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

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 (delay from the dialing of the last digit until the ringing tone) approaches zero.
- Makes use of HDLC -protocol framing and principles.

Summary of course scope

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.

Basis of CCS7 is the signaling network - a special kind of data network.
Signaling connection can be either direct or indirect (through STP nodes)

In non-associated mode, voice is routed on a different path than signaling. This 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 routing (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. 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 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 sequential 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
MAP - Mobile Application Part
TCAP - Transaction Capabilities Application Part
MTP - Message Transfer Part

Transport of signaling messages

Call setup and release

Structure of CCS7

INAP
CAP
MAP
BSSAP
TCAP
ISUP
TUP
MTP
HUP

Structure of CCS7

Message transfer part, MTP, is the basis of CCS7

MTP service to upper layers is connectionless

Terms

- BSSAP - Base Station Subsystem Application Part
  - used for BSS to MSC signaling in GSM
  - MSC - Mobile Switching Center

- ISUP - ISDN user part
  - SCCP - Signaling Connection Control Part

- TCAP - Transaction Capabilities Application Part
  - used for call un-related signaling

- INAP - Intelligent Network Application Part
  - the protocol that exchanges (containing SSF service switching functions) use to access IN service logic in SCFs, Service Control Functions and SCFs use to access data in Service Data Functions (SDF)

Key concepts in MTP are

- Signaling link set
- Signaling link
- Signaling route set
- Voice channels
- Signaling transfer point

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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

Message Signaling Unit structure is

Service Information Octet (SIO) defines the target application

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

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MTP Route Label has three fields

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

Visited network, e.g. France Telecom
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

- **Connection-less services**
  - Connection-less Basic Service
  - Order preserving connection-less service

- **Connection Oriented Services**
  - Flow controlled connection oriented service

Use case: BSSAP

Only classes 1 …3 are in use.

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

**SCCP service classes**

<table>
<thead>
<tr>
<th>Service Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Connection-less Basic Service</td>
</tr>
<tr>
<td>2</td>
<td>Order preserving connection-less service</td>
</tr>
<tr>
<td>3</td>
<td>Connection Oriented Basic Service</td>
</tr>
<tr>
<td>4</td>
<td>Flow controlled connection oriented service</td>
</tr>
</tbody>
</table>

**Global Title in SCCP supports global messaging over the CCS7 network**

Calling and called party in SCCP

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SCCP management</td>
</tr>
<tr>
<td>2</td>
<td>TUP</td>
</tr>
<tr>
<td>3</td>
<td>ISUP</td>
</tr>
<tr>
<td>4</td>
<td>OMAP - Operation and Maintenance AP</td>
</tr>
<tr>
<td>5</td>
<td>MAP - Mobile AP</td>
</tr>
<tr>
<td>6</td>
<td>MAP/HLR</td>
</tr>
<tr>
<td>7</td>
<td>MAP/VLR</td>
</tr>
<tr>
<td>8</td>
<td>MAP/MSCC</td>
</tr>
<tr>
<td>9</td>
<td>MAP/ER - Equipment Id reg</td>
</tr>
<tr>
<td>10</td>
<td>MAP/AuC</td>
</tr>
<tr>
<td>11</td>
<td>ISUP/SS ISUP supplementary services</td>
</tr>
<tr>
<td>12…247</td>
<td>Reserved</td>
</tr>
<tr>
<td>248</td>
<td>MUP (NMT Mobile UP)</td>
</tr>
<tr>
<td>253</td>
<td>OMC - Operation and Maintenance Center</td>
</tr>
<tr>
<td>254</td>
<td>BSSAP - BSS Applic. part</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>GT Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>E.212</td>
<td>IMSI: MCC MNC MSIN E.g. 244 05 87654321</td>
</tr>
<tr>
<td>E.164</td>
<td>MISDN: CC NDC SN E.g. 358 40 540 3127</td>
</tr>
<tr>
<td>E.214</td>
<td>Hybrid: CC NDC MSIN E.g. 358 40 3127</td>
</tr>
</tbody>
</table>

**Address Information**
- MSC - 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**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signaling Point A</td>
<td>Signaling point code=7654 GT=358/403152</td>
</tr>
<tr>
<td>Signaling Point B</td>
<td>Signaling point code =2456 GT=584/065523</td>
</tr>
</tbody>
</table>

**SCCP use cases**

- **SCCP** uses are 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).
- If a call requires global addressing, then globally unique E.164 telephone numbers are used in ISUP, no SCCP is in practice 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, 284, 536, 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

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The current CCS7 environment may have potentially hostile third parties

- Service provider Y
- Service provider X
- Network provider V
- Network provider W

New CCS7 speakers

- Client 1

A need to worry about the security

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CCS7

**Strengths** and **weaknesses**

**Strengths**
- 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

**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.