3GPP TSG SA WG3 Security — S3#33 **S3-040428**
10 - 14 May 2004
Beijing, China

Title: Draft CR on VGCS and VBS security

Release: 6

Work Item:

Source: 3GPP TSG-SA WG3

To: SA1, CN1, CN4, GERAN2, T3

Cc: ETSI EP RT

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Attachments: S3-040427

1. Overall Description:

SA3 would like to inform the addressed groups that the content (without the following open points below) of the attached CR was agreed at S3#33 (10-14 May 2004, Beijing, China). It is intended to resolve the following open points by SA#34 in order to approve the CR at SA#34 by SA3 and in September 2004 by TSG-SA#25.

The following issues are currently open:

1. Provisioning of CELL_GLOBAL_COUNT

GERAN2 are investigating whether CELL_GLOBAL_COUNT can be provided on the air interface. Depending on the outcome of their investigation, the length of CELL_GLOBAL_COUNT will be defined or the usage of CELL_GLOBAL_COUNT will be dropped.

2. Length of VSTK_RAND

ETSI SAGE is asked whether a 32 bit VSTK_RAND provides sufficient security for the intended purpose. Depending on their analysis the length of VSTK_RAND might be changed.

3. Definition of KMF

Exact definition of the key modification function KMF (implemented in the BSS and ME) has to be done. However, it is expected that the function is quite simple and fast since it does not need to fulfil special cryptographic requirements.

2. Actions:

To SA1, CN1, CN4, GERAN2, T3

ACTION: **TSG- SA3** ask the addressed groups to kindly consider the attached CR and the above statements and to provide the necessary changes in their specifications. Moreover all groups are invited to send comments on this work.

To GERAN2

ACTION: Concerning the question raised in GERAN2's LS (TSGG#19(04)1210 – S3-040255) SA3 would like to answer that CGI and VSTK_RAND shall be used. However, as pointed out above, the length of VSTK_RAND will be checked by ETSI SAGE. SA3 will inform GERAN2 about the outcome of the analysis. GERAN2 is asked to consider this in their specifications.

3. Date of next TSG-SA WG3 Meetings:

SA3#34	6–9 July 2004	Acapulco, Mexico
SA3#35	5–8 Oct 2004	Malta

3GPP TSG SA WG3 Security — S3#33 **S3-040427**
10 - 14 May 2004, Beijing, China

CR-Form-v7

CHANGE REQUEST

⌘	**43.020**	**CR**	**CRNum**	⌘ **rev**	**-**	⌘	Current version:	**5.0.0** ⌘

*For **HELP** on using this form, see bottom of this page or look at the pop-up text over the ⌘ symbols.*

Proposed change affects: UICC apps⌘ ☒ ME ☒ Radio Access Network ☒ Core Network ☒

Title:	⌘	Introducing VGCS/VBS ciphering		
Source:	⌘	Siemens, Vodafone		
Work item code:	⌘	SECGKYV	***Date:*** ⌘	13/05/2004
Category:	⌘	**B**	***Release:*** ⌘	Rel-6
		Use one of the following categories: ***F*** *(correction)* ***A*** *(corresponds to a correction in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)* Detailed explanations of the above categories can be found in 3GPP TR 21.900.		*Use one of the following releases:* *2 (GSM Phase 2)* *R96 (Release 1996)* *R97 (Release 1997)* *R98 (Release 1998)* *R99 (Release 1999)* *Rel-4 (Release 4)* *Rel-5 (Release 5)* *Rel-6 (Release 6)*

Reason for change:	⌘	Introducing a new feature VGCS/VBS ciphering
Summary of change:	⌘	The new ciphering feature is introduced into Annex F
Consequences if not approved:	⌘	The feature cannot be realized Open issues are still (highlighted by coloured text): - The inclusion of Global_Count (waiting for GERAN2 feasibility) - An assesment of the timing requirements - SAGE to assess if the RAND length is ok

Clauses affected:	⌘	New Annex F				
		Y	**N**			
Other specs affected:	⌘	**Y**		Other core specifications	⌘	31.102, 42.068, 43.068, 42.069, 43.069, 44.018, 48.008
			N	Test specifications		
			N	O&M Specifications		
Other comments:	⌘					

Annex F (normative): Ciphering of Voice Group Call Service (VGCS) and Voice Broadcast Service (VBS)

This Annex defines the security related service and functions for VGCS and VBS in order to provide confidentiality protection to the group calls.

F.1 Introduction

F.1.1 Scope

In this Annex the ciphering of the voice group call service (VGCS) [1] and voice broadcast service (VBS) [4] is described. The following functions are required:

- Key derivation
- Encryption of voice group/broadcast calls

[3] 3G TS 31.102: 3rd Generation Partnership Project; Technical Specification Group Terminals; Characteristics of the USIM application

[4] 3G TS 42.069: 3rd Generation Partnership Project; Technical Specification Group Services and system Aspects; Voice Broadcast Service (VBS) - Stage 1

[5] 3G TS 43.069: 3rd Generation Partnership Project; Technical Specification Group Services and system Aspects; Voice Broadcast Service (VBS) - Stage 2

- The secure storage of the master group keys

VGCS and VBS provide no authentication functions, i.e. authentication is performed implicitly via encryption/decryption since only a legitimate subscriber shall be able to encrypt and decrypt the VGCS/VBS speech call when the group call requires confidentiality protection. To include a subscriber into a voice group the required group data (including the 2 master group keys) shall be stored on theUSIM, e.g. during the personalisation process or via OTA (over-the-air). To exclude a subscriber from a voice group the group data shall be deleted from the USIM. In case of a stolen or lost USIM, all USIMs of the remaining members of the voice groups that the USIM is a member of, need to be changed (e.g. via OTA or manual provisioning).

A pre- Rel-6 VGCS/VBS capable mobile shall be able to participate in an un-ciphered group call, if it is part of that group.NOTE: The only security relevant difference between VBS and VGCS is that in the case of VBS there exists no uplink channel.

F.1.2 References

[1] 3G TS 42.068: 3rd Generation Partnership Project; Technical Specification Group Services and system Aspects; Voice Group Call Service (VGCS) - Stage 1

[2] 3G TS 43.068: 3rd Generation Partnership Project; Technical Specification Group Services and system Aspects; Voice Group Call Service (VGCS) - Stage 2

[6] 3G TS 23.003: 3rd Generation Partnership Project; Technical Specification Group Core Network; Numbering, addressing and identification

F.1.3 Definitions and Abbreviations

F.1.3.1 Definitions

A5_Id Identifier of the encryption algorithm which shall be used.

CELL_GLOBAL_COUNT: A counter valid for all voice group calls within a cell (4 bit).

Group_Id Unique identifier of a voice call group.

KMF Key Modification Function. KMF derives from the short term key VSTK, the CGI and the CELL_GLOBAL_COUNT the cipher key V_Kc which is valid for that specific cell.

VSTK Short Term Key provided by the USIM and the GCR. VSTK is derived from VSTK_RAND and V_Ki (128 bit)

VK_Id Identifier of the Master Group Key (1 bit) of a group. There are up to 2 V_Ki per group

VSTK_RAND A random value (32 bit) for derivation of a short term key VSTK.

V_Ki (Group_Id, i) Voice Group or Broadcast Group Key (128 bit) number i::=VK_Id of group with Group_Id. In short also called Master Group Key or Group Key in this Annex

V_Kc Voice Group or Broadcast Ciphering Key (128 bit). V_Kc is derived from VSTK

F.1.3.2 Abbreviations

The following list describes the abbreviations and acronyms used in this Annex.

CGI	Cell Global Identifier
GCR	Group Call Register
VBS	Voice Broadcast Service
VGCS	Voice Group Call Service

F.2 Security Requirements

The ciphering concept for VGCS, VBS fulfils following security requirements

REQ-1. Prevent the same Voice group or Broadcast group ciphering key being used within different cells.

This requirement protects an observer of getting more information on the plaintext if different data is enciphered with the same key and COUNT (TDMA-numbers derived) in different cells.

REQ-2. The master group key shall never leave the USIM and the GCR.

