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Signaling System Number 7

(SS7)

Architecture, Protocol and Applications

Professor Aimé M. Mbobi, PhD., MSc., M.Eng.

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COURSE OBJECTIVE

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This course is addressed to:

- People who don't have acquaintance with SS7
- Those who already have familiarized to this area

This course will provide you with the knowledge to:

- Understand the role of telecom Signalings
- Grasp the philosophy and understand the architecture of the SS7 Network
- Understand the stack of SS7 protocol from the lower layers to the upper layers.
- Understand what are circuit and non-circuit related parts of SS7
- Acquire substantial technical knowledge that helps consolidating your SS7 understanding

This course will not present:

- Distributed 7 (D7) (Another session)
- Intelligent Networks (Another session)

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Content

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Object and Technical Basis of Signaling

S... MEng.

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Standard Organizations and OSI Reference Model (ISO 7498-1)

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Standard Organizations

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- State the guidelines to guarantee
  - Interoperability across various platforms offered by vendors, regardless of who built them.

- **"De Jure" Organizations (Legal establishment)**
  - Provide standards accepted unanimously in national or international level.
  - Example: **ISO** (Standards) and **ITU** (Recommendations).

- **"De Facto" Organizations (Not by Legal establishment)**
  - Example: **IETF**

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OSI Reference Model (ISO 7498-1)

- To reduce the development cost
- To reduce the maintenance cost
- To facilitate component reuse
- Increase software quality

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OSI Reference Model (ISO 7498-1)

Software company's Niche

Level	Layer	Data Unit	Function	Examples
7	Application	Data	-Interaction Human-Computer -How to access information on the network / application -Application services for file transfers (MMI)	Email, SMS, HTTP, MLP
6	Presentation	Data	Syntax: translates from application to network format and vice versa.	Alphabet, ASCHII, MPEG
5	Session	Sessions	Set up, coordinates, and terminates conversations, exchanges, and dialogues between end applications	Access Control to a service, Password
4	Transport	Messages	-End-to-end transparent connections - End-to-end error recovery and flow control.	TCP, UDP, Flow control
3	Network	Pacquets	-How to Switch, route, forward, and, address - Error handling, congestion control, packet sequencing	X.25, IP, Router
2	Data Link	Frames	Controls (frame synch, flow) and error checking	HDLC, LAP B, Bridge, 802.11 Wifi
1	Physical	Bit, el. impulse, radio signal	Electrical and Physical specifications for devices and media (layout of pins, voltages)	Rj45, Cable, V35

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Some Telecommunication Transfer Paradigms

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Some Telecommunication Transfer Paradigms

- Around the world, digital trunks follow two basic standards: T1 and E1.
- Both of them are digital transmission links where data is transmitted in 64 kb/s channels: Digital Signal Level 0, (DS-0).

	T1	E1
Geographic Coverage	USA, Canada, Japan and Hong Kong	Europe, Asia and South America
Technology	Digital	Digital
Nb. Channels carried	24	32
Channel Rate	64 000 bps (DS-0)	64 000 bps (DS-0)
Transmission speed	64 000 bps x 24 = 1 544 Mbps (DS-1)	64 000 bps x 32 = 2 048 Mbps (DS-1)

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Some Telecommunication Transfer Paradigms

Circuits Switching

- Before communication, a physical Ci
  fixed bandwidth and delay is set-up
- This circuit belongs to this communic
  as it is not interrupted even if they
  nothing to say
- Fast but small Bandwidth (64kb/s)
- Example: Telephone Circuits

Packets Transfer

ase Transmission rate.
of bits (1000 bits < length < 2000 bits)
plicitly affected to a given couple of
on
dth but a bit slow
rnet Router

IN ANY NETWORK, SIGLALING IS OF CAPITAL IMPORTANCE

Cells Switching

- Purpose: Replace CS and PT.
- Speed of CS + Large Bandwidth PT
- Packet length = 53 octets (5 for header, 48 for data).
- Example: ATM

Frames Switching

MEng.

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Some Telecommunication Transfer Paradigms

Circuits Switching

- Before communication, a physical Circuit with fixed bandwidth and delay is set up between T/R
- This circuit belongs to this communication as long as it is not interrupted even if they do not have nothing to say
- Fast but small Bandwidth (64kb/s)
- Example: Telephone Circuits

Packets Transfer

- Purpose: Increase Transmission rate.
- Packet= suite of bits (1000 bits < length < 2000 bits)
- Link is not explicitly affected to a given couple of communication
- Large Bandwidth but a bit slow
- Example: Internet Router

Cells Switching

- Purpose: Replace CS and PT.
- Speed of CS + Large Bandwidth PT
- Packet length = 53 octets (5 for header, 48 for data).
- Example: ATM

Frames Switching

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The meaning of Signaling in Telecommunications

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The meaning of Signaling in various Fields

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The meaning of Signaling in various Fields

the field

Traffic t

It depends on

Gestur

Air traffic Controller

Lighthouse

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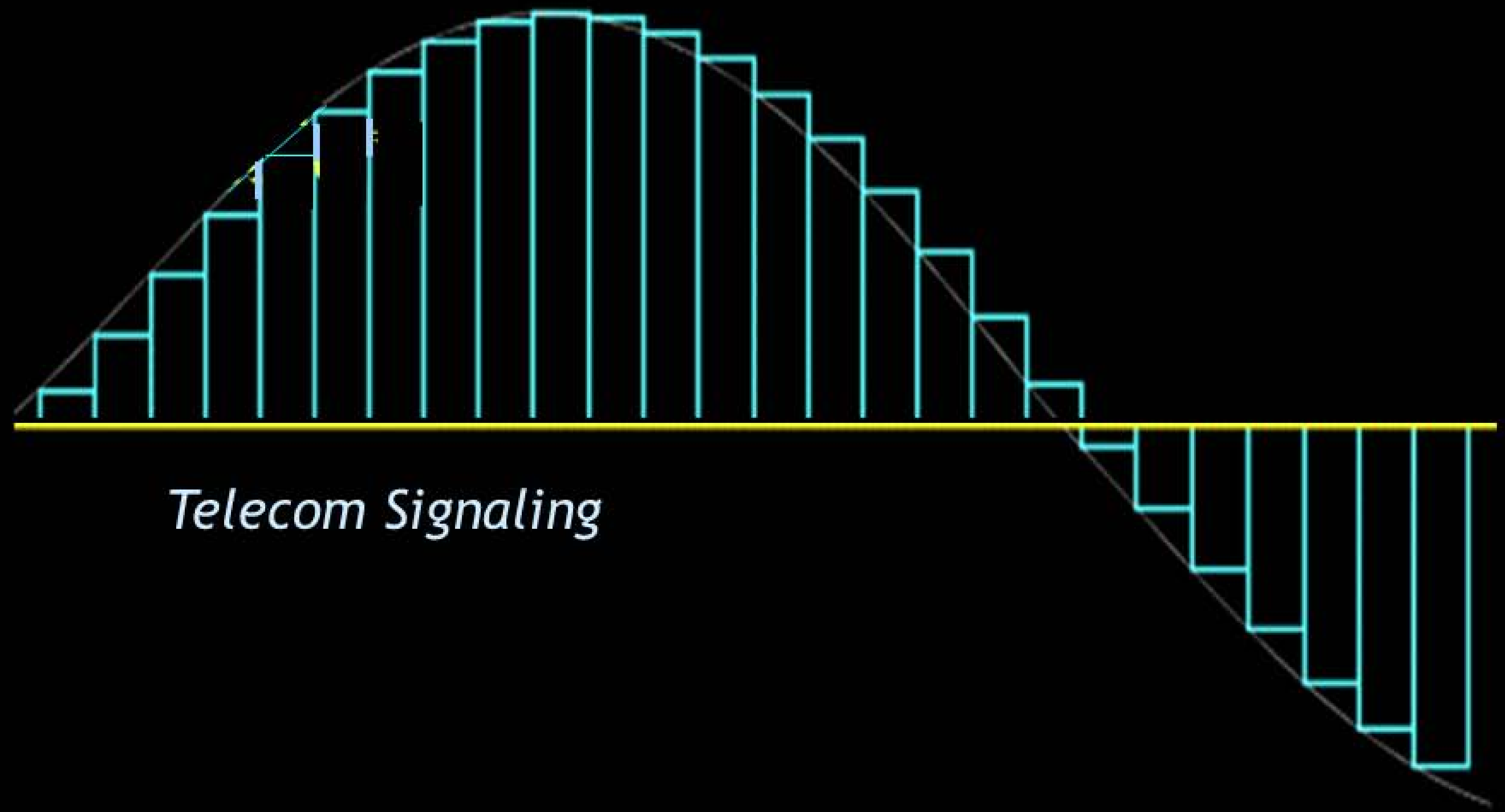
The meaning of Signaling in Telecommunications



ABSOLUTE NEED FOR A MECHANISM TO REGULATE INTERACTIONS

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The meaning of Signaling in Telecommunications

An asynchronous notification used between two specific endpoints identified uniquely by a predefined addressing scheme.

It refers to the exchange of information between call equipments in order to provide and maintain service.

- Sent to
  - Establish (Set up)
  - Supervise (Communication)
  - Clear down a session (Release)

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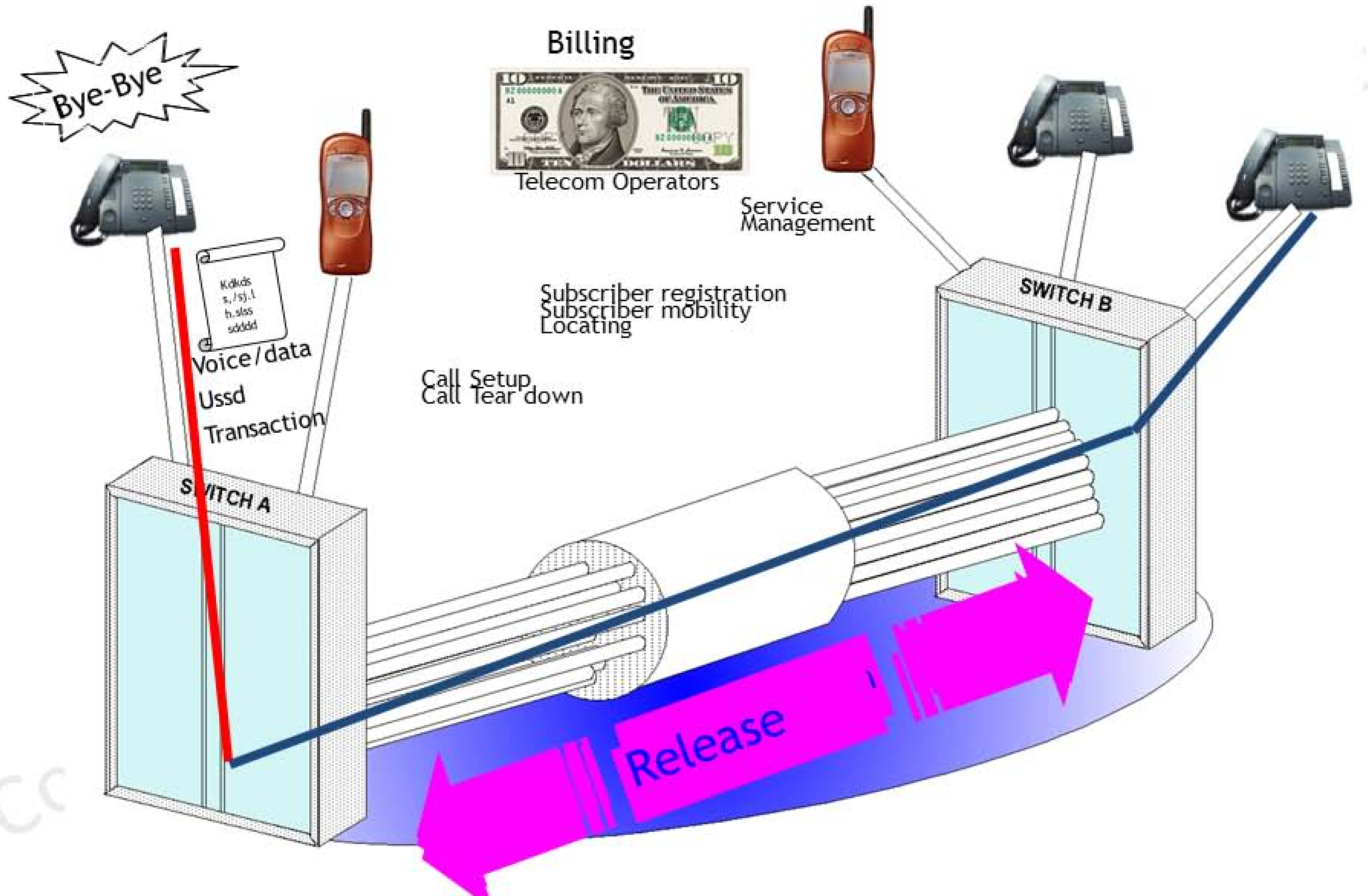
The meaning of Signaling in Telecommunications



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Types of Signaling

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Types of Signaling

- In-Band Signaling
- Out-of-Band Signaling

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In-Band Signaling

- In In-Band Signaling, information about network control and information about data are sent in the same band, on the same channel as used for voice.
  - Example:
    - In in-Band Signaling, dialed phone number is sent over the same channel and in the same band as the voice.
    - Insecure because it exposes control signals, protocols and management systems to the user.

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Out-of-Band Signaling

- In Out-of-Band Signaling, information about network control and information about data are sent in a separate band of the data or voice channel, or on an entirely separate, dedicated channel (as in Common Channel Signaling).
  - Example (SS7)
    - In out-of-Band Signaling, dialed phone number, number display, etc. are sent over a another dedicated channel different from the voice channel.

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In-Band and Out-Band Signaling

- In-band Signaling applies only to Channel Associated Signaling (CAS).

- In Common Channel Signaling (CCS) all control is out-of-band.

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In-Band and Out-Band Signaling

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- In North America, signaling can be placed on its own T1 carrier even though it only takes up one timeslot.
- This means that two physical networks, "speech" and "signaling," can have different routings.
- Outside of North America, the signaling is placed in its own timeslot on an E1 (that is, logically rather than physically separated).
- The other timeslots on E1 are for user traffic—apart from TS0, which is used for synchronization.
- E1 systems tend to use the TS16 timeslot for signaling,

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Channel Associated Signaling (CAS)

- Advantages
  - Inexpensive to implement
  - Can be used on any transmission medium
- Disadvantages
  - Signaling for a particular traffic circuit is permanently associated with that circuit, this makes CAS inflexible and slow
  - Vulnerable to fraud and Interferences

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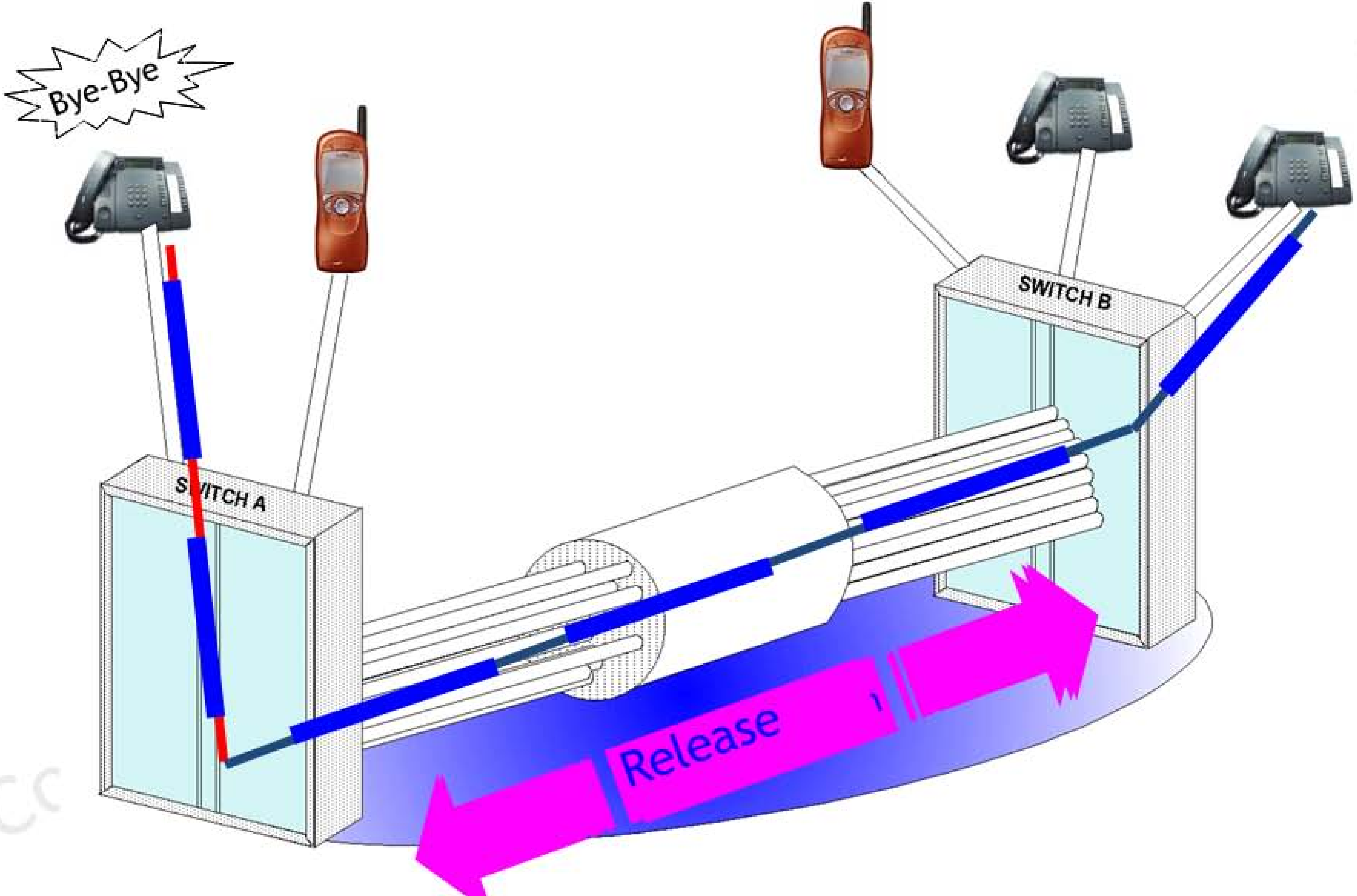
Channel Associated Signaling (CAS)



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Common Channel Signaling (CCS)

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- Signaling and user's information are completely dissociated.
- So information is sent in a dedicated channel.
- Voice circuits are only used when a connection is established, not before.
- Example: Signaling System 7 (SS7).

- Advantages
  - Quicker Call setup time
  - Open Possibilities for future services
  - Almost invulnerable to fraud and interferences

- Disadvantages
  - Complex to implement

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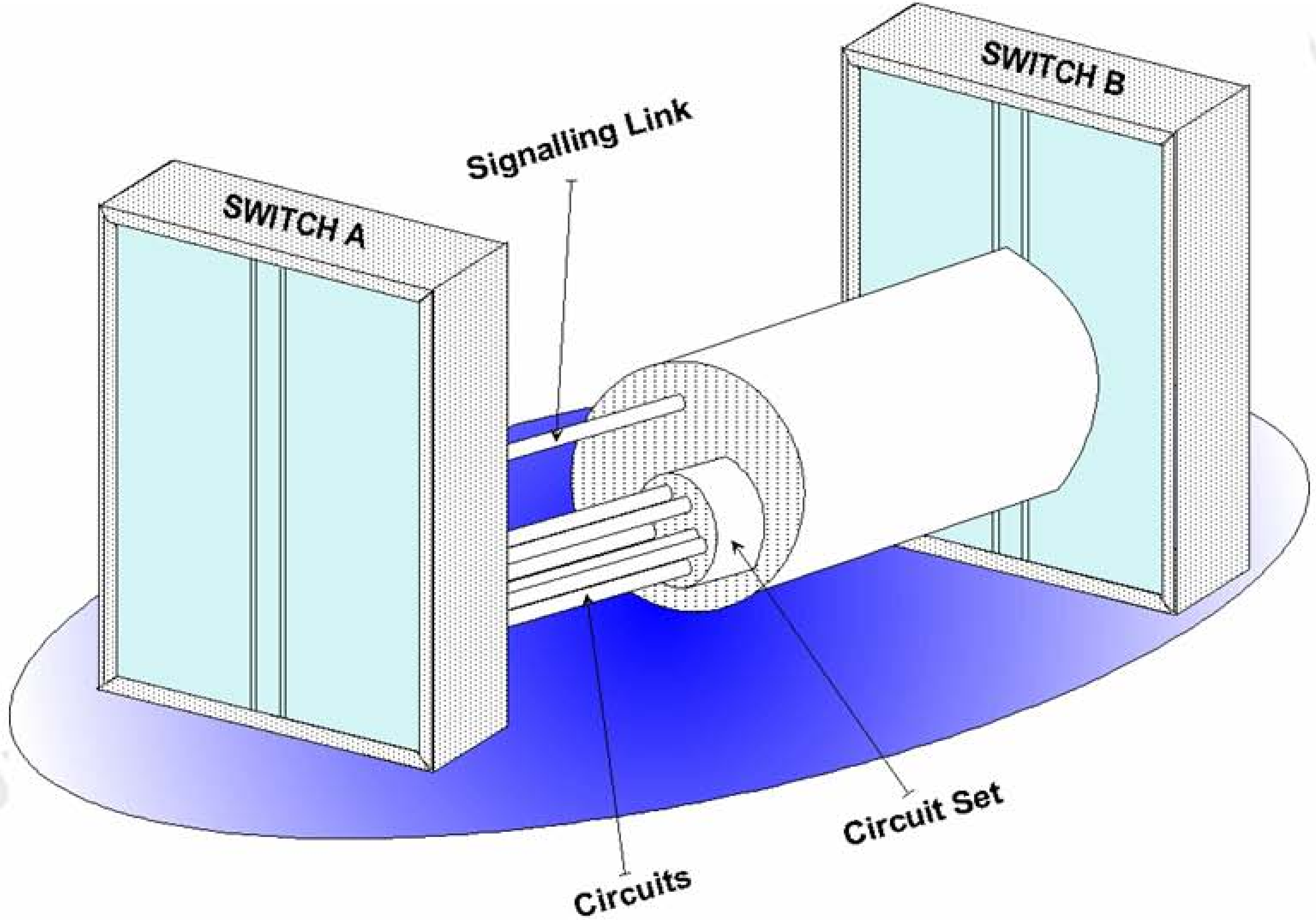
Common Channel Signaling (CCS)



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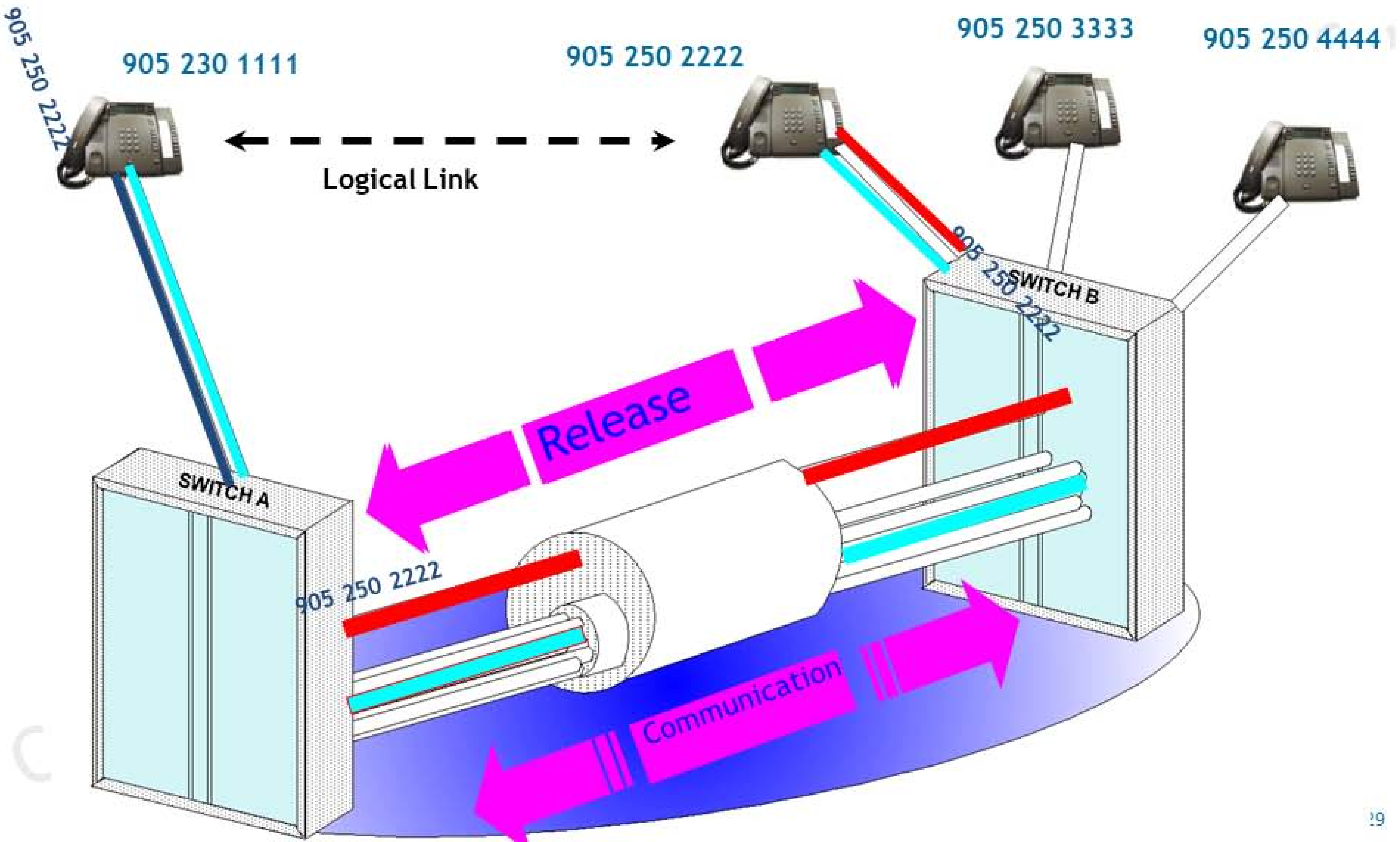
Common Channel Signaling (CCS)



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Circuit-Related and Non-Circuit Related Signaling

- Due to the packet-based aspect of CCS, there is no rigid tie between the signaling and the circuits it controls
- This brings about two concepts: circuit-related and non-circuit-related signaling
- In NCR, signaling capacity is not pre-allocated for each traffic circuit, it is allocated as it is required.
- Because no dedicated relationship exists between the circuits and the signaling, to identify the traffic circuit to which a particular signal message refers, a circuit reference field is included in each signaling message

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SS7 Network Architecture

MSc MEng.

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SS7 Lineage

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SS7 Lineage

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- Today, Signaling System No. 7 is the most advanced and widely used signaling system for both cellular and fixed-line telecommunications networks.

- CCITT 6 or SS6
  - Developed in the 1960s, was first introduced in the United States as Common Channel Interoffice Signaling System #6 (SS6).
  - Has been deployed throughout the United States telephone network until 1983
  - In the end of 1980s Replaced by SS7

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SS7 Lineage

Signaling System 7 (SS7) Characteristics

• Type of Signaling	: Out-of Band Signaling
• Derived from	: SS4, SS5, SS6
• Developed by	: ITU-T in 1975, Standardization in 1981 (Q.7XX-series)
• Deployment Area	: Worldwide
• Major Components	: SP, STP
• Advantages	: - Greater Speed, flexibility, Almost invulnerable to fraud and interferences - Faster Call Set up, answer detection, Easy to upgrade to new services - Ability to reduce telecom costs by purchasing (HC Trunks) - Suitable for mobile applications and wireless services
•Disadvantage	: Complex to implement
• Market	: - Local Carriers (variants defined by some Telcos) - International and Long Distance Carriers - New services in IN and Large Internet Telephony Service Providers (ITSP)

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Definition of SS7

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Definition of SS7 Signaling

Set of telephony procedures and protocols by which network elements exchange circuit and/or non-circuit related information.

- Used to
  - Establish (Set up)
  - Route
  - Supervise
  - Release a wireless or wireline communication

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Definition of SS7 Network

Packet Switching Network made of two SS7 equipments (Signaling Points and Signaling Transfer Points) connected by bidirectional channels called SS7 links.

- Concretely
  - Equipment implement SS7 protocols in Levels 1 to 7
  - Links implement SS7 protocols in Levels 1-2

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Relationship between SS7 Network and Intelligent Network (IN)

SS7 supports Intelligent Network Services.

- Postulate:
  - Out-of-band Signaling supports Intelligent Network services
- Since SS7 is an out-of-band
- Therefore, SS7 supports Intelligent Network services

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SS7 Network Architecture

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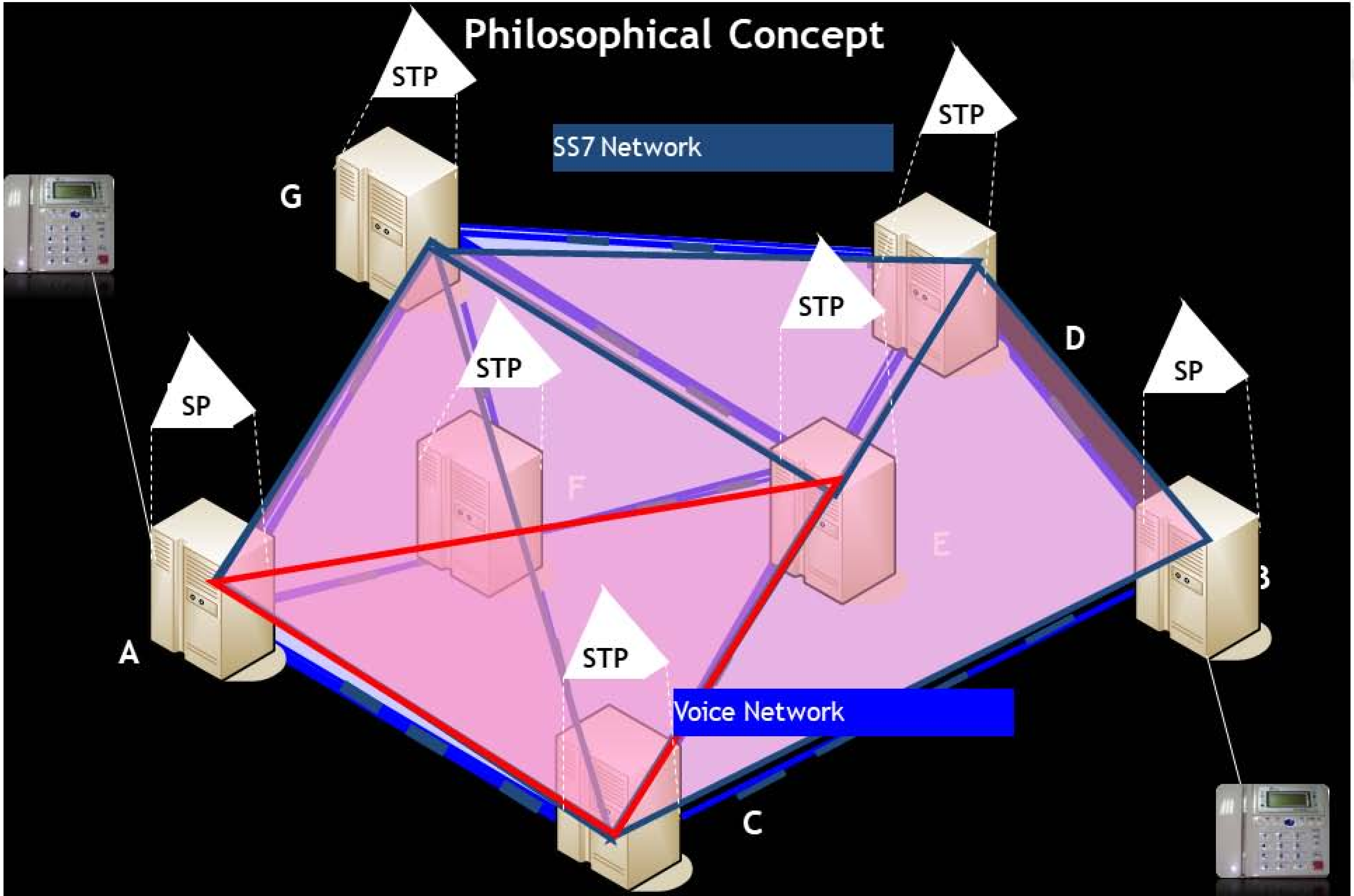
SS7 Network Architecture



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SS7 Signaling Point and Signaling Transfer Point

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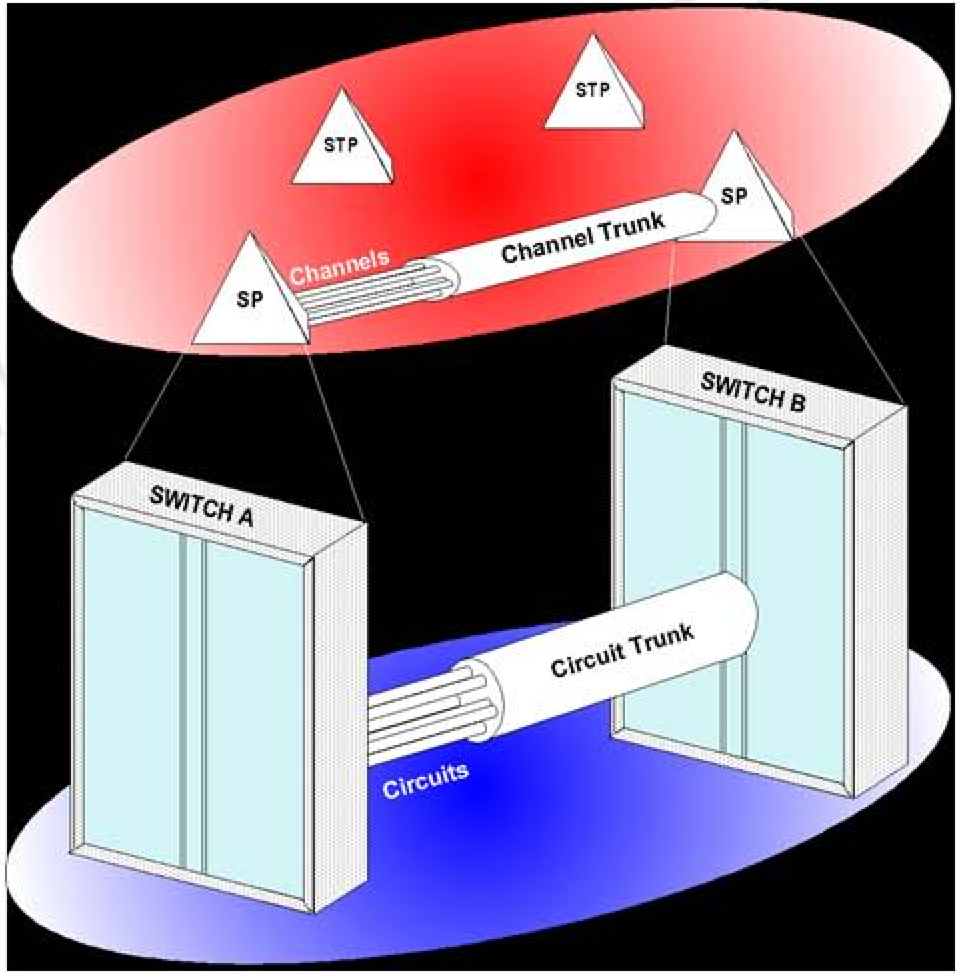
- Signaling Point (SP) is a Signaling end point (SEP) that converts Signaling received from the voice switch into SS7 Signaling.
- SPs act as a Signaling source

- Signaling Transfer Point (STP) is a signal packet switch equipped with SS7 software that receives and routes incoming Signaling messages onto their destinations.
- Dialogue between switches is done by STPs



SS7 Links

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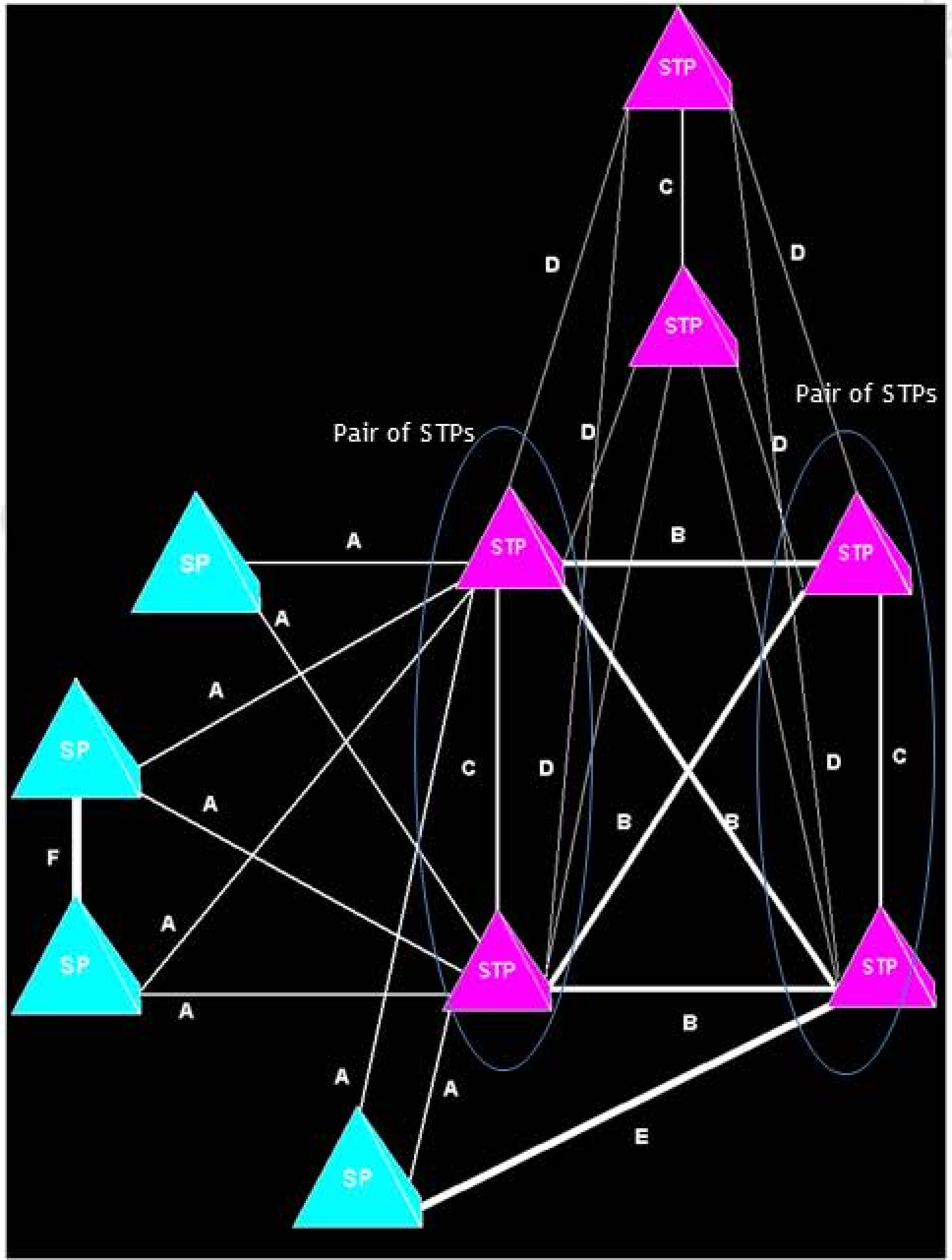
The most common method for deploying SS7 links is for each link to occupy a timeslot, such as a T1 or E1, on a digital trunk

- A = (Access) link connects an STP to a Signaling End Point (e.g an STP or SCP).
- B = (Bridge) link connects peers pairs of STP
- C = (Cross) link connects matted pair of STP performing identical functions in the same region (for redundancy)
- D = (Diagonal) link connects STP from adjacent hierarchical levels
- E = (Extended) link is a backup of A link, connects SP to a second pair of STPs for reliability. These two STPs belong to different regions (remote STP)
- F = (Fully associated) link connects two SP in associated mode



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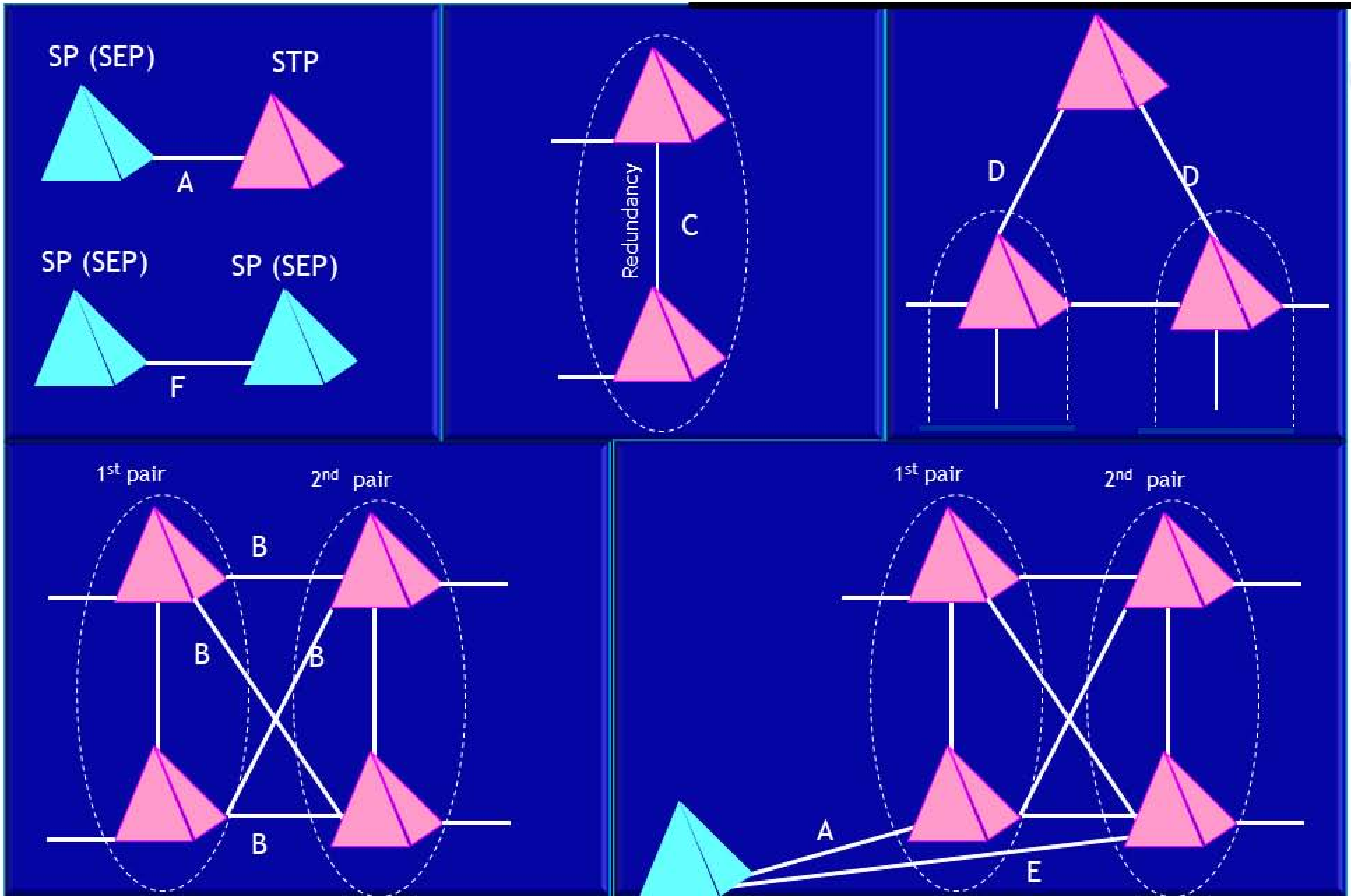
SS7 Link Pairing



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Signaling Modes

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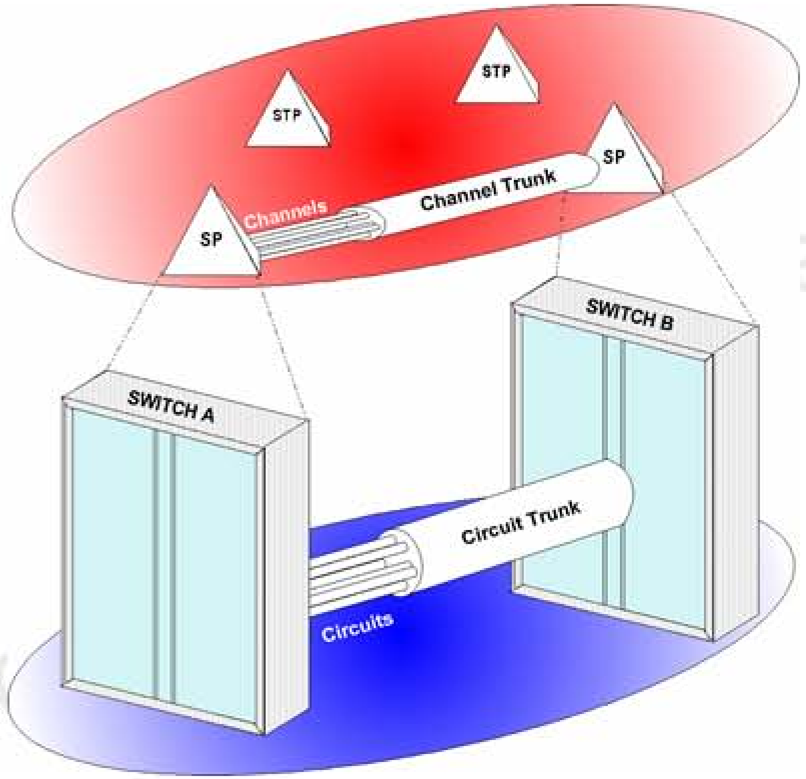
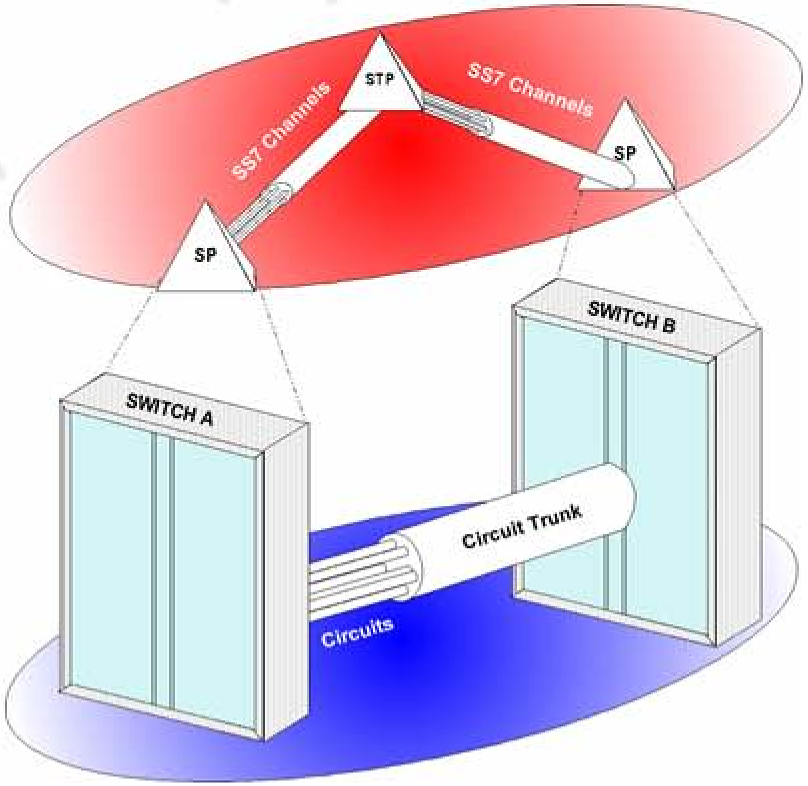
- Three Signaling Modes can be used in an SS7 Network:
  - Associated Mode (Signaling message from one SP goes straight to another SP)
  - Non-Associated Mode (Use of intermediary non-predetermined SP)
  - Quasi-Associated Mode (Use of intermediary predetermined SP; Not applicable to SS7)





Signaling Modes

- SS7 runs in associated or quasi-associated mode, but not in non-associated mode because non-associated does not have procedures for reordering out-of-sequence messages.
- Associated and quasi-associated signaling modes ensure sequential delivery

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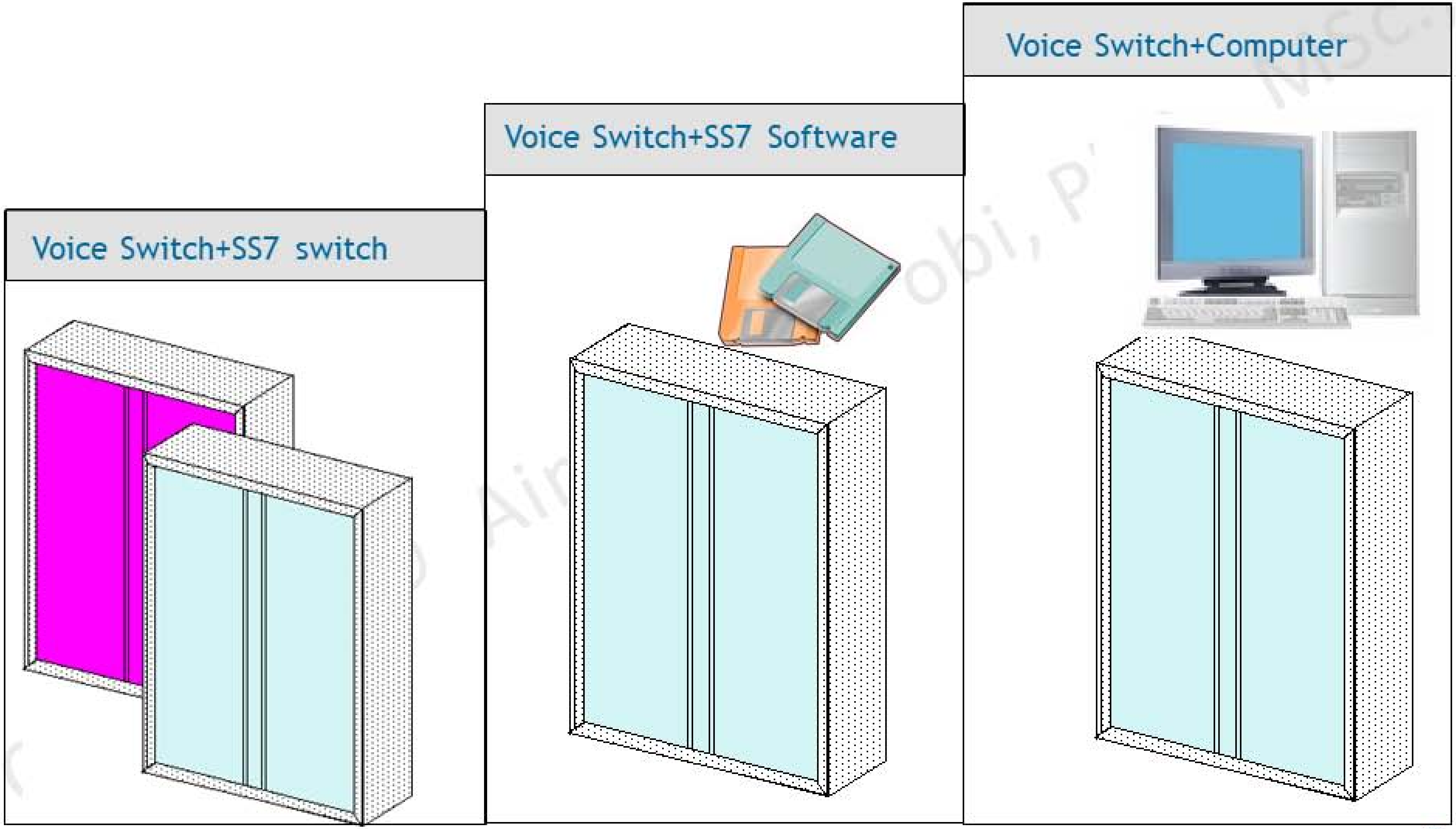
Signaling Point (SP)



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SS7 Components: Signaling Transfer Point (STP)

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- Messages from SP to STP are packets that contain the requests related to
  - Connection Set up (Must be relayed to the following SP)
  - Data Bases Transactions (seeking a physical-tool free number)
  - Release communication
- STP can be
  - Autonomous STP when it acts only as STP
  - Integrated STP when it acts as STP and also as SP
- 3 Types of STP
  - National
  - Gateway
  - International

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National STP

- A given PLMN or PSTN managed by an operator has its own SS7 network made of its SP and STP.
- The SP and STP address modes are internal to this network and are carried out in accordance with a specific numbering plan, generally different from the standard numbering plan.

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National STP

- This STP belongs to a national SS7 network and can relay messages by using the national protocol.
- It does not have the function of translating national protocol to another protocol.

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International STP

- International SS7 network is dedicated to international calls.
- International SS7 network interconnects all the countries by using SS7 protocol.
- International SS7 network provides interoperability between national SS7 networks in spite of some differences in addressing format and others data specific to each country.

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Gateway STP

- Contains national/international protocol converters
  - As a national STP: Translates national protocol to another national protocol.
  - As an international STP: Translates national protocol to an international protocol.
  - Thus, a Gateway SP belongs to both networks.
- Particularly used in cellular networks
  - GW STP terminates the PSTN Signaling and traffic formats and converts this to protocols employed in mobile networks.
  - This function can be carried by a GMSC (Gateway Mobile Switching Center) that interfaces PSTN to PLMN.

