Data Communication

Data Communication is the exchange of information from one entity to the other using a Transmission Medium.

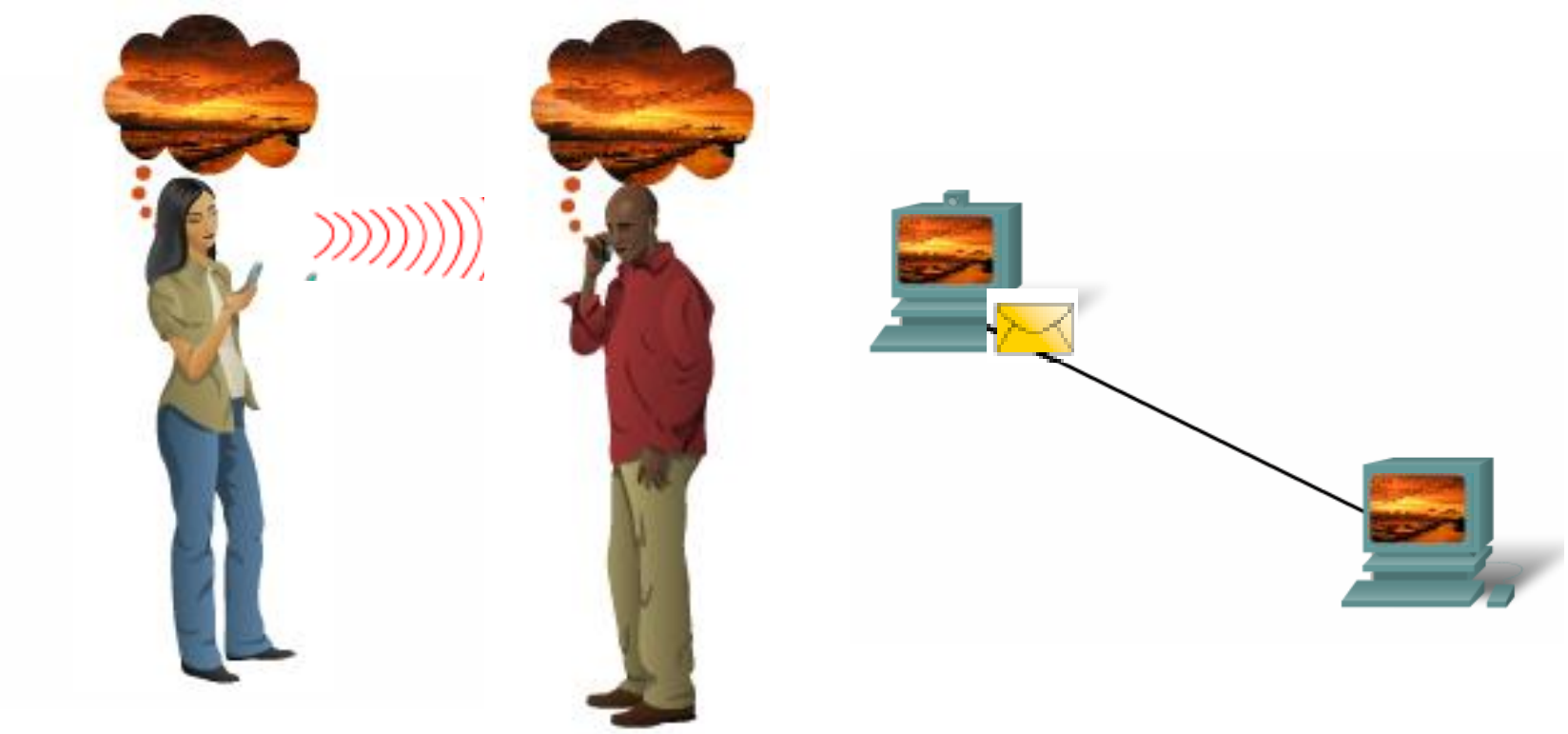
Data Communication

- **1883: Samuel Morse & Alfred Veil invent Morse Code Telegraph System**
- **1876: Alexander Graham Bell invented Telephone**
- **1930: Development of ASCII Transmission Code**
- **1950: IBM releases its first computer IBM 710**
- **1960: IBM releases the First Commercial Computer IBM 360**

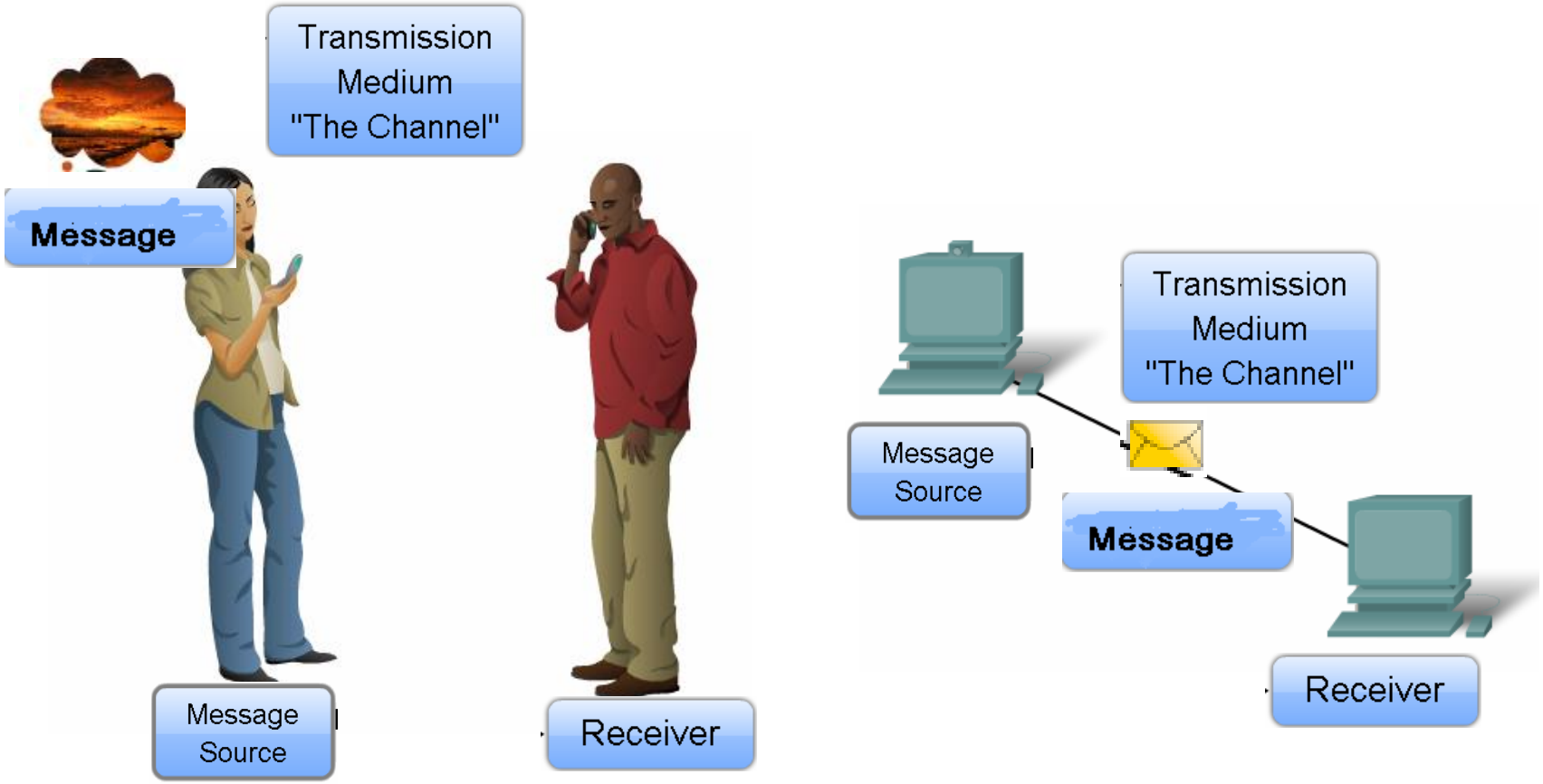
Data Communication Definition (Modified)

Data Communication is the exchange of data (in the form of 0's and 1's) between two devices (computers) via some form of the transmission medium.

Elements of Communication

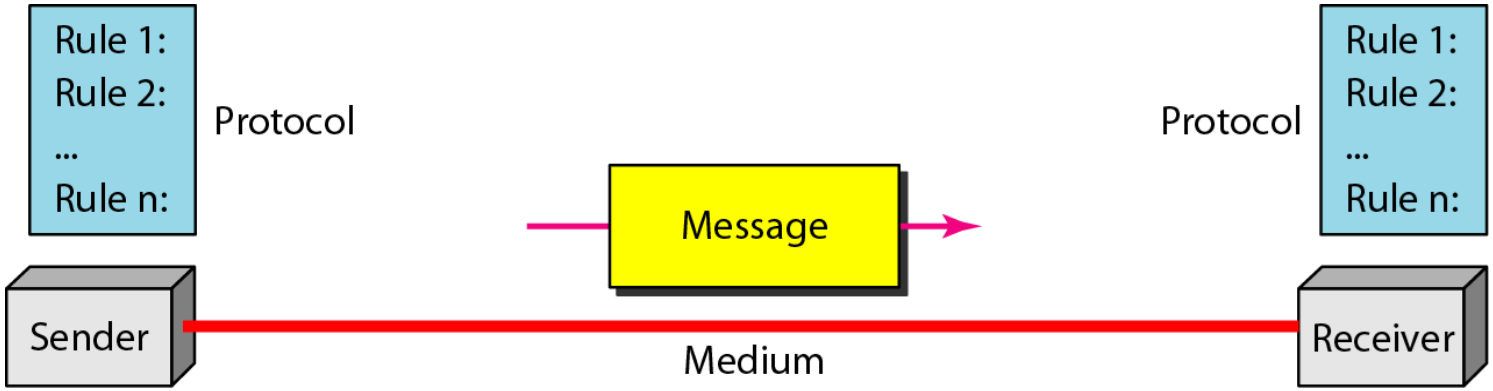


Elements of Communication



- What are the elements?

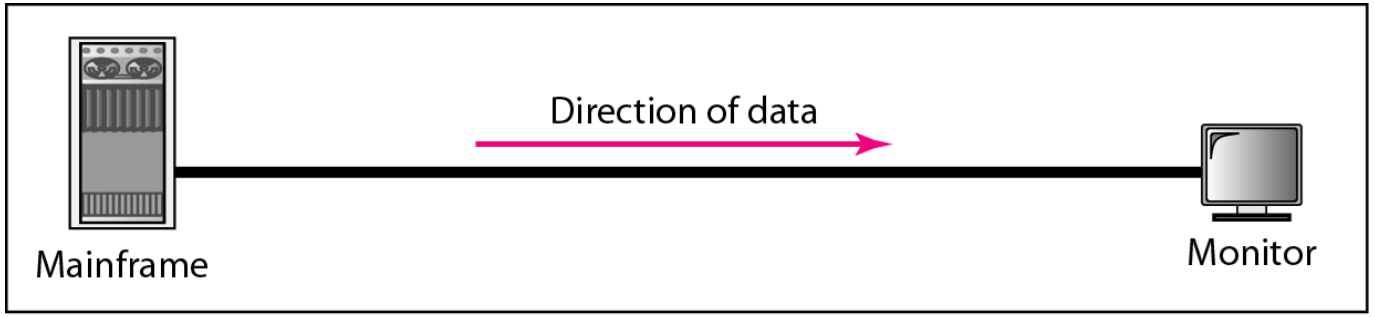
Five elements/components of data communication



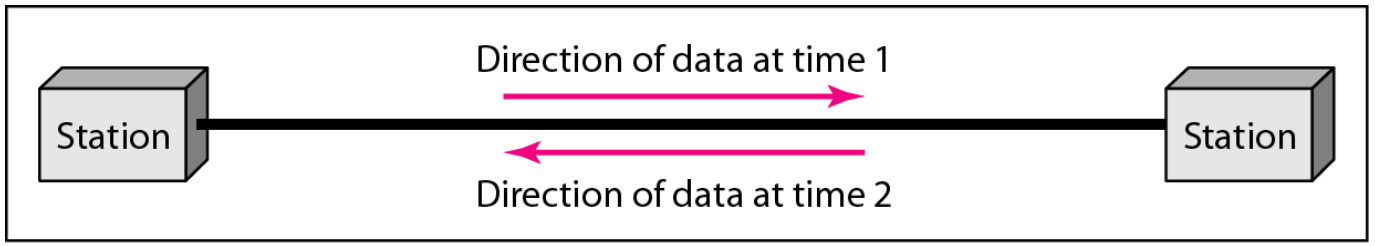
Elements of Communication over Networks

- **Devices (Sender/Receiver)**
  - These are used to communicate with one another
- **Medium**
  - This is how the devices are connected together
- **Messages**
  - Information that travels over the medium
- **Rules/Protocols**
  - Governs how messages flow across network

