3GPP TSG SA WG3 Security — S3#12 **S3-000323**

24-26 Mai, 2000, Yokohama, Japan

Source: T-Mobil

Title: Review 31.102 and 33.102 on USIM related security issues

Document for: Approval

Agenda Item:

A need was identified to ensure that S3 security features are properly integrated into the R99/R00 specifications. Therefore S3 has started to identify affected specifications on

- Authentication and key agreement,
- Confidentiality and integrity protection,
- Secure 2G-3G interworking.

This document summarizes the review of TS 31.102 and TS 33.102 with the target that security issues related to the USIM are integrated properly in both specifications.

The following 5 CRs are drafted on TS 33.102 to be presented for approval at S3#13.

- <<33102CR097-align-note-and-star-in-figure18.doc>>
  This CR links the NOTE added to TS 33.102 and the stars in figure 18, section 6.8.1.1.
- <<33102CR098-change-COUNT-to-COUNT-C.doc>>
  This CR changes COUNT to COUNT-C in the security mode set-up procedure; section 6.4.5.
- <<33102CR099-conidition-on-rejecting-keys.doc>>
  This CR clarifies the conditions on rejecting the keys CR and IK depending on the values $START_{CS}$ and $START_{PS}$.
- <<33102CR100-replace-count-by-start.doc>>
  This CR replaces COUNT by $START_{CS}$ and $START_{PS}$ in section 6.4.3 on cipher key and integrity key lifetime for alignment with the already agreed CR88.
- <<33102CR101-UICC-interworking-conditions.doc>>
  This CR clarifies the interworking procedure when a UICC has to support GSM and UMTS AKA.

CRs on TS 31.102 will be tabled by T-Mobil on the 3GPP TSG T3 meeting to be held in Visby/Gotland, Sweden (24.-26.05.2000).

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Yokohama, Japan, 24-26 Mai 2000

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33.102	CR	097	Current Version:	3.4.0

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

For submission to:	SA#8	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	X	ME	X	UTRAN / Radio		Core Network	

Source: TSG SA WG3 **Date:** 18 Mai 2000

Subject: Align of note and star in figure 18

Work item: Security

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

F	Correction		**Release:**	Phase 2	
A	Corresponds to a correction in an earlier release			Release 96	
B	Addition of feature			Release 97	
C	Functional modification of feature			Release 98	
D	Editorial modification	X		Release 99	X
				Release 00	X

Reason for change: Clarification

Clauses affected: 6.8.1.1

Other specs affected:

Other 3G core specifications	X	→ 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:

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6.8.1.1 General

For UMTS subscribers, authentication and key agreement will be performed as follows:

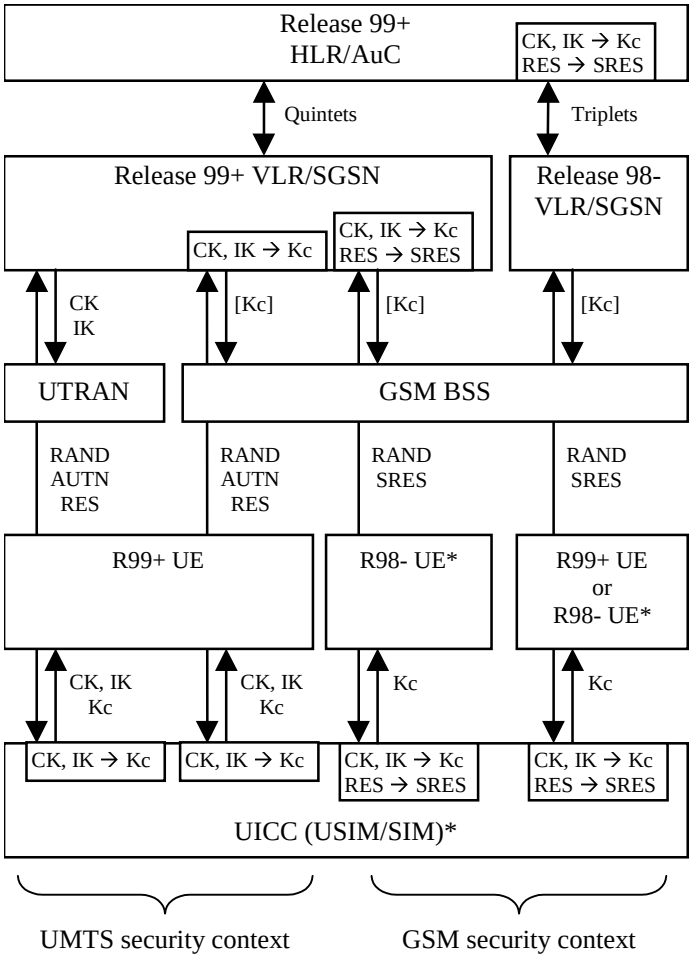
- UMTS AKA shall be applied when the user is attached to a UTRAN.
- UMTS AKA shall be applied when the user is attached to a GSM BSS, in case the user has R99+ UE and also the VLR/SGSN is R99+. In this case, the GSM cipher key Kc is derived from the UMTS cipher/integrity keys CK and IK, by the VLR/SGSN on the network side and by the USIM on the user side.
- GSM AKA shall be applied when the user is attached to a GSM BSS, in case the user has R98- UE. In this case, the GSM user response SRES and the GSM cipher key Kc are derived from the UMTS user response RES and the UMTS cipher/integrity keys CK and IK. A R98- VLR/SGSN uses the stored Kc and RES and a R99+ VLR/SGSN derives the SRES from RES and Kc from CK, IK.

