**3GPP TSG-SA3 Meeting #116 *S3-242172***

**Jeju, South Korea, 20 – 24 May 2024**  (revision of S3-yyxxxx)

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| **CHANGE REQUEST** |
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|  | **33.501** | **CR** | **2008** | **rev** |  | **Current version:** | **18.5.0** |  |
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| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* |
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| ***Proposed change affects:*** | UICC apps |  | ME |  | Radio Access Network |  | Core Network | **X** |

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|  |
| ***Title:***  | Modification on the name of IPX, roaming intermediary, Roaming Hub, etc. |
|  |  |
| ***Source to WG:*** | Huawei, HiSilicon |
| ***Source to TSG:*** | S3 |
|  |  |
| ***Work item code:*** | Roaming5G |  | ***Date:*** | 2024-04-29 |
|  |  |  |  |  |
| ***Category:*** | **D** |  | ***Release:*** | Rel-18 |
|  | *Use one of the following categories:****F*** *(correction)****A*** *(mirror corresponding to a change in an earlier release)****B*** *(addition of feature),* ***C*** *(functional modification of feature)****D*** *(editorial modification)*Detailed explanations of the above categories canbe found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | *Use one of the following releases:Rel-8 (Release 8)Rel-9 (Release 9)Rel-10 (Release 10)Rel-11 (Release 11)…Rel-15 (Release 15)Rel-16 (Release 16)Rel-17 (Release 17)Rel-18 (Release 18)* |
|  |  |
| ***Reason for change:*** | Due to historical reasons, there are various names related to roaming, including IPX, cIPX/pIPX, IPX provider, IPX provider entity, IPX node, Roaming Intermediary, and Roaming Hub. This is confusing, redundant and difficult to maintain.  |
|  |  |
| ***Summary of change:*** | 1. replacing IPX provider with Roaming Intermediary, since IPX provider is Roaming Intermediary defined in TS 33.501.2. replacing IPXs with Roaming Intermediaries.3. replacing IPX node and RI node with Roaming Intermediaries.4. replacing IPX provider entity (i.e., cIPX or pIPX) with RI (i.e., cRI or pRI).After the modification, only two kinds of names are left:1. Roaming Intermediary, which is an entity that provides roaming related services.3. Roaming Hub, which is a type of Roaming Intermediary |
|  |  |
| ***Consequences if not approved:*** | Confusing names related to roaming |
|  |  |
| ***Clauses affected:*** | 3.1, 3.2, 5.9.3, 13.1.2, 13.2.1, 13.2.4, 13.2.4.5, 13.2.4.7, 13.2.4.8, 13.2.4.9, G.1, I.8.1 |
|  |  |
|  | **Y** | **N** |  |  |
| ***Other specs*** |  | **X** |  Other core specifications  | TS/TR ... CR ...  |
| ***affected:*** |  | **X** |  Test specifications | TS/TR ... CR ...  |
| ***(show related CRs)*** |  | **X** |  O&M Specifications | TS/TR ... CR ...  |
|  |  |
| ***Other comments:*** |  |
|  |  |
| ***This CR's revision history:*** |  |

\*\*\* BEGIN of 1st CHANGE \*\*\*

## 3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP 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].

**5G security context:** The state that is established locally at the UE and a serving network domain and represented by the "5G security context data" stored at the UE and a serving network.

NOTE 1: The "5G security context data" consists of the 5G NAS security context, and the 5G AS security context for 3GPP access and/or the 5G AS security context for non-3GPP access.

NOTE 2: A 5G security context has type "mapped", "full native" or "partial native". Its state can either be "current" or "non-current". A context can be of one type only and be in one state at a time. The state of a particular context type can change over time. A partial native context can be transformed into a full native. No other type transformations are possible.

**5G AS security context for 3GPP access:** The cryptographic keys at AS level with their identifiers, the Next Hop parameter (NH), the Next Hop Chaining Counter parameter (NCC) used for next hop access key derivation, the identifiers of the selected AS level cryptographic algorithms, the UE security capabilities, and the UP Security Policy at the network side, UP security activation status and the counters used for replay protection.

NOTE 3: NH and NCC need to be stored also at the AMF during connected mode.

NOTE 4: UP security activation status is sent from gNB/ng-eNB in step 1b in clause 6.6.2 corresponding to the active PDU session(s).

**5G AS security context for non-3GPP access:** The key KN3IWF, the cryptographic keys, cryptographic algorithms and tunnel security association parameters used at IPsec layer for the protection of IPsec SA.

**5G AS Secondary Cell security context**: The cryptographic keys at AS level for secondary cell with their identifiers, the identifier of the selected AS level cryptographic algorithms for secondary cell, the UP Security Policy at the network side, and counters used for replay protection.

**5G** **Home Environment Authentication Vector:** authentication data consisting of RAND, AUTN, XRES\*, and KAUSF for the purpose of authenticating the UE using 5G AKA.

NOTE 3a: This vector is received by the AUSF from the UDM/ARPF in the Nudm\_UEAuthentication\_Get Response.

**5G Authentication Vector:** authentication data consisting of RAND, AUTN, HXRES\*, and KSEAF.

NOTE 3b: This vector is received by the SEAF from the AUSF in the Nausf\_Authentication\_Authenticate Response.

**5G NAS security context:** The key KAMF with the associated key set identifier, the UE security capabilities, the uplink and downlink NAS COUNT values.

NOTE 4: The distinction between native 5G security context and mapped 5G security context also applies to 5G NAS security contexts. The 5G NAS security context is called "full" if it additionally contains the integrity and encryption keys and the associated identifiers of the selected NAS integrity and encryption algorithms.

**5G Serving Environment Authentication Vector:** a vector consisting of RAND, AUTN and HXRES\*.

**ABBA parameter:** Parameter that provides antibidding down protection of security features against security features introduced in higher release to a lower release and indicates the security features that are enabled in the current network.