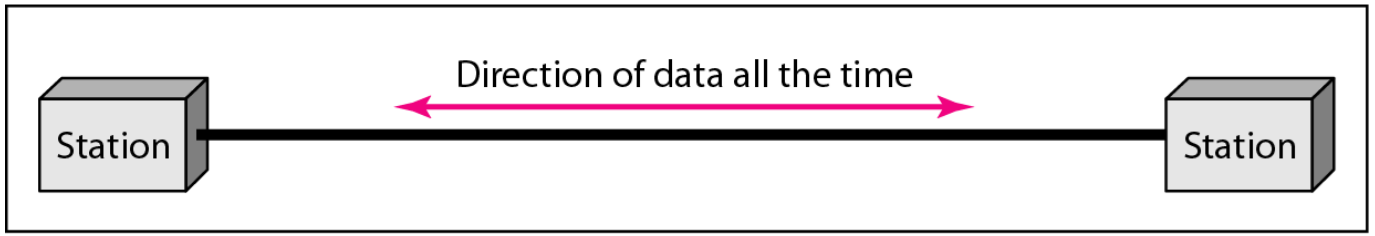
Transmission Mode / Data flow (simplex, half-duplex, and full-duplex)



a. Simplex

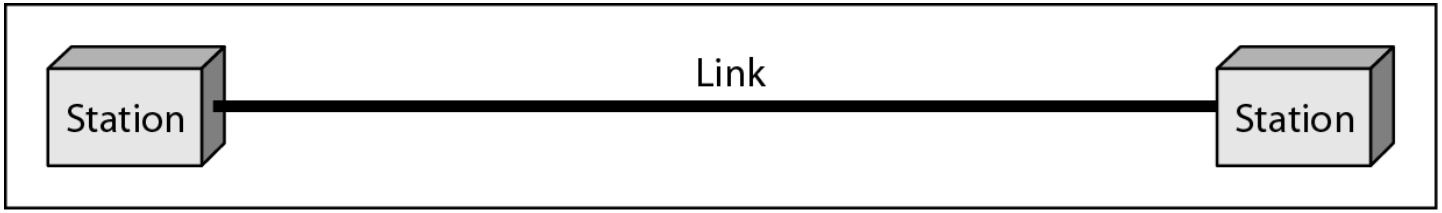


b. Half-duplex

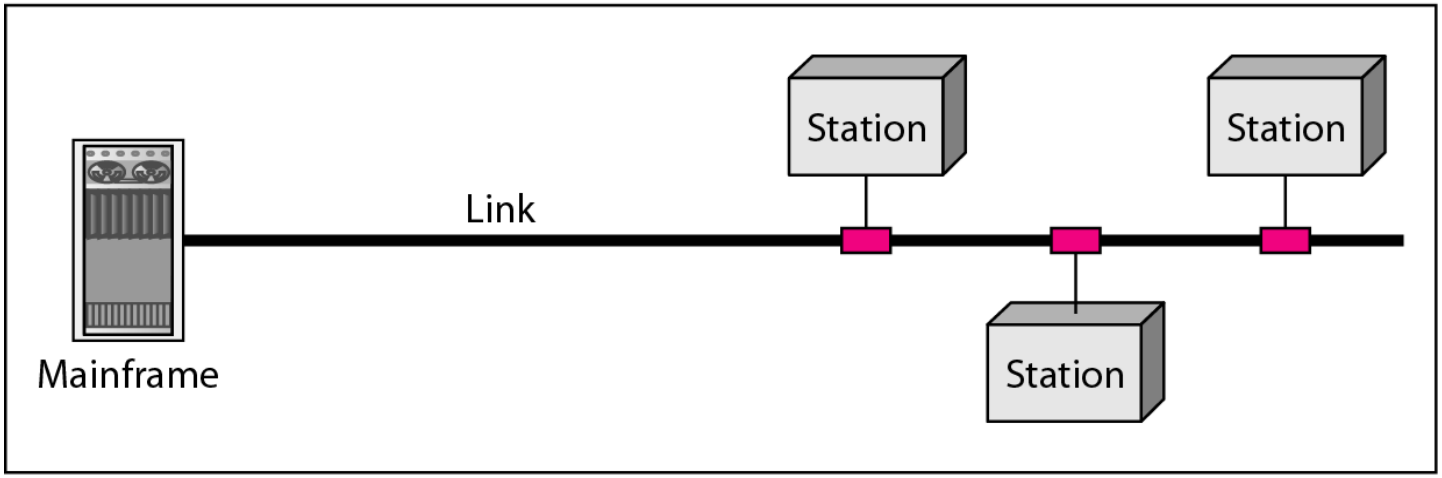


c. Full-duplex

Figure 1.3 *Types of connections: point-to-point and multipoint*



a. Point-to-point



b. Multipoint

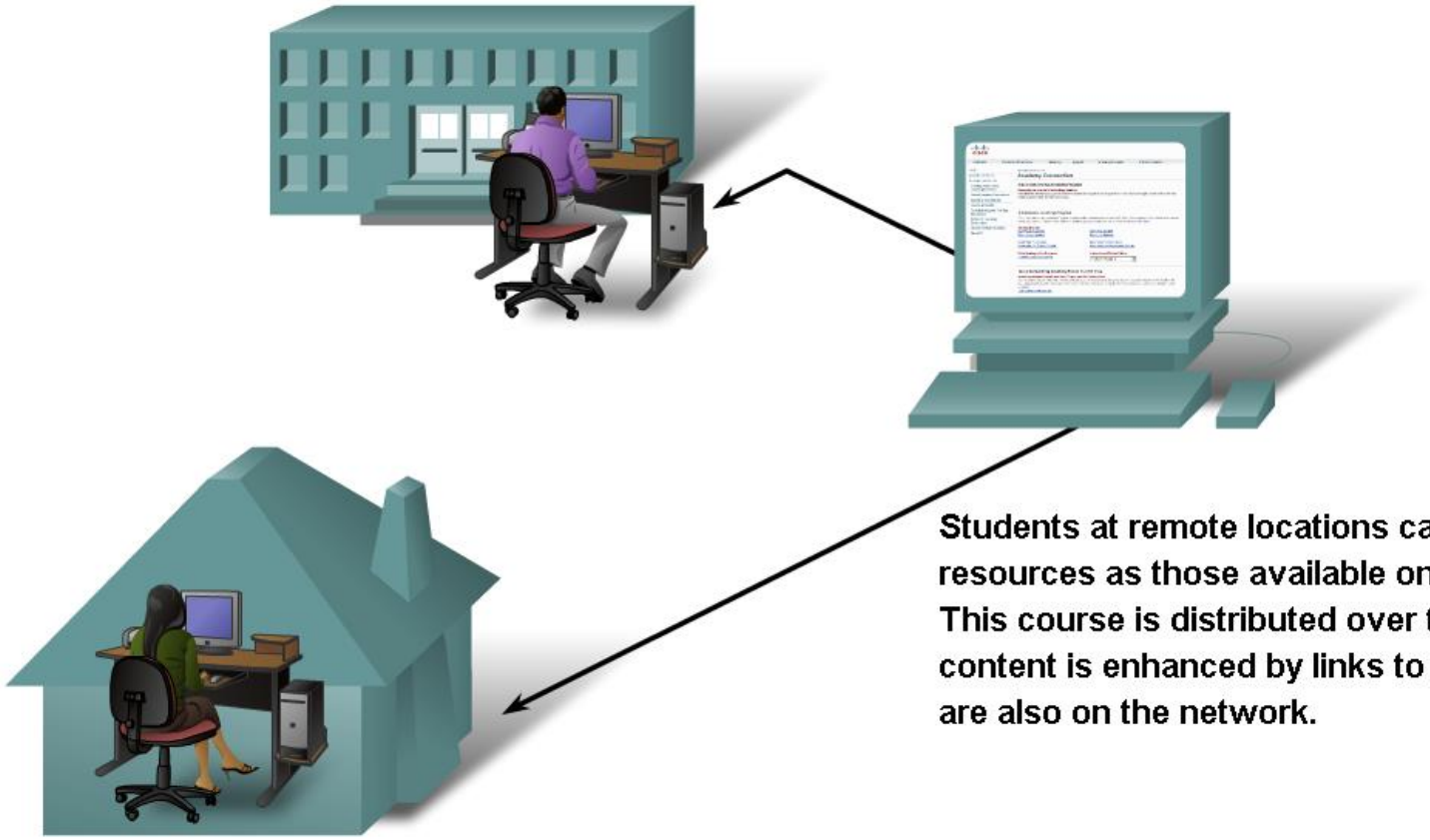
NETWORKS

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

Topics discussed in this section:

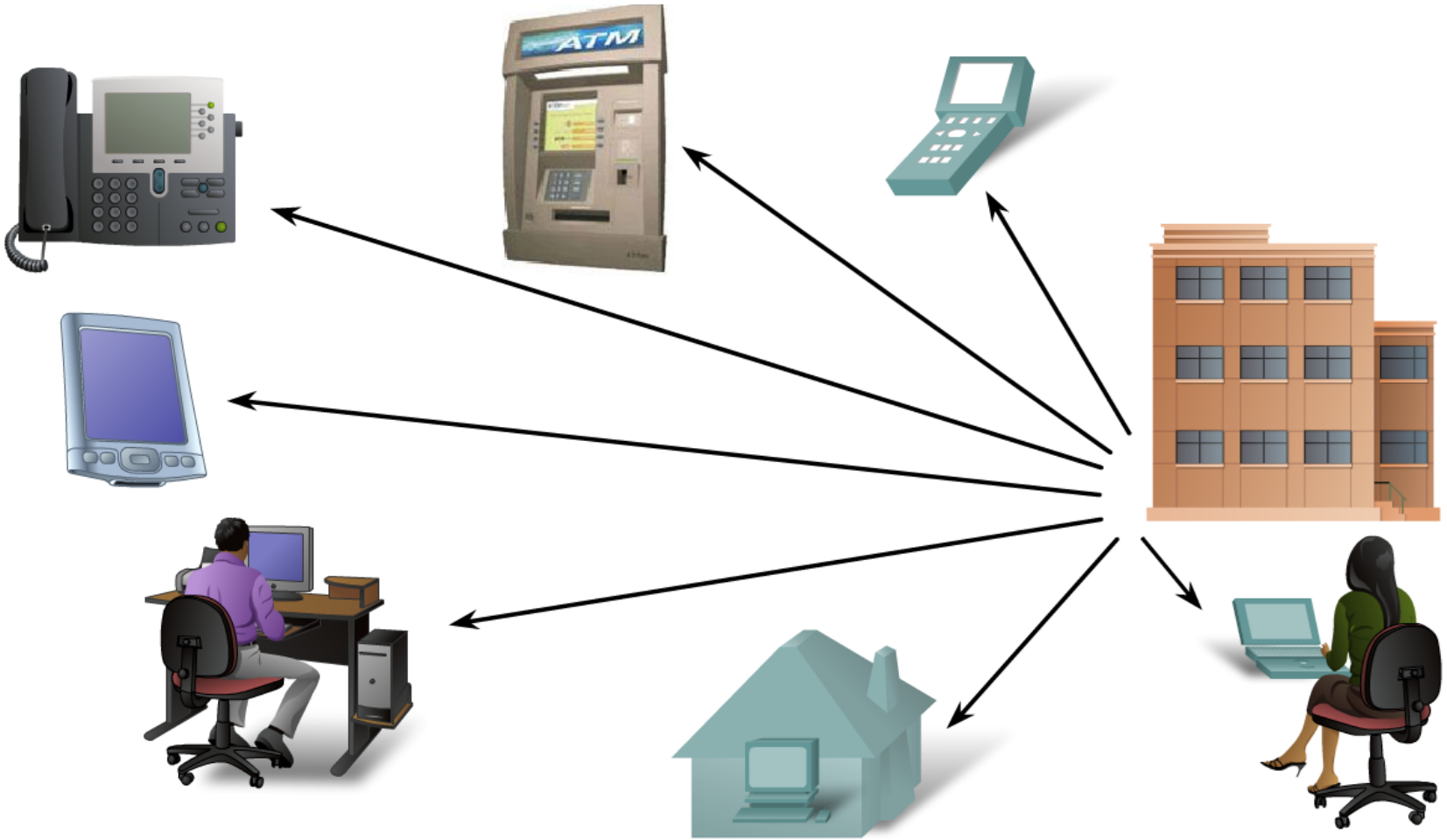
Distributed Processing
Physical Structures
Categories of Networks
Interconnection of Networks: Internetwork

Networks supporting the way we learn.

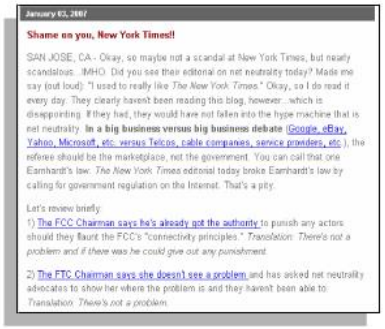


Students at remote locations can access the same resources as those available on campus.
This course is distributed over the network and the content is enhanced by links to other resources, which are also on the network.

