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| 3GPP TR 33.721 V0.3.0 (2024-08) | |
| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group Services and System Aspects;  Study on security aspects of 5G Mobile Metaverse services;  (Release 19) | |
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# Foreword

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

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

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

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

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

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

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

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

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

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

**should** indicates a recommendation to do something

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

**may** indicates permission to do something

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

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

**can** indicates that something is possible

**cannot** indicates that something is impossible

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

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

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

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

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

In addition:

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

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

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

# Introduction

Editor's Note: The introduction clause content is left for future consideration.

# 1 Scope

The present document studies security impacts of the procedures introduced in Study on Application enablement architecture for mobile metaverse services studied in TR 23.700-21[2], specifically, the security aspects that are to be covered in this study are as follows:

- authentication and authorization of digital identity (non-IMS based)

NOTE: The term digital identity is defined in clause 3.1.

- support security aspects of digital asset container

 Editor's Note: Whether the digital asset container is specified in 5GC or in the application layer is under the remit of SA6.

- security and privacy aspects of user sensitive information for Localized Mobile Metaverse Services

NOTE: The potential security requirements will be updated based on the study progress in SA6.

# 2 References

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

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

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

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

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

…

[2] 3GPP TR 23.700-21: "Study on Application enablement architecture for mobile metaverse services".

[3] 3GPP TS 22.156: "Mobile Metaverse Services; Stage 1".

[4] 3GPP TS 33.434: "Security aspects of Service Enabler Architecture Layer (SEAL) for verticals".

[5] 3GPP TS 33.122: "Security aspects of Common API Framework (CAPIF) for 3GPP northbound APIs"

[6] 3GPP TS 33.501: "Security architecture and procedures for 5G System"

[7] 3GPP TS 23.434: "Service Enabler Architecture Layer for Verticals (SEAL); Functional architecture and information flows"

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms 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].

**Digital Asset Identifier:** In the context of this TR, digital asset identifier is used to uniquely identify a digital asset across different mobile metaverse services.

## 3.2 Symbols

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

<symbol> <Explanation>

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 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].

<ABBREVIATION> <Expansion>

clause includes the overview applicable for the study.

# 4 Security assumptions

The following security assumptions are applied to the study:

- The application enabler architecture for mobile metaverse services as described in TR 23.700-21 [2] is taken into account.

Editor’s Note: alignment with TR 23.700-21 is FFS.

- The security architecture, requirements and procedures for SEAL as defined in TS 33.434 [4] are used as a baseline.

Editor's Note: Whether SA6 architecture options are based on SEAL is FFS.

- Digital Asset Identifier is used in this study to identify a digital asset associated with a user.

# 5 Key issues

Editor’s Note: This clause contains all the key issues identified during the study.

## 5.1 Key Issue #1: Authorization supporting spatial localization service

### 5.1.1 Key issue details

In clause 4.1 of TR 23.700-21 [2], enabler support for managing spatial anchors is documented as a key issue, with the open issue regarding the access to spatial anchor as the following:

"*How to discover spatial anchors by the consumer (e.g. UE, VAL server)?*"

In clause 4.2 of TR 23.700-21 [2], exposing spatial map to third parties is documented as a key issue, with the open issue regarding the third party who needs to be authorized as the following:

"*How to expose a spatial map to authorized third parties?*"

Either for discovering spatial anchors or for exposing spatial maps, authorization of the consumer (e.g. UE, VAL server) needs to be considered. This key issue focuses on the authorization aspect supporting spatial localization service.

### 5.1.2 Security threats

Spatial map or spatial anchor could be a piece of information sensitive to the operator or the operator’s customer or the users in the map. If the consumer (e.g. UE, VAL server) is not authorized for obtaining the spatial map or accessing the spatial anchor, such sensitive information could be leaked to an undesired party. Further, the operator will not be able to correctly charge the consumer (e.g. UE, VAL server) for using spatial localization service supporting localized mobile metaverse services.

Editor’s Note: What sensitive information is for an operator or operator’s customer is FFS.

