THE_URL:file://localhost/Users/jehodges/documents/work/standards/W3C/webauthn/index-master-tr-dda3e24-WD-05.html
THE_TITLE:Web Authentication: An API for accessing Public Key Credentials
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W3C

Web Authentication: An API for accessing Public Key Credentials

W3C Working Draft, 5 May 2017

This version:
https://www.w3.org/TR/2017/WD-webauthn-20170505/

Latest published version:
https://www.w3.org/TR/webauthn/

Editor's Draft:
https://w3c.github.io/webauthn/

Previous Versions:

https://www.w3.org/TR/2017/WD-webauthn-20170216/
https://www.w3.org/TR/2016/WD-webauthn-20161207/
https://www.w3.org/TR/2016/WD-webauthn-20160928/
https://www.w3.org/TR/2016/WD-webauthn-20160902/
https://www.w3.org/TR/2016/WD-webauthn-20160531/

Issue Tracking:
Github

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Tests:
web-platform-tests webauthn/ (ongoing work)

Abstract

This specification defines an API enabling the creation and use of strong, attested, scoped, public key-based credentials by web applications, for the purpose of strongly authenticating users. Conceptually, one or more credentials, each scoped to a given Relying Party, are created and stored on an authenticator by the user agent in conjunction with the web application. The user agent mediates access to public key credentials in order to preserve user privacy. Authenticators are responsible for ensuring that no operation is performed without user consent. Authenticators provide cryptographic proof of their properties to relying parties via attestation. This specification also describes the functional model for WebAuthn conformant authenticators, including their signature and attestation functionality.

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 W3C publications and the latest revision of this technical

THE_URL:file://localhost/Users/jehodges/documents/work/standards/W3C/WebAuthn/index-master-tr-598ac41-WD-06.html
THE_TITLE:Web Authentication: An API for accessing Public Key Credentials Level 1
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W3C

Web Authentication: An API for accessing Public Key Credentials Level 1

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This document was published by the Web Authentication Working Group as a Working Draft. This document is intended to become a W3C Recommendation. Feedback and comments on this specification are welcome. Please use Github issues. Discussions may also be found in the public-webauthn@w3.org archives.

Publication as a Working Draft does not imply endorsement by the W3C Membership. This is a draft document and may be updated, replaced or obsoleted by other documents at any time. It is inappropriate to cite this document as other than work in progress.

This document was produced by a group operating under the 5 February 2004 W3C Patent Policy. W3C maintains a public list of any patent disclosures made in connection with the deliverables of the group; that page also includes instructions for disclosing a patent. An individual who has actual knowledge of a patent which the individual believes contains Essential Claim(s) must disclose the information in accordance with section 6 of the W3C Patent Policy.

This document is governed by the 1 March 2017 W3C Process Document.

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1. Introduction

This section is not normative.

This specification defines an API enabling the creation and use of strong, attested, scoped, public key-based credentials by web applications, for the purpose of strongly authenticating users. A public key credential is created and stored by an authenticator at the behest of a Relying Party, subject to user consent. Subsequently, the public key credential can only be accessed by origins belonging to that Relying Party. This scoping is enforced jointly by conforming User Agents and authenticators. Additionally, privacy across Relying Parties is maintained; Relying Parties are not able to detect any properties, or even the existence, of credentials scoped to other Relying Parties.

Relying Parties employ the Web Authentication API during two distinct, but related, ceremonies involving a user. The first is Registration, where a public key credential is created on an authenticator, and associated by a Relying Party with the present user's account (the account may already exist or may be created at this time). The second is Authentication, where the Relying Party is presented with an Authentication Assertion proving the presence and consent of the user who registered the public key credential. Functionally, the Web Authentication API comprises a PublicKeyCredential which extends the Credential Management API [CREDENTIAL-MANAGEMENT-1], and infrastructure which allows those credentials to be used with navigator.credentials.create() and navigator.credentials.get(). The former is used during Registration, and the latter during Authentication.

Broadly, compliant authenticators protect public key credentials, and interact with user agents to implement the Web Authentication API. Some authenticators may run on the same computing device (e.g., smart phone, tablet, desktop PC) as the user agent is running on. For instance, such an authenticator might consist of a Trusted Execution Environment (TEE) applet, a Trusted Platform Module (TPM), or a Secure Element (SE) integrated into the computing device in conjunction with some means for user verification, along with appropriate platform software to mediate access to these components' functionality. Other authenticators may operate autonomously from the computing device running the user agent, and be accessed over a transport such as Universal Serial Bus (USB), Bluetooth Low Energy (BLE) or Near Field Communications (NFC).

1.1. Use Cases

The below use case scenarios illustrate use of two very different types of authenticators, as well as outline further scenarios. Additional scenarios, including sample code, are given later in 11 Sample scenarios.

1.1.1. Registration

* On a phone:
  + User navigates to example.com in a browser and signs in to an existing account using whatever method they have been using (possibly a legacy method such as a password), or creates a new account.
  + The phone prompts, "Do you want to register this device with example.com?"
  + User agrees.
  + The phone prompts the user for a previously configured authorization gesture (PIN, biometric, etc.); the user provides this.
  + Website shows message, "Registration complete."

1.1.2. Authentication

1. Normative References
2. Informative References
15. IDL Index

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  + User agrees.
  + The phone prompts the user for a previously configured authorization gesture (PIN, biometric, etc.); the user provides this.
  + Website shows message, "Registration complete."

1.1.2. Authentication

* On a laptop or desktop:
  + User navigates to example.com in a browser, sees an option to "Sign in with your phone."
  + User chooses this option and gets a message from the browser, "Please complete this action on your phone."
* Next, on their phone:
  + User sees a discrete prompt or notification, "Sign in to example.com."
  + User selects this prompt / notification.
  + User is shown a list of their example.com identities, e.g., "Sign in as Alice / Sign in as Bob."
  + User picks an identity, is prompted for an authorization gesture (PIN, biometric, etc.) and provides this.
* Now, back on the laptop:
  + Web page shows that the selected user is signed-in, and navigates to the signed-in page.

1.1.3. Other use cases and configurations

A variety of additional use cases and configurations are also possible, including (but not limited to):
* A user navigates to example.com on their laptop, is guided through a flow to create and register a credential on their phone.
* A user obtains an discrete, roaming authenticator, such as a "fob" with USB or USB+NFC/BLE connectivity options, loads example.com in their browser on a laptop or phone, and is guided though a flow to create and register a credential on the fob.
* A Relying Party prompts the user for their authorization gesture in order to authorize a single transaction, such as a payment or other financial transaction.

2. Conformance

This specification defines criteria for a Conforming User Agent: A User Agent MUST behave as described in this specification in order to be considered conformant. Conforming User Agents MAY implement algorithms given in this specification in any way desired, so long as the end result is indistinguishable from the result that would be obtained by the specification's algorithms. A conforming User Agent MUST also be a conforming implementation of the IDL fragments of this specification, as described in the "Web IDL" specification. [WebIDL-1]

This specification also defines a model of a conformant authenticator (see 5 WebAuthn Authenticator model). This is a set of functional and security requirements for an authenticator to be usable by a Conforming User Agent. As described in 1.1 Use Cases, an authenticator may be implemented in the operating system underlying the User Agent, or in external hardware, or a combination of both.

2.1. Dependencies

This specification relies on several other underlying specifications, listed below and in Terms defined by reference.

Base64url encoding
    The term Base64url Encoding refers to the base64 encoding using the URL- and filename-safe character set defined in Section 5 of [RFC4648], with all trailing '=' characters omitted (as permitted by Section 3.2) and without the inclusion of any line breaks, whitespace, or other additional characters.

CBOR
    A number of structures in this specification, including attestation statements and extensions, are encoded using the Compact Binary Object Representation (CBOR) [RFC7049].

CDDL
    This specification describes the syntax of all CBOR-encoded data using the CBOR Data Definition Language (CDDL) [CDDL].

* On a laptop or desktop:
  + User navigates to example.com in a browser, sees an option to "Sign in with your phone."
  + User chooses this option and gets a message from the browser, "Please complete this action on your phone."
* Next, on their phone:
  + User sees a discrete prompt or notification, "Sign in to example.com."
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The API described in this document is an extension of the Credential concept defined in [CREDENTIAL-MANAGEMENT-1].

DOM
DOMException and the DOMException values used in this specification are defined in [DOM4].

ECMAScript
%ArrayBuffer% is defined in [ECMAScript].

HTML
The concepts of relevant settings object, origin, opaque origin, and is a registrable domain suffix of or is equal to are defined in [HTML52].

Web Cryptography API
The AlgorithmIdentifier type and the method for normalizing an algorithm are defined in Web Cryptography API algorithm-dictionary.

Web IDL
Many of the interface definitions and all of the IDL in this specification depend on [WebIDL-1]. This updated version of the Web IDL standard adds support for Promises, which are now the preferred mechanism for asynchronous interaction in all new web APIs.

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].

3. Terminology

Assertion
See Authentication Assertion.

Attestation
Generally, a statement that serves to bear witness, confirm, or authenticate. In the WebAuthn context, attestation is employed to attest to the provenance of an authenticator and the data it emits; including, for example: credential IDs, credential key pairs, signature counters, etc. Attestation information is conveyed in attestation objects. See also attestation statement format, and attestation type.

Attestation Certificate
A X.509 Certificate for the attestation key pair used by an authenticator to attest to its manufacture and capabilities. At registration time, the authenticator uses the attestation private key to sign the Relying Party-specific credential public key (and additional data) that it generates and returns via the authenticatorMakeCredential operation. Relying Parties use the attestation public key conveyed in the attestation certificate to verify the attestation signature. Note that in the case of self attestation, the authenticator has no distinct attestation key pair nor attestation certificate, see self attestation for details.

Authentication
The ceremony where a user, and the user's computing device(s) (containing at least one authenticator) work in concert to cryptographically prove to an Relying Party that the user controls the private key associated with a previously-registered

COSE
CBOR Object Signing and Encryption (COSE) [RFC8152]. The IANA COSE Algorithms registry established by this specification is also used.

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public key credential (see Registration). Note that this includes employing user verification.

Authentication Assertion
The cryptographically signed AuthenticatorAssertionResponse object returned by an authenticator as the result of a authenticatorGetAssertion operation.

Authenticator
A cryptographic device used by a WebAuthn Client to (i) generate a public key credential and register it with a Relying Party, and (ii) subsequently used to cryptographically sign and return, in the form of an Authentication Assertion, a challenge and other data presented by a Relying Party (in concert with the WebAuthn Client) in order to effect authentication.

Authorization Gesture
An authorization gesture is a physical interaction performed by a user with an authenticator as part of a ceremony, such as registration or authentication. By making such an authorization gesture, a user provides consent for (i.e., authorizes) a ceremony to proceed. This may involve user verification if the employed authenticator is capable, or it may involve a simple test of user presence.

Biometric Recognition
The automated recognition of individuals based on their biological and behavioral characteristics [ISOBiometricVocabulary].

Ceremony
The concept of a ceremony [Ceremony] is an extension of the concept of a network protocol, with human nodes alongside computer nodes and with communication links that include user interface(s), human-to-human communication, and transfers of physical objects that carry data. What is out-of-band to a protocol is in-band to a ceremony. In this specification, Registration and Authentication are ceremonies, and an authorization gesture is often a component of those ceremonies.

Client
See Conforming User Agent.

Conforming User Agent
A user agent implementing, in conjunction with the underlying platform, the Web Authentication API and algorithms given in this specification, and handling communication between authenticators and Relying Parties.

previously-registered public key credential (see Registration). Note that this typically includes employing a test of user presence or user verification.

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Client
See Conforming User Agent.

Client-Side
This refers in general to the combination of the user's platform device, user agent, authenticators, and everything gluing it all together.

Client-side-resident Credential Private Key
A Client-side-resident Credential Private Key is stored either on the client platform, or in some cases on the authenticator itself, e.g., in the case of a discrete first-factor roaming authenticator. Such client-side credential private key storage has the property that the authenticator is able to select the credential private key given only an RP ID, possibly with user assistance (e.g., by providing the user a pick list of credentials associated with the RP ID). By definition, the private key is always exclusively controlled by the Authenticator. In the case of a Client-side-resident Credential Private Key, the Authenticator might offload storage of wrapped key material to the client platform, but the client platform is not expected to offload the key storage to remote entities (e.g. RP Server).

Conforming User Agent
A user agent implementing, in conjunction with the underlying platform, the Web Authentication API and algorithms given in this specification, and handling communication between authenticators and Relying Parties.

Credential Public Key
: The public key portion of an Relying Party-specific credential key pair, generated by an authenticator and returned to an Relying Party at registration time (see also public key credential). The private key portion of the credential key pair is known as the credential private key. Note that in the case of self attestation, the credential key pair is also used as the attestation key pair, see self attestation for details.

Registration
: The ceremony where a user, a Relying Party, and the user's computing device(s) (containing at least one authenticator) work in concert to create a public key credential and associate it with the user's Relying Party account. Note that this includes employing user verification.

Relying Party
: The entity whose web application utilizes the Web Authentication API to register and authenticate users. See Registration and Authentication, respectively.

Note: While the term Relying Party is used in other contexts (e.g., X.509 and OAuth), an entity acting as a Relying Party in one context is not necessarily a Relying Party in other contexts.

Relying Party Identifier
RP ID
: An identifier for the Relying Party on whose behalf a given registration or authentication ceremony is being performed. Public Key credentials can only be used for authentication by the same entity (as identified by RP ID) that created and registered them. By default, the RP ID for a WebAuthn operation is set to the origin specified by the relevant settings object of the CredentialsContainer object. This default can be overridden by the caller subject to certain restrictions, as specified in 4.1.3 Create a new credential - PublicKeyCredential's \[[Create]](options) method and 4.1.4 Use an existing credential - PublicKeyCredential::[[DiscoverFromExternalSource]](options) method.

Public Key Credential

Credential Public Key
: The public key portion of an Relying Party-specific credential key pair, generated by an authenticator and returned to an Relying Party at registration time (see also public key credential). The private key portion of the credential key pair is known as the credential private key. Note that in the case of self attestation, the credential key pair is also used as the attestation key pair, see self attestation for details.

Rate Limiting
: The process (also known as throttling) by which an authenticator implements controls against brute force attacks by limiting the number of consecutive failed authentication attempts within a given period of time. If the limit is reached, the authenticator should impose a delay that increases exponentially with each successive attempt, or disable the current authentication modality and offer a different authentication factor if available. Rate limiting is often implemented as an aspect of user verification.

Registration
: The ceremony where a user, a Relying Party, and the user's computing device(s) (containing at least one authenticator) work in concert to create a public key credential and associate it with the user's Relying Party account. Note that this typically includes employing a test of user presence or user verification.

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Note: While the term Relying Party is used in other contexts (e.g., X.509 and OAuth), an entity acting as a Relying Party in one context is not necessarily a Relying Party in other contexts.

Relying Party Identifier
RP ID
: A valid domain string that identifies the Relying Party on whose behalf a given registration or authentication ceremony is being performed. A public key credential can only be used for authentication with the same entity (as identified by RP ID) it was registered with. By default, the RP ID for a WebAuthn operation is set to the caller's origin's effective domain. This default MAY be overridden by the caller, as long as the caller-specified RP ID value is a registrable domain suffix of or is equal to the caller's origin's effective domain. See also 4.1.3 Create a new credential - PublicKeyCredential's [[Create]](options) method and 4.1.4 Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method.

Note: A Public key credential's scope is for a Relying Party's origin, with the following restrictions and relaxations:

+ The scheme is always https (i.e., a restriction), and,
+ the host may be equal to the Relying Party's origin's effective domain, or it may be equal to a registrable domain suffix of the Relying Party's origin's effective domain (i.e., an available relaxation), and,
+ all (TCP) ports on that host (i.e., a relaxation).

This is done in order to match the behavior of pervasively deployed ambient credentials (e.g., cookies, [RFC6265]). Please note that this is a greater relaxation of "same-origin" restrictions than what document.domain's setter provides.

Public Key Credential

Generically, a credential is data one entity presents to another in order to authenticate the former's identity [RFC4949]. A WebAuthn public key credential is a { identifier, type } pair identifying authentication information established by the authenticator and the Relying Party, together, at registration time. The authentication information consists of an asymmetric key pair, where the public key portion is returned to the Relying Party, which stores it in conjunction with the present user's account. The authenticator maps the private key to the Relying Party's RP ID and stores it. Subsequently, only that Relying Party, as identified by its RP ID, is able to employ the public key credential in authentication ceremonies, via the get() method. The Relying Party uses its copy of the stored public key to verify the resultant Authentication Assertion.

Test of User Presence
TUP

A test of user presence is a simple form of authorization gesture and technical process where a user interacts with an authenticator by (typically) simply touching it (other modalities may also exist), yielding a boolean result. Note that this does not constitute user verification because TUP, by definition, is not capable of biometric recognition, nor does it involve the presentation of a shared secret such as a password or PIN.

Client-side-resident Credential Private Key

A Client-side-resident Credential Private Key is stored either on the client platform, or in some cases on the authenticator itself, e.g., in the case of a discrete first-factor roaming authenticator. Such client-side credential private key storage has the property that the authenticator is able to select the credential private key given only an RP ID, possibly with user assistance (e.g., by providing the user a pick list of credentials associated with the RP ID). By definition, the private key is always exclusively controlled by the Authenticator. In the case of a Client-side-resident Credential Private Key, the Authenticator might offload storage of wrapped key material to the client platform, but the client platform is not expected to offload the key storage to remote entities (e.g. RP Server).

Client-Side

This refers in general to the combination of the user's platform device, user agent, authenticators, and everything gluing it all together.

User Consent

User consent means the user agrees with what they are being asked, i.e., it encompasses reading and understanding prompts. An authorization gesture is a ceremony component often employed to indicate user consent.

User Verification

The technical process by which an authenticator locally authorizes the invocation of the authenticatorMakeCredential and authenticatorGetAssertion operations. User verification may be instigated through various authorization gesture modalities; for example, through a touch plus pin code, password entry, or biometric recognition (e.g., presenting a fingerprint) [ISOBiometricVocabulary]. The intent is to be able to distinguish individual users. Note that invocation of the authenticatorMakeCredential and authenticatorGetAssertion operations implies use of key material managed by the authenticator. Note that for security, user verification and use of credential private keys must occur within a single logical security boundary defining the authenticator.

Generically, a credential is data one entity presents to another in order to authenticate the former to the latter [RFC4949]. A WebAuthn public key credential is a { identifier, type } pair identifying authentication information established by the authenticator and the Relying Party, together, at registration time. The authentication information consists of an asymmetric key pair, where the public key portion is returned to the Relying Party, who then stores it in conjunction with the present user's account. The authenticator maps the private key portion to the Relying Party's RP ID and stores it. Subsequently, only that Relying Party, as identified by its RP ID, is able to employ the public key credential in authentication ceremonies, via the get() method. The Relying Party uses its stored copy of the credential public key to verify the resultant authentication assertion.

Test of User Presence

A test of user presence is a simple form of authorization gesture and technical process where a user interacts with an authenticator by (typically) simply touching it (other modalities may also exist), yielding a boolean result. Note that this does not constitute user verification because a user presence test, by definition, is not capable of biometric recognition, nor does it involve the presentation of a shared secret such as a password or PIN.

User Consent

User consent means the user agrees with what they are being asked, i.e., it encompasses reading and understanding prompts. An authorization gesture is a ceremony component often employed to indicate user consent.

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User Present

User Verified

Upon successful completion of a user verification process, the user is said to be "verified".

WebAuthn Client
Also referred to herein as simply a client. See also Conforming User Agent.

4. Web Authentication API

This section normatively specifies the API for creating and using public key credentials. The basic idea is that the credentials belong to the user and are managed by an authenticator, with which the Relying Party interacts through the client (consisting of the browser and underlying OS platform). Scripts can (with the user's consent) request the browser to create a new credential for future use by the Relying Party. Scripts can also request the user's permission to perform authentication operations with an existing credential. All such operations are performed in the authenticator and are mediated by the browser and/or platform on the user's behalf. At no point does the script get access to the credentials themselves; it only gets information about the credentials in the form of objects.

In addition to the above script interface, the authenticator may implement (or come with client software that implements) a user interface for management. Such an interface may be used, for example, to reset the authenticator to a clean state or to inspect the current state of the authenticator. In other words, such an interface is similar to the user interfaces provided by browsers for managing user state such as history, saved passwords and cookies. Authenticator management actions such as credential deletion are considered to be the responsibility of such a user interface and are deliberately omitted from the API exposed to scripts.

The security properties of this API are provided by the client and the authenticator working together. The authenticator, which holds and manages credentials, ensures that all operations are scoped to a particular origin, and cannot be replayed against a different origin, by incorporating the origin in its responses. Specifically, as defined in 5.2 Authenticator operations, the full origin of the requester is included, and signed over, in the attestation object produced when a new credential is created as well as in all assertions produced by WebAuthn credentials.

Additionally, to maintain user privacy and prevent malicious Relying Parties from probing for the presence of credentials belonging to other Relying Parties, each credential is also associated with a Relying Party Identifier, or RP ID. This RP ID is provided by the client to the authenticator for all operations, and the authenticator ensures that credentials created by a Relying Party can only be used in operations requested by the same RP ID. Separating the origin from the RP ID in this way allows the API to be used in cases where a single Relying Party maintains multiple origins.

The client facilitates these security measures by providing correct origins and RP IDs to the authenticator for each operation. Since this is an integral part of the WebAuthn security model, user agents MUST only expose this API to callers in secure contexts.

The Web Authentication API is defined by the union of the Web IDL fragments presented in the following sections. A combined IDL listing is given in the IDL Index.

4.1. PublicKeyCredential Interface

UP
Upon successful completion of a user presence test, the user is said to be "present".

User Verified
UV
Upon successful completion of a user verification process, the user is said to be "verified".

WebAuthn Client
Also referred to herein as simply a client. See also Conforming User Agent.

4. Web Authentication API

This section normatively specifies the API for creating and using public key credentials. The basic idea is that the credentials belong to the user and are managed by an authenticator, with which the Relying Party interacts through the client (consisting of the browser and underlying OS platform). Scripts can (with the user's consent) request the browser to create a new credential for future use by the Relying Party. Scripts can also request the user's permission to perform authentication operations with an existing credential. All such operations are performed in the authenticator and are mediated by the browser and/or platform on the user's behalf. At no point does the script get access to the credentials themselves; it only gets information about the credentials in the form of objects.

In addition to the above script interface, the authenticator may implement (or come with client software that implements) a user interface for management. Such an interface may be used, for example, to reset the authenticator to a clean state or to inspect the current state of the authenticator. In other words, such an interface is similar to the user interfaces provided by browsers for managing user state such as history, saved passwords and cookies. Authenticator management actions such as credential deletion are considered to be the responsibility of such a user interface and are deliberately omitted from the API exposed to scripts.

The security properties of this API are provided by the client and the authenticator working together. The authenticator, which holds and manages credentials, ensures that all operations are scoped to a particular origin, and cannot be replayed against a different origin, by incorporating the origin in its responses. Specifically, as defined in 5.2 Authenticator operations, the full origin of the requester is included, and signed over, in the attestation object produced when a new credential is created as well as in all assertions produced by WebAuthn credentials.

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The client facilitates these security measures by providing the Relying Party's origin and RP ID to the authenticator for each operation. Since this is an integral part of the WebAuthn security model, user agents MUST only expose this API to callers in secure contexts.

The Web Authentication API is defined by the union of the Web IDL fragments presented in the following sections. A combined IDL listing is given in the IDL Index.

4.1. PublicKeyCredential Interface

The PublicKeyCredential interface inherits from Credential [CREDENTIAL-MANAGEMENT-1], and contains the attributes that are returned to the caller when a new credential is created, or a new assertion is requested.

```
[SecureContext]
interface PublicKeyCredential : Credential {
    readonly attribute ArrayBuffer          rawId;
    readonly attribute AuthenticatorResponse response;
    readonly attribute AuthenticationExtensions clientExtensionResults;

};
```

id

This attribute is inherited from Credential, though PublicKeyCredential overrides Credential's getter, instead returning the base64url encoding of the data contained in the object's [[identifier]] internal slot.

rawId

This attribute returns the ArrayBuffer contained in the [[identifier]] internal slot.

response, of type AuthenticatorResponse, readonly

This attribute contains the authenticator's response to the client's request to either create a public key credential, or generate an authentication assertion. If the PublicKeyCredential is created in response to create(), this attribute's value will be an AuthenticatorAttestationResponse, otherwise, the PublicKeyCredential was created in response to get(), and this attribute's value will be an AuthenticatorAssertionResponse.

clientExtensionResults, of type AuthenticationExtensions, readonly

This attribute contains a map containing extension identifier -> client extension output entries produced by the extension's client extension processing.

[[type]]

The PublicKeyCredential interface object's [[type]] internal slot's value is the string "public-key".

Note: This is reflected via the type attribute getter inherited from Credential.

[[discovery]]

The PublicKeyCredential interface object's [[discovery]] internal slot's value is "remote".

[[identifier]]

This internal slot contains an identifier for the credential, chosen by the platform with help from the authenticator. This identifier is used to look up credentials for use, and is therefore expected to be globally unique with high probability across all credentials of the same type, across all authenticators. This API does not constrain the format or length of this identifier, except that it must be sufficient for the platform to uniquely select a key. For example, an authenticator without on-board storage may create identifiers containing a credential private key wrapped with a symmetric key that is burned into the authenticator.

PublicKeyCredential's interface object inherits Credential's implementation of [[CollectFromCredentialStore]](options) and [[Store]](credential), and defines its own implementation of [[DiscoverFromExternalSource]](options) and [[Create]](options).

4.1.1. CredentialRequestOptions Extension

To support obtaining assertions via navigator.credentials.get(), this document extends the CredentialRequestOptions dictionary as follows:

```
partial dictionary CredentialRequestOptions {
```


The PublicKeyCredential interface inherits from Credential [CREDENTIAL-MANAGEMENT-1], and contains the attributes that are returned to the caller when a new credential is created, or a new assertion is requested.

```
[SecureContext]
interface PublicKeyCredential : Credential {
    [SameObject] readonly attribute ArrayBuffer              rawId;
    [SameObject] readonly attribute AuthenticatorResponse    response;
    [SameObject] readonly attribute AuthenticationExtensions clientExtensionResu
lts;
};
```

id

This attribute is inherited from Credential, though PublicKeyCredential overrides Credential's getter, instead returning the base64url encoding of the data contained in the object's [[identifier]] internal slot.

rawId

This attribute returns the ArrayBuffer contained in the [[identifier]] internal slot.

response, of type AuthenticatorResponse, readonly

This attribute contains the authenticator's response to the client's request to either create a public key credential, or generate an authentication assertion. If the PublicKeyCredential is created in response to create(), this attribute's value will be an AuthenticatorAttestationResponse, otherwise, the PublicKeyCredential was created in response to get(), and this attribute's value will be an AuthenticatorAssertionResponse.

clientExtensionResults, of type AuthenticationExtensions, readonly

This attribute contains a map containing extension identifier -> client extension output entries produced by the extension's client extension processing.

[[type]]

The PublicKeyCredential interface object's [[type]] internal slot's value is the string "public-key".

Note: This is reflected via the type attribute getter inherited from Credential.

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The PublicKeyCredential interface object's [[discovery]] internal slot's value is "remote".

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This internal slot contains an identifier for the credential, chosen by the platform with help from the authenticator. This identifier is used to look up credentials for use, and is therefore expected to be globally unique with high probability across all credentials of the same type, across all authenticators. This API does not constrain the format or length of this identifier, except that it must be sufficient for the platform to uniquely select a key. For example, an authenticator without on-board storage may create identifiers containing a credential private key wrapped with a symmetric key that is burned into the authenticator.

PublicKeyCredential's interface object inherits Credential's implementation of [[CollectFromCredentialStore]](options) and [[Store]](credential), and defines its own implementation of [[DiscoverFromExternalSource]](options) and [[Create]](options).

