**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**

The diagram illustrates the integration of various signaling protocols and systems, highlighting the control part of an exchange or call processing server. The network includes components such as H.323 or SIP, ISUP, MAP, and HLR/HSS, among others, showcasing the complexity and interconnectivity of signaling protocols in modern telecommunications networks.
**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 $\approx 50$ ms. --> post dialling delay until 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.**

Signaling Point (SP) with signaling transfer and routing functions

SP without signaling transfer functions

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

- Non-associated mode of signaling
- Associated mode
- In non-associated mode, voice is routed on a different path than signaling

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**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!!
Use of PCM time slots in the Finnish CCS7 network

Voice channels

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Signaling link

PCM - alarms, frame alignment

Principal components in CCS7

Management

TCAP

SCCP

MTP

ISUP

TUP

Call setup and release

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
- ISUP
- TUP
- MUP
- HUP

TC

INAP - CAP - MAP - BSSAP - ISUP - TUP - MUP - HUP

SCCP

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

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 discrimination

Message routing

ISUP

MAP

BSSAP

TCAP

TUP

Signaling data link

Signaling link functions

Switching functions

Transmission channel

Testing and maintenance functions

Signaling traffic management

Routing management

Link management

Signaling network functions

Map

SCCP

ISUP

TUP

MUP

HUP
Key concepts in MTP are

- Signalling link
- Signalling link set (SLS)
- Signalling Route
- Signalling Route set

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

- Distributed part
- Preprocessors
- Main processors
- Level 2
- Handling of messages
- User parts
- Signaling terminal
- Switch Fabric
- Internal messaging
- PCM x/ tsl 1
- Signaling links
- Centralized and replicated
- Management functions

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**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**

- **MSU - Message Signal Unit**: carries all payload of upper layers
- **LSSU - Link State Signal Unit**: MTP level messaging between neighboring SPs
- **FISU - Fill-in Signal Unit**: 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
- **CK** - Check bits

Service Information Octet (SIO) defines the target application:

- **SSF** - Sub-service field
- **SI** - Service indicator

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.
**MTP Route Label has three fields**

<table>
<thead>
<tr>
<th>4</th>
<th>14</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLS</td>
<td>OPC</td>
<td>DPC</td>
</tr>
</tbody>
</table>

Direction of transmission

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

The shown lengths are according to the 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 !!

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: 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.
Forth 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.

SCCP provides four service classes

- Connection-less services
  - Connection-less Basic Service
  - Order preserving connection-less service
- Connection Oriented Services
  - Connection Oriented basic service
  - Flow controlled connection oriented service

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

<table>
<thead>
<tr>
<th>SSN (cmp. Port Numbers in TCP/IP)</th>
<th>Calling and called party in SCCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - SCCP management</td>
<td>National use RI - Routing indicator GT Indicator SSN ind PCode ind</td>
</tr>
<tr>
<td>2 - TUP</td>
<td></td>
</tr>
<tr>
<td>3 - ISUP</td>
<td></td>
</tr>
<tr>
<td>4 - OMAP - Operation and Maintenance AP</td>
<td></td>
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<tr>
<td>5 - MAP - Mobile AP</td>
<td></td>
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<tr>
<td>6 - MAP/HLR</td>
<td></td>
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<tr>
<td>7 - MAP/VLR</td>
<td></td>
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<tr>
<td>8 - MAP/MSC</td>
<td></td>
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<tr>
<td>9 - MAP/EIR - Equipment Id reg</td>
<td></td>
</tr>
<tr>
<td>10 - MAP/AuC</td>
<td></td>
</tr>
<tr>
<td>11 - ISUP/SS ISUP supplementary services</td>
<td></td>
</tr>
<tr>
<td>12...247 , 249...252 reserved</td>
<td></td>
</tr>
<tr>
<td>248 - MUP - NMT Mobile UP</td>
<td></td>
</tr>
<tr>
<td>253 - OMC - Operation and Maintenance Center</td>
<td></td>
</tr>
<tr>
<td>254 - BSSAP - BSS Applic. part</td>
<td></td>
</tr>
</tbody>
</table>

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

E.212: IMSI:  
E.164: MISDN:  
E.214: Hybrid:  

IMO - 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
TCAP SSN = 7
SCCP
MTP

Signaling Point B
Signaling point code = 2456
GT = 3584065523

MAP
TCAP SSN = 6
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 emerging CCS7 environment may have potentially hostile third parties

New CCS7 speakers

Service provider Y
Service provider X
Client 1
Network provider V
Network provider W

A need to worry about the security