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Detailed Signalling Interworking within the PLMN and with the PSTN/ISDN

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Detailed Signalling Interworking within the PLMN and with the PSTN/ISDN

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PREFATORY NOTE

ETSI has constituted stable and consistent documents which give specifications for the implementation of the European Cellular Telecommunications System. Historically, these documents have been identified as "GSM recommendations".

Some of these recommendations may subsequently become Interim European Telecommunications Standards (I-ETSs) or European Telecommunications Standards (ETSs), whilst some continue with the status of ETSI-GSM Technical Specifications. These ETSI-GSM Technical Specifications are for editorial reasons still referred to as GSM recommendations in some current GSM documents.

The numbering and version control system is the same for ETSI-GSM Technical Specifications as for "GSM recommendations".

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1. SCOPE

The scope of this Recommendation is to give guidance with regard to the signalling interworking between messages defined in Recommendations GSM 04.08, GSM 08.08 and GSM 09.02. Interworking for call control with the fixed network is implemented using TUP or ISUP of signalling system number 7. National variants of the signalling are not considered in this recommendation.

This Recommendation handles normally only messages. The mapping of message contents is shown in Recommendation GSM 09.10.

2. SIGNALLING INTERWORKING IN THE BSS

Signalling interworking in the BSS is described in recommendations GSM 08.08, 08.58 and 09.10.

3. SIGNALLING INTERWORKING IN THE MSC

3.1 General

The following cases are defined in this chapter with the signalling diagrams:

- call establishment
- call release
- location registration
- handover
- authentication

The message interworking is shown with the diagrams, which show the layer 3 messages between the MSC and the MS and between the MSC and the BSS, the MAP messages and the messages between MSC and the fixed network. In general the diagrams also show messages, which are optional. Thus all the messages are not always present in real implementations.

The diagrams have been done with the same format. The diagrams are on the left side of the page (See e.g. section 3.2.2.1). The right side is reserved for message names and explanatory text. The MSC is in the middle of the diagrams. The MS and BSS on the left and the location registers, other MSCs and the fixed network on the right. The arrows show the direction of the messages. Time is running from top to bottom. The vertical line between messages describes the processing in the MSC.

3.2 Call establishment

3.2.1 General

The call establishment procedures are divided into MS originating calls (3.2.2) and MS destinating calls (3.2.3). All the cases which are defined and the corresponding sections are shown in the table 3.1.

	Call to		
	PLMN	PSTN	ISDN
Call from			
PLMN	3.2.2.1 3.2.3.1	3.2.2.2	3.2.2.3
PSTN	3.2.3.2		
ISDN	3.2.3.3		

Table 3.1 Call establishment procedures

The procedures are based on the GSM and CCITT recommendations shown in the table 3.2.

Rec.	Title
GSM 04.08	Mobile Radio Interface Layer 3 Specification
GSM 08.08	Base Station to Switch Interface, Layer 3 Specification
GSM 09.02	Mobile Application Part
CCITT Q.721-Q.725	Telephone User Part
CCITT Q.761-Q.764	ISDN User Part

Table 3.2 The recommendations which define the call establishment procedures in the MSC.

3.2.2 MS originating calls

3.2.2.1 Call to PLMN

This section contains the case where the calling and called subscriber are in the same PLMN. The procedure for the originating MSC is defined. The procedures for the terminating MSC are shown in section 3.2.3.1. If the called subscriber is in an other PLMN the call establishment procedure is then like that in section 3.2.3.2.

TUP or ISUP may be used in signalling between MSCs in the PLMN depending on the network type between the MSCs.

The call can be established in two ways in the GSM. Either with the early assignment or with the off air call set up (OACSU). The difference between these is that in the latter case the radio channel is reserved at the latest possible moment i.e. when the called subscriber answers. In this recommendation only the procedure with the early assignment is shown.

In the following procedures for succesful operation it is assumed that signalling towards the fixed network uses only three messages IAM, ACM and answer. Examples of other interworking cases are not shown in this recommendation (for further information see eg. CCITT rec Q.699).

3.2.2.1.1 Successful operation

MSC

BSS -> *Complete layer 3 information* (08.08)
! After carrying out initial assignment procedure the MS sends the
! *CM SERVice REQuest* message to the BSS. This message is sent to the
! MSC as a part of *Complete layer 3 information* message. It does not
! contain any confidential information. It contains service identity,
! classmark and mobile identity.
!
-> VLR *process access request* (09.02)
The MSC sends an access request to the VLR.

AUTHENTICATION (See 3.6)

<- VLR *start ciphering* (9.02)
If authentication was successful, the VLR requests the MSC to start ciphering procedures. Message contains ciphering information and it also indicates whether ciphering is used or not.

<- VLR *access request accepted* (09.02)
Process access request message is acknowledgeded.

<- VLR *forward new TMSI* (09.02)
The message is sent to the MSC if reallocation of the TMSI is wished. The information of this and *start ciphering* message may also be sent simultaneously .

BSS <- *Cipher Mode Command* (08.08)
The message passes encryption information to the BSS.

BSS -> *Cipher Mode Complete* (08.08)
! This message is an indication that appropriate action on enciphering and
! deciphering has been started by the MS and the BSS.
!
MS <- *TMSI REALlocation CoMmanD* (04.08)
Message transfers the value of new TMSI in ciphered mode.

MS -> *TMSI REALlocation COMplete* (04.08)
! Reallocation has been completed in the MS.
!
-> VLR *TMSI acknowledge* (09.02)

TMSI reallocation is acknowledged

MS ->
! *SETUP* (04.08)
! This message contains confidential call control information eg.
! called party address and bearer capability.
!
-> VLR *send information for O/G call set-up* (09.02)
The MSC sends a request for subscriber parameters.

<- VLR *complete call* (09.02)
! The VLR sends the subscriber information to the MSC.
!
MS <- *CALL PROCeeding* (04.08)
! The MSC sends this message to the MS to indicate that the call is
! being proceeded.
!
BSS <- *ASSignment REQuest* (08.08)
The MSC seizures a terrestrial channel and asks the BSS to seizure a radio channel. This message contains information about the resource that is needed.

BSS ->
! *ASSignment COMplete* (08.08)
! The BSS seizures a radio channel and, if the MS tunes to the channel, the
! BSS sends acknowledgement with this message.
!
-> HLR *send routing information* (09.02)
The MSC sends the routing data request message to the HLR of the called subscriber. The address of the HLR is derived in the MSC from the ISDN number of the called subscriber.

<- HLR *routing information acknowledge* (09.02)
! The HLR sends information (eg. the roaming number) of the called
! subscriber to the MSC.
!
-> EXC *initial address message* (Q.721-Q.725, Q.761-Q.764)
! The MSC starts the connection establishment to the called subscriber .
!
<- EXC *address complete message* (Q.721-Q.725, Q.761-Q.764)
! The complete called party number has been received by the destination
! exchange
!
MS <- *ALERT ing* (04.08)
The MSC changes the *address complete* message to an *ALERTing* message to the MS.

<- EXC *answer signal* (Q.721-Q.725), *answer message* (Q.761-Q.764)
! The called subscriber answers.
!
MS <- *CONNect* (04.08)
The MSC informs the MS, that the call has been accepted by the called subscriber.

MS -> *CONNect ACKnowledge* (04.08)
The MS acknowledges the *CONNect* message.

