

More on Telecommunications

Module C

Panko and Panko

Business Data Networks and Security, 9th Edition

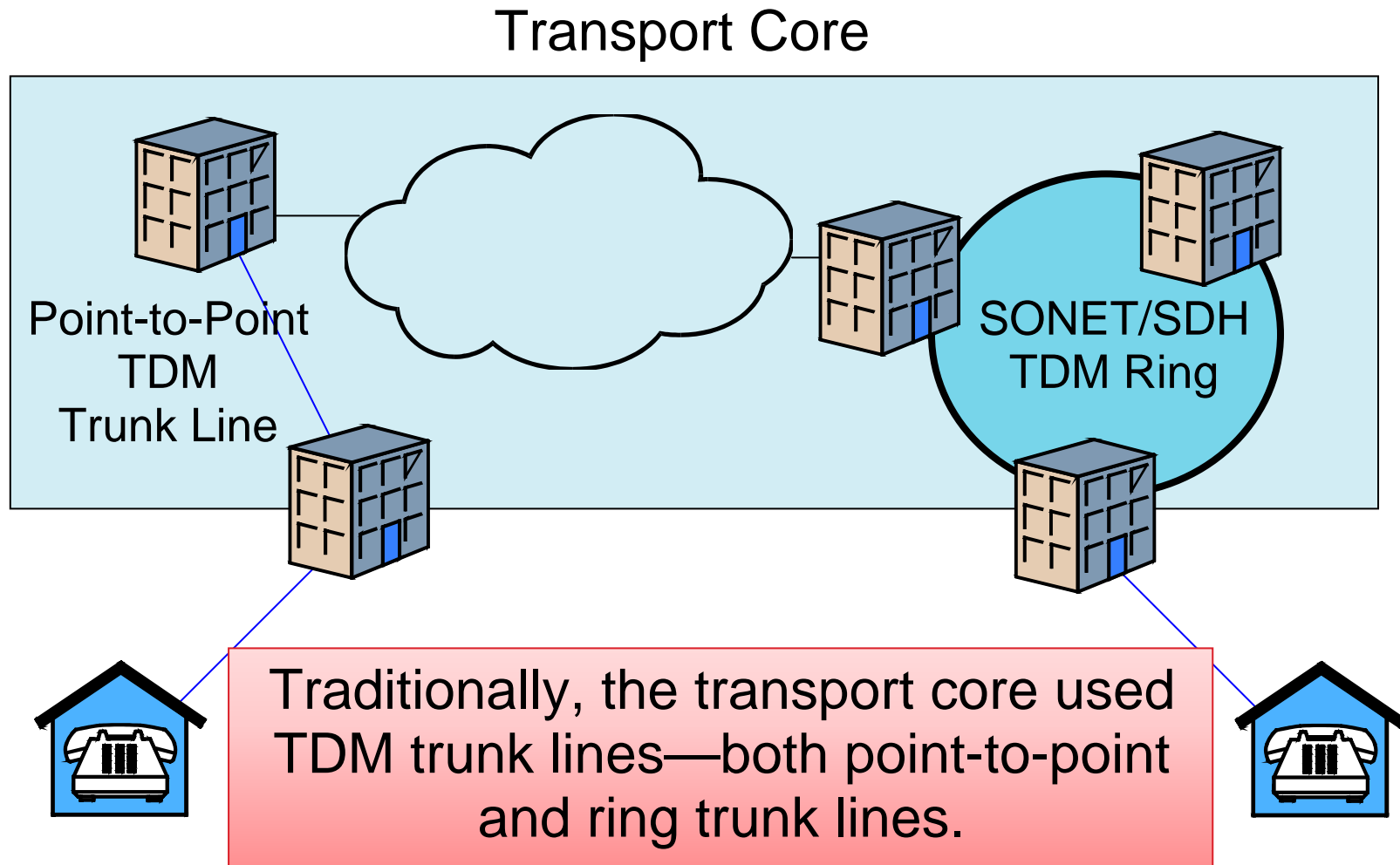
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Introduction

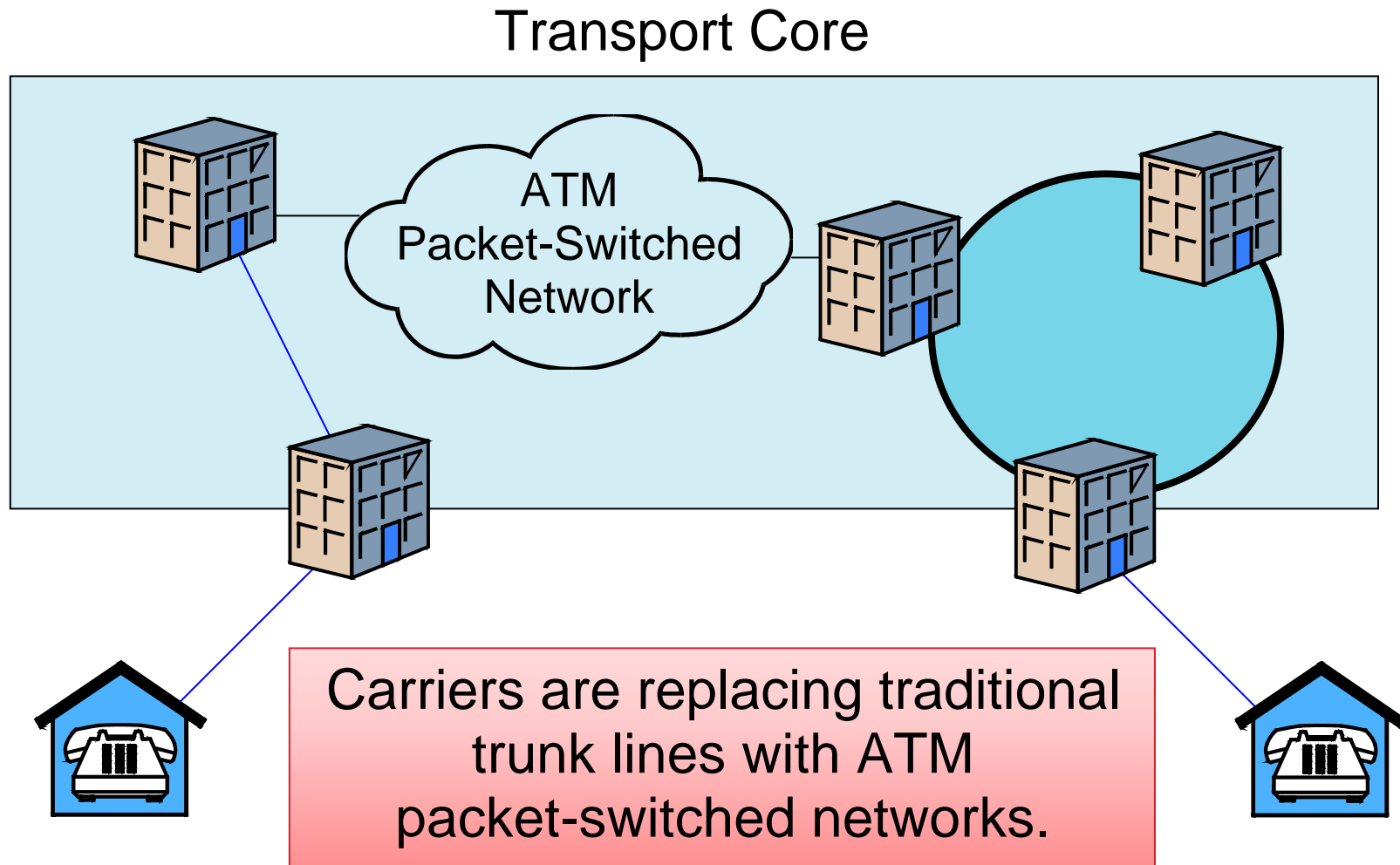
- ▶ This module covers telecommunications topics that are not covered in the 11 core chapters.
- ▶ Teachers are likely to pick which topics they will cover.

C.1: TDM and ATM Switch Connections in the PSTN

Transport Core



C.1: TDM and ATM Switch Connections in the PSTN Transport Core



C.2: Leased Lines and Multiplexing

North American Digital Hierarchy Line	Speed	Multiplexed Voice Calls
56 kbps	56 kbps	1
T1	1.544 Mbps	24
T3	44.736 Mbps	672

Leased lines, which are based on trunk lines, are often used to multiplex voice calls.

