Chapter 2
LAN & WAN Technologies

Objectives

- LANs
- Gigabit and 10-Gigabit Ethernet
- WANs
- WAN Design

OSI Model

Benefits of the OSI Model:

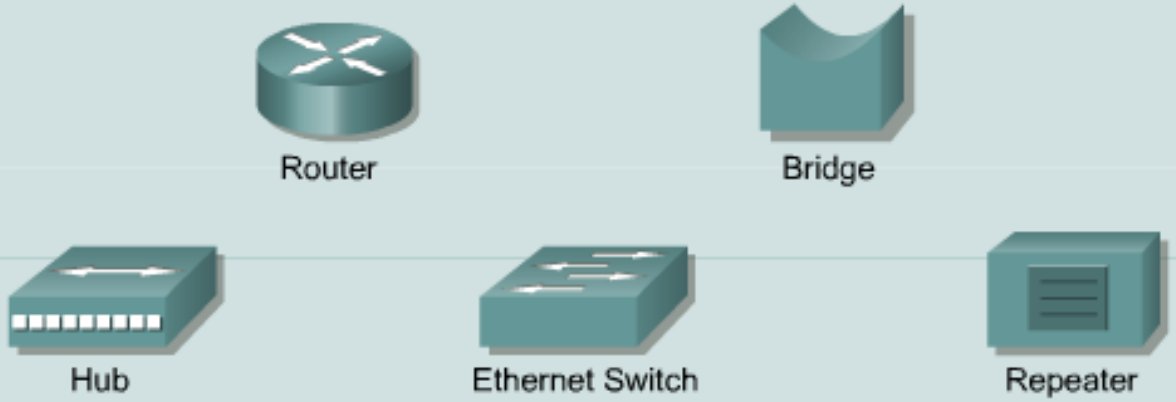
- Reduces complexity
- Standardizes interfaces
- Facilitates modular engineering
- Ensures interoperable technology
- Accelerates evolution
- Simplifies teaching and learning

Local-area Networks (LANs)

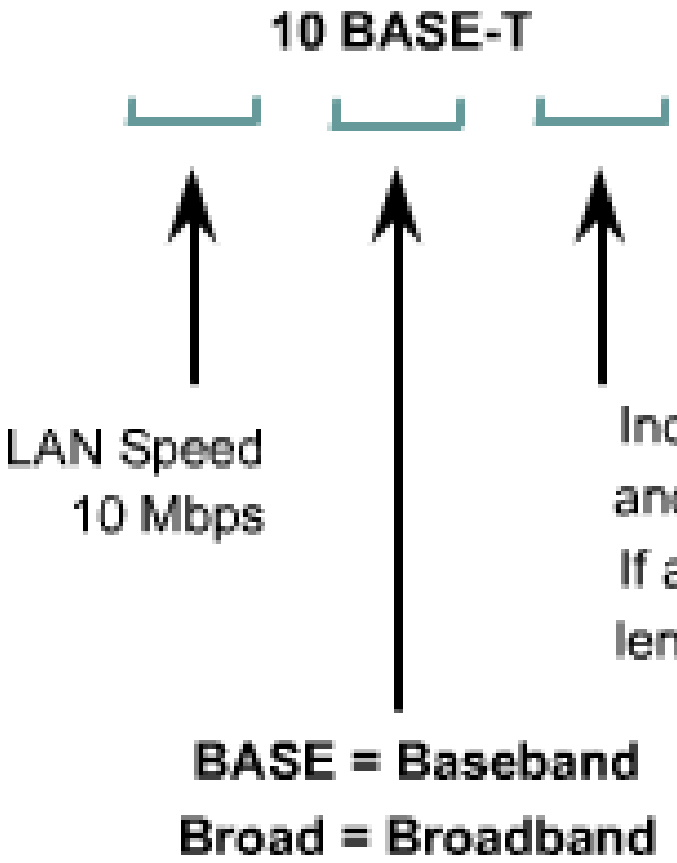
LANS are designed to:

- Operate within a limited geographic area
- Allow multi-access to high-bandwidth media
- Control the network privately under local administration
- Provide full-time connectivity to local services
- Connect physically adjacent devices

Using:

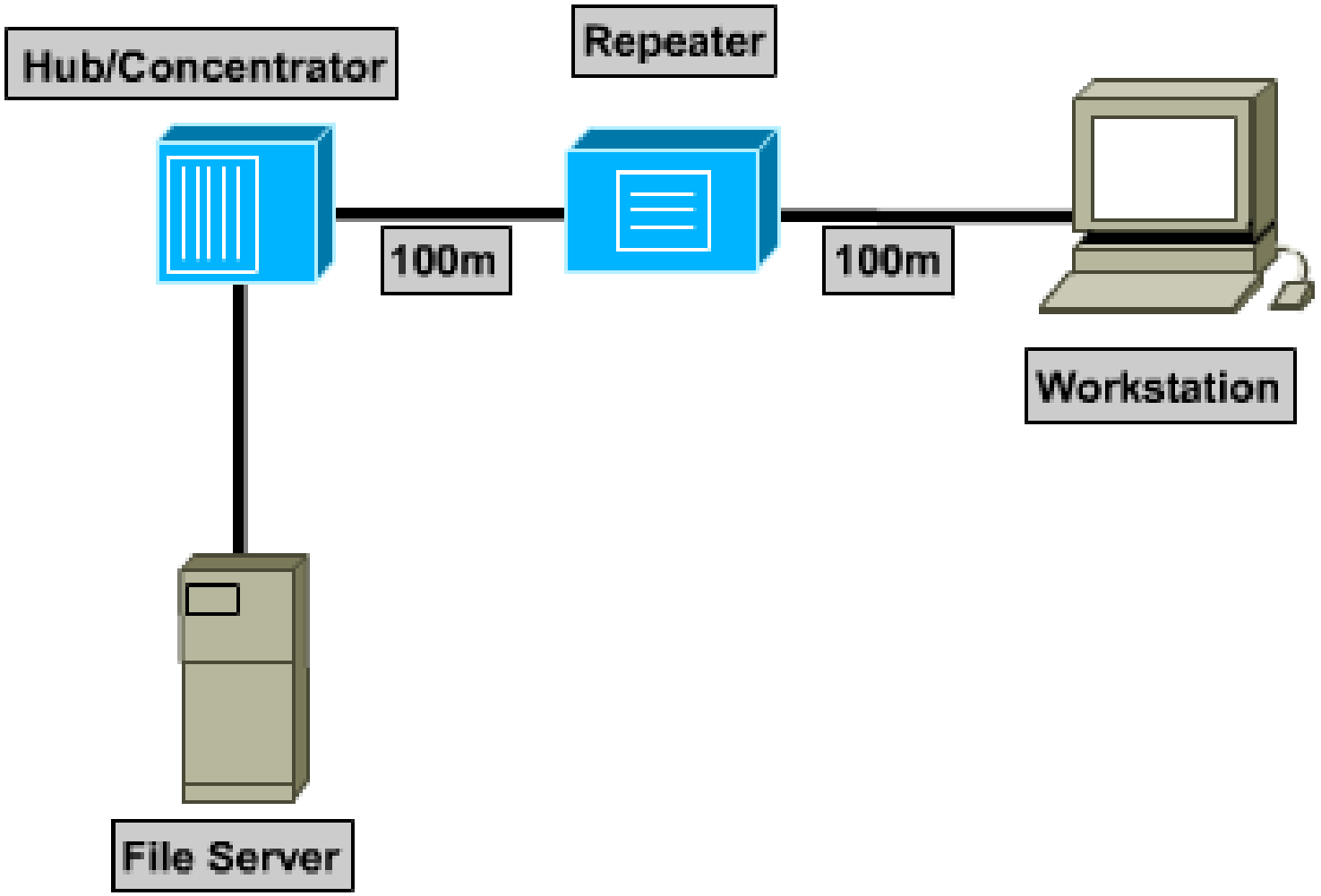


Cable Specifications

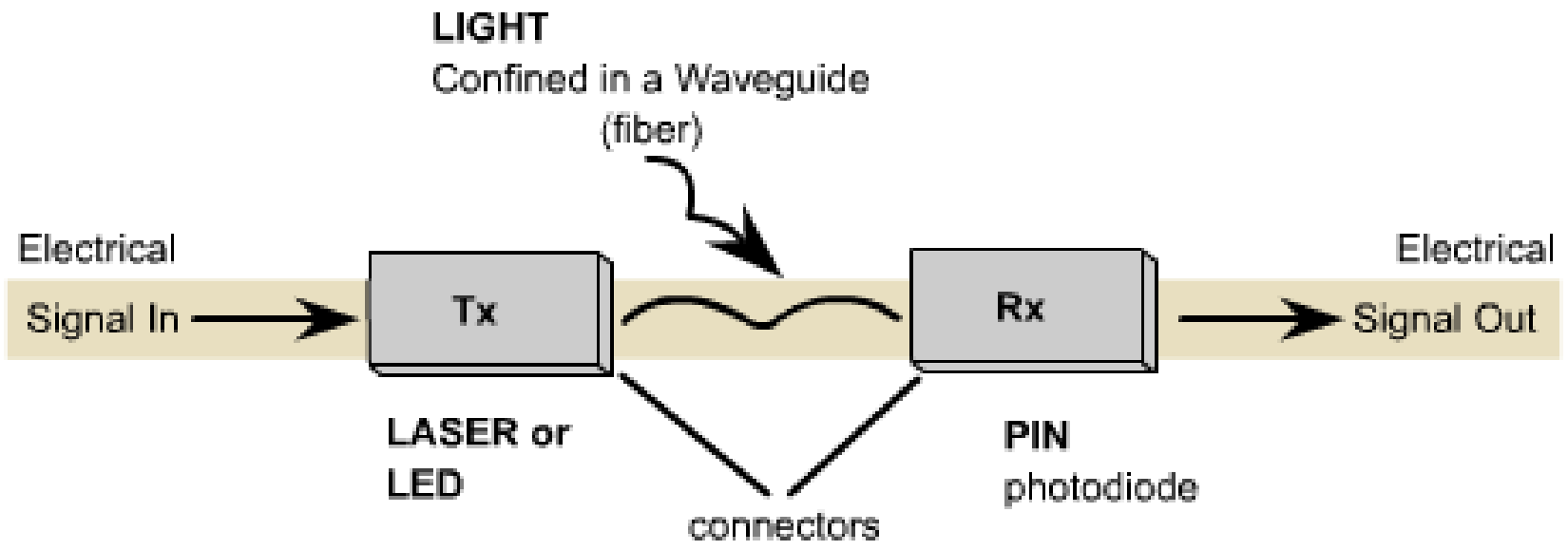


1000BASE-T
(IEEE 802.3ab)
Gigabit Ethernet

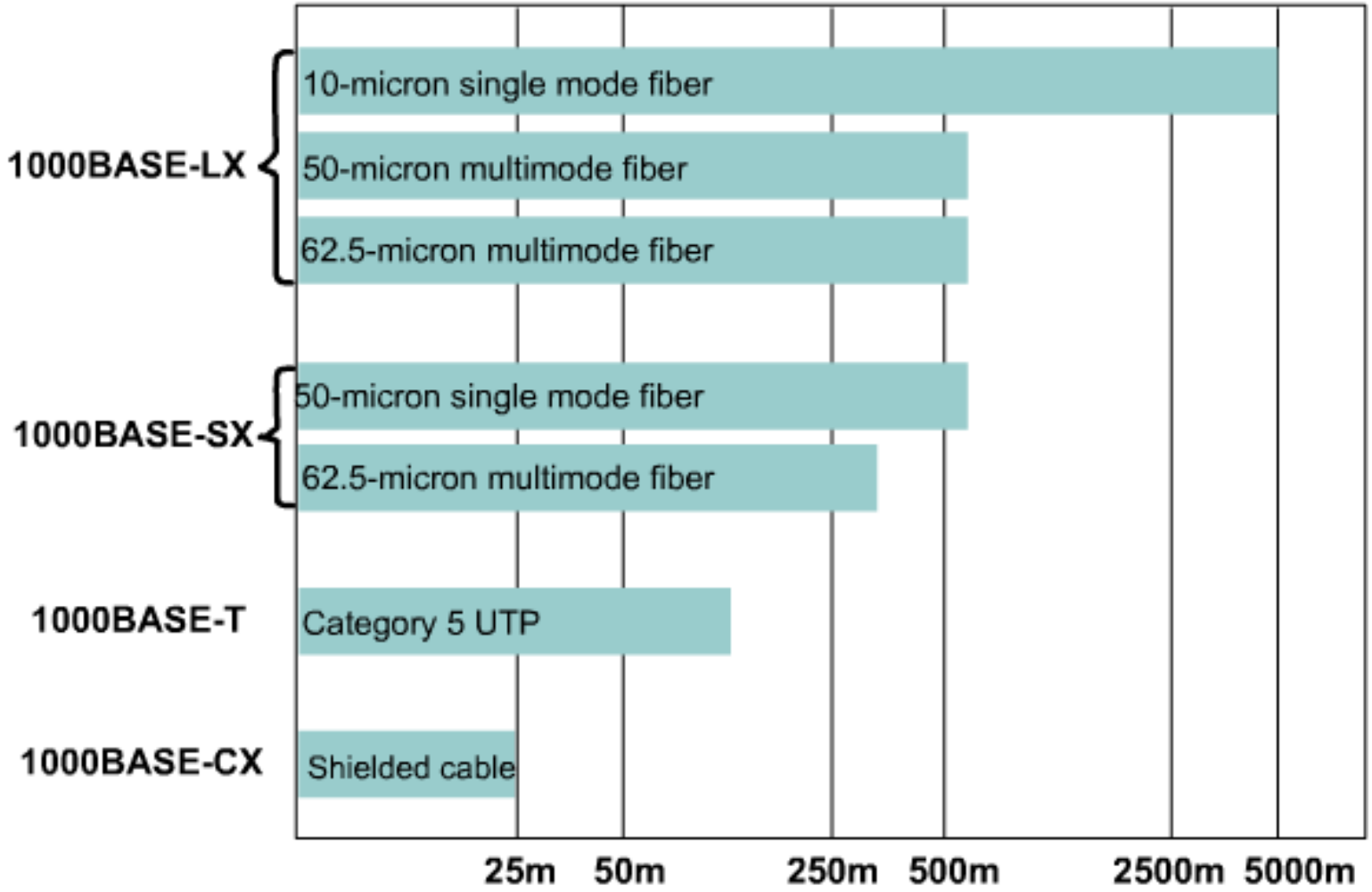
Unshielded Twisted Pair (UTP)



Optical Media



Gigabit Ethernet Media Comparison

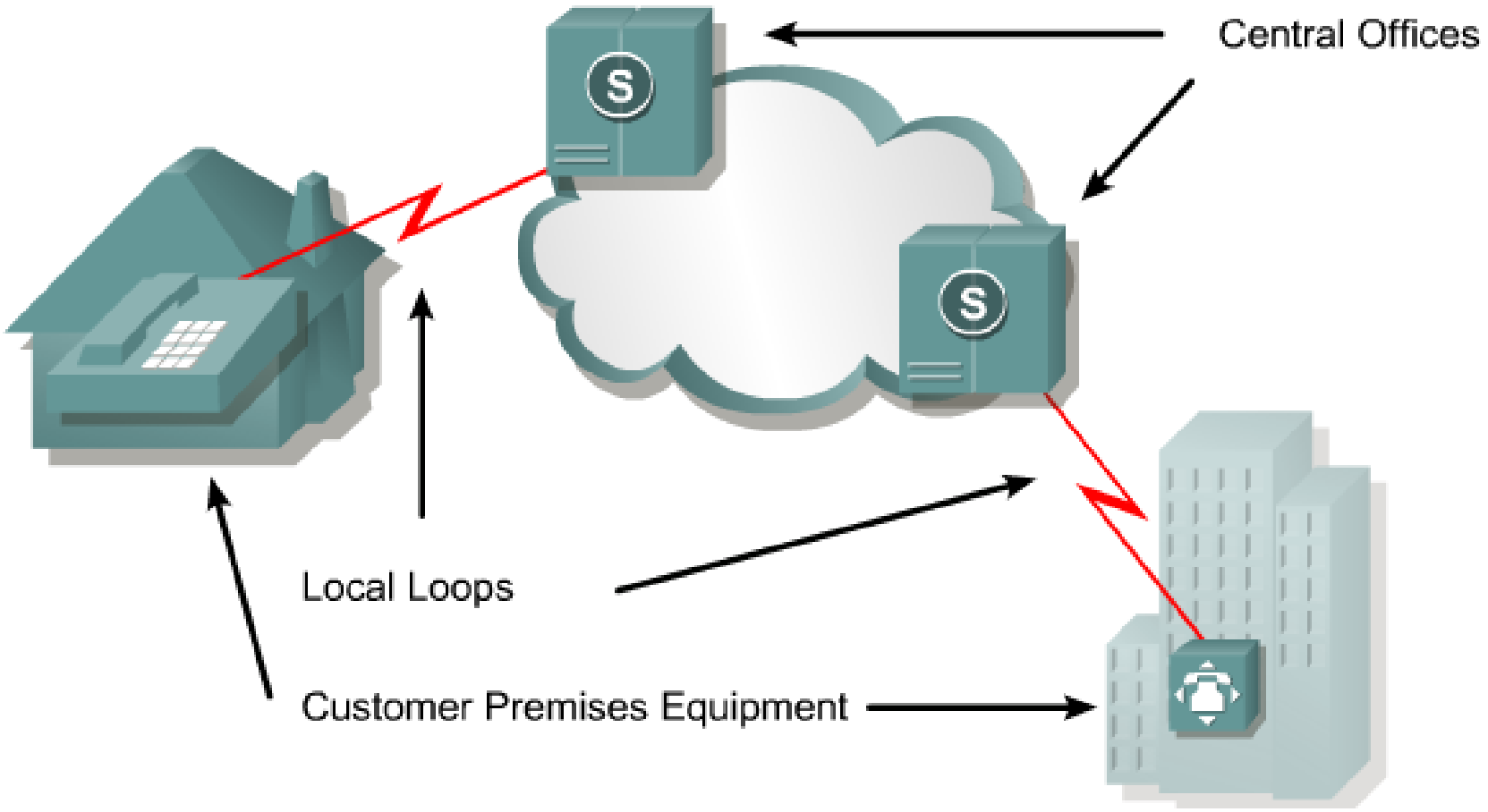


10-Gigabit Ethernet Implementations

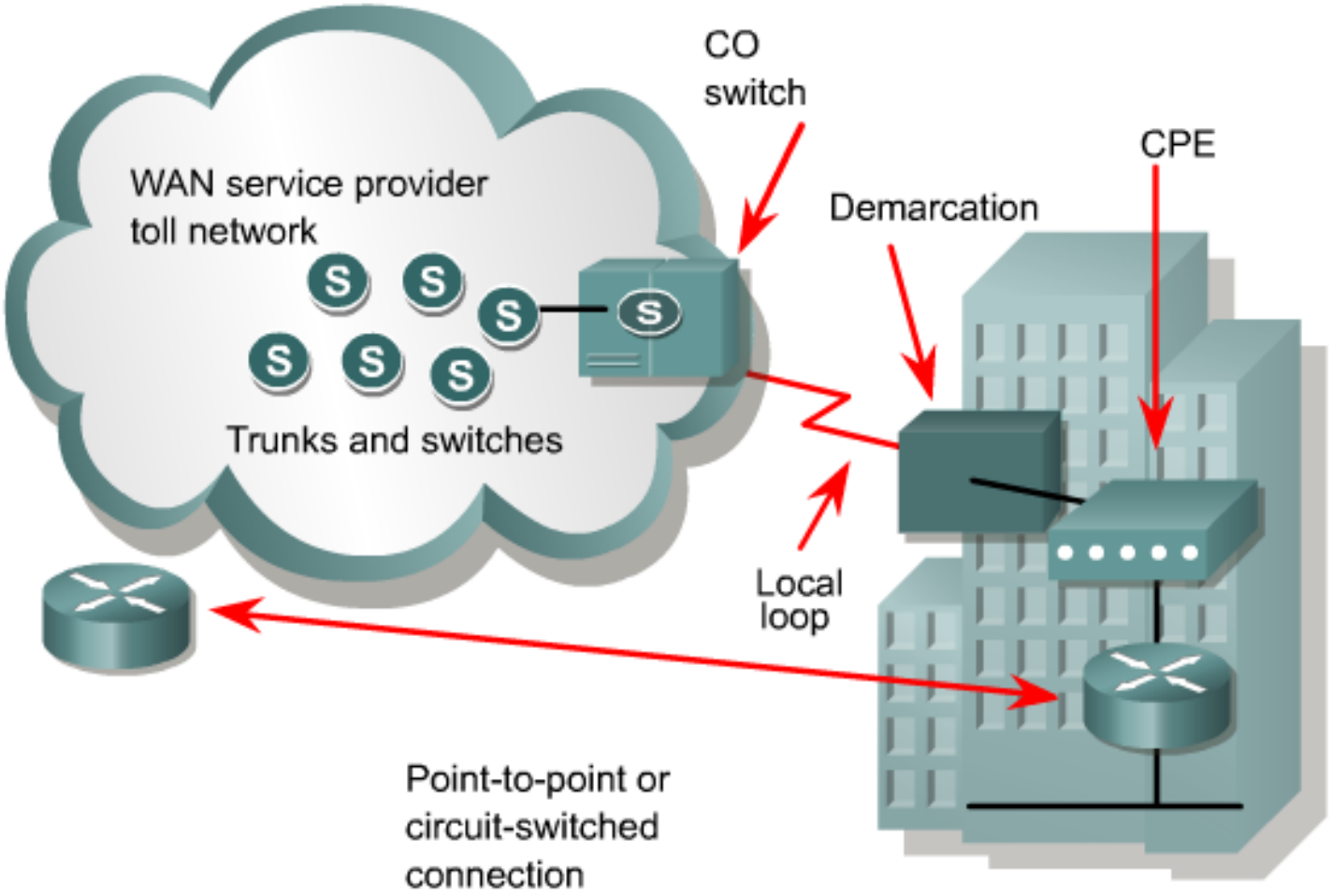
Implementation	Wavelength	Medium	Minimum Modal Bandwidth	Operating Distance
10GBASE-LX4	1310 nm	62.5µm MMF	500 MHz/km	2 - 300 m
10GBASE-LX4	1310 nm	50µm MMF	400 MHz/km	2 - 240 m
10GBASE-LX4	1310 nm	50µm MMF	500 MHz/km	2 - 300 m
10GBASE-LX4	1310 nm	10µm MMF	N/A	2 - 10 km
10GBASE-S	850 nm	62.5µm MMF	160 MHz/km	2 - 26 m
10GBASE-S	850 nm	62.5µm MMF	200 MHz/km	2 - 33 m
10GBASE-S	850 nm	50µm MMF	400 MHz/km	2 - 66 m
10GBASE-S	850 nm	50µm MMF	500 MHz/km	2 - 82 m
10GBASE-S	850 nm	50µm MMF	2000 MHz/km	2 - 300 m
10GBASE-L	1310 nm	10µm SMF	N/A	2 - 10 km
10GBASE-E	1550 nm	10µm SMF	N/A	2 - 30 km*