3.2.2.1.2 **Abnormal cases**

Negative response to process access request message

-> VLR *process access request* (09.02)
The MSC sends access request to the VLR.

<- VLR negative acknowledge for *process access request* (09.02)
! If the acknowledgement is an error message eg.
! - *unknown subscriber*
! - *unidentified subscriber*
! the call is cleared.
!
MS <- *CM SERVice REJect* (04.08)
! The rejection is indicated to the MS by sending this message.
!
BSS <- *CLeaR CoMmanD* (08.08)
The MSC instructs the BSS to release the associated dedicated resource.

BSS -> *CLeaR COMplete* (08.08)
The BSS has completed the release of the associated dedicated resource.

A-subscriber not allowed to make outgoing calls

MSC

-> VLR *send information for O/G call set-up* (09.02)
The MSC sends information request for authentication to the VLR.

<- VLR negative acknowledge for O/G call set-up (09.02)
! If the acknowledgement is an error message eg.
! - *call barred*
! - etc. (see 09.02 for further details)
! the call is released.
!
MS <- *RELease COMPlete* (04.08)
!
BSS <- *CLeaR CoMmanD* (08.08)
The MSC instructs the BSS to release the associated dedicated resource.

BSS -> *CLeaR COMplete* (08.08)
The BSS has completed the release of the associated dedicated resource.

Assignment failure

MSC

BSS <- *ASSignment REQuest* (08.08)

BSS -> *ASSignment FAILure* (08.08)
If the assignment has failed eg. for the following reasons
- use of indicated (by the MSC) terrestial channel impossible
- the radio channel assignment fails
the call will be released.

MS <- *DISConnect* (04.08)
The MSC initiates the clear procedure in the MS.

MS -> *RELease* (04.08)
! The MS sends a *RELease* message to the MSC.
!
MS <- *RELease COMplete* (04.08)
The MSC completes the clear procedure with the MS.

BSS <- *CLeaR CoMmanD* (08.08)
The MSC instructs the BSS to release the associated dedicated resource.

BSS -> *CLeaR COMplete* (08.08)
The BSS has completed the release of the associated dedicated resource.

Routing failure

MSC

-> HLR *send routing information* (09.02)

<- HLR negative routing information acknowledge (09.02)
! If the routing of the call is not possible eg. for the following reasons
! - *unknown subscriber*
! - *call barred*
! - *CUG reject* etc.
! the call is cleared.
!
MS <- *DISConnect* (04.08)
! Clear sequence is started by *DISConnect* message towards the MS .
!
MS -> *RELease* (04.08)
! The MS sends a *RELease* message to the MSC.
!
MS <- *RELease COMplete* (04.08)
The MSC completes the clear procedure with the MS.

BSS <- *CLeaR CoMmanD* (08.08)
The MSC instructs the BSS to release the associated dedicated resource.

BSS -> *CLeaR COMplete* (08.08)
The BSS has completed the release of the associated dedicated resource.

Failure to access B-subscriber

MSC

-> EXC *initial address message* (Q.721-Q.725, Q.761-Q.764)

<- EXC *CGC, SSB, LOS* etc. failure signal (Q.721-Q.725) or *release message* (Q.761-Q.764)
! Failure is indicated by corresponding message or cause field.
!

MS <- *DISConnect* (04.08)
! Clear sequence is started by *DISConnect* message towards the MS .
!

-> EXC *clear-forward signal* (Q.721-Q.725) or *release complete message* (Q.761-Q.764)
MSC indicates by this message that *release message* or corresponding TUP message has been received

MS -> *RELease* (04.08)
! The MS sends a *RELease* message to the MSC.
!

MS <- *RELease COMplete* (04.08)
The MSC completes the clear procedure with the MS.

BSS <- *CLeaR CoMmanD* (08.08)
The MSC instructs the BSS to release the associated dedicated resource.

BSS -> *CLeaR COMplete* (08.08)
The BSS has completed the release of the associated dedicated resource.

<- EXC *release-guard signal* (Q.721-Q.725)
The fixed network has released the connection. The message is used only in TUP.

3.2.2.2 Call to PSTN

The connection establishment from the MS to the PSTN is the same as that to the PLMN (section 3.2.2.1) except that the MSC does not perform the routing data inquiry from the HLR and the signalling is always implemented with TUP.

PROGRESS message may also be used to carry progress indicator element instead of *ALERT* or *CONNECT* message.

3.2.2.3 Call to ISDN

Call establishment to ISDN may alternatively use ISUP instead of TUP. The description in section 3.2.2.1 covers also the use of ISUP. No routing data inquiry is however done by the originating MSC.

3.2.3 MS terminating calls

3.2.3.1 Call from PLMN

The TUP (Telephone User Part) or ISUP of CCITT Signalling System No 7 is used for signalling between the MSC and the preceding exchange in the procedure described below.

It is assumed that the location of the subscriber is determined before the phases defined below.

3.2.3.1.1 Succesful operation

MSC

<- EXC *initial address message* (Q.721-Q.725, Q.761-Q.764)
! The MSC which sends this message knows the location of a roaming
! subscriber. The called MS is identified by the roaming number. When
! the terminating MS supports several services, the different services can
! be accessed by methods described in rec. GSM 09.07 (eg. using different
! bearer capabilities).
!

-> VLR *send information for I/C call set-up* (09.02)
The MSC sends information request of the parameters of the called subscriber to the VLR.

<- VLR *page MS* (09.02)
! VLR requests MSC to start paging procedure.
!

BSS <- *Paging* (08.08)
The MSC initiates the paging of the MS. The paging message contains IMSI and usually also TMSI for identifying the subscriber.

BSS -> *Complete layer 3 information* (08.08)
! The addressed MS has responded to the paging.
!

-> VLR *process access request* (09.02)
The MSC sends an access request to the VLR.

AUTHENTICATION (See 3.6)

<- VLR *start ciphering* (09.02)
If authentication was successful, the VLR requests MSC to start ciphering procedures.

<- VLR *access request accepted* (09.02)
Process access request message is acknowledged.

<- VLR *forward new TMSI* (09.02)
The message is sent if reallocation of the TMSI is wished.

<- VLR *complete call* (09.02)
The VLR sends the required parameters for call set-up. The information of the *complete call* message and the information of the *start ciphering* and *reallocate TMSI* messages may be sent simultaneously .

BSS <- *Cipher Mode Command* (08.08)

The message passes encryption information to the BSS. It also indicates whether ciphering is used or not.

BSS -> *Cipher Mode Complete* (08.08)
! This message is an indication that appropriate action on enciphering and
! deciphering has been started by the MS and the BSS.
!
MS <- *TMSI REALlocation CoMmanD* (04.08)
Message transfers the value of new TMSI in ciphered mode.

MS -> *TMSI REALlocation COMplete* (04.08)
! Reallocation has been completed in the MS.
!
-> VLR *TMSI acknowledge* (09.02)
TMSI reallocation is acknowledged

MS <- *SETUP* (04.08)
The MSC starts call establishment to the MS.

MS -> *CALL CONFirmed* (04.08)
! The MS responds after compatibility checking.
!
BSS <- *ASSignment REQuest* (08.08)
The MSC seizures a terrestrial channel and asks the BSS to seizure a radio channel.

BSS -> *ASSignment COMplete* (08.08)
The BSS seizures a radio channel and, if the MS tunes to the channel, the BSS sends acknowledgement with the message *ASSignment COMplete.*

MS -> *ALERTing* (04.08)
! The called user alerting has been initiated.
!
-> EXC *address complete message* (Q.721-Q.725, Q.761-Q.764)
The *address complete message* is sent backwards to inform, that the connection is established.