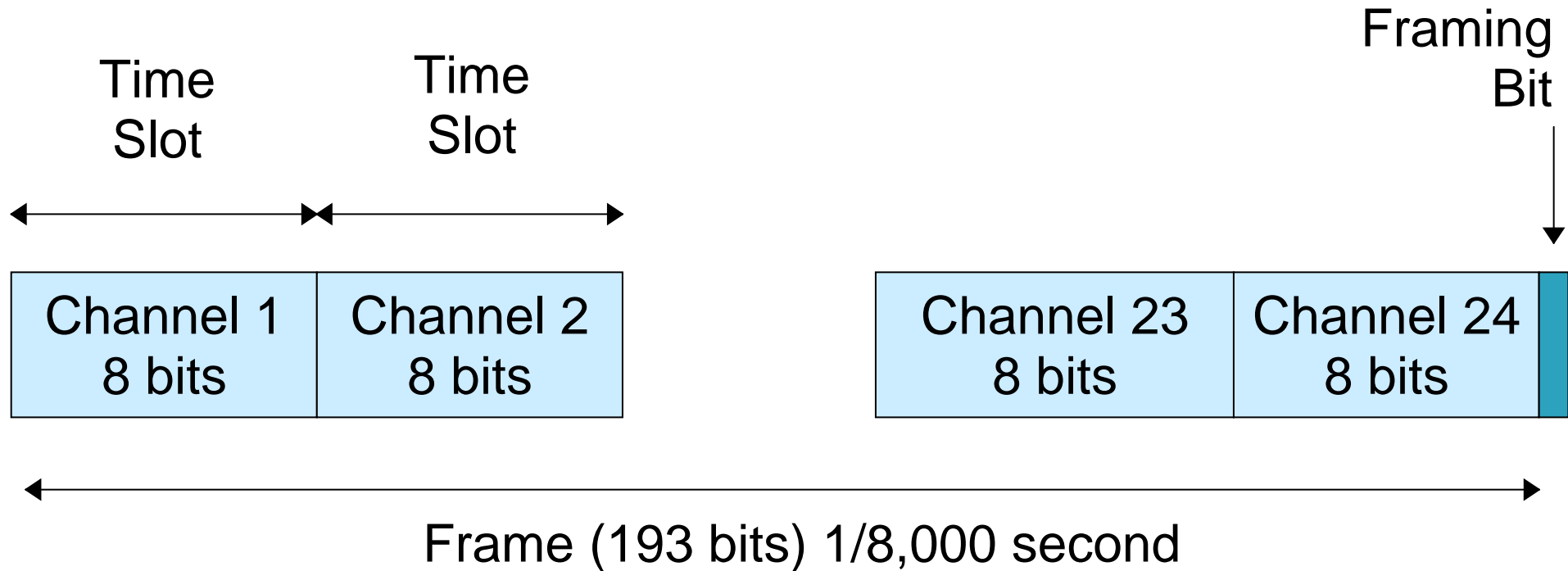
C.2: Leased Lines and Multiplexing

CEPT Line	Speed	Multiplexed Voice Calls
64 kbps	64 kbps	1
E1	2.048 Mbps	30
E3	34.368 Mbps	480

C.2: Leased Lines and Multiplexing

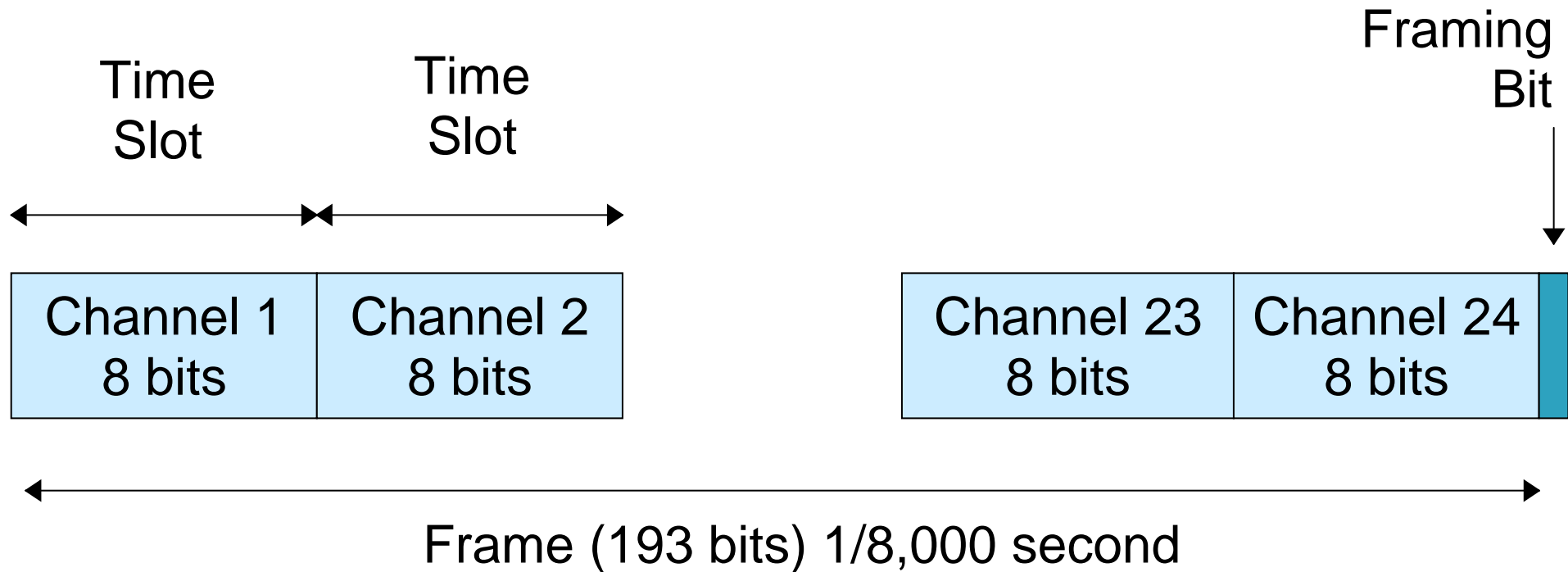
SONET/SDH Line	Speed (Mbps)	Multiplexed Voice Calls
OC3/STM1	155.52	2,016
OC12/STM4	622.08	6,048
OC48/STM16	2,488.32	18,144
OC192/STM64	9,954.28	54,432
OC768/STM256	39,813.12	163,296

C.3: Time Division Multiplexing on a T1 Line



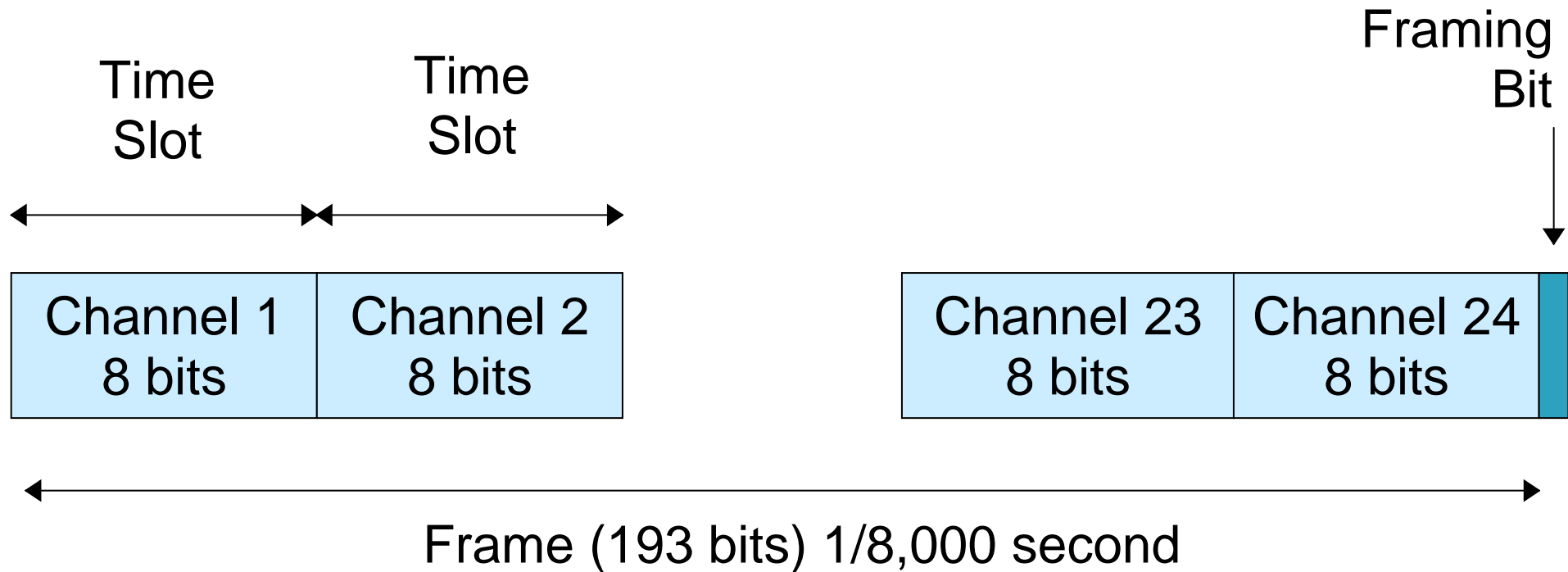
$$24 \text{ slots/frame} * 8 \text{ bits/slot} + \text{Framing Bit} = 193 \text{ bits/frame}$$

