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| 3GPP TS 33.535 V17.0.0 (2020-12) |
| Technical Specification |
| 3rd Generation Partnership Project;Technical Specification Group Services and System Aspects;Authentication and Key Management for Applications (AKMA)based on 3GPP credentials in the 5G System (5GS)(Release 17) |
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# Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

The present document specifies the security features and mechanisms to support authentication and key management aspects for applications based on subscription credential(s) in 5G system as defined in TS 33.501 [2].

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 33.501: "Security architecture and procedures for 5G system".

[3] 3GPP TS 23.501: "System Architecture for the 5G System".

[4] 3GPP TS 33.220: "Generic Authentication Architecture (GAA); Generic Bootstrapping Architecture (GBA)".

[5] 3GPP TS 23.222: "Common API Framework for 3GPP Northbound APIs".

[6] IETF RFC 7542: "The Network Access Identifier".

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

**AKMA subscription data:** The data in the home operator's network indicating whether or not the subscriber is allowed to use AKMA.

**AKMA context:** A set of parameters stored in AAnF, including SUPI, KAKMA and A-KID.

## 3.2 Symbols

Void.

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

A-KID AKMA Key IDentifier

A-TID AKMA Temporary UE IDentifier

AAnF AKMA Anchor Function

AF Application Function

AKMA Authentication and Key Management for Applications

AMFAccess and Mobility Management Function

AUSFAUthentication Server Function

KAF AKMA Application Key

KAKMA AKMA Anchor Key

KDF Key Derivation Function

NEFNetwork Exposure Function

UDM Unified Data Management

# 4 Architecture for AKMA

## 4.1 Reference model

Figure 4.1-1 shows a fundamental network model of AKMA, as well as the interfaces between them.



Figure 4.1-1: Fundamental Network Model for AKMA

NOTE: Figure 4.1-1 shows the case where AAnF is deployed as a standalone function. Deployments can choose to collocate AAnF with AUSF or with NEF according to operators' deployment scenarios.

Figure 4.1-2 shows the AKMA architecture using the reference point representation.



Figure 4.1-2: AKMA Architecture in reference point representation for (a) internal AFs and (b) external AFs

The AKMA service requires a new logical entity, called the AKMA Anchor Function (AAnF).

## 4.2 Network elements

### 4.2.1 AAnF

The AAnF is the anchor function in the HPLMN. The AAnF stores the AKMA Anchor Key (KAKMA) for AKMA service, which is received from the AUSF after the UE completes a successful 5G primary authentication. The AAnF also generates the key material to be used between the UE and the Application Function (AF) and maintains UE AKMA contexts.

### 4.2.2 AF

The AF is defined in TS 23.501 [3] with additional functions:

- AF with the AKMA service enabling requests for AKMA Application Key, called KAF, from the AAnF using A-KID.

- AF shall be authenticated and authorized by the operator network before providing the KAF to the AF.

### 4.2.3 NEF

The NEF is defined in TS 23.501 [3] with additional functions:

- The NEF enables and authorizes the external AF assessing AKMA service and forwards the request towards the AAnF.

- The NEF performs the AAnF selection.

### 4.2.4 AUSF

The AUSF is defined in TS 23.501 [3] with additional functions:

- AUSF provides the SUPI and AKMA key material (A-KID,KAKMA) of the UE to the AAnF.

### 4.2.5 UDM

The UDM is defined in TS 23.501 [3] with the additional functions:

 - UDM stores AKMA subscription data of the subscriber.

## 4.3 AKMA Service Based Interfaces(SBIs)

### 4.3.0 General

The following interfaces are involved in AKMA network architecture:

**- Nnef:** Service-based interface exhibited by NEF.

**- Nudm:** Service-based interface exhibited by UDM.

NOTE 1: UDM services related to AKMA service are defined in TS 33.501 [2] clause 14.2.2.

**- Naanf:** Service-based interface exhibited by AAnF.

The AAnF interacts with the AUSF and the AF using Service-based Interfaces. When the AF is located in the operator's network, the AAnF shall use Service-Based Interface to communicate with the AF directly. When the AF is located outside the operator's network, the NEF shall be used to exchange the messages between the AF and the AAnF.

### 4.3.1 Void

## 4.4 Security requirements and principles for AKMA

## 4.4.0 General

The following security requirements are applicable to AKMA:

- AKMA shall reuse the same UE subscription and the same credentials used for 5G access.