MS -> *CONNect* (04.08)
! The called subscriber accepts the call.
!
MS <- *CONNect ACKnowledge* (04.08)
! The MS acknowledges the *CONNect* message.
!
-> EXC *answer signal* (Q.721-Q.725), *answer message* (Q.761-Q.764)
The answer signal is sent backwards.

3.2.3.1.2 Abnormal cases

IMSI detach flag of the B subscriber is set

MSC
-> VLR *send information for I/C call set-up* (09.02)

The MSC sends information request of the parameters of the called subscriber to the VLR.

<- VLR *absent subscriber* (09.02)
! The MSC is informed that the subscriber cannot be reached, because
! IMSI detach flag is set.
!
-> EXC appropriate message in TUP (Q.721-Q.725) or *release message* (Q.761-Q.764)
The call is released.

<- EXC *clear forward* (Q.721-Q.725) or *release complete* (Q.761-Q.764)
!
-> EXC *release-guard signal* (Q.721-Q.725)
Used only in TUP.

If a proper call forwarding service is active the following is applied.

MSC
-> VLR *send information for I/C call set-up* (09.02)
The MSC sends information request of the parameters of the called subscriber to the VLR.

<- VLR *connect to following address* (09.02)
The VLR asks the MSC to forward the call to a given address. The MSC takes all the measures to forward the call to this address.

Access to B subscriber not possible for a reason indicated by VLR

-> VLR *send information for I/C call set-up* (09.02)
The MSC sends information request of the parameters of the called subscriber to the VLR.

<- VLR negative acknowledge for I/C call set-up (09.02)
! The negative acknowledgement is indicated eg. in the following messages
! - *call barred*
! - *unexpected data value*
! - etc. (see 09.02)
! the call is released.
!
-> EXC appropriate message in TUP (Q.721-Q.725) or *release message* (Q.761-Q.764)
The call is released.

<- EXC *clear forward* (Q.721-Q.725) or *release complete* (Q.761-Q.764)
!
-> EXC *release-guard signal* (Q.721-Q.725)
Used only in TUP.

No paging response

BSS <- *Paging* (08.08)

The MSC initiates the paging of the MS.

.
.
.

If the timer for paging response has expired, the paging may be repeated n times . The number of successive paging attempts and the time intervals are a network dependent choice. If the paging has failed, VLR is informed of this.

-> VLR *absent subscriber* (09.02)
MSC sends *absent subscriber* message to the VLR.

<- VLR *impossible call completion* (09.02)
VLR acknowledges the *absent subscriber* message to the MSC, when there is no call forwarding.

-> EXC appropriate message in TUP (Q.721-Q.725) or *release message* (Q.761-Q.764)
! The call is released.

<- EXC *clear forward* (Q.721-Q.725) or *release complete* (Q.761-Q.764)

-> EXC *release-guard signal* (Q.721-Q.725)
Used only in TUP.

If a proper call forwarding service is active *impossible call completion* message from VLR to MSC is replaced by *connect to following address* message.

Called MS busy

The call has proceeded in a normal way into the paging phase.

MSC

<- VLR *page MS* (09.02)
! VLR requests MSC to start paging procedure.

-> VLR *busy subscriber* (09.02)
MSC has knowledge of the 'busy' state of the subscriber. Thus the MSC sends *busy subscriber* message to the VLR without subscriber signalling.

<- VLR *impossible call completion* (09.02)
VLR acknowledges the *busy subscriber* message to the MSC, when there is no call forwarding.

-> EXC appropriate message in TUP (Q.721-Q.725) or *release message* (Q.761-Q.764)
The call is released.

<- EXC *clear forward* (Q.721-Q.725) or *release complete* (Q.761-Q.764)
!

-> EXC *release-guard signal* (Q.721-Q.725)
Used only in TUP.

If a proper call forwarding service is active *impossible call completion* message from VLR to MSC is replaced by *connect to following address* message.

Assignment failure

BSS <- *ASSignment REQuest* (08.08)

BSS -> *ASSignment FAILure* (08.08)
! If the assignment has failed eg. for the following reasons
! - use of indicated (by the MSC) terrestial channel impossible
! - the radio channel assignment fails
! the call will be released.
!
MS <- *DISConnect* (04.08)
!
-> EXC appropriate message in TUP (Q.721-Q.725) or *release message* (Q.761-Q.764)
The call is released. The cause code is mapped into the message.

MS -> *RELease* (04.08)
!
MS <- *RELease COMPlete* (04.08)
!
BSS <- *CLeaR CoMmanD* (08.08)
The MSC asks the BSS to release the associated dedicated resource.

BSS -> *CLeaR COMplete* (08.08)
The BSS has completed the release of the associated dedicated resource.
The MSC releases the terrestrial channel.

<- EXC *clear forward* (Q.721-Q.725) or *release complete* (Q.761-Q.764)
!
-> EXC *release-guard signal* (Q.721-Q.725)
Used only in TUP.

No answer from B subscriber

If the network does not receive any response to the *SETUP* message prior to the expiration of a particular timer the network shall initiate clearing procedures towards the calling and the called mobile station .

The call has proceeded in a normal way into ALERT phase.

MS -> *ALERTing* (04.08)
! The called user alerting has been initiated.
!
-> EXC *address complete message* (Q.721-Q.725, Q.761-Q.764)
The *address complete message* is sent backwards to inform, that the connection is established.

Timer has expired. Terminating MSC releases the call.

MS <- *DISConnect* (04.08)
! The MSC initiates the clear procedure in the MS.
!
-> EXC *clear-back signal* (Q.721-Q.725) or *release message* (Q.761-Q.764)
After receiving a *DISConnect* message from the MS the MSC sends a *clear-back signal* or a *release message* to the fixed network.

MS -> *RELease* (04.08)
! The MS has started the clear procedure.
!
MS <- *RELease COMplete* (04.08)
! The MSC also acknowledges the *RELease* message to the MS. The MS
! completes the clear procedure.
!
BSS <- *CLeaR CoMmanD* (08.08)
The MSC asks the BSS to release the associated dedicated resource.

BSS -> *CLeaR COMplete* (08.08)
The BSS has completed the release of the associated dedicated resource.
The MSC releases the terrestrial channel.

<- EXC *clear-forward signal* (Q.721-Q.725) or *release complete message* (Q.761-
! Q.764)
!
-> EXC *release-guard signal* (Q.721-Q.725)
The MSC has released the fixed network circuit.
Note: If the ISDN User Part is applied, this message does not exist.

If a 'call forwarding service on no response' is active this is indicated to the MSC in the *complete call* message. If there is no answer from the subscriber before timer expiration *no reply from subscriber* message is sent to the VLR after the timer has expired. The VLR responds to the MSC by *connect to following address* message.

3.2.3.2 Call from PSTN

The procedure for the MSC-B is the same as that in section 3.2.3.1 exept that only TUP is applied. The gateway MSC or other interrogating exchange performs the interrogation of routing data from the HLR as described in 3.2.3.4.

3.2.3.3 Call from ISDN

See 3.2.3.1 . ISUP or TUP is applied as a fixed network signalling method.The routing data enquiry is performed by the gateway MSC or other interrogating exchange as described in 3.2.3.4.

