
# Report 5G Mobile Roaming Revisited (5GMRR) Phase 1

# Version 1.0

# 28 April 2022

*This is a Non-binding Permanent Reference Document of the GSMA*

## Security Classification: Non-confidential



## Copyright Notice



## Disclaimer



## Compliance Notice

The information contain herein is in full compliance with the GSM Association's antitrust compliance policy.

*[Note to editor: Include one of the following statements only; delete the other]:*

This Permanent Reference Document is classified by GSMA as an Industry Specification, as such it has been developed and is maintained by GSMA in accordance with the provisions set out in GSMA AA.35 - Procedures for Industry Specifications.

OR

This Permanent Reference Document has been developed and is maintained by GSMA in accordance with the provisions set out in GSMA AA.34 - Policy and Procedures for Official Documents.

**Table of Contents**

# 1 Introduction

## 1.1 Overview

This report provides the conclusions phase 1 of the GSMA 5G Mobile Roaming Revisited (5GMRR) task force.

The report provides an outline of the 5GS roaming security architecture, how it is different from the roaming architecture in 4G/LTE, and how this architecture addressing the business, operational and security requirements. A comparison of the existing 5GS roaming solutions as described in the 3GPP specifications (see TS 33.501 0, TS 23.501 0 and TS 29.573 0 is provided, followed by key issues and alternative solutions.

The report concludes with recommendations for the selected solution(s) and the follow-up actions in GSMA and 3GPP.

## 1.2 5GMRR Task Force

The role of the 5G Mobile Roaming Revisited (5GMRR) task force is to define realizable implementations using the 3GPP 5GS roaming security solution that optimally align the business needs, technical operation and security for 5G roaming. These requirement areas are present in 5GMRR Task Force through the participation of members of the following expert groups in GSMA, Wholesale Agreements and Solutions (WAS), Networks Group (NG) and Fraud and Security (FASG) as follows:

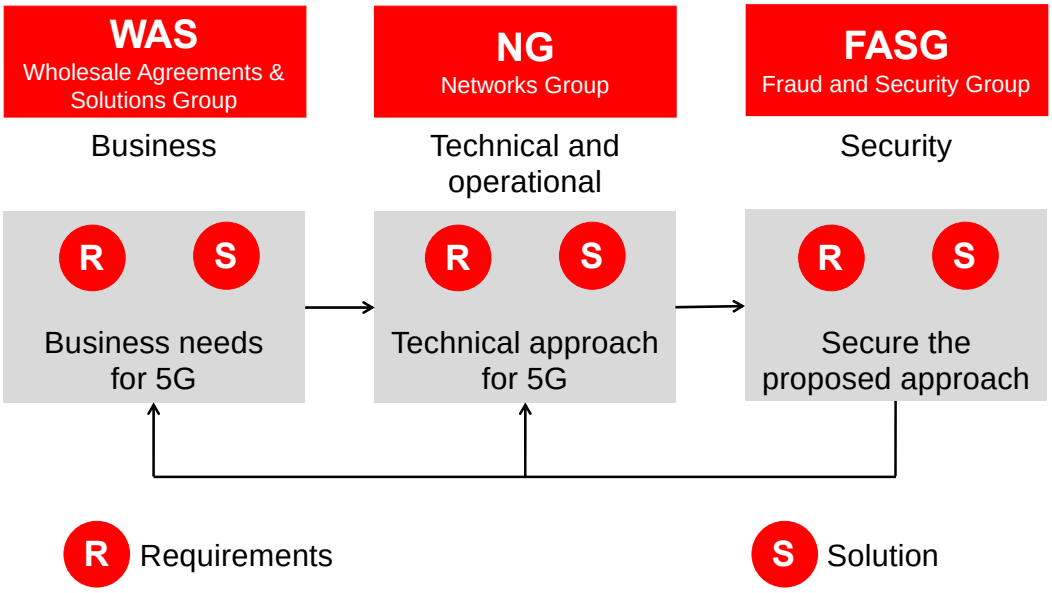



**Figure 1 – Requirements & Solution Design**

## 1.3 Scope

This document proposes a set of recommendations for the establishment of 5G roaming agreements between two MNOs (potentially via intermediates like IPX, Roaming VAS and Roaming HUB with further details outlined in section 2) both using a 5GS Core that meet the business needs of MNOs and intermediates.

## 1.4 Phases of 5GMRR work

In 5GMRR Phase 1 the use case descriptions are restricted to the bilateral inter-PLMN connections. The detailed solution is described in NG.113 Annex B 0 and is based on the following deployment principles and implementation restrictions:

- 5GS Roaming Architecture for bilateral inter-PLMN connections via either direct TLS connections between SEPPs or with TLS connections via a “IPX Class 0” service (IP routing, managed QoS).
- Support of inter-PLMN Roaming Hub (RH) solutions for Operator Groups but without a description of the internal implementation details.
- Including support of PLMN solutions with hosted SEPP with TLS as secure interface between PLMN and hosted SEPP.
- The implementation details of the internal Roaming Value Added Services (RVAS) solution are not described.

The timeline for 5GMRR Phase 1 is shown in Figure 2.

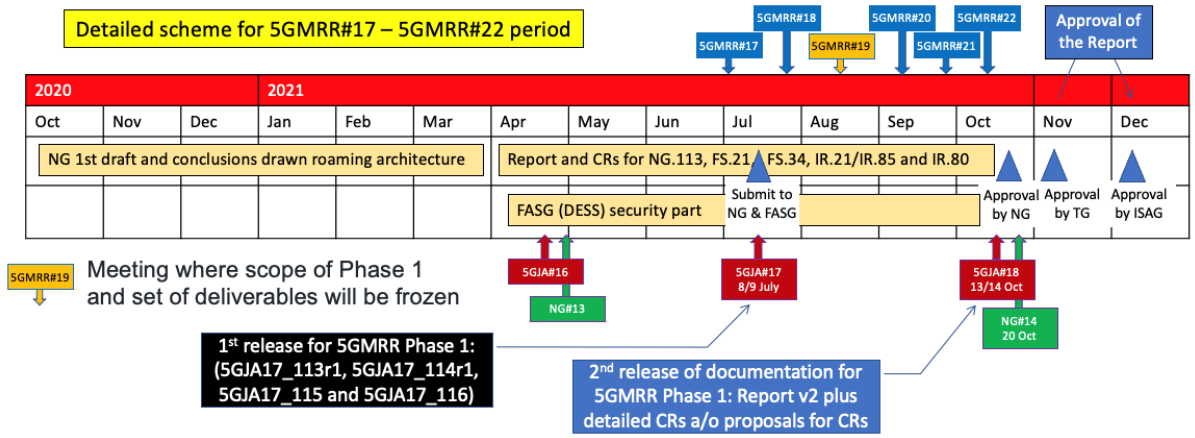



**Figure 2 – Timeline for the activities of the 5GMRR task force**

GSMA originally requested 3GPP to provide a secure roaming solution for 5G. During the process of revisiting the current roaming solutions to consider all business need, 3GPP will be actively engaged. Depending on the set of recommendations, this timeline may need adaptation in case work is needed in 3GPP.

