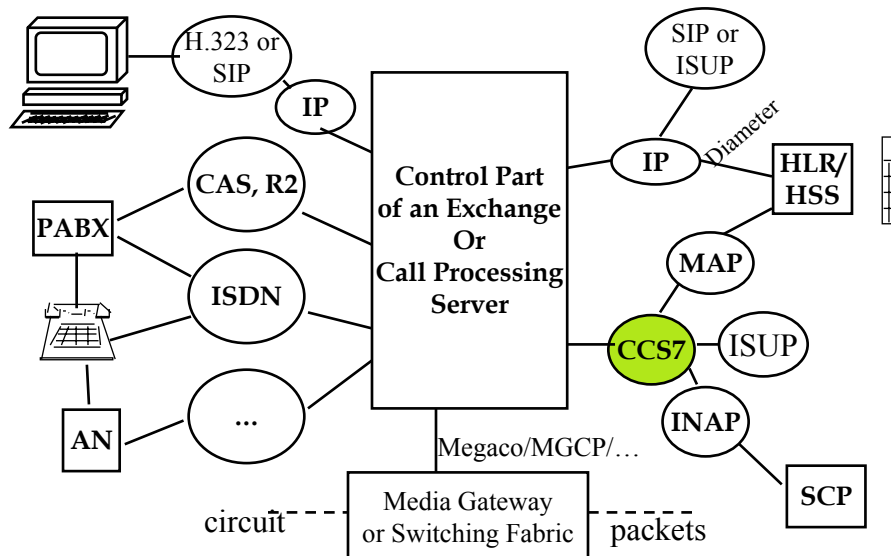# Common Channel Signaling Nr 7 (CCS7)

CCS7 is a *message based*, *multi-layer network to network* signaling system designed for fully digital exchanges.

- ✓ **Limitation of analogue signaling systems**
- ✓ **Basic definitions for CCS7**
- ✓ **CCS7 Requirements**
- ✓ **Functional Structure**
- ✓ **MTP and SCCP**
- ✓ **User Parts**
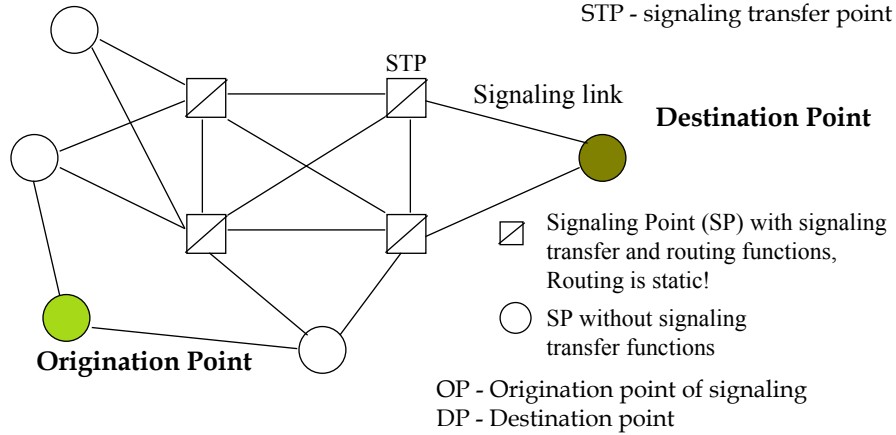- ✓ **Strengths and weaknesses**

Summary of course scope

Limitations of Analogue signaling

› **Limited set of signals --> limited set of services**

› **Always bound to a voice path --> architectural limitation.**

› **Difficult to change anything in an established call because registers have been released and voice channel is reserved for voice.**

› **Slow --> uneconomical use of network resources.**

› **MF requires special equipment - Only recently general purpose DSPs have become powerful and cost efficient enough.**

› **HDLC on silicon --> processing hdlc frames and messages is simple and efficient on any computer.**

Does CCS7 remove all limitations?