3.2.3.4 Signalling in the gateway MSC

Below the signalling in the gateway MSC is presented. In the signalling diagrams calls are routed by call forwarding method (see GSM 03.04).

GMSC

<- EXC *initial address message* (Q.721-Q.725, Q.761-Q.764)
! A call is coming from the PSTN/ISDN to the PLMN.
!
-> HLR *send routing information* (09.02)
The GMSC sends the routing data request to the HLR of the called subscriber.

<- HLR *routing information acknowledge* (09.02)
! The HLR sends the roaming number of the called subscriber to the
! MSC.
!
->MSC-B *initial address message* (Q.721-Q.725, Q.761-Q.764)
The GMSC starts the connection establishment to the destinating MSC.

<-MSC-B *address complete message* (Q.721-Q.725, Q.761-Q.764)
! The MSC-B has established the connection.
!
-> EXC *address complete message* (Q.721-Q.725, Q.761-Q.764)
The GMSC sends this message towards the PSTN.

<-MSC-B *answer signal* (Q.721-Q.725), *answer message* (Q.761-Q.764)
! The called subscriber has answered.
!
-> EXC *answer signal* (Q.721-Q.725), *answer message* (Q.761-Q.764)
The GMSC transfers this message to the PSTN.

3.3 Call release

The call release cases and the related sections, where the cases are handled, are shown in the table 3.3.

	Calling subscriber clears	Called subscriber clears
Originating calls	3.3.1.1	3.3.1.2
Destinating calls	3.3.2.1	3.3.2.2

Table 3.3 Call release procedures

3.3.1 MS originating call

3.3.1.1 Calling subscriber clears

This section shows the call release procedure of the originating MSC when the calling subscriber clears the call.

MSC

MS -> *DISConnect* (04.08)
! *RELease* (04.08)
! The calling subscriber initiates the clearing of call. If the MS initiates the
! call clearing by sending a *RELease* message, the clearing procedure
! described in section 3.3.1.2 towards the MS is then followed.
!
-> EXC *clear-forward signal* (Q.721-Q.725) or *release message* (Q.761-Q.764)
! The MSC starts the release of fixed network circuit.
!
MS <- *RELease* (04.08)
The MSC asks the MS to accomplish the clear procedure.

MS -> *RELease COMplete* (04.08)
! The clear procedure is completed in the MS.
!
BSS <- *CLeaR CoMmanD* (08.08)
The MSC asks the BSS to release the allocated dedicated resource.

BSS -> *CLeaR COMplete* (08.08)
The BSS has completed the release of the allocated dedicated resource.
The MSC releases the terrestrial channel.

<- EXC *release-guard signal* (Q.721-Q.725) or *release complete message* (Q.761-Q.764)
The exchange of the fixed network responses to the release. The circuit is released.

3.3.1.2 Called subscriber clears

This section shows the call release procedure in the exchange of the calling subscriber when the called subscriber clears first.

MSC

<- EXC *clear-back signal* (Q.721-Q.725) or *release message* (Q.761-Q.764)
! The remote exchange sends a *clear-back signal* or *release message* when
! the called subscriber clears. If the former signal is employed the MSC
! sets a timer and waits for a DISConnect message from the MS or a *re-answer signal* (Q.721-725) from the succeeding exchange. If the calling
! subscriber clears before the timer expires, the release procedure will be
! like that in section 3.3.1.1. If the timer expires, the release procedure will
! continue with the DISConnect message to the MS. If a reanswer is made
! by called subscriber within the time limit, the timer is canceled. If the
! latter message is employed, no timer is set. The release procedure will
! continue immediately with the DISConnect message to the MS instead.
!
MS <- *DISConnect* (04.08)
! The MSC initiates the clear procedure in the MS.
!
-> EXC *clear-forward signal* (Q.721-Q.725) or *release complete message* (Q.761-Q.764)

The MSC generates a *clear-forward signal* or *release complete message* to the fixed network.

MS -> *RELease* (04.08)
! The MS sends a RELease message to the MSC.
!
MS <- *RELease COMplete* (04.08)
! The MSC sends a RELease COMplete message to the MS. The MS
! completes the clear procedure.
!
BSS <- *CLeaR CoMmanD* (08.08)
The MSC asks the BSS to release the allocated dedicated resource.

BSS -> *CLeaR COMplete* (08.08)
The BSS has completed the release of the allocated dedicated resource and sends an acknowledgement to the MSC. The MSC releases he terrestrial channel.

<- EXC *release-guard signal* (Q.721-Q.725)
The fixed network has released the connection. The circuit is released.
Note: If the ISDN User Part is applied, this message does not exist.

3.3.1.3 Abnormal cases

No response to RELease

MSC

MS -> *DISConnect* (04.08)
! The calling subscriber initiates the clearing of call.
!
-> EXC *clear-forward signal* (Q.721-Q.725) or *release message* (Q.761-Q.764)
! The MSC starts the release of fixed network circuit.
!
MS <- *RELease* (04.08)
The MSC asks the MS to accomplish the clear procedure.

<- EXC *release-guard signal* (Q.721-Q.725) or *release complete message* (Q.761-Q.764)
The MSC releases the fixed network circuit and acknowledges the clear message to the fixed network.

MS <- *RELease* (04.08)
If a *RELease COMplete* message is not received the *RELease* message to the MS is repeated once. If no response is received to the second message, the release procedure is completed anyhow as described in section 3.3.1.1.

No response to DISConnect

MSC

<- EXC *clear-back signal* (Q.721-Q.725) or *release message* (Q.761-Q.764)
! The remote exchange sends a *clear-back signal* or *release message* when
! the called subscriber clears.
!
MS <- *DISConnect* (04.08)
! The MSC initiates the clear procedure in the MS.
!
-> EXC *clear-forward signal* (Q.721-Q.725) or *release complete message* (Q.761-Q.764)
The MSC generates a *clear-forward signal* or *release complete message* to the fixed network.

<- EXC *release-guard signal* (Q.721-Q.725)
The fixed network has released the connection. The circuit is released.
Note: If the ISDN User Part is applied, this message does not exist.

MS <- *RELease* (04.08)
If a *RELease* message is not received in response to the DISConnect message, the MSC sends a *RELease* message to the MS. If no *RELease COMPlete* message is received in response to the *RELease* message, the release procedure will be completed anyhow as described in section 3.3.1.2.

3.3.2 MS terminating call

3.3.2.1 Calling subscriber clears

MSC

<- EXC *clear-forward signal* Q.721-Q.725) or *release message* (Q.761-Q.764)
! The MSC receives a clearing message from the fixed network.
!
MS <- *DISConnect* (04.08)
! The MSC initiates the clear procedure in the MS.
!
-> EXC *release-guard signal* (Q.721-Q.725) or *release complete message* (Q.761-Q.764)
The MSC releases the fixed network circuit and acknowledges the clear message to the fixed network.

MS -> *RELease* (04.08)
! The MS has started the clear procedure.
!
MS <- *RELease COMplete* (04.08)
! The MSC also acknowledges the *RELease* message to the MS. The MS
! completes the clear procedure.
!
BSS <- *CLeaR CoMmanD* (08.08)
The MSC asks the BSS to release the allocated dedicated resource.

BSS -> *CLeaR COMplete* (08.08)

The BSS has completed the release of the allocated dedicated resource and sends an acknowledgement to the MSC. The MSC releases the terrestrial channel.

