3GPP TSG SA 3 Meeting #12
Stockholm, Sweden, 11-14 April 2000

***Document* S3-000254**
e.g. for 3GPP use the format TP-99xxx or for SMG, use the format P-99-xxx

CHANGE REQUEST

Please see embedded help file at the bottom of this page for instructions on how to fill in this form correctly.

33.102	CR		Current Version:	3.3.1

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

For submission to:	TSG SA #7	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: Siemens Atea **Date:** 2000-04-04

Subject: Authentication and key agreement

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	X

Reason for change: Quintets should only be deleted in the VLR or SGSN when the authentication request indicated a sync failure (was incorrect implementation of CR 37r1).
MAC-S needs padding with zeros to make a full 128 bit input for f5.
The USIM does not need to store RAND for re-synchronisation
RAND-MS is no part of the authentication failure message with indication of sync failure (was incorrect implementation of CR 37r1).

Clauses affected: 6.3

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.

6.3.3 Authentication and key agreement

The purpose of this procedure is to authenticate the user and establish a new pair of cipher and integrity keys between the VLR/SGSN and the USIM. During the authentication, the USIM verifies the freshness of the authentication vector that is used.

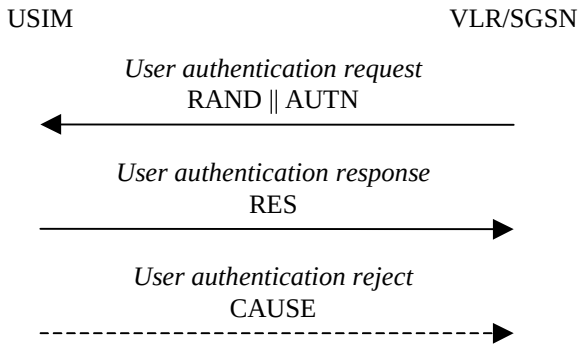

Figure 8: Authentication and key establishment

The VLR/SGSN invokes the procedure by selecting the next unused authentication vector from the ordered array of authentication vectors in the VLR/SGSN database. The VLR/SGSN sends to the USIM the random challenge RAND and an authentication token for network authentication AUTN from the selected authentication vector.

Upon receipt the user proceeds as shown in Figure 9.

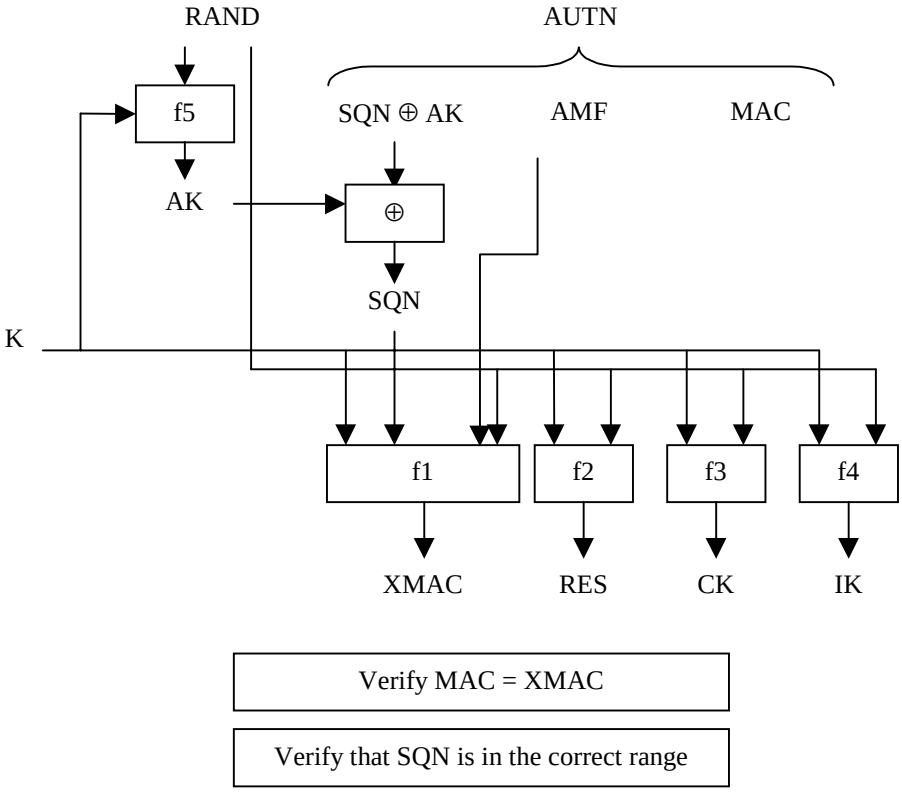

Figure 9: User authentication function in the USIM

Upon receipt of RAND and AUTN the USIM first computes the anonymity key AK = $f5_K$ (RAND) and retrieves the sequence number SQN = (SQN ⊕ AK) ⊕ AK.

