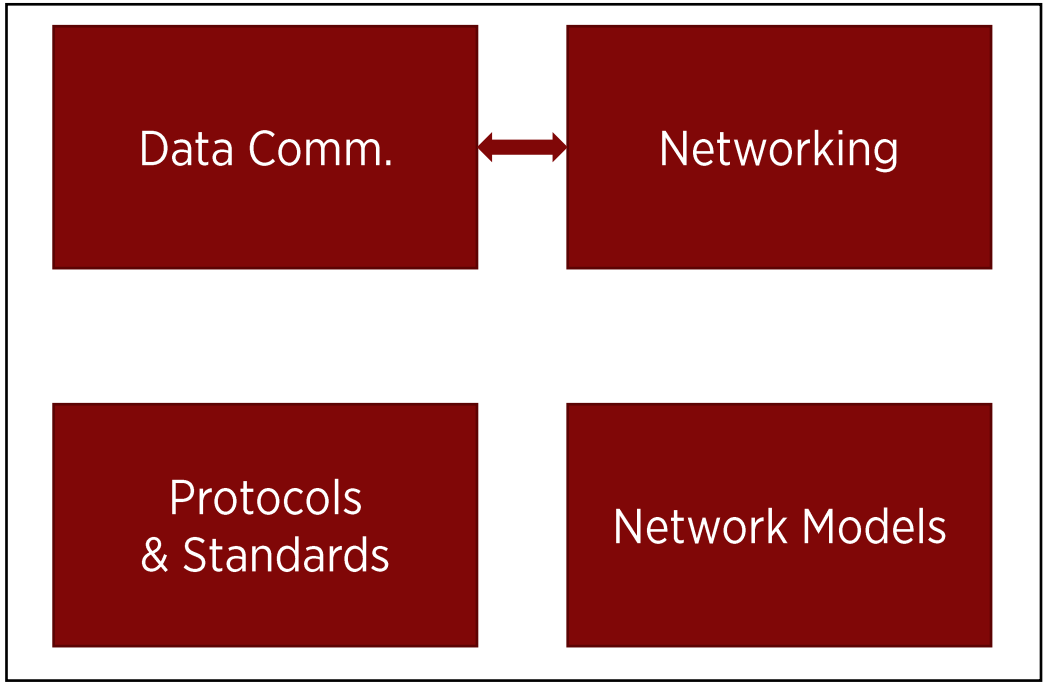
@eaJAN25

Learning Objectives

- Introduces data communications and their components.

- Introduces networks and defines their criteria and structures.

Major Concepts



Major Concepts

Data Comm.

Interchange of data/information between parties . .
. . through a process called *networking*
. . . so that data may be sent from one place to another

Networking

Data communications & Networking:
To understand basic concept such types of data, flow of data, error control / checking, etc..

Protocols & Standards

Protocols refer to the rules . . .
Standard refers to an adopted protocol . . .

Network Models

… serves to organize components (both HW/SW) of data communications and networking.
. . .also implying a relationship between networking and data communications.

DATA COMMUNICATIONS

Data Comm. (1): Game changing

What does it bring?

1. Daily lives: Who doesn't "communicate"?
   - Personal → Entertainment (gaming, music), Information (internet, , . . .
   - Professional → Business: Quick decisions, fast access, accurate information

2. Technology
   - Innovation in ICT: Prof. Covid19 (2020-2022)
     - Remote ("online"): WFH/O/A, tele-conferences, job interview, meetings, . . .
   - R&D: IPv4 vs. IPv6; text – audio – video; Wireless TCP; . . . .

3. What else?

Data Comm. (2): Terminology

- *Communication* (Greek: *commūnicāre / to share*) is the purposeful activity of information exchange between two or more participants, in order to convey or receive the intended meanings . . .

- *Tele* + communication = Telecommunication → communication at a distance

- *Data* refers to information presented in whatever form in which is agreed upon by the parties generating and using the data.

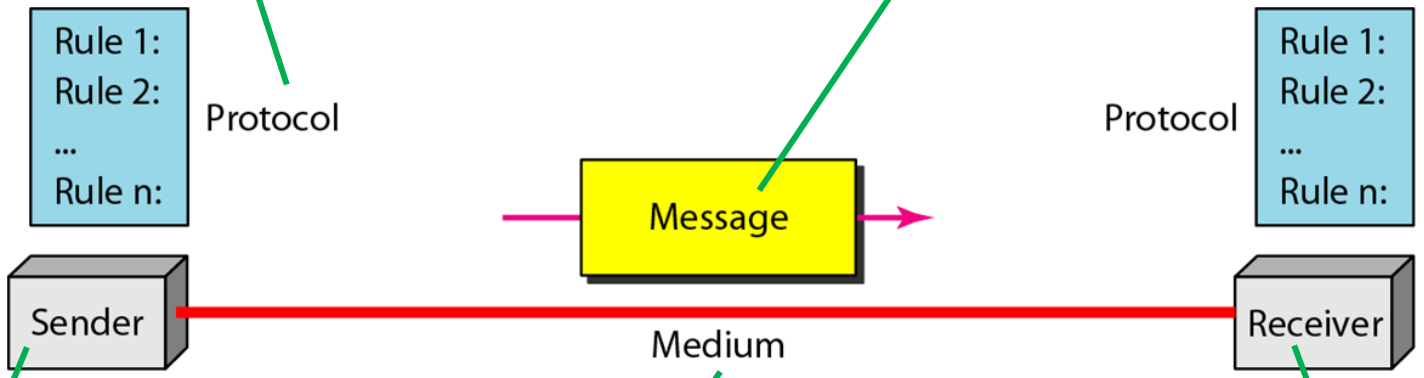
- *Data* ***communications*** are the exchange of data between two parties (usually called *Tx/Sender* and *Rx/Receiver*) via some form of transmission medium.
  - The communicating devices must be part of a communication system that is a combination of software (programs, protocols, . .) and hardware (physical equipment / device).

Data Comm. (3): Components

A set of rules that manage data communications;
an agreement between the communicating devices.

Without a protocol, two devices may be connected but not communicating

The information (data) to be communicated, such text, numbers, pictures, audio, video, etc..



Communicating device/person
Ex.: PC, telephone handset, video camera, etc

Communicating device/person
Similar to Sender, such workstation, appliances, television, and so on.

The physical path by which a message travels from sender to receiver. Ex. wires, cables, radio waves, etc..

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Data Comm. (4): Effectiveness

The effectiveness of a data communications (Forouzan, B. A.) system depends on:

- **Guaranteed delivery**
  Data must be received and only by the intended/requested device.

- **Accuracy**
  The data also needs to be accurate, not distorted! Noise/interference data are useless!

- **Timeliness**
  For the case of video/ audio, timely delivery means delivering data as they are (same order), and without significant delay. No need to be in real-time, but in acceptable time manner ("real-time").