100 Gigabit Ethernet (100 GbE)

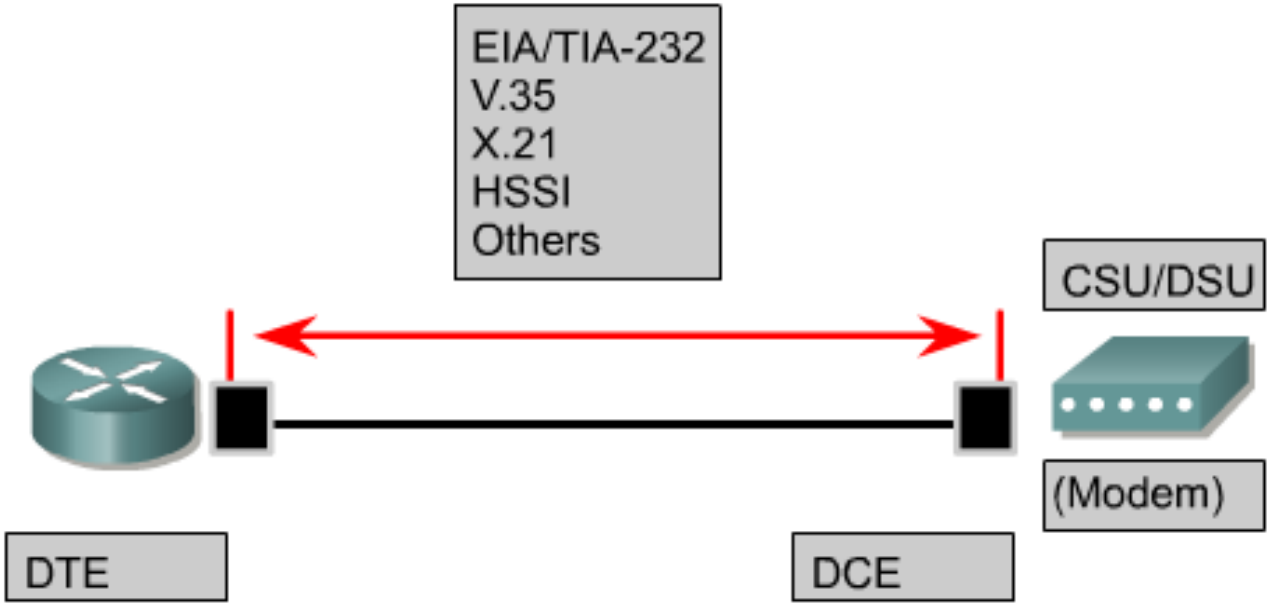
WAN Technology



WAN Service Providers



Physical Layer: WANs



Data Terminal Equipment
User device with interface connecting to the WAN link

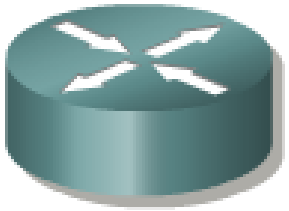
Data Circuit-Terminating Equipment
End of the WAN provider's side of the communication facility

WAN Line Types and Bandwidth

Line Type	Signal Standard	Bit Rate Capacity
56	DS0	56 Kbps
64	DS0	64 Kbps
T1	DS1	51.84 Mbps
E1	ZM	2.048 Mbps
E3	M3	34.064 Mbps
J1	Y1	2.048 Mbps
T3	DS3	44.736 Mbps
OC-1	SONET	51.84 Mbps
OC-3	SONET	155.54 Mbps
OC-9	SONET	466.56 Mbps
OC-12	SONET	622.08 Mbps
OC-18	SONET	933.12 Mbps
OC-24	SONET	1244.16 Mbps
OC-36	SONET	1866.24 Mbps
OC-48	SONET	2488.32 Mbps
OC-192	**SONET**	**10G**
OC-768	**SONET**	**40G**

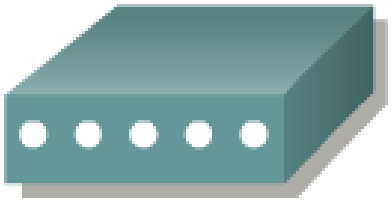
WAN Devices

Router



Switch

Modem (CSU/DSU)

