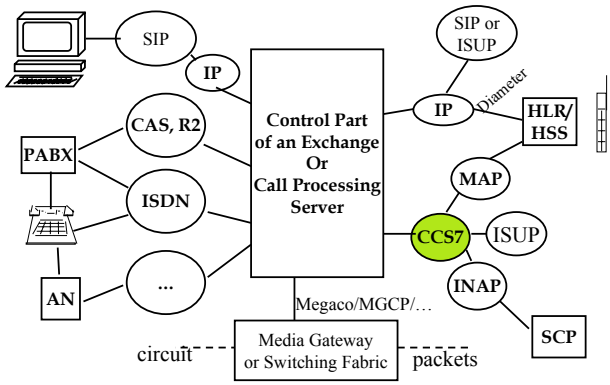
Common Channel Signaling Nr 7 (CCS7)

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



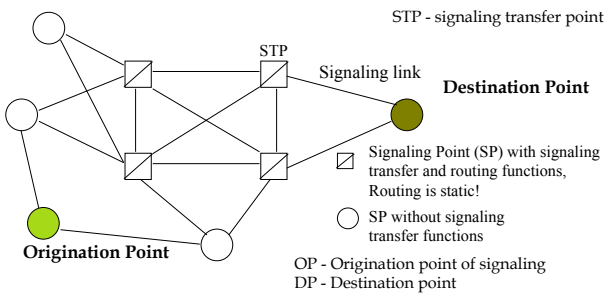
Limitations of Analogue signaling

- › **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.**

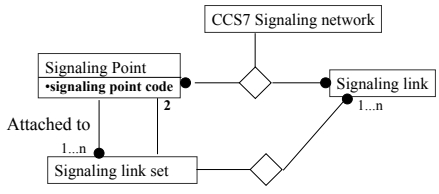
Basis of CCS7 is the signaling network - a special kind of data network.



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. A use case of STPs is for concentrating IN signaling traffic towards IN nodes that provide Nationwide services.

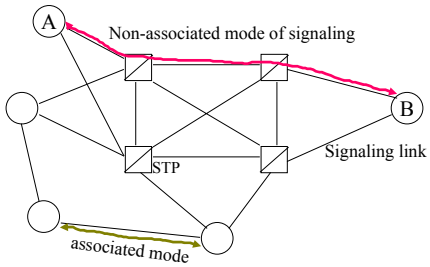
Key definitions for CCS7

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.*



An exchange or any other CCS7 node that resides on a border Of two CSS7 networks will have two or more signaling point codes.

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



In non-associated mode, voice is routed on a different path than signaling → There must be direct voice circuits between SP A and SP B in the Fig. Otherwise, how could telephony routing work? It follows that non-associated mode is more relevant for non-call associated signaling such as location updates or IN services.

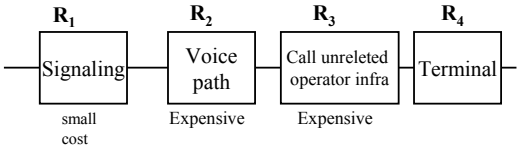
Between exchanges, normally calls are routed hop by hop

- ✓ **On an end to end path, through several intermediate exchanges, call setup progresses hop-by-hop, i.e. each exchange processes call setup signaling and performs call routeing (associated mode of signaling in CCS7).**
- ✓ **For call related signaling, CCS7 uses ISUP. ISUP messages are mapped (1-to-1) to voice circuits by Circuit Identification Code (CIC) in each message. I.e. each control plane signaling and call control FSM is tied to the corresponding voice circuit 1-to-1.**
- ✓ **Some of the information fields in signaling messages may just need to be copied blindly from incoming signaling to outgoing signaling. Still this operation is done by the call control FSM running on a call processing computer in each intermediate exchange.**

CCS7 reliability is built by software

- Speed: post dial delay (until ringing tone) ≤ 2.2s.
- MTP:
  - unavailability of signaling route set ≤ 10 min/annum
  - share of undetected faulty signaling messages: ≤ 10^{-10}
  - loss probability of signaling messages ≤ 10^{-7}
  - probability of reordering or replication of signaling messages ≤ 10^{-10}
- Expected quality of of the underlying transmission network:
  - Long term bit error rate ≤ 10^{-6}
  - Medium term bit error rate ≤ 10^{-4}
- Using software means reliability is increased by several 10-folds!!

Why is it a good idea to require high availability performance from signaling?