- **Jitter**
  Jitter refers to the variation/un-even latency in the packet delivery.
  - It is very problematic in real-time communications (IP telephony, video conferencing, ..).
  - *For example, video packets are sent every 70 ms. What if some of the packets arrive with 90-ms delay and others with 50-ms delay?*

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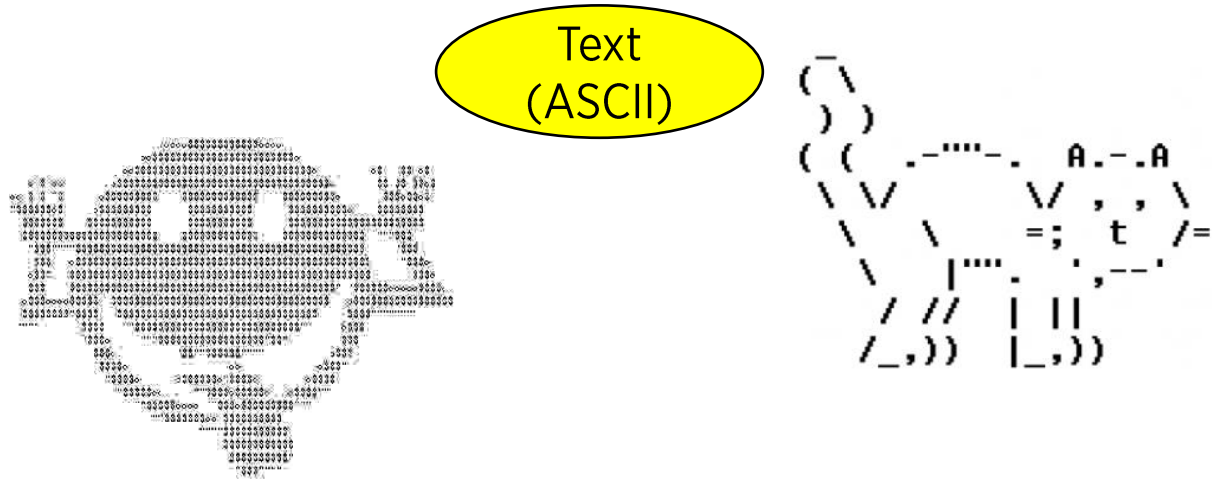
Data Representation

Data Representation (1): Text

- In data communications, text is represented as a bit pattern, a sequence of bits (0s or 1s).
- 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.

- The **American Standard Code for Information Interchange (ASCII)**, developed some decades ago in the United States, now constitutes the first 127 characters in Unicode and is also referred to as **Basic Latin**



ASCII

- **ASCII** (American Standard Code for Information Interchange) is a one byte code used to represent characters.

- **Standard ASCII** uses the low 7 bits and can represent 128 (2^7) characters.
  - The first 32 characters (00_h-$1F_h$) are not printable - they are control characters.
  - .. the rest are the 96 printable characters

Dec	Hx	Oct	Char	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr
0	0	000	NUL (null)	32	20	040		Space	64	40	100	@	@	96	60	140	`	`
1	1	001	SOH (start of heading)	33	21	041	!	!	65	41	101	A	A	97	61	141	a	a
2	2	002	STX (start of text)	34	22	042	"	"	66	42	102	B	B	98	62	142	b	b
3	3	003	ETX (end of text)	35	23	043	#	#	67	43	103	C	C	99	63	143	c	c
4	4	004	EOT (end of transmission)	36	24	044	$	$	68	44	104	D	D	100	64	144	d	d
5	5	005	ENQ (enquiry)	37	25	045	%	%	69	45	105	E	E	101	65	145	e	e
6	6	006	ACK (acknowledge)	38	26	046	&	&	70	46	106	F	F	102	66	146	f	f
7	7	007	BEL (bell)	39	27	047	'	'	71	47	107	G	G	103	67	147	g	g
8	8	010	BS (backspace)	40	28	050	(	(	72	48	110	H	H	104	68	150	h	h
9	9	011	TAB (horizontal tab)	41	29	051	)	)	73	49	111	I	I	105	69	151	i	i
10	A	012	LF (NL line feed, new line)	42	2A	052	*	*	74	4A	112	J	J	106	6A	152	j	j
11	B	013	VT (vertical tab)	43	2B	053	+	+	75	4B	113	K	K	107	6B	153	k	k
12	C	014	FF (NP form feed, new page)	44	2C	054	,	,	76	4C	114	L	L	108	6C	154	l	l
13	D	015	CR (carriage return)	45	2D	055	-	-	77	4D	115	M	M	109	6D	155	m	m
14	E	016	SO (shift out)	46	2E	056	.	.	78	4E	116	N	N	110	6E	156	n	n
15	F	017	SI (shift in)	47	2F	057	/	/	79	4F	117	O	O	111	6F	157	o	o
16	10	020	DLE (data link escape)	48	30	060	0	0	80	50	120	P	P	112	70	160	p	p
17	11	021	DC1 (device control 1)	49	31	061	1	1	81	51	121	Q	Q	113	71	161	q	q
18	12	022	DC2 (device control 2)	50	32	062	2	2	82	52	122	R	R	114	72	162	r	r
19	13	023	DC3 (device control 3)	51	33	063	3	3	83	53	123	S	S	115	73	163	s	s
20	14	024	DC4 (device control 4)	52	34	064	4	4	84	54	124	T	T	116	74	164	t	t
21	15	025	NAK (negative acknowledge)	53	35	065	5	5	85	55	125	U	U	117	75	165	u	u
22	16	026	SYN (synchronous idle)	54	36	066	6	6	86	56	126	V	V	118	76	166	v	v
23	17	027	ETB (end of trans. block)	55	37	067	7	7	87	57	127	W	W	119	77	167	w	w
24	18	030	CAN (cancel)	56	38	070	8	8	88	58	130	X	X	120	78	170	x	x
25	19	031	EM (end of medium)	57	39	071	9	9	89	59	131	Y	Y	121	79	171	y	y
26	1A	032	SUB (substitute)	58	3A	072	:	:	90	5A	132	Z	Z	122	7A	172	z	z
27	1B	033	ESC (escape)	59	3B	073	;	;	91	5B	133	[	[	123	7B	173	{	{
28	1C	034	FS (file separator)	60	3C	074	<	<	92	5C	134	\	\	124	7C	174			|
29	1D	035	GS (group separator)	61	3D	075	=	=	93	5D	135	]	]	125	7D	175	}	}
30	1E	036	RS (record separator)	62	3E	076	>	>	94	5E	136	^	^	126	7E	176	~	~
31	1F	037	US (unit separator)	63	3F	077	?	?	95	5F	137	_	_	127	7F	177	&#127;	DEL