### 5.1.3 Potential security requirements

The 5G system shall provide a means to authorize a consumer (e.g. UE, VAL server) for accessing spatial localization services (e.g. spatial map obtaining, spatial anchor accessing).

Editor’s Note: The requirement details with respect to the potential consumers of localized mobile metaverse services, the host of such service and exposed information via such service is subject to SA6 progress.

## 5.2 Key Issue #2: Privacy of user sensitive information

### 5.2.1 Key issue details

According to clause 4.2 of TR 23.700-21 [2], user sensitive information (e.g. relating to user/UE identity, body movement or location, authentication result) needs to be accessed, managed and exposed through the enabler layer for localized mobile metaverse service.

In clause 4.2 of TR 23.700-21 [2], exposure of user sensitive information is documented as a key issue.,

This key issue focuses on the privacy aspect of user sensitive information which is transferred within or outside the network.

### 5.2.2 Security threats

User sensitive information needs to be accessed and exposed through the enabler layer to a party other than the user. Without proper protection, the privacy sensitive information could be leaked to undesired party, leading to privacy violation, trust and reputation impairment, regulatory incompliance, etc. An attacker can avail the user sensitive information to launch targeted attacks that cause data breaches, identity theft, etc.

### 5.2.3 Potential security requirements

The 5G system shall provide a means for privacy protection of user sensitive information during exposure of user specific information (e.g. user identity, user location) in localized mobile metaverse services through the application enabler layer.

## 5.3 Key issue #3: Security aspects of digital asset container in 5G

### 5.3.1 Key issue details

Avatar and digital asset support, including digital asset avatar management and discovery, is discussed in Key issue #3 in TR 23.700-21[2]. Correspondingly, the security aspect of the digital asset as well as the digital asset container itself deserve a thorough KI in order to further clarify the potential risks of the digital asset container in 5G.

This KI aims to comprehensively study the security requirements of the digital asset container in 5G.

### 5.3.2 Security threats

An attacker may access a digital asset if the authentication and authorisation of the usage of digital assets are not performed.

### 5.3.3 Potential security requirements

The 5G system shall support to authenticate and authorize a digital asset service consumer to access the digital asset(s) in a digital asset container.

NOTE: Digital asset service can be consumed by VAL applications as per TR 23.700-21[2], e.g. VAL client, VAL server.

## 5.4 Key Issue #4: Authentication and authorization of digital representation

### 5.4.1 Key issue details

In clause 7.2.4 of TS 22.156 [3], the following requirement implies the need of authentication of digital assets:

"*[R-7.2.4-002] The 5G system shall provide mechanisms to certify the authenticity of digital assets associated with a user.*"

In clause 7.2.3 of TS 22.156 [3], the following requirement implies the need of authorization of digital assets:

"*[R-7.2.3-001] Subject to operator policy, regulatory requirements and user consent, the 5G system shall be able to authorize the avatar to be used in mobile metaverse services.*"

Digital assets used in mobile metaverse services can be digital representation (avatar), software licenses, gift certificates, tokens, etc., which should be uniquely identifiable according to the definition of in clause 3.1 of TS 22.156 [3]. Avatars are digital representations of users interacting with the metaverse and other users in mobile metaverse services. In current mobile network services, users need to be authenticated to connect to mobile networks and authorized to access the requested services. In mobile metaverse services with avatar representing the user, user authentication and authorization need to be realized via the avatar.

This key issue focuses on authentication and authorization of digital representation (e.g. avatar) which has its unique identifier.

### 5.4.2 Security threats

Without authentication of avatar, an attacker can falsify an avatar to impersonate the user represented by the legitimate avatar. Then the attacker can manipulate the falsified avatar in a mobile metaverse service to launch more types of attacks. Even if the unique identifier of a legitimate avatar can be changed from time to time, the attacker can still launch such attack during the valid period of the identifier.

Editor’s Note: more clarification on the threats is FFS.

### 5.4.3 Potential security requirements

The 5G system shall provide a means to support authenticating a digital representation to represent a user in mobile metaverse services.