In Phase 2 more 5GS roaming use cases will be addressed that allow more comprehensive services like by IPX, Roaming VAS and Roaming HUB to be incorporated. The scope and timeline for 5GMRR Phase 2 is not yet defined.

This report is to reflect the findings of 5GMRR Phase 1 with the aim to outline the deliverables that will provide the updated guidelines for 5G Roaming foreseen as CRs to GSMA PRDs like NG.113 0, FS.21 0 and FS.36 0, and the potential refinements of the 3GPP standards. See section 8 for more details about the documentation impact.

## 1.5 Abbreviations

| Term | Description |
|---|---|
| 5GC | 5G Core Network |
| 5GMRR | 5G Mobile Roaming Revisited |
| 5GS | 5G System |
| APT | Advanced Persistent Threat |
| B2BUA | Back-To-Back User Agent |
| CNI | Critical National Infrastructure |
| CP-SOR | Control Plane Steering Of Roaming |
| DRC | Data Roaming Control |
| E2E | End-To-End |
| EECC | European Electronic Communications Code |
| ENISA | European Union Agency for Cybersecurity |
| EPC | Evolved Packet Core |
| HPLMN | Home Public Land Mobile Network |
| IMSI | International Mobile Subscriber Identity |
| IPUPS | Inter-PLMN User Plane Security |
| IPX | IP Exchange |
| MNO | Mobile Network Operator |
| MVNO | Mobile Virtual Network Operator |
| NF | Network Function |
| PRD | Permanent Reference Document |
| PRINS | PRotocol for N32 INterconnect Security |
| pSEPP | Producer Security Edge Protection Proxy |
| RH | Roaming Hub |
| RVAS | Roaming Value Added Services |
| SBA | Service Based Architecture |
| SBI | Service Based Interfaces |
| SCP | Service Communication Proxy |
| SEPP | Secure Edge Protection Proxy |
| SLA | Service Level Agreement |
| SLO | Service Level Objective |
| SMSF | Short Message Service Function |
| SMSoIP | SMS over IP |
| SMSoNAS | SMS over 5G NAS |
| SOR-AF | Steering Of Roaming Application Function |
| TLS | Transport Layer Security |
| TSR | Telecoms Security Requirements |
| UPF | User Plane Function |

| Term | Description |
|---|---|
| VAS | Value Added Services |
| VPLMN | Visited Public Land Mobile Network |

## 1.6 References

| Ref | Doc Number | Title |
|---|---|---|
| 1 | 3GPP TS 33.501 | Security architecture and procedures for 5G |
| 2 | IETF RFC 7540 | Hypertext Transfer Protocol Version 2 (HTTP/2) |
| 3 | IETF RFC 793 | Transmission Control Protocol (TCP) |
| 4 | IETF RFC 7159 | The JavaScript Object Notation (JSON) Data Interchange Format |
| 5 | GSMA PRD IR.73 | Steering of Roaming Implementation Guidelines |
| 6 | GSMA PRD NG.113 | 5GS Roaming Guidelines |
| 7 | 3GPP TS 23.501 | System architecture for the 5G System (5GS) |
| 8 | GSMA PRD FS.21 | Interconnect Signaling Security Recommendations |
| 9 | GSMA PRD FS.36 | 5G Interconnect Security |
| 10 | 3GPP TR 29.829 | Technical Specification Group Core Network and Terminals; Service-based support for SMS in 5GC (Release 17) |
| 11 | 3GPP TS 23.122 | Technical Specification Group Core Network and Terminals; Non-Access-Stratum (NAS) functions related to Mobile Station (MS) in idle mode |
| 12 | 3GPP TS 29.550 | Technical Specification Group Core Network and Terminals; 5G System; Steering of roaming application function services; Stage 3 |
| 13 | ENISA | Guideline on Security Measures under the EECC https://www.enisa.europa.eu/publications/guideline-on-security-measures-under-the-eecc |
| 14 | ENISA | 5G Supplement - to the Guideline on Security Measures under the EECC https://www.enisa.europa.eu/publications/5g-supplement-security-measures-under-eecc |
| 15 | EU Toolbox | The EU toolbox for 5G security https://ec.europa.eu/digital-single-market/en/news/eu-toolbox-5g-security |
| 16 | NCSC | Security analysis for the UK telecoms sector https://www.ncsc.gov.uk/files/Summary%20of%20the%20NCSCs%20security%20analysis%20for%20the%20UK%20telecoms%20sector.pdf |
| 17 | UK Cabinet Office | https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/678927/Public_Summary_of_Sector_Security_and_Resilience_Plans_2017__FINAL_pdf___002_.pdf |
| 18 | GSMA PRD AA.51 | IPX Definition |
| 19 | GSMA PRD IR.34 | Guidelines for IPX Provider networks |
| 20 | GSMA PRD BA.60 | Roaming Hubbing Handbook |
| 21 | GSMA PRD BA.62 | Roaming Hubbing Business Requirements Commercial Model |

| Ref | Doc Number | Title |
|---|---|---|
| 22 | GSMA PRD BA.63 | Roaming Hubbing Hub to Hub Operational Procedures |
| 23 | S3-212287 | Change Request 33.501 CR 1080 rev 1 v16.6.0 “Clarification on the number of PLMN ID use by SEPP over N32” |
| 24 | S3-212367 | Change Request 33.501 CR 1105 rev 1 v15.12.0 “Clarify the usage of TLS and PRINS between SEPPs” |
| 25 | 3GPP TS 29.573 | Technical Specification Group Core Network and Terminals; 5G System; Public Land Mobile Network (PLMN) Interconnection; Stage 3 |
| 26 | EU Toolbox | The EU Toolbox for Security, March 2021, https://digital-strategy.ec.europa.eu/en/library/eu-toolbox-5g-security |
| 27 | UK TSR | United Kingdom Telecom Security Requirements, not yet published. |
| 28 | GSMA Whitepaper | Mobile Network Operator Business-Need Security and National Security |

# 2 5G roaming architecture

## 2.1 Definitions

### 2.1.1 General

IP Exchange (IPX) providers and Roaming Value Added Services (RVAS) providers are important stakeholders in the IPX ecosystem and in the framework of the whole roaming services ecosystem. In addition, Roaming Hubs (RH) offer a special deployment model in the IPX ecosystem that is typically suited to provide roaming services to two or more Mobile Network Operators (MNO) who have no roaming agreements with each other.

The IPX, RVAS and RH provider roles are independent of the legal entity that has these roles. A single legal entity can have multiple instances of these roles in parallel and can offer multiple services in parallel.

The following definitions only apply to the 5GS roaming traffic between a 5G Core network in the HPLMN and a 5G Core network in the VPLMN including the ongoing session context when PDU sessions are to be handed over to/from EPC and 5GC in LTE/5G interworking situations.