3.3.2.2 Called subscriber clears

MSC

MS -> *DISConnect* (04.08)
! *RELease*. (04.08)
! The called subscriber initiates the clearing of call. If the MS initiates the
! call clearing by sending a *RELease* message, the clearing procedure
! described in section 3.3.2.1 towards the MS is then followed.
!
-> EXC *clear-back signal* (Q.721-Q.725) or *release message* (Q.761-Q.764)
! After receiving a DISConnect message from the MS the MSC sends a
! *clear-back signal* or a *release message* to the fixed network.
!
MS <- *RELease* (04.08)
The MSC asks the MS to accomplish the clear procedure.

<- EXC *clear-forward signal* (Q.721-Q.725) or *release complete message* (Q.761-
! Q.764)
!
-> EXC *release-guard signal* (Q.721-Q.725)
The MSC has released the fixed network circuit.
Note: If the ISDN User Part is applied, this message does not exist.

MS -> *RELease COMplete* (04.08)
! The MS has completed the clear procedure.
!
BSS <- *CLeaR CoMmanD* (08.08)
The MSC asks the BSS to release the allocated dedicated resource.

BSS -> *CLeaR COMplete* (08.08)
The BSS has completed the release of the allocated dedicated resource and sends an acknowledgement to the MSC. The MSC releases the terrestrial channel.

3.3.2.3 Abnormal cases

No response to DISConnect

MSC

<- EXC *clear-forward signal* Q.721-Q.725) or *release message* (Q.761-Q.764)
! The MSC receives a clearing message from the fixed network.
!
MS <- *DISConnect* (04.08)
! The MSC initiates the clear procedure in the MS.
!

-> EXC *release-guard signal* (Q.721-Q.725) or *release complete message* (Q.761-Q.764)
The MSC releases the fixed network circuit and acknowledges the clear message to the fixed network.

MS <- *RELease* (04.08)
If a *RELese* message is not received in response to the DISConnect message, the MSC sends a *RELease* message to the MS. If no *RELease COMPlete* message is received in response to the *RELease* message, the release procedure will be completed anyhow as described in section 3.3.2.1.

No response to RELease

MSC

MS -> *DISConnect* (04.08)
! The calling subscriber initiates the clearing of call.
!
-> EXC *clear-back signal* (Q.721-Q.725) or *release message* (Q.761-Q.764)
! After receiving a DISConnect message from the MS the MSC sends a
! *clear-back signal* or a *release message* to the fixed network. The clear
! procedure continues in the MSC if it receives a *clear-forward signal* or a
! *release complete message* .
!
MS <- *RELease* (04.08)
The MSC asks the MS to accomplish the clear procedure.

<- EXC *clear-forward signal* (Q.721-Q.725) or *release complete message* (Q.761-Q.764)
!
!
-> EXC *release-guard signal* (Q.721-Q.725)
The MSC has released the fixed network circuit.
Note: If the ISDN User Part is applied, this message does not exist.

MS <- *RELease* (04.08)
If a *RELease COMplete* message is not received the *RELease* message to the MS is repeated once. If no response is received to the second message, the release procedure will be completed anyhow as described in section 3.3.2.2.

3.4 Location registration

3.4.1 General

GSM Recommendation 03.12 defines the location registration procedures in the MS, MSC, VLR and HLR. GSM Recommendation 04.08 defines the signalling between the MS and the network. GSM Recommendation 09.02 defines the communication between the MSC, VLR and HLR.

The MSC takes part in the following location registration procedures:

- location register updating
- IMSI detach/attach
- periodic location registration

Location register updating is a procedure which is started by the MS when it arrives at a new location area.

By IMSI detach procedure the MS informs the network that it is deactivated. When the MS is activated it will initiate the IMSI attach procedure.

Periodic location registration is done along the timer located in the MS.

The different procedures of the location registration from the MSC point of view are defined in the following sections.

3.4.2 Location register updating

3.4.2.1 Successful operation

MSC

BSS -> *Complete layer 3 information* (08.08)
! The MS is switched on in a location area different from the previous
! one or it moves across the boundaries of a location area in the idle
! state. *LOCation UPDating REQuest* message, which is sent from MS to
! BSS, is relayed in the *Complete layer 3 information* message.
!
-> VLR *update location area* (09.02)
The MSC will send an *update location area* message to the VLR.

AUTHENTICATION (See 3.6)

<- VLR *start ciphering* (09.02)
If authentication was successful, the VLR requests the MSC to start ciphering procedures. The message contains also indication whether ciphering is needed or not.

<- VLR *forward new TMSI* (09.02)
The message is sent if reallocation of the TMSI is wished.

<- VLR *location area updating accepted* (09.02)
The VLR accepts location area updating.

BSS <- *Cipher Mode Command* (08.08)
The message passes encryption information to the BSS. It also indicates whether ciphering is used or not.

BSS -> *Cipher Mode Complete* (08.08)
! This message is an indication that appropriate action on enciphering and
! deciphering has been started by the MS and the BSS.
!
MS <- *LOCation UPDating ACCepted* (04.08)
The new TMSI is transferred to the MS in a ciphered mode.

MS -> *TMSI REALlocation COMplete* (04.08)
! Reallocation has been completed in the MS. If a new TMSI was allocated
! to the MS, this message is returned to the network.
!
-> VLR *TMSI acknowledge* (09.02)
TMSI reallocation is acknowledged to the VLR.

BSS <- *CLeaR CoMmanD* (08.08)
The MSC asks the BSS to release the allocated dedicated resource.

BSS -> *CLeaR COMplete* (08.08)
The BSS has completed the release of the allocated dedicated resource.

3.4.2.2 Abnormal cases

Location updating not accepted

MSC

MS -> *Complete layer 3 information* (08.08)
! The MS is switched on in a location area different from the previous
! one or it moves across the boundaries of a location area in the idle
! state.
!
-> VLR *update location area* (09.02)
The MSC will send an update location area message to the VLR.

AUTHENTICATION (see 3.6)

<- VLR location area updating not accepted
! Roaming is not allowed or location updating is otherwise unsuccessful
! eg. because of one of the following reasons:
! - *Unknown Subscriber* (09.02)
! - *Unknown Loc Area* (09.02)
! - *Roaming Not Allowed* (09.02)
! - *System Failure* (09.02)
!
MS <- *LOCation UPDating REJect* (04.08)
The location updating is not accepted by the network. The cause of rejection is provided.

BSS <- *CLeaR CoMmanD* (08.08)
The MSC asks the BSS to release the allocated dedicated resources.

BSS -> *CLeaR COMplete* (08.08)
The BSS has completed the release of allocated dedicated resources.

TMSI not known

The procedure used for authentication in this case is shown in section 3.6.

Once the authentication has been performed, the location register updating is completed as in successful operation described in section 3.4.2.1.