Editor’s Note: more requirements are FFS.

## 5.X Key Issue #X: <Key Issue Name>

### 5.X.1 Key issue details

### 5.X.2 Security threats

### 5.X.3 Potential security requirements

# 6 Solutions

Editor’s Note: This clause contains the proposed solutions addressing the identified key issues.

6.0 Mapping of solutions to key issues

Editor's Note: This clause contains a table mapping between key issues and solutions.

**Table 6.0-1: Mapping of solutions to key issues**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Solutions** | **KI#1** | **KI#2** | **KI#3** | **KI#4** |
| **Solution #1** | X |  |  |  |
| **Solution #2** | X |  |  |  |
| **Solution #3** | X |  |  |  |
| **Solution #4** |  | X |  |  |

## 6.1 Solution #1: Support for spatial localization service authorization

### 6.1.1 Introduction

This solution is for KI #1 and addresses the security requirements for authorizing UE to access spatial localization services. This solution is based on the SEAL identity management (SIM) service to perform UE authentication and authorization.

### 6.1.2 Solution details

Before getting authorization to specific service, the VAL UE authentication is executed by the SIM-S as described in TS 33.434 [4]. After successful authentication, the SIM-C requests and receives an access token from SIM-S as shown in Figure 6.1.2-1.



**Figure 6.1.2-1: Get Access Token**

1. User Authentication is completed between VAL UE and the SIM-S.
2. The VAL UE sends an access token request to the SIM-S, including the identity of the VAL UE and the specific spatial localization service the UE requests to access.
3. The SIM-S authorizes the VAL UE for the requested service and provides access token for the VAL UE.

With the received access token, the VAL UE can request for spatial localization service from corresponding SEAL server supporting the requested service. The procedure of getting spatial map for metaverse application is shown in Figure 6.1.2-2.



**Figure 6.1.2-2: Get Spatial Map**

1. A secure channel is established between SEAL client and SEAL server. Subsequent communication makes use of this channel.

1. The VAL UE sends a request message containing the access token to the SEAL server to get the spatial map via SEAL LM client.

2. On receiving the service authorization message, the SEAL server validates the access token.

3. If the access token is valid, the SEAL server provides the spatial map information to the VAL UE via SEAL client. Otherwise, the response included the failure cause indicating that the token is invalid.

The same procedure can also be applied for getting spatial anchor and any other spatial localization services provided by other SEAL servers by changing the request service.

Editor’s Note: The application enablement architecture for metaverse services is to be aligned with SA6.

### 6.1.3 Evaluation

This solution satisfies the potential security requirements of authorizing UE for access spatial localization services.

In particular, the SIM-S performs UE authorization by issuing UE access token for the requested spatial localization service. The access token is included in the service request sent by UE and verified by the corresponding SEAL server. If the verification is successful, the UE will be granted use of the requested spatial localization service.

NOTE: The SEAL server(s) supporting spatial localization services are to be defined in SA6.

To achieve this, the following changes are needed:

- Spatial localization related SEAL service IDs are assigned and provisioned to the SIM-S.

Editor's Note: Further evaluation is FFS

Editor’s Note: Whether the spatial map contains spatial anchors from other users and the potential resulting threats and requirements are FFS.

## 6.2 Solution #2: Solution for KI#1 on Authorization supporting spatial localization service with CAPIF Core Function (CCF)

### 6.2.1 Introduction

The solution addresses KI#1 on Authorization supporting spatial localization service.

According to TR 23.700-21[2], SEAL architecture as defined in TS 23.434[7] is reused for spatial anchor and spatial map management. Based on TS 33.434[4], when CAPIF is used as specified in TS 23.434[7], the security mechanism for CAPIF specified in TS 33.122[5] shall be followed.

The solution proposes security procedures to authenticate and authorize the spatial anchor management service consumers.

### 6.2.2 Solution details

In TR 23.700-21[2], Service Enabler Architecture Layer (SEAL) service is enhanced to provide spatial anchor management service to the VAL server (VAL-S) or SEAL client (SEAL-C) in UE. VAL-C/SEAL-C may invoke service provided by SEAL server (SEAL-S) to create, read, update, delete or discovery spatial anchor. Based on TS 23.434[7], when CAPIF is used, the VAL server acts as CAPIF's API invoker and the SEAL server acts as CAPIF's API exposing function. CAPIF framework is reused in this solution to authorize spatial localization service consumer.

NOTE: OAuth 2.0 token based authorization of CAPIF is adopted for this solution.

#### 6.2.2.1 Procedure of authorization for spatial localization service



Figure 6.x.2.1-1 Procedure of authorization for spatial localization service

0. Mutual authentication is performed between VAL server and CAPIF Core function (CCF), and secure session is established between the entities.

1. VAL server sends request to CCF to receive access token for authorization to create/read/update/delete (CRUD) or discovery spatial anchor(s) in SEAL server. The request specifies the desired operation, e.g. CRUD, spatial anchor instances to be operated, etc.

2. The CCF verifies the request's based on preconfigured policies and issues an access token to the VAL server if authorized. This token incorporates authorization attributes in different access levels.

For example,

- SEAL/VAL service level: e.g. permission to CRUD operations on metaverse localization services such as spatial anchor management service, spatial map management service.

- Spatial anchor instance level: permission to operate on specific spatial anchor instance(s)

- 3rd party service level: e.g. if multiple service information (from different service provider) is included in a spatial anchor, authorization to update all or specific service information associated with a spatial anchor.

3. The CCF returns the access token to the VAL server.

4. After mutual authentication, the VAL server establishes secure session with a SEAL server.

5. The VAL Server, equipped with the access token, sends CRUD spatial anchor request to the SEAL Server.

6. The SEAL Server verifies the access token, e.g. the issuer (CCF), subject (VAL Server), and scope (matching the requested operation).

7-8. If all validations and checks pass, the SEAL Server processes the CRUD operation on spatial anchors and sends a success response to the VAL Server.

NOTE: The security procedure is applicable to spatial map management with changing spatial anchor to spatial map.

### 6.2.3 Evaluation

TBD

## 6.3 Solution #3: Solution for KI#1 on Authorization supporting spatial localization service with CAPIF Core Function (CCF)

### 6.3.1 Introduction

The solution addresses KI#1 on Authorization supporting spatial localization service.

In Solution #2 of TR 23-700-21, Support for spatial anchor management of 23-700-2, a VAL server may include following information in the request when create a spatial anchor:

- service information of the product to associate it with the spatial anchor,

- access control rules defining which entities are permitted to discover and access the spatial anchor,

- customer premise information (e.g. a residence, office, or shop).

- spatial anchor discoverable visibility levels like universal to facilitate shared spatial anchor discovery

When one VAL server discovers or manages a spatial anchor created by another VAL server, the access control policies from the creating VAL server should be considered to authorize the spatial anchor services to the accessing VAL server.

The solution proposes to authorize one VAL server/SEAL client to access spatial anchor created by another VAL server/SEAL client with considering the access control polices from the creating VAL server.

CAPIF framework is based to authorize spatial localization service consumer in this solution.

NOTE: OAuth 2.0 token based authorization of CAPIF is adopted in this solution.

### 6.3.2 Solution details

A VAL server (VAL server1) creates a spatial anchor in a SEAL server which including access control rules/authorization policies in the creation request and the SEAL server synchronizes authorization policies with CAPIF Core Function (CCF) together with the VAL server1 information. When another VAL server (VAL server 2) requests access token from CCF for the spatial anchor, CCF checks the authorization policy of the spatial anchor. If VAL server2 is allowed to access the spatial anchor, CCF generates an access token and provides it to VAL server2. The VAL server2 initiates a spatial anchor service request along with the access token to the SEAL server. The SEAL server, upon successful validation of access token, provides the spatial anchor service to the VAL server2.

