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| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group Services and System Aspects;  Study on 3GPP Cryptographic Inventory  (Release 19) | |
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# Foreword

This Technical Report 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 lists the security protocols that use cryptography in 3GPP specifications for the 5G System in the Standalone mode. They

* include the type of cryptography used by the protocol (symmetric/asymmetric)
* include the pointers to the protocol specification
* include the pointers to the relevant 3GPP cryptographic profiles
* include usage type (e.g., integrity, confidentiality, and/or authentication)

NOTE: the present document does not include resolution to PQC migration, and does not contain solutions that lead to any specification/normative work.

# 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 33.210: "3G security; Network Domain Security (NDS); IP network layer security".

[3] 3GPP TS 33.310: "Network Domain Security (NDS); Authentication Framework (AF)".

[4] 3GPP TS 33.501: “Security architecture and procedures for 5G system”.

[5] IETF RFC 9190: "EAP-TLS 1.3: Using the Extensible Authentication Protocol with TLS 1.3".

[6] IETF RFC 5216, "The EAP-TLS Authentication Protocol",

[7] SECG SEC 1: “Recommended Elliptic Curve Cryptography”, Version 2.0, 2009. Available <http://www.secg.org/sec1-v2.pdf>

[8] SECG SEC 2: “Recommended Elliptic Curve Domain Parameters”, Version 2.0, 2010. Available at <http://www.secg.org/sec2-v2.pdf>

[9] IETF RFC 9001: "Using TLS to Secure QUIC".

[10] IETF RFC 8152: "CBOR Object Signing and Encryption (COSE)".

[11] 3GPP TS 33.220: “Generic Authentication Architecture (GAA); Generic Bootstrapping Architecture (GBA)”

[12] IETF RFC 8613: "Object Security for Constrained RESTful Environments (OSCORE)".

[13] 3GPP TS 33.180: "Security of the Mission Critical (MC) service".

[14] IETF RFC 6509: ''MIKEY-SAKKE: Sakai-Kasahara Key Encryption in Multimedia Internet KEYing (MIKEY)''

[15] IETF RFC 5448: "Improved Extensible Authentication Protocol Method for 3rd Generation Authentication and Key Agreement (EAP-AKA')".

[16] 3GPP TS 35.205: "3G Security; Specification of the MILENAGE algorithm set: An example algorithm set for the 3GPP authentication and key generation functions f1, f1\*, f2, f3, f4, f5 and f5\*".

[17] 3GPP TS 35.231: "Specification of the TUAK algorithm set: A second example algorithm set for the 3GPP authentication and key generation functions f1, f1\*, f2, f3, f4, f5 and f5\*; Document 1: Algorithm specification".

[18] 3GPP TS 35.234: "Specification of the MILENAGE-256 algorithm set; An example set of 256-bit 3GPP authentication and key generation functions f1, f1\*, f2, f3, f4, f5, f5\* and f5\*\*; Document 1: General".

# 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 TR 21.905 [1].

**example:** text used to clarify abstract rules by applying them literally.

## 3.2 Symbols

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

<symbol> <Explanation>

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 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 TR 21.905 [1].

BSF Bootstrapping Server Function

CBOR Concise Binary Object Representation

COSE CBOR Object Signing and Encryption

ECDSA Elliptic Curve Digital Signature Algorithm

KDF Key Derivation Function

MPQUIC Multipath QUIC

OCSP Online Certificate Status Protocol

OSCORE Object Security for Constrained RESTful Environments

PKI Public Key Infrastructure

QUIC Quick UDP Internet Connections

REST Representational State Transfer

SECG Standards for Efficient Cryptography

SUPI Subscription Permanent Identifier

TLS Transport Layer Security

UDP User Datagram Protocol

# 4 3GPP Cryptographic Inventory – 5G System

## 4.1 General

This clause provides inventory of security protocols that use cryptography in 3GPP specifications for 5G systems (limited to the standalone mode). The clause 4.2 and 4.3 present inventory in table formats whereas the detailed protocol list is described in 4.4.