- AKMA shall reuse the 5G primary authentication procedure and methods specified in TS 33.501 [2] for the sake of implicit authentication for AKMA services.

 - The SBA interface between the AAnF and the AUSF shall be confidentiality, integrity and replay protected.

- The SBA interface between AAnF and AF/NEF shall be confidentiality, integrity and replay protected.

- The AKMA Application Key (KAF) shall be provided with a maximum lifetime.

NOTE: Roaming aspects are not considered in the present document.

### 4.4.1 Requirements on Ua\* reference point

The Ua\* reference point is application specific. The generic requirements for Ua\* are:

- Ua\* protocol shall be able to carry AKMA Key Identifier (A-KID);

- the UE and the AKMA AF shall be able to secure the reference point Ua\* using the AKMA Application Key derived from the AKMA Anchor Key.

NOTE 1: The exact method of securing the reference point Ua\* depends on the application protocol used over reference point Ua\*.

NOTE 2: Specifying Ua\* protocol identifier is not considered in the present document.

- The Ua\* protocol shall be able to handle the expiration of KAF.

### 4.4.2 Requirements on AKMA Key Identifier (A-KID)

Requirements for AKMA Key Identifier (A-KID) are:

- A-KID shall be globally unique;

- A-KID shall be usable as a key identifier in protocols used in the reference point Ua\*;

- AKMA AF shall be able to identify the AAnF serving the UE from the A-KID.

## 4.5 AKMA reference points

The AKMA architecture reuses the following reference point from the 5GC for the execution of the primary authentication procedure:

**N1:** Reference point between the UE and the AMF.

**N2:** Reference point between the (R)AN and the AMF.

**N12:** Reference point between AMF and AUSF.

**N13:** Reference point between the UDM and the AUSF.

**N33:** Reference point between NEF and an external AF.

The AKMA architecture defines the following reference points:

**N61**: Reference point between the AAnF and the AUSF.

**N62**: Reference point between the AAnF and an internal AF.

**N63**: Reference point between the AAnF and NEF.

**Ua\***: Reference point between the UE and an AF.

NOTE: The reference point Ua\* carries the application protocol, which is secured using the key material agreed between UE and AAnF as a result of successful AKMA procedures.

# 5 Key management

## 5.1 AKMA key hierarchy

The key hierarchy (see Figure 5.1-1) includes the following keys: KAUSF, KAKMA, KAF. KAUSF is generated by AUSF as specified in clause 6 of TS 33.501 [2].

Keys for AAnF:

- KAKMA is a key derived by ME and AUSF from KAUSF.

Keys for AF:

- KAF is a key derived by ME and AAnF from KAKMA.

KAKMA and KAF are derived according to the procedures of clauses 6.1 and 6.2.



Figure 5.1-1: AKMA Key Hierarchy

## 5.2 AKMA key lifetimes

The KAKMA and A-KID are valid until the next successful primary authentication is performed (implicit lifetime), in which case the KAKMA and A-KID are replaced.

AKMA Application Keys KAF shall use explicit lifetimes based on the operator's policy. The lifetime of KAF shall be sent by the AAnF as described in clauses 6.2 and 6.3. In case that a new AKMA Anchor Key KAKMA is established, the AKMA Application Key KAF can continue to be used until its lifetime expires. When the KAF lifetime expires, a new AKMA Application Key is established based on the current AKMA Anchor Key KAKMA.

# 6 AKMA Procedures

## 6.1 Deriving AKMA key after primary authentication

There is no separate authentication of the UE to support AKMA functionality. Instead, AKMA reuses the 5G primary authentication procedure executed e.g. during the UE Registration to authenticate the UE. A successful 5G primary authentication results in KAUSF being stored at the AUSF and the UE. Figure 6.1-1 shows the procedure to derive KAKMA after a successful primary authentication.



Figure 6.1-1: Deriving KAKMA after primary authentication

1) During the primary authentication procedure, the AUSF interacts with the UDM in order to fetch authentication information such as subscription credentials (e.g. AKA Authentication vectors) and the authentication method using the Nudm\_UEAuthentication\_Get Request service operation.

2) In the response, the UDM may also indicate to the AUSF whether AKMA Anchor keys need to be generated for the UE.

3) If the AUSF receives the AKMA indication from the UDM, the AUSF shall store the KAUSF and generate the AKMA Anchor Key (KAKMA) and the A-KID from KAUSF after the primary authentication procedure is successfully completed.