Networks supporting the way we work.



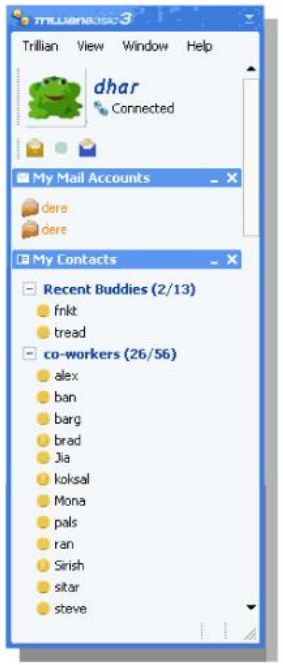
Networks supporting the way we play.



Online Interest Groups

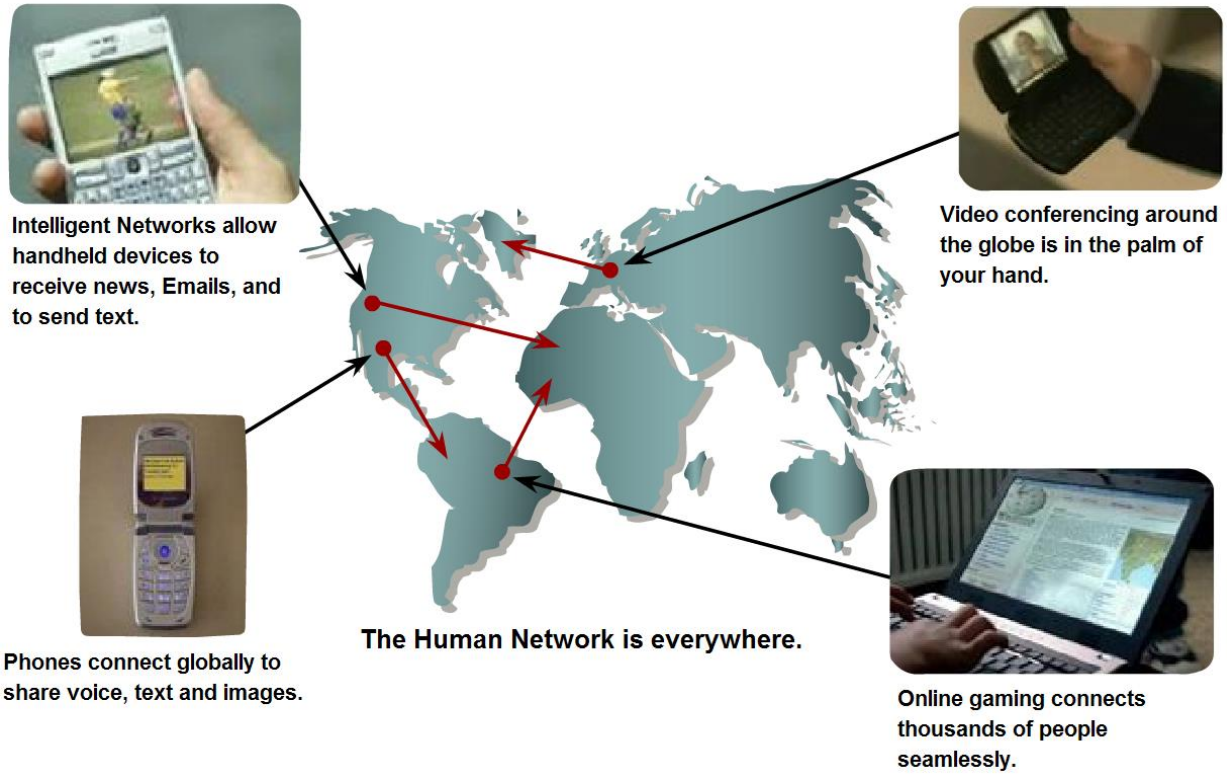
Online Entertainment

The onboard data network provides a range of services to airline personal seatback video systems.



Instant Messaging

Networks- Purpose???



- Communication.