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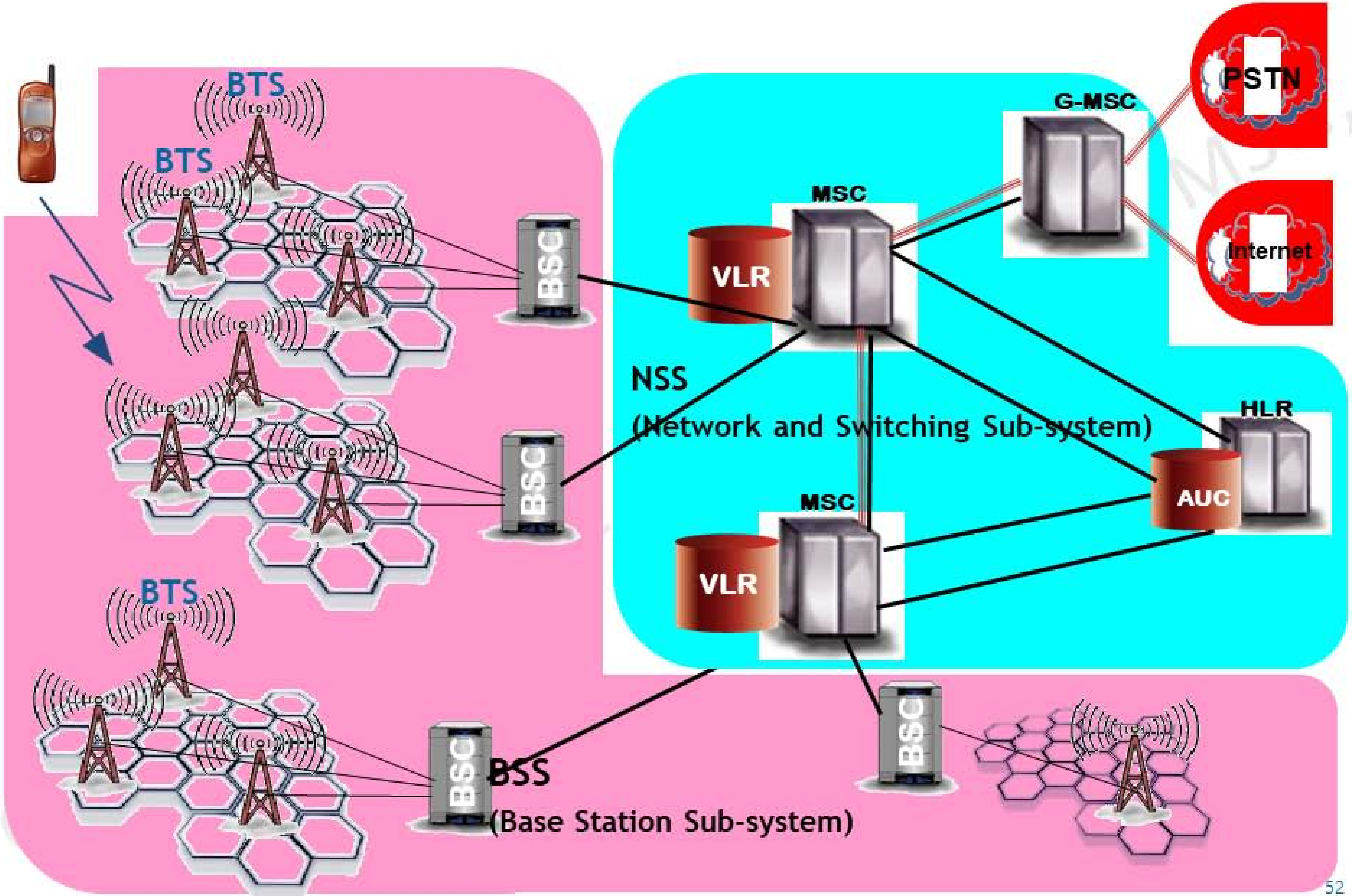
GSM Network



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STPs Comparison

- National STP exists in one network, no capability to convert messages into other formats.
- International STP provides SS7 based interconnection between national networks.
- Gateway STP provides protocol conversion between a national and international network or other non-SS7 networks such as GSM network. Belongs to both networks.

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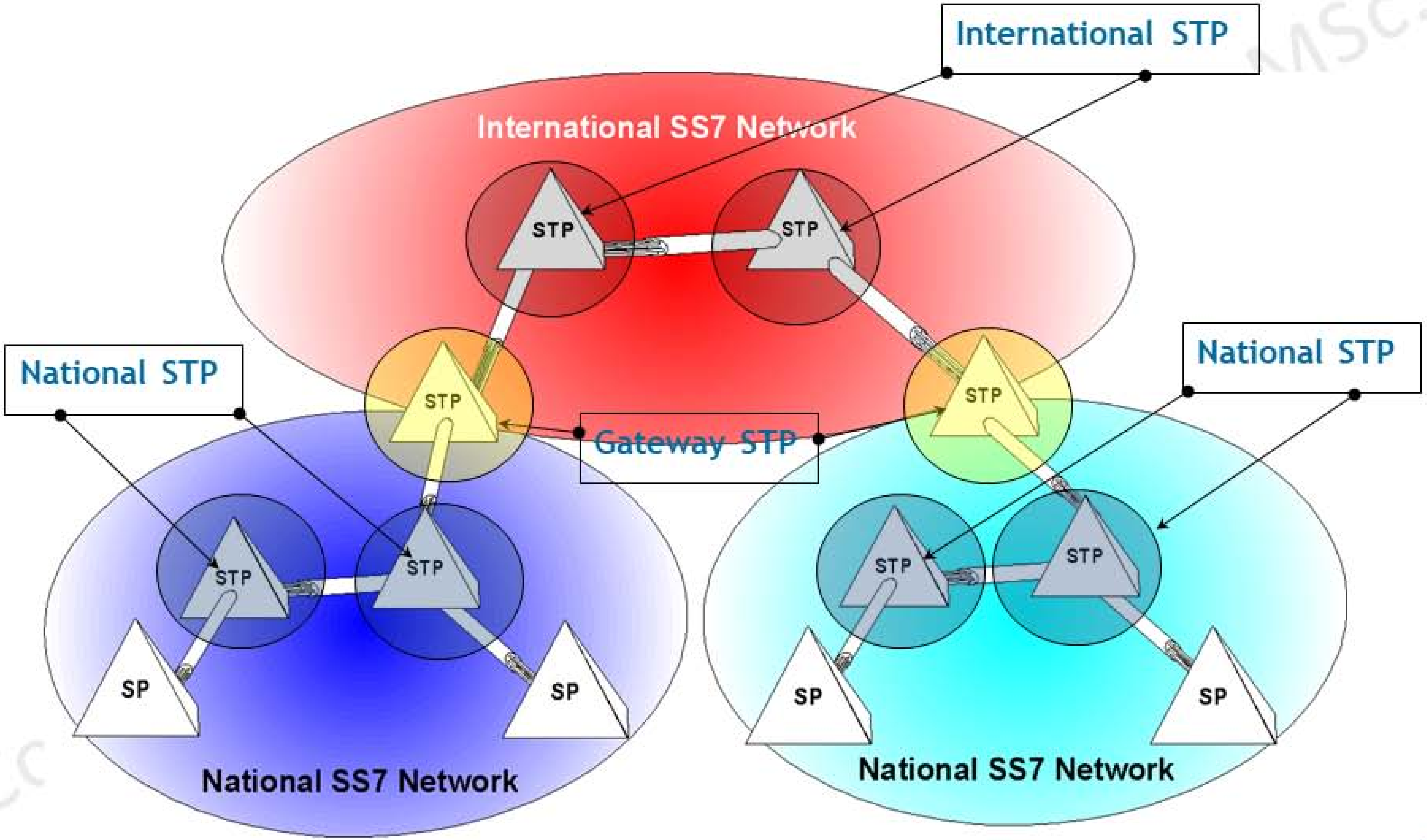
Structure of International SS7 Network



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SS7 Network Architecture

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Recap on SS7 Network Architecture

CONCERNS

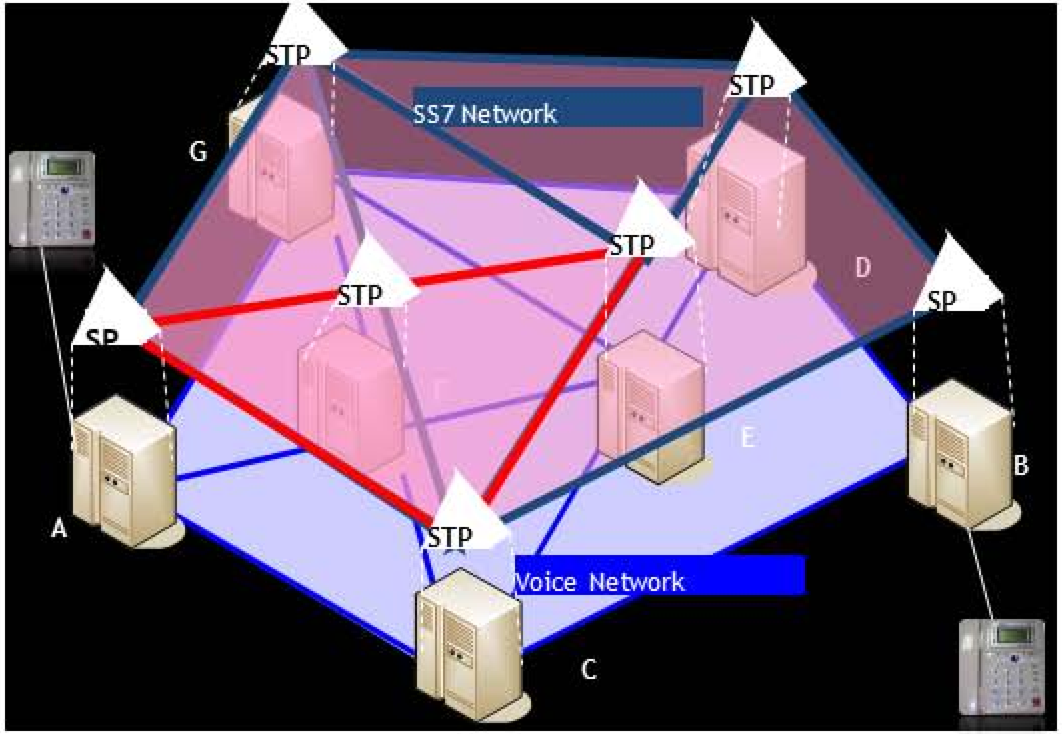
Previous signalings
- Mixing of signaling and voice
- Slowness of set up phase
- Vulnerable (fraud and interferences)
- Heaviness to upgrade
- Inadequacy to wireless network

Goal

Develop a signaling
- Dissociate signaling from voice (physic or logic)
- Greater Speed and faster call set up
- Invulnerable and Flexible to upgrade
- Suitable for wireless network
- Provides range of services

SOLUTION

SIGNALING SYSTEM N0 7 (SS7)



- Signaling Point (SP) converts Signaling received into SS7 Signaling
- Signaling Transfer Point (STP) = packet switch + SS7 software: receives and routes incoming SM STP can be National, Gateway or International
- SP and STP can be connected through Associated, Non-Associated and Quasi-Associated Modes by the links A, B, C, D, E, F

KEY WORDS

SS7, SP, STP, Link, Network, Signaling, IN

MEng.

ACTIVITY

1. In your own words, how would you describe Telecom signaling?
2. Choose the right answer:
   a. STP uses Circuits switching mode
   b. STP uses Packets transfer mode
   c. STP uses Cell switching mode
   d. STP uses Frames switching mode

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ACTIVITY

1. Choose the right answer
    1. SS7 uses
        a. In-bound signaling
        b. Out-of-bound signaling
2. True or False
    a. A Signaling End Point is a packet switch of an SS7 Network
    b. STP is deployed as a packet switch of an SS7 Network

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ACTIVITY

1. Why an STP is different from an SP.
2. Name the existing types of links and give their fundamental characteristics.
3. How non-associated mode is different from quasi-associated mode?

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SS7 Protocol Architecture

SS7 Protocol Stack

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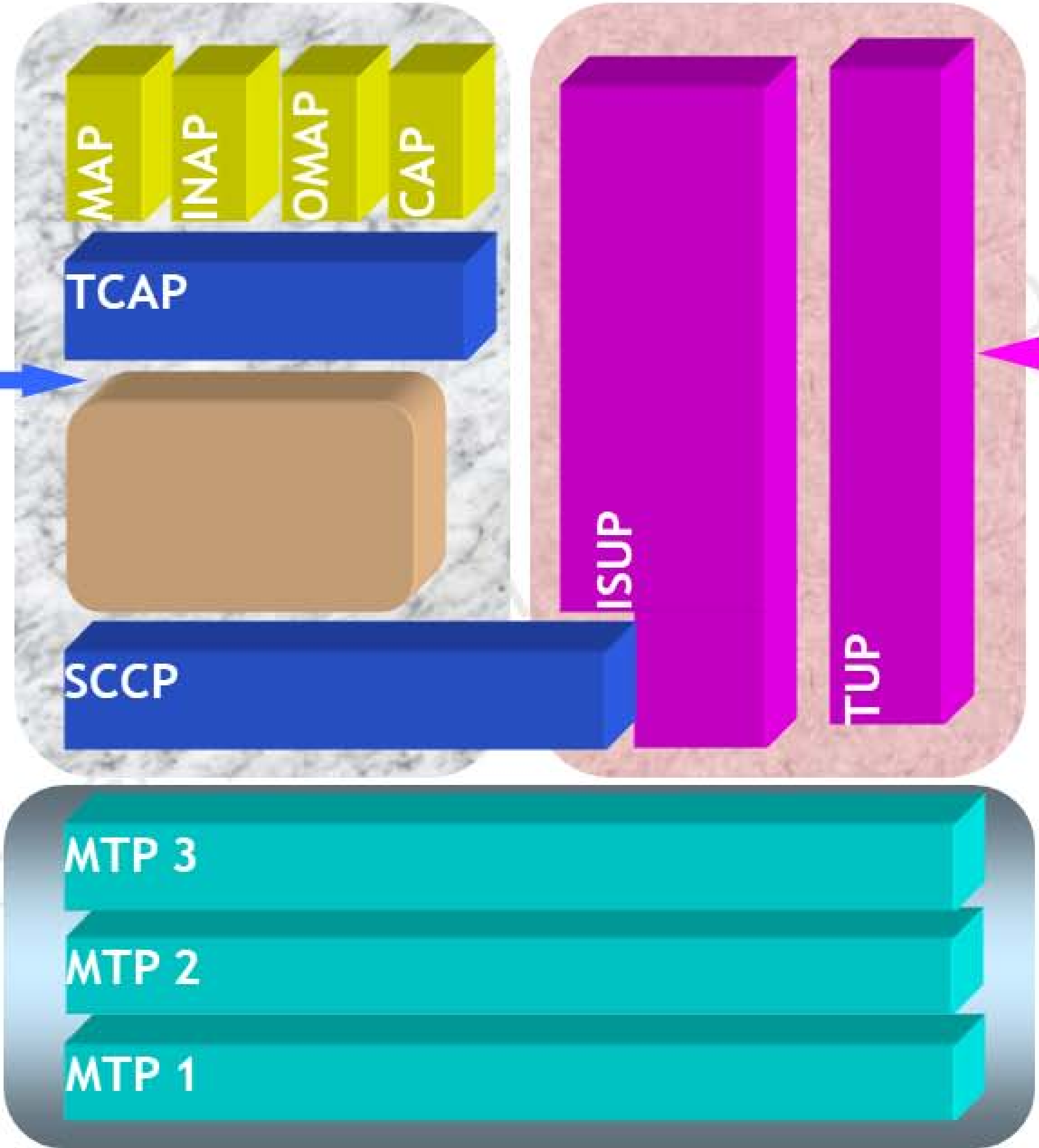
SS7 Protocol Stack

Non-Circuit Related Parts

Circuit Related Parts (User Part)

Transfer Parts



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SS7 Protocol Stack

SS7 Protocol Architecture

Application Part

Transaction Capabilities Application Part (TCAP)

Uses SCCP to support exchange of non-circuit related data between applications.

TCAP messages carry queries and responses between SSP and SCP in IN (ex code PIN checking).

ISDN and Telephone User Part (ISUP and TUP)

Set-up, manages and releases V/D circuits

Signaling Connection Control Part (SCCP)

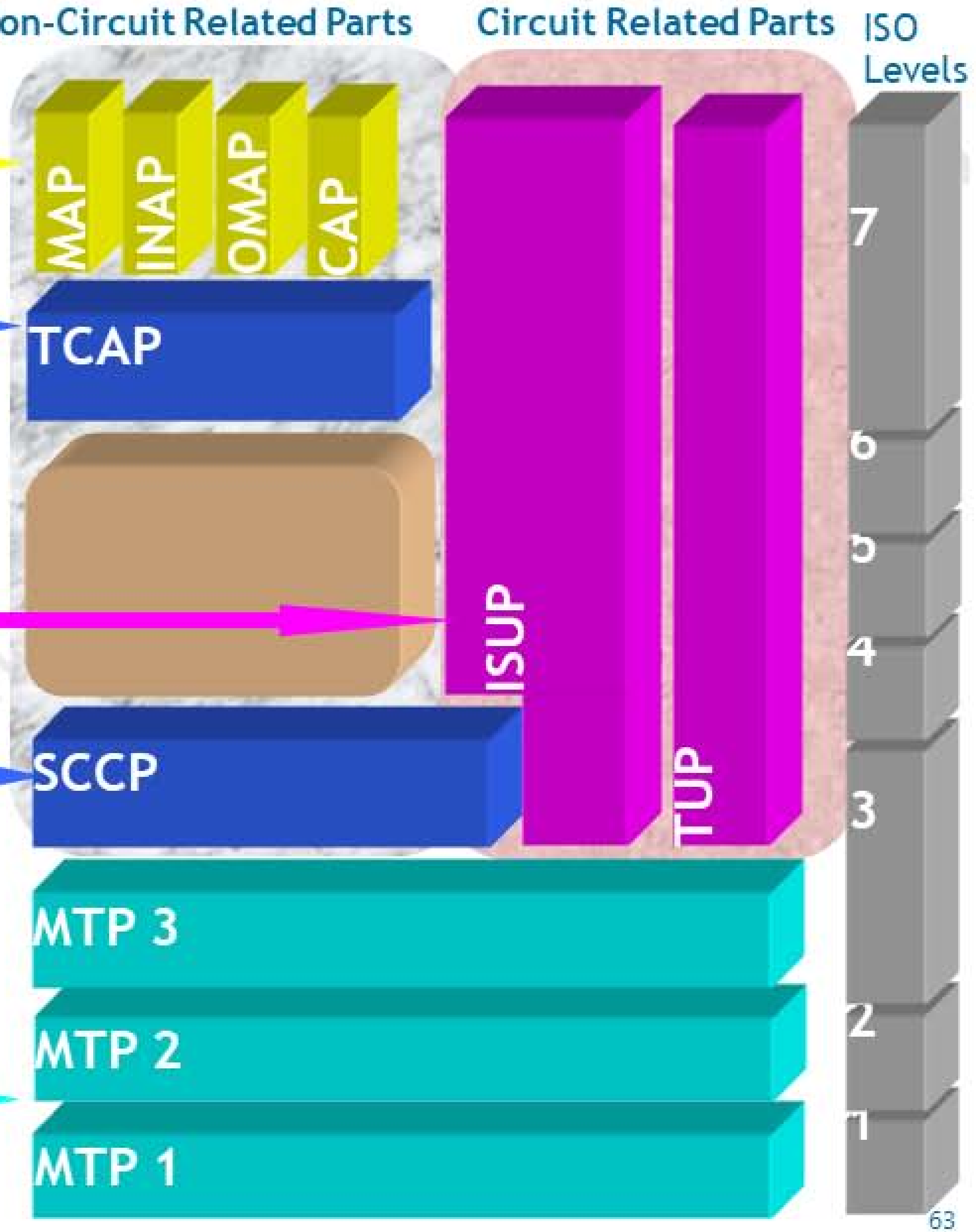
Provides connectionless and connection-oriented network services

Provides SSN and GTT capabilities above MTP L3

Message Transfer Part (MTP)

Provides transfer of SM between SS7 nodes.

Provides set of necessary functions to manage the network



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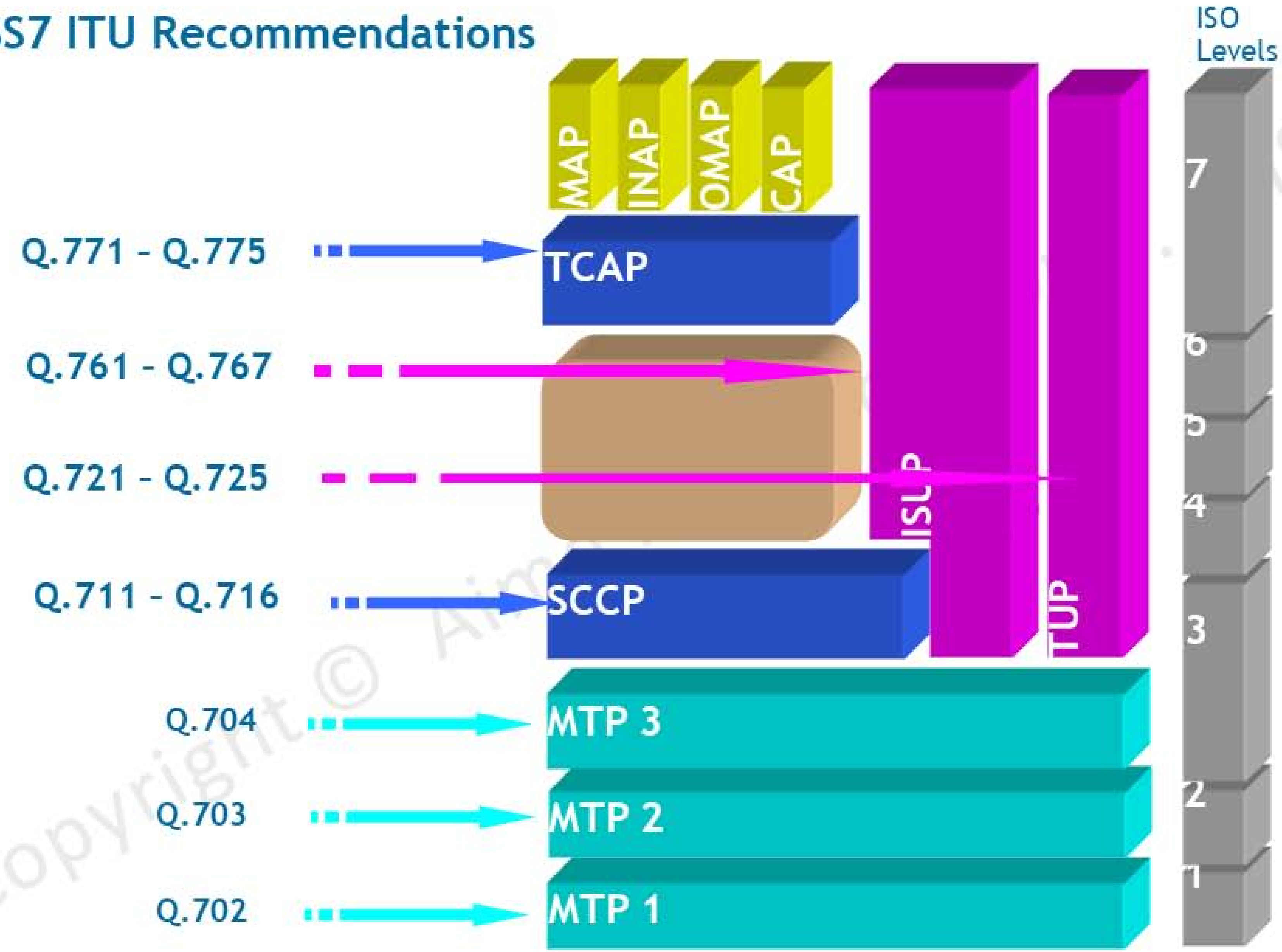
SS7 Protocol Stack

SS7 ITU Recommendations



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Message Transfer Protocol (MTP)

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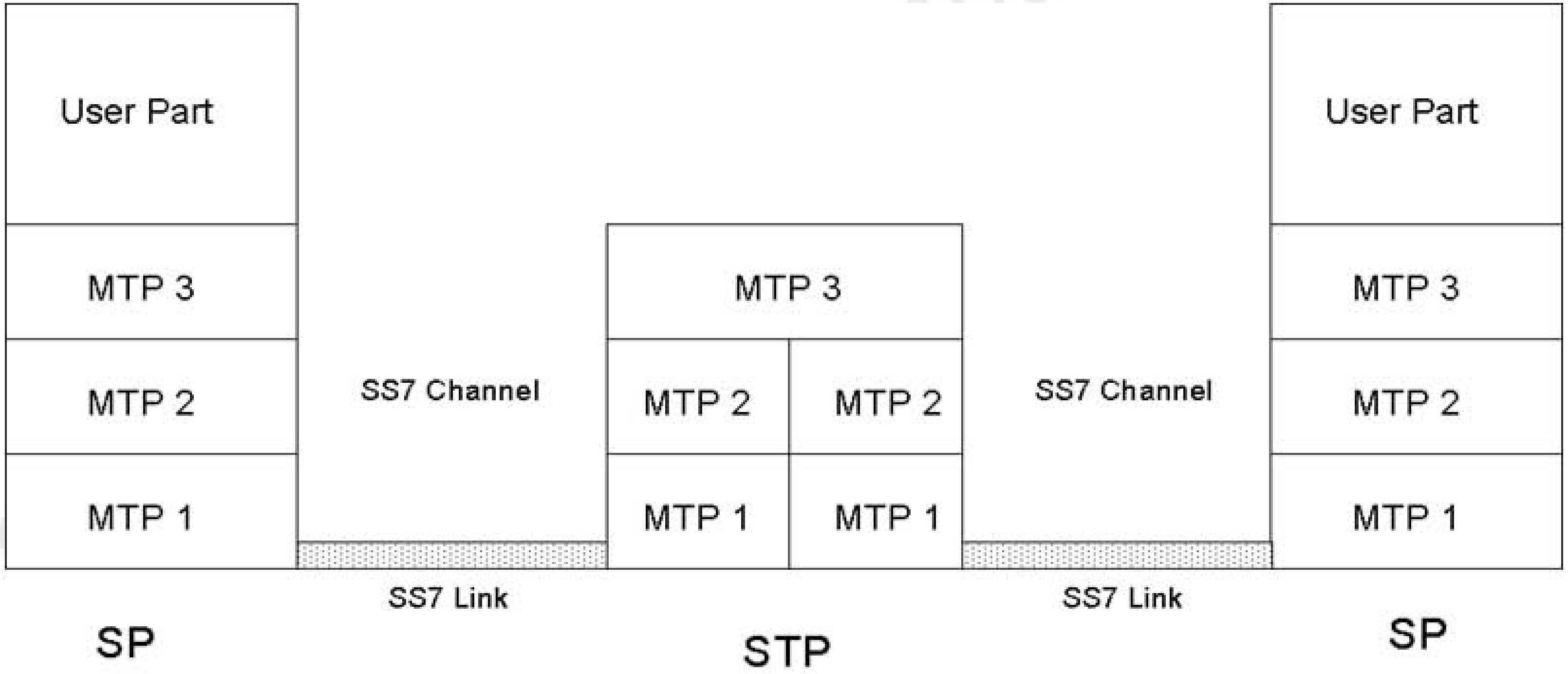
- Made up of three layers MTP 1, MTP 2, and MTP 3 similar to OSI L1, L2, L3.
- Provides services for reliable transfer of SM used by User Parts depending on whether it is a network (ISDN, PSTN) or applications.



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Message Transfer Protocol Level 2 (MTP 2)

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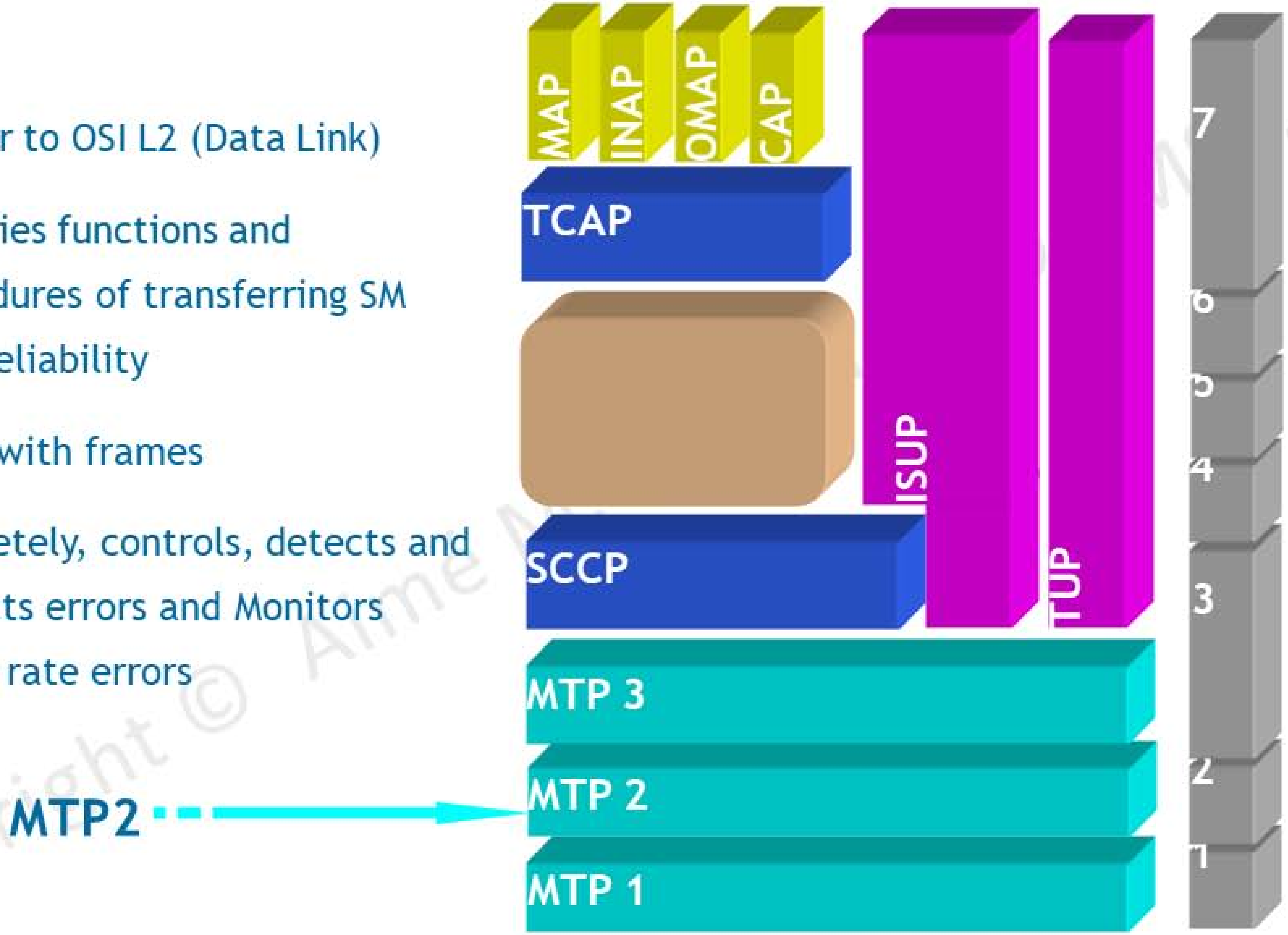
Message Transfer Protocol Level 2

- Similar to OSI L2 (Data Link)
- Specifies functions and procedures of transferring SM with reliability
- Deals with frames
- Concretely, controls, detects and corrects errors and Monitors frame rate errors



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Link and Circuit Identification

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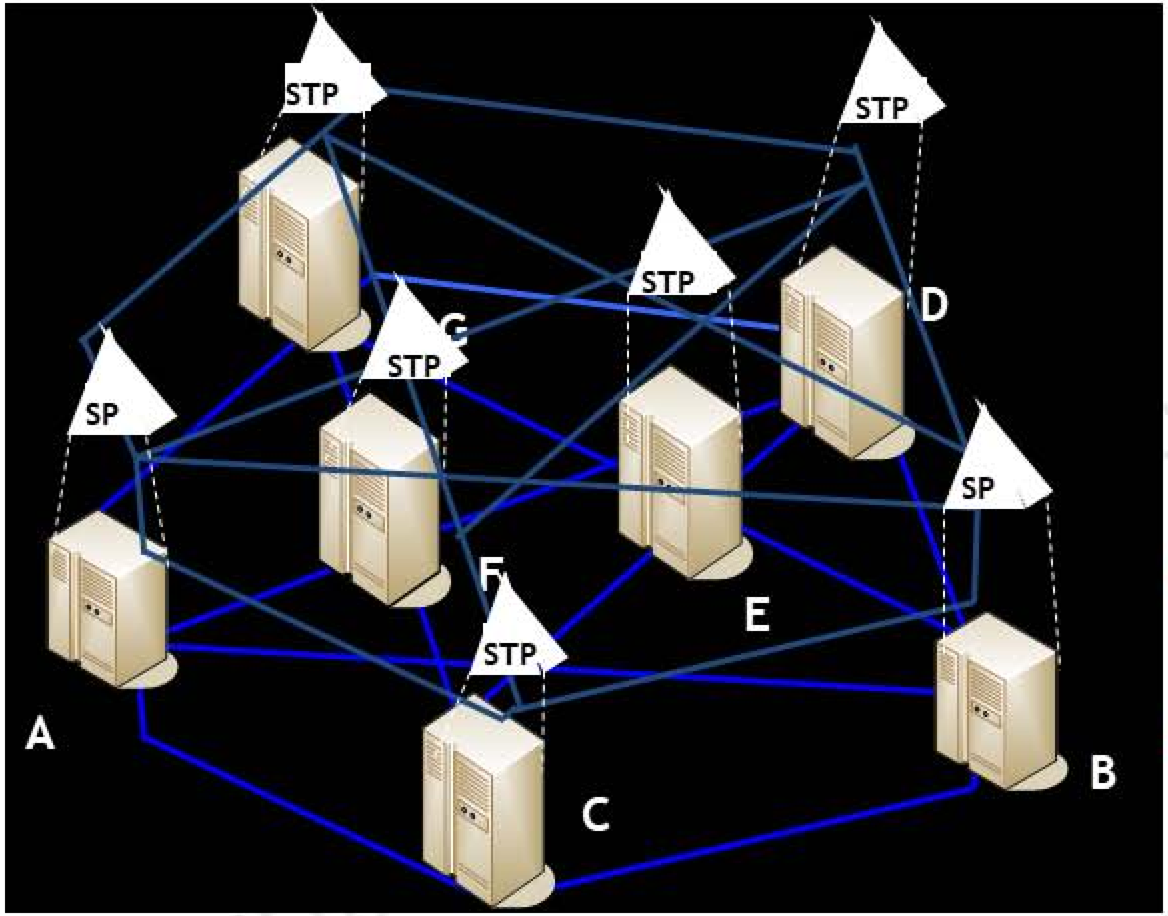
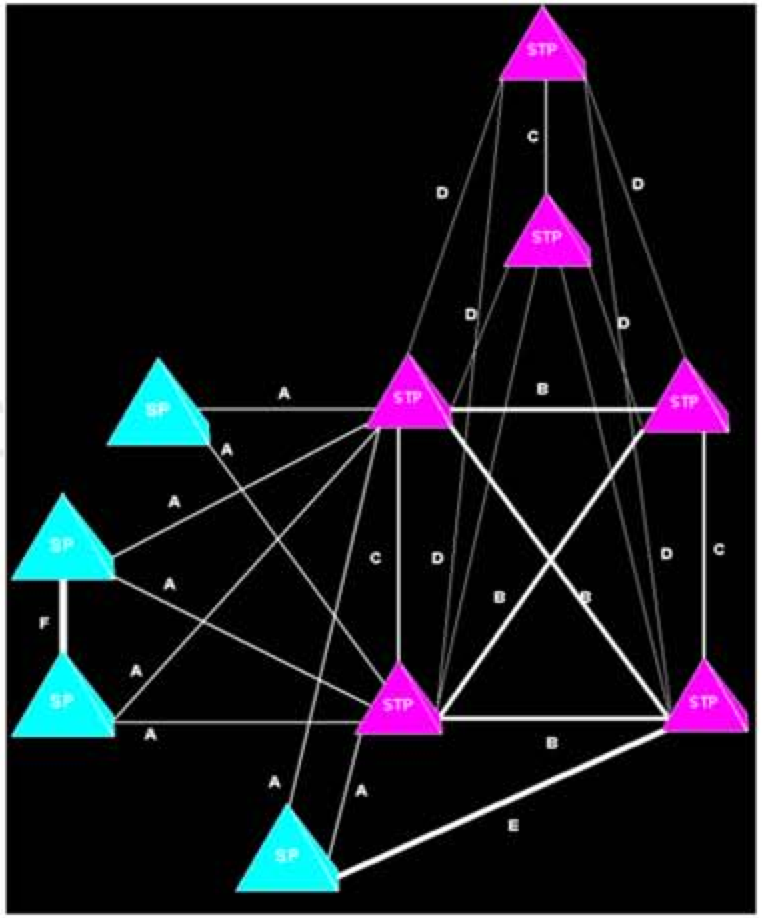
Need for Link and Circuit Identification





ABSOLUTE NEED FOR IDENTIFYING LINKS AND CIRCUITS

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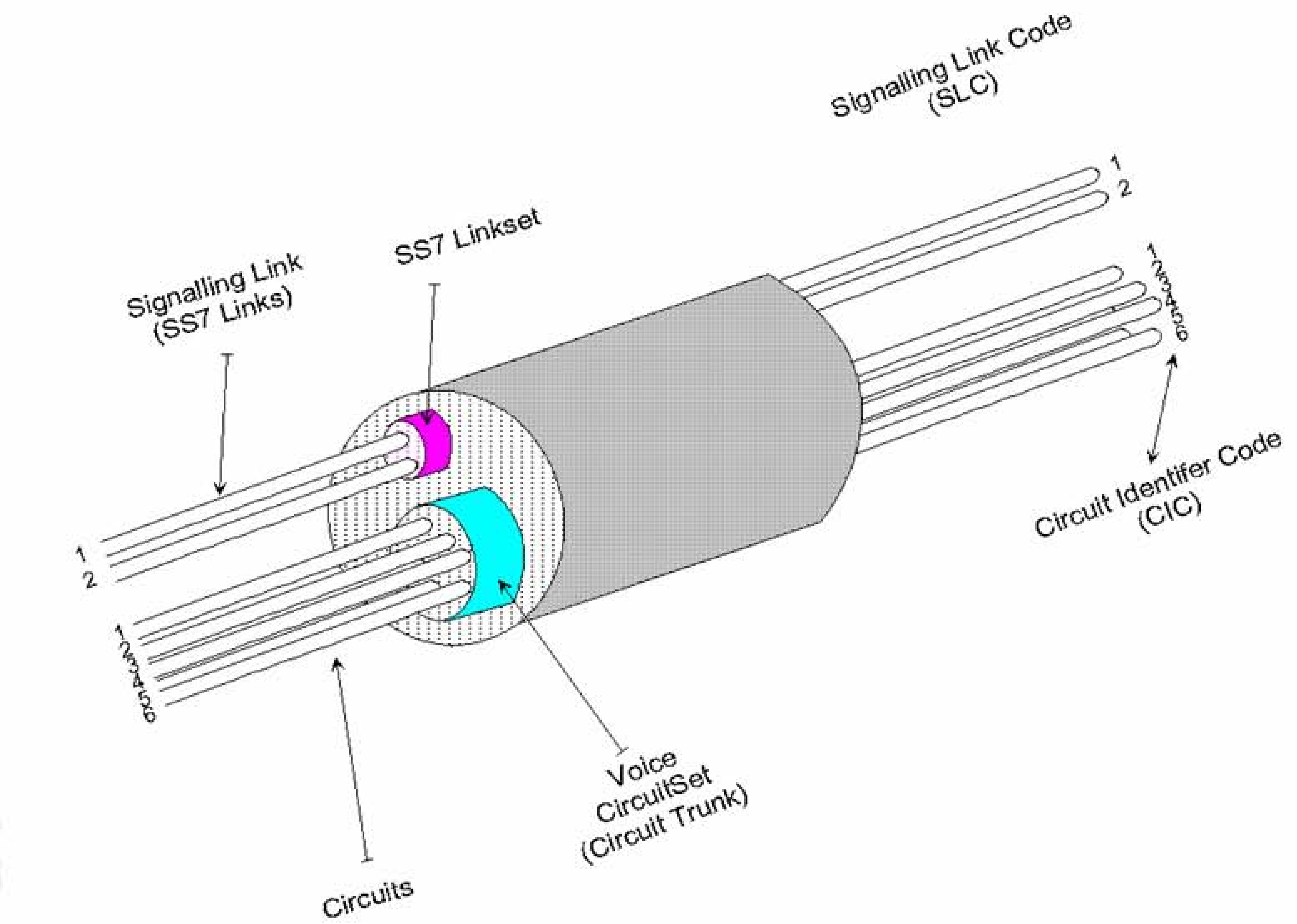
SS7 Channels (Links) and Circuits Identification



Each linkset can contain up to 16 (32) separate links

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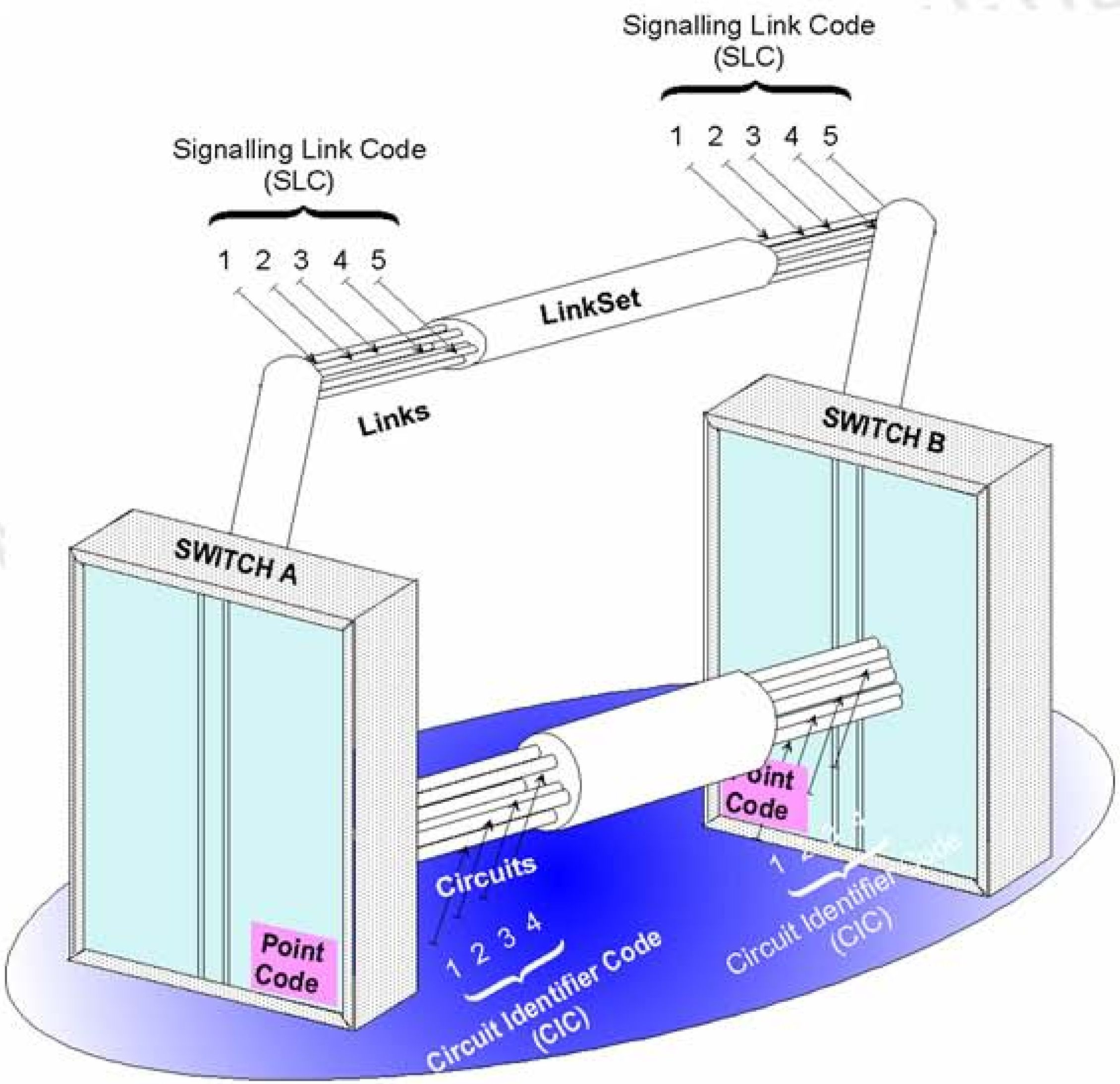
SS7 Channels (Links) and Circuits Identification

- SS7 channels connecting two adjacent SS7 points are identified in an univocal way by a Signaling Link Code (SLC)/Signaling Link Selection (SLS).

- A link that supports Signaling link must have the same SLC in both of its two connected points.

- SS7 circuits are identified by a Circuit Identifier Code (CIC).



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MTP2 Functions

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MTP2 Functions

1. Signaling Frame Delimitation
2. Signaling Frame error Detection
3. Signaling Frame error Correction
4. Error Rate Monitoring (SUERM)
5. Link Flow Control
6. Signaling Frame Alignment
7. Signaling Frame Initial Alignment

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Signaling Frame Delimitation

- SS7 uses the flag $7E_{16} = (0\ 1\ 1\ 1\ 1\ 1\ 1\ 0)_2$ to delimitate the beginning and the end of each frame since their lengths are variables.

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Signaling Frame error Detection

- Calculates the Check sum.

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Signaling Frame Error Correction

- Sent frame is stored in a retransmitting buffer until the positive acknowledge, which will activate its suppression. Otherwise, it is retransmitted.
- If the error rate becomes greater than predefined limits, MTP2 reports the failure to Message Transfer Part 3 (MTP3), which subsequently orders MTP2 to remove the link from service.
- Conversely, initial alignment procedures are used to bring links into service

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Signaling Frame Error Rate Monitoring (SUERM)

- By SUERM, each erroneous frame increments the corresponding counter.
- Each 256th frame correctly received decrements the counter if > 0.
- When the counter reaches the threshold = 64, the channel is out of order and the alignment procedure is performed.

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Flow Control

- A congested entity doesn’t send any acknowledge (positive or negative).
- It sends an LSSU every 80 or 120 ms as long as the congestion persist.
- If the congestion persist more than 3 to 6 sec, failure indication (level 3).

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Signaling Frame Alignment

- There is lost of alignment if:
  - SS7 frames are not sequentially received.
  - SS7 frame is received with a number of octets different from the frame type.
  - A frame is not multiple of an octet.
  - More than consecutive six “1” is received.
- Consequence: data are removed until the reception of a flag

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Signaling Frame Alignment

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- The purpose of the signaling link alignment procedure is to establish SU timing and alignment *so that the SPs on either side of the link know where SUs begin and end.*
- This procedure ensures that both ends have managed to correctly recognize flags in the data stream.
- *Alignment is based on the obligated exchange of status information and a proving period to ensure that SUs are framed correctly.*

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Signaling Frame Alignment

- There are two forms of alignment procedures:
  - Emergency procedure: used when the link being aligned is the only available link for any of the routes defined within the SP.
    - If the local SP detects an emergency alignment situation, emergency alignment is used regardless of the type of the alignment received from the distant SP.
    - Similarly, emergency alignment is used if an emergency alignment is received from the distant SP, even when the local MTP3 indicates a normal alignment situation (more than one in-service link between the two adjacent nodes).
  - Normal alignment procedure: when there are more than one link available

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MTP2 Message Types

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MTP Message Types

- SS7 networks are packet switched networks.
- Information is passed between nodes are called Signal Units (SUs).
- There are three types of SUs:
  - **FISU**, Fill-In Signal Unit: acts as a flag and is continuously sent when there is no other information to send.
  - **LSSU**, Link Status Signal Unit: used to indicate the status of a specific link.
  - **MSU**, Message Signal Unit: SS7 frames for messages.
- SS7 network management uses all three types of signal units whereas information is sent using only one type of signal unit (MSU).

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MTP Message Types

- FISUs and LSSUs are used only for MTP2 functions.
- MSUs also contain the same MTP2 fields, but they have two additional fields filled with information from MTP3 and Level 4 users that contain the real signaling content.

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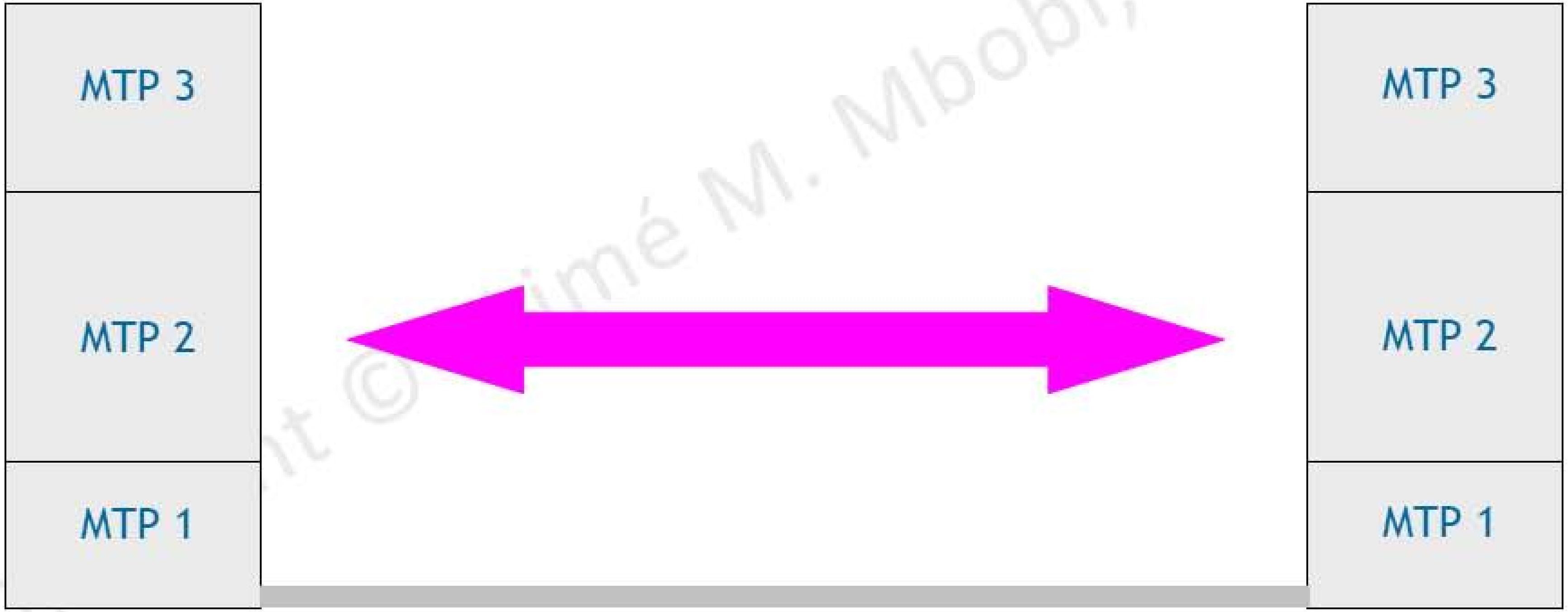
FISU



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FISU

- Carries only basic level 2 information (Ack of signal unit receipt by a pair SP).
- When the channel is idle, FISU are transmitted continuously from one end to another (2 ways).
- FISU is used by MTP to monitor error rates on links, this allows SS7 to be highly reliable as it can detect link quality even when idle.

