



# Signaling System

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## Reference (1/2)

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- [1] Wireless and Mobile Network Architectures , Y-Bing Lin and Imrich Chlamtac , Wiley Computer Publishing 。
  - Chapters 2 and 5.
- [2] 第七號共通信號系統概論 ， 湯鴻沼 ， 全華科技圖書股份有限公司 。
- [3] Telephone Network and PBX Software ， Yi-Bing Lin ， 維科出版社 。
- [4] Mobile and Wireless Networks ， Uyles Black ， Prentice Hall 。 Appendix A.



## Reference (2/2)

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- [5] SS7信號系統，林添財，中華電信訓練所教材。
- [6] Carrier Grade Voice over IP，2nd，Daniel Collins，Mc Graw-Hill Companies Inc.。
- [7] Signaling System #7, 2nd, Travis Russell, McGraw-Hill.



# Outlines

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- Introduction
- Signaling System Number 7
- Components and Links of SS7
- SS7 Protocol Stack
- SS7 Messages
- PCS/PSTN Call Control Using ISUP
- Summary



# Introduction

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- PSTN
- SS7 Network Architecture
- SS7 Components





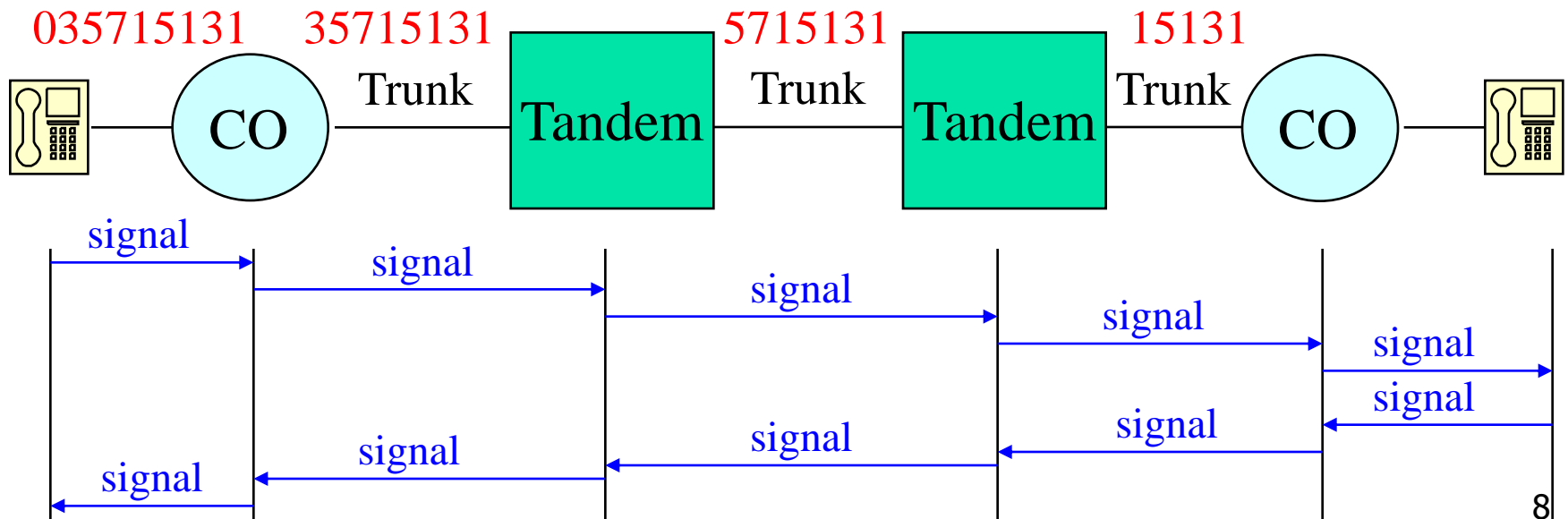
# Components in PSTN

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- Customer premises equipment (CPE)
  - Telephone set, PBX (Private Branch Exchanges), ISDN (Integrated Services Digital Network) PBX, ISDN Adaptor
- Transmission facilities
  - Trunks and subscriber lines
- Switching system
  - Central offices (CO) or exchange, tandems, ISDN CO

# Call Setup and Release

- A call requires a communications circuit between two subscribers.
- The setup and release of connection is triggered by signals.







# Signaling Systems (1/2)

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- Besides delivering subscriber voice and data information, telecommunication network requires a signaling system.
- Signaling is the communication of control information between the signaling elements via some prescribed protocol.
  - For call setup control, administration, disconnect of the circuit



# Signaling Systems (2/2)

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- Two types of signaling functions:
  - Supervisory signals – initiate a call request, to hold or release an established connection
    - Supervising signals: recognize if subscriber lines/interoffice trunks are busy or idle
    - Call progress signals: provide call status information
    - Alerting signals: provide warning to a subscriber
  - Address signals

# Customer-Line Signaling

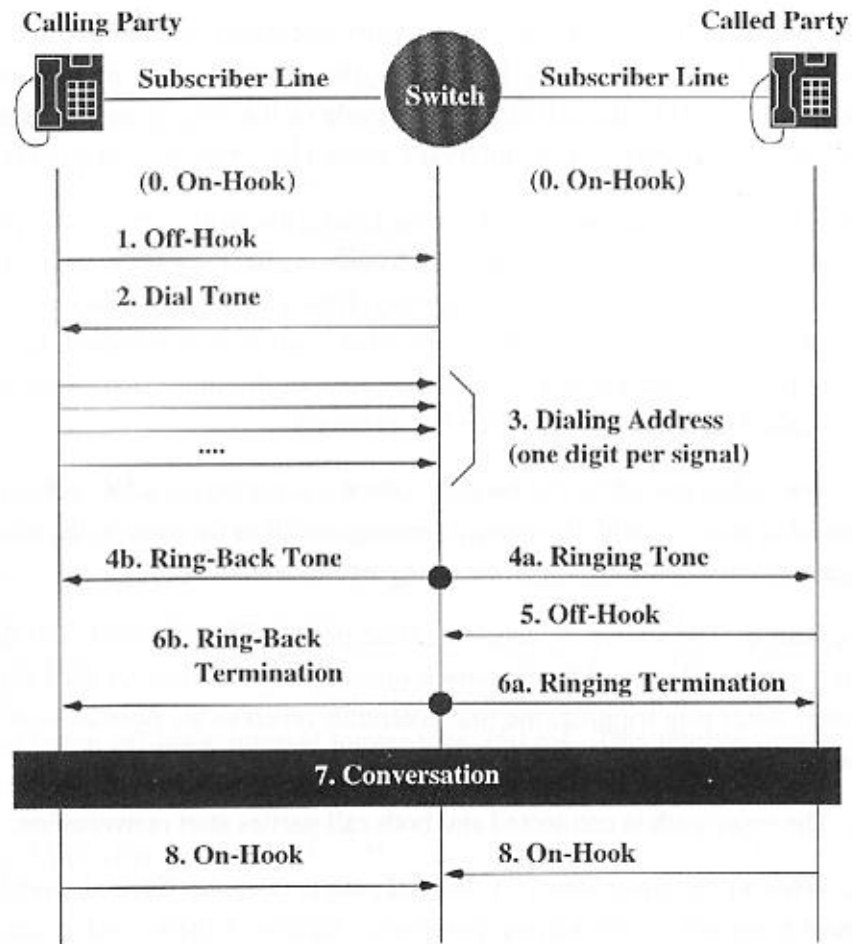


Figure 3.1: Customer-Line Signaling for Call Control

# Dial Pulse vs. Dual Tone Multi-Frequency

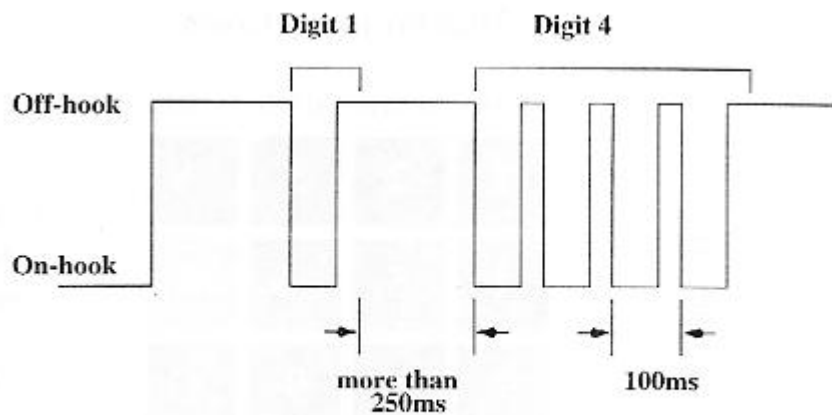


Figure 3.2: Dial Pulse Sequence for the Digits "14"

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



# Interoffice Trunk Signaling

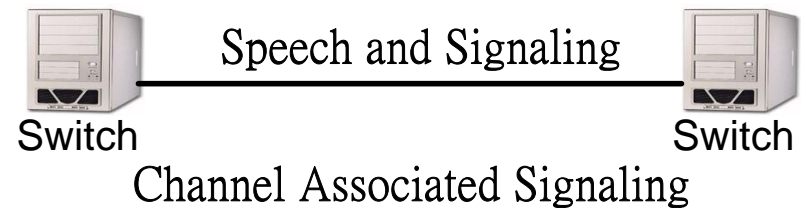
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- Control information exchange among the switches is achieved by interoffice trunk signaling.
- Two approaches:
- Channel associated signaling (CAS)
  - Signaling and voice share the same *inband* channel.
- Common channel signaling (CCS)
  - A separate *out-of-band* signaling network to carry signaling message.

