3GPP TSG SA WG 3 (Security) meeting #11
Mainz, 22—24 January, 2000

S3-000098

3G 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**	**045r1**		Current Version:	3.3.1

3G specification number ↑ *↑ CR number as allocated by 3G support team*

For submission to TSG: SA #7

list TSG meeting no. here ↑

for approval ☒
for information □

(only one box should be marked with an X)

Form: 3G CR cover sheet, version 1.0   *The latest version of this form is available from: ftp://ftp.3gpp.org/Information/3GCRF-xx.rtf*

Proposed change affects: USIM ☒ ME ☒ UTRAN ☒ Core Network ☒
(at least one should be marked with an X)

Source: T-Mobil **Date:** 2000-Feb-17

Subject: Refinement of EUIC (revision no. 1 of S3-000081)

3G Work item: Security

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

F	Correction	☒
A	Corresponds to a correction in a 2G specification	□
B	Addition of feature	□
C	Functional modification of feature	□
D	Editorial modification	□

Reason for change:
1) Clarification needed after meeting with TSG CN2 experts.
2) Correction of a potential weakness caused by paging an UE with IMSI in clear was needed. Therefore concealed paging with TEMSI is introduced.
3) Separation of User identity request and Authentication data request.

Clauses affected: 2.1, 3.3, 6.2, 6.3.2 and annex B

Other specs affected:

Other 3G core specifications	□	→ List of CRs:	23.003, 23.008, 23.012, 23.018, 23.060, 24.008, 25.331, 29.002, 31.102, 33.103, 33.105
Other 2G 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.

2.1 Normative references

[1] 3G TS 21.133: "3rd Generation Partnership Project (3GPP); Technical Specification Group (TSG) SA; 3G Security; Security Threats and Requirements".

[2] 3G TS 33.120: "3rd Generation Partnership Project (3GPP); Technical Specification Group (TSG) SA; 3G Security; Security Principles and Objectives".

[3] UMTS 33.21, version 2.0.0: "Security requirements".

[4] UMTS 33.22, version 1.0.0: "Security features".

[5] UMTS 33.23, version 0.2.0: "Security architecture".

[6] Proposed UMTS Authentication Mechanism based on a Temporary Authentication Key.

[7] TTC Work Items for IMT-2000 – System Aspects.

[8] Annex 8 of "Requirements and Objectives for 3G Mobile Services and systems" – "Security Design Principles".

[9] ETSI GSM 09.02 Version 4.18.0: Mobile Application Part (MAP) Specification.

[10] ISO/IEC 11770-3: *Key Management – Mechanisms using Asymmetric Techniques*.

[11] ETSI SAGE: Specification of the BEANO encryption algorithm, Dec. 1995 (confidential).

[12] ETSI SMG10 WPB: SS7 Signalling Protocols Threat Analysis , Input Document AP 99-28 to SMG10 Meeting#28, Stockholm, Sweden.

[13] 3G TS 33.105: "3rd Generation Partnership Project (3GPP); Technical Specification Group (TSG) SA; 3G Security; Cryptographic Algorithm Requirements".

[26] 3G TS 23.003: 3rd Generation Partnership Project (3GPP); Technical Specification Group (TSG) Core Network (CN); Numbering, addressing and identification

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AK	Anonymity Key
AKA	Authentication and key agreement
AMF	Authentication management field
AUTN	Authentication Token
AV	Authentication Vector
CK	Cipher Key
CKSN	Cipher key sequence number
CS	Circuit Switched
$D_{SK(X)}$(data)	Decryption of "data" with Secret Key of X used for signing
EMSI	Encrypted Mobile Subscriber Identity
EMSIN	Encrypted MSIN
$E_{KSXY(i)}$(data)	Encryption of "data" with Symmetric Session Key #i for sending data from X to Y
$E_{PK(X)}$(data)	Encryption of "data" with Public Key of X used for encryption
GI	Group Identifier
GK	Group Key
Hash(data)	The result of applying a collision-resistant one-way hash-function to "data"
HE	Home Environment
HLR	Home Location Register
IK	Integrity Key
IMSI	International Mobile Subscriber Identity
IV	Initialisation Vector

