3GPP TSG SA WG 3 (Security) meeting #15
Washington (USA), 12—14 September, 2000

Document **S3-000535**
e.g. for 3GPP use the format TP-99xxx
or for SMG, use the format P-99-xxx

CHANGE REQUEST

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33.102	**CR**	**xxx**	Current Version:	3.5.0

GSM (AA.BB) or 3G (AA.BBB) specification number ↑ *↑ CR number as allocated by MCC support team*

For submission to:	SA #9	for approval	X	strategic		(for SMG use only)
list expected approval meeting # here ↑		for information		non-strategic		

Form: CR cover sheet, version 2 for 3GPP and SMG *The latest version of this form is available from: ftp://ftp.3gpp.org/Information/CR-Form-v2.doc*

Proposed change affects: *(at least one should be marked with an X)* (U)SIM [ ] ME [ ] UTRAN / Radio [ ] Core Network [X]

Source: Ericsson **Date:** 2000-08-31

Subject: Clarifications on the START parameter handling

Work item: Security

Category: *(only one category shall be marked with an X)*

F	Correction	X
A	Corresponds to a correction in an earlier release	
B	Addition of feature	
C	Functional modification of feature	
D	Editorial modification	

Release:

Phase 2	
Release 96	
Release 97	
Release 98	
Release 99	X
Release 00	

Reason for change:

Misleading use of the term “HFN”, where the term “START” should be used instead.

During established RRC connection, the START values are the same in the ME and the SRNC.

Editorial modifications

Clauses affected: 6.4.5, 6.4.8, 6.5.4.1, 6.5.4.2, 6.6.3, 6.6.4.1, 6.6.4.2, 6.8.4, 6.8.5

Other specs affected:

Other 3G core specifications	[ ]	→ List of CRs:
Other GSM core specifications	[ ]	→ List of CRs:
MS test specifications	[ ]	→ List of CRs:
BSS test specifications	[ ]	→ List of CRs:
O&M specifications	[ ]	→ List of CRs:

Other comments:


help.doc

<--------- double-click here for help and instructions on how to create a CR

6.4.5 Security mode set-up procedure

This section describes one common procedure for both ciphering and integrity protection set-up. It is mandatory to start integrity protection of signalling messages by use of this procedure at each new signalling connection establishment between MS and MSC/VLR respective SGSN. The three exceptions when it is not mandatory to start integrity protection are:

- If the only purpose with the signalling connection establishment and the only result is periodic location registration, i.e. no change of any registration information.
- If there is no MS-MSC/VLR (or MS–SGSN) signalling after the initial L3 signalling message sent from MS to MSC/VLR (or SGSN), i.e. in the case of deactivation indication sent from the MS followed by connection release.
- If the only MS-MSC/VLR (or MS–SGSN) signalling after the initial L3 signalling message sent from MS to MSC/VLR (or SGSN), and possible user identity request and authentication (see below), is a reject signalling message followed by a connection release.

When the integrity protection shall be started, the only procedures between MS and MSC/VLR respective SGSN that are allowed after the initial connection request (i.e. the initial Layer 3 message sent to MSC/VLR or SGSN) and before the security mode set-up procedure are the following:

- Identification by a permanent identity (i.e. request for IMSI), and
- Authentication and key agreement

The message sequence flow below describes the information transfer at initial connection establishment, possible authentication and start of integrity protection and possible ciphering.