4.1.1. CredentialCreationOptions Extension

```
    PublicKeyCredentialRequestOptions? publicKey;
};

    4.1.2. CredentialCreationOptions Extension

   To support registration via navigator.credentials.create(), this
   document extends the CredentialCreationOptions dictionary as follows:
partial dictionary CredentialCreationOptions {
    MakeCredentialOptions? publicKey;
};

    4.1.3. Create a new credential - PublicKeyCredential's \[[Create]](options)

    method

   PublicKeyCredential's interface object's implementation of the
   [[Create]](options) method allows scripts to call
   navigator.credentials.create() to request the creation of a new
   credential key pair and PublicKeyCredential, managed by an
   authenticator. The user agent will prompt the user for consent. On
   success, the returned promise will be resolved with a
   PublicKeyCredential containing an AuthenticatorAttestationResponse
   object.

   Note: This algorithm is synchronous; the Promise resolution/rejection
   is taken care of by navigator.credentials.create().

   This method accepts a single argument:

   options
          This argument is a CredentialCreationOptions object whose
          options["publicKey"] member contains a MakeCredentialOptions
          object specifying how the credential is to be made.

   When this method is invoked, the user agent MUST execute the following
   algorithm:
    1. Assert: options["publicKey"] is present.
    2. Let options be the value of options["publicKey"].
    3. If any of the name member of options.rp, the name member of
       options.user, the displayName member of options.user, or the id
       member of options.user are not present, return a TypeError simple
       exception.
    4. If the timeout member of options is present, check if its value
       lies within a reasonable range as defined by the platform and if
       not, correct it to the closest value lying within that range. Set
       adjustedTimeout to this adjusted value. If the timeout member of
       options is not present, then set adjustedTimeout to a
       platform-specific default.
    5. Let global be the PublicKeyCredential interface object's
       environment settings object's global object.
    6. Let callerOrigin be the origin specified by this
       PublicKeyCredential interface object's relevant settings object. If
       callerOrigin is an opaque origin, return a DOMException whose name
       is "NotAllowedError", and terminate this algorithm.
    7. If the id member of options.rp is not present, then set rpId to
       callerOrigin.
       Otherwise:
         1. Let effectiveDomain be the callerOrigin's effective domain.
         2. If effectiveDomain is null, then return a DOMException whose
            name is "SecurityError" and terminate this algorithm.
         3. If options.rp.id is not a registrable domain suffix of and is
```

/Users/jehodges/Documents/work/standards/W3C/webauthn/index-master-tr-598ac41-WD-06.txt, Top line: 738

```
   To support registration via navigator.credentials.create(), this
   document extends the CredentialCreationOptions dictionary as follows:
partial dictionary CredentialCreationOptions {
    MakePublicKeyCredentialOptions      publicKey;
};

    4.1.2. CredentialRequestOptions Extension

   To support obtaining assertions via navigator.credentials.get(), this
   document extends the CredentialRequestOptions dictionary as follows:
partial dictionary CredentialRequestOptions {
    PublicKeyCredentialRequestOptions      publicKey;
};

    4.1.3. Create a new credential - PublicKeyCredential's [[Create]](options)
    method

   PublicKeyCredential's interface object's implementation of the
   [[Create]](options) method allows scripts to call
   navigator.credentials.create() to request the creation of a new
   credential key pair and PublicKeyCredential, managed by an
   authenticator. The user agent will prompt the user for consent. On
   success, the returned promise will be resolved with a
   PublicKeyCredential containing an AuthenticatorAttestationResponse
   object.

   Note: This algorithm is synchronous; the Promise resolution/rejection
   is handled by navigator.credentials.create().

   This method accepts a single argument:

   options
          This argument is a CredentialCreationOptions object whose
          options.publicKey member contains a
          MakePublicKeyCredentialOptions object specifying the desired
          attributes of the to-be-created public key credential.

   When this method is invoked, the user agent MUST execute the following
   algorithm:
    1. Assert: options.publicKey is present.
    2. Let options be the value of options.publicKey.
    3. If any of the name member of options.rp, the name member of
       options.user, the displayName member of options.user, or the id
       member of options.user are not present, return a TypeError simple
       exception.
    4. If the timeout member of options is present, check if its value
       lies within a reasonable range as defined by the platform and if
       not, correct it to the closest value lying within that range. Set
       adjustedTimeout to this adjusted value. If the timeout member of
       options is not present, then set adjustedTimeout to a
       platform-specific default.
    5. Let global be the PublicKeyCredential's interface object's
       environment settings object's global object.
    6. Let callerOrigin be the origin specified by this
       PublicKeyCredential interface object's relevant settings object. If
       callerOrigin is an opaque origin, return a DOMException whose name
       is "NotAllowedError", and terminate this algorithm.
    7. Let effectiveDomain be the callerOrigin's effective domain. If
       effective domain is not a valid domain, then return a DOMException
       whose name is "SecurityError" and terminate this algorithm.
       Note: An effective domain may resolve to a host, which can be
       represented in various manners, such as domain, ipv4 address, ipv6
       address, opaque host, or empty host. Only the domain format of host
       is allowed here.
    8. Let rpId be effectiveDomain.
```

/Users/jehodges/Documents/work/standards/W3C/webauthn/index-master-tr-dda3e24-WD-05.txt, Top line: 759

not equal to effectiveDomain, return a DOMException whose name is "SecurityError", and terminate this algorithm.
4. Set rpId to options.rp.id.
8. Let normalizedParameters be a new list whose items are pairs of PublicKeyCredentialType and a dictionary type (as returned by normalizing an algorithm).
9. For each current of options.parameters:

1. If current.type does not contain a PublicKeyCredentialType supported by this implementation, then continue.
2. Let normalizedAlgorithm be the result of normalizing an algorithm [WebCryptoAPI], with alg set to current.algorithm and op set to "generateKey". If an error occurs during this procedure, then continue.
3. Append the pair of current.type and normalizedAlgorithm to normalizedParameters.
10. If normalizedParameters is empty and options.parameters is not empty, cancel the timer started in step 2, return a DOMException whose name is "NotSupportedError", and terminate this algorithm.
11. Let clientExtensions be a new map and let authenticatorExtensions be a new map.
12. If the extensions member of options is present, then for each extensionId -> clientExtensionInput of options.extensions:
1. If extensionId is not supported by this client platform or is not a registration extension, then continue.
2. Set clientExtensions[extensionId] to clientExtensionInput.
3. If extensionId is not an authenticator extension, then continue.
4. Let authenticatorExtensionInput be the (CBOR) result of running extensionId's client extension processing algorithm on clientExtensionInput. If the algorithm returned an error, continue.
5. Set authenticatorExtensions[extensionId] to the base64url encoding of authenticatorExtensionInput.
13. Let collectedClientData be a new CollectedClientData instance whose fields are:

challenge
The base64url encoding of options.challenge

origin
The unicode serialization of rpId

hashAlg
The recognized algorithm name of the hash algorithm selected by the client for generating the hash of the serialized client data

tokenBinding
The Token Binding ID associated with callerOrigin, if one is available.

clientExtensions
clientExtensions

authenticatorExtensions
authenticatorExtensions

14. Let clientDataJSON be the JSON-serialized client data constructed from collectedClientData.
15. Let clientDataHash be the hash of the serialized client data represented by clientDataJSON.
16. Let currentlyAvailableAuthenticators be a new ordered set consisting of all authenticators available on this platform.
17. Let selectedAuthenticators be a new ordered set.
18. If currentlyAvailableAuthenticators is empty, return a DOMException

/Users/jehodges/Documents/work/standards/W3C/webauthn/index-master-tr-598ac41-WD-06.txt, Top line: 804

9. If options.rp.id is present:
1. If options.rp.id is not a registrable domain suffix of and is not equal to effectiveDomain, return a DOMException whose name is "SecurityError", and terminate this algorithm.
2. Set rpId to options.rp.id.
Note: rpId represents the caller's RP ID. The RP ID defaults to being the caller's origin's effective domain unless the caller has explicitly set options.rp.id when calling create().
10. Let credTypesAndPubKeyAlgs be a new list whose items are pairs of PublicKeyCredentialType and a COSEAlgorithmIdentifier.
11. For each current of options.pubKeyCredParams:
1. If current.type does not contain a PublicKeyCredentialType supported by this implementation, then continue.
2. Let alg be current.alg.
3. Append the pair of current.type and alg to credTypesAndPubKeyAlgs.
12. If credTypesAndPubKeyAlgs is empty and options.pubKeyCredParams is not empty, cancel the timer started in step 2, return a DOMException whose name is "NotSupportedError", and terminate this algorithm.
13. Let clientExtensions be a new map and let authenticatorExtensions be a new map.
14. If the extensions member of options is present, then for each extensionId -> clientExtensionInput of options.extensions:
1. If extensionId is not supported by this client platform or is not a registration extension, then continue.
2. Set clientExtensions[extensionId] to clientExtensionInput.
3. If extensionId is not an authenticator extension, then continue.
4. Let authenticatorExtensionInput be the (CBOR) result of running extensionId's client extension processing algorithm on clientExtensionInput. If the algorithm returned an error, continue.
5. Set authenticatorExtensions[extensionId] to the base64url encoding of authenticatorExtensionInput.
15. Let collectedClientData be a new CollectedClientData instance whose fields are:

challenge
The base64url encoding of options.challenge.

origin
The serialization of callerOrigin.

hashAlgorithm
The recognized algorithm name of the hash algorithm selected by the client for generating the hash of the serialized client data.

tokenBindingId
The Token Binding ID associated with callerOrigin, if one is available.

clientExtensions
clientExtensions

authenticatorExtensions
authenticatorExtensions

16. Let clientDataJSON be the JSON-serialized client data constructed from collectedClientData.
17. Let clientDataHash be the hash of the serialized client data represented by clientDataJSON.
18. Let currentlyAvailableAuthenticators be a new ordered set consisting of all authenticators currently available on this platform.
19. Let selectedAuthenticators be a new ordered set.
20. If currentlyAvailableAuthenticators is empty, return a DOMException

whose name is "NotFoundError", and terminate this algorithm.

19. If options.authenticatorSelection is present, iterate through currentlyAvailableAuthenticators and do the following for each authenticator:
    1. If attachment is present and its value is not equal to authenticator's attachment modality, continue.
    2. If requireResidentKey is set to true and the authenticator is not capable of storing a Client-Side-Resident Credential Private Key, continue.
    3. Append authenticator to selectedAuthenticators.
20. If selectedAuthenticators is empty, return a DOMException whose name is "ConstraintError", and terminate this algoritm.
21. Let issuedRequests be a new ordered set.
22. For each authenticator in currentlyAvailableAuthenticators:
    1. Let excludeList be a new list.
    2. For each credential C in options.excludeList:
        1. If C.transports is not empty, and authenticator is connected over a transport not mentioned in C.transports, the client MAY continue.
        2. Otherwise, Append C to excludeList.
    3. In parallel, invoke the authenticatorMakeCredential operation on authenticator with rpId, clientDataHash, options.rp, options.user, normalizedParameters, excludeList, and authenticatorExtensions as parameters.
    4. Append authenticator to issuedRequests.
23. Start a timer for adjustedTimeout milliseconds. Then execute the following steps in parallel. The task source for these tasks is the dom manipulation task source.
24. While issuedRequests is not empty, perform the following actions depending upon the adjustedTimeout timer and responses from the authenticators:

    If the adjustedTimeout timer expires,
        For each authenticator in issuedRequests invoke the authenticatorCancel operation on authenticator and remove authenticator from issuedRequests.

    If any authenticator returns a status indicating that the user cancelled the operation,

        1. Remove authenticator from issuedRequests.
        2. For each remaining authenticator in issuedRequests invoke the authenticatorCancel operation on authenticator and remove it from issuedRequests.

    If any authenticator returns an error status,
        Remove authenticator from issuedRequests.

    If any authenticator indicates success,

        1. Remove authenticator from issuedRequests.
        2. Let attestationObject be a new ArrayBuffer, created using global's %ArrayBuffer%, containing the bytes of the value returned from the successful authenticatorMakeCredential operation (which is attObj, as defined in 5.3.4 Generating an Attestation Object).
        3. Let id be attestationObject.authData.attestation data.credential ID (see 5.3.1 Attestation data and 5.1 Authenticator data).
        4. Let value be a new PublicKeyCredential object associated with global whose fields are:

            [[identifier]]
                id

            response

whose name is "NotFoundError", and terminate this algorithm.

21. If options.authenticatorSelection is present, iterate through currentlyAvailableAuthenticators and do the following for each authenticator:
    1. If aa is present and its value is not equal to authenticator's attachment modality, continue.
    2. If rk is set to true and the authenticator is not capable of storing a Client-Side-Resident Credential Private Key, continue.
    3. If uv is set to true and the authenticator is not capable of performing user verification, continue.
    4. Append authenticator to selectedAuthenticators.
22. If selectedAuthenticators is empty, return a DOMException whose name is "ConstraintError", and terminate this algoritm.
23. Let issuedRequests be a new ordered set.
24. For each authenticator in currentlyAvailableAuthenticators:
    1. Let excludeCredentialDescriptorList be a new list.
    2. For each credential descriptor C in options.excludeCredentials:
        1. If C.transports is not empty, and authenticator is connected over a transport not mentioned in C.transports, the client MAY continue.
        2. Otherwise, Append C to excludeCredentialDescriptorList.
    3. In parallel, invoke the authenticatorMakeCredential operation on authenticator with rpId, clientDataHash, options.rp, options.user, options.authenticatorSelection.rk, credTypesAndPubKeyAlgs, excludeCredentialDescriptorList, and authenticatorExtensions as parameters.
    4. Append authenticator to issuedRequests.
25. Start a timer for adjustedTimeout milliseconds. Then execute the following steps in parallel. The task source for these tasks is the dom manipulation task source.
26. While issuedRequests is not empty, perform the following actions depending upon the adjustedTimeout timer and responses from the authenticators:

    If the adjustedTimeout timer expires,
        For each authenticator in issuedRequests invoke the authenticatorCancel operation on authenticator and remove authenticator from issuedRequests.

    If any authenticator returns a status indicating that the user cancelled the operation,

        1. Remove authenticator from issuedRequests.
        2. For each remaining authenticator in issuedRequests invoke the authenticatorCancel operation on authenticator and remove it from issuedRequests.

    If any authenticator returns an error status,
        Remove authenticator from issuedRequests.

    If any authenticator indicates success,

        1. Remove authenticator from issuedRequests.
        2. Let attestationObject be a new ArrayBuffer, created using global's %ArrayBuffer%, containing the bytes of the value returned from the successful authenticatorMakeCredential operation (which is attObj, as defined in 5.3.4 Generating an Attestation Object).
        3. Let id be attestationObject.authData.attestation data.credential ID (see 5.3.1 Attestation data and 5.1 Authenticator data).
        4. Let value be a new PublicKeyCredential object associated with global whose fields are:

            [[identifier]]
                id

            response

A new AuthenticatorAttestationResponse object associated with global whose fields are:

clientDataJSON
A new ArrayBuffer, created using global's %ArrayBuffer%, containing the bytes of clientDataJSON.

attestationObject
attestationObject

clientExtensionResults
A new AuthenticationExtensions object containing the extension identifier -> client extension output entries created by running each extension's client extension processing algorithm to create the client extension outputs, for each client extension in clientDataJSON.clientExtensions.

5. For each remaining authenticator in issuedRequests invoke the authenticatorCancel operation on authenticator and remove it from issuedRequests.
6. Return value and terminate this algorithm.

25. Return a DOMException whose name is "NotAllowedError".

During the above process, the user agent SHOULD show some UI to the user to guide them in the process of selecting and authorizing an authenticator.

4.1.4. Use an existing credential - PublicKeyCredential::[[DiscoverFromExternalSource]](options) method

The [[DiscoverFromExternalSource]](options) method is used to discover and use an existing public key credential, with the user's consent. The script optionally specifies some criteria to indicate what credentials are acceptable to it. The user agent and/or platform locates credentials matching the specified criteria, and guides the user to pick one that the script will be allowed to use. The user may choose not to provide a credential even if one is present, for example to maintain privacy.

Note: This algorithm is synchronous; the Promise resolution/rejection is taken care of by navigator.credentials.get().
This method takes the following parameters:

options
A CredentialRequestOptions object, containing a challenge that the selected authenticator is expected to sign to produce the assertion, and additional options as described in 4.6 Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions)

When this method is invoked, the user agent MUST execute the following algorithm:
1. Let publicKeyOptions be the value of options publicKey member.
2. If the timeout member of publicKeyOptions is present, check if its value lies within a reasonable range as defined by the platform and if not, correct it to the closest value lying within that range. Set adjustedTimeout to this adjusted value. If the timeout member of publicKeyOptions is not present, then set adjustedTimeout to a platform-specific default.
3. Let global be the PublicKeyCredential's relevant settings object's environment settings object's global object.
4. Let callerOrigin be the origin of this CredentialsContainer

A new AuthenticatorAttestationResponse object associated with global whose fields are:

clientDataJSON
A new ArrayBuffer, created using global's %ArrayBuffer%, containing the bytes of clientDataJSON.

attestationObject
attestationObject

clientExtensionResults
A new AuthenticationExtensions object containing the extension identifier -> client extension output entries created by running each extension's client extension processing algorithm to create the client extension outputs, for each client extension in clientDataJSON.clientExtensions.

5. For each remaining authenticator in issuedRequests invoke the authenticatorCancel operation on authenticator and remove it from issuedRequests.
6. Return value and terminate this algorithm.

27. Return a DOMException whose name is "NotAllowedError".

During the above process, the user agent SHOULD show some UI to the user to guide them in the process of selecting and authorizing an authenticator.

4.1.4. Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method

The [[DiscoverFromExternalSource]](options) method is used to discover and use an existing public key credential, with the user's consent. The script optionally specifies some criteria to indicate what credentials are acceptable to it. The user agent and/or platform locates credentials matching the specified criteria, and guides the user to pick one that the script will be allowed to use. The user may choose not to provide a credential even if one is present, for example to maintain privacy.

Note: This algorithm is synchronous; the Promise resolution/rejection is handled by navigator.credentials.get().

This method accepts a single argument:

options
This argument is a CredentialRequestOptions object whose options.publicKey member contains a challenge and additional options as described in 4.5 Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions). The selected authenticator signs the challenge along with other collected data in order to produce an assertion. See 5.2.2 The authenticatorGetAssertion operation.

When this method is invoked, the user agent MUST execute the following algorithm:
1. Assert: options.publicKey is present.
2. Let options be the value of options.publicKey.
3. If the timeout member of options is present, check if its value lies within a reasonable range as defined by the platform and if not, correct it to the closest value lying within that range. Set adjustedTimeout to this adjusted value. If the timeout member of options is not present, then set adjustedTimeout to a platform-specific default.
4. Let global be the PublicKeyCredential's interface object's environment settings object's global object.
5. Let callerOrigin be the origin specified by this

object's relevant settings object. If callerOrigin is an opaque origin, return DOMException whose name is "NotAllowedError", and terminate this algorithm.

5. If the rpId member of publicKeyOptions is not present, then set rpId to callerOrigin. Otherwise:
   1. Let effectiveDomain be the callerOrigin's effective domain.
   2. If effectiveDomain is null, then return a DOMException whose name is "SecurityError" and terminate this algorithm.
   3. If rpId is not a registrable domain suffix of and is not equal to effectiveDomain, return a DOMException whose name is "SecurityError", and terminate this algorithm.
   4. Set rpId to the rpId.
6. Let clientExtensions be a new map and let authenticatorExtensions be a new map.
7. If the extensions member of publicKeyOptions is present, then for each extensionId -> clientExtensionInput of publicKeyOptions.extensions:
   1. If extensionId is not supported by this client platform or is not an authentication extension, then continue.
   2. Set clientExtensions[extensionId] to clientExtensionInput.
   3. If extensionId is not an authenticator extension, then continue.
   4. Let authenticatorExtensionInput be the (CBOR) result of running extensionId's client extension processing algorithm on clientExtensionInput. If the algorithm returned an error, continue.
   5. Set authenticatorExtensions[extensionId] to the base64url encoding of authenticatorExtensionInput.
8. Let collectedClientData be a new CollectedClientData instance whose fields are:

   challenge
      The base64url encoding of publicKeyOptions.challenge

   origin
      The unicode serialization of rpId

   hashAlg
      The recognized algorithm name of the hash algorithm selected by the client for generating the hash of the serialized client data

   tokenBinding
      The Token Binding ID associated with callerOrigin, if one is available.

   clientExtensions
      clientExtensions

   authenticatorExtensions
      authenticatorExtensions

9. Let clientDataJSON be the JSON-serialized client data constructed from collectedClientData.
10. Let clientDataHash be the hash of the serialized client data represented by clientDataJSON.
11. Let issuedRequests be a new ordered set.
12. If there are no authenticators currently available on this platform, return a DOMException whose name is "NotFoundError", and terminate this algorithm.
13. For each authenticator currently available on this platform,

PublicKeyCredential interface object's relevant settings object. If callerOrigin is an opaque origin, return a DOMException whose name is "NotAllowedError", and terminate this algorithm.

6. Let effectiveDomain be the callerOrigin's effective domain. If effective domain is not a valid domain, then return a DOMException whose name is "SecurityError" and terminate this algorithm.
   Note: An effective domain may resolve to a host, which can be represented in various manners, such as domain, ipv4 address, ipv6 address, opaque host, or empty host. Only the domain format of host is allowed here.
7. If options.rpId is not present, then set rpId to effectiveDomain. Otherwise:
   1. If options.rpId is not a registrable domain suffix of and is not equal to effectiveDomain, return a DOMException whose name is "SecurityError", and terminate this algorithm.
   2. Set rpId to options.rpId.
      Note: rpId represents the caller's RP ID. The RP ID defaults to being the caller's origin's effective domain unless the caller has explicitly set options.rpId when calling get().
8. Let clientExtensions be a new map and let authenticatorExtensions be a new map.
9. If the extensions member of options is present, then for each extensionId -> clientExtensionInput of options.extensions:
   1. If extensionId is not supported by this client platform or is not an authentication extension, then continue.
   2. Set clientExtensions[extensionId] to clientExtensionInput.
   3. If extensionId is not an authenticator extension, then continue.
   4. Let authenticatorExtensionInput be the (CBOR) result of running extensionId's client extension processing algorithm on clientExtensionInput. If the algorithm returned an error, continue.
   5. Set authenticatorExtensions[extensionId] to the base64url encoding of authenticatorExtensionInput.
10. Let collectedClientData be a new CollectedClientData instance whose fields are:

   challenge
      The base64url encoding of options.challenge

   origin
      The serialization of callerOrigin.

   hashAlgorithm
      The recognized algorithm name of the hash algorithm selected by the client for generating the hash of the serialized client data

   tokenBindingId
      The Token Binding ID associated with callerOrigin, if one is available.

   clientExtensions
      clientExtensions

   authenticatorExtensions
      authenticatorExtensions

11. Let clientDataJSON be the JSON-serialized client data constructed from collectedClientData.
12. Let clientDataHash be the hash of the serialized client data represented by clientDataJSON.
13. Let issuedRequests be a new ordered set.
14. If there are no authenticators currently available on this platform, return a DOMException whose name is "NotFoundError", and terminate this algorithm.
15. Let authenticator be a platform-specific handle whose value identifies an authenticator.
16. For each authenticator currently available on this platform,

perform the following steps:

1. Let credentialList be a new list.
2. If publicKeyOptions.allowList is not empty, execute a platform-specific procedure to determine which, if any, credentials in publicKeyOptions.allowList are present on this authenticator by matching with publicKeyOptions.allowList.id and publicKeyOptions.allowList.type, and set credentialList to this filtered list.
3. If credentialList is empty then continue.
4. In parallel, for each credential C in credentialList:
    1. If C.transports is not empty, the client SHOULD select one transport from transports. Then, using transport, invoke the authenticatorGetAssertion operation on authenticator, with rpId, clientDataHash, credentialList, and authenticatorExtensions as parameters.
    2. Otherwise, using local configuration knowledge of the appropriate transport to use with authenticator, invoke the authenticatorGetAssertion operation on authenticator with rpId, clientDataHash, credentialList, and clientExtensions as parameters.
5. Append authenticator to issuedRequests.

14. Start a timer for adjustedTimeout milliseconds. Then execute the following steps in parallel. The task source for these tasks is the dom manipulation task source.
15. While issuedRequests is not empty, perform the following actions depending upon the adjustedTimeout timer and responses from the authenticators:

If the adjustedTimeout timer expires,
For each authenticator in issuedRequests invoke the

perform the following steps:

1. Let allowCredentialDescriptorList be a new list.
2. If options.allowCredentials is not empty, execute a platform-specific procedure to determine which, if any, public key credentials described by options.allowCredentials are bound to this authenticator, by matching with rpId, options.allowCredentials.id, and options.allowCredentials.type. Set allowCredentialDescriptorList to this filtered list.
3. If allowCredentialDescriptorList

    is not empty

    1. Let distinctTransports be a new ordered set.
    2. For each credential descriptor C in allowCredentialDescriptorList, append each value, if any, of C.transports to distinctTransports.
       Note: This will aggregate only distinct values of transports (for this authenticator) in distinctTransports due to the properties of ordered sets.
    3. If distinctTransports

        is not empty
            The client selects one transport value from distinctTransports, possibly incorporating local configuration knowledge of the appropriate transport to use with authenticator in making its selection.

            Then, using transport, invoke in parallel the authenticatorGetAssertion operation on authenticator, with rpId, clientDataHash, allowCredentialDescriptorList, and authenticatorExtensions as parameters.

        is empty
            Using local configuration knowledge of the appropriate transport to use with authenticator, invoke in parallel the authenticatorGetAssertion operation on authenticator with rpId, clientDataHash, allowCredentialDescriptorList, and clientExtensions as parameters.

    is empty
        Using local configuration knowledge of the appropriate transport to use with authenticator, invoke in parallel the authenticatorGetAssertion operation on authenticator with rpId, clientDataHash, and clientExtensions as parameters.

        Note: In this case, the Relying Party did not supply a list of acceptable credential descriptors. Thus the authenticator is being asked to exercise any credential it may possess that is bound to the Relying Party, as identified by rpId.

4. Append authenticator to issuedRequests.

17. Start a timer for adjustedTimeout milliseconds. Then execute the following steps in parallel. The task source for these tasks is the dom manipulation task source.
18. While issuedRequests is not empty, perform the following actions depending upon the adjustedTimeout timer and responses from the authenticators:

If the adjustedTimeout timer expires,
For each authenticator in issuedRequests invoke the

authenticatorCancel operation on authenticator and remove authenticator from issuedRequests.

If any authenticator returns a status indicating that the user cancelled the operation,

1. Remove authenticator from issuedRequests.
2. For each remaining authenticator in issuedRequests invoke the authenticatorCancel operation on authenticator and remove it from issuedRequests.

If any authenticator returns an error status, Remove authenticator from issuedRequests.

If any authenticator indicates success,

1. Remove authenticator from issuedRequests.
2. Let value be a new PublicKeyCredential associated with global whose fields are:

[[identifier]]
A new ArrayBuffer, created using global's %ArrayBuffer%, containing the bytes of the credential ID returned from the successful authenticatorGetAssertion operation, as defined in [#op-get-assertion]].

response
A new AuthenticatorAssertionResponse object associated with global whose fields are:

clientDataJSON
A new ArrayBuffer, created using global's %ArrayBuffer%, containing the bytes of clientDataJSON

authenticatorData
A new ArrayBuffer, created using global's %ArrayBuffer%, containing the bytes of the returned authenticatorData

signature
A new ArrayBuffer, created using global's %ArrayBuffer%, containing the bytes of the returned signature

clientExtensionResults
A new AuthenticationExtensions object containing the extension identifier -> client extension output entries created by running each extension's client extension processing algorithm to create the client extension outputs, for each client extension in clientDataJSON.clientExtensions.

3. For each remaining authenticator in issuedRequests invoke the authenticatorCancel operation on authenticator and remove it from issuedRequests.
4. Return value and terminate this algorithm.

16. Return a DOMException whose name is "NotAllowedError".

During the above process, the user agent SHOULD show some UI to the user to guide them in the process of selecting and authorizing an authenticator with which to complete the operation.

authenticatorCancel operation on authenticator and remove authenticator from issuedRequests.

If any authenticator returns a status indicating that the user cancelled the operation,

1. Remove authenticator from issuedRequests.
2. For each remaining authenticator in issuedRequests invoke the authenticatorCancel operation on authenticator and remove it from issuedRequests.

If any authenticator returns an error status, Remove authenticator from issuedRequests.

If any authenticator indicates success,

1. Remove authenticator from issuedRequests.
2. Let value be a new PublicKeyCredential associated with global whose fields are:

[[identifier]]
A new ArrayBuffer, created using global's %ArrayBuffer%, containing the bytes of the credential ID returned from the successful authenticatorGetAssertion operation, as defined in 5.2.2 The authenticatorGetAssertion operation.

response
A new AuthenticatorAssertionResponse object associated with global whose fields are:

clientDataJSON
A new ArrayBuffer, created using global's %ArrayBuffer%, containing the bytes of clientDataJSON

authenticatorData
A new ArrayBuffer, created using global's %ArrayBuffer%, containing the bytes of the returned authenticatorData

signature
A new ArrayBuffer, created using global's %ArrayBuffer%, containing the bytes of the returned signature

clientExtensionResults
A new AuthenticationExtensions object containing the extension identifier -> client extension output entries created by running each extension's client extension processing algorithm to create the client extension outputs, for each client extension in clientDataJSON.clientExtensions.

3. For each remaining authenticator in issuedRequests invoke the authenticatorCancel operation on authenticator and remove it from issuedRequests.
4. Return value and terminate this algorithm.

19. Return a DOMException whose name is "NotAllowedError".

During the above process, the user agent SHOULD show some UI to the user to guide them in the process of selecting and authorizing an authenticator with which to complete the operation.

4.1.5. Platform Authenticator Availability - PublicKeyCredential's isPlatformAuthenticatorAvailable() method

4.2. Authenticator Responses (interface AuthenticatorResponse)

Authenticators respond to relying party requests by returning an object derived from the AuthenticatorResponse interface:

```
[SecureContext]
interface AuthenticatorResponse {
  readonly attribute ArrayBuffer clientDataJSON;
};
```

clientDataJSON, of type ArrayBuffer, readonly
This attribute contains a JSON serialization of the client data passed to the authenticator by the client in its call to either create() or get().

4.2.1. Information about Public Key Credential (interface AuthenticatorAttestationResponse)

The AuthenticatorAttestationResponse interface represents the authenticator's response to a client's request for the creation of a new public key credential. It contains information about the new credential that can be used to identify it for later use, and metadata that can be used by the Relying Party to assess the characteristics of the credential during registration.

```
[SecureContext]
interface AuthenticatorAttestationResponse : AuthenticatorResponse {
  readonly attribute ArrayBuffer attestationObject;
};
```

clientDataJSON
This attribute, inherited from AuthenticatorResponse, contains the JSON-serialized client data (see 5.3 Credential

Relying Parties use this method to determine whether they can create a new credential using a platform authenticator. Upon invocation, the client employs a platform-specific procedure to discover available platform authenticators. If successful, the client then assesses whether the user is willing to create a credential using one of the available platform authenticators. This assessment may include various factors, such as:

* Whether the user is running in private or incognito mode.
* Whether the user has configured the client to not create such credentials.
* Whether the user has previously expressed an unwillingness to create a new credential for this Relying Party, either through configuration or by declining a user interface prompt.
* The user's explicitly stated intentions, determined through user interaction.

If this assessment is affirmative, the promise is resolved with the value of True. Otherwise, the promise is resolved with the value of False. Based on the result, the Relying Party can take further actions to guide the user to create a credential.

This method has no arguments and returns a boolean value.

If the promise will return False, the client SHOULD wait a fixed period of time from the invocation of the method before returning False. This is done so that callers can not distinguish between the case where the user was unwilling to create a credential using one of the available platform authenticators and the case where no platform authenticator exists. Trying to make these cases indistinguishable is done in an attempt to not provide additional information that could be used for fingerprinting. A timeout value on the order of 10 minutes is recommended; this is enough time for successful user interactions to be performed but short enough that the dangling promise will still be resolved in a reasonably timely fashion.

```
[SecureContext]
partial interface PublicKeyCredential {
  [Unscopable] Promise < boolean > isPlatformAuthenticatorAvailable();
};
```

4.2. Authenticator Responses (interface AuthenticatorResponse)

Authenticators respond to Relying Party requests by returning an object derived from the AuthenticatorResponse interface:

```
[SecureContext]
interface AuthenticatorResponse {
  [SameObject] readonly attribute ArrayBuffer    clientDataJSON;
};
```

clientDataJSON, of type ArrayBuffer, readonly
This attribute contains a JSON serialization of the client data passed to the authenticator by the client in its call to either create() or get().

4.2.1. Information about Public Key Credential (interface AuthenticatorAttestationResponse)

The AuthenticatorAttestationResponse interface represents the authenticator's response to a client's request for the creation of a new public key credential. It contains information about the new credential that can be used to identify it for later use, and metadata that can be used by the Relying Party to assess the characteristics of the credential during registration.

```
[SecureContext]
interface AuthenticatorAttestationResponse : AuthenticatorResponse {
  [SameObject] readonly attribute ArrayBuffer    attestationObject;
};
```

clientDataJSON
This attribute, inherited from AuthenticatorResponse, contains the JSON-serialized client data (see 5.3 Attestation) passed to

Attestation) passed to the authenticator by the client in order to generate this credential. The exact JSON serialization must be preserved, as the hash of the serialized client data has been computed over it.

attestationObject, of type ArrayBuffer, readonly
This attribute contains an attestation object, which is opaque to, and cryptographically protected against tampering by, the client. The attestation object contains both authenticator data and an attestation statement. The former contains the AAGUID, a unique credential ID, and the credential public key. The contents of the attestation statement are determined by the attestation statement format used by the authenticator. It also contains any additional information that the Relying Party's server requires to validate the attestation statement, as well as to decode and validate the authenticator data along with the JSON-serialized client data. For more details, see 5.3 Credential Attestation as well as Figure 3.