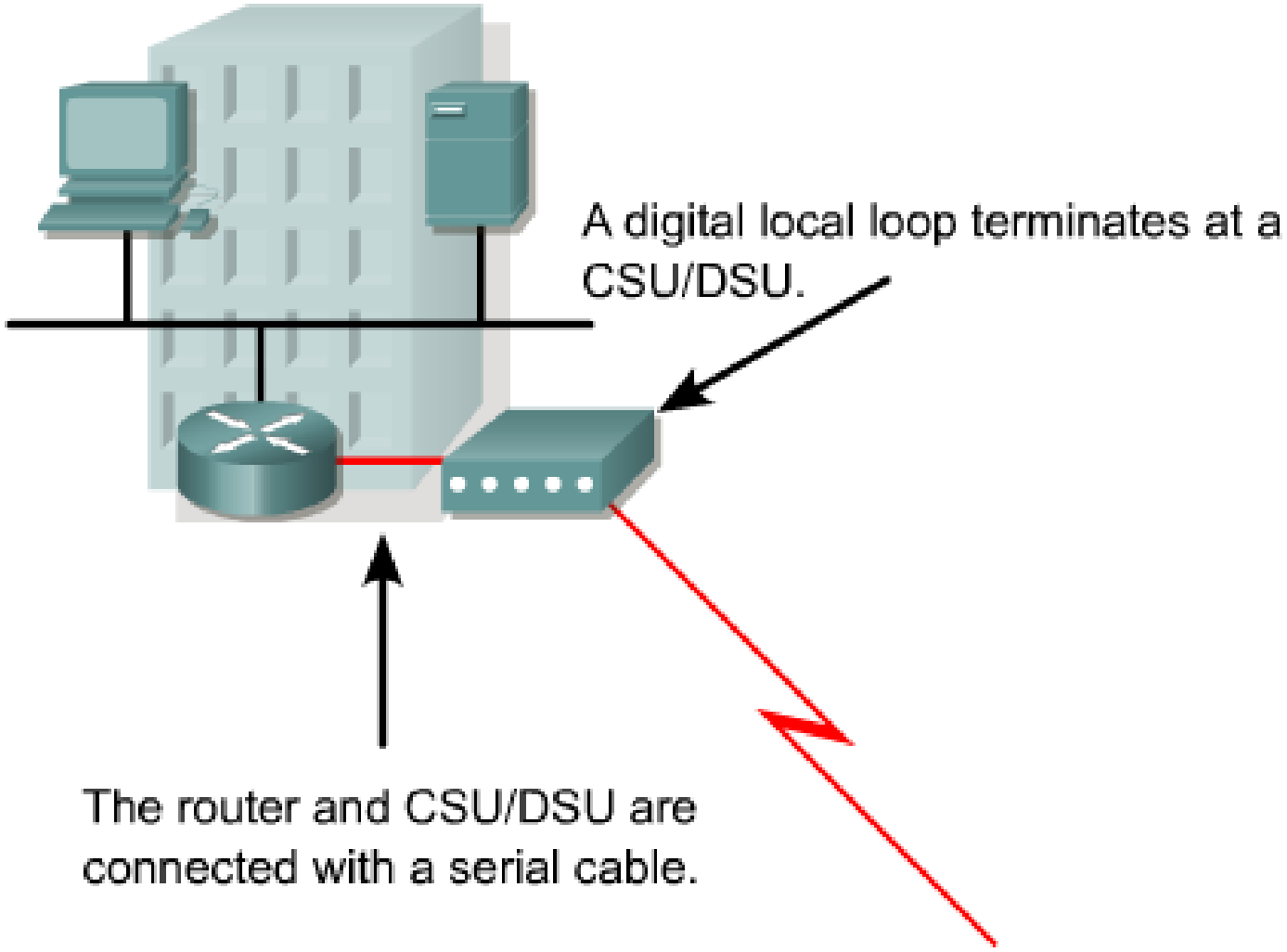


Communication Server

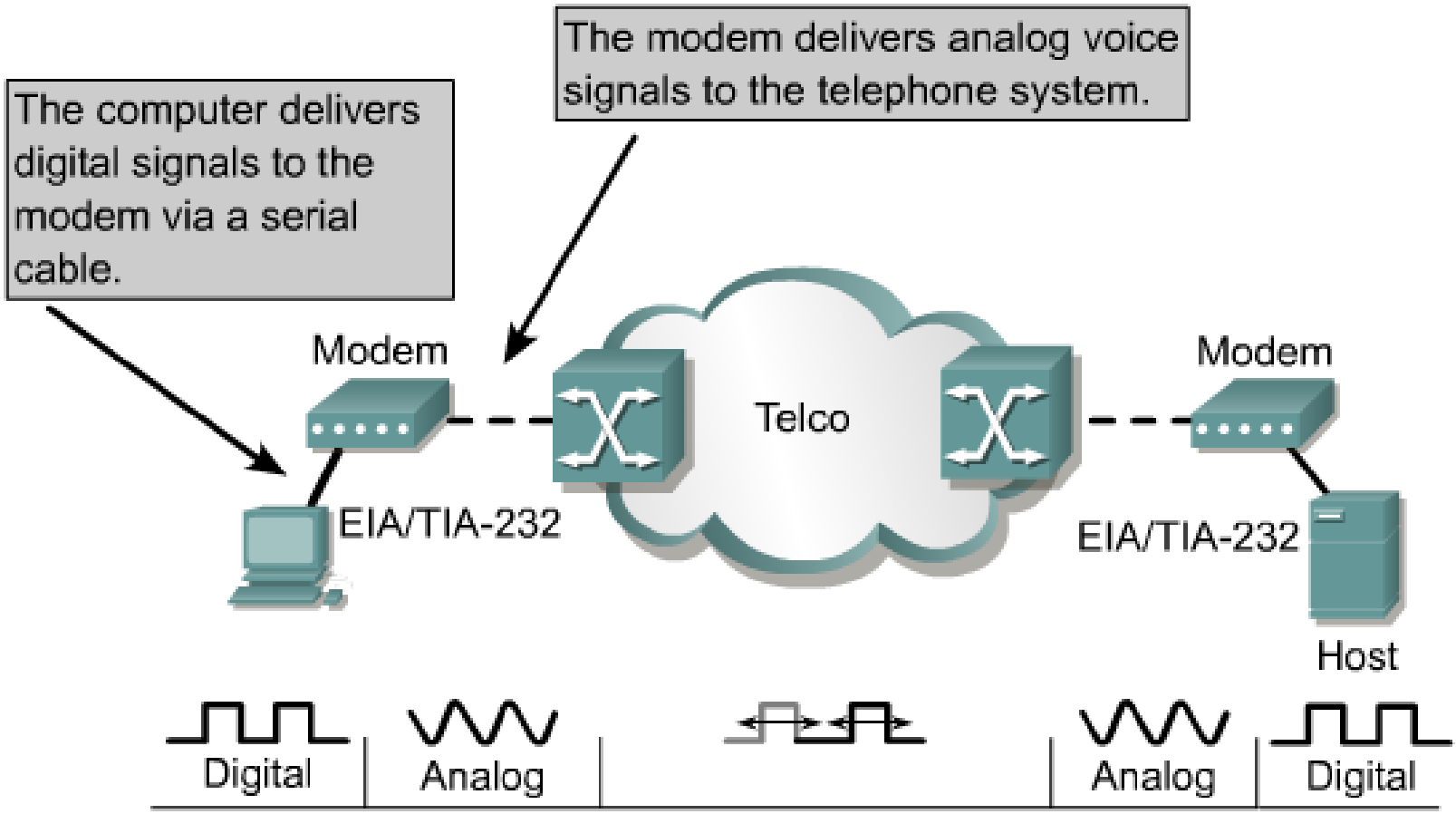
WANs are designed to:

- Operate over large geographic area.
- Allow access over serial interfaces operating at lower speeds.
- Provide full-time and part-time connectivity.

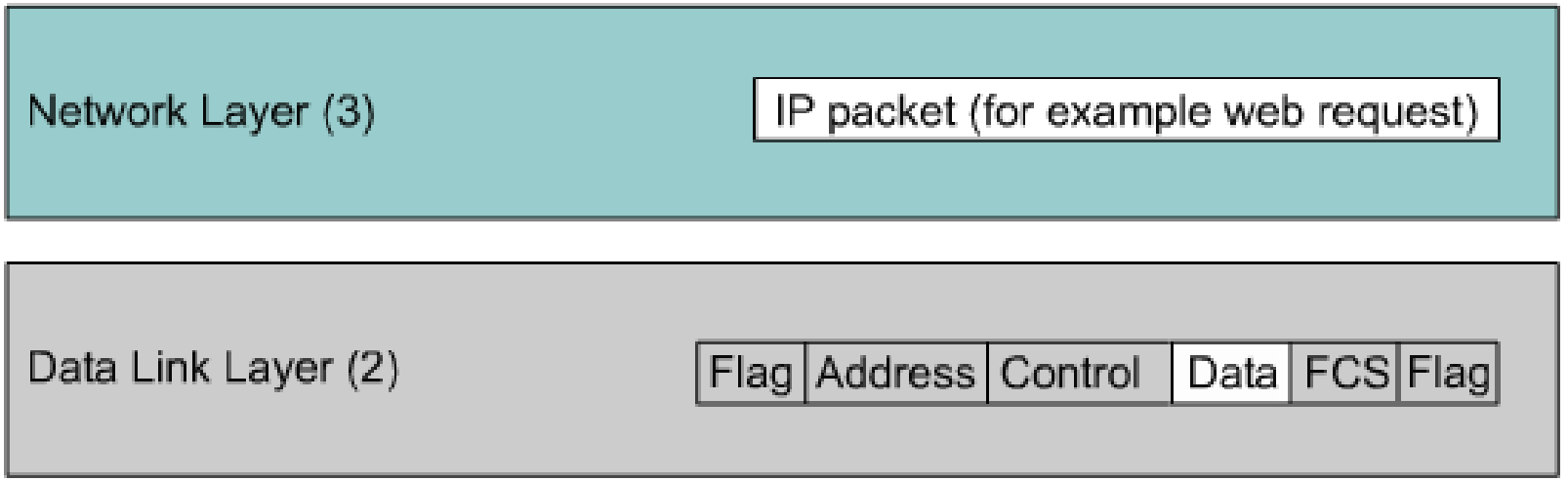
CSU/DSU



Modem Transmission



WAN Encapsulation

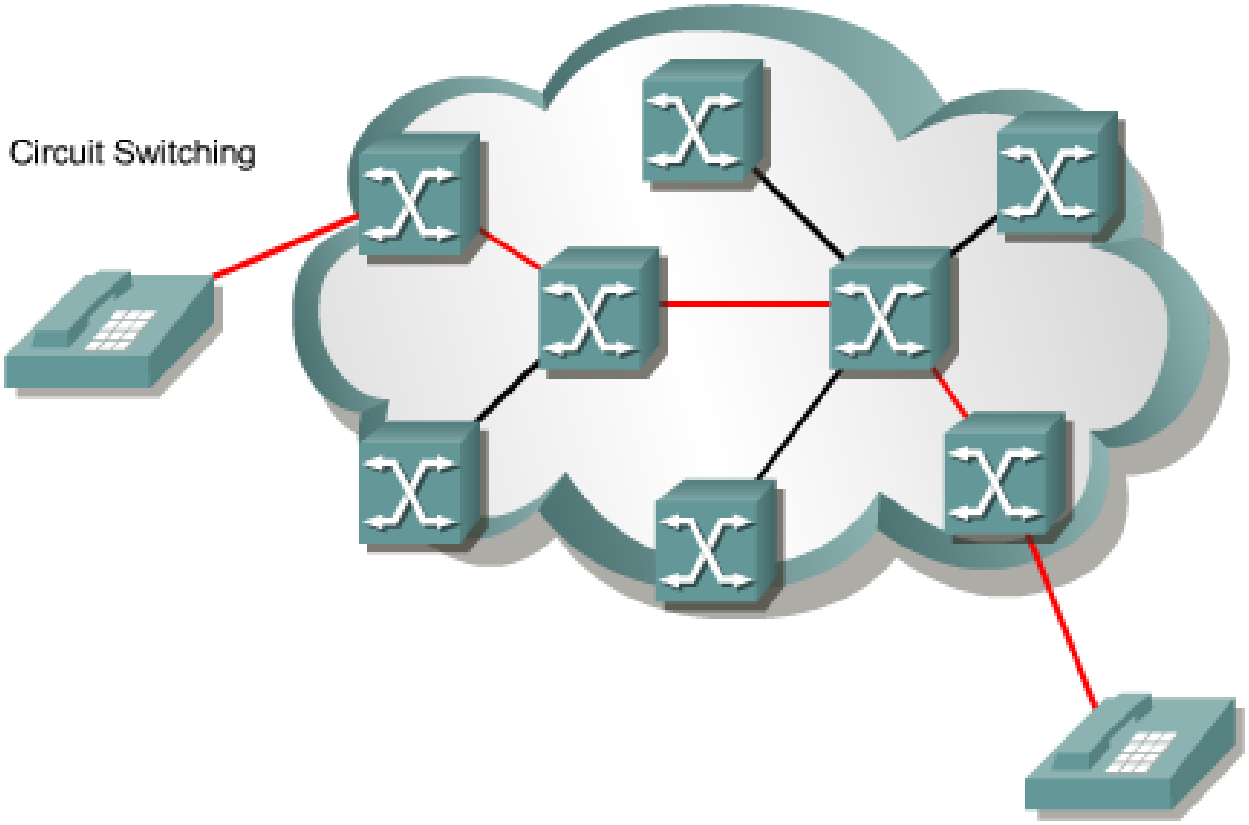


Network data is encapsulated in an HDLC frame.

WAN Data-Link Protocols

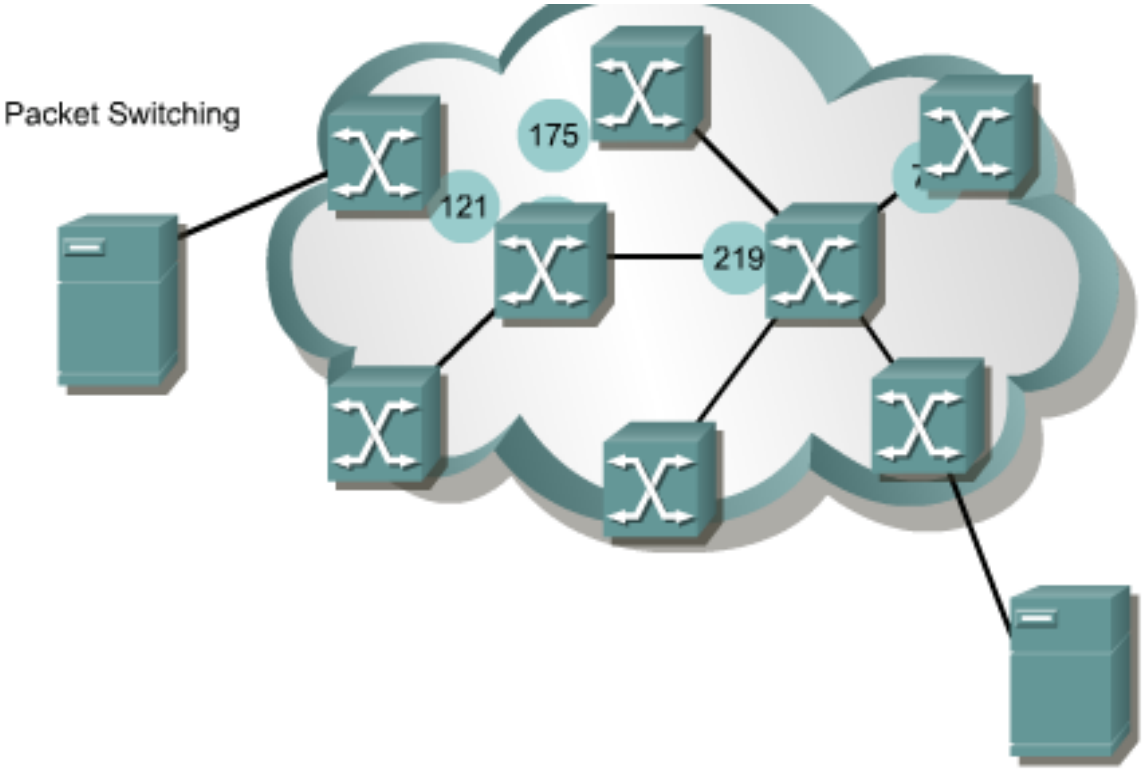
Protocol	Usage
Link Access Protocol Balanced (LAPB)	X.25
Link Access Protocol D Channel (LAPD)	ISDN D channel
Link Access Protocol Frame (LAPF)	Frame Relay
High-Level Data Link Control (HDLC)	Cisco's implementation has an extra header field
Point-to-Point Protocol (PPP)	Dialup connections

Circuit Switching



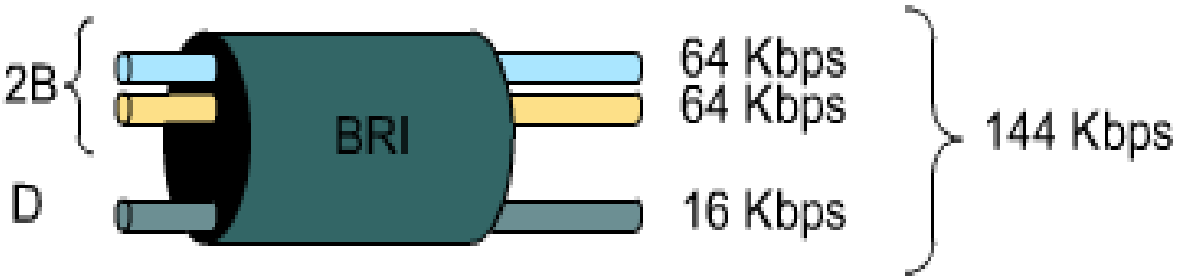
Dialing sets up a physical circuit through the system.