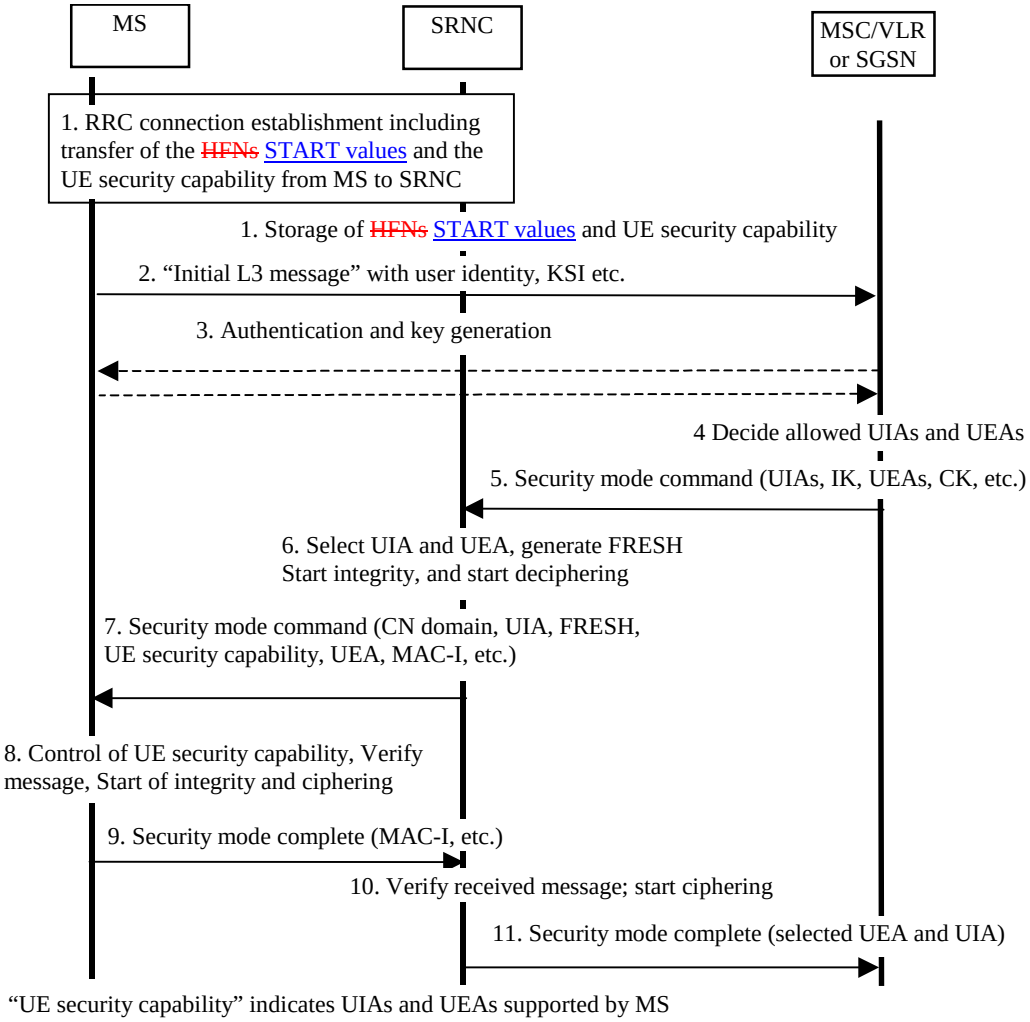

Figure 14: Local authentication and connection set-up

NOTE 1: The network must have the "ME security capability" information before the integrity protection can start, i.e. the "ME security capability" must be sent to the network in an unprotected message. Returning the "ME security capability" later on to the ME in a protected message will give ME the possibility to verify that it was the correct "ME security capability" that reached the network.

Detailed description of the flow above:

1. RRC connection establishment includes the transfer from MS to RNC of the ME security capability and the ~~initial hyperframe numbers (HFN)~~START values for the CS service domain respective the PS service domain. The UE security capability information includes the ciphering capabilities (UEAs) and the integrity capabilities (UIAs) of the MS. ~~The initial HFN is used to initialise the HFN to be used as part of one of the input parameters COUNT-I for the integrity algorithm and COUNT-C, ,for the ciphering algorithm.~~ The ~~initial HFNs~~START values and the UE security capability information are stored in the SRNC.

2. The MS sends the Initial L3 message (Location update request, CM service request, Routing area update request, attach request, paging response etc.) to the MSC/VLR or SGSN. This message contains e.g. the user identity and the KSI. The included KSI (Key Set Identifier) is the KSI allocated by the CS service domain or PS service domain at the last authentication for this CN domain.

3. User identity request may be performed (see 6.2). Authentication of the user and generation of new security keys (IK and CK) may be performed (see 6.3.3). A new KSI will then also be allocated.

4. The MSC/VLR or SGSN determines which UIAs and UEAs that are allowed to be used.

5. The MSC/VLR or SGSN initiates integrity and ciphering by sending the RANAP message Security Mode Command to SRNC. This message contains a list of allowed UIAs and the IK to be used. If ciphering shall be started, it contains the allowed UEAs and the CK to be used. If a new authentication and security key generation

has been performed (see 3 above), this shall be indicated in the message sent to the SRNC. The indication of new generated keys implies that the ~~initial HFN~~START value to be used shall be reset (i.e. set to zero) at start use of the new keys. Otherwise, it is the ~~HFN~~ START value already available in the SRNC that shall be used (see 1. above).

6. The SRNC decides which algorithms to use by selecting from the list of allowed algorithms, and the list of algorithms supported by the MS (see 6.4.2). The SRNC generates a random value FRESH and initiates the downlink integrity protection. If the requirements received in the Security mode command can not be fulfilled, the SRNC sends a SECURITY MODE REJECT message to the requesting MSC/VLR or SGSN. The further actions are described in 6.4.2.

7. The SRNC generates the RRC message Security mode command. The message includes the ME security capability, the UIA and FRESH to be used and if ciphering shall be started also the UEA to be used. Additional information (start of ciphering) may also be included. Because of that the MS can have two ciphering and integrity key sets, the network must indicate which key set to use. This is obtained by including a CN type indicator information in the Security mode command message. Before sending this message to the MS, the SRNC generates the MAC-I (Message Authentication Code for Integrity) and attaches this information to the message.

8. At reception of the Security mode command message, the MS controls that the ME security capability received is equal to the ME security capability sent in the initial message. The MS computes XMAC-I on the message received by using the indicated UIA, the stored COUNT-I and the received FRESH parameter. The MS verifies the integrity of the message by comparing the received MAC-I with the generated XMAC-I.

9. If all controls are successful, the MS compiles the RRC message Security mode complete and generates the MAC-I for this message. If any control is not successful, the procedure ends in the MS.

10. At reception of the response message, the SRNC computes the XMAC-I on the message. The SRNC verifies the data integrity of the message by comparing the received MAC-I with the generated XMAC-I.

11. The transfer of the RANAP message Security Mode Complete response, including the selected algorithms, from SRNC to the MSC/VLR or SGSN ends the procedure.

The Security mode command to MS starts the downlink integrity protection, i.e. also all following downlink messages sent to the MS are integrity protected and possibly ciphered. The Security mode complete from MS starts the uplink integrity protection and possible ciphering, i.e. also all following messages sent from the MS are integrity protected and possibly ciphered.

6.4.8 Initialisation of synchronisation for ciphering and integrity protection

The ciphering and integrity protection algorithms are driven by counters (COUNT-C and COUNT-I) that at connection establishment need to be initialised. For that purpose the ME and the USIM have the ability to store a START value. The ME and the USIM store a $START_{CS}$ value for the CS cipher/integrity keys and a $START_{PS}$ value for the PS cipher/integrity keys. The length of START is 20 bits.

The ME only contains (valid) START values when it is powered-on and a USIM is inserted. When the ME is powered-off or the USIM is removed, the ME deletes its START values. After power-on or insertion of a USIM, the USIM sends its START values to the ME, and the ME stores them. During idle mode, the START values in the ME and in the USIM are identical and static.

At radio connection establishment for a particular serving network domain (CS or PS) the ME sends the $START_{CS}$ and the $START_{PS}$ value to the RNC in the *RRC connection setup complete* message. The ME marks the START values in the USIM as invalid by setting $START_{CS}$ and $START_{PS}$ to THRESHOLD.

The ME and the RNC initialise the 20 most significant bits of the RRC HFN (for integrity protection), the RLC HFN (for ciphering) and the MAC-d HFN (for ciphering) to the START value of the corresponding service domain; the remaining bits are initialised to 0. Also the RRC SN (for integrity protection), the RLC SN (for ciphering) and the MAC-d HFN (for ciphering) are initialised to 0.

During an ongoing radio connection, the $START_{CS}$ value in the ME and in the SRNC is defined as the 20 most significant bits of the maximum of all current COUNT-C and COUNT-I values for all signalling and CS user data logical channels protected using CK_{CS} and/or $IK_{CS,}$ incremented by 1, i.e.:

$START_{CS}$ = MSB_{20} (MAX {COUNT-C, COUNT-I | all logical channels protected with CK_{CS} and IK_{CS}}) + 1.