3.4.3 IMSI detach/attach

The IMSI detach procedure may be invoked by a mobile station if the mobile station is deactivated or if the IMSI module is detached from the MS. The procedure is as follows:

```
    MSC

BSS ->          Complete layer 3 information (08.08)
  !             The MS sends the IMSI DETach INDication message to the BSS to
  !             indicate that it has entered inactive state. BSS relays this message as a
  !             part of Complete layer 3 information message.
  !
  -> VLR        detach IMSI ( 09.02 )
                The information is updated in the VLR. All the terminating calls to the
                MS are rejected without sending paging messages.

BSS <-          CLeaR CoMmanD (08.08)
                The MSC asks the BSS to release the allocated dedicated resources.

BSS ->          CLeaR COMplete (08.08)
                The BSS has completed the release of allocated dedicated resources.
```

The IMSI attach procedure is used by the MS to indicate that it has reentered the active state . The IMSI attach is performed by using the location updating procedure as described in section 3.4.2, when the location area has changed. When the location area has not changed since IMSI detach, the IMSI attach procedure is carried out as described below.

```
    MSC

BSS ->          Complete layer 3 information (04.08)
  !             LOCation UPDating REQuest message, which is sent from MS to
  !             BSS, is included in the Complete layer 3 information message.
  !             The location updating type information element indicates IMSI attach
  !             procedure.
  !
  -> VLR        attach IMSI ( 09.02 )
                The VLR is requested to mark the IMSI as active.

  <- VLR        IMSI attach acknowledge ( 09.02 )
  !             The VLR indicates that is has marked the IMSI as active in the network.
  !
MS <-           LOCation UPDating ACCepted (04.08)
                The acknowledgement is sent to the MS.

BSS <-          CLeaR CoMmanD (08.08)
                The MSC asks the BSS to release the allocated dedicated resources.

BSS ->          CLeaR COMplete (08.08)
                The BSS has completed the release of allocated dedicated resources.
```

3.4.4 Periodic location registration

Periodic location registration enables the location of silent and stationary MSs to be updated at a reasonable rate. When the timer at the MS expires, the location registration updating procedure is started as described in section 3.4.2.

3.5 Handover

The purpose of handover is to ensure that the most suitable radio path is allocated throughout the duration of the call in spite of the motion of the MS or other reasons that may have effect on the quality of the radio path.

The following cases of handover are considered:

- handover between radio channels of the same base station
- handover between base stations of the same MSC
- handover between base stations of different MSCs of the same PLMN

Handover between base stations belonging to different PLMNs is beyond the scope of GSM recommendations.

Handover procedures are described in detail in the following recommendations:

- GSM 03.09 Handover procedures
- GSM 04.08 Mobile radio interface layer 3 specification
- GSM 08.08 Base station to switch interface, layer 3 specification
- GSM 09.02 Mobile application part

The following sections show the signalling during the handover from the MSC point of view. Abnormal cases are presented in recommendations listed in table 3.2. Authentication is performed after the handover if required (see section 3.6.3).

3.5.1 Handover between radio channels of the same base station

This handover case (internal handover) is autonomously carried out by the BSS. The BSS sends *HANDOVER PERFORMED* message to the MSC on completion of the handover.

3.5.2 Handover between base stations of the same MSC

The signalling sequence of the MSC is as follows:

MSC	
BSS1 <-	[*HaNDover CaNDidate ENQuiry* (08.08)] This message is sent to a BSS when the MSC wishes the BSS to identify handover candidates in a particular cell, that can be handed over to other nominated cells. This message is not used, when handover is initiated by a BSS eg. for radio reasons.
BSS1->	*HaNDOver ReQuireD* (08.08)

! *HANDOverReQuired* message shows cause for handover and preferred
! list of target cells . If the cause for handover is *HaNDover*
! *CaNDidate ENQuiry* the BSS generates a single *HaNDover*
! *ReQuireD* message for each candidate MS, which can be handed over.
! The MSC must always be capable of handling list of the target cells. The
! list is arranged in order of predicted best performance.
!

BSS1-> [*HaNDover CaNDidate RESponse* (08.08)]
! This message is expected in response to the *HaNDover CaNDidate*
! *ENQuiry* to indicate that BSS has gone through all candidates. If BSS
! has initiated handover this message is not used. The message contains
! the number of mobiles for which the *HaNDOver ReQuireD*
! messages have been sent.
!

BSS2<- *HaNDover REQuest* (08.08)
This message is sent to indicate to the new BSS (BSS2) that a mobile is to be handed over to that BSS. The MSC chooses an appropriate BSS and reserves a terrestrial resource to that BSS. The message contains an indication of the required radio channel type and the terrestrial resource.

BSS2-> *HaNDover REQuest ACKnowledge* (08.08)
! As the BSS has selected a suitable idle radio resource, it sends
! acknowledgement to the MSC.
!

BSS1<- *HaNDover CoMmanD* (08.08)
The execution phase of handover is started by sending a *HaNDover CoMmanD* message via the old BSS to the MS. The message contains information of the target channel to which the MS should retune . At this phase a three party bridge, if available, may be switched on connecting BSS1 and BSS2 to the destination network simultaneously.

BSS2-> *HaNDover CoMPlete* (08.08)
! This message indicates that the MS has successfully accessed the target
! cell in the BSS2 .
!

BSS1<- *CLeaR CoMmanD* (08.08)
The MSC asks the BSS 1 to release the allocated dedicated resource.

BSS1-> *CLeaR COMplete* (08.08)
The BSS 1 has completed the release of the allocated dedicated resource.

3.5.3 Handover between base stations of different MSCs of the same PLMN

Two procedures are defined as described in GSM 03.09
- -basic handover procedure where the call is handed over from the controlling MSC (MSC-A) to another MSC (MSC-B)
- - subsequent handover procedure where the call is handed over from MSC-B to MSC-A or to a third MSC (MSC-B')

In the diagrams following notations are used:
- - MSC A = controlling MSC
- - MSC-B = the exchange which controls the BSS2 (= BSS after the basic handover)

- MSC-B' = the exchange which controls the BSS2' (= BSS after the subsequent handover)
- VLR-B = VLR used in the MSC-B area
- VLR-B' = VLR used in the MSC-B' area

3.5.3.1 Basic handover

In the basic handover flow diagrams it is also shown how call control messages are transferred during a handover.

3.5.3.1.1 Basic handover, MSC-A

The following sequence shows the signalling on MSC-A , through which the connection is originally established to BSS1.

MSC-A

BSS1<- [*HaNDover CaNDidate ENQuiry* (08.08)]
See 3.5.2

BSS1->
! *HaNDover ReQuireD* (08.08)
! See 3.5.2
!
BSS1-> [*HaNDover CaNDidate RESponse* (08.08)]
! See 3.5.2
!
->MSC-B *perform handover* (09.02)
The message is sent to the MSC which controls the selected new BSS. It contains all necessary information required by MSC-B to allocate a radio channel.

<-MSC-B *radio channel ack* (09.02)
! After MSC-B has interrogated its associated VLR handover number
! and received *HaNDover REQuest ACKnowledgement* from
! the BSS2, it returns *radio channel ack*, to the MSC-A. The message
! contains eg. the handover number.
!
->MSC-B *initial address message* (Q.721-Q.725, Q.761 - Q.764)
MSC-A starts the establishment of the connection to the MSC-B by sending *IAM* to the MSC-B using handover number as an address.

<-MSC-B *address complete message*(Q.721-Q.725, Q.761 - Q.764)
! MSC-B sends this message to indicate that all the address information
! required for routing has been received.
!
BSS1<- *HaNDover CoMmanD* (08.08)
The execution phase of handover is started by sending a *HaNDover CoMmanD* message via the old BSS to the MS. At this phase a three party bridge, if available, should be switched on connecting BSS1 and BSS2 (the latter through the established fixed network connection between MSC-A and MSC-B) to the destination network simultaneously.