✓ **Digital messages --> unlimited signal set: e.g. 2^{100} different signals can easily be devised.**

✓ **Common signaling channel for many voice channels (out-of-band) --> signaling is not, in principle, bound to calls nor voice/information channels. Signaling can continue during the call.**

✓ **Message round-trip delay on a 64kbit/s channel is ≈ 50 ms. --> post dialling delay (delay from the dialing of the last digit until the ringing tone) approaches zero.**
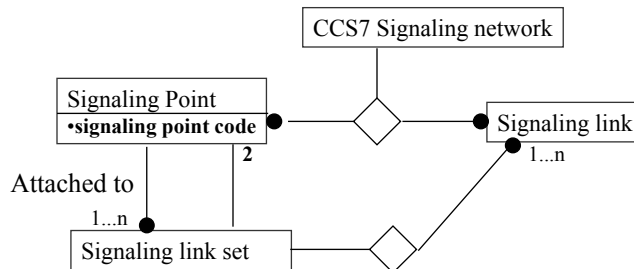
✓ **Makes use of HDLC -protocol framing and principles.**

Basis of CCS7 is the signaling network - a special kind of data network.

STP - signaling transfer point

STP

Signaling link

Destination Point

Signaling Point (SP) with signaling transfer and routing functions, Routing is static!

SP without signaling transfer functions

Origination Point

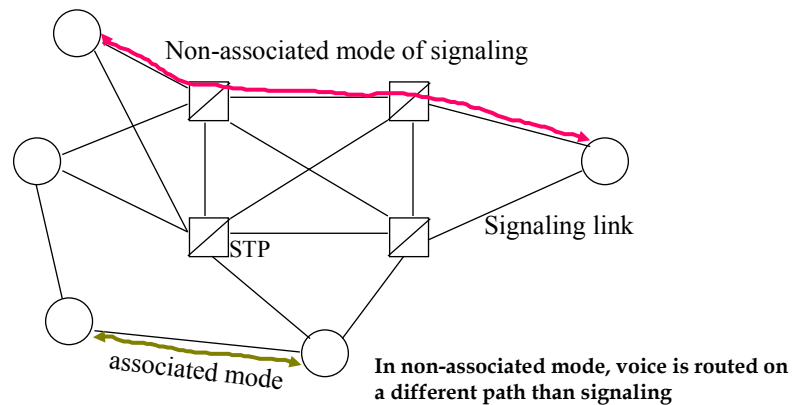OP - Origination point of signaling
DP - Destination point

Examle: In Finnish CCS7 no specialized STP -nodes were originally deployed. STP functions were integrated in exchanges. E.g in USA, specialized STP-nodes are commonplace.

Key definitions for CCS7

Signaling Point is a logical entity, e.g. in an exchange
there can be one or more SPs. In one CCS7 signaling network
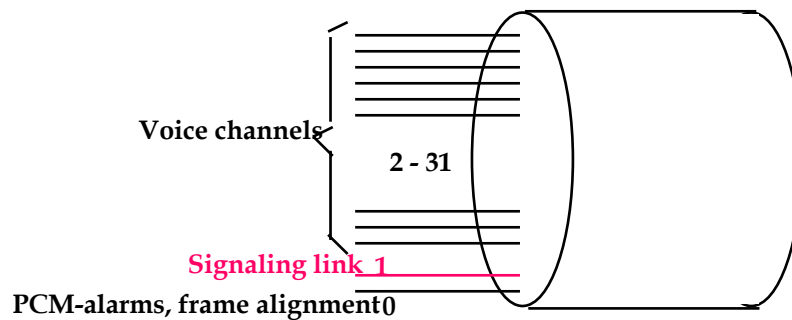an exchange will, however, have only one *Signaling Point Code*

CCS7 Signaling network

Signaling Point
•**signaling point code**

2

Signaling link

1...n

Attached to

1...n

Signaling link set

Signaling connection can be either direct or indirect (through STP nodes)