The UE shall generate the AKMA Anchor Key (KAKMA) and the A-KID from the KAUSF before initiating communication with an AKMA Application Function.

4) After AKMA key material is generated, the AUSF shall send the generated A-KID, and KAKMA to the AAnF together with the SUPI of the UE using the Naanf\_AKMA\_KeyRegistration Request service operation. The AAnF shall store the latest information sent by the AUSF.

NOTE 1: The AUSF need not store any AKMA key material after delivery to the AAnF.

NOTE 1a: When re-authentication runs, the AUSF generates a new A-KID, and a new KAKMA and sends the new generated A-KID and KAKMA to the AAnF. After receiving the new generated A-KID and KAKMA, the AAnF deletes the old A-KID and KAKMA and stores the new generated A-KID and KAKMA.

5) The AAnF sends the response to the AUSF using the Naanf\_AKMA\_AnchorKey\_Register Response service operation.

A-KID identifies the KAKMA key of the UE.

A-KID shall be in NAI format as specified in clause 2.2 of IETF RFC 7542 [6], i.e. username@realm. The username part shall include the Routing Identifier and the A-TID (AKMA Temporary UE Identifier), and the realm part shall include Home Network Identifier.

The A-TID shall be derived from KAUSF as specified in Annex A.3.

NOTE 2: The chance of A-TID collision is not zero but practically low as the A-TID derivation is based on KDF specified in Annex B of TS 33.220 [4]. The detection of A-TID collision as well as potential handling of collision is not addressed in the present document.

KAKMA shall be derived from KAUSF as specified in Annex A.2. Since KAKMA and A-TID in A-KID are both derived from KAUSF based on primary authentication run, the KAKMA and A-KID can only be refreshed by a new successful primary authentication.

## 6.2 Deriving AKMA Application Key for a specific AF

Figure 6.2-1 shows the procedure used by the AF to request application function specific AKMA keys from the AAnF, when the AF is located inside the operator's network.



Figure 6.2-1: KAF generation from KAKMA

Before communication between the UE and the AKMA AF can start, the UE and the AKMA AF needs to know whether to use AKMA. This knowledge is implicit to the specific application on the UE and the AKMA AF or indicated by the AKMA AF to the UE (see clause 6.5).

1. The UE shall generate the AKMA Anchor Key (KAKMA) and the A-KID from the KAUSF before initiating communication with an AKMA Application Function. When the UE initiates communication with the AKMA AF, it shall include the derived A-KID (see clause 6.1) in the Application Session Establishment Request message. UE may derive KAF before sending the message or afterwards.

2. If the AF does not have an active context associated with the A-KID, then the AF sends a Naanf\_AKMA\_ApplicationKey\_Get request to AAnF with the A-KID to request the KAF for the UE. The AF also includes its identity (AF\_ID) in the request.

AF\_ID consists of the FQDN of the AF and the Ua\* security protocol identifier. The latter parameter identifies the security protocol that the AF will use with the UE.

The AAnF shall check whether the AAnF can provide the service to the AF based on the configured local policy or based on the authorization information or policy provided by the NRF using the AF\_ID. If it succeeds, the following procedures are executed. Otherwise, the AAnF shall reject the procedure.

The AAnF shall verify whether the subscriber is authorized to use AKMA based on the presence of the UE specific KAKMA key identified by the A-KID.

 If KAKMA is present in AAnF, the AAnF shall continue with step 3.

 If KAKMA is not present in the AAnF, the AAnF shall continue with step 4 with an error response.

3. The AAnF derives the AKMA Application Key (KAF) from KAKMA if it does not already have KAF.

 The key derivation of KAF shall be performed as specified in Annex A.4.

4. The AAnF sends Naanf\_AKMA\_ApplicationKey\_Get response to the AF with KAF and the KAF expiration time.

5. The AF sends the Application Session Establishment Response to the UE. If the information in step 4 indicates failure of AKMA key request, the AF shall reject the Application Session Establishment by including a failure cause. Afterwards, UE may trigger a new Application Session Establishment request with the latest A-KID to the AKMA AF.

## 6.3 AKMA Application Key request via NEF

Figure 6.3-1 shows the procedure used by the AF to request KAF from the AAnF via NEF, when the AF is located outside the operator's network.



Figure 6.3-1: AKMA Application Key request via NEF

1. When the AF is about to request AKMA Application Key for the UE from the AAnF, e.g. when UE initiates application session establishment request as in clause 6.2, the AF discovers the HPLMN of the UE based on the A-KID and sends the request towards the AAnF via NEF service API. The request shall include the A-KID and the AF\_ID.