KAC$_X$	Key Administration Centre of Network X
KS$_{XY}$(i)	Symmetric Session Key #i for sending data from X to Y
KSI	Key Set Identifier
KSS	Key Stream Segment
LAI	Location Area Identity
MAP	Mobile Application Part
MAC	Message Authentication Code
MAC-A	The message authentication code included in AUTN, computed using f1
MS	Mobile Station
MSC	Mobile Services Switching Centre
MSIN	Mobile Station Identity Number
MT	Mobile Termination
NE$_X$	Network Element of Network X
PS	Packet Switched
P-TMSI	Packet-TMSI
Q	Quintet, UMTS authentication vector
RAI	Routing Area Identifier
RAND	Random challenge
RND$_X$	Unpredictable Random Value generated by X
SQN	Sequence number
SQN$_{UIC}$	Sequence number user for enhanced user identity confidentiality
SQN$_{HE}$	Sequence number counter maintained in the HLR/AuC
SQN$_{MS}$	Sequence number counter maintained in the USIM
SGSN	Serving GPRS Support Node
SIM	(GSM) Subscriber Identity Module
SN	Serving Network
T	Triplet, GSM authentication vector
TE	Terminal Equipment
TEMSI	Temporary Encrypted Mobile Subscriber Identity used for paging instead of IMSI
Text1	Optional Data Field
Text2	Optional Data Field
Text3	Public Key algorithm identifier and Public Key Version Number (eventually included in Public Key Certificate)
TMSI	Temporary Mobile Subscriber Identity
TTP	Trusted Third Party
UE	User equipment
UEA	UMTS Encryption Algorithm
UIA	UMTS Integrity Algorithm
UIDN	User Identity Decryption Node
USIM	User Services Identity Module
VLR	Visitor Location Register
X	Network Identifier
XEMSI	Extended Encrypted Mobile Subscriber Identity
XRES	Expected Response
Y	Network Identifier

6.2 Identification by a permanent identity

The mechanism described in here allows the identification of a user on the radio path by means of the permanent ~~user~~ subscriber identity (~~IMUI~~IMSI).

The mechanism should be invoked by the serving network whenever the user cannot be identified by means of a temporary identity. In particular, it should be used when the user registers for the first time in a serving network, or when the serving network cannot retrieve the ~~IMUI~~ IMSI from the ~~TMUI~~ TMSI by which the user identifies itself on the radio path.

The mechanism is illustrated in Figure 4.

