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 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.

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)

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) ≤ 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 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

Signaling link 1

PCM-alarms, frame alignment

Principal components in CCS7

Management

TCAP

INAP

CAP

MAP

ISUP

TUP

SCCP

MTP

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**

- **7 Application services**
  - INAP
  - CAP
  - MAP
  - BSSAP
  - TCAP
  - INAP
  - CAP
  - MAP
  - BSSAP
  - ISUP
  - TUP
  - MUP
  - HUP

- **6 Presentation**
- **5 Session**
- **4 Transport**
- **3 Network**
  - SCCP
  - MTP - message transfer part
    - 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**
  - ISUP
  - MAP
  - BSSAP
  - TCAP
  - TUP

- **Level 3**
  - SCCP
    - Message distribution
    - Message discrimination
    - Message routing

- **Level 2**
  - Signaling network functions
  - Signaling message handling
  - Signaling link functions
  - Switching functions
  - Transmission channel

- **Level 1**
  - Signaling data link
  - Testing and maintenance functions

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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)

- Distributed part
  - pre processors
  - Main processors
- Level 2
  - Signaling terminal
  - Handling of messages
  - User parts
- Internal messaging
  - PCM x/ ts1 1
  - Switch Fabric
  - Signaling links
  - 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

MSU - Message Signal Unit

LSSU - Link State Signal Unit

FISU - Fill-in Signal Unit

DP

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**

<table>
<thead>
<tr>
<th>8</th>
<th>16</th>
<th>8n, n &gt;2</th>
<th>8</th>
<th>2</th>
<th>6</th>
<th>1</th>
<th>7</th>
<th>1</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>CK</td>
<td>SIF</td>
<td>SIO</td>
<td>LI</td>
<td>F</td>
<td>B</td>
<td>FSN</td>
<td>B</td>
<td>BSN</td>
<td>F</td>
</tr>
</tbody>
</table>

- **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** = payload
- **CK** - Check bits

**Routing Label**

**Service Information Octet (SIO) defines the target application**

<table>
<thead>
<tr>
<th>SIO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DCBA</strong></td>
</tr>
<tr>
<td>Sub-service field, SSF</td>
</tr>
</tbody>
</table>

**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!

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**Load sharing has an impact on signal routing**

OP → STP

SLS = xxx0

STP → STP

SLS = xxx1

STP → DP

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.
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

Connection-less services
1. Connection-less Basic Service
2. Order preserving connection-less service

Connection Oriented Services
3. Connection Oriented basic service
4. Flow controlled connection oriented service

✓ 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**

<table>
<thead>
<tr>
<th>Calling and called party in SCCP</th>
<th>SSN (cmp. Port Numbers in TCP/IP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI - Routing indicator</td>
<td>1 - SCCP management</td>
</tr>
<tr>
<td>GT Indicator</td>
<td>2 - TUP</td>
</tr>
<tr>
<td>SSN ind</td>
<td>3 - ISUP</td>
</tr>
<tr>
<td>PCode ind</td>
<td>4 - OMAP - Operation and Maintenance AP</td>
</tr>
<tr>
<td>8             7               6    5    4    3   2       1</td>
<td>5 - MAP - Mobile AP</td>
</tr>
<tr>
<td>National use</td>
<td>6 - MAP/HLR</td>
</tr>
<tr>
<td>Sub System Number (SSN)</td>
<td>7 - MAP/VLR</td>
</tr>
<tr>
<td>Global title translation type</td>
<td>8 - MAP/MSC</td>
</tr>
<tr>
<td>Numbering plan</td>
<td>9 - MAP/EIR - Equipment Id reg</td>
</tr>
<tr>
<td>Coding method</td>
<td>10 - MAP/AuC</td>
</tr>
<tr>
<td>Address type</td>
<td>11 - ISUP/SS ISUP supplementary services</td>
</tr>
<tr>
<td>Address information</td>
<td>12...247, 249...252 reserved</td>
</tr>
<tr>
<td>E.212: IMSI:</td>
<td>248 - MUP (NMT Mobile UP)</td>
</tr>
<tr>
<td></td>
<td>253 - OMC - Operation and Maintenance Center</td>
</tr>
<tr>
<td></td>
<td>254 - BSSAP - BSS Appl. part</td>
</tr>
</tbody>
</table>

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

| E.212: IMSI: | E.g. 244 05 87654321 |
| E.164: MISDN: | E.g. 358 40 540 3127 |
| E.214: Hybrid: | 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

Signaling Point B
- Signaling point code = 2456
- GT = 3584065523

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**
- Large number 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

**Weaknesses**
- 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

A need to worry about the security