NOTE: In the case of architecture without CAPIF support, the AF is locally configured with the API termination points for the service. In the case of architecture with CAPIF support, the AF obtains the service API information from the CAPIF core function via the Availability of service APIs event notification or Service Discover Response as specified in TS 23.222 [5].

2. If the AF is authorized by the NEF to request KAF, the NEF discovers and selects an AAnF based on local configuration or via NRF in the same way as the AF selects the AAnF in clause 6.2.

3. The NEF forwards the KAF request to the selected AAnF.

4. The AAnF generates the KAF as specified in clause 6.2 and sends the response to the NEF with the KAF, the KAF expiration time (KAFexptime) and potentially other parameters.

5. The NEF forwards the response to the AF.

Editor's Note: Whether other parameters are to be returned to the AF via NEF is FFS.

## 6.4 AKMA key change

### 6.4.1 KAKMA re-keying

KAKMA shall be re-keyed by running a successful primary authentication as described in clause 6.1.

### 6.4.2 KAF re-keying

The KAF re-keying depends on the lifetime of the KAF and may be trigged by the AF, which means that when a new KAKMA is derived, the KAF will not be re-keyed automatically.

When the lifetime of KAF expires, the AF may reject UE’s access to the AF or refresh the KAF as description in clause 6.4.3 based on its policy. If there has been a change of KAUSF (e.g., due to a successful run of primary authentication), the UE may re-try accessing the AF by using the A-KID derived from the new KAUSF .

### 6.4.3 KAF refresh

Ua\* protocol may support refresh of KAF. If the Ua\* protocol supports refresh of KAF, the AF may refresh the KAF at any time using the Ua\* protocol.

## 6.5 Initiation of AKMA

In case when the UE does not know to use AKMA for a service, then the following procedure shown in figure 6.5-1 applies.



Figure 6.5-1: Initiation of AKMA

1. The UE may start communication over reference point Ua\* with the AF with or without any AKMA-related parameters.

2. If the AF requires the use of shared keys obtained by means of the AKMA, but the request from UE does not include AKMA-related parameters, the AF replies with an AKMA initiation message. The form of this initiation message may depend on the particular reference point Ua\*.

In case the UE knows to use AKMA for a service, then it directly initiates the procedure in clause 6.2.

# 7 Security related services

## 7.1 Services provided by AAnF

### 7.1.1 General

The following table shows the AAnF Services and AAnF Service Operations.

Table 7.1.1-1: List of AAnF Services

|  |  |  |  |
| --- | --- | --- | --- |
| Service Name | Service Operations | OperationSemantics | Example Consumer(s) |
| Naanf\_AKMA | AnchorKey\_Register | Request/Response | AUSF |
| ApplicationKey\_Get | Request/Response | AF, NEF |

### 7.1.2 Naanf\_AKMA\_AnchorKey\_Register service operation

**Service operation name:** Naanf\_AKMA\_AnchorKey\_Register.

**Description:** The NF consumer requests the AAnF to store the AKMA related key material.

**Input, Required:** SUPI, A-KID, KAKMA

**Input, Optional:** None.

**Output, Required:** None.

**Output, Optional:** None.

## 7.2 Void

## 7.3 Services provided by NEF

### 7.3.1 General

The NEF exposes AKMA Application Key derivation service to the requester NF.

The following table shows the NEF Services and NEF Service Operations related to AKMA service.

Table 7.1.1-1: List of AAnF Services

|  |  |  |  |
| --- | --- | --- | --- |
| Service Name | Service Operations | OperationSemantics | Example Consumer(s) |
| Nnef\_AKMA | ApplicationKey\_Get | Request/Response | AF |

### 7.3.2 Nnef\_AKMA\_ApplicationKey\_Getservice operation

**Service operation name:** Nnef\_AKMA\_ApplicationKey\_Get.

**Description:** The NF consumer requests the NEF to provide AF related key material.

**Input, Required:** A-KID, AF\_ID

**Input, Optional:** None.

**Output, Required:** KAF, KAF expiration time.

**Output, Optional:** None.

## 7.4 Services provided by UDM

UDM services related to AKMA service are defined in TS 33.501 [2] clause 14.2.2.

