Abstract
This document defines all the strings and constants reserved by UAF protocols. The values defined in this document are referenced by various UAF specifications.

Status of This Document
This section describes the status of this document at the time of its publication. Other documents may supersede this document. A list of current FIDO Alliance publications and the latest revision of this technical report can be found in the FIDO Alliance specifications index at https://www.fidoalliance.org/specifications/.

This document was published by the FIDO Alliance as a Review Draft. This document is intended to become a FIDO Alliance Proposed Standard. If you wish to make comments regarding this document, please Contact Us. All comments are welcome.

This is a Review Draft Specification and is not intended to be a basis for any implementations as the Specification may change. Permission is hereby granted to use the Specification solely for the purpose of reviewing the Specification. No rights are granted to prepare derivative works of this Specification. Entities seeking permission to reproduce portions of this Specification for other uses must contact the FIDO Alliance to determine whether an appropriate license for such use is available.

Implementation of certain elements of this Specification may require licenses under third party intellectual property rights, including without limitation, patent rights. The FIDO Alliance, Inc. and its Members and any other contributors to the Specification are not, and shall not be held, responsible in any manner for identifying or failing to identify any or all such third party intellectual property rights.

THIS FIDO ALLIANCE SPECIFICATION IS PROVIDED “AS IS” AND WITHOUT ANY WARRANTY OF ANY KIND, INCLUDING, WITHOUT LIMITATION, ANY EXPRESS OR IMPLIED WARRANTY OF NON-INFRINGEMENT, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

Table of Contents

1. Notation
   1.1 Key Words
2. Overview
3. Authenticator Characteristics
   3.1 Assertion Schemes
4. Predefined Tags
1. Notation

Type names, attribute names and element names are written as code.

String literals are enclosed in “”, e.g. “UAF-TLV”.

In formulas we use “I” to denote byte wise concatenation operations.

UAF specific terminology used in this document is defined in [FIDO Glossary].

All diagrams, examples, notes in this specification are non-normative.

1.1 Key Words

The key words “must”, “must not”, “required”, “shall”, “shall not”, “should”, “should not”, “recommended”, “may”, and “optional” in this document are to be interpreted as described in [RFC 2119].

2. Overview

This section is non-normative.

This document defines the registry of UAF-specific constants that are used and referenced in various UAF specifications. It is expected that, over time, new constants will be added to this registry. For example new authentication algorithms and new types of authenticator characteristics will require new constants to be defined for use within the specifications.

FIDO-specific constants that are common to multiple protocol families are defined in [FIDO Registry].

3. Authenticator Characteristics

This section is normative.

3.1 Assertion Schemes

Names of assertion schemes are strings with a length of 8 characters.

UAF TLV based assertion scheme “UAFV1TLV”

This assertion scheme allows the authenticator and the FIDO Server to exchange an asymmetric authentication key generated by the authenticator. The authenticator must generate a key pair (UAuth.pub/UAuth.priv) to be used with algorithm suites listed in [FIDO Registry] section "Authentication Algorithms" (with prefix ALG_). This assertion scheme is using a compact Tag Length Value (TLV) encoding for the KRD and SignData messages generated by the authenticators. This is the default assertion scheme for the UAF protocol.

4. Predefined Tags

This section is normative.

The internal structure of UAF authenticator commands is a “Tag-Length-Value” (TLV) sequence. The tag is a 2-byte unique unsigned value describing the type of field the data represents, the length is a 2-byte unsigned value indicating the size of the value in bytes, and the value is the variable-sized series of bytes which contain data for this item in the sequence.

Although 2 bytes are allotted for the tag, only the first 14 bits (values up to 0x3FFF) should be used to accommodate the limitations of some hardware platforms.

A tag that has the 14th bit (0x2000) set indicates that it is critical and a receiver must abort processing the entire message if it cannot process that tag.

A tag that has the 13th bit (0x1000) set indicates a composite tag that can be parsed by recursive descent.

4.1 Tags used in the protocol

The following tags have been allocated for data types in UAF protocol messages:

TAG_UAFV1_REG_ASSERTION 0x3E01
The content of this tag is the authenticator response to a Register command.

TAG_UAFV1_AUTH_ASSERTION 0x3E02
Indicates Key Registration Data.