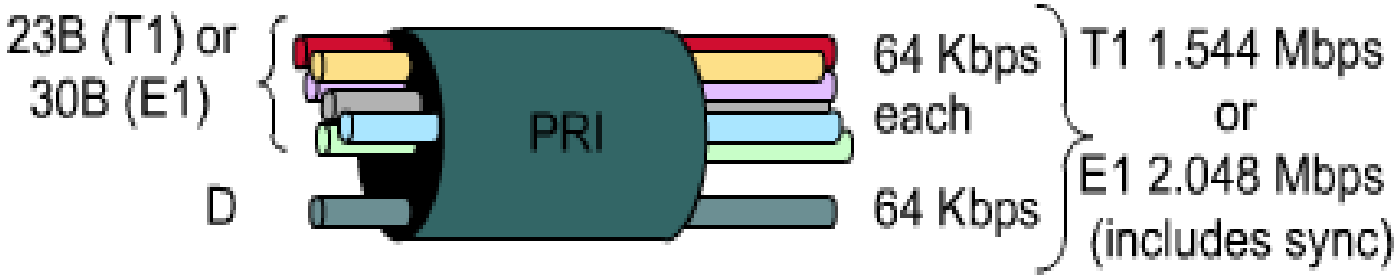
Packet Switching



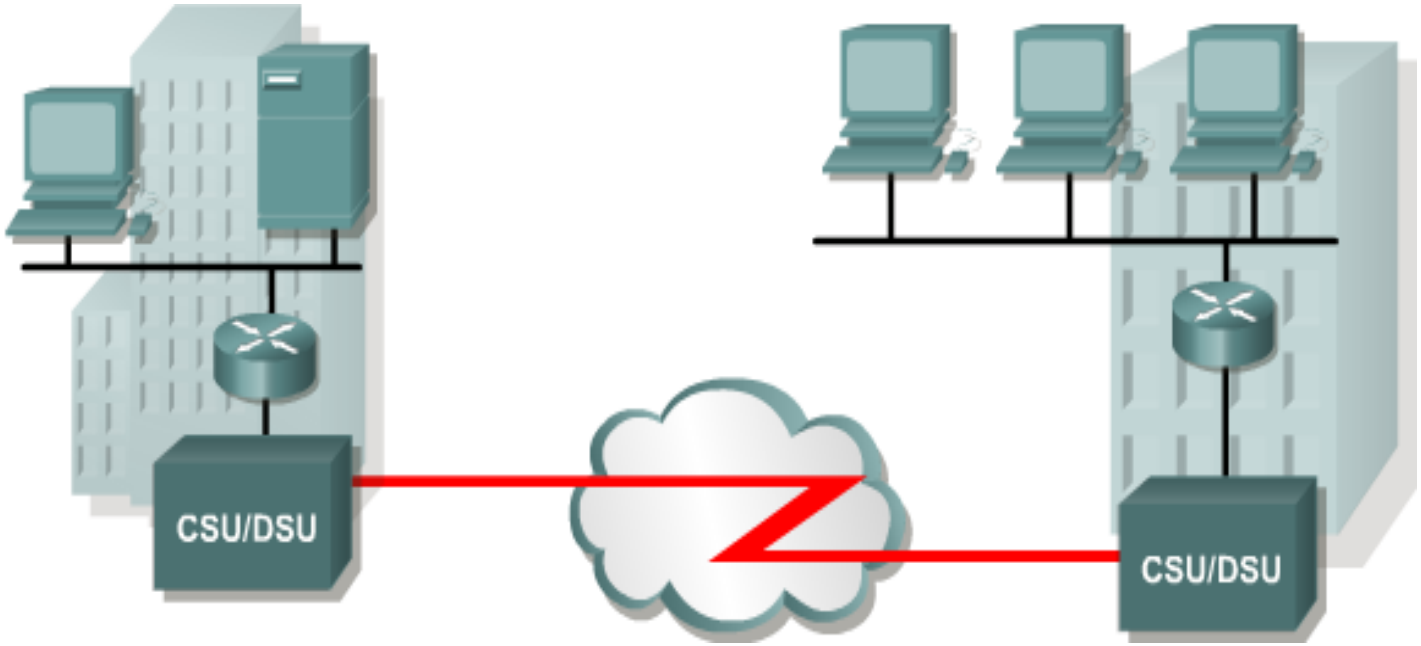
Labeled data is passed from switch to switch. It may have to wait its turn on a link.

ISDN





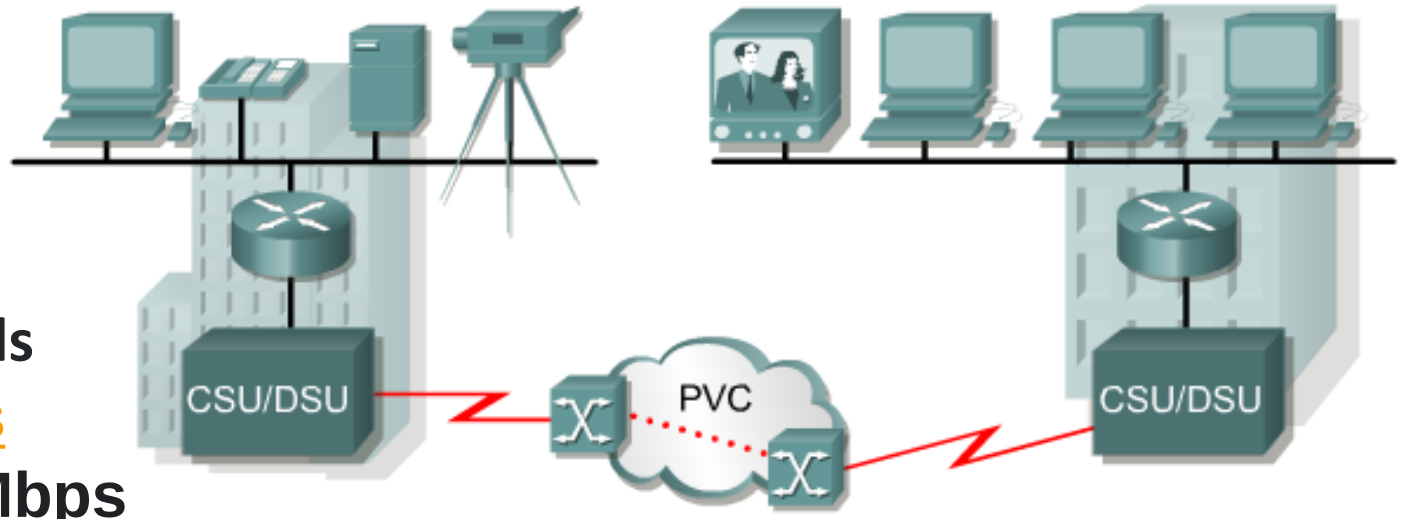
Leased Line



- **Leased lines are not only used to provide direct point-to-point connections between Enterprise LANS, they can also be used to connect individual branches to a packet switched network.**

ATM

- **Asynchronous Transfer Mode (ATM) is a technology capable of transferring voice, video, and data through private and public networks. It is built on a cell based architecture rather than on a frame-based architecture.**

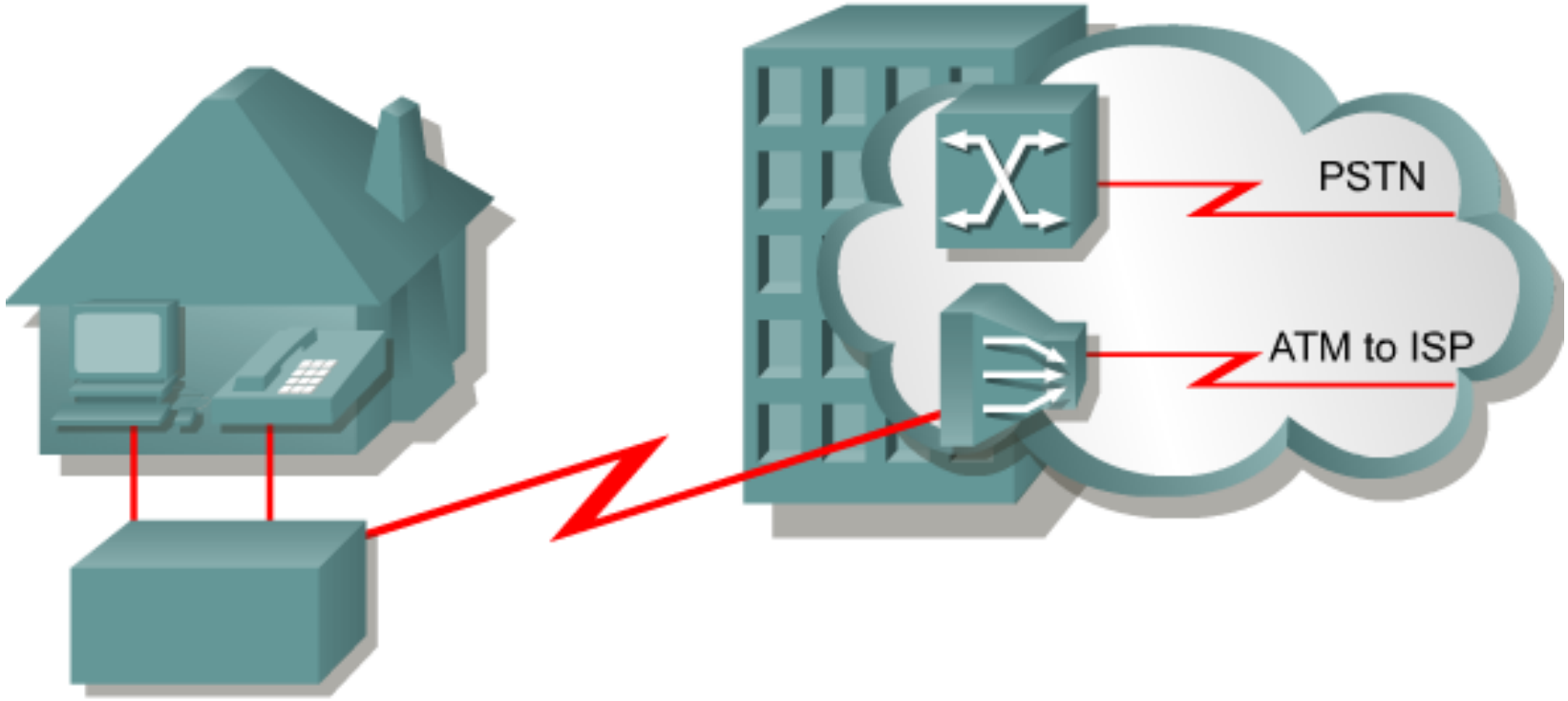


ATM cells
53 bytes
1.544 Mbps to 622 Mbps

DSL (Digital subscriber line)