Non-associated mode of signaling

STP

Signaling link

associated mode

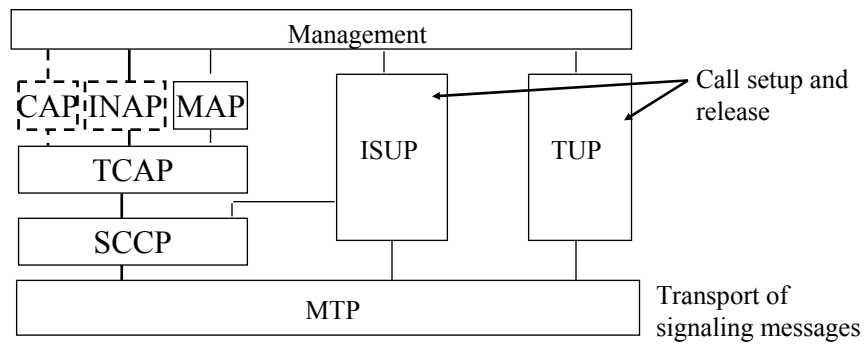**In non-associated mode, voice is routed on a different path than signaling**

CCS7 reliability is built by software

- Speed: post dial delay (until ringing tone) $\leq$ 2.2s.
- MTP:
    - unavailability of signaling route set $\leq$ 10 min/annum
    - share of undetected faulty signaling messages: $\leq 10^{-10}$
    - loss probability of signaling messages $\leq 10^{-7}$
    - probability of reordering or replication of signaling messages $\leq 10^{-10}$

- Expected quality of of the underlying transmission network:
    - Long term bit error rate $\leq 10^{-6}$
    - Medium term bit error rate $\leq 10^{-4}$

- Using software means reliability is increased by several 10-folds!!
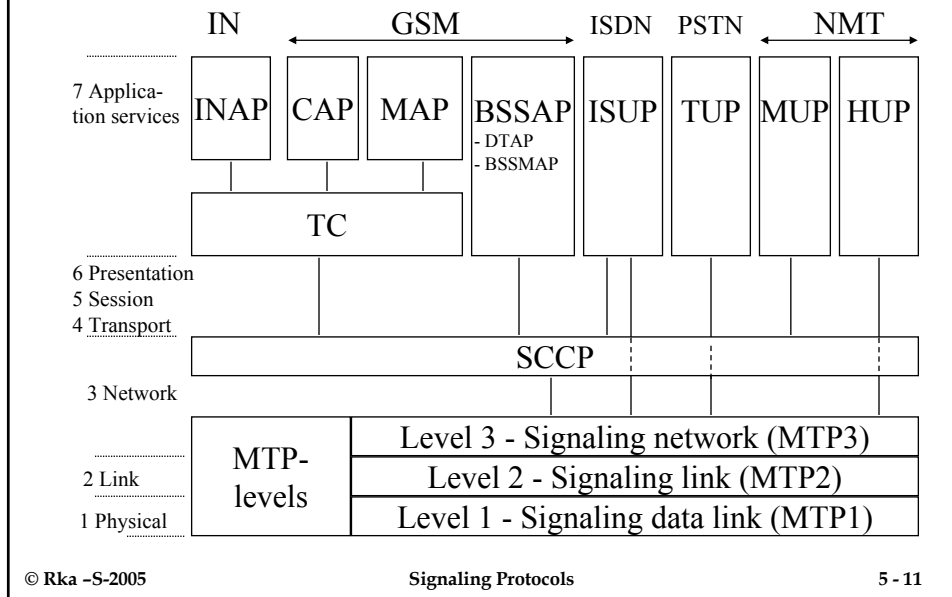
Use of PCM time slots in the Finnish CCS7 network