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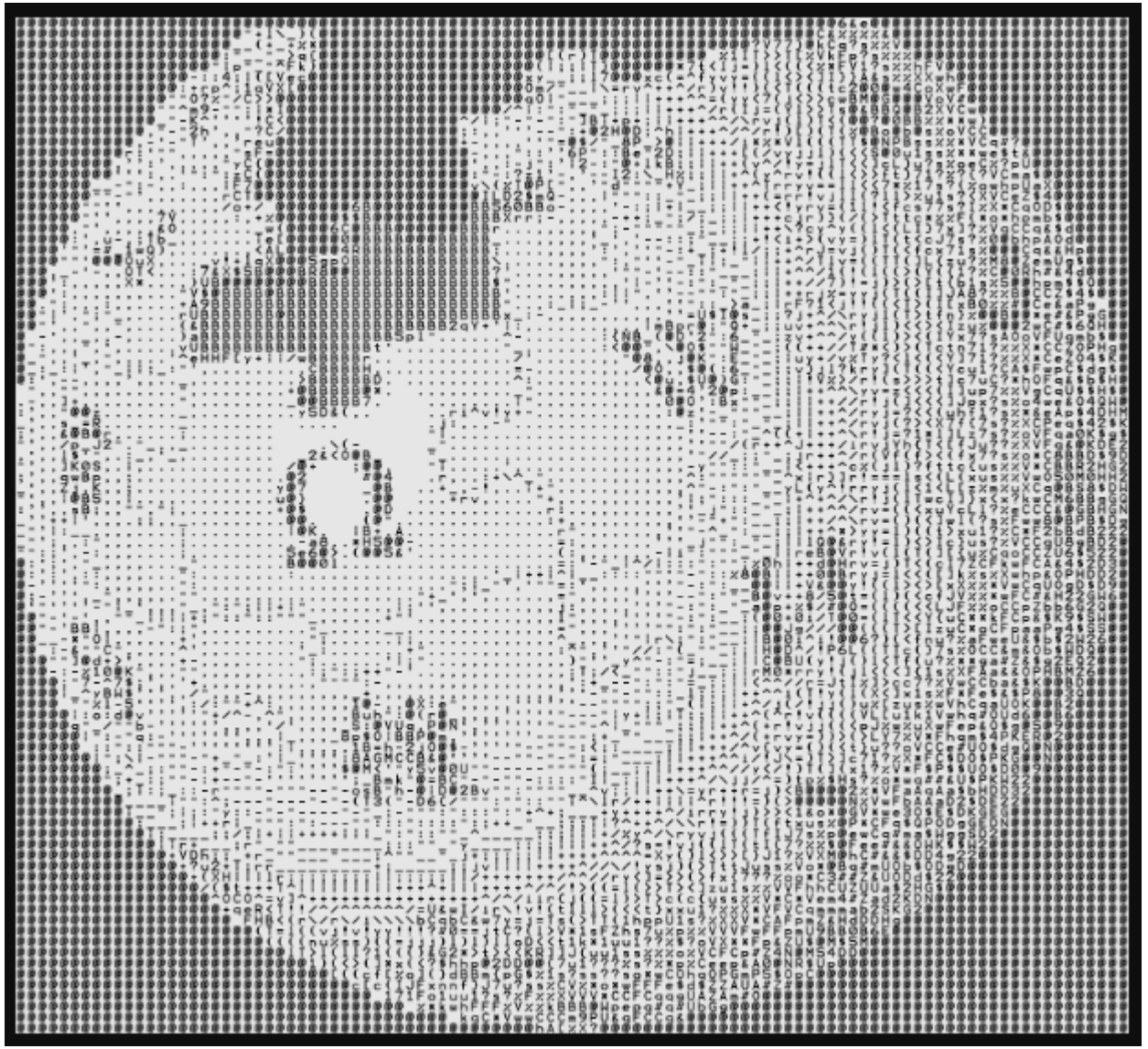
Extended ASCII

- The eighth bit (high bit, leftmost bit, bit 7) of an ASCII byte can be mapped to one of many possible "code pages" (extended character set) of which there are many.

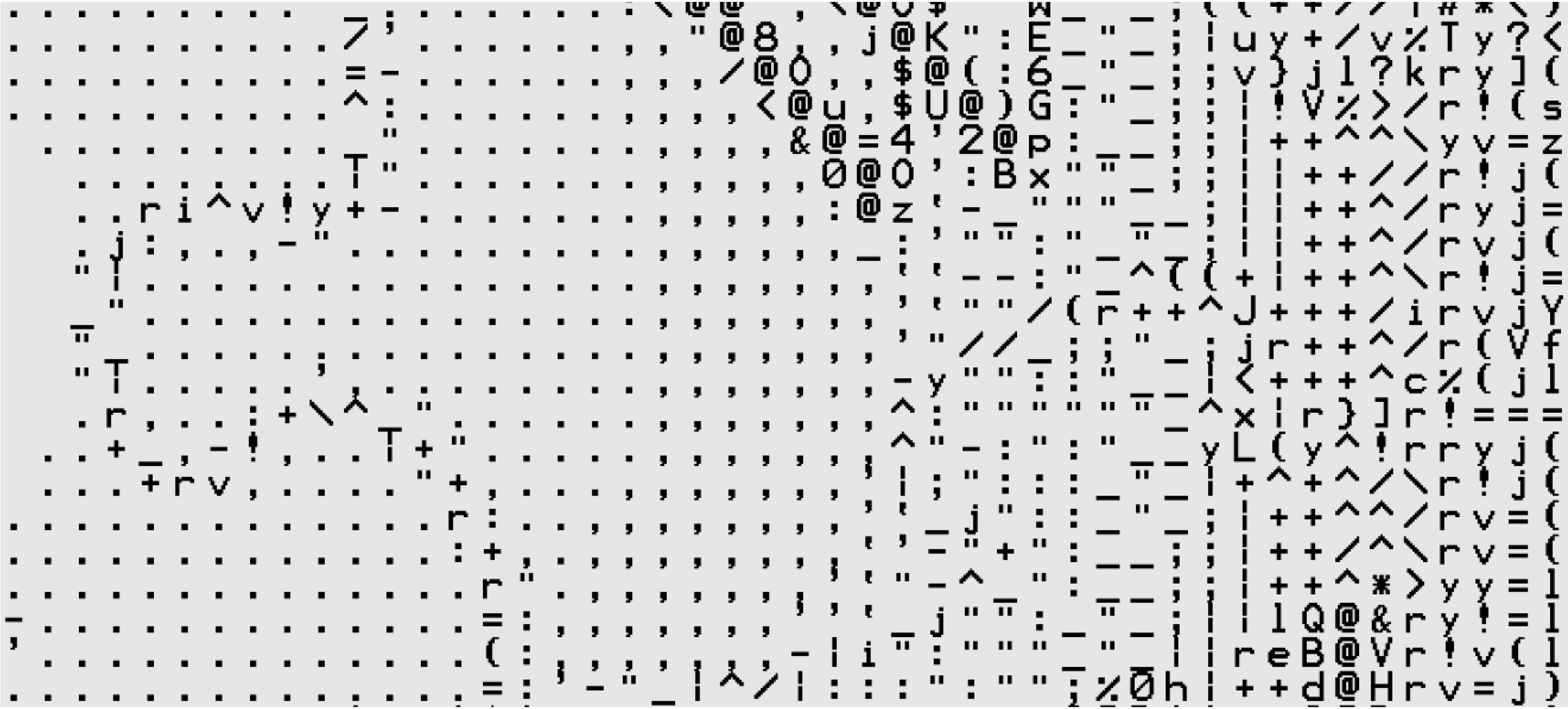
- Code pages include codes for Hebrew, Greek, Arabic, Cyrilic, Chinese, Japanese or whatever symbol set you define, BUT you can use one code page at a time.
  - This means that you can't use Japanese characters and Chinese characters at the same time

Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char
128	80	Ç	160	A0	á	192	C0	└	224	E0	α
129	81	ü	161	A1	í	193	C1	┴	225	E1	ß
130	82	é	162	A2	ó	194	C2	┬	226	E2	Γ
131	83	â	163	A3	ú	195	C3	├	227	E3	π
132	84	ä	164	A4	ñ	196	C4	─	228	E4	Σ
133	85	à	165	A5	Ñ	197	C5	┼	229	E5	σ
134	86	å	166	A6	ª	198	C6	╞	230	E6	µ
135	87	ç	167	A7	º	199	C7	╟	231	E7	τ
136	88	ê	168	A8	¿	200	C8	╚	232	E8	Φ
137	89	ë	169	A9	⌐	201	C9	╔	233	E9	Θ
138	8A	è	170	AA	¬	202	CA	╩	234	EA	Ω
139	8B	ï	171	AB	½	203	CB	╦	235	EB	δ
140	8C	î	172	AC	¼	204	CC	╠	236	EC	∞
141	8D	ì	173	AD	¡	205	CD	═	237	ED	ø
142	8E	Ä	174	AE	«	206	CE	╬	238	EE	ε
143	8F	Å	175	AF	»	207	CF	╧	239	EF	∩
144	90	É	176	B0	░	208	D0	╨	240	F0	≡
145	91	æ	177	B1	▒	209	D1	╤	241	F1	±
146	92	Æ	178	B2	▓	210	D2	╥	242	F2	≥
147	93	ô	179	B3	│	211	D3	╙	243	F3	≤
148	94	ö	180	B4	┤	212	D4	╘	244	F4	⌠
149	95	ò	181	B5	╡	213	D5	╒	245	F5	⌡
150	96	û	182	B6	╢	214	D6	╓	246	F6	÷
151	97	ù	183	B7	╖	215	D7	╫	247	F7	≈
152	98	ÿ	184	B8	╕	216	D8	╪	248	F8	°
153	99	Ö	185	B9	╣	217	D9	┘	249	F9	∙
154	9A	Ü	186	BA	║	218	DA	┌	250	FA	·
155	9B	¢	187	BB	╗	219	DB	█	251	FB	√
156	9C	£	188	BC	╝	220	DC	▄	252	FC	ⁿ
157	9D	¥	189	BD	╜	221	DD	▌	253	FD	²
158	9E	₧	190	BE	╛	222	DE	▐	254	FE	■
159	9F	ƒ	191	BF	┐	223	DF	▀	255	FF	

ASCII Art (1/2)



ASCII Art (2/2)



Data Representation (2): Numbers

- Numbers are also represented by bit patterns.
- However, a code such as ASCII is not used to represent numbers; the number is directly converted to a binary number to simplify mathematical operations.

Numbers
(Binary, Hex)

DEC	OCT	HEX	BIN	Symbol	HTML Number	HTML Name	Description
48	060	30	00110000	0	&#48;		Zero
49	061	31	00110001	1	&#49;		One
50	062	32	00110010	2	&#50;		Two
51	063	33	00110011	3	&#51;		Three
52	064	34	00110100	4	&#52;		Four
53	065	35	00110101	5	&#53;		Five
54	066	36	00110110	6	&#54;		Six
55	067	37	00110111	7	&#55;		Seven
56	070	38	00111000	8	&#56;		Eight
57	071	39	00111001	9	&#57;		Nine

Data Representation (3): Images

- **Images** are also represented by bit patterns. In its simplest form, an image is composed of a matrix of pixels (picture elements), where each pixel is a small dot.

- After an image is divided into pixels, each pixel is assigned a bit pattern. The size and the value of the pattern depend on the image.

- For example: Four levels of gray scale, we can use 2-bit patterns

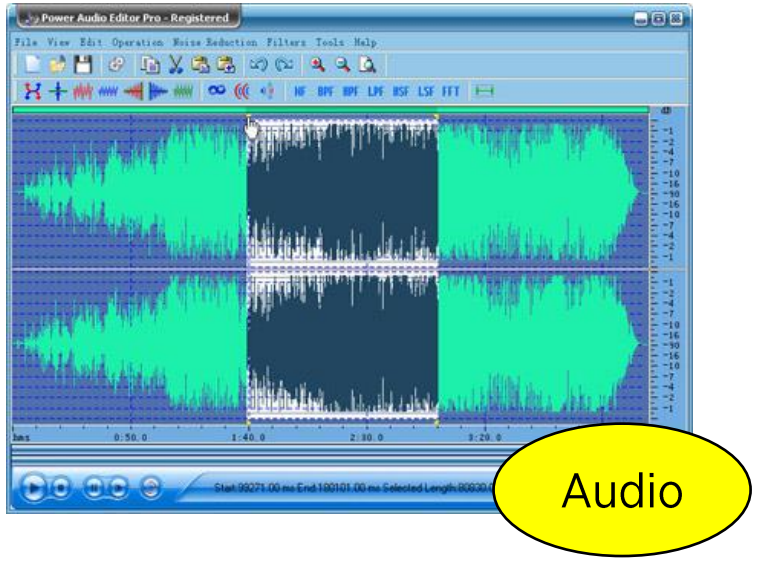
More info:
There are several methods to represent color images.

- One method is called **RGB,** so called because each color is made of a combination of three primary colors: *r*ed, *g*reen, and *b*lue. The intensity of each color is measured, and a bit pattern is assigned to it.
- Another method is called **YCM,** in which a color is made of a combination of three other primary colors: *y*ellow, *c*yan, and *m*agenta

Data Representation (4): Audio & Video

Audio refers to the recording or broadcasting of sound or music.

- Audio is by nature different from text, numbers, or images.
- It is continuous, not discrete.
- Even when we use a microphone to change voice or music to an electric signal, we create a continuous signal.



Video refers to the recording or broadcasting of a picture or movie.

- Video can either be produced as a continuous entity (e.g., by a TV camera), or it can be a combination of images, each a discrete entity, arranged to convey the idea of motion.

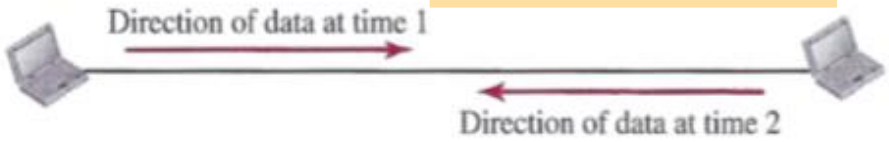
Data Flow

Data Flow

SIMPLEX

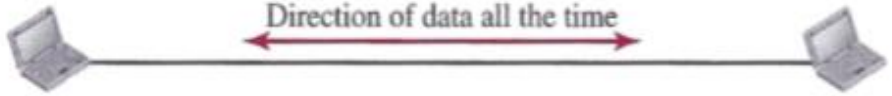
- Unidirectional, as on a one-way street. Only one (of the users) can transmit
- Use the entire capacity of the channel to send data in one direction.
- Ex. keyboards, monitors...

HALF-DUPLEX



- Each party can both sending and receiving, but not at the same time
- The entire channel is taken over by the party who is transmitting
- Ex. Walkie-talkies

FULL-DUPLEX / DUPLEX



- Both stations can transmit and receive simultaneously.
- Signals are shared between both parties:
  a. the link must have two physically separate transmission paths
  b. or the capacity of the channel is divided between signals traveling in both parties
- Ex. telephone network

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NETWORKS

Network: Definition

- A network is the interconnection of a set of devices, capable of doing communication.

- The devices can be:
  - a host (end-system) such as PCs, cellular phone, or security system.
  - a connecting device can be a router, switch, . .

- These devices in a network are connected using wired or wireless transmission media, such as cable or air.

Network Criteria

Network: Criteria (1)

- A network must be able to meet a certain number of criteria. The most important of these are performance, reliability, and security.

Performance

- Transit time - the amount of time required for a message to travel from one device to another.
- Response time - the elapsed time between an inquiry and a response.
- Other factors: number of users, type of medium (wired/wireless), hardware or software used, . . .
- Throughput (TP) / Goodput (GP)
- Delay
- Others . . .