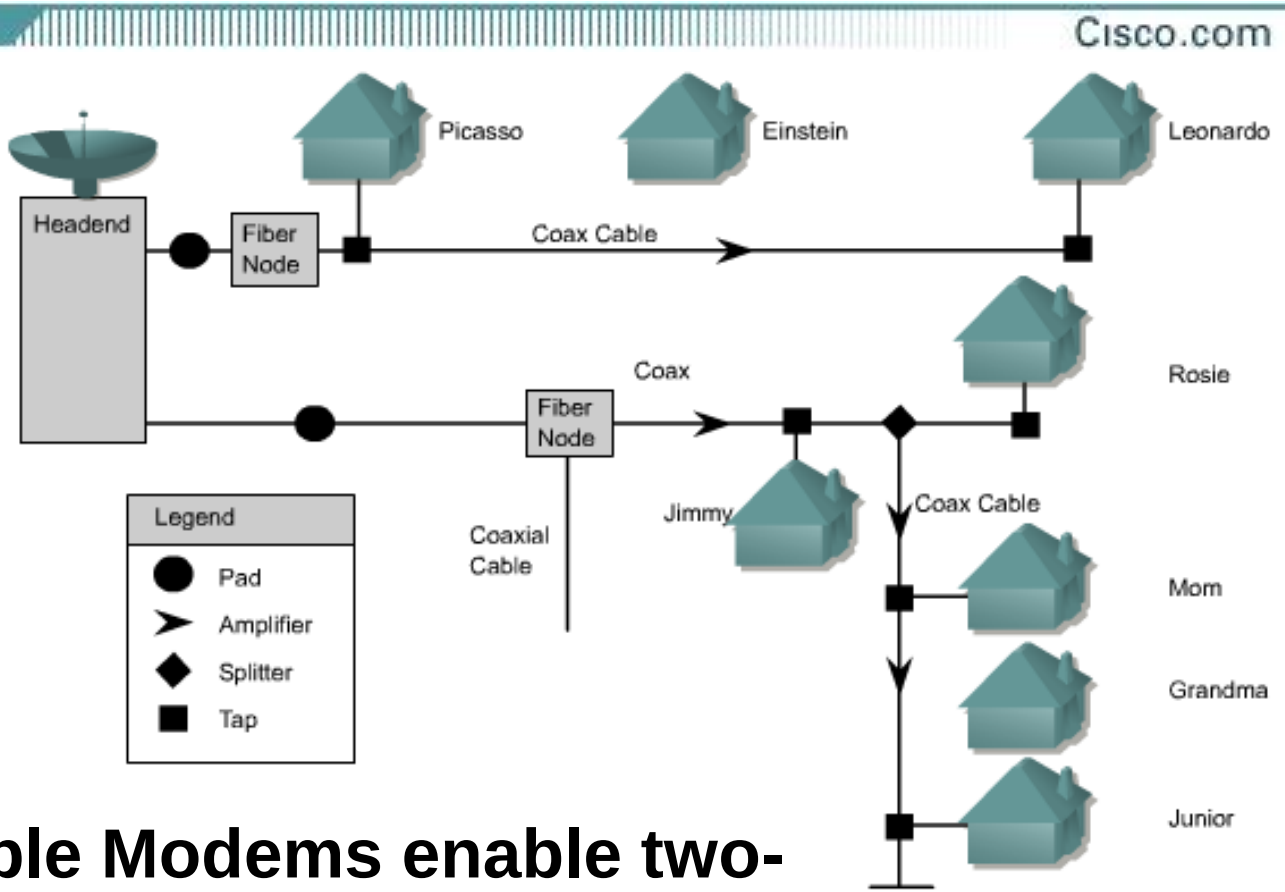
Service	Download	Upload
ADSL	1.5 M - 8.192 M	16 K - 640 K
SDSL	1.544 M - 2.048 M	1.544 M - 2.048 M
HDSL	1.544 M - 2.048 M	1.544 M - 2.048 M
IDSL	144 K	144 K
RADSL	64 K - 8.192 M	16 M - 768 M
CDSL	1 M	16 K -160 K

ADSL Technology



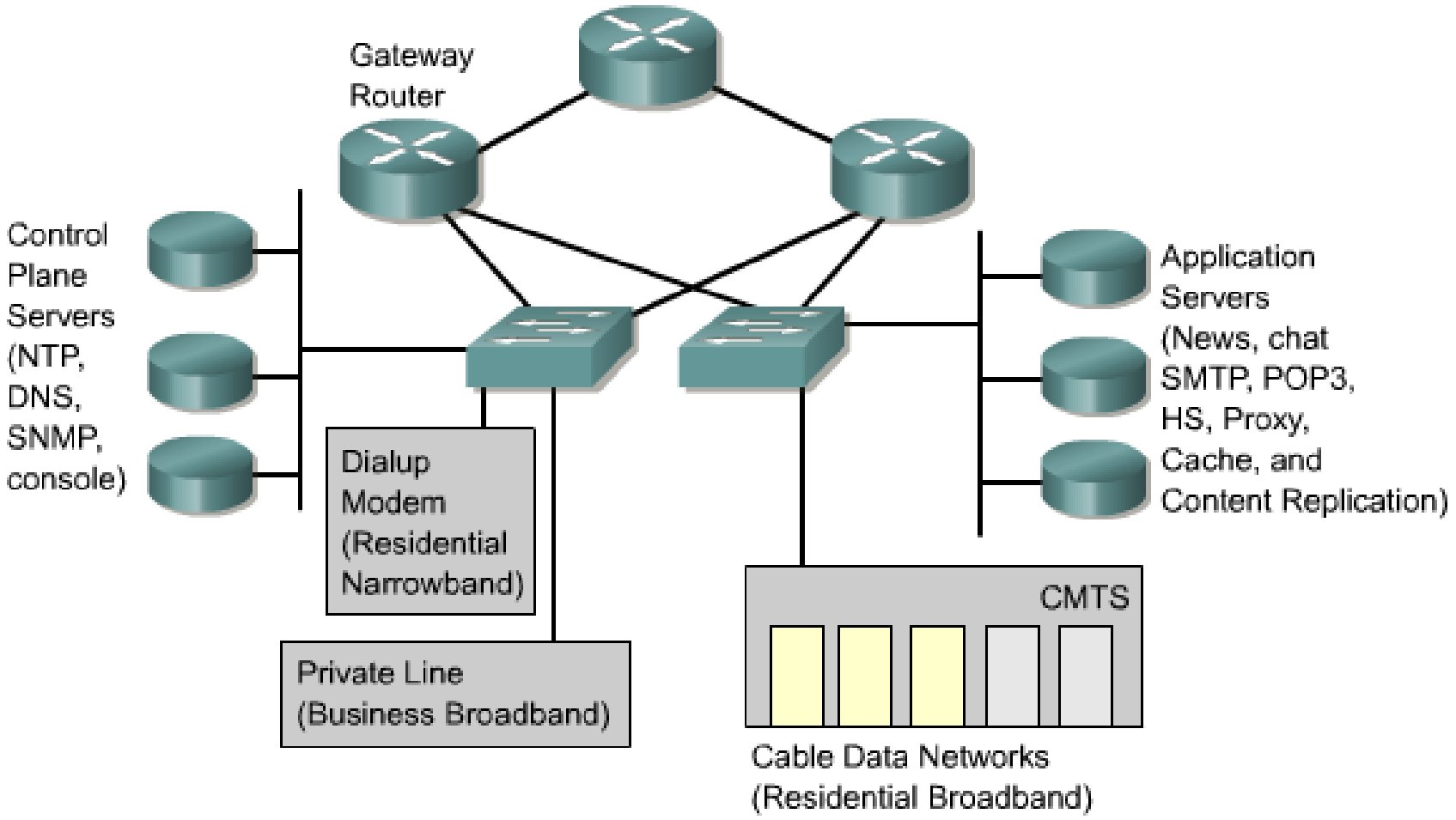
Local loop connects splitter in house to DSLAM in central office.
Voice and data use separate frequency ranges.

Cable Modem



- **Enhanced Cable Modems enable two-way. High speed data transmissions using the same coaxial lines that transmit cable television.**