Voice channels

2 - 31

Signaling link 1

PCM-alarms, frame alignment 0

Principal components in CCS7

Management

CAP INAP MAP

ISUP   TUP

Call setup and release

TCAP

SCCP

MTP

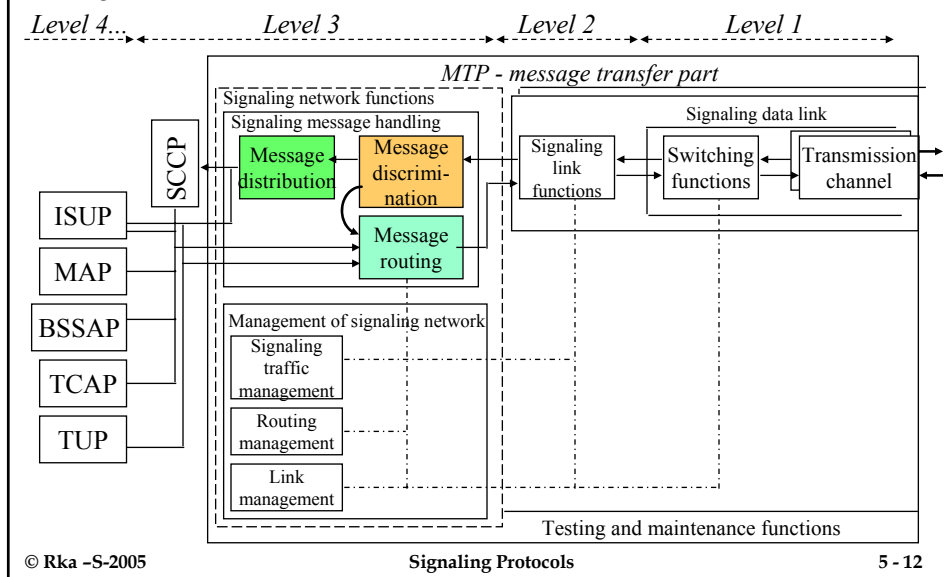Transport of signaling messages

INAP - IN Application part
CAP - CAMEL Application part
CAMEL - Customized Applications
    for Mobile Enhanced
    Logic = "INAP"
    extension in GSM

TUP - Telephony User Part
ISUP - ISDN User Part
SCCP - Signaling Connection Control Part
TCAP - Transaction Capabilities Application Part
MAP - Mobile Application Part
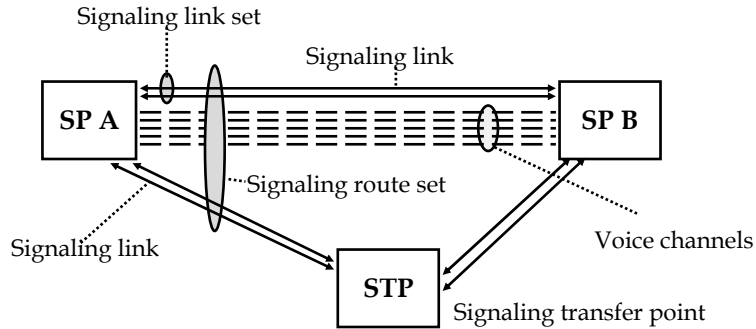MTP - Message Transfer Part

Structure of CCS7

	IN	GSM		ISDN	PSTN	NMT	

7 Application services: **INAP** | **CAP** | **MAP** | **BSSAP** (- DTAP, - BSSMAP) | **ISUP** | **TUP** | **MUP** | **HUP**

TC

6 Presentation
5 Session
4 Transport

SCCP

3 Network

MTP-levels	Level 3 - Signaling network (MTP3)
	Level 2 - Signaling link (MTP2)
	Level 1 - Signaling data link (MTP1)

2 Link
1 Physical

Message transfer part, MTP, is the basis of CCS7

Level 4... | *Level 3* | *Level 2* | *Level 1*

MTP - message transfer part

Signaling network functions

Signaling message handling

Message distribution | Message discrimination | Signaling link functions | Switching functions | Transmission channel

Signaling data link

Message routing

ISUP
MAP
BSSAP
TCAP
TUP

SCCP

Management of signaling network
- Signaling traffic management
- Routing management
- Link management