4.2.2. Web Authentication Assertion (interface AuthenticatorAssertionResponse)

The AuthenticatorAssertionResponse interface represents an authenticator's response to a client's request for generation of a new authentication assertion given the Relying Party's challenge and optional list of credentials it is aware of. This response contains a cryptographic signature proving possession of the credential private key, and optionally evidence of user consent to a specific transaction.

```
[SecureContext]
interface AuthenticatorAssertionResponse : AuthenticatorResponse {
    readonly attribute ArrayBuffer      authenticatorData;
    readonly attribute ArrayBuffer      signature;
};
```

clientDataJSON
This attribute, inherited from AuthenticatorResponse, contains the JSON-serialized client data (see 4.8.1 Client data used in WebAuthn signatures (dictionary CollectedClientData)) passed to the authenticator by the client in order to generate this assertion. The exact JSON serialization must be preserved, as the hash of the serialized client data has been computed over it.

authenticatorData, of type ArrayBuffer, readonly
This attribute contains the authenticator data returned by the authenticator. See 5.1 Authenticator data.

signature, of type ArrayBuffer, readonly
This attribute contains the raw signature returned from the authenticator. See 5.2.2 The authenticatorGetAssertion operation.

4.3. Parameters for Credential Generation (dictionary PublicKeyCredentialParameters)

```
dictionary PublicKeyCredentialParameters {
    required PublicKeyCredentialType  type;
    required AlgorithmIdentifier   algorithm;
};
```

This dictionary is used to supply additional parameters when creating a new credential.

The type member specifies the type of credential to be created.

The algorithm member specifies the cryptographic signature algorithm with which the newly generated credential will be used, and thus also the type of asymmetric key pair to be generated, e.g., RSA or Elliptic Curve.

the authenticator by the client in order to generate this credential. The exact JSON serialization must be preserved, as the hash of the serialized client data has been computed over it.

attestationObject, of type ArrayBuffer, readonly
This attribute contains an attestation object, which is opaque to, and cryptographically protected against tampering by, the client. The attestation object contains both authenticator data and an attestation statement. The former contains the AAGUID, a unique credential ID, and the credential public key. The contents of the attestation statement are determined by the attestation statement format used by the authenticator. It also contains any additional information that the Relying Party's server requires to validate the attestation statement, as well as to decode and validate the authenticator data along with the JSON-serialized client data. For more details, see 5.3 Attestation, 5.3.4 Generating an Attestation Object, and Figure 3.

4.2.2. Web Authentication Assertion (interface AuthenticatorAssertionResponse)

The AuthenticatorAssertionResponse interface represents an authenticator's response to a client's request for generation of a new authentication assertion given the Relying Party's challenge and optional list of credentials it is aware of. This response contains a cryptographic signature proving possession of the credential private key, and optionally evidence of user consent to a specific transaction.

```
[SecureContext]
interface AuthenticatorAssertionResponse : AuthenticatorResponse {
    [SameObject] readonly attribute ArrayBuffer      authenticatorData;
    [SameObject] readonly attribute ArrayBuffer      signature;
};
```

clientDataJSON
This attribute, inherited from AuthenticatorResponse, contains the JSON-serialized client data (see 4.7.1 Client data used in WebAuthn signatures (dictionary CollectedClientData)) passed to the authenticator by the client in order to generate this assertion. The exact JSON serialization must be preserved, as the hash of the serialized client data has been computed over it.

authenticatorData, of type ArrayBuffer, readonly
This attribute contains the authenticator data returned by the authenticator. See 5.1 Authenticator data.

signature, of type ArrayBuffer, readonly
This attribute contains the raw signature returned from the authenticator. See 5.2.2 The authenticatorGetAssertion operation.

4.3. Parameters for Credential Generation (dictionary PublicKeyCredentialParameters)

```
dictionary PublicKeyCredentialParameters {
    required PublicKeyCredentialType      type;
    required COSEAlgorithmIdentifier      alg;
};
```

This dictionary is used to supply additional parameters when creating a new credential.

The type member specifies the type of credential to be created.

The alg member specifies the cryptographic signature algorithm with which the newly generated credential will be used, and thus also the type of asymmetric key pair to be generated, e.g., RSA or Elliptic Curve.

4.4. User Account Parameters for Credential Generation (dictionary PublicKeyCredentialUserEntity)

```
dictionary PublicKeyCredentialUserEntity : PublicKeyCredentialEntity {
  DOMString displayName;
};
```

This dictionary is used to supply additional parameters about the user account when creating a new credential.

The displayName member contains a friendly name for the user account (e.g., "John P. Smith").

4.5. Options for Credential Creation (dictionary MakeCredentialOptions)

```
dictionary MakeCredentialOptions {
  required PublicKeyCredentialEntity rp;
  required PublicKeyCredentialUserEntity user;

  required BufferSource                    challenge;
  required sequence<PublicKeyCredentialParameters> parameters;

  unsigned long                   timeout;
  sequence<PublicKeyCredentialDescriptor> excludeList;
  AuthenticatorSelectionCriteria       authenticatorSelection;
  AuthenticationExtensions           extensions;
};
```

rp, of type PublicKeyCredentialEntity
This member contains data about the relying party responsible for the request.

Its value's name member is required, and contains the friendly name of the relying party (e.g. "Acme Corporation", "Widgets, Inc.", or "Awesome Site".

Its value's id member specifies the relying party identifier with which the credential should be associated. If this identifier is not explicitly set, it will default to the ASCII serialization of the CredentialsContainer object's relevant settings object's origin.

user, of type PublicKeyCredentialUserEntity
This member contains data about the user account for which the relying party is requesting attestation.

Its value's name member is required, and contains a name for the user account (e.g., "john.p.smith@example.com" or "+14255551234").

Its value's displayName member is required, and contains a friendly name for the user account (e.g., "John P. Smith").

Its value's id member is required, and contains an identifier for the account, specified by the relying party. This is not meant to be displayed to the user, but is used by the relying party to control the number of credentials - an authenticator will never contain more than one credential for a given relying party under the same id.

challenge, of type BufferSource
This member contains a challenge intended to be used for generating the newly created credential's attestation object.

parameters, of type sequence<PublicKeyCredentialParameters>
This member contains information about the desired properties of the credential to be created. The sequence is ordered from most preferred to least preferred. The platform makes a best-effort

Note: we use "alg" as the latter member name, rather than spelling-out "algorithm", because it will be serialized into a message to the authenticator, which may be sent over a low-bandwidth link.

4.4. Options for Credential Creation (dictionary MakePublicKeyCredentialOptions)

```
dictionary MakePublicKeyCredentialOptions {
  required PublicKeyCredentialEntity          rp;
  required PublicKeyCredentialUserEntity       user;

  required BufferSource                        challenge;
  required sequence<PublicKeyCredentialParameters>  pubKeyCredParams;

  unsigned long                         timeout;
  sequence<PublicKeyCredentialDescriptor>     excludeCredentials = [];
  AuthenticatorSelectionCriteria             authenticatorSelection;
  AuthenticationExtensions                  extensions;
};
```

rp, of type PublicKeyCredentialEntity
This member contains data about the Relying Party responsible for the request.

Its value's name member is required, and contains the friendly name of the Relying Party (e.g. "Acme Corporation", "Widgets, Inc.", or "Awesome Site".

Its value's id member specifies the relying party identifier with which the credential should be associated. If omitted, its value will be the CredentialsContainer object's relevant settings object's origin's effective domain.

user, of type PublicKeyCredentialUserEntity
This member contains data about the user account for which the Relying Party is requesting attestation.

Its value's name member is required, and contains a name for the user account (e.g., "john.p.smith@example.com" or "+14255551234").

Its value's displayName member is required, and contains a friendly name for the user account (e.g., "John P. Smith").

Its value's id member is required, and contains an identifier for the account, specified by the Relying Party. This is not meant to be displayed to the user, but is used by the Relying Party to control the number of credentials - an authenticator will never contain more than one credential for a given Relying Party under the same id.

challenge, of type BufferSource
This member contains a challenge intended to be used for generating the newly created credential's attestation object.

pubKeyCredParams, of type sequence<PublicKeyCredentialParameters>
This member contains information about the desired properties of the credential to be created. The sequence is ordered from most preferred to least preferred. The platform makes a best-effort

to create the most preferred credential that it can.

timeout, of type unsigned long
This member specifies a time, in milliseconds, that the caller is willing to wait for the call to complete. This is treated as a hint, and may be overridden by the platform.

excludeList, of type sequence<PublicKeyCredentialDescriptor>

This member is intended for use by Relying Parties that wish to limit the creation of multiple credentials for the same account on a single authenticator. The platform is requested to return an error if the new credential would be created on an authenticator that also contains one of the credentials enumerated in this parameter.

authenticatorSelection, of type AuthenticatorSelectionCriteria
This member is intended for use by Relying Parties that wish to select the appropriate authenticators to participate in the create() or get() operation.

extensions, of type AuthenticationExtensions
This member contains additional parameters requesting additional processing by the client and authenticator. For example, the caller may request that only authenticators with certain capabilies be used to create the credential, or that particular information be returned in the attestation object. Some extensions are defined in 8 WebAuthn Extensions; consult the IANA "WebAuthn Extension Identifier" registry established by [WebAuthn-Registries] for an up-to-date list of registered WebAuthn Extensions.

4.5.1. Entity Description

The PublicKeyCredentialEntity dictionary describes a user account or a relying party with which a credential is associated.

```
dictionary PublicKeyCredentialEntity {
    DOMString id;
    DOMString name;
    USVString icon;
};
```

id, of type DOMString
A unique identifier for the entity. This will be the ASCII serialization of an origin for a relying party, and an arbitrary string specified by the relying party for user accounts.

name, of type DOMString
A human-friendly identifier for the entity. For example, this could be a company name for a relying party, or a user's name. This identifier is intended for display.

icon, of type USVString
A serialized URL which resolves to an image associated with the entity. For example, this could be a user's avatar or a relying party's logo.

4.5.2. Authenticator Selection Criteria

to create the most preferred credential that it can.

timeout, of type unsigned long
This member specifies a time, in milliseconds, that the caller is willing to wait for the call to complete. This is treated as a hint, and may be overridden by the platform.

excludeCredentials, of type sequence<PublicKeyCredentialDescriptor>, defaulting to None
This member is intended for use by Relying Parties that wish to limit the creation of multiple credentials for the same account on a single authenticator. The platform is requested to return an error if the new credential would be created on an authenticator that also contains one of the credentials enumerated in this parameter.

authenticatorSelection, of type AuthenticatorSelectionCriteria
This member is intended for use by Relying Parties that wish to select the appropriate authenticators to participate in the create() or get() operation.

extensions, of type AuthenticationExtensions
This member contains additional parameters requesting additional processing by the client and authenticator. For example, the caller may request that only authenticators with certain capabilies be used to create the credential, or that particular information be returned in the attestation object. Some extensions are defined in 8 WebAuthn Extensions; consult the IANA "WebAuthn Extension Identifier" registry established by [WebAuthn-Registries] for an up-to-date list of registered WebAuthn Extensions.

4.4.1. Public Key Entity Description (dictionary PublicKeyCredentialEntity)

The PublicKeyCredentialEntity dictionary describes a user account, or a Relying Party, with which a public key credential is associated.

```
dictionary PublicKeyCredentialEntity {
    DOMString      id;
    DOMString      name;
    USVString      icon;
};
```

id, of type DOMString
A unique identifier for the entity. For a relying party entity, sets the RP ID. For a user account entity, this will be an arbitrary string specified by the relying party.

name, of type DOMString
A human-friendly identifier for the entity. For example, this could be a company name for a Relying Party, or a user's name. This identifier is intended for display.

icon, of type USVString
A serialized URL which resolves to an image associated with the entity. For example, this could be a user's avatar or a Relying Party's logo.

4.4.2. User Account Parameters for Credential Generation (dictionary PublicKeyCredentialUserEntity)

The PublicKeyCredentialUserEntity dictionary is used to supply additional user account attributes when creating a new credential.

```
dictionary PublicKeyCredentialUserEntity : PublicKeyCredentialEntity {
    DOMString      displayName;
};
```

displayName, of type DOMString
A friendly name for the user account (e.g., "John P. Smith").

4.4.3. Authenticator Selection Criteria (dictionary

Relying Parties may use the AuthenticatorSelectionCriteria dictionary to specify their requirements regarding authenticator attributes.

```
dictionary AuthenticatorSelectionCriteria {
    Attachment    attachment;
    boolean       requireResidentKey = false;
};
```

attachment, of type Attachment
If this memeber is present, eligible authenticators are filtered to only authenticators attached with the specified 4.5.3 Credential Attachment enumeration (enum Attachment).

requireResidentKey, of type boolean, defaulting to false
This member describes the Relying Parties' requirements regarding availability of the Client-side-resident Credential Private Key. If the parameter is set to true, the authenticator MUST create a Client-side-resident Credential Private Key when creating a public key credential.

4.5.3. Credential Attachment enumeration (enum Attachment)

```
enum Attachment {
    "platform",
    "cross-platform"
};
```

Clients may communicate with authenticators using a variety of mechanisms. For example, a client may use a platform-specific API to communicate with an authenticator which is physically bound to a platform. On the other hand, a client may use a variety of standardized cross-platform transport protocols such as Bluetooth (see 4.8.4 Credential Transport enumeration (enum ExternalTransport)) to discover and communicate with cross-platform attached authenticators. Therefore, we use Attachment to describe an authenticator's attachment modality. We define authenticators that are part of the client's platform as having a platform attachment, and refer to them as platform authenticators. While those that are reachable via cross-platform transport protocols are defined as having cross-platform attachment, and refer to them as roaming authenticators.

* platform attachment - the respective authenticator is attached using platform-specific transports. Usually, authenticators of this class are non-removable from the platform.
* cross-platform attachment - the respective authenticator is attached using cross-platform transports. Authenticators of this class are removable from, and can "roam" among, client platforms.

This distinction is important because there are use-cases where only platform authenticators are acceptable to a Relying Party, and conversely ones where only roaming authenticators are employed. As a concrete example of the former, a credential on a platform authenticator may be used by Relying Parties to quickly and conveniently reauthenticate the user with a minimum of friction, e.g.,

AuthenticatorSelectionCriteria)

Relying Parties may use the AuthenticatorSelectionCriteria dictionary to specify their requirements regarding authenticator attributes.

```
dictionary AuthenticatorSelectionCriteria {
    AuthenticatorAttachment     aa;       // authenticatorAttachment
    boolean                     rk = false; // requireResidentKey
    boolean                     uv = false; // requireUserVerification
};
```

aa (authenticatorAttachment), of type AuthenticatorAttachment
If this member is present, eligible authenticators are filtered to only authenticators attached with the specified 4.4.4 Authenticator Attachment enumeration (enum AuthenticatorAttachment).

rk (requireResidentKey), of type boolean, defaulting to false
This member describes the Relying Parties' requirements regarding availability of the Client-side-resident Credential Private Key. If the parameter is set to true, the authenticator MUST create a Client-side-resident Credential Private Key when creating a public key credential.

uv (requireUserVerification), of type boolean, defaulting to false
This member describes the Relying Parties' requirements regarding the authenticator being capable of performing user verification. If the parameter is set to true, the authenticator MUST perform user verification when performing the create() operation and future 4.1.4 Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method operations when it is requested to verify the credential.

Note: These identifiers are intentionally short, rather than descriptive, because they will be serialized into a message to the authenticator, which may be sent over a low-bandwidth link.

4.4.4. Authenticator Attachment enumeration (enum AuthenticatorAttachment)

```
enum AuthenticatorAttachment {
    "plat",  // Platform attachment
    "xplat"  // Cross-platform attachment
};
```

Clients may communicate with authenticators using a variety of mechanisms. For example, a client may use a platform-specific API to communicate with an authenticator which is physically bound to a platform. On the other hand, a client may use a variety of standardized cross-platform transport protocols such as Bluetooth (see 4.7.4 Authenticator Transport enumeration (enum AuthenticatorTransport)) to discover and communicate with cross-platform attached authenticators. Therefore, we use AuthenticatorAttachment to describe an authenticator's attachment modality. We define authenticators that are part of the client's platform as having a platform attachment, and refer to them as platform authenticators. While those that are reachable via cross-platform transport protocols are defined as having cross-platform attachment, and refer to them as roaming authenticators.

* platform attachment - the respective authenticator is attached using platform-specific transports. Usually, authenticators of this class are non-removable from the platform.
* cross-platform attachment - the respective authenticator is attached using cross-platform transports. Authenticators of this class are removable from, and can "roam" among, client platforms.

This distinction is important because there are use-cases where only platform authenticators are acceptable to a Relying Party, and conversely ones where only roaming authenticators are employed. As a concrete example of the former, a credential on a platform authenticator may be used by Relying Parties to quickly and conveniently reauthenticate the user with a minimum of friction, e.g., the user will not have to dig around in their pocket for their key fob or phone. As a concrete example of the latter, when the user is accessing the Relying Party from a given client for the first time, they may be required to use a roaming authenticator which was originally registered with the Relying Party using a different client.

4.6. Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions)

The PublicKeyCredentialRequestOptions dictionary supplies get() with the data it needs to generate an assertion. Its challenge member must be present, while its other members are optional.

```
dictionary PublicKeyCredentialRequestOptions {
    required BufferSource                challenge;
    unsigned long                        timeout;
    USVString                            rpId;
    sequence<PublicKeyCredentialDescriptor> allowList = [];
    AuthenticationExtensions             extensions;
};
```

challenge, of type BufferSource
    This member represents a challenge that the selected authenticator signs, along with other data, when producing an authentication assertion.

timeout, of type unsigned long
    This optional member specifies a time, in milliseconds, that the caller is willing to wait for the call to complete. The value is treated as a hint, and may be overridden by the platform.

rpId, of type USVString
    This optional member specifies the relying party identifier claimed by the caller. If omitted, its value will be the ASCII serialization of the CredentialsContainer object's relevant settings object's origin.

allowList, of type sequence<PublicKeyCredentialDescriptor>, defaulting to None
    This optional member contains a list of PublicKeyCredentialDescriptor object representing public key credentials acceptable to the caller, in decending order of the caller's preference (the first item in the list is the most preferred credential, and so on down the line).

extensions, of type AuthenticationExtensions
    This optional member contains additional parameters requesting additional processing by the client and authenticator. For example, if transaction confirmation is sought from the user, then the prompt string might be included as an extension.

4.7. Authentication Extensions (typedef AuthenticationExtensions)

```
typedef record<DOMString, any> AuthenticationExtensions;
```

This is a dictionary containing zero or more WebAuthn extensions, as defined in 8 WebAuthn Extensions. An AuthenticationExtensions instance can contain either client extensions or authenticator extensions, depending upon context.

4.8. Supporting Data Structures

The public key credential type uses certain data structures that are specified in supporting specifications. These are as follows.

4.8.1. Client data used in WebAuthn signatures (dictionary CollectedClientData)

The client data represents the contextual bindings of both the Relying Party and the client platform. It is a key-value mapping with string-valued keys. Values may be any type that has a valid encoding in

the user will not have to dig around in their pocket for their key fob or phone. As a concrete example of the latter, when the user is accessing the Relying Party from a given client for the first time, they may be required to use a roaming authenticator which was originally registered with the Relying Party using a different client.

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dictionary PublicKeyCredentialRequestOptions {
    required BufferSource                challenge;
    unsigned long                        timeout;
    USVString                            rpId;
    sequence<PublicKeyCredentialDescriptor> allowCredentials = [];
    AuthenticationExtensions             extensions;
};
```

challenge, of type BufferSource
    This member represents a challenge that the selected authenticator signs, along with other data, when producing an authentication assertion.

timeout, of type unsigned long
    This optional member specifies a time, in milliseconds, that the caller is willing to wait for the call to complete. The value is treated as a hint, and may be overridden by the platform.

rpId, of type USVString
    This optional member specifies the relying party identifier claimed by the caller. If omitted, its value will be the CredentialsContainer object's relevant settings object's origin's effective domain.

allowCredentials, of type sequence<PublicKeyCredentialDescriptor>, defaulting to None
    This optional member contains a list of PublicKeyCredentialDescriptor object representing public key credentials acceptable to the caller, in decending order of the caller's preference (the first item in the list is the most preferred credential, and so on down the list).

extensions, of type AuthenticationExtensions
    This optional member contains additional parameters requesting additional processing by the client and authenticator. For example, if transaction confirmation is sought from the user, then the prompt string might be included as an extension.

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4.7.1. Client data used in WebAuthn signatures (dictionary CollectedClientData)

The client data represents the contextual bindings of both the Relying Party and the client platform. It is a key-value mapping with string-valued keys. Values may be any type that has a valid encoding in

JSON. Its structure is defined by the following Web IDL.

```
dictionary CollectedClientData {
    required DOMString           challenge;
    required DOMString           origin;
    required DOMString           hashAlg;
    DOMString                    tokenBinding;
    AuthenticationExtensions     clientExtensions;
    AuthenticationExtensions     authenticatorExtensions;
};
```

The challenge member contains the base64url encoding of the challenge provided by the RP.

The origin member contains the fully qualified origin of the requester, as provided to the authenticator by the client, in the syntax defined by [RFC6454].

The hashAlg member is a recognized algorithm name that supports the "digest" operation, which specifies the algorithm used to compute the hash of the serialized client data. This algorithm is chosen by the client at its sole discretion.

The tokenBinding member contains the base64url encoding of the Token Binding ID that this client uses for the Token Binding protocol when communicating with the Relying Party. This can be omitted if no Token Binding has been negotiated between the client and the Relying Party.

The optional clientExtensions and authenticatorExtensions members contain additional parameters generated by processing the extensions passed in by the Relying Party. WebAuthn extensions are detailed in Section 8 WebAuthn Extensions.

This structure is used by the client to compute the following quantities:

JSON-serialized client data
    This is the UTF-8 encoding of the result of calling the initial value of JSON.stringify on a CollectedClientData dictionary.

Hash of the serialized client data
    This is the hash (computed using hashAlg) of the JSON-serialized client data, as constructed by the client.

4.8.2. Credential Type enumeration (enum PublicKeyCredentialType)

```
enum PublicKeyCredentialType {
    "public-key"
};
```

This enumeration defines the valid credential types. It is an extension point; values may be added to it in the future, as more credential types are defined. The values of this enumeration are used for versioning the Authentication Assertion and attestation structures according to the type of the authenticator.

Currently one credential type is defined, namely "public-key".

4.8.3. Credential Descriptor (dictionary PublicKeyCredentialDescriptor)

```
dictionary PublicKeyCredentialDescriptor {
    required PublicKeyCredentialType type;
    required BufferSource id;
    sequence<Transport>   transports;
};
```

This dictionary contains the attributes that are specified by a caller when referring to a credential as an input parameter to the create() or get() methods. It mirrors the fields of the PublicKeyCredential object returned by the latter methods.

JSON. Its structure is defined by the following Web IDL.

```
dictionary CollectedClientData {
    required DOMString           challenge;
    required DOMString           origin;
    required DOMString           hashAlgorithm;
    DOMString                    tokenBindingId;
    AuthenticationExtensions     clientExtensions;
    AuthenticationExtensions     authenticatorExtensions;
};
```

The challenge member contains the base64url encoding of the challenge provided by the RP.

The origin member contains the fully qualified origin of the requester, as provided to the authenticator by the client, in the syntax defined by [RFC6454].

The hashAlgorithm member is a recognized algorithm name that supports the "digest" operation, which specifies the algorithm used to compute the hash of the serialized client data. This algorithm is chosen by the client at its sole discretion.

The tokenBindingId member contains the base64url encoding of the Token Binding ID that this client uses for the Token Binding protocol when communicating with the Relying Party. This can be omitted if no Token Binding has been negotiated between the client and the Relying Party.

The optional clientExtensions and authenticatorExtensions members contain additional parameters generated by processing the extensions passed in by the Relying Party. WebAuthn extensions are detailed in Section 8 WebAuthn Extensions.

This structure is used by the client to compute the following quantities:

JSON-serialized client data
    This is the UTF-8 encoding of the result of calling the initial value of JSON.stringify on a CollectedClientData dictionary.

Hash of the serialized client data
    This is the hash (computed using hashAlgorithm) of the JSON-serialized client data, as constructed by the client.

4.7.2. Credential Type enumeration (enum PublicKeyCredentialType)

```
enum PublicKeyCredentialType {
    "public-key"
};
```

This enumeration defines the valid credential types. It is an extension point; values may be added to it in the future, as more credential types are defined. The values of this enumeration are used for versioning the Authentication Assertion and attestation structures according to the type of the authenticator.

Currently one credential type is defined, namely "public-key".

4.7.3. Credential Descriptor (dictionary PublicKeyCredentialDescriptor)

```
dictionary PublicKeyCredentialDescriptor {
    required PublicKeyCredentialType      type;
    required BufferSource                 id;
    sequence<AuthenticatorTransport>      transports;
};
```

This dictionary contains the attributes that are specified by a caller when referring to a credential as an input parameter to the create() or get() methods. It mirrors the fields of the PublicKeyCredential object returned by the latter methods.

The type member contains the type of the credential the caller is referring to.

The id member contains the identifier of the credential the caller is referring to.

4.8.4. Credential Transport enumeration (enum ExternalTransport)

```
enum Transport {
    "usb",
    "nfc",
    "ble"
};
```

Authenticators may communicate with Clients using a variety of transports. This enumeration defines a hint as to how Clients might communicate with a particular Authenticator in order to obtain an assertion for a specific credential. Note that these hints represent the Relying Party's best belief as to how an Authenticator may be reached. A Relying Party may obtain a list of transports hints from some attestation statement formats or via some out-of-band mechanism; it is outside the scope of this specification to define that mechanism.

* usb - the respective Authenticator may be contacted over USB.
* nfc - the respective Authenticator may be contacted over Near Field Communication (NFC).
* ble - the respective Authenticator may be contacted over Bluetooth Smart (Bluetooth Low Energy / BLE).

4.8.5. Cryptographic Algorithm Identifier (type AlgorithmIdentifier)

A string or dictionary identifying a cryptographic algorithm and optionally a set of parameters for that algorithm. This type is defined in [WebCryptoAPI].

5. WebAuthn Authenticator model

The API defined in this specification implies a specific abstract functional model for an authenticator. This section describes the authenticator model.

Client platforms may implement and expose this abstract model in any way desired. However, the behavior of the client's Web Authentication API implementation, when operating on the authenticators supported by that platform, MUST be indistinguishable from the behavior specified in 4 Web Authentication API.

For authenticators, this model defines the logical operations that they must support, and the data formats that they expose to the client and the Relying Party. However, it does not define the details of how authenticators communicate with the client platform, unless they are required for interoperability with Relying Parties. For instance, this abstract model does not define protocols for connecting authenticators to clients over transports such as USB or NFC. Similarly, this abstract model does not define specific error codes or methods of returning them; however, it does define error behavior in terms of the needs of the client. Therefore, specific error codes are mentioned as a means of showing which error conditions must be distinguishable (or not) from each other in order to enable a compliant and secure client implementation.

In this abstract model, the authenticator provides key management and cryptographic signatures. It may be embedded in the WebAuthn client, or housed in a separate device entirely. The authenticator may itself contain a cryptographic module which operates at a higher security level than the rest of the authenticator. This is particularly important for authenticators that are embedded in the WebAuthn client, as in those cases this cryptographic module (which may, for example, be

The type member contains the type of the credential the caller is referring to.

The id member contains the identifier of the credential the caller is referring to.

4.7.4. Authenticator Transport enumeration (enum AuthenticatorTransport)

```
enum AuthenticatorTransport {
    "usb",
    "nfc",
    "ble"
};
```

Authenticators may communicate with Clients using a variety of transports. This enumeration defines a hint as to how Clients might communicate with a particular Authenticator in order to obtain an assertion for a specific credential. Note that these hints represent the Relying Party's best belief as to how an Authenticator may be reached. A Relying Party may obtain a list of transports hints from some attestation statement formats or via some out-of-band mechanism; it is outside the scope of this specification to define that mechanism.

* usb - the respective Authenticator may be contacted over USB.
* nfc - the respective Authenticator may be contacted over Near Field Communication (NFC).
* ble - the respective Authenticator may be contacted over Bluetooth Smart (Bluetooth Low Energy / BLE).

4.7.5. Cryptographic Algorithm Identifier (typedef COSEAlgorithmIdentifier)