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FISU

- A CRC is calculated for each FISU, allowing both signaling points at either end of the link to continuously check signaling link quality.
- This check allows faulty links to be identified quickly and taken out of service so that traffic can be shifted to alternative links, thereby helping meet the SS7/C7 network's high availability requirement

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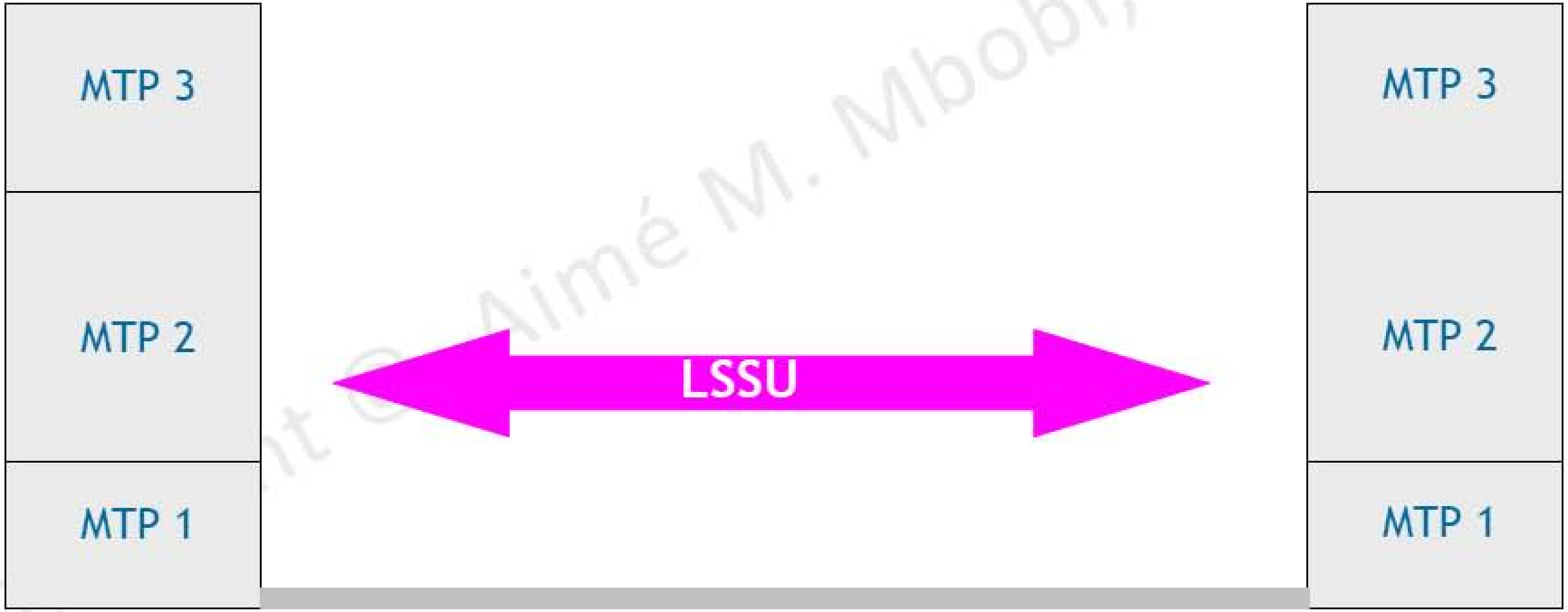
FISU



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LSSU

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- The link status controls link alignment, indicates the link's status, and indicates a signaling point's status to the remote signaling point.
- No information traffic is carried on a link when LSSU are sent.
- In case of possible dysfunction, the concerned SP sends an LSSU that carries one or two octets of link status information.

LSSU

- After the fault is cleared, the transmission of LSSUs ceases, and normal traffic flow can continue.
- As with FISUs, only MTP2 of adjacent signaling points exchanges LSSUs
- FISUs and LSSUs are neither acknowledged nor resent if corrupt; however, the error occurrences are noted for error rate monitoring purposes.

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FISU Message Format

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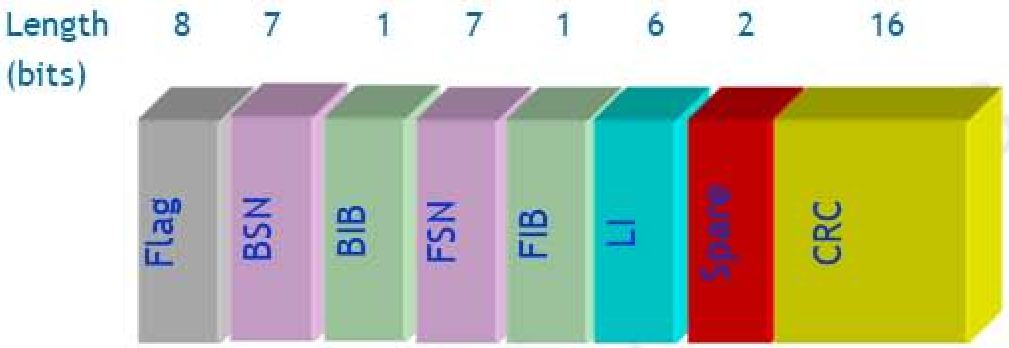
Flag $7E_{16} = (01111110)_2$



- This sequence of bits cannot be initiated anywhere in the frame.
- Before a flag is attached for transmitting, the SU is scanned, and a 0 is inserted after every sequence of five consecutive 1s.
- This solves the problem of false flags
- The receiving MTP2 carries out the reverse process by removing any (01111110) sequence by adding a zero-bit after any sequence of five one-bits to restore the original contents of the message.

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FISU Message Format

Example

Message to transfer

10010101110010101000110111111011000101010110101001

Message really transferred

01111110 100101011100101010001101111101011000101010110101001 01111110

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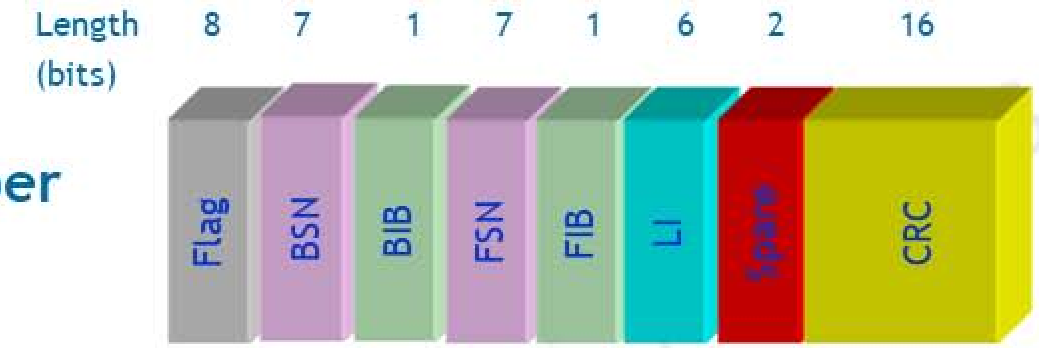
FISU Message Format

Forward Sequence Number (FSN)



- Contains the sequence number of the SU (MSU or LSSU).
- When an SU is ready for transmission, the SP increments the FSN by 1.
- FSN = 7, then 0 <= MTP2 window = 2^7-1 = 127.
- A n SP can anticipate 128 SU before requiring acknowledge.

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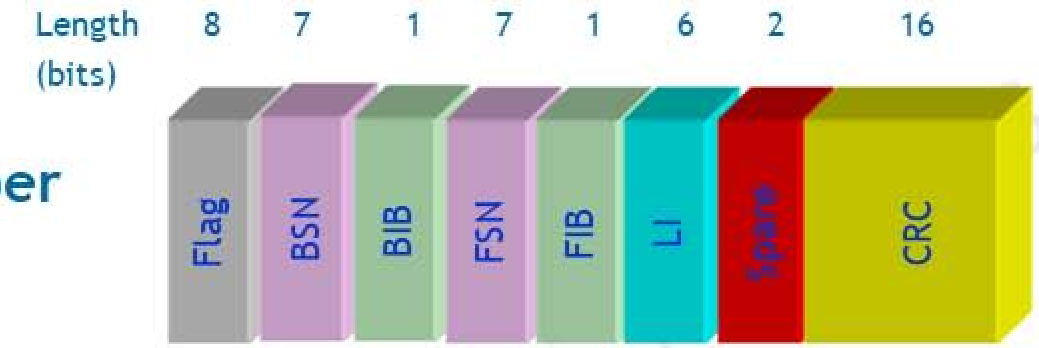
FISU Message Format

Forward Sequence Number (FSN)



- FSN = FSN + 1
- The FSN value uniquely identifies the MSU until the receiving SP accepts its delivery without errors and in the correct sequence.
- *FISUs and LSSUs are not assigned new FSNs; instead, they are sent with an FSN value of the last MSU that was sent*

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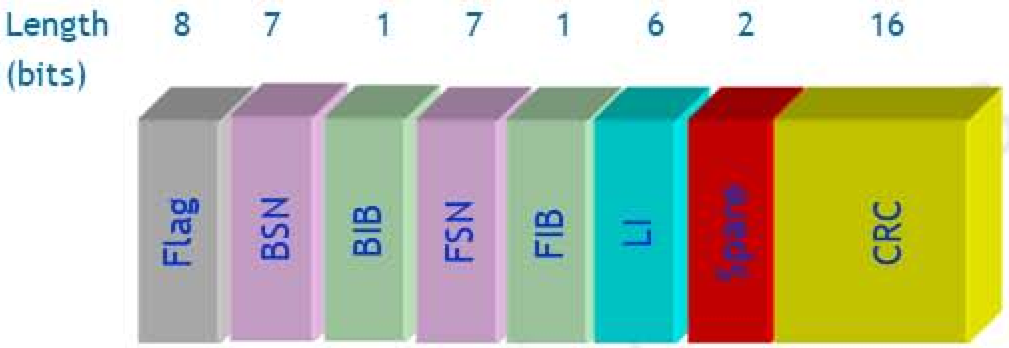
FISU Message Format



Backward Sequence Number (BSN)

- Contains the sequence number of the SU being acknowledged.
- Acknowledge the receipt of all previously received SU by the remote SP.
- If an SU is received with a BSN that does not equal the previously sent BSN or one of the FSNs in the retransmission buffer, it is discarded.
- If an incorrect BSN is received three consecutive times, MTP2 informs MTP3 that the link is faulty, therefore resulting in an order for MTP2 to remove the link from service

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FISU Message Format

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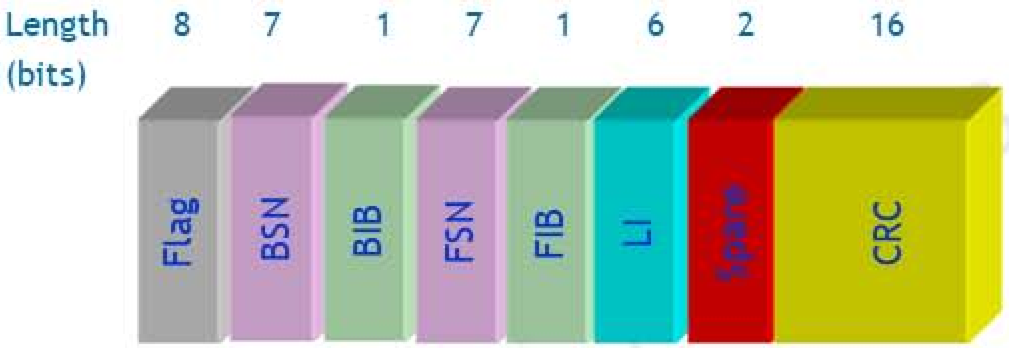
Backward Indicator Bit (BIB)



- When the BIB in the received SU has the same value as the FIB that was sent previously, this indicates a positive acknowledgment
- When the BIB in the received SU is not the same value as the FIB that was sent previously, this indicates a negative acknowledgment (when toggled).

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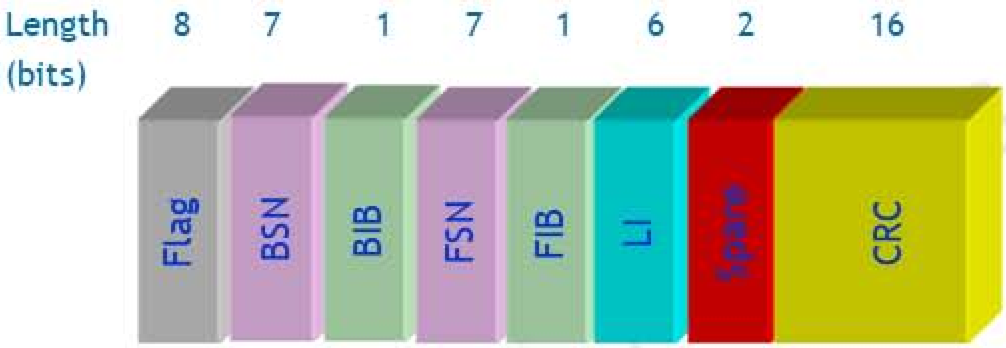
FISU Message Format

Forward Indicator Bit (FIB)



- The FSN of receiving MU is copied into BSN of the next available MU scheduled for transmission back.
- PS checks the CRC (if correct, don't toggle the BIB and send BSN. If not, toggled BIB and send BSN).
- When SP receives a MU with BIB toggled, it retransmits all forward MU, beginning by the MU with the FIB toggled.

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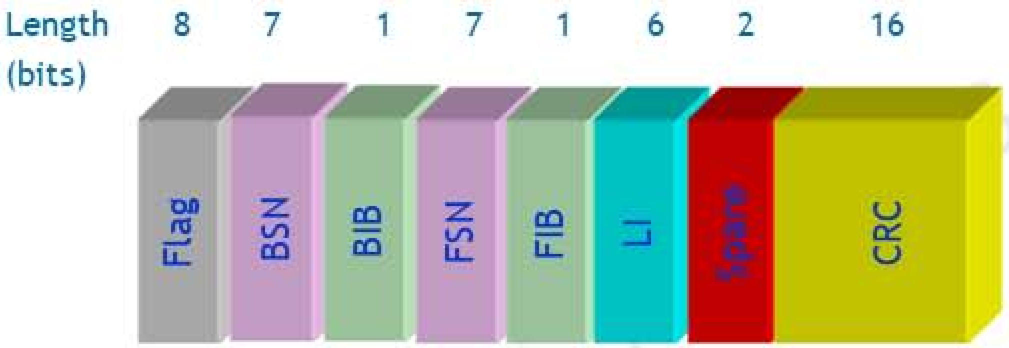
FISU Message Format



Forward Indicator Bit (FIB)

- At the start of retransmission, FIB is inverted so that it equals the BIB again
- The new FIB is maintained in subsequently transmitted SUs until a new retransmission is required.
- If an SU is received with a toggled FIB (indicating the start of retransmission) when no negative acknowledgment has been sent, the SU is discarded.
- If this occurs three consecutive times, MTP2 informs MTP3 that the link is faulty, resulting in an order for MTP2 to remove the link from service.

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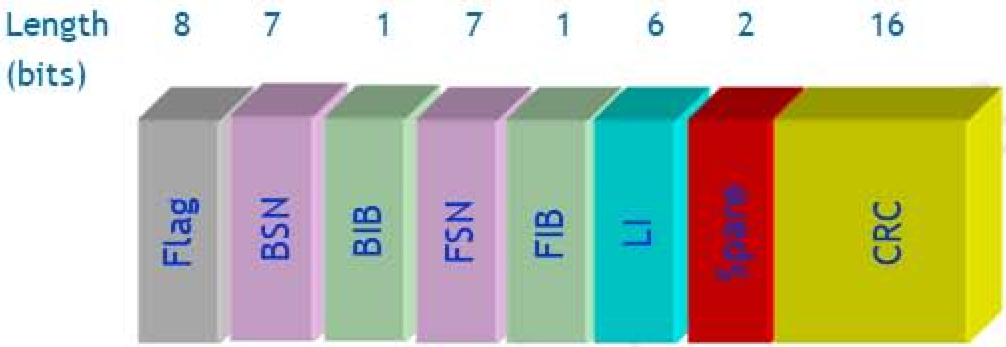
FISU Message Format

Length Indicator (LI)



- Layers above the MTP can handle larger data streams than the MTP; however, these streams must be segmented into MSUs at MTP2 for transmission over the signaling link.
- If the MSU size is greater than 62 octets, the LI is set to the value of 63; therefore, an LI of 63 means that the SIF length is between 63 and 272 octets.

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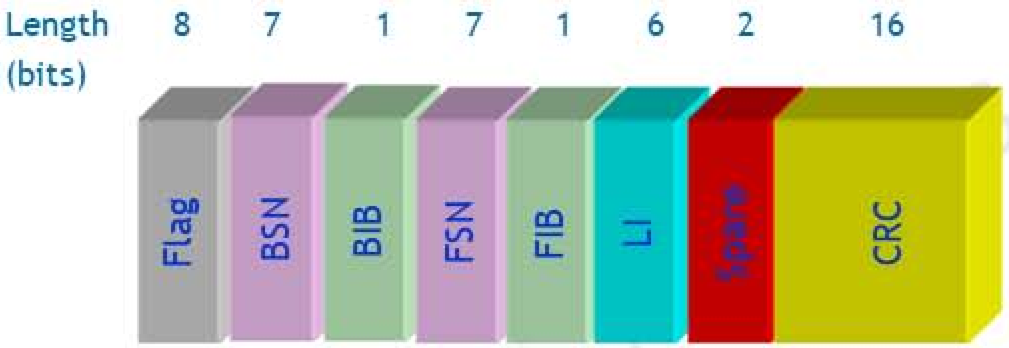
FISU Message Format

Length Indicator (LI)



- The LI indicates the number of octets between the LI and the CRC fields.
- LI contains 6 bits that determine the SU type:
  - Since 2^6-1 = 63
  - LI = 0: FISU
  - LI = 1 or 2: LSSU,
  - LI = 3 … 62: MSU (real size)
  - LI = 63: MSU (any size <=272 octets)

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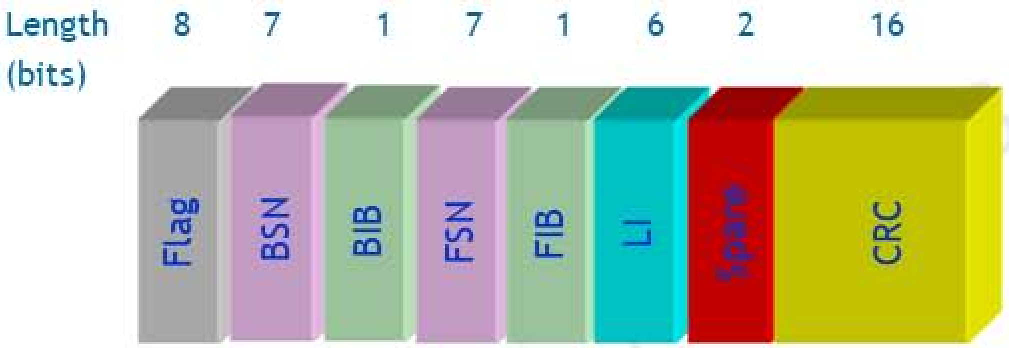
FISU Message Format

Length Indicator (LI)



- MTP2 uses the LI information to determine the type of SU with minimum processing overhead
- The inaccuracy of the indicator above 62 octets is not an issue.
- MTP2 adds an overhead of six octets along with one additional octet for the MTP3 SIO when creating each MSU.
- This brings the total maximum size of a transmitted SU to 279 octets (272 maximum SIF size plus seven for MTP2 overhead and the SIO).

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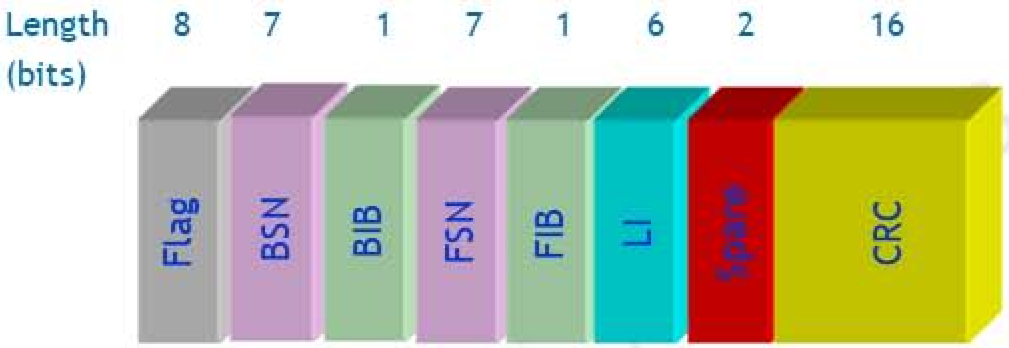
FISU Message Format

Check Sum



- Division of the frame polynomial by the generator polynomial ($X^{16}+X^{12}+X^{5}+1$).
- Complement by 1 of the rest.
- Same calculus is done at the reception.

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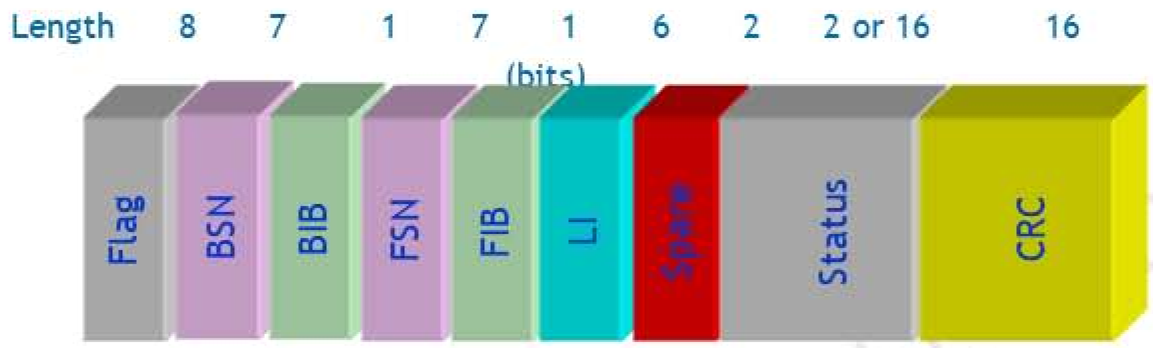
LSSU Message Format



- Currently only a single-octet SF is used, even though the specifications allow for a two-octet SF.
- From the single octet, only the first 3 bits are defined

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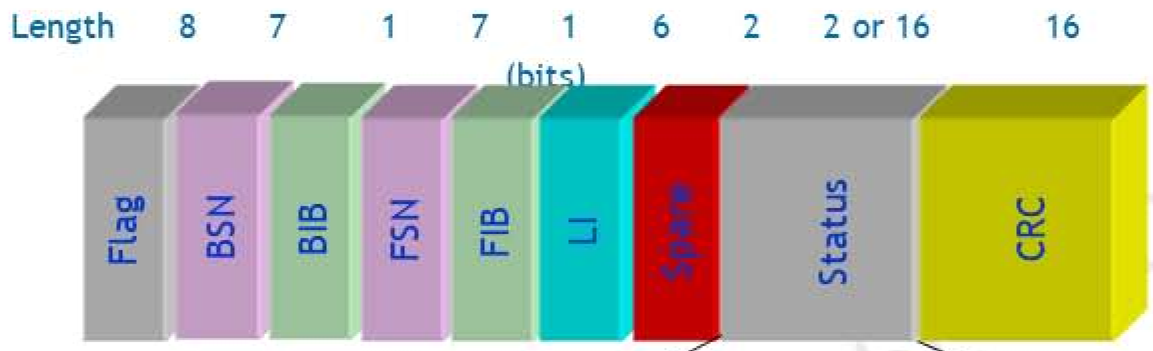
LSSU Message Format



C	B	A	Status Indication	Acronym	Meaning
0	0	0	O: Out of Alignment	SIO	Link not aligned; attempting alignment
0	0	1	N: Normal Alignment	SIN	Link is aligned
0	1	0	E: Emergency Alignment	SIE	Link is aligned
0	1	1	OS: Out of Service	SIOS	Link out of service; alignment failure
1	0	0	PO: Processor Outage	SIPO	MTP2 cannot reach MTP3
1	0	1	B: Busy	SIB	MTP2 congestion

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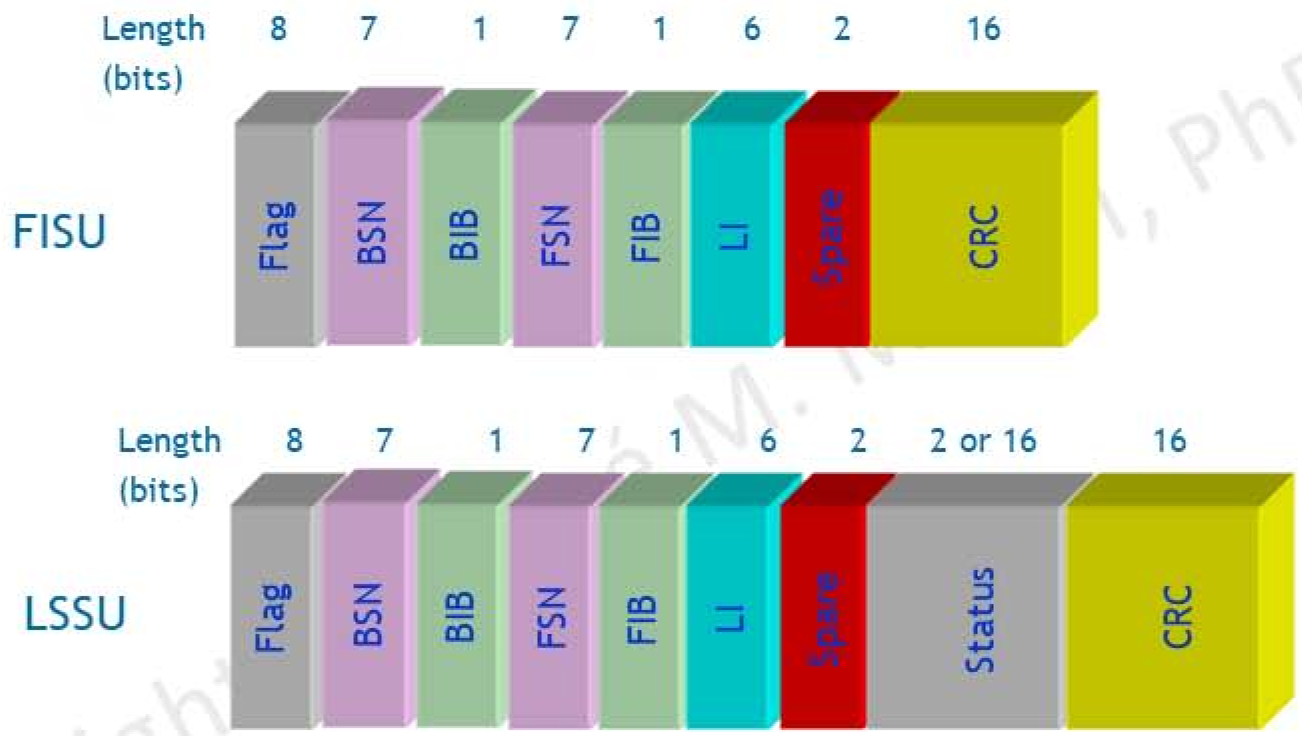
FISU and LSSU Comparison



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Alignment Status

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Alignment Status

- Idle:
  - State
    - when an SP is powered up (initial state) it
    - (first state) entered in the alignment procedure
    - that a link returns to when a procedure fails.
    - that indicates that the procedure is suspended.
  - LSSUs of out of service are continuously sent during the idle state until the link is powered down or until an order to begin initial alignment is received from MTP3.
  - The FIB and the BIB of the LSSUs are set to 1, and the FSN and BSN are set to 127

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Alignment Status

- Not Aligned:
  - When MTP2 receives an order to begin initial alignment, the SP changes the status of the transmitted LSSUs to indication SIO (out of alignment) and starts the timer T2.
  - If T2 expires, the status of the transmitted LSSUs reverts to SIOS.

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Alignment Status

- **Aligned:**
  - During T2 SIO, if SIN (normal alignment) or SIE (emergency alignment) is received from the remote SP, T2 is stopped, and the transmission of SIO ceases.
  - SP then transmits SIN or SIE, depending on whether normal or emergency alignment has been selected and timer T3 is started.

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Alignment Status

- Aligned:
  - The link is now aligned, indicating that it can detect flags and signal units without error.
  - If T3 expires, the alignment process begins again, transmitting LSSUs with a status field of SIOS.
  - The aligned state indicates that the link is aligned and can detect flags and signal units without error.

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Alignment Status

- Proving:
  - Proving period is governed by T4, and the Alignment Error Rate Monitor (AERM) is used during this period.
  - The proving period is used *to test the signaling link's integrity*.
  - FISUs are sent and errors (CRC and SU acceptance) are counted.
  - LSSUs are also sent, indicating whether this is a SIN or SIE alignment.
  - If four errors are detected during the proving period, the link is returned to state 00 (idle), and the procedure begins again

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Alignment Status

- **AERM**

- The AERM is active when the link is in the proving period of the initial alignment procedure.
- The counter is initialized to 0 at the start of the proving period and is increased for every LSSU that is received in error.
- If octet counting mode is entered during the proving period, the counter is increased for every block of N octets that is counted.

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Alignment Status

- **AERM**

- The proving period is aborted if the counter reaches a threshold value of T_i; it is reentered upon receiving a correct LSSU, or upon the expiration of the aborted proving period.
- Different threshold values T_{in} and T_{ie} are used for the normal and emergency alignment procedures, respectively.
- If the proving is aborted M times, the link is removed from service and enters the idle state.
- ($T_{in} = 4$, $T_{ie} = 1$, $M = 5$, $N = 16$)

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An Example of Transmission

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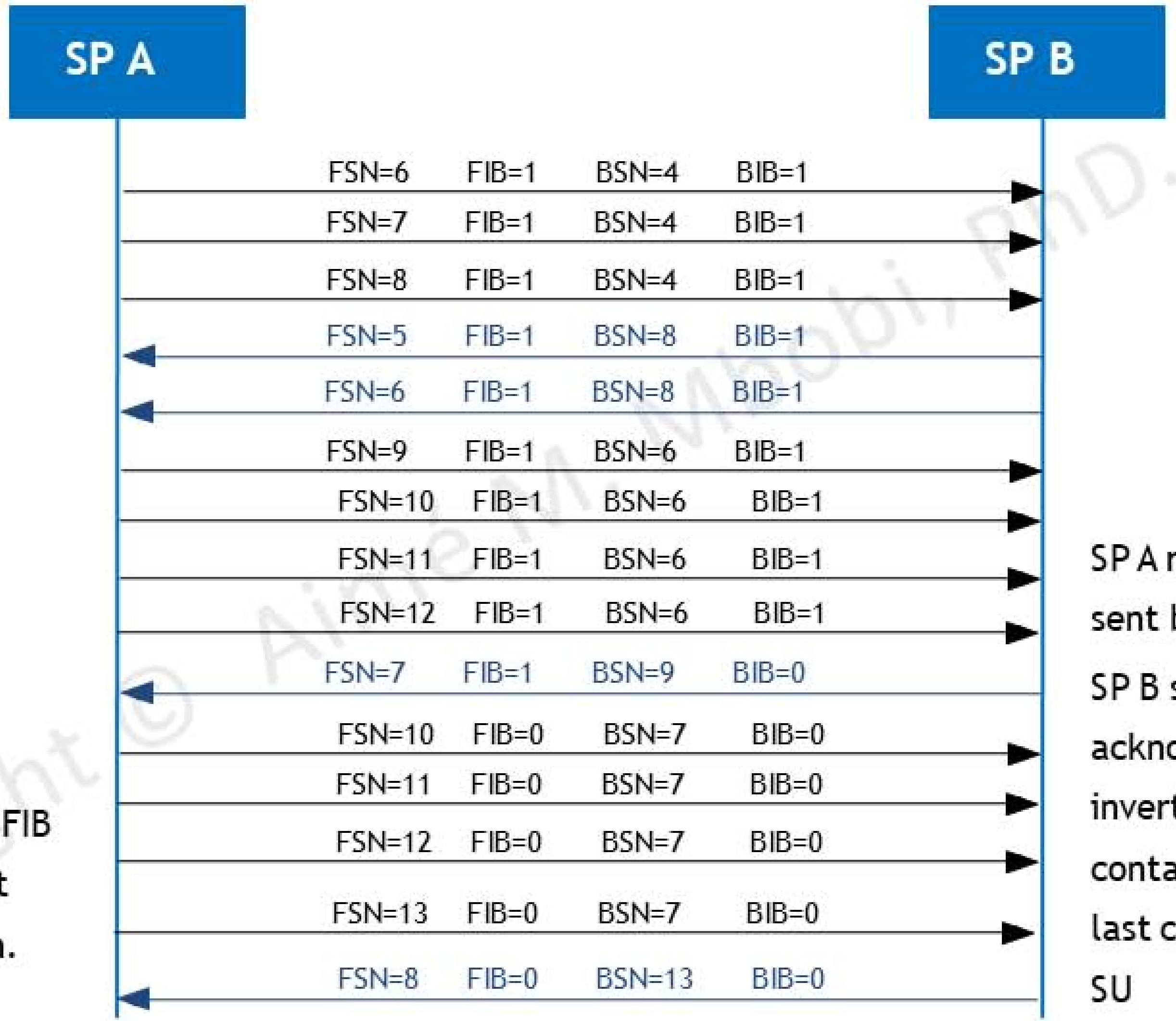
An Example of Transmission



At the start of retransmission, the FIB is inverted so that it equals the BIB again.

SP A receives the MSU sent by SP A in error.

SP B sends a negative acknowledgment. BIB is inverted, and BSN contains the FSN of the last correctly received SU

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MTP L2 Tracing

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MTP L2 Tracing

1	2	3	4	5	6	7	8		
BIB	BSN								MTP2 Header Trace
FIB	FSN								
Spare		LI							

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An Example of MTP L2 Tracing

```
 Ch#:RD3 ³ ANSI SS7         ³Flg:1     Cnt:1     Time:03:12:17.317          ³
³ 10110100 ³ BIB/BSN.......... ³ 1/52                                        ³
³ 11100000 ³ FIB/FSN.......... ³ 1/96                                        ³
³ ..111111 ³ SU type/length.... ³ MSU63                                      ³
³ 00...... ³ Spare............ ³ 0                                           ³
³ octet003  Service information octet........................................³
³ ....0011 ³ Service indicator. ³ SCCP Signalling Connection Control Part    ³
³ ..00.... ³ Message priority.. ³ 0                                          ³
³ 10...... ³ Network indicator. ³ N National network                         ³
³ octet004  Routing label.....................................................³
³ ........ ³ DPC: Net-Clstr-Mbr ³ 001-044-230                                ³
³ ........ ³ OPC: Net-Clstr-Mbr ³ 005-080-120                                ³
³ 00010110 ³ SLS.............. ³ 22                                          ³
³ octet011  SCCP Message type.................................................³
³ 00001001 ³ Headers H1/H0..... ³ UDT   Unitdata                             ³
³ ....0001 ³ Protocol class.... ³ 1                                          ³
³ 1000.... ³ Message handling.. ³ Return message on error                    ³
³ 00000011 ³ Pointer-> Called # ³ 3                                          ³
³ 00001110 ³ Pointer-> Call'g # ³ 14                                         ³
³ 00010111 ³ Pointer-> Data.... ³ 23                                         ³
³ octet016  Called Party Address..............................................³
³ 00001011 ³ Parameter length.. ³ 11                                         ³
³ .......1 ³ SSN indicator..... ³ Address contains a Subsystem Number        ³
³ ......0. ³ SPC indicator..... ³ No Signalling Point Code in Address        ³
³ ..0010.. ³ Global Title...... ³ GT includes Translation type               ³
³ .0...... ³ Routing basis..... ³ RoutingBasedOnGlobalTitleInTheAddress      ³
³ 1....... ³ Address indicator. ³ Nat'l address, coded to nat'l specification ³
³ 00000110 ³ Subsystem name.... ³ HLR                                        ³
³ 00001001 ³ Translation type.. ³ Translation type                           ³
³ ........ ³ Address digits.... ³ 2341590459443280                           ³
³ octet028  Calling Party Address.............................................³
³ 00001001 ³ Parameter length.. ³ 9                                          ³
³ .......1 ³ SSN indicator..... ³ Address contains a Subsystem Number        ³
³ ......0. ³ SPC indicator..... ³ No Signalling Point Code in Address        ³
³ ..0010.. ³ Global Title...... ³ GT includes Translation type               ³
³ .0...... ³ Routing basis..... ³ RoutingBasedOnGlobalTitleInTheAddress      ³
³ 1....... ³ Address indicator. ³ Nat'l address, coded to nat'l specification ³
³ 00000111 ³ Subsystem name.... ³ VLR                                        ³
```


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Recap on MTP2

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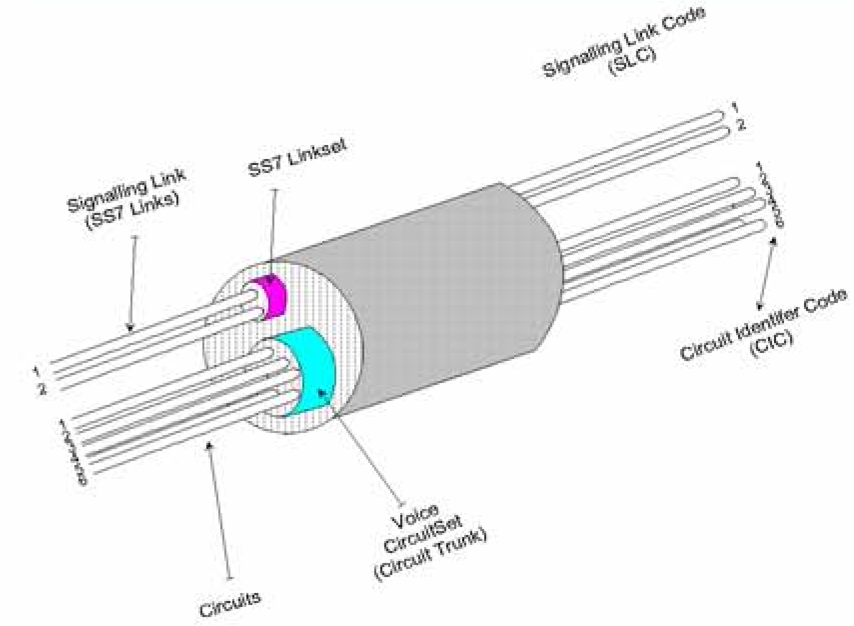
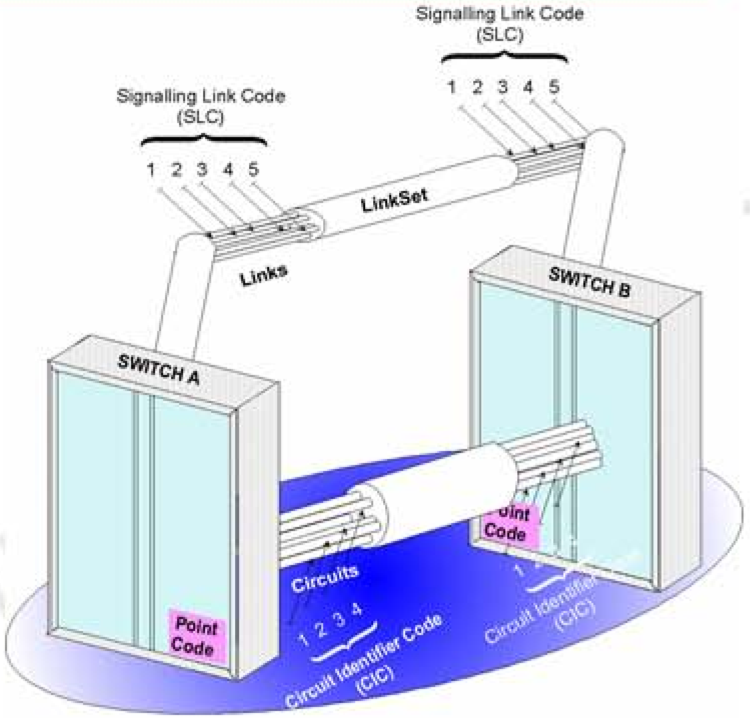
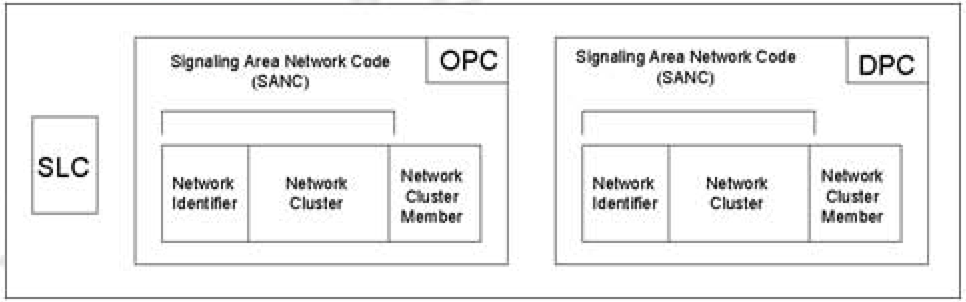
Recap on MTP2





Routing Label



OPC and DPC format

Network Identifier	Network Cluster	Network Member

N M L (N.Id 3 bits)	K J I H G F E D (N. Cl 8 bits)	C B A (N. M.3bits)
Signaling Area Network Code SANC		SP Identification (SP ID)
International Signaling Point Code (ISPC)		

Recap on MTP2

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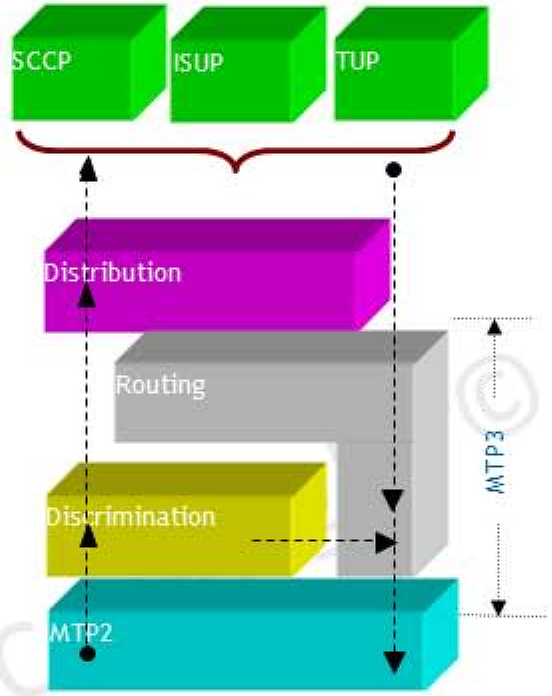
Recap on MTP2

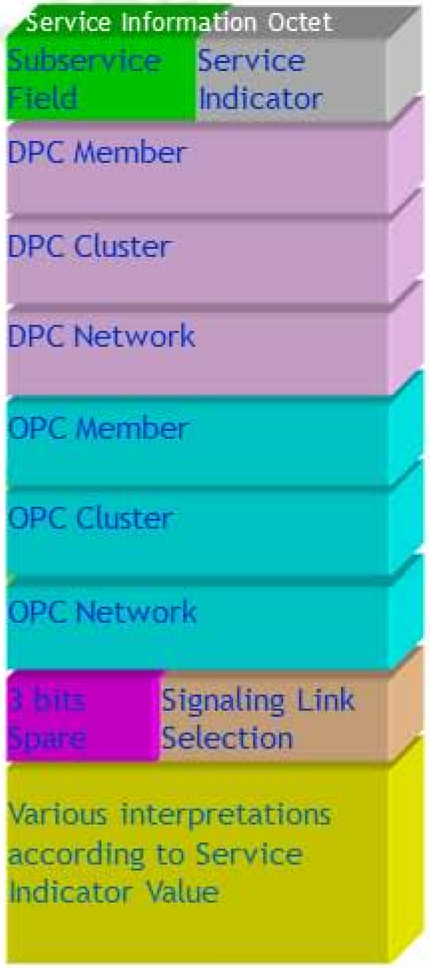


DC BA	
00 00	International Network (LP)
01 01	Spare
10 10	National Network
11 11	Reserved for National Use (HP)

Sub-Service

DCBA	Protocol
0000	Signaling Network Management
0001	Signaling Network Testing (SNT)
0011	SCCP
0100	Telephone User Part (TUP)
0101	ISUP
0110	Data User Part (DUP), call and circuit related DUP, facility
0111	registration and cance

Service Indicator



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Message Transfer Protocol Level 3 (MTP 3)

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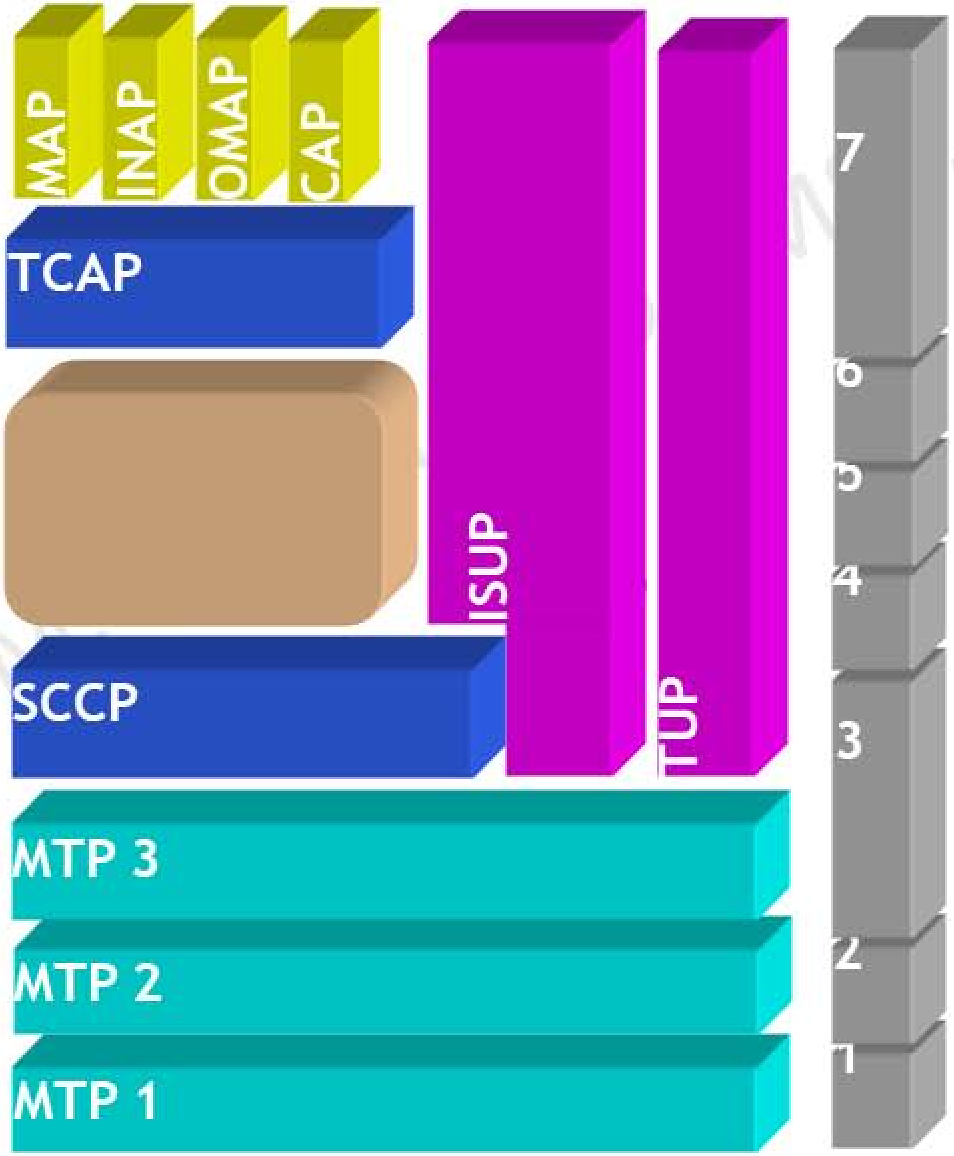
Message Transfer Protocol L3

- Similar to OSI L3 (Network).
- Specifies functions/procedures of transferring SS7 messages between 2 nodes.
- Provides message handling and traffic management functions.
- Deals with SS7 messages.
- Acts as an interface between MTP and MTP users in an SP.

MTP3



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Switch Identification

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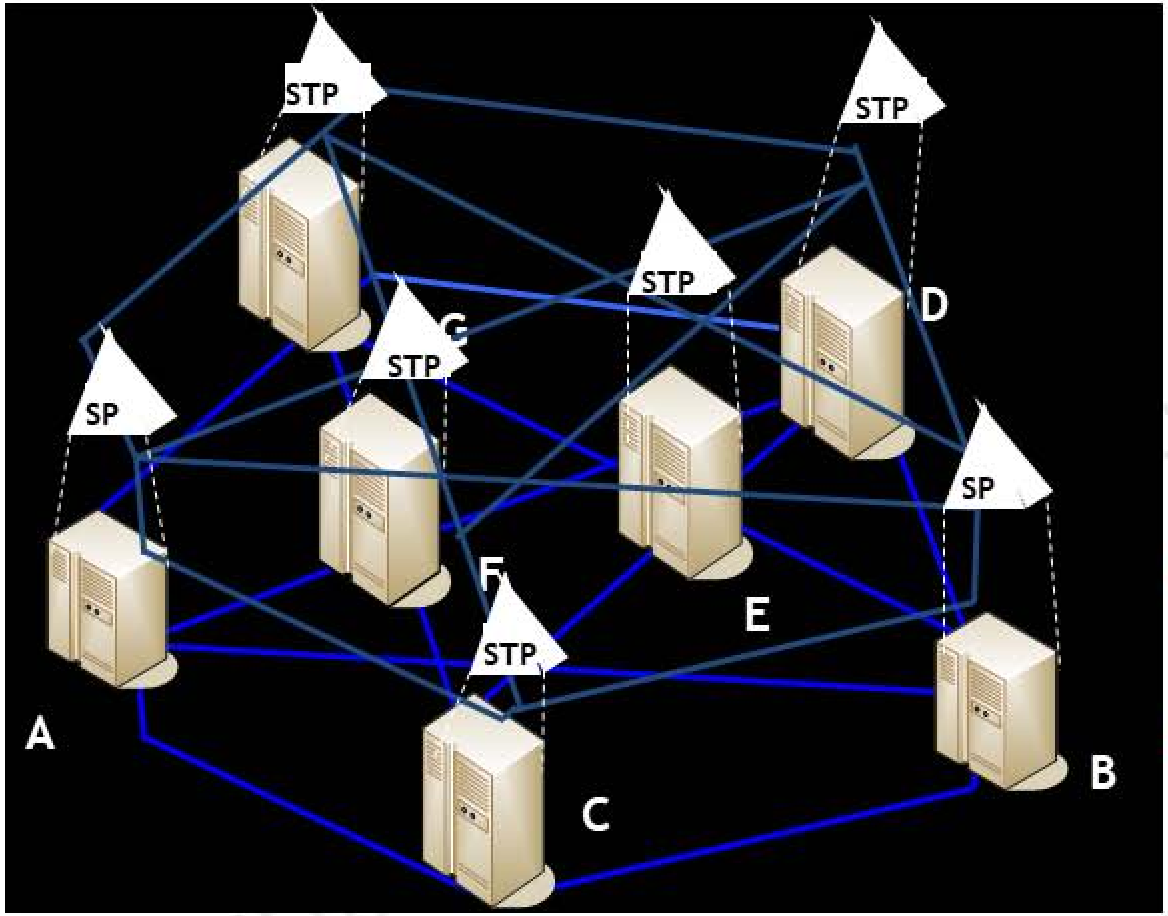
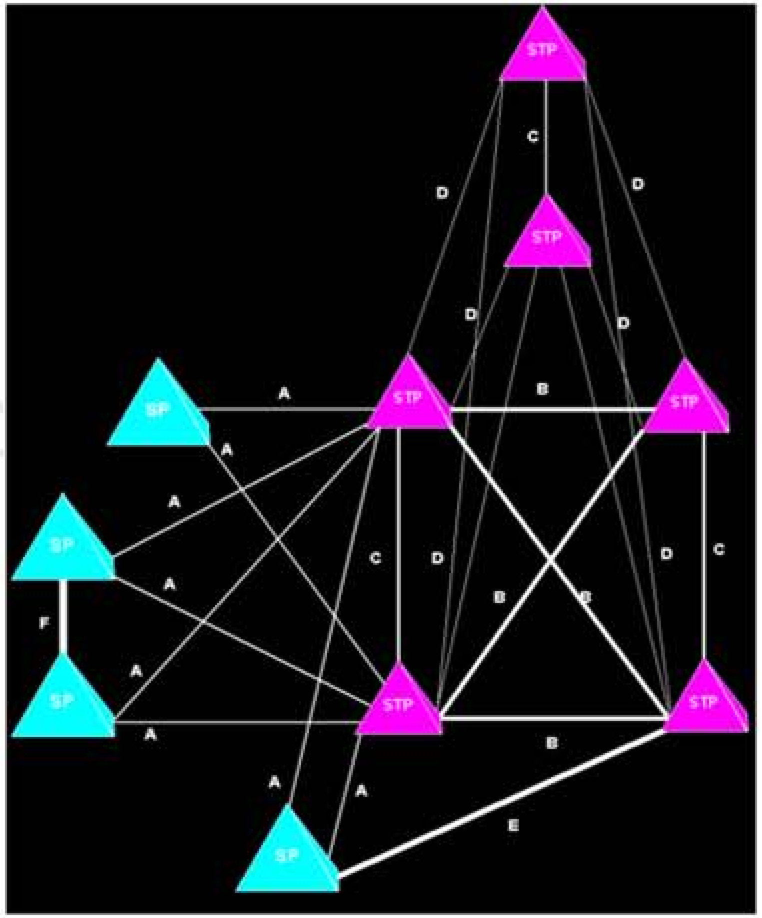
Need for Switch Identification





ABSOLUTE NEED FOR IDENTIFYING SWITCHES

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Switch Identification

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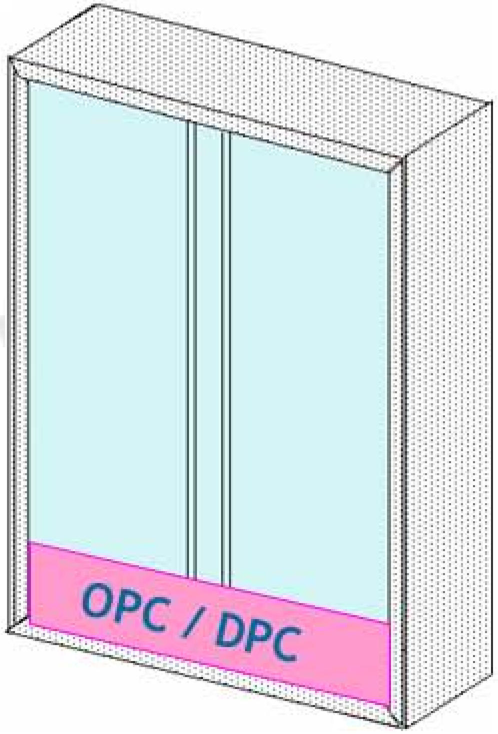
- Each Switch is identified by a unique Point Code:
  - Origination Point Code (OPC): sending SP or STP
  - Destination Point Code (DPC): receiving SP or STP



- OPC and DPC are divided into three sub fields:
  - Network Identifier: identifies world geographical areas (Zone)
  - Network Cluster: identifies an area or network
  - Network Member: identifies an SP

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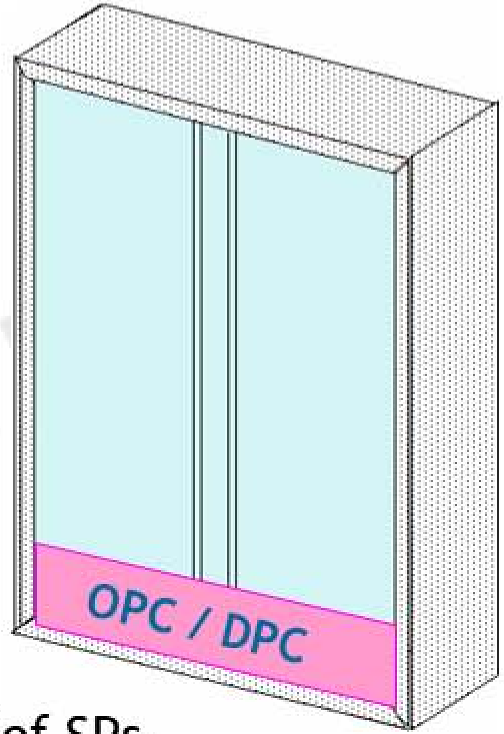
Switch Identification

OPC and DPC format

Network Identifier	Network Cluster	Network Member
3/8 bits	8 bits	3/8 bits



1. Individual SPs are identified as belonging to a "cluster" of SPs.
2. Within that cluster, each SPs is assigned a "member" number.
3. Similarly, a cluster is defined as being part of a "network".