**activation of security context:** The process of taking a security context into use.

**anchor key:** The security key KSEAF provided during authentication and used for derivation of subsequent security keys.

**application Layer Security:** mechanism by which HTTP messages, exchanged between a Network Function in one PLMN and a Network Function in another PLMN, are protected on the N32-f interface between the two SEPPs in the two PLMNs.

**authentication data:** An authentication vectoror transformed authentication vector.

**authentication vector:** A vector consisting of CK, IK, RAND, AUTN, and XRES.

**backward security**: The property that for an entity with knowledge of Kn, it is computationally infeasible to compute any previous Kn-m (m>0) from which Kn is derived.

NOTE 5: In the context of KgNB key derivation, backward security refers to the property that, for a gNB with knowledge of a KgNB, shared with a UE, it is computationally infeasible to compute any previous KgNB that has been used between the same UE and a previous gNB.

**CM-CONNECTED state:** This is as defined in TS 23.501 [2].

NOTE5a: The term CM-CONNECTED state corresponds to the term 5GMM-CONNECTED mode used in TS 24.501 [35].

**CM-IDLE state:** As defined in TS 23.501 [2].

NOTE5b: The term CM-IDLE state corresponds to the term 5GMM-IDLE mode used in TS 24.501 [35].

**consumer's RI (cRI):** RI with a business relationship with the cSEPP operator.

**consumer's NRF (cNRF):** The NRF that authenticates the service consumer NF and resides in the PLMN where the service consumer NF is located.

**consumer's PLMN (cPLMN):** The PLMN where the service consumer NF is located**.**

**consumer's SEPP (cSEPP):** The SEPP residing in the PLMN where the service consumer NF is located.

**Credentials Holder:** As defined in TS 23.501 [2].

**current 5G security context:** The security context which has been activated most recently.

NOTE5c: A current 5G security context originating from either a mapped or native 5G security context can exist simultaneously with a native non-current 5G security context.

**Default Credentials Server:** As defined in TS 23.501[2].

**Default UE credentials:** As defined in TS 23.501[2].

**forward security**: The fulfilment of the property that for an entity with knowledge of Km that is used between that entity and a second entity, it is computationally infeasible to predict any future Km+n (n>0) used between a third entity and the second entity.

NOTE 6: In the context of KgNB key derivation, forward security refers to the property that, for a gNB with knowledge of a KgNB, shared with a UE, it is computationally infeasible to predict any future KgNB that will be used between the same UE and another gNB. More specifically, n hop forward security refers to the property that a gNB is unable to compute keys that will be used between a UE and another gNB to which the UE is connected after n or more handovers (n=1 or more).

**full native 5G security context:** A native 5G security context for which the 5G NAS security context is full according to the above definition.

NOTE6a: A full native 5G security context is either in state "current" or state "non-current".

**Home Network Identifier:** An identifier identifying the home network of the subscriber.

NOTE6b: Described in detail in TS 23.003 [19].

**Home Network Public Key Identifier:** An identifier used to indicate which public/private key pair is used for SUPI protection and de-concealment of the SUCI.

NOTE6c: Described in this document and detailed in TS 23.003 [19].

**IAB-donor-CU**: As defined in TS 38.401 [78] .

**IAB-donor-DU**: As defined in TS 38.401 [78].

**IAB-node**: As defined in TS 38.300 [52].

**IAB-donor gNB**:As defined in TS 38.300 [52].

**IAB-UE**: The function within an IAB node, which behaves as a UE.

**mapped 5G security context**: An 5G security context, whose KAMF was derived from EPS keys during interworking and which is identified by mapped ngKSI.

**Master node**: As defined in TS 37.340 [51].

**N32-c connection:** A TLS based connection between a SEPP in one PLMN and a SEPP in another PLMN.

NOTE 6d: This is a short-lived connection that is used between the SEPPs for negotiation of the N32-f protection mechanism, cipher suite and protection policy exchange, and error notifications. Every N32-f connection requires an N32-c connection that was established before establishing N32-f.

**N32-f connection:** Logical connection that exists between a SEPP in one PLMN and a SEPP in another PLMN for exchange of protected HTTP messages.

NOTE 6e: When Roaming Intermediaries are present in the path between the two SEPPs, an N32-f HTTP connection is setup on each hop towards the other SEPP.

**native 5G security context:** An 5G security context, whose KAMF was created by a run of primary authentication and which is identified by native ngKSI.

**ng-eNB**: As defined in TS 38.300 [52].

**NG-RAN node**: gNB or ng-eNB (as defined in TS 38.300 [52]).

**non-current 5G security context:** A native 5G security context that is not the current one.

NOTE 7: A non-current 5G security context may be stored along with a current 5G security context in the UE and the AMF. A non-current 5G security context does not contain 5G AS security context. A non-current 5G security context is either of type "full native" or of type "partial native".

**Operator Group Roaming Hub:** Roaming hub used by a group of network operators that reside in the same security domain to consolidate and secure operator group roaming.

**partial native 5G security context:** A partial native 5G security context consists of KAMF with the associated key set identifier, the UE security capabilities, and the uplink and downlink NAS COUNT values, which are initially set to zero before the first NAS SMC procedure for this security context.

NOTE 8: A partial native 5G security context is created by primary authentication, for which no corresponding successful NAS SMC has been run. A partial native context is always in state "non-current".

**producer's RI (pRI)**: RI with a business relationship with the pSEPP operator.

**producer's NRF (pNRF):** The NRF where the service producer NF is registered in the PLMN where the service producer NF is located.