<-MSC-B *answer signal* (Q.721-Q.725), *answer message* (Q.761 - Q.764)
! Answer message is not related to answering by the MS. The message is

! needed for bringing the connection into the answered state in the
! intermediate PSTN/ISDN exchanges.
!
<-MSC-B *send end signal* (09.02)
! This message indicates that the radio path has been succesfully
! established on MSC-B. Connection through MSC-A is established.
!
BSS1<- *CLeaR CoMmanD* (08.08)
The MSC asks the BSS 1 to release the allocated dedicated resource.

BSS1 -> *CLeaR COMplete* (08.08)
The BSS 1 has completed the release of the allocated dedicated resource.
.
.
.

MS -> call control or mobility management message (04.08)
! Call control and mobility management message is received during a
! stable state of handover. Information should be transferred to the
! B-subscriber.
!
->MSC-B *process call control information* (09.02)
Call control and mobility management message information is inserted to the *process call control information* message and sent to the MSC-B. Message is composed in such a way that the information can be passed transparently to the MS-B via the MSC-B.

<-MSC-B *call control information acknowledge* (09.02)
MSC-A receives the acknowledge of the previous *process call control information* message. An acknowledge may be sent to the MS depending on the message.
.
.
.

<-MSC-B *perform call control* (09.02)
! A *perform call control* message is received from the MSC -B either as a
! consequense of *process call control information* message or as a new
! message transferring call control information .
!
MS <- call control or mobility management message (04.08)
The *perform call control* message is changed into a call control or mobility management message. An acknowledgement from the MS to the MSC is returned when necessary. No positive acknowledgement is returned to the MSC-B.
.
.
.

->MSC-B *end signal* (09.02)
MSC-A has the overall call control until the call is cleared by the fixed subscriber or the MS. MSC-A informs the MSC-B by *end signal*, that it should remove the handover number from the VLR. Also the physical connection between the MSC-A and MSC-B is cleared in a normal way.

3.5.3.1.2 Basic handover, MSC-B

The following sequence shows the signalling on MSC-B , which is associated to the new BSS (BSS2).

MSC-B

<-MSC-A *perform handover* (09.02)
! MSC-B is requested to reserve a handover number and allocate handover
! resources in BSS2.
!
-> VLR-B *allocate handover number* (09.02)
! MSC-B interrogates the handover number from its associated VLR
! (VLR-B).
!
BSS2 <- *HaNDover REQuest* (08.08)
This message is sent to indicate to the new BSS (BSS2) that a mobile is to be handed over to that BSS.

<-VLR-B *send handover report* (09.02)
! VLR-B returns the handover number to the MSC-B.
!
BSS2-> *HaNDover REQuest ACKnowledge* (08.08)
! As the BSS2 has selected a suitable idle radio resource, it sends
! acknowledgement to the MSC-B.
!
->MSC-A *radio channel ack* (09.02)
When MSC-B has received the handover number from the VLR and *HaNDover REQuest ACKnowledge* from the BSS2 it sends to the MSC-A *radio channel ack*, which contains eg. the handover number.

<-MSC-A *initial address message* (Q.721-Q.725, Q.761 - Q.764)
! MSC-B starts the establishment of the connection after receiving *IAM*
! from MSC-A.
!
!
->MSC-A *address complete message* (Q.721-Q.725, Q.761 - Q.764)
MSC-B sends this message to indicate that all the address information required for routing the MS has been received.

BSS2-> *HaNDover CoMPlete* (08.08)
! This message indicates that the MS has successfully accessed the target
! cell in the BSS2 .
!
->MSC-A *answer signal* (Q.721-Q.725), *answer message* (Q.761 - Q.764)
! The message is needed for bringing the connection in the answered state
! in the intermediate PSTN/ISDN exchanges.
!
->MSC-A *send end signal* (09.02)
This message is sent to indicate that the radio path has been succesfully established on MSC-B . Connection through MSC-B is established.
.
.
.
<-MSC-A *process call control information* (09.02)

```
      !          Call control and mobility management message information is received
      !          inserted in the process call control information message .
      !
MS <-            call control or mobility management message ( 04.08 )
                 Information is sent to the MS as a call control or mobility management
                 message.

MS -->           acknowlegement ( 04.08 )
      !          An acknowledgement is received.
      !
      ->MSC-A    call control information acknowledge ( 09.02 )
                 MSC-B sends the acknowledge of the previous process call control
                 information message if the message was succesfully delivered into the
                 radio path.
                 .
                 .
                 .

MS ->            call control or mobility management message ( 04.08 )
      !          A call control or mobility management message contains information
      !          which should be sent to the MS-A. This may be a response to a previous
      !          call control message or a new operation.
      !
      ->MSC-A    perform call control ( 09.02 )
                 Message information received from MS is inserted in a perform
                 call control message. This is an independent operation transferring call
                 control information from MSC-B to MSC-A . The information is coded
                 in such a way that it can be passed transparently in MSC-A to the
                 BSS/MSC-A interface. No positive response is expected.
                 .
                 .
                 .
      <-MSC-A    end signal 09.02 )
      !          MSC-A has the overall call control until the call is cleared by the fixed
      !          subscriber or the MS. MSC-A informs the MSC-B by end signal, that it
      !          should remove the handover number from the VLR. Also the physical
      !          connection between the MSC-A and MSC-B is cleared.
      !
      ->VLR-B    remove handover report ( 09.02 )
                 The message frees the handover number for other calls.
```

3.5.3.2 Subsequent handover

In this section subsequent handover to a third MSC is described from the MSC-A, MSC-B and MSC-B' point of wiev.

3.5.3.2.1 Subsequent handover , MSC-A

```
MSC-A

      <-MSC-B    perform subsequent handover ( 09.02 )
      !          This message is invoked by MSC-B to request MSC-A to perform
      !          handover with a third MSC ( MSC-B' ). The message contains target base
```

! station identity and target MSC identity.
!
->MSC-B' *perform handover* (09.02)
The message contains all necessary information required by MSC-B' to allocate a radio channel .

<-MSC-B' *radio channel ack* (09.02)
! After MSC-B' has interrogated its associated VLR handover number
! and received *HaNDover REQuest ACKnowledge* from
! the BSS2', it returns *radio channel ack* to the MSC-A.
!
->MSC-B' *initial address message* (Q.721-Q.725, Q.761 - Q.764)
MSC-A starts the establishment of the connection between MSC-A and MSC-B' by sending *IAM* to the MSC-B' using handover number as an address.

<-MSC-B' *address complete message* (Q.721-Q.725, Q.761 - Q.764)
! MSC-B' sends this message to indicate that all the address information
! required for routing has been received.
!
->MSC-B *subsequent handover acknowledge* (09.02)
The message identifies the traffic channel on which a mobile station has to be handed over. A three party bridge, if available, should be switched on connecting BSS2 and BSS2 ' (BSS2' through the established fixed network connection between MSC-A and MSC-B ') to the destination network simultaneously.

<-MSC-B' *send end signal* (09.02)
! This message indicates that the radio path has been succesfully
! established on MSC-B' . The connection from the MS through BSS2 and
! MSC-B to MSC-A is freed.
!
<-MSC-B' *answer signal* (Q.721-Q.725), *answer message* (Q.761 - Q.764)
! The message is needed for bringing the connection in the answered state
! in the intermediate PSTN/ISDN exchanges.
!
->MSC-B *clear-forward signal* (Q.721-Q.725) or *release message* (Q.761-Q.764)
! The MSC starts the release of fixed network circuit.
!
->MSC-B *end signal* (09.02)
MSC-A informs the MSC-B by *end signal*, that it should remove the handover number from the VLR.