- ✓ **All parts of the above sequencial reliability model need to work for an operator to earn money on a voice call. The weakest link determines the availability perceived by the end user.**
- ✓ **By eliminating loss of revenue due to signaling and call control failures, operators make good of the investment on the expensive transmission path for voice and recover the huge fixed cost that they must carry.**

In previous setting the total reliability is

$$R = R_1 \times R_2 \times R_3 \times R_4$$

Example

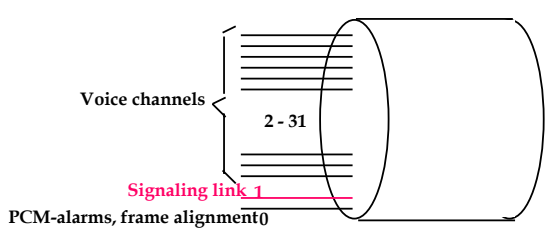
$R_1 = 0{,}999$, $R_2 = 0{,}998$, $R_3 = 0{,}997$, $R_4 = 0{,}92$

$R = 0{,}999 \times 0{,}998 \times 0{,}997 \times 0{,}92 = 0{,}914$

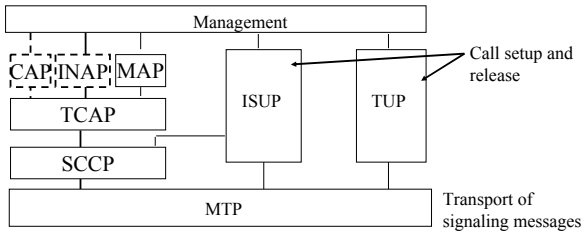
The weakest link determines the total reliability

A term that is close to 1 has no impact.

Use of PCM time slots in the Finnish CCS7 network

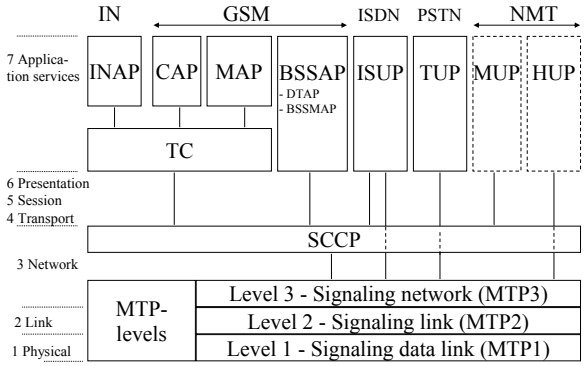


Principal components in CCS7

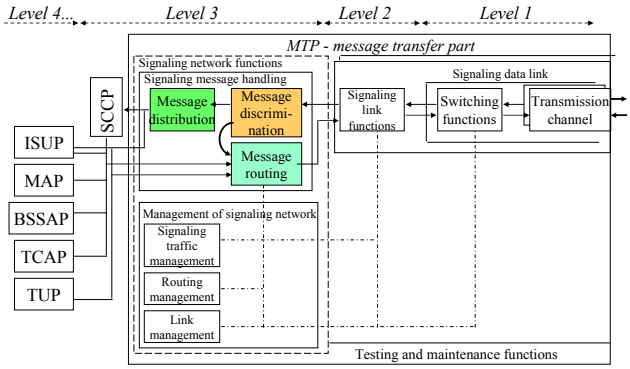


INAP - IN Application part
CAP - CAMEL Application part
CAMEL - Customized Applications for Mobile Enhanced Logic = "INAP" extension in GSM
TUP - Telephony User Part
ISUP - ISDN User Part
SCCP - Signaling Connection Control Part
TCAP - Transaction Capabilities Application Part
MAP - Mobile Application Part
MTP - Message Transfer Part

Structure of CCS7



Message transfer part, MTP, is the basis of CCS7



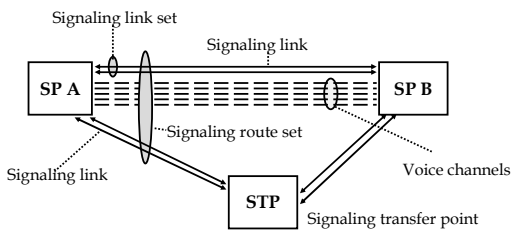
MTP service to upper layers is connectionless

- ✓ **The term "signaling connection" means a path on which MTP sends messages, there is no dynamic connection state that needs to be dynamically "set up" or released.**
- ✓ **Routing is static – i.e. MTP forms a network that is similar to an IP network except that**
  - › **There are no dynamic routing protocols like in IP networks**
  - › **Routing is based on 14 bit signaling point codes, not IP addresses**
  - › **MTP has enhanced reliability features such as: a node saves all sent messages until it sees an acknowledgement. If there is no acknowledgement within a time limit or an indication of channel failure is detected, the channel is "switched over", the saved messages are resent on a spare channel, the receiver is able to remove possible dublicates and from an MTP user's point of view, MTP has performed a perfect, faultless service within time limits for each message.**