TAG_UAFV1_KRD 0x3E03
Indicates data signed by the authenticator using UAuth.priv key.

TAG_ATTESTATION_CERT 0x3E05
Indicates DER encoded attestation certificate.

TAG_SIGNATURE 0x2E06
Indicates a cryptographic signature.

TAG_ATTESTATION_BASIC_FULL 0x3E07
Indicates full basic attestation as defined in [UAFProtocol].

TAG_ATTESTATION_BASIC_SURROGATE 0x3E08
Indicates surrogate basic attestation as defined in [UAFProtocol].

TAG_EXTENSION 0x3E11, 0x3E12
This is a composite tag indicating that the content is an extension.

TAG_EXTENSION_ID 0x2E13
Represents extension ID. Content of this tag is a UINT8[] encoding of a UTF-8 string.

TAG_EXTENSION_DATA 0x2E14
Represents extension data. Content of this tag is a UINT8[] byte array.

TAG_RAW_USER_VERIFICATION_INDEX 0x0103
This is the raw UVI as it might be used internally by authenticators. This TAG shall not appear in assertions leaving the authenticator boundary as it could be used as global correlation handle.

TAG_RAW_USER_VERIFICATION_INDEX 0x0104
The user verification index (UVI) is a value uniquely identifying a user verification data record. Each UVI value must be specific to the related key (in order to provide unlinkability). It also must contain sufficient entropy that makes guessing impractical. UVI values must not be reused by the Authenticator (for other biometric data or users).

The UVI data can be used by FIDO Servers to understand whether an authentication was authorized by the exact same biometric data as the initial key generation. This allows the detection and prevention of "friendly fraud".

As an example, the UVI could be computed as SHA256(KeyID | SHA256(rawUVI)), where the rawUVI reflects (a) the biometric reference data, (b) the related OS level user ID and (c) an identifier which changes whenever a factory reset is performed for the device, e.g. rawUVI = biometricReferenceData | OSLevelUserID | FactoryResetCounter.

FIDO Servers supporting UVI extensions must support a length of up to 32 bytes for the UVI value.

Example of the TLV encoded UVI extension (contained in an assertion, i.e. TAG_UAFV1_REG_ASSERTION or TAG_UAFV1_AUTH_ASSERTION)

... 04 01 -- TAG_USER_VERIFICATION_INDEX (0x0104) 20 -- length of UVI 00 43 B8 E3 BE 27 95 8C -- the UVI value itself 28 D5 74 BF 46 8A 85 CF 46 9A 14 F0 E5 16 69 31 DA 4B CF FF C1 BB 11 32 82 ...
The UVS data can be used by FIDO Servers to understand whether an authentication was authorized by one of the biometric data records already known at the initial key generation.

As an example, the UVS could be computed as SHA256(KeyID | SHA256(rawUVS)), where the rawUVS reflects (a) the biometric reference data sets, (b) the related OS level user ID and (c) an identifier which changes whenever a factory reset is performed for the device, e.g. rawUVS = biometricReferenceDataSet | OSLeverUserID | FactoryResetCounter.

FIDO Servers supporting UVS extensions must support a length of up to 32 bytes for the UVS value.

Example of the TLV encoded UVS extension (contained in an assertion, i.e. TAG_UAFV1_REG_ASSERTION or TAG_UAFV1_AUTH_ASSERTION)

```
... 06 01 -- TAG_USER_VERIFICATION_STATE (0x0106)
  20 -- length of UVS
  00 18 C3 47 81 73 2B 65 -- the UVS value itself
  83 E7 43 31 46 8A 85 CF
  93 6C 36 F0 AF 16 69 14
  DA 4B 1D 43 FE C7 43 24
  45
...
```

**TAG_RESERVED_5 0x0201**

Reserved for future use. Name of the tag will change, value is fixed.

5. Predefined (untagged) Extensions

*This section is normative.*

5.1 Android SafetyNet Extension

This extension can be added

- by FIDO Servers to the UAF Request object (request extension) in the OperationHeader in order to trigger generation of the related response extension.
- by FIDO Clients to the ASM Request object (request extension) in order to trigger generation of the related response extension.
- by the ASM to the respective exts array in the ASMResponse object (response extension).
- by the FIDO Client to the respective exts array in either the OperationHeader, or the AuthenticatorRegistrationAssertion, or the AuthenticatorSignAssertion of the UAF Response object (response extension).