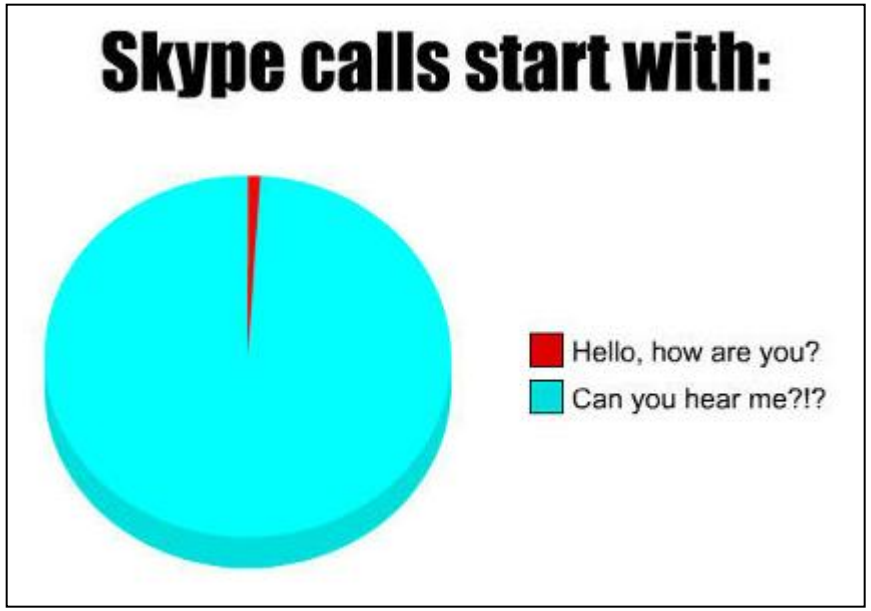
Note:
There are trade-offs between TP/GP and Delay. For example, when we want to send more data to the network, we may increase throughput but the delay will also increase due to the traffic congestion in the network.

Network: Criteria (2)

Reliability

- Network **reliability** is measured by the frequency of failure, the time it takes a link to recover from a failure, and the network's robustness in a catastrophe
- A reliable protocol is bounded to the delivery of data to the intended recipient(s).

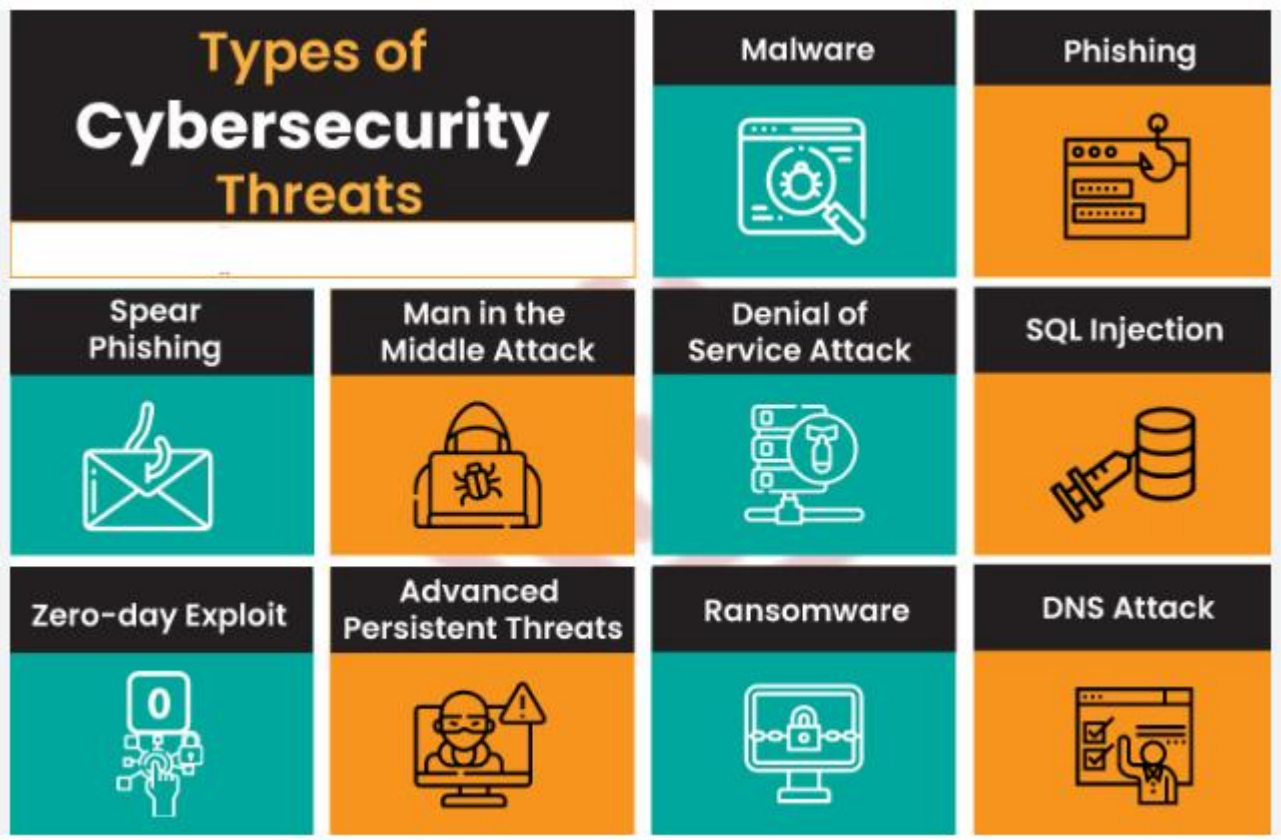
- Example of reliable protocol is TCP (the main protocol used on the internet) as opposed to UDP (situations where speed is preferable than loss of data, i.e. voice and video traffic, computer games, etc..).



Network: Criteria (3)

Security

- Network security issues include authorization of access to data in a network, protecting data from damage and development, and adopting policies to prevent unauthorized access from breaches and data losses.

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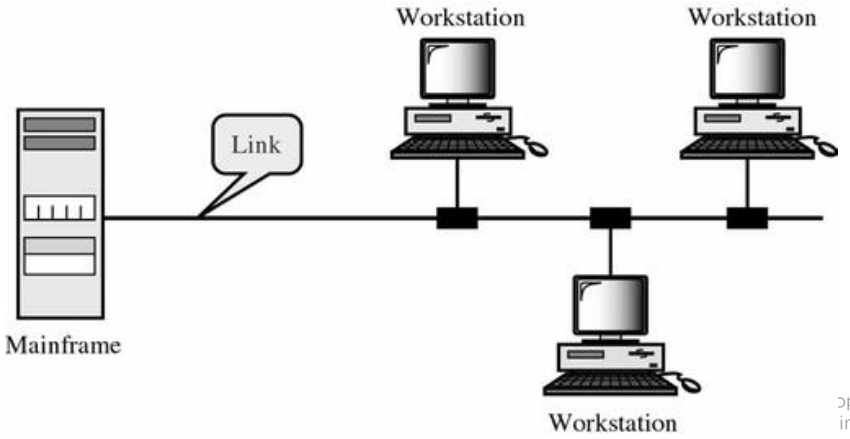
Network Attributes

Network: Attributes (1)

Type of Connection

Point-to-Point

- A point-to-point connection provides a dedicated link between two devices.
- The entire capacity of the link is reserved for transmission between those two devices.
- Examples: IR Remote control, satellite link, . . .



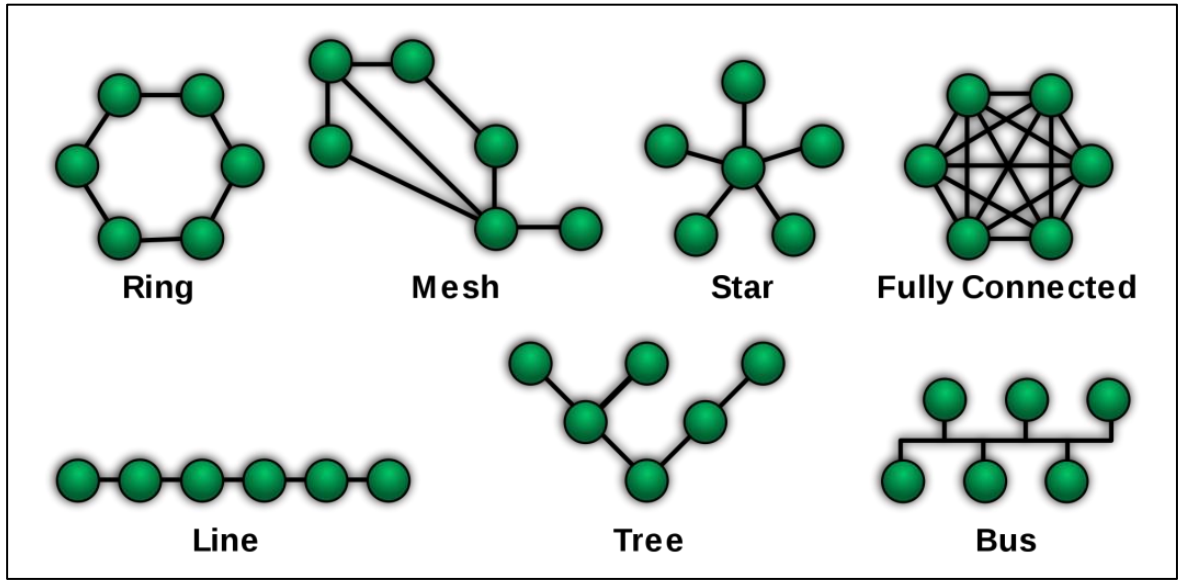
Multi-point

- A connection in which more than two specific devices share a single link
- The capacity of the channel is shared, either spatially (simultaneously) or temporally (time-sharing).

Network: Attributes (2)

(Physical) Topology

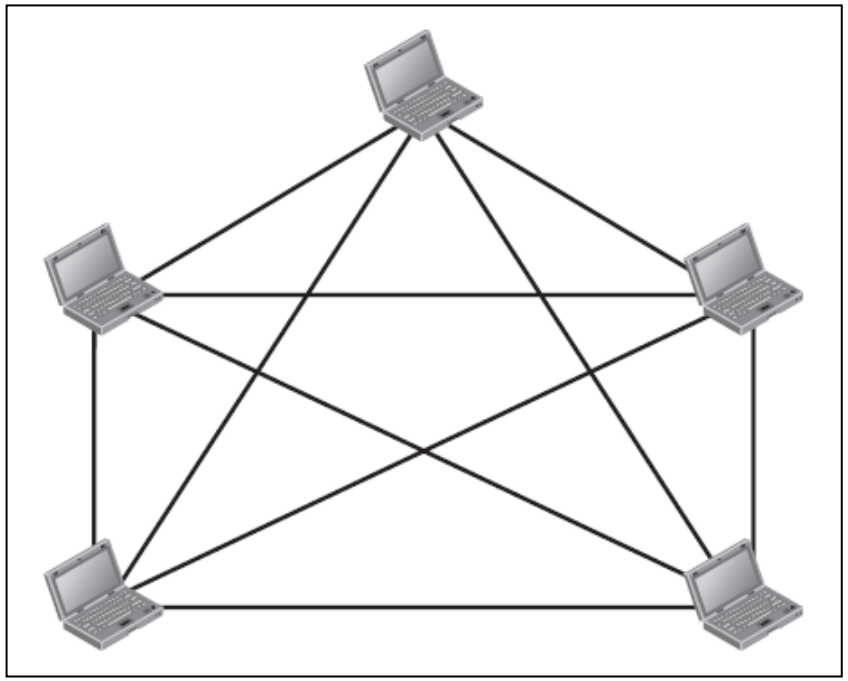
- When two or more devices connect they form a link; two or more links form a topology.
- The topology of a network is the geometric representation of the relationship of all the links and linking devices (usually called nodes) to one another..
- There are several topologies possible . . . .



MESH Topology (1/2)

- In a mesh topology, every device has a dedicated point-to-point link to every other device.

- The term *dedicated* means that the link carries traffic only between the two devices it connects.



Example of (fully connected) mesh* topology

**The term "mesh" does not always mean all links are connected. It depends on the scenario*

MESH Topology (2/2)

Advantages

- Dedicated links much better than shared links: reliable connection (wired vs. wireless); privacy; security
- Robust ➔ If one link becomes unusable, it does not incapacitate the entire system.
- Fault identification and fault isolation is relatively easy. Traffic can be routed to avoid links with suspected problems. This facility enables the network manager to discover the precise location of the fault and aids in finding its cause and solution.

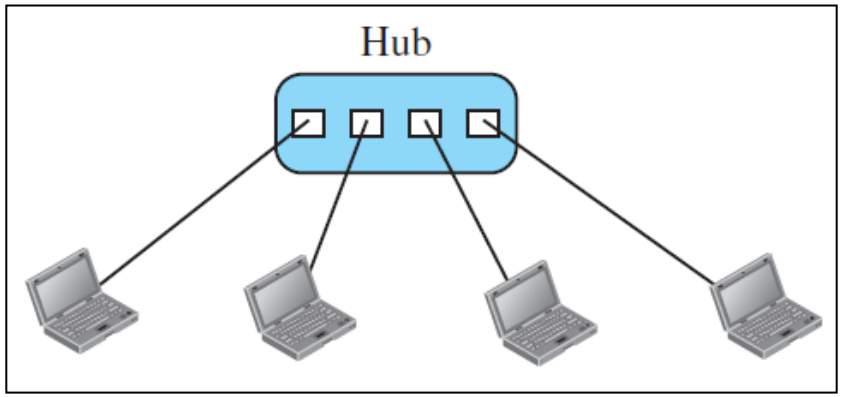
Disadvantages

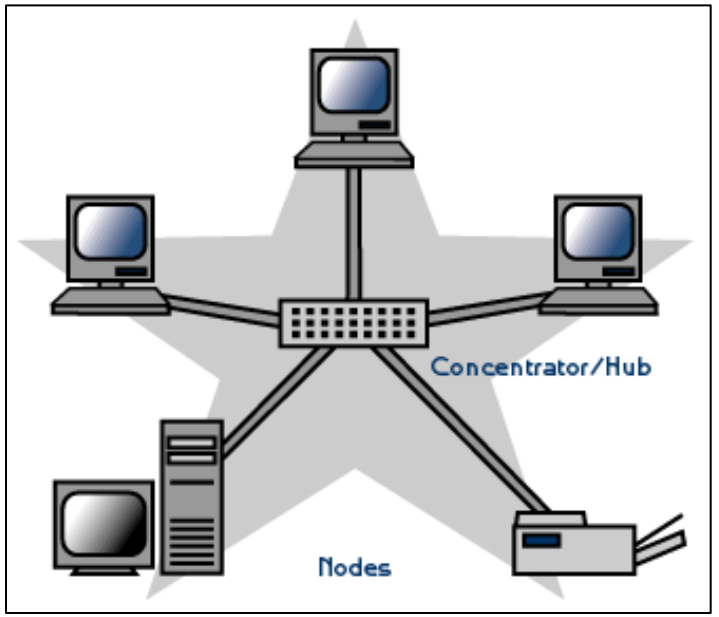
- the amount of cabling or I/O ports required → installation, reconnection
- Wiring is everywhere
- Hardware → budget & cost of maintenance/deploying/upgrade

For these reasons a mesh topology is usually implemented in a limited fashion, for example, as a backbone connecting the main computers of a hybrid network that can include several other topologies.

STAR Topology

- In a star topology, each device has a dedicated point-to-point link only to a central controller, usually called a hub.

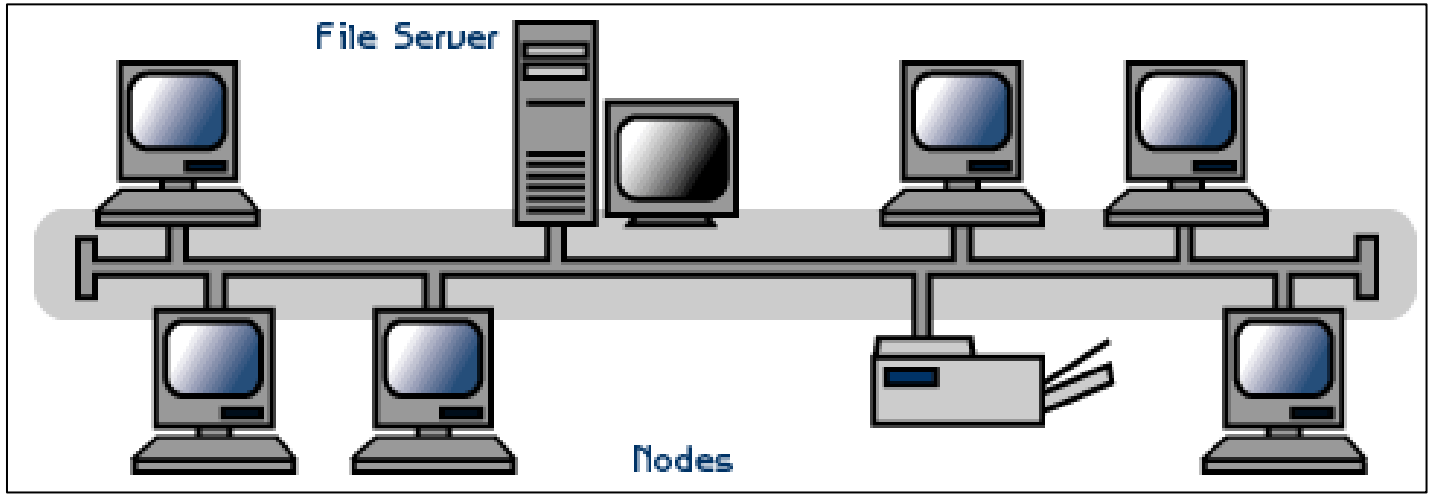




- The devices are not directly linked to one another.
- Unlike a mesh topology, a star topology does **not** allow direct traffic between devices. The controller (Hub) acts as an exchange: If one device wants to send data to another, it sends the data to the controller, which then relays the data to the other connected device.
- Can you think of its advantages & disadvantages?

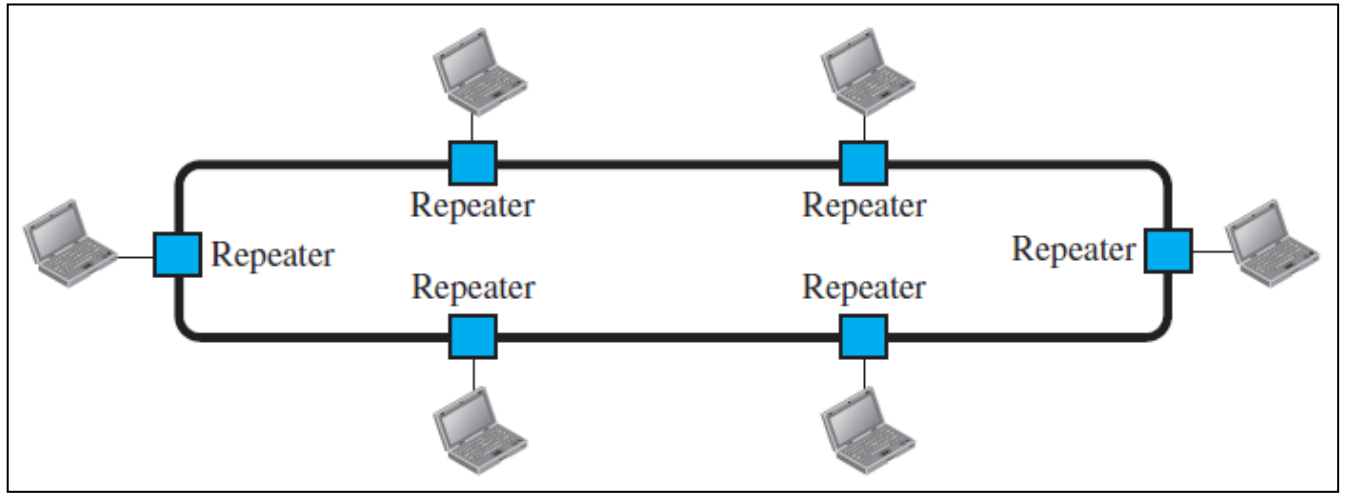
BUS Topology

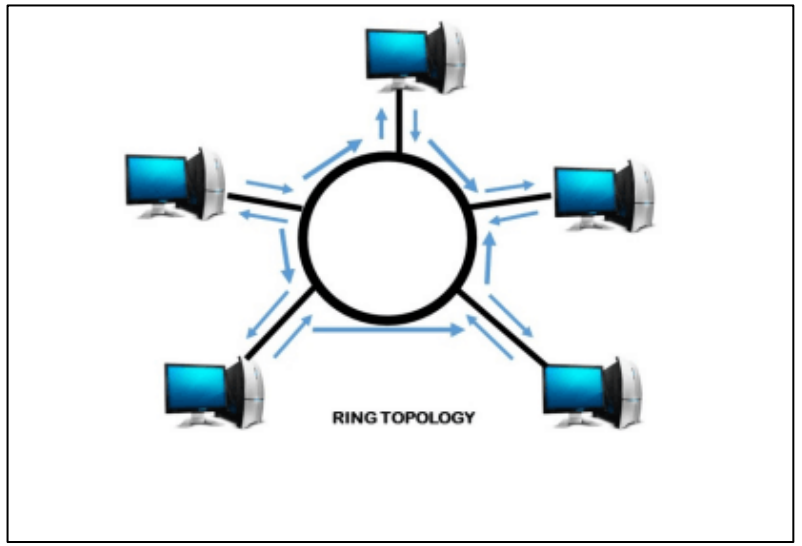
- The preceding examples all describe point-to-point connections.
- A (linear) bus topology, on the other hand, is multipoint. One long cable acts as a backbone to link all the devices in a network



RING Topology

- In a ring topology, each device has a dedicated point-to-point connection with only the two devices on either side of it.