Likewise, during an ongoing radio connection, the $START_{PS}$ value in the ME and in the SRNC is defined as the 20 most significant bits of the maximum of all current COUNT-C and COUNT-I values for all signalling and PS user data logical channels protected using CK_{PS} and/or IK_{PS}, incremented by 1, i.e.:

$START_{PS}$ = MSB_{20} (MAX {COUNT-C, COUNT-I | all logical channels protected with CK_{PS} and IK_{PS}}) + 1.

Upon radio connection release and when a set of cipher/integrity keys is no longer used, the ME updates $START_{CS}$ and $START_{PS}$ in the USIM with the current values.

During authentication and key agreement ~~the ME sets~~ the START value~~s~~ associated with the new key set of the corresponding service domain is set to 0 in the USIM and in the ME ~~itself~~.

6.5.4 Input parameters to the integrity algorithm

6.5.4.1 COUNT-I

The integrity sequence number COUNT-I is 32 bits long.

There is one COUNT-I value per logical signalling channel.

COUNT-I is composed of two parts: a "short" sequence number and a "long" sequence number. The "short" sequence number is the 4-bit RRC sequence number RRC SN that is available in each RRC PDU. The "long" sequence number is the 28-bit RRC hyperframe number RRC HFN which is incremented at each RRC SN cycle.

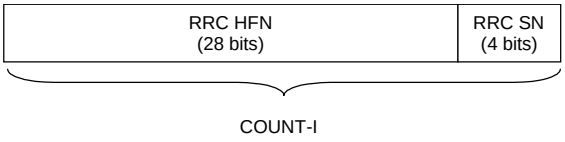

Figure 16a: The structure of COUNT-I

The hyperframe number RRC HFN is initialised by means of the parameter START, which is described in subsection 6.4.8~~transmitted from ME to RNC during *RRC connection establishment*~~. The ME and the RNC then initialise the 20 most significant bits of the RRC HFN to START; the remaining bits of the RRC HFN are initialised to 0. The RRC HFN are incremented independently for each logical channel used for signalling.

6.5.4.2 IK

The integrity key IK is 128 bits long.

There may be one IK for CS connections (IK_{CS}), established between the CS service domain and the user and one IK for PS connections (IK_{PS}) established between the PS service domain and the user. Which integrity key to use for a particular connection is described in 6.5.~~6~~5.

For UMTS subscribers IK is established during UMTS AKA as the output of the integrity key derivation function f4, that is available in the USIM and in the HLR/AuC. For GSM subscribers, that access the UTRAN, IK is established following GSM AKA and is derived from the GSM cipher key Kc, as described in 6.8.2.

IK is stored in the USIM and a copy is stored in the ME. IK is sent from the USIM to the ME upon request of the ME. The USIM shall send IK under the condition that 1) a valid IK is available, 2) the current value of START in the USIM is up-to-date and 3) START has not reached THRESHOLD. The ME shall delete IK from memory after power-off as well as after removal of the USIM.

IK is sent from the HLR/AuC to the VLR or SGSN and stored in the VLR or SGSN as part of a quintet. It is sent from the VLR or SGSN to the RNC in the (RANAP) *security mode command*.

At handover, the IK is transmitted within the network infrastructure from the old RNC to the new RNC, to enable the communication to proceed, and the synchronisation procedure is resumed. The IK remains unchanged at handover.

6.6.3 Ciphering method

Figure 16b illustrates the use of the ciphering algorithm f8 to encrypt plaintext by applying a keystream using a bit per bit binary addition of the plaintext and the ~~ciphertext~~keystream. The plaintext may be recovered by generating the same keystream using the same input parameters and applying a bit per bit binary addition with the ciphertext.