C.3: Time Division Multiplexing on a T1 Line



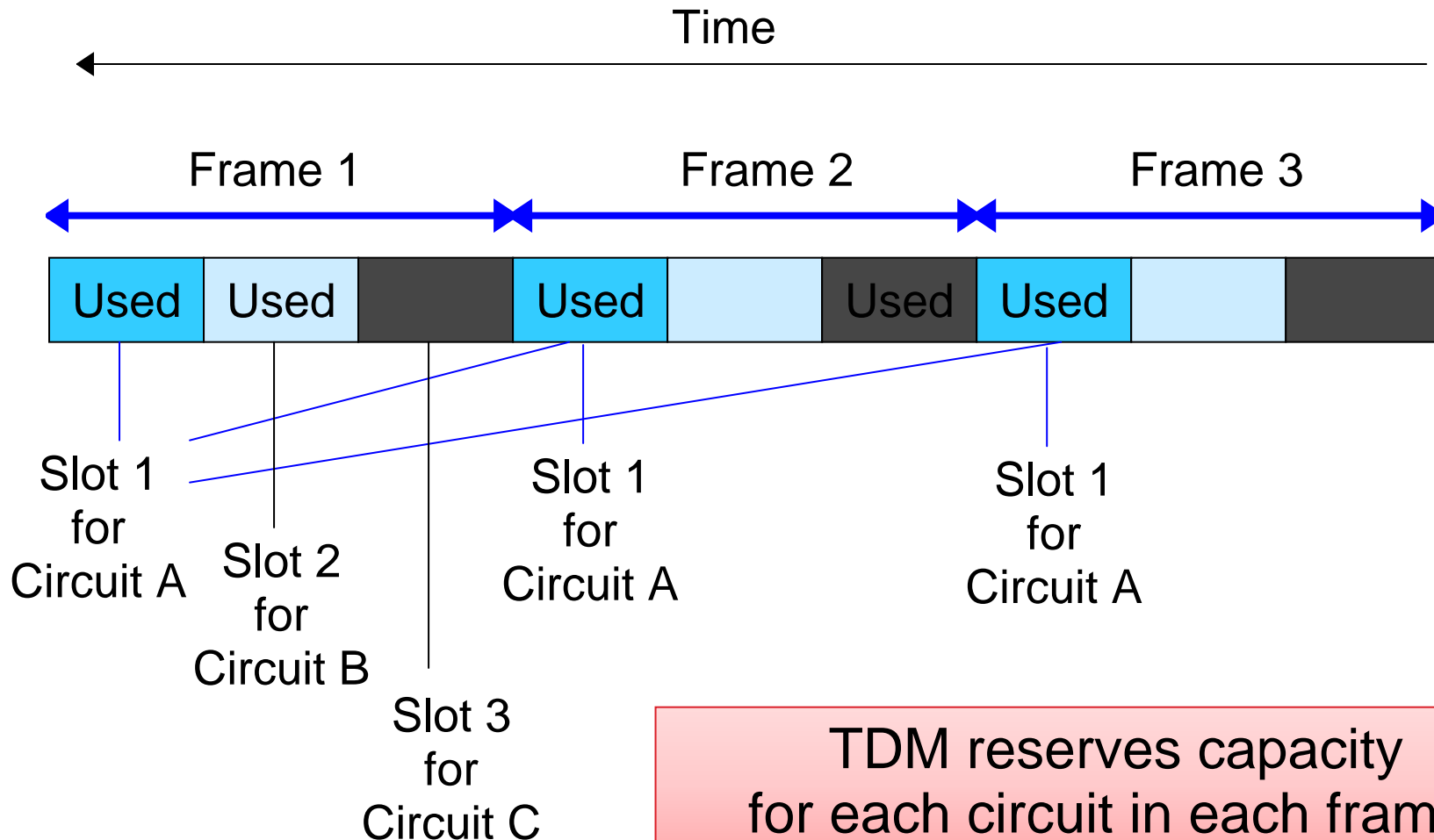
$$8,000 \text{ frames/second} * 193 \text{ bits/frame} = 1.544 \text{ Mbps}$$

C.3: Time Division Multiplexing on a T1 Line



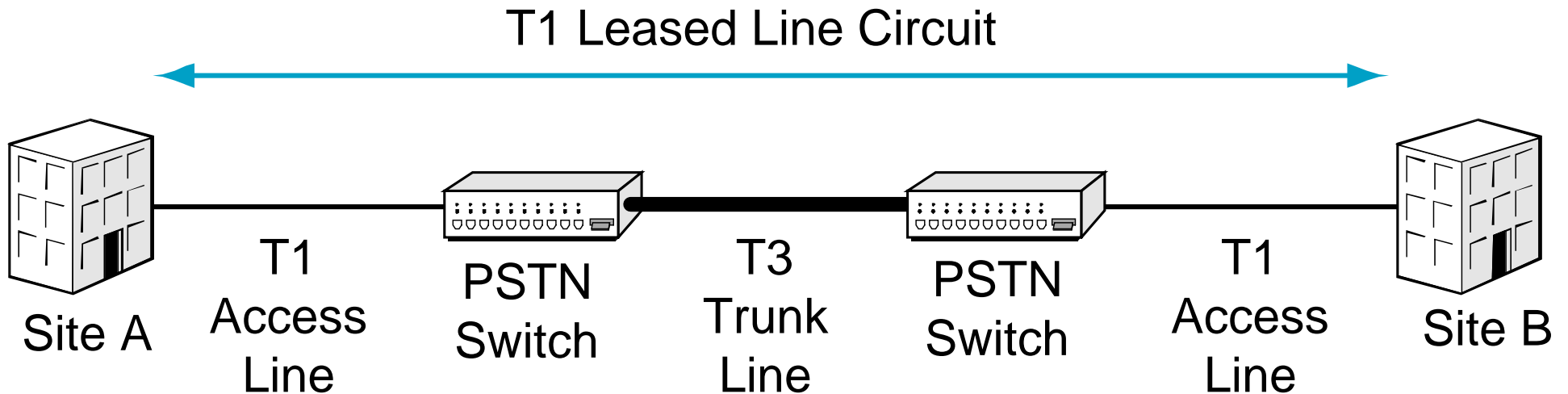
$$8 \text{ bits/channel/frame} * 8,000 \text{ frames/second} \\ = 64 \text{ kbps/channel}$$

C.4: Reserved Capacity in TDM Multiplexing



TDM reserves capacity for each circuit in each frame; assures speed but is wasteful.

C.5: Leased Line Circuits and Trunk Lines

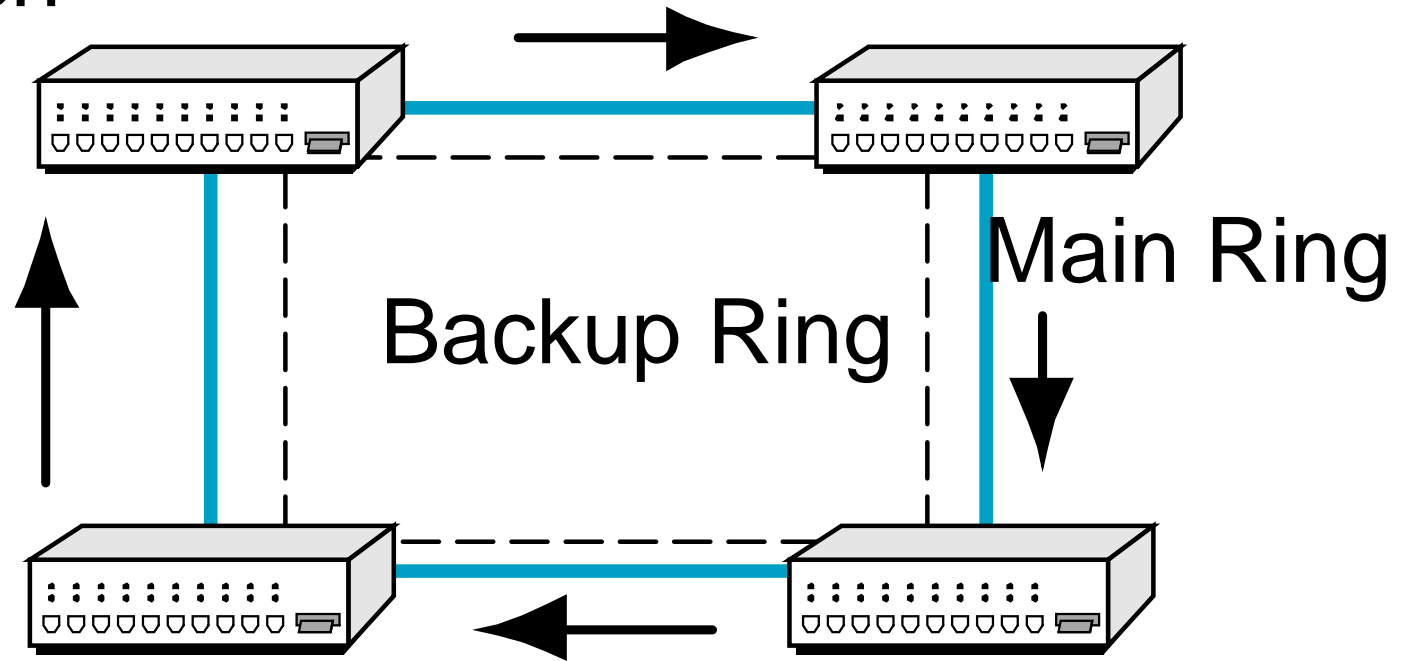


Leased lines deliver trunk line speeds across multiple trunk lines.

C.6: SONET/SDH Dual Rings

PSTN
Switch

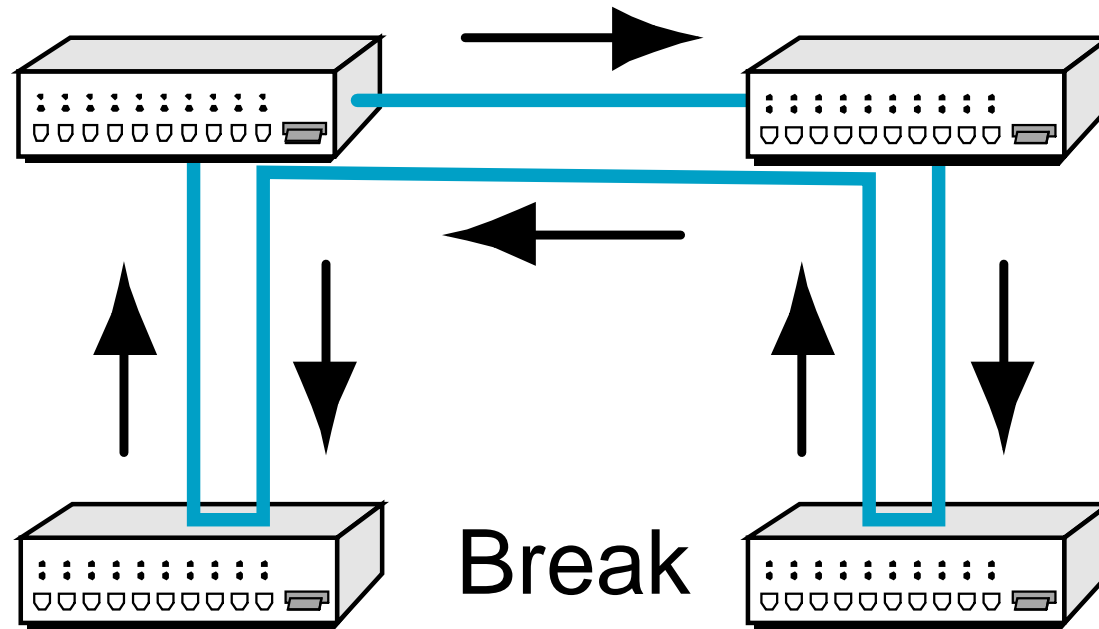
Normal Operation



SONET/SDH uses a dual ring.
Usually, one ring is used and the other is a backup ring.