Terms

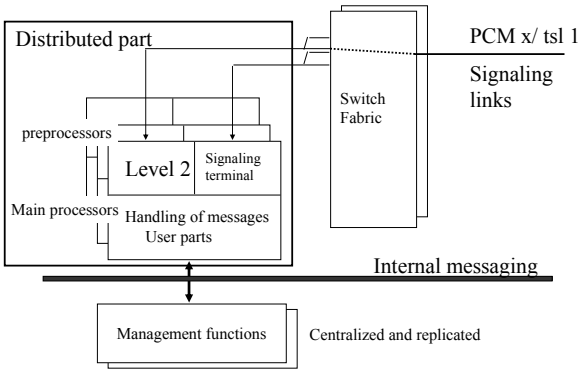
- ✓ **BSSAP – Base Station Subsystem Application Part**
  - › **used for BSS to MSC signaling in GSM**
  - › **MSC – Mobile Switching Center**
  - › **Handover support and location updates are important features of BSSAP**
  - › **BSSAP includes DTAP data transfer application part**
- ✓ **ISUP – ISDN user part**
- ✓ **SCCP – Signaling Connection Control Part**
  - › **used for call unrelated signaling**
- ✓ **TCAP – Transaction Capabilities Application Part**
  - › **provides generic application services for transactions such as IN service logic requests and responses**
- ✓ **INAP – Intelligent Network Application Part**
  - › **the protocol that exchanges (containing SSF service switching functions) use to access IN service logic in SCFs, Service Contorol Functions and SCFs use to access data in Service Data Functions (SDF)**

Key concepts in MTP are



- ✓ **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)



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

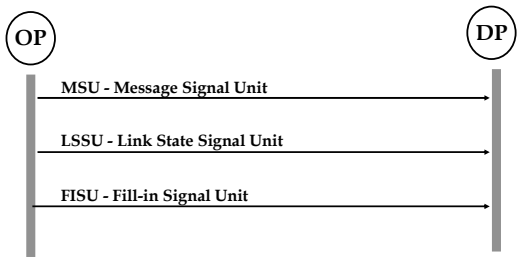
LEVEL 3:

- *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 adds reliability

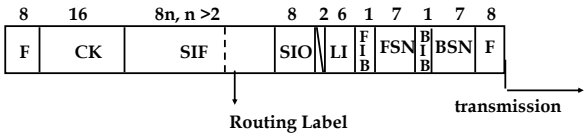
- ✓ **The function on the previous slide mean that if PCM connection with a signaling link fails,**
  - › **MTP will quickly detect the failure,**
  - › **It will automatically, switch the traffic to another signaling link**
  - › **it will go back to copies of the unacknowledged MTP messages it has sent,**
  - › **It will resend the messages**
- ✓ **The receiver will detect duplicate messages and**
- ✓ **The UP or AP will see no difference**
  - › **All these recovery actions have high real time performance requirements**

MTP has three message types



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!

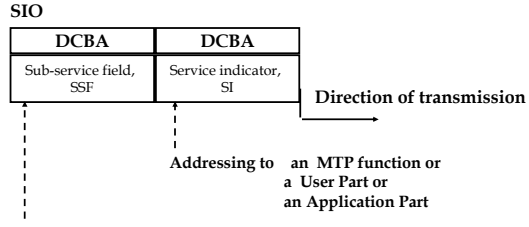
Message Signaling Unit structure is



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

BSN and FSN have link local significance

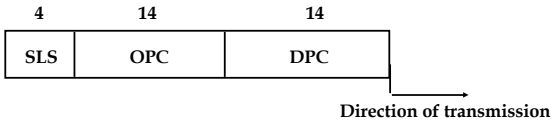
Service Information Octet (SIO) defines the target application



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.

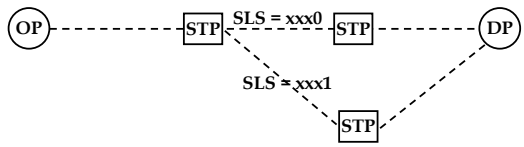
MTP Route Label has three fields



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

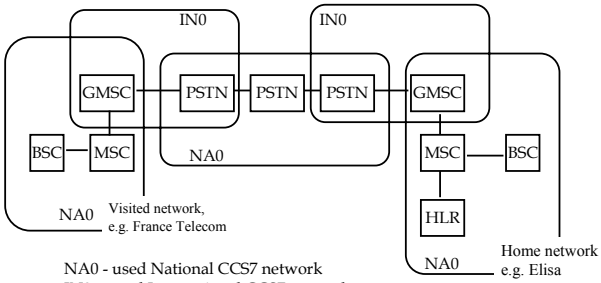
The shown lengths are acc to International(and Finnish) specification, in ANSI specs OPC/DPC lengths are 24 bits!

