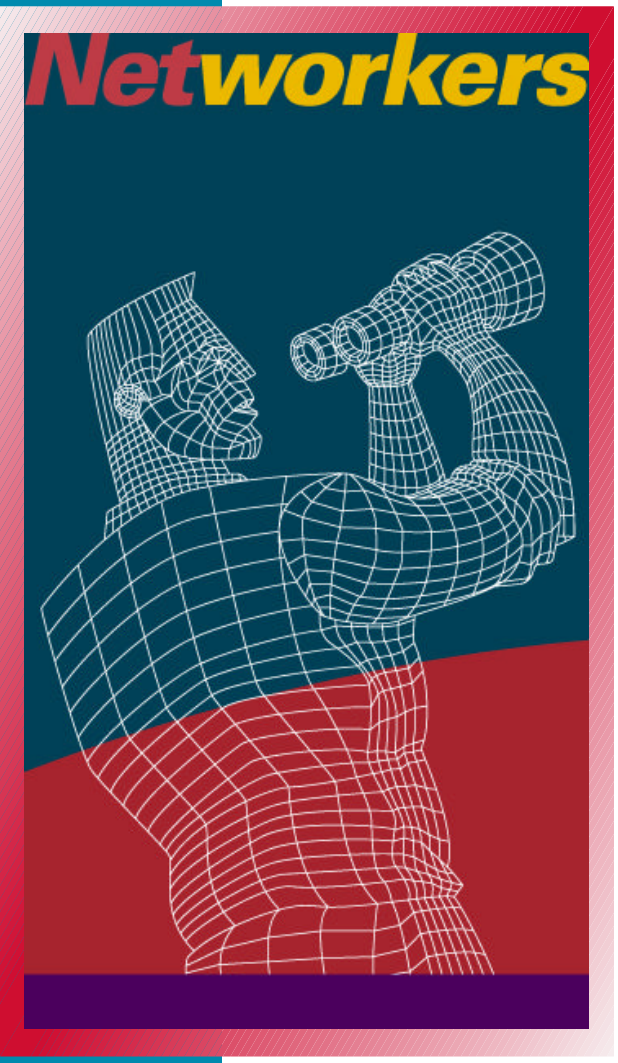

Introduction to Telephony

Part 1

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Agenda

- Basic Analog Telephony
- Basic Digital Telephony
- Consolidated Transport Networking

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Telephony Equipment

- **Telephone set**
- **Key system**
  - **Optimizes use of telephone sets to lines**
  - **Mechanical to electronic**
  - **2 to 10+ sets typically**
- **PBX (Private Branch Exchange)**
  - **Advanced features and call routing**
  - **10s to 100s of telephone sets**
- **Central office switch**

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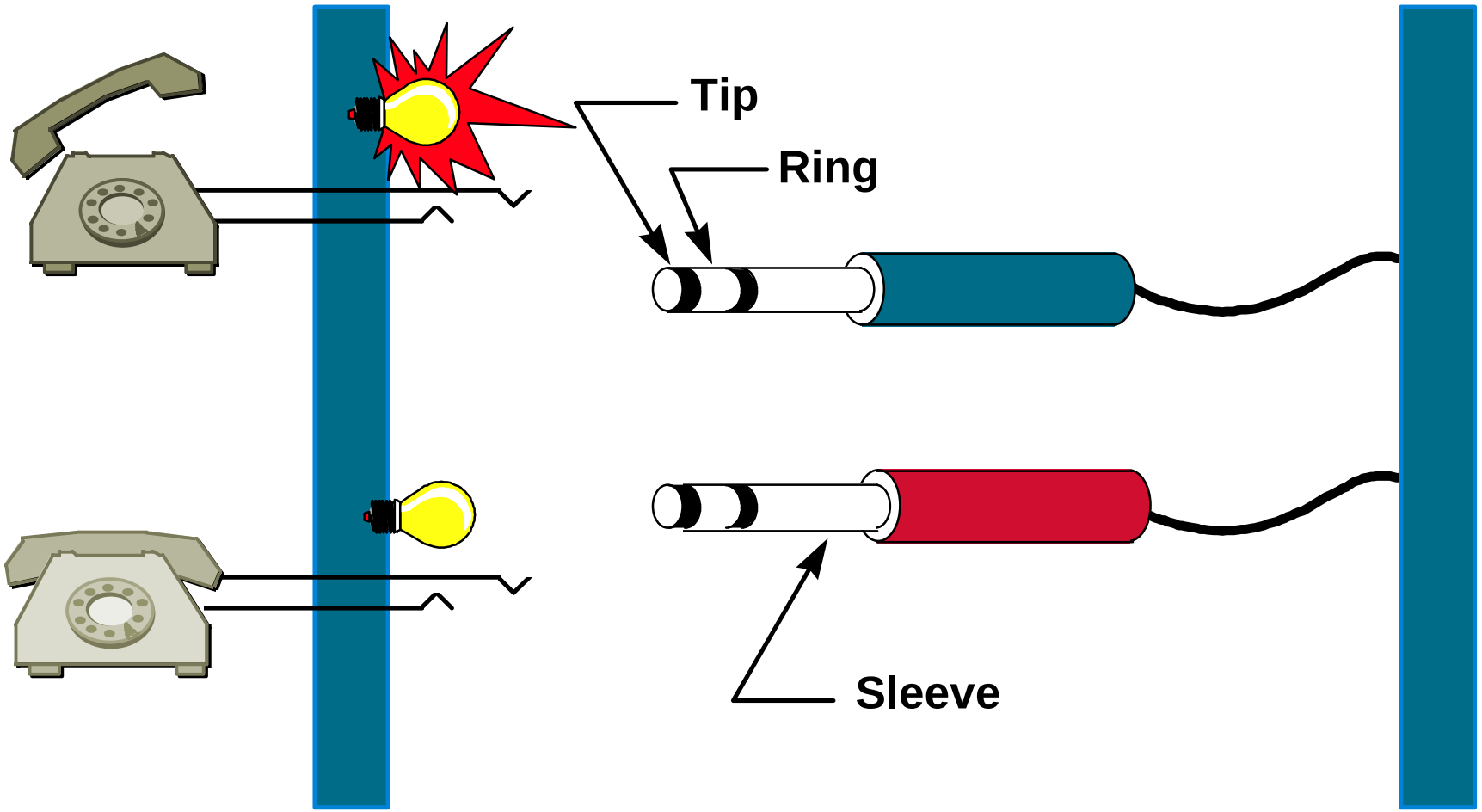
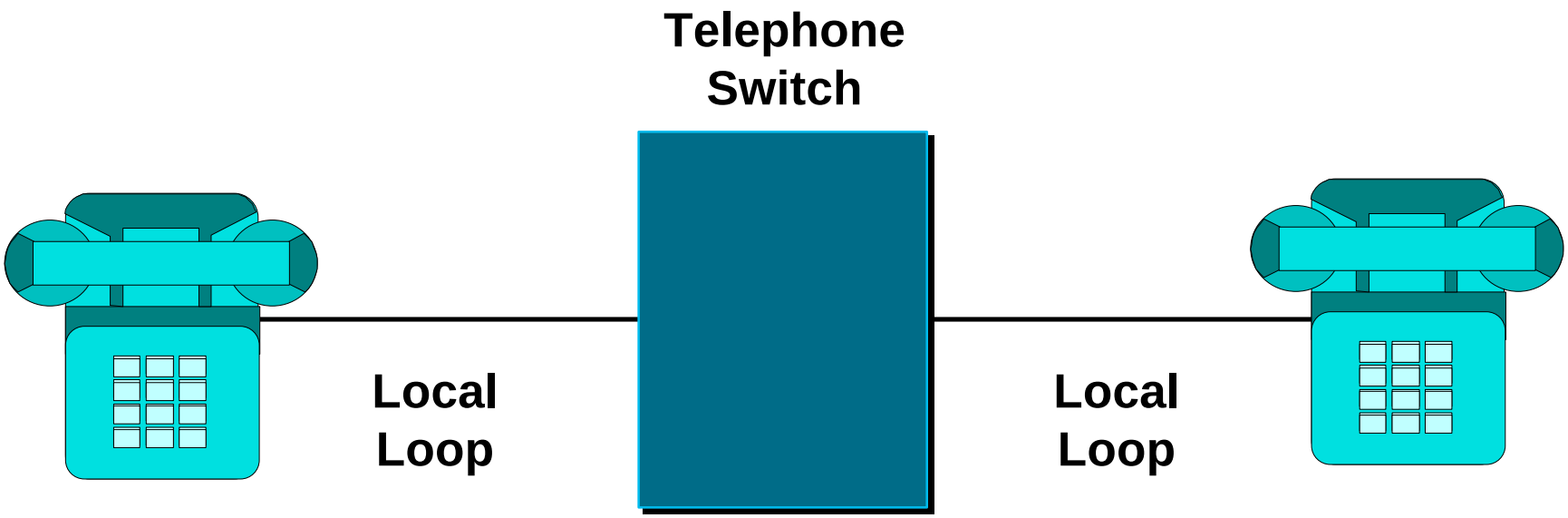
Analog Telephony—POTS Basics



CISCO SYSTEMS

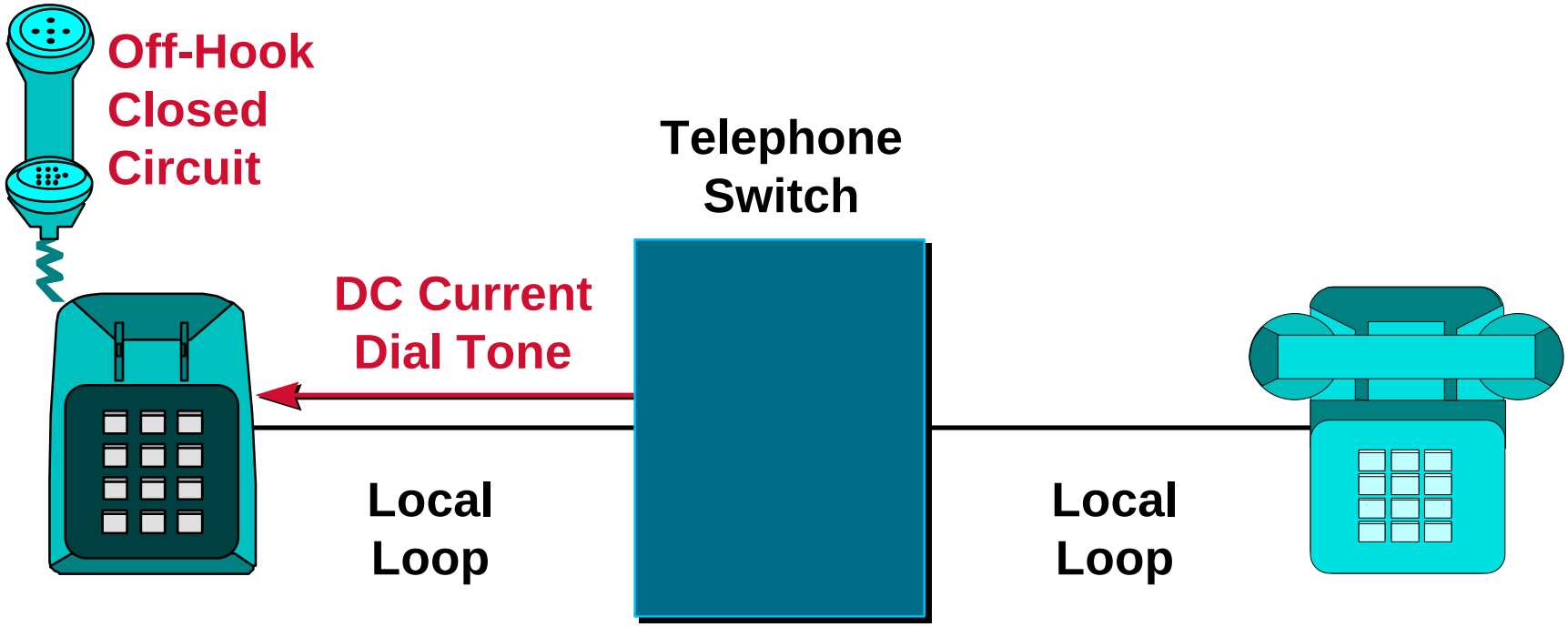
Basic Call Progress: On-Hook



-48 DC Voltage
DC Open Circuit
No Current Flow

Cisco Systems

Basic Call Progress: Off-Hook



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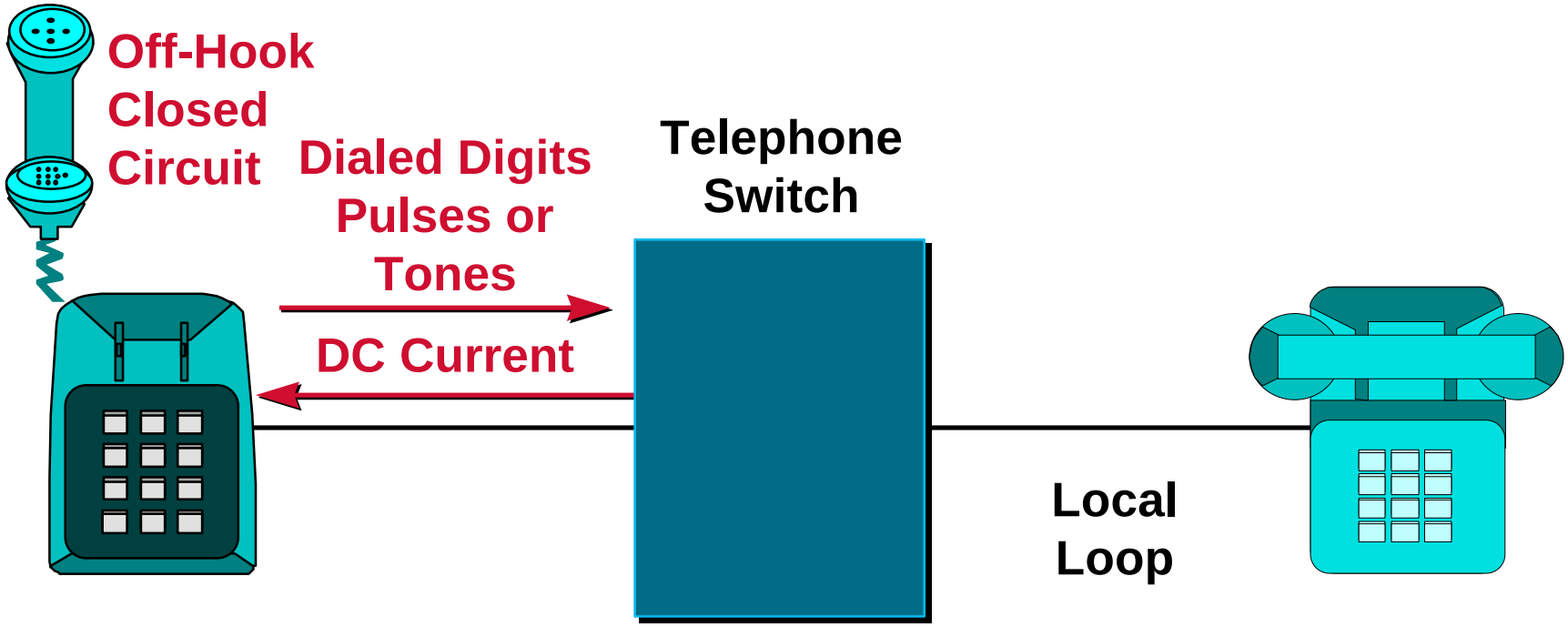
Basic Call Progress: Dialing



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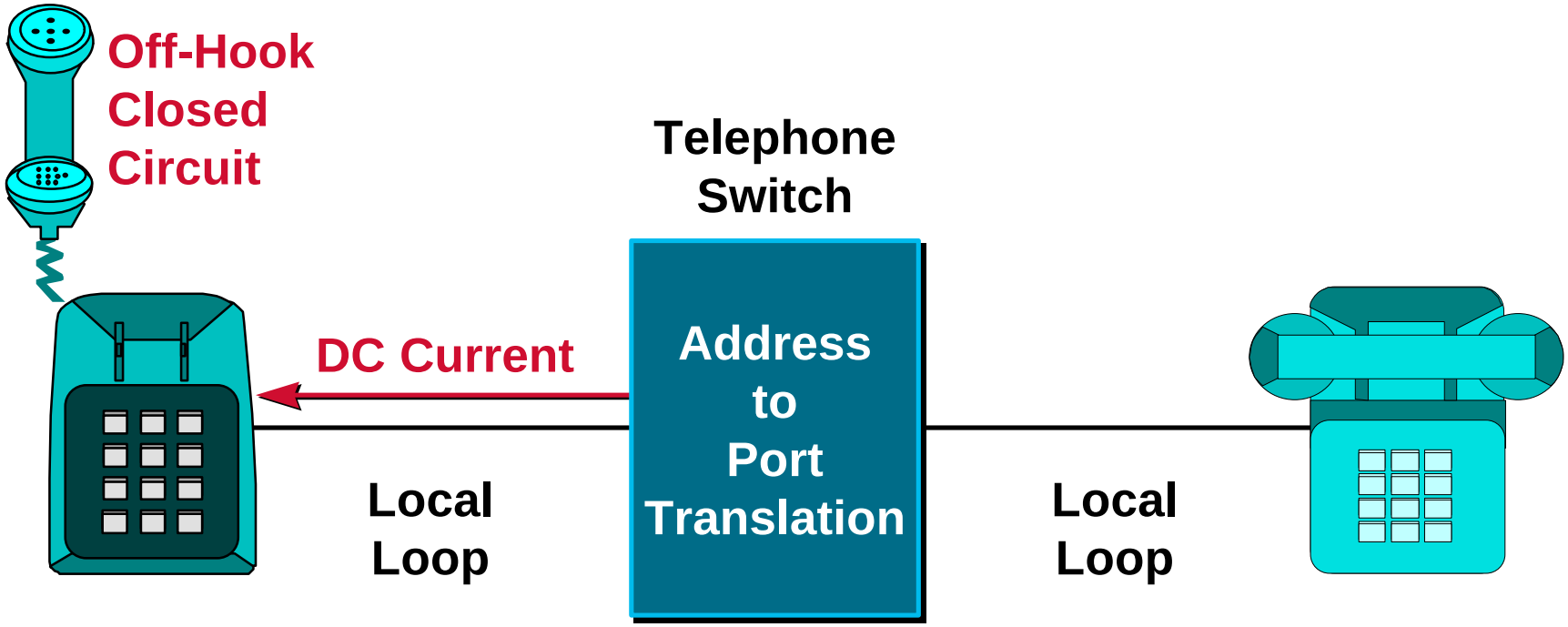
Basic Call Progress: Switching