NOTE: To support R98- UE the UICC may contain a GSM SIM application which provides the corresponding GSM functionality for calculating SRES and Kc based on the 3G authentication key K and the 3G authentication algorithm implemented in the USIM. Due to the fact that the 3G authentication algorithm only computes CK/IK and RES, conversion of CK/IK to Kc shall be achieved by using the conversion function c3, and conversion of RES to SRES by c2.

- GSM AKA shall be applied when the user is attached to a GSM BSS, in case the VLR/SGSN is R98-. In this case, the USIM derives the GSM user response SRES and the GSM cipher key Kc from the UMTS user response RES and the UMTS cipher/integrity keys CK, IK.

The execution of the UMTS (resp. GSM) AKA results in the establishment of a UMTS (resp. GSM) security context between the user and the serving network domain to which the VLR/SGSN belongs. The user needs to separately establish a security context with each serving network domain.

Figure 18 shows the different scenarios that can occur with UMTS subscribers using either R98- or R99+ UE in a mixed network architecture.



(See the note for further explanation on * in figure 18.)

Figure 18: Authentication and key agreement of UMTS subscribers

Note that the UMTS parameters RAND, AUTN and RES are sent transparently through the UTRAN or GSM BSS and that the GSM parameters RAND and SRES are sent transparently through the GSM BSS.

In case of a GSM BSS, ciphering is applied in the GSM BSS for services delivered via the MSC/VLR, and by the SGSN for services delivered via the SGSN. In the latter case the GSM cipher key Kc is not sent to the GSM BSS.

In case of a UTRAN, ciphering and integrity are always applied in the RNC, and the UMTS cipher/integrity keys CK an IK are always sent to the RNC.

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33.102	CR	098	Current Version:	3.4.0

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

For submission to:	SA#8	for approval	X	strategic		(for SMG use only)
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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	X	ME	X	UTRAN / Radio		Core Network	

Source: TSG SA WG3 **Date:** 18 Mai 2000

Subject: Security mode set-up procedure

Work item: Security

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

F	Correction	X	**Release:**	Phase 2	
A	Corresponds to a correction in an earlier release			Release 96	
B	Addition of feature			Release 97	
C	Functional modification of feature			Release 98	
D	Editorial modification			Release 99	X
				Release 00	X

Reason for change: Change COUNT to COUNT-C

Clauses affected: 6.4.5

Other specs affected:

Other 3G core specifications	X	→ 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:

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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.

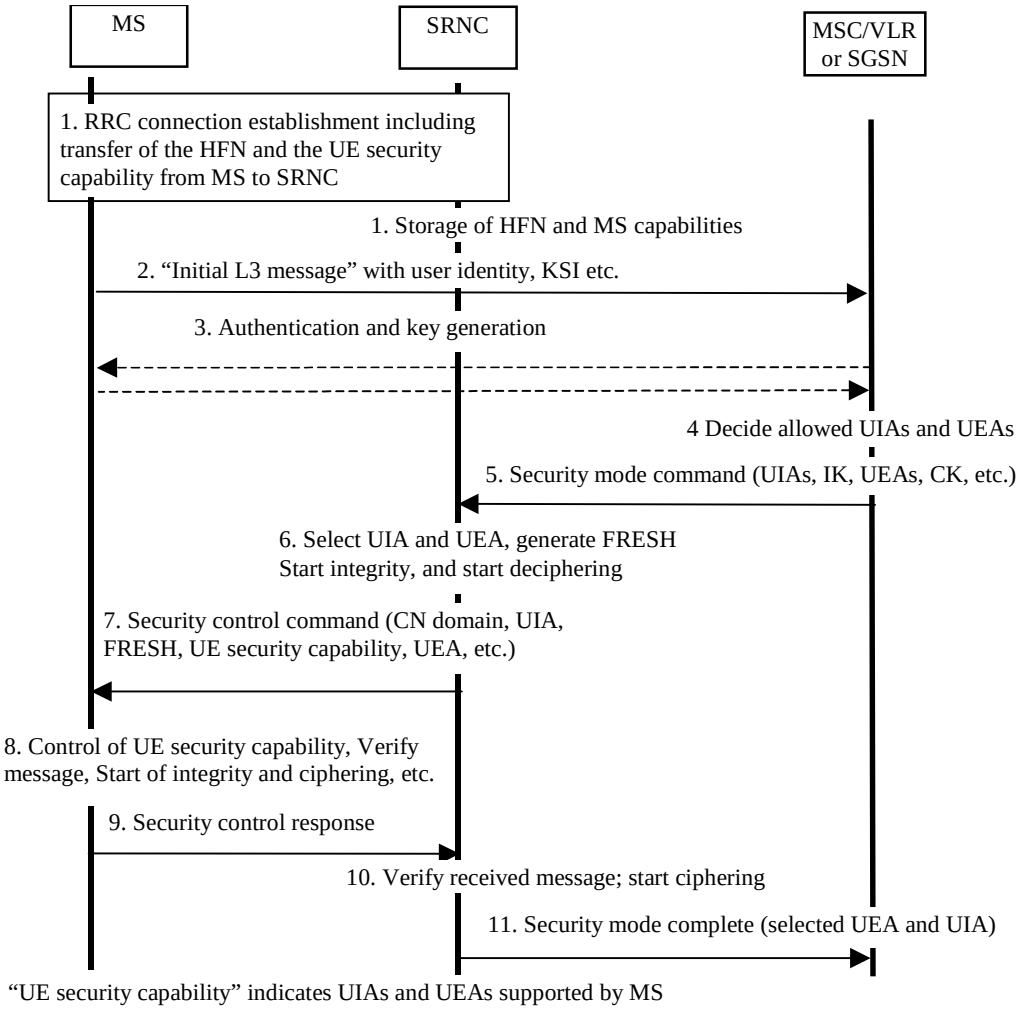

Figure 14: Local authentication and connection set-up

NOTE 1: The network must have the "UE security capability" information before the integrity protection can start, i.e. the "UE security capability" must be sent to the network in an unprotected message. Returning the "UE security capability" later on to the UE in a protected message will give UE the possibility to verify that it was the correct "UE security capability" that reached the network.
This latter point, as well as the RRC interwork described below, is yet to be agreed in RAN WG2.

Detailed description of the flow above:

1. RRC connection establishment includes the transfer from MS to RNC of the UE security capabiltiy and the hyperframe number to be used as part of one of the input parameters for the integrity algorithm and for the ciphering algorithm. The COUNT-I parameter (together with COUNT-C which is used for ciphering) is 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 relevant CN domain. This message contains relevant MM information e.g. KSI. The KSI (Key Set Identifier) is the number allocated by the CN at the last authentication for this CN domain.

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

4. The CN node determines which UIAs and UEAs that are allowed to be used.

5. The CN initiates integrity (and possible also 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. It may also contain the allowed UEAs and the CK to be used.

6. The SRNC decides which algorithms to use by selecting from the list of allowed algorithms, the first UEA and the first UIA it supports. The SRNC generates a random value FRESH and initiates the downlink integrity protection. If SRNC supports no UIA algorithms in the list, it sends a SECURITY MODE REJECT message to CN.

7. The SRNC generates the RRC message Security control command. The message includes the UE security capability, the UIA and FRESH to be used and possibly also the UEA to be used. Additional information (start of ciphering) may also be included. Since we have two CNs with an IK each, the network must indicate which IK to use. This is obtained by including a CN type indicator information in "Security control command". 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 control command message, the MS controls that the UE security capability received is equal to the UE 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 control command response and generates the MAC-I for this message. If any control is not successful, a SECURITY CONTROL REJECT message is sent from 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 CN node 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 command response 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.