#### 6.3.2.1 Procedure of authorization of spatial anchor service with multiple VAL server



Figure 6.x.2.1-1 Procedure of authorization of spatial anchor service with multiple VAL server

0. VAL server1 and server2 are onboarded to CCF and authenticated with CCF. VAL server1 is authorized by CCF and access token for creation of spatial anchor has been obtained from CCF.

1. VAL server1 sends a spatial anchor creation request to SEAL server with the spatial anchor information and access token obtained from CCF.

2. SEAL server validates the access token against the service request and creates a spatial anchor, e.g. with spatial anchor id set to “anchor\_123”.

3. SEAL server sends spatial anchor creation response to VAL server1.

4. SEAL server publishes the spatial anchor information, e.g. spatial anchor id (anchor\_123), owner of the spatial anchor (VAL server 1) and optionally the authorization policies associated with the spatial anchor to CCF.

5. CCF stores the spatial anchor information in the VAL server1 profile.

6. VAL server 2 sends access token request to CCF to access the spatial anchor (anchor\_123).

7. CCF authorizes the request based on local policies (e.g. if a VAL server is allowed to consume spatial anchor related services) and authorization policies associated with the spatial anchor (e.g. if the anchor\_123 can be read/updated by the VAL server 2) presented in VAL server 1 profile. If VAL server2 is authorized, generates an access token.

NOTE: Optional CCF may implicitly ask authorization from VAL server1 if there's no authorization information associated with the spatial anchor based on local policies.

8. CCF sends the access token to VAL server2.

9. VAL server2 sends request to SEAL server to access the spatial anchor, along with the access token received from CCF.

10. SEAL server validates the access token and service request and perform the request on successful validation.

11 SEAL server sends the spatial anchor response to VAL server2.

### 6.3.3 Evaluation

TBD

## 6.4 Solution #4: Privacy protection for user sensitive information exposure

### 6.4.1 Introduction

This solution addresses Key Issue #2 on privacy of user sensitive information. Specifically, it addresses the requirements that the 5G system shall provide a means for privacy protection of user sensitive information during exposure of user specific information in localized mobile metaverse services through the application enabler layer.

### 6.4.2 Solution details

According to TR 23.700-21 [2], user sensitive information needs to be exposed through the enabler layer to a party other than the user. The information that can be exposed may include user/UE identity, body movement or location, ownership rights of digital assets, authentication result, etc. As all these information is related to a specific user, user privacy needs to be ensured when exposing any of the information, for which user authorization or user consent is required.

To protect the privacy of the user whose sensitive information is to be exposed, regardless of whether the user is a 3GPP subscriber or not, it is proposed to reuse RNAA framework defined in TS 33.122 [5], by regarding the user sensitive information as the resource of the user. The API invoker requesting the user sensitive information through the enable layer can only be authorized if the authorization function (CCF) obtains permission from the user, i.e. the resource owner.

For the case where the user is a 3GPP subscriber, the user consent framework defined in TS 33.501 [6] Annex V can also be reused for privacy protection via static user authorization based on UE subscription.

### 6.4.3 Evaluation

TBA.

## 6.Y Solution #Y: <Solution Name>

### 6.Y.1 Introduction

Editor’s Note: Each solution should list the key issues being addressed.

### 6.Y.2 Solution details

### 6.Y.3 Evaluation

Editor’s Note: Each solution should motivate how the potential security requirements of the key issues being addressed are fulfilled.

# 7 Conclusions

Editor’s Note: This clause contains the agreed conclusions that will form the basis for any normative work.

Annex <X> (informative):  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2024-04 | SA3#115 Adhoc-e | S3-241422 |  |  |  | Skeleton for TR 33.721 | 0.0.0 |
| 2024-04 | SA3#115 Adhoc-e | S3-241632 |  |  |  | S3-241584, S3-241548, S3-241549, S3-241553, S3-241554 | 0.1.0 |
| 2024-05 | SA3#116 | S3-242608 |  |  |  | S3-242583 implemented | 0.2.0 |
| 2024-08 | SA3#117 | S3‑243720 |  |  |  | S3-243650, S3-243651, S3-243715, S3-243652, S3-243653, S3-243654, S3-243275 | 0.3.0 |