C.6: SONET/SDH Dual Rings

Wrapped Ring



If there is a break between switches,
the ring is wrapped, and there still is a loop.
Dual rings give reliability.

C.7: Signaling

▶ Transport versus Signaling

Transport is the transmission of voice conversations between customers.

Signaling is the supervision of transport connections.

- Call setup, management, and termination
- The collection and transmission of billing information
- Three-party calling, and other advanced services

C.7: Signaling

▶ Signaling System 7

The worldwide standard for PSTN signaling

Slight differences exist in the United States and Europe

- United States: Signaling System 7
- Europe: C7
- Interconnected with a simple gateway

C.7: Signaling

▶ C7 Signaling Used Packet-Switched Technology

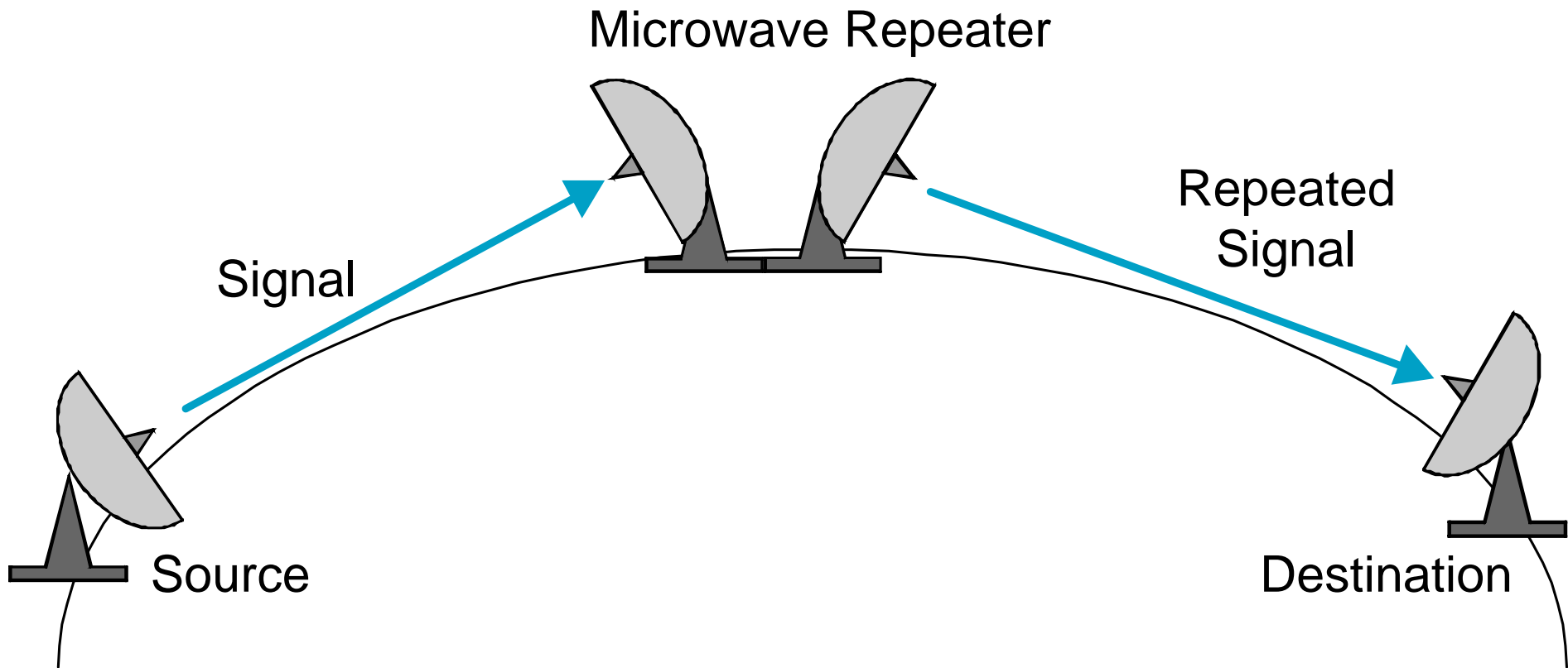
Not circuit-switched

Runs over telephone company lines

Uses a distributed database

- Data for supervising calls
- Call setup, and so on, requires the querying of the

C.8: Microwave Transmission



Microwave signals do not bend around the curve of the earth or pass through mountains. Microwave repeaters solve these problems.

C.9: Geosynchronous Earth Orbit (GEO)

Communication Satellite System

Geosynchronous Communication Satellite

GEOs operate about 36,000 km (22,300 miles) above the earth.

GEOs appear to be stationary in the sky. This permits easy dish aiming.