```
typedef long COSEAlgorithmIdentifier;
```

A COSEAlgorithmIdentifier's value is a number identifying a cryptographic algorithm. The algorithm identifiers SHOULD be values registered in the IANA COSE Algorithms registry [IANA-COSE-ALGS-REG], for instance, -7 for "ES256" and -257 for "RS256".

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In this abstract model, the authenticator provides key management and cryptographic signatures. It may be embedded in the WebAuthn client, or housed in a separate device entirely. The authenticator may itself contain a cryptographic module which operates at a higher security level than the rest of the authenticator. This is particularly important for authenticators that are embedded in the WebAuthn client, as in those cases this cryptographic module (which may, for example, be a TPM) could be considered more trustworthy than the rest of the authenticator.

Each authenticator stores some number of public key credentials. Each public key credential has an identifier which is unique (or extremely unlikely to be duplicated) among all public key credentials. Each credential is also associated with a Relying Party, whose identity is represented by a Relying Party Identifier (RP ID).

Each authenticator has an AAGUID, which is a 128-bit identifier that indicates the type (e.g. make and model) of the authenticator. The AAGUID MUST be chosen by the manufacturer to be identical across all substantially identical authenticators made by that manufacturer, and different (with probability 1-2^-128 or greater) from the AAGUIDs of all other types of authenticators. The RP MAY use the AAGUID to infer certain properties of the authenticator, such as certification level and strength of key protection, using information from other sources.

The primary function of the authenticator is to provide WebAuthn signatures, which are bound to various contextual data. These data are observed, and added at different levels of the stack as a signature request passes from the server to the authenticator. In verifying a signature, the server checks these bindings against expected values. These contextual bindings are divided in two: Those added by the RP or the client, referred to as client data; and those added by the authenticator, referred to as the authenticator data. The authenticator signs over the client data, but is otherwise not interested in its contents. To save bandwidth and processing requirements on the authenticator, the client hashes the client data and sends only the result to the authenticator. The authenticator signs over the combination of the hash of the serialized client data, and its own authenticator data.

The goals of this design can be summarized as follows.

* The scheme for generating signatures should accommodate cases where the link between the client platform and authenticator is very limited, in bandwidth and/or latency. Examples include Bluetooth Low Energy and Near-Field Communication.
* The data processed by the authenticator should be small and easy to interpret in low-level code. In particular, authenticators should not have to parse high-level encodings such as JSON.
* Both the client platform and the authenticator should have the flexibility to add contextual bindings as needed.
* The design aims to reuse as much as possible of existing encoding formats in order to aid adoption and implementation.

Authenticators produce cryptographic signatures for two distinct purposes:

1. An attestation signature is produced when a new credential is created, and provides cryptographic proof of certain properties of the credential and the authenticator. For instance, an attestation signature asserts the type of authenticator (as denoted by its AAGUID) and the public key of the credential. The attestation signature is signed by an attestation key, which is chosen depending on the type of attestation desired. For more details on attestation, see 5.3 Credential Attestation.

2. An assertion signature is produced when the authenticatorGetAssertion method is invoked. It represents an assertion by the authenticator that the user has consented to a specific transaction, such as logging in, or completing a purchase. Thus, an assertion signature asserts that the authenticator which possesses a particular credential private key has established, to the best of its ability, that the human who is requesting this transaction is the same human who consented to creating that particular credential. It also provides additional information that might be useful to the caller, such as the means by which user consent was provided, and the prompt that was shown to the user by the authenticator.

a TPM) could be considered more trustworthy than the rest of the authenticator.

Each authenticator stores some number of public key credentials. Each public key credential has an identifier which is unique (or extremely unlikely to be duplicated) among all public key credentials. Each credential is also associated with a Relying Party, whose identity is represented by a Relying Party Identifier (RP ID).

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* The design aims to reuse as much as possible of existing encoding formats in order to aid adoption and implementation.

Authenticators produce cryptographic signatures for two distinct purposes:

1. An attestation signature is produced when a new public key credential is created via an authenticatorMakeCredential operation. An attestation signature provides cryptographic proof of certain properties of the the authenticator and the credential. For instance, an attestation signature asserts the authenticator type (as denoted by its AAGUID) and the credential public key. The attestation signature is signed by an attestation private key, which is chosen depending on the type of attestation desired. For more details on attestation, see 5.3 Attestation.
2. An assertion signature is produced when the authenticatorGetAssertion method is invoked. It represents an assertion by the authenticator that the user has consented to a specific transaction, such as logging in, or completing a purchase. Thus, an assertion signature asserts that the authenticator possessing a particular credential private key has established, to the best of its ability, that the user requesting this transaction is the same user who consented to creating that particular public key credential. It also asserts additional information, termed client data, that may be useful to the caller, such as the means by which user consent was provided, and the prompt shown to the user by the authenticator. The assertion signature format is illustrated in Figure 2, below.

The formats of these signatures, as well as the procedures for generating them, are specified below.

5.1. Authenticator data

The authenticator data structure encodes contextual bindings made by the authenticator. These bindings are controlled by the authenticator itself, and derive their trust from the Relying Party's assessment of the security properties of the authenticator. In one extreme case, the authenticator may be embedded in the client, and its bindings may be no more trustworthy than the client data. At the other extreme, the authenticator may be a discrete entity with high-security hardware and software, connected to the client over a secure channel. In both cases, the Relying Party receives the authenticator data in the same format, and uses its knowledge of the authenticator to make trust decisions.

The authenticator data has a compact but extensible encoding. This is desired since authenticators can be devices with limited capabilities and low power requirements, with much simpler software stacks than the client platform components.

The authenticator data structure is a byte array of 37 bytes or more, as follows.

Length (in bytes) Description
32 SHA-256 hash of the RP ID associated with the credential.
1 Flags (bit 0 is the least significant bit):
 * Bit 0: Test of User Presence (TUP) result.
 * Bits 1-5: Reserved for future use (RFU).
 * Bit 6: Attestation data included (AT). Indicates whether the authenticator added attestation data.
 * Bit 7: Extension data included (ED). Indicates if the authenticator data has extensions.

4 Signature counter (signCount), 32-bit unsigned big-endian integer.
variable (if present) attestation data (if present). See 5.3.1 Attestation data for details. Its length depends on the length of the credential public key and credential ID being attested.
variable (if present) Extension-defined authenticator data. This is a CBOR [RFC7049] map with extension identifiers as keys, and authenticator extension outputs as values. See 8 WebAuthn Extensions for details.

The RP ID is originally received from the client when the credential is created, and again when an assertion is generated. However, it differs from other client data in some important ways. First, unlike the client data, the RP ID of a credential does not change between operations but instead remains the same for the lifetime of that credential. Secondly, it is validated by the authenticator during the authenticatorGetAssertion operation, by verifying that the RP ID associated with the requested credential exactly matches the RP ID supplied by the client.

The TUP flag SHALL be set if and only if the authenticator detected a user through an authenticator specific gesture. The RFU bits SHALL be set to zero.

For attestation signatures, the authenticator MUST set the AT flag and include the attestation data. For authentication signatures, the AT flag MUST NOT be set and the attestation data MUST NOT be included.

The formats of these signatures, as well as the procedures for generating them, are specified below.

5.1. Authenticator data

The authenticator data structure encodes contextual bindings made by the authenticator. These bindings are controlled by the authenticator itself, and derive their trust from the Relying Party's assessment of the security properties of the authenticator. In one extreme case, the authenticator may be embedded in the client, and its bindings may be no more trustworthy than the client data. At the other extreme, the authenticator may be a discrete entity with high-security hardware and software, connected to the client over a secure channel. In both cases, the Relying Party receives the authenticator data in the same format, and uses its knowledge of the authenticator to make trust decisions.

The authenticator data has a compact but extensible encoding. This is desired since authenticators can be devices with limited capabilities and low power requirements, with much simpler software stacks than the client platform components.

The authenticator data structure is a byte array of 37 bytes or more, as follows.

Length (in bytes) Description
32 SHA-256 hash of the RP ID associated with the credential.
1 Flags (bit 0 is the least significant bit):
 * Bit 0: User Present (UP) result.
   + 1 means the user is present.
   + 0 means the user is not present.
 * Bit 1: Reserved for future use (RFU1).
 * Bit 2: User Verified (UV) result.
   + 1 means the user is verified.
   + 0 means the user is not verified.
 * Bits 3-5: Reserved for future use (RFU2).
 * Bit 6: Attestation data included (AT).
   + Indicates whether the authenticator added attestation data.
 * Bit 7: Extension data included (ED).
   + Indicates if the authenticator data has extensions.

4 Signature counter (signCount), 32-bit unsigned big-endian integer.
variable (if present) attestation data (if present). See 5.3.1 Attestation data for details. Its length depends on the length of the credential public key and credential ID being attested.
variable (if present) Extension-defined authenticator data. This is a CBOR [RFC7049] map with extension identifiers as keys, and authenticator extension outputs as values. See 8 WebAuthn Extensions for details.

The RP ID is originally received from the client when the credential is created, and again when an assertion is generated. However, it differs from other client data in some important ways. First, unlike the client data, the RP ID of a credential does not change between operations but instead remains the same for the lifetime of that credential. Secondly, it is validated by the authenticator during the authenticatorGetAssertion operation, by verifying that the RP ID associated with the requested credential exactly matches the RP ID supplied by the client, and that the RP ID is a registrable domain suffix of or is equal to the effective domain of the RP's origin's effective domain.

The UP flag SHALL be set if and only if the authenticator detected a user through an authenticator specific gesture. The RFU bits SHALL be set to zero.

For attestation signatures, the authenticator MUST set the AT flag and include the attestation data. For authentication signatures, the AT flag MUST NOT be set and the attestation data MUST NOT be included.

If the authenticator does not include any extension data, it MUST set the ED flag in the first byte to zero, and to one if extension data is included.

The figure below shows a visual representation of the authenticator data structure.
[fido-signature-formats-figure1.html] Authenticator data layout.

Note that the authenticator data describes its own length: If the AT and ED flags are not set, it is always 37 bytes long. The attestation data (which is only present if the AT flag is set) describes its own length. If the ED flag is set, then the total length is 37 bytes plus the length of the attestation data, plus the length of the CBOR map that follows.

5.2. Authenticator operations

A client must connect to an authenticator in order to invoke any of the operations of that authenticator. This connection defines an authenticator session. An authenticator must maintain isolation between sessions. It may do this by only allowing one session to exist at any particular time, or by providing more complicated session management.

The following operations can be invoked by the client in an authenticator session.

5.2.1. The authenticatorMakeCredential operation

This operation must be invoked in an authenticator session which has no other operations in progress. It takes the following input parameters:
* The caller's RP ID, as determined by the user agent and the client.
* The hash of the serialized client data, provided by the client.
* The relying party's PublicKeyCredentialEntity.
* The user account's PublicKeyCredentialEntity.
* The PublicKeyCredentialType and cryptographic parameters requested by the Relying Party, with the cryptographic algorithms normalized as per the procedure in Web Cryptography API algorithm-normalization-normalize-an-algorithm.
* A list of PublicKeyCredential objects provided by the Relying Party with the intention that, if any of these are known to the authenticator, it should not create a new credential.
* Extension data created by the client based on the extensions requested by the Relying Party.
* The requireResidentKey parameter of the options.authenticatorSelection dictionary.

When this operation is invoked, the authenticator must perform the following procedure:
* Check if all the supplied parameters are syntactically well-formed and of the correct length. If not, return an error code equivalent to UnknownError and terminate the operation.
* Check if at least one of the specified combinations of PublicKeyCredentialType and cryptographic parameters is supported. If not, return an error code equivalent to NotSupportedError and terminate the operation.
* Check if a credential matching any of the supplied PublicKeyCredential identifiers is present on this authenticator. If so, return an error code equivalent to NotAllowedError and terminate the operation.
* If the requireResidentKey flag is set to true and the authenticator cannot store a Client-side-resident Credential Private Key, return an error code equivalent to ConstraintError and terminate the operation.
* Prompt the user for consent to create a new credential. The prompt for obtaining this consent is shown by the authenticator if it has

If the authenticator does not include any extension data, it MUST set the ED flag to zero, and to one if extension data is included.

The figure below shows a visual representation of the authenticator data structure.
[fido-signature-formats-figure1.svg] Authenticator data layout.

Note that the authenticator data describes its own length: If the AT and ED flags are not set, it is always 37 bytes long. The attestation data (which is only present if the AT flag is set) describes its own length. If the ED flag is set, then the total length is 37 bytes plus the length of the attestation data, plus the length of the CBOR map that follows.

5.2. Authenticator operations

A client must connect to an authenticator in order to invoke any of the operations of that authenticator. This connection defines an authenticator session. An authenticator must maintain isolation between sessions. It may do this by only allowing one session to exist at any particular time, or by providing more complicated session management.

The following operations can be invoked by the client in an authenticator session.

5.2.1. The authenticatorMakeCredential operation

This operation must be invoked in an authenticator session which has no other operations in progress. It takes the following input parameters:
* The caller's RP ID, as determined by the user agent and the client.
* The hash of the serialized client data, provided by the client.
* The Relying Party's PublicKeyCredentialEntity.
* The user account's PublicKeyCredentialUserEntity.
* A sequence of pairs of PublicKeyCredentialType and COSEAlgorithmIdentifier requested by the Relying Party. This sequence is ordered from most preferred to least preferred. The platform makes a best-effort to create the most preferred credential that it can.
* An optional list of PublicKeyCredentialDescriptor objects provided by the Relying Party with the intention that, if any of these are known to the authenticator, it should not create a new credential.
* The rk member of the options.authenticatorSelection dictionary.
* The uv member of the options.authenticatorSelection dictionary.
* Extension data created by the client based on the extensions requested by the Relying Party, if any.

When this operation is invoked, the authenticator must perform the following procedure:
* Check if all the supplied parameters are syntactically well-formed and of the correct length. If not, return an error code equivalent to "UnknownError" and terminate the operation.
* Check if at least one of the specified combinations of PublicKeyCredentialType and cryptographic parameters is supported. If not, return an error code equivalent to "NotSupportedError" and terminate the operation.
* Check if a credential matching any of the supplied PublicKeyCredential identifiers is present on this authenticator. If so, return an error code equivalent to "NotAllowedError" and terminate the operation.
* If rk is true and the authenticator cannot store a Client-side-resident Credential Private Key, return an error code equivalent to "ConstraintError" and terminate the operation.
* If uv is true and the authenticator cannot perform user verification, return an error code equivalent to "ConstraintError" and terminate the operation.
* Prompt the user for consent to create a new credential. The prompt for obtaining this consent is shown by the authenticator if it has

its own output capability, or by the user agent otherwise. If the user denies consent, return an error code equivalent to NotAllowedError and terminate the operation.
* Once user consent has been obtained, generate a new credential object:
  + Generate a set of cryptographic keys using the most preferred combination of PublicKeyCredentialType and cryptographic parameters supported by this authenticator.
  + Generate an identifier for this credential, such that this identifier is globally unique with high probability across all credentials with the same type across all authenticators.
  + Associate the credential with the specified RP ID and the user's account identifier user.id.
  + Delete any older credentials with the same RP ID and user.id that are stored locally in the authenticator.
* If any error occurred while creating the new credential object, return an error code equivalent to UnknownError and terminate the operation.
* Process all the supported extensions requested by the client, and generate the authenticator data with attestation data as specified in 5.1 Authenticator data. Use this authenticator data and the hash of the serialized client data to create an attestation object for the new credential using the procedure specified in 5.3.4 Generating an Attestation Object. For more details on attestation, see 5.3 Credential Attestation.

On successful completion of this operation, the authenticator returns the attestation object to the client.

5.2.2. The authenticatorGetAssertion operation

This operation must be invoked in an authenticator session which has no other operations in progress. It takes the following input parameters:
* The caller's RP ID, as determined by the user agent and the client.
* The hash of the serialized client data, provided by the client.
* A list of credentials acceptable to the Relying Party (possibly filtered by the client).
* Extension data created by the client based on the extensions requested by the Relying Party.

When this method is invoked, the authenticator must perform the following procedure:
* Check if all the supplied parameters are syntactically well-formed and of the correct length. If not, return an error code equivalent to UnknownError and terminate the operation.
* If a list of credentials was supplied by the client, filter it by removing those credentials that are not present on this authenticator. If no list was supplied, create a list with all credentials stored for the caller's RP ID (as determined by an exact match of the RP ID).
* If the previous step resulted in an empty list, return an error code equivalent to NotAllowedError and terminate the operation.
* Prompt the user to select a credential from among the above list. Obtain user consent for using this credential. The prompt for obtaining this consent may be shown by the authenticator if it has its own output capability, or by the user agent otherwise.
* Process all the supported extensions requested by the client, and generate the authenticator data without attestation data as specified in 5.1 Authenticator data. Concatenate this authenticator data with the hash of the serialized client data to generate an assertion signature using the private key of the selected credential as shown below. A simple, undelimited concatenation is safe to use here because the authenticator data describes its own length. The hash of the serialized client data (which potentially has a variable length) is always the last element.
* If any error occurred while generating the assertion signature, return an error code equivalent to UnknownError and terminate the operation.

its own output capability, or by the user agent otherwise. If the user denies consent, return an error code equivalent to "NotAllowedError" and terminate the operation.
* Once user consent has been obtained, generate a new credential object:
  + Generate a set of cryptographic keys using the most preferred combination of PublicKeyCredentialType and cryptographic parameters supported by this authenticator.
  + Generate an identifier for this credential, such that this identifier is globally unique with high probability across all credentials with the same type across all authenticators.
  + Associate the credential with the specified RP ID and the user's account identifier user.id.
  + Delete any older credentials with the same RP ID and user.id that are stored locally by the authenticator.
* If any error occurred while creating the new credential object, return an error code equivalent to "UnknownError" and terminate the operation.
* Process all the supported extensions requested by the client, and generate the authenticator data with attestation data as specified in 5.1 Authenticator data. Use this authenticator data and the hash of the serialized client data to create an attestation object for the new credential using the procedure specified in 5.3.4 Generating an Attestation Object. For more details on attestation, see 5.3 Attestation.

On successful completion of this operation, the authenticator returns the attestation object to the client.

5.2.2. The authenticatorGetAssertion operation

This operation must be invoked in an authenticator session which has no other operations in progress. It takes the following input parameters:
* The caller's RP ID, as determined by the user agent and the client.
* The hash of the serialized client data, provided by the client.
* A list of credentials acceptable to the Relying Party (possibly filtered by the client), if any.
* Extension data created by the client based on the extensions requested by the Relying Party, if any.

When this method is invoked, the authenticator must perform the following procedure:
* Check if all the supplied parameters are syntactically well-formed and of the correct length. If not, return an error code equivalent to "UnknownError" and terminate the operation.
* If a list of credentials was supplied by the client, filter it by removing those credentials that are not present on this authenticator. If no list was supplied, create a list with all credentials stored for the caller's RP ID (as determined by an exact match of the RP ID).
* If the previous step resulted in an empty list, return an error code equivalent to "NotAllowedError" and terminate the operation.
* Prompt the user to select a credential from among the above list. Obtain user consent for using this credential. The prompt for obtaining this consent may be shown by the authenticator if it has its own output capability, or by the user agent otherwise.
* Process all the supported extensions requested by the client, and generate the authenticator data as specified in 5.1 Authenticator data, though without attestation data. Concatenate this authenticator data with the hash of the serialized client data to generate an assertion signature using the private key of the selected credential as shown in Figure 2, below. A simple, undelimited concatenation is safe to use here because the authenticator data describes its own length. The hash of the serialized client data (which potentially has a variable length) is always the last element.
* If any error occurred while generating the assertion signature, return an error code equivalent to "UnknownError" and terminate the operation.

[fido-signature-formats-figure2.html] Generating a signature on the authenticator.

On successful completion, the authenticator returns to the user agent:

* The identifier of the credential used to generate the signature.
* The authenticator data used to generate the signature.
* The assertion signature.

If the authenticator cannot find any credential corresponding to the specified Relying Party that matches the specified criteria, it terminates the operation and returns an error.

If the user refuses consent, the authenticator returns an appropriate error status to the client.

5.2.3. The authenticatorCancel operation

This operation takes no input parameters and returns no result.

When this operation is invoked by the client in an authenticator session, it has the effect of terminating any authenticatorMakeCredential or authenticatorGetAssertion operation currently in progress in that authenticator session. The authenticator stops prompting for, or accepting, any user input related to authorizing the canceled operation. The client ignores any further responses from the authenticator for the canceled operation.

This operation is ignored if it is invoked in an authenticator session which does not have an authenticatorMakeCredential or authenticatorGetAssertion operation currently in progress.

5.3. Credential Attestation

Authenticators must also provide some form of attestation. The basic requirement is that the authenticator can produce, for each credential public key, attestation information that can be verified by a Relying Party. Typically, this information contains a signature by an attestation private key over the attested credential public key and a challenge, as well as a certificate or similar information providing provenance information for the attestation public key, enabling a trust decision to be made. However, if an attestation key pair is not available, then the authenticator MUST perform self attestation of the credential public key with the corresponding credential private key. All this information is returned by the authenticator any time a new credential is generated, in the form of an attestation object. The relationship of authenticator data and the attestation data, attestation object, and attestation statement data structures is illustrated in the figure below.

[fido-attestation-structures.html] Relationship of authenticator data and attestation data structures.

An important component of the attestation object is the credential attestation statement. This is a specific type of signed data object, containing statements about a credential itself and the authenticator that created it. It contains an attestation signature created using the key of the attesting authority (except for the case of self attestation, when it is created using the private key associated with the credential). In order to correctly interpret an attestation statement, a Relying Party needs to understand two aspects of the attestation:

1. The attestation statement format is the manner in which the signature is represented and the various contextual bindings are incorporated into the attestation statement by the authenticator. In other words, this defines the syntax of the statement. Various

[fido-signature-formats-figure2.svg] Generating an assertion signature.

On successful completion, the authenticator returns to the user agent:

* The identifier of the credential (credential ID) used to generate the assertion signature.
* The authenticator data used to generate the assertion signature.
* The assertion signature.

If the authenticator cannot find any credential corresponding to the specified Relying Party that matches the specified criteria, it terminates the operation and returns an error.

If the user refuses consent, the authenticator returns an appropriate error status to the client.

5.2.3. The authenticatorCancel operation

This operation takes no input parameters and returns no result.

When this operation is invoked by the client in an authenticator session, it has the effect of terminating any authenticatorMakeCredential or authenticatorGetAssertion operation currently in progress in that authenticator session. The authenticator stops prompting for, or accepting, any user input related to authorizing the canceled operation. The client ignores any further responses from the authenticator for the canceled operation.

This operation is ignored if it is invoked in an authenticator session which does not have an authenticatorMakeCredential or authenticatorGetAssertion operation currently in progress.

5.3. Attestation

Authenticators must also provide some form of attestation. The basic requirement is that the authenticator can produce, for each credential public key, an attestation statement verifiable by the Relying Party. Typically, this attestation statement contains a signature by an attestation private key over the attested credential public key and a challenge, as well as a certificate or similar data providing provenance information for the attestation public key, enabling the Relying Party to make a trust decision. However, if an attestation key pair is not available, then the authenticator MUST perform self attestation of the credential public key with the corresponding credential private key. All this information is returned by authenticators any time a new public key credential is generated, in the overall form of an attestation object. The relationship of the attestation object with authenticator data (containing attestation data) and the attestation statement is illustrated in figure 3, below.

Attestation Object Layout diagram Attestation object layout illustrating the included authenticator data (containing attestation data) and the attestation statement.

This figure illustrates only the packed attestation statement format. Several additional attestation statement formats are defined in 7 Defined Attestation Statement Formats.

An important component of the attestation object is the attestation statement. This is a specific type of signed data object, containing statements about a public key credential itself and the authenticator that created it. It contains an attestation signature created using the key of the attesting authority (except for the case of self attestation, when it is created using the credential private key). In order to correctly interpret an attestation statement, a Relying Party needs to understand these two aspects of attestation:

1. The attestation statement format is the manner in which the signature is represented and the various contextual bindings are incorporated into the attestation statement by the authenticator. In other words, this defines the syntax of the statement. Various

existing devices and platforms (such as TPMs and the Android OS) have previously defined attestation statement formats. This specification supports a variety of such formats in an extensible way, as defined in 5.3.2 Attestation Statement Formats.

2. The attestation type defines the semantics of the attestation statement and its underlying trust model. It defines how a Relying Party establishes trust in a particular attestation statement, after verifying that it is cryptographically valid. This specification supports a number of attestation types, as described in 5.3.3 Attestation Types.

In general, there is no simple mapping between attestation statement formats and attestation types. For example the "packed" attestation statement format defined in 7.2 Packed Attestation Statement Format can be used in conjunction with all attestation types, while other formats and types have more limited applicability.

The privacy, security and operational characteristics of attestation depend on:

* The attestation type, which determines the trust model,
* The attestation statement format, which may constrain the strength of the attestation by limiting what can be expressed in an attestation statement, and
* The characteristics of the individual authenticator, such as its construction, whether part or all of it runs in a secure operating environment, and so on.

It is expected that most authenticators will support a small number of attestation types and attestation statement formats, while Relying Parties will decide what attestation types are acceptable to them by policy. Relying Party will also need to understand the characteristics of the authenticators that they trust, based on information they have about these authenticators. For example, the FIDO Metadata Service [FIDOMetadataService] provides one way to access such information.

5.3.1. Attestation data

Attestation data is added to the authenticator data when generating an attestation object for a given credential. It has the following format:

Length (in bytes) Description
16 The AAGUID of the authenticator.
2 Byte length L of Credential ID
L Credential ID
variable Credential public key encoded in CBOR format. This is a CBOR map defined by the following CDDL rules:

```
pubKey = $pubKeyFmt

; All public key formats must include an alg name
pubKeyTemplate = { alg: text }
pubKeyTemplate .within $pubKeyFmt

pubKeyFmt /= rsaPubKey
rsaPubKey = { alg: rsaAlgName, n: biguint, e: uint }
rsaAlgName = "RS256" / "RS384" / "RS512" / "PS256" / "PS384" / "PS51
2"

pubKeyFmt /= eccPubKey
eccPubKey = { alg: eccAlgName, x: biguint, y: biguint }
eccAlgName = "ES256" / "ES384" / "ES512"
```

Thus, each public key type is a CBOR map starting with an entry named alg, which contains a text string that specifies the name of the signature algorithm associated with the credential private key, using values defined in [RFC7518] section 3.1. The semantics and naming of the other fields (though not their encoding) follows the definitions in [RFC7518] section 6. Specifically, for ECC keys, the semantics of the x and y fields are defined in [RFC7518] sections 6.2.1.2 and 6.2.1.3, while for RSA keys, the semantics of the n and e fields are defined in

existing devices and platforms (such as TPMs and the Android OS) have previously defined attestation statement formats. This specification supports a variety of such formats in an extensible way, as defined in 5.3.2 Attestation Statement Formats.

2. The attestation type defines the semantics of attestation statements and their underlying trust models. Specifically, it defines how a Relying Party establishes trust in a particular attestation statement, after verifying that it is cryptographically valid. This specification supports a number of attestation types, as described in 5.3.3 Attestation Types.

In general, there is no simple mapping between attestation statement formats and attestation types. For example, the "packed" attestation statement format defined in 7.2 Packed Attestation Statement Format can be used in conjunction with all attestation types, while other formats and types have more limited applicability.

The privacy, security and operational characteristics of attestation depend on:

* The attestation type, which determines the trust model,
* The attestation statement format, which may constrain the strength of the attestation by limiting what can be expressed in an attestation statement, and
* The characteristics of the individual authenticator, such as its construction, whether part or all of it runs in a secure operating environment, and so on.

It is expected that most authenticators will support a small number of attestation types and attestation statement formats, while Relying Parties will decide what attestation types are acceptable to them by policy. Relying Parties will also need to understand the characteristics of the authenticators that they trust, based on information they have about these authenticators. For example, the FIDO Metadata Service [FIDOMetadataService] provides one way to access such information.

5.3.1. Attestation data

Attestation data is added to the authenticator data when generating an attestation object for a given credential. It has the following format:

Length (in bytes) Description
16 The AAGUID of the authenticator.
2 Byte length L of Credential ID
L Credential ID
variable The credential public key encoded in COSE_Key format, as defined in Section 7 of [RFC8152]. The encoded credential public key MUST contain the "alg" parameter and MUST NOT contain any other optional parameters. The "alg" parameter MUST contain a COSEAlgorithmIdentifier value.

[RFC7518] sections 6.3.1.1 and 6.3.1.2.

5.3.2. Attestation Statement Formats

As described above, an attestation statement format is a data format which represents a cryptographic signature by an authenticator over a set of contextual bindings. Each attestation statement format is defined by the following attributes:
* Its attestation statement format identifier.
* The set of attestation types supported by the format.
* The syntax of an attestation statement produced in this format, defined using CDDL for the extension point $attStmtFormat defined in 5.3.4 Generating an Attestation Object.
* The procedure for computing an attestation statement in this format given the credential to be attested, the authenticator data structure containing the authenticator data for the attestation, and the hash of the serialized client data.
* The procedure for verifying an attestation statement, which takes as inputs the authenticator data structure containing the authenticator data claimed to have been used for the attestation and the hash of the serialized client data, and returns either:
  + An error indicating that the attestation is invalid, or
  + The attestation type, and the trust path of the attestation. This trust path is either empty (in case of self-attestation), an identifier of a ECDAA-Issuer public key (in the case of ECDAA), or a set of X.509 certificates.

The initial list of supported attestation statement formats is in 7 Defined Attestation Statement Formats.

5.3.3. Attestation Types

WebAuthn supports multiple attestation types:

Basic Attestation
In the case of basic attestation [UAFProtocol], the authenticator's attestation key pair is specific to an authenticator model. Thus, authenticators of the same model often share the same attestation key pair. See 5.3.5.1 Privacy for futher information.

Self Attestation
In the case of self attestation, also known as surrogate basic attestation [UAFProtocol], the Authenticator doesn't have any specific attestation key. Instead it uses the authentication key itself to create the attestation signature. Authenticators without meaningful protection measures for an attestation private key typically use this attestation type.

Privacy CA
In this case, the Authenticator owns an authenticator-specific (endorsement) key. This key is used to securely communicate with a trusted third party, the Privacy CA. The Authenticator can generate multiple attestation key pairs and asks the Privacy CA to issue an attestation certificate for it. Using this approach, the Authenticator can limit the exposure of the endorsement key (which is a global correlation handle) to Privacy CA(s). Attestation keys can be requested for each public key credential individually.

Note: This concept typically leads to multiple attestation certificates. The attestation certificate requested most recently is called "active".

Elliptic Curve based Direct Anonymous Attestation (ECDAA)
In this case, the Authenticator receives direct anonymous attestation (DAA) credentials from a single DAA-Issuer. These DAA credentials are used along with blinding to sign the

5.3.2. Attestation Statement Formats

As described above, an attestation statement format is a data format which represents a cryptographic signature by an authenticator over a set of contextual bindings. Each attestation statement format MUST be defined using the following template:
* Attestation statement format identifier:
* Supported attestation types:
* Syntax: The syntax of an attestation statement produced in this format, defined using [CDDL] for the extension point $attStmtFormat defined in 5.3.4 Generating an Attestation Object.
* Signing procedure: The signing procedure for computing an attestation statement in this format given the public key credential to be attested, the authenticator data structure containing the authenticator data for the attestation, and the hash of the serialized client data.
* Verification procedures: The procedure for verifying an attestation statement, which takes as inputs the authenticator data structure containing the authenticator data claimed to have been used for the attestation and the hash of the serialized client data, and returns either:
  + An error indicating that the attestation is invalid, or
  + The attestation type, and the trust path of the attestation. This trust path is either empty (in case of self attestation), an identifier of a ECDAA-Issuer public key (in the case of ECDAA), or a set of X.509 certificates.

The initial list of specified attestation statement formats is in 7 Defined Attestation Statement Formats.

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In the case of basic attestation [UAFProtocol], the authenticator's attestation key pair is specific to an authenticator model. Thus, authenticators of the same model often share the same attestation key pair. See 5.3.5.1 Privacy for futher information.

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In the case of self attestation, also known as surrogate basic attestation [UAFProtocol], the Authenticator does not have any specific attestation key. Instead it uses the authentication key itself to create the attestation signature. Authenticators without meaningful protection measures for an attestation private key typically use this attestation type.

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In this case, the Authenticator owns an authenticator-specific (endorsement) key. This key is used to securely communicate with a trusted third party, the Privacy CA. The Authenticator can generate multiple attestation key pairs and asks the Privacy CA to issue an attestation certificate for it. Using this approach, the Authenticator can limit the exposure of the endorsement key (which is a global correlation handle) to Privacy CA(s). Attestation keys can be requested for each public key credential individually.

Note: This concept typically leads to multiple attestation certificates. The attestation certificate requested most recently is called "active".

Elliptic Curve based Direct Anonymous Attestation (ECDAA)
In this case, the Authenticator receives direct anonymous attestation (DAA) credentials from a single DAA-Issuer. These DAA credentials are used along with blinding to sign the

attestation data. The concept of blinding avoids the DAA credentials being misused as global correlation handle. WebAuthn supports DAA using elliptic curve cryptography and bilinear pairings, called ECDAA (see [FIDOEcdaaAlgorithm]) in this specification. Consequently we denote the DAA-Issuer as ECDAA-Issuer (see [FIDOEcdaaAlgorithm]).

5.3.4. Generating an Attestation Object

This section specifies the algorithm for generating an attestation object for any attestation statement format.

In order to construct an attestation object for a given credential using a particular attestation statement format, the authenticator MUST first generate the authenticator data.

The authenticator MUST then run the signing procedure for the desired attestation statement format with this authenticator data and the hash of the serialized client data as input, and use this to construct an attestation statement in that attestation statement format.

Finally, the authenticator MUST construct the attestation object as a CBOR map with the following syntax:

```
attObj = {
            authData: bytes,
            $$attStmtType
         }

attStmtTemplate = (
                      fmt: text,
                      attStmt: bytes
                  )

; Every attestation statement format must have the above fields
attStmtTemplate .within $$attStmtType
```

The semantics of the fields in the attestation object are as follows:

fmt
The attestation statement format identifier associated with the attestation statement. Each attestation statement format defines its identifier.

authData
The authenticator data used to generate the attestation statement.

attStmt
The attestation statement constructed above. The syntax of this is defined by the attestation statement format used.

5.3.5. Security Considerations

5.3.5.1. Privacy

Attestation keys may be used to track users or link various online identities of the same user together. This may be mitigated in several ways, including:
* A WebAuthn authenticator manufacturer may choose to ship all of their devices with the same (or a fixed number of) attestation key(s) (called Basic Attestation). This will anonymize the user at the risk of not being able to revoke a particular attestation key should its WebAuthn Authenticator be compromised.
* A WebAuthn Authenticator may be capable of dynamically generating different attestation keys (and requesting related certificates) per origin (following the Privacy CA approach). For example, a WebAuthn Authenticator can ship with a master attestation key (and certificate), and combined with a cloud operated privacy CA, can dynamically generate per origin attestation keys and attestation certificates.

attestation data. The concept of blinding avoids the DAA credentials being misused as global correlation handle. WebAuthn supports DAA using elliptic curve cryptography and bilinear pairings, called ECDAA (see [FIDOEcdaaAlgorithm]) in this specification. Consequently we denote the DAA-Issuer as ECDAA-Issuer (see [FIDOEcdaaAlgorithm]).

5.3.4. Generating an Attestation Object

This section specifies the algorithm for generating an attestation object (see: Figure 3) for any attestation statement format.

In order to construct an attestation object for a given public key credential using a particular attestation statement format, the authenticator MUST first generate the authenticator data.

The authenticator MUST then run the signing procedure for the desired attestation statement format with this authenticator data and the hash of the serialized client data as input, and use this to construct an attestation statement in that attestation statement format.

Finally, the authenticator MUST construct the attestation object as a CBOR map with the following syntax:

```
attObj = {
            authData: bytes,
            $$attStmtType
         }

attStmtTemplate = (
                      fmt: text,
                      attStmt: bytes
                  )

; Every attestation statement format must have the above fields
attStmtTemplate .within $$attStmtType
```

The semantics of the fields in the attestation object are as follows:

fmt
The attestation statement format identifier associated with the attestation statement. Each attestation statement format defines its identifier.

authData
The authenticator data used to generate the attestation statement.

attStmt
The attestation statement constructed above. The syntax of this is defined by the attestation statement format used.

5.3.5. Security Considerations

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Attestation keys may be used to track users or link various online identities of the same user together. This may be mitigated in several ways, including:
* A WebAuthn authenticator manufacturer may choose to ship all of their devices with the same (or a fixed number of) attestation key(s) (called Basic Attestation). This will anonymize the user at the risk of not being able to revoke a particular attestation key should its WebAuthn Authenticator be compromised.
* A WebAuthn Authenticator may be capable of dynamically generating different attestation keys (and requesting related certificates) per origin (following the Privacy CA approach). For example, a WebAuthn Authenticator can ship with a master attestation key (and certificate), and combined with a cloud operated privacy CA, can dynamically generate per origin attestation keys and attestation certificates.

* A WebAuthn Authenticator can implement Elliptic Curve based direct anonymous attestation (see [FIDOEcdaaAlgorithm]). Using this scheme, the authenticator generates a blinded attestation signature. This allows the Relying Party to verify the signature using the ECDAA-Issuer public key, but the attestation signature doesn't serve as a global correlation handle.

5.3.5.2. Attestation Certificate and Attestation Certificate CA Compromise

When an intermediate CA or a root CA used for issuing attestation certificates is compromised, WebAuthn authenticator attestation keys are still safe although their certificates can no longer be trusted. A WebAuthn Authenticator manufacturer that has recorded the public attestation keys for their devices can issue new attestation certificates for these keys from a new intermediate CA or from a new root CA. If the root CA changes, the Relying Parties must update their trusted root certificates accordingly.

A WebAuthn Authenticator attestation certificate must be revoked by the issuing CA if its key has been compromised. A WebAuthn Authenticator manufacturer may need to ship a firmware update and inject new attestation keys and certificates into already manufactured WebAuthn Authenticators, if the exposure was due to a firmware flaw. (The process by which this happens is out of scope for this specification.) If the WebAuthn Authenticator manufacturer does not have this capability, then it may not be possible for Relying Parties to trust any further attestation statements from the affected WebAuthn Authenticators.

If attestation certificate validation fails due to a revoked intermediate attestation CA certificate, and the Relying Party's policy requires rejecting the registration/authentication request in these situations, then it is recommended that the Relying Party also un-registers (or marks with a trust level equivalent to "self attestation") public key credentials that were registered after the CA compromise date using an attestation certificate chaining up to the same intermediate CA. It is thus recommended that Relying Parties remember intermediate attestation CA certificates during Authenticator registration in order to un-register related public key credentials if the registration was performed after revocation of such certificates.

If an ECDAA attestation key has been compromised, it can be added to the RogueList (i.e., the list of revoked authenticators) maintained by the related ECDAA-Issuer. The Relying Party should verify whether an authenticator belongs to the RogueList when performing ECDAA-Verify (see section 3.6 in [FIDOEcdaaAlgorithm]). For example, the FIDO Metadata Service [FIDOMetadataService] provides one way to access such information.

5.3.5.3. Attestation Certificate Hierarchy

A 3-tier hierarchy for attestation certificates is recommended (i.e., Attestation Root, Attestation Issuing CA, Attestation Certificate). It is also recommended that for each WebAuthn Authenticator device line (i.e., model), a separate issuing CA is used to help facilitate isolating problems with a specific version of a device.

If the attestation root certificate is not dedicated to a single WebAuthn Authenticator device line (i.e., AAGUID), the AAGUID should be specified in the attestation certificate itself, so that it can be verified against the authenticator data.

6. Relying Party Operations

Upon successful execution of create() or get(), the Relying Party's script receives a PublicKeyCredential containing an AuthenticatorAttestationResponse or AuthenticatorAssertionResponse structure, respectively, from the client. It must then deliver the contents of this structure to the Relying Party server, using methods outside the scope of this specification. This section describes the

* A WebAuthn Authenticator can implement Elliptic Curve based direct anonymous attestation (see [FIDOEcdaaAlgorithm]). Using this scheme, the authenticator generates a blinded attestation signature. This allows the Relying Party to verify the signature using the ECDAA-Issuer public key, but the attestation signature does not serve as a global correlation handle.

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operations that the Relying Party must perform upon receipt of these structures.

6.1. Registering a new credential

When registering a new credential, represented by a AuthenticatorAttestationResponse structure, as part of a registration ceremony, a Relying Party MUST proceed as follows:

1. Perform JSON deserialization on the clientDataJSON field of the AuthenticatorAttestationResponse object to extract the client data C claimed as collected during the credential creation.
2. Verify that the challenge in C matches the challenge that was sent to the authenticator in the create() call.
3. Verify that the origin in C matches the Relying Party's origin.
4. Verify that the tokenBinding in C matches the Token Binding ID for the TLS connection over which the attestation was obtained.
5. Verify that the clientExtensions in C is a proper subset of the extensions requested by the RP and that the authenticatorExtensions in C is also a proper subset of the extensions requested by the RP.
6. Compute the hash of clientDataJSON using the algorithm identified by C.hashAlg.
7. Perform CBOR decoding on the attestationObject field of the AuthenticatorAttestationResponse structure to obtain the attestation statement format fmt, the authenticator data authData, and the attestation statement attStmt.
8. Verify that the RP ID hash in authData is indeed the SHA-256 hash of the RP ID expected by the RP.
9. Determine the attestation statement format by performing an USASCII case-sensitive match on fmt against the set of supported WebAuthn Attestation Statement Format Identifier values. The up-to-date list of registered WebAuthn Attestation Statement Format Identifier values is maintained in the in the IANA registry of the same name [WebAuthn-Registries].
10. Verify that attStmt is a correct, validly-signed attestation statement, using the attestation statement format fmt's verification procedure given authenticator data authData and the hash of the serialized client data computed in step 6.
11. If validation is successful, obtain a list of acceptable trust anchors (attestation root certificates or ECDAA-Issuer public keys) for that attestation type and attestation statement format fmt, from a trusted source or from policy. For example, the FIDO Metadata Service [FIDOMetadataService] provides one way to obtain such information, using the AAGUID in the attestation data contained in authData.
12. Assess the attestation trustworthiness using the outputs of the verification procedure in step 10, as follows:
    + If self-attestation was used, check if self-attestation is acceptable under Relying Party policy.
    + If ECDAA was used, verify that the identifier of the ECDAA-Issuer public key used is included in the set of acceptable trust anchors obtained in step 11.
    + Otherwise, use the X.509 certificates returned by the verification procedure to verify that the attestation public key correctly chains up to an acceptable root certificate.
13. If the attestation statement attStmt verified successfully and is found to be trustworthy, then register the new credential with the account that was denoted in the options.user passed to create(), by associating it with the credential ID and credential public key contained in authData's attestation data, as appropriate for the Relying Party's systems.
14. If the attestation statement attStmt successfully verified but is not trustworthy per step 12 above, the Relying Party SHOULD fail the registration ceremony.
    NOTE: However, if permitted by policy, the Relying Party MAY register the credential ID and credential public key but treat the credential as one with self-attestation (see 5.3.3 Attestation Types). If doing so, the Relying Party is asserting there is no cryptographic proof that the public key credential has been generated by a particular authenticator model. See [FIDOSecRef] and [UAFProtocol] for a more detailed discussion.

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2. Verify that the challenge in C matches the challenge that was sent to the authenticator in the create() call.
3. Verify that the origin in C matches the Relying Party's origin.
4. Verify that the tokenBindingId in C matches the Token Binding ID for the TLS connection over which the attestation was obtained.
5. Verify that the clientExtensions in C is a proper subset of the extensions requested by the RP and that the authenticatorExtensions in C is also a proper subset of the extensions requested by the RP.
6. Compute the hash of clientDataJSON using the algorithm identified by C.hashAlgorithm.
7. Perform CBOR decoding on the attestationObject field of the AuthenticatorAttestationResponse structure to obtain the attestation statement format fmt, the authenticator data authData, and the attestation statement attStmt.
8. Verify that the RP ID hash in authData is indeed the SHA-256 hash of the RP ID expected by the RP.
9. Determine the attestation statement format by performing an USASCII case-sensitive match on fmt against the set of supported WebAuthn Attestation Statement Format Identifier values. The up-to-date list of registered WebAuthn Attestation Statement Format Identifier values is maintained in the in the IANA registry of the same name [WebAuthn-Registries].
10. Verify that attStmt is a correct, validly-signed attestation statement, using the attestation statement format fmt's verification procedure given authenticator data authData and the hash of the serialized client data computed in step 6.
11. If validation is successful, obtain a list of acceptable trust anchors (attestation root certificates or ECDAA-Issuer public keys) for that attestation type and attestation statement format fmt, from a trusted source or from policy. For example, the FIDO Metadata Service [FIDOMetadataService] provides one way to obtain such information, using the AAGUID in the attestation data contained in authData.
12. Assess the attestation trustworthiness using the outputs of the verification procedure in step 10, as follows:
    + If self attestation was used, check if self attestation is acceptable under Relying Party policy.
    + If ECDAA was used, verify that the identifier of the ECDAA-Issuer public key used is included in the set of acceptable trust anchors obtained in step 11.
    + Otherwise, use the X.509 certificates returned by the verification procedure to verify that the attestation public key correctly chains up to an acceptable root certificate.
13. If the attestation statement attStmt verified successfully and is found to be trustworthy, then register the new credential with the account that was denoted in the options.user passed to create(), by associating it with the credential ID and credential public key contained in authData's attestation data, as appropriate for the Relying Party's systems.
14. If the attestation statement attStmt successfully verified but is not trustworthy per step 12 above, the Relying Party SHOULD fail the registration ceremony.
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15. If verification of the attestation statement failed, the Relying Party MUST fail the registration ceremony.

Verification of attestation objects requires that the Relying Party has a trusted method of determining acceptable trust anchors in step 11 above. Also, if certificates are being used, the Relying Party must have access to certificate status information for the intermediate CA certificates. The Relying Party must also be able to build the attestation certificate chain if the client did not provide this chain in the attestation information.

To avoid ambiguity during authentication, the Relying Party SHOULD check that each credential is registered to no more than one user. If registration is requested for a credential that is already registered to a different user, the Relying Party SHOULD fail this ceremony, or it MAY decide to accept the registration, e.g. while deleting the older registration.

6.2. Verifying an authentication assertion

When verifying a given PublicKeyCredential structure (credential) as part of an authentication ceremony, the Relying Party MUST proceed as follows:

1. Using credential's id attribute (or the corresponding rawId, if base64url encoding is inappropriate for your use case), look up the corresponding credential public key.
2. Let cData, aData and sig denote the value of credential's response's clientDataJSON, authenticatorData, and signature respectively.
3. Perform JSON deserialization on cData to extract the client data C used for the signature.
4. Verify that the challenge member of C matches the challenge that was sent to the authenticator in the PublicKeyCredentialRequestOptions passed to the get() call.
5. Verify that the origin member of C matches the Relying Party's origin.
6. Verify that the tokenBinding member of C (if present) matches the Token Binding ID for the TLS connection over which the signature was obtained.
7. Verify that the clientExtensions member of C is a proper subset of the extensions requested by the Relying Party and that the authenticatorExtensions in C is also a proper subset of the extensions requested by the Relying Party.
8. Verify that the RP ID hash in aData is the SHA-256 hash of the RP ID expected by the Relying Party.
9. Let hash be the result of computing a hash over the cData using the algorithm represented by the hashAlg member of C.
10. Using the credential public key looked up in step 1, verify that sig is a valid signature over the binary concatenation of aData and hash.
11. If all the above steps are successful, continue with the authentication ceremony as appropriate. Otherwise, fail the authentication ceremony.

7. Defined Attestation Statement Formats

WebAuthn supports pluggable attestation statement formats. This section defines an initial set of such formats.

7.1. Attestation Statement Format Identifiers

Attestation statement formats are identified by a string, called a attestation statement format identifier, chosen by the author of the attestation statement format.

Attestation statement format identifiers SHOULD be registered per [WebAuthn-Registries] "Registries for Web Authentication (WebAuthn)". All registered attestation statement format identifiers are unique amongst themselves as a matter of course.

15. If verification of the attestation statement failed, the Relying Party MUST fail the registration ceremony.

Verification of attestation objects requires that the Relying Party has a trusted method of determining acceptable trust anchors in step 11 above. Also, if certificates are being used, the Relying Party must have access to certificate status information for the intermediate CA certificates. The Relying Party must also be able to build the attestation certificate chain if the client did not provide this chain in the attestation information.

To avoid ambiguity during authentication, the Relying Party SHOULD check that each credential is registered to no more than one user. If registration is requested for a credential that is already registered to a different user, the Relying Party SHOULD fail this ceremony, or it MAY decide to accept the registration, e.g. while deleting the older registration.

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2. Let cData, aData and sig denote the value of credential's response's clientDataJSON, authenticatorData, and signature respectively.
3. Perform JSON deserialization on cData to extract the client data C used for the signature.
4. Verify that the challenge member of C matches the challenge that was sent to the authenticator in the PublicKeyCredentialRequestOptions passed to the get() call.
5. Verify that the origin member of C matches the Relying Party's origin.
6. Verify that the tokenBindingId member of C (if present) matches the Token Binding ID for the TLS connection over which the signature was obtained.
7. Verify that the clientExtensions member of C is a proper subset of the extensions requested by the Relying Party and that the authenticatorExtensions in C is also a proper subset of the extensions requested by the Relying Party.
8. Verify that the RP ID hash in aData is the SHA-256 hash of the RP ID expected by the Relying Party.
9. Let hash be the result of computing a hash over the cData using the algorithm represented by the hashAlgorithm member of C.
10. Using the credential public key looked up in step 1, verify that sig is a valid signature over the binary concatenation of aData and hash.
11. If all the above steps are successful, continue with the authentication ceremony as appropriate. Otherwise, fail the authentication ceremony.

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Attestation statement format identifiers SHOULD be registered per [WebAuthn-Registries] "Registries for Web Authentication (WebAuthn)". All registered attestation statement format identifiers are unique amongst themselves as a matter of course.

Unregistered attestation statement format identifiers SHOULD use lowercase reverse domain-name naming, using a domain name registered by the developer, in order to assure uniqueness of the identifier. All attestation statement format identifiers MUST be a maximum of 32 octets in length and MUST consist only of printable USASCII characters, excluding backslash and doublequote, i.e., VCHAR as defined in [RFC5234] but without %x22 and %x5c. (Note: This means attestation statement format identifiers based on domain names MUST incorporate only LDH Labels [RFC5890].) Implementations MUST match WebAuthn attestation statement format identifiers in a case-sensitive fashion.

Attestation statement formats that may exist in multiple versions SHOULD include a version in their identifier. In effect, different versions are thus treated as different formats, e.g., packed2 as a new version of the packed attestation statement format.

The following sections present a set of currently-defined and registered attestation statement formats and their identifiers. The up-to-date list of registered WebAuthn Extensions is maintained in the IANA "WebAuthn Attestation Statement Format Identifier" registry established by [WebAuthn-Registries].

7.2. Packed Attestation Statement Format

This is a WebAuthn optimized attestation statement format. It uses a very compact but still extensible encoding method. It is implementable by authenticators with limited resources (e.g., secure elements).

Attestation statement format identifier
    packed

Attestation types supported
    All

Syntax
    The syntax of a Packed Attestation statement is defined by the following CDDL:

```
 $$attStmtType //= (
                      fmt: "packed",
                      attStmt: packedStmtFormat
                  )

 packedStmtFormat = {
                       alg: rsaAlgName / eccAlgName,
                       sig: bytes,
                       x5c: [ attestnCert: bytes, * (caCert: bytes) ]
                   } //
                   {
                       alg: "ED256" / "ED512",
                       sig: bytes,
                       ecdaaKeyId: bytes
                   }
```

The semantics of the fields are as follows:

alg
    A text string containing the name of the algorithm used to generate the attestation signature. The types rsaAlgName and eccAlgName are as defined in 5.3.1 Attestation data. "ED256" and "ED512" refer to algorithms defined in [FIDOEcdaaAlgorithm].

sig
    A byte string containing the attestation signature.

x5c

Unregistered attestation statement format identifiers SHOULD use lowercase reverse domain-name naming, using a domain name registered by the developer, in order to assure uniqueness of the identifier. All attestation statement format identifiers MUST be a maximum of 32 octets in length and MUST consist only of printable USASCII characters, excluding backslash and doublequote, i.e., VCHAR as defined in [RFC5234] but without %x22 and %x5c.

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Implementations MUST match WebAuthn attestation statement format identifiers in a case-sensitive fashion.

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Attestation statement format identifier
    packed

Attestation types supported
    All

Syntax
    The syntax of a Packed Attestation statement is defined by the following CDDL:

```
 $$attStmtType //= (
                      fmt: "packed",
                      attStmt: packedStmtFormat
                  )

 packedStmtFormat = {
                       alg: rsaAlgName / eccAlgName,
                       sig: bytes,
                       x5c: [ attestnCert: bytes, * (caCert: bytes) ]
                   } //
                   {
                       alg: "ED256" / "ED512",
                       sig: bytes,
                       ecdaaKeyId: bytes
                   }
```

The semantics of the fields are as follows:

alg
    A text string containing the name of the algorithm used to generate the attestation signature. The types rsaAlgName and eccAlgName are as defined in 5.3.1 Attestation data. "ED256" and "ED512" refer to algorithms defined in [FIDOEcdaaAlgorithm].

sig
    A byte string containing the attestation signature.

x5c

The elements of this array contain the attestation certificate and its certificate chain, each encoded in X.509 format. The attestation certificate must be the first element in the array.

ecdaaKeyId
The identifier of the ECDAA-Issuer public key. This is the BigNumberToB encoding of the component "c" of the ECDAA-Issuer public key as defined section 3.3, step 3.5 in [FIDOEcdaaAlgorithm].

Signing procedure
The signing procedure for this attestation statement format is similar to the procedure for generating assertion signatures.

Let authenticatorData denote the authenticator data for the attestation, and let clientDataHash denote the hash of the serialized client data.

If Basic or Privacy CA attestation is in use, the authenticator produces the sig by concatenating authenticatorData and clientDataHash, and signing the result using an attestation private key selected through an authenticator-specific mechanism. It sets x5c to the certificate chain of the attestation public key and alg to the algorithm of the attestation private key.

If ECDAA is in use, the authenticator produces sig by concatenating authenticatorData and clientDataHash, and signing the result using ECDAA-Sign (see section 3.5 of [FIDOEcdaaAlgorithm]) with a ECDAA-Issuer public key selected through an authenticator-specific mechanism (see [FIDOEcdaaAlgorithm]). It sets alg to the algorithm of the ECDAA-Issuer public key and ecdaaKeyId to the identifier of the ECDAA-Issuer public key (see above).

If self attestation is in use, the authenticator produces sig by concatenating authenticatorData and clientDataHash, and signing the result using the credential private key. It sets alg to the algorithm of the credential private key, and omits the other fields.

Verification procedure
Verify that the given attestation statement is valid CBOR conforming to the syntax defined above.

Let authenticatorData denote the authenticator data claimed to have been used for the attestation, and let clientDataHash denote the hash of the serialized client data.

If x5c is present, this indicates that the attestation type is not ECDAA. In this case:

+ Verify that sig is a valid signature over the concatenation of authenticatorData and clientDataHash using the attestation public key in x5c with the algorithm specified in alg.
+ Verify that x5c meets the requirements in 7.2.1 Packed attestation statement certificate requirements.
+ If x5c contains an extension with OID 1 3 6 1 4 1 45724 1 1 4 (id-fido-gen-ce-aaguid) verify that the value of this extension matches the AAGUID in authenticatorData.
+ If successful, return attestation type Basic and trust path x5c.

If ecdaaKeyId is present, then the attestation type is ECDAA. In this case:

+ Verify that sig is a valid signature over the concatenation of authenticatorData and clientDataHash using ECDAA-Verify with ECDAA-Issuer public key identified by ecdaaKeyId (see

The elements of this array contain the attestation certificate and its certificate chain, each encoded in X.509 format. The attestation certificate must be the first element in the array.

ecdaaKeyId
The identifier of the ECDAA-Issuer public key. This is the BigNumberToB encoding of the component "c" of the ECDAA-Issuer public key as defined section 3.3, step 3.5 in [FIDOEcdaaAlgorithm].

Signing procedure
The signing procedure for this attestation statement format is similar to the procedure for generating assertion signatures.

Let authenticatorData denote the authenticator data for the attestation, and let clientDataHash denote the hash of the serialized client data.

If Basic or Privacy CA attestation is in use, the authenticator produces the sig by concatenating authenticatorData and clientDataHash, and signing the result using an attestation private key selected through an authenticator-specific mechanism. It sets x5c to the certificate chain of the attestation public key and alg to the algorithm of the attestation private key.

If ECDAA is in use, the authenticator produces sig by concatenating authenticatorData and clientDataHash, and signing the result using ECDAA-Sign (see section 3.5 of [FIDOEcdaaAlgorithm]) with a ECDAA-Issuer public key selected through an authenticator-specific mechanism (see [FIDOEcdaaAlgorithm]). It sets alg to the algorithm of the ECDAA-Issuer public key and ecdaaKeyId to the identifier of the ECDAA-Issuer public key (see above).

If self attestation is in use, the authenticator produces sig by concatenating authenticatorData and clientDataHash, and signing the result using the credential private key. It sets alg to the algorithm of the credential private key, and omits the other fields.

Verification procedure
Verify that the given attestation statement is valid CBOR conforming to the syntax defined above.

Let authenticatorData denote the authenticator data claimed to have been used for the attestation, and let clientDataHash denote the hash of the serialized client data.

If x5c is present, this indicates that the attestation type is not ECDAA. In this case:

+ Verify that sig is a valid signature over the concatenation of authenticatorData and clientDataHash using the attestation public key in x5c with the algorithm specified in alg.
+ Verify that x5c meets the requirements in 7.2.1 Packed attestation statement certificate requirements.
+ If x5c contains an extension with OID 1 3 6 1 4 1 45724 1 1 4 (id-fido-gen-ce-aaguid) verify that the value of this extension matches the AAGUID in authenticatorData.
+ If successful, return attestation type Basic and trust path x5c.

If ecdaaKeyId is present, then the attestation type is ECDAA. In this case:

+ Verify that sig is a valid signature over the concatenation of authenticatorData and clientDataHash using ECDAA-Verify with ECDAA-Issuer public key identified by ecdaaKeyId (see

[FIDOEcdaaAlgorithm]).
+ If successful, return attestation type ECDAA and trust path ecdaaKeyId.

If neither x5c nor ecdaaKeyId is present, self attestation is in use.

+ Validate that alg matches the algorithm of the credential private key in authenticatorData.
+ Verify that sig is a valid signature over the concatenation of authenticatorData and clientDataHash using the credential public key with alg.
+ If successful, return attestation type Self and empty trust path.

7.2.1. Packed attestation statement certificate requirements

The attestation certificate MUST have the following fields/extensions:
* Version must be set to 3.
* Subject field MUST be set to:

Subject-C
Country where the Authenticator vendor is incorporated

Subject-O
Legal name of the Authenticator vendor

Subject-OU
Authenticator Attestation

Subject-CN
No stipulation.

* If the related attestation root certificate is used for multiple authenticator models, the Extension OID 1 3 6 1 4 1 45724 1 1 4 (id-fido-gen-ce-aaguid) MUST be present, containing the AAGUID as value.
* The Basic Constraints extension MUST have the CA component set to false
* An Authority Information Access (AIA) extension with entry id-ad-ocsp and a CRL Distribution Point extension [RFC5280] are both optional as the status of many attestation certificates is available through authenticator metadata services. See, for example, the FIDO Metadata Service [FIDOMetadataService].

7.3. TPM Attestation Statement Format

This attestation statement format is generally used by authenticators that use a Trusted Platform Module as their cryptographic engine.

Attestation statement format identifier
tpm

Attestation types supported
Privacy CA, ECDAA

Syntax
The syntax of a TPM Attestation statement is as follows:

```
$$attStmtType // = (
                  fmt: "tpm",
                  attStmt: tpmStmtFormat
              )

tpmStmtFormat = {
                ver: "2.0",
                (
                  alg: rsaAlgName / eccAlgName,
                  x5c: [ aikCert: bytes, * (caCert: bytes) ]
                ) //
```


[FIDOEcdaaAlgorithm]).
+ If successful, return attestation type ECDAA and trust path ecdaaKeyId.

If neither x5c nor ecdaaKeyId is present, self attestation is in use.

+ Validate that alg matches the algorithm of the credential private key in authenticatorData.
+ Verify that sig is a valid signature over the concatenation of authenticatorData and clientDataHash using the credential public key with alg.
+ If successful, return attestation type Self and empty trust path.

7.2.1. Packed attestation statement certificate requirements

The attestation certificate MUST have the following fields/extensions:
* Version must be set to 3.
* Subject field MUST be set to:

Subject-C
Country where the Authenticator vendor is incorporated

Subject-O
Legal name of the Authenticator vendor

Subject-OU
Authenticator Attestation

Subject-CN
No stipulation.

* If the related attestation root certificate is used for multiple authenticator models, the Extension OID 1 3 6 1 4 1 45724 1 1 4 (id-fido-gen-ce-aaguid) MUST be present, containing the AAGUID as value.
* The Basic Constraints extension MUST have the CA component set to false
* An Authority Information Access (AIA) extension with entry id-ad-ocsp and a CRL Distribution Point extension [RFC5280] are both optional as the status of many attestation certificates is available through authenticator metadata services. See, for example, the FIDO Metadata Service [FIDOMetadataService].

7.3. TPM Attestation Statement Format

This attestation statement format is generally used by authenticators that use a Trusted Platform Module as their cryptographic engine.

Attestation statement format identifier
tpm

Attestation types supported
Privacy CA, ECDAA

Syntax
The syntax of a TPM Attestation statement is as follows:

```
$$attStmtType // = (
                  fmt: "tpm",
                  attStmt: tpmStmtFormat
              )

tpmStmtFormat = {
                ver: "2.0",
                (
                  alg: rsaAlgName / eccAlgName,
                  x5c: [ aikCert: bytes, * (caCert: bytes) ]
                ) //
```

```
                (
                   alg:  "ED256" / "ED512",
                   ecdaaKeyId: bytes
                ),
                sig: bytes,
                certInfo: bytes,
                pubArea: bytes
             }
```

The semantics of the above fields are as follows:

ver
: The version of the TPM specification to which the signature conforms.

alg
: The name of the algorithm used to generate the attestation signature. The types rsaAlgName and eccAlgNAme are as defined in 5.3.1 Attestation data. The types "ED256" and "ED512" refer to the algorithms specified in [FIDOEcdaaAlgorithm].

x5c
: The AIK certificate used for the attestation and its certificate chain, in X.509 encoding.

ecdaaKeyId
: The identifier of the ECDAA-Issuer public key. This is the BigNumberToB encoding of the component "c" as defined section 3.3, step 3.5 in [FIDOEcdaaAlgorithm].

sig
: The attestation signature, in the form of a TPMT_SIGNATURE structure as specified in [TPMv2-Part2] section 11.3.4.

certInfo
: The TPMS_ATTEST structure over which the above signature was computed, as specified in [TPMv2-Part2] section 10.12.8.

pubArea
: The TPMT_PUBLIC structure (see [TPMv2-Part2] section 12.2.4) used by the TPM to represent the credential public key.

Signing procedure

Let authenticatorData denote the authenticator data for the attestation, and let clientDataHash denote the hash of the serialized client data.

Concatenate authenticatorData and clientDataHash to form attToBeSigned.

Generate a signature using the procedure specified in [TPMv2-Part3] Section 18.2, using the attestation private key and setting the qualifyingData parameter to attToBeSigned.

Set the pubArea field to the public area of the credential public key, the certInfo field to the output parameter of the same name, and the sig field to the signature obtained from the above procedure.

Verification procedure

Verify that the given attestation statement is valid CBOR conforming to the syntax defined above.

Let authenticatorData denote the authenticator data claimed to have been used for the attestation, and let clientDataHash denote the hash of the serialized client data.