# CAS v.s. CCS

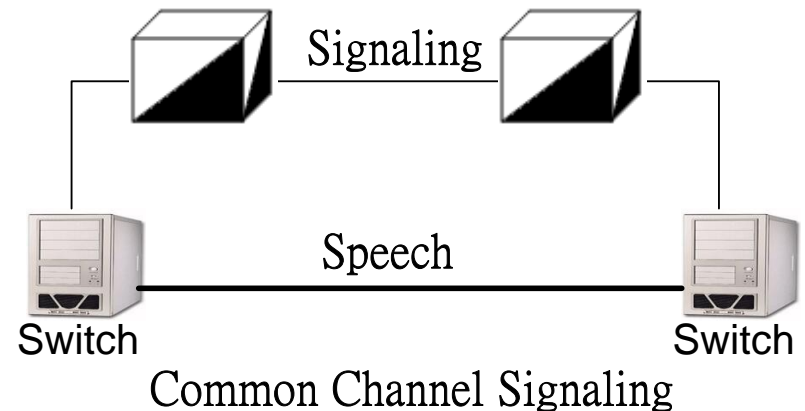
## ■ Channel Associated Signaling

- Signaling and voice share the same channel



## ■ Common Channel Signaling

- Separation of signaling and call paths
- Signaling System 7 (SS7)





# The Advantages of CCS

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- Signaling packets can be efficiently delivered using signaling links, which reduces the call setup time.
- Since the ineffective call attempts are released by the signaling links, better utilization of voice trunks can be expected.
- Signaling can be performed during conversation.



# Signaling System No. 7 (1/2)

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- The first CCS system is **signaling system number 6** developed in the 1970s.
- The modern CCS system is **SS7**.
- SS7 is the foundation for Intelligent Network (IN) services.
- SS7 is a dedicated data communication network and similar to the packet network.
  - **SS7 follows OSI 7 layer architecture.**
  - **Message-based signaling protocol**





# Signaling System No. 7 (2/2)

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- To enable **a wide range of services** to be provided to the end-user
- Caller ID, toll-free calling, call screening, number portability, etc.
- Signaling between a **PCS** network and the **PSTN** are typically achieved by the SS7 network.

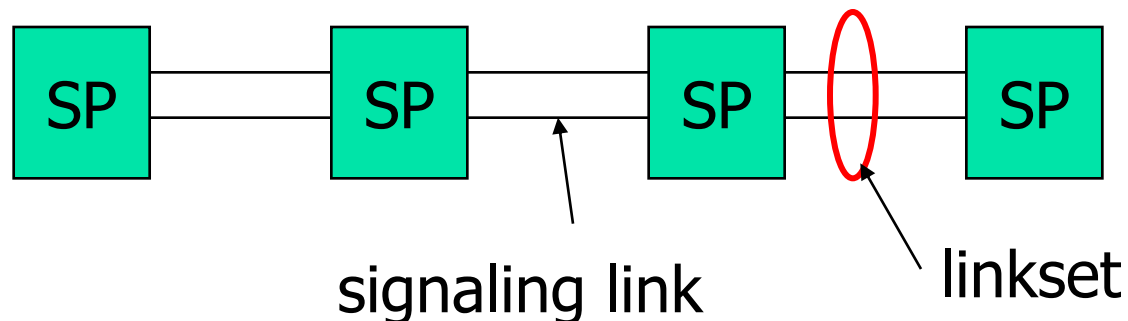


# Components and Links of SS7

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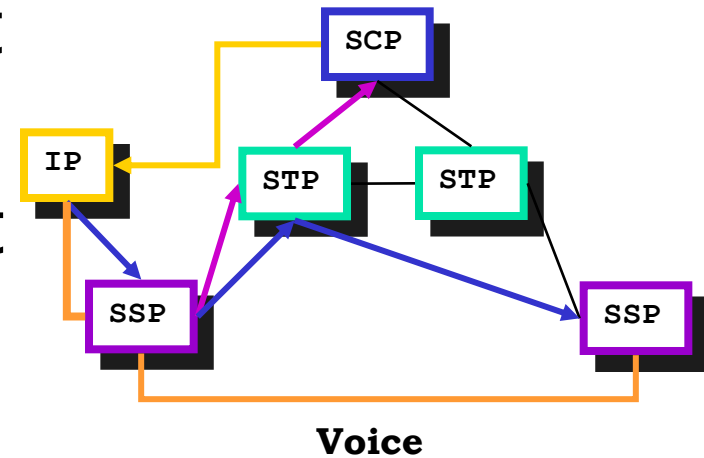
# Signaling Point (SP)

- Each node in an SS7 network is an **signal point (SP)**.
- The signaling address of the SP is known as a signaling **point code**.
- Linkset
  - Group of **signaling links** directly connecting two adjacent SPs
  - For capability and security reasons



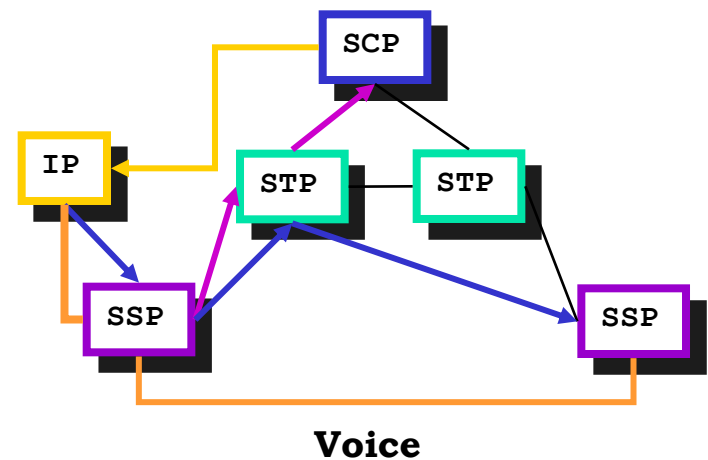
# Basic Components

- SSP/Service Switching Point
  - **switching**, service invocation
- STP/Signal Transfer Point
  - signal **routing**
- SCP/Service Control Point
  - service logic **execution**
- IP/Intelligent Peripheral
  - **resources** such as customized voice announcement, voice recognition, DTMF digit collection



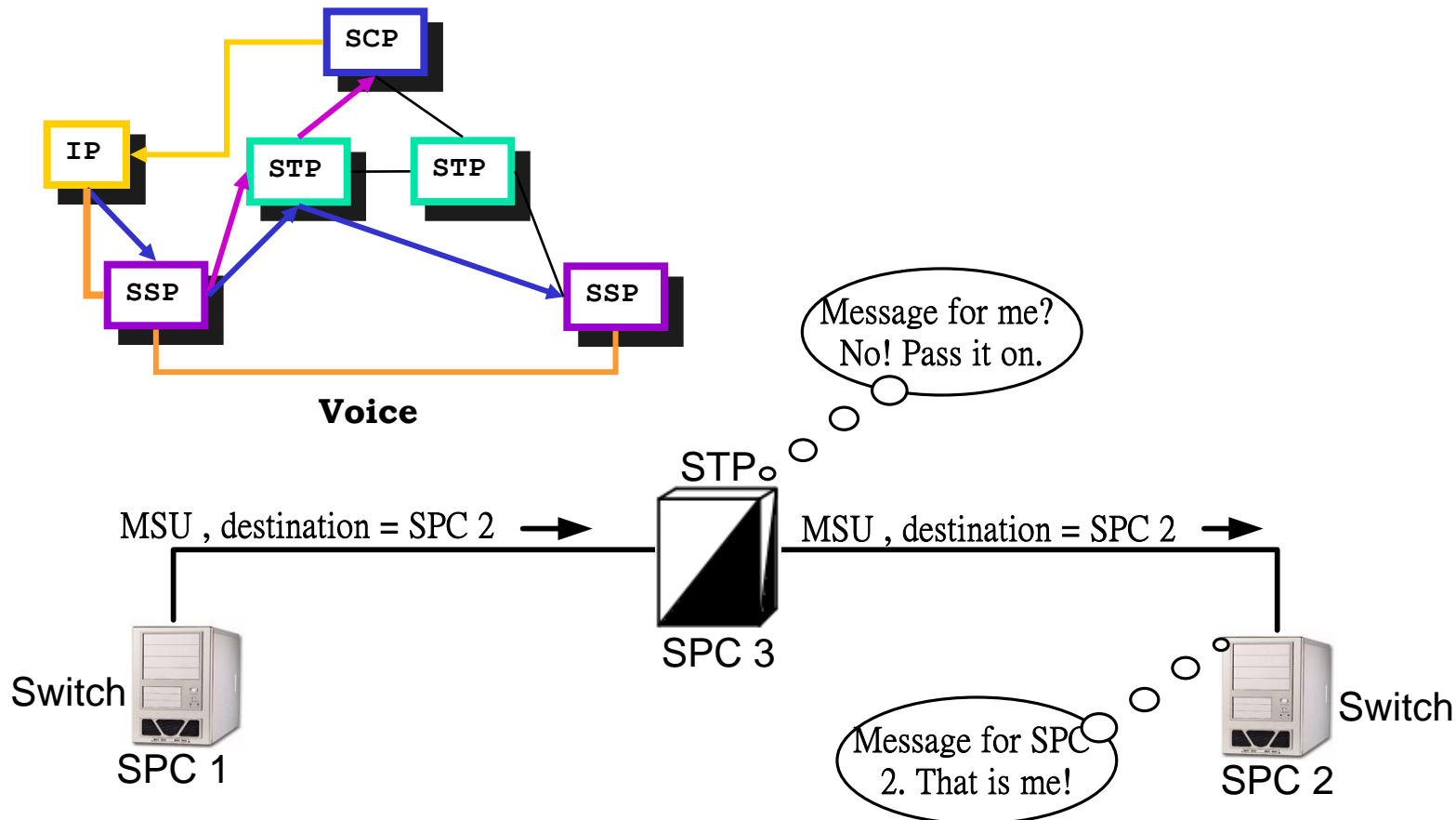
# Service Switching Point (SSP)

- Trunks connects SSPs to carry user data/voice information.
- Signaling links connect SCPs to STPs, and STPs to SSPs.