Testing and maintenance functions

Key concepts in MTP are

Signaling link set

Signaling link

SP A

SP B

Signaling route set

Signaling link

Voice channels

STP

Signaling transfer point
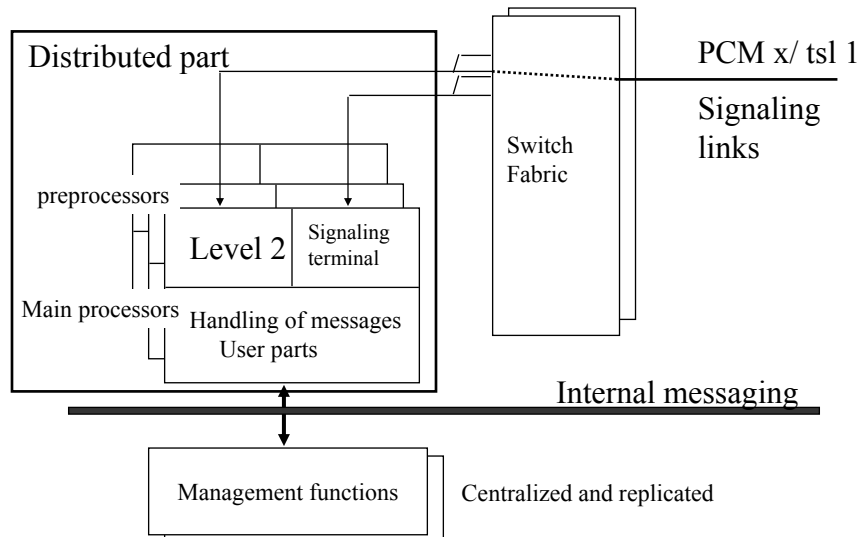
- ✓ **Signalling link – one 64 kbit/s point-to-point channel**
- ✓ **Signalling link set (SLS) – set of sig. links with the same endpoints**
- ✓ **Signalling Route – a sequence of sign link sets between two SPs.**
- ✓ **Signalling Route set – all sign. Routes connecting two SPs.**

An example allocation of MTP -functions in a Switching system (DX 200)

Distributed part

PCM x/ tsl 1

Signaling links

Switch Fabric

preprocessors

Level 2 | Signaling terminal

Main processors | Handling of messages User parts

Internal messaging

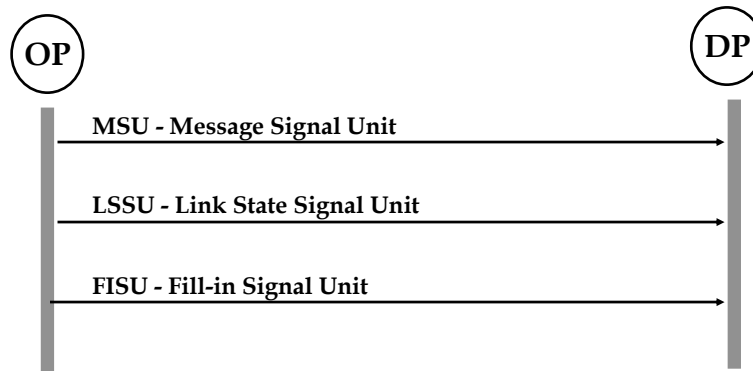Management functions | Centralized and replicated

MTP - main functions are

• Switching functions: - reconfiguration of the signaling network

• LEVEL 2: Signaling channel functions: - LAPB / cmp. HDLC
   • frame alignment flags (delimiters) acc to HDLC principles
   • checksum, retransmission of message units, supervision of message
     ordering, acknowledgements, link fault detection and recovery

LEVEL 3:
• *Load sharing among signaling links*
• *STP and distribution to User Parts*
• *Routing is based on 14-bit
  (ETSI) signaling point codes.*
                                        • Management of signaling traffic:
                                            • link switchover - messages are not lost!
                                            • (Original) link restoration
                                            • forced re-routing
                                            • controlled re-routing

---

MTP has three message types

OP   DP

MSU - Message Signal Unit

LSSU - Link State Signal Unit
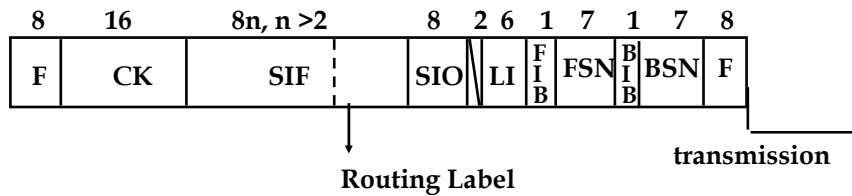
FISU - Fill-in Signal Unit

MSU - carries all payload of upper layers
LSSU - MTP level messaging between neighboring SPs
FISU - when there is nothing else to send! Originally made implementation
        difficult - short FISUs -> when there is no useful information to send
        the signaling terminal had the peak load!