Cable Data Network Architecture

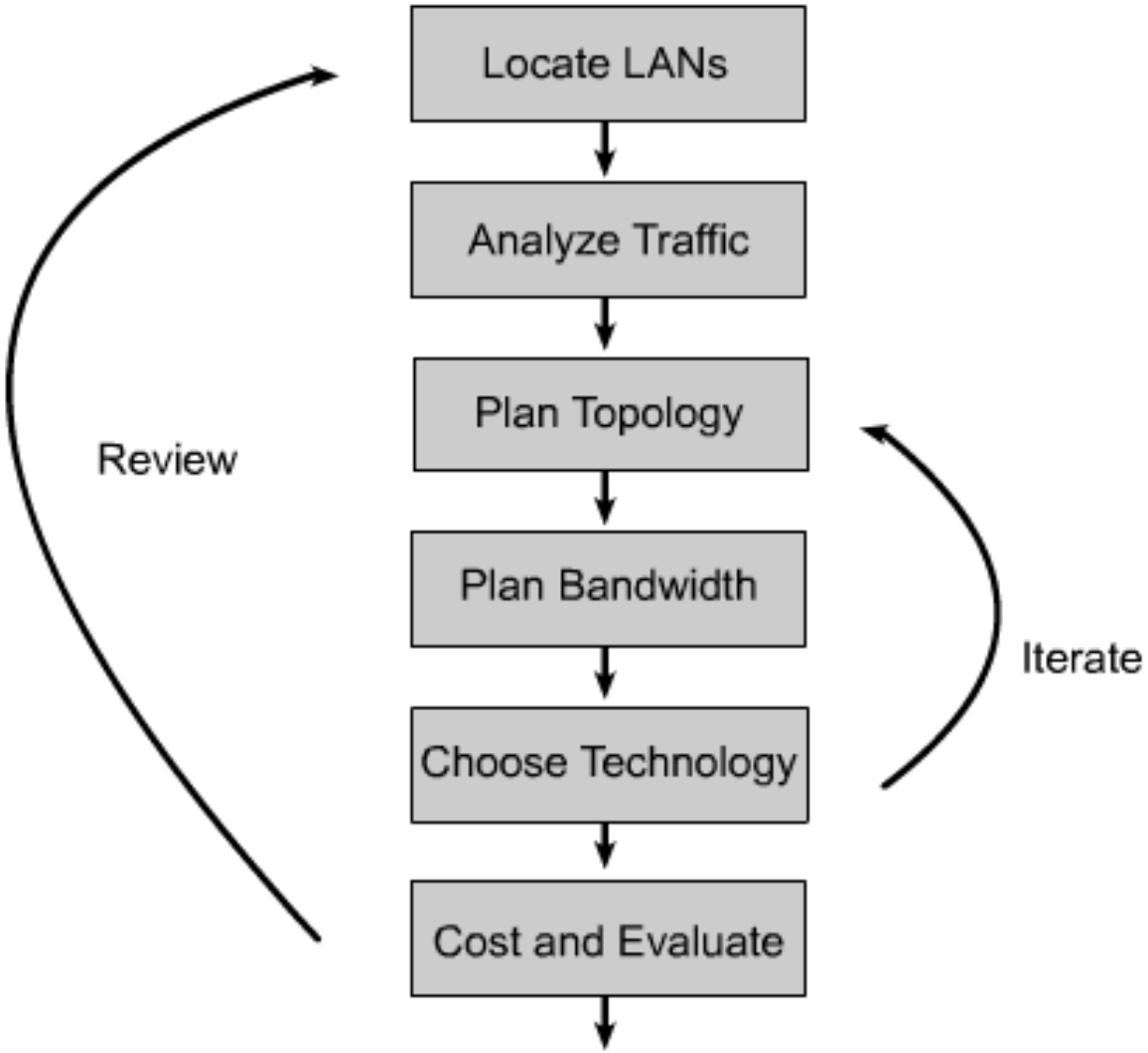


Comparing WAN Traffic Types

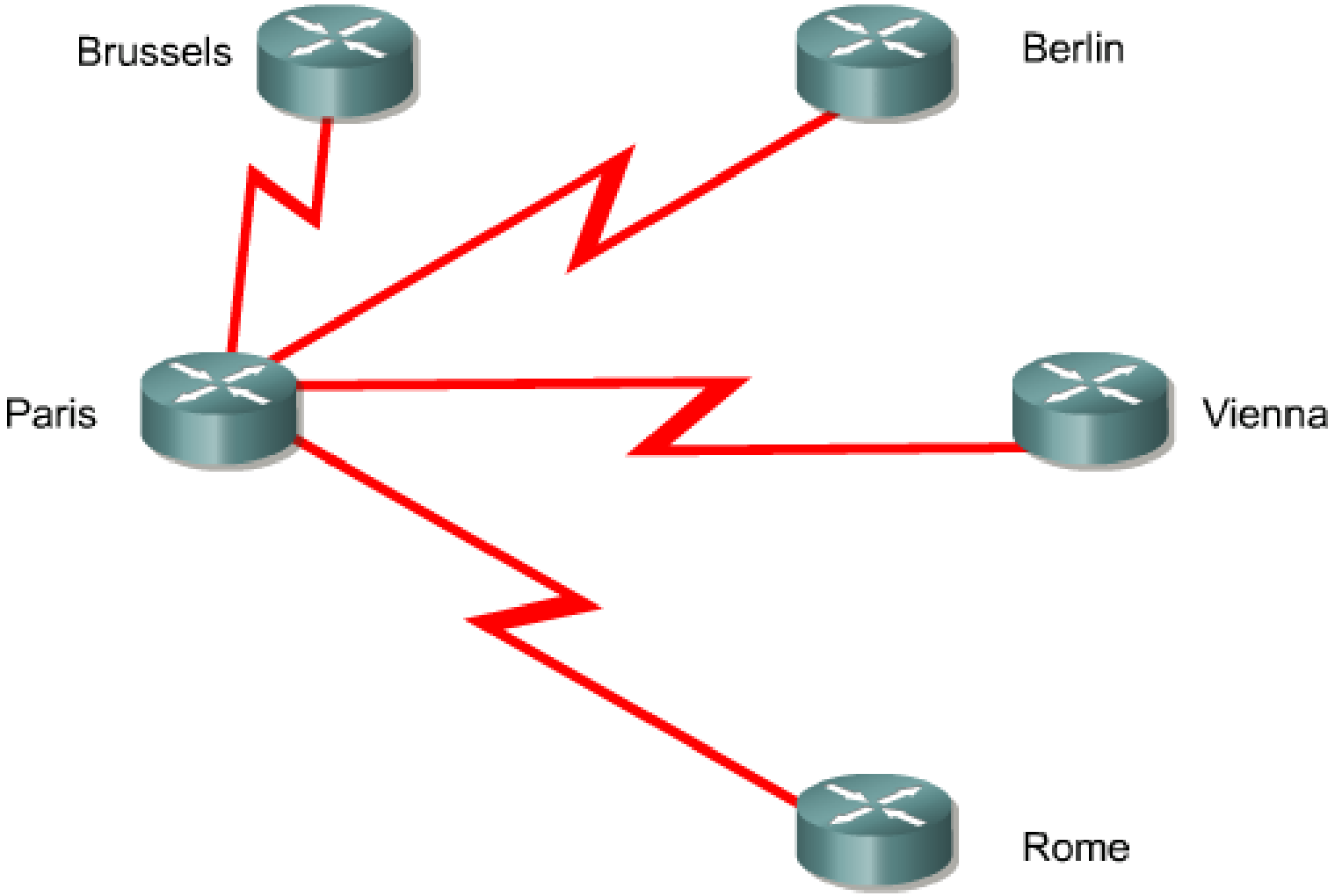
Traffic	Latency	Jitter	Bandwidth
Voice	Low	Low	Medium
Transaction data (for example, SNA)	Medium	Medium	Medium
Messaging (e-mail)	High	High	High
File transfer	High	High	High
Batch data	High	High	High
Network management	High	High	Low
Videoconferencing	Low	Low	High

Some WAN traffic types with tolerance to latency and jitter, along with bandwidth requirements.