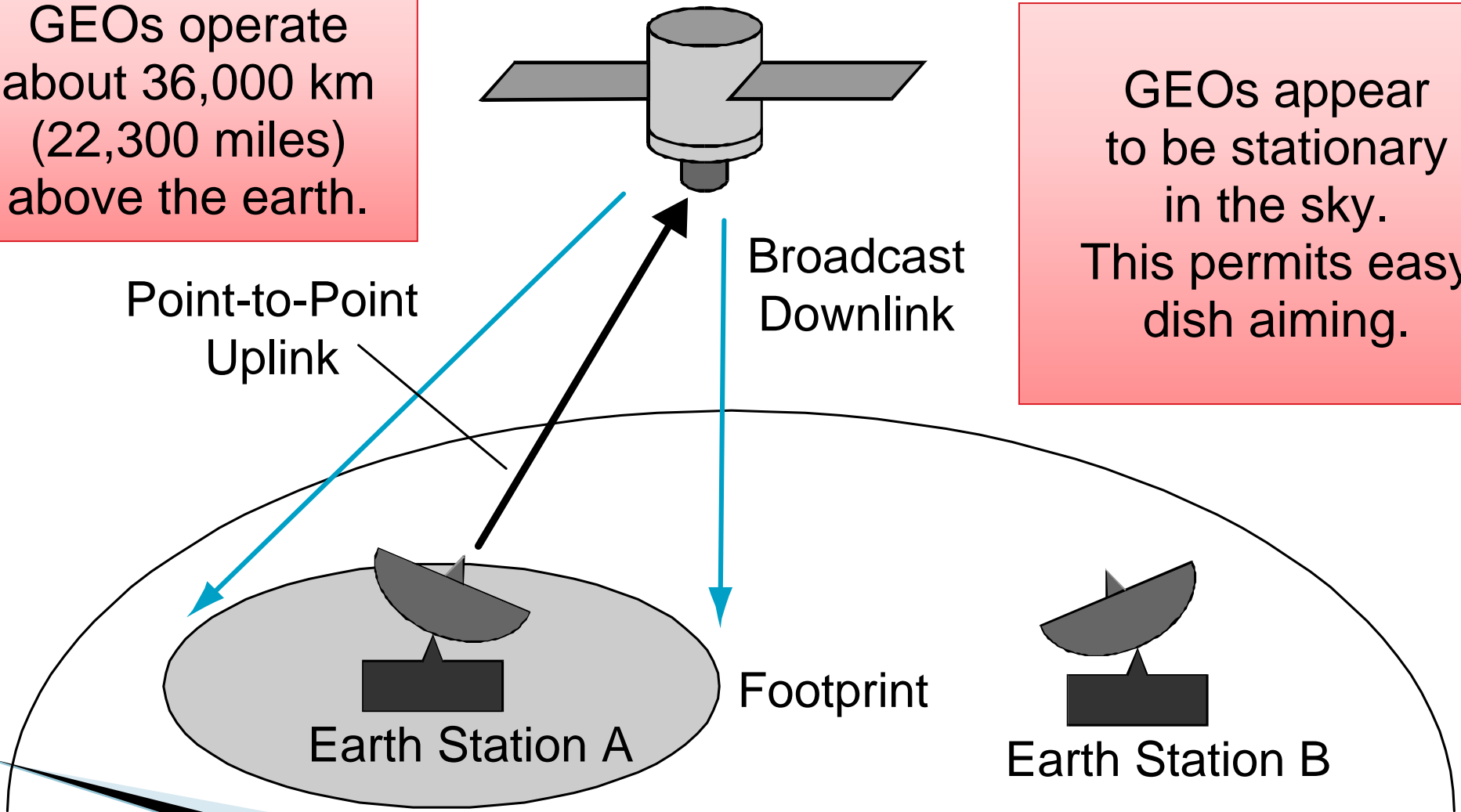
Point-to-Point Uplink

Broadcast Downlink

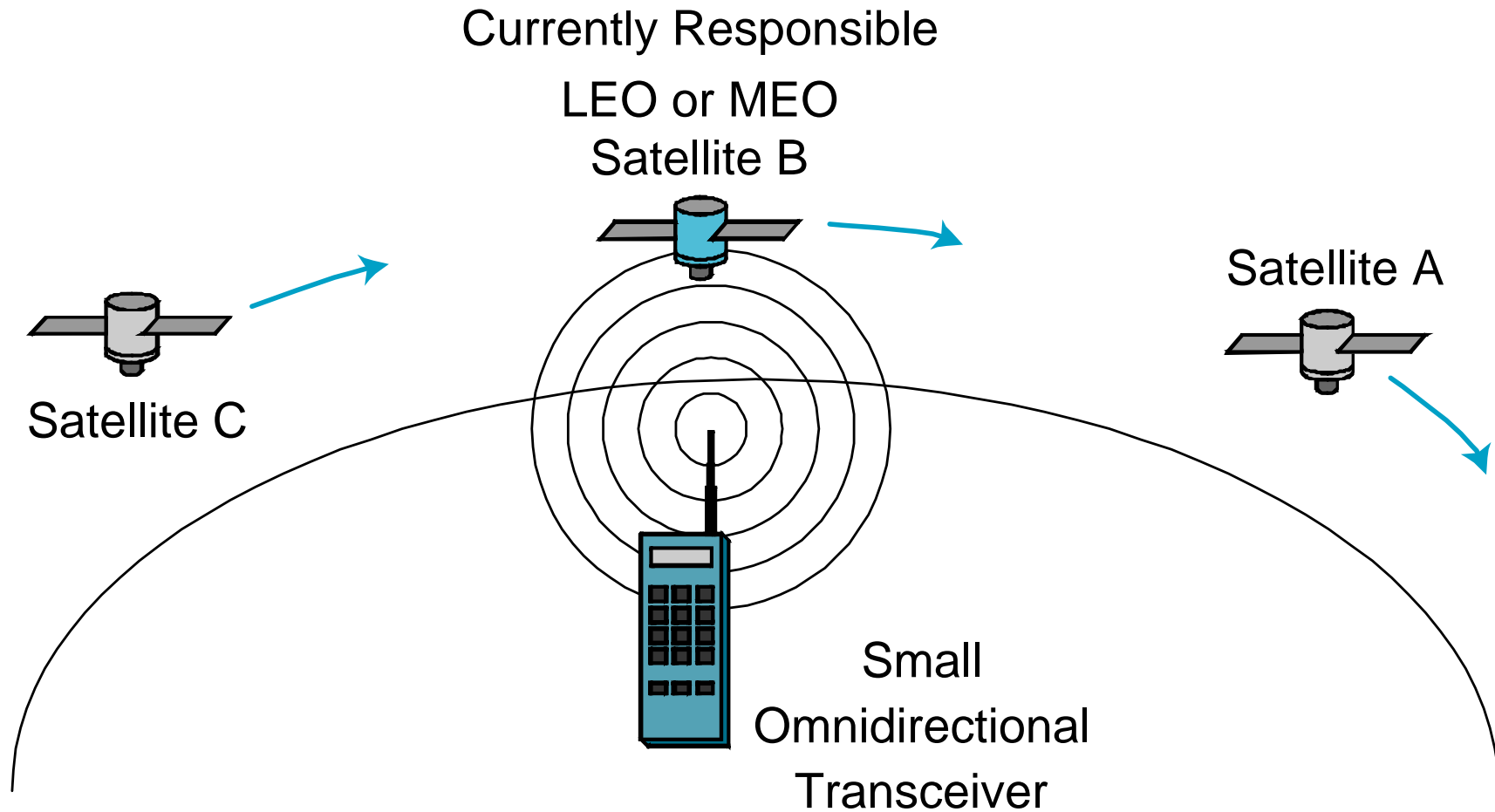
Footprint

Earth Station A

Earth Station B

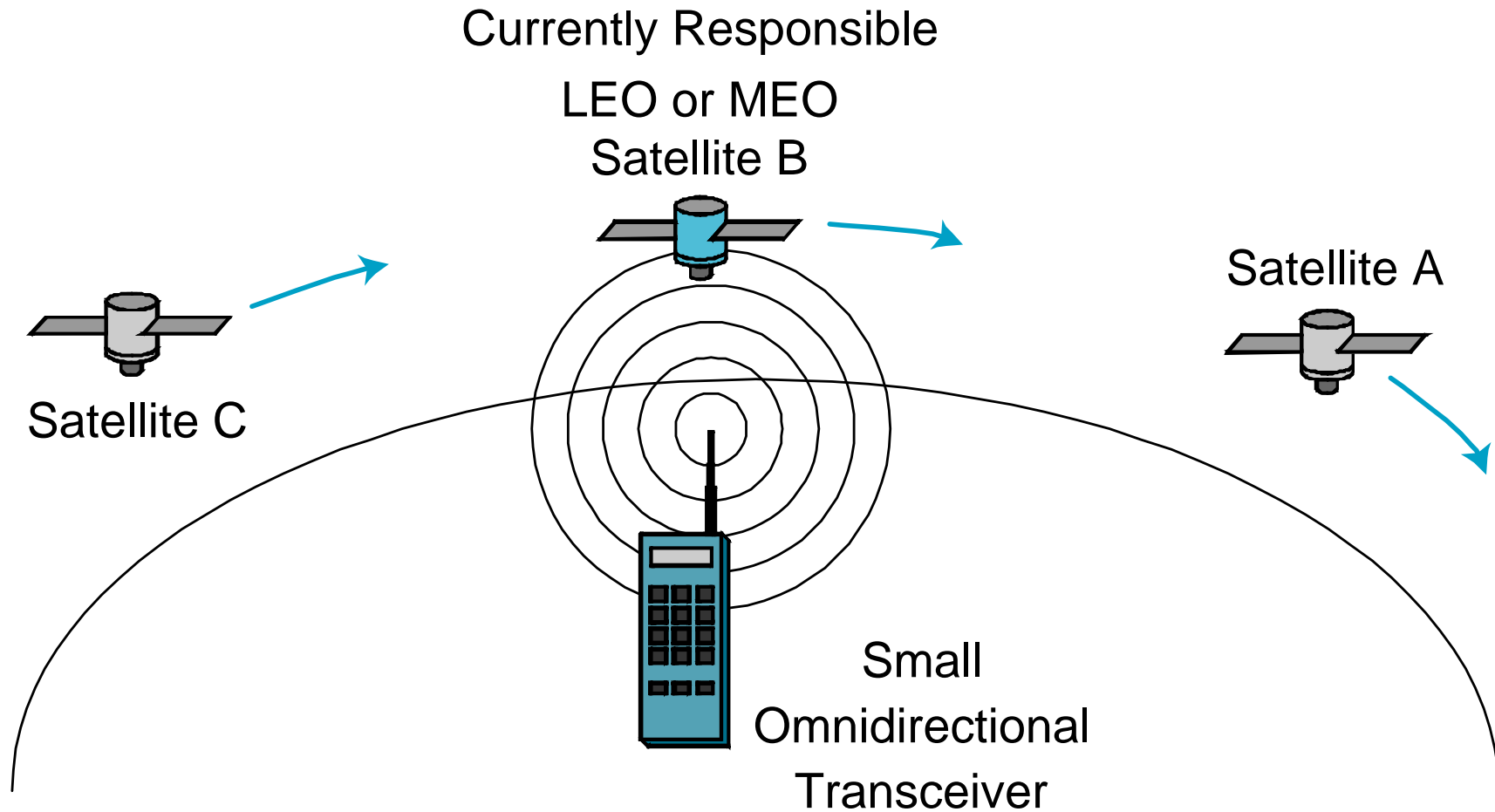


C.10: LEOs and MEOs



Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) Satellites do not appear to be stationary in the sky.
Dish antennas cannot be used.

C.10: LEOs and MEOs



Fortunately, LEO and MEO distances are (relatively) small, so omnidirectional receivers can be used.

LEOs and MEOs

- ▶ Low Earth Orbit Satellites (LEOs)

 - A few hundred miles above the earth

 - Satellites pass out of view rapidly, requiring constant shifting

- ▶ Medium Earth Orbit Satellites (MEOs)

 - A few thousand miles above the earth

 - Farther than LEOs, so signals must be stronger

 - Satellites stay in view longer because they have longer orbital periods

C.1 1: VSAT Satellite System

▶ Traditional Satellite Systems

Used very large dishes (3 meters or more)

Very expensive

▶ VSAT Satellite System

Very small aperture terminal (VSAT) earth stations

Use small (1 meter or less) diameter dishes

Small dishes allow earth stations small and inexpensive enough to be used in homes

C.1 1: VSAT Satellite System

▶ VSAT Satellite System

Used primarily in one-way transmission, such as television distribution

Occasionally used for two-way communication

News reporting in the field

Military communication

High-cost Internet access for rural subscribers

Perspective on Satellites

- ▶ Compared to landline service

 - 1-way broadcast TV and radio distribution are affordable.

 - 2-way communication is extremely expensive.

 - 2-way transceivers on the ground are very expensive.