Message Signaling Unit structure is

8	16	8n, n >2	8	2 6	1	7	1	7	8

F | CK | SIF | SIO | LI | FIB | FSN | BIB | BSN | F

transmission

Routing Label

F - Flag (delimiter -01111110)
BSN - Backward sequence number
BIB - Backward indicator bit
FSN - Forward sequence number
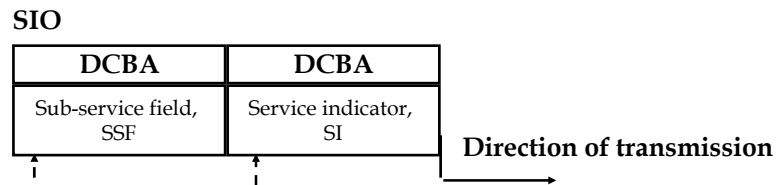FIB - Forward indicator bit

LI - Length indicator
SIO - Service information octet
SIF - Service Information field
    = payload
CK - Check bits

Service Information Octet (SIO) defines the target application

SIO

DCBA	DCBA
Sub-service field, SSF	Service indicator, SI

Direction of transmission
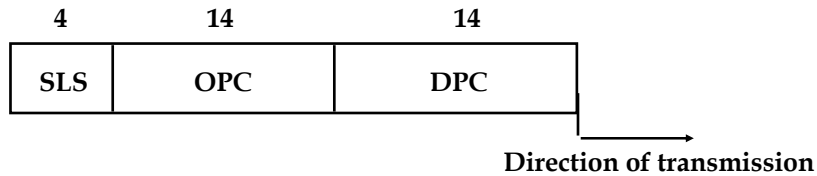
Addressing to   an MTP function or
           a User Part or
           an Application Part

Network indicator: National NA0, 1 or International IN0, 1 -network.

A CCS7 network is not global. The global signaling network is formed by interconnecting
CCS7 networks owned by different operators.

MTP Route Label has three fields

4	14	14
SLS	OPC	DPC

Direction of transmission

SLS - Signalling link selection (for link load sharing)
DPC - destination point code
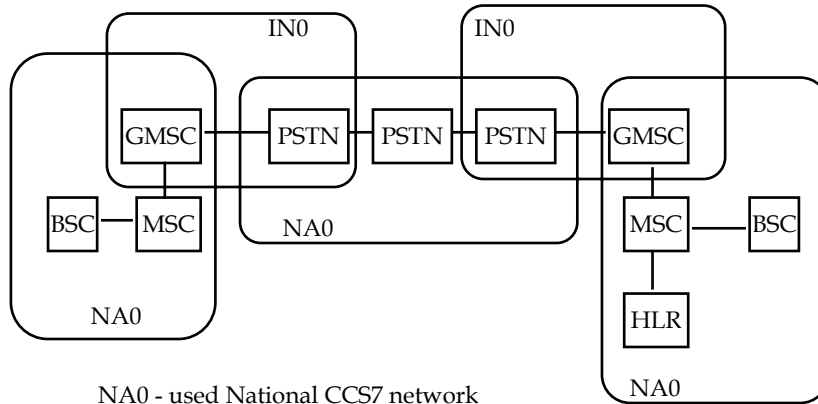**OPC - originating point code**

The shown lengths are acc to International(and Finnish) specification, in ANSI specs OPC/DPC lengths are 24 bits!

Load sharing has an impact on signal routing

OP - - - - - STP **SLS = xxx0** STP - - - - - DP

SLS = xxx1

STP
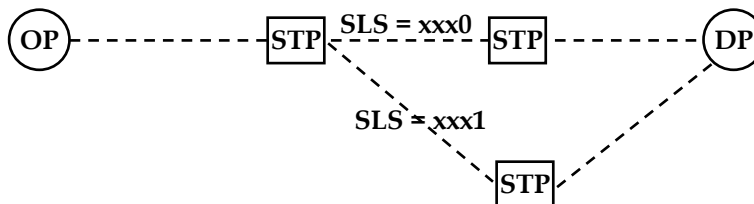
To preserve the order of signals, higher levels set the SLS value so that the route remains the same e.g. for all signal messages of a single call.