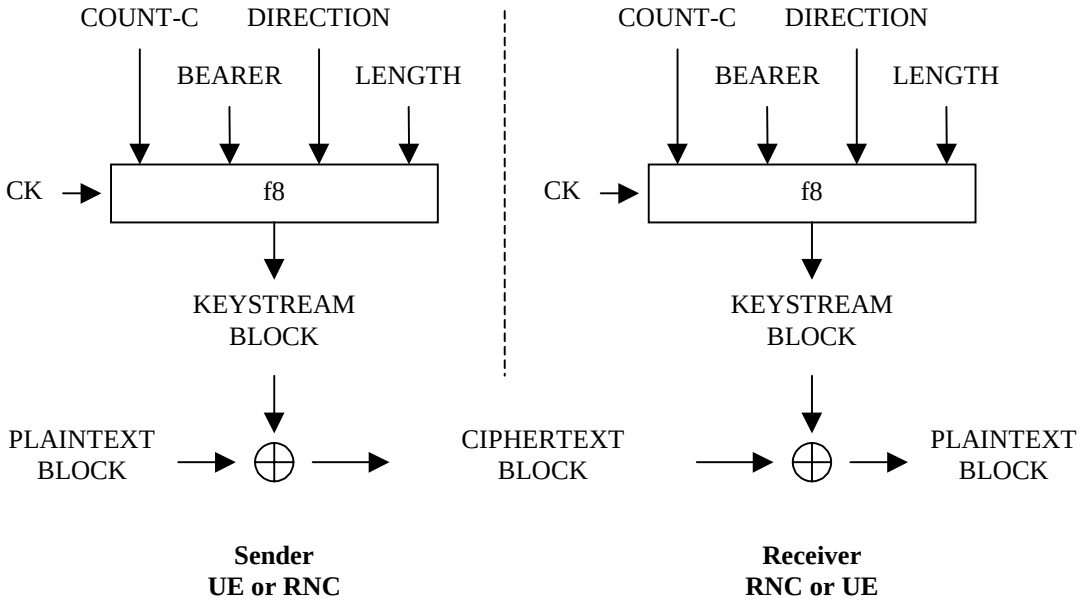

Figure 16b: Ciphering of user and signalling data transmitted over the radio access link

The input parameters to the algorithm are the cipher key CK, a time dependent input COUNT-C, the bearer identity BEARER, the direction of transmission DIRECTION and the length of the keystream required LENGTH. Based on these input parameters the algorithm generates the output keystream block KEYSTREAM which is used to encrypt the input plaintext block PLAINTEXT to produce the output ciphertext block CIPHERTEXT.

The input parameter LENGTH shall affect only the length of the KEYSTREAM BLOCK, not the actual bits in it.

6.6.4 Input parameters to the cipher algorithm

6.6.4.1 COUNT-C

The ciphering sequence number COUNT-C is 32 bits long.

There is one COUNT-C value per logical RLC AM channel, one per logical RLC UM channel and one for all logical channels using the transparent RLC mode (and mapped onto DCH).

COUNT-C is composed of two parts: a "short" sequence number and a "long" sequence number. The update of COUNT-C depends on the transmission mode as described below (see figure 16c).

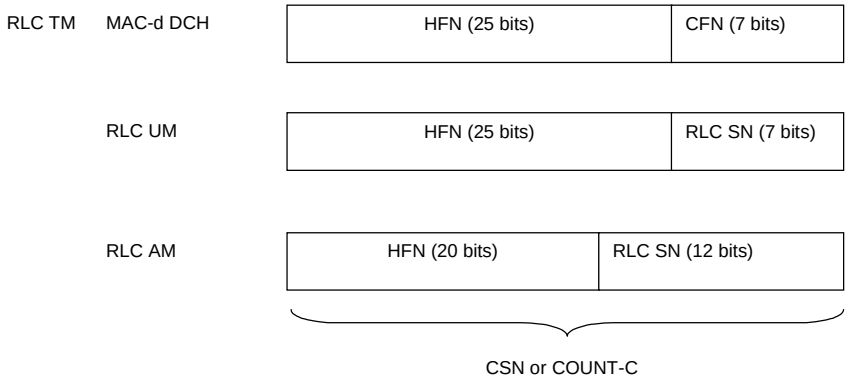

Figure 16c: The structure of COUNT-C for all transmission modes

- For RLC TM on DCH, the "short" sequence number is the 7-bit ~~ciphering~~ connection frame number CFN of the UEFN. It is independently maintained in the ME MAC entity and the SRNC MAC-d entity. The "long" sequence number is the 25-bit MAC HFN which is incremented at each CFN cycle. The ciphering sequence number CSN or COUNT-C is identical to the UEFN.

- For RLC UM mode, the "short" sequence number is the 7-bit RLC sequence number RLC SN that is available in each RLC PDU (it is not ciphered). The "long" sequence number is the 25-bit RLC HFN which is incremented at each RLC SN cycle.