## 4.2 3GPP Symmetric Cryptographic Algorithms

Editor’s Note: The current table is for example and placeholder purposes. It would be revised/refined onces the detailed protocol list description has been agreed.

The following table summarizes the security related protocols used in 3GPP employing symmetric cryptographic algorithms including hash functions (5G System).

Table 4.2-1: Protocols Used in 3GPP Employing Symmetric Cryptographic Algorithms (5G System)

|  |  |  |  |
| --- | --- | --- | --- |
| Protocol/Function | Protocol Profile, Clause | Cryptographic Algorithm(s) | Feature(s), Usage Type |
| e.g., PDCP (TS 38.323[]) | TS 33.501 [4] | 128-NxA1 | Confidentiality and Integrity Protection |
|  |  | 128-NxA2 | Confidentiality and Integrity Protection |
|  |  |  |  |

## 4.3 3GPP Asymmetric Cryptographic Algorithms

Editor’s Note: The current table is for example and placeholder purposes. It would be revised/refined onces the detailed protocol list description has been agreed.

The following table summarizes the security related protocols used in 3GPP employing asymmetric cryptographic algorithms (5G System).

Table 4.3-1: Protocols Used in 3GPP Employing Asymmetric Cryptographic Algorithms (5G System)

|  |  |  |  |
| --- | --- | --- | --- |
| Protocol/Function | Protocol Profile/Clauses | Cryptographic Algorithm(s) | Feature(s), Usage Type |
| e.g., TLS (IETF RFC 8446) | TS 33.210 [2] | ECDHE (IETF RFC 8996) | Key Agreement |
|  |  | RSA (IETF RFC 8017) | Digital Signature and Authentication |
|  |  |  |  |

## 4.4 Detailed Protocol List

Editor’s Note: This detailed protocol list is expected to finalize first.

### 4.4.1 DTLS

DTLS is used in 5G system in standalone mode to protect the following:

* N2 interface (see clause 9.2 of TS 33.501 [4]).
* Xn interface (see clause 9.4 of TS 33.501 [4]).
* DIAMETER or GTP-based interfaces (see clause 9.5 of TS 33.501 [4]).
* gNB internal interfaces (see clause 9.8 of TS 33.501 [4]).

Security profiles for DTLS implementation and usage in 3GPP are given in clause 6.2 of TS 33.210 [2] and the certificate profile is given in clause 6.1.3a of TS 33.310 [3].

DTLS employs symmetric cryptography for confidentiality and integrity protection.

DTLS employs asymmetric cryptography for digital signature and key agreement.

### 4.4.2 TLS

TLS is used in 5G system in standalone mode to protect the following:

* NIDD interfaces (see clause 6.16.3 of TS 33.501 [4]).
* DIAMETER or GTP-based interfaces (see clause 9.5 of TS 33.501 [4]).
* NEF – AF interface (see clauses 12.2 and 12.3 of TS 33.501 [4]).
* Interfaces between network functions (see clauses 13.1, 13.2, 13.5 of TS 33.501 [4]).
* N32 interface (see clause 13.2 of TS 33.501 [4]).
* Network slice management interfaces (see clauses 15.2 and 15.3 of TS 33.501 [4]).
* Message Service interfaces for MIoT over the 5G System (see clauses Y.2 – Y.4 of TS 33.501 [4]).

Security profiles for TLS implementation and usage in 3GPP are given in clause 6.2 of TS 33.210 [2] and the certificate profile is given in clause 6.1.3a of TS 33.310 [3].

TLS employs symmetric cryptography for confidentiality and integrity protection.

TLS employs asymmetric cryptography for digital signature and key agreement.