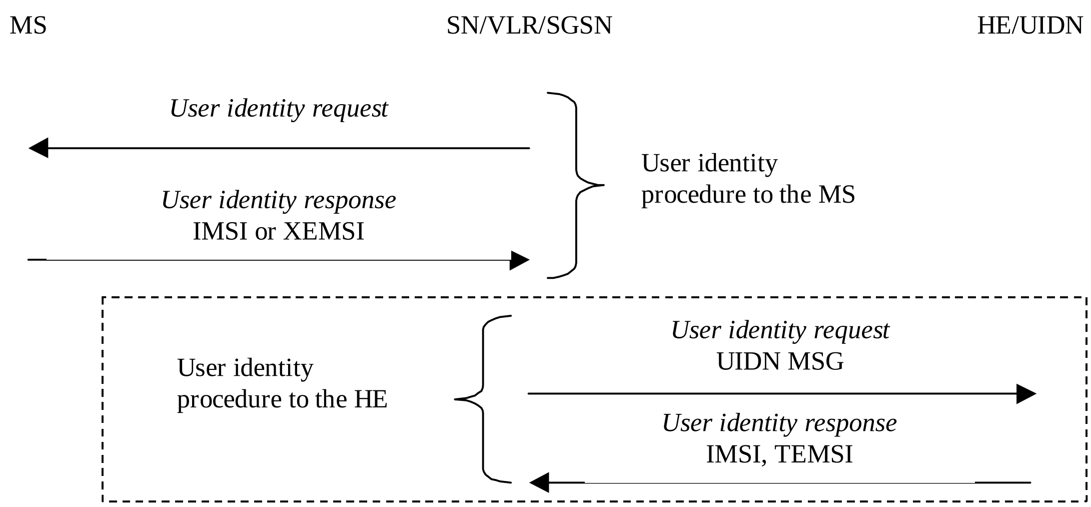


Figure 4: Identification by the permanent identity

The mechanism is initiated by the visited SN/VLR that requests the user to send its permanent identity. According to the user's preferences, his response may contain either 1) the ~~IMUI~~ IMSI in cleartext, or 2) the Extended Encrypted Mobile Subscriber Identity (XEMSI).

A mobile station configured for Enhanced User Identity Confidentiality shall always use the XEMSI instead of the IMSI. XEMSI consists of the User Identity Decryption Node address (UIDN_ADR, see below) ~~address~~ and a ~~UIDN-message~~container transporting the Encrypted Mobile Subscriber Identity EMSI. UIDN_ADR shall consist of a global title according to E164. For details concerning the structure of the XEMSI see [26]. ~~UIDN address shall exist of a global title according to E164.~~ ~~user's HE-identity in cleartext and an HE-message that contains an encrypted IMUI.~~

~~The term HE-id denotes an expression which is sufficient to route the user identity request message to an appropriate network element in the HE. Annex B contains a proposal to use MCC, MNC and the first three digits of the user's MSIN as routing information to address an HE/HLR.~~

In case the response contains the ~~IMUI~~ IMSI in cleartext, the procedure is ended successfully. This variant represents a breach in the provision of user identity confidentiality.

In case the response contains ~~an encrypted IMUI~~the XEMSI, the visited SN/VLR/SGSN forwards ~~the HE UIDN message~~ EMSI to the user's UIDN/HE in a request to send the user's ~~IMUI~~ IMSI and TEMSI (temporary EMSI). The user's UIDN/HE then derives the ~~IMUI~~ IMSI from ~~the HEUIDN-message~~EMSI, calculates TEMSI and sends ~~the IMUI~~ IMSI and TEMSI back to the SN/VLR/SGSN. Annex B describes an example mechanism that makes use of group keys to encrypt the ~~IMUI~~IMSI and to calculate the TEMSI and provides details on ~~the UIDN-message~~EMSI.

The SN shall use TEMSI instead of IMSI to page a particular user because using the IMSI in clear would compromise the security goal of the Enhanced User Identity Confidentiality feature. Therefore on UE side the TEMSI is calculated and stored by USIM and transmitted to the UE. This TEMSI shall become active if the following authentication procedure has successfully been performed. After the current TEMSI has successfully been used once SN shall trigger the *User Identity Request* procedure to establish a new TEMSI.

For the purpose of the Enhanced User Identity Confidentiality a new logical network node UIDN is introduced. The serving VLR or SGSN shall be able to request decryption of the user identity and calculation of paging identities by this home network node.

The UIDN is in charge of decrypting the encrypted IMSI provided by the mobile station in ~~the UIDN-message~~EMSI and of calculating the TEMSI. The UIDN is a home network operator specific logical network node and may be co-located with the HLR.