# Signal Transfer Point (STP)

- To transfer messages from one SPC to another





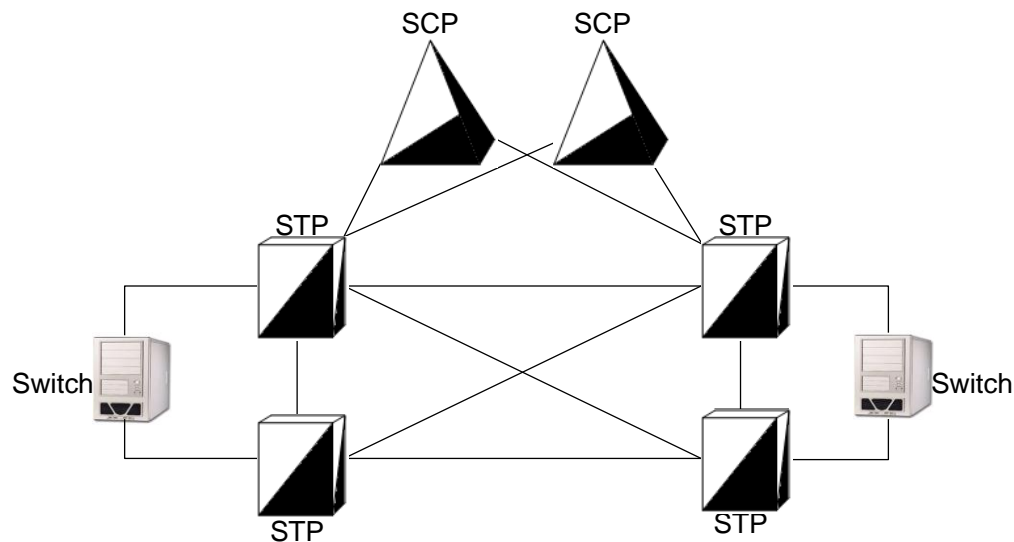
# Service Control Point (SCP)

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- A network entity that contains additional logic and that can be used to offer advanced services
- The switch sends a message to the SCP asking for instructions.
  - The SCP, based upon data and service logic that is available, will tell the switch which actions need to be taken.
- An good example – toll-free 080 number

# Typical SS7 Network Arrangement

- A typical SS7 network arrangement.
- Two switches do not communicate **signaling** to each other via direct paths.
- The quad arrangement ensures great robustness.