Next the USIM computes XMAC = $f1_K$ (SQN || RAND || AMF) and compares this with MAC which is included in AUTN. If they are different, the user sends *user authentication reject* back to the VLR/SGSN with an indication of the cause and the user abandons the procedure. In this case, VLR/SGSN shall initiate an Authentication Failure Report procedure towards the HLR as specified in section 6.3.6. VLR/SGSN may also decide to initiate a new identification and authentication procedure towards the user.

Next the USIM verifies that the received sequence number SQN is in the correct range.

If the USIM considers the sequence number to be not in the correct range, it sends *synchronisation failure* back to the VLR/SGSN including an appropriate parameter, and abandons the procedure.

The synchronisation failure message contains the parameter AUTS. It is AUTS = Conc(SQN_{MS}) || MAC-S. Conc(SQN_{MS}) = $SQN_{MS} \oplus f5_K$(MAC-S || 0…0) is the concealed value of the counter SEQ_{MS} in the MS, and MAC-S = $f1^*_K$(SEQ_{MS} || RAND || AMF) where RAND is the random value received in the current user authentication request. f1* is a message authentication code (MAC) function with the property that no valuable information can be inferred from the function values of f1* about those of f1, ... , f5 and vice versa.

The AMF used to calculate MAC-S assumes a dummy value of all zeros so that it does not need to be transmitted in the clear in the re-synch message.

The construction of the parameter AUTS in shown in the following Figure 10:

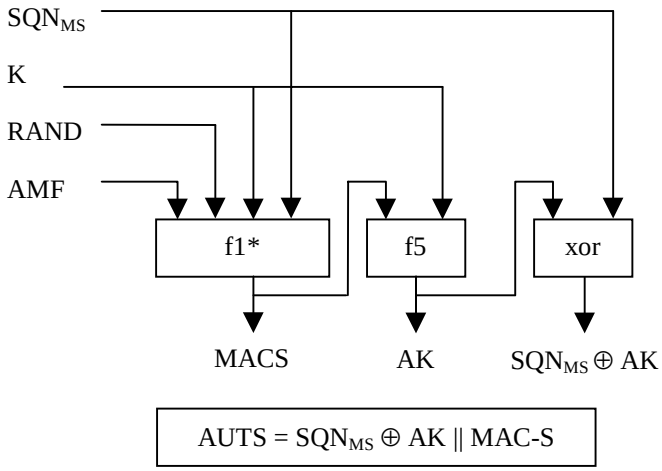

Figure 10: Construction of the parameter AUTS

If the sequence number is considered to be in the correct range however, the USIM computes RES = $f2_K$ (RAND) and includes this parameter in a *user authentication response* back to the VLR/SGSN. Finally the USIM computes the cipher key CK = $f3_K$ (RAND) and the integrity key IK = $f4_K$ (RAND). Note that if this is more efficient, RES, CK and IK could also be computed earlier at any time after receiving RAND. If the USIM also supports GSM AKA, it shall derive the GSM cipher key Kc from the UMTS cipher/integrity keys CK and IK using conversion function c3. UMTS keys are sent to the MS along with the derived GSM key for UMTS-GSM interoperability purposes. USIM shall store original CK, IK until the next successful execution of AKA. ~~The USIM also stores RAND until completion of the current AKA, for re-synchronisation purposes.~~

Upon receipt of *user authentication response* the VLR/SGSN compares RES with the expected response XRES from the selected authentication vector. If XRES equals RES then the authentication of the user has passed. The VLR/SGSN also selects the appropriate cipher key CK and integrity key IK from the selected authentication vector. If XRES and RES are different, VLR/SGSN shall initiate an Authentication Failure Report procedure towards the HLR as specified in section 6.3.6. VLR/SGSN may also decide to initiate a new identification and authentication procedure towards the user.

Conditions on the use of authentication information by the VLR/SGSN: The **VLR/SGSN** shall use a UMTS authentication vector (i.e. a quintuplet) only once and, hence, shall send out each user authentication request *RAND* || *AUTN* only once no matter whether the authentication attempt was successful or not. A consequence is that UMTS authentication vectors (quintuplets) cannot be reused.

6.3.5 Re-synchronisation procedure

A VLR/SGSN may send two types of *authentication data requests* to the HE/AuC, the (regular) one described in subsection 6.3.2 and one used in case of synchronisation failures, described in this subsection.

Upon receiving a *synchronisation failure* message from the user, the VLR/SGSN sends an *authentication data request* with a "*synchronisation failure indication*" to the HE/AuC, together with the parameters

- *RAND* sent to the MS in the preceding user authentication request and
- ~~*RAND*$_{MS}$ ||~~ *AUTS* received by the VLR/SGSN in the response to that request, as described in subsection 6.3.3.

An VLR/SGSN will not react to unsolicited "~~-~~synchronisation failure indication" messages from the MS.

The VLR/SGSN does not send new user authentication requests to the user before having received the response to its authentication data request from the HE/AuC (or before it is timed out).

When the HE/AuC receives an *authentication data request* with a "*synchronisation failure indication*" it acts as follows:

1. The HE/AuC retrieves SEQ_{MS} from Conc(SEQ_{MS}) by computing $f5_K(MAC\text{-}S \,||\, 0\ldots0)$,.
2. The HE/AuC checks if SEQ_{HE} is in the correct range, i.e. if the next sequence number generated SEQ_{HE} using would be accepted by the USIM.
3. If SEQ_{HE} is in the correct range then the HE/AuC continues with step (6), otherwise it continues with step (4).
4. The HE/AuC verifies *AUTS* (cf. subsection 6.3.3.).
5. If the verification is successful the HE/AuC resets the value of the counter SEQ_{HE} to $SEQ_{MS.}$
6. The HE/AuC sends an *authentication data response* with a new batch of authentication vectors to the VLR/SGSN. If the counter SEQ_{HE} was not reset then these authentication vectors can be taken from storage, otherwise they are newly generated after resetting SEQ_{HE}. In order to reduce the real-time computation burden on the HE/AuC, the HE/AuC may also send only a single authentication vector in the latter case.

Whenever the VLR/SGSN receives a new batch of authentication vectors from the HE/AuC in an authentication data response to an authentication data request with synchronisation failure indication it deletes the old ones for that user in the VLR/SGSN.

The user may now be authenticated based on a new authentication vector from the HE/AuC. Figure 12 shows how re-synchronisation is achieved by combining a *user authentication request* answered by a *synchronisation failure* message (as described in subclause 6.3.3) with an *authentication data request* with *synchronisation failure* indication answered by an *authentication data response* (as described in this subclause).

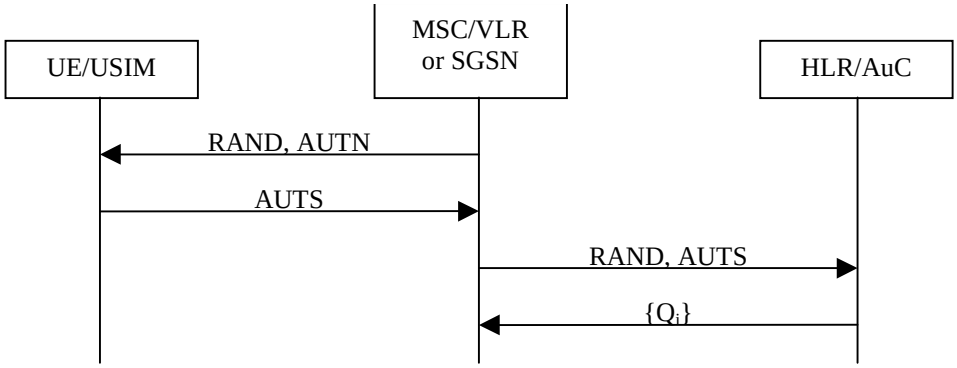

Figure 12: Resynchronisation mechanism