### 4.4.3 EAP-TLS

EAP-TLS [5][6] is used in 5G system in standalone mode to realise the following:

* Mutual authentication between UE and AUSF (see Annex B of TS 33.501 [4])
* Mutual authentication between UE and AAA (see Annex I of TS 33.501 [4])
* Mutual authentication between UE and AUSF (see Annex I of TS 33.501 [4])
* Mutual authentication between N5GC and AUSF (see Annex O of TS 33.501 [4])

The 3GPP TLS protocol profile related to supported TLS versions and supported TLS cipher suites in 3GPP networks is specified in clause 6.2 of TS 33.210 [2]. The 3GPP profile of TLS certificates is specified in clause 6.1.3a of TS 33.310 [3].

EAP-TLS employs asymmetric cryptography for authentication and key agreement.

EAP-TLS employs symmetric cryptography for authentication and key agreement.

EAP-TLS employs hash function for session key derivation.

### 4.4.4 ECIES

ECIES is used in 5G system in standalone mode for the following:

* Confidentiality and Integrity Protection of the SUPI (see Annex C.3 of TS 33.501 [4]).

The ECIES profiles follow the terminology and processing specified in SECG version 2 [7] and [8]. The security profiles for the ECIES implementation and usage in 3GPP is given in clause C.3.4 of TS 33.501 [4].

ECIES employs asymmetric cryptography for the key agreement of the symmetric keys.

ECIES employs symmetric cryptography for the confidentiality and integrity protection of the SUPI.

### 4.4.5 PKI

PKI is used in 5G system in standalone mode for the following:

* Issuing of X.509 certificates (see Clause 4 of TS 33.310 [3]).
* PKI architecture for NDS/AF (see Clause 5.1 of TS 33.310 [3]).

PKI employs asymmetric cryptography for certificate signing and verification.

PKI employs hash function for computation of digests.

### 4.4.6 Online Certificate Status Protocol (OCSP)

Online Certificate Status Protocol (OCSP) is used in 5G system in standalone mode for the following:

* OSCP and the related profiles (see Clause 6.1b of TS 33.310 [3]).
* TLS profiles for TLS certificate status request extension, i.e., OCSP stapling (see Clause 6 of TS 33.210 [2]).
* Introduction to Revocation of subscriber certificates (see Clause B.2.2 of TS 33.501 [4]).

OCSP employs asymmetric cryptography for digital signing and signature verification.

OSCP employs hash algorithms for computation of digests.

### 4.4.7 QUIC and MPQUIC

The QUIC and MPQUIC are used in 5G system in standalone mode for the following:

* Security of the QUIC connection between UPF and AS proxy (see Clause 18 of TS 33.501 [4]).
* Multipath QUIC (MPQUIC) steering functionality is used for ATSSS (see Clause AA of TS 33.501 [4]).

For the QUIC establishment, the RFC 9001 [9] mandates the use of TLS, therefore please refer to the corresponding TLS clause of this technical report.

### 4.4.8 CBOR Object Signing and Encryption (COSE)

The COSE [10] is used in 5G system in standalone mode for the following:

* OSCORE [12] for cryptographic algorithm selection between UE and BSE (reference point Ua) (see Clause P.3.3 of TS 33.220 [11]).

COSE employs asymmetric cryptography for digital signature and key agreement.

COSE employs symmetric cryptography for confidentiality and integrity protection.

COSE employs hash functions for session key derivation.

### 4.4.9 MIKEY-SAKKE

MIKEY-SAKKE is used in the 5G system to securely transport cryptographic keys for Mission Critical Services. It is used in the following scenarios:

* Group Master Keys (GMKs) from a Group Management Server to a Group Management Client on a MC UE (see Annex E clause E.2 TS 33.180 [13])
* Private Call Keys (PCKs) between MC UEs (see Annex E clause E.3 TS 33.180 [13])
* Client-Server keys (CSKs) between MCX Server and MC client (see Annex E clause E.3 TS 33.180 [13])
* Multicast Signalling Keys (MuSiK) from MCX Servers to MC clients (see Annex E clause E.3 TS 33.180 [13])

Security profiles for MIKEY-SAKKE are left for implementation.

MIKEY-SAKKE is specified in IETF RFC 6509 [14]

MIKEY-SAKKE employs asymmetric cryptography for key distribution.