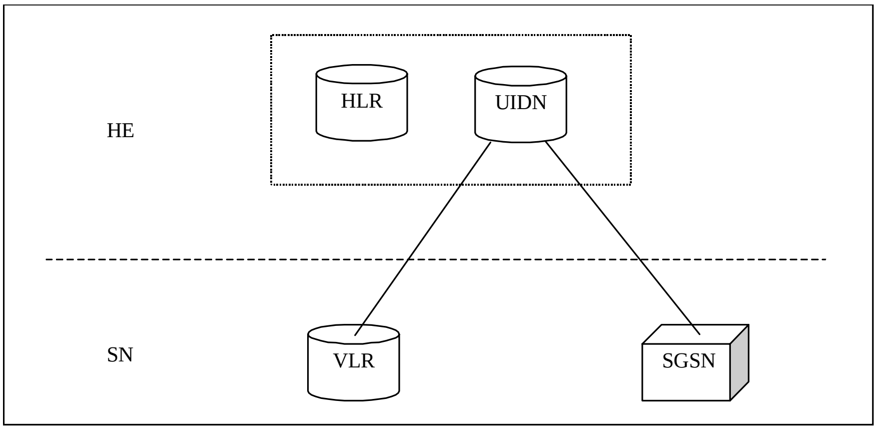


Figure 5: Core Network Architecture for Enhanced User Identity Confidentiality

The interface between the VLR/SGSN and the UIDN is used by the VLR to request the

- revelation ~~decryption~~ of the ~~E~~IMSI contained in ~~the UIDN message~~EMSI from the UIDN and
- calculation of the TEMSI for the circuit/packet switched domain.

~~The interface between the SGSN and the UIDN is used by the SGSN to request the decryption of the EIMSI contained in the UIDN-message from the UIDN for the packet switched domain.~~

6.3.2 Distribution of authentication data from HE to SN

The purpose of this procedure is to provide the VLR/SGSN with an array of fresh authentication vectors from the user's HE to perform a number of user authentications.

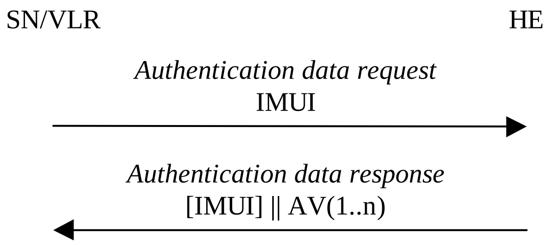


Figure 1: Distribution of authentication data from HE to VLR/SGSN

The VLR/SGSN invokes the procedures by requesting authentication vectors to the HE/AuC.

The *authentication data request* shall include a user identity. If the user is known in the VLR/SGSN by means of the IMUI, the *authentication data request* shall include the IMUI. ~~However, if the user is identified by means of an encrypted permanent identity (see 6.2), the HLR-message from which the HE can derive the IMUI is included instead. In that case, this procedure and the procedure *user identity request to the HLR* are integrated.~~

Upon the receipt of the *authentication data request* from the VLR/SGSN, the HE may have pre-computed the required number of authentication vectors and retrieve them from the HLR database or may compute them on demand. The HE/AuC sends an authentication response back to the VLR/SGSN that contains an ordered array of n authentication vectors AV(1..n).

Figure 2 shows the generation of an authentication vector AV by the HE/AuC.