```
                (
                   alg:  "ED256" / "ED512",
                   ecdaaKeyId: bytes
                ),
                sig: bytes,
                certInfo: bytes,
                pubArea: bytes
             }
```

The semantics of the above fields are as follows:

ver
: The version of the TPM specification to which the signature conforms.

alg
: The name of the algorithm used to generate the attestation signature. The types rsaAlgName and eccAlgNAme are as defined in 5.3.1 Attestation data. The types "ED256" and "ED512" refer to the algorithms specified in [FIDOEcdaaAlgorithm].

x5c
: The AIK certificate used for the attestation and its certificate chain, in X.509 encoding.

ecdaaKeyId
: The identifier of the ECDAA-Issuer public key. This is the BigNumberToB encoding of the component "c" as defined section 3.3, step 3.5 in [FIDOEcdaaAlgorithm].

sig
: The attestation signature, in the form of a TPMT_SIGNATURE structure as specified in [TPMv2-Part2] section 11.3.4.

certInfo
: The TPMS_ATTEST structure over which the above signature was computed, as specified in [TPMv2-Part2] section 10.12.8.

pubArea
: The TPMT_PUBLIC structure (see [TPMv2-Part2] section 12.2.4) used by the TPM to represent the credential public key.

Signing procedure

Let authenticatorData denote the authenticator data for the attestation, and let clientDataHash denote the hash of the serialized client data.

Concatenate authenticatorData and clientDataHash to form attToBeSigned.

Generate a signature using the procedure specified in [TPMv2-Part3] Section 18.2, using the attestation private key and setting the qualifyingData parameter to attToBeSigned.

Set the pubArea field to the public area of the credential public key, the certInfo field to the output parameter of the same name, and the sig field to the signature obtained from the above procedure.

Verification procedure

Verify that the given attestation statement is valid CBOR conforming to the syntax defined above.

Let authenticatorData denote the authenticator data claimed to have been used for the attestation, and let clientDataHash denote the hash of the serialized client data.

Verify that the public key specified by the parameters and unique fields of pubArea is identical to the public key contained in the attestation data inside authenticatorData.

Concatenate authenticatorData and clientDataHash to form attToBeSigned.

Validate that certInfo is valid:

+ Verify that magic is set to TPM_GENERATED_VALUE.
+ Verify that type is set to TPM_ST_ATTEST_CERTIFY.
+ Verify that extraData is set to attToBeSigned.
+ Verify that attested contains a TPMS_CERTIFY_INFO structure, whose name field contains a valid Name for pubArea, as computed using the algorithm in the nameAlg field of pubArea using the procedure specified in [TPMv2-Part1] section 16.

If x5c is present, this indicates that the attestation type is not ECDAA. In this case:

+ Verify the sig is a valid signature over certInfo using the attestation public key in x5c with the algorithm specified in alg.
+ Verify that x5c meets the requirements in 7.3.1 TPM attestation statement certificate requirements.
+ If x5c contains an extension with OID 1 3 6 1 4 1 45724 1 1 4 (id-fido-gen-ce-aaguid) verify that the value of this extension matches the AAGUID in authenticatorData.
+ If successful, return attestation type Privacy CA and trust path x5c.

If ecdaaKeyId is present, then the attestation type is ECDAA.

+ Perform ECDAA-Verify on sig to verify that it is a valid signature over certInfo (see [FIDOEcdaaAlgorithm]).
+ If successful, return attestation type ECDAA and the identifier of the ECDAA-Issuer public key ecdaaKeyId.

7.3.1. TPM attestation statement certificate requirements

TPM attestation certificate MUST have the following fields/extensions:

* Version must be set to 3.
* Subject field MUST be set to empty.
* The Subject Alternative Name extension must be set as defined in [TPMv2-EK-Profile] section 3.2.9.
* The Extended Key Usage extension MUST contain the "joint-iso-itu-t(2) internationalorganizations(23) 133 tcg-kp(8) tcg-kp-AIKCertificate(3)" OID.
* The Basic Constraints extension MUST have the CA component set to false.
* An Authority Information Access (AIA) extension with entry id-ad-ocsp and a CRL Distribution Point extension [RFC5280] are both optional as the status of many attestation certificates is available through metadata services. See, for example, the FIDO Metadata Service [FIDOMetadataService].

7.4. Android Key Attestation Statement Format

When the authenticator in question is a platform-provided Authenticator on the Android "N" or later platform, the attestation statement is based on the Android key attestation. In these cases, the attestation statement is produced by a component running in a secure operating environment, but the authenticator data for the attestation is produced outside this environment. The Relying Party is expected to check that the authenticator data claimed to have been used for the attestation is consistent with the fields of the attestation certificate's extension data.

Attestation statement format identifier
    android-key

Verify that the public key specified by the parameters and unique fields of pubArea is identical to the public key contained in the attestation data inside authenticatorData.

Concatenate authenticatorData and clientDataHash to form attToBeSigned.

Validate that certInfo is valid:

+ Verify that magic is set to TPM_GENERATED_VALUE.
+ Verify that type is set to TPM_ST_ATTEST_CERTIFY.
+ Verify that extraData is set to attToBeSigned.
+ Verify that attested contains a TPMS_CERTIFY_INFO structure, whose name field contains a valid Name for pubArea, as computed using the algorithm in the nameAlg field of pubArea using the procedure specified in [TPMv2-Part1] section 16.

If x5c is present, this indicates that the attestation type is not ECDAA. In this case:

+ Verify the sig is a valid signature over certInfo using the attestation public key in x5c with the algorithm specified in alg.
+ Verify that x5c meets the requirements in 7.3.1 TPM attestation statement certificate requirements.
+ If x5c contains an extension with OID 1 3 6 1 4 1 45724 1 1 4 (id-fido-gen-ce-aaguid) verify that the value of this extension matches the AAGUID in authenticatorData.
+ If successful, return attestation type Privacy CA and trust path x5c.

If ecdaaKeyId is present, then the attestation type is ECDAA.

+ Perform ECDAA-Verify on sig to verify that it is a valid signature over certInfo (see [FIDOEcdaaAlgorithm]).
+ If successful, return attestation type ECDAA and the identifier of the ECDAA-Issuer public key ecdaaKeyId.

7.3.1. TPM attestation statement certificate requirements

TPM attestation certificate MUST have the following fields/extensions:

* Version must be set to 3.
* Subject field MUST be set to empty.
* The Subject Alternative Name extension must be set as defined in [TPMv2-EK-Profile] section 3.2.9.
* The Extended Key Usage extension MUST contain the "joint-iso-itu-t(2) internationalorganizations(23) 133 tcg-kp(8) tcg-kp-AIKCertificate(3)" OID.
* The Basic Constraints extension MUST have the CA component set to false.
* An Authority Information Access (AIA) extension with entry id-ad-ocsp and a CRL Distribution Point extension [RFC5280] are both optional as the status of many attestation certificates is available through metadata services. See, for example, the FIDO Metadata Service [FIDOMetadataService].

7.4. Android Key Attestation Statement Format

When the authenticator in question is a platform-provided Authenticator on the Android "N" or later platform, the attestation statement is based on the Android key attestation. In these cases, the attestation statement is produced by a component running in a secure operating environment, but the authenticator data for the attestation is produced outside this environment. The Relying Party is expected to check that the authenticator data claimed to have been used for the attestation is consistent with the fields of the attestation certificate's extension data.

Attestation statement format identifier
    android-key

Attestation types supported
Basic

Syntax
An Android key attestation statement consists simply of the Android attestation statement, which is a series of DER encoded X.509 certificates. See the Android developer documentation. Its syntax is defined as follows:

```
 $$attStmtType //= (
                       fmt: "android-key",
                       attStmt: androidStmtFormat
                   )

 androidStmtFormat = bytes
```

Signing procedure
Let authenticatorData denote the authenticator data for the attestation, and let clientDataHash denote the hash of the serialized client data.

Concatenate authenticatorData and clientDataHash to form attToBeSigned.

Request a Android Key Attestation by calling "keyStore.getCertificateChain(myKeyUUID)") providing attToBeSigned as the challenge value (e.g., by using setAttestationChallenge), and set the attestation statement to the returned value.

Verification procedure
Verification is performed as follows:

+ Let authenticatorData denote the authenticator data claimed to have been used for the attestation, and let clientDataHash denote the hash of the serialized client data.
+ Verify that the public key in the first certificate in the series of certificates represented by the signature matches the credential public key in the attestation data field of authenticatorData.
+ Verify that in the attestation certificate extension data:
  o The value of the attestationChallenge field is identical to the concatenation of authenticatorData and clientDataHash.
  o The AuthorizationList.allApplications field is not present, since PublicKeyCredentials must be bound to the RP ID.
  o The value in the AuthorizationList.origin field is equal to KM_TAG_GENERATED.
  o The value in the AuthorizationList.purpose field is equal to KM_PURPOSE_SIGN.
+ If successful, return attestation type Basic with the trust path set to the entire attestation statement.

7.5. Android SafetyNet Attestation Statement Format

When the authenticator in question is a platform-provided Authenticator on certain Android platforms, the attestation statement is based on the SafetyNet API. In this case the authenticator data is completely controlled by the caller of the SafetyNet API (typically an application running on the Android platform) and the attestation statement only provides some statements about the health of the platform and the identity of the calling application.

Attestation statement format identifier
android-safetynet

Attestation types supported
Basic

Attestation types supported
Basic

Syntax
An Android key attestation statement consists simply of the Android attestation statement, which is a series of DER encoded X.509 certificates. See the Android developer documentation. Its syntax is defined as follows:

```
 $$attStmtType //= (
                       fmt: "android-key",
                       attStmt: androidStmtFormat
                   )

 androidStmtFormat = bytes
```

Signing procedure
Let authenticatorData denote the authenticator data for the attestation, and let clientDataHash denote the hash of the serialized client data.

Concatenate authenticatorData and clientDataHash to form attToBeSigned.

Request an Android Key Attestation by calling "keyStore.getCertificateChain(myKeyUUID)") providing attToBeSigned as the challenge value (e.g., by using setAttestationChallenge), and set the attestation statement to the returned value.

Verification procedure
Verification is performed as follows:

+ Let authenticatorData denote the authenticator data claimed to have been used for the attestation, and let clientDataHash denote the hash of the serialized client data.
+ Verify that the public key in the first certificate in the series of certificates represented by the signature matches the credential public key in the attestation data field of authenticatorData.
+ Verify that in the attestation certificate extension data:
  o The value of the attestationChallenge field is identical to the concatenation of authenticatorData and clientDataHash.
  o The AuthorizationList.allApplications field is not present, since PublicKeyCredentials must be bound to the RP ID.
  o The value in the AuthorizationList.origin field is equal to KM_TAG_GENERATED.
  o The value in the AuthorizationList.purpose field is equal to KM_PURPOSE_SIGN.
+ If successful, return attestation type Basic with the trust path set to the entire attestation statement.

7.5. Android SafetyNet Attestation Statement Format

When the authenticator in question is a platform-provided Authenticator on certain Android platforms, the attestation statement is based on the SafetyNet API. In this case the authenticator data is completely controlled by the caller of the SafetyNet API (typically an application running on the Android platform) and the attestation statement only provides some statements about the health of the platform and the identity of the calling application.

Attestation statement format identifier
android-safetynet

Attestation types supported
Basic

Syntax
The syntax of an Android Attestation statement is defined as follows:

```
$$attStmtType //= (
                      fmt: "android-safetynet",
                      attStmt: safetynetStmtFormat
                  )

safetynetStmtFormat = {
                          ver: text,
                          response: bytes
                      }
```

The semantics of the above fields are as follows:

ver
The version number of Google Play Services responsible for providing the SafetyNet API.

response
The value returned by the above SafetyNet API. This value is a JWS [RFC7515] object (see SafetyNet online documentation) in Compact Serialization.

Signing procedure
Let authenticatorData denote the authenticator data for the attestation, and let clientDataHash denote the hash of the serialized client data.

Concatenate authenticatorData and clientDataHash to form attToBeSigned.

Request a SafetyNet attestation, providing attToBeSigned as the nonce value. Set response to the result, and ver to the version of Google Play Services running in the authenticator.

Verification procedure
Verification is performed as follows:

+ Verify that the given attestation statement is valid CBOR conforming to the syntax defined above.
+ Verify that response is a valid SafetyNet response of version ver.
+ Verify that the nonce in the response is identical to the concatenation of the authenticatorData and clientDataHash.
+ Verify that the attestation certificate is issued to the hostname "attest.android.com" (see SafetyNet online documentation).
+ Verify that the ctsProfileMatch attribute in the payload of response is true.
+ If successful, return attestation type Basic with the trust path set to the above attestation certificate.

7.6. FIDO U2F Attestation Statement Format

This attestation statement format is used with FIDO U2F authenticators using the formats defined in [FIDO-U2F-Message-Formats].

Attestation statement format identifier
fido-u2f

Attestation types supported
Basic

Syntax
The syntax of a FIDO U2F attestation statement is defined as follows:

Syntax
The syntax of an Android Attestation statement is defined as follows:

```
$$attStmtType //= (
                      fmt: "android-safetynet",
                      attStmt: safetynetStmtFormat
                  )

safetynetStmtFormat = {
                          ver: text,
                          response: bytes
                      }
```

The semantics of the above fields are as follows:

ver
The version number of Google Play Services responsible for providing the SafetyNet API.

response
The value returned by the above SafetyNet API. This value is a JWS [RFC7515] object (see SafetyNet online documentation) in Compact Serialization.

Signing procedure
Let authenticatorData denote the authenticator data for the attestation, and let clientDataHash denote the hash of the serialized client data.

Concatenate authenticatorData and clientDataHash to form attToBeSigned.

Request a SafetyNet attestation, providing attToBeSigned as the nonce value. Set response to the result, and ver to the version of Google Play Services running in the authenticator.

Verification procedure
Verification is performed as follows:

+ Verify that the given attestation statement is valid CBOR conforming to the syntax defined above.
+ Verify that response is a valid SafetyNet response of version ver.
+ Verify that the nonce in the response is identical to the concatenation of the authenticatorData and clientDataHash.
+ Verify that the attestation certificate is issued to the hostname "attest.android.com" (see SafetyNet online documentation).
+ Verify that the ctsProfileMatch attribute in the payload of response is true.
+ If successful, return attestation type Basic with the trust path set to the above attestation certificate.

7.6. FIDO U2F Attestation Statement Format

This attestation statement format is used with FIDO U2F authenticators using the formats defined in [FIDO-U2F-Message-Formats].

Attestation statement format identifier
fido-u2f

Attestation types supported
Basic, self attestation

Syntax
The syntax of a FIDO U2F attestation statement is defined as follows:

```
$$attStmtType //= (
                      fmt: "fido-u2f",
                      attStmt: u2fStmtFormat
                  )

u2fStmtFormat = {
                    x5c: [ attestnCert: bytes, * (caCert: bytes) ],
                    sig: bytes
                }
```

The semantics of the above fields are as follows:

x5c
: The elements of this array contain the attestation certificate and its certificate chain, each encoded in X.509 format. The attestation certificate must be the first element in the array.

sig
: The attestation signature.

Signing procedure
: If the credential public key of the given credential is not of algorithm "ES256", stop and return an error.

Let authenticatorData denote the authenticator data for the attestation, and let clientDataHash denote the hash of the serialized client data.

If clientDataHash is 256 bits long, set tbsHash to this value. Otherwise set tbsHash to the SHA-256 hash of clientDataHash.

Generate a signature as specified in [FIDO-U2F-Message-Formats] section 4.3, with the application parameter set to the SHA-256 hash of the RP ID associated with the given credential, the challenge parameter set to tbsHash, and the key handle parameter set to the credential ID of the given credential. Set this as sig and set the attestation certificate of the attestation public key as x5c.

Verification procedure
: Verification is performed as follows:

+ Verify that the given attestation statement is valid CBOR conforming to the syntax defined above.
+ If x5c is not a certificate for an ECDSA public key over the P-256 curve, stop verification and return an error.
+ Let authenticatorData denote the authenticator data claimed to have been used for the attestation, and let clientDataHash denote the hash of the serialized client data.
+ If clientDataHash is 256 bits long, set tbsHash to this value. Otherwise set tbsHash to the SHA-256 hash of clientDataHash.
+ From authenticatorData, extract the claimed RP ID hash, the claimed credential ID and the claimed credential public key.
+ Generate the claimed to-be-signed data as specified in [FIDO-U2F-Message-Formats] section 4.3, with the application parameter set to the claimed RP ID hash, the challenge parameter set to tbsHash, the key handle parameter set to the claimed credential ID of the given credential, and the user public key parameter set to the claimed credential public key.
+ Verify that the sig is a valid ECDSA P-256 signature over the to-be-signed data constructed above.
+ If successful, return attestation type Basic with the trust path set to x5c.

8. WebAuthn Extensions

The mechanism for generating public key credentials, as well as requesting and generating Authentication assertions, as defined in 4 Web Authentication API, can be extended to suit particular use cases.


```
$$attStmtType //= (
                      fmt: "fido-u2f",
                      attStmt: u2fStmtFormat
                  )

u2fStmtFormat = {
                    x5c: [ attestnCert: bytes, * (caCert: bytes) ],
                    sig: bytes
                }
```

The semantics of the above fields are as follows:

x5c
: The elements of this array contain the attestation certificate and its certificate chain, each encoded in X.509 format. The attestation certificate must be the first element in the array.

sig
: The attestation signature.

Signing procedure
: If the credential public key of the given credential is not of algorithm -7 ("ES256"), stop and return an error.

Let authenticatorData denote the authenticator data for the attestation, and let clientDataHash denote the hash of the serialized client data.

If clientDataHash is 256 bits long, set tbsHash to this value. Otherwise set tbsHash to the SHA-256 hash of clientDataHash.

Generate a signature as specified in [FIDO-U2F-Message-Formats] section 4.3, with the application parameter set to the SHA-256 hash of the RP ID associated with the given credential, the challenge parameter set to tbsHash, and the key handle parameter set to the credential ID of the given credential. Set this as sig and set the attestation certificate of the attestation public key as x5c.

Verification procedure
: Verification is performed as follows:

+ Verify that the given attestation statement is valid CBOR conforming to the syntax defined above.
+ If x5c is not a certificate for an ECDSA public key over the P-256 curve, stop verification and return an error.
+ Let authenticatorData denote the authenticator data claimed to have been used for the attestation, and let clientDataHash denote the hash of the serialized client data.
+ If clientDataHash is 256 bits long, set tbsHash to this value. Otherwise set tbsHash to the SHA-256 hash of clientDataHash.
+ From authenticatorData, extract the claimed RP ID hash, the claimed credential ID and the claimed credential public key.
+ Generate the claimed to-be-signed data as specified in [FIDO-U2F-Message-Formats] section 4.3, with the application parameter set to the claimed RP ID hash, the challenge parameter set to tbsHash, the key handle parameter set to the claimed credential ID of the given credential, and the user public key parameter set to the claimed credential public key.
+ Verify that the sig is a valid ECDSA P-256 signature over the to-be-signed data constructed above.
+ If successful, return attestation type Basic with the trust path set to x5c.

8. WebAuthn Extensions

The mechanism for generating public key credentials, as well as requesting and generating Authentication assertions, as defined in 4 Web Authentication API, can be extended to suit particular use cases.

Each case is addressed by defining a registration extension and/or an authentication extension.

Every extension is a client extension, meaning that the extension involves communication with and processing by the client. Client extensions define the following steps and data:
  * navigator.credentials.create() extension request parameters and response values for registration extensions.
  * navigator.credentials.get() extension request parameters and response values for authentication extensions.
  * Client extension processing for registration extensions and authentication extensions.

When creating a public key credential or requesting an authentication assertion, a Relying Party can request the use of a set of extensions. These extensions will be invoked during the requested operation if they are supported by the client and/or the authenticator. The Relying Party sends the client extension input for each extension in the get() call (for authentication extensions) or create() call (for registration extensions) to the client platform. The client platform performs client extension processing for each extension that it supports, and augments the client data as specified by each extension, by including the extension identifier and client extension output values.

An extension can also be an authenticator extension, meaning that the extension invoves communication with and processing by the authenticator. Authenticator extensions define the following steps and data:
  * authenticatorMakeCredential extension request parameters and response values for registration extensions.
  * authenticatorGetAssertion extension request parameters and response values for authentication extensions.
  * Authenticator extension processing for registration extensions and authentication extensions.

For authenticator extensions, as part of the client extension processing, the client also creates the CBOR authenticator extension input value for each extension (often based on the corresponding client extension input value), and passes them to the authenticator in the create() call (for registration extensions) or the get() call (for authentication extensions). These authenticator extension input values are represented in CBOR and passed as name-value pairs, with the extension identifier as the name, and the corresponding authenticator extension input as the value. The authenticator, in turn, performs additional processing for the extensions that it supports, and returns the CBOR authenticator extension output for each as specified by the extension. Part of the client extension processing for authenticator extensions is to use the authenticator extension output as an input to creating the client extension output.

All WebAuthn extensions are optional for both clients and authenticators. Thus, any extensions requested by a Relying Party may be ignored by the client browser or OS and not passed to the authenticator at all, or they may be ignored by the authenticator. Ignoring an extension is never considered a failure in WebAuthn API processing, so when Relying Parties include extensions with any API calls, they must be prepared to handle cases where some or all of those extensions are ignored.

Clients wishing to support the widest possible range of extensions may choose to pass through any extensions that they do not recognize to authenticators, generating the authenticator extension input by simply encoding the client extension input in CBOR. All WebAuthn extensions MUST be defined in such a way that this implementation choice does not endanger the user's security or privacy. For instance, if an extension requires client processing, it could be defined in a manner that ensures such a nave pass-through will produce a semantically invalid authenticator extension input value, resulting in the extension being ignored by the authenticator. Since all extensions are optional, this will not cause a functional failure in the API operation. Likewise,

Each case is addressed by defining a registration extension and/or an authentication extension.

Every extension is a client extension, meaning that the extension involves communication with and processing by the client. Client extensions define the following steps and data:
  * navigator.credentials.create() extension request parameters and response values for registration extensions.
  * navigator.credentials.get() extension request parameters and response values for authentication extensions.
  * Client extension processing for registration extensions and authentication extensions.

When creating a public key credential or requesting an authentication assertion, a Relying Party can request the use of a set of extensions. These extensions will be invoked during the requested operation if they are supported by the client and/or the authenticator. The Relying Party sends the client extension input for each extension in the get() call (for authentication extensions) or create() call (for registration extensions) to the client platform. The client platform performs client extension processing for each extension that it supports, and augments the client data as specified by each extension, by including the extension identifier and client extension output values.

An extension can also be an authenticator extension, meaning that the extension invoves communication with and processing by the authenticator. Authenticator extensions define the following steps and data:
  * authenticatorMakeCredential extension request parameters and response values for registration extensions.
  * authenticatorGetAssertion extension request parameters and response values for authentication extensions.
  * Authenticator extension processing for registration extensions and authentication extensions.

For authenticator extensions, as part of the client extension processing, the client also creates the CBOR authenticator extension input value for each extension (often based on the corresponding client extension input value), and passes them to the authenticator in the create() call (for registration extensions) or the get() call (for authentication extensions). These authenticator extension input values are represented in CBOR and passed as name-value pairs, with the extension identifier as the name, and the corresponding authenticator extension input as the value. The authenticator, in turn, performs additional processing for the extensions that it supports, and returns the CBOR authenticator extension output for each as specified by the extension. Part of the client extension processing for authenticator extensions is to use the authenticator extension output as an input to creating the client extension output.

All WebAuthn extensions are optional for both clients and authenticators. Thus, any extensions requested by a Relying Party may be ignored by the client browser or OS and not passed to the authenticator at all, or they may be ignored by the authenticator. Ignoring an extension is never considered a failure in WebAuthn API processing, so when Relying Parties include extensions with any API calls, they must be prepared to handle cases where some or all of those extensions are ignored.

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clients can choose to produce a client extension output value for an extension that it does not understand by encoding the authenticator extension output value into JSON, provided that the CBOR output uses only types present in JSON.

The IANA "WebAuthn Extension Identifier" registry established by [WebAuthn-Registries] should be consulted for an up-to-date list of registered WebAuthn Extensions.

8.1. Extension Identifiers

Extensions are identified by a string, called an extension identifier, chosen by the extension author.

Extension identifiers SHOULD be registered per [WebAuthn-Registries] "Registries for Web Authentication (WebAuthn)". All registered extension identifiers are unique amongst themselves as a matter of course.

Unregistered extension identifiers should aim to be globally unique, e.g., by including the defining entity such as myCompany_extension.

All extension identifiers MUST be a maximum of 32 octets in length and MUST consist only of printable USASCII characters, excluding backslash and doublequote, i.e., VCHAR as defined in [RFC5234] but without %x22 and %x5c. Implementations MUST match WebAuthn extension identifiers in a case-sensitive fashion.

Extensions that may exist in multiple versions should take care to include a version in their identifier. In effect, different versions are thus treated as different extensions, e.g., myCompany_extension_01

9 Defined Extensions defines an initial set of extensions and their identifiers. See the IANA "WebAuthn Extension Identifier" registry established by [WebAuthn-Registries] for an up-to-date list of registered WebAuthn Extension Identifiers.

8.2. Defining extensions

A definition of an extension must specify an extension identifier, a client extension input argument to be sent via the get() or create() call, the client extension processing rules, and a client extension output value. If the extension communicates with the authenticator (meaning it is an authenticator extension), it must also specify the CBOR authenticator extension input argument sent via the authenticatorGetAssertion or authenticatorMakeCredential call, the authenticator extension processing rules, and the CBOR authenticator extension output value.

Any client extension that is processed by the client MUST return a client extension output value so that the Relying Party knows that the extension was honored by the client. Similarly, any extension that requires authenticator processing MUST return an authenticator extension output to let the Relying Party know that the extension was honored by the authenticator. If an extension does not otherwise require any result values, it SHOULD be defined as returning a JSON Boolean client extension output result, set to true to signify that the extension was understood and processed. Likewise, any authenticator extension that does not otherwise require any result values MUST return a value and SHOULD return a CBOR Boolean authenticator extension output result, set to true to signify that the extension was understood and processed.

8.3. Extending request parameters

An extension defines one or two request arguments. The client extension input, which is a value that can be encoded in JSON, is passed from the Relying Party to the client in the get() or create() call, while the CBOR authenticator extension input is passed from the client to the authenticator for authenticator extensions during the processing of

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Any client extension that is processed by the client MUST return a client extension output value so that the Relying Party knows that the extension was honored by the client. Similarly, any extension that requires authenticator processing MUST return an authenticator extension output to let the Relying Party know that the extension was honored by the authenticator. If an extension does not otherwise require any result values, it SHOULD be defined as returning a JSON Boolean client extension output result, set to true to signify that the extension was understood and processed. Likewise, any authenticator extension that does not otherwise require any result values MUST return a value and SHOULD return a CBOR Boolean authenticator extension output result, set to true to signify that the extension was understood and processed.

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An extension defines one or two request arguments. The client extension input, which is a value that can be encoded in JSON, is passed from the Relying Party to the client in the get() or create() call, while the CBOR authenticator extension input is passed from the client to the authenticator for authenticator extensions during the processing of

these calls.

A Relying Party simultaneously requests the use of an extension and sets its client extension input by including an entry in the extensions option to the create() or get() call. The entry key is the extension identifier and the value is the client extension input.