## *Flow of signaling messages in case of International GSM location update*

```
        IN0                      IN0

    GMSC ── PSTN ── PSTN ── PSTN ── GMSC

BSC ─ MSC                        MSC ─ BSC
        NA0
                                   HLR
    NA0
                                   NA0
```

NA0 - used National CCS7 network
IN0 - used International CCS7 network

Signaling Point Codes are unique only in one signaling network !!

SCCP - Signalling Connection Control Part expands MTP networking services

- ✓ **MTP uses 14-bit signaling point codes as addresses - this is not enough in the global network.**

- ✓ **No relationship to voice channels: SCCP can be used to signal events that are unrelated to calls (such as location updates in mobile networks).**

- ✓ **SCCP brings Global Title - an extension to the addressing mechanisms provided by the MTP.**

## Fourth level is needed, when MTP-signal message routing is not enough
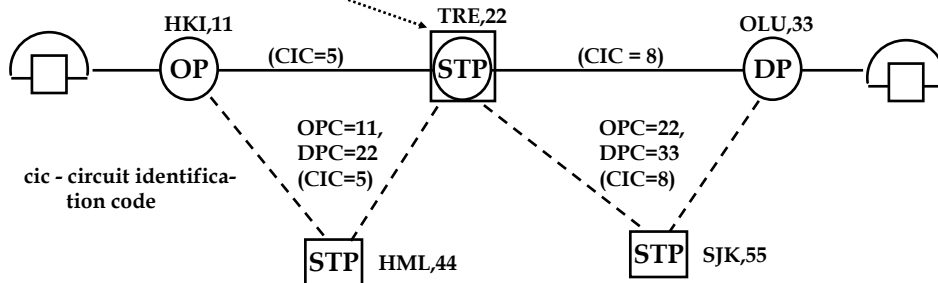
- Messages/calls through an international signaling point
- Calls across an operator boundary
- Intelligent Network calls
- In general, when the OP does not know the location of the called party

4th level = SCCP or a User Part.

If signaling is call related – UP, if not SCCP. If UP usually no SCCP is needed.

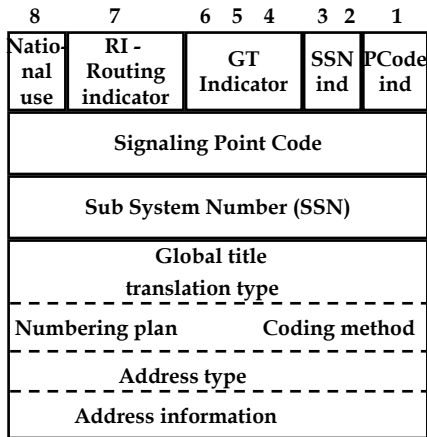## SCCP provides four service classes

vrt. IP
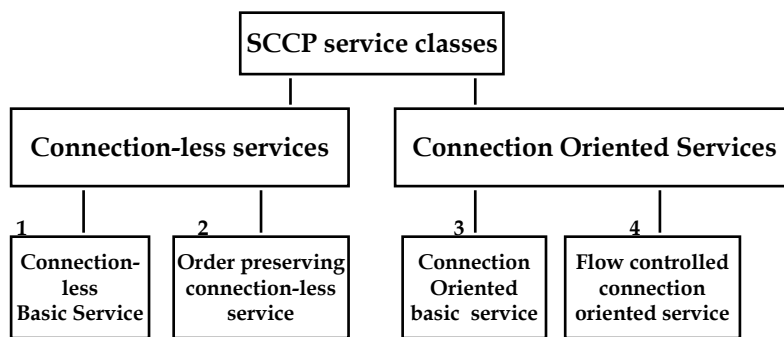
Only classes 1 …3 are in use.