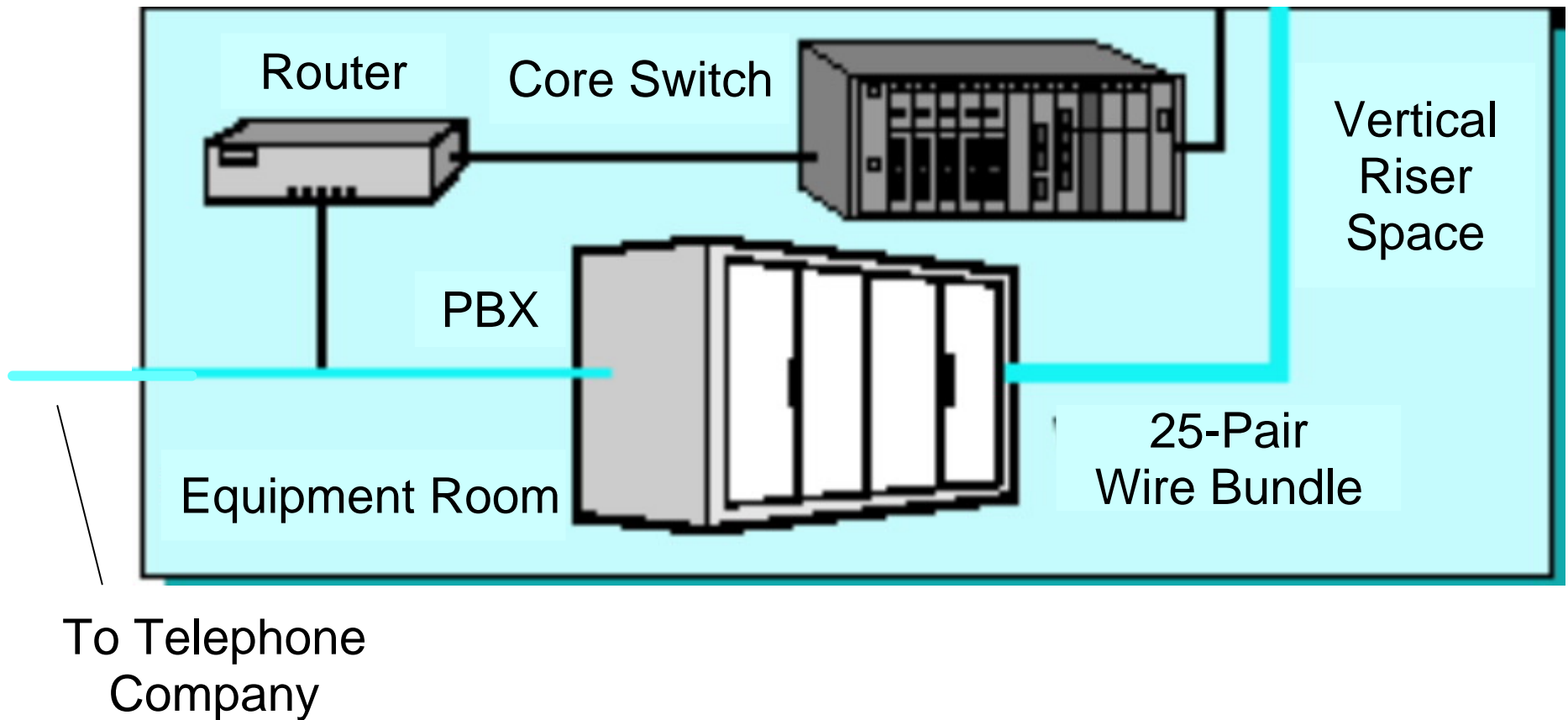
 - Controlling multiple access from stations that want to transmit at the same time is expensive and inefficient.

- ▶ Usually limited to specialized and expensive services

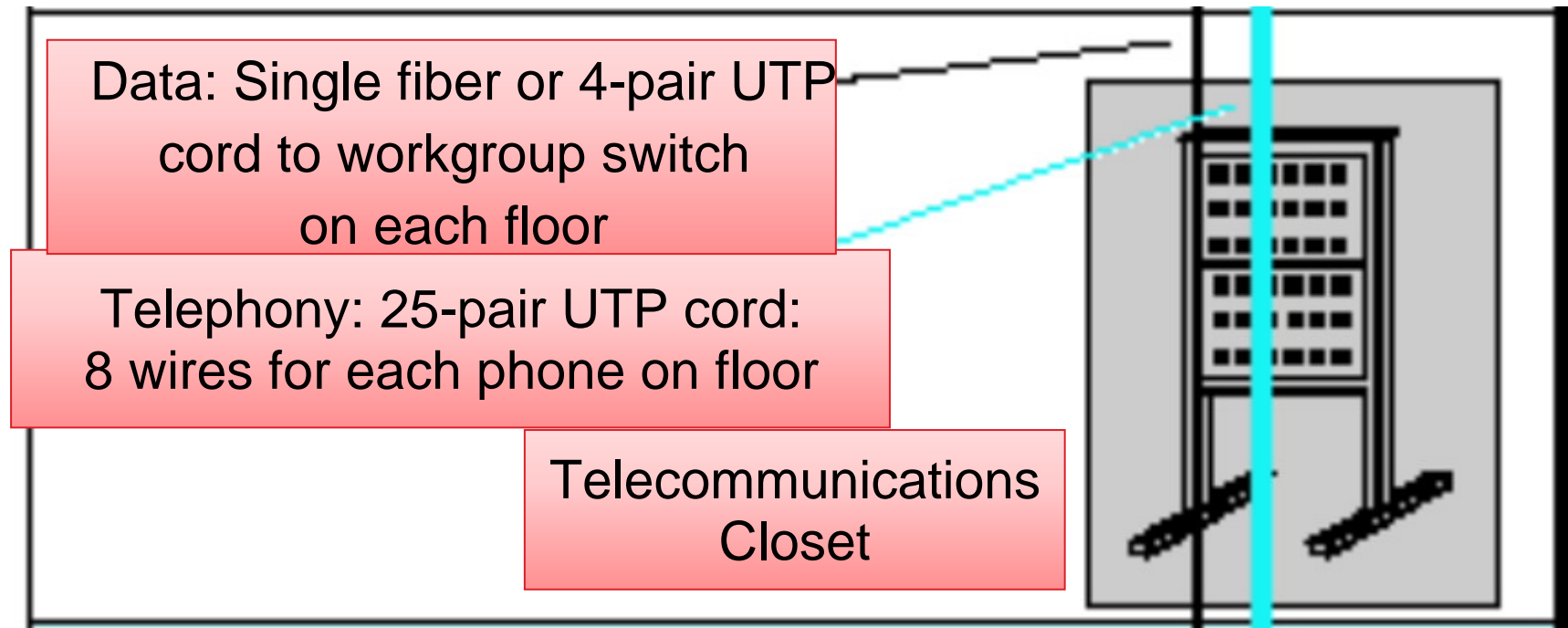
 - Serving rural areas with Internet access

 - Serving moving vehicles with 2-way communication

C.12: First Bank of Paradise Building Wiring



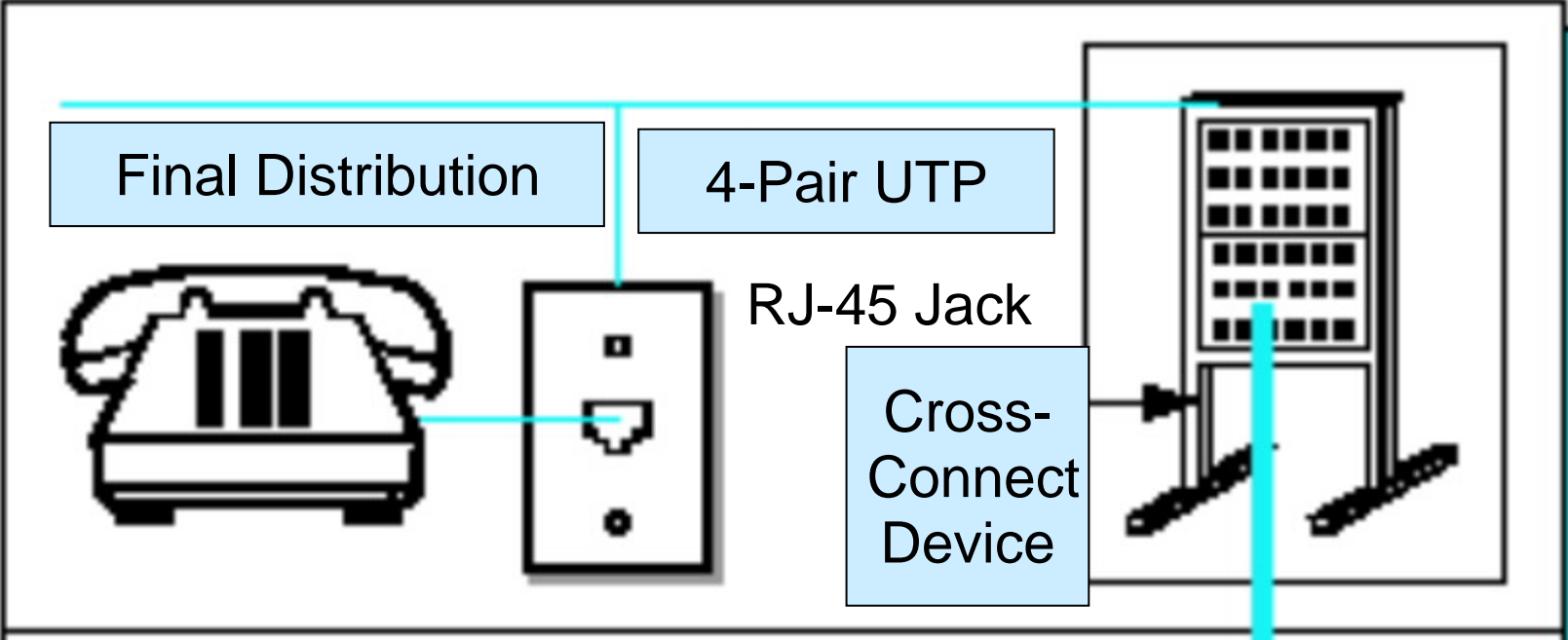
C.12: First Bank of Paradise Building Wiring



Horizontal Telephone Wiring
Versus Vertical Data Wiring

C.12: First Bank of Paradise Building Wiring

Office Building



Horizontal Telephone Wiring

C.12: First Bank of Paradise Building Wiring

- ▶ **Horizontal Distribution Is Identical for Voice and Data**

One 4-pair UTP cord to each wall jack.

This is no accident; 4-pair UTP was developed for telephone wiring and data technologists learned how to use it for horizontal distribution.

- ▶ **Vertical Distribution Is Very Different for Voice and Data**

Telephone wiring: 8 wires for every wall jack on every floor

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each

C.12: First Bank of Paradise Building Wiring

- ▶ Example

 - 25 Floors

 - 50 telephone jacks and 25 data jacks per floor

- ▶ Vertical Telephone Wiring

 - 25 floors x 50 phone jacks/floor x 8 wires/jack

 - 10,000 wires must be routed vertically

 - At least 200 25-pair UTP cords (vertical phone wiring uses 25-pair cords)

C.12: First Bank of Paradise Building Wiring

- ▶ Example

 - 25 Floors

 - 50 telephone jacks and 25 data jacks per floor

- ▶ Vertical Data Wiring

 - 25 floors, so only 25 4-pair UTP cords (one to each floor's workgroup switch)

 - If all UTP, (200 wires) run vertically

 - If fiber, only 25 fiber cords run vertically

 - Can run UTP to some floors, fiber to others

C.12: First Bank of Paradise Building Wiring

▶ Example

25 Floors

50 telephone jacks and 25 data jacks per floor

▶ Horizontal Wiring

One 4-pair UTP cord to each wall jack

Same for voice and data

50 phone jacks x 25 floors x 8 wires/cord = 10 k wires

25 phone jacks x 25 floors x 8 wires/cord = 5 k wires

C.12: First Bank of Paradise Building Wiring

- ▶ Building Telephone Wiring in Perspective
- ▶ For Vertical Distribution, Voice and Data Are Different

Phone: 8 wires (4 pairs) for every phone wall jack on every floor. 25-pair UTP cords run vertically.

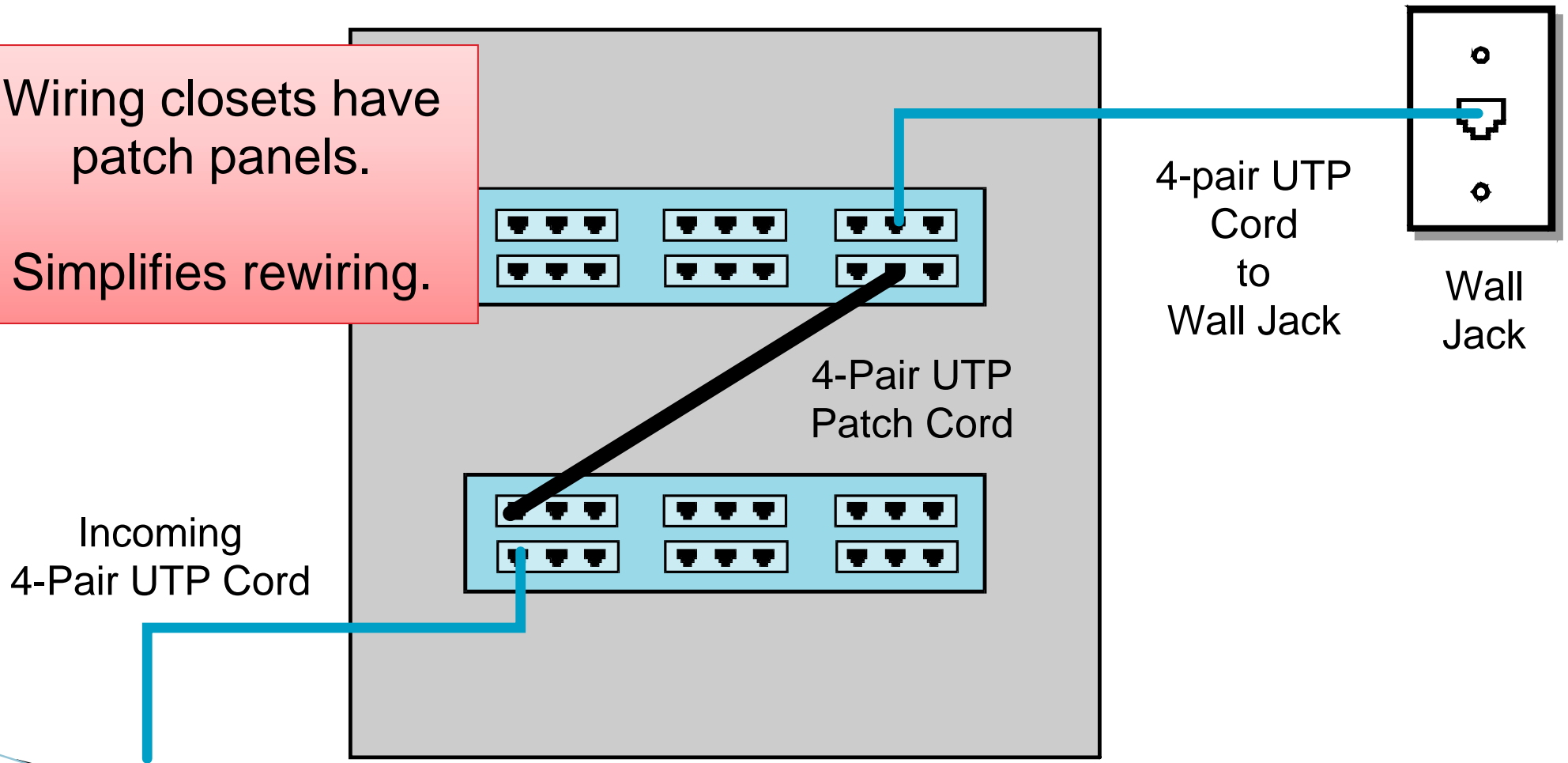
Data: one 4-pair UTP cord or one 2-strand fiber cord to each floor's workgroup switch.

- ▶ For Horizontal Wiring, Voice and Data are the Same

C.13: Patch Panels

Telecommunications Closet

Wiring closets have patch panels. Simplifies rewiring.



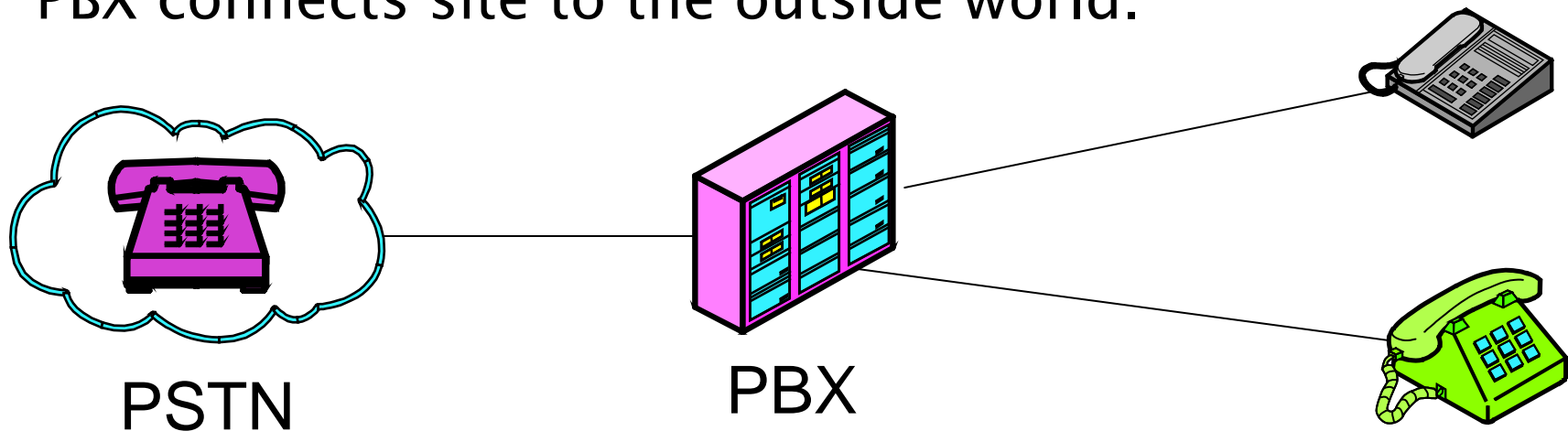
C.14: Digital PBX Services

▶ Internal Telephone System for Site

Private branch exchange (PBX) is a switch.

System also needs internal wires and telephones.

PBX connects site to the outside world.