```
var assertionPromise = navigator.credentials.get({
  publicKey: {
    challenge: "...",
    extensions: {
      "webauthnExample_foobar": 42
    }
  }
});
```

Extension definitions MUST specify the valid values for their client extension input. Clients SHOULD ignore extensions with an invalid client extension input. If an extension does not require any parameters from the Relying Party, it SHOULD be defined as taking a Boolean client argument, set to true to signify that the extension is requested by the Relying Party.

Extensions that only affect client processing need not specify authenticator extension input. Extensions that have authenticator processing MUST specify the method of computing the authenticator extension input from the client extension input. For extensions that do not require input parameters and are defined as taking a Boolean client extension input value set to true, this method SHOULD consist of passing an authenticator extension input value of true (CBOR major type 7, value 21).

Note: Extensions should aim to define authenticator arguments that are as small as possible. Some authenticators communicate over low-bandwidth links such as Bluetooth Low-Energy or NFC.

8.4. Client extension processing

Extensions may define additional processing requirements on the client platform during the creation of credentials or the generation of an assertion. The client extension input for the extension is used an input to this client processing. Supported client extensions are recorded as a dictionary in the client data with the key clientExtensions. For each such extension, the client adds an entry to this dictionary with the extension identifier as the key, and the extension's client extension input as the value.

Likewise, the client extension outputs are represented as a dictionary in the clientExtensionResults with extension identifiers as keys, and the client extension output value of each extension as the value. Like the client extension input, the client extension output is a value that can be encoded in JSON.

Extensions that require authenticator processing MUST define the process by which the client extension input can be used to determine the CBOR authenticator extension input and the process by which the CBOR authenticator extension output can be used to determine the client extension output.

8.5. Authenticator extension processing

As specified in 5.1 Authenticator data, the CBOR authenticator extension input value of each processed authenticator extension is included in the extensions data part of the authenticator data. This part is a CBOR map, with CBOR extension identifier values as keys, and the CBOR authenticator extension input value of each extension as the value.

Likewise, the extension output is represented in the authenticator data as a CBOR map with CBOR extension identifiers as keys, and the CBOR authenticator extension output value of each extension as the value.

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var assertionPromise = navigator.credentials.get({
  publicKey: {
    challenge: "...",
    extensions: {
      "webauthnExample_foobar": 42
    }
  }
});

Extension definitions MUST specify the valid values for their client extension input. Clients SHOULD ignore extensions with an invalid client extension input. If an extension does not require any parameters from the Relying Party, it SHOULD be defined as taking a Boolean client argument, set to true to signify that the extension is requested by the Relying Party.

Extensions that only affect client processing need not specify authenticator extension input. Extensions that have authenticator processing MUST specify the method of computing the authenticator extension input from the client extension input. For extensions that do not require input parameters and are defined as taking a Boolean client extension input value set to true, this method SHOULD consist of passing an authenticator extension input value of true (CBOR major type 7, value 21).

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As specified in 5.1 Authenticator data, the CBOR authenticator extension input value of each processed authenticator extension is included in the extensions data part of the authenticator data. This part is a CBOR map, with CBOR extension identifier values as keys, and the CBOR authenticator extension input value of each extension as the value.

Likewise, the extension output is represented in the authenticator data as a CBOR map with CBOR extension identifiers as keys, and the CBOR authenticator extension output value of each extension as the value.

The authenticator extension processing rules are used create the authenticator extension output from the authenticator extension input, and possibly also other inputs, for each extension.

8.6. Example Extension

This section is not normative.

To illustrate the requirements above, consider a hypothetical registration extension and authentication extension "Geo". This extension, if supported, enables a geolocation location to be returned from the authenticator or client to the Relying Party.

The extension identifier is chosen as webauthnExample_geo. The client extension input is the constant value true, since the extension does not require the Relying Party to pass any particular information to the client, other than that it requests the use of the extension. The Relying Party sets this value in its request for an assertion:

```
var assertionPromise =
  navigator.credentials.get({
    publicKey: {
      challenge: "SGFulFNvbG8gc2hvdCBmaXJzdC4",
      allowList: [], /* Empty filter */
      extensions: { 'webauthnExample_geo': true }
    }
  });
```

The extension also requires the client to set the authenticator parameter to the fixed value true.

The extension requires the authenticator to specify its geolocation in the authenticator extension output, if known. The extension e.g. specifies that the location shall be encoded as a two-element array of floating point numbers, encoded with CBOR. An authenticator does this by including it in the authenticator data. As an example, authenticator data may be as follows (notation taken from [RFC7049]):

```
81 (hex)                                    -- Flags, ED and TUP both set.
20 05 58 1F                                   -- Signature counter
A1                                        -- CBOR map of one element
  73                                      -- Key 1: CBOR text string of 19 byt
es
    77 65 62 61 75 74 68 6E 45 78 61
    6D 70 6C 65 5F 67 65 6F             -- "webauthnExample_geo" [=UTF-8 enc
oded=] string
  82                                      -- Value 1: CBOR array of two elemen
ts
    FA 42 82 1E B3                     -- Element 1: Latitude as CBOR encod
ed float
    FA C1 5F E3 7F                     -- Element 2: Longitude as CBOR enco
ded float
```

The extension defines the client extension output to be the geolocation information, if known, as a GeoJSON [GeoJSON] point. The client constructs the following client data:

```
{
  ...,
  'extensions': {
    'webauthnExample_geo': {
      'type': 'Point',
      'coordinates': [65.059962, -13.993041]
    }
  }
}
```

9. Defined Extensions

This section defines the initial set of extensions to be registered in the IANA "WebAuthn Extension Identifier" registry established by [WebAuthn-Registries]. These are recommended for implementation by user

The authenticator extension processing rules are used create the authenticator extension output from the authenticator extension input, and possibly also other inputs, for each extension.

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To illustrate the requirements above, consider a hypothetical registration extension and authentication extension "Geo". This extension, if supported, enables a geolocation location to be returned from the authenticator or client to the Relying Party.

The extension identifier is chosen as webauthnExample_geo. The client extension input is the constant value true, since the extension does not require the Relying Party to pass any particular information to the client, other than that it requests the use of the extension. The Relying Party sets this value in its request for an assertion:

```
var assertionPromise =
  navigator.credentials.get({
    publicKey: {
      challenge: "SGFulFNvbG8gc2hvdCBmaXJzdC4",
      allowCredentials: [], /* Empty filter */
      extensions: { 'webauthnExample_geo': true }
    }
  });
```

The extension also requires the client to set the authenticator parameter to the fixed value true.

The extension requires the authenticator to specify its geolocation in the authenticator extension output, if known. The extension e.g. specifies that the location shall be encoded as a two-element array of floating point numbers, encoded with CBOR. An authenticator does this by including it in the authenticator data. As an example, authenticator data may be as follows (notation taken from [RFC7049]):

```
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20 05 58 1F                                   -- Signature counter
A1                                        -- CBOR map of one element
  73                                      -- Key 1: CBOR text string of 19 byt
es
    77 65 62 61 75 74 68 6E 45 78 61
    6D 70 6C 65 5F 67 65 6F             -- "webauthnExample_geo" [=UTF-8 enc
oded=] string
  82                                      -- Value 1: CBOR array of two elemen
ts
    FA 42 82 1E B3                     -- Element 1: Latitude as CBOR encod
ed float
    FA C1 5F E3 7F                     -- Element 2: Longitude as CBOR enco
ded float
```

The extension defines the client extension output to be the geolocation information, if known, as a GeoJSON [GeoJSON] point. The client constructs the following client data:

{
  ...,
  'extensions': {
    'webauthnExample_geo': {
      'type': 'Point',
      'coordinates': [65.059962, -13.993041]
    }
  }
}

9. Defined Extensions

This section defines the initial set of extensions to be registered in the IANA "WebAuthn Extension Identifier" registry established by [WebAuthn-Registries]. These are recommended for implementation by user

agents targeting broad interoperability.

9.1. FIDO AppId Extension (appid)

This authentication extension allows Relying Parties that have previously registered a credential using the legacy FIDO JavaScript APIs to request an assertion. Specifically, this extension allows Relying Parties to specify an appId [FIDO-APPID] to overwrite the otherwise computed rpId. This extension is only valid if used during the get() call; other usage will result in client error.

Extension identifier
    appid

Client extension input
    A single JSON string specifying a FIDO appId.

Client extension processing
    If rpId is present, reject promise with a DOMException whose name is "NotAllowedError", and terminate this algorithm. Replace the calculation of rpId in Step 3 of 4.1.4 Use an existing credential - PublicKeyCredential::[[DiscoverFromExternalSource]](options) method with the following procedure: The client uses the value of appid to perform the AppId validation procedure (as defined by [FIDO-APPID]). If valid, the value of rpId for all client processing should be replaced by the value of appid.

Client extension output
    Returns the JSON value true to indicate to the RP that the extension was acted upon

Authenticator extension input
    None.

Authenticator extension processing
    None.

Authenticator extension output
    None.

9.2. Simple Transaction Authorization Extension (txAuthSimple)

This registration extension and authentication extension allows for a simple form of transaction authorization. A Relying Party can specify a prompt string, intended for display on a trusted device on the authenticator.

Extension identifier
    txAuthSimple

Client extension input
    A single JSON string prompt.

Client extension processing
    None, except creating the authenticator extension input from the client extension input.

Client extension output
    Returns the authenticator extension output string UTF-8 decoded into a JSON string

Authenticator extension input
    The client extension input encoded as a CBOR text string (major type 3).

Authenticator extension processing
    The authenticator MUST display the prompt to the user before performing either user verification or test of user presence. The authenticator may insert line breaks if needed.

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Extension identifier
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Client extension processing
    If rpId is present, reject promise with a DOMException whose name is "NotAllowedError", and terminate this algorithm. Replace the calculation of rpId in Step 3 of 4.1.4 Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method with the following procedure: The client uses the value of appid to perform the AppId validation procedure (as defined by [FIDO-APPID]). If valid, the value of rpId for all client processing should be replaced by the value of appid.

Client extension output
    Returns the JSON value true to indicate to the RP that the extension was acted upon

Authenticator extension input
    None.

Authenticator extension processing
    None.

Authenticator extension output
    None.

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Client extension input
    A single JSON string prompt.

Client extension processing
    None, except creating the authenticator extension input from the client extension input.

Client extension output
    Returns the authenticator extension output string UTF-8 decoded into a JSON string

Authenticator extension input
    The client extension input encoded as a CBOR text string (major type 3).

Authenticator extension processing
    The authenticator MUST display the prompt to the user before performing either user verification or test of user presence. The authenticator may insert line breaks if needed.

Authenticator extension output
A single CBOR string, representing the prompt as displayed (including any eventual line breaks).

9.3. Generic Transaction Authorization Extension (txAuthGeneric)

This registration extension and authentication extension allows images to be used as transaction authorization prompts as well. This allows authenticators without a font rendering engine to be used and also supports a richer visual appearance.

Extension identifier
txAuthGeneric

Client extension input
A CBOR map defined as follows:

```
 txAuthGenericArg = {
                   contentType: text,   ; MIME-Type of the content, e.g.
"image/png"
                   content: bytes
                }
```

Client extension processing
None, except creating the authenticator extension input from the client extension input.

Client extension output
Returns the base64url encoding of the authenticator extension output value as a JSON string

Authenticator extension input
The client extension input encoded as a CBOR map.

Authenticator extension processing
The authenticator MUST display the content to the user before performing either user verification or test of user presence. The authenticator may add other information below the content. No changes are allowed to the content itself, i.e., inside content boundary box.

Authenticator extension output
The hash value of the content which was displayed. The authenticator MUST use the same hash algorithm as it uses for the signature itself.

9.4. Authenticator Selection Extension (authnSel)

This registration extension allows a Relying Party to guide the selection of the authenticator that will be leveraged when creating the credential. It is intended primarily for Relying Parties that wish to tightly control the experience around credential creation.

Extension identifier
authnSel

Client extension input
A sequence of AAGUIDs:

```
typedef sequence<AAGUID> AuthenticatorSelectionList;
```

Each AAGUID corresponds to an authenticator model that is acceptable to the Relying Party for this credential creation. The list is ordered by decreasing preference.

An AAGUID is defined as an array containing the globally unique identifier of the authenticator model being sought.

```
typedef BufferSource AAGUID;
```


Authenticator extension output
A single CBOR string, representing the prompt as displayed (including any eventual line breaks).

9.3. Generic Transaction Authorization Extension (txAuthGeneric)

This registration extension and authentication extension allows images to be used as transaction authorization prompts as well. This allows authenticators without a font rendering engine to be used and also supports a richer visual appearance.

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                   content: bytes
                }
```

Client extension processing
None, except creating the authenticator extension input from the client extension input.

Client extension output
Returns the base64url encoding of the authenticator extension output value as a JSON string

Authenticator extension input
The client extension input encoded as a CBOR map.

Authenticator extension processing
The authenticator MUST display the content to the user before performing either user verification or test of user presence. The authenticator may add other information below the content. No changes are allowed to the content itself, i.e., inside content boundary box.

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```
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```

Each AAGUID corresponds to an authenticator model that is acceptable to the Relying Party for this credential creation. The list is ordered by decreasing preference.

An AAGUID is defined as an array containing the globally unique identifier of the authenticator model being sought.

```
typedef BufferSource     AAGUID;
```

Client extension processing
This extension can only be used during create(). If the client supports the Authenticator Selection Extension, it MUST use the first available authenticator whose AAGUID is present in the AuthenticatorSelectionList. If none of the available authenticators match a provided AAGUID, the client MUST select an authenticator from among the available authenticators to generate the credential.

Client extension output
Returns the JSON value true to indicate to the RP that the extension was acted upon

Authenticator extension input
None.

Authenticator extension processing
None.

Authenticator extension output
None.

9.5. Supported Extensions Extension (exts)

This registration extension enables the Relying Party to determine which extensions the authenticator supports.

Extension identifier
exts

Client extension input
The Boolean value true to indicate that this extension is requested by the Relying Party.

Client extension processing
None, except creating the authenticator extension input from the client extension input.

Client extension output
Returns the list of supported extensions as a JSON array of extension identifier strings

Authenticator extension input
The Boolean value true, encoded in CBOR (major type 7, value 21).

Authenticator extension processing
The authenticator sets the authenticator extension output to be a list of extensions that the authenticator supports, as defined below. This extension can be added to attestation objects.

Authenticator extension output
The SupportedExtensions extension is a list (CBOR array) of extension identifier (UTF-8 encoded strings).

9.6. User Verification Index Extension (uvi)

This registration extension and authentication extension enables use of a user verification index.

Extension identifier
uvi

Client extension input
The Boolean value true to indicate that this extension is requested by the Relying Party.

Client extension processing
None, except creating the authenticator extension input from the

Client extension processing
This extension can only be used during create(). If the client supports the Authenticator Selection Extension, it MUST use the first available authenticator whose AAGUID is present in the AuthenticatorSelectionList. If none of the available authenticators match a provided AAGUID, the client MUST select an authenticator from among the available authenticators to generate the credential.

Client extension output
Returns the JSON value true to indicate to the RP that the extension was acted upon

Authenticator extension input
None.

Authenticator extension processing
None.

Authenticator extension output
None.

9.5. Supported Extensions Extension (exts)

This registration extension enables the Relying Party to determine which extensions the authenticator supports.

Extension identifier
exts

Client extension input
The Boolean value true to indicate that this extension is requested by the Relying Party.

Client extension processing
None, except creating the authenticator extension input from the client extension input.

Client extension output
Returns the list of supported extensions as a JSON array of extension identifier strings

Authenticator extension input
The Boolean value true, encoded in CBOR (major type 7, value 21).

Authenticator extension processing
The authenticator sets the authenticator extension output to be a list of extensions that the authenticator supports, as defined below. This extension can be added to attestation objects.

Authenticator extension output
The SupportedExtensions extension is a list (CBOR array) of extension identifier (UTF-8 encoded strings).

9.6. User Verification Index Extension (uvi)

This registration extension and authentication extension enables use of a user verification index.

Extension identifier
uvi

Client extension input
The Boolean value true to indicate that this extension is requested by the Relying Party.

Client extension processing
None, except creating the authenticator extension input from the

client extension input.

Client extension output
Returns a JSON string containing the base64url encoding of the authenticator extension output

Authenticator extension input
The Boolean value true, encoded in CBOR (major type 7, value 21).

Authenticator extension processing
The authenticator sets the authenticator extension output to be a user verification index indicating the method used by the user to authorize the operation, as defined below. This extension can be added to attestation objects and assertions.

Authenticator extension output
The user verification index (UVI) is a value uniquely identifying a user verification data record. The UVI is encoded as CBOR byte string (type 0x58). 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 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.

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

Example for authenticator data containing one UVI extension

```
...                                  -- RP ID hash (32 bytes)
81                                    -- TUP and ED set
00 00 00 01                               -- (initial) signature counter
...                                  -- all public key alg etc.
A1                                    -- extension: CBOR map of one elemen
t
   63                                 -- Key 1: CBOR text string of 3 byte
s
      75 76 69                          -- "uvi" [=UTF-8 encoded=] string
   58 20                                -- Value 1: CBOR byte string with 0x
20 bytes
      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
```

9.7. Location Extension (loc)

The location registration extension and authentication extension provides the client device's current location to the WebAuthn relying party.

Extension identifier
loc

Client extension input
The Boolean value true to indicate that this extension is

client extension input.

Client extension output
Returns a JSON string containing the base64url encoding of the authenticator extension output

Authenticator extension input
The Boolean value true, encoded in CBOR (major type 7, value 21).

Authenticator extension processing
The authenticator sets the authenticator extension output to be a user verification index indicating the method used by the user to authorize the operation, as defined below. This extension can be added to attestation objects and assertions.

Authenticator extension output
The user verification index (UVI) is a value uniquely identifying a user verification data record. The UVI is encoded as CBOR byte string (type 0x58). 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 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.

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

Example for authenticator data containing one UVI extension

```
...                                  -- [=RP ID=] hash (32 bytes)
81                                    -- UP and ED set
00 00 00 01                               -- (initial) signature counter
...                                  -- all public key alg etc.
A1                                    -- extension: CBOR map of one elemen
t
   63                                 -- Key 1: CBOR text string of 3 byte
s
      75 76 69                          -- "uvi" [=UTF-8 encoded=] string
   58 20                                -- Value 1: CBOR byte string with 0x
20 bytes
      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
```

9.7. Location Extension (loc)

The location registration extension and authentication extension provides the client device's current location to the WebAuthn Relying Party.

Extension identifier
loc

Client extension input
The Boolean value true to indicate that this extension is

/Users/jehodges/Documents/work/standards/W3C/webauthn/index-master-tr-dda3e24-WD-05.txt, Top line: 3462

requested by the Relying Party.

Client extension processing
None, except creating the authenticator extension input from the client extension input.

Client extension output
Returns a JSON object that encodes the location information in the authenticator extension output as a Coordinates value, as defined by The W3C Geolocation API Specification.

Authenticator extension input
The Boolean value true, encoded in CBOR (major type 7, value 21).

Authenticator extension processing
If the authenticator does not support the extension, then the authenticator MUST ignore the extension request. If the authenticator accepts the extension, then the authenticator SHOULD only add this extension data to a packed attestation or assertion.

Authenticator extension output
If the authenticator accepts the extension request, then authenticator extension output SHOULD provide location data in the form of a CBOR-encoded map, with the first value being the extension identifier and the second being an array of returned values. The array elements SHOULD be derived from (key,value) pairings for each location attribute that the authenticator supports. The following is an example of authenticator data where the returned array is comprised of a {longitude, latitude, altitude} triplet, following the coordinate representation defined in The W3C Geolocation API Specification.

```
...                                  -- RP ID hash (32 bytes)
81                                    -- TUP and ED set
00 00 00 01                               -- (initial) signature counter
...                                  -- all public key alg etc.
A1                                    -- extension: CBOR map of one elemen
t
   63                                 -- Value 1: CBOR text string of 3 by
tes
      6C 6F 63                            -- "loc" [=UTF-8 encoded=] string
   86                                 -- Value 2: array of 6 elements
      68                  -- Element 1:  CBOR text string of 8 bytes
        6C 61 74 69 74 75 64 65         -- "latitude" [=UTF-8 encoded=] stri
ng
      FB ...                -- Element 2:  Latitude as CBOR encoded double-p
recision float
      69                  -- Element 3:  CBOR text string of 9 bytes
        6C 6F 6E 67 69 74 75 64 65       -- "longitude" [=UTF-8 encoded=] str
ing
      FB ...                -- Element 4:  Longitude as CBOR encoded double-
precision float
      68                  -- Element 5:  CBOR text string of 8 bytes
        61 6C 74 69 74 75 64 65         -- "altitude" [=UTF-8 encoded=] stri
ng
      FB ...                -- Element 6:  Altitude as CBOR encoded double-p
recision float
```

9.8. User Verification Method Extension (uvm)

This registration extension and authentication extension enables use of a user verification method.

Extension identifier
uvm

Client extension input
The Boolean value true to indicate that this extension is

/Users/jehodges/Documents/work/standards/W3C/webauthn/index-master-tr-598ac41-WD-06.txt, Top line: 3635

requested by the Relying Party.

Client extension processing
None, except creating the authenticator extension input from the client extension input.

Client extension output
Returns a JSON object that encodes the location information in the authenticator extension output as a Coordinates value, as defined by The W3C Geolocation API Specification.

Authenticator extension input
The Boolean value true, encoded in CBOR (major type 7, value 21).

Authenticator extension processing
If the authenticator does not support the extension, then the authenticator MUST ignore the extension request. If the authenticator accepts the extension, then the authenticator SHOULD only add this extension data to a packed attestation or assertion.

Authenticator extension output
If the authenticator accepts the extension request, then authenticator extension output SHOULD provide location data in the form of a CBOR-encoded map, with the first value being the extension identifier and the second being an array of returned values. The array elements SHOULD be derived from (key,value) pairings for each location attribute that the authenticator supports. The following is an example of authenticator data where the returned array is comprised of a {longitude, latitude, altitude} triplet, following the coordinate representation defined in The W3C Geolocation API Specification.

```
...                                  -- [=RP ID=] hash (32 bytes)
81                                    -- UP and ED set
00 00 00 01                               -- (initial) signature counter
...                                  -- all public key alg etc.
A1                                    -- extension: CBOR map of one elemen
t
   63                                 -- Value 1: CBOR text string of 3 by
tes
      6C 6F 63                            -- "loc" [=UTF-8 encoded=] string
   86                                 -- Value 2: array of 6 elements
      68                  -- Element 1:  CBOR text string of 8 bytes
        6C 61 74 69 74 75 64 65         -- "latitude" [=UTF-8 encoded=] stri
ng
      FB ...                -- Element 2:  Latitude as CBOR encoded double-p
recision float
      69                  -- Element 3:  CBOR text string of 9 bytes
        6C 6F 6E 67 69 74 75 64 65       -- "longitude" [=UTF-8 encoded=] str
ing
      FB ...                -- Element 4:  Longitude as CBOR encoded double-
precision float
      68                  -- Element 5:  CBOR text string of 8 bytes
        61 6C 74 69 74 75 64 65         -- "altitude" [=UTF-8 encoded=] stri
ng
      FB ...                -- Element 6:  Altitude as CBOR encoded double-p
recision float
```

9.8. User Verification Method Extension (uvm)

This registration extension and authentication extension enables use of a user verification method.

Extension identifier
uvm

Client extension input
The Boolean value true to indicate that this extension is

requested by the WebAuthn Relying Party.

Client extension processing
None, except creating the authenticator extension input from the client extension input.

Client extension output
Returns a JSON array of 3-element arrays of numbers that encodes the factors in the authenticator extension output

Authenticator extension input
The Boolean value true, encoded in CBOR (major type 7, value 21).

Authenticator extension processing
The authenticator sets the authenticator extension output to be a user verification index indicating the method used by the user to authorize the operation, as defined below. This extension can be added to attestation objects and assertions.

Authenticator extension output
Authenticators can report up to 3 different user verification methods (factors) used in a single authentication instance, using the CBOR syntax defined below:

```
uvmFormat = [ 1*3 uvmEntry ]
uvmEntry = [
           userVerificationMethod: uint .size 4,
           keyProtectionType: uint .size 2,
           matcherProtectionType: uint .size 2
        ]
```

The semantics of the fields in each uvmEntry are as follows:

userVerificationMethod
The authentication method/factor used by the authenticator to verify the user. Available values are defined in [FIDOReg], "User Verification Methods" section.

keyProtectionType
The method used by the authenticator to protect the FIDO registration private key material. Available values are defined in [FIDOReg], "Key Protection Types" section.

matcherProtectionType
The method used by the authenticator to protect the matcher that performs user verification. Available values are defined in [FIDOReg], "Matcher Protection Types" section.

If >3 factors can be used in an authentication instance the authenticator vendor must select the 3 factors it believes will be most relevant to the Server to include in the UVM.

Example for authenticator data containing one UVM extension for a multi-factor authentication instance where 2 factors were used:

```
...                 -- RP ID hash (32 bytes)
81                   -- TUP and ED set
00 00 00 01          -- (initial) signature counter
...                 -- all public key alg etc.
A1                   -- extension: CBOR map of one element
   63                -- Key 1: CBOR text string of 3 bytes
      75 76 6d       -- "uvm" [=UTF-8 encoded=] string
   82                -- Value 1: CBOR array of length 2 indicating two factor
usage
      83             -- Item 1: CBOR array of length 3
         02          -- Subitem 1: CBOR integer for User Verification Method
 Fingerprint
```


requested by the WebAuthn Relying Party.

Client extension processing
None, except creating the authenticator extension input from the client extension input.

Client extension output
Returns a JSON array of 3-element arrays of numbers that encodes the factors in the authenticator extension output

Authenticator extension input
The Boolean value true, encoded in CBOR (major type 7, value 21).

Authenticator extension processing
The authenticator sets the authenticator extension output to be a user verification index indicating the method used by the user to authorize the operation, as defined below. This extension can be added to attestation objects and assertions.

Authenticator extension output
Authenticators can report up to 3 different user verification methods (factors) used in a single authentication instance, using the CBOR syntax defined below:

```
uvmFormat = [ 1*3 uvmEntry ]
uvmEntry = [
           userVerificationMethod: uint .size 4,
           keyProtectionType: uint .size 2,
           matcherProtectionType: uint .size 2
        ]
```

The semantics of the fields in each uvmEntry are as follows:

userVerificationMethod
The authentication method/factor used by the authenticator to verify the user. Available values are defined in [FIDOReg], "User Verification Methods" section.

keyProtectionType
The method used by the authenticator to protect the FIDO registration private key material. Available values are defined in [FIDOReg], "Key Protection Types" section.

matcherProtectionType
The method used by the authenticator to protect the matcher that performs user verification. Available values are defined in [FIDOReg], "Matcher Protection Types" section.

If >3 factors can be used in an authentication instance the authenticator vendor must select the 3 factors it believes will be most relevant to the Server to include in the UVM.

Example for authenticator data containing one UVM extension for a multi-factor authentication instance where 2 factors were used:

```
...                 -- [=RP ID=] hash (32 bytes)
81                   -- UP and ED set
00 00 00 01          -- (initial) signature counter
...                 -- all public key alg etc.
A1                   -- extension: CBOR map of one element
   63                -- Key 1: CBOR text string of 3 bytes
      75 76 6d       -- "uvm" [=UTF-8 encoded=] string
   82                -- Value 1: CBOR array of length 2 indicating two factor
usage
      83             -- Item 1: CBOR array of length 3
         02          -- Subitem 1: CBOR integer for User Verification Method
 Fingerprint
```

```
          04          -- Subitem 2: CBOR short for Key Protection Type TEE
          02          -- Subitem 3: CBOR short for Matcher Protection Type TE
E
       83           -- Item 2: CBOR array of length 3
          04          -- Subitem 1: CBOR integer for User Verification Method
 Passcode
          01          -- Subitem 2: CBOR short for Key Protection Type Softwa
re
          01          -- Subitem 3: CBOR short for Matcher Protection Type So
ftware
```

10. IANA Considerations

10.1. WebAuthn Attestation Statement Format Identifier Registrations

This section registers the attestation statement formats defined in Section 7 Defined Attestation Statement Formats in the IANA "WebAuthn Attestation Statement Format Identifier" registry established by [WebAuthn-Registries].

* WebAuthn Attestation Statement Format Identifier: packed
* Description: The "packed" attestation statement format is a WebAuthn-optimized format for attestation data. It uses a very compact but still extensible encoding method. This format is implementable by authenticators with limited resources (e.g., secure elements).
* Specification Document: Section 7.2 Packed Attestation Statement Format of this specification
* WebAuthn Attestation Statement Format Identifier: tpm
* Description: The TPM attestation statement format returns an attestation statement in the same format as the packed attestation statement format, although the the rawData and signature fields are computed differently.
* Specification Document: Section 7.3 TPM Attestation Statement Format of this specification
* WebAuthn Attestation Statement Format Identifier: android-key
* Description: Platform-provided authenticators based on Android versions "N", and later, may provide this proprietary "hardware attestation" statement.
* Specification Document: Section 7.4 Android Key Attestation Statement Format of this specification
* WebAuthn Attestation Statement Format Identifier: android-safetynet
* Description: Android-based, platform-provided authenticators may produce an attestation statement based on the Android SafetyNet API.
* Specification Document: Section 7.5 Android SafetyNet Attestation Statement Format of this specification
* WebAuthn Attestation Statement Format Identifier: fido-u2f
* Description: Used with FIDO U2F authenticators
* Specification Document: Section 7.6 FIDO U2F Attestation Statement Format of this specification

10.2. WebAuthn Extension Identifier Registrations

This section registers the extension identifier values defined in Section 8 WebAuthn Extensions in the IANA "WebAuthn Extension Identifier" registry established by [WebAuthn-Registries].

* WebAuthn Extension Identifier: appid
* Description: This authentication extension allows Relying Parties that have previously registered a credential using the legacy FIDO JavaScript APIs to request an assertion.
* Specification Document: Section 9.1 FIDO AppId Extension (appid) of this specification
* WebAuthn Extension Identifier: txAuthSimple
* Description: This registration extension and authentication extension allows for a simple form of transaction authorization. A WebAuthn Relying Party can specify a prompt string, intended for display on a trusted device on the authenticator
* Specification Document: Section 9.2 Simple Transaction Authorization Extension (txAuthSimple) of this specification
* WebAuthn Extension Identifier: txAuthGeneric


```
          04          -- Subitem 2: CBOR short for Key Protection Type TEE
          02          -- Subitem 3: CBOR short for Matcher Protection Type TE
E
       83           -- Item 2: CBOR array of length 3
          04          -- Subitem 1: CBOR integer for User Verification Method
 Passcode
          01          -- Subitem 2: CBOR short for Key Protection Type Softwa
re
          01          -- Subitem 3: CBOR short for Matcher Protection Type So
ftware
```

10. IANA Considerations

10.1. WebAuthn Attestation Statement Format Identifier Registrations

This section registers the attestation statement formats defined in Section 7 Defined Attestation Statement Formats in the IANA "WebAuthn Attestation Statement Format Identifier" registry established by [WebAuthn-Registries].

* WebAuthn Attestation Statement Format Identifier: packed
* Description: The "packed" attestation statement format is a WebAuthn-optimized format for attestation data. It uses a very compact but still extensible encoding method. This format is implementable by authenticators with limited resources (e.g., secure elements).
* Specification Document: Section 7.2 Packed Attestation Statement Format of this specification
* WebAuthn Attestation Statement Format Identifier: tpm
* Description: The TPM attestation statement format returns an attestation statement in the same format as the packed attestation statement format, although the the rawData and signature fields are computed differently.
* Specification Document: Section 7.3 TPM Attestation Statement Format of this specification
* WebAuthn Attestation Statement Format Identifier: android-key
* Description: Platform-provided authenticators based on Android versions "N", and later, may provide this proprietary "hardware attestation" statement.
* Specification Document: Section 7.4 Android Key Attestation Statement Format of this specification
* WebAuthn Attestation Statement Format Identifier: android-safetynet
* Description: Android-based, platform-provided authenticators may produce an attestation statement based on the Android SafetyNet API.
* Specification Document: Section 7.5 Android SafetyNet Attestation Statement Format of this specification
* WebAuthn Attestation Statement Format Identifier: fido-u2f
* Description: Used with FIDO U2F authenticators
* Specification Document: Section 7.6 FIDO U2F Attestation Statement Format of this specification

10.2. WebAuthn Extension Identifier Registrations

This section registers the extension identifier values defined in Section 8 WebAuthn Extensions in the IANA "WebAuthn Extension Identifier" registry established by [WebAuthn-Registries].