<-MSC-B *release-guard signal* (Q.721-Q.725) or *release complete message* (Q.761-Q.764)
The exchange of the fixed network responses to the release. The circuit is released.

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->MSC-B' *end signal* (09.02)
MSC-A has the overall call control until the call is cleared by the fixed subscriber or the MS. MSC-A informs the MSC-B' by *end signal*, that it should remove the handover number from the VLR. Also the physical

connection between the MSC-A and MSC-B' is cleared by a normal ISDN/PSTN clear sequence.

3.5.3.2.2 Subsequent handover, MSC-B

MSC-B

BSS2<- [*HaNDover CaNDidate ENQuiry* (08.08)]
See 3.5.2.

BSS2-> *HaNDover ReQuireD* (08.08)
! See3.5.2.
!

BSS2-> [*HaNDover CaNDidate RESponse* (08.08)]
! See 3.5.2.
!

->MSC-A *perform subsequent handover* (09.02)
The message is sent to the MSC-A, to indicate that the call should be handed over to a third MSC (MSC-B').

<-MSC-A *subsequent handover acknowledge* (09.02)
! The message identifies the traffic channel on which a mobile station has
! to be handed over.
!

BSS2<- *HaNDover CoMmanD* (08.08)
The execution phase of handover is started by sending a *HaNDover CoMmanD* message via the BSS2 to the MS. The message contains information of the target channel to which the MS should retune .

<-MSC-A *clear-forward signal* (Q.721-Q.725) or *release message* (Q.761-Q.764)
! The MSC starts the release of fixed network circuit.
!

->MSC-A *release-guard signal* (Q.721-Q.725) or *release complete message* (Q.761-
! Q.764)
! The exchange of the fixed network responses to the release. The circuit is
! released.
!

<-MSC-A *end signal* (09.02)
! MSC-A informs the MSC-B by *end signal*, that it should remove the
! old handover number from the VLR-B.
!

->VLR-B *remove handover report* (09.02)
! The message frees the handover number for other calls.
!

BSS2<- *CLeaR CoMmanD* (08.08)
The MSC asks the BSS 2 to release the allocated dedicated resource.

BSS2-> *CLeaR COMplete* (08.08)
The BSS 2 has completed the release of the allocated dedicated resource.

3.5.3.2.3 Subsequent handover, MSC-B'

The following sequence shows the signalling on MSC-B ', which is associated to BSS2'.

MSC-B'

<-MSC-A *perform handover* (09.02)
! MSC-B' is requested to reserve a handover number and allocate
! handover resources in BSS2'. The message contains all necessary
! information required by MSC-B' to allocate a radio channel.
!
->VLR-B' *allocate handover number* (09.02)
! MSC-B' interrogates the handover number from its associated VLR. If
! the handover number is allocated by the MSC this operation is not
! needed.
!
BSS2'<- *HaNDover REQuest* (08.08)
This message is sent to indicate to the new BSS (BSS2') that a mobile is to be handed over to that BSS. The message contains eg. information of the required radio channel type.

<-VLR-B' *send handover report* (09.02)
! VLR returns the handover number to the MSC-B'.
!
BSS2'-> *HaNDover REQuest ACKnowledgement* (08.08)
! After the BSS2' has selected a suitable idle radio resource, it sends
! acknowledgement to the MSC-B'.
!
->MSC-A *radio channel ack* (09.02)
When MSC-B' has received the handover number from the VLR-B' and *HaNDover REQuest ACKnowledgement* from the BSS2' it returns it to the MSC-A by *radio channel ack* message.

<-MSC-A *initial address message* (Q.721-Q.725, Q.761 - Q.764)
! MSC-B' starts the establishment of the connection after receiving *IAM*
! from MSC-A.
!
->MSC-A *address complete message* (Q.721-Q.725, Q.761 - Q.764)
MSC-B' sends this message to indicate that all the address information required for routing the MS has been received.

BSS2'-> *HaNDover CoMPlete (* 08.08)
! This message indicates that the MS has successfully accessed the target
! cell in the BSS2' .
!
->MSC-A *send end signal* (09.02)
! This message indicates that the new radio path has been succesfully
! established on MSC-B' .
!
->MSC-A *answer signal* (Q.721-Q.725), *answer message* (Q.761 - Q.764)
The message is needed for bringing the connection in the answered state in the intermediate PSTN/ISDN exchanges.

.
.
.

<-MSC-A *end signal* 09.02)
! MSC-A has the overall call control until the call is cleared by the fixed
! subscriber or the MS. MSC-A informs the MSC-B' by *end signal*, that it
! should remove the handover number from the VLR. Also the physical
! connection between the MSC-A and MSC-B' is cleared.
!
-> VLR-B' *remove handover report* (09.02)
The message frees the handover number for other calls.

3.6 Authentication

Authentication may be executed during call setup, location updating and supplementary services.

3.6.1 Successful operation

If the VLR knows the TMSI of the originating subscriber and authentication is required the following procedure apply.

MSC

<- VLR *authenticate* (09.02)
! The VLR activates authentication.
!
MS <- *AUThentication REQuest* (04.08)
The MSC converts the MAP authenticate message to layer 3 message of the MS-MSC interface.

MS -> *AUThentication RESponse* (04.08)
! The MS sends back the *AUThentication RESponse* message.
!
-> VLR *authentication response* (09.02)
The MSC changes the message to the MAP authentication response for authenticity checking.

3.6.2 Abnormal cases

TMSI not known to the VLR

If the VLR does not know the TMSI of the originating subscriber, it may use identification to interrogate the IMSI of the subscriber during the originating call establishment or location updating.

MSC

<- VLR *provide IMSI* (09.02)
! The VLR requests mobile subscriber to identify itself by the IMSI.
!
MS <- *IDentity REQuest* (04.08)
The MSC requests the MS to send its IMSI to the MSC

MS -> *IDentity RESponse* (04.08)
! The MS returns the IMSI to the MSC.
!
-> VLR *IMSI acknowledge* (09.02)
The MSC returns IMSI to the VLR.

<- VLR *authenticate* (09.02)
! The VLR activates authentication using IMSI as an identity.
!
MS <- *AUThentication REQuest* (04.08)
The MSC converts the MAP authenticate message to layer 3 message of the MS-MSC interface.

MS -> *AUThentication RESponse* (04.08)
! The MS sends back the *AUThentication RESponse* message.
!
-> VLR *authentication response* (09.02)
The MSC changes the message to the MAP authentication response for authenticity checking.

Illegal subscriber

The subscriber cannot provide a correct response to the authentication request.

MSC

<- VLR *authenticate* (09.02)
! The VLR activates authentication.
!
MS <- *AUThentication REQuest* (04.08)
The MSC converts the MAP authenticate message to layer 3 message of the MS-MSC interface.

MS -> *AUThentication RESponse* (04.08)
! The MS sends back the *AUThentication RESponse* message for
! authenticity checking.
!
-> VLR *authentication response* (09.02)
The MSC changes the message to the MAP authentication response.

<- VLR *illegal subscriber* (09.02)
! A negative authentication heck result is returned to the MSC .
!
MS <- *AUThentication REJect* (04.08)
AUThentication REJect is sent to the MS to indicate that authentication failure has occurred.