### 2.1.2 IP Exchange (IPX)

An IP Exchange (IPX) provider is an interconnect partner enabling transport of inter-PLMN traffic between operators on the IPX network. Service Level Agreements (SLAs), specific Service Level Objectives (SLOs), bandwidth guarantees, and latency guarantees may be part of the service provided.

A more elaborated list of IPX services and its supported roaming service classes is included in section 2.3.4. For further details of the IPX network and the IPX services please see:

- GSMA PRD AA.51 “IPX Definition” 0 that provides an overview of both the key components of the IPX network and a summary of the defined IPX services.

- GSMA PRD IR.34 “Guidelines for IPX Provider networks” 0 that gives guidelines and technical information on the IPX network consisting of the IP interconnection backbone of IPX Providers and GPRS Roaming eXchange of GRX Providers.

### 2.1.3 Roaming Value Added Service (RVAS)

A RVAS provider is an external entity, acting outside the perimeter of the MNO’s network domain, providing RVAS business services to an MNO. The services provided may include services that serve the subscriber (e.g. roaming control service, roaming welcome SMS), or those that serve the network (e.g. to solve interoperability issues, corrective actions). The use of RVAS is optional for MNOs.

For further details of the services and implementation guidelines for RVAS please see section 7.

### 2.1.4 Roaming Hub (RH)

The Roaming Hub (RH) provides a set of services to client MNOs to facilitate the deployment and operation of roaming and interworking services, often in a selectable ‘a la carte’ type set of options. Functions and operations like RVAS, routing, filtering, testing, troubleshooting, billing, invoicing, and dispute management will need to continue to be provided by RHs in 5GS roaming to preserve the range of services currently provided to client MNOs.

Within the roaming ecosystem , the RH is a separate entity that acts like a VPMN for HPMNs, and an HPMN for VPMNs. Client MNOs (clients of the roaming hub) have one roaming hub agreement with the RH provider in order to have roaming relations with participating client MNOs.

In order to avoid fraud and to ensure consistency a RH does not manipulate content, format or any information related to the traffic transmitted through its solution, unless manipulation is explicitly required within GSMA specifications or required by local regulations and laws, or subject to arrangements made between two parties.

For further details of RH service offering and definitions please see:

- GSMA PRD BA.60 “Roaming Hubbing Handbook” 0 that provides an overview about Roaming Hubbing.
- GSMA PRD BA.62 “Roaming Hubbing Business Requirements Commercial Model” 0 summarizing the commercial high level commercial requirements on Roaming Hubs and their commercial relationships to Client Operators including mandatory requirements on the commercial relationship between Roaming Hub and Client(s).
- GSMA PRD BA.63 “Roaming Hubbing Hub to Hub Operational Procedures” 0 that defines the operational procedures for efficient interconnection, interworking and interoperability between Roaming Hubs.

## 2.2 Regulatory Considerations and Outsourcing

The 5GS roaming architecture and procedures allow the outsourcing of edge elements, i.e. SEPP to third parties, although this business scenario and its implications are thus far not specifically addressed in 3GPP specifications TS 33.501 0, TS 23.501 0 and TS 29.573 0.

There are different regulatory frameworks, such as the EU Tool Box [26] and the United Kingdom Telecom Security Requirements (TSR) [27], that describe specific conditions for outsourcing of functions and actions within a jurisdiction. It is the responsibility of all companies subject to the specific regulations to comply with local regulatory frameworks.

Please see the reference to the GSMA whitepaper in 10 for details of regulations that would apply for SEPP Outsourcing in different regions and countries. Any position on SEPP Outsourcing will vary significantly with each individual country and potential outsource.

Further security considerations for SEPP outsourcing are given in section 14.4 in FS.21 0.

## 2.3 Control Plane and User Plane

### 2.3.1 Roaming 5G System Architecture

In the 5G System Architecture a clear separation is made between the Control Plane and User Plane network functions and reference points as outlined in 3GPP TS 23.501 0. Figure 3 shows this split between the N32-based Control Plane and the N9-based User Plane as part of the Roaming 5G System Architecture.

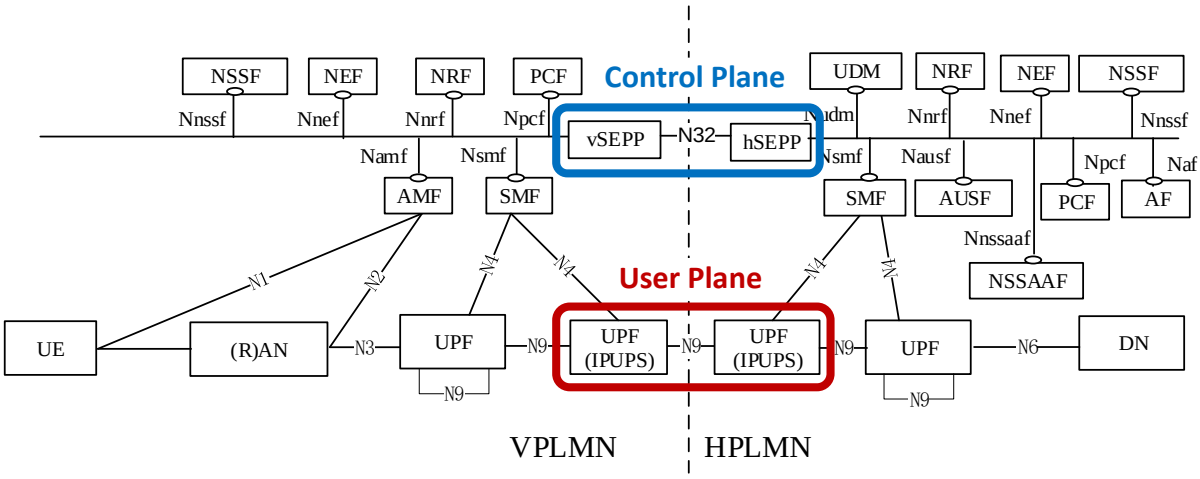



**Figure 3 – Roaming 5G System Architecture**

### 2.3.2 Roaming 5G Reference Points

Based on the list of reference points in 3GPP TS 23.501 0, Figure 4 provides an overview of the control plane reference points that can apply end-to-end (E2E) between the 5G Core network functions of roaming partners.