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International Signaling Point Code (ISPC)

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International Signaling Point Code (ISPC)

N M L (N.Id 3 bits)	K J I H G F E D (N. Cl 8 bits)	C B A (N. M. 3bits)
Signaling Area Network Code		Signaling Point Identification (SP ID)
International Signaling Point Code (ISPC)		

1. ITU-T has defined six major geographical zones that represent the major areas of the world.
2. A Zone number that forms the first part of the PC represents each geographical zone

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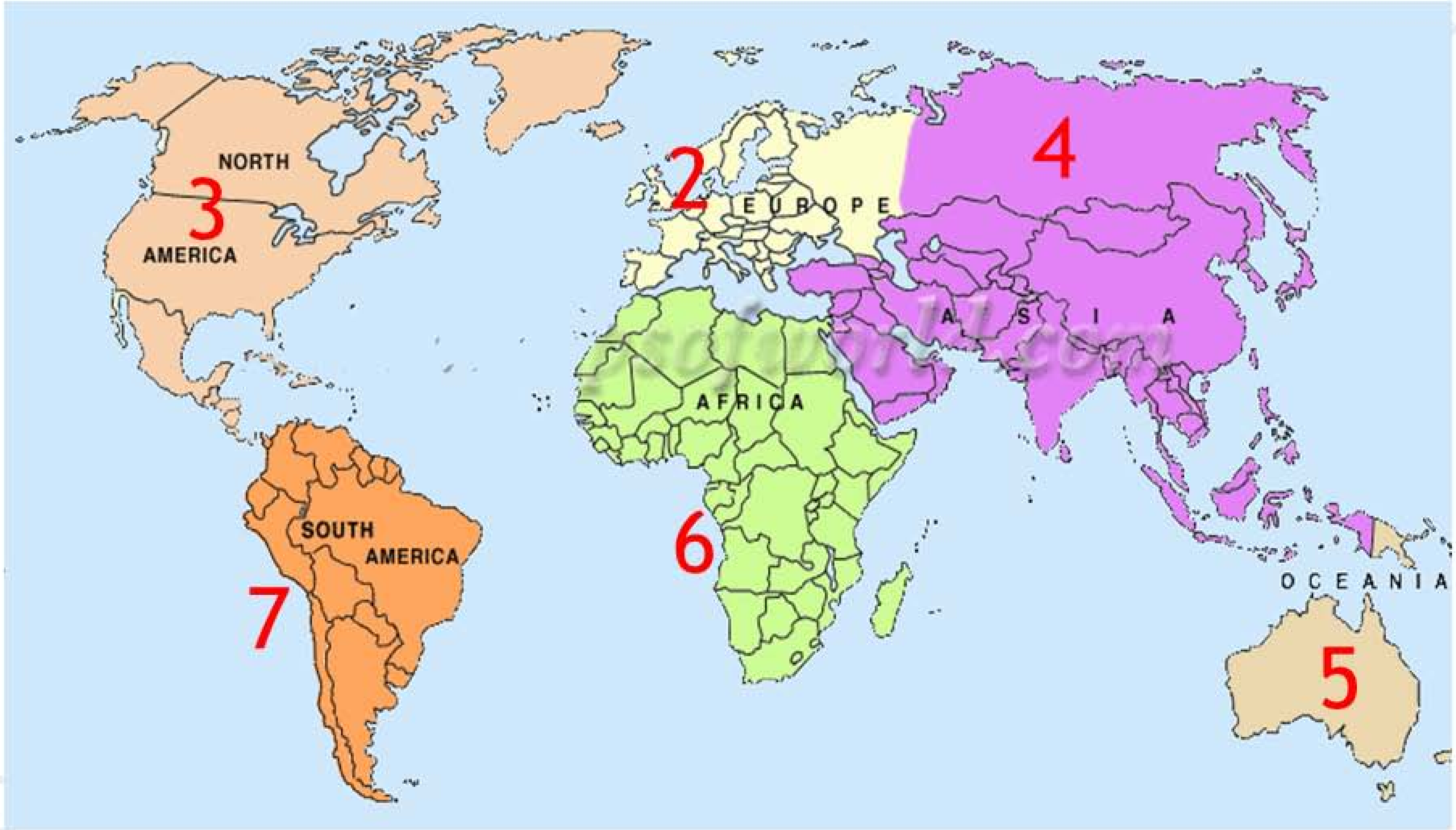
International Signaling Point Code (ISPC)



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International Signaling Point Code (ISPC)

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- The OPC is inserted into messages at the MTP3 level to identify the SP that originated the message
- National PC is unique only within a particular operator's national NTW.
- International PCs are unique only within the international network.
- Same PC can be shared by multiple operators.
- Therefore, additional routing information is provided so that the P can be interpreted correctly (international network, national network, or another operator's national network).

International Signaling Point Code (ISPC)

- All nodes that are part of the international signaling network use the ITU-T ISPC globally.
- However, national point codes are based on either the ITU national format or the ANSI format (North America).

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From Decimal PC to (NI – NC – NM) format

1. Transform the decimal OPC (DPC) into digital number
2. Group the digits by either (3, 8, 3) for ITU-T format or (8, 8, 8) for ANSI format
3. Transform each group into decimal number
4. First number = Network Identifier (NI)
5. Second number = Network Cluster (NC)
6. Third number = Network Member (NM)
7. SANC = NI + NC

NI NC NM

- Example:
- PC = $(6243)_{10}$ = $(011\ 00001100\ 011)_2$ may be stated as 3-012-3: is a Canadian PS
- PC = $(5040)_{10}$ = $(010\ 01110110\ 000)_2$ may be stated as 2-118-0: is a Russian PS
- PC = $(5088)_{10}$ = $(010\ 01111100\ 000)_2$ may be stated as 2-124-0: is a German PS

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From (NI – NC – NM) format to Decimal PC

Decimal Point Code = (2048 x Network) + (8 x Cluster) + Member

Example, for PC 3-012-3, Network = 3, Cluster = 012, Member = 3

Decimal Point Code = (2048 x 3) + (8 x 012) + 3

Decimal Point Code = 6144 + 96 + 3

= 6243

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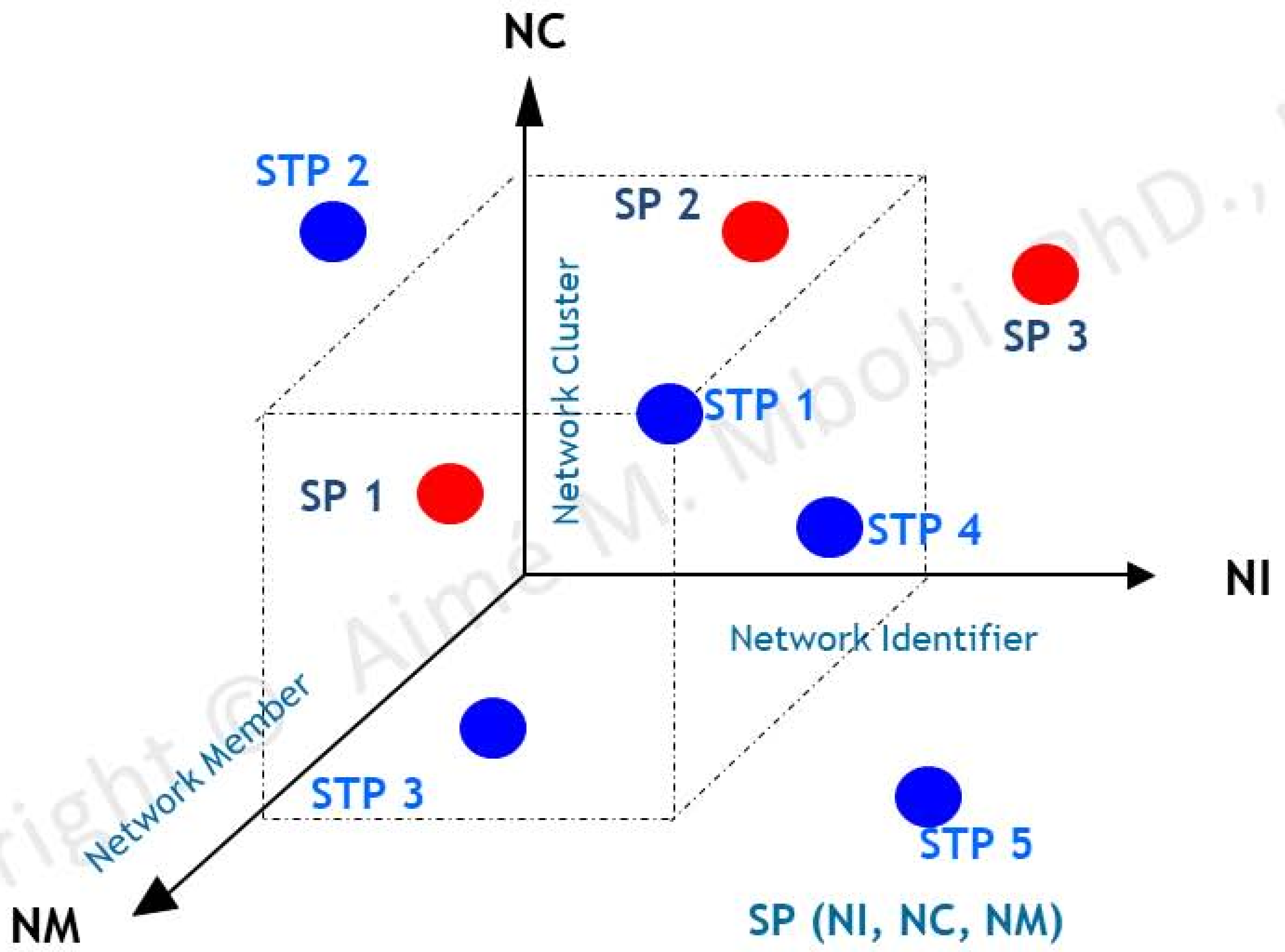
SWITCH Trihedral Abstraction



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Identifying a Gateway STP

- Gateway STP functions as an international SP and a national SP
- So, G-STP belongs to both international and national signaling networks and is identified by a specific SPC (OPC or DPC) in each of the signaling networks.

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Structure of International SS7 Network

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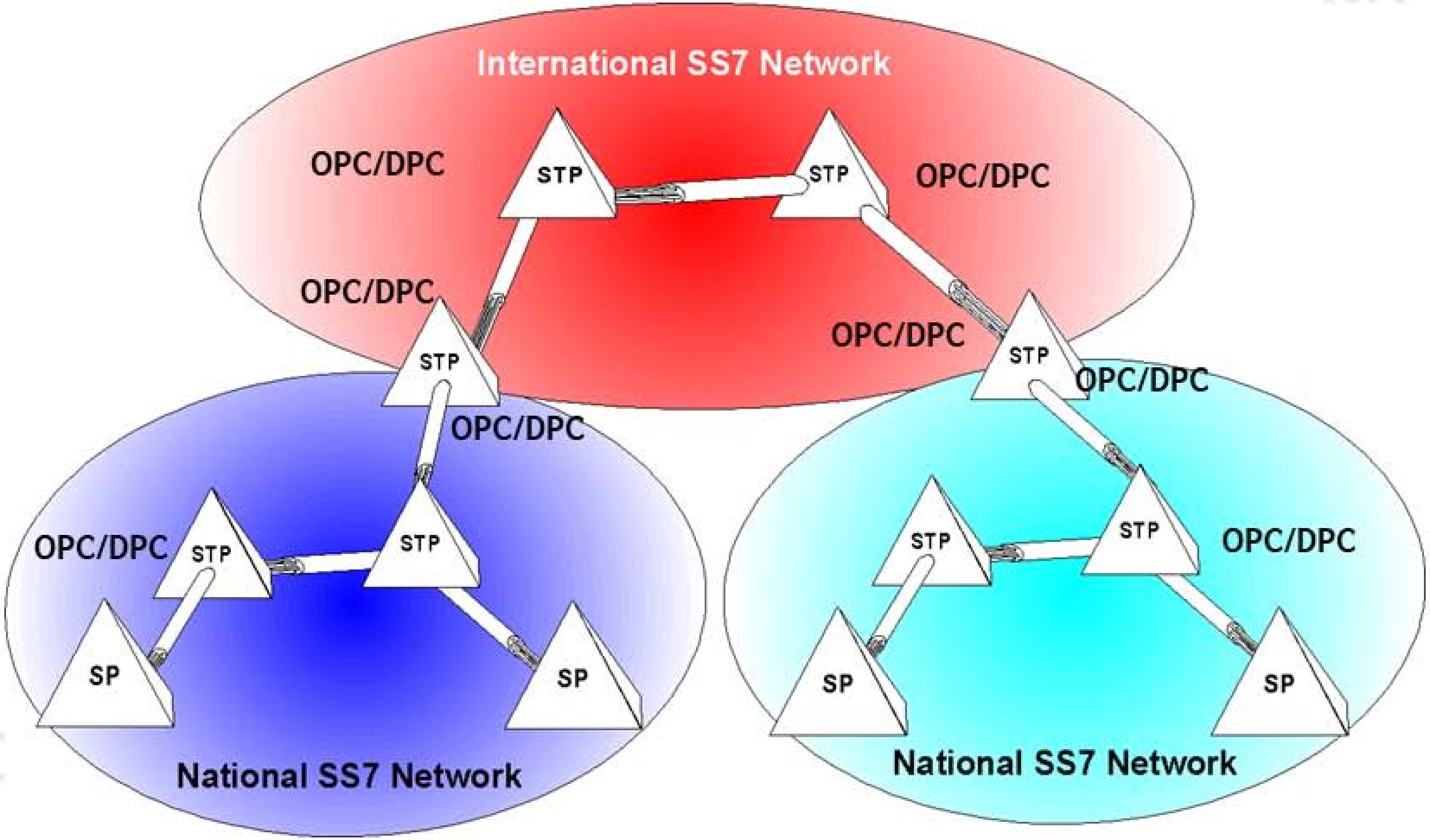
Structure of International SS7 Network



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Network, Cluster, and Member Number Assignments

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• Network, Cluster, and Member Number Assignments

- A "large" network as one that has a minimum of 75 nodes, including six STPs in the first year of operation and 150 nodes with 12 STPs by the fifth year of operation.
- Small networks are defined as those that do not meet the criteria for large networks.
- Because of the rarity of PC numbers, certain size requirement must be met in order to be attributed a Network Number.
- The smallest network is assigned the number 5.

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Network, Cluster, and Member Number Assignments

- For the purpose of Point Code allocation, networks are divided into three categories:
  - Large Networks
  - Small Networks
  - CCS Groups
- A "large" network as one that has a minimum of 75 nodes, including six STPs in the first year of operation and 150 nodes with 12 STPs by the fifth year of operation.

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Network, Cluster, and Member Number Assignments

- Small networks are defined as those that do not meet the criteria for large networks.
- Because of the rarity of PC numbers, certain size requirement must be met in order to be attributed a Network Number.
- Network ID 5 is used for CCS groups.
- These groups are blocks of Point Codes belonging to a set of signaling points that are commonly owned but do not have any STPs in the network.
- These are the smallest category of networks assigned the number 5.

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MTP3: Routing Label

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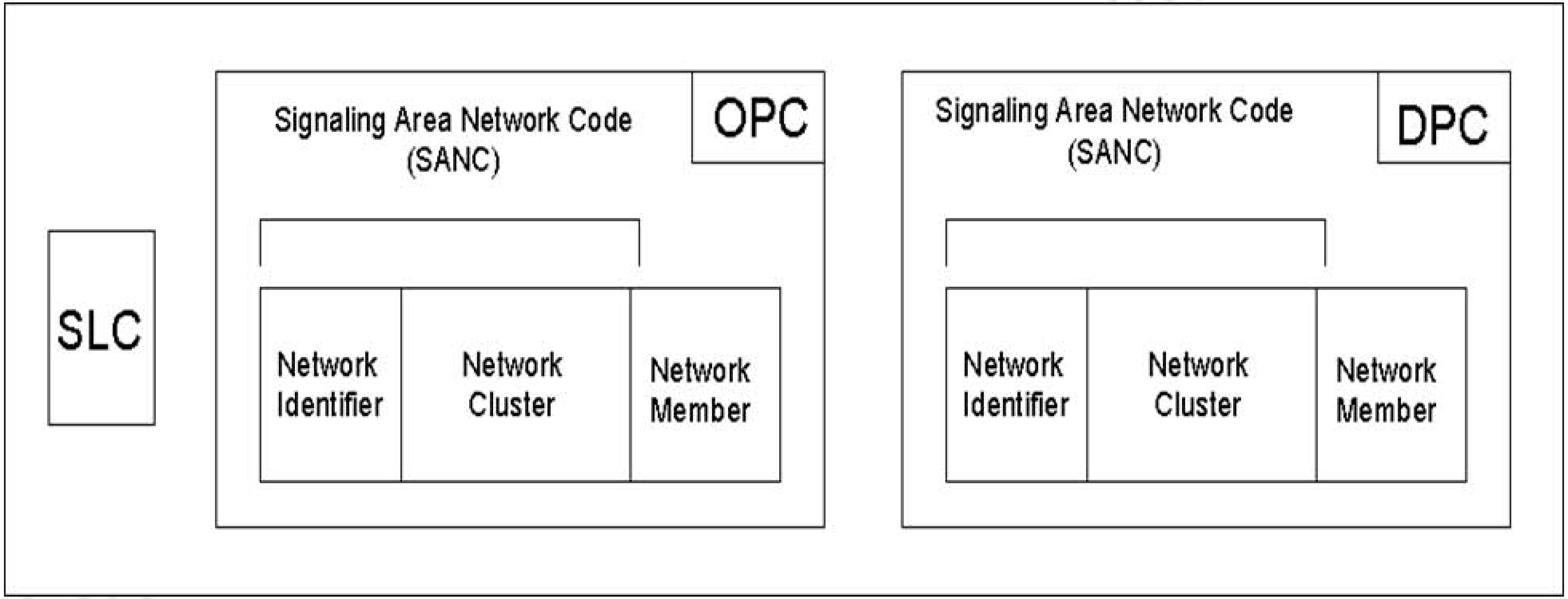
MTP3: Routing Label

- MTP 3 provides a Routing Label
- Routing is based on the destination point code (DPC).



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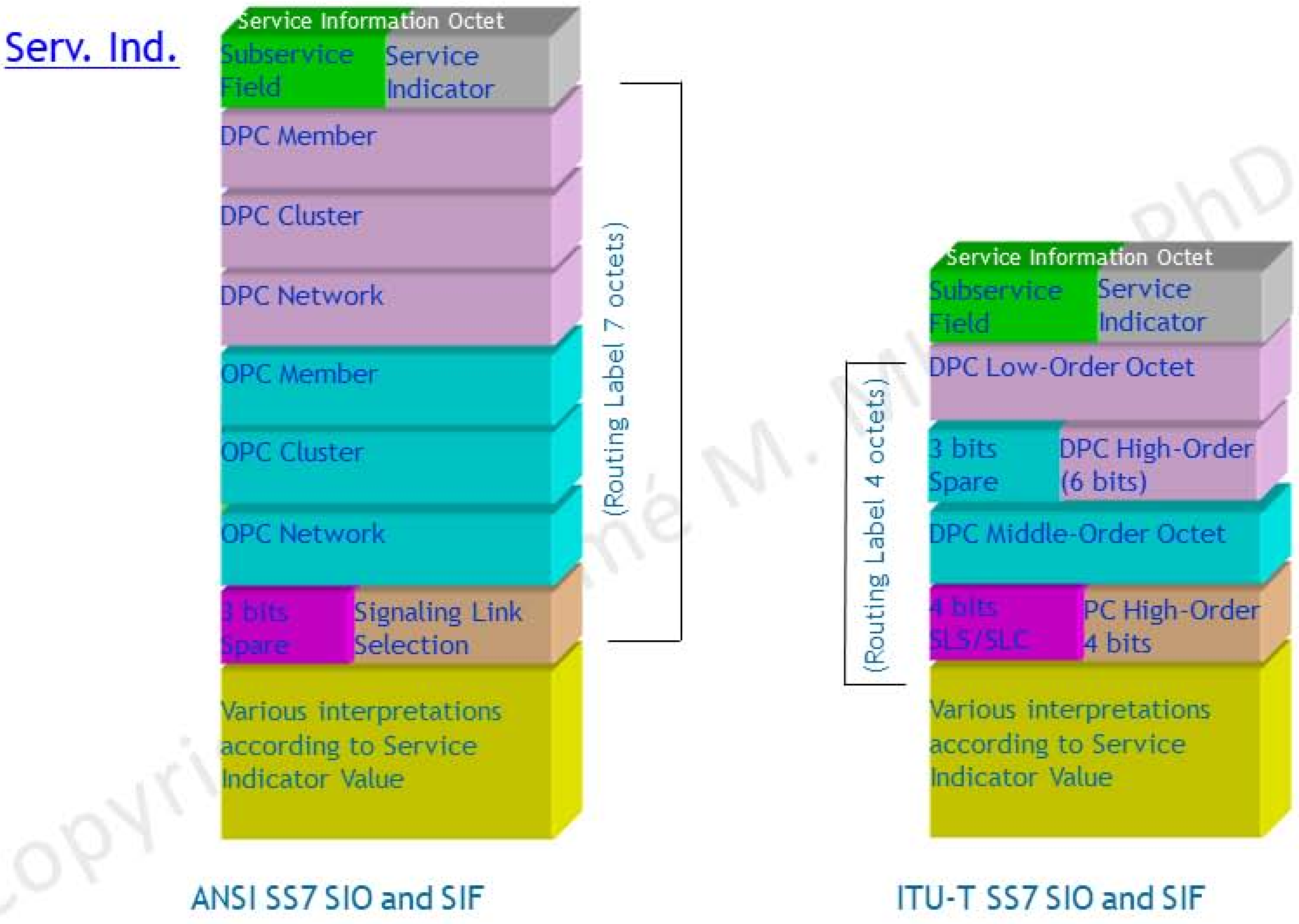
MTP3: Routing Label Structure



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Message Signal Unit

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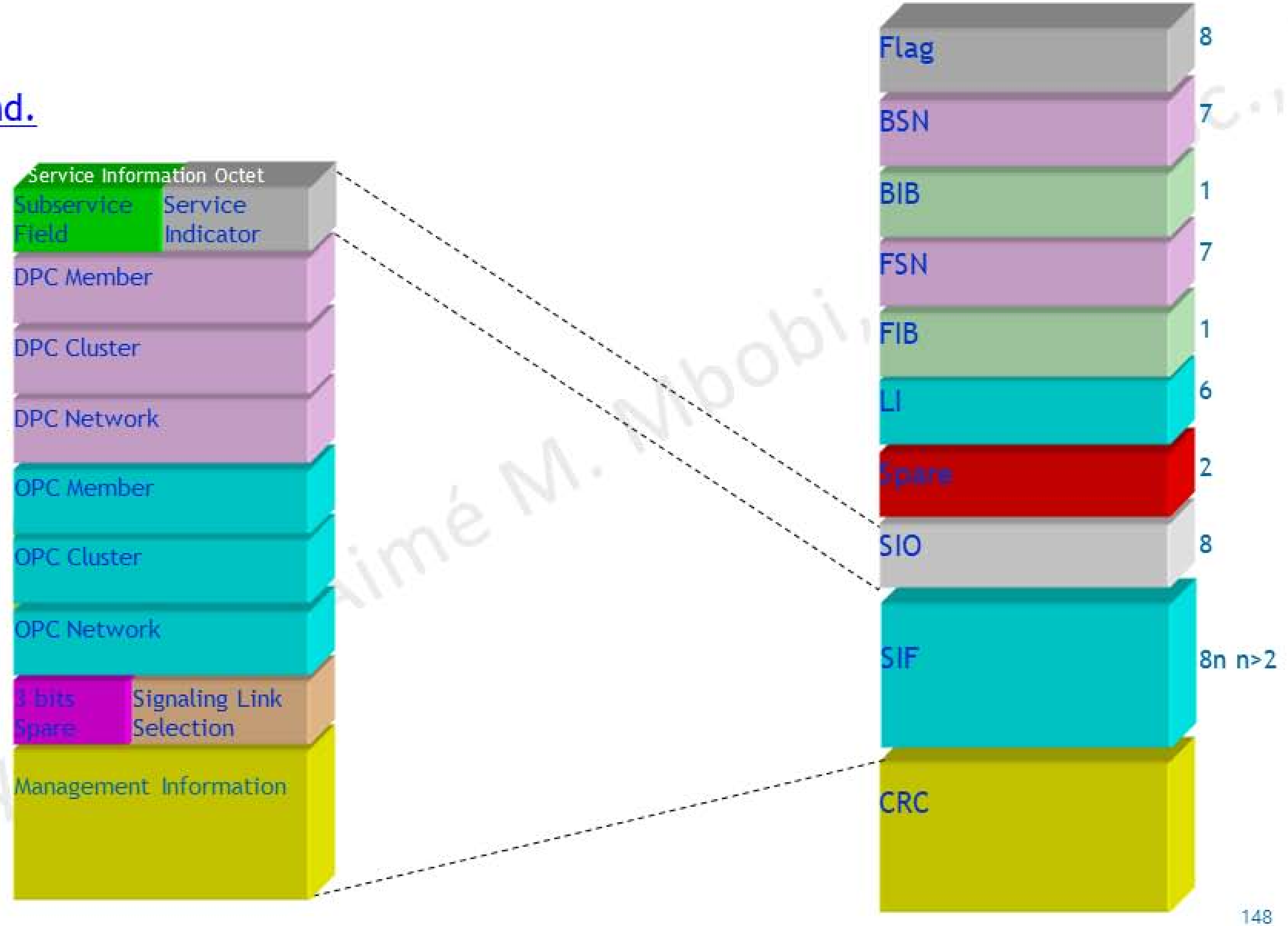
MTP3: Message Unit

Serv. Ind.



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Role of Message Unit

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- MSU carries SS7 information and consists of MTP protocol fields and two additional fields:
  - Service Information Octet (SIO) indicates type of protocol at level 4, e.g. TUP, ISUP, SCCP, and type of standard, e.g. national, international and message priority.
  - Service Information Field (SIF) used to carry control information as well as level 3 routing label. SIF can be up to 272 octets and is used by all level 4 protocols Used to transfer user data.

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Service Indicator (Overall Payload)

D C B A	Type of Payload
0 0 0 0	Signaling Network Management Messages
0 0 0 1	Signaling Network Testing and Maintenance Messages
0 0 1 0	Signaling Network Testing and Maintenance Special Messages (ANSI) or Spare (ITU-T)
0 0 1 1	SCCP
0 1 0 0	Telephone User Part
0 1 0 1	ISDN User Part
0 1 1 0	Data User Part (call and circuit-related messages)
0 1 1 1	Data User Part (facility registration and cancellation messages)
1 0 0 0	Reserved for MTP Testing User Part
1 0 0 1	Broadband ISDN User Part
1 0 1 0	Satellite ISDN User Part
1 0 1 1 – 1 1 1 1	Spare

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Sub-Service (Type of Standard)

D C B A	Protocol
0 0 0 0	International Network (Lowest Priority)
0 1 0 1	Reserved for International Use
1 0 1 0	National Network
1 1 1 1	Reserved for National Use (Highest Priority)

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SIF Structure

- Contains upper layer data, including the Routing Label.
- Can be of variable length, between 3 and 252 octets.
- In ITU-T implementations, SLS is interpreted as SLC in MTP messages.

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MTP 3 Functions

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MTP 3 Functions

- MTP 3 has three major functions:
  - Routing
  - Discrimination
  - Distribution

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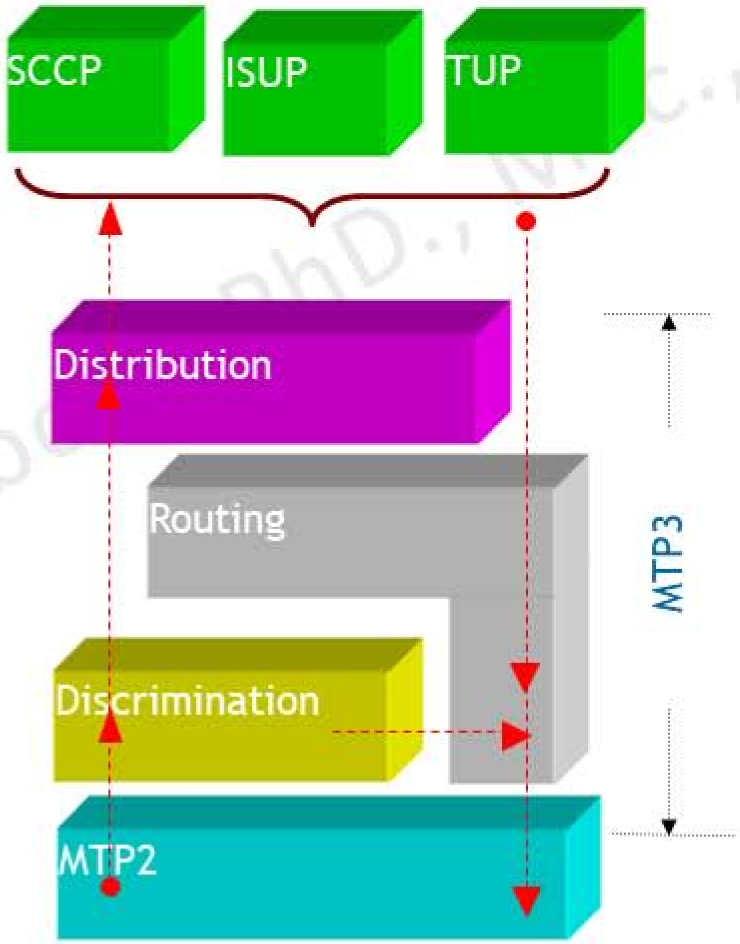
Routing, Discrimination and Distribution Functions

- When an SU reaches an SP, the discrimination function compares the DPC carried in that SU from the DPC of this SP.
- If equal, that SU is intended for this SP and transfers it to the distribution function.
- Distribution Function tests the 4 digits in Service Indicator field of the received message.



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Signaling Message-handling Functions

- Message discrimination determines upon PC if message is destined for this node.
- Message distribution passes message to appropriate application within node, and recipient is identified by Service Indicator in Service Information Octet.

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Signaling Message-handling Functions

- Message routing passes message to an appropriate link based on PC in the routing label.
- It also uses the Signaling Link Selection (SLS) field to determine which link in the link set to use.

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Routing in SS7 Networks

- Routing is based on the destination point code (DPC)
- Structure and contents of SS7 routing tables is not defined in standards.
- Approach is to design tables and software according to routing needs.

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Routing in SS7 Networks

- The DPC field is populated based on the internal routing tables.
- The SLS code is used for load sharing MTP3 User Part messages across links and linksets

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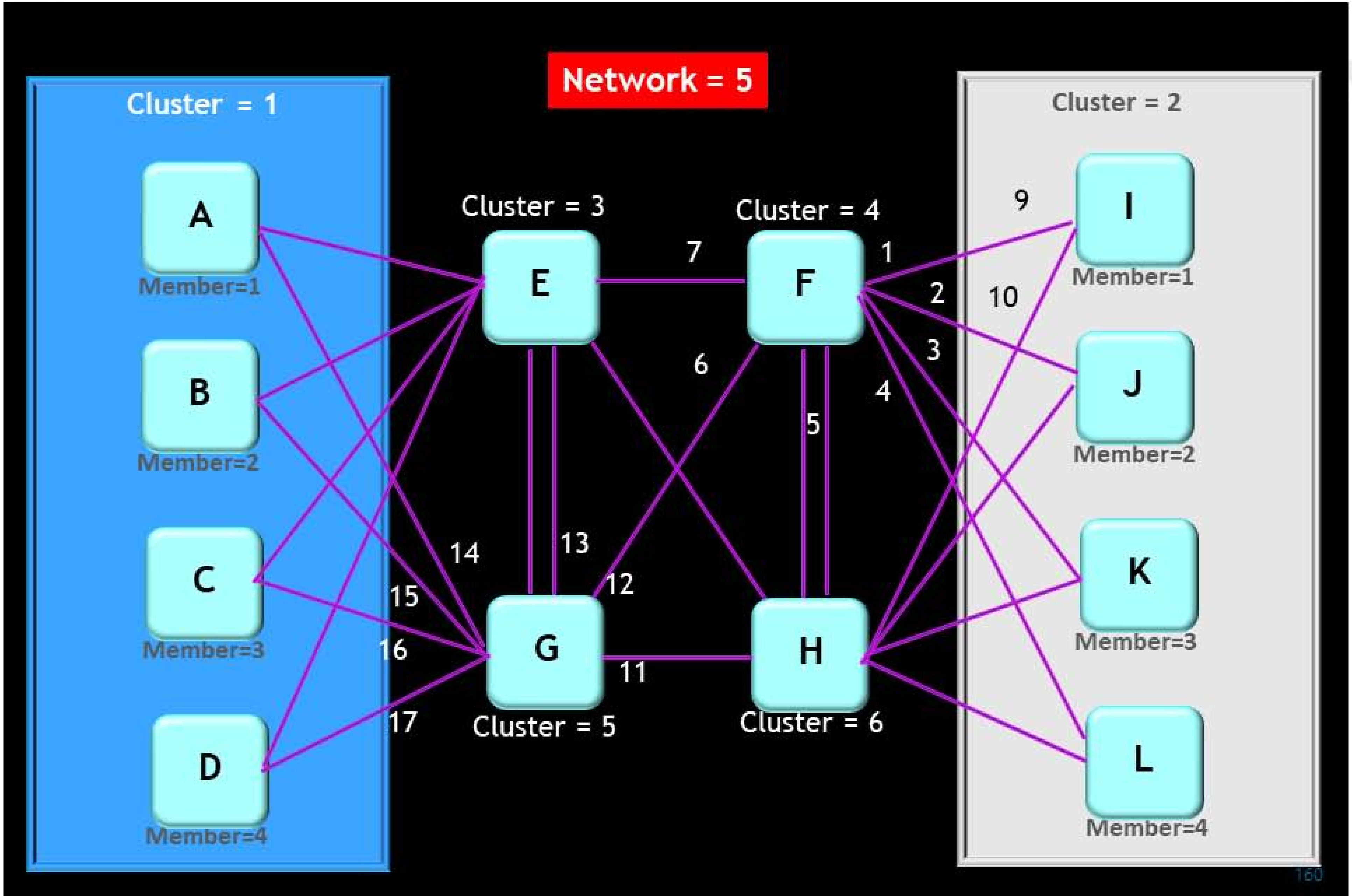
SS7 Numbering Plan



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Address Table for Topology

Signaling Point (SP)	SPC Network	SPC Cluster	SPC Member
A	0000 0101	0000 0001	0000 0001
B	0000 0101	0000 0001	0000 0010
C	0000 0101	0000 0001	0000 0011
D	0000 0101	0000 0001	0000 0100
E	0000 0101	0000 0011	0000 0000
F	0000 0101	0000 0100	0000 0000
G	0000 0101	0000 0101	0000 0000
H	0000 0101	0000 0110	0000 0000
I	0000 0101	0000 0010	0000 0001
J	0000 0101	0000 0010	0000 0010
K	0000 0101	0000 0010	0000 0011
L	0000 0101	0000 0010	0000 0100

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Routing Tables for Signaling Point I

Routing Tables for Signaling Point I

Network Code	Route	Alternate Route
0000 0101	Pointer to cluster Table	-
	9	10

Cluster Code	Route	Alternate Route
0000 0100	9	10
0000 0110	10	9

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Routing Tables for Signaling Point F

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Routing Tables for Signaling Point F

Network Code	Route	Alternate Route
0000 0101	Pointer to cluster Table	-
	To other quad pairs, not shown	-

Cluster Code	Route	Alternate Route
0000 0011	7	6
0000 0101	6	5
0000 0110	5	6
0000 0010	Pointer to member Table	-

Member Code	Route	Alternate Route
0000 0001	1	5
0000 0010	2	5
0000 0011	3	5
0000 0100	4	5

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MTP 3 Functions

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MTP L3 Tracing

1	2	3	4	5	6	7	8		
BIB	BSN								MTP2 Header Trace
FIB	FSN								
Spare		LI							
				Service Indicator				Service Information Octet	MTP3 Header Trace
		Message Priority							
Network Indicator									
DPC								Routing Label	
OPC									
				SLS					
Spare									

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Example of MTP L3 Tracing

```
 Ch#:RD3 ³ ANSI SS7            ³Flg:1     Cnt:1     Time:03:12:17.317        ³
³ 10110100 ³ BIB/BSN.......... ³ 1/52                                          ³
³ 11100000 ³ FIB/FSN.......... ³ 1/96                                          ³
³ ..111111 ³ SU type/length.... ³ MSU63                                         ³
³ 00....... ³ Spare............ ³ 0                                             ³
³ octet003  Service information octet.......................................³
³ ....0011 ³ Service indicator. ³ SCCP Signalling Connection Control Part      ³
³ ..00.... ³ Message priority.. ³ 0                                             ³
³ 10...... ³ Network indicator. ³ N National network                           ³
³ octet004  Routing label...................................................³
³ ........ ³ DPC: Net-Clstr-Mbr ³ 001-044-230                                   ³
³ ........ ³ OPC: Net-Clstr-Mbr ³ 005-080-120                                   ³
³ 00010110 ³ SLS.............. ³ 22                                            ³
³ octet011  SCCP Message type.................................................³
³ 00001001 ³ Headers H1/H0..... ³ UDT   Unitdata                                ³
³ ....0001 ³ Protocol class.... ³ 1                                             ³
³ 1000.... ³ Message handling.. ³ Return message on error                       ³
³ 00000011 ³ Pointer-> Called # ³ 3                                             ³
³ 00001110 ³ Pointer-> Call'g # ³ 14                                            ³
³ 00010111 ³ Pointer-> Data.... ³ 23                                            ³
³ octet016  Called Party Address..............................................³
³ 00001011 ³ Parameter length.. ³ 11                                            ³
³ .......1 ³ SSN indicator..... ³ Address contains a Subsystem Number          ³
³ ......0. ³ SPC indicator..... ³ No Signalling Point Code in Address          ³
³ ..0010.. ³ Global Title...... ³ GT includes Translation type                  ³
³ .0...... ³ Routing basis..... ³ RoutingBasedOnGlobalTitleInTheAddress         ³
³ 1....... ³ Address indicator. ³ Nat'l address, coded to nat'l specification  ³
³ 00000110 ³ Subsystem name.... ³ HLR                                           ³
³ 00001001 ³ Translation type.. ³ Translation type                              ³
³ ........ ³ Address digits.... ³ 2341590459443280                              ³
³ octet028  Calling Party Address.............................................³
³ 00001001 ³ Parameter length.. ³ 9                                             ³
³ .......1 ³ SSN indicator..... ³ Address contains a Subsystem Number          ³
³ ......0. ³ SPC indicator..... ³ No Signalling Point Code in Address          ³
³ ..0010.. ³ Global Title...... ³ GT includes Translation type                  ³
³ .0...... ³ Routing basis..... ³ RoutingBasedOnGlobalTitleInTheAddress         ³
³ 1....... ³ Address indicator. ³ Nat'l address, coded to nat'l specification  ³
³ 00000111 ³ Subsystem name.... ³ VLR                                           ³
```

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User Part
Integrated Services Digital Network User Part (ISUP)

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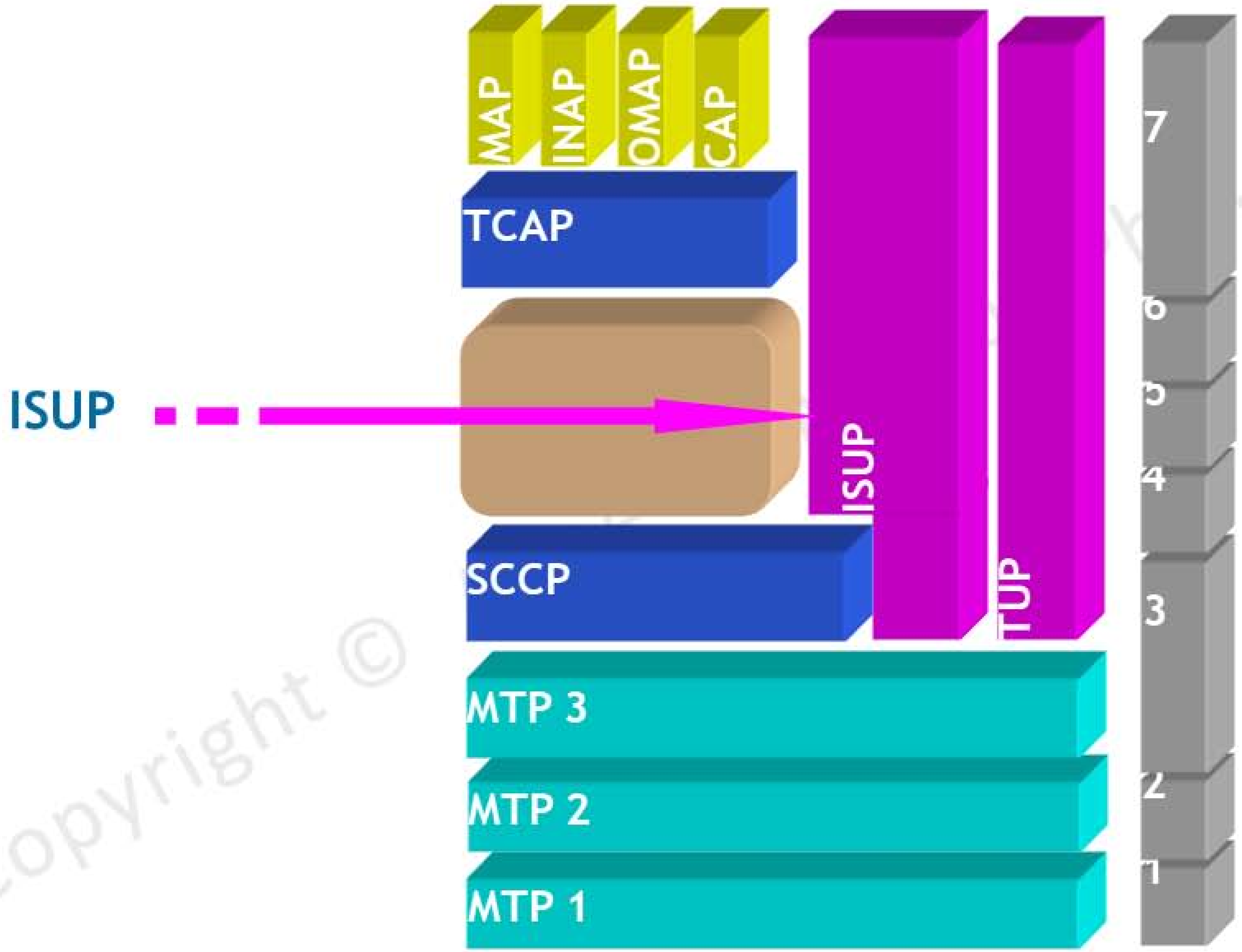
Integrated Services Digital Network User Part (ISUP)

SS7 Protocol Architecture



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Integrated Services Digital Network User Part (ISUP)

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Integrated Services Digital Network User Part (ISUP)

- SS7 is a protocol used to manage connections such as:
  - Circuit setup up
  - Release
  - Monitoring in national and international circuit switching networks
- ISUP is circuit related part that uses MTP 3 services and SCCP services in certain cases.

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Integrated Services Digital Network User Part (ISUP)

- An ISUP message is sent through SS7 channel in MSU frame.
- ISUP is associated only with voice or data calls and does not support broadband technologies such as Frame Relay or ATM

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Integrated Services Digital Network User Part (ISUP)

- The first pat of the SIO field of ISUP frame contains:
  - Sequence "0 1 0 1" to notify that the frame is for ISUP (done by Distribution Function).
  - A routing label (from MTP3).
  - A Circuit Identifier Code (CIC) that determines the voice circuit to setup or release
  - Affectation of circuit identifier is no standard. It is done according to the bilateral agreement between two operators.

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ISUP Message Format

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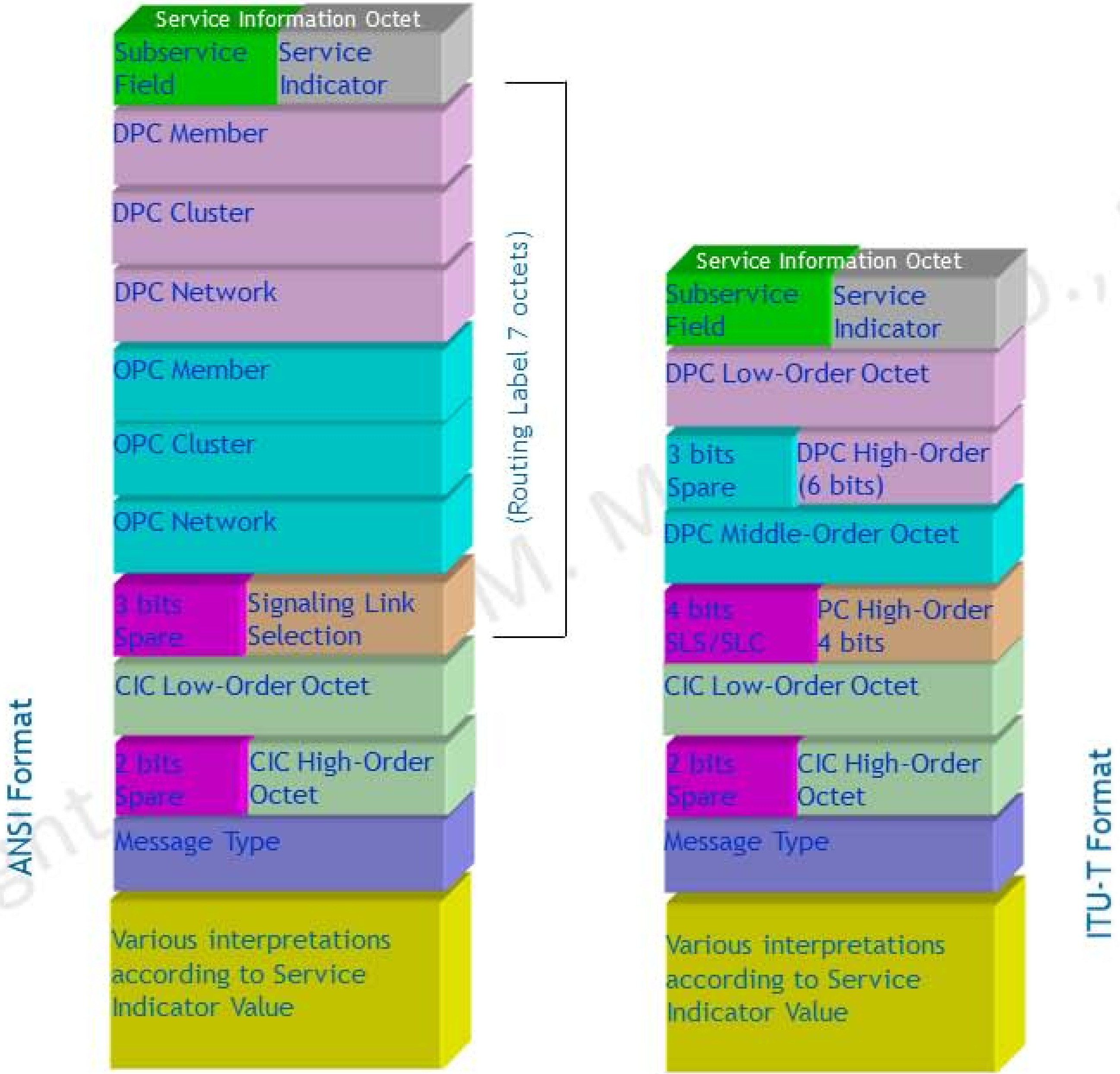
ISUP Message Format



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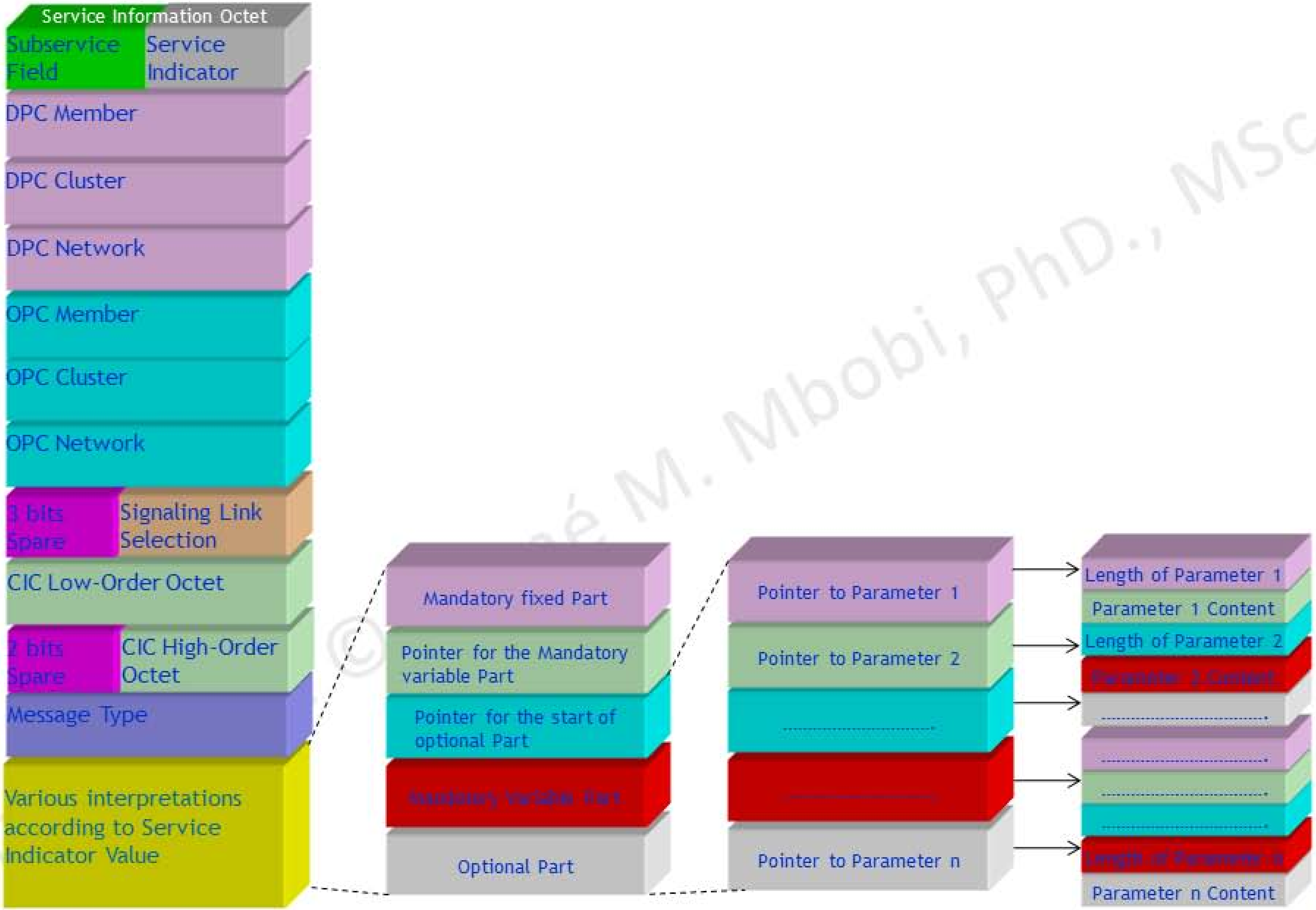
General ISUP Message Format: Pointer Selection



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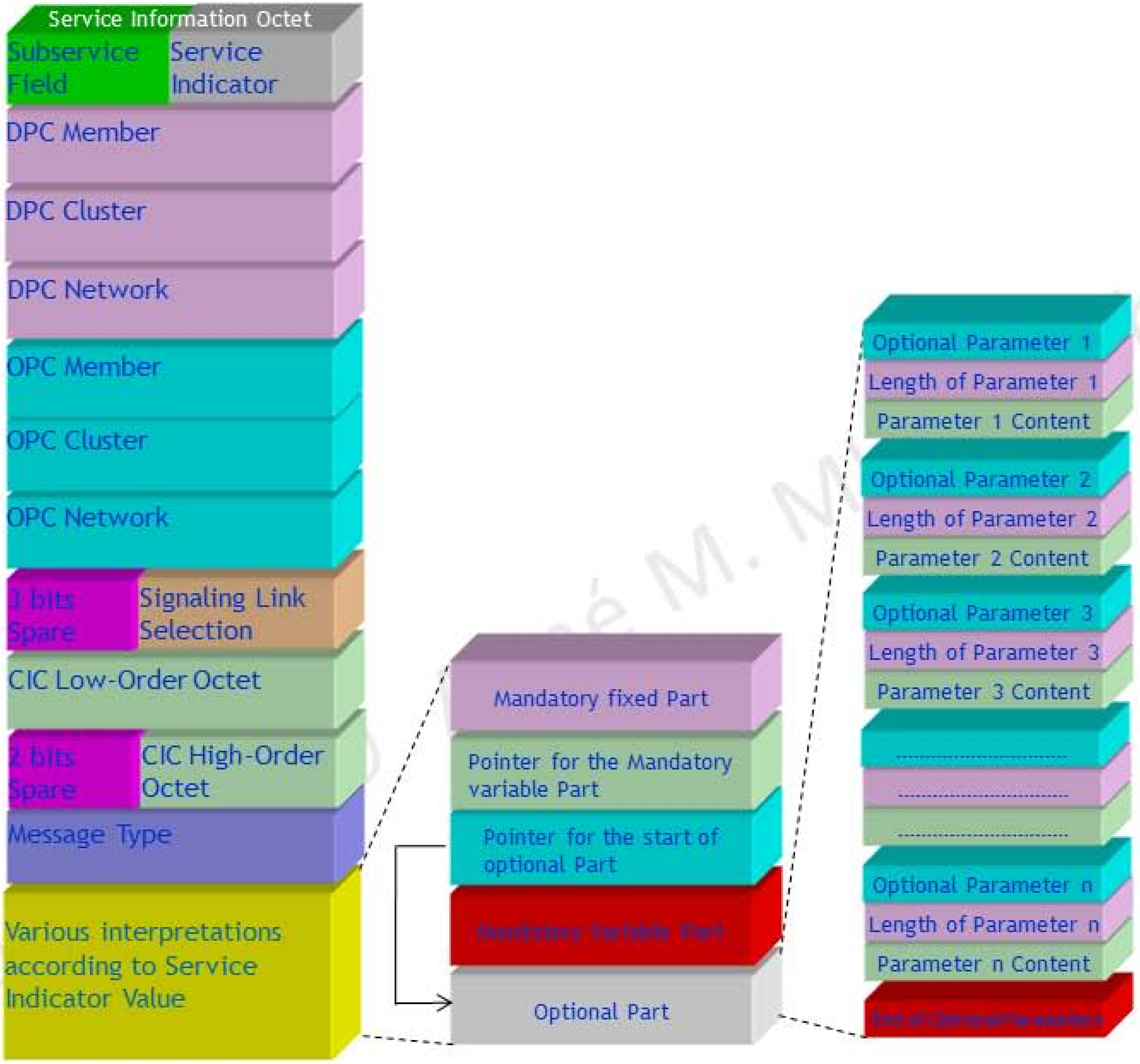
General ISUP Message Format (Optional Portion)



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ISUP Messages

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ISUP Messages

1. Initial Address Message (IAM)
2. Segmentation Message (SGM)
3. Address Complete Message (ACM)
4. Answer Message (ANM)
5. Connection (Con)
6. Information Request
7. Information (INF)
8. Release Message (REL)

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ISUP: Set-up and Release Messages

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1. Initial Address Message (IAM)

- To setup a call, calling user sends information required by the switch that serves him.
- This information is related to the address and call treatment for routing and selecting an available circuit in this switch.
- The setup message is transform to an Initial Address Message by the origination switch and transmitted it to the intermediary switch.

ISUP: Segmentation Message (SGM)

- If the message size > 272 octets, IAM message is segmented by the switch sender by using Segmentation Message and two messages are sent successively: IAM and SGM.
- When IAM message is received by an intermediary switch, it selects an available circuit from the DPC in this IAM message, and sends the message to the following switch.
- When IAM message is received by a destination switch, it analyses the requested number to determine the subscriber to connect.
- It translates IAM message into an ISDN SETUP if state and authorizations are OK.

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ISUP: IAM Message

IAM Message

IAM ANSI SS7 Format

IAM ITU-T SS7 Format

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ISUP: IAM Message

Information Elements in IAM

- Message Type: 1 octet (00000001) that identifies the message.
- Called Party Number: 2 -11 octets containing called party phone number.
- Calling Party's Category: 1 octet containing info about the language used by the originating operator and the type of call (test, data, regular voice, pay phone, emergency, etc.)
- Forward Call Indicators: 2 octets containing parameters used to inform the receiving switch about the services used (international origin call, the IAM is segmented into more than one message, SCCP is employed).
- Nature of Connection Identifiers: 1 octet determining circuit being setup, e.g. satellite links, etc.
- User Service Information: variable length, provides information regarding a data call

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ISUP: Address Complete Message (ACM)

- When the called party (Phone) receives the SETUP message, it sends an ALERTING message that indicates that it is alerted.
- When the end switch receives this ALERTING message, it translates it into ISUP message **Address Complete Message (ACM)** and sends it to the originating switch via intermediary switch to inform that the called user is alerted.
- The originating Switch translates this ACM message into a Signaling message ALERTING to notify the calling user (phone) that the called is alerted (This is a silence before the remote ringing).

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ISUP: Address Complete Message (ACM)

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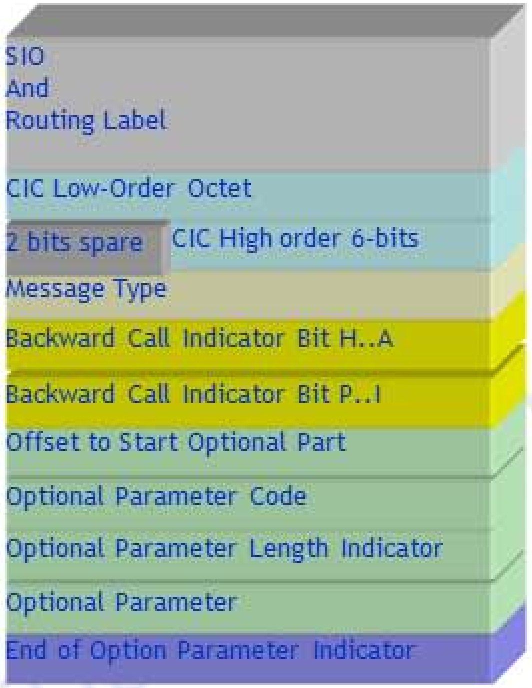
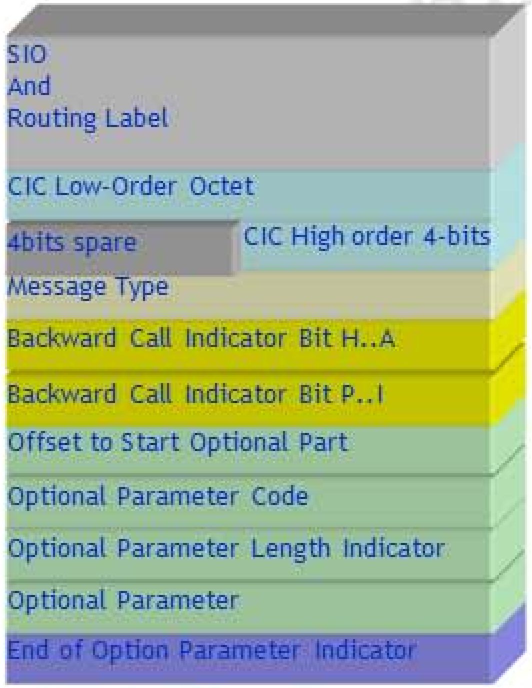


ACM ANSI SS7 Format



ACM ITU-T Format

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ISUP: Answer Message (ANM)

- When the called takes the phone, an SS7 message ISDN CONNECT is sent to the end switch.
- The corresponding ISUP message is **Answer Message (ANM)**.
- This message goes gradually to the sender switch that translates it into an SS7 ISDN message sent forward.

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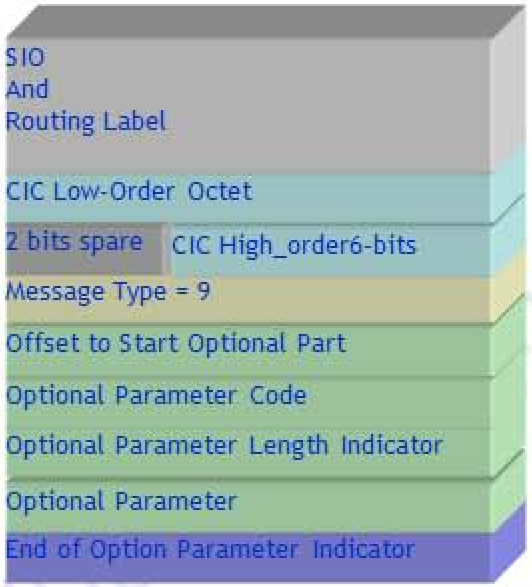
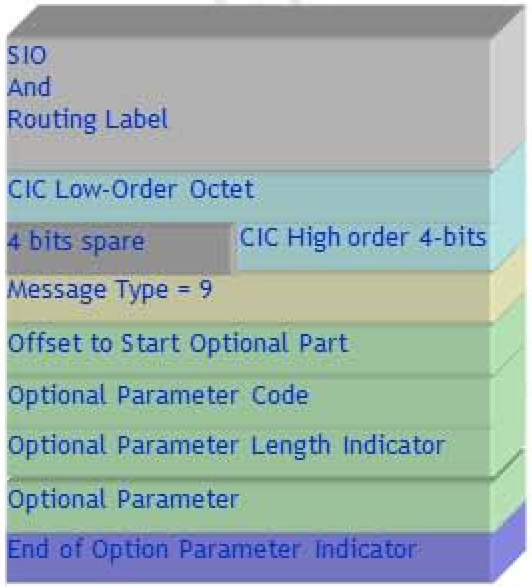
ISUP: Answer Message (ANM)



ANM ANSI SS7 Format



ANM ITU-T Format

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ISUP: Connection Message (Con)

- When the connection is set up to the terminal, it directly sent a Signaling message CONNECT instead of ALERTING.
- An ISUP message called Connection (CON) is thus sent by the end switch to the sender. This message means both ACM and ANM.

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ISUP: Information Request (INR) and Information (INF) Messages

- If destination switch receives an IAM that does not contain calling number, (which is optional), but this switch requires it, it sends an INR.

- For example when the called user has a call display, it sends an INFormation Request (INR) to the calling switch during the call setup i.e. until the ACM message.

- The origination switch responds by an INFormation (INF) message that is sent gradually to the destination switch.

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ISUP: Release Message (REL)

- Release procedure is based on two ISUP messages called RELease (REL) and Release Complete.

- The release of a connection can be initiated by the calling or called user.

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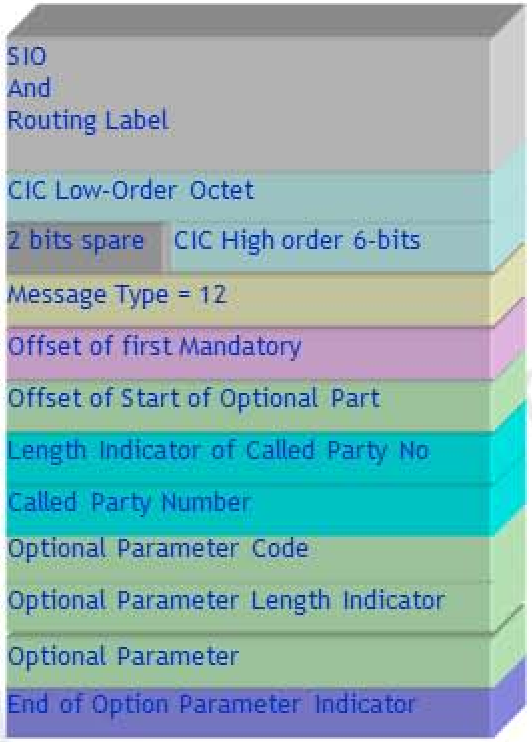
ISUP: Release Message (REL)



REL ANSI SS7 Format

REL ITU-T Format

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ISUP: Release Complete (RLC) Message

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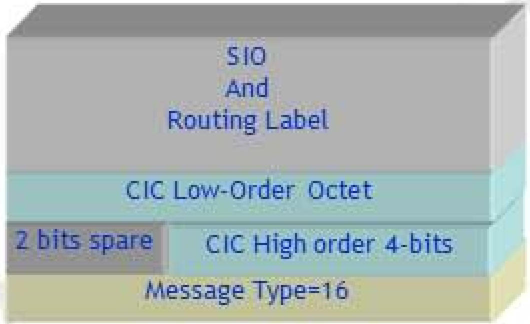
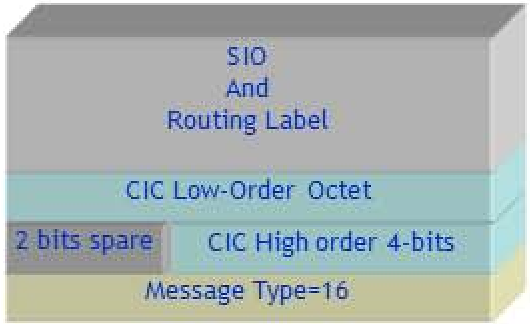
- At the reception of REL message by the destination switch, it releases the switched route and send a DISC message to the called.
- A Release Complete (RLC) message is sent to the preceding switch.



RLC ANSI SS7 Format



RLC ITU-T Format

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ISUP Message Type Tables

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ISUP Message Type Table

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Acronym	Message Type	Code
ACM	Address Complete	00000110
ANM	Answer	00001001
BLO	Blocking	00010011
BLA	Blocking Acknowledgment	00010101
CMC	Call Modification Completed	00011101*
CMRJ	Call Modification Reject	00011110*
CMR	Call Modification Request	00011100*
CPG	Call Progress	00101100
CGB	Circuit Group Blocking	00011000
CGBA	Circuit Group Blocking Acknowledgment	00011010
CQM	Circuit (Group) Query	00101010
CQR	Circuit (Group) Query Response	00101011
GRS	Circuit Group Reset	00010111
GRA	Circuit Group Reset Acknowledgment	00101001
CGU	Circuit Group Unblocking	00011001
CGUA	Circuit Group Unblocking Acknowledgment	00011011
CRM	Circuit Reservation	11101010*
CRA	Circuit Reservation Acknowledgment	11101001*
CVR	Circuit Validation Response	11101011*
CVT	Circuit Validation Test	11101100*
CSVR	CUG Selection and Validation Request	00100101*
CSVS	CUG Selection and Validation Response	00100110*
CRG	Charge Information	00110001**
CFN	Confusion	00101111
CON	Connect	00000111
COT	Continuity	00000101
CCR	Continuity Check Request	00010001
DRS	Delayed Release	00100111*
EXM	Exit	11101101*

* ANSI-ISUP only, ** ITU-ISUP only

Acronym	Message Type	Code
FAC	Facility	00110011
FAA	Facility Accepted	00100000
FAD	Facility Deactivated	00100010*
FAI	Facility Information	00100011*
FRJ	Facility Reject	00100001
FAR	Facility Request	00011111
FOT	Forward Transfer	00001000
IDR	Identification Request	00110110**
IRS	Identification Response	00110111**
INF	Information	00000100
INR	Information Request	00000011
IAM	Initial Address	00000001
LPA	Loop Back Acknowledgment	00100100
NRM	Network Resource Management	00110010
OLM	Overload	00110000
PAM	Pass-along	00101000
REL	Release	00001100
RLC	Release Complete	00010000
RSC	Reset Circuit	00010010
RES	Resume	00001110
SGM	Segmentation	00111000
SAM	Subsequent Address	00000010
SUS	Suspend	00001101
UBL	Unblocking	00010100
UBA	Unblocking Acknowledgment	00010110
UCIC	Unequipped CIC	00101110
UPA	User Part Available	00110101
UPT	User Part Test	00110100
USR	User-to-user Information	00101101

ISUP Parameter Type Table

Message Type	Code
Access Delivery Information	00101110**
Access Transport	00000011
Automatic Congestion Level	00100111
Backward Call Indicators	00010001
Business Group	11000110*
Call Diversion Information	00110110**
Call History Information	00101101**
Call Modification Indicators	00010111*
Call Reference	00000001
Called Party Number	00000100
Calling Party Number	00001010
Calling Party's Category	00001001
Carrier Identification	11000101*
Carrier Selection Information	11101110*
Cause Indicators	00010010
Charge Number	11101011*
Circuit Assignment Map	00100101*
Circuit Group Characteristic Indicator	11100101*
Circuit Group Supervision Message Type Ind.	00010101
Circuit Identification Name	11101000*
Circuit State Indicator	00100110
Circuit Validation Response Indicator	11100110*
CUG Check Response Indicators	00011100*
CUG Interlock Code	00011010
COMMON LANGUAGE	11101001*
Connected Number	00100001
Connection Request	00001101
Continuity Indicators	00010000

Message Type	Code
Echo Control Information	00110111**
Egress	11000011*
End of Optional Parameters	00000000
Event Information Indicators	00100100
Facility Indicator	00011000
Facility Information Indicators	00011001*
Forward Call Indicators	00000111
Freephone Indicators	01000001**
Generic Address	11000000*
Generic Digits	11000001
Generic Name	11000111*
Generic Notification	00101100**
Generic Number	11000000**
Generic Reference	01000010**
Hop Counter	00111101
Index	00011011*
Information Indicators	00001111
Information Request Indicators	00001110
Jurisdiction	11000100*
Location Number	00111111**
MCID Request Indicator	00111011**
MCID Response Indicator	00111100**
Message Compatibility Information	00111000**
MLPP Precedence	00111010**
Nature of Connection Indicators	00000110
Network Specific Facilities	00101111**
Network Transport	11101111*
Notification Indicator	11100001*

* ANSI-ISUP only, ** ITU-ISUP only

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ISUP Parameter Type Table

Message Type	Code
Message Type	Code
Operator Services Information	11000010*
Optional Backward Call Indicators	00101001
Optional Forward Call Indicators	00001000
Original Called Number	00101000
Originating Line Information	11101010*
Origination ISC Point Code	00101011**
Outgoing Trunk Group Number	11100111*
Parameter Compatibility Information	00111001**
Precedence	00111010*
Propagation Delay Counter	00110001**
Range and Status	00010110
Redirecting Number	00001011
Redirection Information	00010011
Redirection Number	00001100
Redirection Number Restriction	01000000**

* ANSI-ISUP only, ** ITU-ISUP only

Message Type	Code
Remote Operations	00110010
Service Activation	00110011
Service Code Indicator	11101100*
Signaling Point Code	00011110
Special Processing Request	11101101*
Subsequent Number	00000101
Suspend/resume Indicators	00100010
Transaction Request	11100011*
Transit Network Selection	00100011
Transmission Medium Requirement	00000010
Transmission Medium Requirement Prime	00111110**
Transmission Medium Used	00110101
User Service Information	00011101
User Service Information Prime	00110000
User Teleservice Information	00110100**
User-to-user Indicators	00101010
User-to-user Information	00100000

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ISUP Mandatory/Optional Parameters Table (ANSI)

PARAMETER FIELD	IAM	INR	INF	CRA	CRM	COT	ACM	EXM	ANM	CPG	FOT	REL	CFN	CVR	RLC CVT	RSC LPA CCR	UBLU CIC BLO	UBAB LA	RES SUS	CGB CGU	CGUA CGBA	GRAG RS CQM	CQR	FAC
Message Type	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Access Transport	O		O				O		O	O		O												
Automatic Congestion Level												O												
Backward Call Indicators							M		O	O														
Business Group	O		O				O		O	O														
Call Reference	O	O	O				O		O	O	O	O							O					
Called Party Number	M																							
Charge Number	O		O									O												
Calling Party Number	O		O																					
Calling Party's Category	M		O																					
Carrier Identification	O																							
Carrier Selection Information	O																							
Cause Indicators							O			O		M	M											
Circuit Group Assignment Map	O																					O		
Circuit Group Characteristic Indicators														M										
Circuit Group Supervision Message Type Ind																				M	M			
Circuit Indentification Name														O										
Circuit State Indicator																							M	
Circuit Validation Response Ind														M										
CLLI Code														O										
Connection Request	O	O	O				O		O															
Continuity Indicators						M																		
Egress Service	O																							
Event Information										M														
Forward Call Indicators	M																							
Generic Address	O											O												
Generic Digits	O																							

MEng.

ISUP Mandatory/Optional Parameters Table (ANSI)

PARAMETER FIELD	IAM	INR	INF	CRA	CRM	COT	ACM	EXM	ANM	CPG	FOT	REL	CFN	CVR	RLC CVT	RSC LPA CCR	UBLU CIC BLO	UBAB LA	RES SUS	CGB CGU	CGUA CGBA	GRAG RS CQM	CQR	FAC
Generic Name	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Hop Counter	O																							
	O																							
Information Indicators			M				O		O	O														
Information Request Indicators	O	M																						
Jurisdiction Information	O																							
Nature of Connection Indicators	M				M																			
Network Transport	O	O					O		O	O														
Notification Indicator							O			O														
Original Called Number	O																							
Operator Services Information	O																							
Opt. Backward Call Indicators							O		O	O														
Originating Line Information	O		O																					
Outgoing Trunk Group Number								O																
Precedence	O																							
Range and Status																				M	M	M	M	
Redirection Information	O		O				O																	
Redirecting Number	O									O														
Remote Operations	O						O		O	O														O
Service Activation	O						O		O	O		O												O
Service Code	O																							
Special Processing Request	O																							
Suspend/Resume Indicators																			M					
Transaction Request	O																							
Transit Network Selection	O																							
Transmission Medium Used							O		O	O														
User Service Information																								
User Service Information Prime	O																							
User-to-User Indicators							O		O	O														
User-to-User Information	O		O				O		O	O		O												

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ISUP Mandatory/Optional Parameters Table (ITU)

PARAMETER FIELD	IAM	SAM	IN	IN	COT	ACM	CO	CP	ANM	FOT	RE	RL	CC RS LPA	BLO UBL OL	BLA UBA UCI	SU RE	CF	CG CG	CGB CGU	CQ GR GR	CQ	FAA FAR	FR	FAC	ID	IR	NR	SG	PAM	US	UPA UP
Message Type	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
Access Delivery Information						O	O	O	O		O																				
Access Transport	O					O	O	O	O		O															O		O		O	
Automatic Congestion Level											O																				
Backward Call Indicators						F	F	O	O																						
Call Diversion Information						O		O																							
Call History Information							O		O																						
Call Reference	O		O	O		O	O	O	O	O						O						O									
Called Party Number	V																														
Calling Party Number	O			O																						O					
Calling Party's Category	F			O																											
Cause Indicators						O		O			V	O					V						V								
Circuit Group Supervision Message Type Ind.																		F	F												
Circuit State Indicator																					V										
CUG Interlock Code	O																														
Connected Number							O		O																						
Connection Request	O			O																		O									
Continuity Indicators					F																										
Echo Control Information						O	O		O																		O				
End of Optional Parameters	O	O	O	O		O	O	O	O	O	O	O				O	O					O	O	O	O	O	O	O		O	O
Event Information								F																							
Facility Indicator																						F	F								
Forward Call Indicator	F																														
Generic Digit	O																											O			
Generic Notification Ind.	O					O	O	O	O																			O			
Generic Number	O						O		O																	O		O			
Generic Reference	O																														
Information Indicators				F																											
Information Request Indicators			F																												

F = Mandatory fixed length parameter, V = Mandatory variable length parameter, O = Optional parameter, fixed or variable

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ISUP Mandatory/Optional Parameters Table (ITU)

PARAMETER FIELD	IAM	SAM	IN	IN	COT	ACM	CO	CP	ANM	FOT	RE	RL	CC RS LPA	BLO UBL OL	BLA UBA UCI	SU RE	CF	CG CG	CGB CGU	CQ GR GR	CQ	FAA FAR	FR	FAC	ID	IR	NR	SG	PAM	US	UPA UP
Location Number	O																														
																								O	O	O	O	O			
																										O					
Message Compatibility Information																									O						
MCID Response Indicator	O																														
MCID Request Indicators	F																														
MLPP Precedence	O		O	O		O	O	O	O		O																				
Nature of Connection Indicators						O	O	O	O																						
Network Specific Facility	O																														
Optional Backward Call Indicators	O																														
Optional Forward Call Indicators	O																														
Original Called Number	O		O	O		O	O	O	O		O											O		O	O	O	O				O
Originating ISC Point Code	O																														
Parameter Compatibility Information																		V	V	V	V										
Propagation Delay Counter	O										O																				
Range and Status	O																														
Redirection Information						O	O	O	O		O																				
Redirecting Number						O	O	O	O		O																				
Redirection Number	O					O	O	O	O															O							
Redirection Number Restr.	O					O	O	O	O															O							
Remote Operations											O																				
Service Activation		V																													
Signaling Point Code																F															
Subsequent Number	O																														
Suspend/Resume Indicators	F																														
Transit Network Selection	O																														
Transmission Medium Requirement						O	O	O	O																		O				
Transmission Medium Requirement Prime	O																														
Transmission Medium Used	O																														
User Service Information	O					O	O	O	O		O											O	O								
User Service Information Prime	O					O	O	O	O		O																	O		V	

F = Mandatory fixed length parameter, V = Mandatory variable length parameter, O = Optional parameter, fixed or variable

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Call Setup Example

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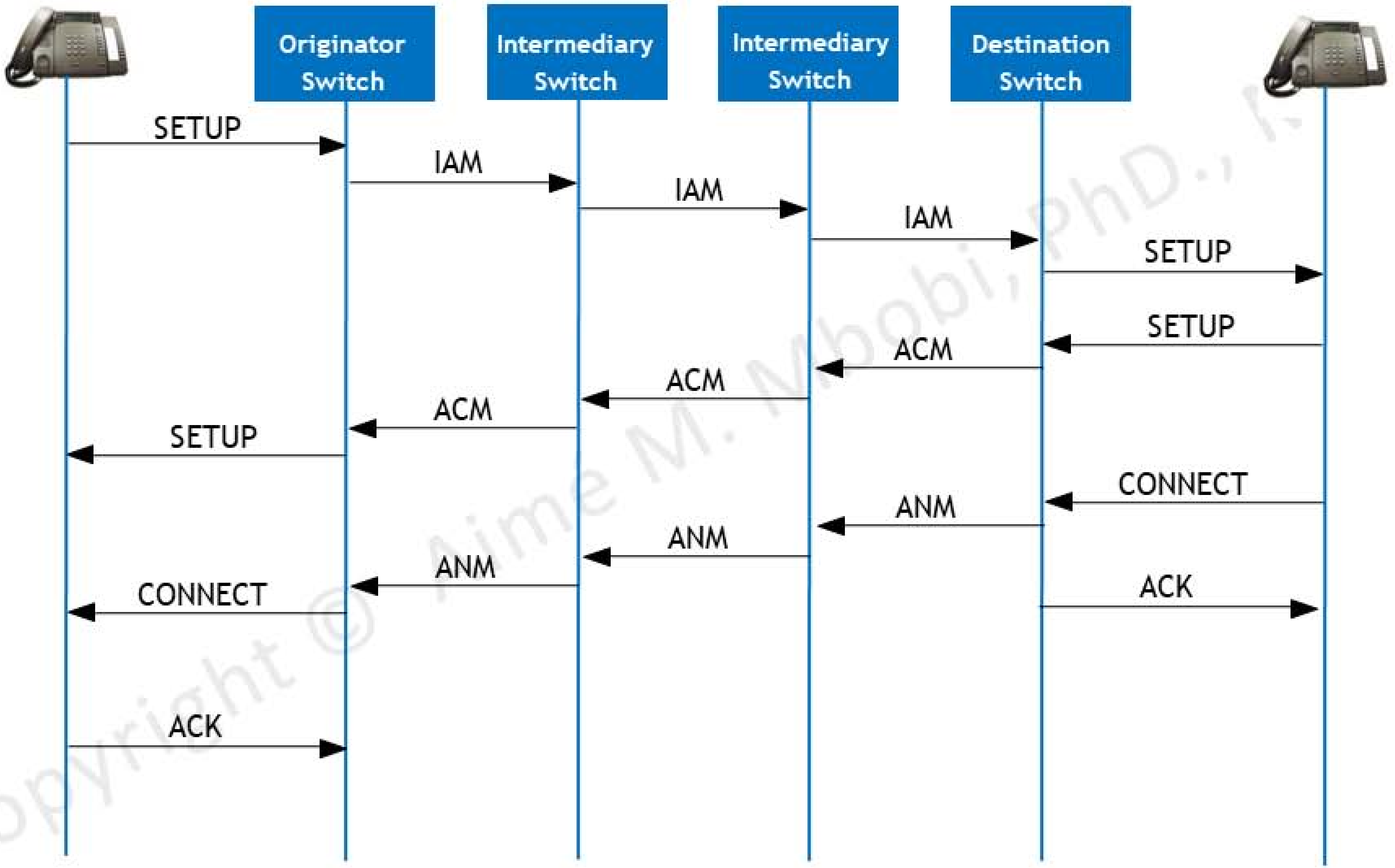
Examples of Call Setup and IN control Call Flow call



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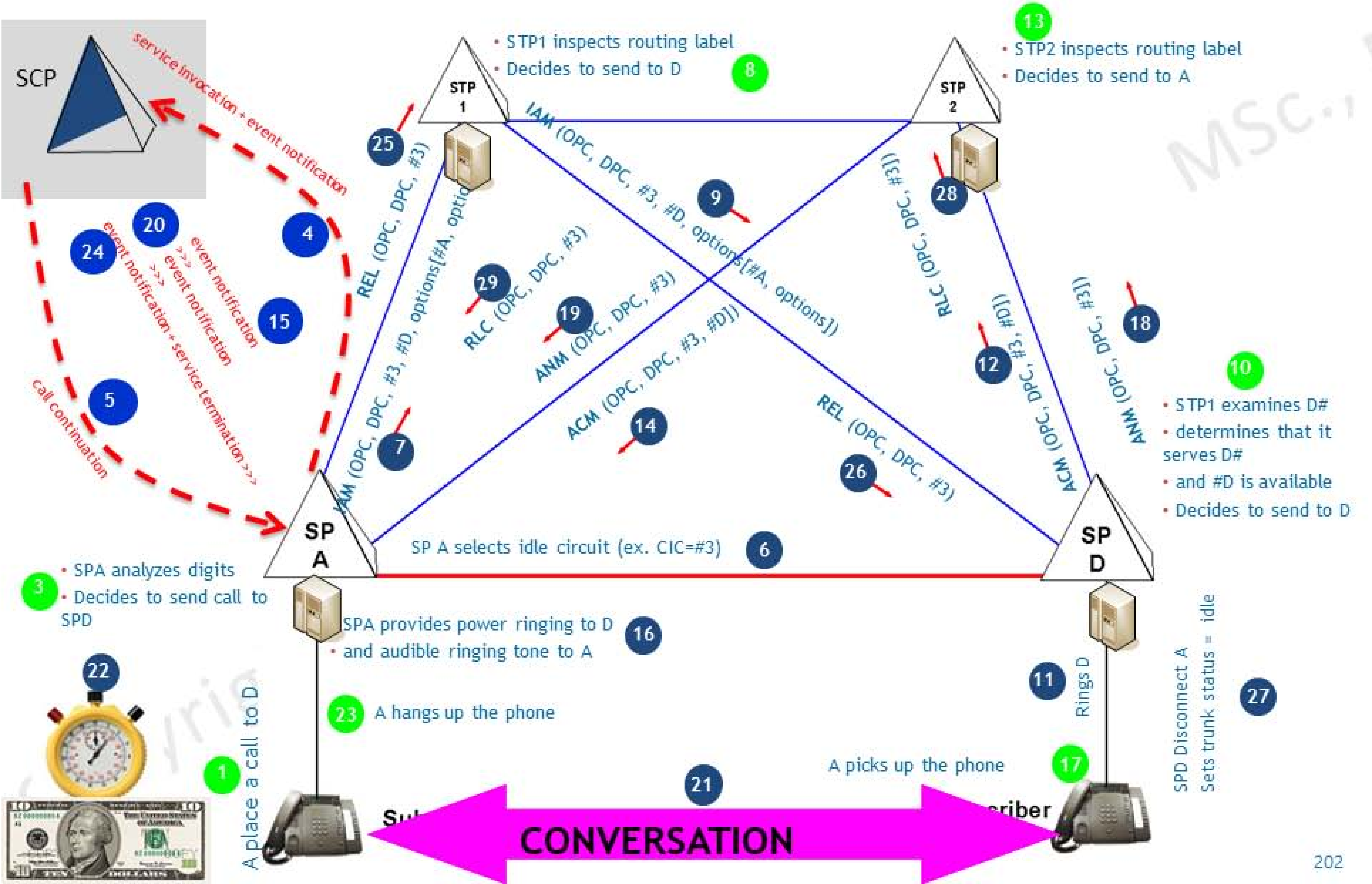
Example of IN control Call Flow call



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Example of IN control Call Flow call

- Audible and power ringing are not synchronized.
- This is why, on a rare occasion, a caller is already on the line when you lift the handset

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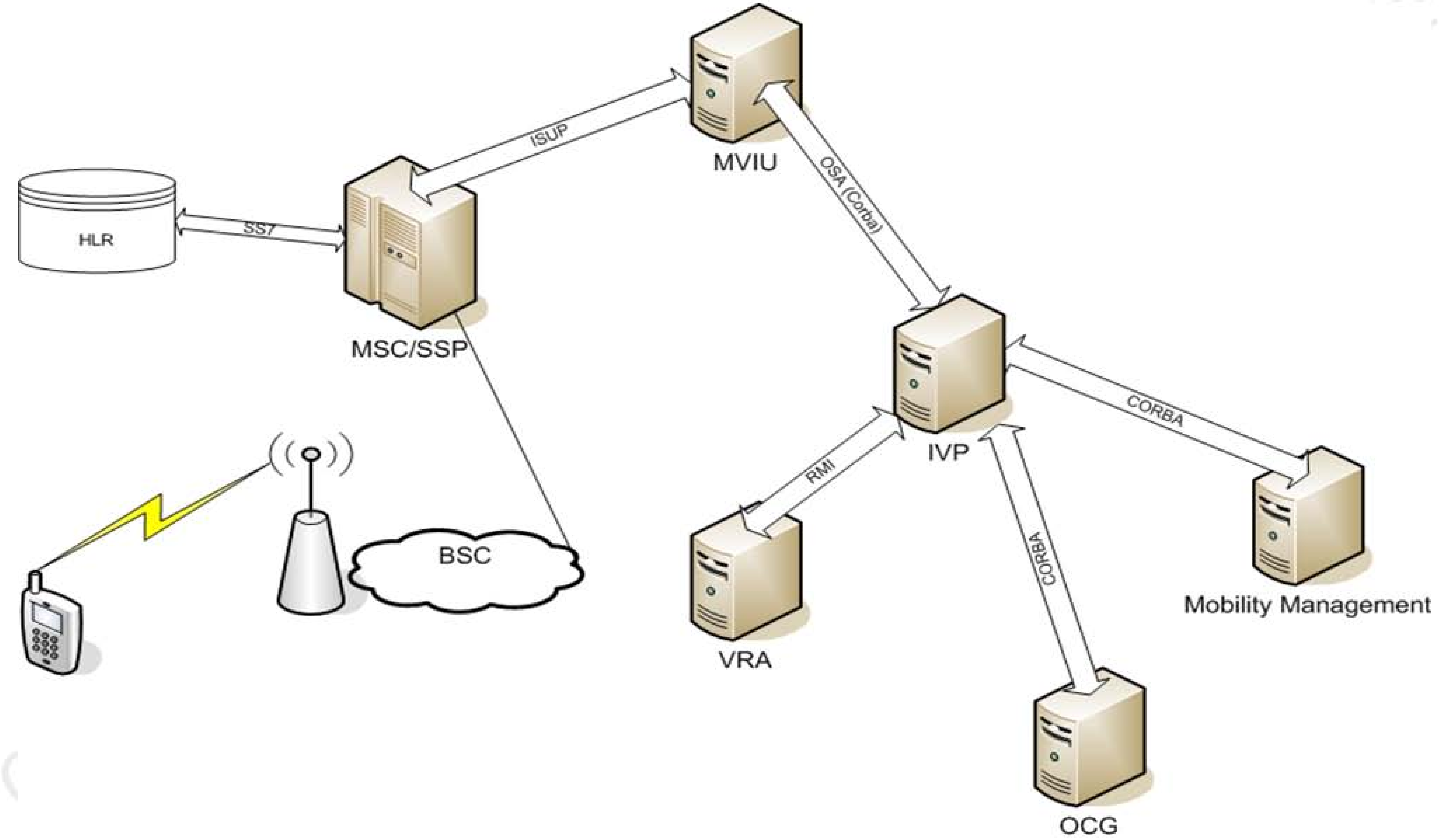
Example of ISUP between MSC and MVIU



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Recap on MTP3

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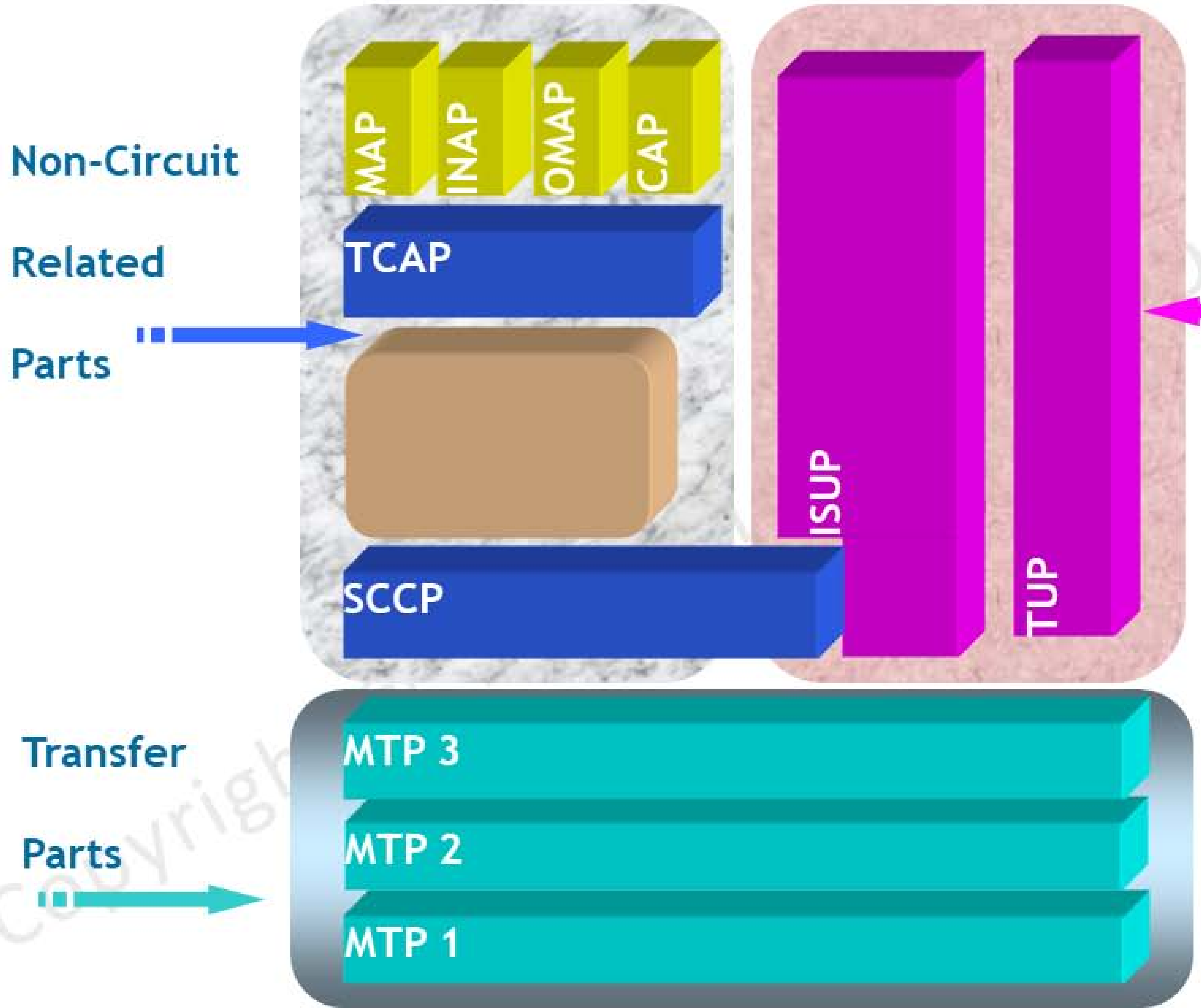

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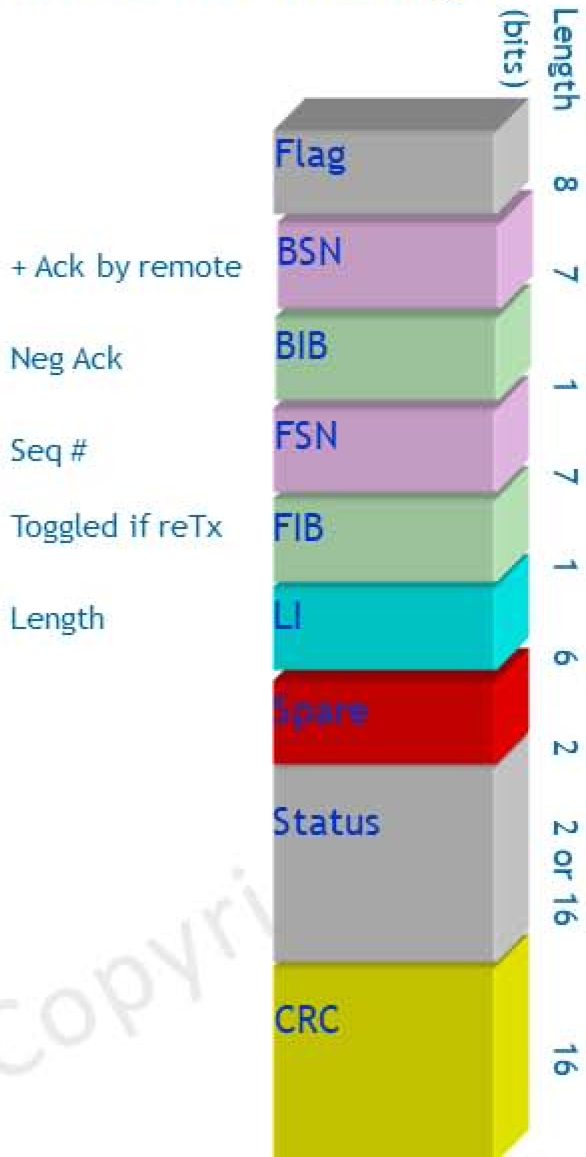
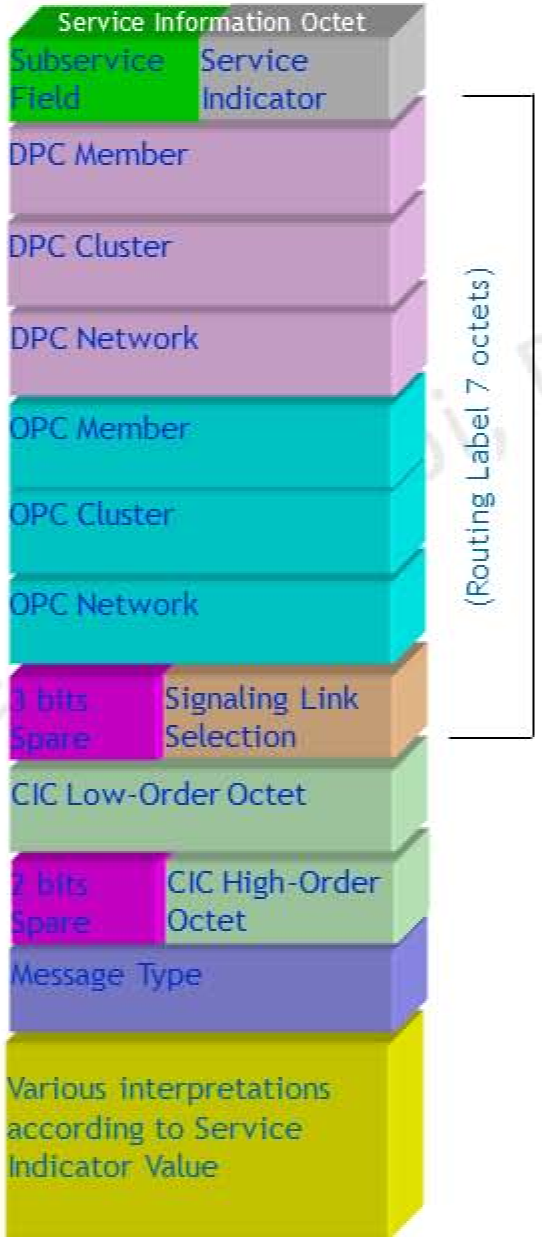
Recap on MTP3

SS7 Basic Message





ISUP Messages

- IAM
- SEG
- ACM
- ANM
- INR
- INF
- REL
- RLC

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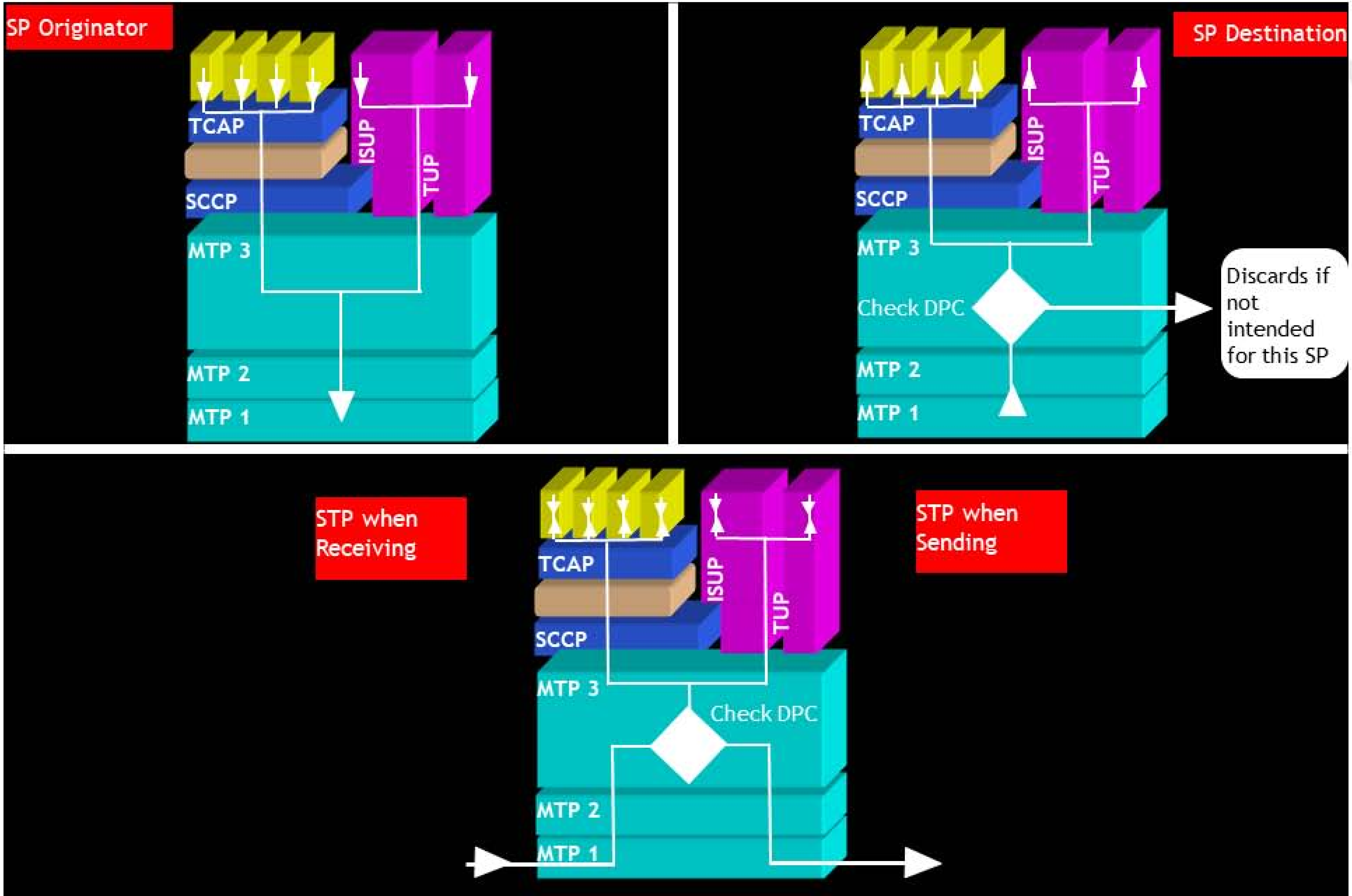
Recap on MTP3



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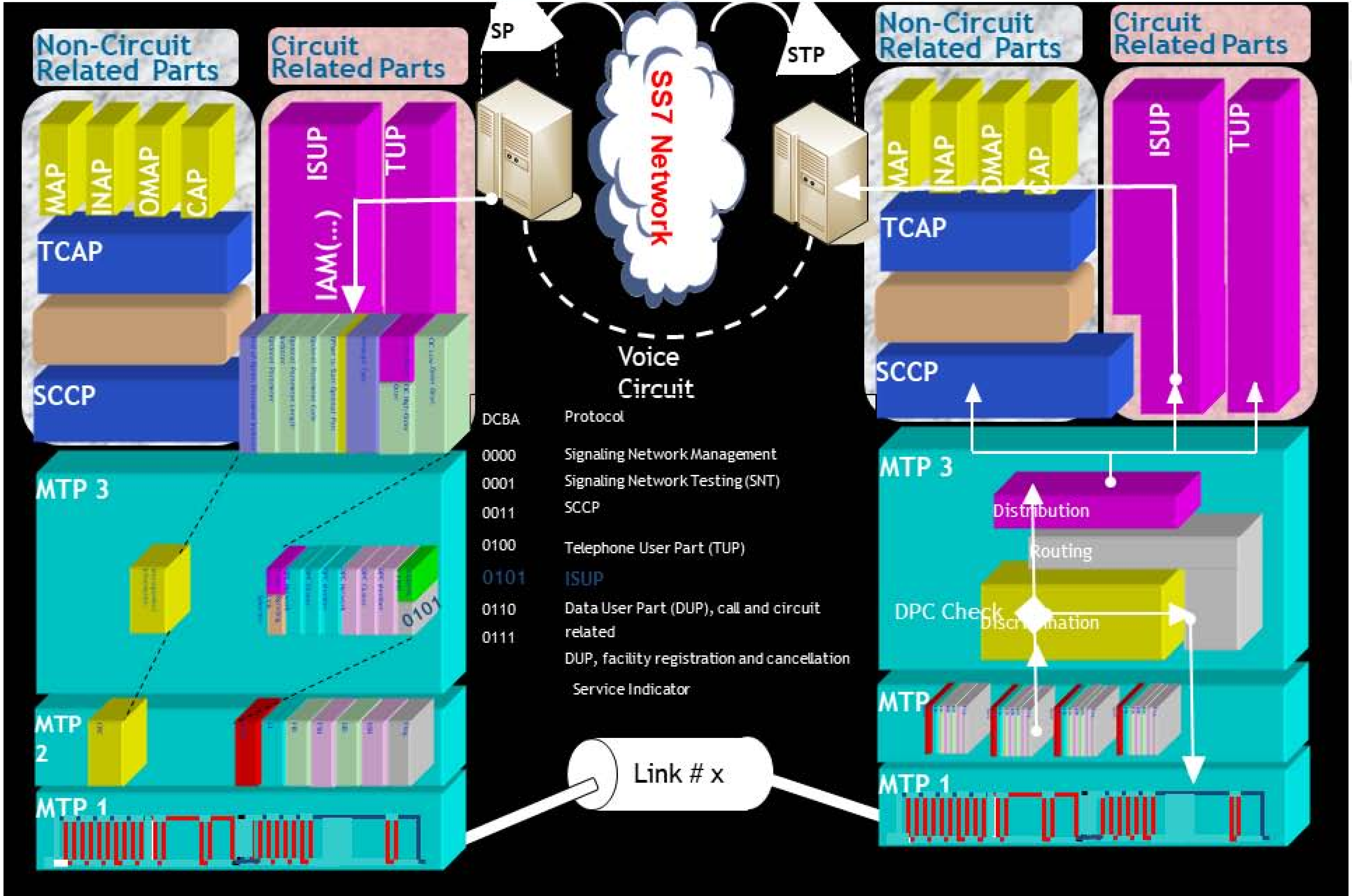
Recap on MTP3



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User Part
Signaling Connection Control Part (SCCP)

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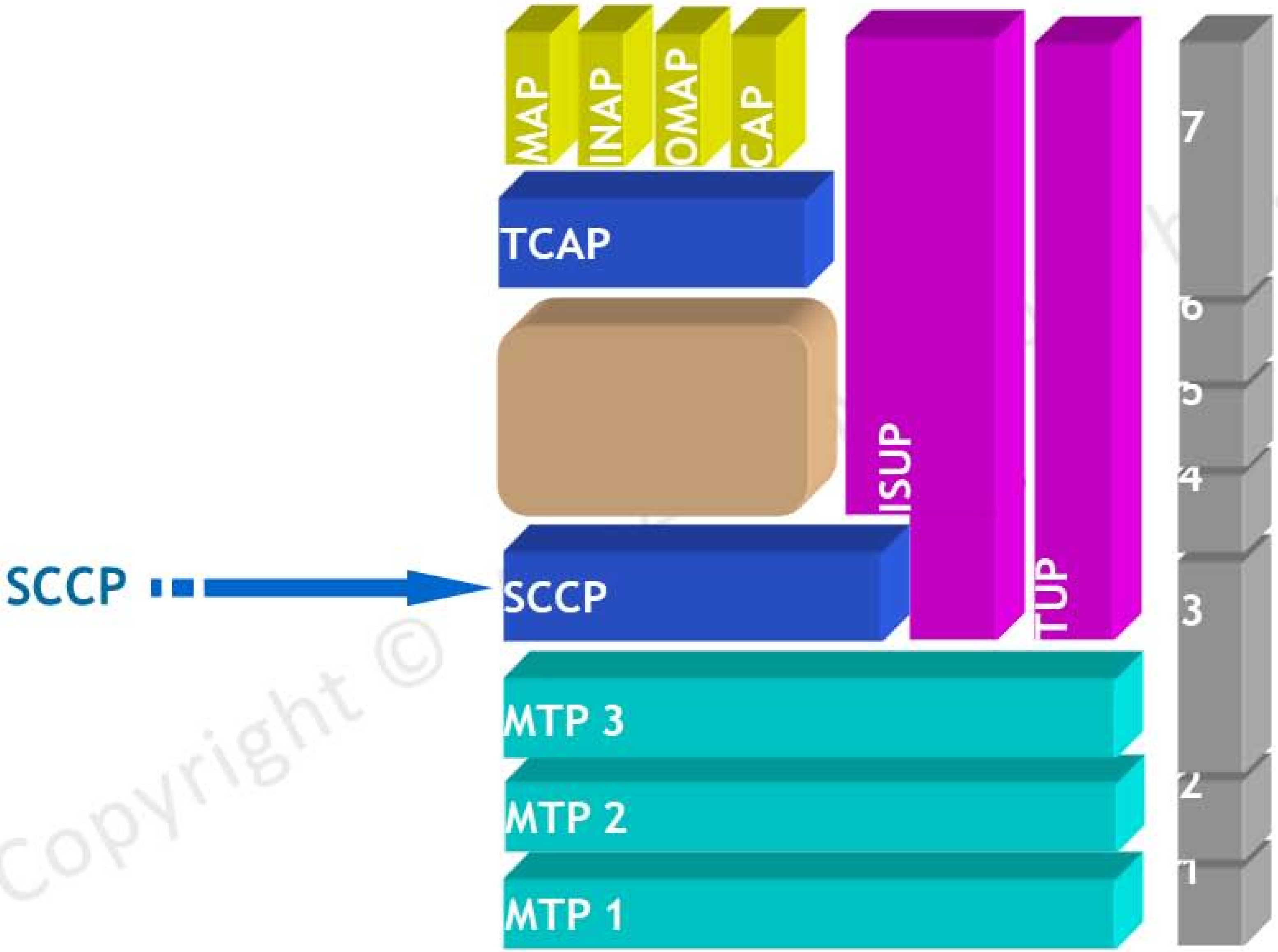
Signaling Connection Control Part (SCCP)

SS7 Protocol Architecture



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Signaling Connection Control Part (SCCP)

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Signaling Connection Control Part (SCCP)

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- SCCP provides supplementary services to MTP to support connectionless and connection-oriented modes.
- These services are grouped in four classes
  - Class 0: basic connectionless
  - Class 1: sequenced connectionless
  - Class 2: basic connection service without control flow
  - Class 3: connection service with control flow
- Generally only classes 0 and 1 have been implemented by most vendors.
- Connection-oriented services, if implemented, would require set up and tear down of a connection.