- For RLC AM mode, the "short" sequence number is the 12-bit RLC sequence number RLC SN that is available in each RLC PDU (it is not ciphered). The "long" sequence number is the 20-bit RLC HFN which is incremented at each RLC SN cycle.

The hyperframe number HFN is initialised by means of the parameter START, which is described in subsection 6.4.8~~transmitted from ME to RNC in *RRC connection establishment*~~. The ME and the RNC then initialise the 20 most significant bits of the RLC HFN and MAC HFN to START; the remaining bits of the RLC HFN and MAC HFN are initialised to 0. The RRC HFN are incremented independently for each logical channel.

When a new logical channel is created during a RRC connection in ciphered mode, the HFN is initialised by the current START value (see subsection 6.4.8).

6.6.4.2 CK

The cipher key CK is 128 bits long.

There may be one CK for CS connections (CK_{CS}), established between the CS service domain and the user and one CK for PS connections (CK_{PS}) established between the PS service domain and the user. Which cipher key to use for a particular logical channel is described in 6.6.~~6.~~5. For UMTS subscribers, CK is established during UMTS AKA, as the output of the cipher key derivation function f3, available in the USIM and in HLR/AuC. For GSM subscribers that access the UTRAN, CK is established following GSM AKA and is derived from the GSM cipher key Kc, as described in 8.2.

CK is stored in the USIM and a copy is stored in the ME. CK is sent from the USIM to the ME upon request of the ME. The USIM shall send CK under the condition that 1) a valid CK is available, 2) the current value of START in the USIM is up-to-date and 3) START has not reached THRESHOLD. The ME shall delete CK from memory after power-off as well as after removal of the USIM.

CK is sent from the HLR/AuC to the VLR or SGSN and stored in the VLR or SGSN as part of the quintet. It is sent from the VLR or SGSN to the RNC in the (RANAP) security mode command.

At handover, the CK is transmitted within the network infrastructure from the old RNC to the new RNC, to enable the communication to proceed. The cipher CK remains unchanged at handover.

6.8.4 Intersystem handover for CS Services – from UTRAN to GSM BSS

If ciphering has been started when an intersystem handover occurs from UTRAN to GSM BSS, the necessary information (e.g. Kc, supported/allowed GSM ciphering algorithms) is transmitted within the system infrastructure before the actual handover is executed to enable the communication to proceed from the old RNC to the new GSM BSS, and to continue the communication in ciphered mode. The RNC requests the MS to send the MS Classmark, which includes information on the GSM ciphering algorithm capabilities of the MS. The intersystem handover will imply a change of ciphering algorithm from a UEA to a GSM A5. The GSM BSS includes the selected GSM ciphering mode in the handover command message sent to the MS via the RNC.

The integrity protection of signalling messages is stopped at handover to GSM BSS.

The START values (see subsection 6.4.8)~~highest hyperframe number value reached for all signalling and user data bearers during the RRC connection~~ shall be stored in the ME/USIM at handover to GSM BSS.

6.8.5 Intersystem handover for CS Services – from GSM BSS to UTRAN

If ciphering has been started when an intersystem handover occurs from GSM BSS to UTRAN, the necessary information (e.g. CK, IK, ~~initial HFN~~START value information, supported/allowed UMTS algorithms) is transmitted within the system infrastructure before the actual handover is executed to enable the communication to proceed from the old GSM BSS to the new RNC, and to continue the communication in ciphered mode. The GSM BSS requests the MS to send the UMTS capability information, which includes information on the ~~initial HFN~~START values and UMTS security capabilities of the MS. The intersystem handover will imply a change of ciphering algorithm from a GSM A5 to a UEA. The target UMTS RNC includes the selected UMTS ciphering mode in the handover to UTRAN command message sent to the MS via the GSM BSS.

The integrity protection of signalling messages shall be started immediately after that the intersystem handover from GSM BSS to UTRAN is completed. The Serving RNC will do this by initiating the RRC security mode control procedure when the first RRC message (i.e. the Handover to UTRAN complete message) has been received from the MS. The UE security capability information, that has been sent from MS to RNC via the GSM radio access and the system infrastructure before the actual handover execution, will then be included in the RRC Security mode command message sent to MS and then verified by the MS (i.e. verified that it is equal to the UE security capability information stored in the MS)