✓ **Connection Oriented message transfer**
  › on demand connections as a service to UPs
  › permanent connections with management commands

Global Title in SCCP supports global messaging over the CCS7 network

Calling and called party in SCCP

8	7	6 5 4	3 2	1
Natio-nal use	RI - Routing indicator	GT Indicator	SSN ind	PCode ind

Signaling Point Code

Sub System Number (SSN)

Global title translation type

Numbering plan   Coding method

Address type

Address information

SSN (cmp. Port Numbers in TCP/IP)
1 - SCCP management
2 - TUP
3 - ISUP
4 - OMAP - Operation and Maintenance AP
5 - MAP - Mobile AP
6 - MAP/HLR
7 - MAP/VLR
8 - MAP/MSC
9 - MAP/EIR - Equipment Id reg
10 - MAP/AuC
11 - ISUP/SS ISUP supplementary services
12...247 , 249...252 reserved
248 - MUP (NMT Mobile UP
253 - OMC - Operation and Maintenance Center
254 - BSSAP - BSS Applic. part

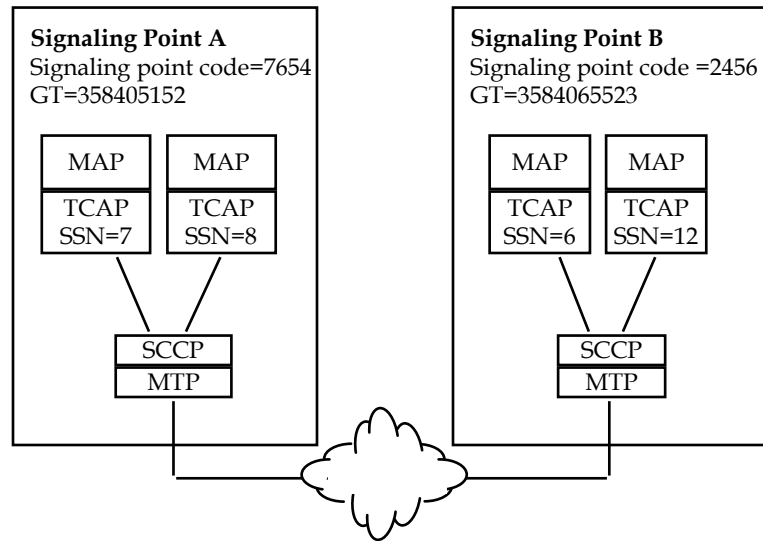# Address Information in GT of SCCP can be a telephone number or a subscriber identity

E.212: IMSI: | MCC | | MNC | | MSIN | E.g. 244 05 87654321

E.164: MISDN: | CC | | NDC | | SN | E.g. 358 40 540 3127

E.214: Hybrid: | CC | | NDC | | MSIN | E.g. 358 40 87654321

IMSI - International Mobile Subscriber Identity
MCC - Mobile Country Code
MNC - Mobile Network Code
MSIN - Mobile Subscriber Identity Number
CC - Country Code
NDC - National Destination Code
SN - Subscriber Number

A use case of addressing

Signaling Point A
Signaling point code=7654
GT=358405152

MAP	MAP
TCAP SSN=7	TCAP SSN=8

SCCP
MTP

Signaling Point B
Signaling point code =2456
GT=3584065523

MAP	MAP
TCAP SSN=6	TCAP SSN=12

SCCP
MTP

User Parts (Ups)

For call setup, release and supplementary services!

✓ **TUP - Telephony User Part - oldest and simples**
› **National variants!**
› **Messages bound to voice channels with Circuit Identification Code (CIC) in every message**

✓ **ISUP - ISDN User Part**
› **supports wire-line ISDN calls
- speech, 64kbit/s, multi-channel: 128, 384, 1536, 1920 kbit/s services**

✓ **MAP - Mobile Application part -**
› **used in GSM e.g. for HLR - MSC communication**
› **provides mobility management**

CCS7
Strengths and *weaknesses*

- ✓ Large nrof of signals
- ✓ message based -> native for digital exchanges and computers
- ✓ out-of-band --> signaling can continue for the duration of the call and even independent of any calls
- ✓ Reliable
- ✓ MAP - provides mobility management

- ✓ Complicated to implement
- ✓ Heritage of a closed market
- ✓ Service dependent - new services require new fields into signaling messages and thus software upgrades in exchanges
- ✓ Requires new features to be secure in a competitive multi-operator environment

* At its best overlying a rather unreliable base network, reliability has been enhanced by software functions.

The current CCS7 environment may have potentially hostile third parties

New CCS7 speakers

Service provider Y

Service provider X

SP

Client 1

SP

Network provider V

SP

SP

SP

Network provider W

SP

SP

SP

A need to worry about the security