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Use of Class 0 and Class 1

- Class 0 is used for pure connectionless transfer of messages.
- Class 1 offers an option of requesting that messages coming from the same source be delivered sequentially.
- In this case, all messages corresponding to the same stream would be assigned the same SLS field value.
- When SCCP messages of class 1 are routed through the network, every node should make sure that the sequence of messages is maintained.

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How does SCCP performs message sequencing

- MTP 3 provides a rotating code value (SLS) to share the load in the linkset.
- To provide sequential delivering of packages, MTP level 3 stops rotating the SLS for the duration of the service request.
- The result is that the SLS stays the same, message after message.
- Messages delivered on the same link remain in sequence.

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SCCP Layer Architecture

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SCCP Layer Architecture

- SCCP sits between the upper layers, which may consist of a wide variety of applications and user parts, such as ISUP, MAP, INAP, CAP, etc., and the lower layer, MTP3
- SCCP is made up of four entities
  - SSCP routing control (SCRC)
  - SCCP connection-oriented control (SCOC)
  - SSCP connectionless control (SCLC)
  - SCCP management (SCMG)

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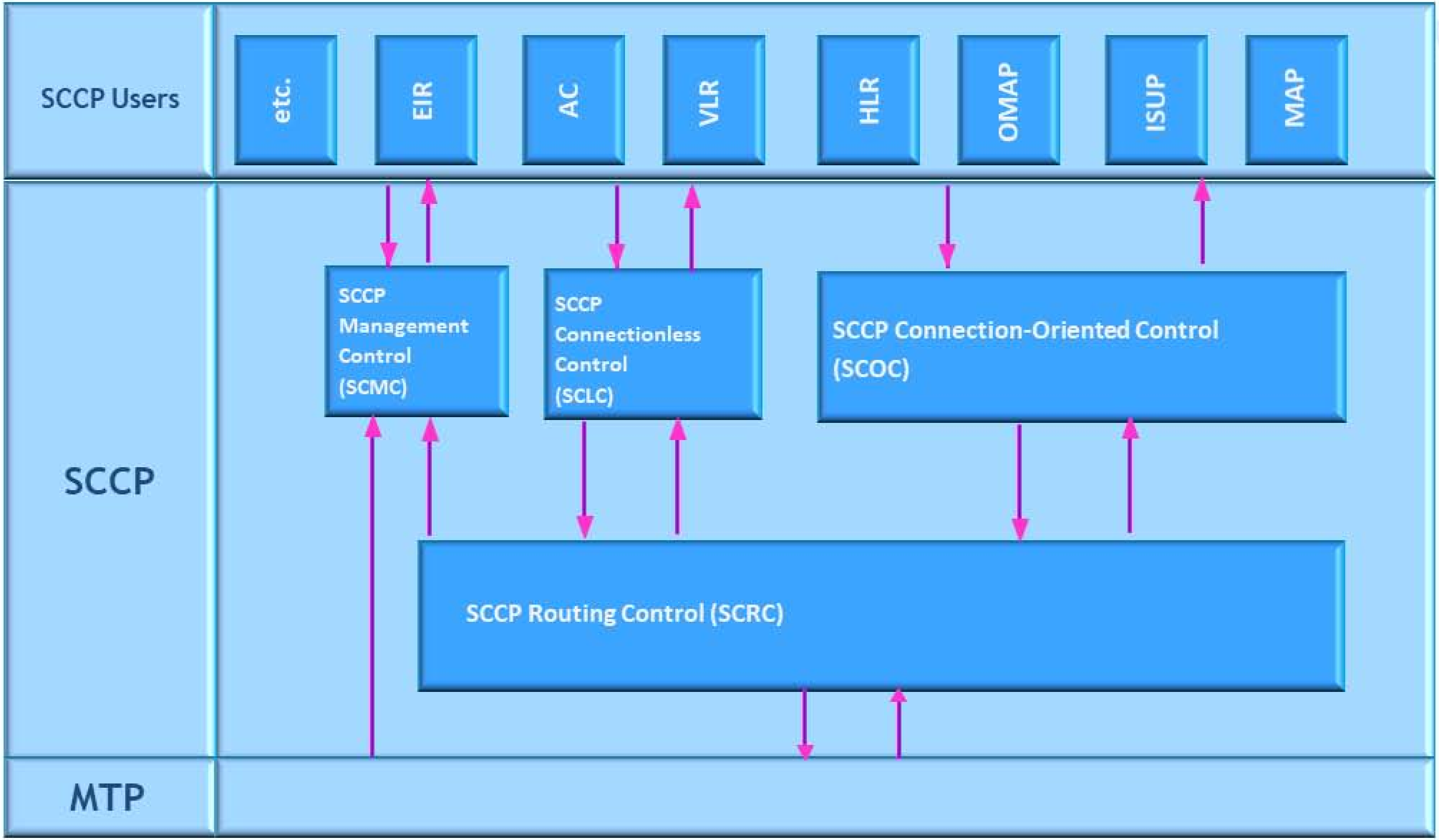
SCCP Layer Architecture



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SCCP Layer Architecture

SSCP Routing Control

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SSCP Routing Control

- SCRC is responsible for:
  - Routing
  - Address Translation

- Routing is performed internally by relaying the traffic to another user entity or to one of the three other SCCP entities.

- SCRC can translate different types of addresses, such as a GT to a DPC.

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SSCP Routing Control

- SCOC is responsible for:
  - Setting up a connection between two users of SCCP
  - Transferring traffic between these users
  - Tearing down the connection

- It supports several features, such as segmentation, sequencing, and flow control.

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SSCP Connectionless Control

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SSCP Connectionless Control

- SCLC is responsible for:
  - Transferring traffic between two users of SCCP but it does not create a connection.

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SCCP management

- SCMG is used for:
  - Management
  - Status operations
- Some of its primary functions are:
  - Coordinating the withdrawal of a subsystem (SSN).
  - Informing SCCP about the status of an originating user or the status of a connection.
  - Providing information about the type of traffic pattern a user is receiving.

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How does SCCP perform message sequencing

- The MTP is concerned only with transferring messages to the end of links.
- So, the MTP addressing is limited to the use of the PC of the location to which the link goes.

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How does SCCP perform message sequencing

- MTP deals only with the PC of its own location in the network (OPC), and the PC of the node at the other end of the link (DPC).
- *SCCP Addressing Capabilities allows locating of database information and invoking of features at a switch.*

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SCCP - Subsystem Number

SCCP - Subsystem Number

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SCCP - Subsystem Number

- SCCP uses DPC provided by MTP as well.
- When the DPC is supplied by the originator of a query, MTP indicates Network location, Network Cluster and Network Member (NI, NC, NM).
- So, the message could be carried to the node that might have several applications, databases running
- But, we don't know
  - Which application to perform
  - Which process to rum in order to retrieve data from a database
  - which service or feature can be invoked

Think about the IP word where you have the IP address but not the port number of your application. How do you run this application?

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SCCP - Subsystem Number

- This is why SCCP provides the value called Subsystem Number (SSN).
- SCCP also provides application management functions. Applications are mostly SCP database driven and are called subsystems.
- The values for database and application identification are one octet coded (range from 0 to 255).
- The SCCP uses:
  - DPC to route to the appropriate node (NI, NC, NM).
  - SSN to route to the appropriate database or application which can be accessed at that node.

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SCCP - Subsystem Number

SSN Value (one octet)	Meaning
0000 0000	SSN not known or not used
0000 0001	SCCP management
0000 0010	Reserved
0000 0011	ISDN User Part (ISUP)
0000 0100	OMAP
0000 0101	Mobile Application Part (MAP)
0000 0110	Home Location Register (HLR)
0000 0111	Visitor Location Register (VLR)
0000 1000	Mobile Switching Center (MSC)
0000 1001	Equipment Identity Register (EIR)
0000 1010	Authentication Center (AC)
0000 1011 to 1111 1110	Spare
1111 1110 to 1111 1111	Reserved

SCCP - Global Title Translation (GTT)

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SCCP - Global Title Translation (GTT)

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- The second SCCP mechanism is the Global Title Translation (GTT).
- Procedure by which the DPC and SSN is determined from digits (GT) present in the signaling message.
- Generally, when a normal number is dialed, these digits received at the switch would contain:
  - DPC
  - Line Number, etc.
- These information allow the switch to consult its routing table and determine the next switch through which to route the call.

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SCCP - Global Title Translation (GTT)

- But number such as 800 number, PIN card number, MSIN, USSD, etc. does not comply with the Numbering Plan which the switch would normally refer to in choosing the routing.
- Let’s take an example of 800 number where the called phone is connected by voice line to an end office somewhere.
- This office has an address in the Numbering Plan and the line to the telephone has a line number.

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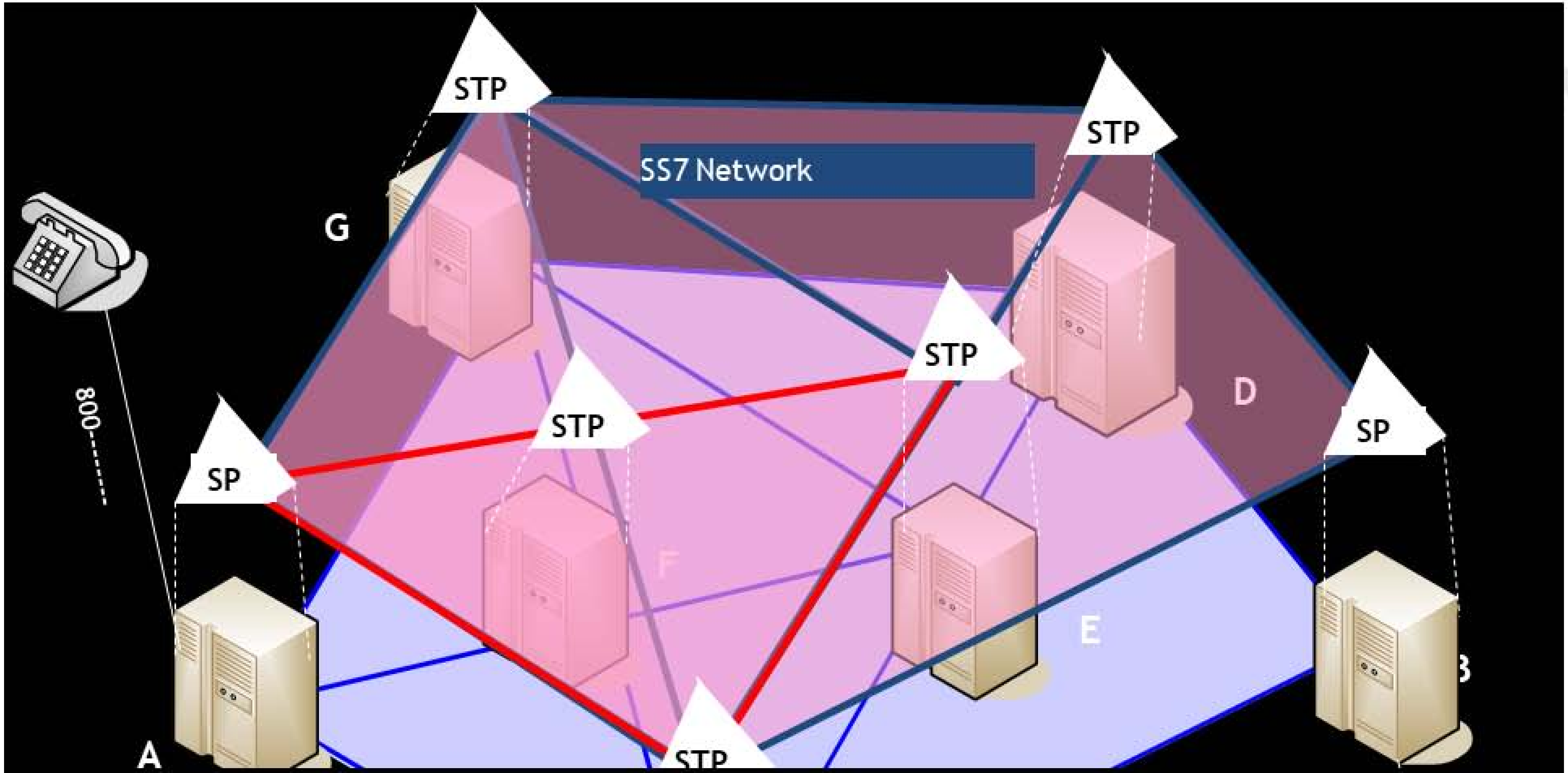
SCCP - Global Title Translation (GTT)



SINCE THIS NUMBER IS NOT KNOWN IN THE NUMBERING PLANE, WHAT CAN THE NETWORK DO ?

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SCCP - Global Title Translation (GTT)

Solution 1

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Solution 1

- Each switch in the country could maintain an 800 # Database
- That allows translating the dialled digits of an 800 # into a normal telephone number

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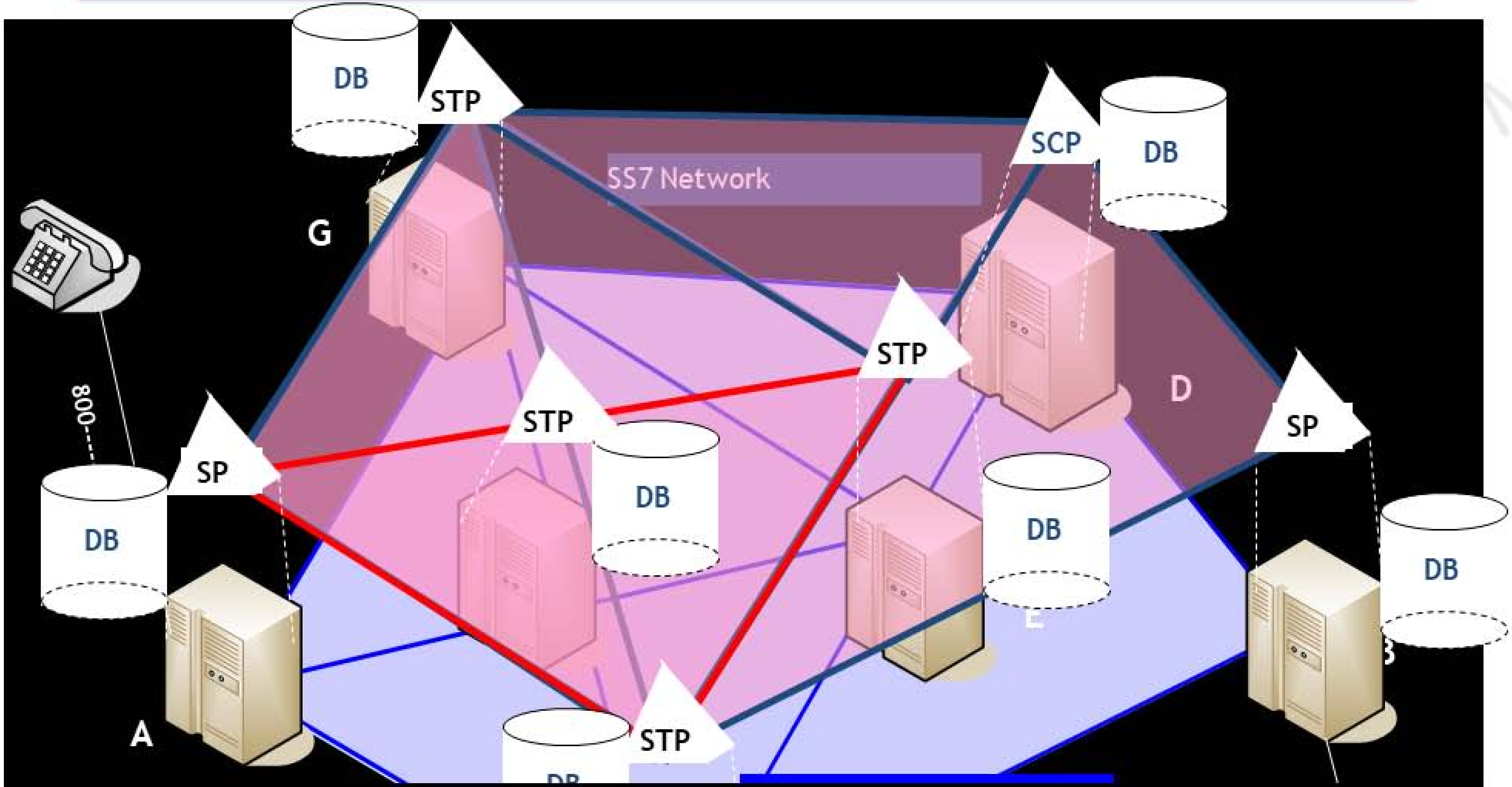
Solution 1



UNILATERAL UPDATING OF ROUTING TABLE: SOURCE OF INCOHERENCIES

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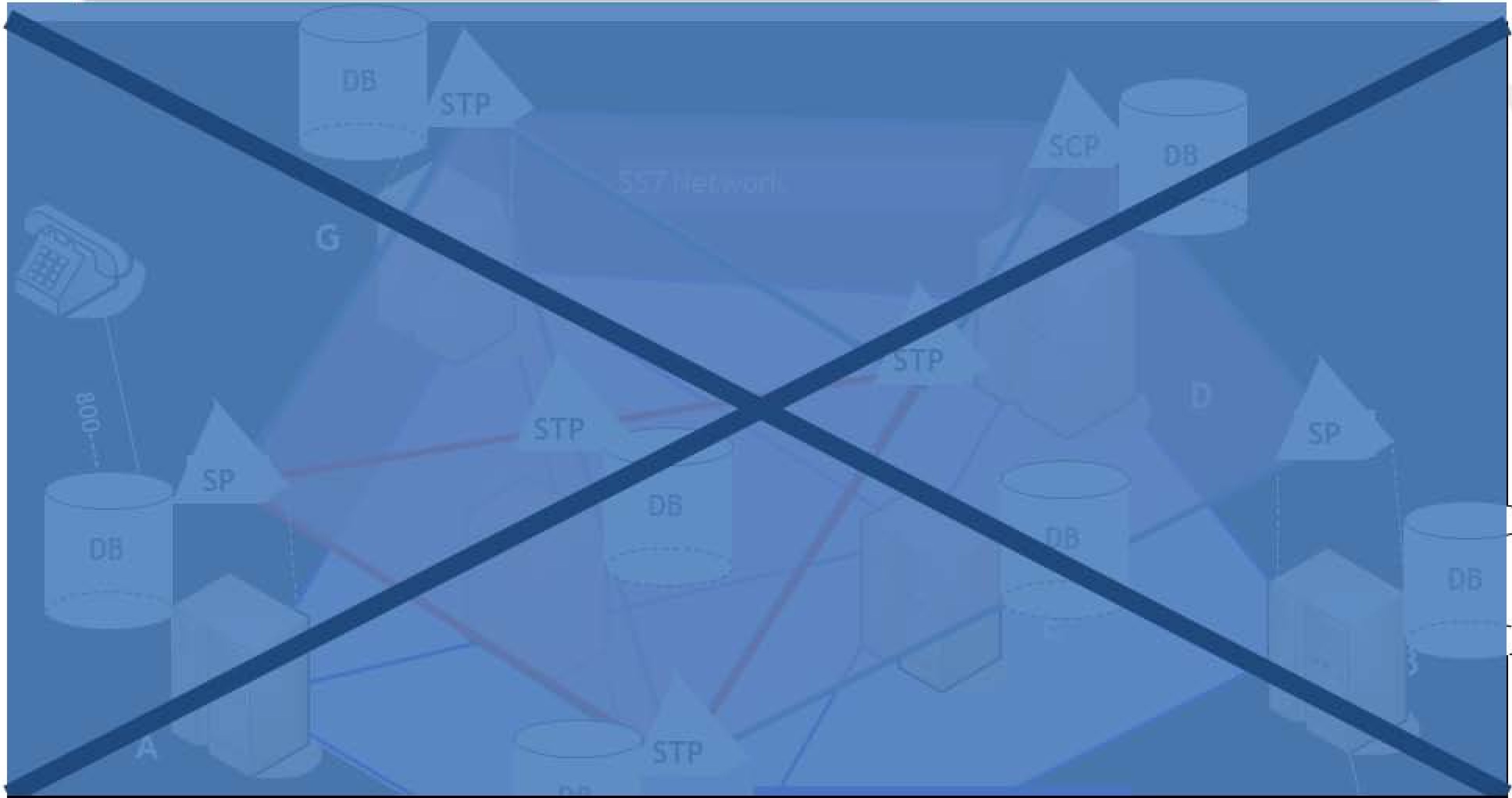
Solution 1



UNILATERAL UPDATING OF ROUTING TABLE: SOURCE OF INCOHERENCIES

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SCCP - Global Title Translation (GTT)

Solution 2

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Solution 2

- Each switch maintains a small database which provides it with the DPC and SSN of a centralized 800 database.
- The switch can send a query there and receive a normal telephone number in return.
- Then, the switch can handle the call as if a normal telephone number was dialled.

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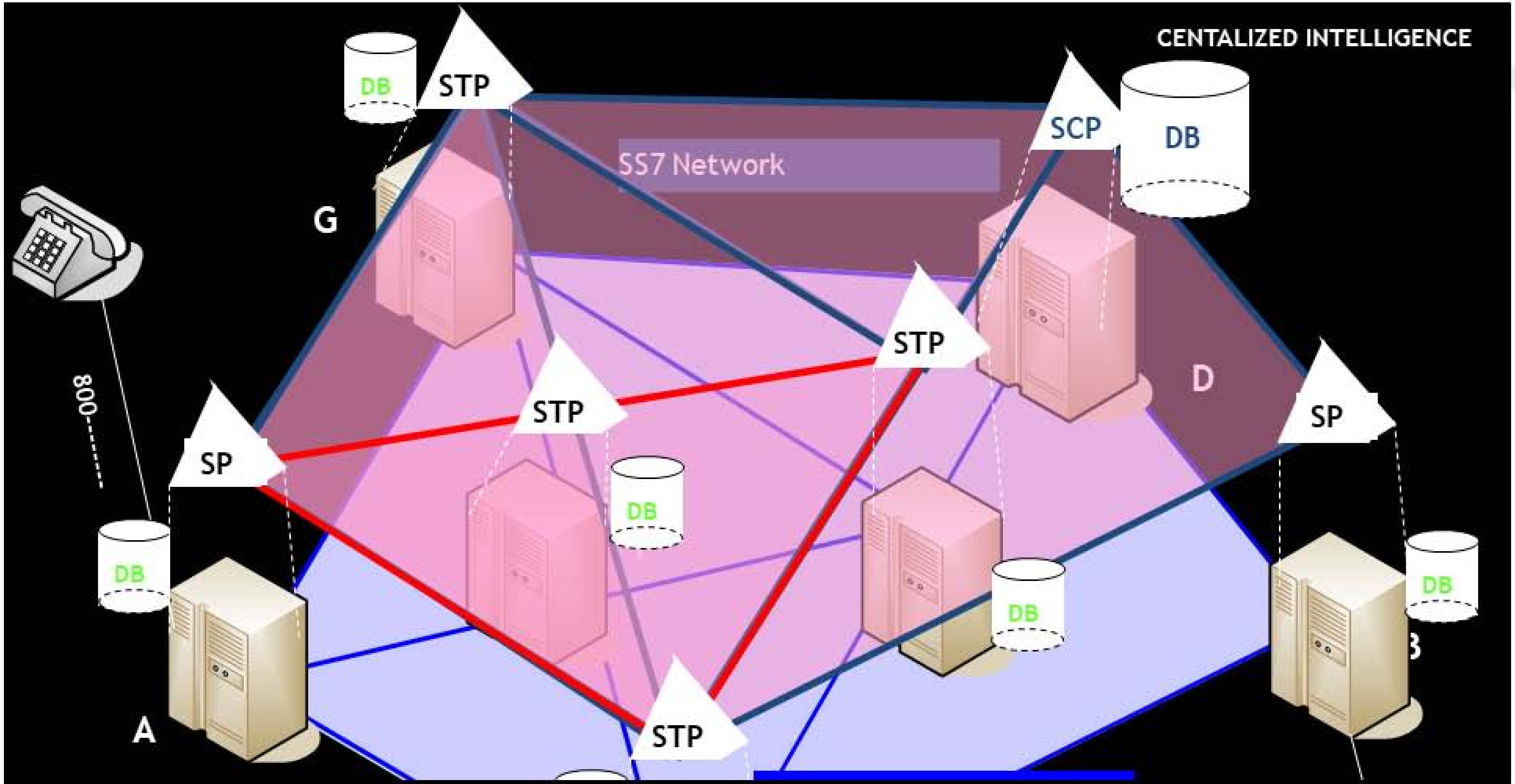
Solution 2



PROLIFERATION OF SERVICES LEADS TO PROLIFERATION OF DATABASE:

MAINTAINING RT DATABASE OF RT DATABSES IS QUITE COMPLEX

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Solution 2

PROLIFERATION OF SERVICES LEADS TO PROLIFERATION OF DATABASE:

MAINTAINING RT DATABASE OF RT DATABSES IS QUITE COMPLEX

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SCCP - Global Title Translation (GTT)

Solution 3 - Solution 3 (Global Title Translation)

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Solution 3 (Global Title Translation)

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- Global Title (GT) is a unique address used by the higher levels of SS7 (ISUP, TUP, SCCP), which refers to only one destination, but its translation to PC number is required at MTP level .
- For example:
  - 800/888 number, calling card number, E.164 and E.212 formats numbers, IMSI
- SCCP provides Global Title Translation (GTT) capabilities above MPT3 that enables MTP layer to pass the message forward to the correct destination.

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Global Title Translation Principle

1. Some STP carry databases and SP needs not to know where the DB is located.
2. SP makes a request for a GTT and passes it on to the STP.
3. The STP may have the DPC and SSN of the DB in its own tables.
4. If so, it redirects the request and later returns the data to PC requestor.
5. If not, it will usually have the location of another STP to which it can pass the Global Title request.
6. When an STP which has access to the data is reached, it can retrieve the data and send it back to the location which was the one that sent the request to its final STP destination.
7. Node by node, the data gets returned to the requestor.

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Global Title Translation Advantages

- Four major advantages derived from GTT
  - SPs can have access to data of all types without having to maintain cumbersome tables.
  - New data can become universally available very quickly.
  - Access to the DB is controlled and can either be restricted, or provided at a fee.
  - Companies can have better control over the data kept within their own networks (For example, the STP serving as the gateway for network can use GTT to hide the location of databases from outsiders).
- GTT keeps SPs from having overly large routing tables that would be difficult to provision and maintain.
- A GT is a directory number that serves as an alias for a physical network address (a point code and an application reference called a subsystem number (SSN)).

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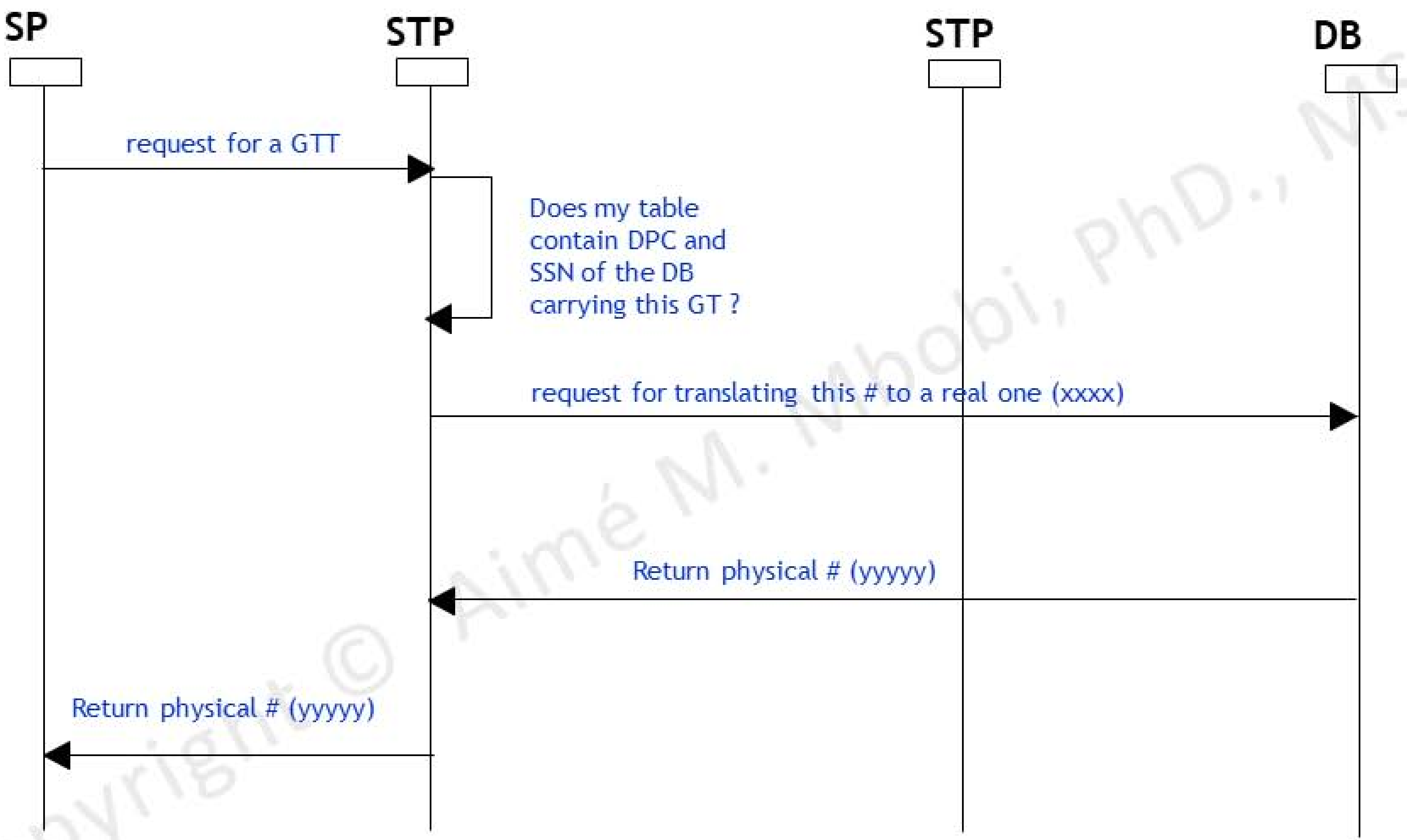
Global Title Translation Call Flow



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SCCP Messages

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SCCP Messages

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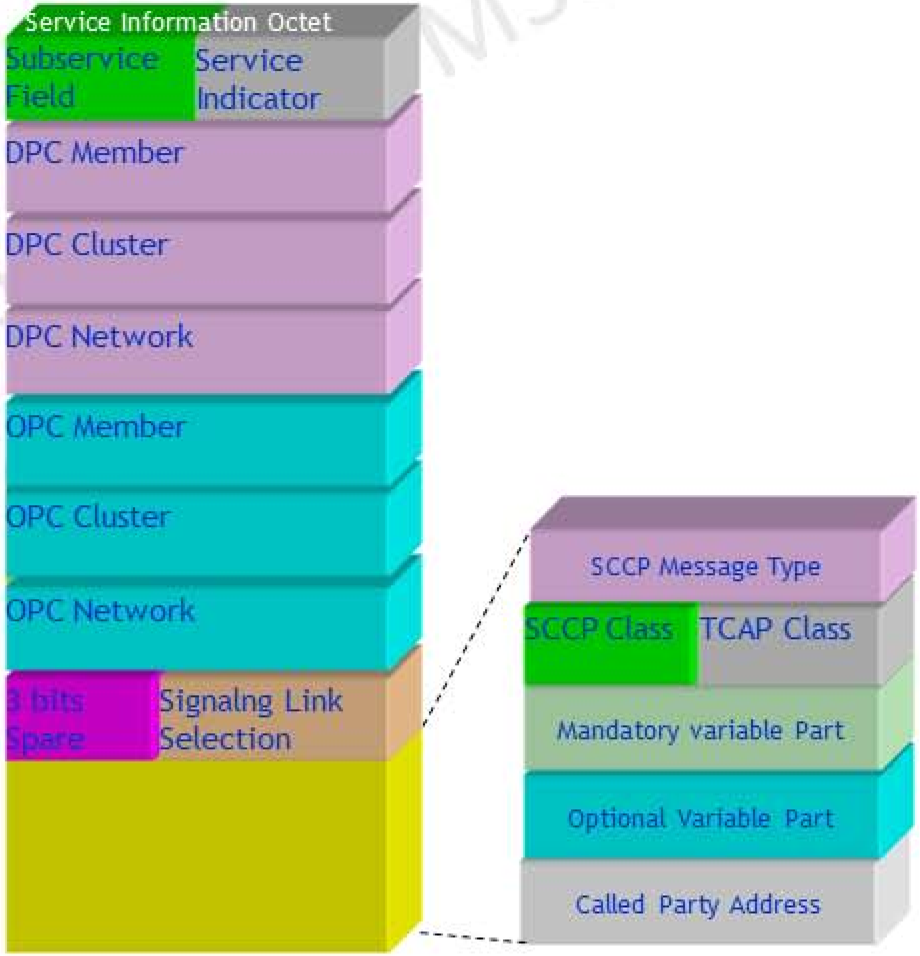
SCCP Message Format

- To address the SCCP, the Service Indicator of the SIO is coded 0011.
- SCCP messages are contained within SIF
- SIF contains the routing label followed by the SCCP message contents.
- SCCP message is comprised of a one-octet message type field which defines the contents of the remainder of the message (message type e.g. Unit data).



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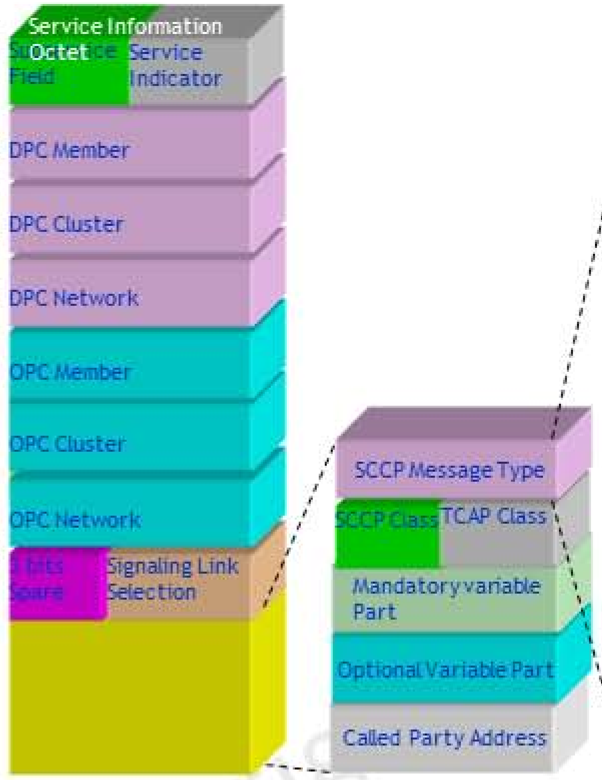
SCCP Message Types



Message Type	Class 0	Class 1	Class 2	Class 3	Code
Connection Request (CR)			X	X	00000001
Connection Confirm (CC)			X	X	00000010
Connection Refused (CREF)			X	X	00000011
Released (RLSD)			X	X	00000100
Release Complete (RC)			X	X	00000101
Data Form 1 (DT1)			X	X	00000110
Data Form 2(DT2)				X	00000111
Data Acknowledgment (AK)				X	00001000
Unidata (UDT)	X	X			00001001
Unidata Service (UDTS)	X	X			00001010
Expedited Data (ED)				X	00001011
Expedited Data Ackt (EA)				X	00001100
Reset Request (RSR)				X	00001101
Reset Confirmation (RSCM)				X	00001110
Error (ERR)			X	X	00001111
Inactivity Test (IT)			X	X	00010000
Extended Unitdata (ANSI only)					00010001
Extended Unitdata Service (ANSI)					00010010

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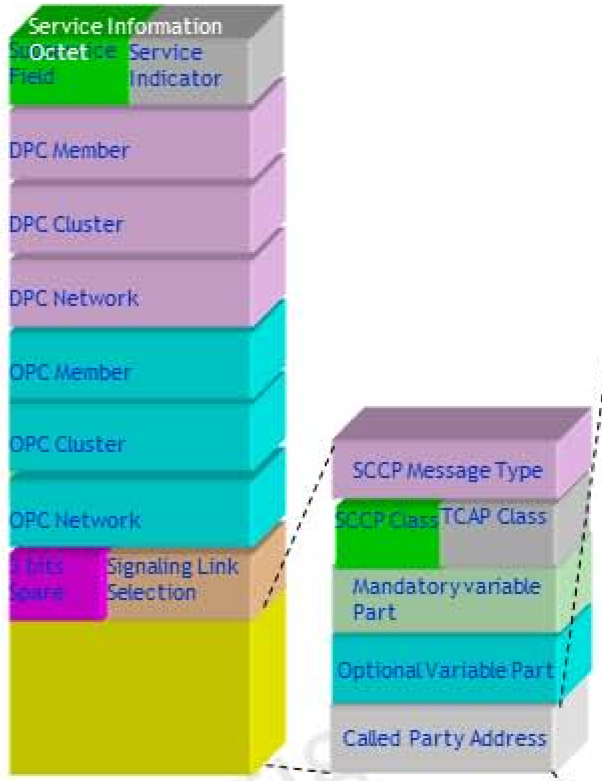
SCCP Called Party Address



[redacted]		
Parameter Length	indicates the total length in octets	
Address Indicator		
	Point Code Indicator	indicates whether point code is present or not
	SSN Indicator	indicates whether subsystem number is present or not
	Global Title Indicator	indicates whether global title information (Encoding Scheme, Translation type, Numbering plan etc) is present or not.
	Routing Indicator	indicates whether routing will be done based on GT/SSN.
	Spare	For national use
Subsystem Number	contains SSN value if present	
Translation Type	contains translation type value if present	
Encoding Scheme	contains encoding scheme value if present.	
Numbering Plan	contains numbering plan information if present	
Nature of address indicator	contains nature of address indicator value if present.	
Spare		
Called Address Signals	contains address signal value in BCD format	

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SCCP Messages Parameters Table

PARAMETER FIELD	CR	CC	CREF	RLSD	RLC	DT1	DT2	AK	ED	EA	RSR	RSC	ERR	IT	UDT	XUDT*	UDTS	XUDTS
Message Type Code	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Destination local ref.		M	M	M	M	M	M	M	M	M	M	M	M	M				
Source local ref.	M	M		M	M						M	M		M				
Called party address	M	O	O												M	M	M	M
Calling party address	O														M	M	M	M
Protocol Class	M	M												M	M	M		
Segmenting/Reassembling						M												
Receive Sequence No.								M										
Sequencing/Segmenting							M							M1				
Credit	O	O						M						M1				
Release cause				M														
Return cause																	M	M
Reset cause											M							
Error cause													M					
Data	O	O	O	O		M	M		M						M	M	M	M
Refusal cause			M															
End of opt. parameters	O	O	O	O												O		O
SCCP Hop Counter	O															M		M
ISNI	O															O		O

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SCCP Messages Parameters Table

PARAMETER NAME	Binary Codes
End of optional parameters	0000 0000
Destinations local reference	0000 0001
Source local reference	0000 0010
Called party address	0000 0011
Calling party address	0000 0100
Protocol class	0000 0101
Segmenting/reassembling	0000 0110
Receive sequence number	0000 0111
Sequencing/segmenting	0000 1000
Credit	0000 1001
Release cause	0000 1010
Return cause	0000 1011
Reset cause	0000 1100
Error cause	0000 1101
Refusal cause	0000 1110
User data	0000 1111
SCCP hop counter*	0001 0000
ISNI (ANSI only)	1111 1010

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SCCP Messages

Address Translation

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Address Translation

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- Two addresses used:
  - Calling party address: reveals origin of message and is required to identify destination of response or return undelivered messages.
  - Called party address: used to send the message.
- SCCP address may contain PC, SSN or GT or combination of them.
- SCRC performs address translation for upper layers and MTP 3.

Message Translation for Upper Layer

- SCRC receives message from user layer (MAP, etc,.) with address in form of:
  - DPC
  - DPC + (SSN and/or GT)
  - GT
  - GT + SSN
- If DPC is not present, SCCP must derive it from GT (using mapping table setup by network engineers).
- If DPC = other node, message is passed to MTP 3.
- Otherwise it is routed internally based on SSN.

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Processing Traffic Received from MTP 3

- SCRC examines Address Indicator field in the SCCP header.

  1. If routing indicator bit indicates that the routing is to be performed on the GT, an address translation will be performed to determine both DPC and SSN.
  2. If the DPC is the node itself, and the SSN is correct, the message is passed either to SCOC or SCLC.
  3. If the DPC is not the node itself, the message is passed back to MPT3

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OPC and DPC in GTT

- GTT sets the OPC to the point code of the node performing GTT and, in most cases, changes the DPC to a new destination.
- From an MTP viewpoint, GTT establishes new origination and destination points (when a new DPC is derived).
- As a result, the OPC and DPC of a message for which GTT has been performed do not necessarily reflect the ultimate origination and destination points for the MTP user within the network.

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Common SCCP Translation

Performed by	Called SCCP Address	Translation Operation	New Called SCCP Address
STP	GT	GT $\rightarrow$ PC+SSN	SSN and PC used in routing label
STP	GT+SSN	GT $\rightarrow$ PC	SSN and PC used in routing label
STP	GT	GT $\rightarrow$ PC+GT	PC and GT used in routing label
End Point	GT	GT $\rightarrow$ SSN	Nothing, message terminates

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Example of Address Translation

Example of Address Translation

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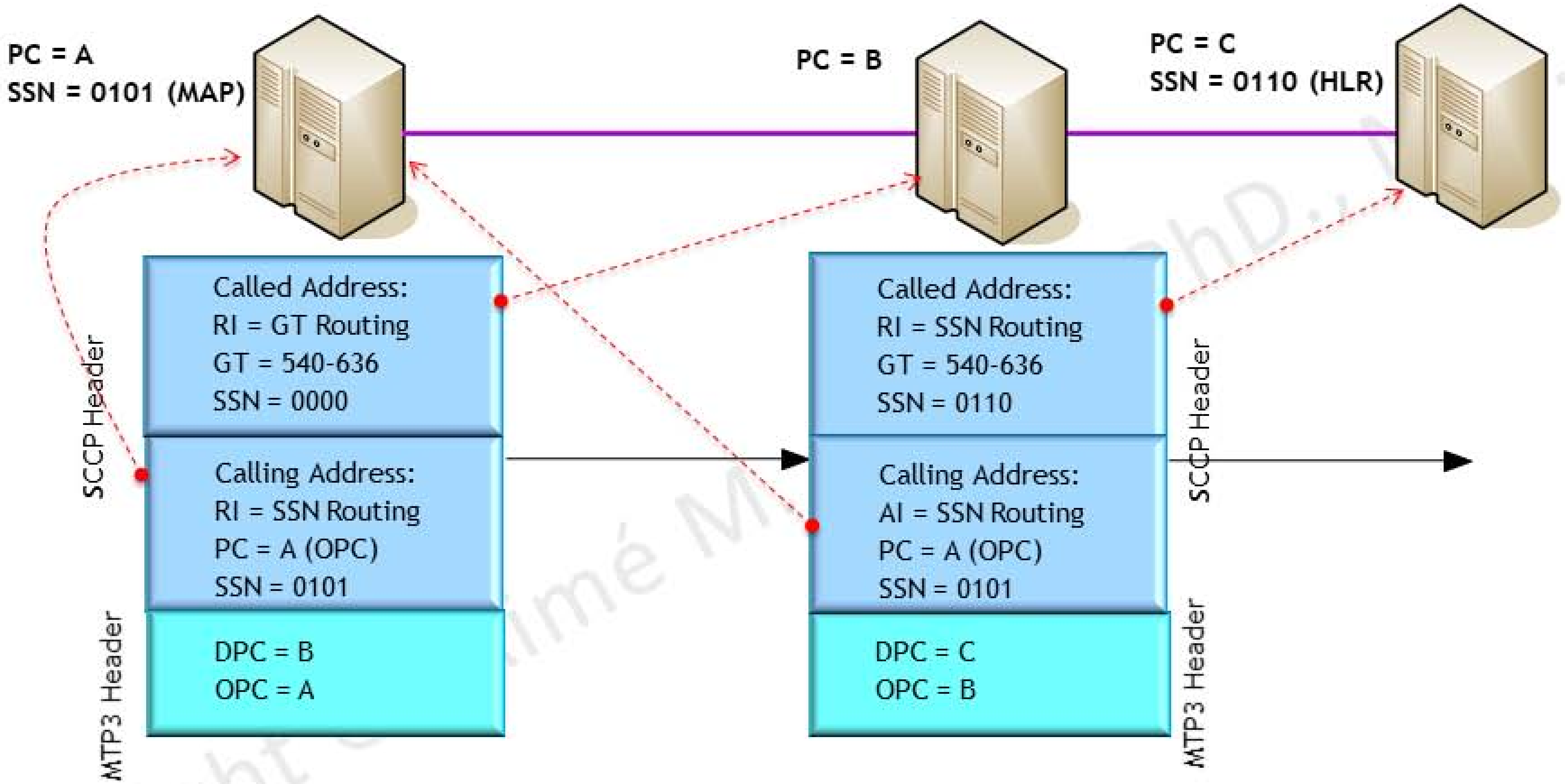
Example of Address Translation



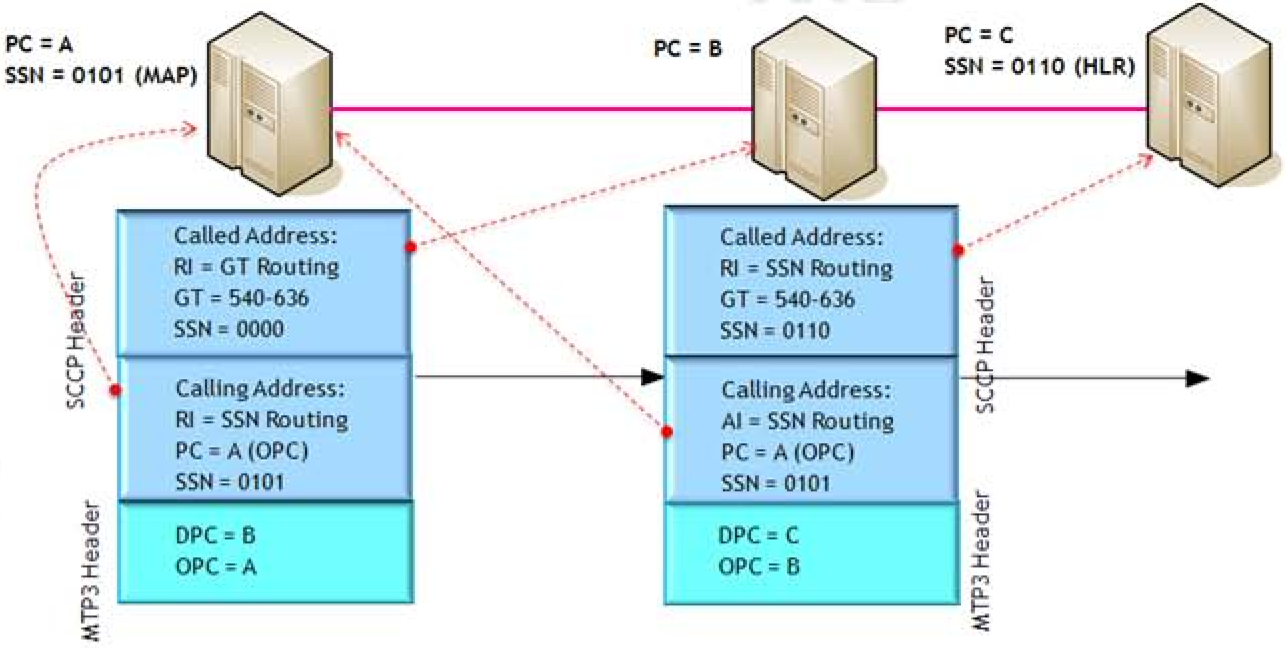
These translations take place at SP B, and three nodes (A, B, C) are involved.

A is sending traffic from its MAP user application, which must be identified with the SSN = 0101 to the DB (HLR) in C with SSN = 0110

Example of Address Translation

1. A places its originating point code (OPC=A) and the destination point code (DPC = B) in the MTP 3 header.

2. In the SCCP header, it codes the called address and calling address fields.



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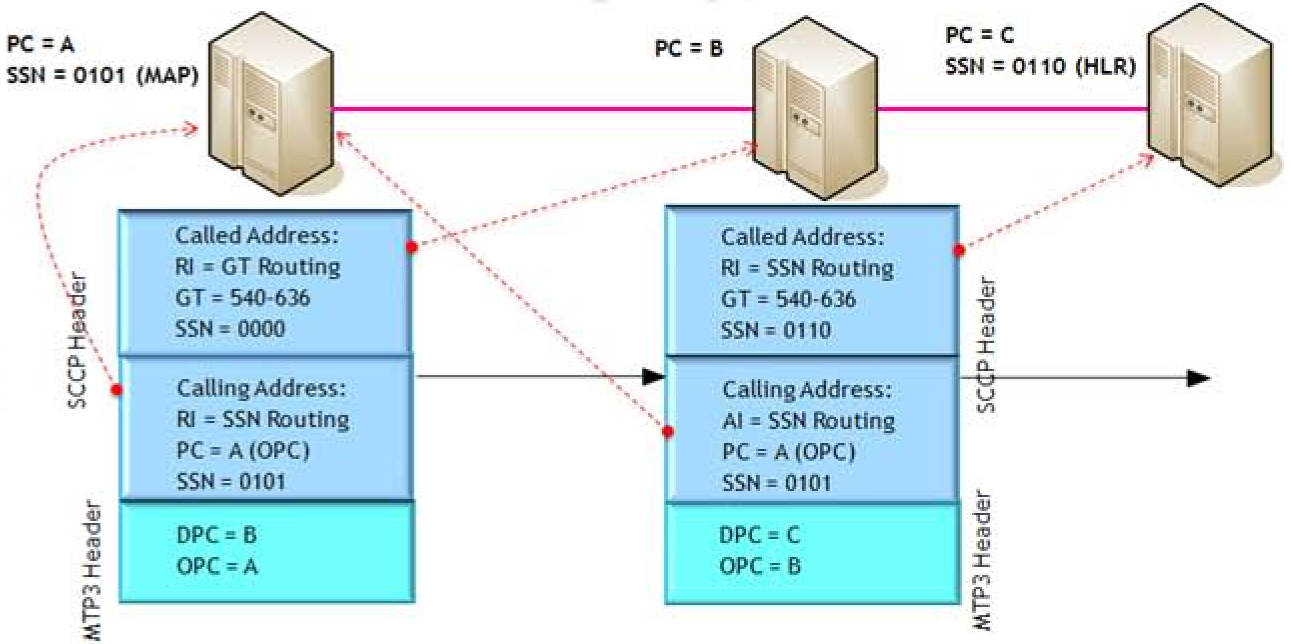
Example of Address Translation

3. For the called address, a bit in the Address Indicator (AI) field indicates routing is to be performed on the global title (GT)=which is 540-636.