Even though VGCS/VBS users should be trusted, this approach protects the 'root'-key (I.e. Master Group key) in the most secure way such that it need not be updated very frequently.

REQ-3. Prevent the reuse of COUNT with the same voice group or broadcast group ciphering key within the same cell.

The COUNT value is determined by the TDMA frame number. An overflow happens after each 3 hour and 8 minutes period. The lifetime of the used cipher key shall not be longer than the overflow period.

NOTE: This enhancement goes beyond the provided level of security of GSM-calls over a point to point channel (i.e. is not a VGCS/VBS-problem only) as long standing calls over a dedicated channel have the same characteristic of reusing the COUNT.

NOTE: GERAN2 is still investigating mechanisms for providing a global count to cope with COUNT number overflows.

REQ-4. Prevent the same key stream block being used in uplink and downlink direction.

This requirement is fulfilled by Point to Point voice calls already (See Annex C.1.2). By reusing the same mechanisms for uplink/downlink key stream derivation (I.e. reusing A5) the VBS/VGCS ciphering also fulfils this requirement.

F.3 Storage of the Master Group Keys and overview of flows

The master group keys (in short called group keys in this Annex) are securely stored at two locations

- GCR: Beside other information, the GCR stores for each Group_Id a list of group keys. Each group key is uniquely identified by the Group_Id and the group key number VK_Id (1-2).
- USIM: The USIM contains a list of 2 group keys for each Group_Id. Deletion or changing of group keys are allowed only via OTA or via USIM-personalisation.

The Short Term Key VSTK shall be deleted by the network entities after tearing down the call and by the ME on power down or UICC removal. On each new VGCS/VBS call set up, a new short term key VSTK shallbe generated.

The following sequence gives an overview of how the different network entities make use of the group keys (and derived information) during the establishment of a voice group/broadcast call.

1. During the voice group/broadcast call set-up the anchor-MSC sends a GCR Interrogation to the GCR containing the Group_Id.
2. The GCR provideson the basis of a fresh Random Number VSTK_RAND the key VSTK as described in Annex F.4. VK_Id, VSTK_RAND, VSTK, the permitted ciphering algorithm (A5_Id) and other voice group/broadcast call related information, are sent from the GCR back to the anchor-MSC.
3. The anchor-MSC sends this information to the relay-MSC's via a MAP-operation.
4. The anchor MSC and relay-MSC's sends this information to the BSS using the VGCS Assignment Request or VBS Assignment Request.
5. The BSS sends the VSTK_RAND, Group_Id and the group key number VK_Id to the ME's via a notification procedure.
6. Each ME generates the VSTK, on the basis of the received information from step 5, as described in Annex F.4.

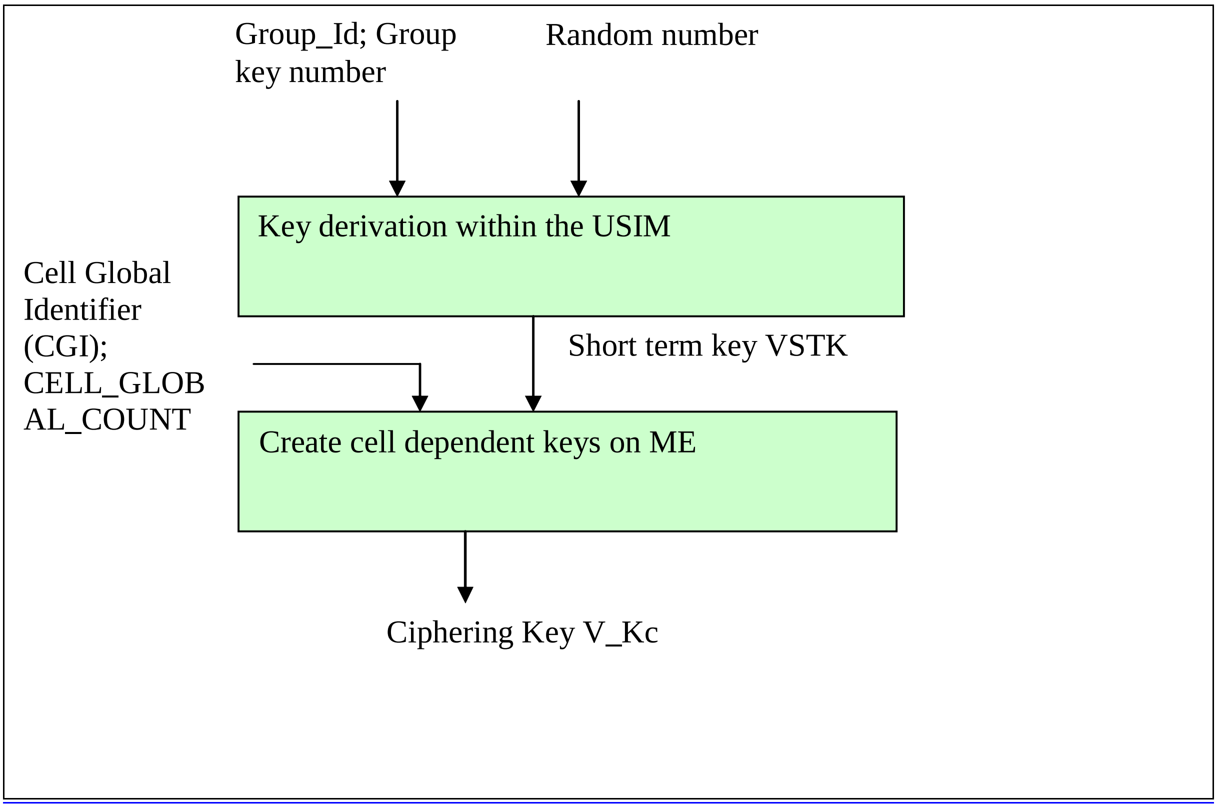
A late entrant belonging to the right Group_Id in a cell where a call is active need to pick out the notification parameters from step 5 and executes step 6.

F.4 Key derivation

The key derivation of the encryption is performed in two steps.

1. Derivation of a short term key VSTK on the GCR-side and USIM; VSTK_RAND generation on the GCR-side and sending it to the ME via the BSS for use on the USIM.

2. Derivation of the actual encryption key V_Kc in the BSS and ME.


Group_Id; Group key number
Random number
Key derivation within the USIM
Cell Global Identifier (CGI); CELL_GLOBAL_COUNT
Short term key VSTK
Create cell dependent keys on ME
Ciphering Key V_Kc

F.4.1 Key derivation within the USIM / GCR

This function is performed on

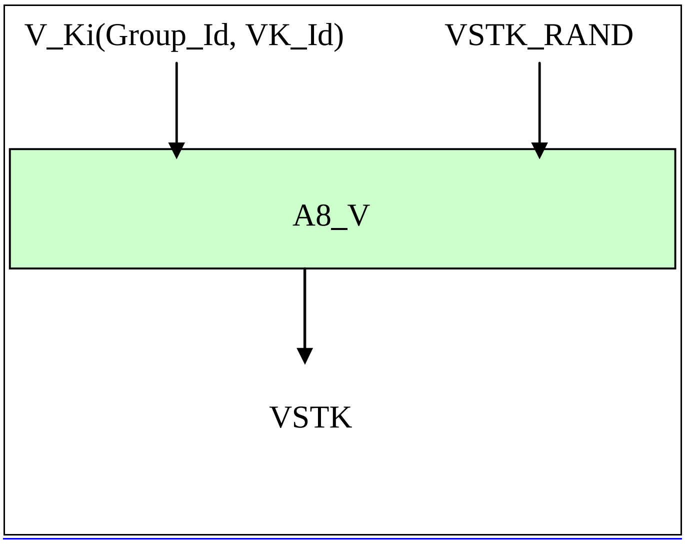
- the set-up of a voice group or broadcast call by the GCR
- entry to a voice group or broadcast call by the USIM

On the set-up of a voice group/broadcast call the GCR generates an unpredictable random number VSTK_RAND. Also an appropriate group key V_Ki (identified by VK_Id) is selected by the GCR. Using the function A8_V a short term key VSTK is derived using as input parameters:

- V_Ki (Group_Id , VK_Id)
- VSTK_RAND

Output of A8_V is

- VSTK



The GCR sends the parameters Group_Id, VK_Id, VSTK_RAND, VSTK, A5_Id via the anchor-MSC and the relay-MSC's to the BSS. The BSS signals the Group_Id, VSTK_RAND and VK_Id to the ME.

On the ME-side, each ME sends the Group_Id of the voice group, the identifier of the key VK_ID and the random number VSTK_RAND to the USIM. The USIM performs the calculation of the short term key VSTK using the function A8_V and returns it (together with the encryption algorithm identifier A5_Id).

F.4.2 Key derivation within the ME/BSS

This function is performed on

- Entry to a voice group/broadcast call
- Cell reselection
- Changing of the value of CELL_GLOBAL_COUNT
- Handover

by the ME.

On the network side the function is performed on

- Set-up of a voice group/broadcast call in a cell
- Changing of the value of CELL_GLOBAL_COUNT

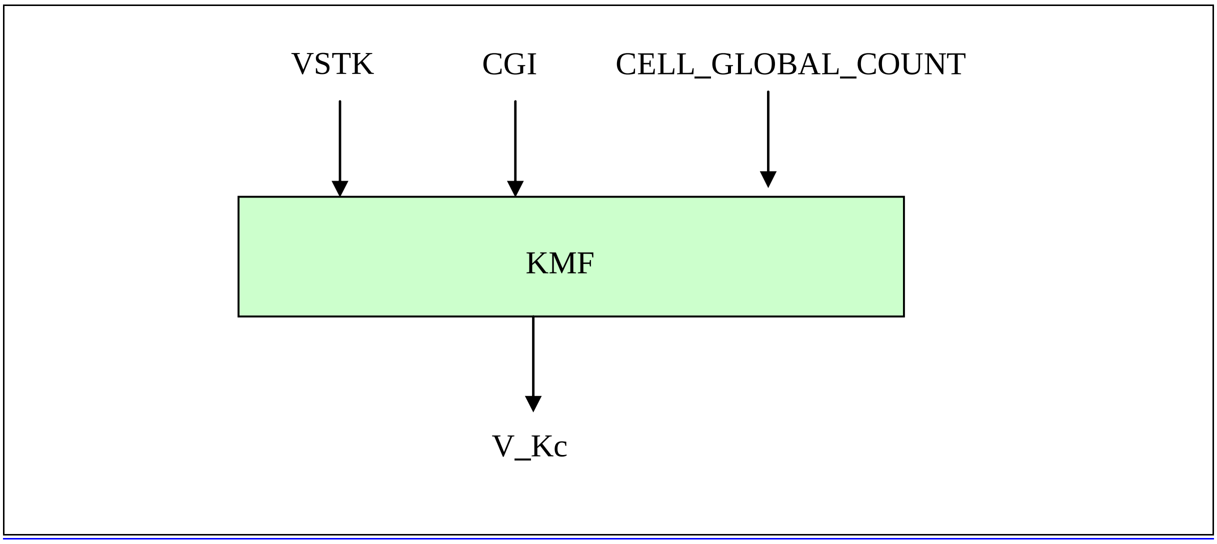
by the BSS.

For each cell the BSS and ME calculate an encryption key V_Kc using the key modification function KMF. Input parameter of the KMF are:

- VSTK: the short term key for this voice call group and this call
- CGI: the cell global identifier which identifies a cell world-wide uniquely.
- CELL_GLOBAL_COUNT: this parameter shall be incremented by the BSS when the TDMA-frame-number wraps around.

NOTE: It is an implementation issue whether the CELL_GLOBAL_COUNT is synchronised between different cells or not.

The output of the key modification function is the actually cipher key V_Kc.



To provide the required information to the ME the parameters CELL_GLOBAL_COUNT and CGI are included in various messages from the BSS to the ME (I.e. on the NCH, FACCH and PCH).

F.4.3 Encryption algorithm selection

The encryption algorithm identifier A5_Id is stored in the GCR and the USIM. For each group key V_Ki(Group_Id, i) there is a unique A5_Id.

A5_Id is transmitted from the GCR to the BSS. The ME fetches the A5_Id together with the VSTK from the USIM.

NOTE: It is possible that different algorithm identifiers are bound to different V_Ki of the same group.

NOTE: The algorithm identifier A5_Id stored in the GCR and on the USIM shall match with the encryption capabilities of the ME's used by the group and the BSS where the voice group calls are allowed to take place.

F.4.4 Algorithm requirements

F.4.3.1 A8_V

The key derivation function A8_V has the following input and output parameter:

Input Parameter:

VSTK_RAND: 32 bit random value

V_Ki (Group_Id, i): 128 bit secret key

Output:

VSTK: 128 bit short term key

A8_V is an operator specific algorithm. The calculation time for A8_V shall not exceed 500 ms.

A8_V is implemented in the GCR and on the USIM

F.4.3.1 KMF

The key derivation function KMF has the following input and output parameter:

Input Parameter:

VSTK: 128 bit random value

CGI: the cell global identifier: 56 bit ([6] TS 23.003)

CELL_GLOBAL_COUNT:4 bit

Output:

V_Kc 128 bit encryption key

The calculation time for KMF shall not exceed 100 ms.

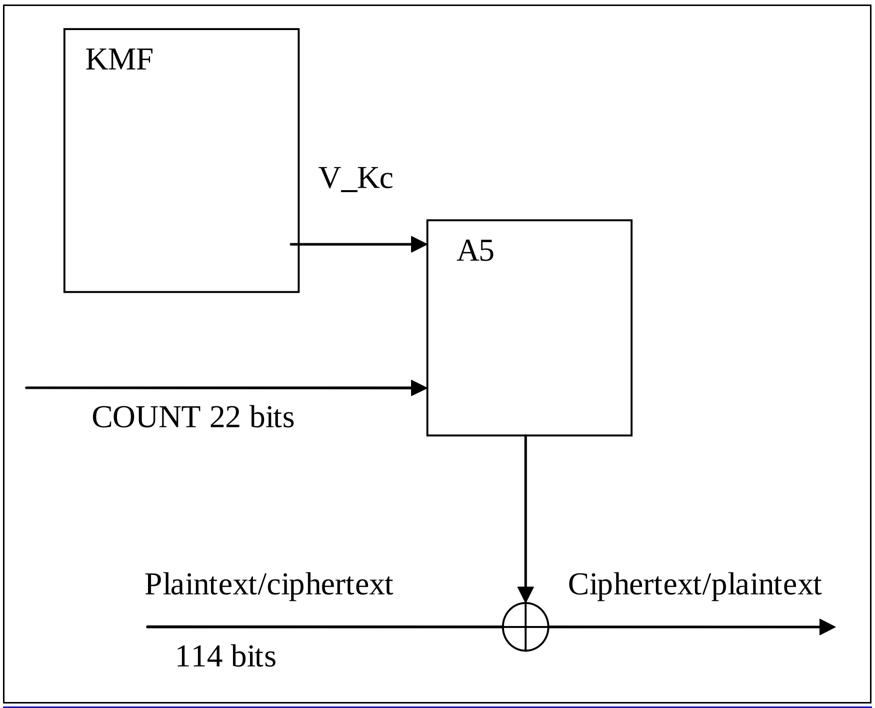
The KMF is implemented in the BSS and in the ME.

The specification of KMF can be found in Annex F.6

F.5 Encryption of voice group calls

For the encryption of a voice group call the same encryption algorithms are used as for a normal GSM speech call. Which algorithm out of the algorithm suite A5/x is used is determined by the identifier A5_Id, which is stored on the USIM (together with the group key V_Ki(Group_Id, i)). The algorithm A5/X is used in the same way as in the GSM (ref. Annex C.1) using the key V_Kc as encryption/decryption key Kc as input to A5/x .

If the key length KL of the encryption algorithm A5/X is shorter than the length of V_Kc (128 bit) then only the KL least-significant KL-bits of V_Kc are used.



F.6 Specification of the Key Modification Function (KMF)

NOTE: The definition of the KMF is left to ETSI SAGE and will be included here when available.