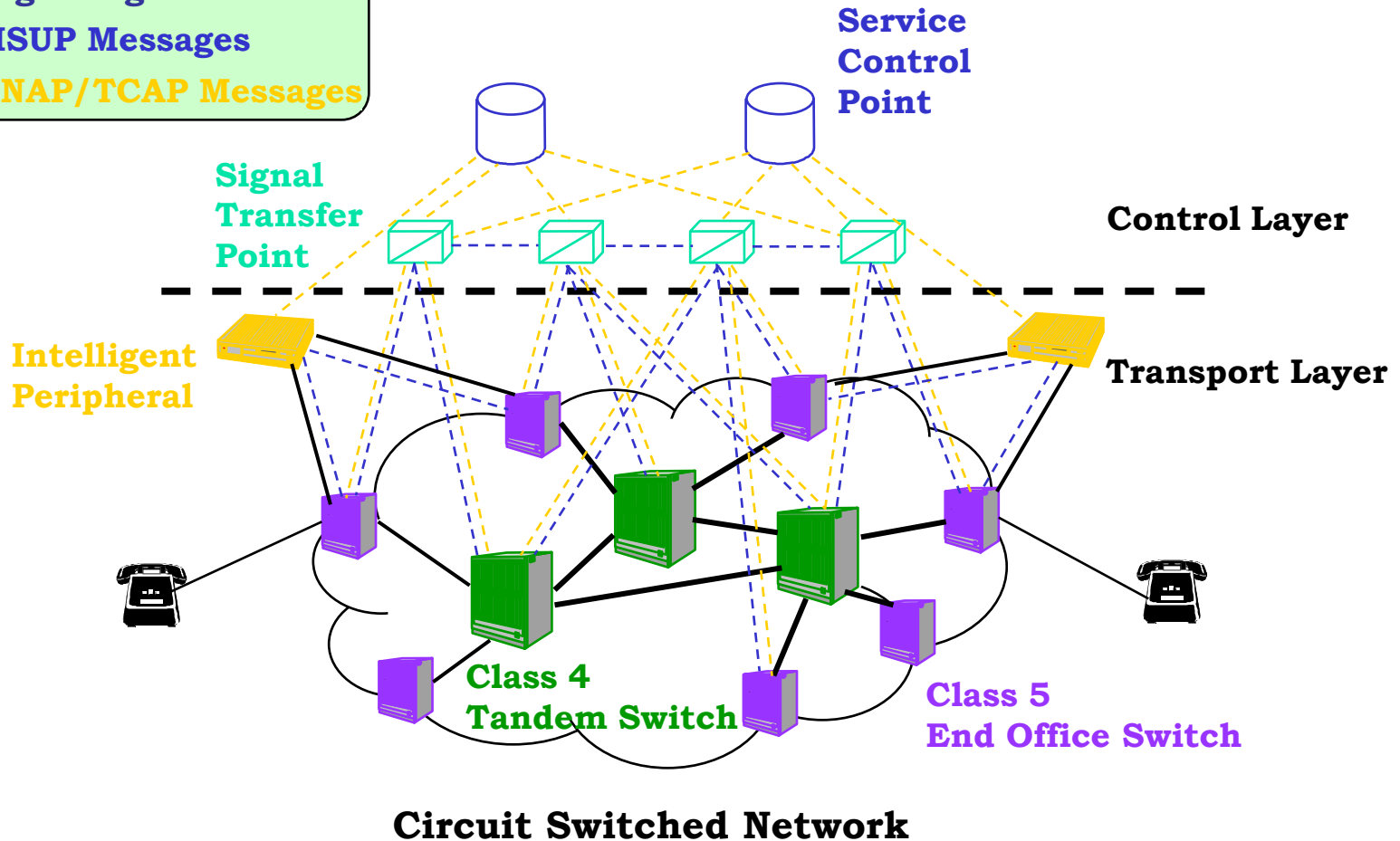


# The Telephone Network

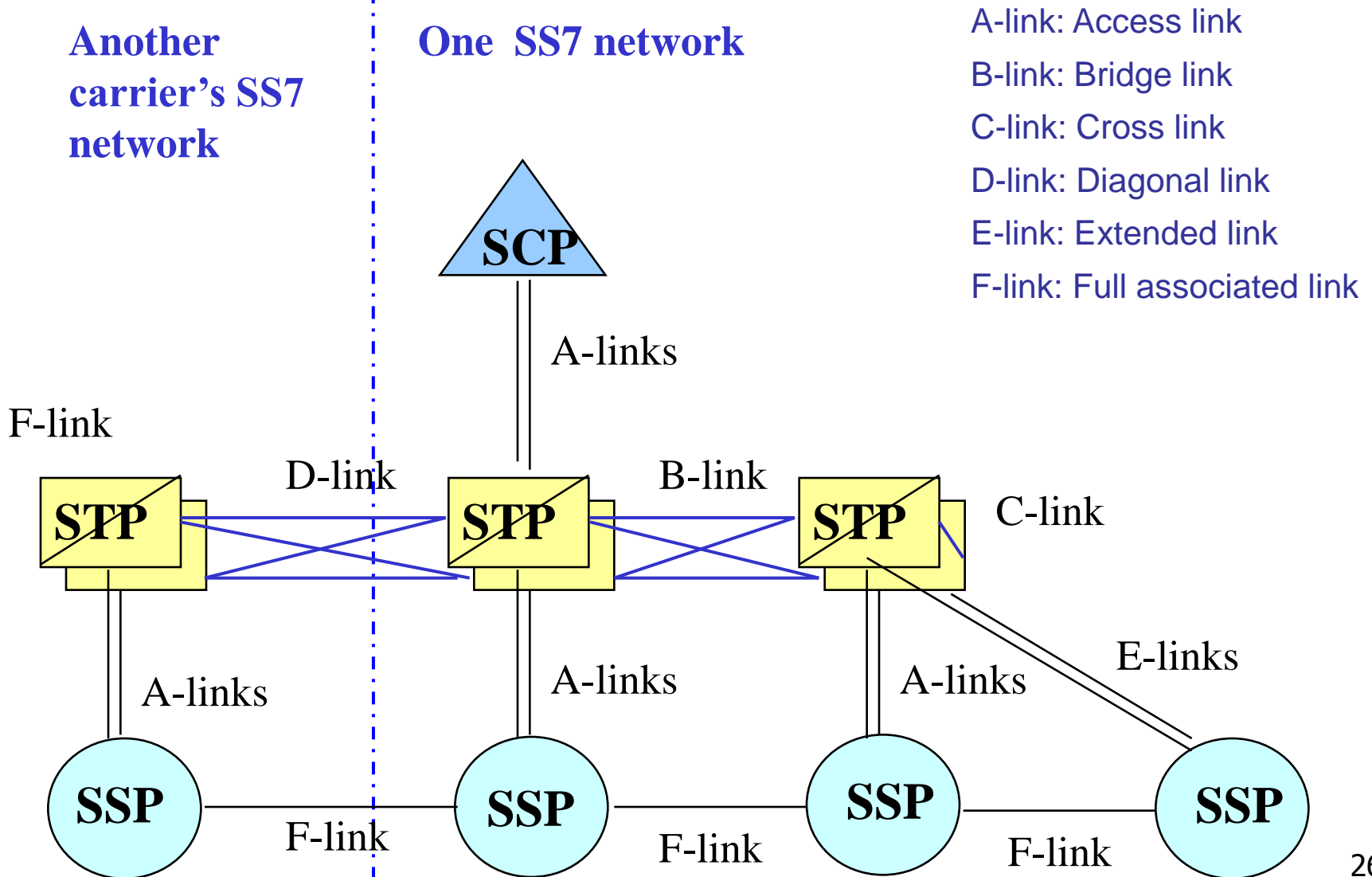
## SS7 Signaling

----- ISUP Messages

----- INAP/TCAP Messages



# Types of Signaling Links in SS7

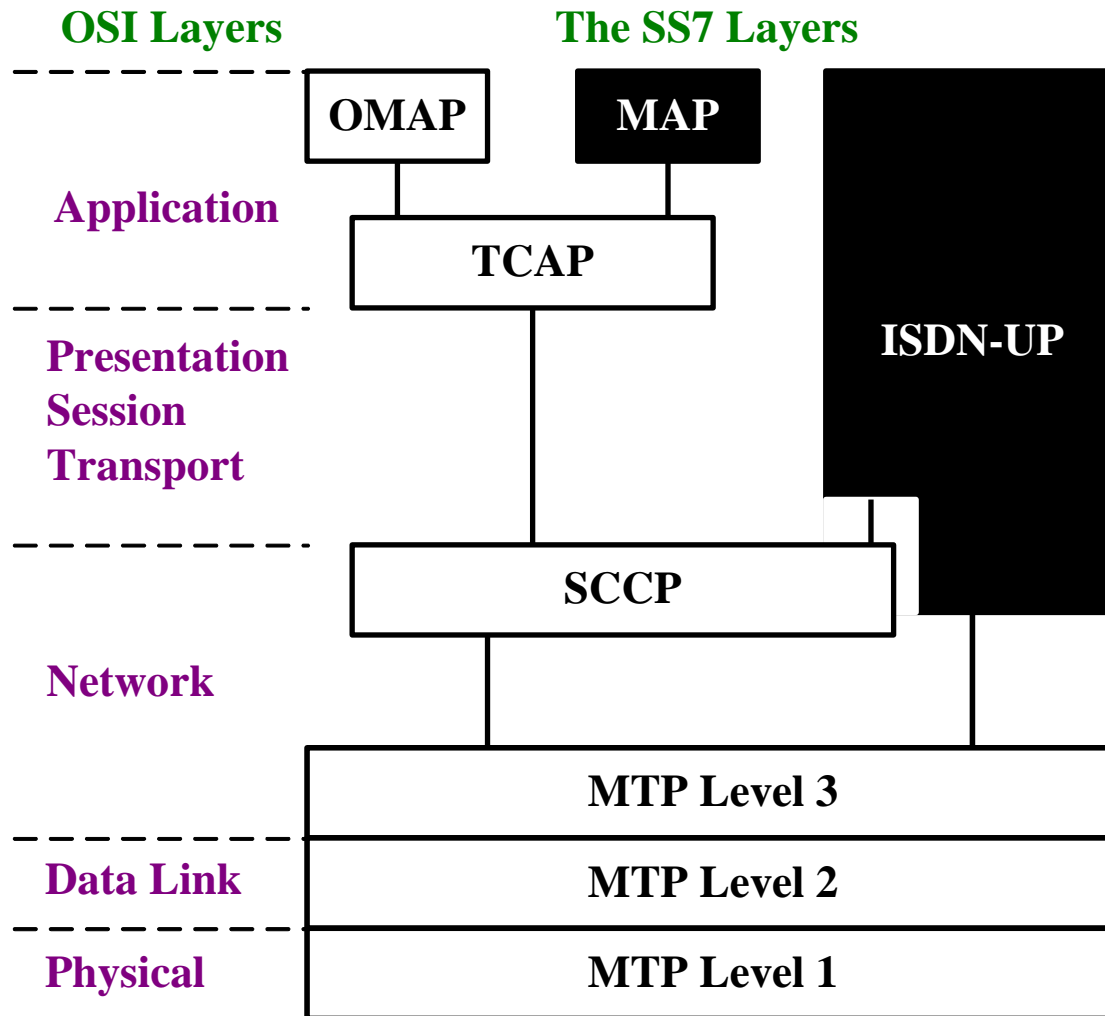




# SS7 Protocol Stack

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# The SS7 Signaling Protocol



# Message Transfer Part (1/2)

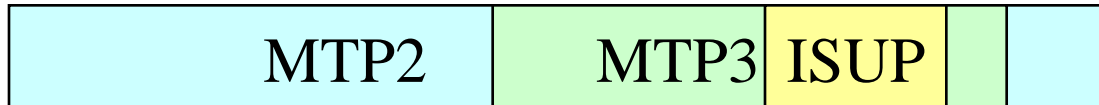
- MTP Level 1

- Defines the physical, electrical and functional characteristics of the signaling.

- 100111010110000011100111001.....

- MTP Level 2

- Dealing with the transfer of messages on a given link from one node to another
- Provides reliable transfer of signaling messages between two directly connected signaling points
- Error detection and correction, flow control, signal unit delimitation, etc.





# Message Transfer Part (2/2)

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- MTP Level 3
  - Provides the functions and procedures related to message routing and network management.
- Signaling message handling
  - Providing message routing between signaling points in the SS7 network
- Signaling network management
  - Rerouting traffic to other SS7 signaling links in the case of link failure, congestion or node failure
  - Load-sharing



# ISUP

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- ISDN User Part
- Used as the protocol for setting up and tearing down phone calls between switches
- Initial Address Message (**IAM**)
  - To initiate a call between two switches
- Answer Message (**ANM**)
  - To indicate that a call has been accepted by the called party
- Release Message (**REL**)
  - To initiate call disconnection



# SCCP

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- Signaling Connection Control Part
- Used as the transport layer for TCAP-based services
- Both connection-oriented and connectionless
  - Mostly connectionless signaling
- Global title translation (GTT) capabilities
  - The destination signaling point and subsystem number is determined from the *global title*



- TCAP (Transaction Capabilities Applications Part)
- Supporting the exchange of **non-circuit related information** between signaling points
- Queries and responses sent between SSPs and SCPs are carried in TCAP messages
- Freephone (800/888), calling card, wireless roaming



# MAP and OMAP

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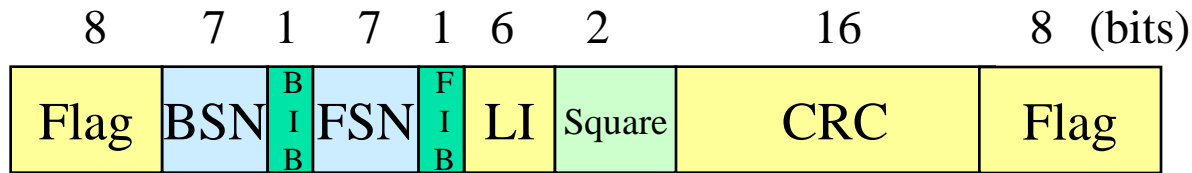
- Operations, Maintenance, and Administration Part (OMAP)
- Mobile Application Part (MAP)
  - Application of TCAP
  - IS-41 & GSM MAP are implemented in MAP layer.



# SS7 Messages

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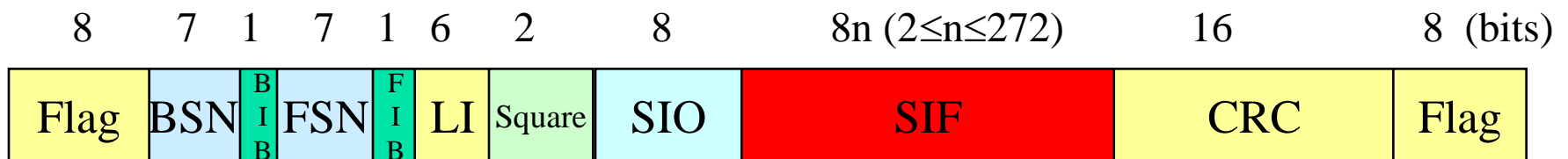
# MTP2 Messages



First bit transmitted                    (a) Fill-in Signal Unit (FISU)