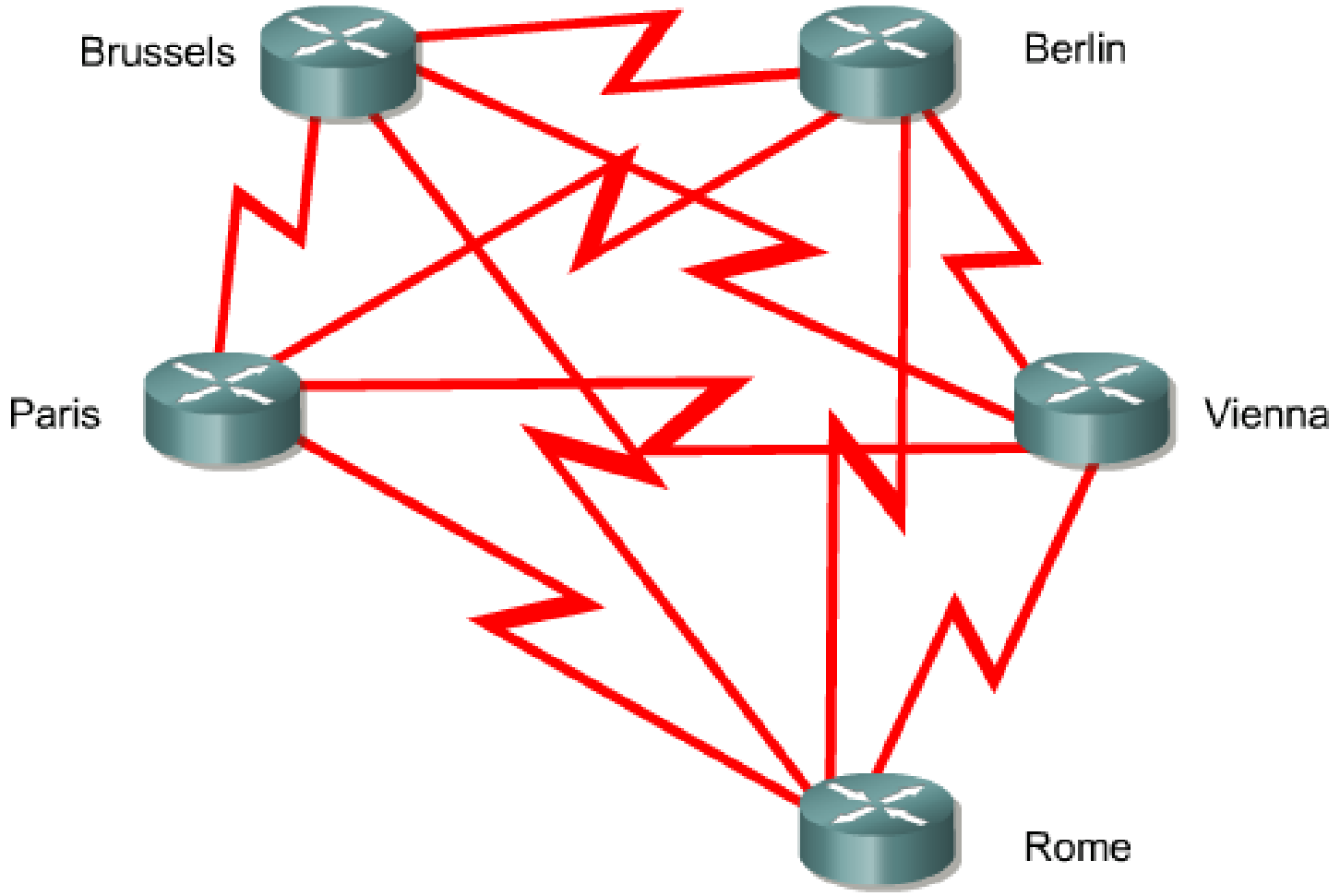
Steps In WAN Design



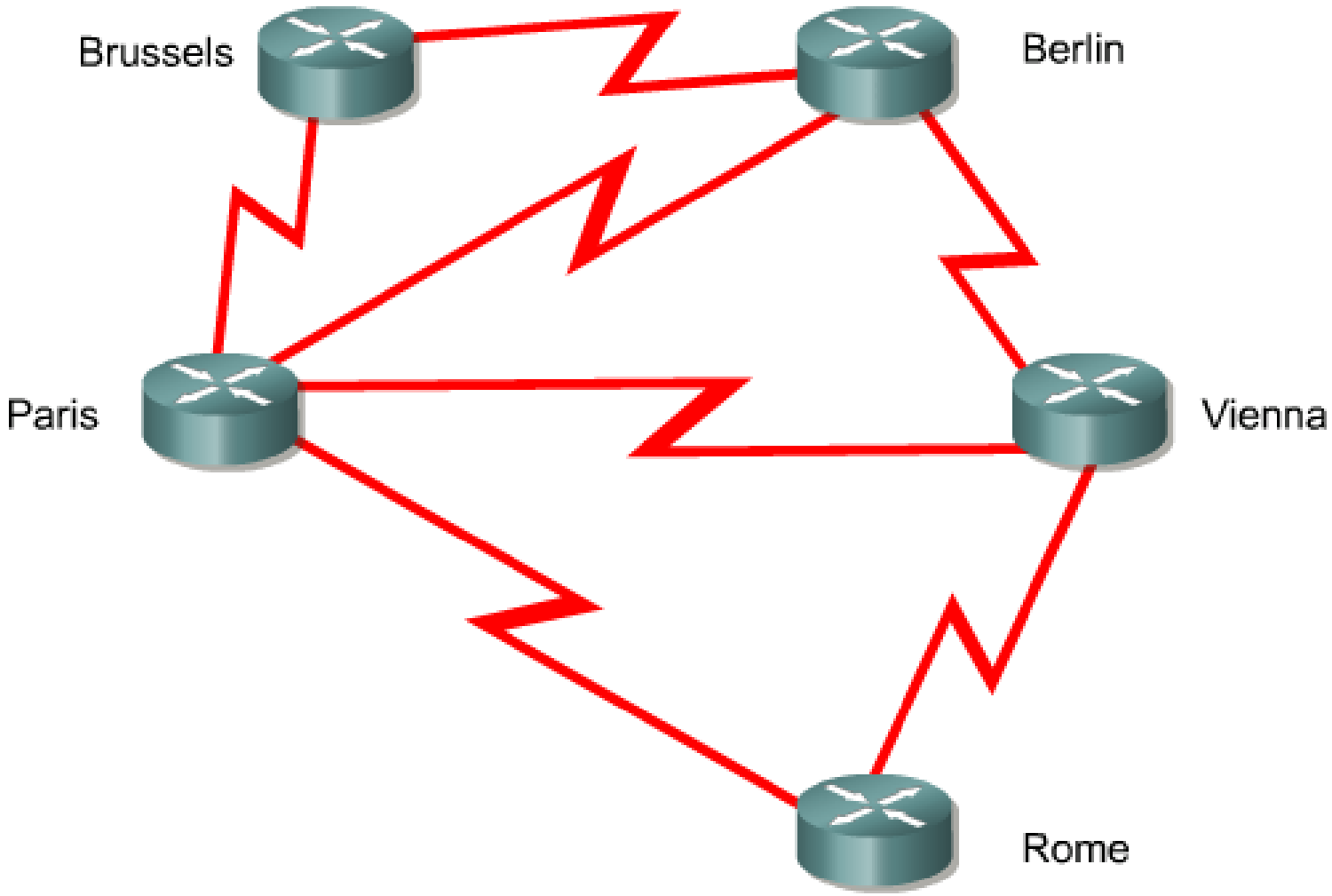
Star Topology



Full-Mesh Topology



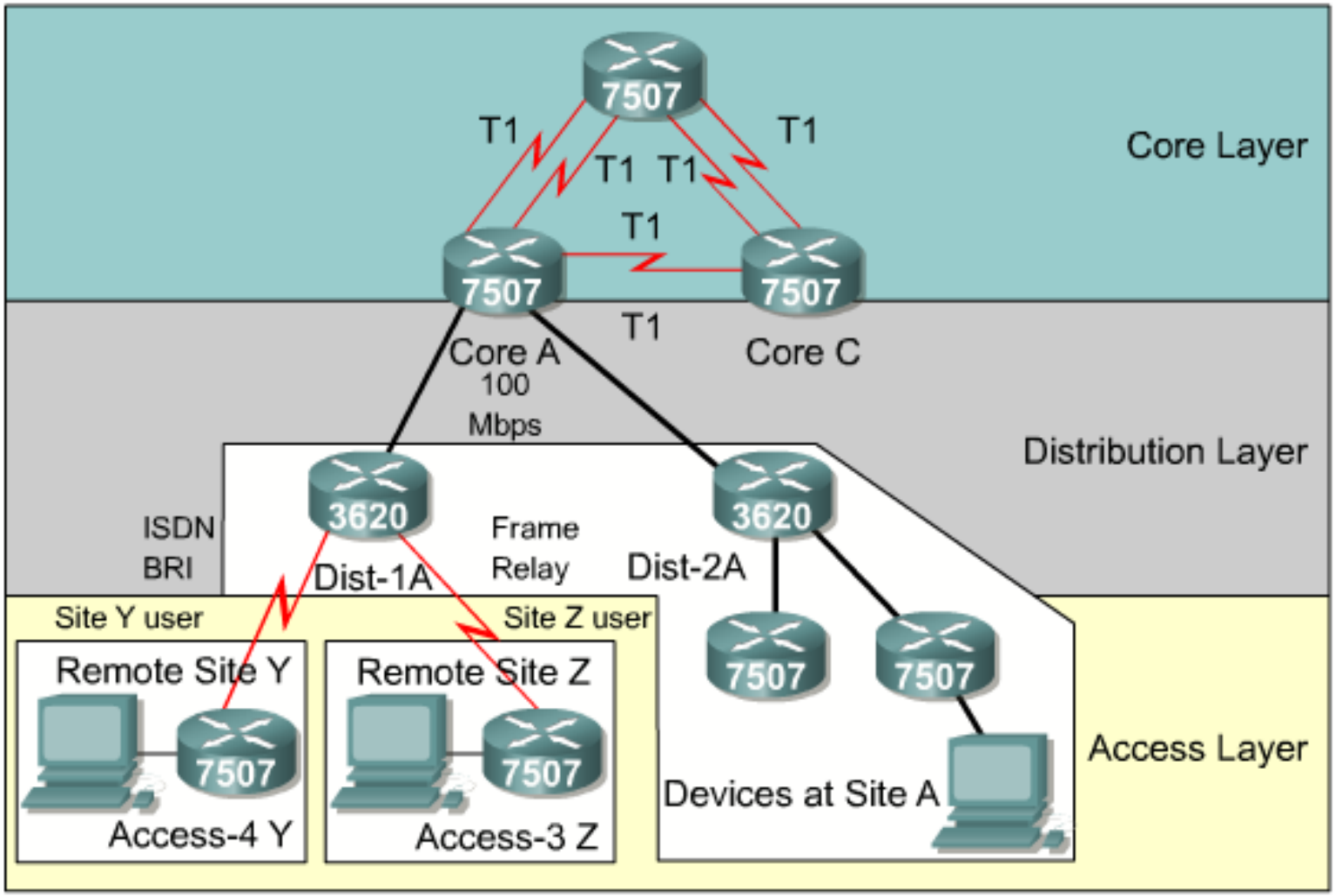
Partial-Mesh Topology



Three-Layer Design Model

- **The links connecting the various sites in an area that provide access to the enterprise network are called the access links or access layer of the WAN.**
- **Traffic between areas is distributed by the distribution links, and is moved onto the core links for transfer to other regions, when necessary.**

Internet for WAN Connectivity



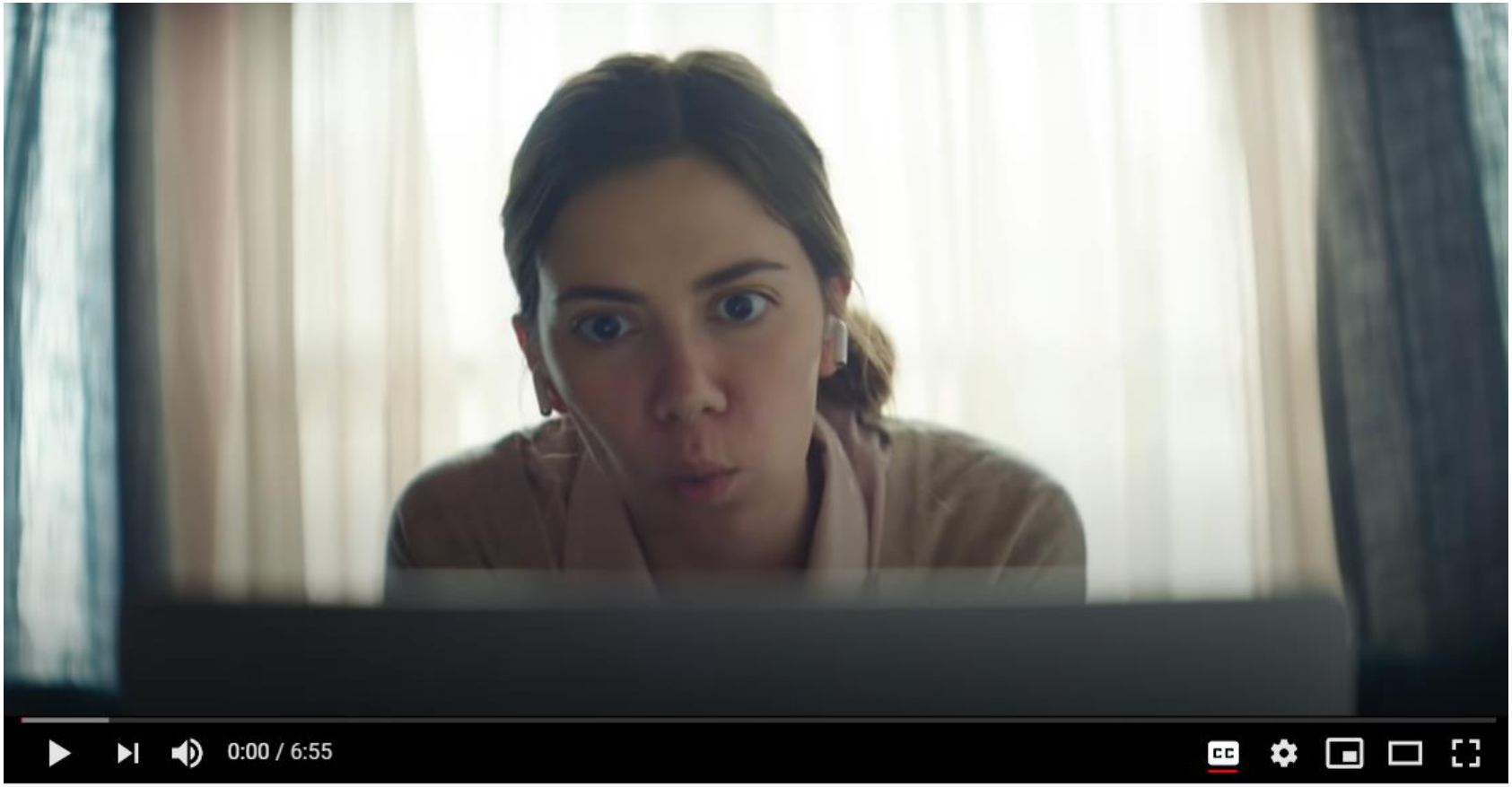
Microsoft IoT in Action

https://www.youtube.com/watch?v=n0LqqadpIIA&t=1s

Microsoft Empowers Telecommunications

https://www.youtube.com/watch?v=sOkhROQESag

APPLE: Working From Home



https://www.youtube.com/watch?v=6_pru8U2RmM&t=40s