4. The SSN is set to 0000, which is a reserved number indicating that the SSN is not used (or not known).



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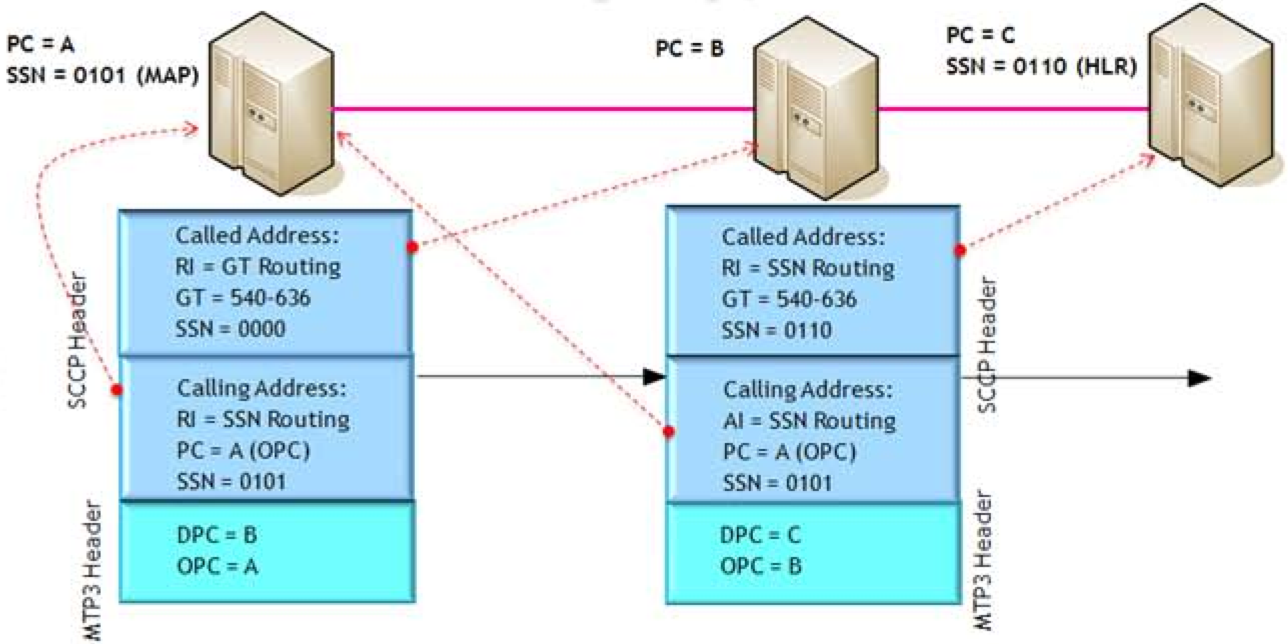
Example of Address Translation

5. For the calling address, the AI bit is set by A, but is not used here.

6. The PC is A (OPC), and the SSN is set to 0101, which identifies the MAP

7. This message is routed to Signaling Point B.



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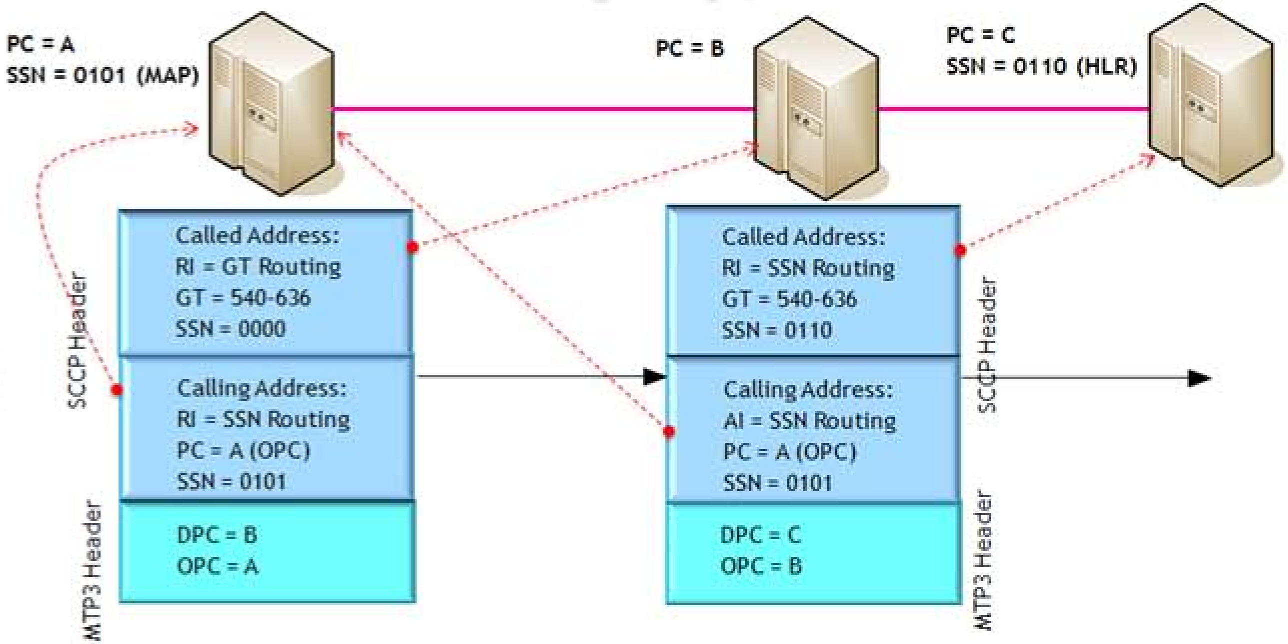
Example of Address Translation

8. MTP 3 passes the message to SCCP, which examines the SCCP header.
9. Based on the header, SCCP creates/modifies these fields, changes DPC and OPC values, and passes this information to its MTP 3 layer for sending on to node C.



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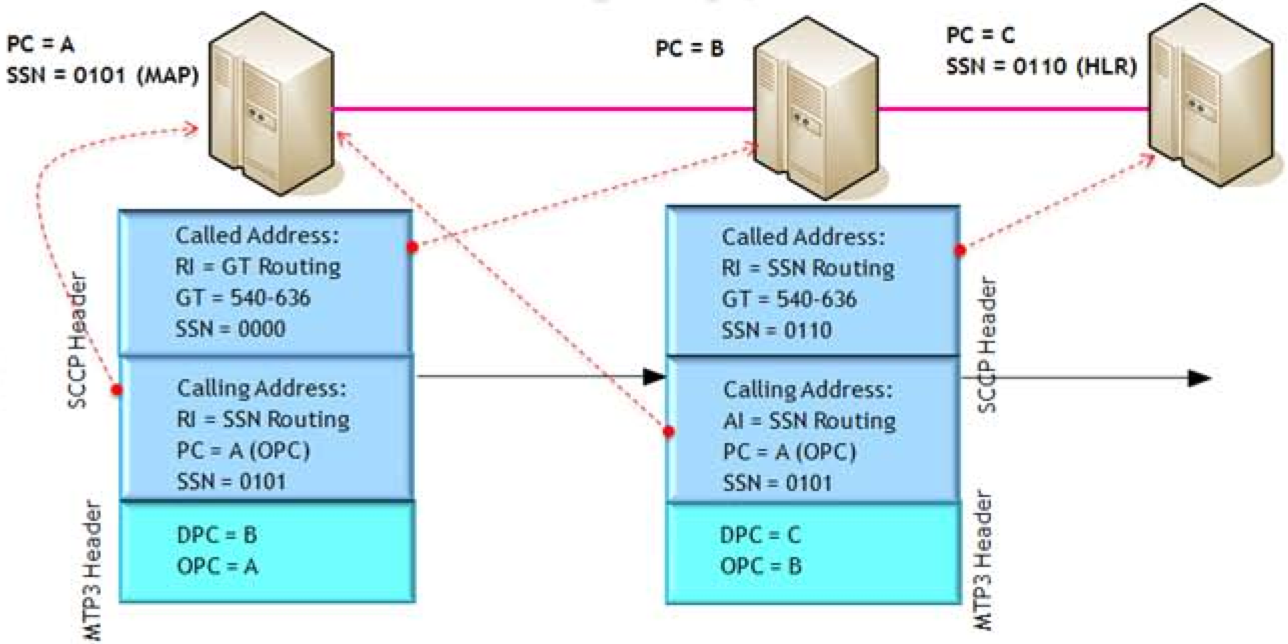
Example of Address Translation

10. SCCP has changed the DPC to C, and the OPC to B.
11. Then, SCCP translated the GT = 540-636 to (PC = B) + (SSN =0110) that is the HLR application at node C.
12. Notice that the AI bit is set to indicate SSN based routing, which is used at C to determine what part of the SCCP address is used.



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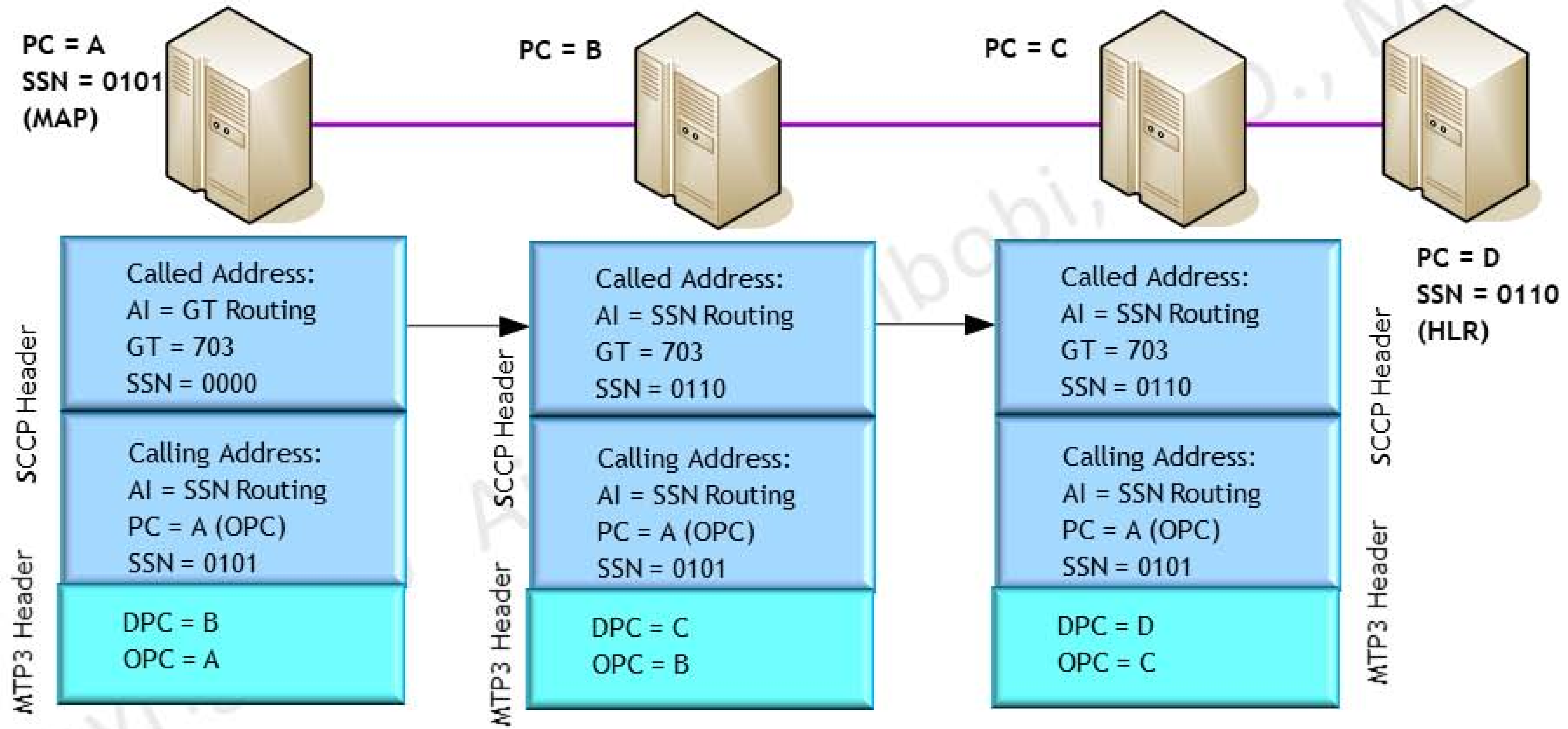
Example of Address Translation



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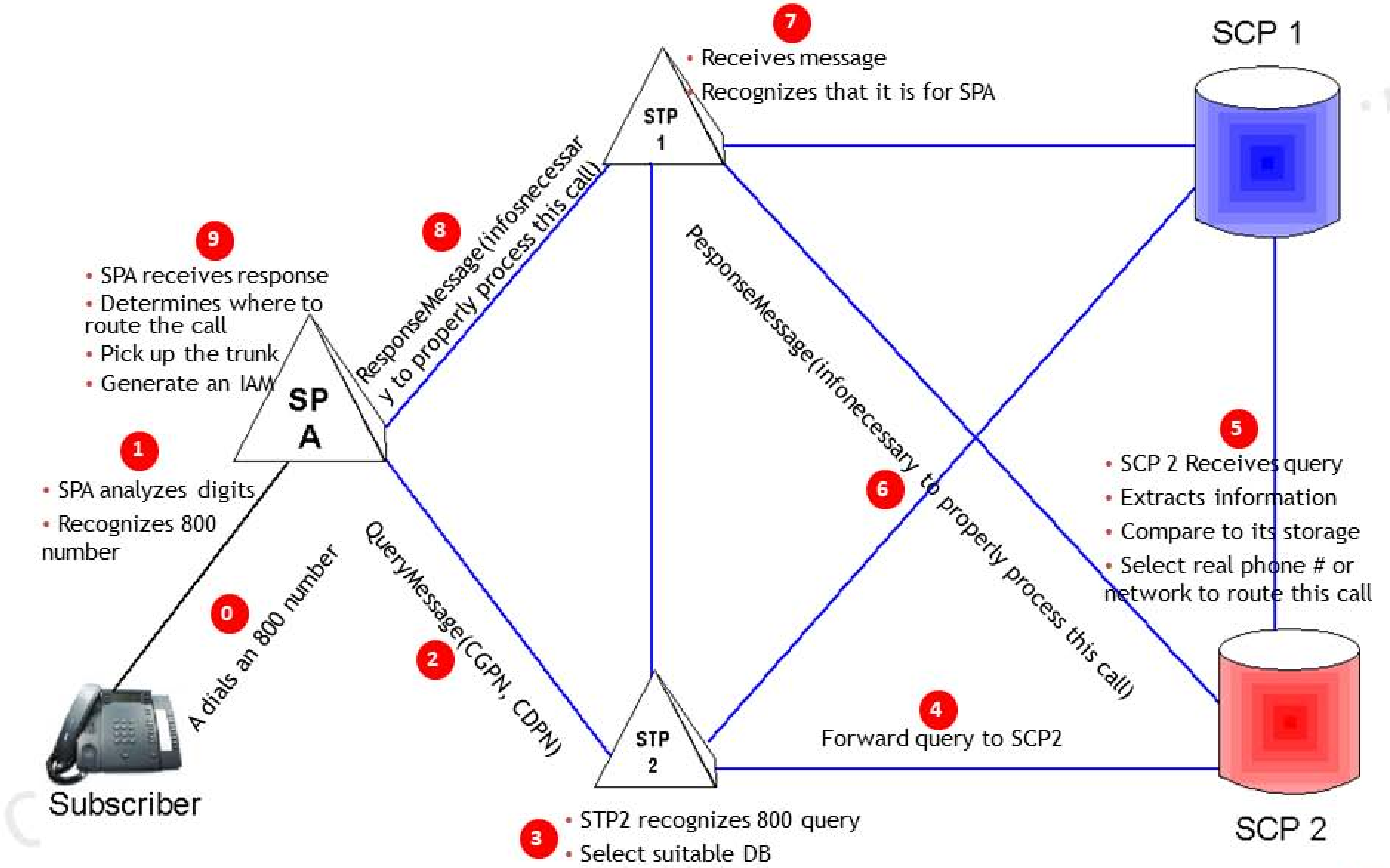
Example of a Database Query



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International Translating Function

- Since SMs do not require a circuit establishing, they do not contain the circuit set number, they rather include a GT.
- The message transfer between two SPs of two different SS7 networks (national or international) is made of three successive transfers.
- The translating function is performed by SCCP.
- In GT E124, for translating (IMSI)
  - The 1st numbers are the country dialling code and the network code (E164)
  - The remainder could be another code such as a MSIM

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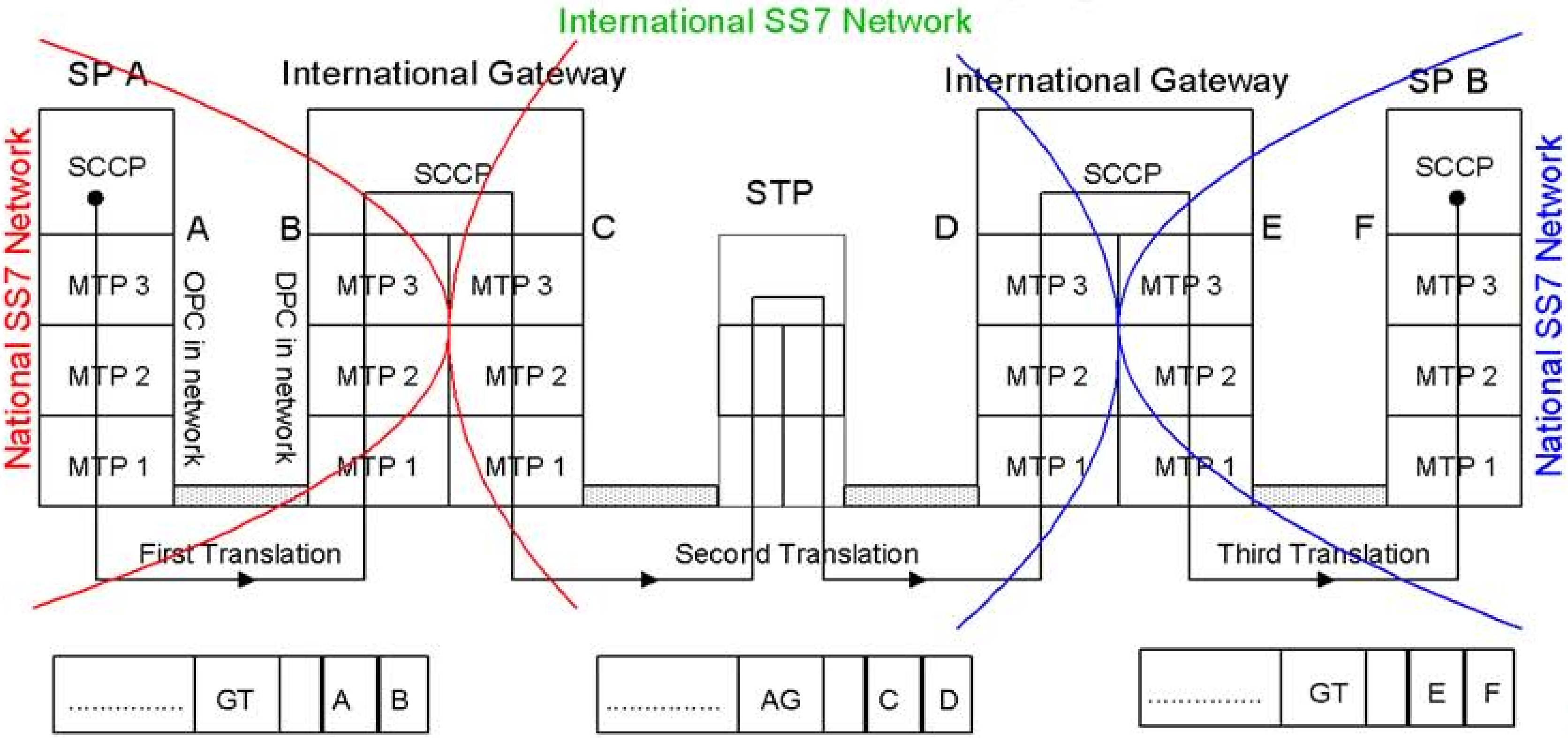
Example of International Translating Function

1. SP Codes are AB, CD and EF, GW1 belongs to country 1, GW2 belongs to country 2
2. In each network, international gateways have two different MTP addresses
3. Message is sent from SP1 to SP2, GW1 finds the PC (D) of GW2
4. It modifies the address field in the message that transits in the international SS7
5. GW2 retrieves the address F of SP2 from the GTT



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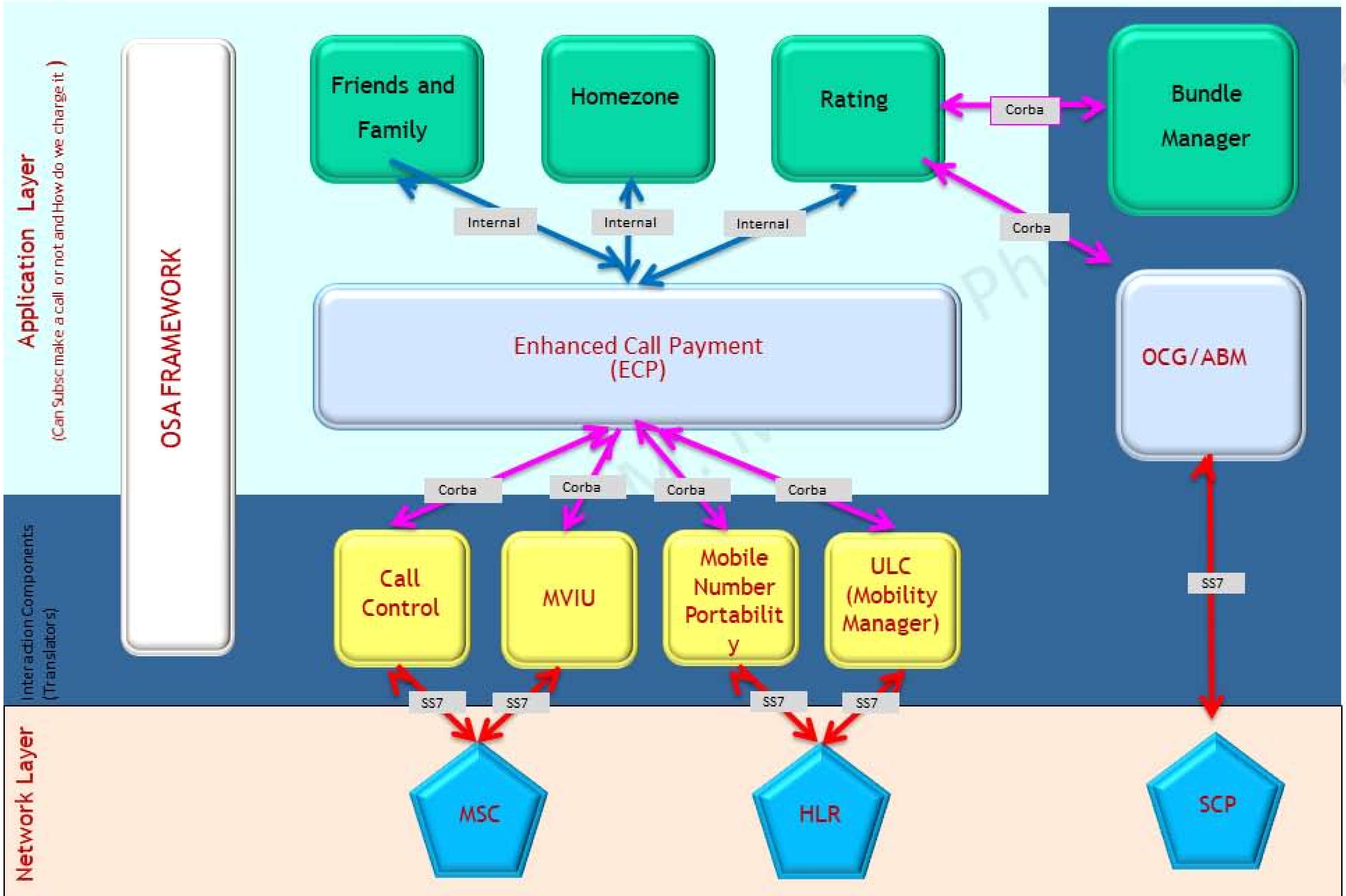
Example of International Translating Function



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SCCP Tracing

1	2	3	4	5	6	7	8		
BIB	BSN								MTP2 Header Trace
FIB	FSN								
Spare		LI							
				Service Indicator				Service Information Octet	MTP3 Header Trace
		Message Priority							
Network Indicator									
DPC								Routing Label	
OPC									
				SLS					
Spare									
SCCP Message Type (SCCP message type e.g. Unit data)									SCCP Header Trace
				SCCP Class (type of SCCP service e.g. basic connectionless service)					
TCAP Class (type of TCAP service e.g. return message on error)									
First parameter offset pointer (offset value from where first mandatory variable parameter (i.e. called address) starts)								Mandatory variable part	
Second parameter offset pointer (offset value from where first mandatory variable parameter (i.e. called address) starts									
Third parameter offset pointer (offset value from where first mandatory variable parameter (i.e. called address) starts)									
optional variable part offset pointer (offset value from where optional part starts, if present)									
Parameter Length								Called (Calling) Address (destination address information)	
PC Ind	SSN Ind	GT Indicator (GT I)				Routing Ind	Spare		
Subsystem Number									
Translation Type									
				Encoding Scheme					
Numbering Plan									
Spare	Nature of address indicator								
Spare									
		Called (Calling) AddressSignals (contains address signal value in BCD format)							
Data Length (contains data parameter length)									
Data (contains SCCP data)									

Example of SCCP Tracing

```
 Ch#:RD3 ³ ANSI SS7          ³Flg:1     Cnt:1     Time:03:12:17.317        ³
³ 10110100 ³ BIB/BSN........... ³ 1/52                                        ³
³ 11100000 ³ FIB/FSN........... ³ 1/96                                        ³
³ ..111111 ³ SU type/length.... ³ MSU63                                       ³
³ 00...... ³ Spare............. ³ 0                                           ³
³ octet003  Service information octet.....................................³
³ ....0011 ³ Service indicator. ³ SCCP Signalling Connection Control Part     ³
³ ..00.... ³ Message priority.. ³ 0                                           ³
³ 10...... ³ Network indicator. ³ N National network                         ³
³ octet004  Routing label.................................................³
³ ........ ³ DPC: Net-Clstr-Mbr ³ 001-044-                                   ³
³ ........ ³ OPC: Net-Clstr-Mbr ³ 005-080-   XXX                              ³
³ 00010110 ³ SLS............... ³ 22                                          ³
³ octet011  SCCP Message type.............................................³
³ 00001001 ³ Headers H1/H0..... ³ UDT   Unitdata                              ³
³ ....0001 ³ Protocol class.... ³ 1                                           ³
³ 1000.... ³ Message handling.. ³ Return message on error                     ³
³ 00000011 ³ Pointer-> Called # ³ 3                                           ³
³ 00001110 ³ Pointer-> Call'g # ³ 14                                          ³
³ 00010111 ³ Pointer-> Data.... ³ 23                                          ³
³ octet016  Called Party Address..........................................³
³ 00001011 ³ Parameter length.. ³ 11                                          ³
³ .......1 ³ SSN indicator..... ³ Address contains a Subsystem Number         ³
³ ......0. ³ SPC indicator..... ³ No Signalling Point Code in Address         ³
³ ..0010.. ³ Global Title...... ³ GT includes Translation type                ³
³ .0...... ³ Routing basis..... ³ RoutingBasedOnGlobalTitleInTheAddress       ³
³ 1....... ³ Address indicator. ³ Nat'l address, coded to nat'l specification ³
³ 00000110 ³ Subsystem name.... ³ HLR                                         ³
³ 00001001 ³ Translation type.. ³ Translation type                            ³
³ ........ ³ Address digits.... ³ 2341590459443280                            ³
³ octet028  Calling Party Address.........................................³
³ 00001001 ³ Parameter length.. ³ 9                                           ³
³ .......1 ³ SSN indicator..... ³ Address contains a Subsystem Number         ³
³ ......0. ³ SPC indicator..... ³ No Signalling Point Code in Address         ³
³ ..0010.. ³ Global Title...... ³ GT includes Translation type                ³
³ .0...... ³ Routing basis..... ³ RoutingBasedOnGlobalTitleInTheAddress       ³
³ 1....... ³ Address indicator. ³ Nat'l address, coded to nat'l specification ³
³ 00000111 ³ Subsystem name.... ³ VLR                                         ³
³ 00001010 ³ Translation type.. ³ Translation type                            ³
³ ........ ³ Address digits.... ³ 187638001500                                ³
³ octet038  SCCP user data................................................³
³ 01001000 ³ SCCP data length.. ³ 72                                          ³
³ octet039  TCAP message, transaction portion.............................³
```

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User Part
Transaction Capabilities Application Part (TCAP)

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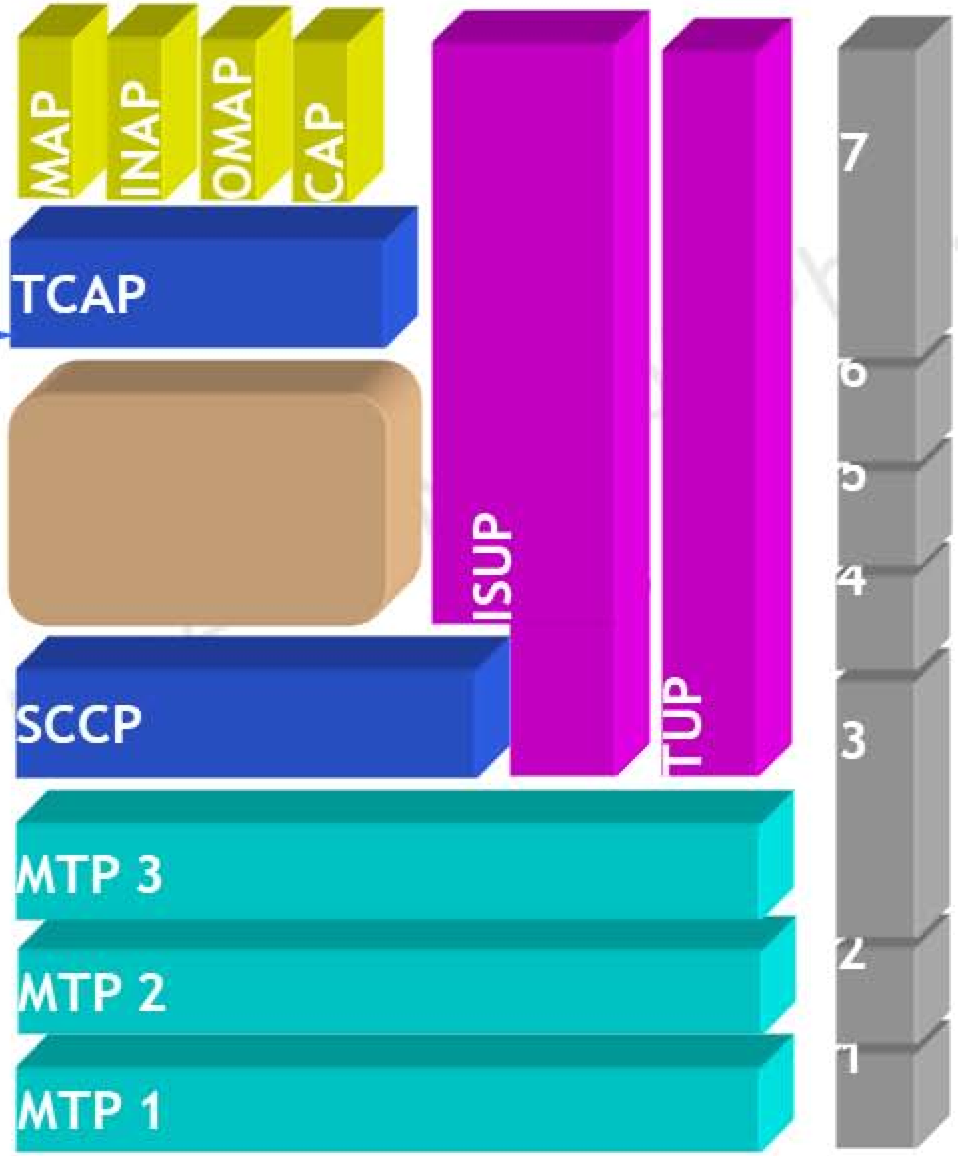
Transaction Capabilities Application Part (TCAP)

SS7 Protocol Architecture

Transaction Capabilities Application Part (TCAP)



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Transaction Capabilities Application Part (TCAP)

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- TCAP is connectionless Remote Procedure Call (RPC) like those used in the Internet application layer.
- TCAP functions on top of SCCP above a connectionless network (class 0 or 1)
- TCAP provides standardized method for network providers to communicate with each other.
- TCAP provides also non-circuit-related communications facilities and supports database access for SS7 switches

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Transaction Capabilities Application Part (TCAP)

- TCAP provides services that enable an application at one node to invoke execution of a procedure at remote node and to exchange the results of such invocation.

Major role of TCAP is to facilitate transactions with external databases

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TCAP Use and Services

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Use of TCAP

- TCAP is used for example by:
  - SP to obtain data from the 800 DBs
  - VLR to obtain subscriber's profile from the HLR (MAP Message)
  - ELS to request the subscriber's location (MAP ATI) from the HLR in VAS configuration
  - ELS and MSC to request/obtain the ERSK (MAP SLR) in E911 configuration
  - Invoke features at another switch (e.g. Automatic Call-back or Recall)
- TCAP Roaming Example:
  - When a mobile subscriber roams into a new MSC area, the VLR requests service profile information from the subscriber's HLR using information carried within TCAP messages

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TCAP services to user applications

- TCAP offers its services to user applications
  - INAP: Intelligent Network Application Part, (protocol for add-value services such as tool free, VPN, prepaid card)
  - GSM MAP: Mobile Application Part that provides service for terminal mobility and some complementary services
  - OMA: Operation Maintenance and Administration Part provides service for SS7 network administration

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Examples of Use of TCAP in Emergency Location Service

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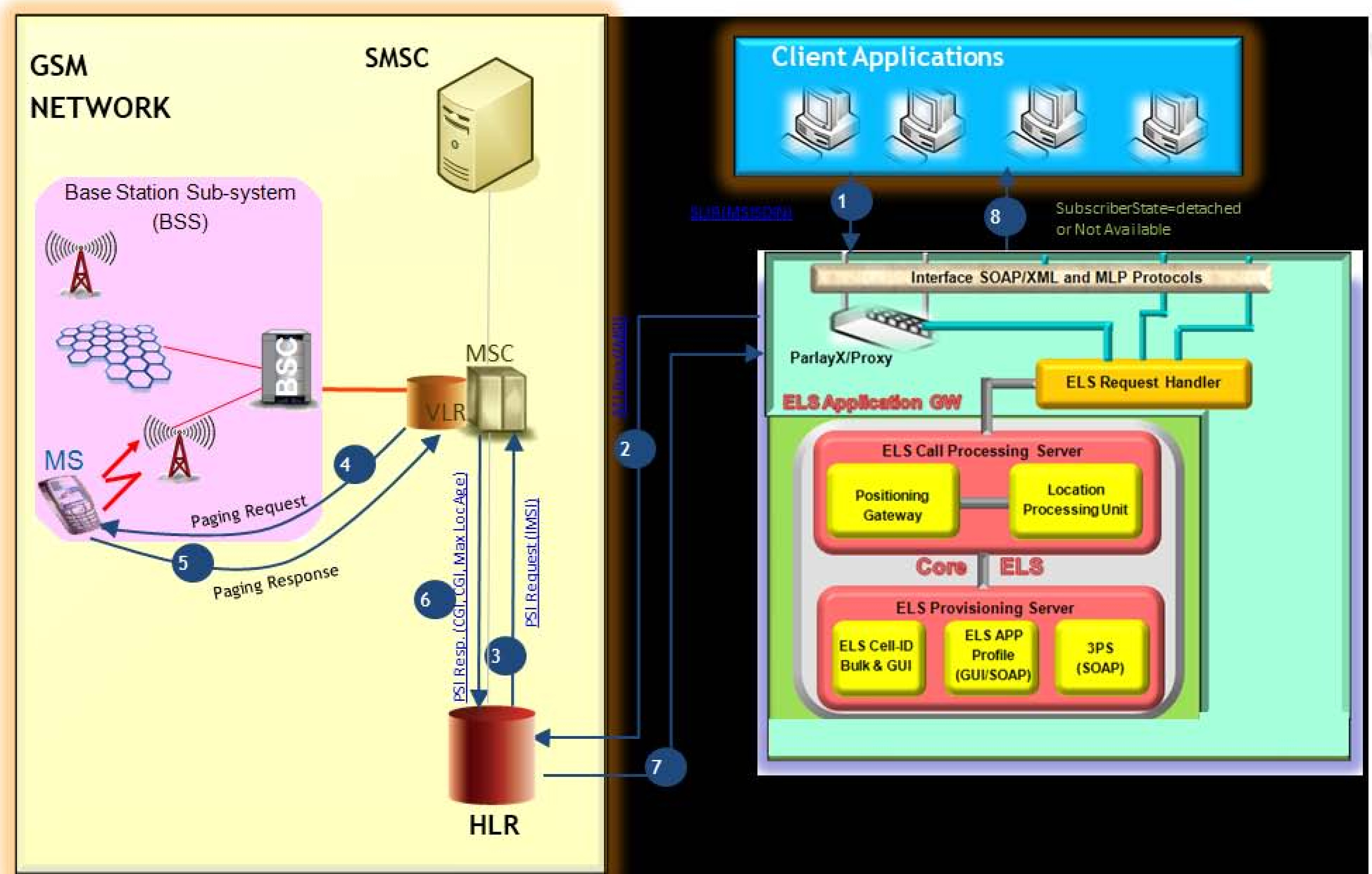
Emergency Location Service: Example of Law Intercept (ATI Call Flow)



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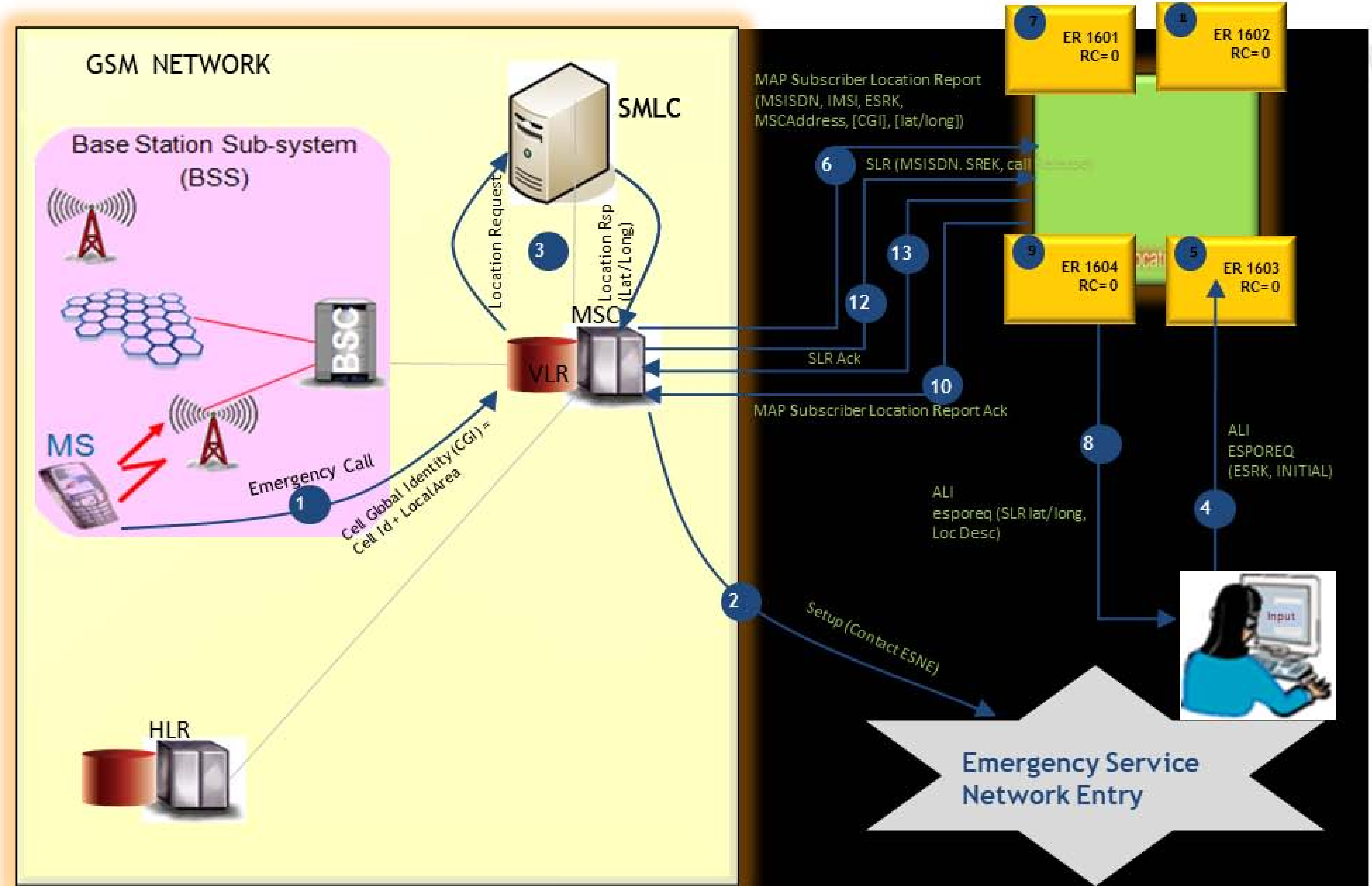
MEng.

Emergency Location Service: Example of ELS Allocates ESRK (E911 CF)



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TCAP Transaction Sub-Layers

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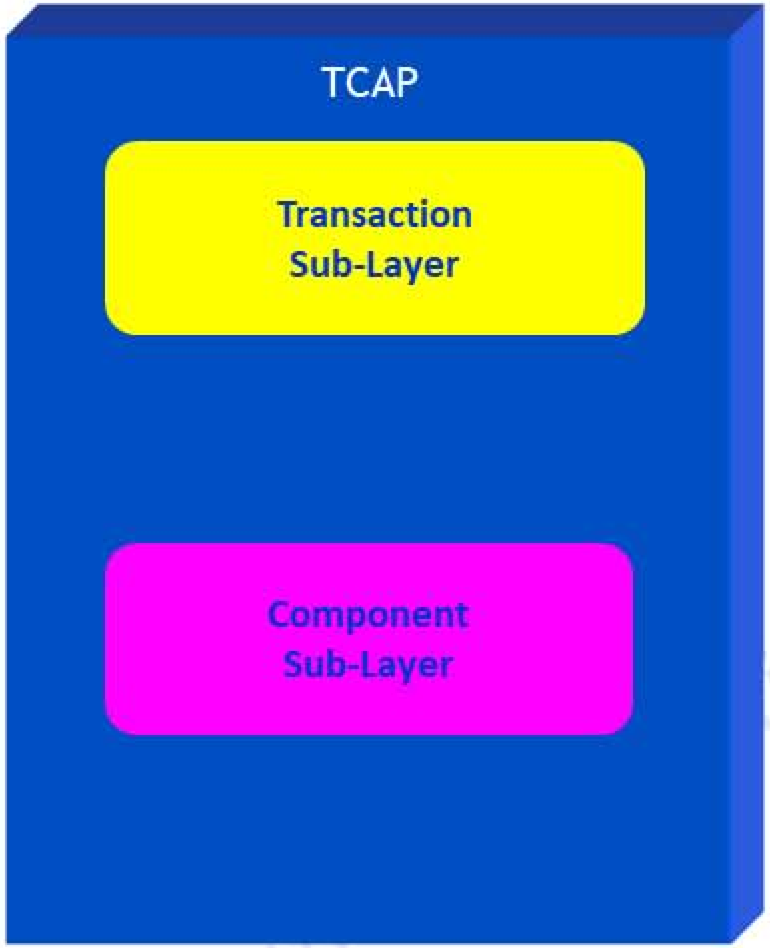
TCAP Transaction Sub-Layers



- TCAP message is made of two sub-layers
  - Transaction sub-layer
    - Provides a connection above the SCCP level (remote entities can open, pursue, and end the dialogues, and interact each others by exchanging components)

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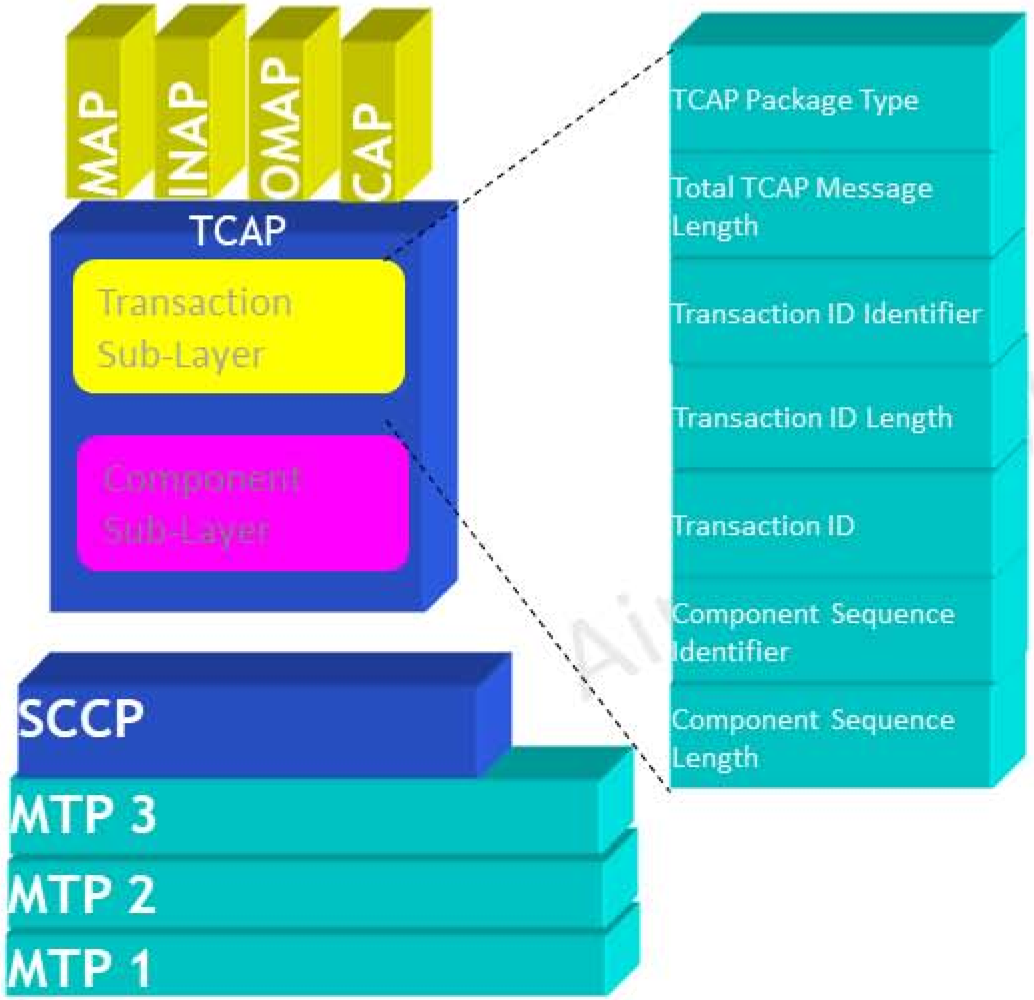
TCAP Sub-Layers



- Message Data are not contained in the TSL
- TSL consists of protocol control that has:
  - Package Type: indicates TCAP message type e.g. TC-Begin
  - Message Length: indicates how many octets of data are contained in the entire message
  - Transaction ID Identifier: Indicates that an identifier is present

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TCAP Sub-Layers

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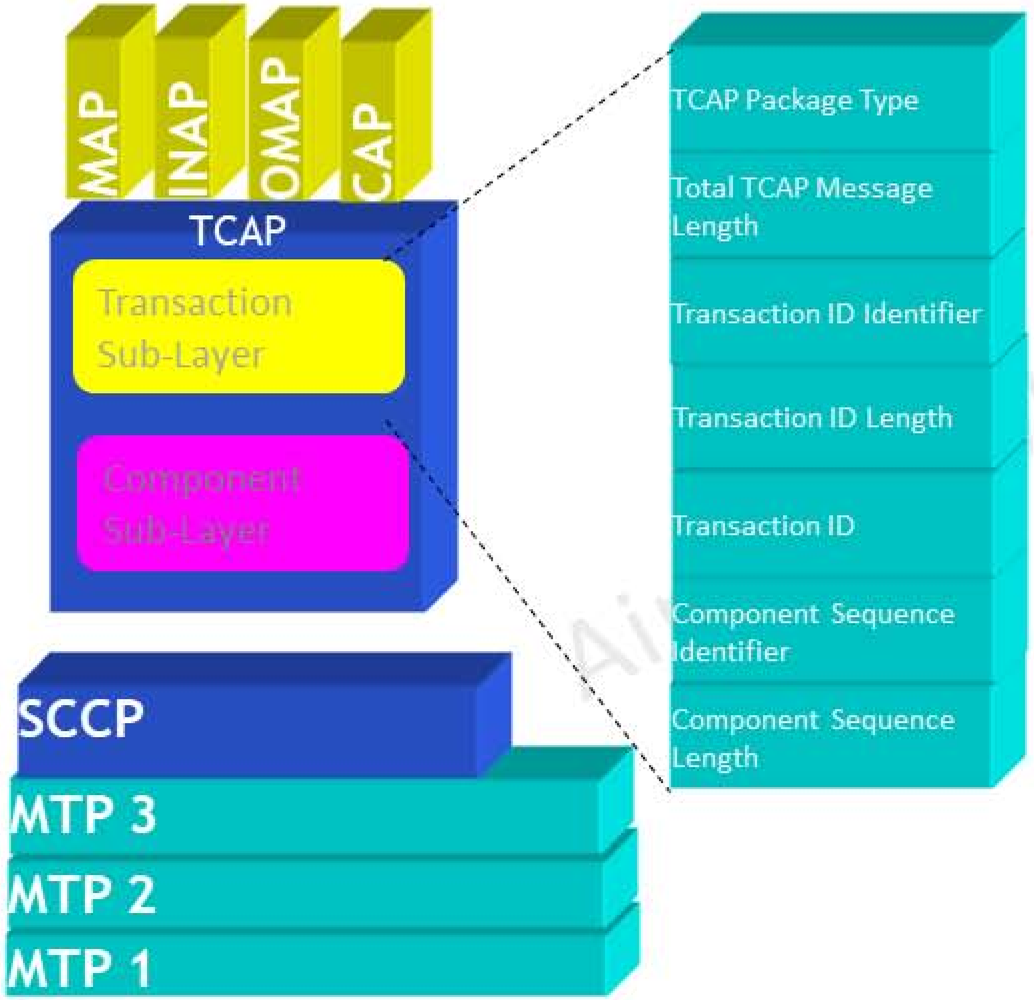

- Transaction ID Length: 0 for unidirectional messages, 4 otherwise
- Transaction ID: specifies value which is assigned to a complete query/response dialog (remains the same for the duration of the dialogue to correlate query/response because of multi queries at one time by an application)
- Component Sequence Identifier: sequence of components to follow
- Component Sequence Length: length of the message

Package Type of Transactions

- ***Unidirectional:*** Transfers component(s) in one direction only without reply
- ***Query with Permission***: Initiates a TCAP transaction (e.g., a 1-800 query)[1] (Begin)
- ***Query without Permission:*** Initiates a TCAP transaction[2] (Begin)
- ***Conversation with Permission:*** Continues a TCAP transaction[1] (Continue)
- ***Conversation without Permission:*** Continues a TCAP transaction[2] (Continue)
- ***Abort:*** Terminates a transaction due to an abnormal situation (End)
- ***Response:*** Ends the TCAP transaction. A response to an 1-800 query with permission may contain the routing number(s) associated with the 800 number

(1): The transaction may be ended by the destination node

(2): The transaction may not be ended by the destination node

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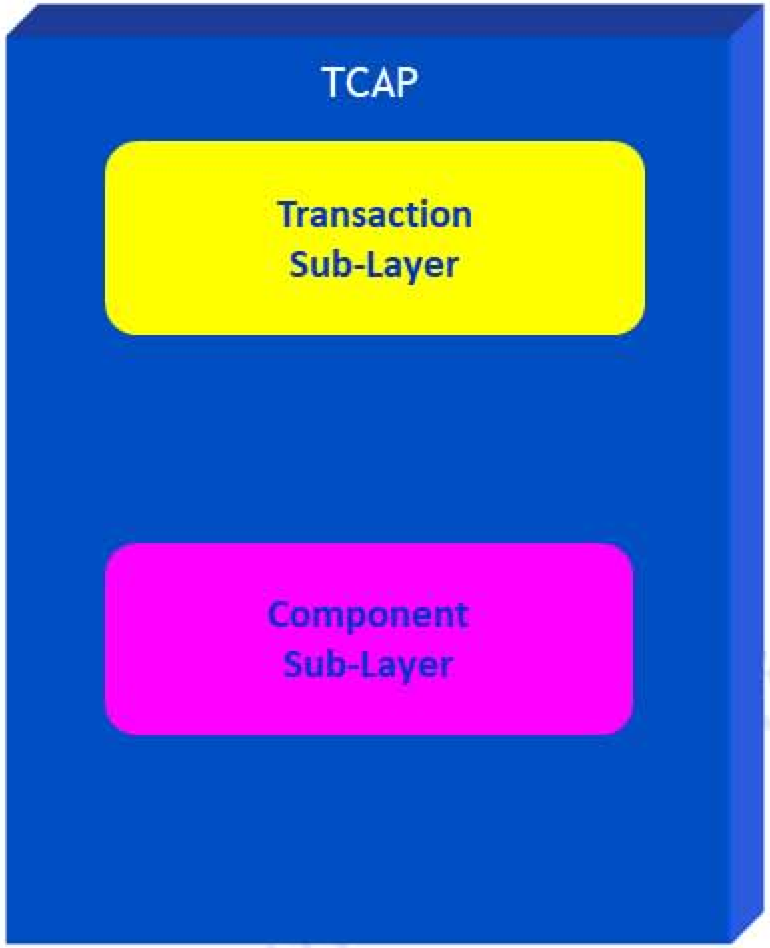
TCAP Component Sub-Layers



- Component sub-layer
  - Components model interactions between two entities
  - Component sub-layer provides a service of managing Components.
  - A sender entity requires from a destination entity to perform an operation.
  - A Receiver entity interprets this request, performs that operation if possible, and makes a report on the result that could be positive or negative.