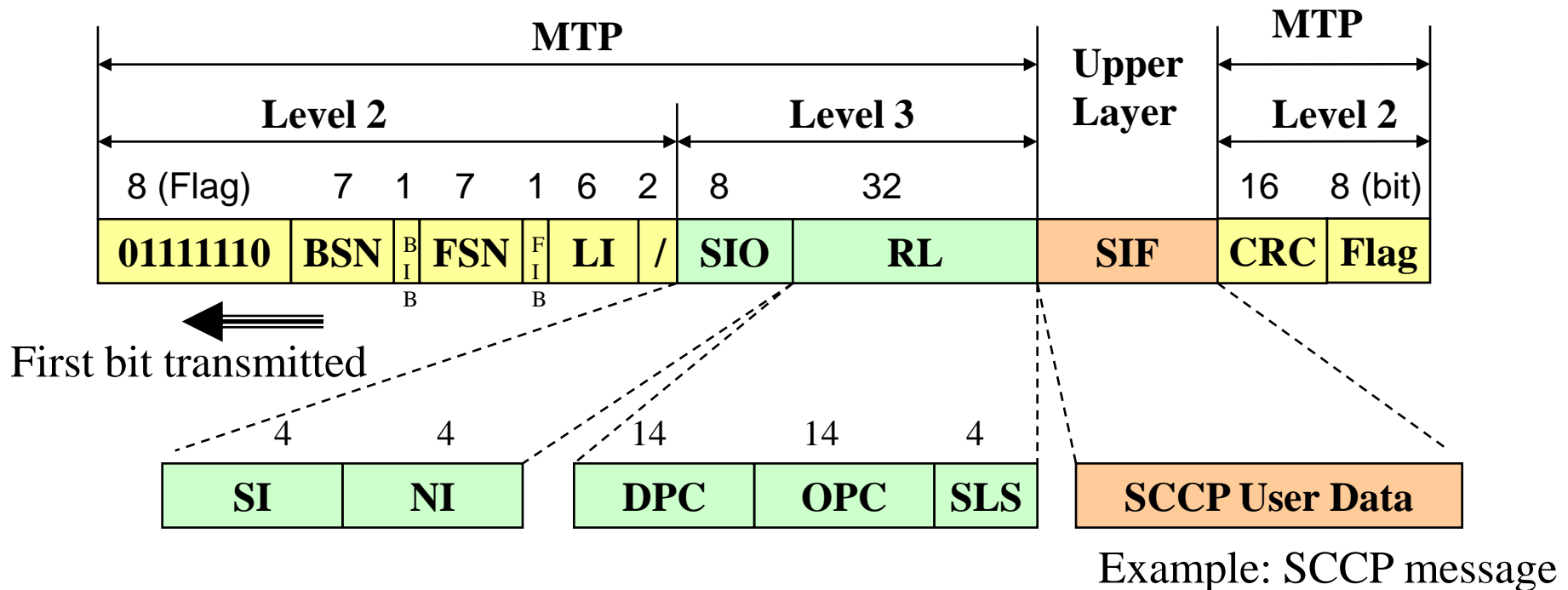


First bit transmitted                    (b) Link Status Signal Unit (LSSI)



First bit transmitted                    (c) Message Signal Unit (MSU)

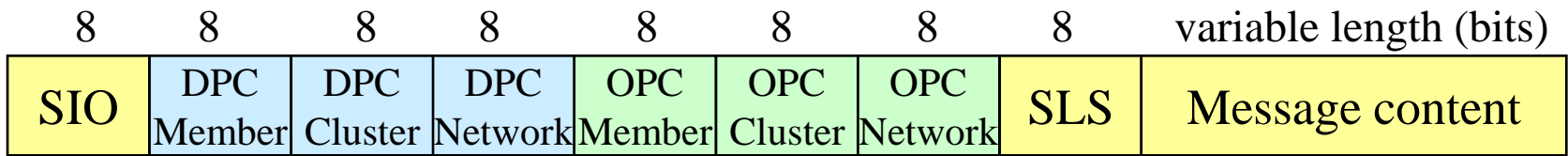
# ITU-T Message Signal Unit



BSN: Backward Sequence Number  
 BIB: Backward Indicator Bit  
 FSN: Forward Sequence Number  
 FIB: Forward Indicator Bit  
 LI: Length Indicator  
 SIO: Service Indicator Octet

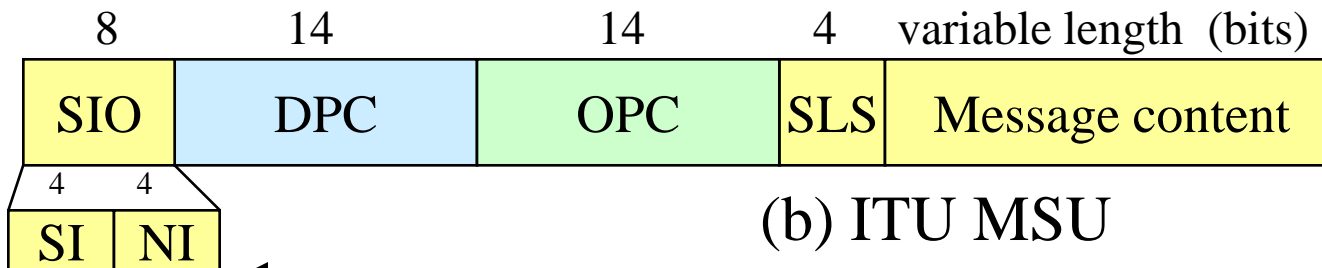
SI: Service Indicator  
 NI: Network Indicator  
 RL: Routing Label  
 DPC: Destination Point Code  
 OPC: Originating Point Code  
 SLS: Signaling Link Selection  
 SIF: Signaling Information Field

# Message Signal Unit (MSU)



(a) ANSI MSU

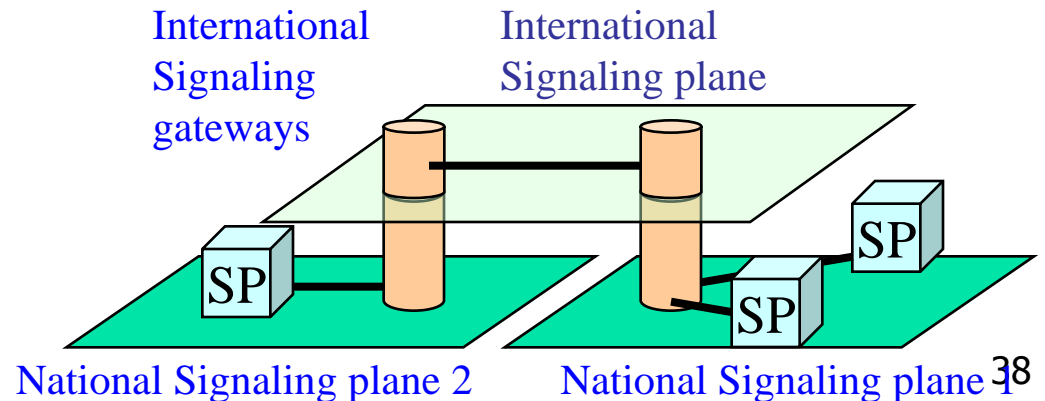
First bit transmitted ←



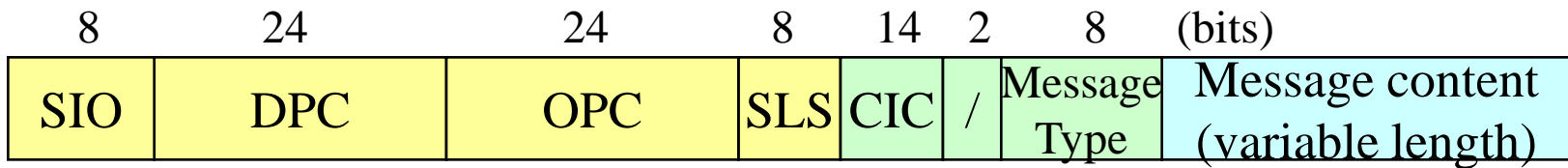
(b) ITU MSU

First bit transmitted ←

- DPC = Destination Point Code
- OPC = Origination Point Code
- SIO = Service Information Octet
- SI = Service Indicator
- NI = Network Indicator
- SLS = Signaling Link Selection

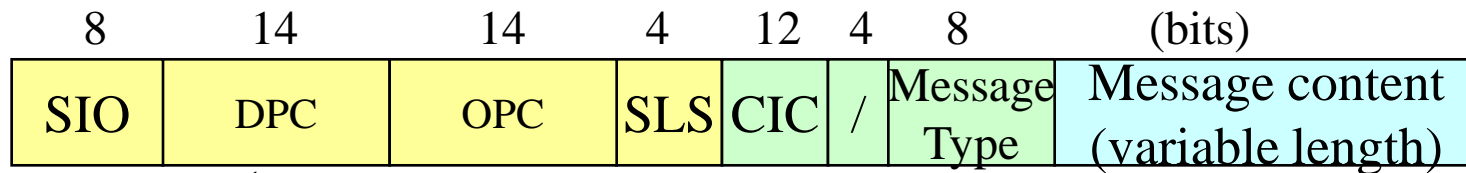


# ISUP Message Format



(a) ANSI MSU

←  
First bit transmitted



(a) ITU MSU

←  
First bit transmitted

DPC = Destination Point Code  
 OPC = Origination Point Code  
 SIO = Service Information Octet  
 SLS = Signaling Link Selection  
 CIC = Circuit ID Code



# ISUP Message

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- ISUP messages
  - Establishes *circuit-switched network* connections
  - Call setup/release between the PSTN and a PCN.
- ISUP messages that are delivered by MTP routing.





# ISUP Messages (1/2)

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- **IAM** (Initial Address Message)
  - called number, calling number, transmission requirement, type of caller, other information
- **ACM** (Address Complete Message)
  - One-way path from destination to calling switch
  - Note: Called switch generates the ring-back tone.
- **ANM** (Answer Message)

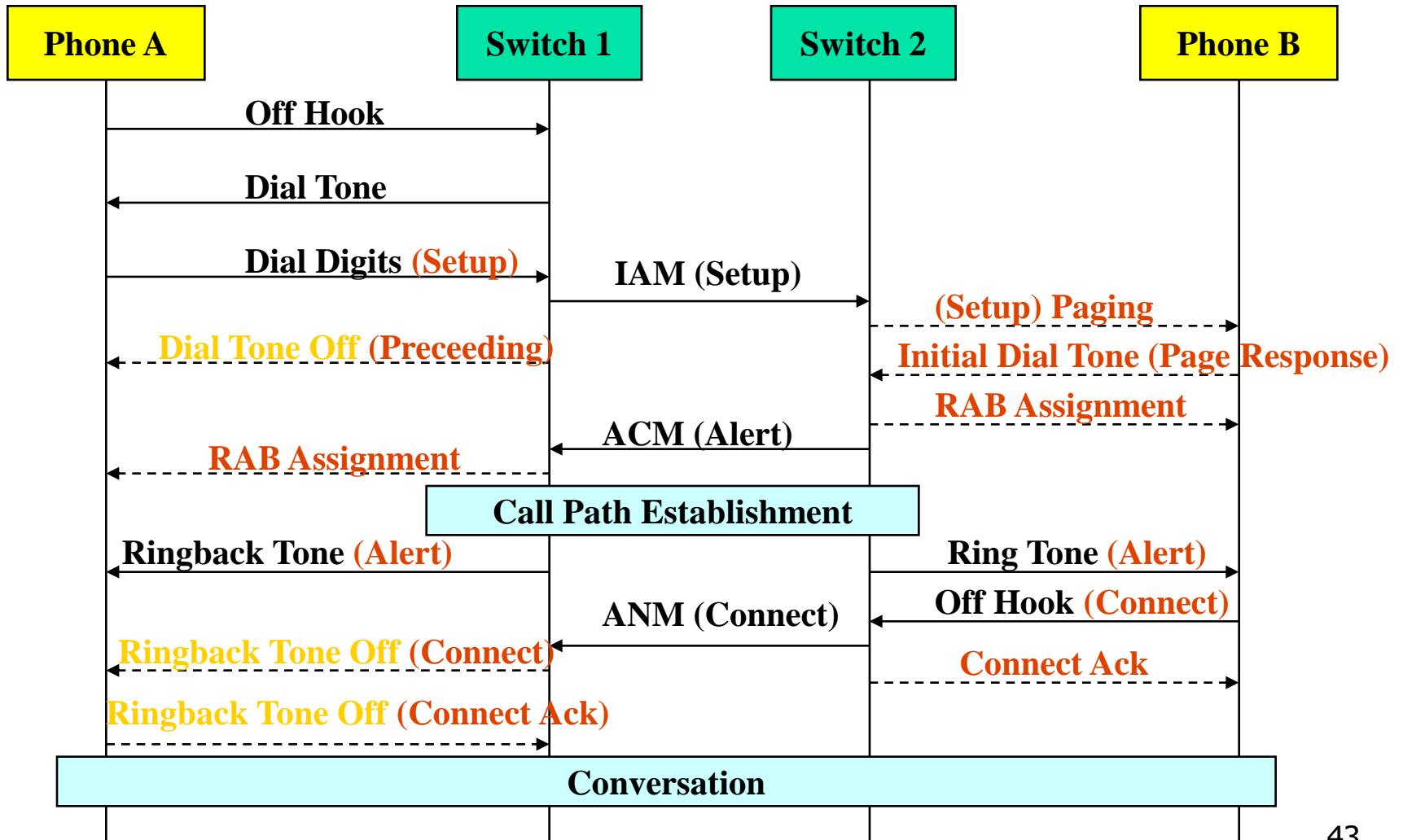


# ISUP Messages (2/2)

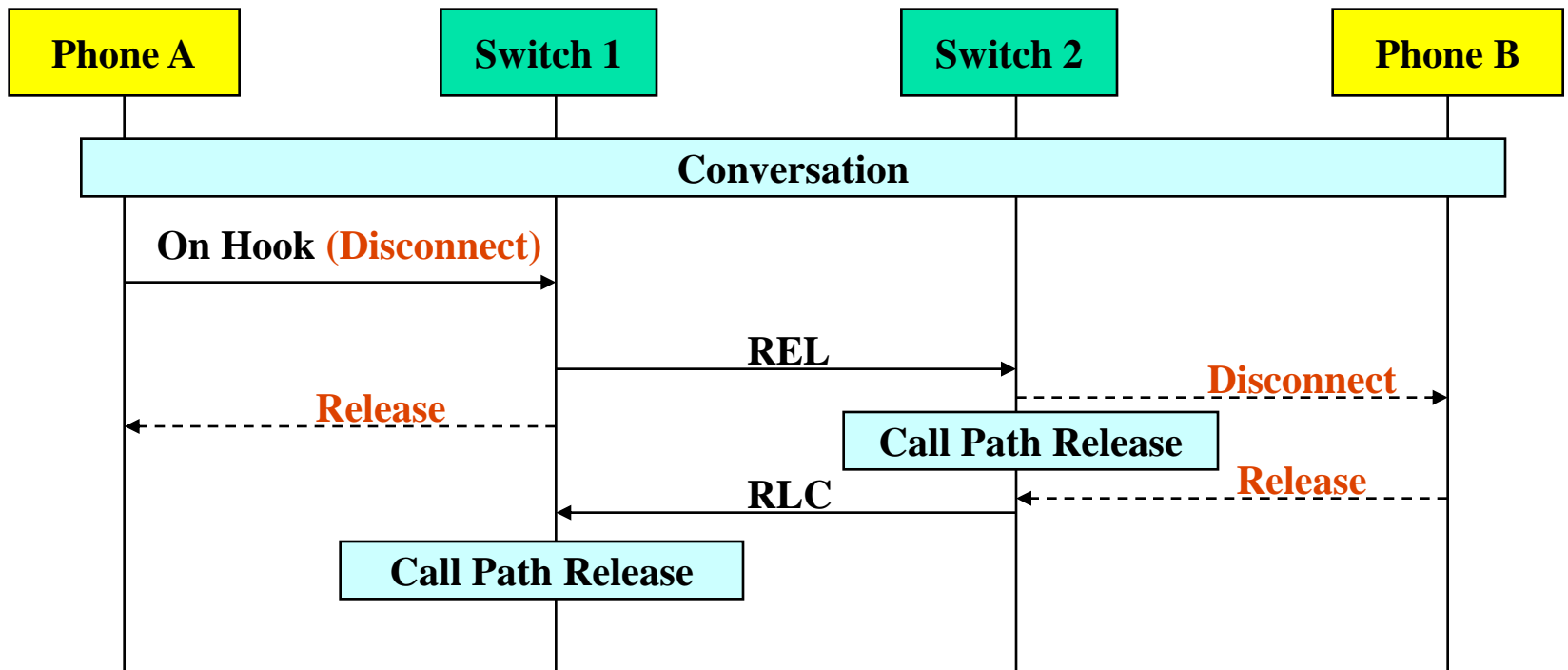
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- **REL** (Release) Message
  - To release the call
- **RLC** (Release Complete) Message
  - Complete the call