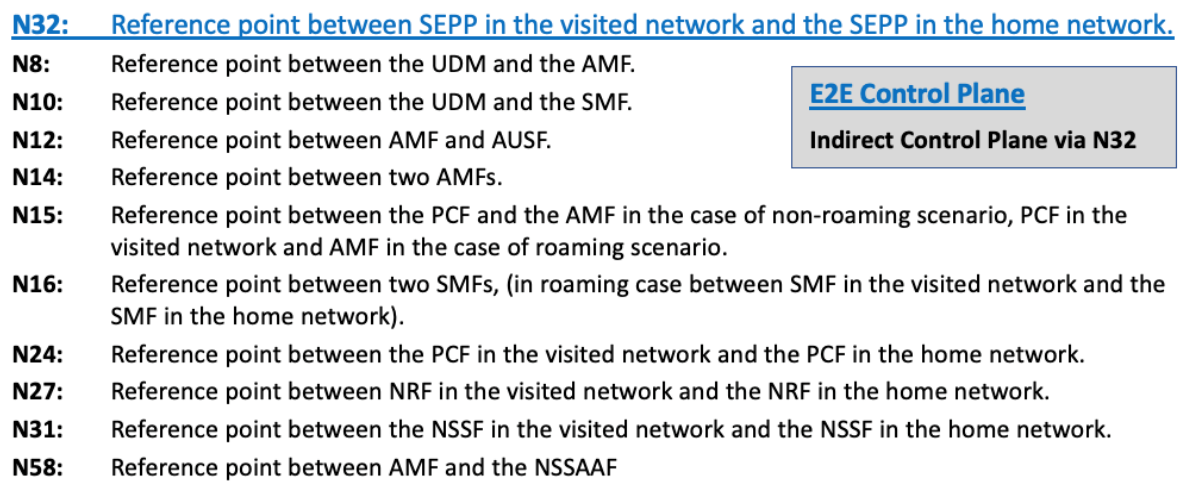



**Figure 4 – Roaming 5G Reference Points for the Control Plane**

Please note that N32 is the only control plane reference point between the 5GC networks of roaming partners. All control plane interactions are exchanged via this N32 reference point.

In parallel, the N9-based User Plane signalling messages for the UPF (IPUPS) interactions are exchanged via the N9-based User Plane reference point.

### 2.3.3 Roaming 5G User Plane Aspects

**Note** – Postponed till 5GMRR Phase 2.

### 2.3.4 Roaming Services

The support of RVAS is considered a home operator internal deployment specific matter in 5GMRR Phase 1. As a result, the implementation details of the internal RVAS solution are not described in 5GMRR Phase 1.

For this phase RVAS are provided on behalf of the HPLMN. If and how RVAS could be provided by VPLMN could be envisaged for new 5G services at a later point in time. The only exception is ‘welcome SMS’, which service interaction needs to be aligned with HPLMN anyway (and not applicable when ‘welcome SMS’ will be based on IMS).

**Note** – Further RVAS descriptions are postponed till 5GMRR Phase 2.

For the support of RVAS with features like ‘welcome SMS’, the solution may depend on cross-generation access via previous mobile generation systems when the UE switches between 2G/3G/4G/5G within the VPLMN; note that the signalling between VPLMN and HPLMN switches from HTTP to Diameter to SS7 in case there are parallel links. This may involve security risks for 5G users during roaming as clarified in both NG.113 0 and FS.21 0 under “Risks from Interworking with Different Technology Generations and Signalling Protocols”. Additional guidance on the use of correlation between protocol instances can be found in FS.21 0 under “Correlation Across Interconnect Signalling Protocols”.

# 3 Requirements

## 3.1 Business/operational requirements

Global roaming is a key service offering for MNOs. From a service and customer satisfaction perspective, ensuring the reliability and security of international roaming services is important. The 3GPP security principles of the 5GS are strongly supported by the operator roaming community.

Considering the business models that have developed and flourished to support the global roaming ecosystem, there are several principles that the GSMA's roaming groups believe are vital requirements and need to be supported when considering 5G security deployment models.

Foremost across all requirements for 5G roaming security is the strong desire for a single 5G roaming deployment (architecture) model that would support the majority of MNOs and roaming ecosystem partners. In practice, this would mean that the security deployment model should be clearly defined so that it does not need to be a negotiating point per roaming agreement.

The industry has experienced significant delays and effort to deploy VoLTE roaming, with initial delays stemming from the availability of multiple deployment architectures and associated business cases. With this lesson learned, multiple security deployment model choices for each use case should be avoided for 5GS roaming, understanding there will be significant complexity associated with deploying these new security solutions and elements. Having multiple deployment options that require additional bi-lateral negotiation and agreement for every roaming partner will impact the timing and proliferation of global 5GS roaming.

Along with the deployment approaches, the GSMA roaming groups evaluated the 5G roaming security requirements against the following categories: contractual; flexibility, practicality, and business needs. From a contractual standpoint, the roaming partners and ecosystem partners will continue to operate using contract vehicles that hold each party accountable with clarity of role, responsibility, privacy, and liability at a minimum. As the baseline for enabling and opening roaming, the contract vehicle can be enhanced to support any new security requirements should that be needed, including the new security requirements in the roaming contract will support compliance.

The analysis of the requirements concluded that while implementing new 5G roaming security methods, the overall ecosystem partner functions need to continue to be supported as they are critical to enabling the global roaming products for all types of MNOs. However, while important to support the business and partner functions, the solution(s) should not compromise the security and privacy of the data exchanged. Some specific examples that illustrate the concept are the need to ensure support for the Roaming Hubbing Model and similarly the concept that some MNOs may need to delegate their 5G Roaming Security controls in order to engage in the 5G Roaming ecosystem. In addition, the solution will need to account for the regulatory requirements across different regions.

Roaming Value Added Services (RVAS) are an enabler to the roaming ecosystem and enhance the roaming experience for consumers and support their MNO customers with

additional capabilities. These RVAS services need to be supported across 5G roaming, however their use should not break the security model designed or endorsed. While relying on many of these RVAS capabilities, the MNOs wish to maintain their independence and do not want the RVAS decisions of their roaming partners to impact their own operations. Visibility to the originating and terminating MNO is needed for a variety of applications/reasons, even when an MNO outsources a particular function. This requirement needs to be supported alongside the need to maintain the integrity and confidentiality of the message content from the terminating MNO. A clear example of this is steering of roaming.

To keep flexibility, the 5GS roaming solution should be designed in a transparent way that technical and security controls do not have to be adjusted to enable an RVAS. RVAS may change over time and new RVAS may come up in the future. Such innovation should not be hindered. However, changes to RVAS will always have to be in the bounds of the roaming agreements and meet the other requirements set out in this document.

Finally, having clear, detailed technical and business deployment guidelines will help ensure that secure 5G roaming is implemented with a high degree of interoperability, minimize deployment issues and support a robust global 5G ecosystem.

## 3.2 Technical Requirements

From the technical perspective, the 5GS roaming solution should consider the following:

- Signaling messages need to be exchanged between MNOs. As defined in the 3GPP 5GS standard, signaling messages are exchanged between roaming partners, as it is done for the previous mobile generations.
- An MNO may want to deploy multiple SEPPs for redundancy and load sharing purposes. The 5GS roaming architecture considers this and supports routing and load sharing accordingly.
- To have the least possible impact on the 3GPP specification, the overall number of network functions (NF), involved in 5G roaming should be minimal. Ideally, only the SEPP and the IPUPS perform all 5G roaming security controls for the roaming interface and no other NF is affected. This provides maximum transparency for other NF and simplifies implementation and operation.

From operational perspective, the additional effort for operating 5G roaming should only be slightly higher than existing roaming solutions. The overall 5GS roaming solution, its security controls and its key management procedures should add as minimal extra effort as possible.

The detailed solution is described in NG.113 Annex B 0.

## 3.3 Security and Privacy Requirements

As defined by 3GPP in TS 33.501 0, the following security and privacy requirements should be met by the 5GS roaming solution.

- The solution shall ensure that signaling messages cannot be manipulated, tampered, or injected by a malicious actor – authenticity and integrity, handled by the SEPP, are required.
- In 5GMRR Phase 1 with TLS connections used between SEPPs, both integrity and confidentiality protection apply to all attributes transferred over the N32 interface.

- IPUPS, as defined by 3GPP Release 16, shall be used. Likewise, a secure N9 message transfer shall be deployed between all MNOs. 3GPP requires the use of NDS/IP.
- The destination network shall be able to determine the authenticity of the source network that sent a signaling message.
- The solution shall prevent replay attacks, and cover algorithm negotiation and prevention of bidding down attacks.
- Standard security protocols should be used.
- Operational aspects of key management should be taken into account.

5GMRR identified that in addition to the above requirements, recipients of messages shall be able to determine the originating MNO.

**Note**- This should equally apply for the case, that a SEPP is outsourced and operated by another trusted entity on behalf of the origin MNO as in alignment with the specific security considerations for SEPP outsourcing in section 14.4 in FS.21 0.

### 3.4 Assessment of the Requirements

**Note** – Postponed till 5GMRR Phase 2 when the full solution for 5G SA Roaming is defined.

## 4 State of the art 5GS roaming solutions

### 4.1 Background

In previous generations of mobile networks inter-operator signalling security was difficult to achieve due to early telephony signalling legacy.

5G addresses the problem in the 3GPP specifications by enabling confidence in signalling integrity and confidentiality and gives the ability to establish authenticity through either:

- end-to-end communication security using Direct TLS, see section 4.3, or
- where intermediaries are used (Hubs, IPX carriers and Value Added Services) 3GPP PRINS to secure the interconnect, see section 4.2.

The following sections summarize the options for 5G Roaming with PRINS and Direct TLS at the start of the 5GMRR task force. It should be noted that this is an open, current discussion and requires further consultation and validation by WGs and membership as part of the work by this task force.

### 4.2 PRINS

The PRotocol for N32 INterconnect Security (PRINS) model for the support of 5G roaming is shown in Figure 5. The use of PRINS is negotiated via N32-c (not depicted).

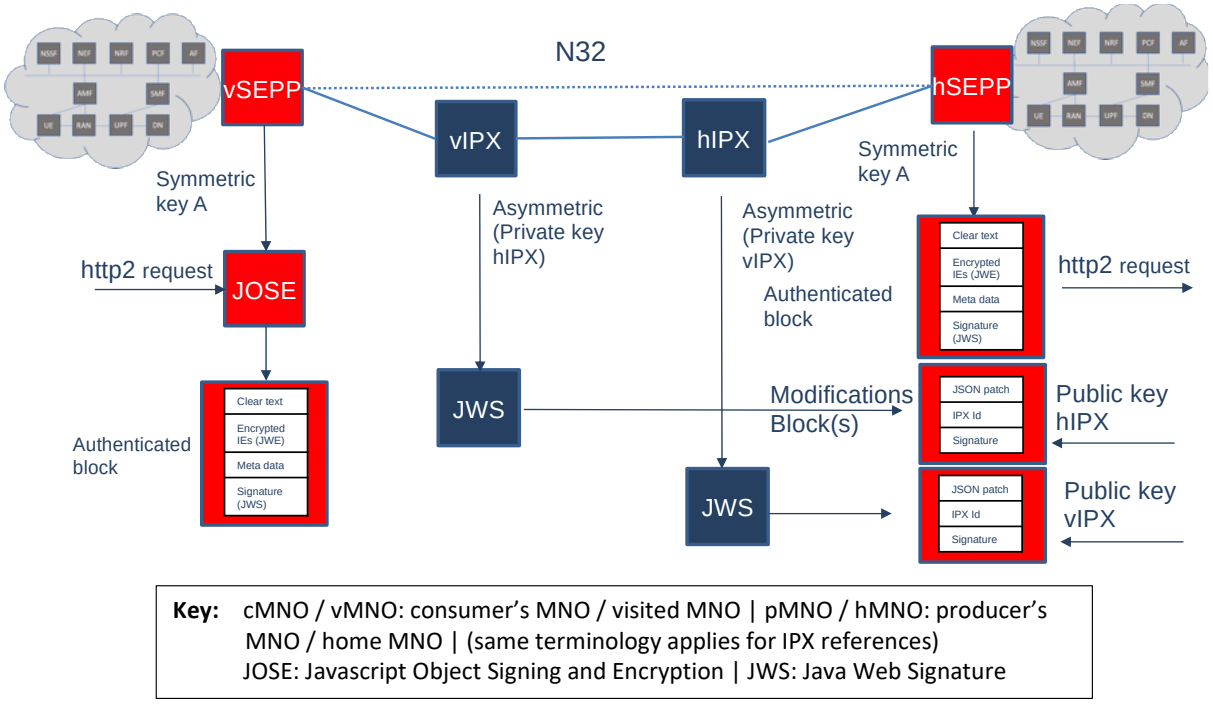



**Figure 5 – PRotocol for N32 INterconnect Security (PRINS) model for 5G roaming**

The PRINS model is designed to fulfil the following:

- Confidentiality and integrity of sensitive information elements during transport via vIPX and hIPX, while still allowing modifications and offering services. Sensitive information is secured end-to-end[1].
- Traceability and attribution of potential changes and modifications to signalling between PLMNs.

However, when analysing PRINS, the following difficulties were detected when using PRINS with modifications by intermediaries:

- Creates operational complexity as signalling consuming MNO needs to perform extensive policy checks:
  - Protection Policies may vary per partner MNO
  - Roaming agreement may vary per partner MNO
  - JSON Patch control for both visited and home network IPX carriers
- Operators will need to be aware of which intermediary IPX is allowed to modify messages, as well as of public keys of these intermediaries.

As a result, introduction of the PRINS model would require solutions that address the complexity for Contracts, Operation and Security that it brings.

[1] A differentiation between non-/sensitive IEs is postponed till 5GMRR Phase 2.

## 4.3 Direct TLS

The Direct TLS model for the support of 5G roaming is shown in Figure 6. The use of direct TLS is negotiated via N32-c (not depicted).

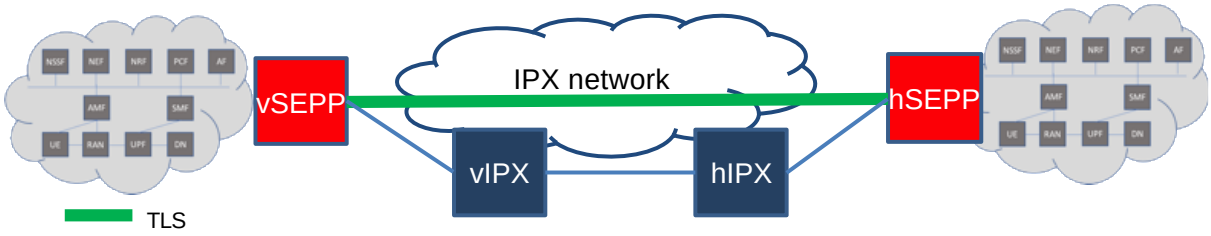



**Figure 6 – Direct TLS model for 5G roaming**

The Direct TLS model is characterised as follows:

- Signalling producing MNO in full control of HTTP/2 message content send to consuming MNO
- Operational simplicity as consuming MNO only needs policy checks for
- Roaming Agreements per producing MNO.
- Signalling information secured end-to-end between both MNOs
- Intermediaries not possible unless there is willingness to disclose all information including UE keying material and authentication tokens to the intermediary.

## 4.4 Incompatibility PRINS and Direct TLS

The 3GPP standard TS 33.501 0 prescribes that for N32-f either Direct TLS is to be used end-to-end for a roaming relation if no intermediaries are on the path, or alternatively, PRINS. If PRINS is used, the communication is end-to-end secured at application layer on top of TLS, which is applied hop-by-hop securing communication between intermediaries at the transport layer. From a deployment perspective, this is a discrete choice to be settled between both 5GS roaming partners.

**Note:** -In this context intermediaries according to 3GPP are network elements that can read a message and possibly also can add a modification. In the TLS end-to-end case, there is no possibility for an RVAS provider and/or IPX provider to intervene as the whole message content is confidentiality protected end-to-end. PRINS allows RVAS providers and IPX providers to intervene at the application layer according to the security policy applied to the underlying roaming agreement.

## 4.5 Comparison PRINS versus Direct TLS

In order to compare PRINS and Direct TLS, the following elements are taken into account:

- Three different cases (bilateral with MNO SEPP, bilateral with outsourced SEPP, roaming hubbing)
- VAS could be provided at different level (before/after the SEPP or in transit)

### 4.5.1 Direct TLS

SEPPs are connected directly via TLS using N32 interface which could be fully encrypted, see Figure 7.

N32-c connection: A TLS based connection between a SEPP in one PLMN and a SEPP in another PLMN. Used to negotiate TLS as security policy for 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 via the same TLS connection as used for N32-c.

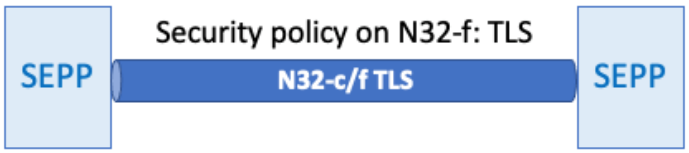



**Figure 7 – Direct TLS Architecture**

TLS offers end-to-end protection of full message content on the N32-f connection between both SEPPs.

MNO could use different approaches to connect the SEPP.

SEPP could be directly provided by the MNO, and VAS could be hosted by the MNO or a 3rd party.

SEPP could be outsourced by the MNO to IPX providers, and VAS could be also outsourced.

Roaming traffic could be managed by a Roaming Hub, based a SEPP connectivity.

### 4.5.2 PRINS

PRINS architecture combined the N32-c connection and N32-f connection to provide both transport and application level security, see Figure 8.

N32-c connection: A TLS based connection between a SEPP in one PLMN and a SEPP in another PLMN. Used to negotiate PRINS as security policy for N32-f and to negotiate the N32-f specific associated security configuration parameters required to enforce application layer security on HTTP messages exchanged between the SEPPs.

N32-f connection: Logical connection that exists between a SEPP in one PLMN and a SEPP in another PLMN, via two IPX providers, each associated with one of the PLMNs, for exchange of protected HTTP messages.

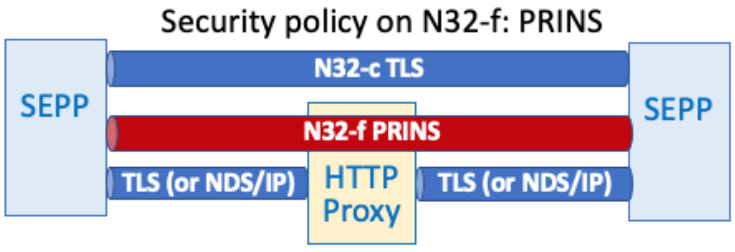



**Figure 8 – PRINS Architecture**

Full end-to-end protection on the N32-f connection is provided by the upper PRINS layer with sensitive IEs protected at the intermediate HTTP Proxy signalling hops. The underlying TLS (or NDS/IP) layer offers hop-to-hop protection of full message content of the N32-f connections between the SEPP and HTTP Proxies.

Compared to Direct TLS, MNO could use RVAS provided by IPX in transit on the N32-f interface based on the non-encrypted fields.

### 4.5.3 TLS/PRINS characteristics

Table 1 summarises the major signalling characteristics and highlights the difference between direct TLS and PRINS.

| | TLS | PRINS |
|---|---|---|
| N32-c IPX role | IP carrier (SEPP-SEPP) | IP carrier (SEPP-SEPP) |
| N32-f IPX role | IP carrier (SEPP-SEPP) | HTTP proxy (SEPP-IPX-IPX-SEPP) |
| 5GC Signalling Security Transport layer | End-to-end (SEPP-SEPP) Integrity protection and encryption | Hop-by-hop (SEPP-IPX-IPX-SEPP) Integrity protection and encryption |
| 5GC Signalling Security Application layer | Not protected | End-to-end (SEPP-SEPP) Integrity protection<br>Partly Encrypted |
| Actors for Security keys | SEPP | SEPP / HTTP proxy |
| SEPP outsourcing | Possible | Possible |
| Coupling security/VAS | No | Yes |
| Hubbing | MNO like | MNO like |

**Table 1 – Differences between Direct TLS and PRINS**

### 4.5.4 TLS/PRINS pro/cons

Table 2 summarises the pros/cons between direct TLS and PRINS in case of using intermediate hops (e.g. RH).

With the model in Figure 9, TLS offers hop-by-hop protection of full message content between SEPPs, hop-by-hop security protection of full message content between SEPPs is provided. However, this concatenation of hop-by-hop TLS connections introduces additional risk by allowing 3rd parties to gain full access to signaling and allowing an intermediary node to hide the originator information.

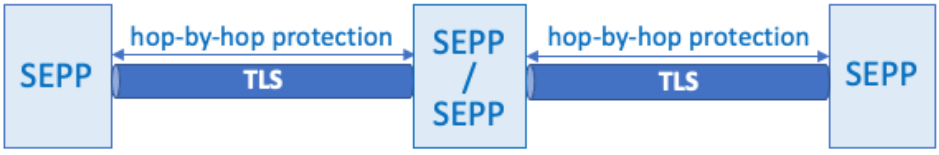



**Figure 9 – Direct TLS used with intermediate hops**

With the model as in Figure 10, PRINS provides end-to-end protection for sensitive IEs at signaling hops for the confidentiality protected IEs via the PRINS ALS layer.

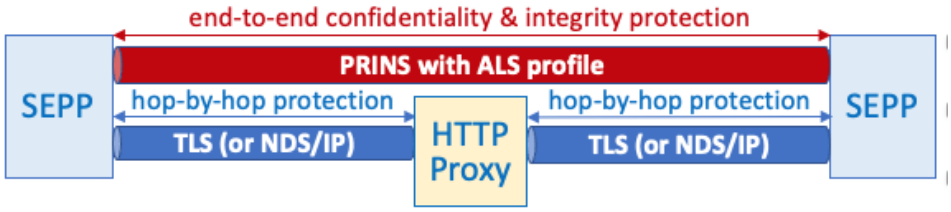



**Figure 10 – PRINS used with intermediate hops**

PRINS provides more granular and flexible security handling of data transferred between SEPPs. From a security point of view, who attaches or modifyies a particular Information Element in the chain, when IPX is involved, may be con by one of the communicating parties. Thus, it should be kept as an option in designing a 5G security interconnect solution. Any operational burdens, in terms of human effort can be optimized with software options such as providing IPX providers with profiles on modification policies.

| | Pros | Cons |
|---|---|---|
| Direct TLS | End-to-end encryption<br>IPX usage for pure IP<br>No audit trail is needed (all changes are within each operator's domain and no intermediate changes by IPX providers) | No transit VAS |
| PRINS | Transit VAS possible (for example signalling normalisation)<br>End-to-end sensitive information element protection<br>Traceability for modifications<br>Most information elements accessible by IPX provider | IPX to provide http proxies for N32-f<br>More actors for security keys (IPX providers)<br>Security policy profiles per N32-f<br>Coupling of security and (transit) VAS policies |

**Table 2 – Pros/Cons between Direct TLS and PRINS**

**Note**: Transit VAS use cases are quite limited (not used for hubbing, sponsor IMSI or MVNO)

The comparison in Table 2 mixes transport and application security. N32-f HTTP/2 traffic in PRINS between Operator and the IPX provider is subject to be protected by NDS/IP. It can be done via TLS or even IPSec, of course hop by hop. It is just a transport security mechanism between networks.

# 5 Key issues

## 5.1 Security

For a description of security issues please refer to FS.21 0 section 14 "Holistic Security approach for Mobile Roaming services". This is specifically developed and written in the context of 5GS roaming and addresses the following aspects:

- Security Considerations
- Security Recommendations
- Specific considerations SEPP Outsourcing.

In addition, please refer to FS.34 for considerations of Key Management.

## 5.2 Normalisation of messages

Normalisation in this context refers to modification of certain attributes in inter-PLMN traffic. This is typically needed to facilitate inter-operability of MNO's network functions where problems arise due to different interpretation or implementation of standards or protocols.

### 5.2.1 Normalisation of messages in 2G/3G/4G inter-PLMN traffic

Control plane messages of inter-PLMN 2G/3G/4G traffic are primarily based on SS7, GTPv1/v2 and Diameter. Although these interfaces are defined in the respective RFC and 3GPP specifications, it is not uncommon that network equipment vendors have different interpretation or implementation of such interfaces in terms of message formatting, information element formats and their actual values. IPX providers are required to perform normalisation of such traffic to resolve such inter-operability issues. Some examples are:

- Uppercase / lowercase conversion of information element values. Usually Diameter host/realm names are case-insensitive, but some DEA/HSS require all their peer names be in lowercase but some MME are configured with uppercase names.
- Modifications of information element values. MME/MSC are programmed to map MAP/Diameter result codes to NAS codes for sending to UE. These NAS codes impacts UE behavior (such as selection of networks). In order to use certain NAS codes, MAP/Diameter result codes from HLRHSS are mediated to specific values.
- Setting/unsetting of information element values to cope with different versions of specifications. Some information element (such as feature bits) values defined in new 3GPP specifications are not available in network equipment with older generations. Mediation of such values are necessary to support certain use cases.

While some normalisation can be handled by MNO's network functions (such as DEA in 4G), some MNO relies on external parties such as IPX provider to perform such normalization.

### 5.2.2 Normalisation of messages in 5G inter-PLMN traffic

In 5G inter-PLMN traffic is based on HTTP/2 protocol, and if using PRINS on N32-f, with JSON format for control plane. GTPv2 is used for user plane. Normalisation of messages in 5G inter-PLMN traffic for message compatibility / interoperability is not required due to the following reasons:

- JSON is a well-defined formatting and serialisation standard and shall facilitate interoperability of MNO's network functions. 3GPP has means for version handling of Service Based Interfaces (SBI) standardised, as well as mechanism for negotiating supported features within a given version, and these should be used, verified, and tested before launching of new roaming relations.
- Any incompatibility or interoperability issues shall be addressed by the MNO at SEPP with configuration, software patching or backward compatibility rules.

- Processing of user plane traffic is not required for normalization as user plane traffic based on GTPv2 is a simple and mature format that is widely used in 3G/4G.

## 5.3 SEPP Security Configuration Criteria

**Note** – Postponed till 5GMRR Phase 2.

## 5.4 When using SEPP and when using SCP?

**Note** – Postponed till 5GMRR Phase 2.

## 5.5 How to secure SCP to SEPP?

**Note** – Postponed till 5GMRR Phase 2.

## 5.6 Support of multiple PLMN IDs

As per update of TS 33.501 0 section 5.9.3.2 “Requirements for Security Edge Protection Proxy (SEPP)” for Rel.17 as in the Change Request S3-212287 0, the SEPP shall be able to use one or more PLMN IDs as follows:

1- **PLMN is using more than one PLMN ID.**
This PLMN's SEPP may use the same N32-connection for all of the PLMN's PLMN IDs as sketched in Figure 11 for a VPLMN owning PLMN ID’s a, b and c.

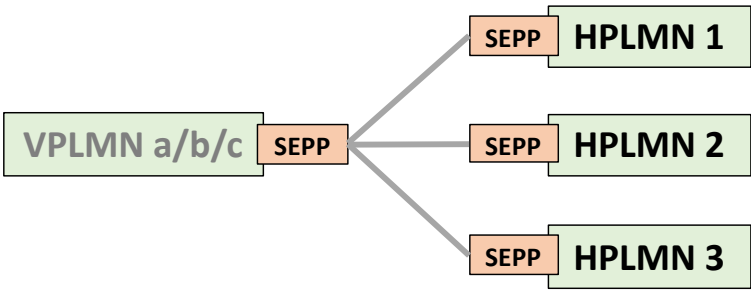
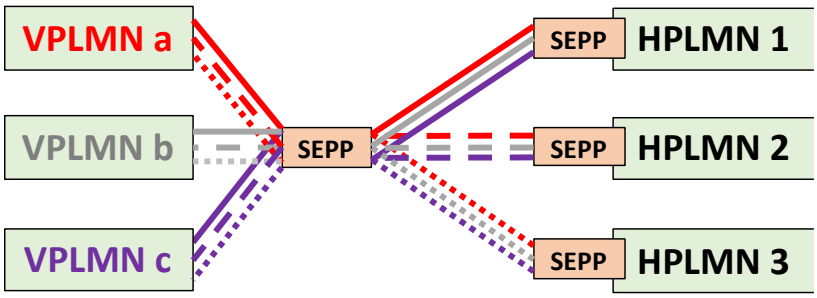



**Figure 11 – SEPP using same N32-connection for all VPLMN's PLMN IDs**

2- **Different PLMNs represented by the PLMN IDs**

If different PLMNs represented by the PLMN IDs are supported by a SEPP, the SEPP shall use separate N32-connections for each pair of PLMNs as sketched in Figure 12 for VPLMNs owning PLMN ID’s a, b and c.




Each line represents a separate N32-connection

**Figure 12 – SEPP using separate N32-connections for the connected VPLMNs**

## 5.7 Usage of TLS and PRINS between SEPPs

As per update of TS 33.501 0 section 13.1 “Protection at the network or transport layer” about the use of TLS and PRINS as in the Change Request S3-212367 0, the usage of TLS and PRINS between SEPP is clarified as depicted in Figure 13:

1. TLS shall be used for N32-c connections between the SEPPs.
2. If there are no IPX providers between the SEPPs, TLS shall be used for N32-f connections between the SEPPs.
3. If there are IPX providers which only offer IP routing service between SEPPs, either TLS or PRINS shall be used for protection of N32-f connections between the SEPPs.
4. If there are IPX providers which, in addition to IP routing offering services like billing, PRINS shall be used for protection of N32-f connections between the SEPPs

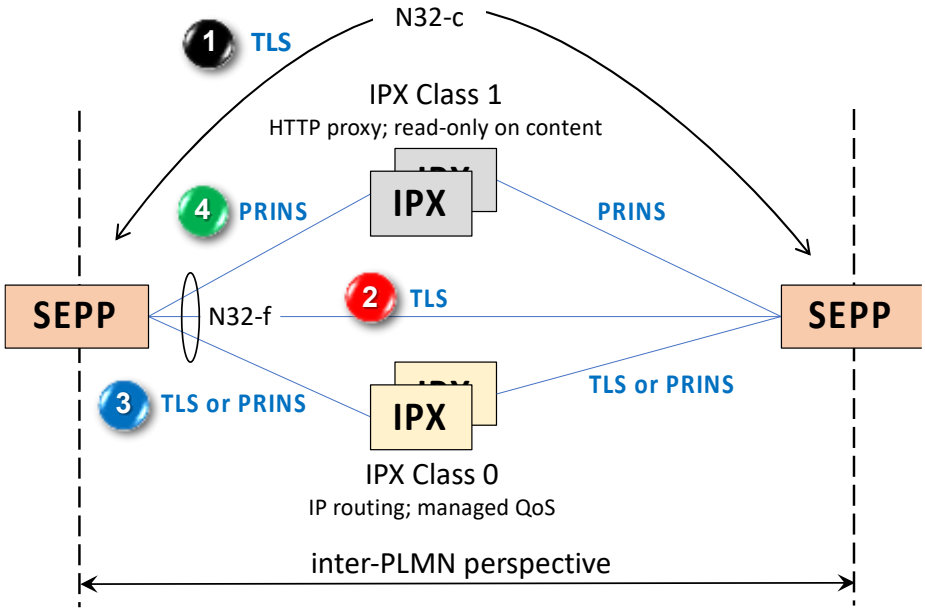



**Figure 13 – SEPP using separate N32-connection for connected PLMNs**

Based on the 5GMRR solution principle “Simplest Model per Use Case”, based on the business/operational requirements outlined in section 3.1, TLS is concluded as connection model for 5GMRR Phase 1 support of bilateral inter-PLMN roaming deployment scenarios

making use of direct connections or utilizing an IPX for http proxy services (read only content for IP routing and managed QoS).

The usage of PRINS and the automated migration to additional IPX service is being further analyzed.

# 6 Use cases

**Note** – Postponed till 5GMRR Phase 2.

# 7 Roaming VAS

**Note** – Postponed till 5GMRR Phase 2 when the full solution for 5G VAS is defined.

# 8 Documentation

Within the scope of 5GMRR Phase 1 the following documentation delivery is followed:

- 5GS Roaming Guidelines in CR proposal to NG.113 with detailed outline of the 5GMRR Phase 1 support of bilateral inter-PLMN deployment scenarios including SEPP Outsourcing and Mobile Operator Group Roaming Hub.
- Documentation of the surrounding security and operational aspects to be covered with the 5GMRR Phase 1 technical solution in CR proposal to FS.21.
- CR proposals to IR.21 and IR.85 for the support of roaming contracts of 5GS bilateral inter-PLMN connection support for 5GMRR Phase 1. With 5GMRR Phase 2 further enhancements are foreseen to cover the additional 5GS roaming use cases.
- Adding options for the internal RHUB solution within operator groups with intuitive descriptions in a CR proposal to IR.80.
- CR to FS.34 v1.0 with enhancements of the manual key management procedure for 5GS roaming support for SEPP Outsourcing as part of the work in FASG DESS.

There is currently no need for a CR to FS.36 v2.0 “5G Interconnect Security” for 5GMRR Phase 1. However, at a later time refinements are foreseen following decisions on how TLS and PRINS will be used.

Following feedback at NG#13 there is no need for CR proposals to align on IPX, RVAS and RH definitions in IR.34, BA.60, etc. with the added cross-references to the definitions in sections 2.1 and 2.3.4.

# 9 Guidelines for Inter-PLMN Connection

The detailed solution is described in NG.113 Annex B 0.

For the initial support of 5GS Roaming as with 5GMRR Phase 1, NG.113 Annex B provides the guidelines for the bilateral inter-PLMN connection deployment scenarios including SEPP Outsourcing and Mobile Operator Group Roaming Hub.

Additional guidelines for 5GS Roaming are planned in a future version of NG.113 for the more comprehensive 5GS Roaming use cases such as IPX services, Roaming Value Added Services (RVAS) and Roaming Hub (RH).

# 10 Considerations for SEPP Outsourcing

Security and national regulation issues related to SEPP Outsourcing are provided in the GSMA whitepaper “Mobile Network Operator Business-Need Security and National Security” [28].

# Annex A Document Management

## A.1 Document History

| Version | Date | Brief Description of Change | Approval Authority | Editor / Company |
|---|---|---|---|---|
| 1.0 | 01 Oct 2021 | First Document Version | ISAG | Pieter Veenstra, NetNumber |

**Other Information**

| Type | Description |
|---|---|
| Document Owner | Networks Group |
| Editor / Company | Pieter Veenstra, NetNumber |

It is our intention to provide a quality product for your use. If you find any errors or omissions, please contact us with your comments. You may notify us at prd@gsma.com

Your comments or suggestions & questions are always welcome.