**producer's PLMN (pPLMN):** The PLMN where the service producer NF is located.

**producer's SEPP (pSEPP):** The SEPP residing in the PLMN where the service producer NF is located.

**Protection Scheme Identifier:** An identifier identifying a protection scheme that is used for concealing the SUPI.

**RM-DEREGISTERED state:** This is as defined in TS 23.501 [2].

NOTE8a: The term RM-DEREGISTERED state corresponds to the term 5GMM-DEREGISTERED mode used in TS 24.501 [35].

**RM-REGISTERED state:** As defined in TS 23.501 [2].

NOTE8b: The term RM-REGISTERED state corresponds to the term 5GMM-REGISTERED mode used in TS 24.501 [35].

**Roaming Hub:** A type ofRoaming Intermediary that provides a set of services to client PLMNs to facilitate the deployment and the operation of roaming and interworking services; as defined by GSMA.

**Roaming Intermediary**: an entity that provides roaming related services.

**Routing Indicator:** An indicator defined in TS 23.003 [19] that can be used for AUSF or UDM selection.

**Scheme Output**: the output of a public key protection scheme used for SUPI protection.

**security anchor function:** The function SEAF that serves in the serving network as the anchor for security in 5G.

**Secondary node**: As defined in TS 37.340 [51].

**subscription credential(s):** The set of values in the USIM and in the home operator's network, consisting of at least the long-term key(s) and the subscription identifier SUPI, used to uniquely identify a subscription and to mutually authenticate the UE and 5G core network.

**subscription identifier:** The SUbscription Permanent Identifier (SUPI).

NOTE8c: As defined in TS 23.501 [2] and detailed in 23.003 [19].

**subscription concealed identifier:** A one-time use subscription identifier, called the SUbscription Concealed Identifier (SUCI), which contains the Scheme-Output, and additional non-concealed information needed for home network routing and protection scheme usage.

NOTE8d: Defined in the present document; detailed in TS 23.003 [19].

**subscription identifier de-concealing function:** The Subscription Identifier De-concealing Function (SIDF) service offered by the network function UDM in the home network of the subscriber responsible for de-concealing the SUPI from the SUCI.

**transformed authentication vector:** an authentication vector where CK and IK have been replaced with CK' and IK'.

**UE 5G security capability:** The UE security capabilities for 5G AS and 5G NAS.

**UE security capabilities:** The set of identifiers corresponding to the ciphering and integrity algorithms implemented in the UE.

NOTE 9: This includes capabilities for NG-RAN and 5G NAS, and includes capabilities for EPS, UTRAN and GERAN if these access types are supported by the UE.

\*\*\* END of 1st CHANGE \*\*\*

\*\*\* BEGIN of 2nd CHANGE \*\*\*

## 3.2 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].

5GC 5G Core Network

5G-AN 5G Access Network

5G-RG 5G Residential Gateway

NG-RAN 5G Radio Access Network

5G AV 5G Authentication Vector

5G HE AV 5G Home Environment Authentication Vector

5G NSWO 5G Non-Seamless WLAN Offload

5G SE AV 5G Serving Environment Authentication Vector

ABBAAnti-Bidding down Between Architectures

AEAD Authenticated Encryption with Associated Data

AES Advanced Encryption Standard

AKA Authentication and Key Agreement

AMF Access and Mobility Management Function

AMF Authentication Management Field

NOTE: If necessary, the full word is spelled out to disambiguate the abbreviation.

ARPF Authentication credential Repository and Processing Function

AUN3 Authenticable Non-3GPP devices

AUSF Authentication Server Function

AUTN AUthentication TokeN

AV Authentication Vector

AV' transformed Authentication Vector

BAP Backhaul Adaptation Protocol

BH Backhaul

CCA Client Credentials Assertion

Cell-ID Cell Identity as used in TS 38.331 [22]

CH Credentials Holder

CHO Conditional Handover

CIoT Cellular Internet of Things

CKSRVCC Cipher Key for Single Radio Voice Continuity

cNRF consumer's NRF

CP Control Plane

CPAC Conditional PSCell Addition or Change

CPA Conditional PSCell Addition

CPC Conditional PSCell Change

cPLMN consumer's PLMN

cRI consumer's RI

cSEPP consumer's SEPP

CTR Counter (mode)