Figure 1.4 *Categories of topology*

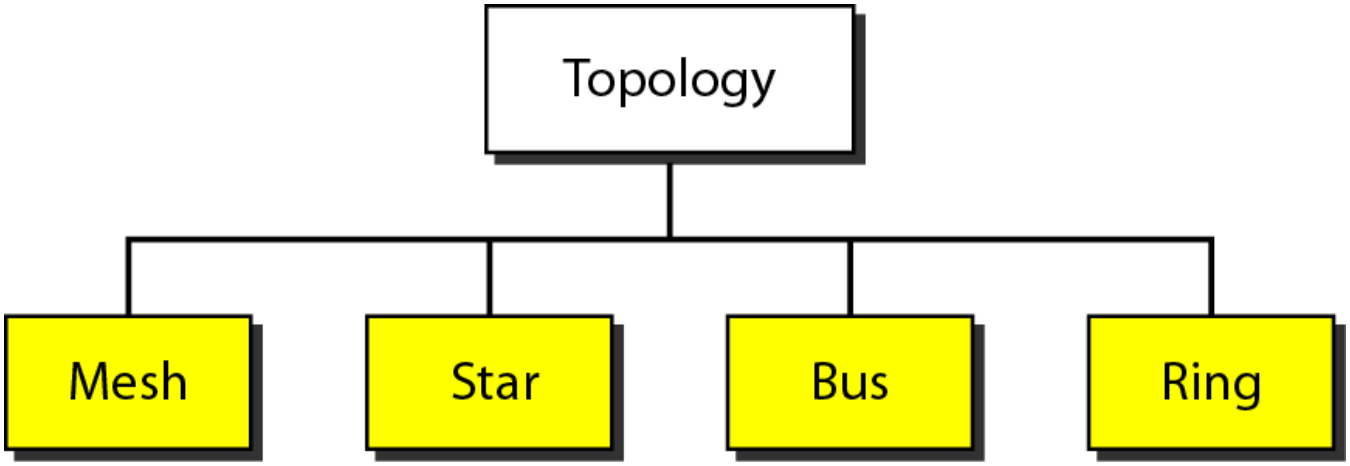


Figure 1.5 *A fully connected mesh topology (five devices)*

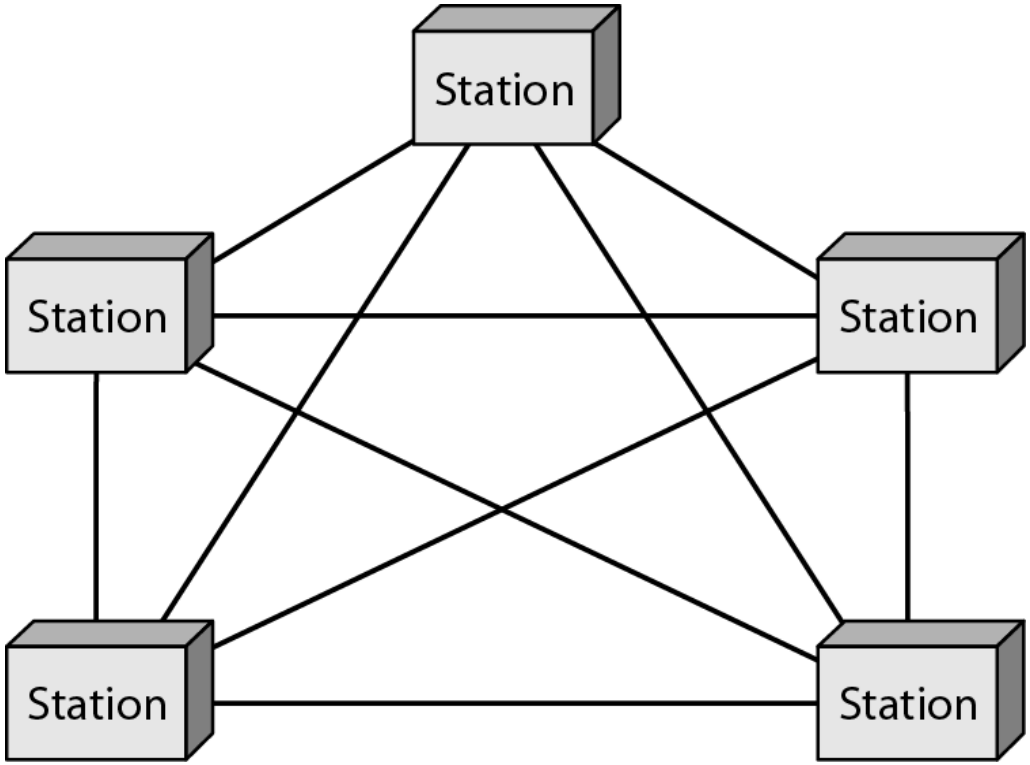


Figure 1.6 *A star topology connecting four stations*

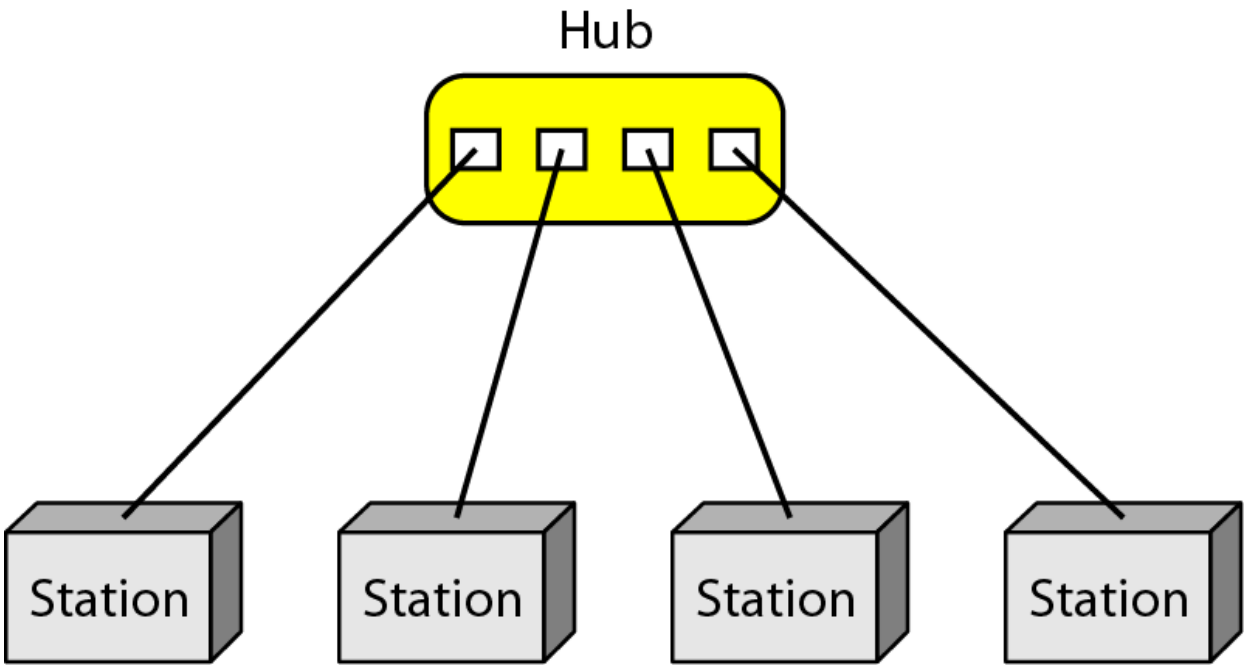


Figure 1.7 *A bus topology connecting three stations*

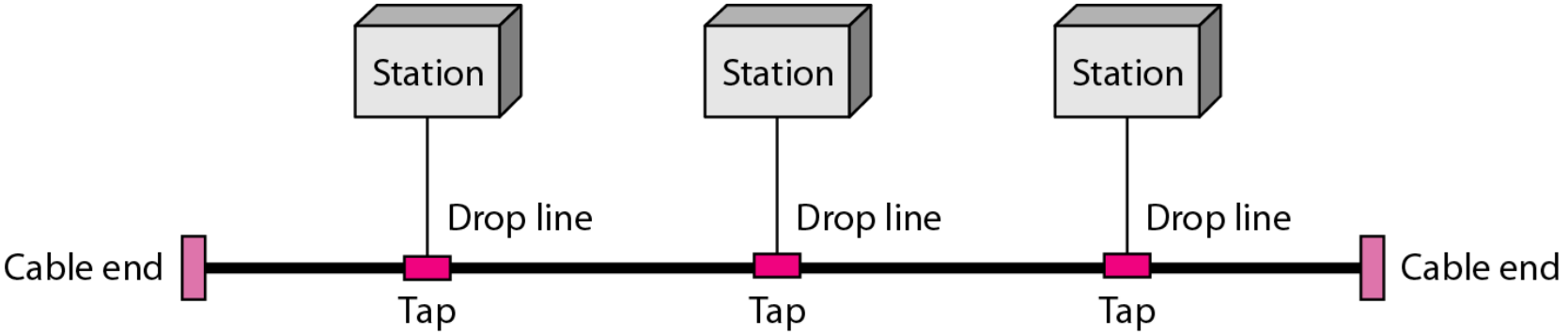


Figure 1.8 *A ring topology connecting six stations*

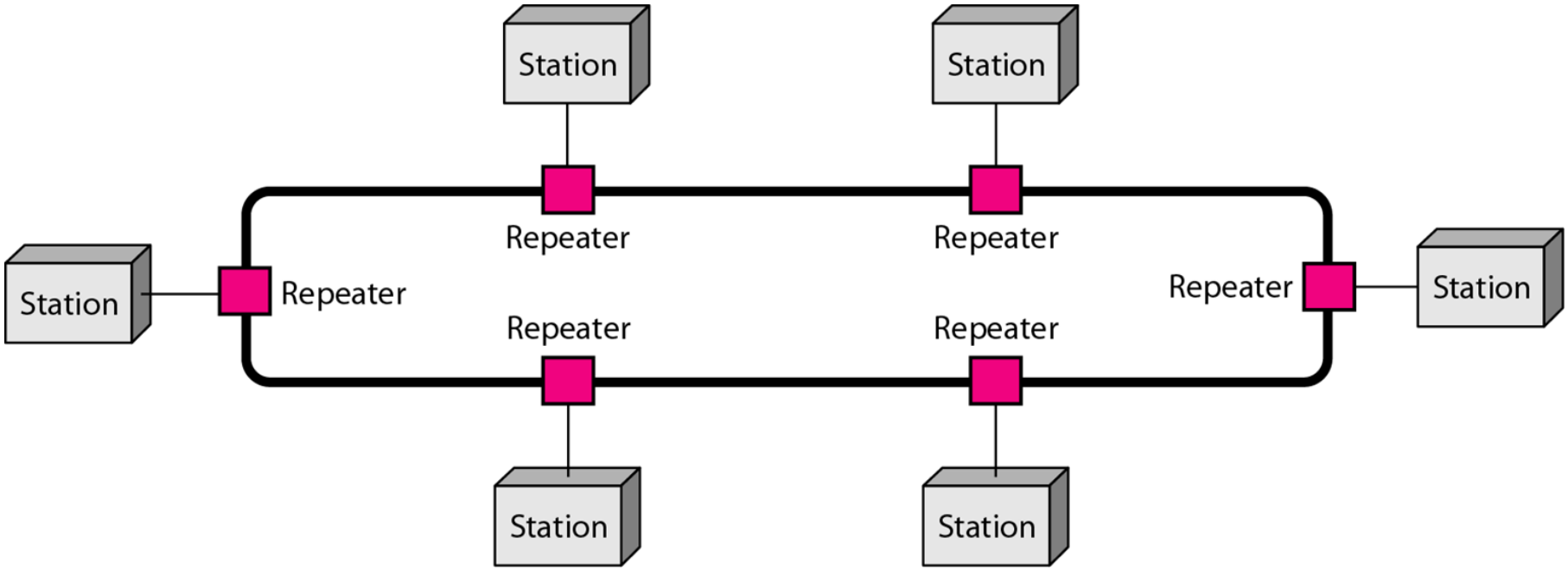
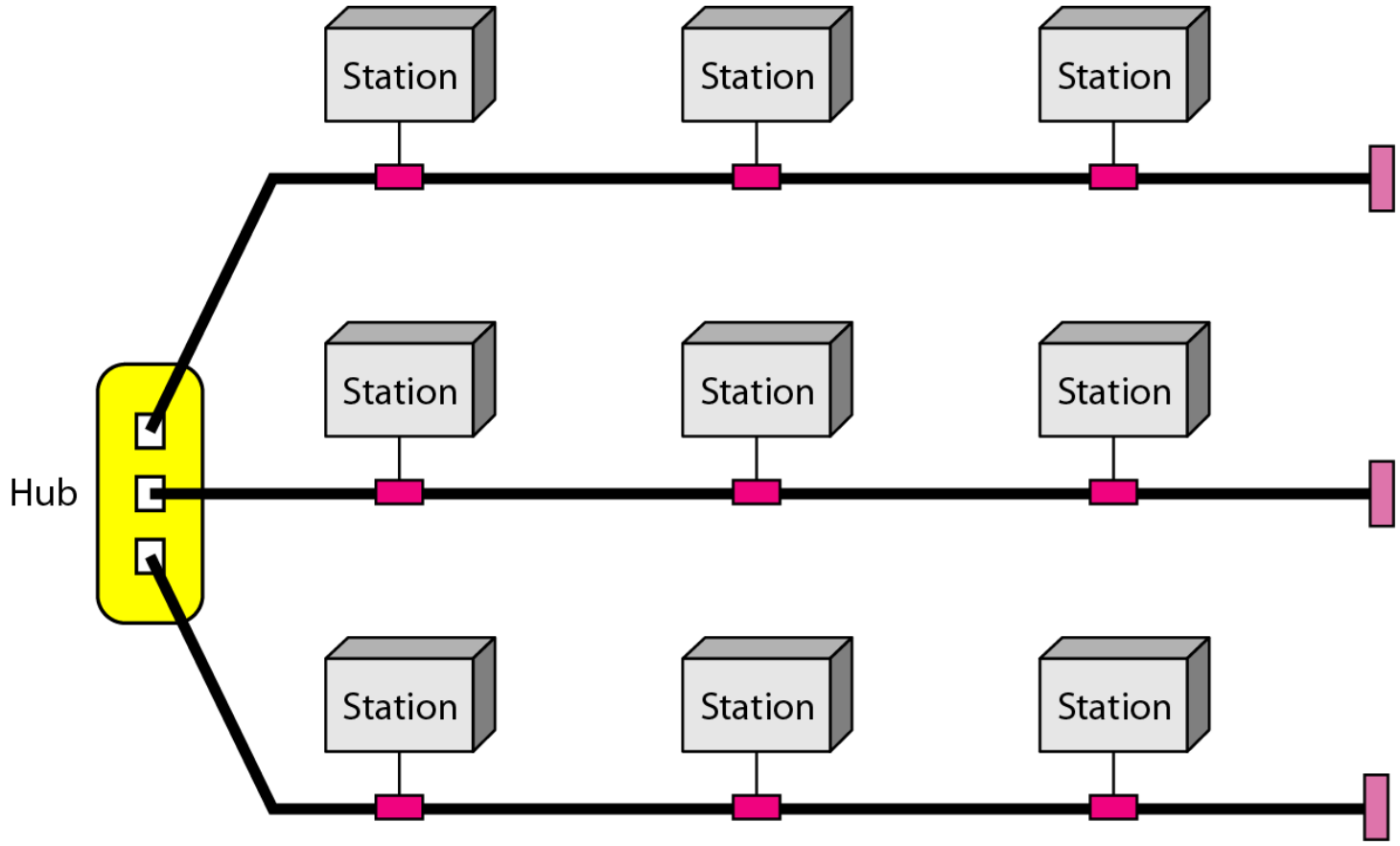


Figure 1.9 *A hybrid topology: a star backbone with three bus networks*



Advantages/disadvantages of Topologies

Topology	Advantages	Disadvantages
Mesh	• No traffic problem • Privacy / security	• Expensive, lots of wires and ports • New connection costly
Star	• Less expensive than mesh • Easy to add/remove nodes	• Single point of failure (HUB) • Traffic congestion
Bus	• Cheap • Easy installation	• Signal degradation, limiting the number of taps • Single point of failure
Ring	• Easy installation • No collision, stable performance	• If one device/connection fails, entire network is disrupted

Topology: Practice problem

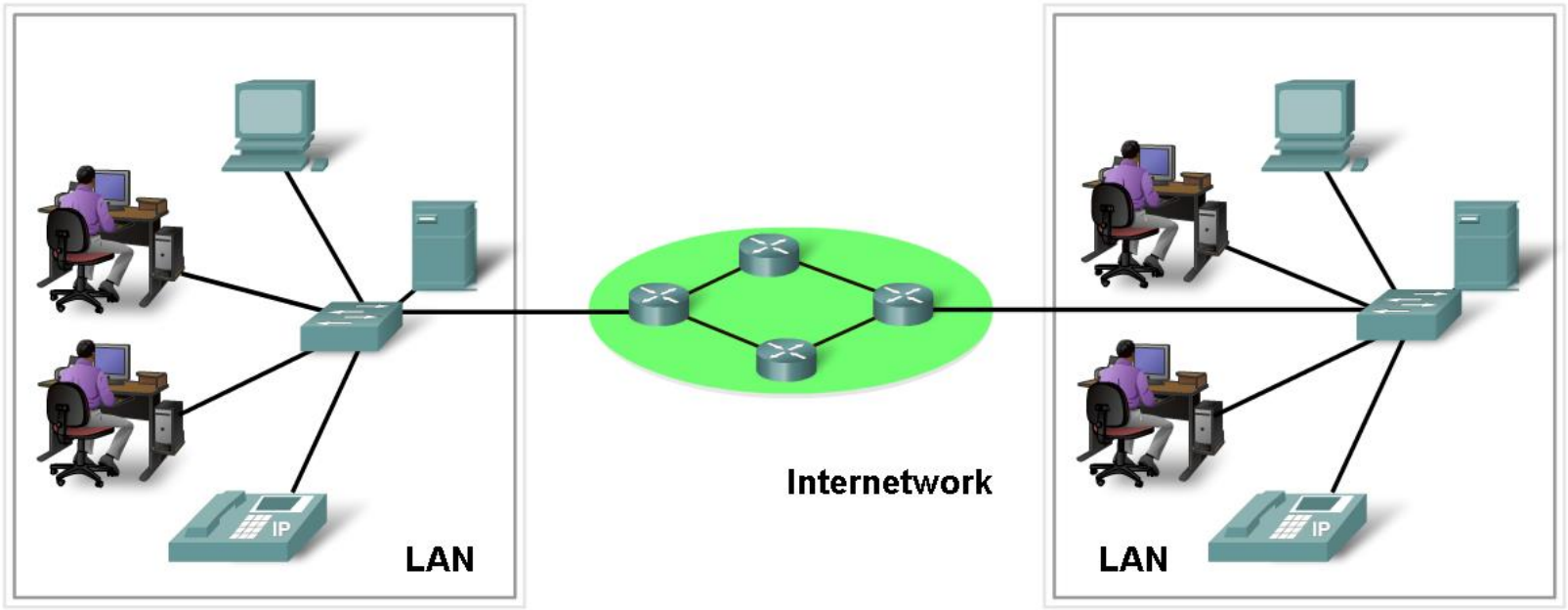
Let's consider the network setting for the following university campus with **FOUR** departments.

- Each department has a faculty area and a student area
- Each area can communicate with each other as they are **connected centrally** using a switch
- There are **THREE** devices in each area that are connected using **multipoint connections** only
- Each department has connection with **all other departments**

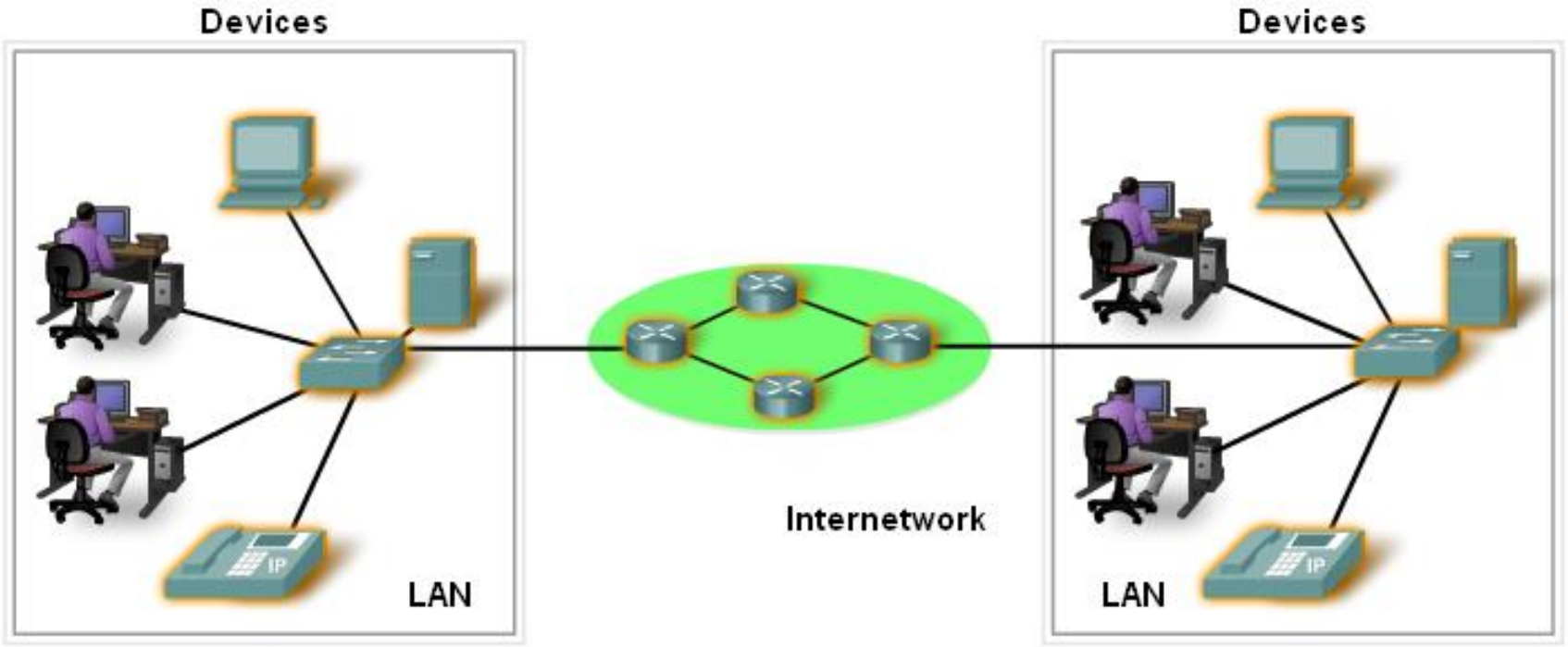
Based on this, IDENTIFY the topologies used in the university network, DRAW the hybrid structure, and CALCULATE the total number of links used.