**Extension identifier**

`fido.uaf.safetynet`

**Extension fail-if-unknown flag**

`false`, i.e. this (request and response) extension can safely be ignored by all entities.

**Extension data value**

When present in a request (request extension) empty string, i.e. the FIDO Server might add this extension to the UAF Request with an empty data value in order to trigger the generation of this extension for the UAF Response.

**EXAMPLE 1:** SafetyNet Request Extension

```
"exts": [{"id": "fido.uaf.safetynet", "data": "", "fail_if_unknown": false}]
```

When present in a response (response extension)

- If the request extension was successfully processed, the data value is set to the JSON Web Signature attestation result as returned by the call to `com.google.android.gms.safetynet.SafetyNetApi.AttestationResult`.
- If the FIDO Client or the ASM support this extension, but the underlying Android platform does not support it (e.g. Google Play Services is not installed), the data value is set to the string "p" (i.e. platform issue).

**EXAMPLE 2:** SafetyNet Response Extension - not supported by platform

```
"exts": [{"id": "fido.uaf.safetynet", "data": "p", "fail_if_unknown": false}]
```

- If the FIDO Client or the ASM support this extension and the underlying Android platform supports it, but the functionality is temporarily unavailable (e.g. Google servers are unreachable), the data value is set to the string "a" (i.e. availability issue).

**EXAMPLE 3:** SafetyNet Response Extension - temporarily unavailable

```
"exts": [{"id": "fido.uaf.safetynet", "data": "a", "fail_if_unknown": false}]
```
FIDO Client processing

FIDO Clients running on Android should support processing of this extension.

If the FIDO Client finds this (request) extension with empty data value in the UAF Request and it supports processing this extension, then the FIDO Client

1. must call the Android API `SafetyNet.SafetyNetApi.attest(mGoogleApiClient, nonce)` (see SafetyNet online documentation) and add the response (or an error code as described above) as extension to the response object.

2. must not copy the (request) extension to the ASM Request object (deviating from the general rule in [UAFProtocol], section 3.4.6.2 and 3.5.7.2).

If the FIDO Client does not support this extension it must copy this extension from the UAF Request to the ASM Request object (according to the general rule in [UAFProtocol], section 3.4.6.2 and 3.5.7.2).

If the ASM supports this extension it must call the SafetyNet API (see above) and add the response as extension to the ASM Response object. The FIDO Client must copy the extension in the ASM Response to the UAF Response object (according to sections 3.4.6.4. and 3.5.7.4 step 4 in [UAFProtocol]).

When calling the Android API, the nonce parameter must be set to the serialized JSON object with the following structure:

```json
{
  "hashAlg": "S256", // the hash algorithm
  "fcHash": "..." // the finalChallengeHash
}
```

Where

- hashAlg identifies the hash algorithm according to [FIDOSignatureFormat], section IANA Considerations.
- fcHash is the base64url encoded hash value of FinalChallenge (see section 3.6.3 and 3.7.4 in [UAFASM] for details on how to compute finalChallengeHash).

We use this method to bind this SafetyNet extension to the respective FIDO UAF message.

Only hash algorithms belonging to the Authentication Algorithms mentioned in [FIDORegistry] shall be used (e.g. SHA256 because it belongs to ALGSIGN_SECP256R1_ECDSA_SHA256_RAW).

NOTE

If neither the FIDO Client nor the ASM support this extension, it won't be present in the response object.

5.2 Android Key Attestation

"exts": [{"id": "fido.uaf.safetynet", "data": "a", "fail_if_unknown": false}]

NOTE

The package name in AttestationResult might relate to either the FIDO Client or the ASM.

NOTE

The response extension is not part of the signed assertion generated by the authenticator. If an MITM or MITB attacker would remove the response extension, the FIDO server might not be able to distinguish this from the "SafetyNet extension not supported by FIDO Client/ASM" case.
This extension can be added

- by FIDO Servers to the UAF Request object (request extension) in the OperationHeader in order to trigger generation of the related response extension.
- by FIDO Clients to the ASM Request object (request extension) in order to trigger generation of the related response extension.
- by the ASM to the respective exts array in the ASMResponse object (response extension).
- by the FIDO Client to the respective exts array in either the OperationHeader, or the AuthenticatorRegistrationAssertion, or the AuthenticatorSignAssertion of the UAF Response object (response extension).