# Basic Call Setup

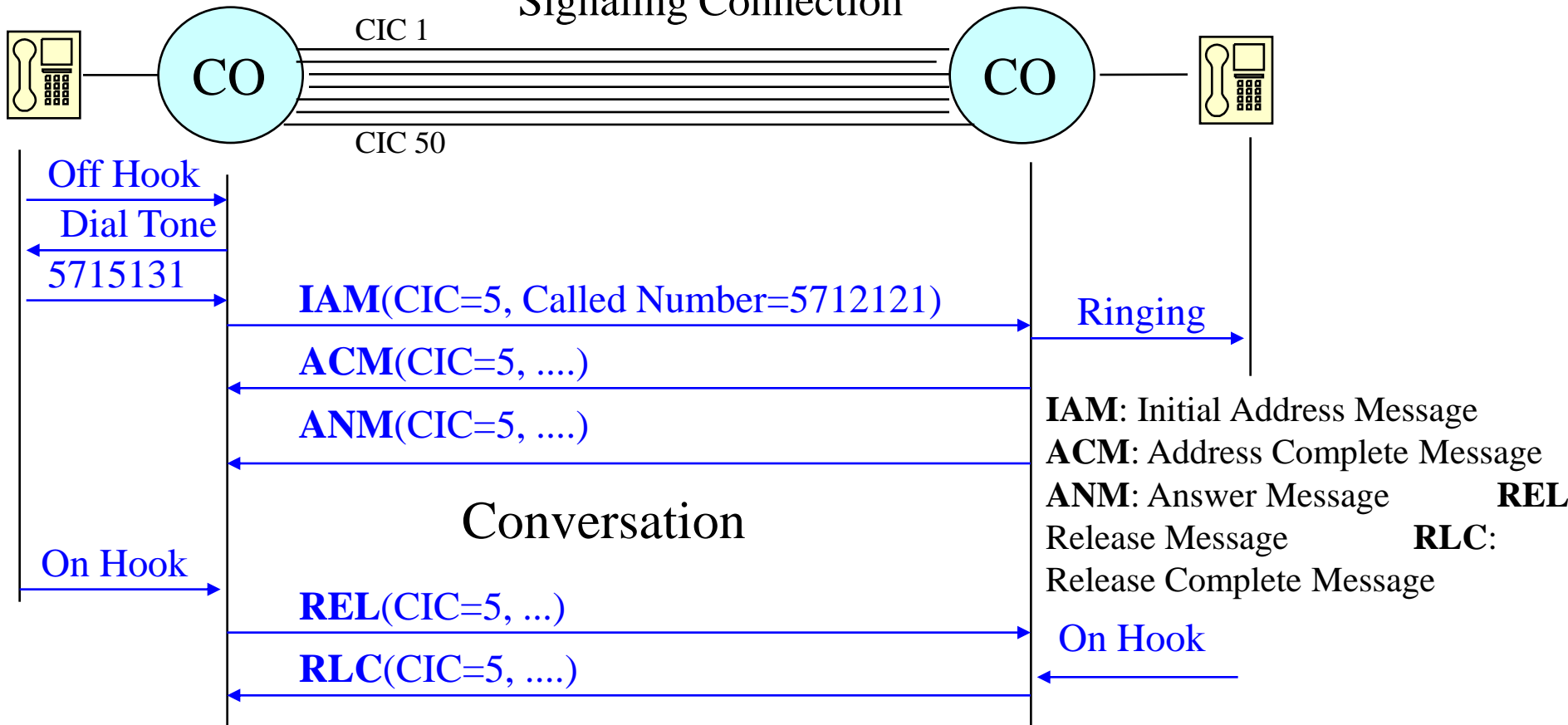


# Basic Call Release



# MTP Layer Routing (1/2)

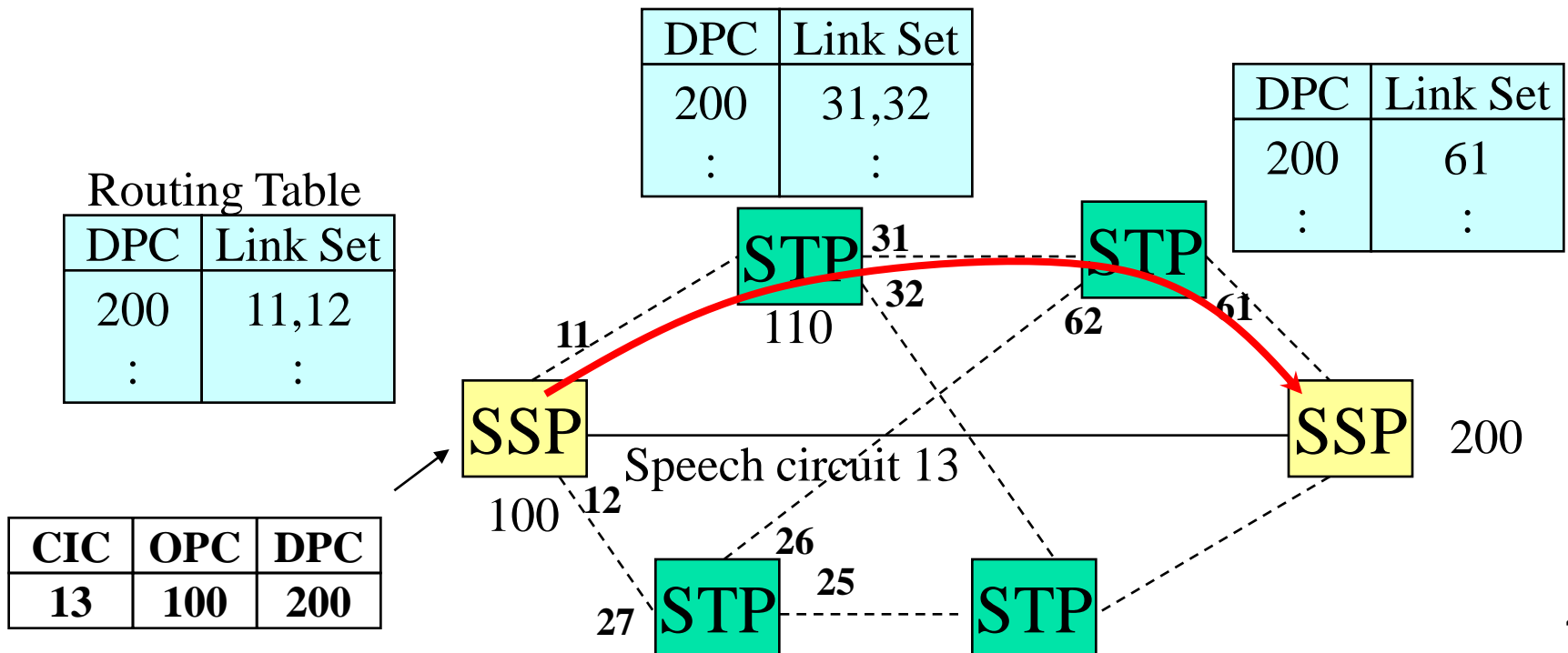
Subscriber Line



**IAM:** Initial Address Message  
**ACM:** Address Complete Message  
**ANM:** Answer Message  
**REL:** Release Message  
**RLC:** Release Complete Message

# MTP Layer Routing (2/2)

- **Destination Point Code (DPC)** = actual address of the destination node.
- Lookup tables is used in the MTP
- Routing based on DPC

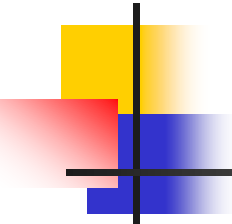


# SCCP Layer Routing

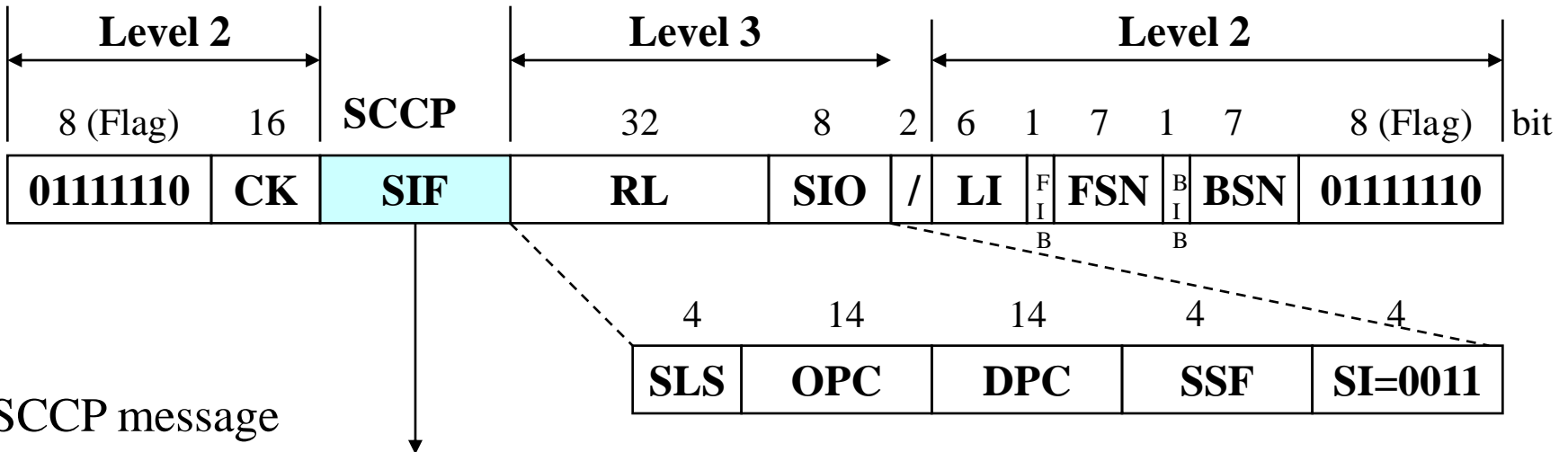
- **Global Title Translation (GTT)** is a function defined within SCCP.
  - Performed at a STP or MSC.
- GTT is **the process** of translating a network layer address, dialed digits, or a service subsystem number (SSN), to the **point code** of the destination SSP.
- Routing based on GT translations
  - Called Party Address (**PC+SSN+GT**)
  - Calling Party Address (**PC+SSN+GT**)

ASE	SSN
Reserved	000010
HLR	0000110
VLR	000011
MSC	000100
EIR	000100
AuC	000101

# SCCP Message Embedded TCAP Message



⇒ First bit transmitted



User Data	Calling Party Address	Called Party Address	Protocol Class	Message Type
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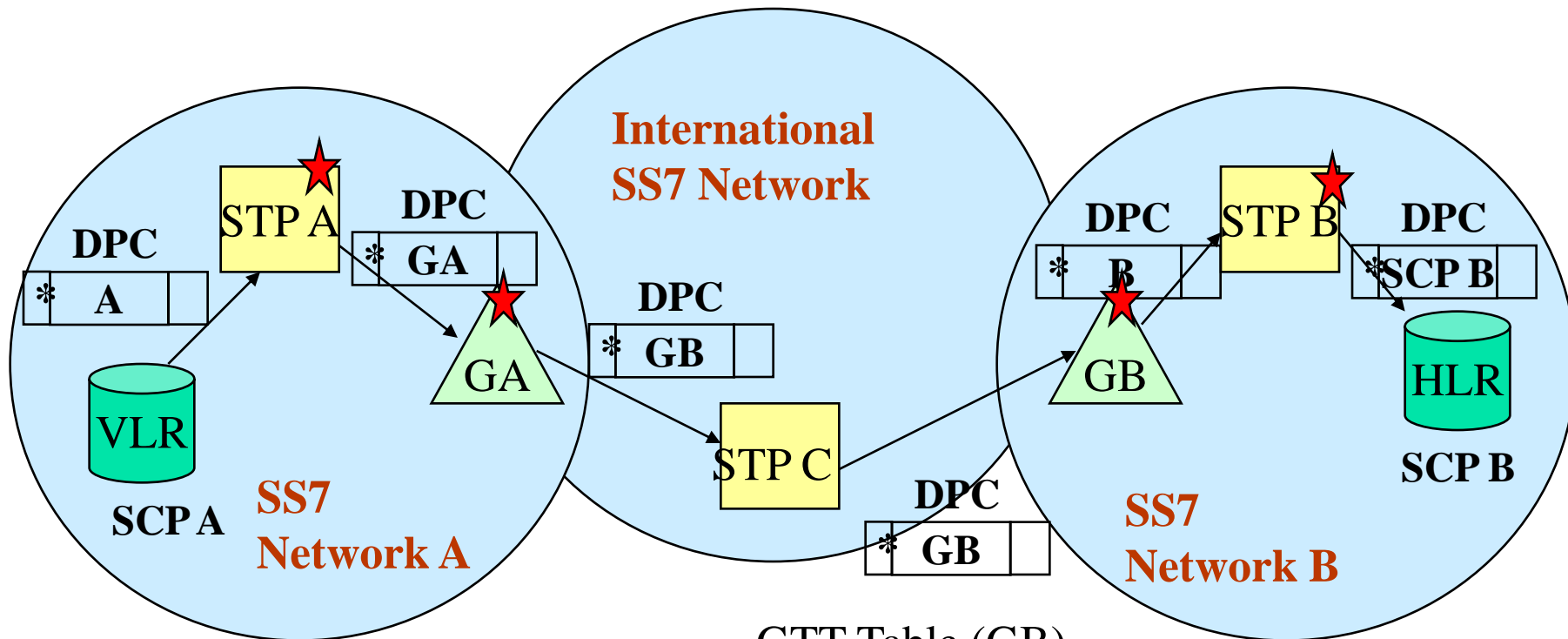
TCAP message