Network Elements/Components

- Network Devices
  - Hardware (Devices and Media)
  - Software (Services and Processes)



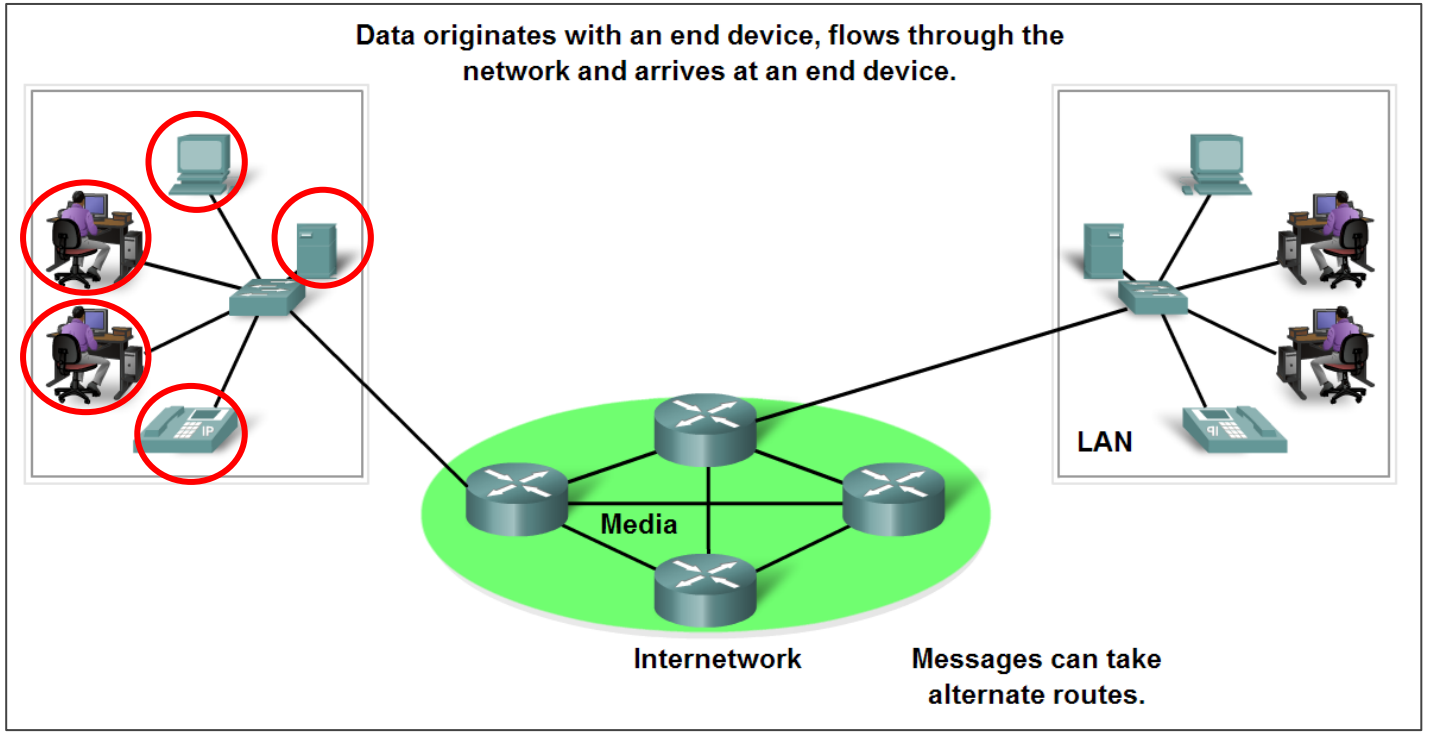
Devices



- Two Types:
  - End Devices
  - Intermediary Devices

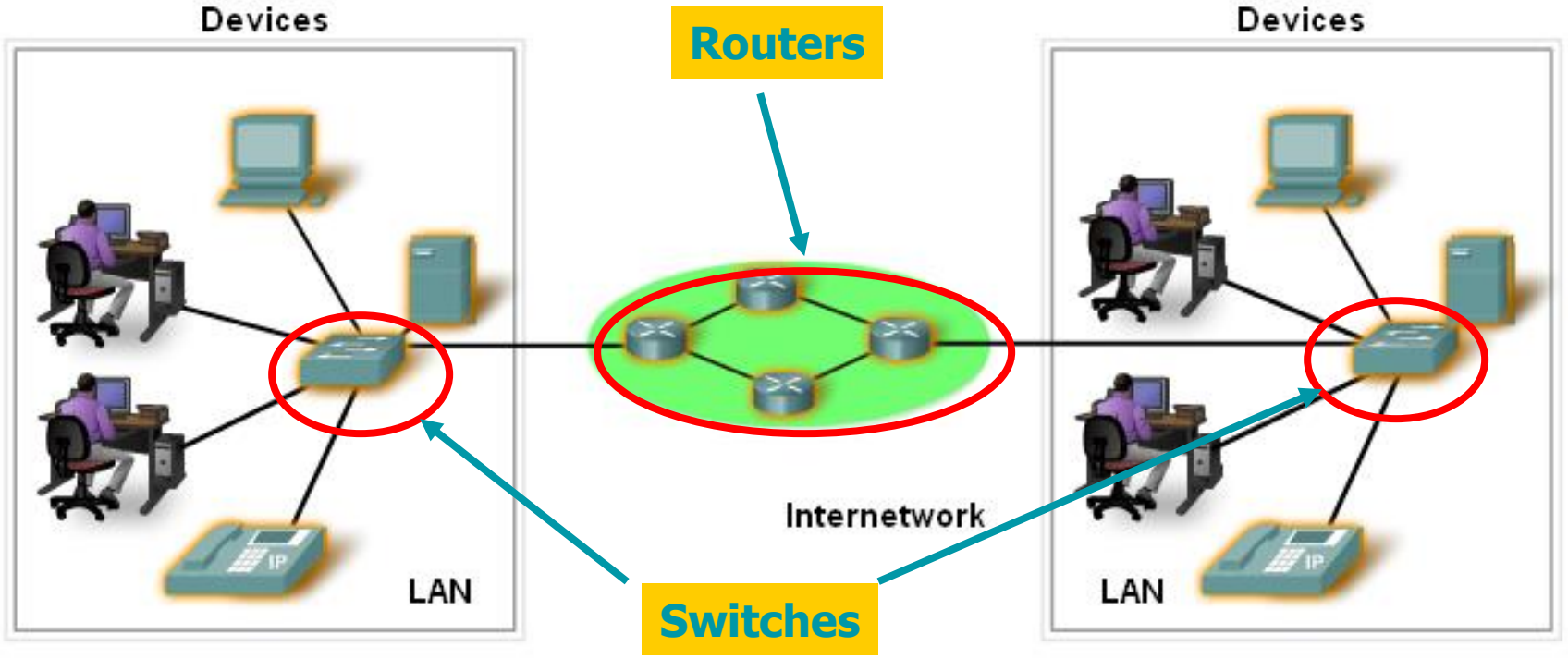
End Devices

- Sits at the edge of a network and interacts directly with users
- Sends, receives, stores data
- Example: PCs, servers, smartphones, IoT devices, printers



Intermediary devices

- Connects end devices to form a network
- Connects multiple networks to form an internetwork
- Manages data as it flows through the network
- Example: Hub, switch, router, firewall, etc



HUB

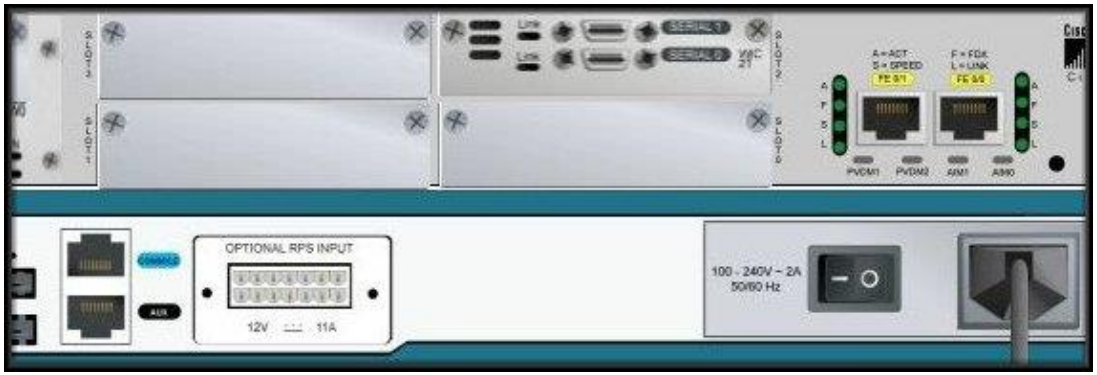
- Connects multiple end devices within a network, allowing them to communicate with one another
- When a device (like a computer) sends data to the hub, the hub **broadcasts the data** to all devices connected to it
- Every connected device receives the data, but only the intended recipient processes it. All other devices ignore it
- Half-duplex communication
- Simple, inexpensive, easy setup, no intelligence

SWITCH

- Intelligent version of HUB
- Instead of broadcasting data to all connected devices, the switch **forwards data only to the intended recipient**
- Maintains a MAC address table of the devices connected to each of its port
- Full-duplex communication
- Intelligent forwarding, expensive, requires configuration

ROUTER

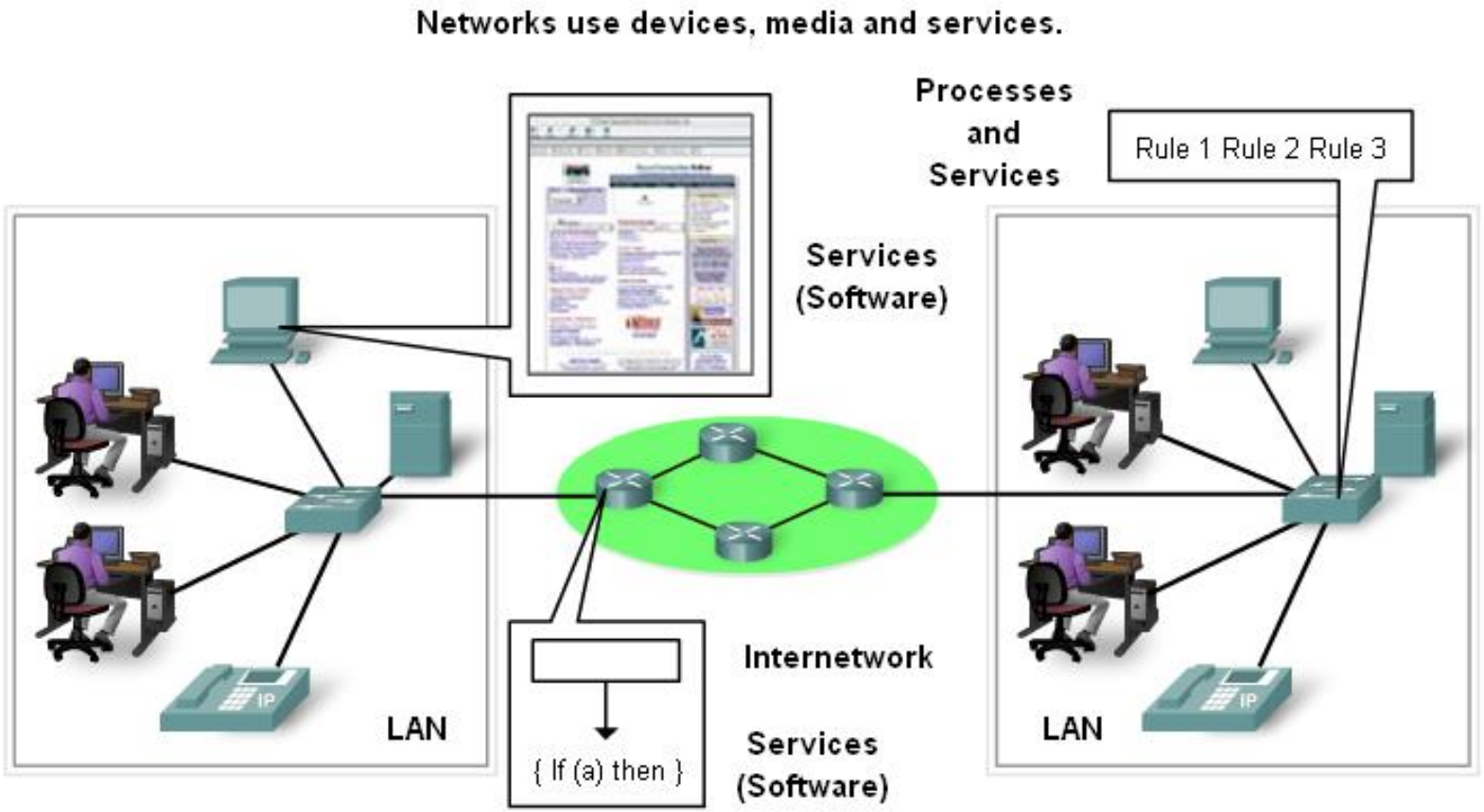
- A gateway between networks; **connects local networks with the internet**
- **LAN ports** (for local devices) and **WAN port** (for connecting to the internet)
- Built-in security features
- Supports wireless connectivity
- Complex, expensive, requires configuration