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TCAP Component Sub-Layers

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- A dialogue may be split out to a succession of elementary actions (query/response)
- A component is an information element representing
  - an action request or
  - a response to this request
- It consists of triggering, positive or negative results, or rejection of an operation

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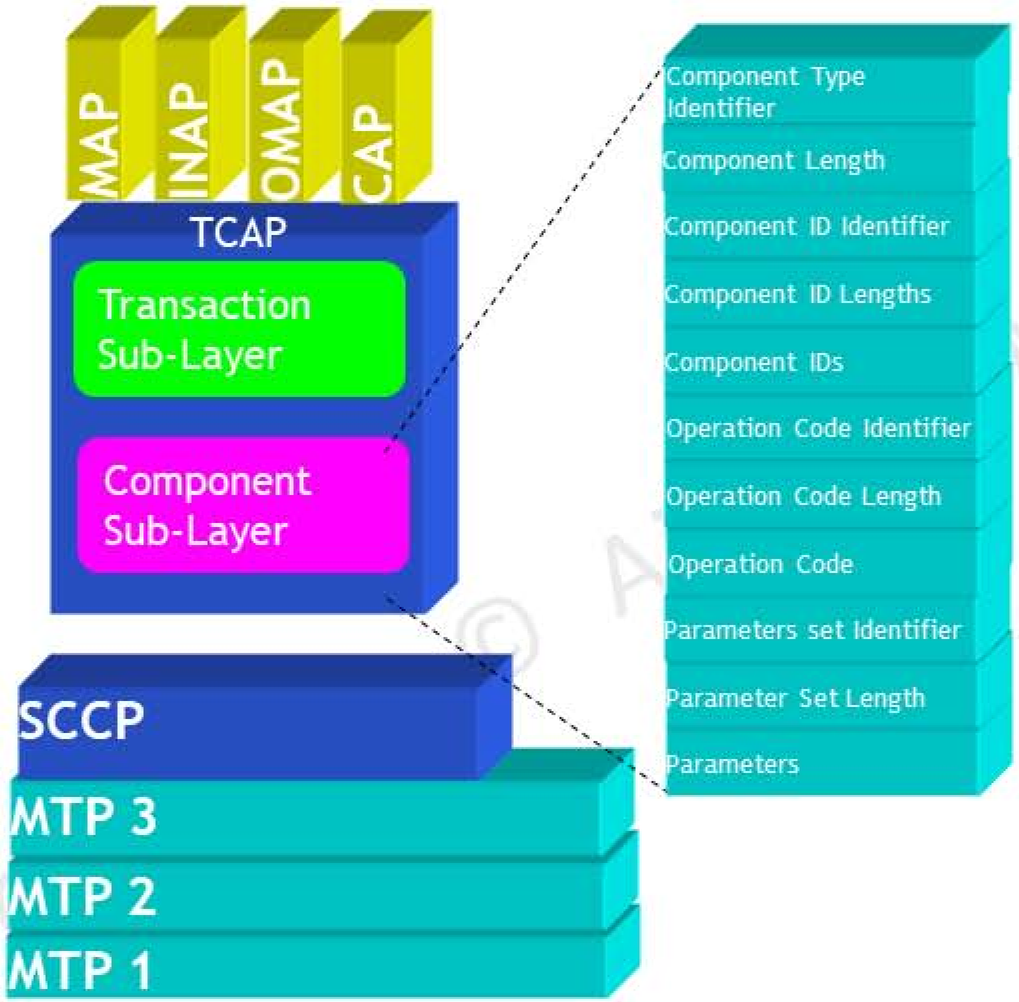
TCAP Component Sub-Layers



- Component Sub-Layers has:
  - Component Type Id: TCAP uses 4 component types
  - Component Length: length of the component in which it is found
  - Component ID Identifier: indicates that this component has an Invoke ID or that another ID is added for the correlation of Invokes with Return Results
  - Component ID Length: length of the ID field (0-8)
  - Component IDs: (optional) ID
  - Operation Code Identifier: identifier for the National or for Private TCAP Networks

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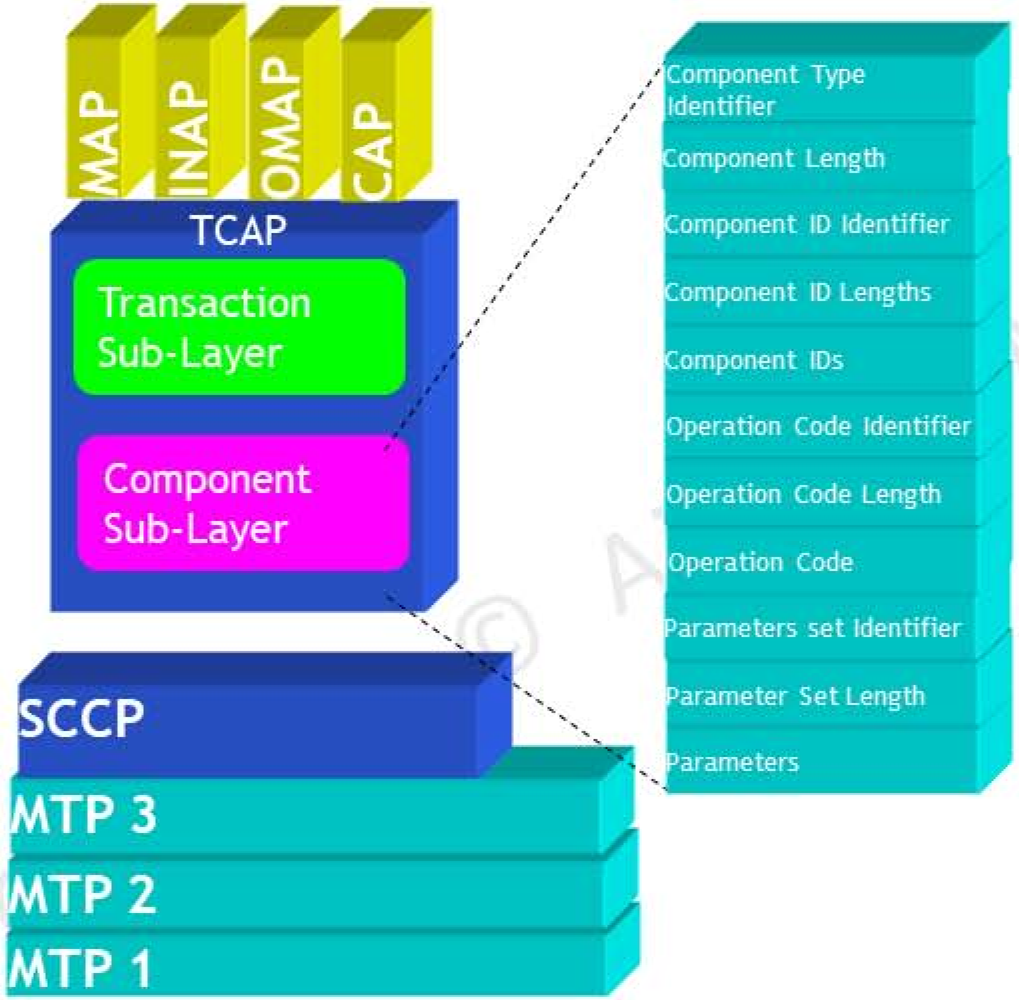
TCAP Component Sub-Layers



- Operation Code Length: length of the operation code only. (2 for National TCAP network)
- Operation Code: not specified in world wide standards
- Parameter Set Identifier: individual types of parameters (timestamp, digits, or a network identifier)
- Parameter Set Length: length of the Parameters field
- Parameters: actual parameter values. (for a timestamp, 2 octets for each year, month , day, hour, minutes + difference between local time and Greenwich Meridian Time

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Type of Components

- ***Invoke (Last):*** Invokes an operation (e.g. Query to request SCP translation of a dialed 800 number) [1].
- ***Invoke (Not Last):*** Similar to previous component except that[2].
- ***Return Result (Last):*** Returns the result of an invoked operation[1].
- ***Return Result (Not Last):*** Similar to previous component except that[2].
- ***Return Error:*** Reports the unsuccessful completion of an invoked operation.
- ***Reject:*** Indicates that an incorrect package type or component was received.

(1): The component is the "last" component in the query.

(2): The component is followed by one or more components.

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SCCP and TCAP Complementarity

- TCAP and SCCP go together.
  - SCCP provides the specialized routing.
  - TCAP provides the appropriate message structuring and parameters to acquire and package the data.

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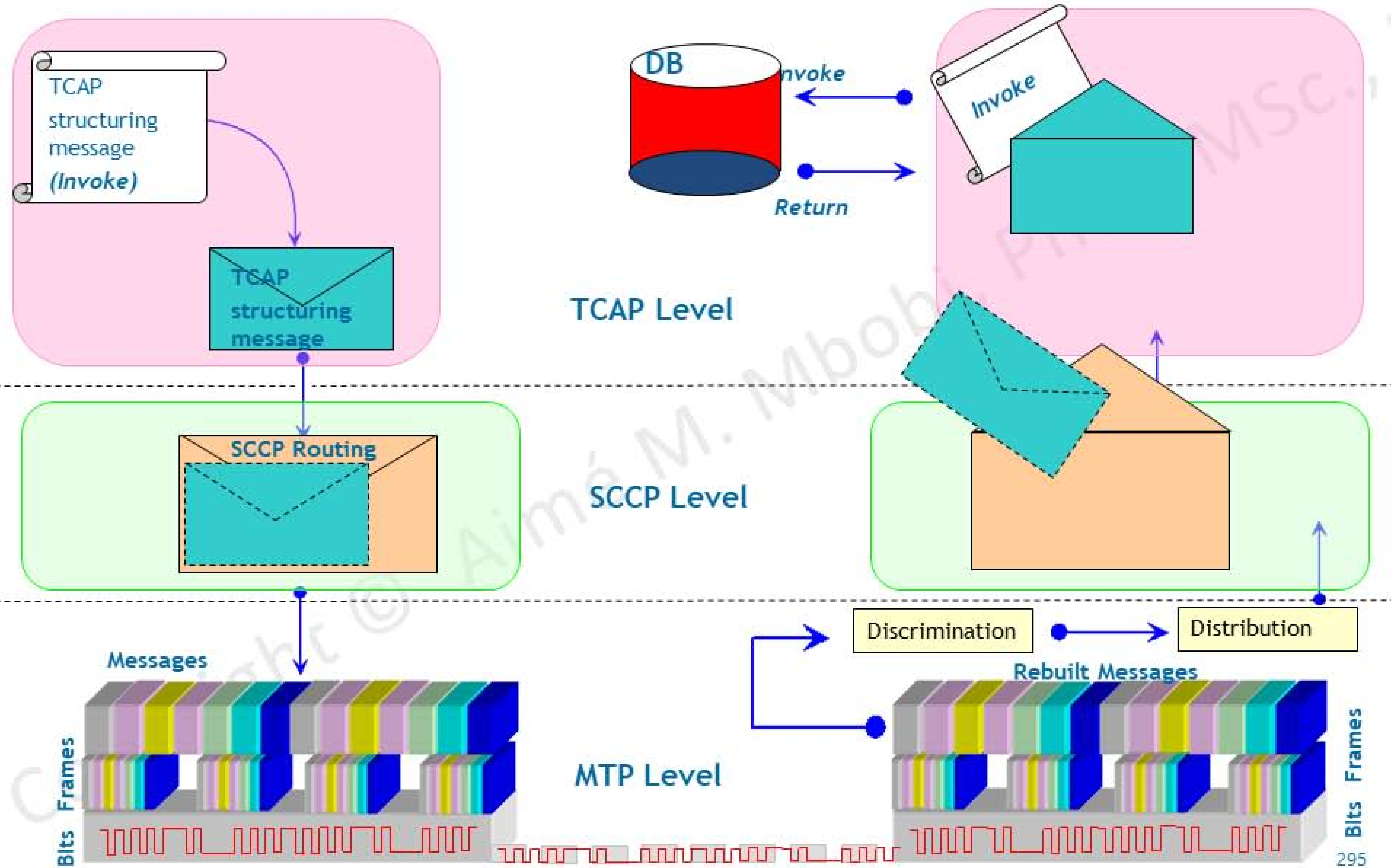
Example of SCCP and TCAP Complementarity



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Example of TCAP Dialogue: 1st subscription of a mobile to at foreign country

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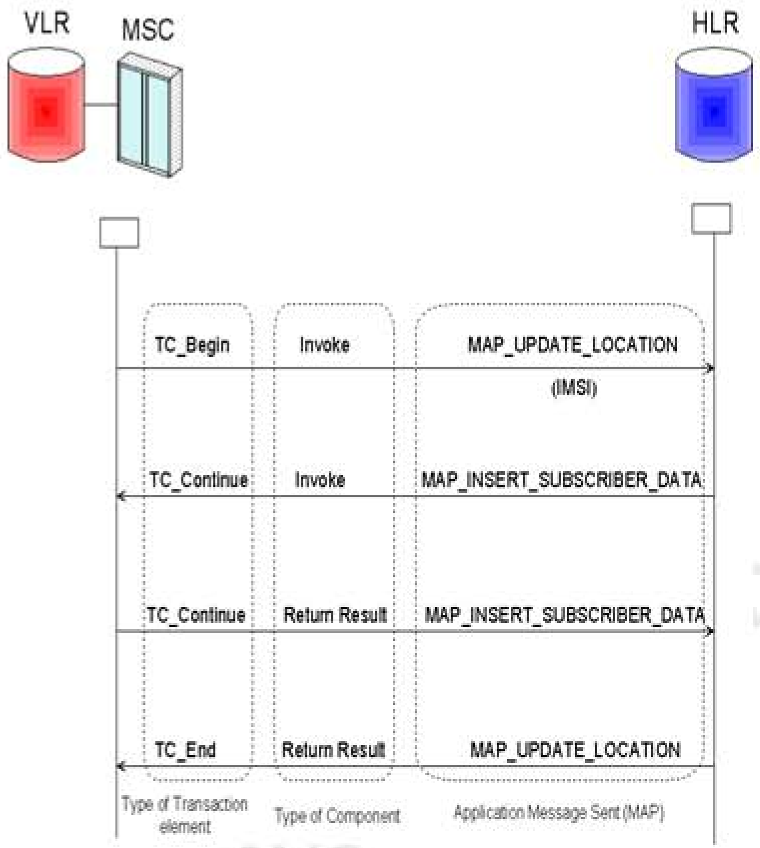
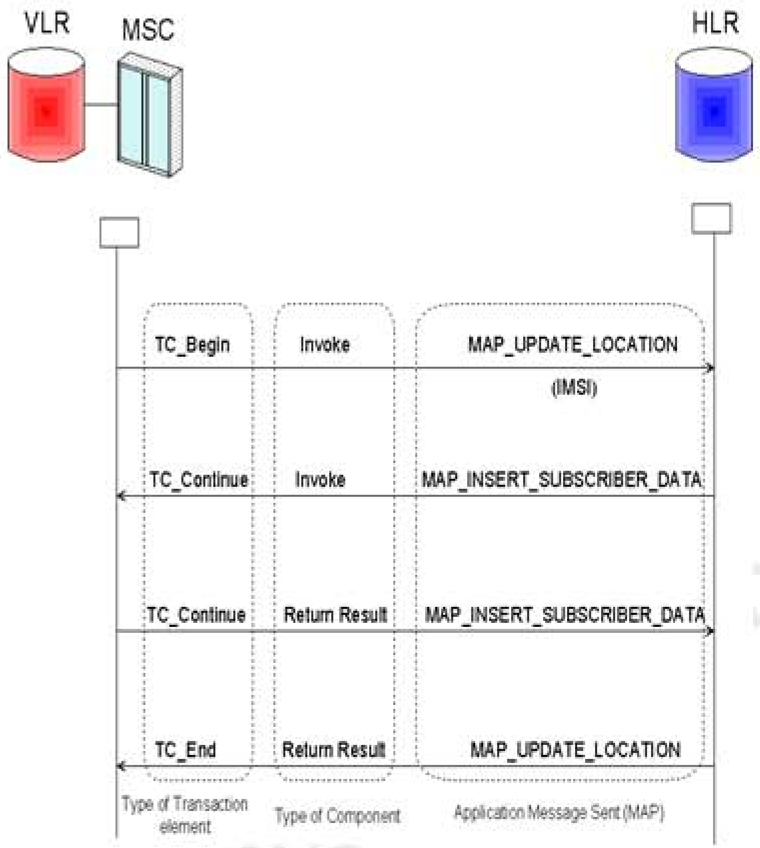


1. The concerned VLR must request for its registration to HLR.
2. Then, it sends a message "MAP_UPDATE_LOCATION" containing
   - IMSI (International Mobile Subscriber Identity),
   - Number of the localized area and its VLR number
3. This message is conveyed by a component ***Invoke*** which contains a specific ID identifier of this operation.
4. Since it is the 1st message, the Transaction Sub Layer opens the transaction by placing a ***TC_Begin*** element in the message.
5. It adds a specific identifier to reference the dialogue.

Example of TCAP Dialogue: 1st subscription of a mobile to at foreign country



6. Once “MAP_UPDATE_LOCATION” is received, the HLR perform the requested operation and send acknowledges by a similar message, but not necessarily containing the same data.

7. This MAP component is contained in a ***Return Result*** managed by the Component Sub Layer with a TC_End element in transaction level.

8. ***Return Result*** message contains ID identifier that allows to link this ***Return Result*** to ***invoke*** without necessity of transmitting mobile IMSI in ***Return Result***.

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TCAP Tracing

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TCAP Tracing

<table>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td></td><td></td></tr>
<tr><td colspan="8"></td><td></td><td></td></tr>
<tr><td colspan="8">Message Tag (TCAP message type e.g. TC-Begin)</td><td></td><td></td></tr>
<tr><td colspan="8">Message Length (TCAP message length)</td><td></td><td></td></tr>
<tr><td colspan="8">Tag (origination/destination Id tag)</td><td rowspan="3"></td><td rowspan="3">Orig/dest Trans. Id (if present)</td></tr>
<tr><td colspan="8">Length (origination/destination Id length)</td></tr>
<tr><td colspan="8">Value (origination/destination Id value)</td></tr>
<tr><td colspan="8">Tag</td><td rowspan="4"></td><td rowspan="4">Protocol Version</td></tr>
<tr><td colspan="8">Length</td></tr>
<tr><td colspan="8">Unused Bits</td></tr>
<tr><td colspan="8">Version</td></tr>
<tr><td colspan="8">Tag (ACN tag)</td><td rowspan="2"></td><td rowspan="11">Application Context Name (reference to an explicitly defined set of the TC-User Application Service Elements (ASEs), related options and any other necessary information for the interworking of two TC-Users during an instance of communication)</td></tr>
<tr><td colspan="8">Length (ACN total length)</td></tr>
<tr><td colspan="8">Tag (CAN object Id tag)</td><td rowspan="9">ACN object id</td></tr>
<tr><td colspan="8">Length (CAN object Id length)</td></tr>
<tr><td colspan="8">Object Id</td></tr>
<tr><td colspan="8">Blank (ETSI)</td></tr>
<tr><td colspan="8">Domain (domain name e.g. Mobile)</td></tr>
<tr><td colspan="8">Sub Domain (sub domain name e.g. GSM network)</td></tr>
<tr><td colspan="8">Common Component Id (common component id value e.g. AC-id)</td></tr>
<tr><td colspan="8">Application Context value (application context value e.g. Subscriber data management, network functional, MS purging)</td></tr>
<tr><td colspan="8">Version value (version value e.g. version2, version3)</td></tr>
<tr><td colspan="8">Tag (indicates user info tag)</td><td rowspan="2"></td><td rowspan="9">User info externals</td></tr>
<tr><td colspan="8">Length (indicates user info total length)</td></tr>
<tr><td colspan="8">Tag (object Id tag)</td><td rowspan="7"></td></tr>
<tr><td colspan="8">Length (object Id length)</td></tr>
<tr><td colspan="8">Object Id</td></tr>
<tr><td colspan="8">Blank (ETSI)</td></tr>
<tr><td colspan="8">Domain (domain name e.g. Mobile)</td></tr>
<tr><td colspan="8">Sub Domain (sub domain name e.g. GSM network)</td></tr>
<tr><td colspan="8">AS Id Branch (e.g. MAP dialogue PDU)</td></tr>
</table>

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Example of TCAP Tracing

```
³ octet039  TCAP message, transaction portion....................................³
³ 01100010 ³ Package type...... ³ BEG   Begin, constructor, Appl. wide           ³
³ 01000110 ³ Message length.... ³ 70                                              ³
³ 01001000 ³ Transaction ID tag ³ Originating transaction ID tag                  ³
³ 00000100 ³ Xaction ID length. ³ 4                                               ³
³ ........ ³ Originating ID.... ³ 4278255831                                      ³
³ octet047  TCAP message portion: GSM3...........................................³
³ 01101011 ³ Portion tag....... ³ Dialogue portion tag                            ³
³ 00011110 ³ DialoguePortionLen ³ 30                                              ³
³ 00101000 ³ External Tag...... ³ External tag, Universal/Constructed             ³
³ 00011100 ³ External Length... ³ 28                                              ³
³ 00000110 ³ ObjectIdentifierTag³ Object identifier, Universal                    ³
³ 00000111 ³ Object Id Length.. ³ 7                                               ³
³ 00000000 ³ {ccitt recommendatn³ CCITT/ITU-T recommendation                      ³
³ 00010001 ³ q................. ³ q                                               ³
³ 10000110 ³ 773 (X305)........ ³ 134                                             ³
³ 00000101 ³            ........ ³ 5                                              ³
                           Page 1
³ 00000001 ³ as(1)............. ³ 10                                              ³
³ 00000001 ³ dialogue-as....... ³ Request,Response or Abort PDU                   ³
³ 00000001 ³ Version}.......... ³ 1                                               ³
³ 10100000 ³ SingleASN1type Tag ³ Single ASN.1-Type                               ³
³ 00010001 ³ SingleASN1type Len ³ 17                                              ³
³ 01100000 ³ Dialogue Tag...... ³ AARQ Dialogue Request                           ³
³ 00001111 ³ Dialogue Len...... ³ 15                                              ³
³ octet064  [0] IMPLICIT Type, Context-Specific, Primitive.......................³
³ 10000000 ³ Parameter Tag..... ³ [0]  Context-Specific/Primitive                 ³
³ 00000010 ³ ProtocolVersionLen ³ 2                                               ³
³ 00000111 ³ Unused bits....... ³ 7                                               ³
³ 1....... ³ Version 1......... ³ Yes                                             ³
³ .0000000 ³ Reserved.......... ³ 0                                               ³
³ octet068  application context name: [1] OBJECT IDENTIFIER......................³
³ 10100001 ³ ApplContext Tag... ³ [1]  Context-Specific/Constructed               ³
³ 00001001 ³ ApplContext Len... ³ 9                                               ³
³ 00000110 ³ ObjectIdentifierTag³ Object identifier, Universal                    ³
³ 00000111 ³ Object Id Length.. ³ 7                                               ³
³ 00000100 ³ Protocol.......... ³ CCITT identified-organization                   ³
³ 00000000 ³ Sub-Protocol...... ³ etsi                                            ³
³ 00000000 ³ Domain............ ³ MobileDomain                                    ³
³ 00000001 ³ Network........... ³ gsm-network                                     ³
³ 00000000 ³ ACName............ ³ ac (application context)                        ³
³ 00001110 ³ Service........... ³ infoRetrieval                                   ³
³ 00000011 ³ Version........... ³ version4 (3)                                    ³
³ octet079  Component tag: OPTIONAL..............................................³
³ 01101100 ³ Component Tag..... ³ Component portion tag                           ³
³ 10000000 ³ Component Len..... ³ 128                                             ³
³ octet081  Component transaction message type: GSM3.............................³
³ 10100001 ³ Component Type.... ³ INVOKE            , ContextSpecific/Constr.     ³
³ 00011010 ³ Component length.. ³ 26                                              ³
³ 00000010 ³ Invoke ID tag..... ³ Invoke ID tag                                   ³
³ 00000001 ³ Invoke ID length.. ³ 1                                               ³
³ 00000001 ³ Invoke ID......... ³ 1                                               ³
³ 00000010 ³ LinkedID/OpCode?.. ³ Local operation code tag                        ³
³ 00000001 ³ OpCode length..... ³ 1                                               ³
³ 00111000 ³ Operation code.... ³ SendAuthenticationInfo                          ³
³ octet089  sendAuthenticationInfo {}............................................³
³ 00110000 ³ Parameter Tag..... ³ Sequence Tag, Universal/Constructed             ³
³ 00010010 ³ Parameter Len..... ³ 18                                              ³
³ ........ ³ Contents.......... ³ 80 08 32 14 95 40 95 44 23 f8 02 01 01 81 00  ³
³ ........ ³ Contents.......... ³ 83 01 00                                        ³
³ octet109  GSM MAP Parameter....................................................³
³ 00000000 ³ Parameter Tag..... ³ EOC? (End-of-Contents tag)                      ³
³ 00000000 ³ Parameter Len..... ³ 0                                               ³
³ Checksum ³ CRC 16............ ³ 1111111111111111  hex=ffff                      ³
```

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Application Part

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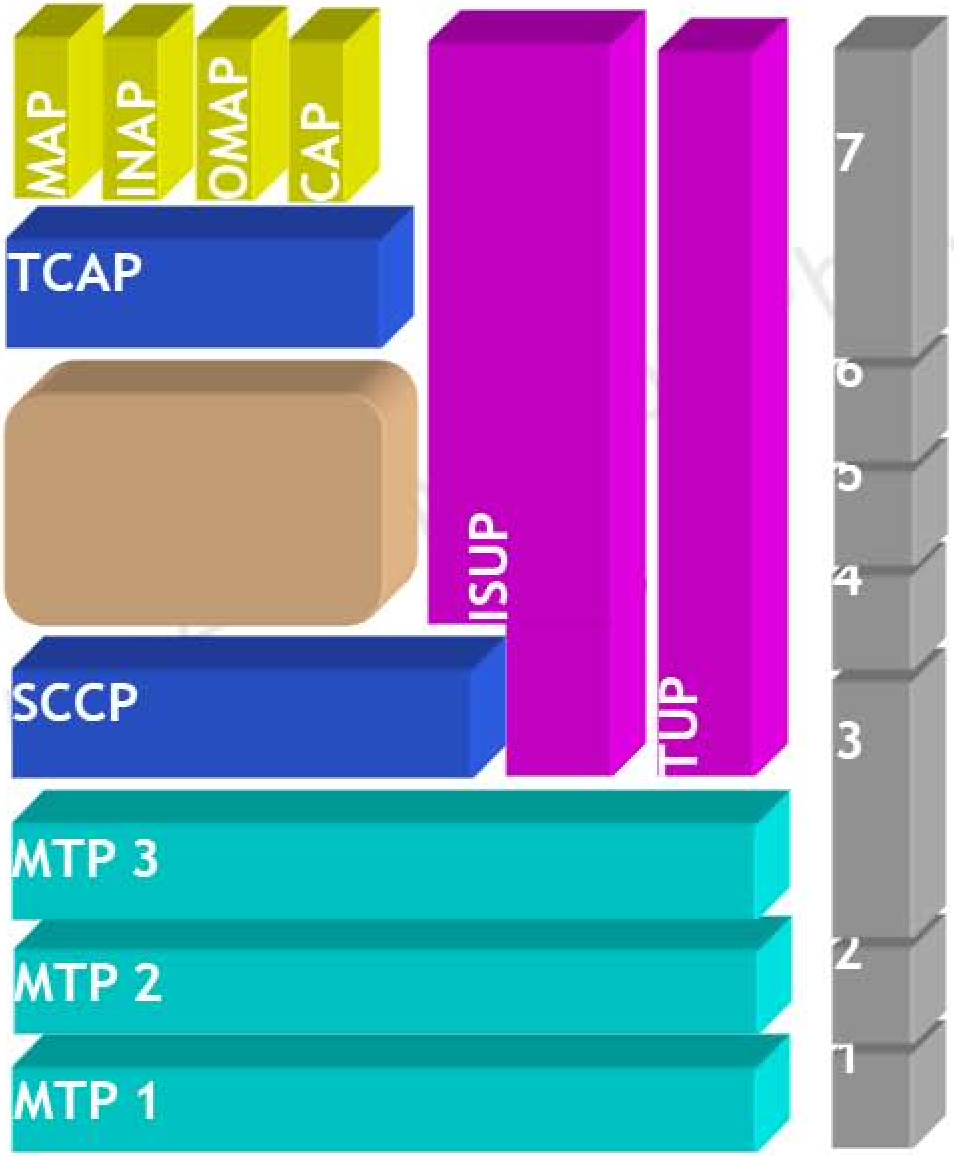
Application Part

SS7 Protocol Architecture

Application Part

AP



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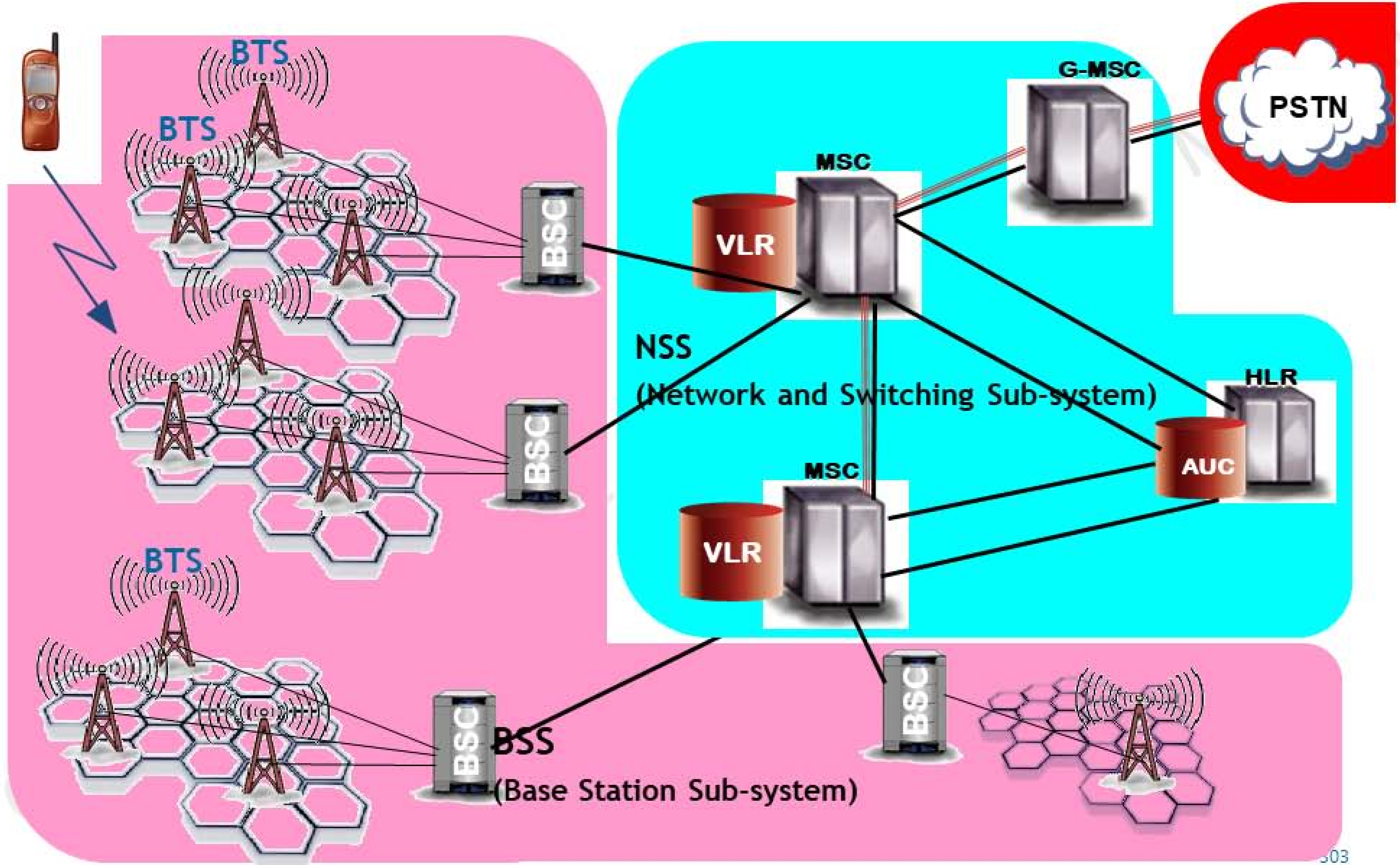
GSM Canonical Architecture



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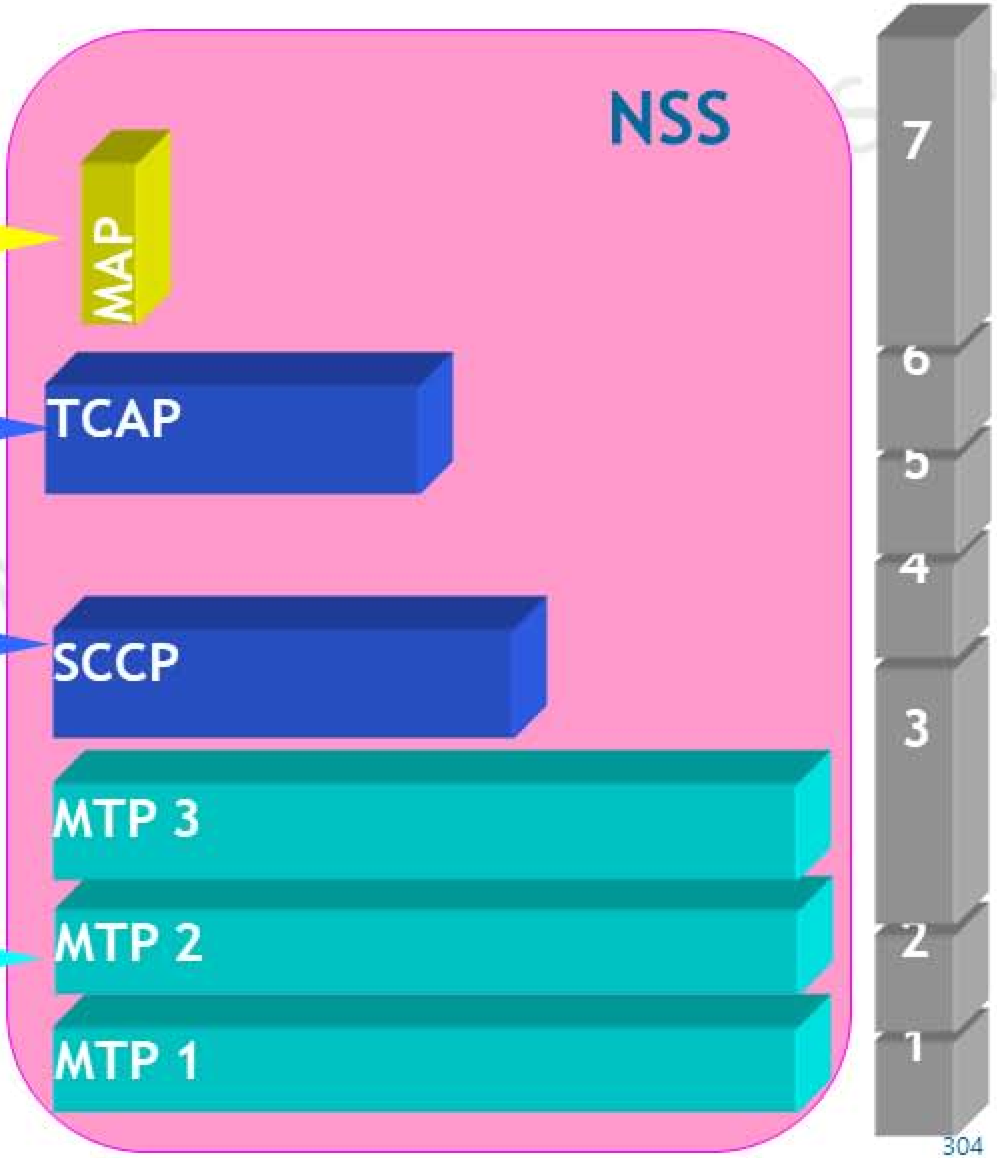
NSS Functional Architecture

MAP
Provides an application protocol specialized in managing mobility

TCAP
TCAP allowing dialogues structuring

SCCP
Transfer messages between PSTNs interconnected by international GWs

MTP1,2,3
Allow the transfer of SU in SS7 PLMN



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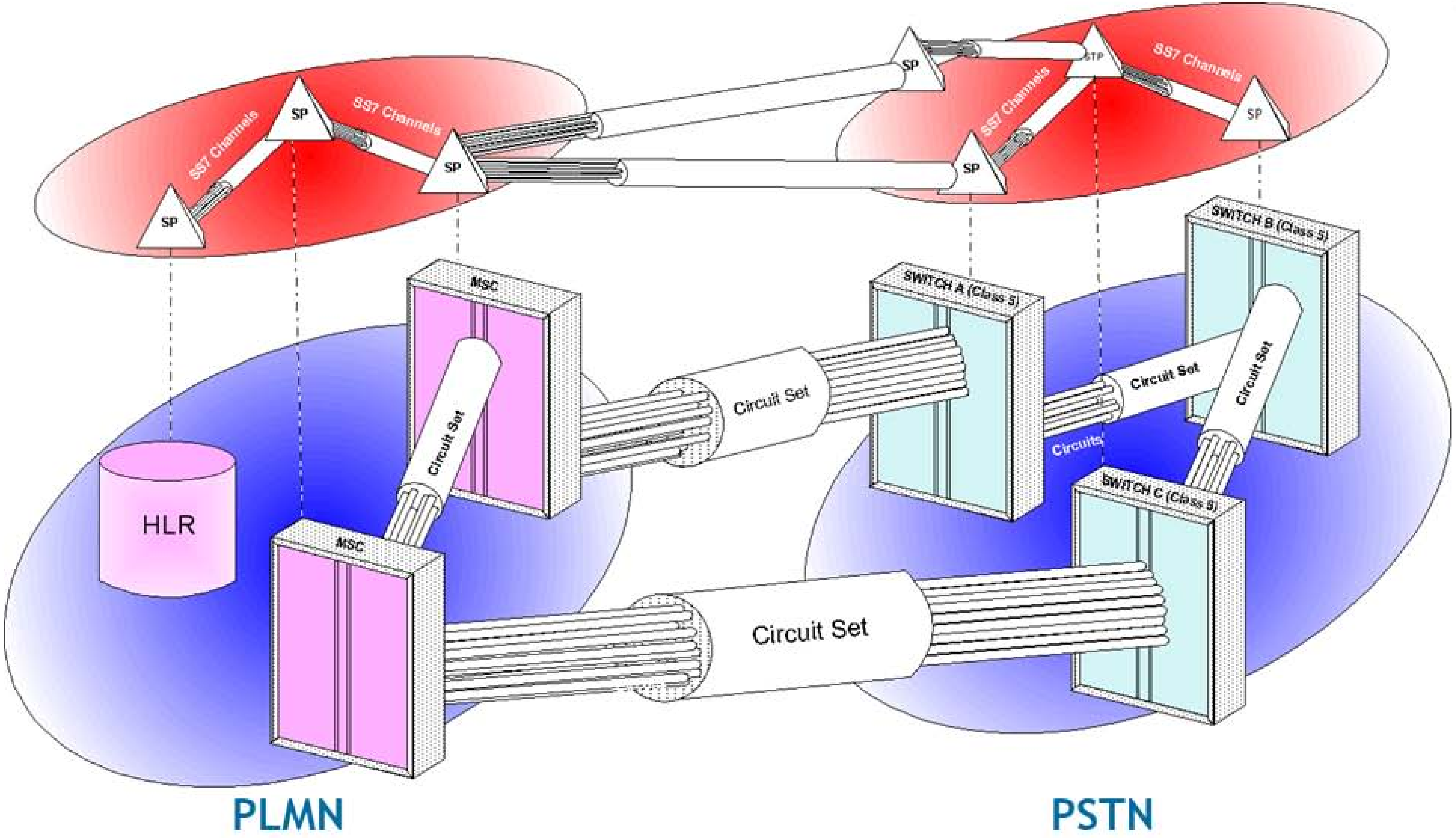
Example of Interconnection PLMN-PSTN



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Application Part: Mobile Application Part (MAP)

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- MAP protocol governs data interchange between NSS equipment.
- Provides Signaling functions to voice or data communication service in a PLMN (allows roaming).
- Structured as a query/response catalogue and deals with interfaces that manage dialogues between MSC, VLR, HLR.
- Relies on TCAP that relies on SCCP.
- Query MAP messages are associated to TCAP components (***Invoke***), responses are associated to TCAP components (***Result***).

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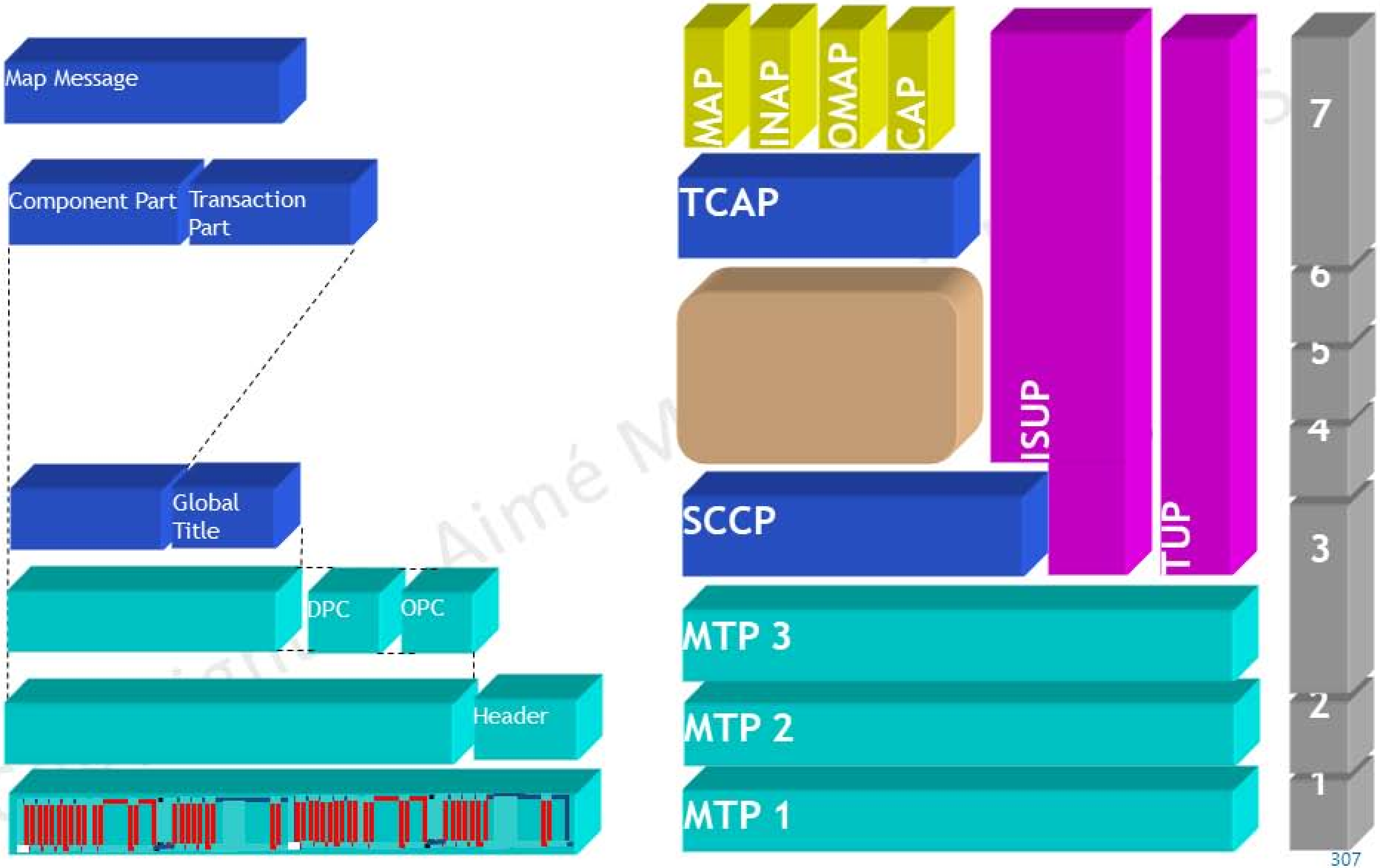
Mobile Application Part Nesting



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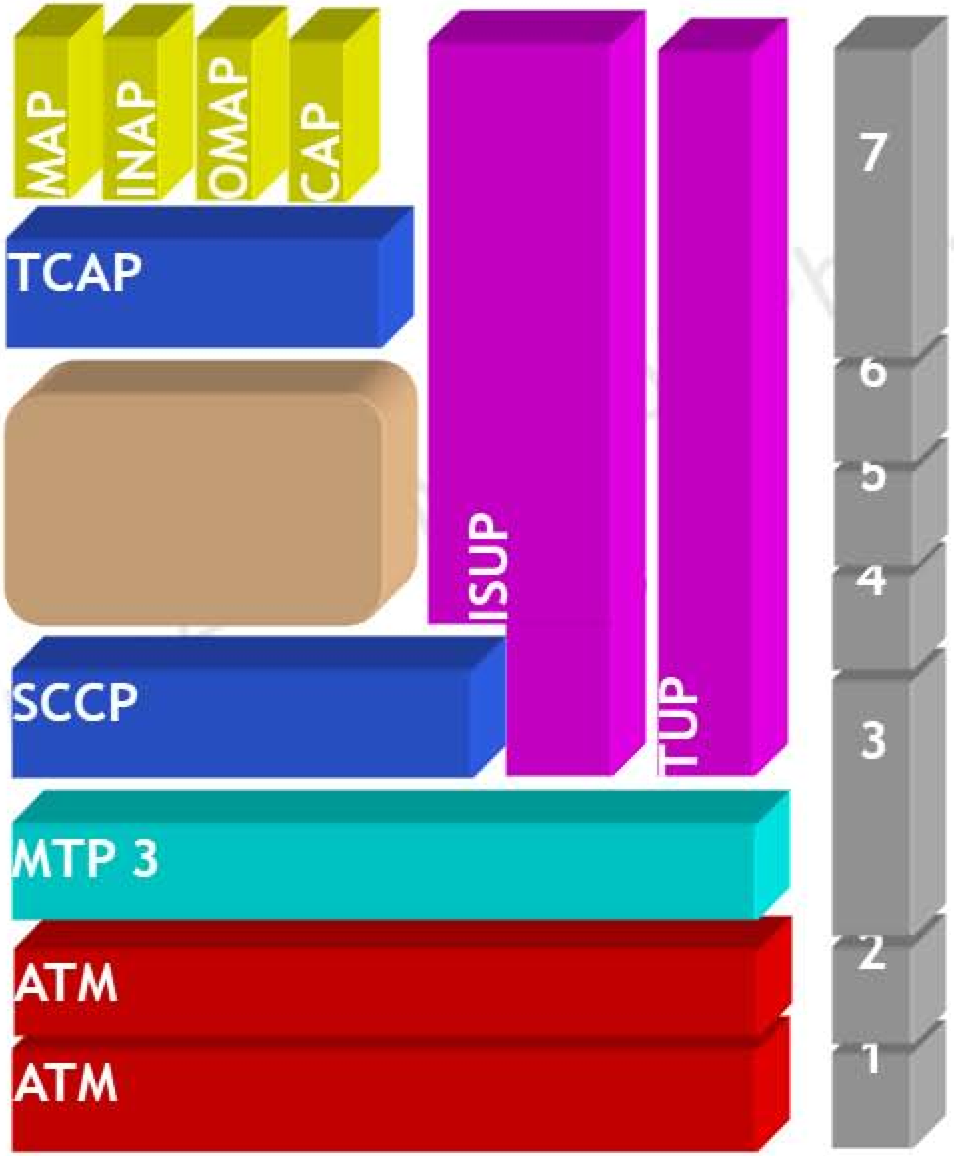
SS7 Over ATM



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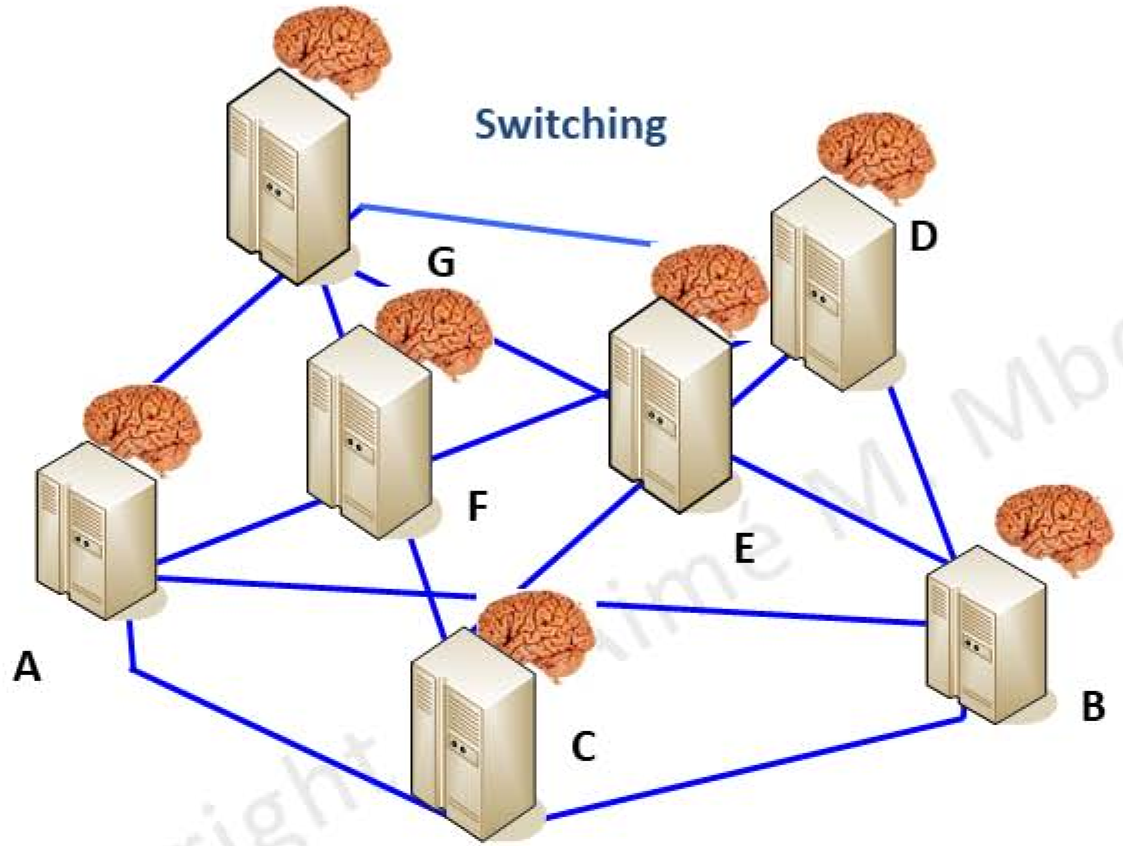
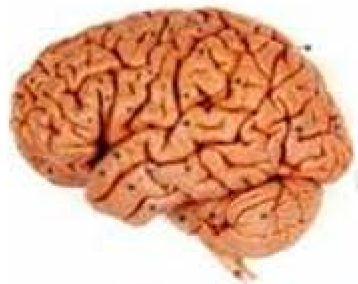
Essence of Intelligent Network





DISSOCIATION BETWEEN INTELLIGENCE AND SWITCHING

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