CU Central Unit

DCS Default Credentials Server

DN Data Network

DNN Data Network Name

DU Distributed Unit

EAP Extensible Authentication Protocol

EDT Early Data Transmission

EMSK Extended Master Session Key

EN-DC E-UTRA-NR Dual Connectivity

ENSI External Network Slice Information

EPS Evolved Packet System

FN-RG Fixed Network RG

gNB NR Node B

GUTI Globally Unique Temporary UE Identity

HRES Hash RESponse

HXRES Hash eXpected RESponse

IAB Integrated Access and Backhaul

IKE Internet Key Exchange

IKSRVCC Integrity Key for Single Radio Voice Continuity

IPUPS Inter-PLMN UP Security

KSI Key Set Identifier

KSISRVCC Key Set Identifier for Single Radio Voice Continuity

LI Lawful Intercept

MBSF Multicast/Broadcast Service Function

MBSSF Multicast/Broadcast Service Security Function

MBSTF Multicast/Broadcast Service Transport Function

MeNB Master eNB

MN Master Node

MO-EDT Mobile Originated Early Data Transmission

MT-EDT Mobile Terminated Early Data Transmission

MR-DC Multi-Radio Dual Connectivity

MSK Master Session Key

N3IWF Non-3GPP access InterWorking Function

NAI Network Access Identifier

NAS Non Access Stratum

NDS Network Domain Security

NEA Encryption Algorithm for 5G

NF Network Function

NG Next Generation

ng-eNB Next Generation Evolved Node-B

ngKSI Key Set Identifier in 5G

N5CW Non-5G-Capable over WLAN

N5GC Non-5G-Capable

NIA Integrity Algorithm for 5G

NR New Radio

NR-DC NR-NR Dual Connectivity

NSSAI Network Slice Selection Assistance Information

NSSAA Network Slice Specific Authentication and Authorization

NSWO Non-Seamless WLAN Offload

NSWOF Non-Seamless WLAN Offload Function

PDN Packet Data Network

PEI Permanent Equipment Identifier

pNRF producer's NRF

pPLMN producer's PLMN

pRI producer's RI

PRINS PRotocol for N32 INterconnect Security

pSEPP producer's SEPP

PUR Preconfigured Uplink Resource

QoS Quality of Service

RES RESponse

RI Roaming Intermediary

RH Roaming Hub

SCG Secondary Cell Group

SEAF SEcurity Anchor Function

SCP Service Communication Proxy

SEPP Security Edge Protection Proxy

SCPAC Subsequent Conditional PSCell Addition or Change

SgNB Secondary gNB

SIDF Subscription Identifier De-concealing Function

SMC Security Mode Command

SMF Session Management Function

SN Secondary Node

SN Id Serving Network Identifier

SUCI Subscription Concealed Identifier

SUPI Subscription Permanent Identifier

TLS Transport Layer Security

TNAN Trusted Non-3GPP Access Network

TNAP Trusted Non-3GPP Access Point

TNGF Trusted Non-3GPP Gateway Function

TWAP Trusted WLAN Access Point

TWIF Trusted WLAN Interworking Function

TSC Time Sensitive Communication

UE User Equipment

UEA UMTS Encryption Algorithm

UDM Unified Data Management

UDR Unified Data Repository

UIA UMTS Integrity Algorithm

ULR Update Location Request

UP User Plane

UPF User Plane Function

URLLC Ultra Reliable Low Latency Communication

USIM Universal Subscriber Identity Module

XRES eXpected RESponse

\*\*\* END of 2nd CHANGE \*\*\*

\*\*\* BEGIN of 3rd CHANGE \*\*\*

### 5.9.3 Requirements for e2e core network interconnection security

#### 5.9.3.1 General

The present sub-clause contains requirements common to sub-clauses 5.9.2 and 5.9.3.

A solution for e2e core network interconnection security shall satisfy the following requirements.

The solution shall support application layer mechanisms for addition, deletion and modification of message elements by Roaming intermediaries except for specific message elements described in the present document.

NOTE: Typical example for such a case is Roaming Intermediaries modifying messages for routing purposes.

The solution shall provide confidentiality and/or integrity end-to-end between source and destination network for specific message elements identified in the present document. For this requirement to be fulfilled, the SEPP – cf [2], clause 6.2.17 shall be present at the edge of the source and destination networks dedicated to handling e2e Core Network Interconnection Security. The confidentiality and/or integrity for the message elements is provided between two SEPPs of the source and destination PLMN.

The destination network shall be able to determine the authenticity of the source network that sent the specific message elements protected according to the preceding bullet. For this requirement to be fulfilled, it shall suffice that a SEPP in the destination network that is dedicated to handling e2e Core Network Interconnection Security can determine the authenticity of the source network.

The solution should have minimal impact and additions to 3GPP-defined network elements.

The solution should be using standard security protocols.

The solution shall cover interfaces used for roaming purposes.

The solution should take into account considerations on performance and overhead.

The solution shall cover prevention of replay attacks.

The solution shall cover algorithm negotiation and prevention of bidding down attacks.

The solution should take into account operational aspects of key management.

#### 5.9.3.2 Requirements for Security Edge Protection Proxy (SEPP)

The feature of supporting roaming hubs by SEPPs introduced in Release 18, i.e. in TS 33.501 (the present document) and TS 29.573 [73], addresses the requirements that may be applicable to SEPPs starting from Release 16.

In order to support PRINS functionality using roaming intermediaries, the feature specified in this document may be supported by Release 16 and 17 implementations of SEPPs.

NOTE: It is implementation specific on how to support the scenario where the Rel 16 and 17 SEPP of the roaming partners are not aligned regarding the support of roaming intermediaries.

\*\*\* END of 3rd CHANGE \*\*\*

\*\*\* BEGIN of 4th CHANGE \*\*\*

### 13.1.2 Protection between SEPPs

TLS shall be used for N32-c connections between the SEPPs.

The SEPP shall maintain a set of trust anchors, each consisting of a list of trusted root certificates and a list of corresponding PLMN-IDs. Any given PLMN-ID shall appear in at most one trust anchor. During N32-c connection setup, the SEPP shall map the PLMN-ID of the remote SEPP leaf (server or client) certificate to the associated trust anchor for the purposes of certificate chain verification. Only the root certificates in the associated list shall be treated as trusted during certificate chain verification. If the remote SEPP certificate contains multiple PLMN-IDs that are mapped to different trust anchors, then that certificate shall be rejected.

Operator Group Roaming Hubs SEPPs are equivalent to a network operator SEPP when they are in the same security domain and are not considered Roaming Intermediaries as detailed in this clause. The communication between a group network operator's SBA network border element and the Operator Group Roaming Hub SEPP is out of scope of the present document.

If there are no Roaming Intermediaries between the SEPPs, TLS shall be used for N32-f connections between the SEPPs. Different TLS connections are used for N32-c and N32-f. If there are Roaming Intermediaries which only offer IP routing service between SEPPs, either TLS or PRINS (application layer security) shall be used for protection of N32-f connections between the SEPPs. PRINS is specified in clause 5.9.3 (requirements) and clause 13.2 (procedures).

If TLS is selected, the SEPP shall correlate the N32-f TLS connection with the N32-c connection. If the peer network is a PLMN, the SEPP compares the PLMN-IDs contained in the SEPP TLS certificates used to establish the N32-c and N32-f connections. Specifically, if the certificate used for N32-f contains one or more PLMN-IDs that are not contained in the TLS certificate used for the corresponding N32-c, the N32-f certificate shall be rejected. If the peer network is an SNPN, the SEPP compares the SNPN-ID contained in the SEPP TLS certificates used to establish the N32-c and N32-f connections.

If there are Roaming Intermediaries which, in addition to IP routing, offer other services that require modification or observation of the information and/or additions to the information sent between the SEPPs, PRINS shall be used for protection of N32-f connections between the SEPPs.

NOTE 1a: The procedure specified in clause 13.5 for security mechanism selection between SEPPs allows SEPPs to negotiate which security mechanism to use for protecting NF service-related signalling over N32, and provides robustness and future-proofness, e.g. in case new algorithms are introduced in the future.

If PRINS is used on the N32-f interface, one of the following additional transport protection methods should be applied between SEPP and Roaming Intermediary or between two Roaming Intermediaries for confidentiality and integrity protection:

- NDS/IP as specified in TS 33.210 [3] and TS 33.310 [5], or

- TLS VPN with mutual authentication following the profile given in clause 6.2 of TS 33.210 [3] and clause clause 6.1.3a of TS 33.310 [5]. The identities in the end entity certificates shall be used for authentication and policy checks, with the restriction that it shall be compliant with the profile given by HTTP/2 as defined in RFC 9113 [47].

NOTE 1: Void

NOTE 2: Void.

\*\*\* END of 4th CHANGE \*\*\*

\*\*\* BEGIN of 5th CHANGE \*\*\*

### 13.2.1 General

The internetwork interconnect allows secure communication between service-consuming and a service-producing NFs in different PLMNs. Security is enabled by the Security Edge Protection Proxies of both networks, henceforth called cSEPP and pSEPP respectively. The SEPPs enforce protection policies regarding application layer security thereby ensuring integrity and confidentiality protection for those elements to be protected.

NOTE: In the following the descriptions are provided for RIs as types of Roaming Intermediaries, but equally apply to Roaming Hubs as types of Roaming Intermediaries.

It is assumed that there are interconnect providers between cSEPP and pSEPP. The interconnect provider the cSEPP's operator has a business relationship with is called cRI, while the interconnect provider the pSEPP's operator has a business relationship with is called pRI. There could be further interconnect providers in between cRI and pRI, but they are assumed to be transparent and simply forward the communication.

The SEPPs use JSON Web Encryption (JWE, specified in RFC 7516 [59]) for protecting messages on the N32-f interface, and the Roaming Intermediaries use JSON Web Signatures (JWS, specified in RFC 7515 [45]) for signing their modifications needed for their mediation services.

For illustration, consider the case where a service-consuming NF sends a message to a service-producing NF. If this communication is across PLMN operators over the N32-f interface, as shown in Figure 13.2.1-1 below, the cSEPP receives the message and applies symmetric key based application layer protection, as defined in clause 13.2 of the present document. The resulting JWE object is forwarded to roaming intermediaries. The pRI and cRI can offer services that require modifications of the messages transported over the interconnect (N32) interface. These modifications are appended to the message as digitally signed JWS objects which contain the desired changes. The pSEPP, which receives the message from pRI, validates the JWE object, extracts the original message sent by the NF, validates the signature in the JWS object and applies patches corresponding to the modifications by roaming intermediaries. The pSEPP then forwards the message to the destination NF.

The N32 interface consists of:

- N32-c connection, for management of the N32 interface, and

- N32-f connection, for sending of JWE and JWS protected messages between the SEPPs.

The application layer security protocol for the N32 interface described in clause 13.2 of the present document is called PRINS.



Figure 13.2.1-1: Overview of PRINS

\*\*\* END of 5th CHANGE \*\*\*

\*\*\* BEGIN of 6th CHANGE \*\*\*

### 13.2.4 N32-f connection between SEPPs

#### 13.2.4.1 General

The SEPP receives HTTP/2 request/response messages from the Network Function. It shall perform the following actions on these messages before they are sent on the N32-f interface to the SEPP in the other PLMN:

a) It parses the incoming message and, if present, rewrites the telescopic FQDN of the receiving NF to obtain the original FQDN as described in clause 13.1.

b) It reformats the message to produce the input to JSON Web Encryption (JWE) [59] as described in clause 13.2.4.3.

c) It applies JWE to the input created in b) to protect the reformatted message as described in clause 13.2.4.4.

d) It encapsulates the resulting JWE object into a HTTP/2 message (as the body of the message) and sends the HTTP/2 message to the SEPP in the other PLMN over the N32-f interface.

The message may be routed via the one or two Roaming Intermediaries, e.g., cRI and pRI. These RI may modify messages as follows:

a) The RI recovers the cleartext part of the HTTP message from the JWE object, modifies it according to the modification policy, and calculates an "operations" JSON Patch object. It then creates a temporary JSON object with the "operators" JSON Patch object and some other parameters for replay protection etc. as described in clause 13.2.4.5.1.

b) The RI uses the temporary JSON object as input into JSON Web Signature (JWS) [45] to create a JWS object, as described in clause 13.2.4.5.2.

c) The RI appends the JWS object to the received message and sends it to the next hop.

The JWS objects generated by the two RI providers form an auditable chain of modifications that to the receiving SEPP shall apply to the parsed message after verifying that the patches conform to the modification policy.

Encryption of IEs shall take place end to end between cSEPP and pSEPP.

A SEPP shall not include IEs in the clear that are encrypted elsewhere in the JSON object.

A SEPP shall verify that an intermediate RI has not moved or copied an encrypted IE to a location that would be reflected from the producer NF in an IE without encryption.

#### 13.2.4.2 Overall Message payload structure for message reformatting at SEPP

The SEPP reformats an HTTP message received from an internal Network Function into two temporary JSON objects that will be intput to JWE:

a. The **dataToIntegrityProtect**, containing information that is only integrity protected. It consists of the following:

- clearTextEncapsulationMessage: contains the complete original HTTP message, excluding attribute values which require encryption and, including the pseudo-header fields, HTTP headers and HTTP message body.

- metadata: contains SEPP generated information i.e. authorizedRI ID, N32-f message ID and N32-f context ID.

b. The **dataToIntegrityProtectAndCipher**: contains attribute values of the original message that require both encryption and integrity protection.

For the details of JSON representation of a reformatted HTTP message, refer to TS 29.573 [92].

#### 13.2.4.3 Message reformatting in sending SEPP

##### 13.2.4.3.1 dataToIntegrityProtect

###### 13.2.4.3.1.1 clearTextEncapsulatedMessage

The clearTextEncapsulatedMessage is a JSON object that contains the non-encrypted portion of the original message.Specifically, it consists of the following objects:

1.a) Pseudo\_Headers – the JSON object that includes all the Pseudo Headers in the message.

- For HTTP Request messages, the object contains one entry for each of the ":method", ":path", ":scheme" and ":authority" pseudo headers. If the ":path" pseudoheader contains multiple parts separated by a slash (/) or includes a query parameter (following a "?"), an array is used to represent :path, with one element per part of the path (i.e. per "directory").

NOTE: This enables encryption of individual elements of the path (e.g. if SUPI is passed).

- For HTTP Response messages, the object contains the ":status" pseudo header.

1.b) HTTP\_Headers – the JSON object that includes all the Headers in the message.

All the headers of the request are put into a JSON array called HTTP\_Headers.Each entry contains a header name and value, where the value part can be an encoded index to the dataToIntegrityProtectAndCipher block, if the header value is encrypted.

1.c) Payload – the JSON object that includes the content of the payload of the HTTP message.

Each attribute or IE in the payload shall form a single entry in the Payload JSON object. If there is any attribute value that requires encryption, it shall be moved into the dataToIntegrityProtectAndCipher JSON object (clause 13.2.4.2), and the original value in this element shall be replaced by the index in the form {"encBlockIdx": <num>} where "num" is the index of the corresponding entry in the dataToIntegrityProtectAndCipher array.

###### 13.2.4.3.1.2 metadata

The JSON object containing information added by the sending SEPP. It shall contain:

a) **N32-f** **message ID**: Unique identifier (64-bit integer) representing a HTTP Request/Response transaction between two SEPPs. The N32-f message ID is generated by the sending SEPP and included in the HTTP Request sent over the N32 interface. The receiving SEPP uses the same N32-f message ID when it responds back with a HTTP Response. The N32-f message ID is included in the metadata portion of the JSON structure.

b) **authorizedRI** **ID**: String identifying the first hop RI (cRI or pRI) that is authorized to update the message. This field shall always be present. When there is no RI that is authorized to update, the value of this field is set to null. The sending SEPP selects one of the RI providers from the list exchanged with the other SEPP during parameter exchange over N32-c and includes its identifier value in this field.

c) **N32-f context ID**: Unique identifier representing the N32-f context information used for protecting the message. This is exchanged during parameter exchange over N32-c (clause 13.2.2.4.1).

##### 13.2.4.3.2 dataToIntegrityProtectAndCipher

The dataToIntegrityProtectAndCipher is a JSON patch document as per RFC 6902 [64] that contains all the attribute values that require both encryption and integrity protection. Attribute values may come from any part of the original HTTP message – Pseudo\_Headers, HTTP\_Headers and Payload.

The JSON array shall contain one array entry per attribute value that needs encryption. Each array entry represents the value of the attribute to be protected, and the index in the array is used to reference the protected value within the dataToIntegrityProtect block. This associates each attribute in the dataToIntegrityProtectAndCipher block with the original attribute in the dataToIntegrityProtect block. This is needed to reassemble the original message at the receiving SEPP.

\*\*\* END of 6th CHANGE \*\*\*

\*\*\* BEGIN of 7th CHANGE \*\*\*

#### 13.2.4.5 Message modifications by roaming intermediary

##### 13.2.4.5.1 modifiedDataToIntegrityProtect



Figure 13.2.4.5.1-1 Example of JSON representation for RI with modifications by RI1

This is a temporary JSON object generated by a RI provider as it modifies the original message. It shall contain the following:

a) **Operations** – This is a JSON patch document that captures RI modifications based on RFC 6902 [64]. If no patch is required, the operations element shall be set to null.

b) **Identity** – This is the identity of the RI performing the modification.

c) **Tag** – A JSON string element to capture the "tag" value (JWE Authentication tag) in the JWE object generated by the sending SEPP. This is required for replay protection.

NOTE: Since there is no central registry that can ensure unique RI Identities, it is expected that an RI will include its Fully Quantified Domain Name (FQDN) in the JSON modification object.

##### 13.2.4.5.2 Modifications by RIs

NOTE 1: It is assumed that operators act as a certification authority for RI providers they have a direct business relationship with. In order to authorize N32-f message modifications, operators sign a digital certificate for each of these RI providers and provide it to both the RI provider itself as well as their roaming partners to enable them to validate any modifications by this RI provider.

Only the maximum two RIs, e.g., cRI and pRI shall be able to modify messages between cSEPP and pSEPP. In cases of messages from cSEPP to pSEPP, the cRI is the first RI, while the pRI is the second RI. In cases of messages from pSEPP to cSEPP the pRI is the first RI, while the cRI is the second RI.

The first RI shall parse the encapsulated request (i.e. the clearTextEncapsulationMsg in the dataToIntegrityProtect block) and determine which changes are required. The first RI creates an Operations JSON patch document to describe the differences between received and desired message, using the syntax and semantic from RFC 6902 [64], such that, when applying the JSON patch to the encapsulated request the result will be the desired request. If no patch is required, the operations element is null.

NOTE 2: It is necessary to create a JWS object even if no patch is required to prevent deletion of modifications.

The first RI shall create a modifiedDataToIntegrityProtect JSON object as described in clause 13.2.4.5.1. The JSON object shall include the RI’s identity and the JWE authentication tag, which associates this update by the RI with the JWE object created by the sending SEPP.

The first RI shall use the modifiedDataToIntegrityProtect JSON object as input to JWS to create a JWS object. The first RI shall append the generated JWS object to the payload in the HTTP message and then send the messageto the next hop.

The second RI shall parse the encapsulated request, apply the modifications described in the JSON patch appended by the first RI and determine further modifications required for obtaining the desired request. The second RI shall record these modifications in an additional JSON patch against the JSON object resulting from application of the first RI's JSON patch. If no patch is required, the operations element for the second JSON patch is null.

The second RI shall create a modifiedDataToIntegrityProtect JSON object as described in clause 13.2.4.5.1. It shall include its identity and the JWE authentication tag, which associates this update by the second RI with the JWE object created by the sending SEPP.

The second RI shall use the modifiedDataToIntegrityProtect JSON object as input to JWS to create a JWS object. The second RI shall append the generated JWS object to the payload in the HTTP message and then send the message to the receiving SEPP.

\*\*\* END of 7th CHANGE \*\*\*

\*\*\* BEGIN of 8th CHANGE \*\*\*

#### 13.2.4.7 Message verification by the receiving SEPP

The receiving SEPP determines that the received message is an error message generated by the Roaming Hub as Roaming Intermediary based on the reformattedData IE.

If the received messages is not generated by a Roaming Hub :

- The receiving SEPP shall decrypt the JWE ciphertext using the shared session key and the following parameters obtained from the JWE object – Initialization Vector, Additional Authenticated Data value (clearTextEncapsulatedMessage in "aad") and JWE Authentication Tag ("tag").

- The receiving SEPP shall check the integrity and authenticity of the clearTextEncapsulatedMessage and the encrypted text by verifying the JWE Authentication Tag in the JWE object with the JWE AAD algorithm. The algorithm returns the decrypted plaintext (dataToIntegrityProtectAndCipher) only if the JWE Authentication Tag is correct.

- The receiving SEPP refers to the NF API in clearTextEncapsulatedMessage with values in the dataToIntegrityProtectAndCipher array.

- The receiving SEPP shall next verify RI provider updates, if included, by verifying the JWS signatures added by the Roaming Intermediaries. The SEPP shall verify the JWS signature, using the corresponding raw public key or certificate that is contained in the Roaming Intermediary’s security information list obtained during parameter exchange in the related N32-c connection setup or, alternatively, has been configured for the particular peer SEPP.

- The receiving SEPP shall then check that the raw public key or certificate of the JWS signature RI's Identity in the modifiedDataToIntegrity block matches to the RI provider referred to in the "authorizedRI ID" field added by the sending SEPP, based on the information given in the RI provider security information list.

- The receiving SEPP shall check whether the modifications performed by the Roaming Intermediaries, i.e. cRI and pRI, were permitted by the respective modification policies. The receiving SEPP shall use the modification policy of the cRI obtained during parameter exchange in the related N32-c connection setup, and use the modification policy of pRI configured within the receiving SEPP.

- If this is the case, the receiving SEPP shall apply the patches in the Operations field in order, perform plausibility checks, and create a new HTTP request according to the "patched" clearTextEncapsulatedMessage.

- The receiving SEPP shall verify that the PLMN-ID contained in the incoming N32-f message matches the PLMN-ID in the related N32-f context.

If the received message is an error message generated by a Roaming Hub:

- The receiving SEPP shall check that the raw public key or certificate of the JWS signature RI's identity in the modifiedDataToIntegrityProtect block matches the adjacent Roaming Hub identity.

- The receiving SEPP dertermines the message in which the error occurred, based on the N32-f message ID.

- If the receiving SEPP determines from the error message that the Roaming Hub requires a modified request message, it can modify if allowed by the MNO's policy, and can resend the modified request message.

\*\*\* END of 8th CHANGE \*\*\*

\*\*\* BEGIN of 9th CHANGE \*\*\*

#### 13.2.4.8 Procedure

The following clause illustrates the message flow between the two SEPPs with modifications from RIs, e.g., cRI and pRI.



Figure 13.2.4.8-1 Message flow between two SEPPs

1. The cSEPP receives an HTTP request message from a network function. If the message contains a telescopic FQDN, the cSEPP removes its domain name from this FQDN to obtain the original FQDN as described in clause 13.1.

2. The cSEPP shall reformate the HTTP Request message as follows:

a. The cSEPP shall generate blocks (JSON objects) for integrity protected data and encrypted data, and protecting them:

The cSEPP shall encapsulate the HTTP request into a clearTextEncapsulatedMessage block containing the following child JSON objects:

- Pseudo\_Headers

- HTTP\_Headers with one element per header of the original request.

- Payload that contains the message body of the original request.

For each attribute that require end-to-end encryption between the two SEPPs, the attribute value is copied into a dataToIntegrityProtectAndCipher JSON object and the attribute's value in the clearTextEncapsulatedMessage is replaced by the index of attribute value in the dataToIntegrityProtectAndCipher block.

The cSEPP shall create a metadata block that contains the N32-f context ID, message ID generated by the cSEPP for this request/response transaction and next hop identity.

The cSEPP shall protect the dataToIntegrityProtect block and the dataToIntegrityProtectAndCipher block as per clause 13.2.4.4. This results in a single JWE object representing the protected HTTP Request message.

b. The cSEPP shall generate payload for the SEPP to SEPP HTTP message:

 The JWE object becomes the payload of the new HTTP message generated by cSEPP.

3. The cSEPP shall use HTTP POST to send the HTTP message to the first Roaming Intermediary.

4. The first Roaming Intermediary (e.g. visited network's Roaming Intermediary) shall create a new modifiedDataToIntegrityProtect JSON object with three elements:

a. The Operations JSON patch document contains modifications performed by the first Roaming Intermediary as per RFC 6902 [64].

b. The first Roaming Intermediary shall include its own identity in the Identity field of the modifiedDataToIntegrityProtect.

c. The first Roaming Intermediary shall copy the "tag" element, present in the JWE object generated by the cSEPP, into the modifiedDataToIntegrityProtect object. This acts as a replay protection for updates made by the first Roaming Intermediary.

The Roaming Intermediary shall execute JWS on the modifiedDataToIntegrityProtect JSON object and append the resulting JWS object to the message.

5. The first Roaming Intermediary shall send the modified HTTP message request to the second Roaming Intermediary (e.g. home network's Roaming Intermediary) as in step 3.

6. The second Roaming Intermediary shall perform further modifications as in step 4 if required. The second Roaming Intermediary shall further execute JWS on the modifiedDataToIntegrityProtect JSON object and shall append the resulting JWS object to the message.

7. The second Roaming Intermediary shall send the modified HTTP message to the pSEPP as in step 3.

 NOTE 1: The behaviour of the Roaming Intermediaries is not normative, but the pSEPP assumes that behaviour for processing the resulting request.

8. The pSEPP receives the message and shall perform the following actions:

- The pSEPP extracts the serialized values from the components of the JWE object.

- The pSEPP invokes the JWE AEAD algorithm to check the integrity of the message and decrypt the dataToIntegrityProtectAndCipher block. This results in entries in the encrypted block becoming visible in cleartext.

- The pSEPP updates the clearTextEncapsulationMessage block in the message by replacing the references to the dataToIntegrityProtectAndCipher block with the referenced decrypted values from the dataToIntegrityProtectAndCipher block.

- The pSEPP then verifies Roaming Intermediary's updates of the attributes in the modificationsArray. It checks whether the modifications performed by the Roaming Intermediaries were permitted by policy.

 The pSEPP further verifies that the PLMN-ID contained in the message is equal to the "Remote PLMN-ID" in the related N32-f context.

- The pSEPP updates the modified values of the attributes in the clearTextEncapsulationMessage in order.

The pSEPP shall re-assemble the full HTTP Request from the contents of the clearTextEncapsulationMessage.

9. The pSEPP shall send the HTTP request resulting from step 8 to the home network's NF.

10.-18. These steps are analogous to steps 1.-9.

#### 13.2.4.9 JOSE profile

SEPPs shall follow the JWE profile defined in TS 33.210 [3] with the restriction that it shall only use AES GCM with a 128-bit or 256-bit key. The security considerations for the use of AES GCM in section 8.4 of RFC 7518 [59] shall be taken into account. In particular, the same key shall not be used more than 232 times and an IV value shall not be used more than once with the same key.

SEPPs and Roaming Intermediaries shall follow the JWS profile as defined in TS 33.210 [3] with the restriction that they shall only use ES256 algorithm.

\*\*\* END of 9th CHANGE \*\*\*

\*\*\* BEGIN of 10th CHANGE \*\*\*

# G.1 Introduction

The SEPP as described in clause 4.2.1 is the entity that sits at the perimeter of the network and performs application layer security on the HTTP message before it is sent externally over the roaming interface.

The application layer traffic comprises all the IEs in the HTTP message payload, sensitive information in HTTP message header and Request URI. Not all the IEs get the same security treatment in SEPP. Some IEs require e2e encryption, some only require e2e integrity protection, while other IEs may require e2e integrity protection but modifiable by Roaming Intermediaries while in-transit.



Figure G.1-1: Signaling message from AMF (vPLMN) to AUSF (hPLMN) traversing the respective SEPPs

In the above figure, an example is shown where the AMF NF in the visited PLM network (vPLMN) invokes an API request on the AUSF NF in the home PLM network (hPLMN) using the following message flow:

- The AMF NF first sends the HTTP Request message to its local SEPP (i.e. vSEPP).

- The vSEPP applies application layer security (PRINS) and sends the secure message on the N32 interface to AUSF NF of the hPLMN.

- The hSEPP at the edge of the hPLMN, receives all incoming HTTP messages from its roaming partners. It verifies the message, removes the protection mechanism applied at the application layer, and forwards the resulting HTTP message to the corresponding AUSF NF.

To allow for the trusted Roaming Intermediary to see and possibly modify specific IEs in the HTTP message, while completely protecting all sensitive information end to end between SEPPs, the SEPP implements application layer security in such a way that:

- Sensitive information such as authentication vectors are fully e2e confidentiality protected between two SEPPs. This ensures that no Roaming Intermediary in the RI network shall be able to view such information while in-transit.

- IEs that are subject to modification by Roaming Intermediaries are integrity protected and can only be modified in a verifiable way by authorized Roaming Intermediaries.

- Receiving SEPP can detect modification by unauthorized Roaming Intermediaries.

\*\*\* END of 10th CHANGE \*\*\*

\*\*\* BEGIN of 11th CHANGE \*\*\*

## I.8.1 Credentials holder using AUSF and UDM for primary authentication

For SNPNs with Credentials Holder using AUSF and UDM for primary authentication, clause 5.30.2.9.3 of TS 23.501 [2] states that the UE is not considered to be roaming, however SNPN and Credentials Holder communicate via SEPPs.

The following requirements and procedures related to SEPPs and interconnect security apply for SNPNs with Credentials Holder using AUSF and UDM for primary authentication:

- Requirements for Security Edge Protection Proxy (SEPP), clause 5.9.3.2

- Protection between SEPPs, clause 13.1.2.

NOTE: Roaming Intermediaries are not expected to be used between SNPN and Credentials holder using AUSF and UDM for primary authentication.

\*\*\* END of 11th CHANGE \*\*\*