### 4.4.10 IKEv2

IKEv2 protocol is used to perform authentication and setup Security Associations (SA) for IPsec tunnels. The IPsec ESP protocol is described in clause 4.4.15.

IKEv2 is used in 5G system to provide security for the following:

- Untrusted non-3GPP access to the 5G core network (see clause 7 of TS 33.501 [4]) and trusted non-3GPP access to the 5G core network (see clause 7 of TS 33.501 [4])

- IP based interfaces for 5GC and 5G-AN according to NDS/IP (see clause 9 of TS 33.501 [4])

- N2 interface between the AMF and the 5G-AN (see clause 9.2 of TS 33.501 [4])

- N3 interface between the UPF and 5G-AN (see clause 9.3 of TS 33.501 [4])

- Xn interface between 5G-AN (see clause 9.4 of TS 33.501 [4])

- F1 and E1 of the gNB internal interfaces (see clause 9.8 of TS 33.501 [4])

- Non-SBA interfaces internal to 5GC and between PLMNs (see clause 9.9 of TS 33.501 [4])

- F1 interface between the IAB-node (gNB-DU) and the IAB-donor-CU (see clause M3.3 and M5 of TS 33.501 [4])

Security profiles for IKEv2 implementation and usage in 3GPP are given in clauses 5.2, 5.4, and 5.6 of TS 33.210 [2] and clauses 5, 6.2, and 7.5 of TS 33.310 [3].

IKEv2 employs symmetric cryptography for confidentiality and integrity protection.

IKEv2 employs asymmetric cryptography for digital signature and key agreement.

IKEv2 employs both symmetric cryptography and asymmetric cryptography for authentication.

### 4.4.11 PDCP security

The PDCP security protocol between the UE and the NG-RAN is responsible for the security protection of the following scenarios in 5G system:

* RRC integrity and confidentiality protection between UE and gNB (see clause 6.5.1 and 6.5.2 of TS 33.501 [4])
* User plane data integrity and confidentiality protection between UE and gNB (see clause 6.6.3 and 6.6.4 of TS 33.501 [4]).

PDCP security protocol employs symmetric cryptography for confidentiality and integrity protection.

### 4.4.12 NAS security

The NAS security mechanisms is to protect NAS signaling and data between the UE and the AMF over the N1 reference point in 5G system:

* NAS signaling integrity and confidentiality protection between UE and AMF (see clause 6.4.3 and 6.4.4 of TS 33.501 [4]).
* User plane data (SMS over NAS) integrity and confidentiality protection between UE and AMF (see clause 6.4.7 and 6.16 of TS 33.501 [4]).

NAS security protocol employs symmetric cryptography for confidentiality and integrity protection.

### 4.4.13 EAP-AKA’

EAP-AKA’ enables mutual authentication between the UE and AUSF and provides keying material that can be used between the UE and the serving network in subsequent security procedures.

The long term key K and the SUPI are preconfigured in the USIM (in the UE) and in the UDM/ARPF.

EAP-AKA' is specified in RFC 5448 [15].

The 3GPP 5G profile for EAP-AKA' is specified in the normative Annex F of TS 33.501 [4].

KDF for key generation is HMAC-SHA-256 as per Annex B.2.0 of TS 33.220 [11].

EAP-AKA’ requires functions as described for 128 Bit MILENAGE in TS 35.205 [16], 128 Bit or 256 Bit TUAK in TS  35.231 [17] and in TS 35.234 [18] for 256 Bit MILENAGE.

EAP-AKA’ employs symmetric cryptography for authentication and key agreement.

EAP-AKA’ employs hash function for session key derivation.

### 4.4.14 5G-AKA

5G-AKA enables mutual authentication between the UE and AUSF with proof of successful authentication of the UE from the visited network. 5G-AKA provides keying material that can be used between the UE and the serving network in subsequent security procedures.

The long term key K and the SUPI are preconfigured in the USIM (in the UE) and in the UDM/ARPF.

5G-AKA is specified in TS 33.501 [4].