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33.102	CR	099	Current Version:	3.4.0

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

For submission to:	SA#8	for approval	X	strategic		(for SMG use only)
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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	X	ME	X	UTRAN / Radio		Core Network	

Source: TSG SA WG3 **Date:** 18 Mai 2000

Subject: Clarification on condition on rejecting keys CR and IK

Work item: Security

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

F	Correction	X	**Release:**	Phase 2	
A	Corresponds to a correction in an earlier release			Release 96	
B	Addition of feature			Release 97	
C	Functional modification of feature			Release 98	
D	Editorial modification			Release 99	X
				Release 00	X

Reason for change:

Clauses affected: 6.5.4.2, 6.6.4.2

Other specs affected:

Other 3G core specifications	X	→ 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: Possible impact on T WG3 specifications

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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.

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 UE. IK is sent from the USIM to the UE upon request of the UE. The USIM shall send IK under the condition that ~~1)~~ a valid IK is available~~,~~. The UE shall reject the currently received IK if ~~2)~~ the current values of $START_{CS}$ or $START_{PS}$ in the USIM ~~is~~are not up-to-date ~~and 3)~~or $START_{CS}$ or $START_{PS}$ ~~has~~ have ~~not~~ reached THRESHOLD. The UE 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*. The MSC/VLR or SGSN shall assure that the IK is updated at least once every 24 hours.

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.

6.6.4.2 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.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 UE. CK is sent from the USIM to the UE upon request of the UE. The USIM shall send CK under the condition that ~~1)~~ a valid CK is available~~,~~. The UE shall reject the currently received CK if~~2)~~ the current value of $START_{CS}$ or $START_{PS}$ in the USIM ~~is~~ are not up-to-date ~~and 3)~~ or $START_{CS}$ or $START_{PS}$ ~~has~~ have ~~not~~ reached THRESHOLD. The UE 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. The VLR or SGSN shall assure that CK is updated at least once every 24 hours.

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.

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CHANGE REQUEST

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33.102	**CR**	**100**	Current Version:	3.4.0

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

For submission to:	SA#8	for approval	X	strategic		(for SMG use only)
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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	X	ME	X	UTRAN / Radio		Core Network	

Source: TSG SA WG3 **Date:** 18 Mai 2000

Subject: Replace COUNT by $START_{CS}$ and $START_{PS}$

Work item: Security

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

F	Correction	X	**Release:**	Phase 2	
A	Corresponds to a correction in an earlier release			Release 96	
B	Addition of feature			Release 97	
C	Functional modification of feature			Release 98	
D	Editorial modification			Release 99	X
				Release 00	X

Reason for change: Alignment with CR88

Clauses affected: 6.4.3, 6.4.7

Other specs affected:

Other 3G core specifications	X	→ 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: Possible impact on T WG3 specifications

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6.4.3 Cipher key and integrity key lifetime

Authentication and key agreement which generates cipher/integrity keys is not mandatory at call set-up, and there is therefore the possibility of unlimited and malicious re-use of compromised keys. A mechanism is needed to ensure that a particular cipher/integrity key set is not used for an unlimited period of time, to avoid attacks using compromised keys. The USIM shall therefore contain a mechanism to limit the amount of data that is protected by an access link key set.

Each time an RRC connection is released the ~~highest~~ values ~~of the hyperframe number (the current value of COUNT~~START$_{CS}$ and START$_{PS}$~~)~~ of the bearers that were protected in that RRC connection ~~is~~ are stored in the USIM. When the next RRC connection is established that values ~~is~~ are read from the USIM ~~and incremented by one~~.

The UE shall trigger the generation of a new access link key set (a cipher key and an integrity key) if START$_{CS}$ or START$_{PS}$ ~~the counter~~ reache~~s~~ a maximum value set by the operator and stored in the USIM at the next RRC connection request message sent out or during an RRC connection. When this maximum value is reached the cipher key and integrity key stored on USIM shall be deleted.

This mechanism will ensure that a cipher/integrity key set cannot be reused beyond the limit set by the operator.

6.4.7 Signalling procedure for periodic local authentication

The following procedure is used by the RNC to periodically perform a local authentication. At the same time, the amount of data sent during the RRC connection is periodically checked by the RNC and the UE. The RNC is monitoring the COUNT-C and COUNT-I value associated to each radio bearer. The procedure is triggered whenever any of these values reaches a critical checking value. The granularity of these checking values and the values themselves are defined by the visited network. All messages in the procedure are integrity protected.