Software

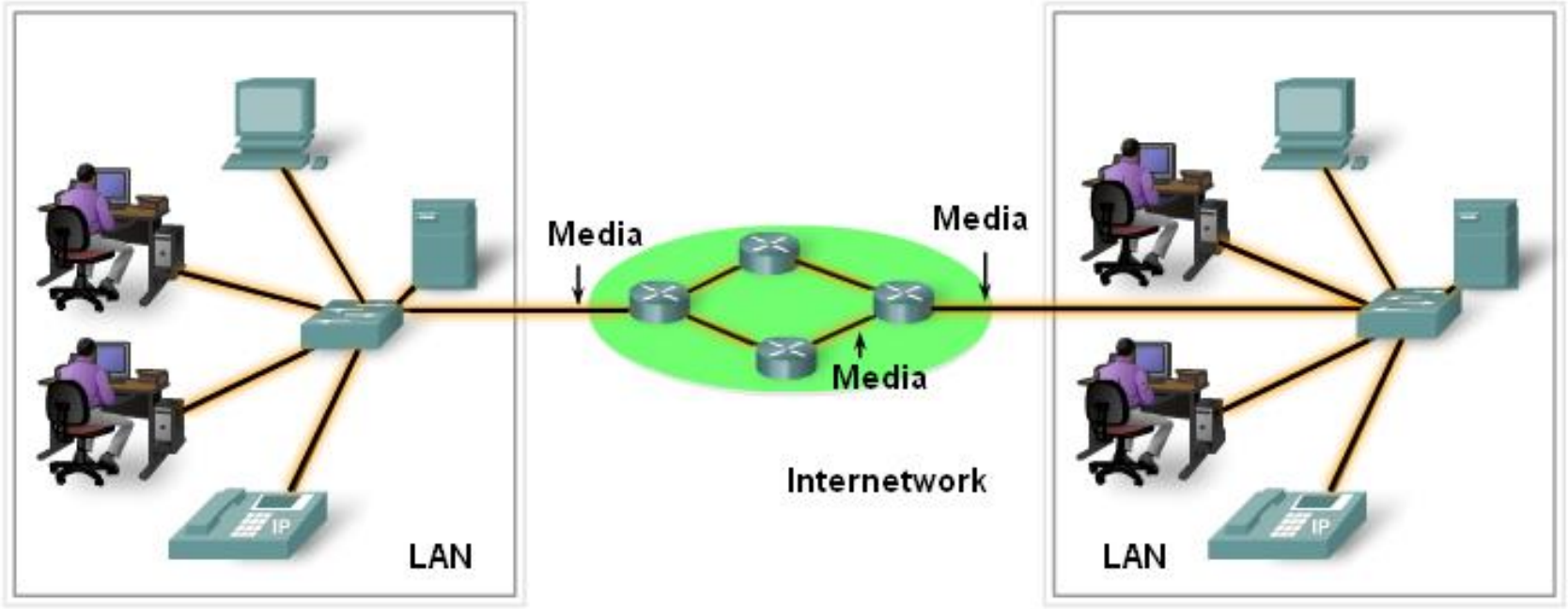
- Services
  - Software-driven functionalities that enable communication and resource sharing within a network
  - Example: file sharing and storage services, web services, email services
- Processes
  - Standardized rules that define how devices on a network should interact
  - Example: authentication (logging in to a wifi network), routing procedures, error detection and connection

Processes and Services

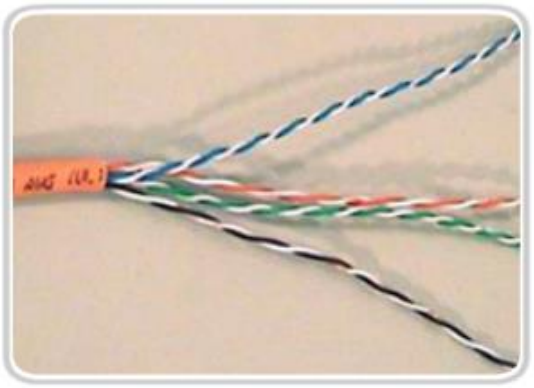


Network Media (Transmission Media)

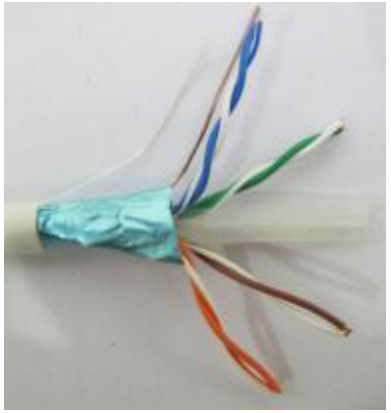
Provides the pathway for data transmission between devices



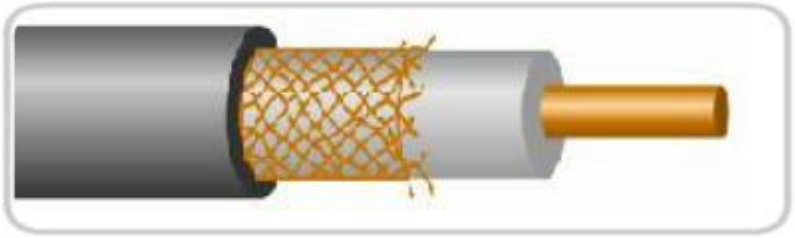
Wired Transmission Media



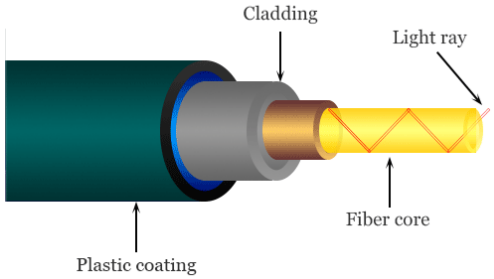
Unshielded Twisted Pair (UTP) Cable



Shielded Twisted Pair (STP) Cable



Coaxial cable



Fiber optic cable

Wireless Transmission Media

- Radio-wave (WiFi, bluetooth, FM radio)
- Satellite (Star-link)

Messages- Data Representation

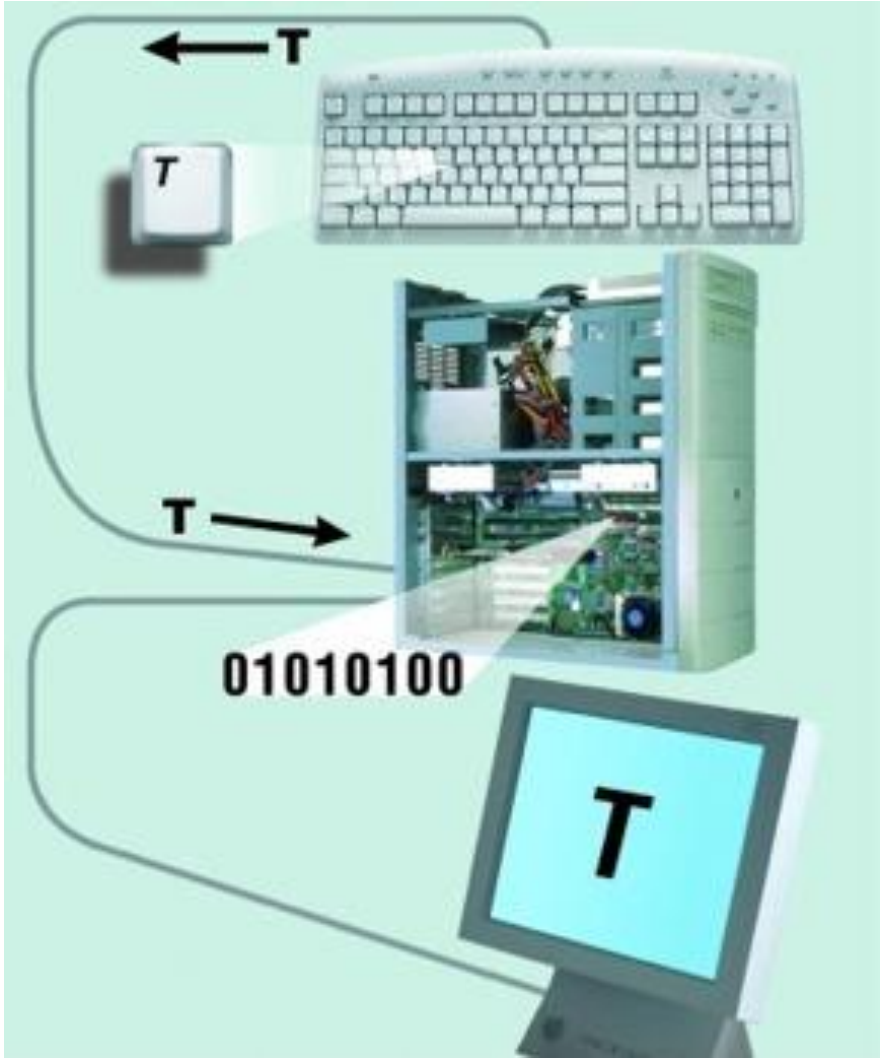
- Information today comes in different forms such as
  - text, numbers, images, audio, and video.

Type of Data	Standards
Alphanumeric	ASCII, Unicode
Image	JPEG, GIF, PCX, TIFF, BMP, etc
Motion picture	MPEG-2, Quick Time, MPEG-4, etc
Sound	Sound Blaster, WAV, AU, MP3, etc..
Outline graphics/fonts	PostScript, TrueType, PDF

Data Representation - Text

- **Text** : Different sets of bit patterns are designed to represent text symbols. Each set is called a code.
  - **ASCII**
    - American Standard Code for Information Interchange: 7-bit code/char, 1 bit for parity.
  - **Unicode** - 16 bit codes to represent a symbol.

Data Representation - Text



Data Representation - Text

ASCII Reference Table

	000	001	010	011	100	101	110	111
0000	NULL	DLE		0	@	P	`	p
0001	SOH	DC1	!	1	A	Q	a	q
0010	STX	DC2	"	2	B	R	b	r
0011	ETX	DC3	#	3	C	S	c	s
0100	EDT	DC4	$	4	D	T	d	t
0101	ENQ	NAK	%	5	E	U	e	u
0110	ACK	SYN	&	6	F	V	f	v
0111	BEL	ETB	'	7	G	W	g	w
1000	BS	CAN	(	8	H	X	h	x
1001	HT	EM	)	9	I	Y	i	y
1010	LF	SUB	*	:	J	Z	j	z
1011	VT	ESC	+	;	K	[	k	{
1100	FF	FS	,	<	L	\	l	|
1101	CR	GS	-	=	M	]	m	}
1110	SO	RS	.	>	N	^	n	~
1111	SI	US	/	?	O	_	o	DEL

Data Representation - Image

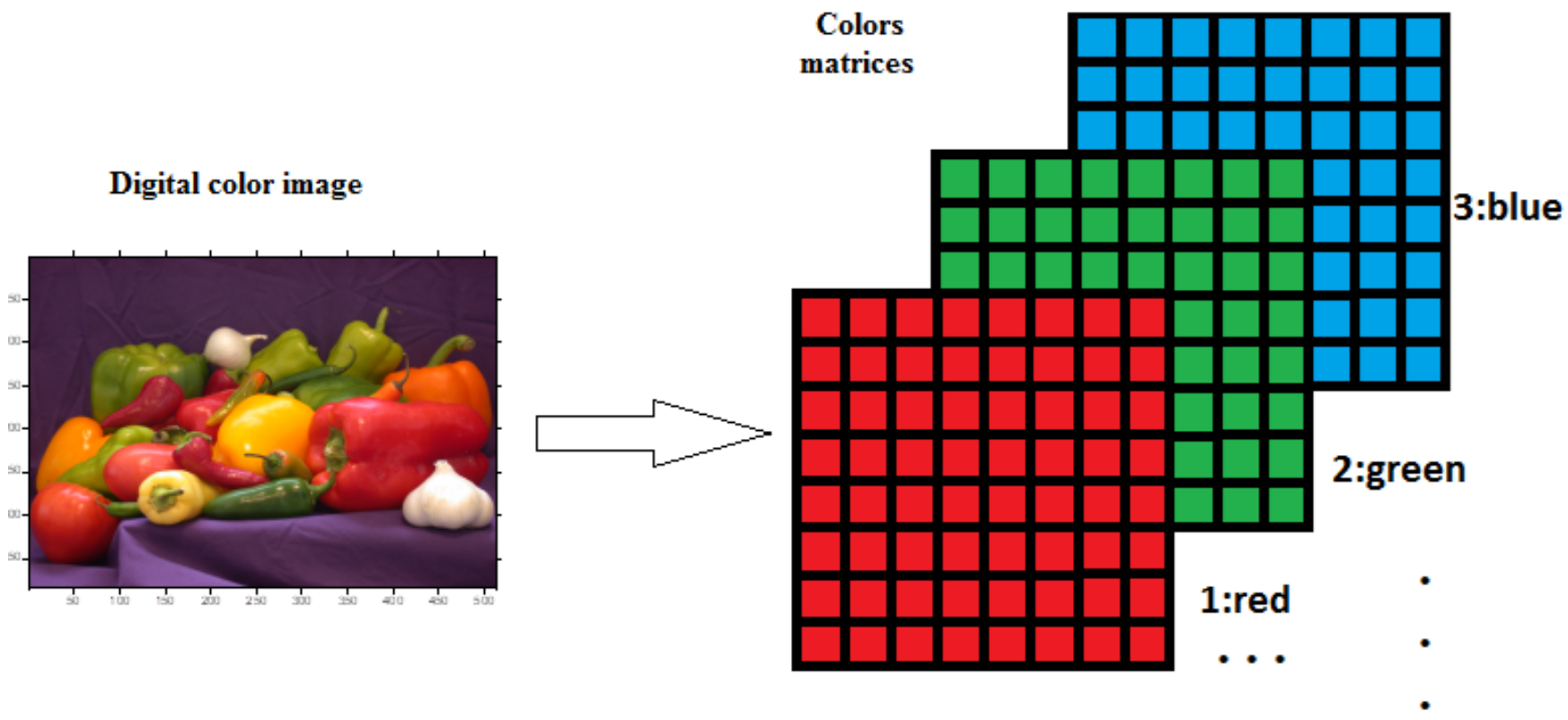
- **Images –**
  - Also represented by bit patterns.
  - Mechanism different. Matrix of Pixels used. Each pixel is assigned to a bit pattern.
  - Color images uses RGB or YCM methods.

RGB Value			Colour
Red	Green	Blue	
0	0	0	black
255	255	255	white
255	255	0	yellow
255	130	255	Pink
146	81	0	brown
157	95	82	purple
140	0	0	maroon

Data Representation - Image

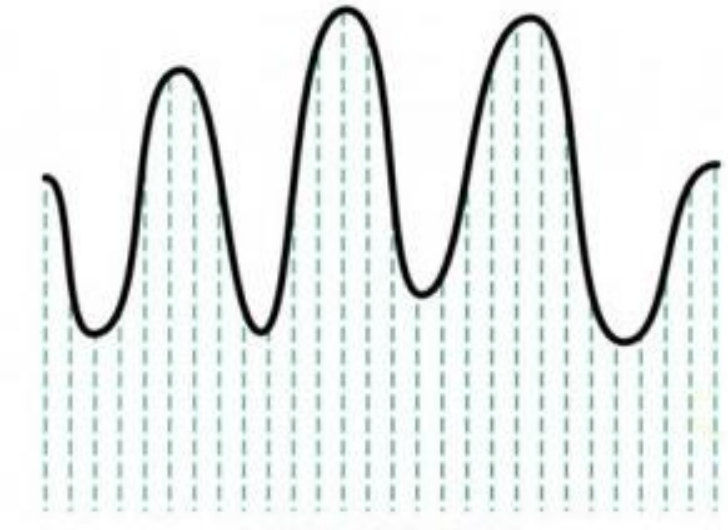
0	2	15	0	0	11	10	0	0	0	0	9	9	0	0	0
0	0	0	4	60	157	236	255	255	177	95	61	32	0	0	29
0	10	16	119	238	255	244	245	243	250	249	255	222	103	10	0
0	14	170	255	255	244	254	255	253	245	255	249	253	251	124	1
2	98	255	228	255	251	254	211	141	116	122	215	251	238	255	49
13	217	243	255	155	33	226	52	2	0	10	13	232	255	255	36
16	229	252	254	49	12	0	0	7	7	0	70	237	252	235	62
6	141	245	255	212	25	11	9	3	0	115	236	243	255	137	0
0	87	252	250	248	215	60	0	1	121	252	255	248	144	6	0
0	13	113	255	255	245	255	182	181	248	252	242	208	36	0	19
1	0	5	117	251	255	241	255	247	255	241	162	17	0	7	0
0	0	0	4	58	251	255	246	254	253	255	120	11	0	1	0
0	0	4	97	255	255	255	248	252	255	244	255	182	10	0	4
0	22	206	252	246	251	241	100	24	113	255	245	255	194	9	0
0	111	255	242	255	158	24	0	0	6	39	255	232	230	56	0
0	218	251	250	137	7	11	0	0	0	2	62	255	250	125	3
0	173	255	255	101	9	20	0	13	3	13	182	251	245	61	0
0	107	251	241	255	230	98	55	19	118	217	248	253	255	52	4
0	18	146	250	255	247	255	255	255	249	255	240	255	129	0	5
0	0	23	113	215	255	250	248	255	255	248	248	118	14	12	0
0	0	6	1	0	52	153	233	255	252	147	37	0	0	4	1
0	0	5	5	0	0	0	0	0	14	1	0	6	6	0	0

Data Representation - Image



Data Representation - Audio

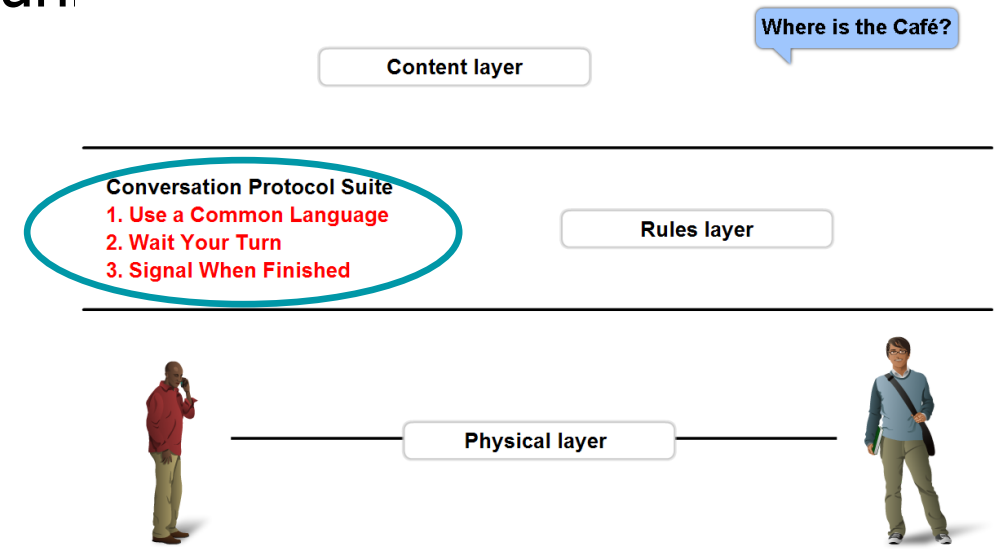
- **Audio**- Continuous, not discrete. Converted to digital or analog signal.



Sampling an audio signal

Rules - Protocols

- A set of predetermined rules that govern communication.
- Defines:
  - What is communicated??
  - How it is communicated??
  - When it is communicated??



Network Types

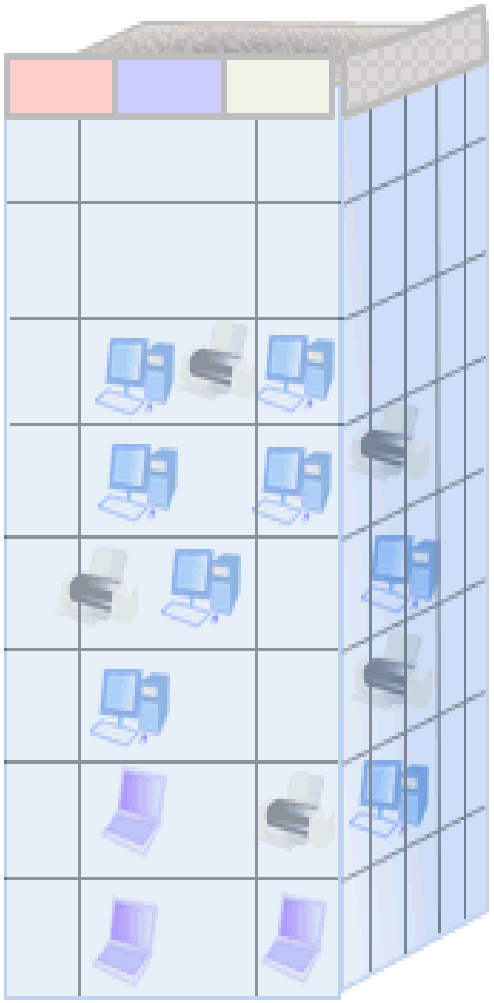
- PAN
- LAN
- MAN
- WAN

Personal Area Networks (PAN)

- A small network that connects computers, peripherals and other devices for personal use through bluetooth or USB
- Range: Short, typically a few meters

Local Area Networks (LAN)

- Connects computers, peripherals and other devices within a building (e.g. varsity campus, office) or in a limited area
- Range: Typically 50 to 300 meters
- Example: Ethernet, Wireless LANs

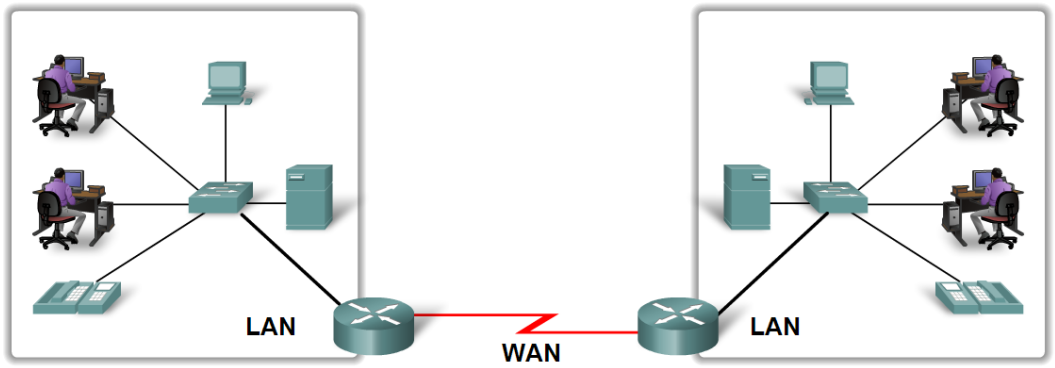


Metropolitan Area Network (MAN)

- Covers larger area than LAN, e.g. a city, suburb, or large campus
- Connects multiple LANs within the area to create a larger network
- Example: University network connecting multiple campuses or buildings

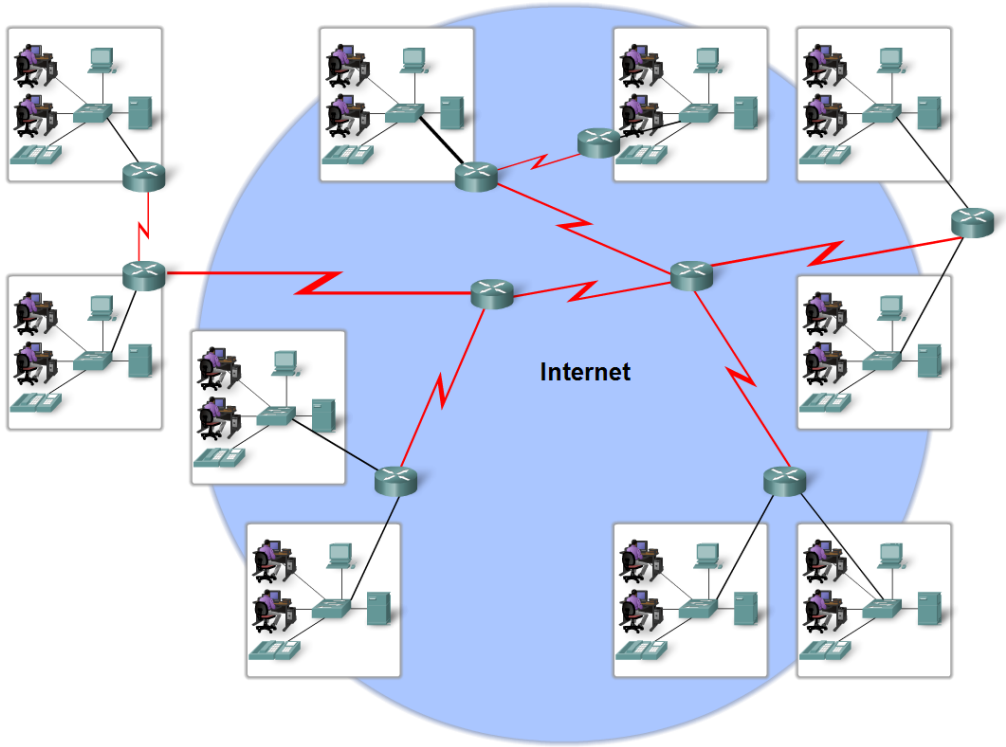
Wide Area Network (WAN)