C.14: Digital PBX Services

▶ User Services

Speed dialing

Last number redial

Display of called number

Camp on (to busy line—rings when they complete their call)

Call waiting

Hold

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C.14: Digital PBX Services

▶ User Services

Three-party conferencing

Call transfer

- To another number if you are away from your desk

Call forwarding

- To transfer an incoming call to another number

Voice mail

C.14: Digital PBX Services

▶ Attendant Services

Operator support

Automatic call distribution

- Outside callers can dial extensions

Message center for taking messages by operator

Paging throughout a building

Nighttime call handling (processing of calls different than in daytime mode)

C.14: Digital PBX Services

▶ Management Services

Automatic route selection

- Minimizes costs for long-distance calls

Call restriction

- Not permitting outgoing calls or outgoing long-distance calls for certain numbers

Call detail reporting

- To

C.15: Telephone Services

- ▶ Local Calling

 - Flat rate

 - Message units

- ▶ Toll Calls

 - Long-distance calling

 - Intra-LATA

 - Inter-LATA

C.15: Telephone Services

▶ Long-distance calls

Inter-LATA or Intra-LATA long-distance calls

- Even in intra-LATA service, there is a local- versus long-distance distinction

Priced per minute

Price based on distance

C.15: Telephone Services

▶ Toll Call Pricing

Direct distance dialing

- Base case for comparison

Toll-Free numbers

- Free to caller but called party pays
- Called party pays less than direct distance dialing rates
- In the United States, 800, 888, and so on

C.15: Telephone Services

▶ Toll Call Pricing

WATS

- Wide Area Telephone Service
- For calling out of a site
- Calling party pays but pays less than with direct distance dialing

900 numbers

- Caller pays
- Pay

C.15: Telephone Services

- ▶ Advanced Services

Caller ID

Three-party calling (conference calling)

Call waiting

Voice mail

C.16: Telephone Carriers

▶ In Most Countries

Public Telephone and Telegraph (PTT) authorities

- Traditionally had a domestic monopoly over telephone service

Ministries of Communication

- Government agency to regulate the PTT

Competitors

- Deregulation has allowed competition in domestic telephone service in most countries.

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C.16: Telephone Carriers

▶ In the United States

AT&T (the Bell System) developed a long-distance monopoly.

- Also owned most local operating companies

AT&T was broken up in the 1980s.

- AT&T retained the name and the (initially) lucrative long-distance business.
- Local operations were assigned to seven Regional Bell Operating Companies (RBOCs).

C.16: Telephone Carriers

▶ In the United States

Later, RBOCs combined with one another and with GTE to form four supercarriers.

- BellSouth
- Quest
- Verizon
- AT&T*

*Eventually, competition in long-distance service made AT&T unprofitable.

C.16: Telephone Carriers

▶ In the United States

Regulation

- Federal Communications Commission (FCC) regulates interstate communication and aspects of intrastate communication that affect national commerce.
- Within each state, a Public Utilities Commission (PUC) regulates telephone service subject to FCC regulations.

C.17: Deregulation

▶ Deregulation

Deregulation releases or removes monopoly over telephone service.

This creates competition, which lowers prices.

In most companies, deregulation began in the 1970s.

▶ Deregulation Around the World

At least some PTT services have been deregulated.

C.17: Deregulation

▶ Carriers in the United States

Pattern was set during the AT&T breakup.

The United States is divided into regions called local access and transport areas (LATAs).

- Within each LATA
 - Local exchange carriers (LECs) provide intra-LATA service
 - Traditional incumbent local exchange carrier (ILECs)

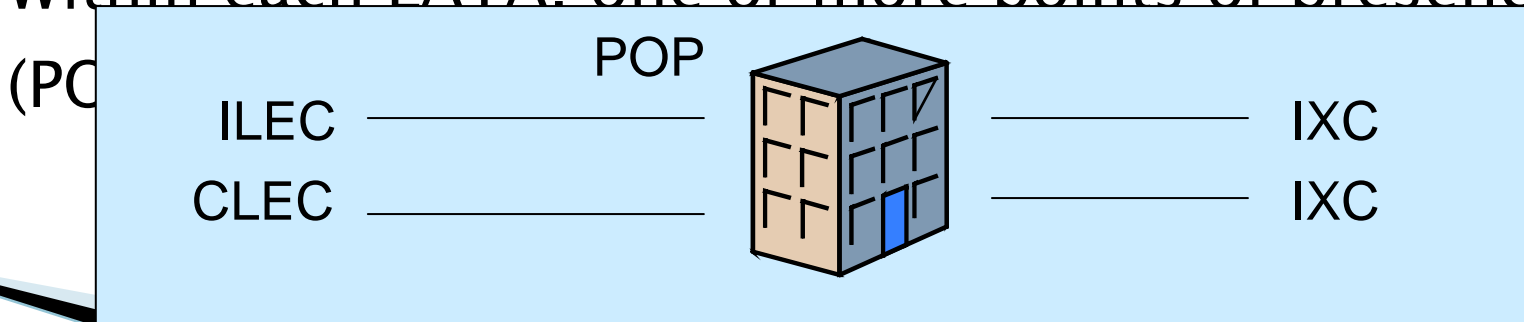
C.17: Deregulation

▶ Carriers in the United States

Interexchange carriers (IXCs) provide transport between LATAs.

- Long-distance service within LATAs is supplied by LECs.
- Long-distance service between LATAs is supplied by IXCs.

Within each LATA, one or more points of presence



C.17: Deregulation

▶ Internationally

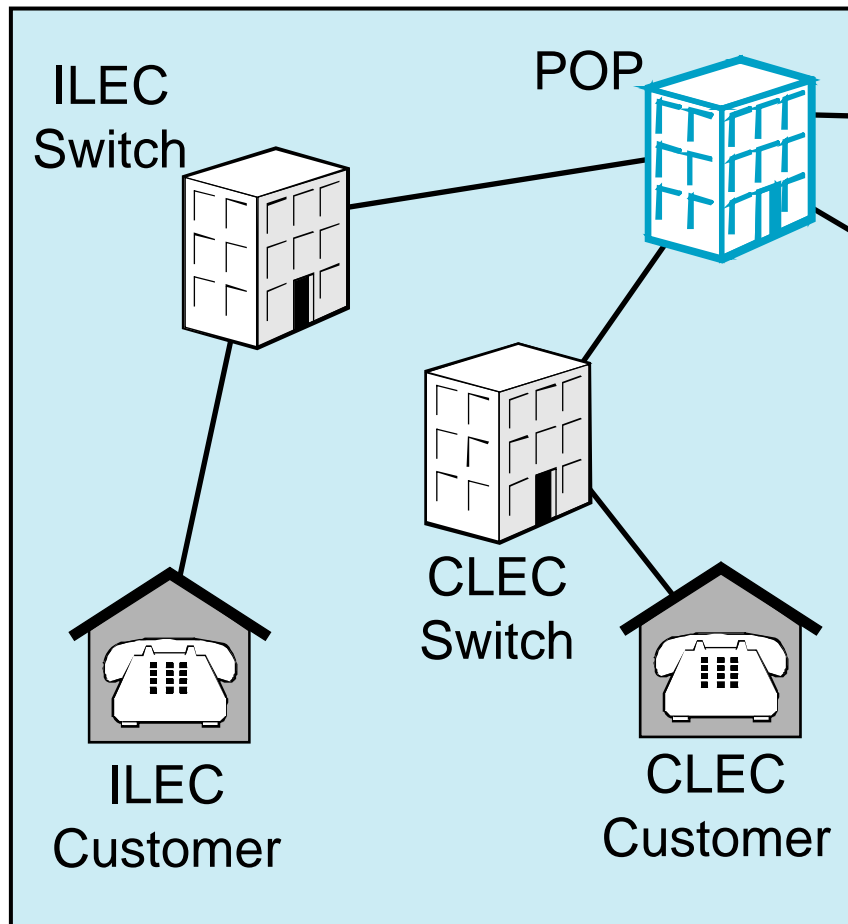
International common carriers (ICCs) provide service between countries.

Do not confuse ICCs with IXC.

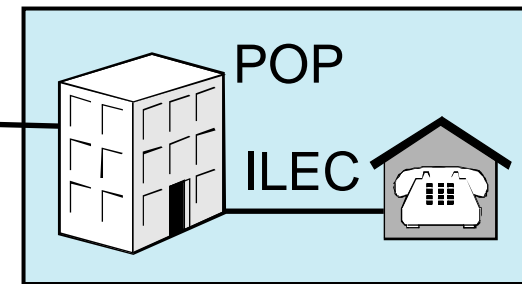
- Both start with the letter “I”
- But “I” only means “international” in ICCs

C.18: Telephone Carriers in the United States

Local Access and Transport Area (LATA)



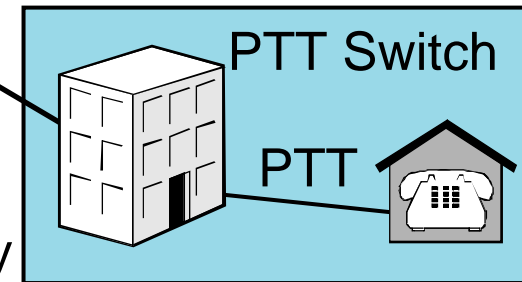
LATA



IXC

ICC

Other Country



- Competitive Local Exchange Carrier (CLEC)
- Incumbent Local Exchange Carrier (ILEC)
- Interexchange Carrier (IXC)
- International Common Carrier (ICC)
- Point of Presence (POP)

Carrier Quiz

▶ In what country do you find each of the following?

1. LATA

2. PTT

3. LEC

4. IXC

Carrier Recap

- ▶ United States

Intra-LATA

- LECs
 - ILEC
 - CLECs

Inter-LATA

- IXC

- ▶ Most of the World

PTTs for domestic service

C.17: Deregulation

- ▶ Degree of Deregulation

Customer premises equipment is almost completely deregulated.


Long-distance and international telephony are heavily deregulated.

C.17: Deregulation

▶ Degree of Deregulation

Local telephone service is the least deregulated.

- The traditional monopoly carriers have largely maintained their telephone monopolies.
- Cellular service has provided local competition, with many people not having a wired phone.
- Voice over IP (VoIP) is providing strong competition via ISPs, cable television companies, and a growing number of other wired and wireless access technologies.



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