Message Type: Unitdata '00001001'  
 Protocol Class: Class 0 or Class 1

Component Portion	Transaction Portion
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# GTT Example



GTT Table (A)

GT	DPC
*	GA
:	:

GTT Table (GA)

GT	DPC
*	GB
:	:

GTT Table (GB)

GT	DPC
*	STP B
:	:

GTT Table (B)

GT	DPC
*	SCP B
:	:

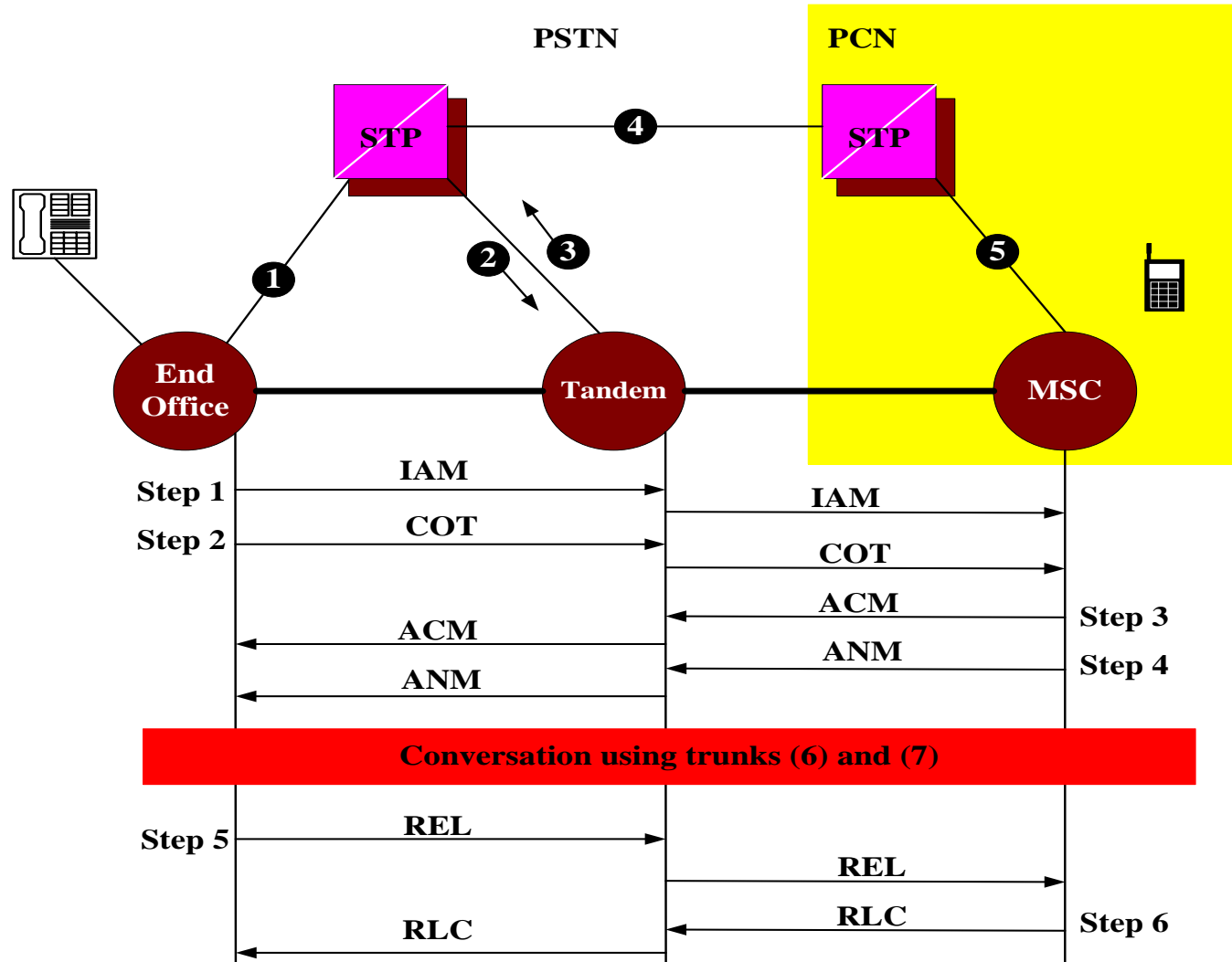
\*: Global Title of HLR ★: Perform GTT



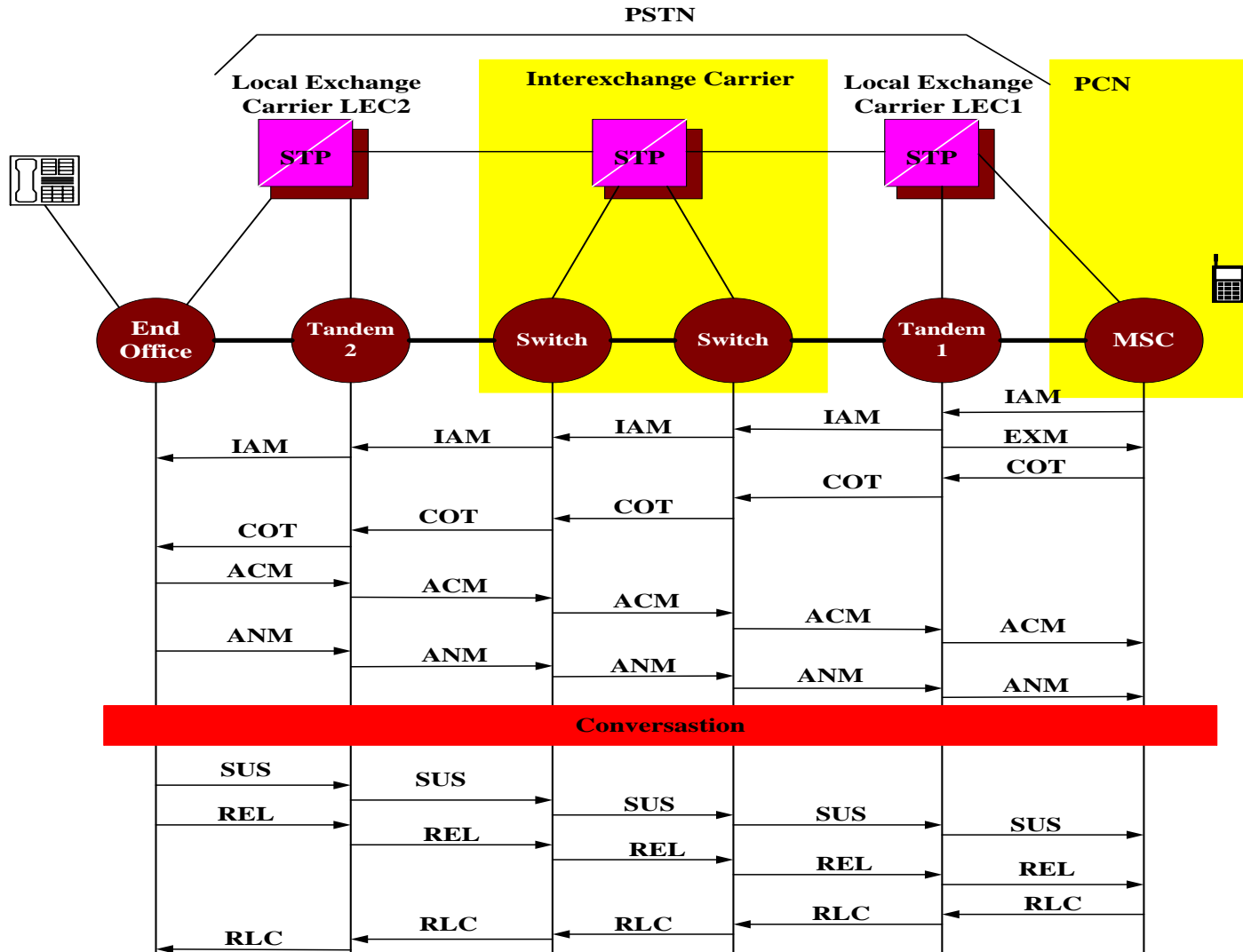
# PCS/PSTN Call Control Using ISUP

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# Land-to-Mobile Call Setup and Release



# Mobile-To-Land Call Setup and Release





# Performance Requirements for SS7

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- A given route set should not be out of service for more than 10 minutes per year.
- No more than  $1 \times 10^{-7}$  messages should be lost.
- No more than  $1 \times 10^{-10}$  messages should be delivered out of sequence.
- In ISUP, numerous timing requirements must be met.



# Summary

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- SS7: out-of-band signaling method
- Components and Links of SS7
  - 3 components: STP, SSP and SCP
  - 6 links: A-F links.
- PCN/PSTN Call Control Using ISUP
  - Land-to-Mobile Call Setup/Release Procedures
  - Mobile-to-Land Call Setup/Release Procedures