Load sharing has an impact on signal routing



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



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

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

In this example, SCCP would be used to carry MAP/TCAP messages

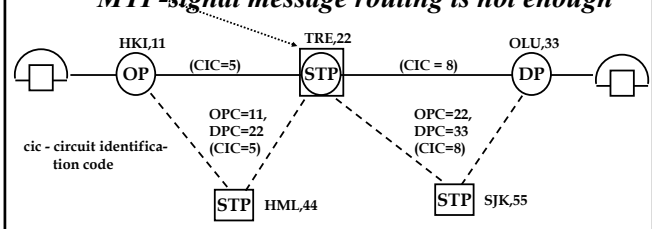
Explanations to location update example

- ✓ **Location update is may be the most obvious use case of non-call related signaling.**
- ✓ **Location update signaling uses MAP (we will discuss MAP later in detail) – adding location update to ISUP would be very cumbersome due ISUP FSM identification principle that is based on CIC**
- ✓ **Because MTP uses point codes unique for a network, in the example, we need to send MAP messages across several addressing spaces (in terms of point codes), therefore, between MAP and MTP, an additional network service is needed. This is called SCCP – signaling connection control part.**

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 (here ISUP) is needed, when MTP-signal message routing is not enough

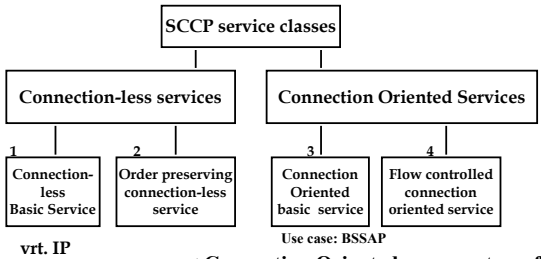


- **Messages/calls through an international signaling point**
- **Calls across an operator boundary**
- **Intelligent Network calls**
- **In general, when the OP does not know the location of the called party**

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

Use case: BSSAP

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

Only classes 1 …3 are in use.

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
National 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				

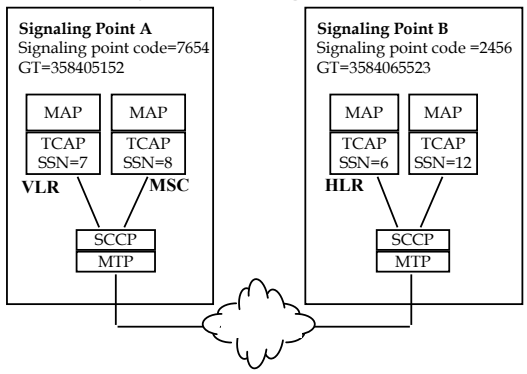
SSN (cmp. Port Numbers in TCP/IP)
1 - SCCP management
2 - TUP
3 - ISUP
4 - OMAP - Operation and Maintenance AP
5 - MAP - Mobile AP
6 - MAP/HLR
7 - MAP/VLR
8 - MAP/MSC
9 - MAP/EIR - Equipment Id reg
10 - MAP/AuC
11 - ISUP/SS ISUP supplementary services
12…247 , 249…252 reserved
248 - MUP (NMT Mobile UP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



CCS7 and PABXs

- ✓ **Signaling Point codes are not allocated to private network devices such as PABXs and CCS7 does not support connecting a PABX to the public network – for this purpose e.g. DSS1 PRI can be used.**
- ✓ **If a PABX network supports a large set of business services, rich information in the private signaling system can not be mapped to any of the User parts in CCS7 and information is lost.**
- ✓ **If an ISDN exchange needs to be a node in a private network with private signaling extensions and providing the same set of services as the private network, then the ISDN exchange needs to support the private network signaling as well (e.g. QSIG).**

SCCP use cases

- ✓ **GT addresses are allocated for *Network elements* such as MSC or HLR. When e.g. a user's MSISDN appears in a call releted ISUP message it is carried in a Called_party or some such information element not Global Title.**
  - › **Number portability will not cause difficulties for GT addressing since GT numbers are not ported from network to network like user allocated MSISDN numbers can be.**
  - › **A user's MSISDN number can point to HLR serving that user and maintaining information about the location of the user**
- ✓ **Use cases for SCCP are not directly call related:**
  - › **MAP: location update, HLR to VLR subscriber profile updates, routing information requests from GMSC to HLR etc**
  - › **INAP: call service logic requests from an exchange (Service Switching Function) to an IN node (SCF – Service Control Function). During such signaling voice channel control stays in the SSF. The SCF may be remote, even in a different network cmp to SSF.**
  - › **CAP: similar to INAP. SCF resides in most cases in the home network.**
- ✓ **If a call requires global addressing, then globally unique E.164 telephone numbers are used in ISUP, no SCCP is in practise needed.**

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 and e.g. GSM 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 and other non-call related services**

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