KDF for key generation is HMAC-SHA-256 as per Annex B.2.0 of TS 33.220 [11].

5G-AKA requires functions as described for 128 Bit MILENAGE in TS 35.205 [16], 128 Bit or 256 Bit TUAK in TS  35.231 [17] and in TS 35.234 [18] for 256 Bit MILENAGE.

5G-AKA employs symmetric cryptography for authentication and key agreement.

5G-AKA employs hash function for session key derivation.

### 4.4.15 IPsec ESP

IPsec ESP is used in 5G system to provide security for the following:

* Untrusted non-3GPP access to the 5G core network (see clause 7 of TS 33.501 [4]) and trusted non-3GPP access to the 5G core network (see clause 7 of TS 33.501 [4])
* IP based interfaces for 5GC and 5G-AN according to NDS/IP (see clause 9 of TS 33.501 [4])
* N2 interface between the AMF and the 5G-AN (see clause 9.2 of TS 33.501 [4])
* N3 interface between the UPF and 5G-AN (see clause 9.3 of TS 33.501 [4])
* Xn interface between 5G-AN (see clause 9.4 of TS 33.501 [4])
* F1 and E1 of the gNB internal interfaces (see clause 9.8 of TS 33.501 [4])
* Non-SBA interfaces internal to 5GC and between PLMNs (see clause 9.9 of TS 33.501 [4])
* F1 interface between the IAB-node (gNB-DU) and the IAB-donor-CU (see Annex M3.3 and M5 of TS 33.501 [4])
* Policy discrimination of GTP-C, GTP-U and protection of GTP-C transport protocol (see Annex B of TS 33.210 [2])

- Protection of IMS protocols and interfaces for all SIP signalling traversing inter-security domain boundaries. (see Annex C of TS 33.210 [2])

- Protection of UTRAN/GERAN IP transport protocols and interfaces for all RANAP and RNSAP messages traversing inter-security domain boundaries. (see Annex D of TS 33.210 [2])

Security profile for IPsec ESP implementation in 3GPP are given in clause 5.3 of TS 33.210 [2].

IPSec ESP employs symmetric cryptography for confidentiality, integrity and replay protection.

Keying happens using IKEv2 (Internet Key Exchange Protocol Version 2 (IKEv2) as mentioned in clause 4.4.10.

### 4.4.16 Key Derivation Function (KDF)

The KDF is used in 5G system in standalone mode and is defined in the normative Annex A of TS 33.501 [4].

* The generic KDF for the purpose of a cryptographic key computation is specified in the normative Annex B.2 of TS 33.220 [11].

The KDF employs hash function for key derivation.

### 4.4.17 JWE and JWS

JSON Web Encryption (JWE) and/or JSON Web Signature (JWS) are used in 5G system in standalone mode to protect the following:

* N32 interface (see clause 13.2 of TS 33.501 [4]).
* NF service access (see clause 13.4 of TS 33.501 [4]).

Profiles for JWE/JWS implementation and usage in 3GPP are given in clause 6.3 of TS 33.210 [2].

JWE/JWS employ symmetric cryptography for confidentiality and integrity protection.

JWE/JWS employ asymmetric cryptography for digital signature and key agreement.

# Annex A (informative): Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Change history | | | | | | | |
| Date | Meeting | TDoc | CR | Rev | Cat | Subject/Comment | New version |
| 2025-02 | SA3#120 | S3-250401 |  |  |  | TR 33.938 skeleton | 0.0.0 |
| 2025-02 | SA3#120 | S3-250977 |  |  |  | Incorporate pCRs from S3‑250402, S3-251072, S3-251073, S3-251074 | 0.1.0 |
| 2025-04 | SA3#121 | S3-251710 |  |  |  | Incorporate pCRs from S3‑251767, S3‑251768, S3‑251769, S3‑251770, S3‑251771, S3‑251772, S3‑251774, S3‑251775, S3‑251776, S3‑251777, S3‑251778, S3‑251522, S3‑251779, S3‑251592, S3‑251780 | 0.2.0 |