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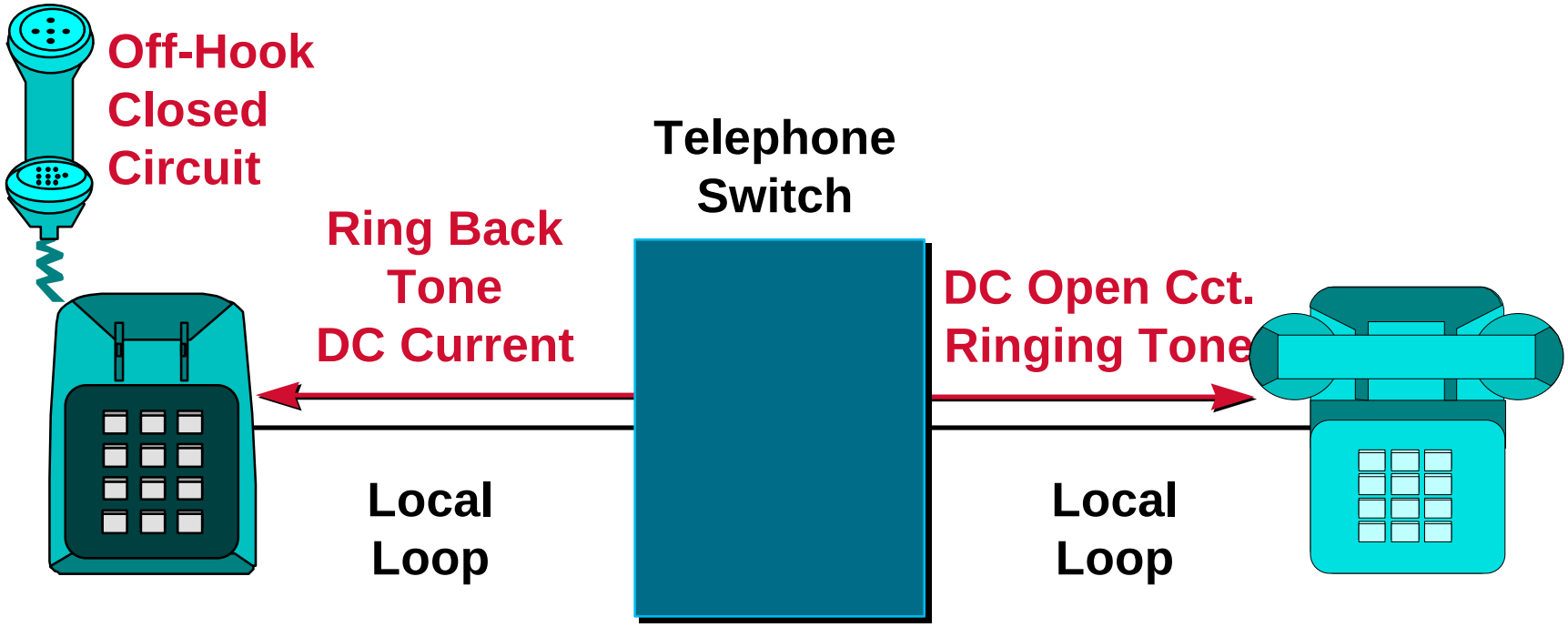
Basic Call Progress: Ringing



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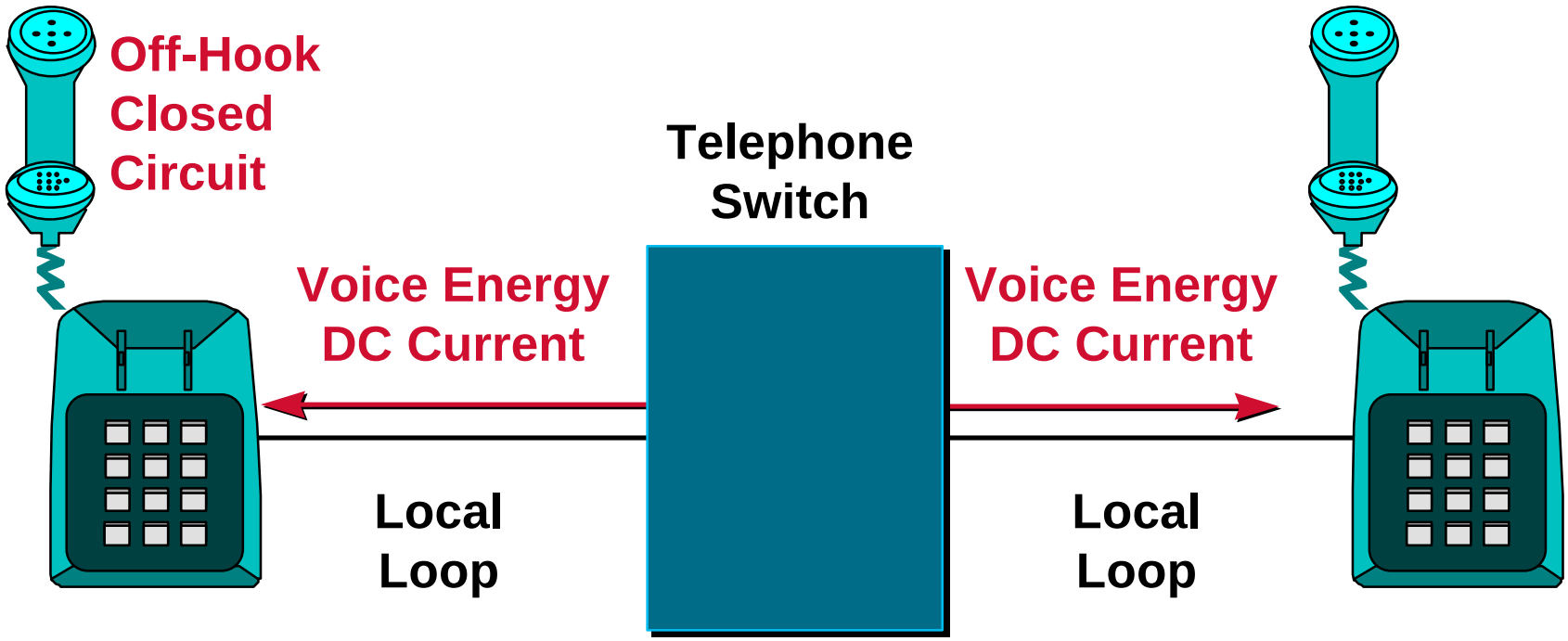
Basic Call Progress: Talking



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Analog Telephony—Signaling

- Supervisory
- Addressing
- Call progress

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Off-Hook Signaling

- **Loop Start (almost all telephones)**

  Seizure is detected when current flows through local loop, due to off-hook

- **Ground Start (PBXs)**

  Seizure is detected when one wire is grounded

  Seizure can be initiated in both directions

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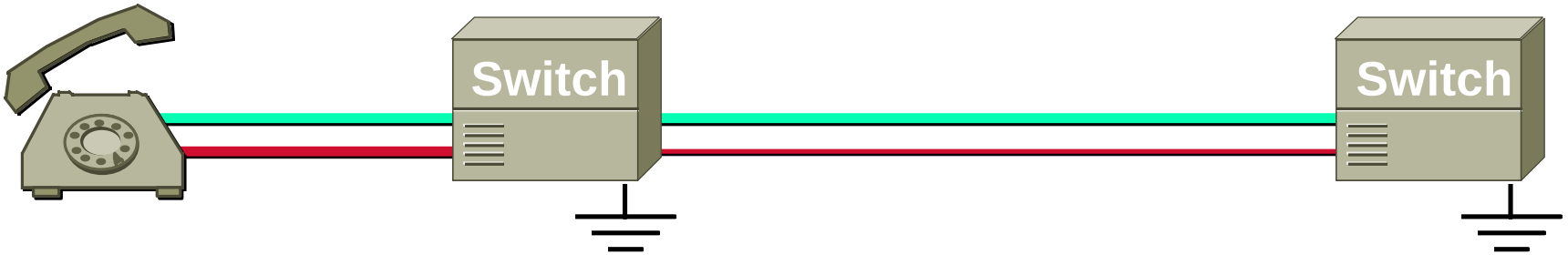
Analog Telephony—Supervisory Signaling

- **Loop start**

  Current flow sensed

- **Ground start**

  Momentary ground ring lead



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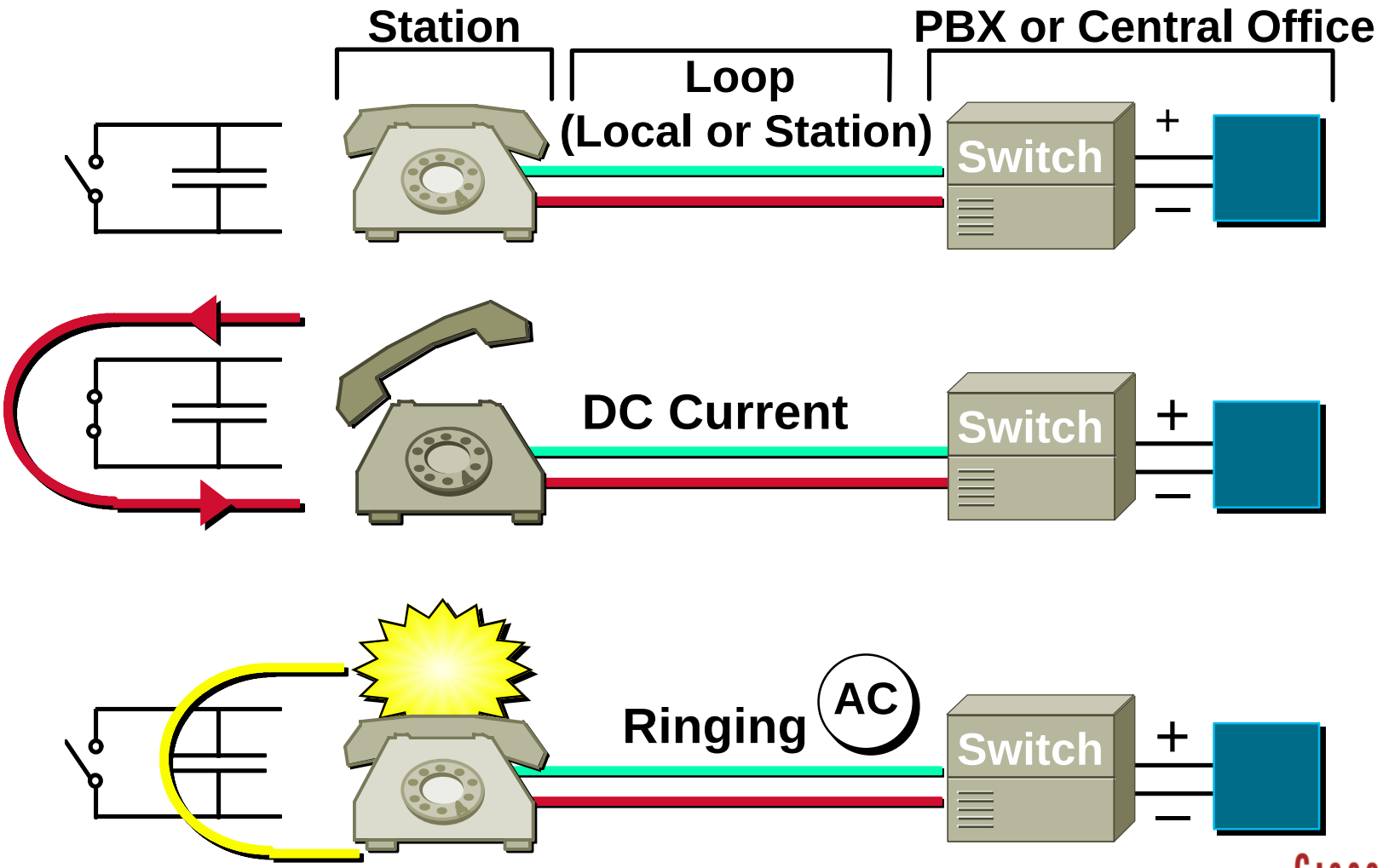
Loop Start



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E&M Signaling

- **PBXs, switches**

  Separate signaling leads for each direction

  E-Lead (inbound direction)

  M-Lead (outbound direction)

  Allows independent signaling

State	E-Lead	M-Lead
On-Hook	Open	Ground
Off-Hook	Ground	Battery Voltage

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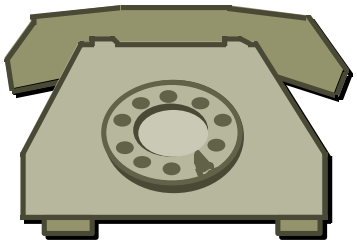
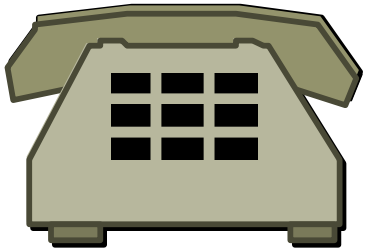
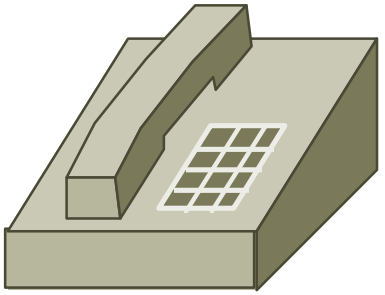
Signaling and Addressing



Dial Pulse



DTMF



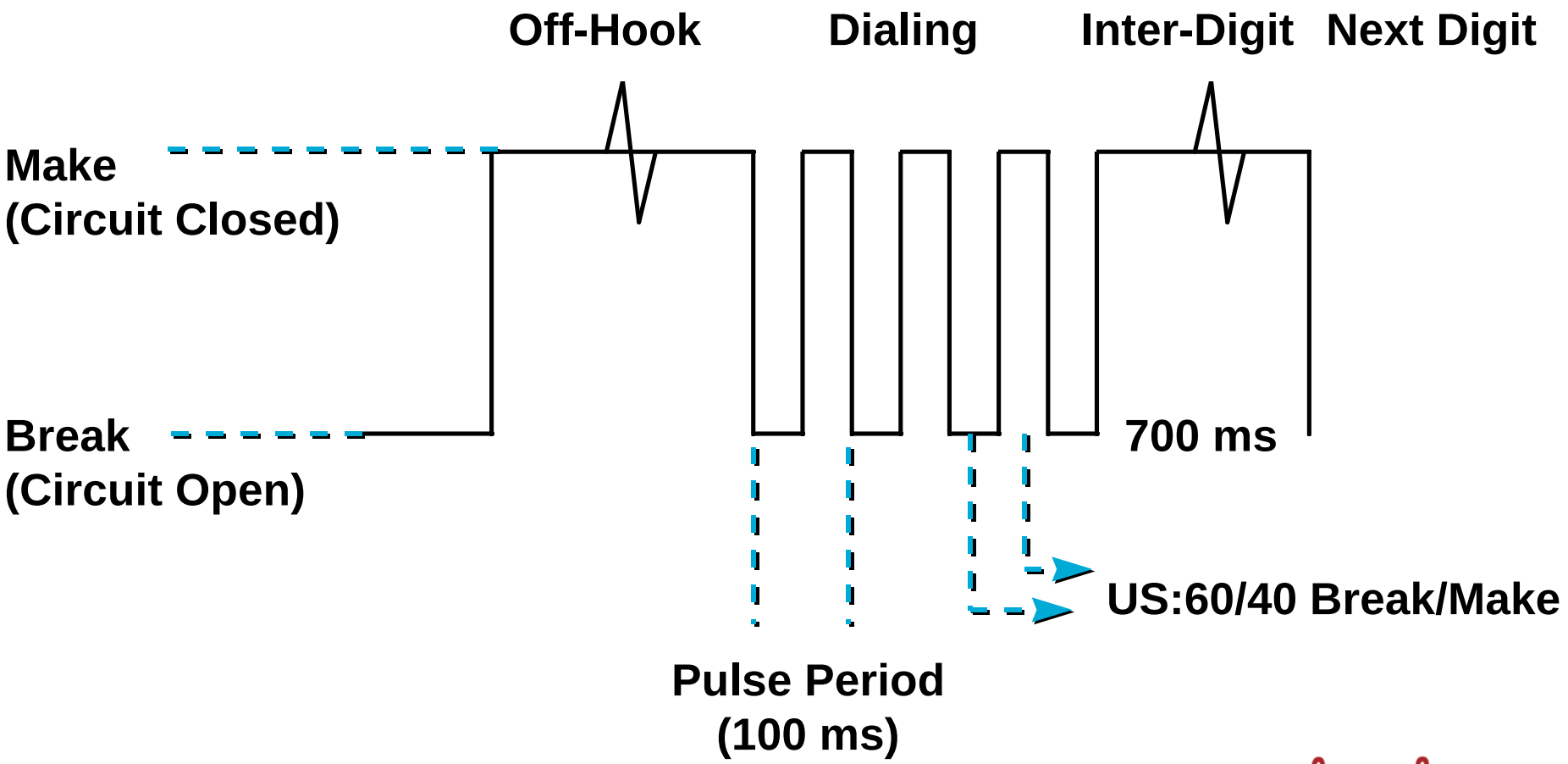
ISDN

Analog Transmission
“In-Band” Signaling
0–9, *, # (12 Digits)

Digital Transmission
“Out-of-Band”
Message-Based
Signaling

CISCO SYSTEMS

Pulse Dialing



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Tone Dialing

Dual Tone Multifrequency (DTMF)

	1209	1336	1477	1633
697	1	2	3	A
770	4	5	6	B
852	7	8	9	C
941	*	0	#	D

Timing:
60 ms Break
40 ms Make

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Network Call Progress Tones

Tone	Frequency (Hz)	On Time	Off Time
Dial	350 + 440	Continuous	
Busy	480 + 620	0.5	O.5
Ringback, Normal	440 + 480	2	4
Ringback, PBX	440 + 480	1	3
Congestion (Toll)	480 + 620	0.2	0.3
Reorder (local)	480 + 620	0.3	0.2
Receiver Off-hook	1400 + 2060 + 2450 +2600	0.1	0.1
No Such Number	200 to 400	Continuous, Freq. Mod 1Hz	