Extension identifier
fido.uaf.android.key_attestation

Extension fail-if-unknown flag
false, i.e. this (request and response) extension can safely be ignored by all entities.

Extension data value

When present in a request (request extension)
empty string, i.e. the FIDO Server might add this extension to the UAF Request with an empty data value in order to trigger the generation of this extension for the UAF Response.

EXAMPLE 4: Android KeyAttestation Request Extension

```
"exts": [{"id": "fido.uaf.android.key_attestation", "data": ", "fail_if_unknown": false}]
```

When present in a response (response extension)

- If the request extension was successfully processed, the data value is set to a JSON array containing the base64 encoded entries of the array returned by the call to the KeyStore API function getCertificateChain.

EXAMPLE 5: Retrieve KeyAttestation and add it as extension

```
KeyPairGenerator kpGenerator = KeyPairGenerator.getInstance(
    KeyProperties.KEY_ALGORITHM_EC, "AndroidKeyStore");
kpGenerator.initialize(    new KeyGenParameterSpec.Builder(keyUUID, KeyProperties.PURPOSE_SIGN)
        .setDigests(KeyProperties.DIGEST_SHA256)
        .setAlgorithmParameterSpec(new ECGenParameterSpec("prime256v1"))
        .setCertificateSubject(            new X500Principal(String.format("CN=%s, OU=%s",
                keyUUID, aContext.getPackageName())))
        .setCertificateSerialNumber(new BigInteger.ONE)
        .setCertificateNotBefore(notBefore.getTime())
        .setCertificateNotAfter(notAfter.getTime())
        .setUserAuthenticationRequired(true)
        .setAttestationChallenge(fcHash) -- bind to Final Challenge
        .build());
kpGenerator.generateKeyPair(); // generate Uauth key pair
Certificate[] certarray=myKeyStore.getCertificateChain(keyUUID);
String certArray[]="new String[certarray.length];
int i=0;
for (Certificate cert : certarray) {
    byte[] buf = cert.getEncoded();
    certArray[i] = new String(Base64.encode(buf, Base64.DEFAULT));
i++;
}
JSONArray jarray=new JSONArray(certArray);
String key_attestation_data=jarray.toString();
```

- If the FIDO Client or the ASM support this extension, but the underlying Android platform does not support it (e.g. Android version doesn't yet support it), the data value is set to the string "p" (i.e. platform issue).

EXAMPLE 6: KeyAttestation Response Extension - not supported by platform

```
"exts": [{"id": "fido.uaf.android.key_attestation", "data": "p", "fail_if_unknown": false}]
```

- If the FIDO Client or the ASM support this extension and the underlying Android platform supports it, but the functionality is temporarily unavailable (e.g. Google servers are unreachable), the data value is set to the string "a".

EXAMPLE 7: KeyAttestation Response Extension - temporarily unavailable

```
"exts": [{"id": "fido.uaf.android.key_attestation", "data": "a", "fail_if_unknown": false}]
```
FIDO Client processing

FIDO Clients running on Android must pass this (request) extension with empty data value to the ASM.

If the ASM supports this extension it must call the KeyStore API (see above) and add the response as extension to the ASM Response object. The FIDO Client must copy the extension in the ASM Response to the UAF Response object (according to sections 3.4.6.4. and 3.5.7.4 step 4 in [UAFProtocol]).

More details on Android key attestation can be found at:

- https://developer.android.com/preview/api-overview.html#key_attestation
- https://source.android.com/security/keystore/
- https://source.android.com/security/keystore/implementer-ref.html

Authenticator argument
N/A

Authenticator processing

The authenticator generates the attestation response. The call keyStore.getCertificateChain is finally processed by the authenticator.