- Spans large geographical areas like countries, continents, or even the entire world
- Connects multiple LANs and MANs separated by geographic distance, to form a global network
- Example: Cellular Networks (GSM etc), corporate WANs (Amazon, Microsoft), Internet

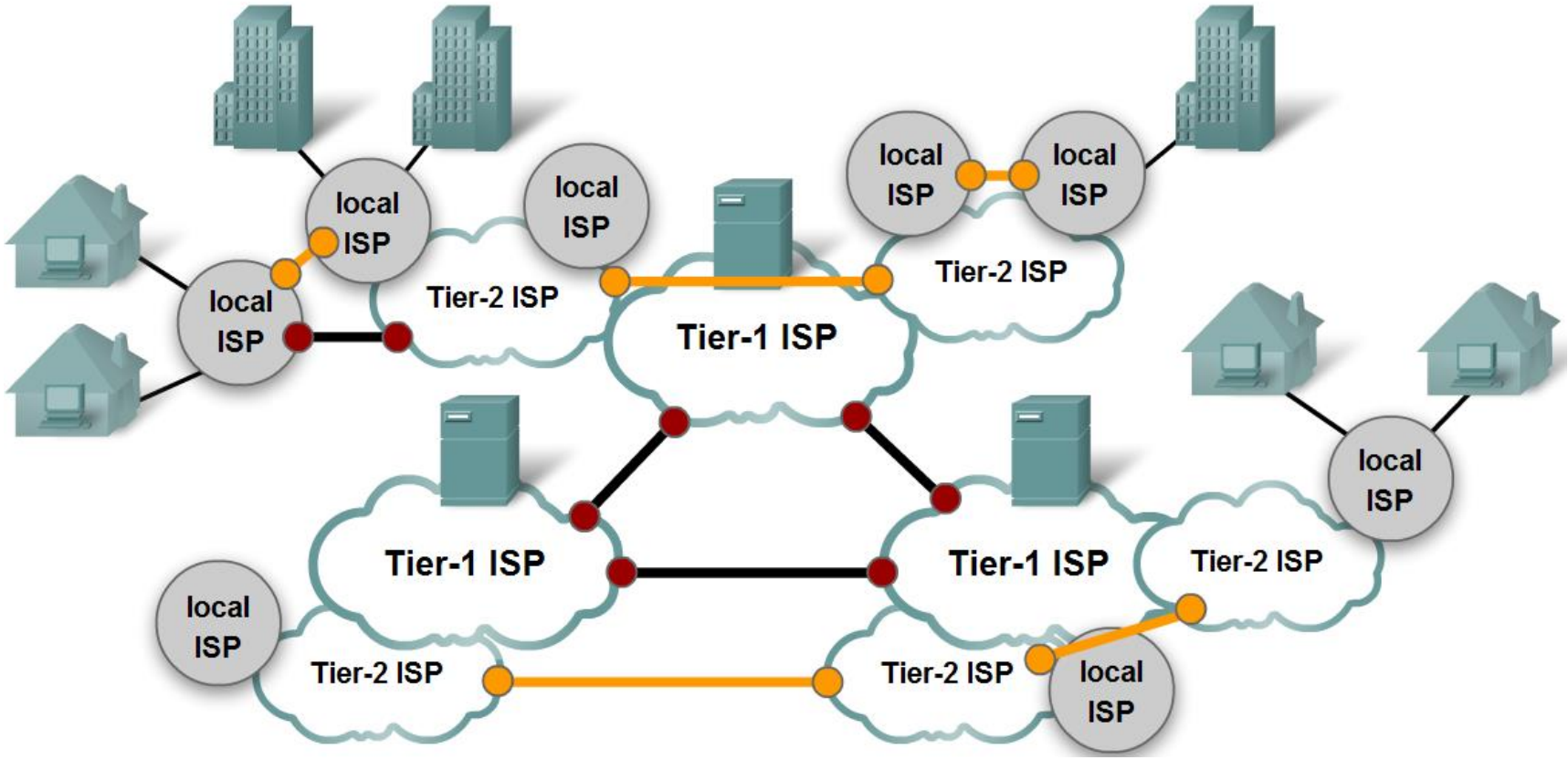


Internet

- The internet is defined as a global mesh of interconnected networks.

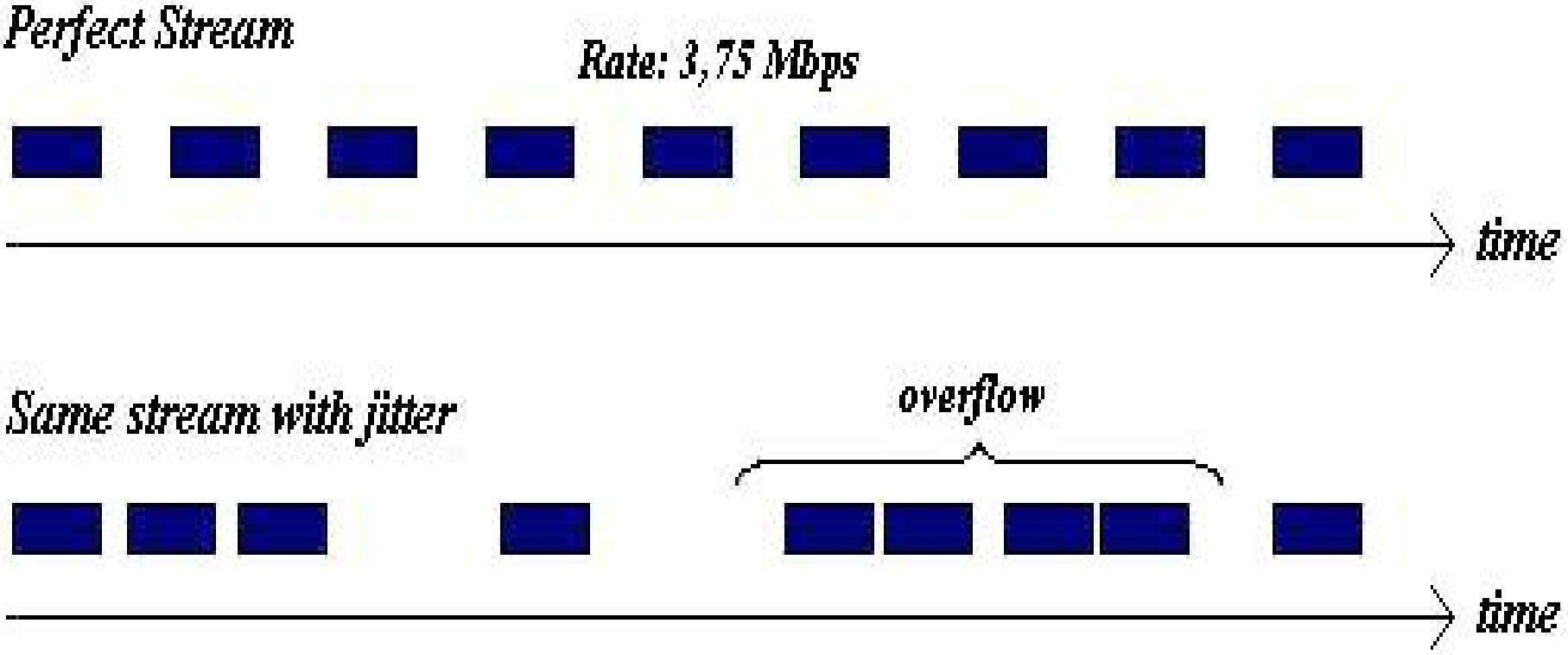


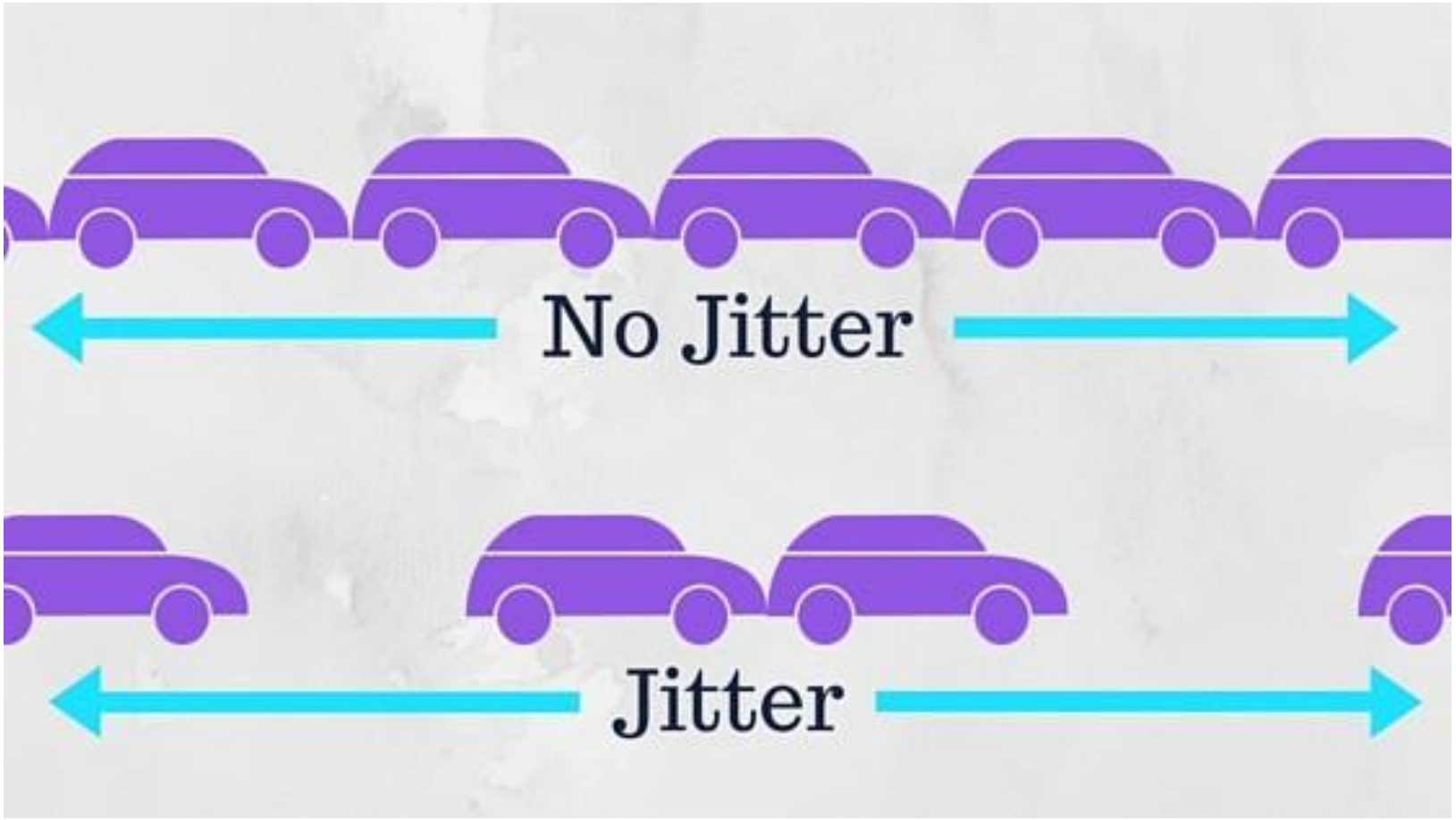
Internet


local ISP
local ISP
local ISP
local ISP
local ISP
local ISP
Tier-2 ISP
Tier-1 ISP
Tier-2 ISP
Tier-1 ISP
Tier-1 ISP
Tier-2 ISP
local ISP
local ISP
Tier-2 ISP
Tier-2 ISP
local ISP

Effectiveness of a system depends upon:

- Delivery
- Accuracy
- Timeliness
- Jitter


Perfect Stream
Rate: 3,75 Mbps
time
Same stream with jitter
overflow
time


No Jitter
Jitter