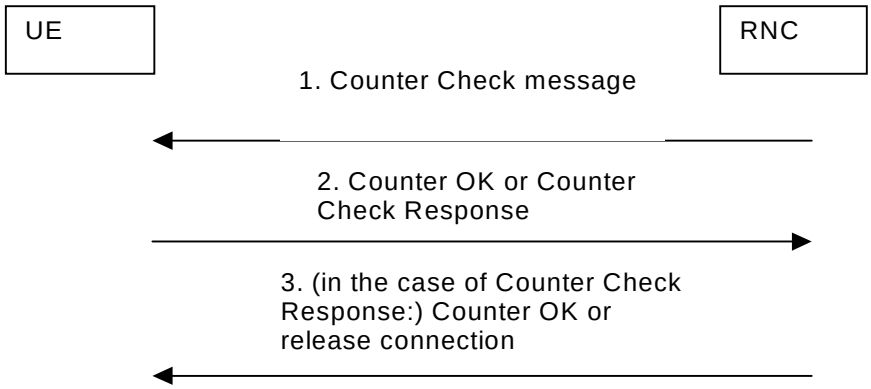

Figure 15a: RNC periodic local authentication procedure

1. When a checking value is reached (e.g. the value in some fixed bit position in the hyperframe number is changed), a Counter Check message is sent by the RNC. The Counter Check message contains the most significant parts of the counter values (which reflect amount of data sent and received) from each active radio bearer.

2. The counter values in the Counter Check message are checked by UE and if they agree with the current status in the UE, a 'Counter OK' message is returned to the RNC. If there is a difference between the counter values in the UE and the values indicated in the Counter Check message, the UE sends a Counter Check response to the RNC. The form of this message is similar to the Counter Check message.

3. In case the RNC receives the 'Counter OK' message the procedure is completed. In case the RNC receives the Counter Check response it compares the counter values indicated in it to counter values in the RNC. If there is no difference or if the difference is acceptable then the RNC completes the procedure by sending the 'Counter OK' message. Otherwise, the connection is released.

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33.102	CR	101	Current Version:	3.4.0

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

For submission to:	SA#8	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	X	ME	X	UTRAN / Radio		Core Network	

Source: TSG SA WG3 **Date:** 18 Mai 2000

Subject: Clarification on the interworking procedure when a UICC has to support GSM and UMTS AKA

Work item: Security

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

F	Correction	X	**Release:**	Phase 2	
A	Corresponds to a correction in an earlier release			Release 96	
B	Addition of feature			Release 97	
C	Functional modification of feature			Release 98	
D	Editorial modification			Release 99	X
				Release 00	X

Reason for change: For better clarification

Clauses affected: 6.8.1.5

Other specs affected:

Other 3G core specifications	X	→ 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:

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6.8.1.5 UICC (USIM/SIM)

The UICC shall support UMTS AKA, ~~(~~i.e. the UICC shall contain a USIM application.~~)~~ ~~and~~The UICC may support GSM AKA, ~~(~~i.e. the USIM supports a GSM security context (this is required to support access to GSM-BSS with a R98- VLR/SGSN), or the UICC ~~may~~ contains a SIM application (this is required to support access to GSM-BSS with a R98- UE). ~~Support of GSM AKA is required to allow access to GSM-BSS with a R98- VLR/SGSN and/~~

~~or with a R98- UE.~~

When the UE provides the ~~UICC~~USIM with RAND and AUTN ("UMTS security context"), UMTS AKA shall be executed. If the verification of AUTN is successful, the ~~UICC~~USIM shall respond with the UMTS user response RES and the UMTS cipher/integrity keys CK and IK. The ~~UICC~~USIM shall store CK and IK as current security context data. If supported, ~~T~~the ~~UICC~~USIM shall also derive the GSM cipher key Kc from the UMTS cipher/integrity keys CK and IK using conversion function c3 and send the derived Kc to the ~~R99+~~ UE. In case the verification of AUTN is not successful, the ~~UICC~~USIM shall respond with an appropriate error indication to the ~~R99+~~ UE.

When the UE provides the UICC (USIM or SIM) with only RAND ("GSM security context"), GSM AKA shall be executed, if supported, as follows:~~.~~ The ~~UICC~~ UISM or SIM first computes the UMTS user response RES and the UMTS cipher/integrity keys CK and IK. The UISM or SIM ~~UICC~~ then derives the GSM user response SRES and the GSM cipher key Kc using the conversion functions c2 and c3. The UISM or SIM ~~UICC~~ then stores the GSM cipher key Kc and sends the GSM user response SRES and the GSM cipher key Kc to the UE, but does not send neither CK nor IK. *(see also note in clause 6.8.1.1)*

In case the UICC does not support GSM AKA (conversion function c3 is not available to derive Kc and pass it to the R99+ UE), the R99+ UE shall be informed. A UICC that does not support GSM AKA cannot operate under a R98- VLR/SGSN or in a R98- UE.