Authenticator data
N/A

Server processing

If the FIDO Server requested the key attestation extension,

1. it must follow the registration response processing rules (see FIDO UAF Protocol, section 3.4.6.5) before processing this extension
2. it must verify the syntax of the key attestation extension and it must perform RFC5280 compliant chain validation of the entries in the array to one attestationRootCertificate specified in the Metadata Statement.
3. it must determine the leaf certificate from that chain, and it must perform the following checks on this leaf certificate
   1. Verify that KeyDescription.attestationChallenge == FCHash (see FIDO UAF Protocol, section 3.4.6.5 Step 6.)
   2. Verify that the public key included in the leaf certificate is identical to the public key included in the FIDO UAF Surrogate attestation block
   3. If the related Metadata Statement claims keyProtection KEY_PROTECTION_TEE, then refer to KeyDescription.teeEnforced using "authzList". If the related Metadata Statement claims keyProtection KEY_PROTECTION_SOFTWARE, then refer to KeyDescription.softwareEnforced using "authzList".
4. Verify that
   1. authzList.origin == KM_TAG_GENERATED
   2. authzList.purpose == KM_PURPOSE_SIGN
   3. authzList.keySize is acceptable, i.e. =2048 (bit) RSA or =256 (bit) ECDSA.
   4. authzList.digest == KM_DIGEST_SHA_2_256.
   5. authzList.authType only contains acceptable user verification methods.
   6. authzList.authTimeout == 0 (or not present).
   7. authzList.noAuthRequired is not present (unless the Metadata Statement marks this authenticator as silent authenticator, i.e. userVerification set to USER_VERIFY_NONE).
   8. authzList.allApplications is not present, since FIDO Uauth keys must be bound to the generating app (AppID).

NOTE

The response extension is not part of the signed assertion generated by the authenticator. If an MITM or MITB attacker would remove the response extension, the FIDO server might not be able to distinguish this from the "KeyAttestation extension not supported by ASM/Authenticator" case.

ExtensionDescriptor data value (for Metadata Statement)

In the case of extension id="fido.uaf.android.key_attestation", the data field of the ExtensionDescriptor as included in the Metadata Statement will contain a dictionary containing the following data fields

DOMString attestationRootCertificates[]

Each element of this array represents a PKIX [RFC5280] X.509 certificate that is valid for this authenticator model. Multiple certificates might be used for different batches of the same model. The array does not represent a certificate chain, but only the trust anchor of that chain.

Each array element is a base64-encoded (section 4 of [RFC4648]), DER-encoded [ITU-X690-2008] PKIX
6. Other Identifiers specific to FIDO UAF

6.1 FIDO UAF Application Identifier (AID)

This AID [ISO/IEC-7816-5] is used to identify FIDO UAF authenticator applications in a Secure Element.

The FIDO UAF AID consists of the following fields:

<table>
<thead>
<tr>
<th>Field</th>
<th>RID</th>
<th>AC</th>
<th>AX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>0xA000000647</td>
<td>0xAF</td>
<td>0x0001</td>
</tr>
</tbody>
</table>

Table 1: FIDO UAF Applet AID

A. References

A.1 Normative references

[FIDOecdaaAlgorithm]
R. Lindemann, FIDO ECDAA Algorithm. FIDO Alliance Draft. To be published.

[FIDOglossary]

[FIDORegistry]
R. Lindemann, Baghdasaryan, B. Hill, FIDO Registry of Predefined Values. FIDO Alliance Proposed Standard.

[ISO/IEC-7816-5]
ISO 7816-5: Identification cards - Integrated circuit cards - Part 5: Registration of application providers

[RFC2119]

A.2 Informative references

[FIDOSignatureFormat]
FIDO 2.0: Signature format. URL: https://fidoalliance.org/specs/fido-v2.0-ps-20150904/fido-signature-format-v2.0-ps-20150904.html

[ITU-X690-2008]
X.690: Information technology - ASN.1 encoding rules: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER), (T-REC-X.690-200811)

[RFC4648]

[RFC5280]
NOTE
A certificate listed here is either a root certificate or an intermediate CA certificate.
[UAFASM]
D. Baghdasaryan, J. Kemp, R. Lindemann, B. Hill, R. Sasson, FIDO UAF Authenticator-Specific Module API. FIDO Alliance Proposed Standard. URLs:

[UAFProtocol]
R. Lindemann, D. Baghdasaryan, E. Tiffany, D. Balfanz, B. Hill, J. Hodges, FIDO UAF Protocol Specification v1.0. FIDO Alliance Proposed Standard. URLs: