FIDO Metadata Service

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Abstract

The FIDO Authenticator Metadata Specification defines so-called "Authenticator Metadata" statements. The metadata statements contains the "Trust Anchor" required to validate the attestation object, and they also describe several other important characteristics of the authenticator. The metadata service described in this document defines a baseline method for relying parties to access the latest metadata statements.

Status of This Document

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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 “|” to denote byte wise concatenation operations.

The notation `base64url(byte[8..64])` reads as 8-64 bytes of data encoded in base64url, "Base 64 Encoding with URL and Filename Safe Alphabet" [RFC4648] *without padding*.

Following [WebIDL-ED], dictionary members are optional unless they are explicitly marked as `required`.

WebIDL dictionary members MUST NOT have a value of null.

Unless otherwise specified, if a WebIDL dictionary member is DOMString, it MUST NOT be empty.

Unless otherwise specified, if a WebIDL dictionary member is a List, it MUST NOT be an empty list.

For definitions of terms, please refer to the FIDO Glossary [FIDOGlossary].

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

> Note: Certain dictionary members need to be present in order to comply with FIDO requirements. Such members are marked in the WebIDL definitions found in this document, as `required`. The keyword `required` has been introduced by [WebIDL-ED], which is a work-in-progress. If you are using a WebIDL parser which implements [WebIDL], then you may remove the keyword `required` from your WebIDL and use other means to ensure those fields are present.

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 [RFC2119].

2. Overview§

This section is not normative.

[FIDOMetadataStatement] defines authenticator metadata statements.

These metadata statements contain the trust anchor required to verify the attestation object (more specifically the `KeyRegistrationData` object), and they also describe several other important characteristics of the authenticator, including supported authentication and registration assertion schemes, and key protection flags.

These characteristics can be used when defining policies about which authenticators are acceptable for registration or authentication.

The metadata service described in this document defines a baseline method for relying parties to access the latest metadata statements.

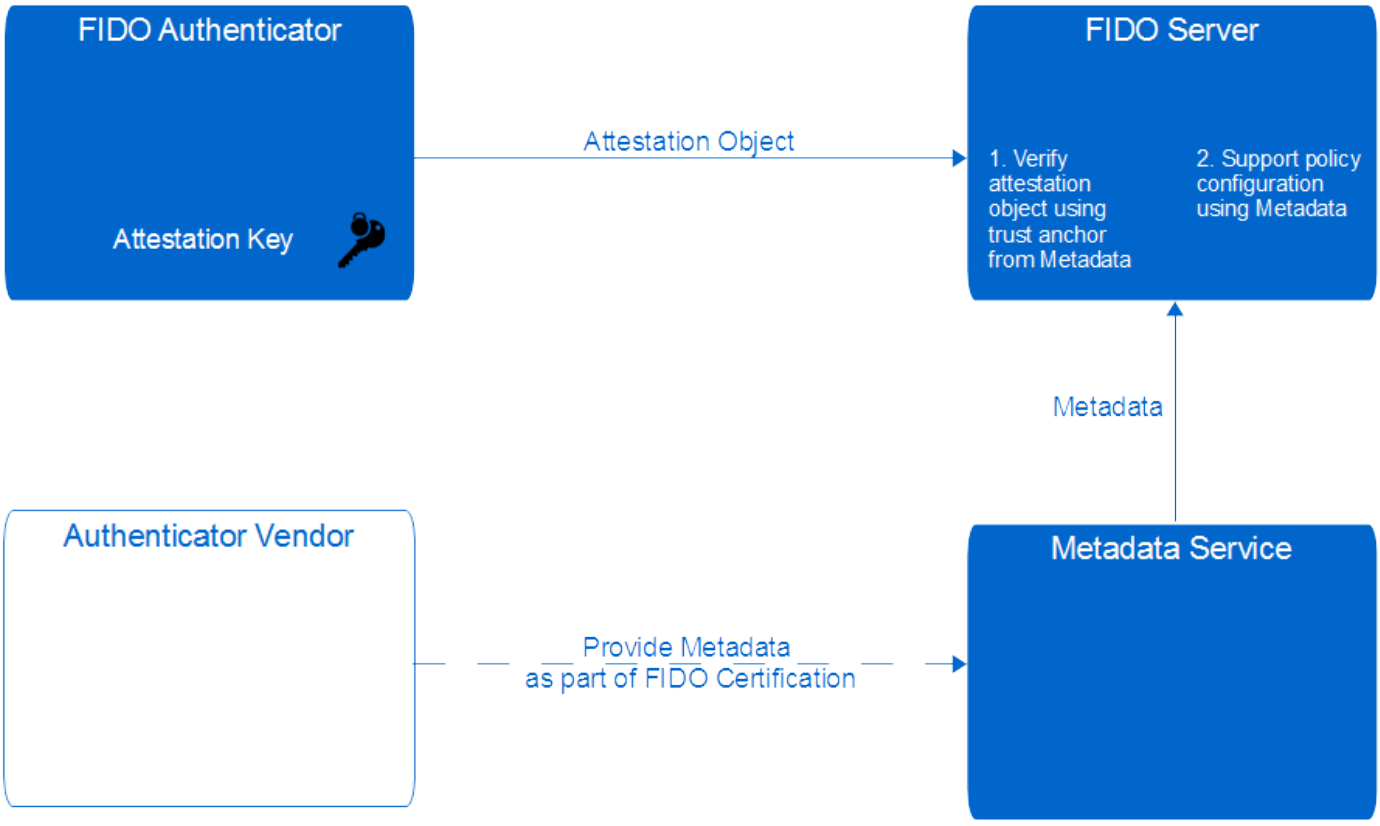

Figure 1 *FIDO Metadata Service Architecture Overview*

2.1. Scope§

This document describes the FIDO Metadata Service architecture in detail and it defines the structure and interface to access this service. It also defines the flow of the metadata related messages and presents the rationale behind the design choices.

2.2. Detailed Architecture§

The metadata BLOB file contains a list of metadata statements related to the authenticators known to the FIDO Alliance (FIDO Authenticators).

The FIDO Server downloads the metadata BLOB file from a well-known FIDO URL and caches it locally.

The FIDO Server verifies the integrity and authenticity of this metadata BLOB file using the digital signature. It then iterates through the individual entries and parses the metadata statements related to authenticator models relevant to the relying party.

Individual metadata statements are included in the entry of the metadata BLOB file, and may be cached by the FIDO Server as required.

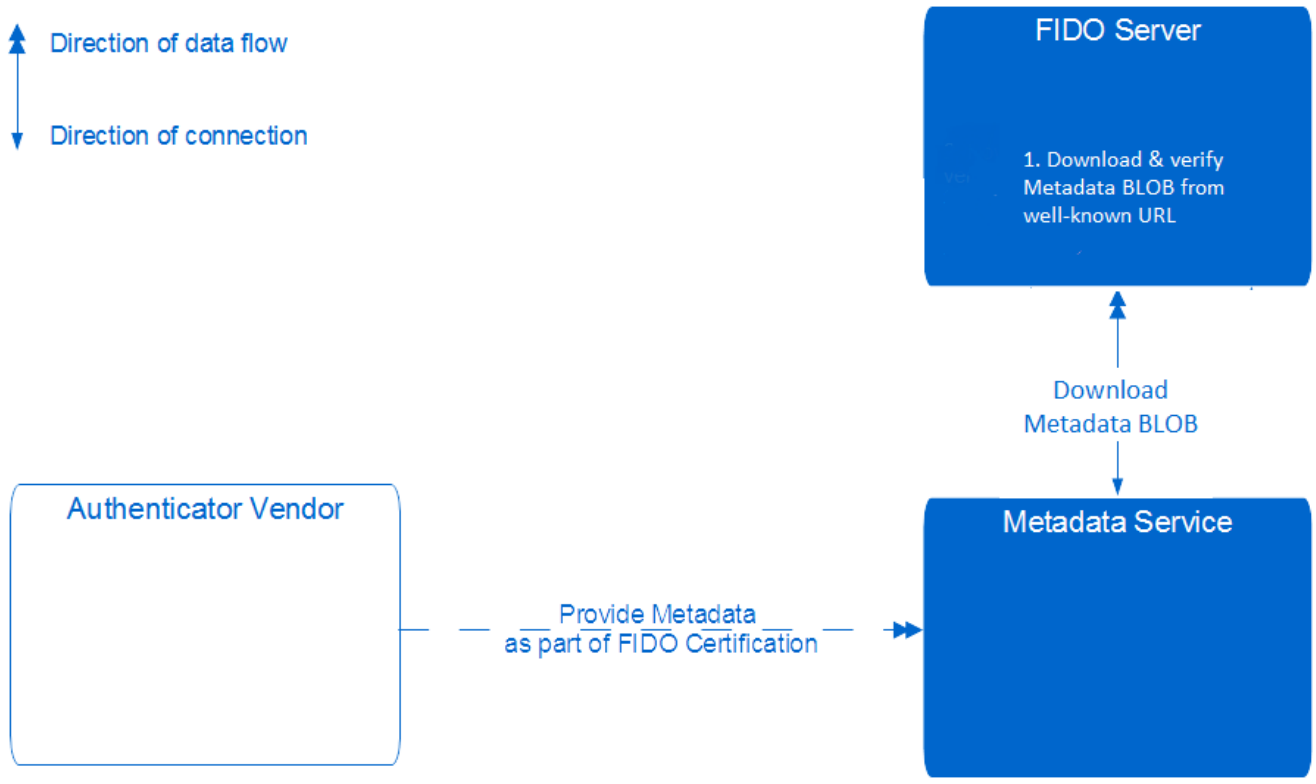

***Figure 2** FIDO Metadata Service Architecture*

The single arrow indicates the direction of the network connection, the double arrow indicates the

direction of the data flow.

The metadata BLOB file is accessible at a well-known URL published by the FIDO Alliance.

The relying party decides how frequently the metadata service is accessed to check for metadata BLOB updates.

3. Metadata Service Details§

This section is normative.

The relying party can decide whether it wants to use the metadata service and whether or not it wants to accept certain authenticators for registration or authentication.

The relying party could also obtain metadata directly from authenticator vendors or other trusted sources.

3.1. Metadata BLOB Format§

The metadata service makes the metadata BLOB object (see Metadata BLOB) accessible to FIDO Servers.

This object contains all metadata for each authenticator including the metadata statements defined in [FIDOMetadataStatement]. The BLOB object contains one signature.

3.1.1. Metadata BLOB Payload Entry dictionary§

Represents the MetadataBLOBPayloadEntry

```
dictionary MetadataBLOBPayloadEntry {
    AAID                    aaid;
    AAGUID                  aaguid;
    DOMString[]             attestationCertificateKeyIdentifiers;
    MetadataStatement       metadataStatement;
    BiometricStatusReport[] biometricStatusReports;
    required StatusReport[] statusReports;
    required DOMString      timeOfLastStatusChange;
```

```
    DOMString               rogueListURL;
    DOMString               rogueListHash;
};
```

***aaid*, of type AAID**

The AAID of the authenticator this metadata BLOB payload entry relates to. See [UAFProtocol] for the definition of the AAID structure. This field MUST be set if the authenticator implements FIDO UAF.

> Note: FIDO UAF authenticators support AAID, but they don't support AAGUID.

***aaguid*, of type AAGUID**

The Authenticator Attestation GUID. See [FIDOKeyAttestation] for the definition of the AAGUID structure. This field MUST be set if the authenticator implements FIDO2.

> Note: FIDO2 authenticators support AAGUID, but they don't support AAID.

***attestationCertificateKeyIdentifiers*, of type DOMString[]**

A list of the attestation certificate public key identifiers encoded as hex string. This value MUST be calculated according to method 1 for computing the keyIdentifier as defined in [RFC5280] section 4.2.1.2.

- The hex string MUST NOT contain any non-hex characters (e.g. spaces).
- All hex letters MUST be lower case.
- This field MUST be set if neither `aaid` nor `aaguid` are set. Setting this field implies that the attestation certificate(s) are dedicated to a single authenticator model.

> FIDO U2F authenticators do not support AAID nor AAGUID, but they use attestation certificates dedicated to a single authenticator model.

***metadataStatement*, of type MetadataStatement**

The metadataStatement JSON object as defined in [FIDOMetadataStatement].

***biometricStatusReports*, of type BiometricStatusReport[]**

Status of the FIDO Biometric Certification of one or more biometric components of the Authenticator [FIDOBiometricsRequirements].

***statusReports*, of type StatusReport[]**

An array of status reports applicable to this authenticator.

***timeOfLastStatusChange*, of type DOMString**

ISO-8601 formatted date since when the status report array was set to the current value.

***rogueListURL*, of type DOMString**

URL of a list of rogue (i.e. untrusted) individual authenticators.

***rogueListHash*, of type DOMString**

`base64url(string[1..512])`

The hash value computed over the Base64url encoding of the UTF-8 representation of the JSON encoded rogueList available at `rogueListURL` (with type rogueListEntry[]). The hash algorithm related to the signature algorithm specified in the JWTHeader (see Metadata BLOB) MUST be used.

This hash value MUST be present and non-empty whenever `rogueListURL` is present.

> This method of base64url-encoding the UTF-8 representation is also used by JWT [JWT] to avoid encoding ambiguities.

```
EXAMPLE 1
{
  "no": 1234,
  "nextUpdate": "2014-03-31",
  "entries": [
    {
      "aaid": "1234#5678",
      "metadataStatement": "Metadata Statement object as defined in Metadata Statement
spec.",
      "statusReports": [
        {
          "status": "FIDO_CERTIFIED",
          "effectiveDate": "2014-01-04"
        }
      ],
      "timeOfLastStatusChange": "2014-01-04"
    },
    {
      "attestationCertificateKeyIdentifiers": [
        "7c0903708b87115b0b422def3138c3c864e44573"
      ],
      "metadataStatement": "Metadata Statement object as defined in Metadata Statement
spec.",
      "statusReports": [
        {
          "status": "FIDO_CERTIFIED",
          "effectiveDate": "2014-01-07"
        },
        {
          "status": "UPDATE_AVAILABLE",
          "effectiveDate": "2014-02-19",
```

```
          "url": "https://example.com/update1234"
        }
      ],
      "timeOfLastStatusChange": "2014-02-19"
    }
  ]
}
```

3.1.2. BiometricStatusReport dictionary§

Contains the current `BiometricStatusReport` of one of the authenticator's biometric component.

```
dictionary BiometricStatusReport {
    required unsigned short certLevel;
    required DOMString      modality;
    DOMString               effectiveDate;
    DOMString               certificationDescriptor;
    DOMString               certificateNumber;
    DOMString               certificationPolicyVersion;
    DOMString               certificationRequirementsVersion;
};
```

***certLevel*, of type unsigned short**

Achieved level of the biometric certification of this biometric component of the authenticator [FIDOBiometricsRequirements].

***modality*, of type DOMString**

A *single* a single USER_VERIFY short form case-sensitive string name constant, representing biometric modality. See section "User Verification Methods" in [FIDORegistry] (e.g. "fingerprint_internal"). This value MUST NOT be empty and this value MUST correspond to one or more entries in field `userVerificationDetails` in the related Metadata Statement [FIDOMetadataStatement]. This value MUST represent a biometric modality.

For example use `USER_VERIFY_FINGERPRINT` for the fingerprint based biometric component. In this case the related Metadata Statement must also claim fingerprint as one of the user verification methods.

***effectiveDate*, of type DOMString**

ISO-8601 formatted date since when the `certLevel` achieved, if applicable. If no date is given, the status is assumed to be effective while present.

***certificationDescriptor*, of type DOMString**

Describes the externally visible aspects of the Biometric Certification evaluation.

> For example it could state that the "biometric component is implemented OnChip - keeping biometric data inside the chip only.".

***certificateNumber*, of type DOMString**
: The unique identifier for the issued Biometric Certification.

***certificationPolicyVersion*, of type DOMString**
: The version of the Biometric Certification Policy the implementation is Certified to, e.g. "1.0.0".

***certificationRequirementsVersion*, of type DOMString**
: The version of the Biometric Requirements [FIDOBiometricsRequirements] the implementation is certified to, e.g. "1.0.0".

3.1.3. StatusReport dictionary§

> Contains an `AuthenticatorStatus` and additional data associated with it, if any.
>
> New `StatusReport` entries will be added to report known issues present in firmware updates.

The latest `StatusReport` entry MUST reflect the "current" status. For example, if the latest entry has status `USER_VERIFICATION_BYPASS`, then it is recommended assuming an increased risk associated with all authenticators of this AAID; if the latest entry has status `UPDATE_AVAILABLE`, then the update is intended to address at least all previous issues *reported* in this StatusReport dictionary.

```
dictionary StatusReport {
    required AuthenticatorStatus status;
    DOMString                    effectiveDate;
    unsigned long                authenticatorVersion;
    DOMString                    certificate;
    DOMString                    url;
    DOMString                    certificationDescriptor;
    DOMString                    certificateNumber;
    DOMString                    certificationPolicyVersion;
    DOMString                    certificationRequirementsVersion;
};
```

***status*, of type AuthenticatorStatus**
: Status of the authenticator. Additional fields MAY be set depending on this value.

***effectiveDate*, of type DOMString**
: ISO-8601 formatted date since when the status code was set, if applicable. If no date is given,

the status is assumed to be effective while present.

***authenticatorVersion*, of type unsigned long**

The authenticatorVersion that this status report relates to. In the case of FIDO_CERTIFIED* status values, the status applies to higher authenticatorVersions until there is a new statusReport.

> For example, if the status would be USER_VERIFICATION_BYPASS, the authenticatorVersion indicates the vulnerable firmware version of the authenticator. Similarly, if the status would be UPDATE_AVAILABLE, the authenticatorVersion indicates the updated firmware version that is available now. If the status would be SELF_ASSERTION_SUBMITTED, the authenticatorVersion indicates the firmware version that the self assertion was based on.

***certificate*, of type DOMString**

Base64-encoded [RFC4648] (not base64url!) DER [ITU-X690-2008] PKIX certificate value related to the current status, if applicable.

> As an example, this could be an Attestation Root Certificate (see [FIDOMetadataStatement]) related to a set of compromised authenticators (ATTESTATION_KEY_COMPROMISE).

***url*, of type DOMString**

HTTPS URL where additional information may be found related to the current status, if applicable.

> For example a link to a web page describing an available firmware update in the case of status `UPDATE_AVAILABLE`, or a link to a description of an identified issue in the case of status `USER_VERIFICATION_BYPASS`.

***certificationDescriptor*, of type DOMString**

Describes the externally visible aspects of the Authenticator Certification evaluation.

> For example it could state that the authenticator is a "SecurityKey based on a CC EAL 5 certified chip hardware".

***certificateNumber*, of type DOMString**

The unique identifier for the issued Certification.

***certificationPolicyVersion*, of type DOMString**

The version of the Authenticator Certification Policy the implementation is Certified to, e.g. "1.0.0".

***certificationRequirementsVersion*, of type DOMString**

The Document Version of the Authenticator Security Requirements (DV)

[FIDOAuthenticatorSecurityRequirements] the implementation is certified to, e.g. "1.2.0".

3.1.4. AuthenticatorStatus enum§

This enumeration describes the status of an authenticator model as identified by its AAID/AAGUID or attestationCertificateKeyIdentifiers and potentially some additional information (such as a specific attestation key).

```
enum AuthenticatorStatus {
    "NOT_FIDO_CERTIFIED",
    "FIDO_CERTIFIED",
    "USER_VERIFICATION_BYPASS",
    "ATTESTATION_KEY_COMPROMISE",
    "USER_KEY_REMOTE_COMPROMISE",
    "USER_KEY_PHYSICAL_COMPROMISE",
    "UPDATE_AVAILABLE",
    "REVOKED",
    "SELF_ASSERTION_SUBMITTED",
    "FIDO_CERTIFIED_L1",
    "FIDO_CERTIFIED_L1plus",
    "FIDO_CERTIFIED_L2",
    "FIDO_CERTIFIED_L2plus",
    "FIDO_CERTIFIED_L3",
    "FIDO_CERTIFIED_L3plus"
};
```

3.1.4.1. Certification Related Statuses§

NOT_FIDO_CERTIFIED
: This authenticator is not FIDO certified.

> Applicable StatusReport fields are:

- effectiveDate - When status was achieved
- authenticatorVersion - The minimum applicable authenticator version.
- url - To the authenticator page or additional information about the authenticator

SELF_ASSERTION_SUBMITTED
: The authenticator vendor has completed and submitted the self-certification checklist to the FIDO Alliance. If this completed checklist is publicly available, the URL will be specified in url.

> Applicable StatusReport fields are:

- effectiveDate - Date of incident being reported
- authenticatorVersion - New authenticator version that is

FIDO_CERTIFIED
This authenticator has passed FIDO functional certification. This certification scheme is phased out and will be replaced by FIDO_CERTIFIED_L1.

> Applicable StatusReport fields are:

- effectiveDate - When certification was issued
- authenticatorVersion - The minimum version of the certified solution
- certificationDescriptor - Authenticator Description. I.e. "Munikey 7c Black Edition"
- certificateNumber - FIDO Alliance Certificate Number
- certificationPolicyVersion - Authenticator Certification Policy
- certificationRequirementsVersion - Security Requirements Version
- url - URL to the certificate, or the news article about achievement of the certification.

These fields are applicable to any of the FIDO_CERTIFIED_*.

FIDO_CERTIFIED_L1
The authenticator has passed FIDO Authenticator certification at level 1. This level is the more strict successor of FIDO_CERTIFIED.

FIDO_CERTIFIED_L1plus
The authenticator has passed FIDO Authenticator certification at level 1+. This level is the more than level 1.

FIDO_CERTIFIED_L2
The authenticator has passed FIDO Authenticator certification at level 2. This level is more strict than level 1+.

FIDO_CERTIFIED_L2plus
The authenticator has passed FIDO Authenticator certification at level 2+. This level is more strict than level 2.

FIDO_CERTIFIED_L3
The authenticator has passed FIDO Authenticator certification at level 3. This level is more strict than level 2+.

FIDO_CERTIFIED_L3plus
The authenticator has passed FIDO Authenticator certification at level 3+. This level is more

strict than level 3.

REVOKED

The FIDO Alliance has determined that this authenticator should not be trusted for any reason. For example if it is known to be a fraudulent product or contain a deliberate backdoor. Relying parties SHOULD reject any future registration of this authenticator model.

> Applicable StatusReport fields are:

- effectiveDate - Date of incident being reported
- authenticatorVersion - New authenticator version that is
- url - URL to the news/corporate article explaining the reason for revocation

3.1.4.2. Security Notification Statuses§

USER_VERIFICATION_BYPASS

Indicates that malware is able to bypass the user verification. This means that the authenticator could be used without the user's consent and potentially even without the user's knowledge.

> Applicable StatusReport fields are:

- effectiveDate - Date of incident being reported
- authenticatorVersion - Minimum affected authenticator version
- url - URL to the news/corporate article explaining the incident

ATTESTATION_KEY_COMPROMISE

Indicates that an attestation key for this authenticator is known to be compromised. The relying party SHOULD check the certificate field and use it to identify the compromised authenticator batch. If the certificate field is not set, the relying party should reject all new registrations of the compromised authenticator. The Authenticator manufacturer should set the date to the date when compromise has occurred.

> Applicable StatusReport fields are:

- effectiveDate - Date of incident being reported
- authenticatorVersion - Minimum affected authenticator version
- certificate - Base64 DER-encoded PKIX certificate identifying compromised attestation root. If missing, then assume all authenticators of this model are compromised.
- url - URL to the news/corporate article explaining the incident

USER_KEY_REMOTE_COMPROMISE

This authenticator has identified weaknesses that allow registered keys to be compromised and should not be trusted. This would include both, e.g. weak entropy that causes predictable keys to be generated or side channels that allow keys or signatures to be forged, guessed or extracted.

> Applicable StatusReport fields are:

- effectiveDate - Date of incident being reported
- authenticatorVersion - Minimum affected authenticator version
- url - URL to the news/corporate article explaining the incident

USER_KEY_PHYSICAL_COMPROMISE

This authenticator has known weaknesses in its key protection mechanism(s) that allow user keys to be extracted by an adversary in physical possession of the device.

> Applicable StatusReport fields are:

- effectiveDate - Date of incident being reported
- authenticatorVersion - Minimum affected authenticator version
- url - URL to the news/corporate article explaining the incident

3.1.4.3. Info Statuses§

UPDATE_AVAILABLE

A software or firmware update is available for the device. The Authenticator manufacturer should set the url to the URL where users can obtain an update and the date the update was published. When this status code is used, then the field authenticatorVersion in the authenticator Metadata Statement [FIDOMetadataStatement] MUST be updated, if the update fixes severe security issues, e.g. the ones reported by preceding StatusReport entries with status code USER_VERIFICATION_BYPASS, ATTESTATION_KEY_COMPROMISE, USER_KEY_REMOTE_COMPROMISE, USER_KEY_PHYSICAL_COMPROMISE, REVOKED. The Relying party MUST reject the Metadata Statement if the authenticatorVersion has not increased

> Applicable StatusReport fields are:

- effectiveDate - Date of incident being reported

- authenticatorVersion - New authenticator version that is available. MUST match authenticatorVersion in the metadata statement.
- url - URL to the page with the update info

> Relying parties might want to inform users about available firmware updates.

More values might be added in the future. FIDO Servers MUST silently ignore all unknown AuthenticatorStatus values.

3.1.5. RogueListEntry dictionary§

> Contains a list of individual authenticators known to be rogue.
> New `RogueListEntry` entries will be added to report new individual authenticators known to be rogue.
>
> Old `RogueListEntry` entries will be removed if the individual authenticator is known to not be rogue any longer.

Contains a list of individual authenticators known to be rogue.

New `RogueListEntry` entries will be added to report new individual authenticators known to be rogue.

Old `RogueListEntry` entries will be removed if the individual authenticator is known to not be rogue any longer.

```
dictionary RogueListEntry {
    required DOMString sk;
    required DOMString date;
};
```

***sk*, of type DOMString**
: Base64url encoding of the rogue authenticator's secret key (sk value, see [FIDOEcdaaAlgorithm], section ECDAA Attestation).

> In order to revoke an individual authenticator, its secret key (sk) must be known.

***date*, of type DOMString**
: ISO-8601 formatted date since when this entry is effective.

```
EXAMPLE: ROGUELISTENTRY[] EXAMPLE
```

```
[
    { "sk": "MO-oaqbeJSSayzXaDUhh9LMKeT4Zio1bqn6W8kDaUfM",
      "date": "2016-06-07"},
    { "sk": "k96Npt4jJIq7NNoNSGH0swp5PhU6jVuyf5jyYNtxrNQ",
      "date": "2016-06-09"},
]
```

3.1.6. Metadata BLOB Payload dictionary§

Represents the MetadataBLOBPayload

```
dictionary MetadataBLOBPayload {
    DOMString                       legalHeader;
    required Number                 no;
    required DOMString              nextUpdate;
    required MetadataBLOBPayloadEntry[] entries;
};
```

***legalHeader*, of type DOMString**

The legalHeader, which MUST be in each BLOB, is an indication of the acceptance of the relevant legal agreement for using the MDS. The FIDO Alliance's Blob will contain this legal header: "legalHeader": "Retrieval and use of this BLOB indicates acceptance of the appropriate agreement located at https://fidoalliance.org/metadata/metadata-legal-terms/"

***no*, of type Number**

The serial number of this UAF Metadata BLOB Payload. Serial numbers MUST be consecutive and strictly monotonic, i.e. the successor BLOB will have a `no` value exactly incremented by one.

***nextUpdate*, of type DOMString**

ISO-8601 formatted date when the next update will be provided at latest.

***entries*, of type MetadataBLOBPayloadEntry[]**

List of zero or more MetadataBLOBPayloadEntry objects.

3.1.7. Metadata BLOB§

The metadata BLOB is a JSON Web Token (see [JWT] and [JWS]). It consists of three elements:

- The base64url encoding, without padding, of the UTF-8 encoded JWT Header (see example below),
- the base64url encoding, without padding, of the UTF-8 encoded Metadata BLOB Payload (see example at the beginning of section Metadata BLOB Format>),

- and the base64url-encoded, also without padding, JWS Signature [JWS] computed over the to-be-signed payload using the Metadata BLOB signing key, i.e.`tbsPayload = EncodedJWTHeader | "." | EncodedMetadataBLOBPayload`

All three elements of the BLOB are concatenated by a period ("."): `MetadataBLOB = EncodedJWTHeader | "." | EncodedMetadataBLOBPayload | "." | EncodedJWSSignature`

The hash algorithm related to the signing algorithm specified in the JWT Header (e.g. SHA256 in the case of "ES256") MUST also be used to compute the hash of the metadata statements (see section Metadata BLOB Payload Entry Dictionary).

3.1.7.1. Examples§

This section is not normative.

EXAMPLE: ENCODED METADATA BLOB

```
ewoJImxlZ2FsSGVhZGVyIjogIlJldHJpZXZhbCBhbmQgdXNlIG9mIHRoaXMgQkxPQiBpbmRpY2F0ZXMg
YWNjZXB0YW5jZSBvZiB0aGUgYXBwcm9wcmlhdGUgYWdyZWVtZW50IGxvY2F0ZWQgYXQgaHR0cHM6Ly9m
aWRvYWxsaWFuY2Uub3JnL21ldGFkYXRhL21ldGFkYXRhLWxlZ2FsLXRlcm1zLyIsCgkibm8iOiAxNSwK
CSJuZXh0VXBkYXRlIjogIjIwMjAtMDMtMzAiLAoJImVudHJpZXMiOiBbewoJCQkiYWFpZCI6ICIxMjM0
IzU2NzgiLAoJCQkibWV0YWRhdGFTdGF0ZW1lbnQiOiB7CgkJCQkibGVnYWxIZWFkZXIiOiAiaHR0cHM6
Ly9maWRvYWxsaWFuY2Uub3JnL21ldGFkYXRhL21ldGFkYXRhLXN0YXRlbWVudC1sZWdhbC1oZWFkZXIv
IiwKCQkJCSJkZXNjcmlwdGlvbiI6ICJGSURPIEFsbGlhbmNlIFNhbXBsZSBVQUYgQXV0aGVudGljYXRv
ciIsCgkJCQkiYWFpZCI6ICIxMjM0IzU2NzgiLAoJCQkJImFsdGVybmF0aXZlRGVzY3JpcHRpb25zIjog
ewoJCQkJCSJydS1SVSI6ICLQn9GA0LjQvNC10YAgVUFGINCw0YPRgtC10L3RgtC40YTQuNC60LDRgtC-
0YDQsCDQvtGCIEZJRE8gQWxsaWFuY2UiLAoJCQkJCSJmci1GUiI6ICJFeGVtcGxlIFVBRiBhdXRoZW50
aWNhdG9yIGRlIEZJRE8gQWxsaWFuY2UiCgkJCQl9LAoJCQkJImF1dGhlbnRpY2F0b3JWZXJzaW9uIjog
MiwKCQkJCSJwcm90b2NvbEZhbWlseSI6ICJ1YWYiLAoJCQkJInNjaGVtYSI6IDMsCgkJCQkidXB2Ijog
W3sKCQkJCQkJIm1ham9yIjogMSwKCQkJCQkJIm1pbm9yIjogMAoJCQkJCX0sCgkJCQkJewoJCQkJCQki
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K3V5R1V4VmRKMEROVlhTbStiMXFSeHBsODRkZGZYMUxwMU8vZDY5dHNvZDB2czVoR3JlOXh1OG8rZnBM
UjFjR2hOVEQ2WjU3QzlLTVdYZWZKZE9aOTRiYjlvcWQxUk9uUzdxSVRUekhpbU1xaXZiTzNnMERkVnlr
M1dRQmhCenRLMzVZS05kT25jOE8zYWNTNmZEWkZnS2FYTHNFSnA1cmRybGlCcXA4OWNKY3MvbTdUdnMw
cmtqR2ZONGIwa1BvWm4zVUp1SU9ybloyMnlQMWZtdlV4K081Z1NxZWJWMW0relN1WU5WaHE3VFdiRGlM
VnZsanBsTGxvcDZDTFhQKzJxdHZHTElMLzF2aW1JU2RNQmd6U29GWnl1NlRxZCtqenhnc1BhVjlCQ3Fl
ZS9OallrNnY2bEs5Y3dpVWMvU1R0ZjFIRHBNM2I1OTJ5N2gzVGh4NW96SzY5SExwWVd1QXdhcVM1Y3Yy
NnE3Y2ViOGVmVllhUmVQM2lGVTh6ajFrblN3WlhITW1uQ2pZME9nYWxvN1VRZlNDTTNxUVFyMkgvWEZQ
N3NzWHg0NVlsOTFCeWVDZXA0bW9ab0grMWZHM3hENHRUN3g4a3d5ajhud2I5ZXYyNlYwQjZkKzdINHpL
dnVkQUg1MzdGanF5ek9IZEpuSEV1em1YcS9XanhPYnZOTWJ2N25oeXdzWDJhVnNXdEM4KzQ4YUxlYXBF
N3A1d0taaTBBMkFRUlY1bnZSNEUrdUpjK2I2MWtBcHFJbnhCZ21kLzRWNVFQL210MThIREM3c1JIZnRt
ZXU1bG1oVjBybi9BTFgyMzJicWQ0QkZuRHg3VmkxY1dTMnVmZjBJYkI0N3FleHhtVWo5UXV0WWp1cGQz
dFlENmFiV0JCTXJoK2FwTmJPS3JORjErdWdDYTRyaVhHZndNUFB0VmlhdmhVM1lNT0FBbnVVYi9SMDdM
MHlPU2VPYWRFODhBcHNYRkdmZjMweW5obEpnTTUxQ1U2dk45RXpnbnB2SEJGVXlpVnJhZVBpd0o1M0RG
NVpUWm5vbUVOZzg1a05VZDJvSmkyV3ByNE9tbWtmTjR4NHpIZmlWRmM4RHY4Tnp1aE5xT2lkaWxHdkE2
REd1ZVp3Tzc4QUFRbjZjaUVrNitydzVWY3ZqdnFORFlQT29JVXdhS1NocnhBdVhMbGtINGFZdUdmTVlE
YzEwV0Y1VGEzMWhQSk9mY1VoclUvSmxJTmk2YzZlbFJZZEJwbzYrK1lmang2MWxHTmZSbTRNRDVySjFq
M0ZvR0huakRTQk5hcllVZ01MeU1zektwYjd0WHBvSGZQczhoM1dwMUx6TmZOazU0WHhDMXdER1VtWXpY
WWVmaDZ6L2NLdFZtNEVCeGE5VlFHRHpZcjNMclVNUmpIRUtrazd6YUZLWVFBMmhHUVUxeis4NU5GV3BY
RHJrejN2eDEwR3F4UTZCemVOYm9CazVuOGs0bmViUmgrazFoV2Z4VEYwRDFFeVdVczVuditkZ1FxS2F4
enVDZEUwaXNIbDAyTlE4YWgwbVhyMTJMYTNtMGY5d2lrOSt3TE5UTVkvODZNUG84eWkzMU9meG1UNlBX
b3FHOStEWnVrWW5hNTZtU1p0NVdXU3k1cVZBMXJ3VXlKcVhBbG56a2lhaS9nSFNEN1JrVHlpaG9nQUFB
QUJKUlU1RXJrSmdnZz09IiwKCQkJCSJzdXBwb3J0ZWRFeHRlbnNpb25zIjogW3sKCQkJCQkJImlkIjog
```

```
ImhtYWMtc2VjcmV0IiwKCQkJCQkJImZhaWxfaWZfdW5rbm93biI6IGZhbHNlCgkJCQkJfSwKCQkJCQl7
CgkJCQkJCSJpZCI6ICJjcmVkUHJvdGVjdCIsCgkJCQkJCSJmYWlsX2lmX3Vua25vd24iOiBmYWxzZQoJ
CQkJCX0KCQkJCV0sCgkJCQkiYXV0aGVudGljYXRvckdldEluZm8iOiB7CgkJCQkJInZlcnNpb25zIjog
WyJVMkZfVjIiLCAiRklET18yXzAiXSwKCQkJCQkiZXh0ZW5zaW9ucyI6IFsiY3JlZFByb3RlY3QiLCAi
aG1hYy1zZWNyZXQiXSwKCQkJCQkiYWFndWlkIjogIjAxMzJkMTEwYmY0ZTQyMDhhNDAzYWI0ZjVmMTJl
ZmU1IiwKCQkJCQkib3B0aW9ucyI6IHsKCQkJCQkJInBsYXQiOiAiZmFsc2UiLAoJCQkJCQkicmsiOiAi
dHJ1ZSIsCgkJCQkJCSJjbGllbnRQaW4iOiAidHJ1ZSIsCgkJCQkJCSJ1cCI6ICJ0cnVlIiwKCQkJCQkJ
InV2IjogInRydWUiLAoJCQkJCQkidXZUb2tlbiI6ICJmYWxzZSIsCgkJCQkJCSJjb25maWciOiAiZmFs
c2UiCgkJCQkJfSwKCQkJCQkibWF4TXNnU2l6ZSI6IDEyMDAsCgkJCQkJInBpblV2QXV0aFByb3RvY29s
cyI6IFsxXSwKCQkJCQkibWF4Q3JlZGVudGlhbENvdW50SW5MaXN0IjogMTYsCgkJCQkJIm1heENyZWRl
bnRpYWxZExlbmd0aCI6IDEyOCwKCQkJCQkidHJhbnNwb3J0cyI6IFsidXNiIiwgIm5mYyJdLAoJCQkJ
CSJhbGdvcml0aG1zIjogW3sKCQkJCQkJCSJ0eXBlIjogInB1YmxpYy1rZXkiLAoJCQkJCQkJImFsZyI6
IC03CgkJCQkJCX0sCgkJCQkJCXsKCQkJCQkJCSJ0eXBlIjogInB1YmxpYy1rZXkiLAoJCQkJCQkJImFs
ZyI6IC0yNTcKCQkJCQkJfQoJCQkJCV0sCgkJCQkJIm1heEF1dGhlbnRpY2F0b3JDb25maWdMZW5ndGgi
OiAxMDI0LAoJCQkJCSJkZWZhdWx0Q3JlZFByb3RlY3QiOiAyLAoJCQkJCSJmaXJtd2FyZVZlcnNpb24i
OiA1CgkJCQl9CgkJCX0sCgkJCSJzdGF0dXNSZXBvcnRzIjogW3sKCQkJCQkic3RhdHVzIjogIkZJRE9f
Q0VSVElGSUVEIiwKCQkJCQkiZWZmZWN0aXZlRGF0ZSI6ICIyMDE5LTAxLTA0IgoJCQkJfSwKCQkJCXsK
CQkJCQkic3RhdHVzIjogIkZJRE9fQ0VSVEVX0wxIiwKCQkJCQkiZWZmZWN0aXZlRGF0ZSI6ICIy
MDIwLTExLTE5IiwKCQkJCQkiY2VydGlmaWNhdGlvbkRlc2NyaXB0b3IiOiAiRklETyBBbGxpYW5jZSBT
YW1wbGUgRklETzIgQXV0aGVudGljYXRvciIsCgkJCQkJInNlcnRpZmljYXRlTnVtYmVyIjogIkZJRE8y
MTAwMDIwMTUxMjIxMDAxIiwKCQkJCQkiY2VydGlmaWNhdGlvblBvbGljeVZlcnNpb24iOiAiMS4wLjEi
LAoJCQkJCSJjZXJ0aWZpY2F0aW9uUmVxdWlyZW1lbnRzVmVyc2lvbiI6ICIxLjAuMSIKCQkJCX0KCQkJ
XSwKCQkJInRpbWVPZkxhc3RTdGF0dXNDaGFuZ2UiOiAiMjAxOS0wMS0wNCIKCQl9CgldCn0
```


EXAMPLE: JWT HEADER


```
{
  "alg": "ES256",
  "typ": "JWT",
  "x5c": [
    "MIICZTCCAgugAwIBAgIBATAKBggqhkjOPQQDAjCBozEnMCUGA1UEAwweRVhBTVBM
    RSBNRFMzIFRFU1QgSU5URVJNRURJQVRFMSIwIAYJKoZIhvcNAQkBFhNleGFtcGxl
    QGV4YW1wbGUuY29tMRQwEgYDVQQKDAtFeGFtcGxlIE9SRzEQMA4GA1UECwwHRXhh
    bXBsZTELMAkGA1UEBhMCVVMxCzAJBgNVBAgMAk1ZMRIwEAYDVQQHDAlXYWtlZmll
    bGQwHhcNMjEwNDE5MTEzNTA3WhcNMzEwNDE3MTEzNTA3WjCBpTEpMCcGA1UEAwwg
    RVhBTVBMRSBNRFMzIFNJR05JTkcgQ0VSVElGSUNBVEUxIjAgBgkqhkiG9w0BCQEW
    E2V4YW1wbGVAZXhhbXBsZS5jb20xFDASBgNVBAoMC0V4YW1wbGUgT1JHMRAwDgYD
    VQQLDAdFeGFtcGxlMQswCQYDVQQGEwJVUzELMAkGA1UECAwCTVkxEjAQBgNVBAcM
    CVdha2VmaWVsZDBZMBMGByqGSM49AgEGCCqGSM49AwEHA0IABNQJs6wTqixc+S+V
    DAajFlPNat10KEWJE5jcWOvm6qpO9SDAAMZvb4HHrvs+P5YRpHrSlUPdvK+uEQbd
    Wg31P9ujLDAqMAkGA1UdEwQCMAAwHQYDVR0OBBYEFLqsapcXV4ZoVHAnRpPZwQe7
    Yy20MAoGCCqGSM49BAMCA0gAMEUCIQC67za8EIuyRiKgNDXIP1s1aLr3jzH9WVXf
    Hx4bJ+zCsgIgG/tVButOJUU+vvoHIo/otAUAcH5bNHP3uIziDS+PTUc=",
    "MIIEHzCCAgegAwIBAgIBAjANBgkqhkiG9w0BAQsFADCBmzEfMB0GA1UEAwwWRVhB
    TVBMRSBNRFMzIFRFU1QgUk9PVDEiMCAGCSqGSIb3DQEJARYTZXhhbXBsZUBleGFt
    cGxlLmNvbTEUMBIGA1UECgwLRXhhbXBsZSBPUkcxEDAOBgNVBAsMB0V4YW1wbGUx
    CzAJBgNVBAYTAlVTMQswCQYDVQQIDAJNWTESMBAGA1UEBwwJV2FrZWZpZWxkMB4X
```

```
    DTIxMDQxOTExMzUwN1oXDTQ4MDkwNDExMzUwN1owgaMxJzAlBgNVBAMMHkVYQU1Q
    TEUgTURTMyBURVNUIElOVEVSTUVESUFURTEiMCAGCSqGSIb3DQEJARYTZXhhbXBs
    ZUBleGFtcGxlLmNvbTEUMBIGA1UECgwLRXhhbXBsZSBPUkcxEDAOBgNVBAsMB0V4
    YW1wbGUxCzAJBgNVBAYTAlVTMQswCQYDVQQIDAJNWTESMBAGA1UEBwwJV2FrZWZp
    ZWxkMFkwEwYHKoZIzj0CAQYIKoZIzj0DAQcDQgAENGumBbYnFQnTjP1RSfc70hsh
    gbiI1ZtpwQ5n6xRLA/Wq0PSCfLl5qQ+r7dlcK1d3r3vLa+vm6G6vKHGCPEeUzqMv
    MC0wDAYDVR0TBAUwAwEB/zAdBgNVHQ4EFgQUNk6F4RJnGGVFe+0/cbZwfrZd7ZUw
    DQYJKoZIhvcNAQELBQADggIBACnp1fm0FKlWmUtTplLuYg7mps4xP/COu8dnb38u
    1nMDVuOT4+CZaiM9AGz313GD22hjLGrmPuYn86wGOKI3HOrEpsGdMmfy7tTmKX/e
    M/eS3FEDXZnE82Pn5oFIyBT/f8sGuXyOsFZqWBvVdBIIDldCpD4mxMQZZOZtTrlv
    3WvBQMC/dsicOxe3QKXvWHi6Qb/Rhuaip3rPmwMf+4JpnJO+JMPqAaU1cAH8HVsf
    rLAMoKs148j2+cvbpaWmsT5rIoH/ezVrPaG/MOiIgq79w/efuvSi5AX8J+kDoLSE
    f3d5wOgkJYAqUqcRxXTEEtKIzDM6hzaBQFiAWvTn9IlVWgntQamSXvH+txaTF9iE
    lHxUf5INYFVciCpztSrydeHv/OCNRf7/LVricMSlo8Rh+O3yP9V+2uNf3X8sQJNt
    ufrQNaqq18wiXliTLufSn02/g+mkhIUiNKfTOJpvCjKeCnCFcxQU2/XT3Kh3G8gD
    JwsO6EVRjMUJt4AYKze/hEUCwF55IF2m3jHIoCu8jVfj24CeEX5dnfvSr+SVvN5Q
    B0uZ05M4rmyZXyqBm0zK3fR+iE0/ZpInuwLC7X+W82zXlnMkplI3Q+Jxd7jfQ15S
    YNE2K6rvRIT01w0P9ZqyDF7knGKpRlp7Oqxd37bD/VUbWpQ7gIAfsJNH5KBLowHJ
    FFjW"
  ]
}
```

In order to produce the tbsPayload, we first need the base64url-encoded (without padding) JWT Header:

```
EXAMPLE: ENCODED JWT HEADER
ewogICJhbGciOiAiRVMyNTYiLAogICJ0eXAiOiAiSldUIiwKICAieDVjIjogWwogICAgIk1JSUNaVEND
QWd1Z0F3SUJBZ0lCQVRBS0JnZ3Foa2pPUFFRREFqQ0JvekVuTUNVR0ExVUVBd3dlUlZoQlRWQk1SU0JO
UkZNeklGUkZVMVFnU1U1VVJWSk5SVVJKUVZSRk1TSXdJQVlKS29aSWh2Y05BUWtCRmhObGVHRnRjR3hs
UUdWNFlXMXdiR1V1WTI5dE1SUXdFZ1lEVlFRS0RBdEZlR0Z0Y0d4bElFOVNSekVRTUE0R0ExVUVDd3dI
UlhoaGJYQnNaVEVMTUFrR0ExVUVCaE1DVlZNeEN6QUpCZ05WQkFnTUFrMVpNUkl3RUFZRFZRUUhEQWxY
WVd0bFptbGxiR1F3SGhjTk1qRXdOREU1TVRFek5UQTNXaGNOTXpFd05ERTNNVEV6TlRBM1dqQ0JwVEVw
TUNjR0ExVUVBd3dnUlZoQlRWQk1SU0JOUkZNeklGTkpSMDVKVGtjZ1EwVlNWRWxHU1VOQlZFVXhJakFn
QmdrcWhraUc5dzBCQ1FFV0UyVjRZVzF3YkdWQVpYaGhiWEJzWlM1amIyMHhGREFTQmdOVkJBb01DMFY0
WVcxd2JHVWdUMUpITVJBd0RnWURWUVFMREFkRmVHRnRjR3hsTVFzd0NRWURWUVFHRXdKVlV6RUxNQWtH
QTFVRUNBd0NUVmt4RWpBUUJnTlZCQWNNQ1ZkaGEyVm1hV1ZzWkRCWk1CTUdCeXFHU000OUFnRUdDQ3FH
U000OUF3RUhBMElBQk5RSnM2d1RxaXhjK1MrVkRBYWpGbFBOYXQxMEtFV0pFNWpjV092bTZxcE85U0RB
QU1admI0SEhydnMrUDVZUnBIclNsVVBkdksrdUVRYmRXZzMxUDl1akxEQXFNQWtHQTFVZEV3UUNNQUF3
SFFZRFZSME9CQllFRkxxc2FwY1hWNFpvVkhBblJwUFp3UWU3WXkyME1Bb0dDQ3FHU000OUJBTUNBMGdB
TUVVQ0lRQzY3emE4RUl1eVJpS2dORFhJUDFzMWFMcjNqekg5V1ZYZkh4NGJKK3pDc2dJZ0cvdFZCdXRP
SlVVK3Z2b0hJby9vdEFVQWNINWJOSFAzdUl6aURTK1BUVWM9IiwKICAgICJNSUlFSHpDQ0FnZWdBd0lC
QWdJQkFqQU5CZ2txaGtpRzl3MEJBUXNGQURDQm16RWZNQjBHQTFVRUF3d1dSVmhCVFZCTVJTQk5SRk16
SUZSRlUxUWdVazlQVkRFaU1DQUdDU3FHU0liM0RRRUpBUllUWlhoaGJYQnNaVUJsZUdGdGNHeGxMbU52
YlRFVU1CSUdBMVVFQ2d3TFJYaGhiWEJzWlNCUFVrY3hFREFPQmdOVkJBc01CMFY0WVcxd2JHVXhDekFK
QmdOVkJBWVRBbFZUTVFzd0NRWURWUVFJREFKTldURVNNQkFHQTFVRUJ3d0pWMkZyWldacFpXeGtNQjRY
RFRJeE1EUXhPVEV4TXpVd04xb1hEVFE0TURrd05ERXhNelV3TjFvd2dhTXhKekFsQmdOVkJBTU1Ia1ZZ
```

```
UVUxUVRFVWdUVVJUTXlCVVJWTlVJRWxPVkVWU1RVVkVTVUZVUlRFaU1DQUdDU3FHU0liM0RRRUpBUllU
WlhoaGJYQnNaVUJsZUdGdGNHeGxMbU52YlRFVU1CSUdBMVVFQ2d3TFJYaGhiWEJzWlNCUFVrY3hFREFP
QmdOVkJBc01CMFY0WVcxd2JHVXhDekFKQmdOVkJBWVRBbFZUTVFzd0NRWURWUVFJREFKTldURVNNQkFH
QTFVRUJ3d0pWMkZyWldacFpXeGtNRmt3RXdZSEtvWkl6ajBDQVFZSUtvWkl6ajBEQVFjRFFnQUVOR3Vt
QmJZbkZRblRqUDFSU2ZjNzBoc2hnYmlJMVp0cHdRNW42eFJMQS9XcTBQU0NmTGw1cVErcjdkbGNLMWQz
cjN2TGErdm02RzZ2S0hHQ1BFZVV6cU12TUMwd0RBWURWUjBUQkFVd0F3RUIvekFkQmdOVkhRNEVGZ1FV
Tms2RjRSSm5HR1ZGZSswL2NiWndmclpkN1pVd0RRWUpLb1pJaHZjTkFRRUxCUUFEZ2dJQkFDbnAxZm0w
RktsV21VdFRwbEx1WWc3bXBzNHhQL0NPdThkbmIzOHUxbk1EVnVPVDQrQ1phaU05QUd6MzEzR0QyMmhq
TEdybVB1WW44NndHT0tJM0hPckVwc0dkTW1meTd0VG1LWC9lTS9lUzNGRURYWm5FODJQbjVvRkl5QlQv
ZjhzR3VYeU9zRlpxV0J2VmRCSUlEbGRDcEQ0bXhNUVpaT1p0VHJsdjNXdkJRTUMvZHNpY094ZTNRS1h2
V0hpNlFiL1JodWFpcDNyUG13TWYrNEpwbkpPK0pNUHFBYVUxY0FIOEhWc2ZyTEFNb0tzMTQ4ajIrY3Zi
cGFXbXNUNXJJb0gvZXpWclBhRy9NT2lJZ3E3OXcvZWZ1dlNpNUFYOEora0RvTFNFZjNkNXdPZ2tKWUFx
VXFjUnhYVEVFdEtJekRNNmh6YUJRRmlBV3ZUbjlJbFZXZ250UWFtU1h2SCt0eGFURjlpRWxIeFVmNUlO
WUZWY2lDcHp0U3J5ZGVIdi9PQ05SZjcvTFZyaWNNU2xvOFJoK08zeVA5VisydU5mM1g4c1FKTnR1ZnJR
TmFxcTE4d2lYbGlUTHVmU24wMi9nK21raElVaU5LZlRPSnB2Q2pLZUNuQ0ZjeFFVMi9YVDNLaDNHOGdE
SndzTzZFVlJqTVVKdDRBWUt6ZS9oRVVDd0Y1NUlGMm0zakhJb0N1OGpWZmoyNENlRVg1ZG5mdlNyK1NW
dk41UUIwdVowNU00cm15Wlh5cUJtMHpLM2ZSK2lFMC9acEludXdMQzdYK1c4MnpYbG5Na3BsSTNRK0p4
ZDdqZlExNVNZTkUySzZydlJJVDAxdzBQOVpxeURGN2tuR0twUmxwN09xeGQzN2JEL1ZVYldwUTdnSUFm
c0pOSDVLQkxvd0hKRkZqVyIKICBdCn0
```

then we have to append a period (".") and the base64url encoding of the `EncodedMetadataBLOBPayload` (taken from the example in section Metadata BLOB Format):

```
EXAMPLE: TBSPAYLOAD
eyJhbGciOiJFUzI1NiIsInR5cCI6IkpXVCIsIng1YyI6WyJNSUlDWlRDQ0FndWdBd0lCQWdJQkFUQUtC
Z2dxaGtqT1BRUURBakNCb3pFbk1DVUdBMVVFQXd3ZVJWaEJUVkJNUlNCTlJGTXpJRlJGVTFRZ1NVNVVS
VkpOUlVSSlFWUkZNU0l3SUFZSktvWklodmNOQVFrQkZoTmxlR0Z0Y0d4bFFHVjRZVzF3YkdVdVkyOXRN
UlF3RWdZRFZRUUtEQXRGZUdGdGNHeGxJRTlTUnpFUU1BNEdBMVVFQ3d3SFJYaGhiWEJzWlRFTE1Ba0dB
MVVFQmhNQ1ZWTXhDekFKQmdOVkJBZ01BazFaTVJJd0VBWURWUVFIREFsWFlXdGxabWxsYkdRd0hoY05N
akV3TkRFNU1URXpOVEEzV2hjTk16RXdOREUzTVRFek5UQTNXakNCcFRFcE1DY0dBMVVFQXd3Z1JWaEJU
VkJNUlNCTlJGTXpJRk5KUjA1SlRrY2dRMFZTVkVsR1NVTkJWRVV4SWpBZ0Jna3Foa2lHOXcwQkNRRVdF
MlY0WVcxd2JHVkFaWGhoYlhCc1pTNWpiMjB4RkRBU0JnTlZCQW9NQzBWNFlXMXdiR1VnVDFKSE1SQXdE
Z1lEVlFRTERBZEZlR0Z0Y0d4bE1Rc3dDUVlEVlFRR0V3SlZVekVMTUFrR0ExVUVDQXdDVFZreEVqQVFC
Z05WQkFjTUNWZGhhMlZtYVdWc1pEQlpNQk1HQnlxR1NNNDlBZ0VHQ0NxR1NNNDlBd0VIQTBJQUJOUUpz
NndUcWl4YytTK1ZEQWFqRmxQTmF0MTBLRVdKRTVqY1dPdm02cXBPOVNEQUFNWnZiNEhIcnZzK1A1WVJw
SHJTbFVQZHZLK3VFUWJkV2czMVA5dWpMREFxTUFrR0ExVWRFd1FDTUFBd0hRWURWUjBPQkJZRUZMcXNh
cGNYVjRab1ZIQW5ScFBad1FlN1l5MjBNQW9HQ0NxR1NNNDlCQU1DQTBnQU1FVUNJUUM2N3phOEVJdXlS
aUtnTkRYSVAxczFhTHIzanpIOVdWWGZIeDRiSit6Q3NnSWdHL3RWQnV0T0pVVSt2dm9ISW8vb3RBVUFj
SDViTkhQM3VJemlEUytQVFVjPSIsIk1JSUVIekNDQWdlZ0F3SUJBZ0lCQWpBTkJna3Foa2lHOXcwQkFR
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and finally we have to append another period (".") followed by the base64url-encoded signature.

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EXAMPLE: JWT
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pcm13YXJlVmVyc2lvbiI6NX19LCJzdGF0dXNSZXBvcnRzIjpbeyJzdGF0dXMiOiJGSURPX0NFUlRJRkl
FRCIsImVmZmVjdGl2ZURhdGUiOiIyMDE5LTAxLTA0In0seyJzdGF0dXMiOiJGSURPX0NFUlRJRklFRF9
MMSIsImVmZmVjdGl2ZURhdGUiOiIyMDIwLTExLTE5IiwiY2VydGlmaWNhdGlvbkRlc2NyaXB0b3IiOiJ
GSURPIEFsbGlhbmNlIFNhbXBsZSBGSURPMiBBdXRoZW50aWNhdG9yIiwiY2VydGlmaWNhdGVOdW1iZXI
iOiJGSURPMjEwMDAyMDE1MTIyMTAwMSIsImNlcnRpZmljYXRpb25Qb2xpY3lWZXJzaW9uIjoiMS4wLjE
iLCJjZXJ0aWZpY2F0aW9uUmVxdWlyZW1lbnRzVmVyc2lvbiI6IjEuMC4xIn1dLCJ0aW1lT2ZMYXN0U3R
hdHVzQ2hhbmdlIjoiMjAxOS0wMS0wNCJ9XX0.-kc1wrorJA16bxLXXzeDkFEOCsbKAy2WDEzoCY-Aej_
N0bWIOAmhpHGxSa3CXgmwFwgAuy230Eq_BHTO_RshsA
```

The line breaks are for display purposes only.

The signature in the example above was computed with the following ECDSA key

```
EXAMPLE: ECDSA KEY USED FOR SIGNATURE COMPUTATION
-----BEGIN CERTIFICATE----–
MIICZTCCAgugAwIBAgIBATAKBggqhkjOPQQDAjCBozEnMCUGA1UEAwweRVhBTVBM
RSBNRFMzIFRFU1QgSU5URVJNRURJQVRFMSIwIAYJKoZIhvcNAQkBFhNleGFtcGxl
QGV4YW1wbGUuY29tMRQwEgYDVQQKDAtFeGFtcGxlIE9SRzEQMA4GA1UECwwHRXhh
bXBsZTELMAkGA1UEBhMCVVMxCzAJBgNVBAgMAk1ZMRIwEAYDVQQHDAlXYWtlZmll
bGQwHhcNMjEwNDE5MTEzNTA3WhcNMzEwNDE3MTEzNTA3WjCBpTEpMCcGA1UEAwwg
RVhBTVBMRSBNRFMzIFNJR05JTkcgQ0VSVElGSUNBVEUxIjAgBgkqhkiG9w0BCQEW
```

```
E2V4YW1wbGVAZXhhbXBsZS5jb20xFDASBgNVBAoMC0V4YW1wbGUgT1JHMRAwDgYD
VQQLDAdFeGFtcGxlMQswCQYDVQQGEwJVUzELMAkGA1UECAwCTVkxEjAQBgNVBAcM
CVdha2VmaWVsZDBZMBMGByqGSM49AgEGCCqGSM49AwEHA0IABNQJs6wTqixc+S+V
DAajFlPNat10KEWJE5jcWOvm6qpO9SDAAMZvb4HHrvs+P5YRpHrSlUPdvK+uEQbd
Wg31P9ujLDAqMAkGA1UdEwQCMAAwHQYDVR0OBBYEFLqsapcXV4ZoVHAnRpPZwQe7
Yy20MAoGCCqGSM49BAMCA0gAMEUCIQC67za8EIuyRiKgNDXIP1s1aLr3jzH9WVXf
Hx4bJ+zCsgIgG/tVButOJUU+vvoHIo/otAUAcH5bNHP3uIziDS+PTUc=
-----END CERTIFICATE----—   -----BEGIN EC PRIVATE KEY----—
MHcCAQEEIFNpFhJvod3jKvbrLLzKTWKFxzaZ4l7kMchx3NyytQYUoAoGCCqGSM49
AwEHoUQDQgAE1AmzrBOqLFz5L5UMBqMWU81q3XQoRYkTmNxY6+bqqk71IMAAxm9v
gceu+z4/lhGketKVQ928r64RBt1aDfU/2w==
-----END EC PRIVATE KEY----—
```

The root certificate to validate certificate path in the X5C is:

```
EXAMPLE: CERTIFICATE PATH ROOT CERTIFICATE
-----BEGIN CERTIFICATE----—
MIIGGTCCBAGgAwIBAgIUdT9qLX0sVMRe8l0sLmHd3mZovQ0wDQYJKoZIhvcNAQEL
BQAwgZsxHzAdBgNVBAMMFkVYQU1QTEUgTURTMyBURVNUIFJPT1QxIjAgBgkqhkiG
9w0BCQEWE2V4YW1wbGVAZXhhbXBsZS5jb20xFDASBgNVBAoMC0V4YW1wbGUgT1JH
MRAwDgYDVQQLDAdFeGFtcGxlMQswCQYDVQQGEwJVUzELMAkGA1UECAwCTVkxEjAQ
BgNVBAcMCVdha2VmaWVsZDAeFw0yMTA0MTkxMTM1MDdaFw00ODA5MDQxMTM1MDda
MIGbMR8wHQYDVQQDDBZFWEFNUExFIE1EUzMgVEVTVCBST09UMSIwIAYJKoZIhvcN
AQkBFhNleGFtcGxlQGV4YW1wbGUuY29tMRQwEgYDVQQKDAtFeGFtcGxlIE9SRzEQ
MA4GA1UECwwHRXhhbXBsZTELMAkGA1UEBhMCVVMxCzAJBgNVBAgMAk1ZMRIwEAYD
VQQHDAlXYWtlZmllbGQwggIiMA0GCSqGSIb3DQEBAQUAA4ICDwAwggIKAoICAQDD
jF5wyEWuhwDHsZosGdGFTCcI677rW881vV+UfW38J+K2ioFFNeGVsxbcebK6AVOi
CDPFj0974IpeD9SFOhwAHoDu/LCfXdQWp8ZgQ91ULYWoW8o7NNSp01nbN9zmaO6/
xKNCa0bzjmXoGqglqnP1AtRcWYvXOSKZy1rcPeDv4Dhcpdp6W72fBw0eWIqOhsrI
tuY2/N8ItBPiG03EX72nACq4nZJ/nAIcUbER8STSFPPzvE97TvShsi1FD8aO6l1W
kR/QkreAGjMI++GbB2Qc1nN9Y/VEDbMDhQtxXQRdpFwubTjejkN9hKOtF3B71Yrw
Irng3V9RoPMFdapWMzSlI+WWHog0oTj1PqwJDDg7+z1I6vSDeVWAMKr9mq1w1OGN
zgBopIjd9lRWkRtt2kQSPX9XxqS4E1gDDr8MKbpM3JuubQtNCg9D7Ljvbz6vwvUr
bPHH+oREvucsp0PZ5PpizloepGIcLFxDQqCulGY2n7Ahl0JOFXJqOFCaK3TWHwBv
ZsaY5DgBuUvdUrwtgZNg2eg2omWXEepiVFQn3Fvj43Wh2npPMgIe5P0rwncXvROx
aczd4rtajKS1ucoB9b9iKqM2+M1y/FDIgVf1fWEHwK7YdzxMlgOeLdeV/kqRU5PE
UlLU9a2EwdOErrPbPKZmIfbs/L4B3k4zejMDH3Y+ZwIDAQABo1MwUTAdBgNVHQ4E
FgQU8sWwq1TrurK7xMTwO1dKfeJBbCMwHwYDVR0jBBgwFoAU8sWwq1TrurK7xMTw
O1dKfeJBbCMwDwYDVR0TAQH/BAUwAwEB/zANBgkqhkiG9w0BAQsFAAOCAgEAFw6M
1PiIfCPIBQ5EBUPNmRvRFuDpolOmDofnf/+mv63LqwQZAdo/W8tzZ9kOFhq24SiL
w0H7fsdG/jeREXiIZMNoW/rA6Uac8sU+FYF7Q+qp6CQLlSQbDcpVMifTQjcBk2xh
+aLK9SrrXBqnTAhwS+offGtAW8DpoLuH4tAcQmIjlgMlN65jnELCuqNR/wpA+zch
8LZW8saQ2cwRCwdr8mAzZoLbsDSVCHxQF3/kQjPT7Nao1q2iWcY3OYcRmKrieHDP
67yeLUbVmetfZis2d6ZlkqHLB4ZW1xX4otsEFkuTJA3HWDRsNyhTwx1YoCLsYut5
Zp0myqPNBq28w6qGMyyoJN0Z4RzMEO3R6i/MQNfhK55/8O2HciM6xb5t/aBSuHPK
lBDrFWhpRnKYkaNtlUo35qV5IbKGKau3SdZdSRciaXUd/p81YmoF01UlhhMz/Rqr
```

```
1k2gyA0a9tF8+awCeanYt5izl8YO0FlrOU1SQ5UQw4szqqZqbrf4e8fRuU2TXNx4
zk+ImE7WRB44f6mSD746ZCBRogZ/SA5jUBu+OPe4/sEtERWRcQD+fXgce9ZEN0+p
eyJIKAsl5Rm2Bmgyg5IoyWwSG5W+WekGyEokpslou2Yc6EjUj5ndZWz5EiHAiQ74
hNfDoCZIxVVLU3Qbp8a0S1bmsoT2JOsspIbtZUg=
-----END CERTIFICATE----—
```

3.2. Metadata BLOB object processing rules§

The FIDO Server MUST follow these processing rules:

1. Download and cache the root signing trust anchor from the respective MDS root location e.g. More information can be found at https://fidoalliance.org/metadata/
2. To validate the digital certificates used in the digital signature, the certificate revocation information MUST be available in the form of CRLs at the respective MDS CRL location e.g. More information can be found at https://fidoalliance.org/metadata/
3. The FIDO Server MUST be able to download the latest metadata BLOB object from the well-known URL when appropriate, e.g. https://mds.fidoalliance.org/. The `nextUpdate` field of the Metadata BLOB specifies a date when the download SHOULD occur at latest.
4. If the `x5u` attribute is present in the JWT Header, then:
    1. The FIDO Server MUST verify that the URL specified by the `x5u` attribute has the same web-origin as the URL used to download the metadata BLOB from. The FIDO Server SHOULD ignore the file if the web-origin differs (in order to prevent loading objects from arbitrary sites).
    2. The FIDO Server MUST download the certificate (chain) from the URL specified by the `x5u` attribute [JWS]. The certificate chain MUST be verified to properly chain to the metadata BLOB signing trust anchor according to [RFC5280]. All certificates in the chain MUST be checked for revocation according to [RFC5280].
    3. The FIDO Server SHOULD ignore the file if the chain cannot be verified or if one of the chain certificates is revoked.

        > The requirements for verifying certificate revocation, are only applicable to the MDS BLOB payload certificates. It is up to the server vendors whether to enforce CRL check for the certificates in the individual metadata statements.

5. If the `x5u` attribute is missing, the chain should be retrieved from the `x5c` attribute. If that attribute is missing as well, Metadata BLOB signing trust anchor is considered the BLOB signing certificate chain.
6. Verify the signature of the Metadata BLOB object using the BLOB signing certificate chain (as determined by the steps above). The FIDO Server SHOULD ignore the file if the signature is

invalid. It SHOULD also ignore the file if its number (`no`) is less or equal to the number of the last Metadata BLOB object cached locally.

7. Write the verified object to a local cache as required.
8. Iterate through the individual entries (of type `MetadataBLOBPayloadEntry`). For each entry:
    1. Ignore the entry if the AAID, AAGUID or attestationCertificateKeyIdentifiers is not relevant to the relying party (e.g. not acceptable by any policy)
    2. Check whether the status report of the authenticator model has changed compared to the cached entry by looking at the fields `timeOfLastStatusChange` and `statusReport`.

       Update the status of the cached entry. It is up to the relying party to specify behavior for authenticators with status reports that indicate a lack of certification, or known security issues. However, the status `REVOKED` indicates significant security issues related to such authenticators.

       > Authenticators with an unacceptable status should be marked accordingly.This information is required for building registration and authentication policies included in the registration request and the authentication request [UAFProtocol].

    3. Update the cached metadata statement.

4. Considerations§

This section is not normative.

This section describes the key considerations for designing this metadata service.

Need for Authenticator Metadata

When defining policies for acceptable authenticators, it is often better to describe the required authenticator characteristics in a generic way than to list individual authenticator AAIDs. The metadata statements provide such information. Authenticator metadata also provides the trust anchor required to verify attestation objects.

The metadata service provides a standardized method to access such metadata statements.

Integrity and Authenticity

Metadata statements include information relevant for the security. Some business verticals might even have the need to document authenticator policies and trust anchors used for verifying attestation objects for auditing purposes.

It is important to have a strong method to verify and proof integrity and authenticity and the freshness of metadata statements. We are using a single digital signature to protect the integrity and authenticity of the Metadata BLOB object and all metadata statements.

Organizational Impact

The FIDO Alliance has control over the FIDO certification process and authentication vendors provide the metadata as part of that process. With this metadata service, the list of known authenticators and their metadata statements need to be updated, signed and published regularly. A single signature needs to be generated in order to protect the integrity and authenticity of the metadata BLOB object and all embedded metadata statements.

Performance Impact

Metadata BLOB objects and metadata statements can be cached by the FIDO Server.

The update policy can be specified by the relying party.

The metadata BLOB object includes a date for the next scheduled update. As a result there is *no additional impact* to the FIDO Server during FIDO Authentication or FIDO Registration operations.

High Security Environments

Some high security environments might only trust internal policy authorities. FIDO Servers in such environments could be restricted to use metadata BLOB objects from a proprietary trusted source only. The metadata service is the baseline for most relying parties.

Extended Authenticator Information

Some relying parties might want additional information about authenticators before accepting them. The policy configuration is under control of the relying party, so it is possible to only accept authenticators for which additional data is available and meets the requirements.

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attestationCertificateKeyIdentifiers, in §3.1.1

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- dict-member for StatusReport, in §3.1.3

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"USER_KEY_REMOTE_COMPROMISE", in §3.1.4

"USER_VERIFICATION_BYPASS", in §3.1.4

Terms defined by reference§

[webauthn-1] defines the following terms:

- AAGUID

[WebIDL] defines the following terms:

- DOMString
- unsigned long
- unsigned short

References§

Normative References§

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R. Lindemann; et al. FIDO UAF Protocol Specification v1.2. Proposed Standard. URL: https://fidoalliance.org/specs/fido-uaf-v1.2-ps-20201020/fido-uaf-protocol-v1.2-ps-20201020.html

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```
dictionary MetadataBLOBPayloadEntry {
    AAID                    aaid;
    AAGUID                  aaguid;
    DOMString[]             attestationCertificateKeyIdentifiers;
    MetadataStatement       metadataStatement;
    BiometricStatusReport[] biometricStatusReports;
    required StatusReport[] statusReports;
    required DOMString      timeOfLastStatusChange;
    DOMString               rogueListURL;
    DOMString               rogueListHash;
};

dictionary BiometricStatusReport {
    required unsigned short certLevel;
    required DOMString      modality;
    DOMString               effectiveDate;
    DOMString               certificationDescriptor;
    DOMString               certificateNumber;
    DOMString               certificationPolicyVersion;
    DOMString               certificationRequirementsVersion;
};
```

```
dictionary StatusReport {
    required AuthenticatorStatus status;
    DOMString                    effectiveDate;
    unsigned long                authenticatorVersion;
    DOMString                    certificate;
    DOMString                    url;
    DOMString                    certificationDescriptor;
    DOMString                    certificateNumber;
    DOMString                    certificationPolicyVersion;
    DOMString                    certificationRequirementsVersion;
};

enum AuthenticatorStatus {
    "NOT_FIDO_CERTIFIED",
    "FIDO_CERTIFIED",
    "USER_VERIFICATION_BYPASS",
    "ATTESTATION_KEY_COMPROMISE",
    "USER_KEY_REMOTE_COMPROMISE",
    "USER_KEY_PHYSICAL_COMPROMISE",
    "UPDATE_AVAILABLE",
    "REVOKED",
    "SELF_ASSERTION_SUBMITTED",
    "FIDO_CERTIFIED_L1",
    "FIDO_CERTIFIED_L1plus",
    "FIDO_CERTIFIED_L2",
    "FIDO_CERTIFIED_L2plus",
    "FIDO_CERTIFIED_L3",
    "FIDO_CERTIFIED_L3plus"
};

dictionary RogueListEntry {
    required DOMString sk;
    required DOMString date;
};

dictionary MetadataBLOBPayload {
    DOMString                           legalHeader;
    required Number                     no;
    required DOMString                  nextUpdate;
    required MetadataBLOBPayloadEntry[] entries;
};
```