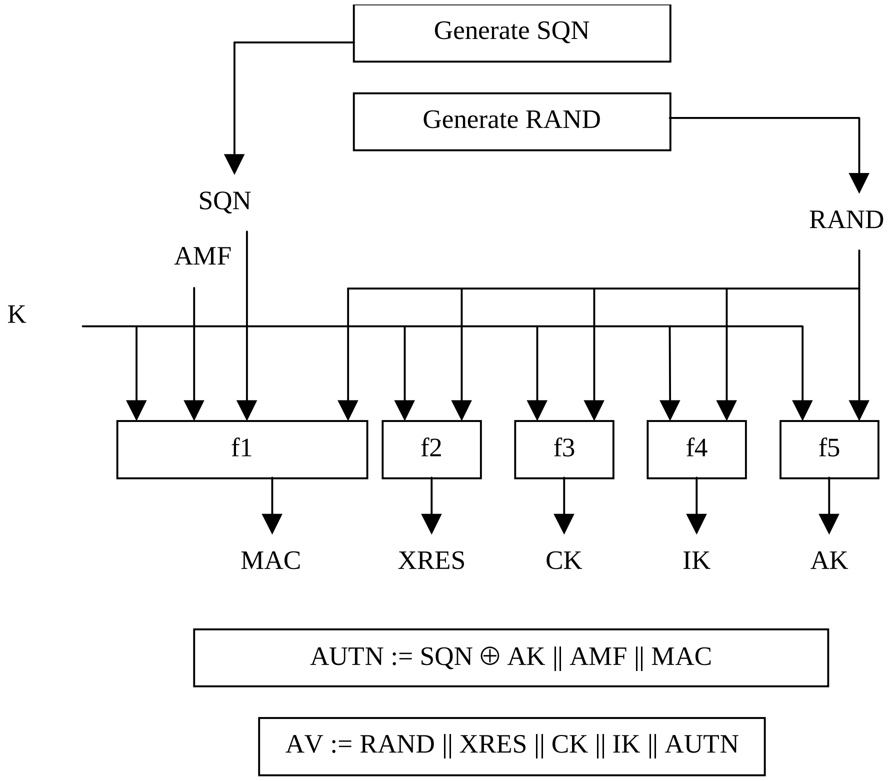

Generate SQN
Generate RAND
SQN
RAND
AMF
K
f1
f2
f3
f4
f5
MAC
XRES
CK
IK
AK
AUTN := SQN ⊕ AK || AMF || MAC
AV := RAND || XRES || CK || IK || AUTN

Figure 2: Generation of authentication vectors

The HE/AuC starts with generating a fresh sequence number SQN and an unpredictable challenge RAND.

For each user the HE/AuC keeps track of a counter: SQN_{HE}

The HE has some flexibility in the management of sequence numbers, but some requirements need to be fulfilled by the mechanism used:

a) The generation mechanism shall allow a re-synchronisation procedure in the HE described in section 6.3.5

b) The SQN should be generated in such way that it does not expose the identity and location of the user.

c) In case the SQN may expose the identity and location of the user, the AK may be used as an anonymity key to conceal it.

d) The generation mechanism shall allow protection against wrap around the counter in the USIM.
A method how to achieve this is given in informative Annex C.2.

The mechanisms for verifying the freshness of sequence numbers in the USIM shall to some extent allow the out-of-order use of sequence numbers. This is to ensure that the authentication failure rate due to synchronisation failures is sufficiently low. This requires the capability of the USIM to store information on past successful authentication events (e.g. sequence numbers or relevant parts thereof). The mechanism shall ensure that a sequence number can still be accepted if it is among the last x = 50 sequence numbers generated. This shall not preclude that a sequence number is rejected for other reasons such as a limit on the age for time-based sequence numbers.
The same minimum number x needs to be used across the systems to guarantee that the synchronisation failure rate is sufficiently low under various usage scenarios, in particular simultaneous registration in the CS- and the PS-service domains, user movement between VLRs/SGSNs which do not exchange authentication information, super-charged networks.

The use of SEQHE is specific to the method of generation sequence numbers. A method is specified in Annex C.1 how to generate a fresh sequence number. A method is specified in Annex C.2 how to verify the freshness of a sequence number.

An authentication and key management field AMF is included in the authentication token of each authentication vector. Example uses of this field are included in Annex F.

Subsequently the following values are computed:

- a message authentication code MAC = $f1_K$(SQN || RAND || AMF) where f1 is a message authentication function;
- an expected response XRES = $f2_K$ (RAND) where f2 is a (possibly truncated) message authentication function;
- a cipher key CK = $f3_K$ (RAND) where f3 is a key generating function;
- an integrity key IK = $f4_K$ (RAND) where f4 is a key generating function;
- an anonymity key AK = $f5_K$ (RAND) where f5 is a key generating function or $f5 \equiv 0$.

Finally the authentication token AUTN = SQN $\oplus$ AK || AMF || MAC is constructed.

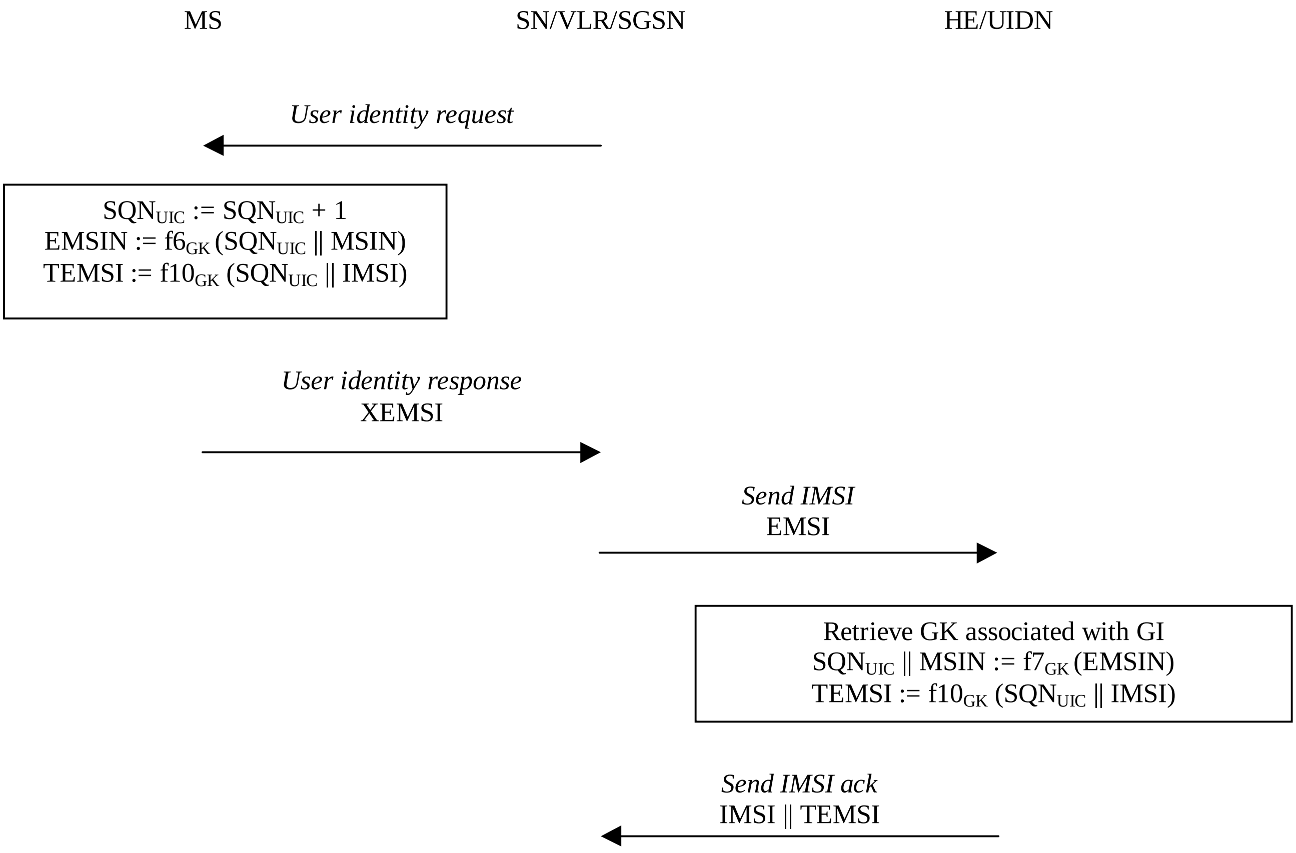
Here, AK is an anonymity key used to conceal the sequence number as the latter may expose the identity and location of the user. The concealment of the sequence number is to protect against passive attacks only. If no concealment is needed then $f5 \equiv 0$.

Annex B (informative): Enhanced user identity confidentiality

This mechanism allows the identification of a user on the radio access by means of the permanent user identity encrypted by means of a group key. The mechanism described here can be used in combination with the mechanism described in 6.2 to provide user identity confidentiality in the event that the user not known by means of a temporary identity in the serving network.

The mechanism assumes that the user belongs to a user group with group identity GI. Associated to the user group is a secret group key GK which is shared between all members of the user group and the user's HE, and securely stored in the USIM and in the HE/~~HLR~~UIDN.

The mechanism is illustrated in Figure B.1.


MS
SN/VLR/SGSN
HE/UIDN
User identity request
$SQN_{UIC} := SQN_{UIC} + 1$
$EMSIN := f6_{GK} (SQN_{UIC} \| MSIN)$
$TEMSI := f10_{GK} (SQN_{UIC} \| IMSI)$
User identity response
XEMSI
Send IMSI
EMSI
Retrieve GK associated with GI
$SQN_{UIC} \| MSIN := f7_{GK} (EMSIN)$
$TEMSI := f10_{GK} (SQN_{UIC} \| IMSI)$
Send IMSI ack
IMSI || TEMSI

Abbreviations

EMSI	:= GI || EMSIN
XEMSI	:= UIDN_ADR || EMSI
UIDN_ADR	:= UIDN’s global title (according to 6.2)

Figure B.1: Identification by means of the ~~IMUI~~ IMSI encrypted by means of a group key

The mechanism illustrated in Figure B.1 works as follows:

1. The user identity procedure is initiated by the visited VLR/SGSN. The visited VLR/SGSN requests the ~~user~~ USIM to send its XEMSI.~~permanent user identity.~~

2. Upon receipt the ~~user~~ USIM
- increments SQN_{UIC} as a time variant parameter. ~~The user~~
- encrypts SQN_{UIC} and ~~the~~ its ~~IMUI I~~MSIN with enciphering algorithm f6 and ~~his~~ its group key GK. The result is called EMSIN, encrypted MSIN.
- constructs EMSI as concatenation of the group identifier GI and EMSIN.
- constructs XEMSI as concatenation of UIDN_ADR and EMSI.
- sends XEMSI in a response to the SN/VLR/SGSN.
- derives TEMSI from IMSI and SQN_{UIC} with cryptographic algorithm f10 and the group key GK.
The SQN_{UIC} prevents traceability attacks and synchronizes the derivation of TEMSI n the USIM and HE.

~~The user sends XEMSI in a response to the SN/VLR/SGSN consisting of UIDN-address and UIDN-message. The UIDN-message itself consists of group key GI and encrypted IMSI EMSI. that includes the MCC || MNC and the first three digits of the user's MSIN that identify an HLR within the user's HE core network.~~

~~Note: Alternatives are~~

- ~~to define a single network element within each HE which performs all decryption related to EMUI, or~~
- ~~that all gateway MSCs are able to decrypt EMUI and route the message to the correct HLR~~

3. Upon receipt of that response the SN/VLR/SGSN ~~should~~ resolves the ~~user's HE/HLR~~UIDN~~- address~~_ADR from XEMSI ~~MCC ||MNC || HLR-id~~ and forwards ~~UIDN-message~~EMSI ~~the group identity GI and the user's EMUI~~ to the user's HE/~~HLR~~UIDN.

4. Upon receipt the HE/~~HLR~~ UIDN

- retrieves the group identity GI contained in EMSI.
- retrieves the group key GK associated with the group identity GI.
- ~~The HE/HLR UIDN then~~ decrypts ~~EMUI~~ EMSIN with the deciphering algorithm f7 ($f7 = f6^{-1}$) and the group key GK and retrieves SQN_{UIC} and ~~IMUI~~IMSIN.
- constructs the user's IMSI according to the following rule: $IMSI := MCC_{UIDN\_ADR} || MNC_{UIDN\_ADR} || MSIN$ ($UIDN\_ADR := MCC_{UIDN\_ADR} || MNC_{UIDN\_ADR} || MSIN_{UIDN\_ADR}$).
- calculates TEMSI as $TEMSI := f10_{GK} (SQN_{UIC} || IMSI)$~~$SQN_{UIC}$ is no longer used~~.
- ~~The HE/HLR UIDN then~~ sends ~~the IMUI~~ IMSI and TEMSI in a response to the visited SN/VLR/SGSN.