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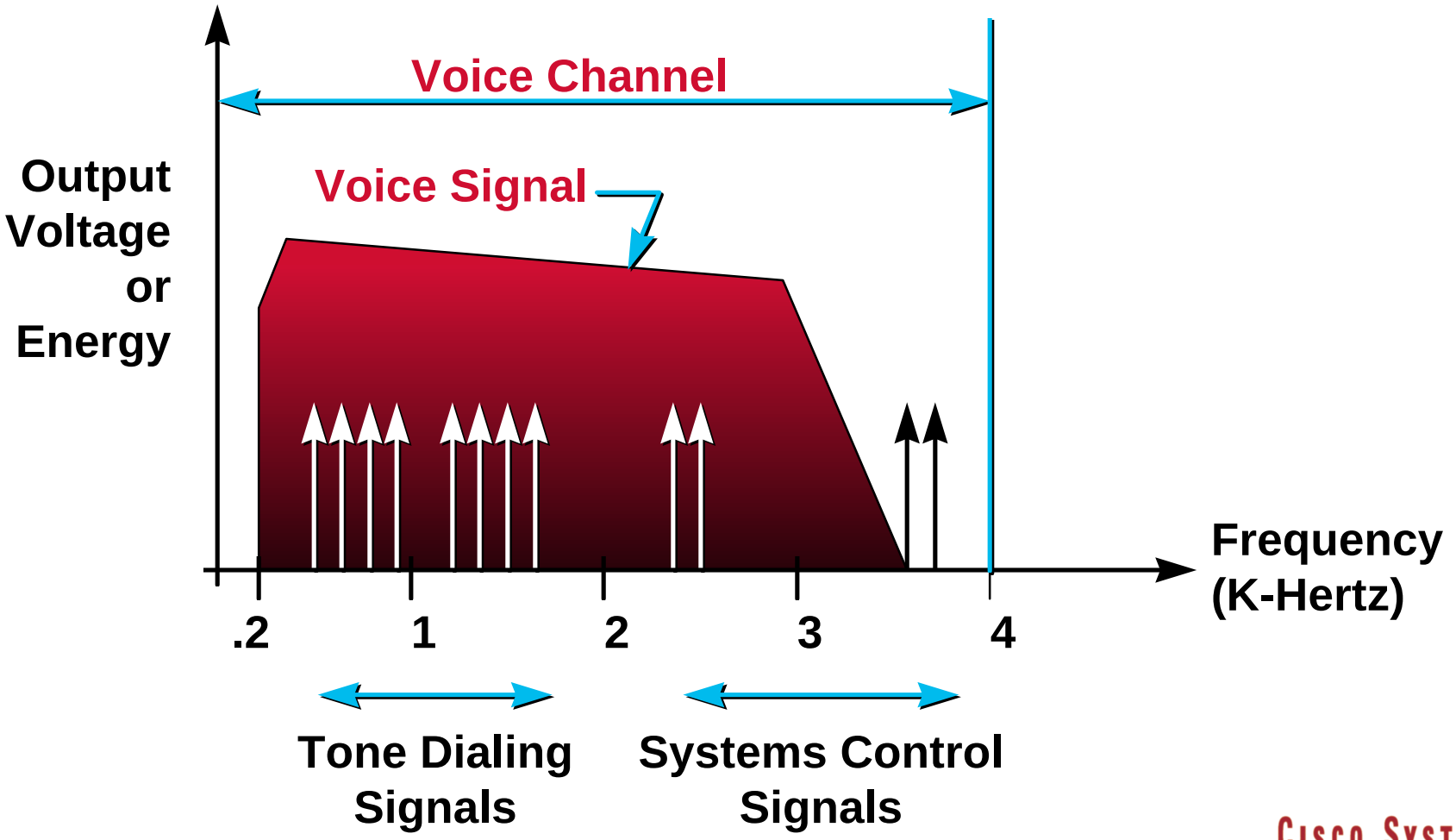
Voice Channel Bandwidth



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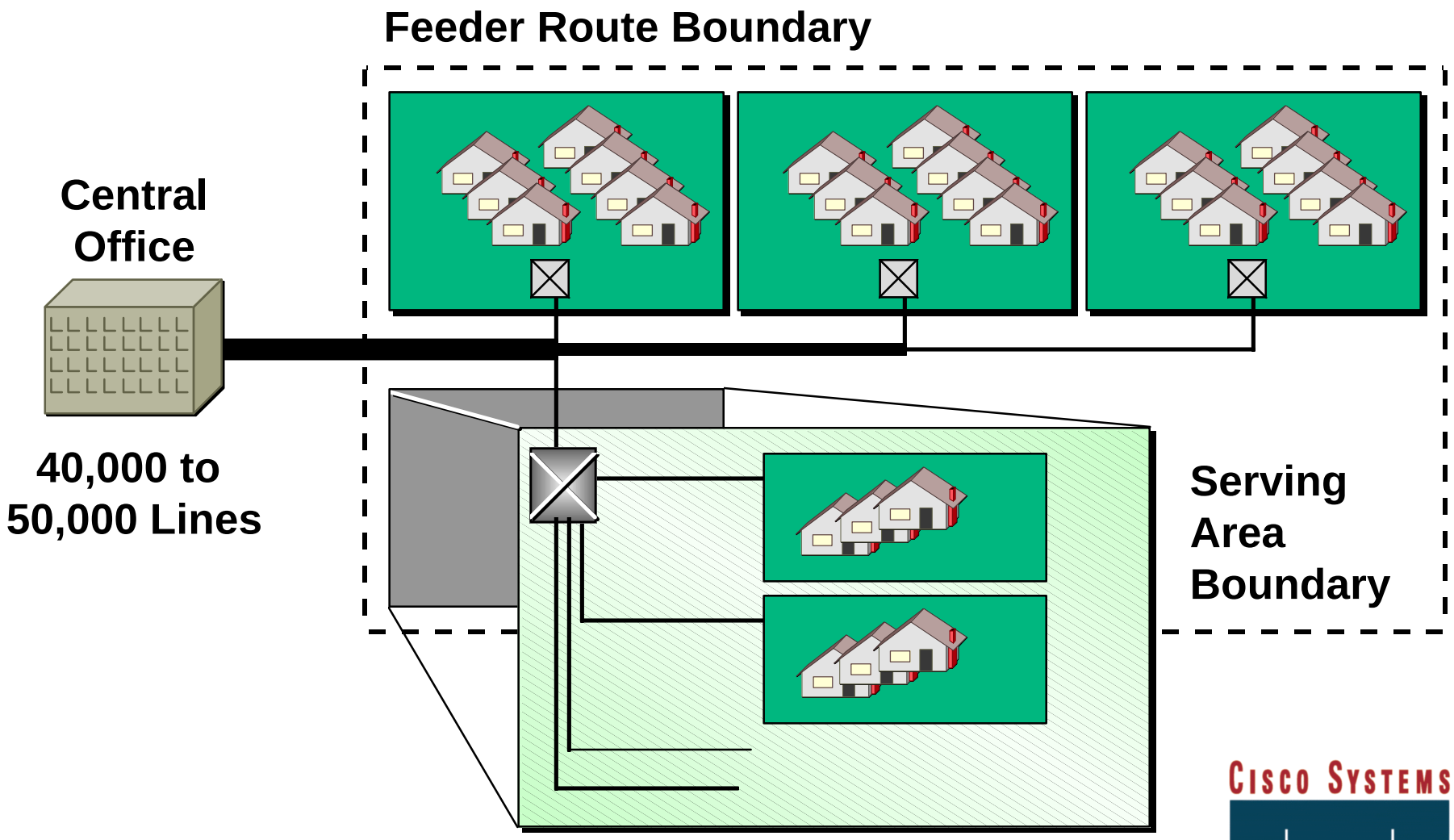
Local Access Network



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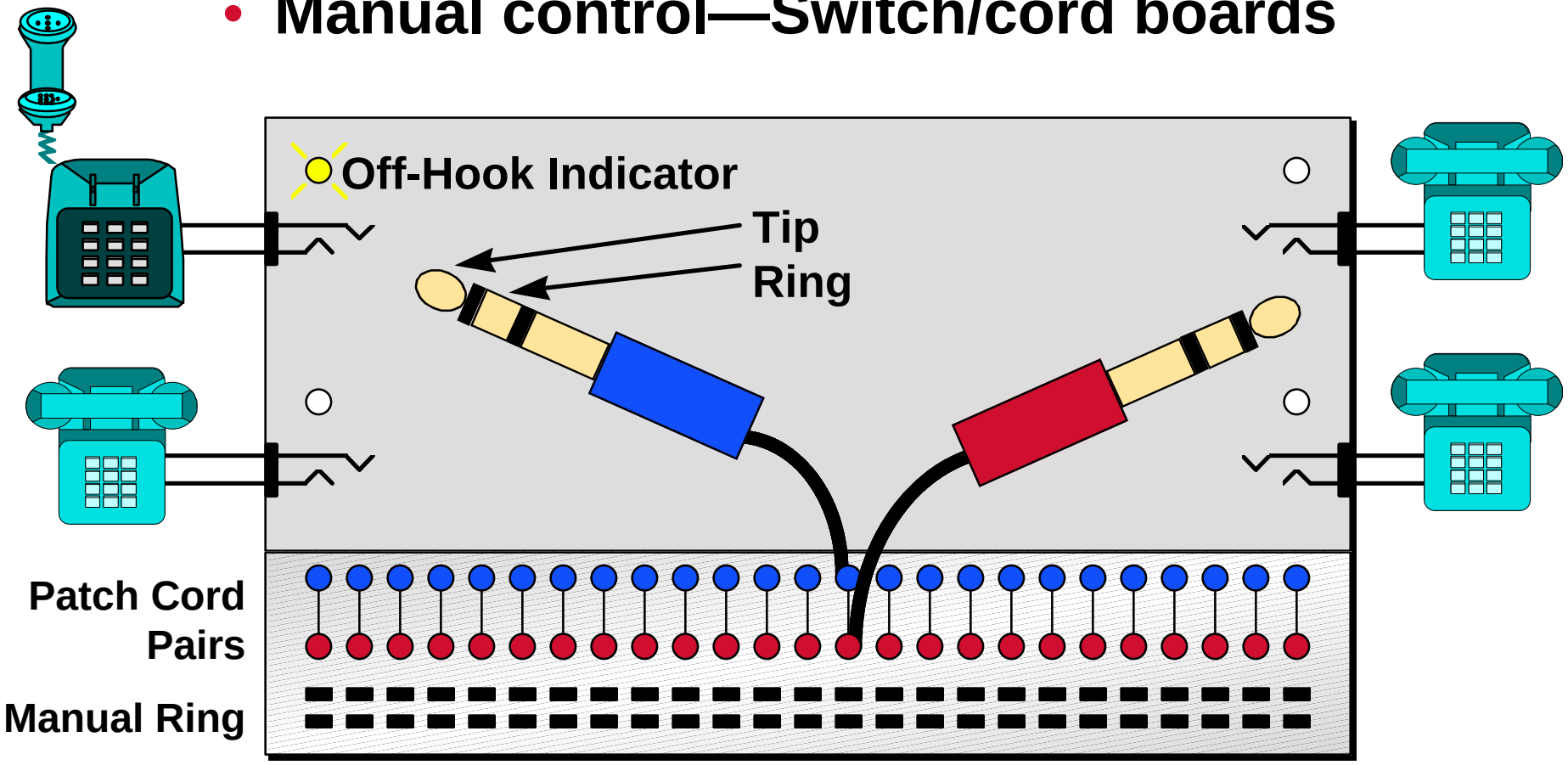
Switching Systems

- Manual control—Switch/cord boards



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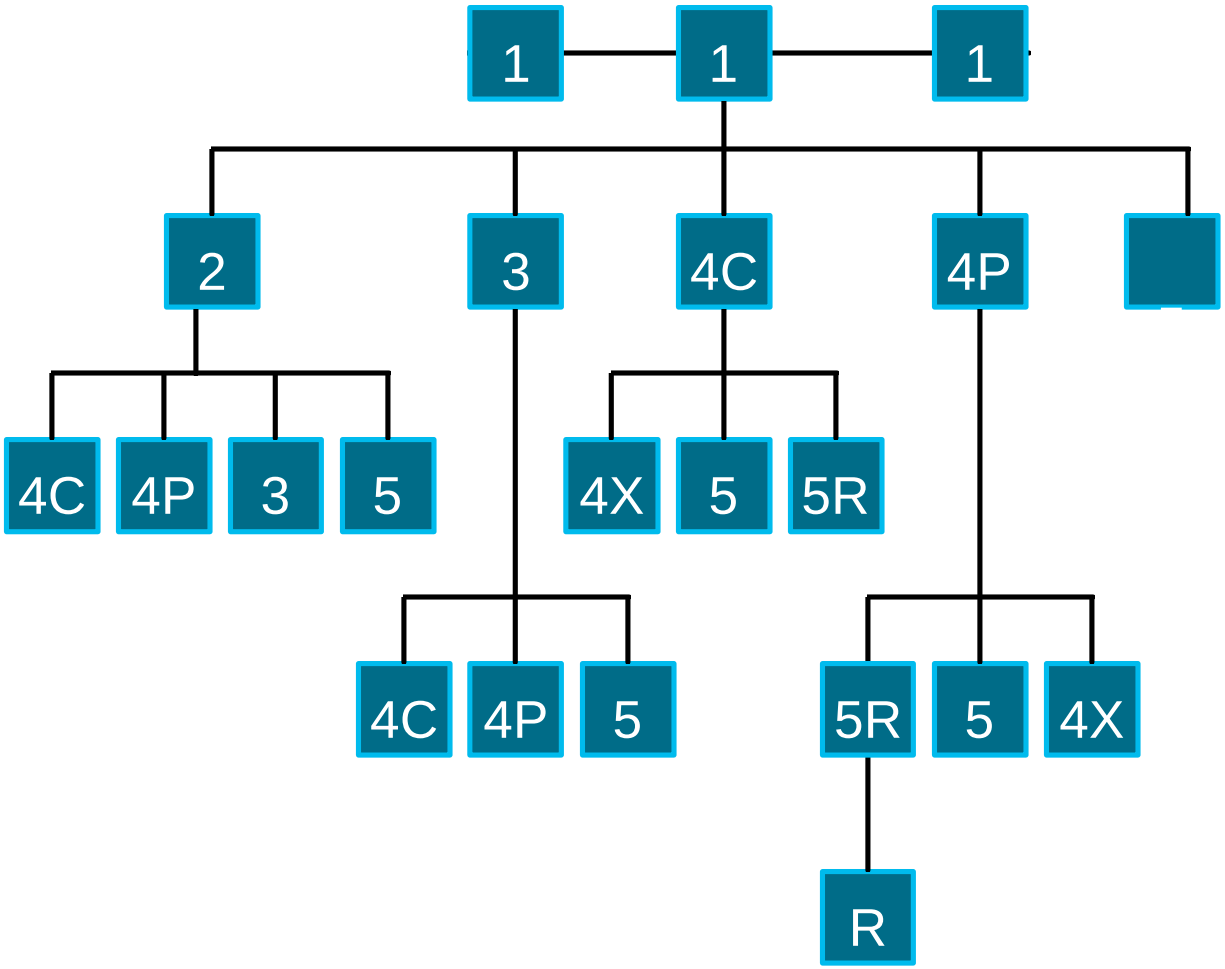
PSTN Network Hierarchy



Class	Name
1	Regional Center
2	Sectional Center
3	Primary Center
4C	Toll Center
4P	Toll Point
4X	Interm. Point
5	End Office
5R	EO w/ RSU
R	Remote Sw. Unit

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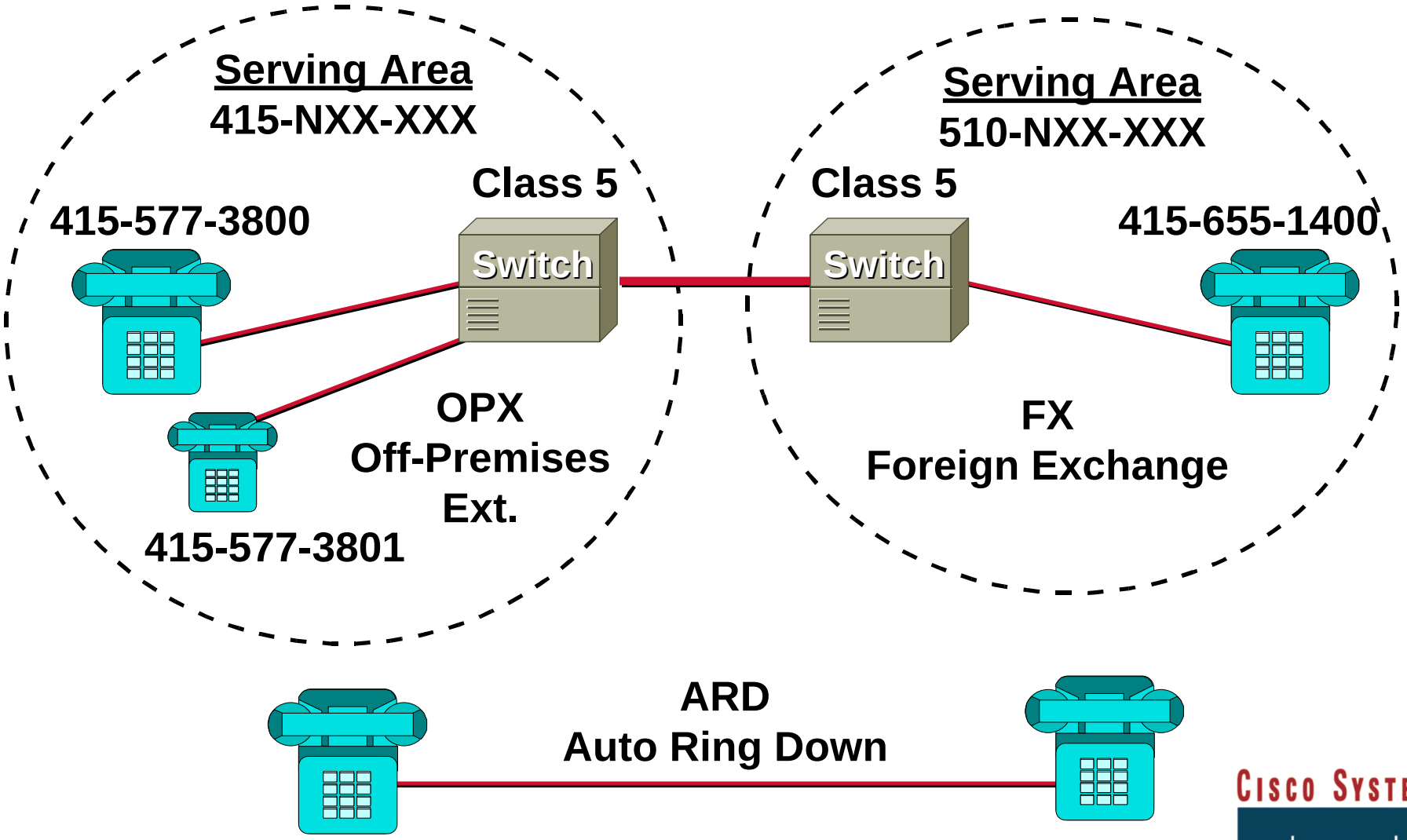
Types of Voice Circuits



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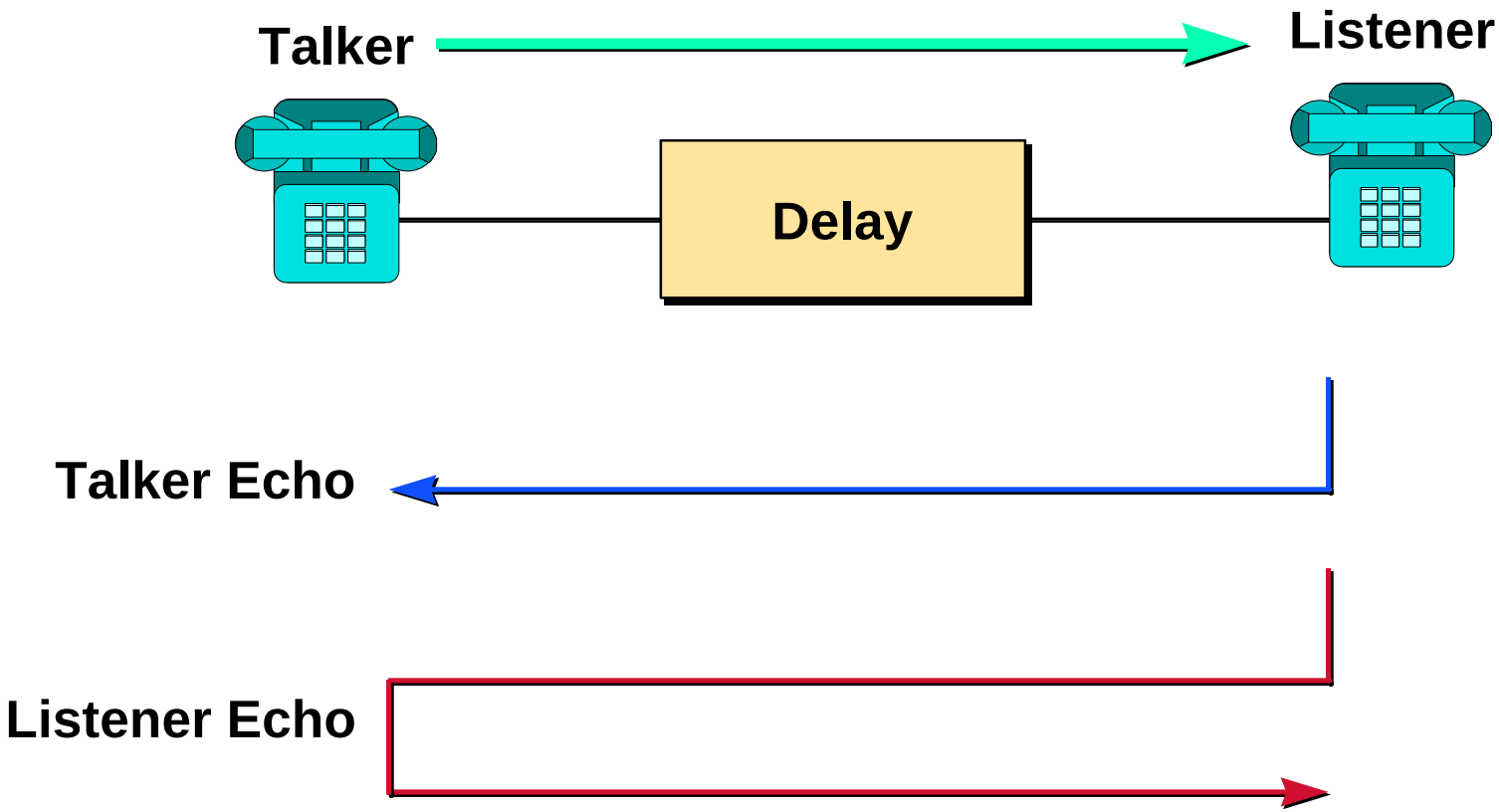
Echo in Voice Networks



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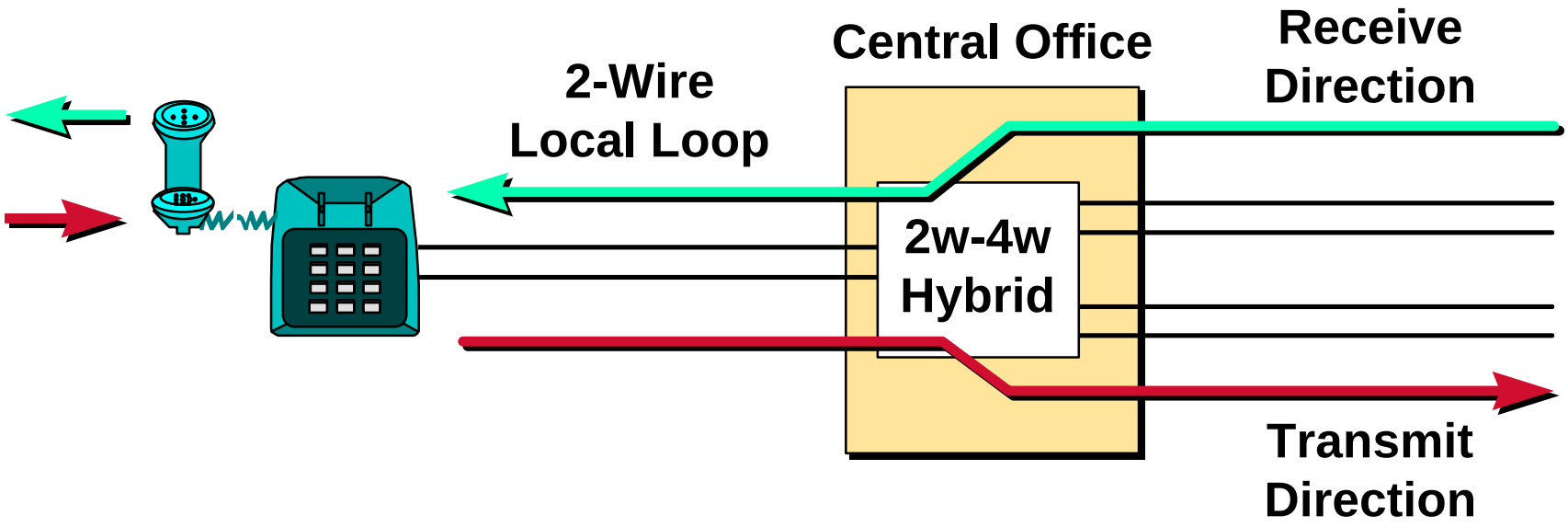
Normal Signal Flow



- 2- to 4-wire hybrid combines receive and transmit signals over the same pair
- 2-wire impedance must match 4-wire impedance

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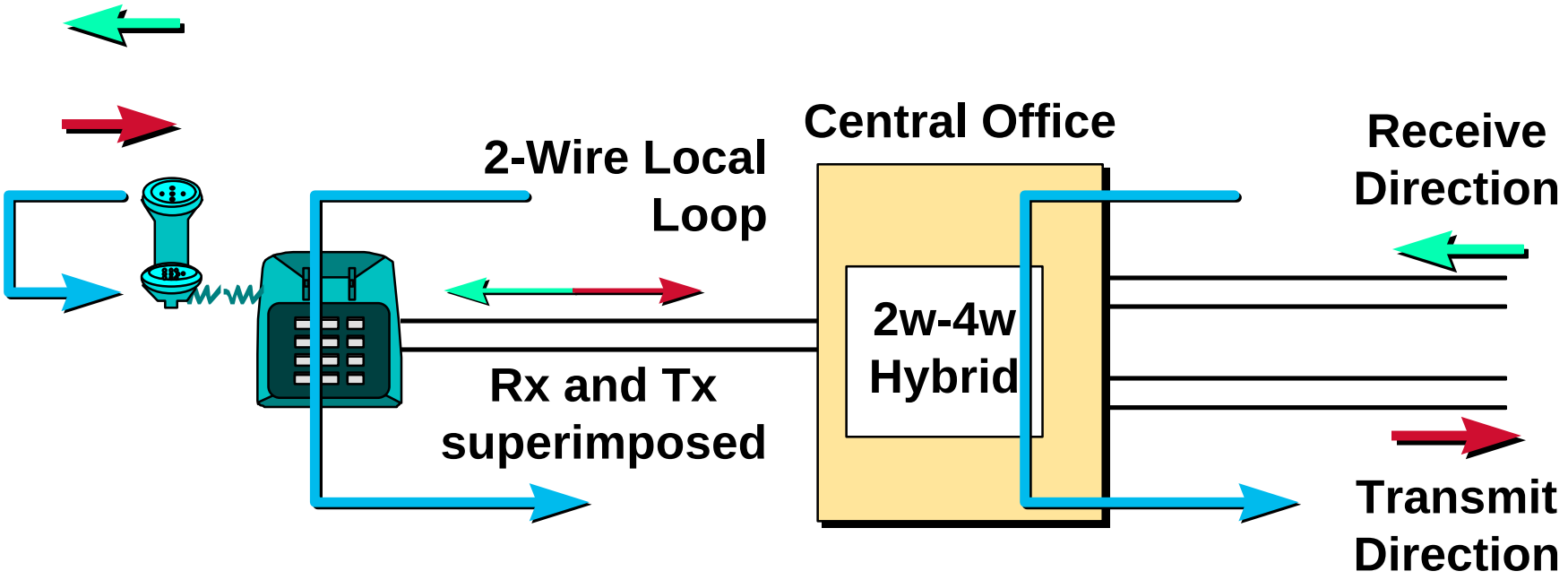
How Does Echo Happen?

- Echo is due to a reflection



Impedance Mismatch at the 2w-4w Hybrid Is the Most Common Reason for Echo

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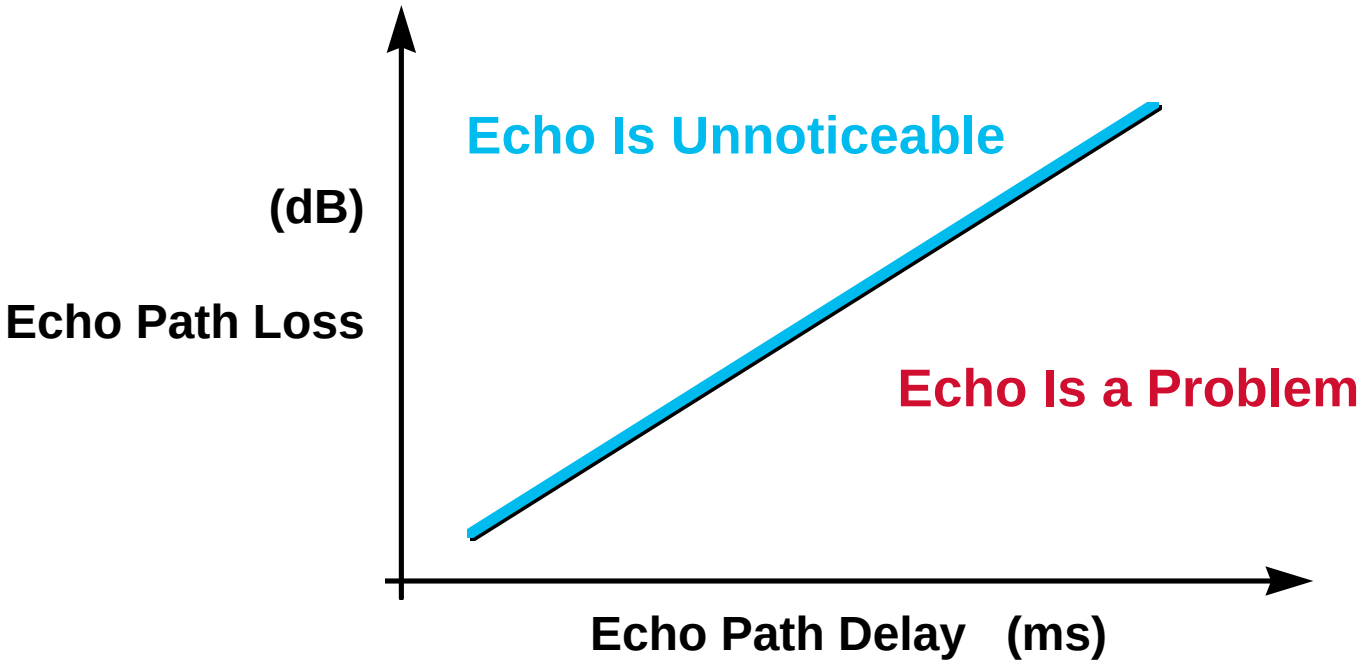
Echo Is Always Present

- **Echo as a problem is a function of the echo delay, and the magnitude of the echo**



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Ways to Defeat Echo

- **Increase the loss in the echo path**

  Can often be the solution

  Disadvantage: Static setting, reduces the signal strength of the speaker

- **Echo suppresser**

  Acts like a noise gate, effectively making communications half-duplex

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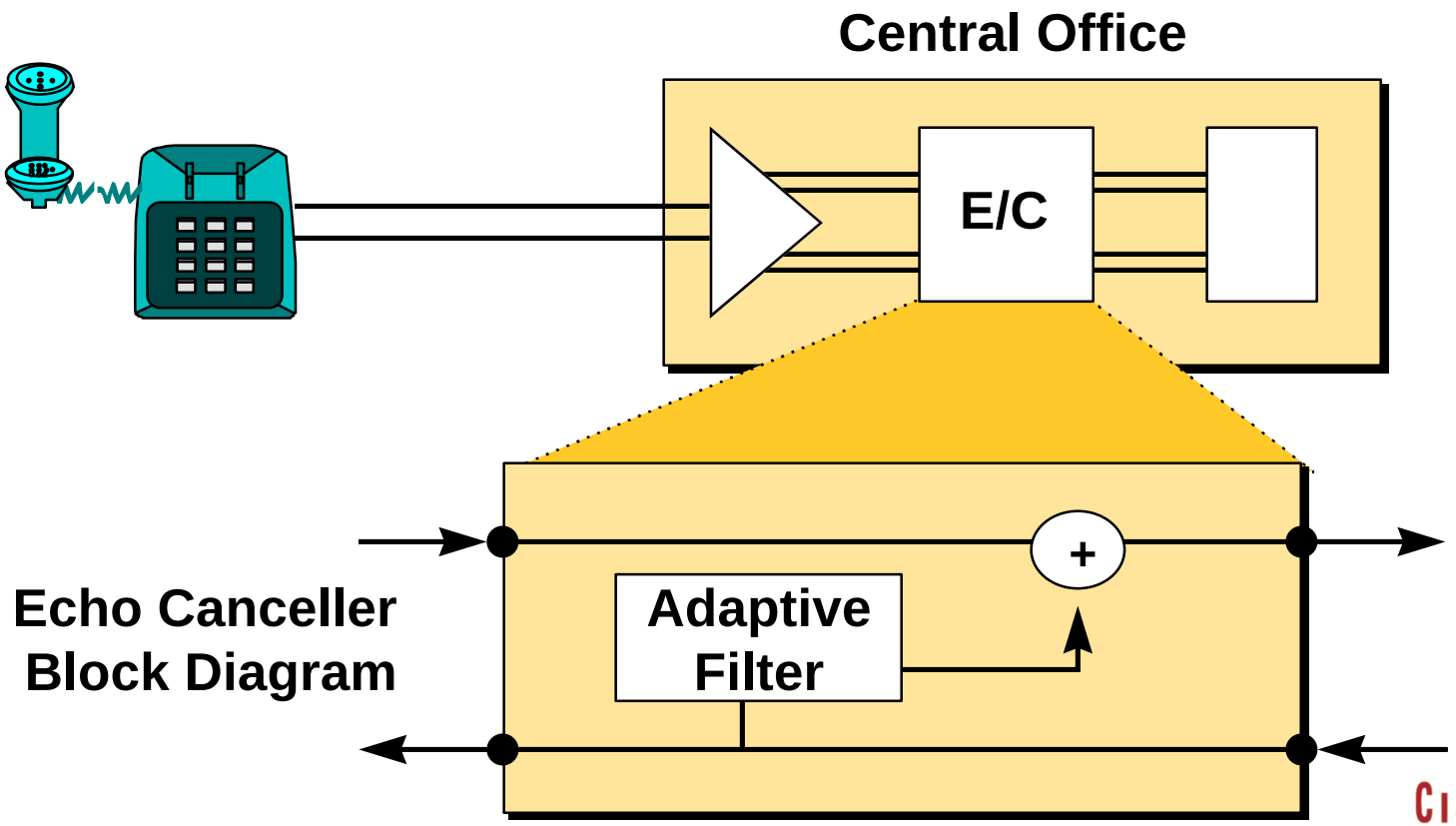
Echo Canceller

- Most effective means for removing echo



Echo Canceller
Block Diagram

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Summary

- Analog voice technology dates back to the 1900's
- Information exchange based on voltage, current flow, grounding, etc.

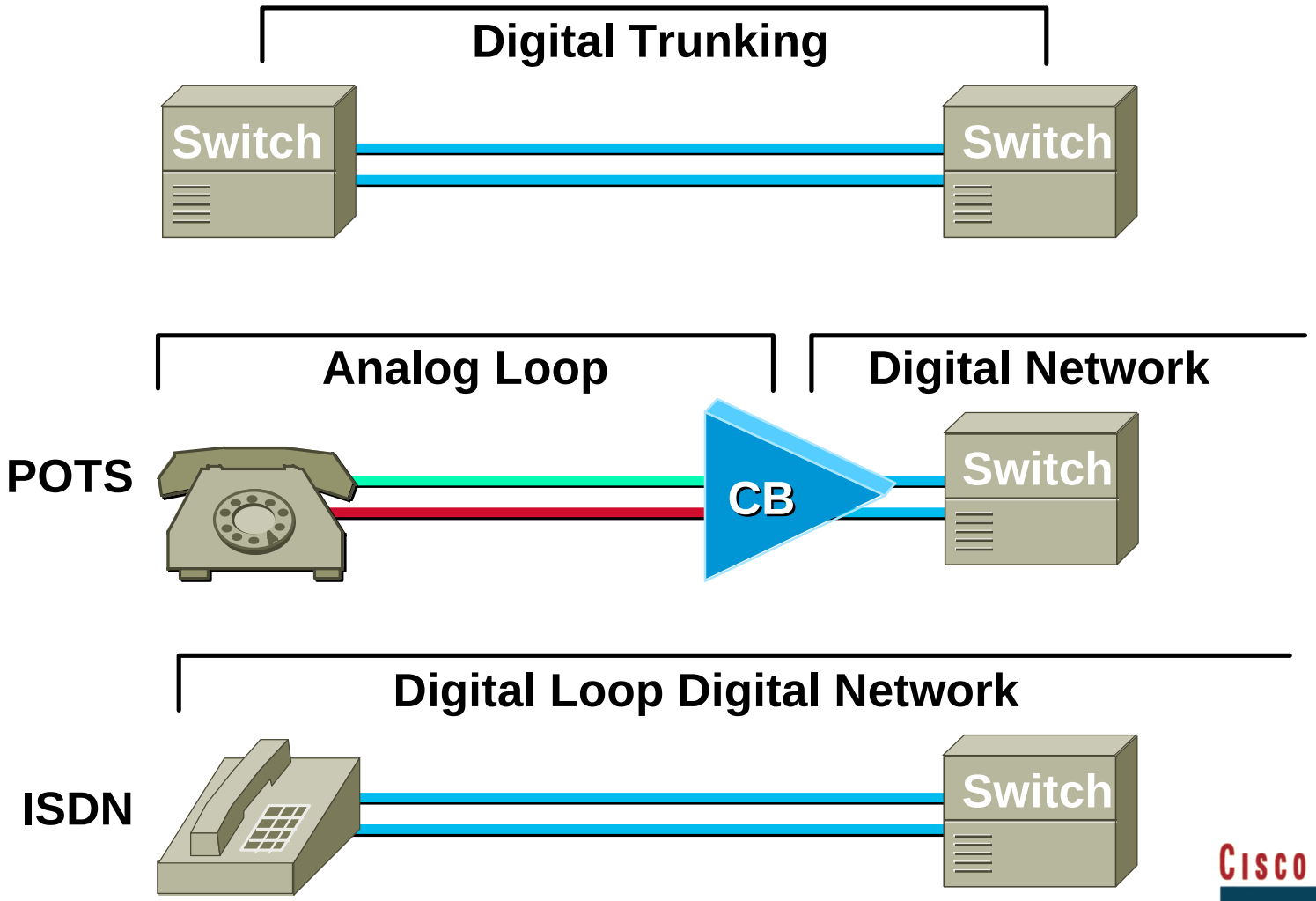
Cisco Systems

Agenda

- ✓ Basic Analog Telephony
- Basic Digital Telephony
- Consolidated Transport Networking

Cisco Systems

Digital Telephony



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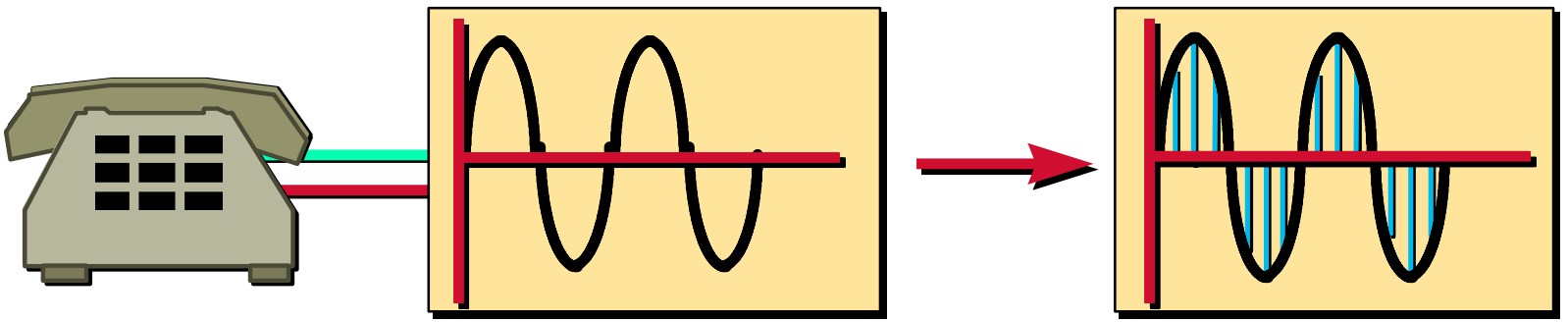
Digital Telephony

Pulse Code Modulation—Nyquist Theorem

Voice Bandwidth = 300 Hz to 3400 Hz



Analog Audio Source

Sampling Stage

Codec Technique

= Sample

8 kHz (8,000 Samples/Sec)

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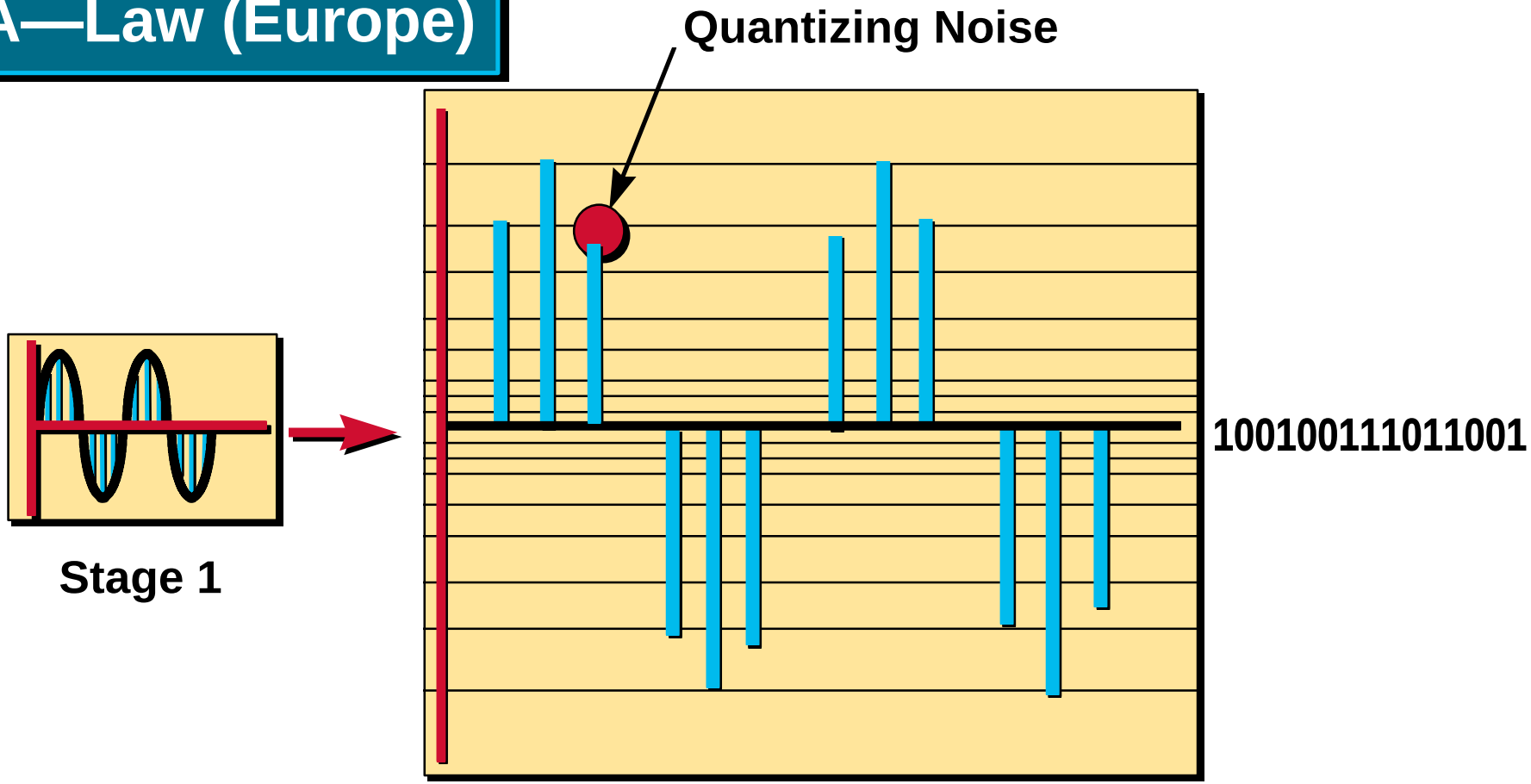
Pulse Code Modulation—Analog to Digital Conversion

A—Law (Europe)



μ—Law (USA–Japan)

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Digital Telephony—T1 and E1/J1

	T1 ITU-T G.733	E1/J1 ITU-T G.732
Sampling Frequency	8 kHz	8 kHz
Channel Bit Rate	DS0—64 kbps	DS0—64 kbps
Time Slots per Frame	24	32
Channels per Frame	24	30
Bits per Frame	24 x 8 + 1 = 193	32 x 8 = 256
Framing	D4/Super Frame (12) Extended Super Frame (24)	E1: Multiframe (16) J1: CRV in Bit 1 of frame
Framing Indicator	193rd Bit of Frame	2.048 kbps Word of 7 Bits in the 0 Channel of Odd Frames
System Bit Rate	8,000 x 193 = 1.544 Mbps	8,000 x 256 = 2.048 Mbps
Signaling	"Robbed Bit" Channel Associated Signaling D4/Super Frame: LSB/Channel, Frame 6 and 12 Extended Super Frame: LSB/Channel, Frames 6, 12, 18, 24	E1: CCS in TS 16 CAS in TS 16—2 Ch Every Other Frame J1: TS0

DS1 Framing Format

193rd Bit of each frame used for frame synchronization.

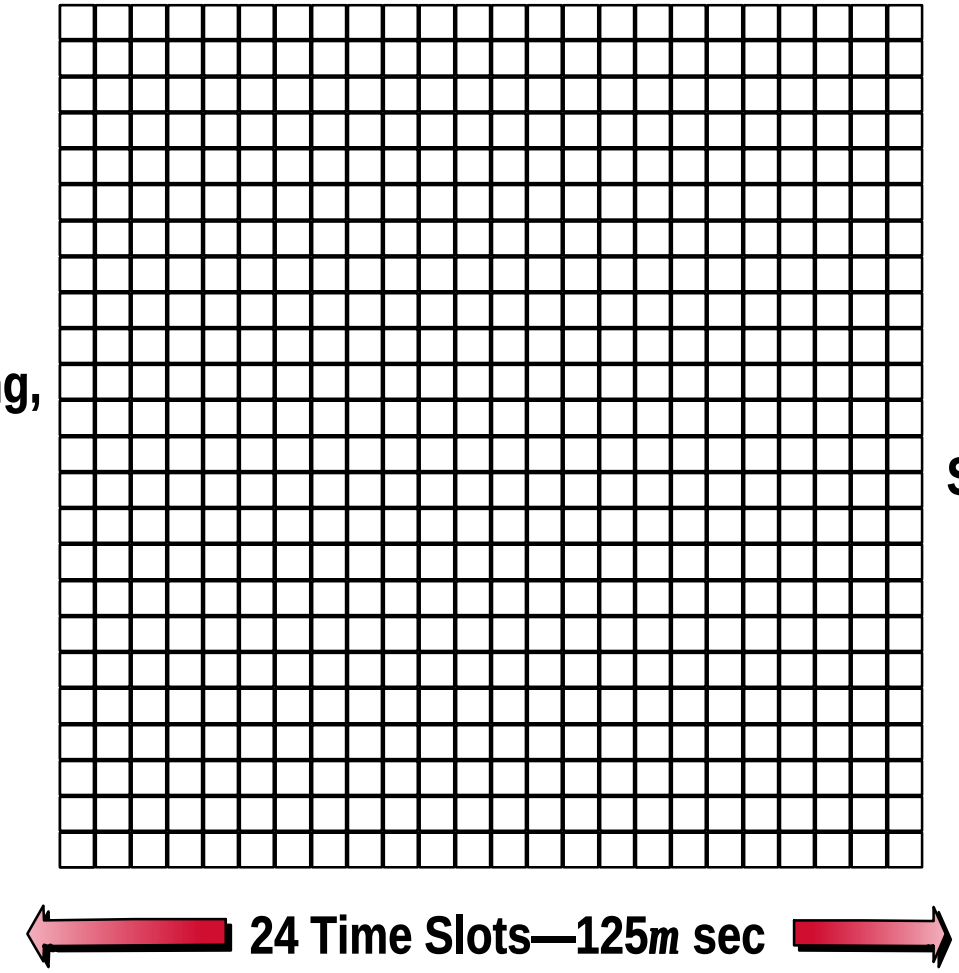
D4 Framing is 12 frames
D4 framing pattern is:
100011011100

ESF is 24 frames, with framing, CRC and an FDL channel

ESF Framing pattern is 001011, in frames 4, 8, 12, 16, 20 and 24

Channel Associated Signaling robs the LSB of every byte in frames 6, 12, 18 and 24 for ABCD bits

Common Channel Signaling (ISDN) uses TS 24



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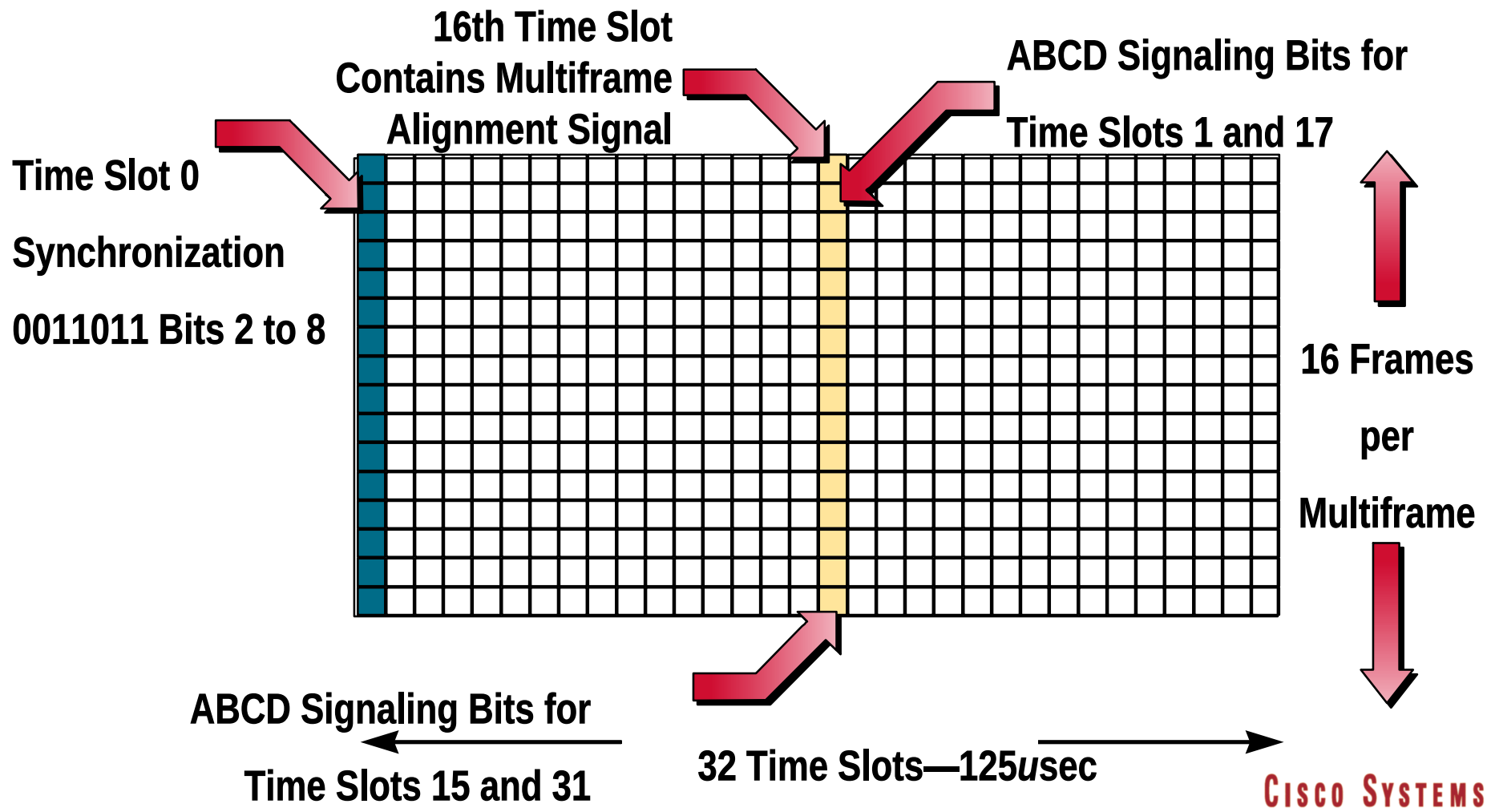
Extended Super-Frame Format

	S Bits			Bit Use in Each Channel Time Slot		Signaling—Bit Use Options			
Frame Number	Fe	DL	BC	Traffic	Signaling	T	2	4	16
1	–	m	–						
2	–	–	C1						
3	–	m	–						
4	0	–	–						
5	–	m	–						
6	–	–	C2	Bits 1–7	Bit 8	*	A	A	A
7	–	m	–						
8	0	–	–						
9	–	m	–						
10	–	–	C3						
11	–	m	–						
12	1	–	–	Bits 1–7	Bit 8	*	A	B	B
13	–	m	–						
14	–	–	C4						
15	–	m	–						
16	0	–	–						
17	–	m	–						
18	–	–	C5	Bits 1–7	Bit 8	*	A	A	C
19	–	m	–						
20	1	–	–						
21	–	m	–						
22	–	–	C6						
23	–	m	–						
24	1	–	–	Bits 1–7	Bit 8	*	A	B	D

E1 Frame Format



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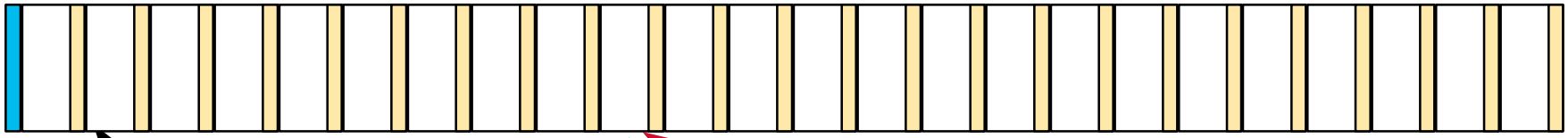
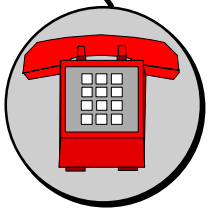
Digital Signaling Schemes

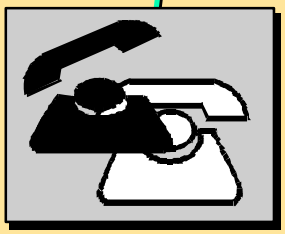
Channel Associated Signaling

Extended Super Frame





Audio
Address Signaling
(DTMF)



Supervision
On/Off Hook

Address Signaling
(Dial Pulse)

Bit	Frame
A	6th
B	12th
C	18th
D	24th

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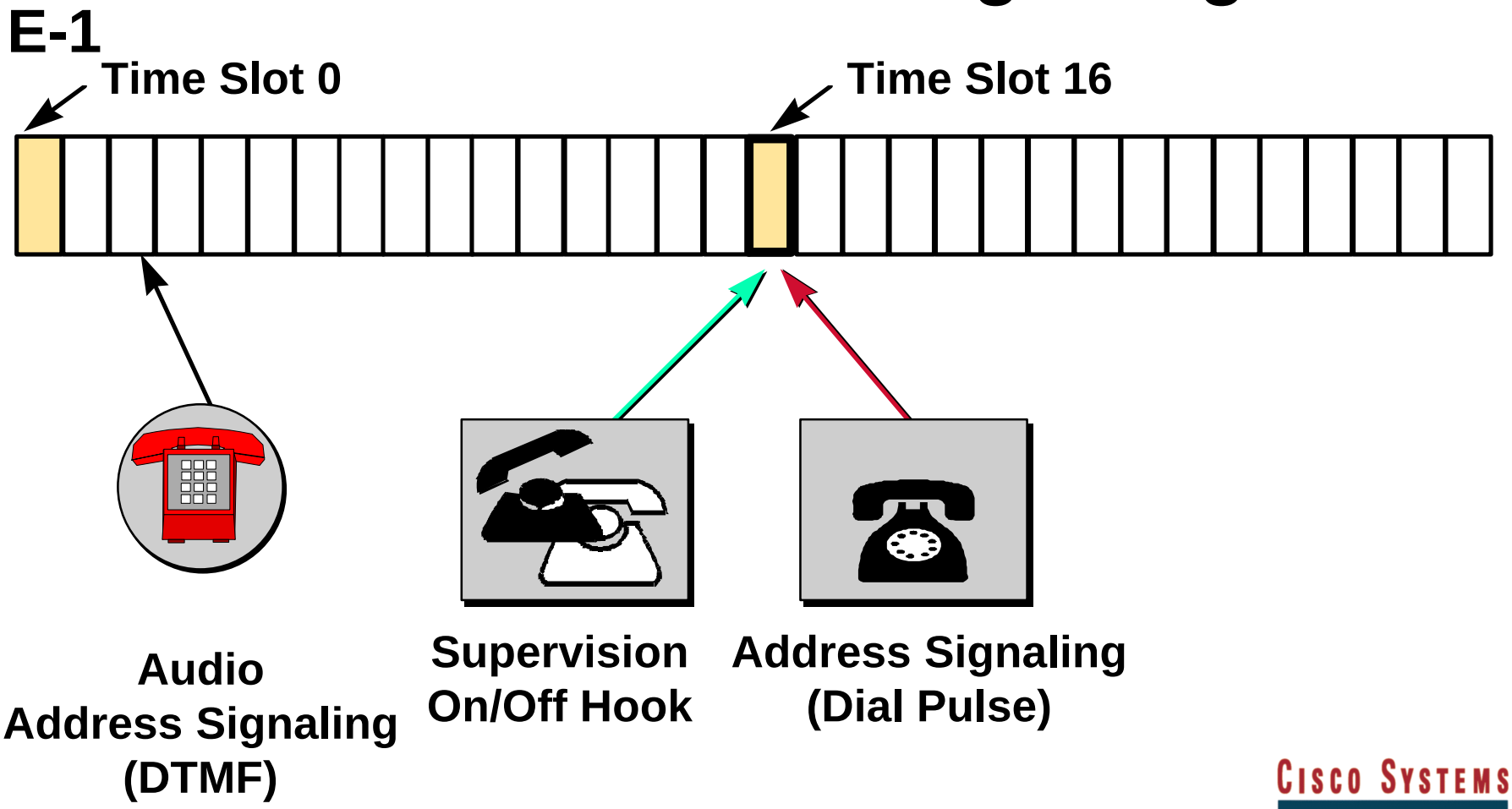
Digital Signaling Schemes

Common Channel Signaling



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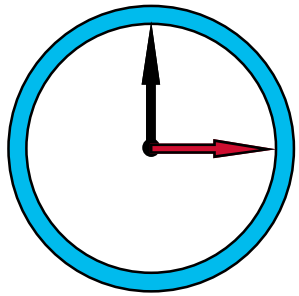
Digital Telephony—Synchronization



- **Bit synchronization**
  - **Primary reference source**
  - **Ones density (except for J1/CMI)**
- **Time slot synchronization**
  - **Bits/byte/channel**
- **Frame alignment**
  - **Basic rule**
  - **193rd bit pattern**

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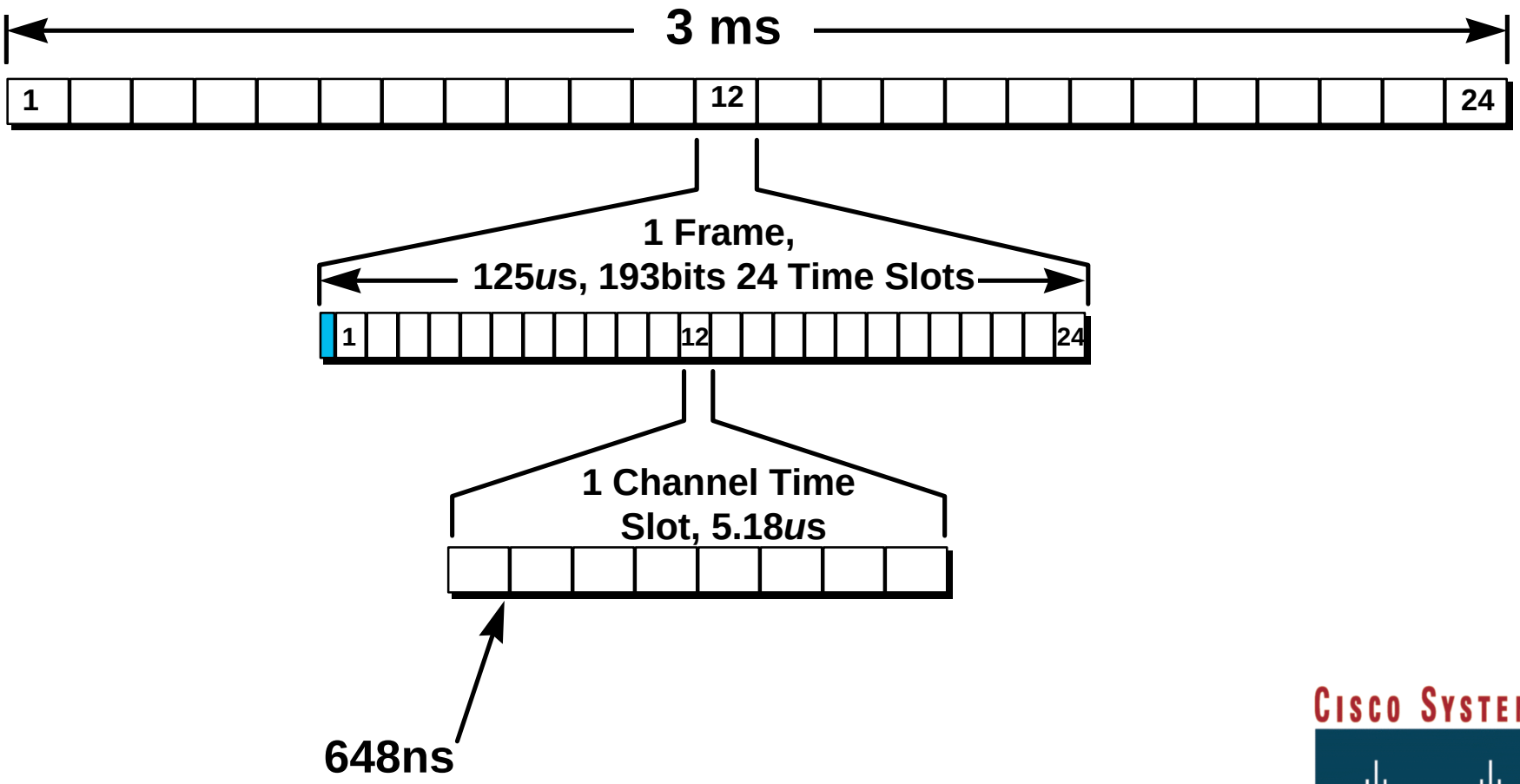
Digital Telephony—Synchronization

One Multiframe (ESF)



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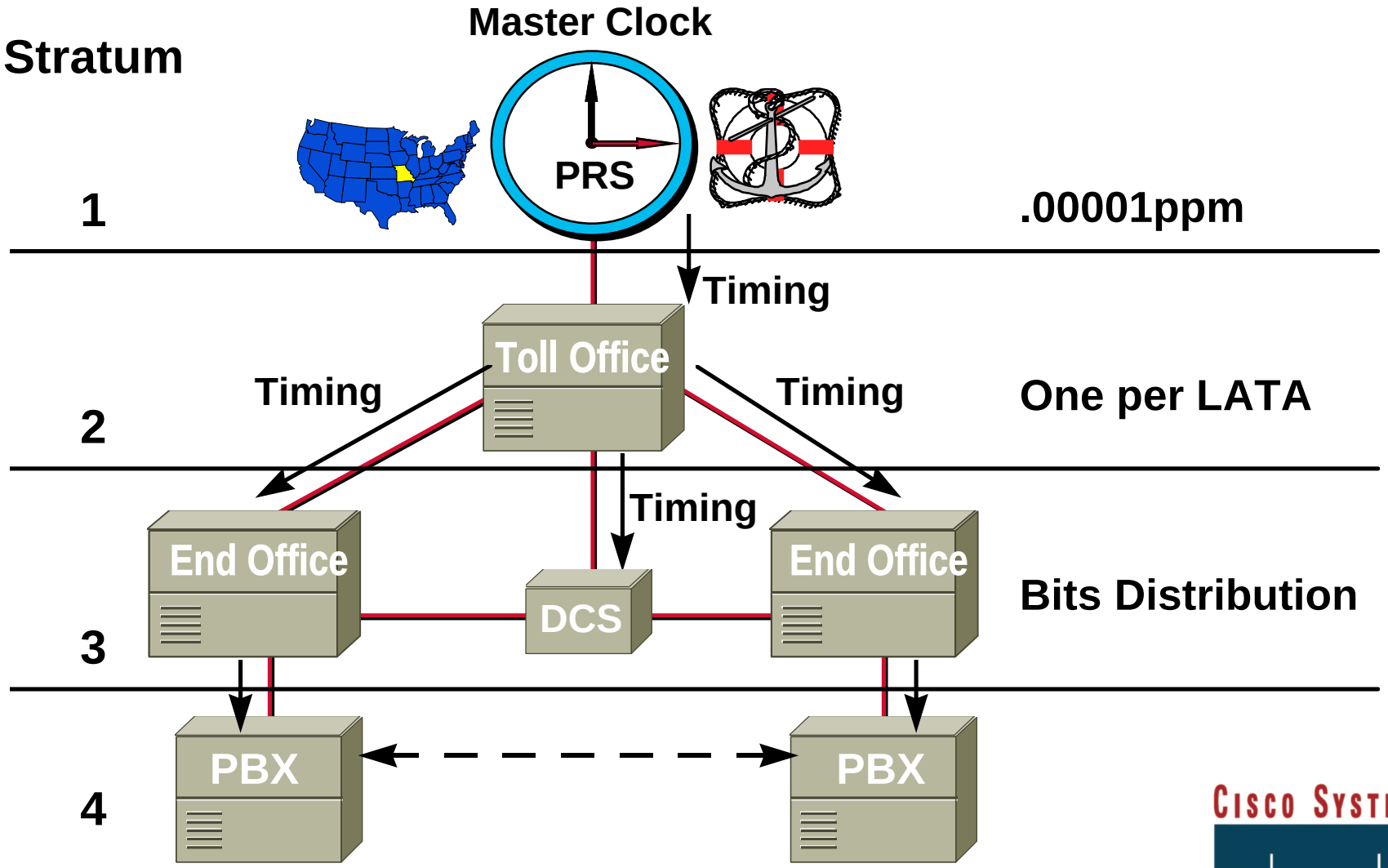
Synchronization—Traditional Network Clocking Strata



Cisco Systems

Digital Telephony—Analog Emulation and Pair Gain

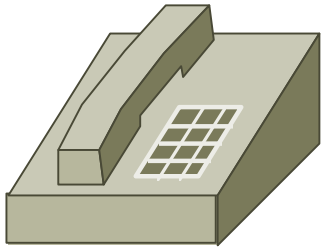
- **Backbone to largest interoperable network in the world**
- **Signaling information exchange based on ~30 year old concepts**

  Twiddling bits based on ~100-year old signaling

CISCO SYSTEMS

Digital Telephony Summary

- **Analog telephony emulation**
  - **Voice encoding**
  - **Limited signaling**
  - **Loop consolidation**



Cisco Systems

Agenda

- ✓ Basic Analog Telephony
- ✓ Basic Digital Telephony
- Consolidated Transport Networking

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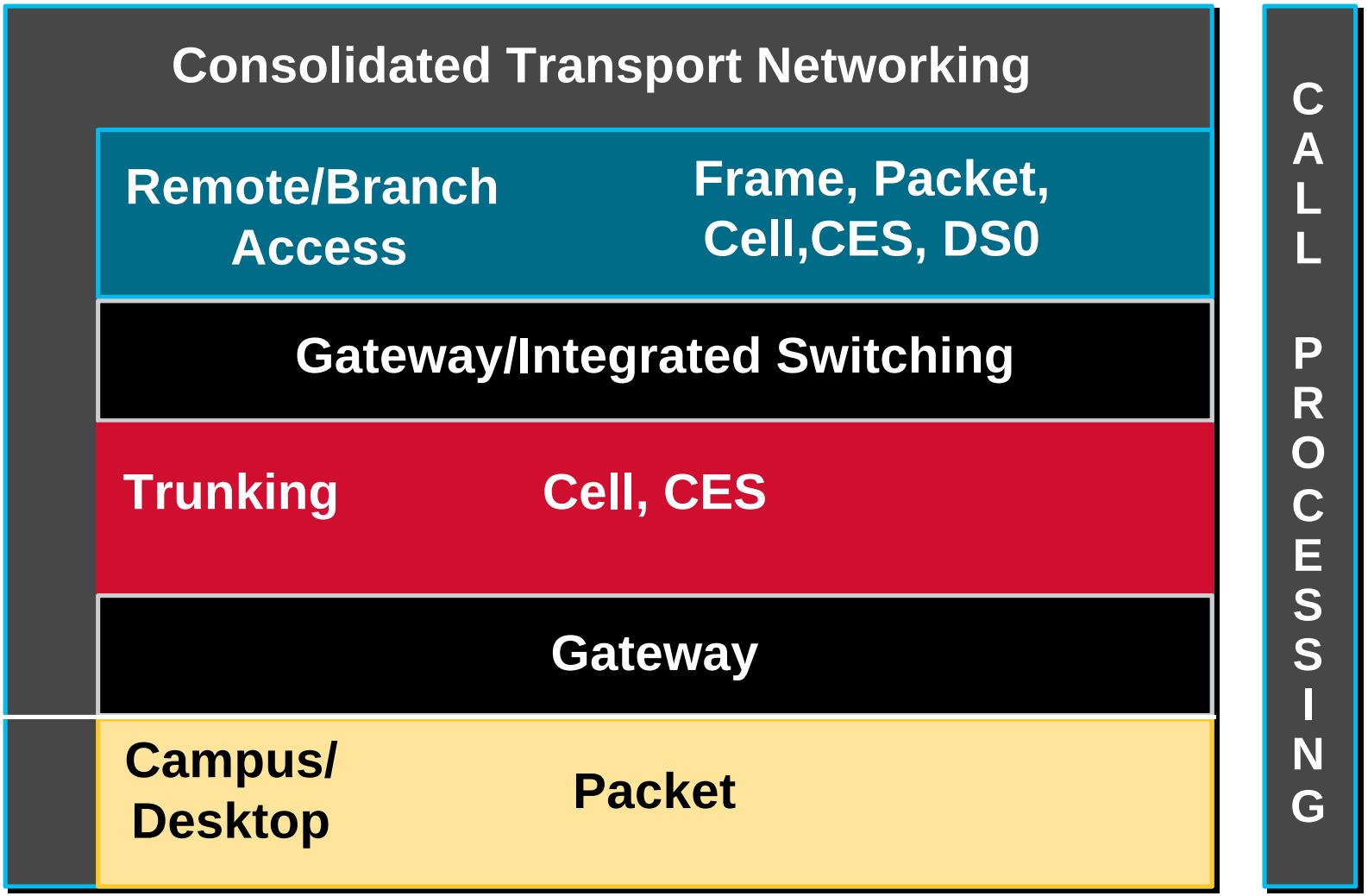
Consolidated Transport Networking



Consolidated Transport Network Solutions

- **PBX trunking**
  - **PBX trunk pathing**
  - **Intelligent voice network switching**
- **Branch/remote office access**
  - **Virtual switch access**
  - **Tie line and OPX transport**
  - **Alternate “packet” routes**

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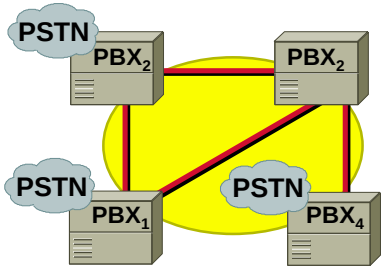
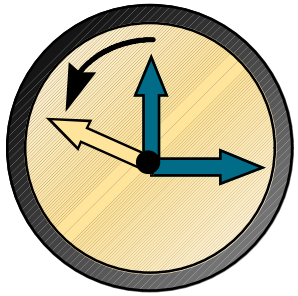
PBX Trunk Pathing



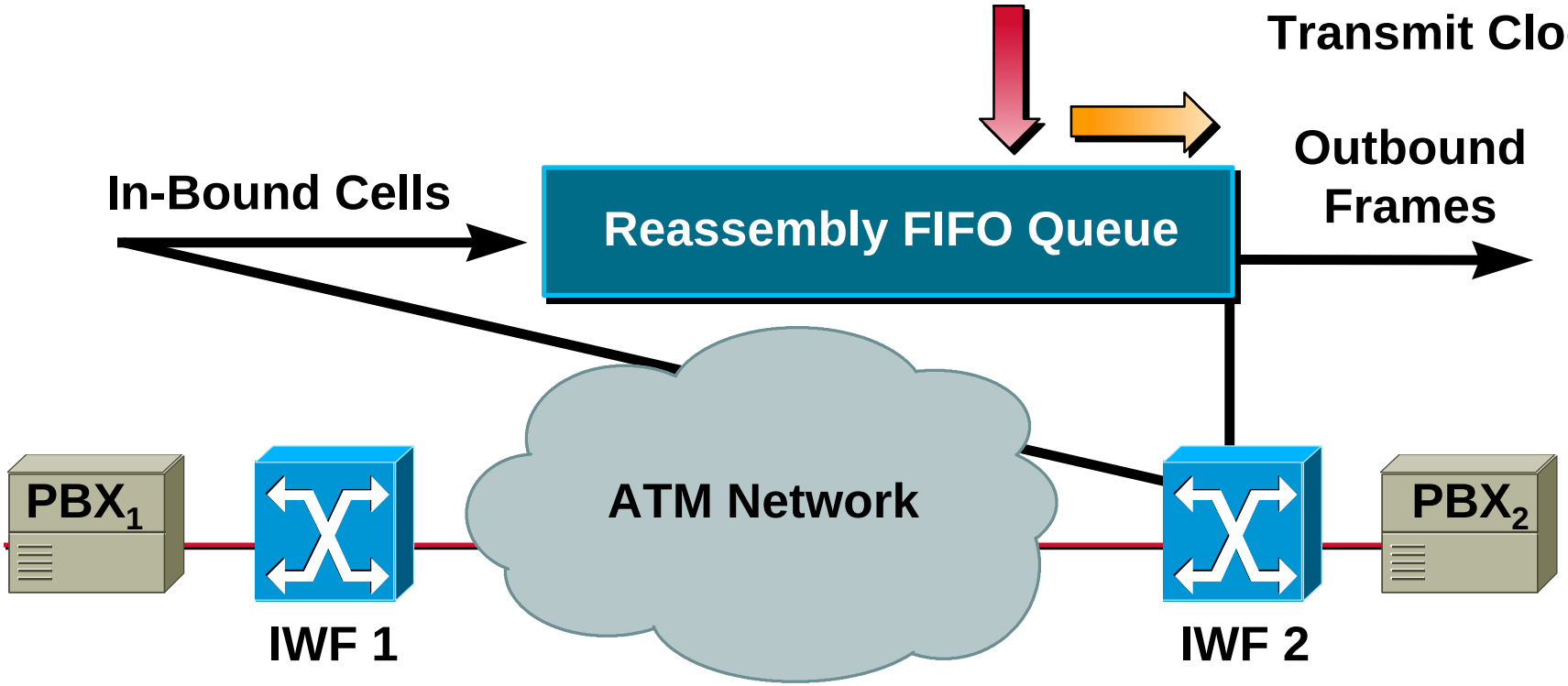
PSTN
PBX2
CES/IWF
PSTN
PBX1
CES/IWF
PVCs
PSTN
PBX4
CES/IWF
CES/IWF
PSTN
PBX3

CISCO SYSTEMS

Network Synchronization—Adaptive Clocking



Transmit Clock



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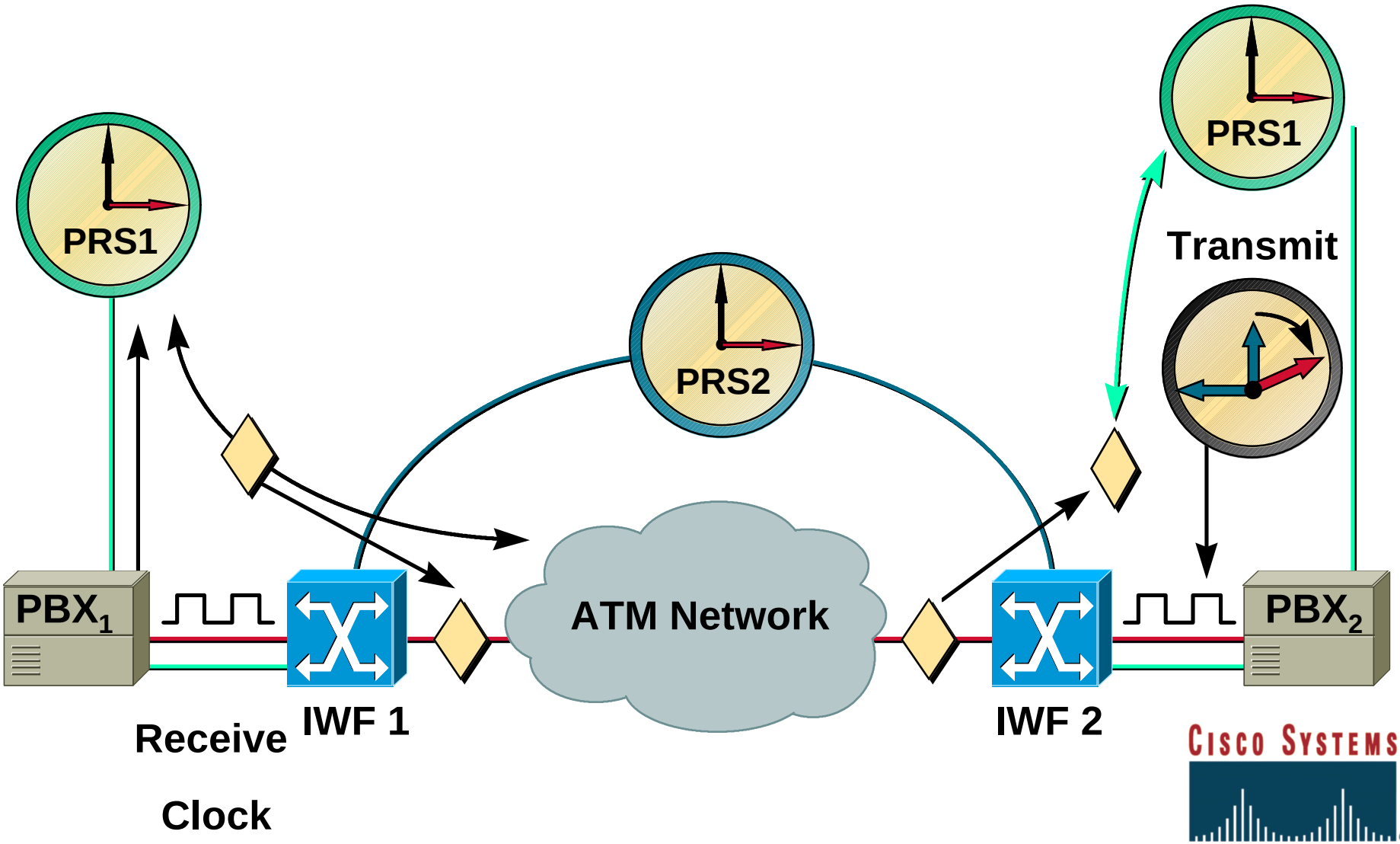
Network Synchronization—Synchronous Residual Time Stamp



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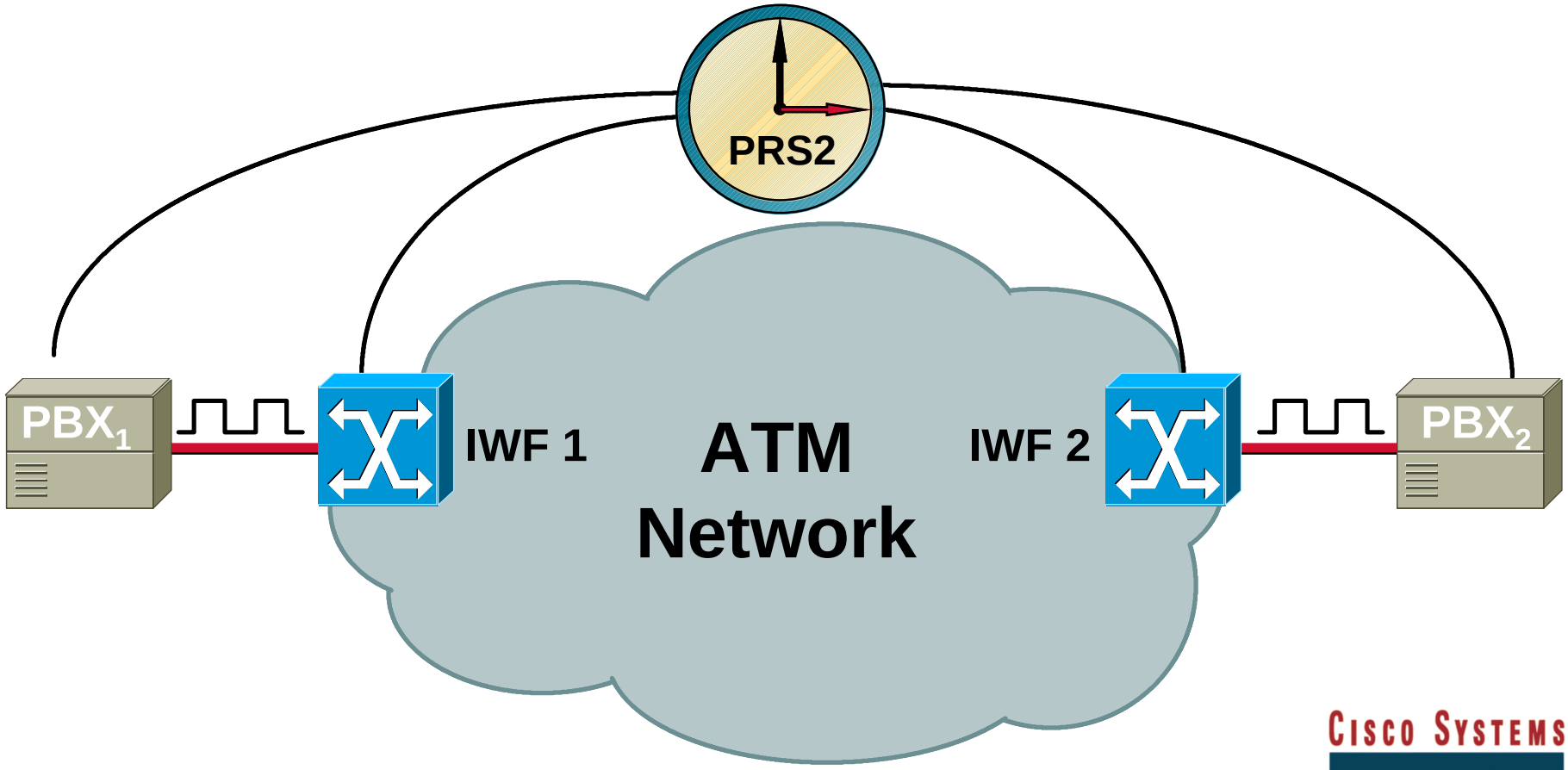
Network Synchronization—Synchronous Clocking

Traceable to a Single Reference Source



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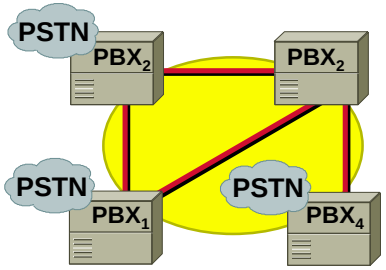
PBX Trunk Pathing

Network Synchronization



PRS2

PSTN

PBX2

CES/IWF

PSTN

PBX1

CES/IWF

PVCs

PSTN

PBX4

CES/IWF

PSTN

PBX3

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PBX Trunking

PBX Trunk Pathing—Considerations

- N^2 connections
- Tandem “hops” dependent on topology
- Dedicated point-to-point circuits
- Point-to-point signaling
- Platform availability

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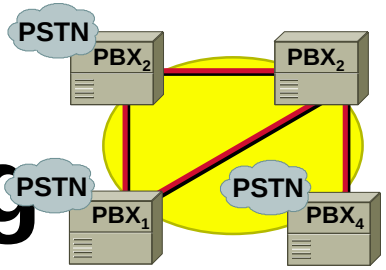
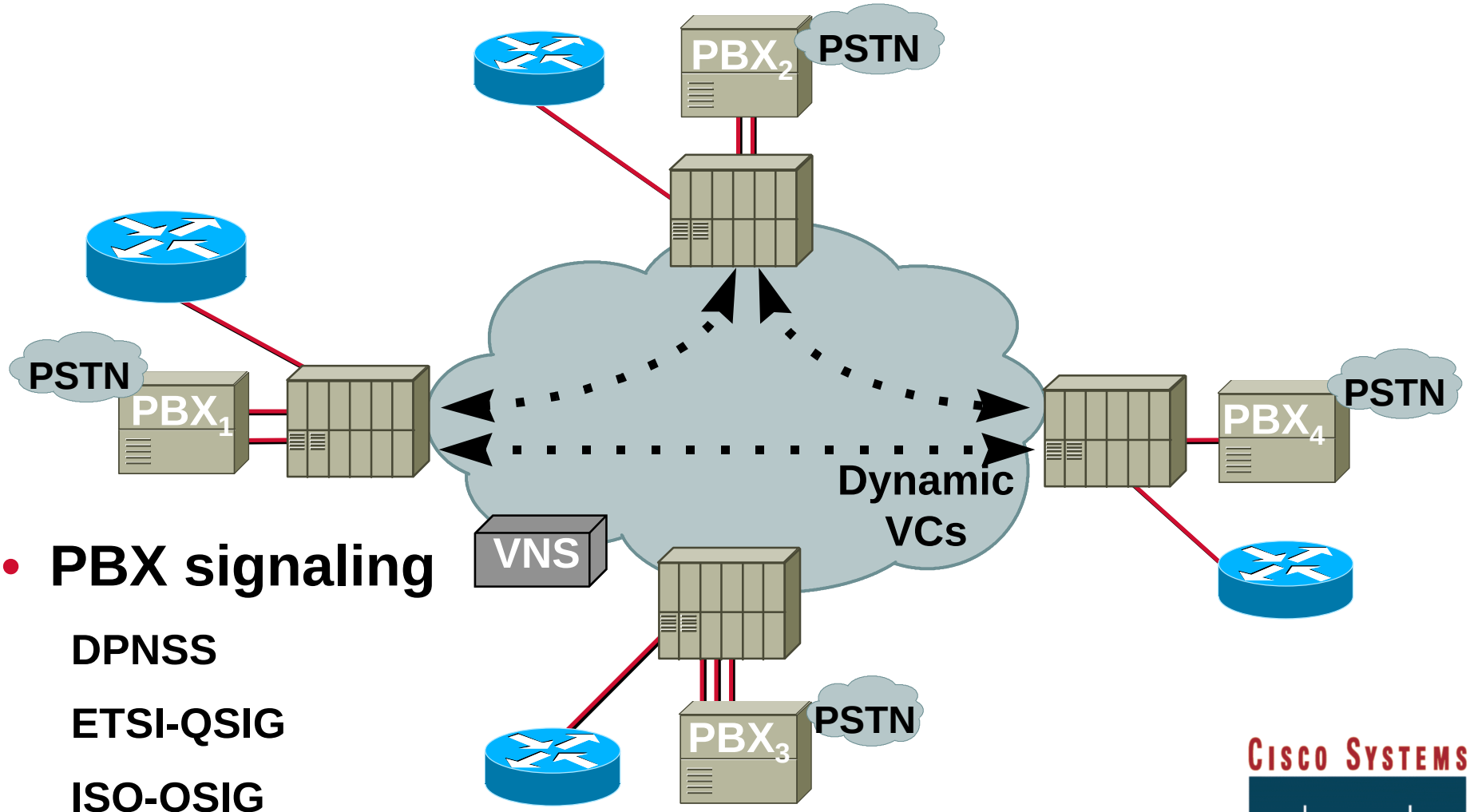
PBX Trunking—Intelligent Voice Switching





- **PBX signaling**
  - **DPNSS**
  - **ETSI-QSIG**
  - **ISO-QSIG**

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PBX Trunking—Intelligent Voice Network Switching

- **Efficient trunk groups**
- **Efficient WAN utilization**
  - **PBX to network signaling**
  - **Tandem switch replacement**
  - **Dynamic setup of virtual circuits**
  - **Compression**
  - **Voice activity detection**

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Consolidated Transport—Branch/Remote Office Access

- Explosive branch office “data” networking
- Similar voice and data traffic patterns
- Technology advancements

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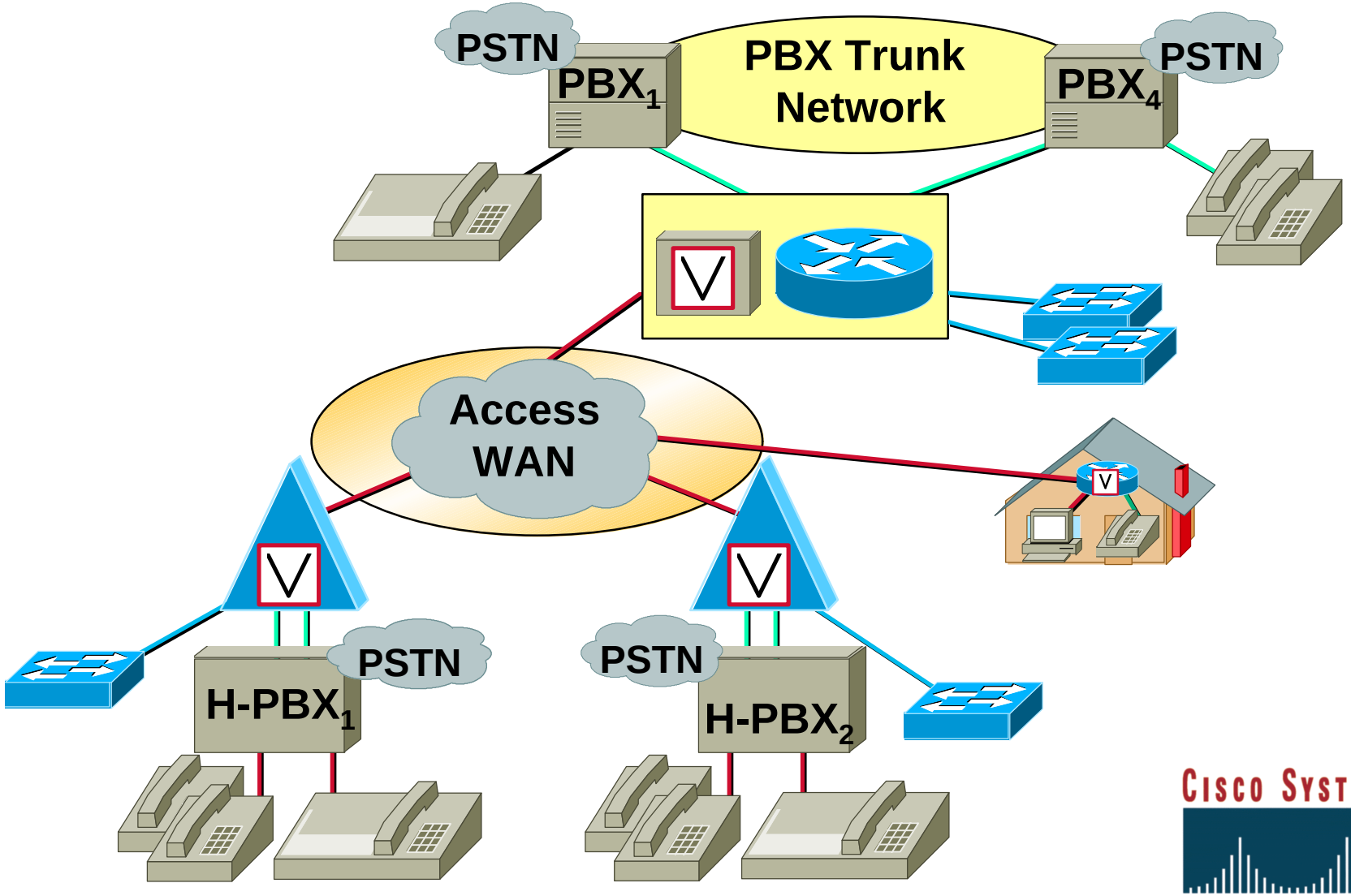
Satellite Access—Consolidated Transport



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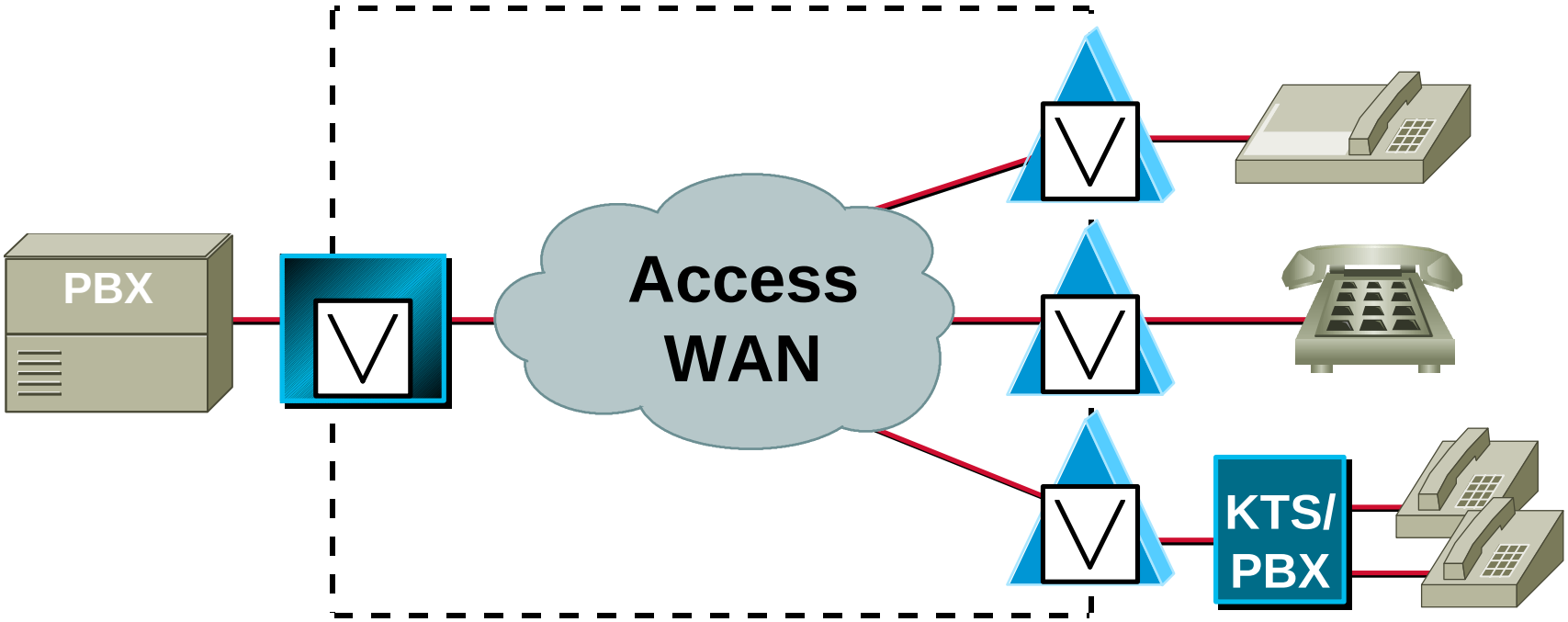
Branch/Remote Office Virtual Switch Access



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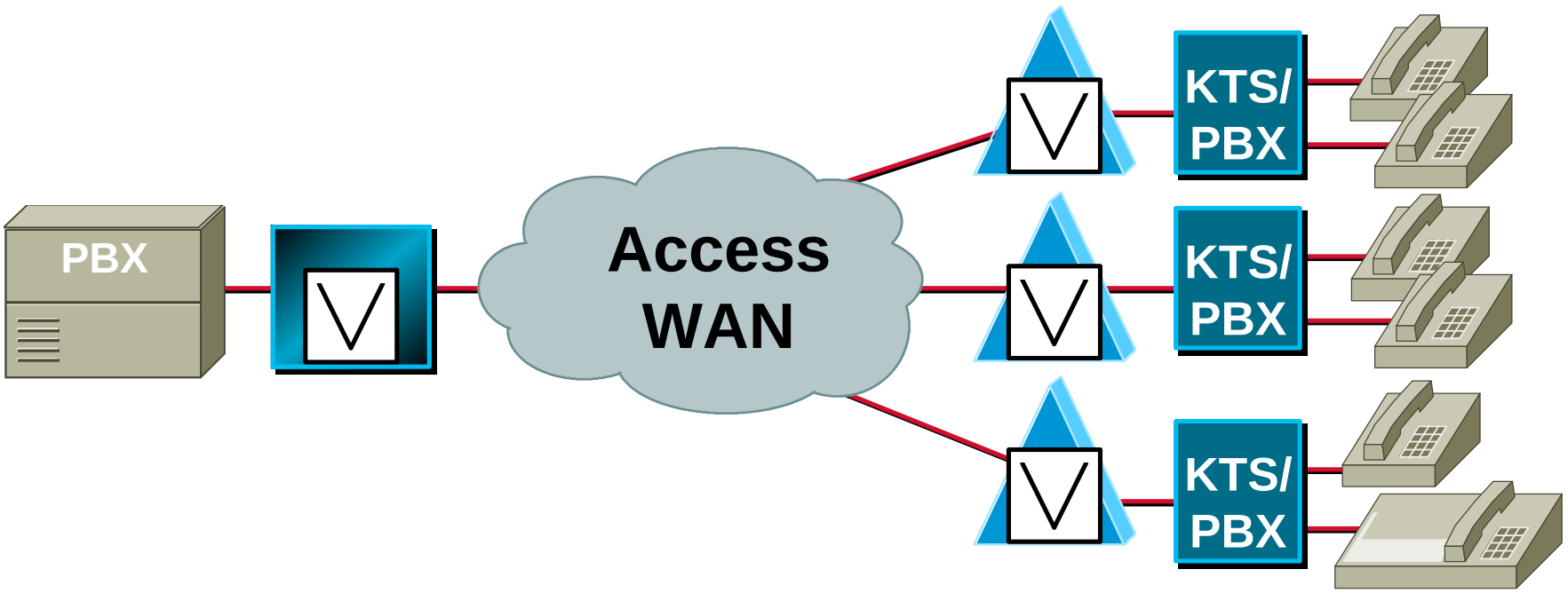
Branch/Remote Office Access Tie Line and OPX Transport



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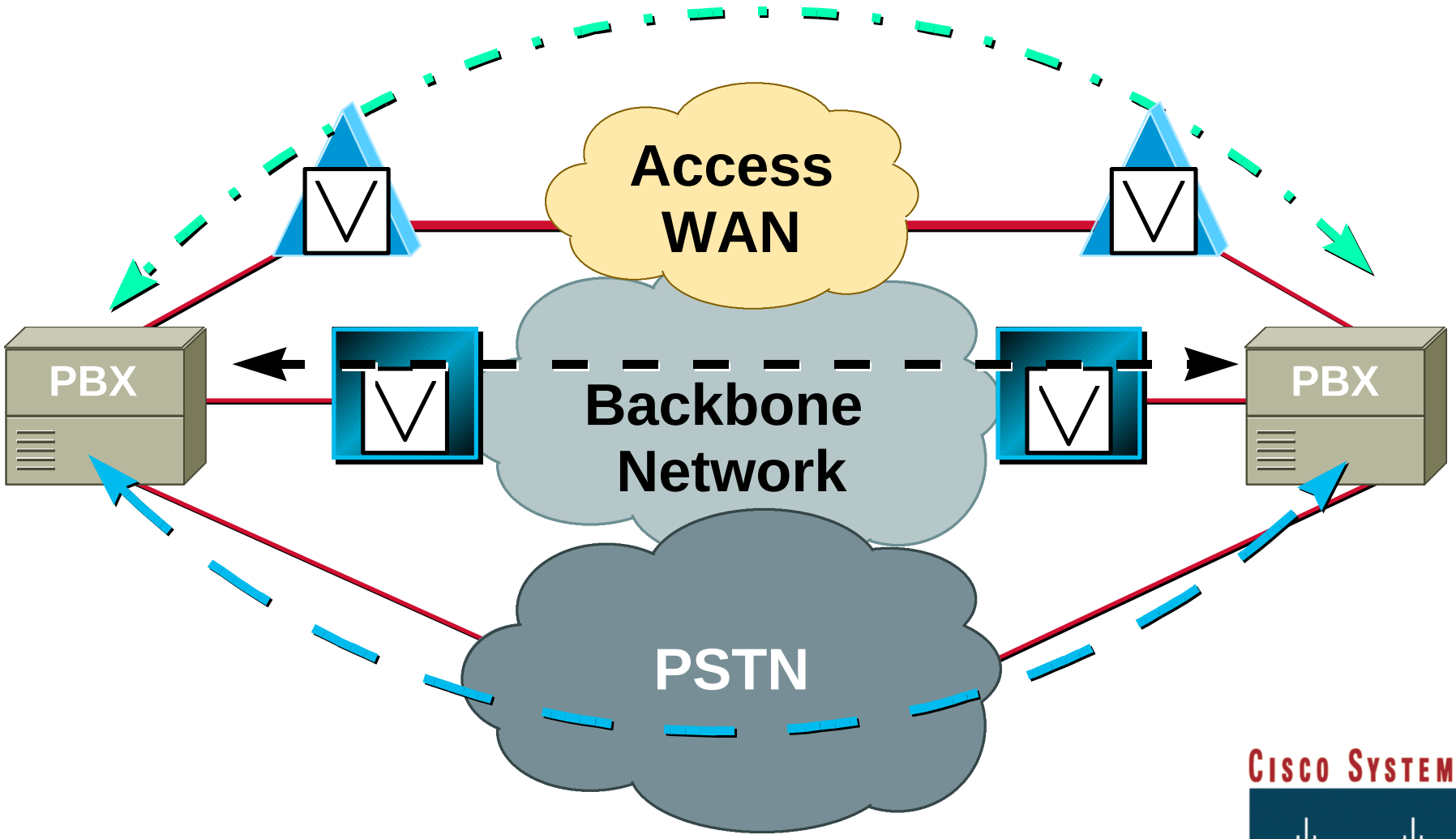
Consolidated Transport—Alternate Routes



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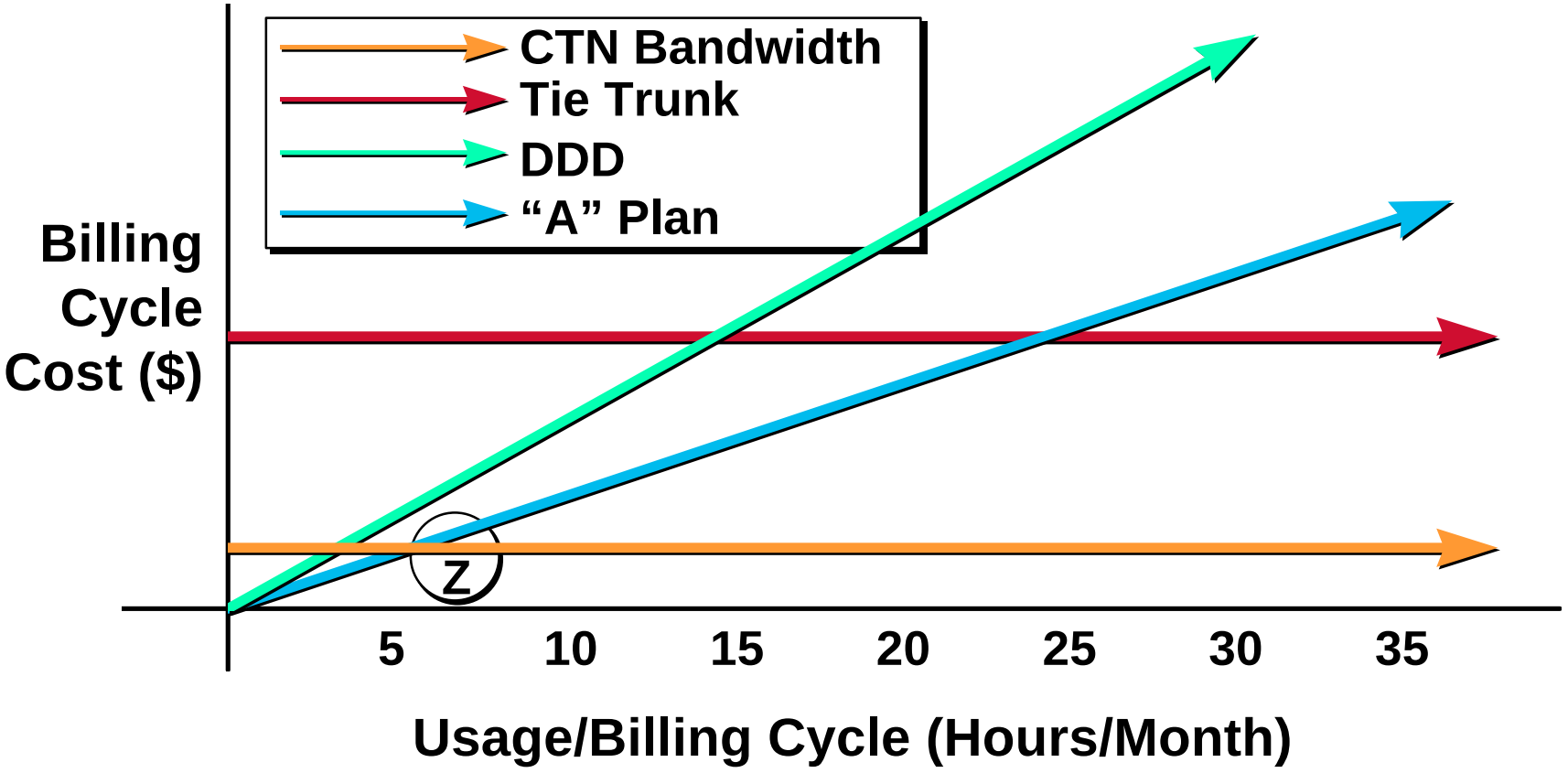
Fixed vs. Usage Billed Service



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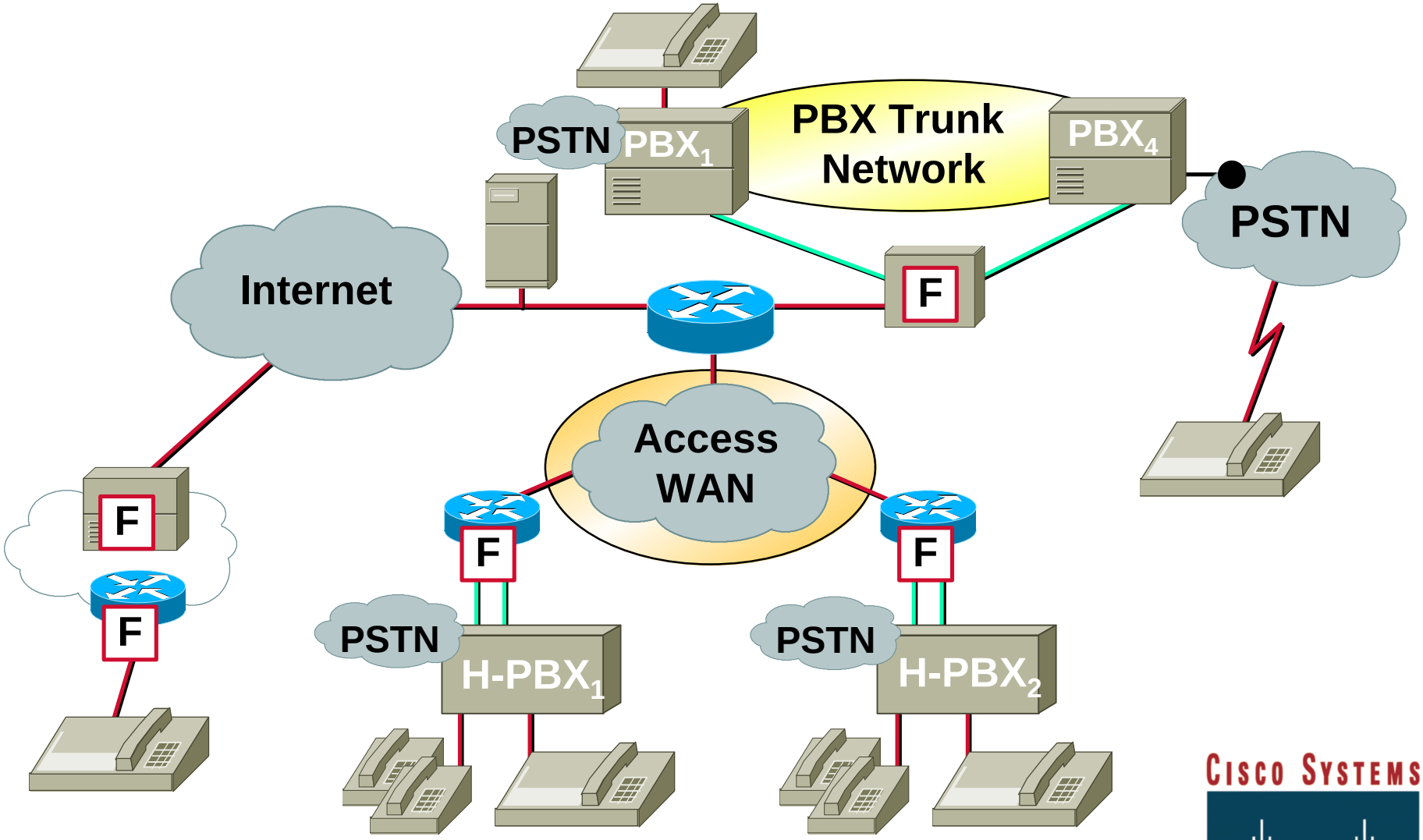
Consolidated Transport—FAX Services



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Agenda

- Basic Analog Telephony
- Basic Digital Telephony
- Consolidated Transport Networking

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Thank You!

Q&A


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