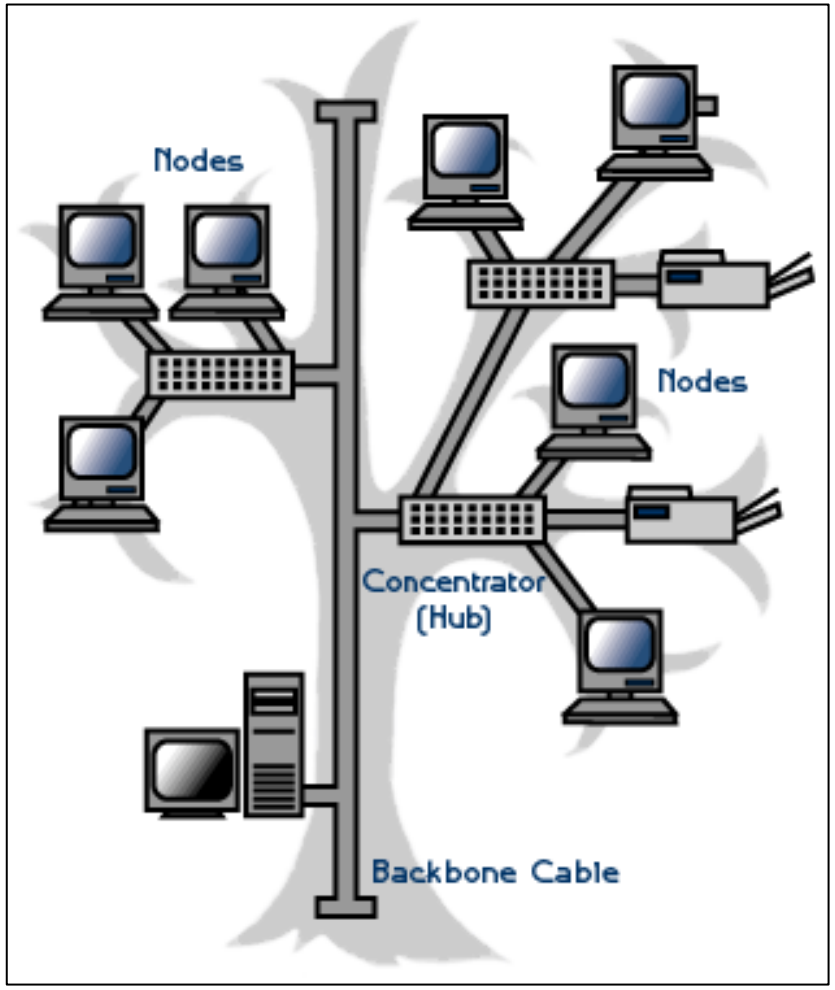




- A signal is passed along the ring in one direction, from device to device, until it reaches its destination. Each device in the ring incorporates a repeater.
- The *unidirectional traffic* can be a disadvantage.
  - In a simple ring, a break in the ring (such as a disabled station) can disable the entire network.
  - This weakness can be solved by using a dual ring or a switch capable of closing off the break.

TREE Topology

- A tree topology combines characteristics of linear bus and star topologies.
- It consists of groups of star workstations connected to a linear bus backbone cable.
- Tree topologies allow for the expansion of an existing network, and enable schools to configure a network to meet their needs

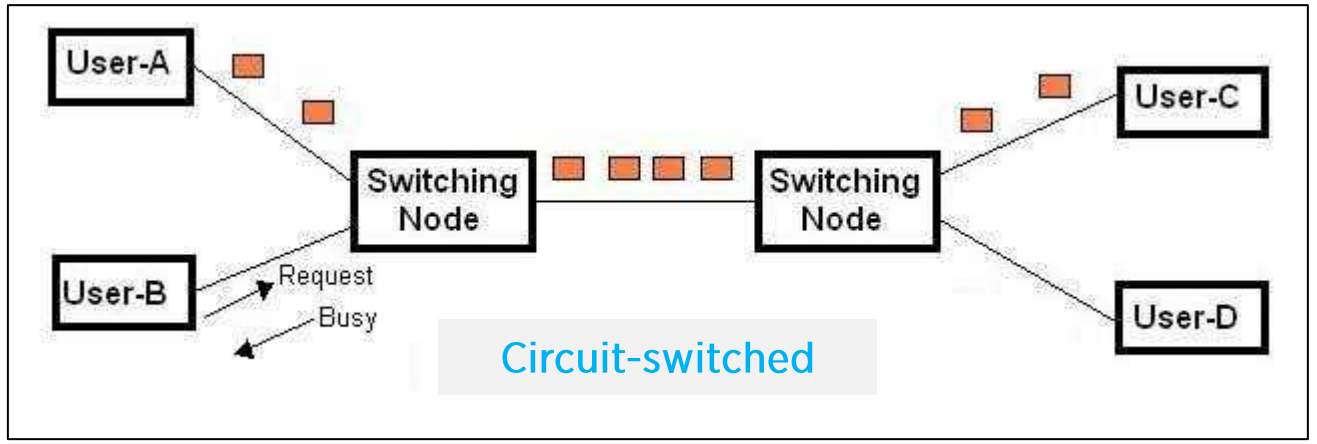


Network: Attributes (3)

Switching

- An internet is a switched network in which a switch connects at least two links together.
- A switch needs to forward data from a network to another network when required.

- In a circuit-switched network, a dedicated connection, called a circuit, is always available between the two end-system; the switch can only make it active or inactive. Circuit switching was very common in telephone networks in the past.



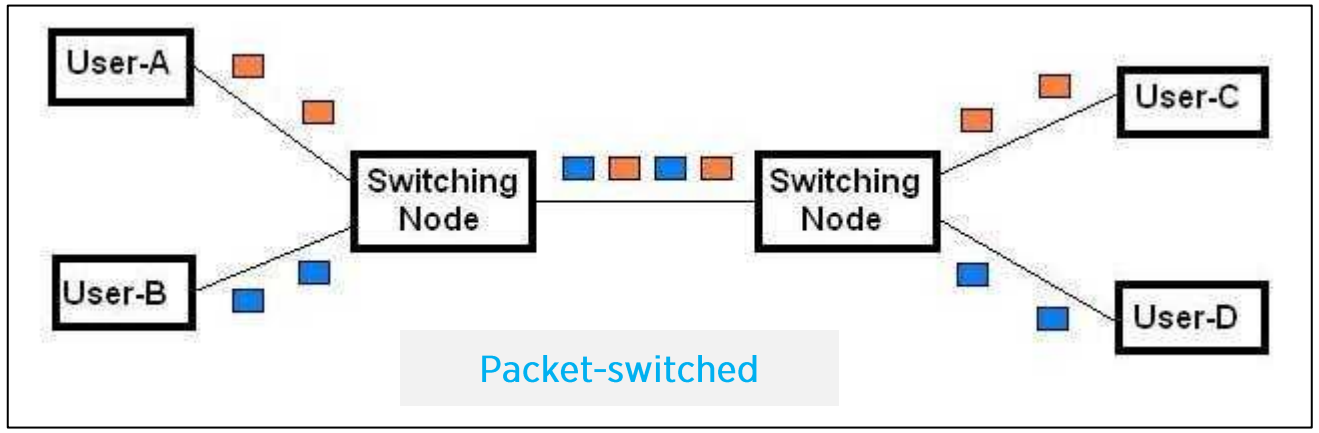
A very simple switched network that connects two users to each end.

Network: Attributes (3)

- In a computer network, the communication between the two ends is done in blocks of data called *packets*.

- Instead of the continuous communication between two users (*A to C* or *B to D* only), it is possible to send simultaneously for A and B to send data to C to D.

- How?
  The information is padded with header which contains addresses of source and destination. This header is sniffed by intermediate switching nodes to determine their route and destination. This is called packet-switched network.



to be continued . .