Annex A (normative):
Key derivation functions

# A.1 KDF interface and input parameter construction

## A.1.1 General

All key derivations for AKMA shall be performed using the key derivation function (KDF) specified in Annex B.2.2 of TS 33.220 [4].

This clause specifies how to construct the input string, S, and the input key, KEY, for each distinct use of the KDF. Note that "KEY" is denoted "Key" in TS 33.220 [4].

## A.1.2 FC value allocations

The FC number space used is controlled by TS 33.220 [4], FC values allocated for the present document are in the range of 0x80 – 0x82.

# A.2 KAKMA derivation function

When deriving a KAKMA from KAUSF, the following parameters shall be used to form the input S to the KDF:

- FC = 0x80;

- P0 = "AKMA";

- L0 = length of "AKMA"; (i.e. 0x00 0x04)

- P1 = SUPI;

- L1 = length of SUPI.

The input key KEY shall be KAUSF.

SUPI shall be have the same value as parameter P0 in Annex A.7.0 of TS 33.501 [2].

# A.3 A-TID derivation function

When deriving the A-TID from KAUSF, the following parameters shall be used to form the input S to the KDF:

- FC = 0x81;

- P0 = "A-TID";

- L0 = length of "A-TID"; (i.e. 0x00 0x05)

- P1 = SUPI;

- L1 = length of SUPI.

The input key KEY shall be KAUSF.

SUPI shall be have the same value as parameter P0 in Annex A.7.0 of TS 33.501 [2].

# A.4 KAF derivation function

When deriving a KAF from KAKMA, the following parameters shall be used to form the input S to the KDF:

- FC = 0x82;

- P0 =AF\_ID;

- L0 = length of AF\_ID

The input key KEY shall be KAKMA.

AF\_ID is constructed as follows:

AF\_ID = FQDN of the AF || Ua\* security protocol identifier, where the Ua\* security protocol identifier is specified as Ua security protocol identifier in Annex H of TS 33.220 [4].

Annex B (informative):
Change history

|  |
| --- |
| **Change history** |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2020-06 | SA#88-e | SP-200381 |  |  |  | EditHelp review.Presented for information and approval | 1.0.0 |
| 2020-07 | SA#88-e |  |  |  |  | Upgrade to change control version | 16.0.0 |
| 2020-09 | SA#89-e | SP-200708 | 0001 | - | D | Add Abbreviations to clause 3.3 | 16.1.0 |
| 2020-09 | SA#89-e | SP-200708 | 0009 | 1 | F | Clarifications on error response handling in AKMA process | 16.1.0 |
| 2020-09 | SA#89-e | SP-200708 | 0013 | 1 | F | Re-authentication in AKMA | 16.1.0 |
| 2020-09 | SA#89-e | SP-200708 | 0020 | - | F | Adding AKMA context description | 16.1.0 |
| 2020-09 | SA#89-e | SP-200708 | 0023 | 1  | F | Corrections and clarifications to clause 4  | 16.1.0 |
| 2020-09 | SA#89-e | SP-200708 | 0024 | 1  | F | Corrections to AKMA key lifetimes  | 16.1.0 |
| 2020-09 | SA#89-e | SP-200708 | 0025 | 1  | F | Corrections and clarifications to AKMA procedures | 16.1.0 |
| 2020-09 | SA#89-e | SP-200708 | 0026 | 1 | F | Assignment of FC values for key derivations | 16.1.0 |
| 2020-09 | SA#89-e | SP-200708 | 0027 | - | F | Specification of value of SUPI for key derivations | 16.1.0 |
| 2020-09 | SA#89-e | SP-200708 | 0032 | 1 | F | AKMA SBA interface clarifications | 16.1.0 |
| 2020-09 | SA#89-e | SP-200708 | 0034 | 1 | F | Several clarifications and editorials | 16.1.0 |
| 2020-12 | SA#90e | SP-201006 | 0043 | - | F | Lifetime of KAF expiration | 16.2.0 |
| 2020-12 | SA#90e | SP-201006 | 0045 | - | F | Corrections of clause 6.1 | 16.2.0 |
| 2020-12 | SA#90e | SP-201006 | 0046 | - | F | Editorial modifications of AKMA | 16.2.0 |
| 2020-12 | SA#90e | SP-201006 | 0053 | 1 | F | Update of the reference point interface names of AKMA | 16.2.0 |
| 2020-12 | SA#90e | SP-201006 | 0047 | - | F | Adding details of AKMA application key generation in the UE | 17.0.0 |