* WebAuthn Extension Identifier: appid
* Description: This authentication extension allows Relying Parties that have previously registered a credential using the legacy FIDO JavaScript APIs to request an assertion.
* Specification Document: Section 9.1 FIDO AppId Extension (appid) of this specification
* WebAuthn Extension Identifier: txAuthSimple
* Description: This registration extension and authentication extension allows for a simple form of transaction authorization. A WebAuthn Relying Party can specify a prompt string, intended for display on a trusted device on the authenticator
* Specification Document: Section 9.2 Simple Transaction Authorization Extension (txAuthSimple) of this specification
* WebAuthn Extension Identifier: txAuthGeneric

* Description: This registration extension and authentication extension allows images to be used as transaction authorization prompts as well. This allows authenticators without a font rendering engine to be used and also supports a richer visual appearance than accomplished with the webauthn.txauth.simple extension.
* Specification Document: Section 9.3 Generic Transaction Authorization Extension (txAuthGeneric) of this specification
* WebAuthn Extension Identifier: authnSel
* Description: This registration extension allows a WebAuthn Relying Party to guide the selection of the authenticator that will be leveraged when creating the credential. It is intended primarily for WebAuthn Relying Parties that wish to tightly control the experience around credential creation.
* Specification Document: Section 9.4 Authenticator Selection Extension (authnSel) of this specification
* WebAuthn Extension Identifier: exts
* Description: This registration extension enables the Relying Party to determine which extensions the authenticator supports. The extension data is a list (CBOR array) of extension identifiers encoded as UTF-8 Strings. This extension is added automatically by the authenticator. This extension can be added to attestation statements.
* Specification Document: Section 9.5 Supported Extensions Extension (exts) of this specification
* WebAuthn Extension Identifier: uvi
* Description: This registration extension and authentication extension enables use of a user verification index. The user verification index is a value uniquely identifying a user verification data record. The UVI data can be used by 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".
* Specification Document: Section 9.6 User Verification Index Extension (uvi) of this specification
* WebAuthn Extension Identifier: loc
* Description: The location registration extension and authentication extension provides the client device's current location to the WebAuthn relying party, if supported by the client device and subject to user consent.
* Specification Document: Section 9.7 Location Extension (loc) of this specification
* WebAuthn Extension Identifier: uvm
* Description: This registration extension and authentication extension enables use of a user verification method. The user verification method extension returns to the Webauthn relying party which user verification methods (factors) were used for the WebAuthn operation.
* Specification Document: Section 9.8 User Verification Method Extension (uvm) of this specification

* Description: This registration extension and authentication extension allows images to be used as transaction authorization prompts as well. This allows authenticators without a font rendering engine to be used and also supports a richer visual appearance than accomplished with the webauthn.txauth.simple extension.
* Specification Document: Section 9.3 Generic Transaction Authorization Extension (txAuthGeneric) of this specification
* WebAuthn Extension Identifier: authnSel
* Description: This registration extension allows a WebAuthn Relying Party to guide the selection of the authenticator that will be leveraged when creating the credential. It is intended primarily for WebAuthn Relying Parties that wish to tightly control the experience around credential creation.
* Specification Document: Section 9.4 Authenticator Selection Extension (authnSel) of this specification
* WebAuthn Extension Identifier: exts
* Description: This registration extension enables the Relying Party to determine which extensions the authenticator supports. The extension data is a list (CBOR array) of extension identifiers encoded as UTF-8 Strings. This extension is added automatically by the authenticator. This extension can be added to attestation statements.
* Specification Document: Section 9.5 Supported Extensions Extension (exts) of this specification
* WebAuthn Extension Identifier: uvi
* Description: This registration extension and authentication extension enables use of a user verification index. The user verification index is a value uniquely identifying a user verification data record. The UVI data can be used by 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".
* Specification Document: Section 9.6 User Verification Index Extension (uvi) of this specification
* WebAuthn Extension Identifier: loc
* Description: The location registration extension and authentication extension provides the client device's current location to the WebAuthn relying party, if supported by the client device and subject to user consent.
* Specification Document: Section 9.7 Location Extension (loc) of this specification
* WebAuthn Extension Identifier: uvm
* Description: This registration extension and authentication extension enables use of a user verification method. The user verification method extension returns to the Webauthn relying party which user verification methods (factors) were used for the WebAuthn operation.
* Specification Document: Section 9.8 User Verification Method Extension (uvm) of this specification

10.3. COSE Algorithm Registrations

This section registers identifiers for RSASSA-PKCS1-v1_5 [RFC8017] algorithms using SHA-2 hash functions in the IANA COSE Algorithms registry [IANA-COSE-ALGS-REG].
* Name: RS256
* Value: -257
* Description: RSASSA-PKCS1-v1_5 w/ SHA-256
* Reference: Section 8.2 of [RFC8017]
* Recommended: No
* Name: RS384
* Value: -258
* Description: RSASSA-PKCS1-v1_5 w/ SHA-384
* Reference: Section 8.2 of [RFC8017]
* Recommended: No
* Name: RS512
* Value: -259
* Description: RSASSA-PKCS1-v1_5 w/ SHA-512
* Reference: Section 8.2 of [RFC8017]

11. Sample scenarios

This section is not normative.

In this section, we walk through some events in the lifecycle of a public key credential, along with the corresponding sample code for using this API. Note that this is an example flow, and does not limit the scope of how the API can be used.

As was the case in earlier sections, this flow focuses on a use case involving an external first-factor authenticator with its own display. One example of such an authenticator would be a smart phone. Other authenticator types are also supported by this API, subject to implementation by the platform. For instance, this flow also works without modification for the case of an authenticator that is embedded in the client platform. The flow also works for the case of an authenticator without its own display (similar to a smart card) subject to specific implementation considerations. Specifically, the client platform needs to display any prompts that would otherwise be shown by the authenticator, and the authenticator needs to allow the client platform to enumerate all the authenticator's credentials so that the client can have information to show appropriate prompts.

11.1. Registration

This is the first-time flow, in which a new credential is created and registered with the server.

1. The user visits example.com, which serves up a script. At this point, the user must already be logged in using a legacy username and password, or additional authenticator, or other means acceptable to the Relying Party.

2. The Relying Party script runs the code snippet below.
3. The client platform searches for and locates the authenticator.
4. The client platform connects to the authenticator, performing any pairing actions if necessary.
5. The authenticator shows appropriate UI for the user to select the authenticator on which the new credential will be created, and obtains a biometric or other authorization gesture from the user.
6. The authenticator returns a response to the client platform, which in turn returns a response to the Relying Party script. If the user declined to select an authenticator or provide authorization, an appropriate error is returned.
7. If a new credential was created,
   + The Relying Party script sends the newly generated credential public key to the server, along with additional information such as attestation regarding the provenance and characteristics of the authenticator.
   + The server stores the credential public key in its database and associates it with the user as well as with the characteristics of authentication indicated by attestation, also storing a friendly name for later use.
   + The script may store data such as the credential ID in local storage, to improve future UX by narrowing the choice of credential for the user.

The sample code for generating and registering a new key follows:

```
if (!PublicKeyCredential) { /* Platform not capable. Handle error. */ }

var publicKey = {
  challenge: Uint8Array.from(window.atob("PGifxAoBwCkWkm4b1CiIl5otCphiIh6MijdjbW
FjomA="), c=>c.charCodeAt(0)),

  // Relying Party:
  rp: {
    name: "Acme"
  },
```


* Recommended: No

11. Sample scenarios

This section is not normative.

In this section, we walk through some events in the lifecycle of a public key credential, along with the corresponding sample code for using this API. Note that this is an example flow, and does not limit the scope of how the API can be used.

As was the case in earlier sections, this flow focuses on a use case involving an external first-factor authenticator with its own display. One example of such an authenticator would be a smart phone. Other authenticator types are also supported by this API, subject to implementation by the platform. For instance, this flow also works without modification for the case of an authenticator that is embedded in the client platform. The flow also works for the case of an authenticator without its own display (similar to a smart card) subject to specific implementation considerations. Specifically, the client platform needs to display any prompts that would otherwise be shown by the authenticator, and the authenticator needs to allow the client platform to enumerate all the authenticator's credentials so that the client can have information to show appropriate prompts.

11.1. Registration

This is the first-time flow, in which a new credential is created and registered with the server. In this flow, the Relying Party does not have a preference for platform authenticator or roaming authenticators.

1. The user visits example.com, which serves up a script. At this point, the user may already be logged in using a legacy username and password, or additional authenticator, or other means acceptable to the Relying Party. Or the user may be in the process of creating a new account.
2. The Relying Party script runs the code snippet below.
3. The client platform searches for and locates the authenticator.
4. The client platform connects to the authenticator, performing any pairing actions if necessary.
5. The authenticator shows appropriate UI for the user to select the authenticator on which the new credential will be created, and obtains a biometric or other authorization gesture from the user.
6. The authenticator returns a response to the client platform, which in turn returns a response to the Relying Party script. If the user declined to select an authenticator or provide authorization, an appropriate error is returned.
7. If a new credential was created,
   + The Relying Party script sends the newly generated credential public key to the server, along with additional information such as attestation regarding the provenance and characteristics of the authenticator.
   + The server stores the credential public key in its database and associates it with the user as well as with the characteristics of authentication indicated by attestation, also storing a friendly name for later use.
   + The script may store data such as the credential ID in local storage, to improve future UX by narrowing the choice of credential for the user.

The sample code for generating and registering a new key follows:

```
if (!PublicKeyCredential) { /* Platform not capable. Handle error. */ }

var publicKey = {
  challenge: Uint8Array.from(window.atob("PGifxAoBwCkWkm4b1CiIl5otCphiIh6MijdjbW
FjomA="), c=>c.charCodeAt(0)),

  // Relying Party:
  rp: {
    name: "Acme"
  },
```

```
    // User:
    user: {
      id: "1098237235409872"
      name: "john.p.smith@example.com",
      displayName: "John P. Smith",
      icon: "https://pics.acme.com/00/p/aBjjjpqPb.png"
    },

    // This Relying Party will accept either an ES256 or RS256 credential, but
    // prefers an ES256 credential.
    parameters: [
      {
        type: "public-key",
        algorithm: "ES256",
      },
      {
        type: "public-key",
        algorithm: "RS256",
      },
    ],

    timeout: 60000,  // 1 minute
    excludeList: [], // No excludeList
    extensions: {"webauthn.location": true}  // Include location information
                                             // in attestation
  };

  // Note: The following call will cause the authenticator to display UI.
  navigator.credentials.create({ publicKey })
    .then(function (newCredentialInfo) {
      // Send new credential info to server for verification and registration.
    }).catch(function (err) {
      // No acceptable authenticator or user refused consent. Handle appropriately
  .
    });

    11.2. Authentication
```



```
    // User:
    user: {
      id: "1098237235409872"
      name: "john.p.smith@example.com",
      displayName: "John P. Smith",
      icon: "https://pics.acme.com/00/p/aBjjjpqPb.png"
    },

    // This Relying Party will accept either an ES256 or RS256 credential, but
    // prefers an ES256 credential.
    pubKeyCredParams: [
      {
        type: "public-key",
        alg: -7 // "ES256" as registered in the IANA COSE Algorithms registry
      },
      {
        type: "public-key",
        alg: -257 // Value registered by this specification for "RS256"
      }
    ],

    timeout: 60000,  // 1 minute
    excludeCredentials: [], // No exclude list of PKCredDescriptors
    extensions: {"webauthn.location": true}  // Include location information
                                             // in attestation
  };

  // Note: The following call will cause the authenticator to display UI.
  navigator.credentials.create({ publicKey })
    .then(function (newCredentialInfo) {
      // Send new credential info to server for verification and registration.
    }).catch(function (err) {
      // No acceptable authenticator or user refused consent. Handle appropriately
  .
    });

    11.2. Registration Specifically with Platform Authenticator

   This is flow for when the Relying Party is specifically interested in
   creating a public key credential with a platform authenticator.
    1. The user visits example.com and clicks on the login button, which
       redirects the user to login.example.com.
    2. The user enters a username and password to log in. After successful
       login, the user is redirected back to example.com.
    3. The Relying Party script runs the code snippet below.
    4. The user agent asks the user whether they are willing to register
       with the Relying Party using an available platform authenticator.
    5. If the user is not willing, terminate this flow.
    6. The user is shown appropriate UI and guided in creating a
       credential using one of the available platform authenticators. Upon
       successful credential creation, the RP script conveys the new
       credential to the server.
if (!PublicKeyCredential) { /* Platform not capable of the API. Handle error. */
 }

PublicKeyCredential.isPlatformAuthenticatorAvailable()
    .then(function (userIntent) {

        // If the user has affirmed willingness to register with RP using an ava
ilable platform authenticator
        if (userIntent) {
            var publicKeyOptions = { /* Public key credential creation options.
*/};

            // Create and register credentials.
            return navigator.credentials.create({ "publicKey": publicKeyOptions
});
        } else {
```

This is the flow when a user with an already registered credential visits a website and wants to authenticate using the credential.

1. The user visits example.com, which serves up a script.
2. The script asks the client platform for an Authentication Assertion, providing as much information as possible to narrow the choice of acceptable credentials for the user. This may be obtained from the data that was stored locally after registration, or by other means such as prompting the user for a username.
3. The Relying Party script runs one of the code snippets below.
4. The client platform searches for and locates the authenticator.
5. The client platform connects to the authenticator, performing any pairing actions if necessary.
6. The authenticator presents the user with a notification that their attention is required. On opening the notification, the user is shown a friendly selection menu of acceptable credentials using the account information provided when creating the credentials, along with some information on the origin that is requesting these keys.
7. The authenticator obtains a biometric or other authorization gesture from the user.
8. The authenticator returns a response to the client platform, which in turn returns a response to the Relying Party script. If the user declined to select a credential or provide an authorization, an appropriate error is returned.
9. If an assertion was successfully generated and returned,
   + The script sends the assertion to the server.
   + The server examines the assertion, extracts the credential ID, looks up the registered credential public key it is database, and verifies the assertion's authentication signature. If valid, it looks up the identity associated with the assertion's credential ID; that identity is now authenticated. If the credential ID is not recognized by the server (e.g., it has been deregistered due to inactivity) then the authentication has failed; each Relying Party will handle this in its own way.
   + The server now does whatever it would otherwise do upon successful authentication -- return a success page, set authentication cookies, etc.

If the Relying Party script does not have any hints available (e.g., from locally stored data) to help it narrow the list of credentials, then the sample code for performing such an authentication might look like this:

```
if (!PublicKeyCredential) { /* Platform not capable. Handle error. */ }

var options = {
              challenge: new TextEncoder().encode("climb a mountain"),
              timeout: 60000,  // 1 minute
              allowList: [{ type: "public-key" }]
            };

navigator.credentials.get({ "publicKey": options })
    .then(function (assertion) {
    // Send assertion to server for verification
}).catch(function (err) {
    // No acceptable credential or user refused consent. Handle appropriately.
});
```



```
          // Record that the user does not intend to use a platform authentica
tor
          // and default the user to a password-based flow in the future.
        }

   }).then(function (newCredentialInfo) {
       // Send new credential info to server for verification and registration.
   }).catch( function(err) {
       // Something went wrong. Handle appropriately.
   });
```

11.3. Authentication

This is the flow when a user with an already registered credential visits a website and wants to authenticate using the credential.

1. The user visits example.com, which serves up a script.
2. The script asks the client platform for an Authentication Assertion, providing as much information as possible to narrow the choice of acceptable credentials for the user. This may be obtained from the data that was stored locally after registration, or by other means such as prompting the user for a username.
3. The Relying Party script runs one of the code snippets below.
4. The client platform searches for and locates the authenticator.
5. The client platform connects to the authenticator, performing any pairing actions if necessary.
6. The authenticator presents the user with a notification that their attention is required. On opening the notification, the user is shown a friendly selection menu of acceptable credentials using the account information provided when creating the credentials, along with some information on the origin that is requesting these keys.
7. The authenticator obtains a biometric or other authorization gesture from the user.
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var options = {
              challenge: new TextEncoder().encode("climb a mountain"),
              timeout: 60000,  // 1 minute
              allowCredentials: [{ type: "public-key" }]
            };

navigator.credentials.get({ "publicKey": options })
    .then(function (assertion) {
    // Send assertion to server for verification
}).catch(function (err) {
    // No acceptable credential or user refused consent. Handle appropriately.
});
```

On the other hand, if the Relying Party script has some hints to help it narrow the list of credentials, then the sample code for performing such an authentication might look like the following. Note that this sample also demonstrates how to use the extension for transaction authorization.

```
if (!PublicKeyCredential) { /* Platform not capable. Handle error. */ }

var encoder = new TextEncoder();
var acceptableCredential1 = {
    type: "public-key",
    id: encoder.encode("!!!!!!!hi there!!!!!!!\n")
};
var acceptableCredential2 = {
    type: "public-key",
    id: encoder.encode("roses are red, violets are blue\n")
};

var options = {
              challenge: encoder.encode("climb a mountain"),
              timeout: 60000,  // 1 minute
              allowList: [acceptableCredential1, acceptableCredential2];

              extensions: { 'webauthn.txauth.simple':
                 "Wave your hands in the air like you just don't care" };
            };

navigator.credentials.get({ "publicKey": options })
    .then(function (assertion) {
    // Send assertion to server for verification
}).catch(function (err) {
    // No acceptable credential or user refused consent. Handle appropriately.
});
```

11.3. Decommissioning

The following are possible situations in which decommissioning a credential might be desired. Note that all of these are handled on the server side and do not need support from the API specified here.

* Possibility #1 -- user reports the credential as lost.
    + User goes to server.example.net, authenticates and follows a link to report a lost/stolen device.
    + Server returns a page showing the list of registered credentials with friendly names as configured during registration.
    + User selects a credential and the server deletes it from its database.
    + In future, the Relying Party script does not specify this credential in any list of acceptable credentials, and assertions signed by this credential are rejected.
* Possibility #2 -- server deregisters the credential due to inactivity.
    + Server deletes credential from its database during maintenance activity.
    + In the future, the Relying Party script does not specify this credential in any list of acceptable credentials, and assertions signed by this credential are rejected.
* Possibility #3 -- user deletes the credential from the device.
    + User employs a device-specific method (e.g., device settings UI) to delete a credential from their device.
    + From this point on, this credential will not appear in any selection prompts, and no assertions can be generated with it.
    + Sometime later, the server deregisters this credential due to inactivity.

12. Acknowledgements

We thank the following for their contributions to, and thorough review of, this specification: Richard Barnes, Dominic Battr, Domenic Denicola, Rahul Ghosh, Brad Hill, Jing Jin, Angelo Liao, Anne van Kesteren, Ian Kilpatrick, Giridhar Mandyam, Axel Nennker, Kimberly

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var options = {
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              timeout: 60000,  // 1 minute
              allowCredentials: [acceptableCredential1, acceptableCredential2]
;
              extensions: { 'webauthn.txauth.simple':
                 "Wave your hands in the air like you just don't care" };
            };

navigator.credentials.get({ "publicKey": options })
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```

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    + In future, the Relying Party script does not specify this credential in any list of acceptable credentials, and assertions signed by this credential are rejected.
* Possibility #2 -- server deregisters the credential due to inactivity.
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* Possibility #3 -- user deletes the credential from the device.
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Paulhamus, Adam Powers, Yaron Sheffer, Mike West, Jeffrey Yasskin,
Boris Zbarsky.

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Terms defined by this specification

Paulhamus, Adam Powers, Yaron Sheffer, Mike West, Jeffrey Yasskin,
Boris Zbarsky.

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Terms defined by this specification

* rawId, in 4.1
* Registration, in 3
* registration extension, in 8
* Relying Party, in 3
* Relying Party Identifier, in 3
* requireResidentKey, in 4.5.2
* response, in 4.1
* roaming authenticators, in 4.5.3
* rp, in 4.5
* rpId, in 4.6

* RP ID, in 3
* Self Attestation, in 5.3.3
* signature, in 4.2.2

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* timeout
    + dict-member for MakeCredentialOptions, in 4.5
    + dict-member for PublicKeyCredentialRequestOptions, in 4.6
* tokenBinding, in 4.8.1
* Transport, in 4.8.4
* transports, in 4.8.3
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* usb, in 4.8.4
* user, in 4.5

* User Consent, in 3

* User Verification, in 3
* User Verified, in 3

* Web Authentication API, in 4
* WebAuthn Client, in 3

Terms defined by reference

* [CREDENTIAL-MANAGEMENT-1] defines the following terms:

    + CredentialCreationOptions

    + create()

* [ECMAScript] defines the following terms:
    + %arraybuffer%
    + internal slot
    + stringify
* [ENCODING] defines the following terms:
    + utf-8 encode
* [HTML] defines the following terms:
    + ascii serialization of an origin
    + dom manipulation task source
    + effective domain
    + global object

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* rawId, in 4.1
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* registration extension, in 8
* Relying Party, in 3
* Relying Party Identifier, in 3

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* WebAuthn Client, in 3
* "xplat", in 4.4.4
* xplat, in 4.4.4

Terms defined by reference

* [CREDENTIAL-MANAGEMENT-1] defines the following terms:
    + Credential
    + CredentialCreationOptions
    + CredentialRequestOptions
    + CredentialsContainer
    + [[CollectFromCredentialStore]](options)
    + [[Store]](credential)
    + [[discovery]]
    + [[type]]
    + create()
    + get()
    + id
    + remote
    + type
* [ECMAScript] defines the following terms:
    + %arraybuffer%
    + internal slot
    + stringify
* [ENCODING] defines the following terms:
    + utf-8 encode
* [HTML] defines the following terms:
    + ascii serialization of an origin
    + dom manipulation task source
    + effective domain
    + global object

  + in parallel
  + is a registrable domain suffix of or is equal to
  + is not a registrable domain suffix of and is not equal to
  + origin
  + relevant settings object
  + task
  + task source
  + unicode serialization of an origin
* [HTML52] defines the following terms:
  + opaque origin
  + origin
* [INFRA] defines the following terms:
  + append (for list)
  + append (for set)
  + continue
  + for each (for list)
  + for each (for map)
  + is empty
  + is not empty
  + item
  + list
  + map
  + ordered set
  + remove
  + set
* [secure-contexts] defines the following terms:
  + secure context
* [TokenBinding] defines the following terms:
  + token binding
  + token binding id
* [URL] defines the following terms:
  + url serializer
* [webappsec-credential-management-1] defines the following terms:
  + Credential
  + CredentialsContainer
  + [[CollectFromCredentialStore]](options)
  + [[Store]](credential)
  + [[discovery]]
  + [[type]]
  + get()
  + id
  + remote
  + type
* [WebCryptoAPI] defines the following terms:
  + AlgorithmIdentifier
  + normalizing an algorithm
  + recognized algorithm name
* [WebIDL] defines the following terms:
  + ArrayBuffer
  + BufferSource
  + ConstraintError
  + DOMException
  + DOMString
  + NotAllowedError
  + NotFoundError
  + NotSupportedError
  + Promise
  + SecureContext
  + SecurityError
  + TypeError
  + USVString

  + in parallel
  + is a registrable domain suffix of or is equal to
  + is not a registrable domain suffix of and is not equal to
  + origin
  + promise
  + relevant settings object
  + task
  + task source
* [HTML52] defines the following terms:
  + document.domain
  + opaque origin
  + origin
* [INFRA] defines the following terms:
  + append (for list)
  + append (for set)
  + continue
  + for each (for list)
  + for each (for map)
  + is empty
  + is not empty
  + item
  + list
  + map
  + ordered set
  + remove
  + set
* [secure-contexts] defines the following terms:
  + secure context
* [TokenBinding] defines the following terms:
  + token binding
  + token binding id
* [URL] defines the following terms:
  + domain
  + empty host
  + host
  + ipv4 address
  + ipv6 address
  + opaque host
  + url serializer
  + valid domain
  + valid domain string
* [WebCryptoAPI] defines the following terms:
  + recognized algorithm name
* [WebIDL] defines the following terms:
  + ArrayBuffer
  + BufferSource
  + ConstraintError
  + DOMException
  + DOMString
  + NotAllowedError
  + NotFoundError
  + NotSupportedError
  + Promise
  + SameObject
  + SecureContext
  + SecurityError
  + TypeError
  + USVString

+ boolean
+ dictionary
+ interface object

+ present
+ simple exception
+ unsigned long

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+ UnknownError
+ Unscopable
+ boolean

+ interface object
+ long
+ present
+ simple exception
+ unsigned long

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        http://www.trustedcomputinggroup.org/wp-content/uploads/TPM-Rev-
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        f-protocol-v1.0-ps-20141208.html

IDL Index

[SecureContext]
interface PublicKeyCredential : Credential {
    readonly attribute ArrayBuffer           rawId;
    readonly attribute AuthenticatorResponse response;
    readonly attribute AuthenticationExtensions clientExtensionResults;
};

partial dictionary CredentialRequestOptions {
    PublicKeyCredentialRequestOptions? publicKey;
};

partial dictionary CredentialCreationOptions {
    MakeCredentialOptions? publicKey;
};

[SecureContext]
interface AuthenticatorResponse {
    readonly attribute ArrayBuffer clientDataJSON;
};

[SecureContext]
interface AuthenticatorAttestationResponse : AuthenticatorResponse {
    readonly attribute ArrayBuffer attestationObject;
};

[SecureContext]
interface AuthenticatorAssertionResponse : AuthenticatorResponse {
    readonly attribute ArrayBuffer      authenticatorData;
    readonly attribute ArrayBuffer      signature;
};

dictionary PublicKeyCredentialParameters {
    required PublicKeyCredentialType  type;
    required AlgorithmIdentifier   algorithm;
};

dictionary PublicKeyCredentialUserEntity : PublicKeyCredentialEntity {
    DOMString displayName;
};

dictionary MakeCredentialOptions {
    required PublicKeyCredentialEntity rp;
    required PublicKeyCredentialUserEntity user;

    required BufferSource                      challenge;
    required sequence<PublicKeyCredentialParameters> parameters;
```



```
   [TPMv2-Part2]
        Trusted Platform Module Library, Part 2: Structures. URL:
        http://www.trustedcomputinggroup.org/wp-content/uploads/TPM-Rev-
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        f-protocol-v1.0-ps-20141208.html

IDL Index

[SecureContext]
interface PublicKeyCredential : Credential {
    [SameObject] readonly attribute ArrayBuffer              rawId;
    [SameObject] readonly attribute AuthenticatorResponse    response;
    [SameObject] readonly attribute AuthenticationExtensions clientExtensionResu
lts;
};

partial dictionary CredentialCreationOptions {
    MakePublicKeyCredentialOptions      publicKey;
};

partial dictionary CredentialRequestOptions {
    PublicKeyCredentialRequestOptions      publicKey;
};

[SecureContext]
partial interface PublicKeyCredential {
    [Unscopable] Promise < boolean > isPlatformAuthenticatorAvailable();
};

[SecureContext]
interface AuthenticatorResponse {
    [SameObject] readonly attribute ArrayBuffer      clientDataJSON;
};

[SecureContext]
interface AuthenticatorAttestationResponse : AuthenticatorResponse {
    [SameObject] readonly attribute ArrayBuffer      attestationObject;
};

[SecureContext]
interface AuthenticatorAssertionResponse : AuthenticatorResponse {
    [SameObject] readonly attribute ArrayBuffer      authenticatorData;
    [SameObject] readonly attribute ArrayBuffer      signature;
};

dictionary PublicKeyCredentialParameters {
    required PublicKeyCredentialType      type;
    required COSEAlgorithmIdentifier      alg;
};

dictionary MakePublicKeyCredentialOptions {
    required PublicKeyCredentialEntity          rp;
    required PublicKeyCredentialUserEntity      user;

    required BufferSource                          challenge;
    required sequence<PublicKeyCredentialParameters>  pubKeyCredParams;
```

```
    unsigned long                    timeout;
    sequence<PublicKeyCredentialDescriptor> excludeList;
    AuthenticatorSelectionCriteria      authenticatorSelection;
    AuthenticationExtensions            extensions;
};

dictionary PublicKeyCredentialEntity {
    DOMString id;
    DOMString name;
    USVString icon;
};

dictionary AuthenticatorSelectionCriteria {
    Attachment    attachment;
    boolean       requireResidentKey = false;

};

enum Attachment {
    "platform",
    "cross-platform"
};

dictionary PublicKeyCredentialRequestOptions {
    required BufferSource              challenge;
    unsigned long                      timeout;
    USVString                          rpId;
    sequence<PublicKeyCredentialDescriptor> allowList = [];
    AuthenticationExtensions           extensions;
};

typedef record<DOMString, any> AuthenticationExtensions;

dictionary CollectedClientData {
    required DOMString          challenge;
    required DOMString          origin;
    required DOMString          hashAlg;
    DOMString                   tokenBinding;
    AuthenticationExtensions    clientExtensions;
    AuthenticationExtensions    authenticatorExtensions;
};

enum PublicKeyCredentialType {
    "public-key"
};

dictionary PublicKeyCredentialDescriptor {
    required PublicKeyCredentialType type;
    required BufferSource id;
    sequence<Transport>   transports;
};

enum Transport {
    "usb",
    "nfc",
    "ble"
};


typedef sequence<AAGUID> AuthenticatorSelectionList;

typedef BufferSource AAGUID;
```



```
    unsigned long                          timeout;
    sequence<PublicKeyCredentialDescriptor>    excludeCredentials = [];
    AuthenticatorSelectionCriteria            authenticatorSelection;
    AuthenticationExtensions                  extensions;
};

dictionary PublicKeyCredentialEntity {
    DOMString      id;
    DOMString      name;
    USVString      icon;
};

dictionary PublicKeyCredentialUserEntity : PublicKeyCredentialEntity {
    DOMString      displayName;
};

dictionary AuthenticatorSelectionCriteria {
    AuthenticatorAttachment     aa;       // authenticatorAttachment
    boolean                     rk = false; // requireResidentKey
    boolean                     uv = false; // requireUserVerification
};

enum AuthenticatorAttachment {
    "plat",  // Platform attachment
    "xplat"  // Cross-platform attachment
};

dictionary PublicKeyCredentialRequestOptions {
    required BufferSource              challenge;
    unsigned long                      timeout;
    USVString                          rpId;
    sequence<PublicKeyCredentialDescriptor> allowCredentials = [];
    AuthenticationExtensions           extensions;
};

typedef record<DOMString, any>      AuthenticationExtensions;

dictionary CollectedClientData {
    required DOMString          challenge;
    required DOMString          origin;
    required DOMString          hashAlgorithm;
    DOMString                   tokenBindingId;
    AuthenticationExtensions    clientExtensions;
    AuthenticationExtensions    authenticatorExtensions;
};

enum PublicKeyCredentialType {
    "public-key"
};

dictionary PublicKeyCredentialDescriptor {
    required PublicKeyCredentialType      type;
    required BufferSource                 id;
    sequence<AuthenticatorTransport>      transports;
};

enum AuthenticatorTransport {
    "usb",
    "nfc",
    "ble"
};

typedef long COSEAlgorithmIdentifier;

typedef sequence<AAGUID>      AuthenticatorSelectionList;

typedef BufferSource      AAGUID;
```

#base64url-encodingReferenced in:
 * 4.1. PublicKeyCredential Interface
 * 4.1.3. Create a new credential - PublicKeyCredential's
 \[[Create]](options) method (2)
 * 4.1.4. Use an existing credential -
 PublicKeyCredential::[[DiscoverFromExternalSource]](options) method
 (2)
 * 6.2. Verifying an authentication assertion

#cborReferenced in:
 * 4.1.3. Create a new credential - PublicKeyCredential's
 \[[Create]](options) method
 * 4.1.4. Use an existing credential -
 PublicKeyCredential::[[DiscoverFromExternalSource]](options) method

 * 5.1. Authenticator data (2)
 * 8. WebAuthn Extensions (2) (3)
 * 8.2. Defining extensions (2)
 * 8.3. Extending request parameters
 * 8.4. Client extension processing (2)
 * 8.5. Authenticator extension processing (2) (3) (4) (5)

#attestation-objectsReferenced in:
 * 4. Web Authentication API
 * 4.2.1. Information about Public Key Credential (interface
 AuthenticatorAttestationResponse) (2)
 * 4.5. Options for Credential Creation (dictionary
 MakeCredentialOptions) (2)
 * 5.2.1. The authenticatorMakeCredential operation (2)
 * 5.3. Credential Attestation (2)
 * 5.3.1. Attestation data
 * 5.3.4. Generating an Attestation Object (2) (3) (4)
 * 6.1. Registering a new credential

#attestation-certificateReferenced in:
 * 3. Terminology (2)
 * 7.3.1. TPM attestation statement certificate requirements

#attestation-key-pairReferenced in:
 * 3. Terminology (2)

#authenticationReferenced in:
 * 1. Introduction (2)
 * 3. Terminology (2) (3) (4) (5)
 * 6.2. Verifying an authentication assertion

#authentication-assertionReferenced in:
 * 1. Introduction
 * 3. Terminology (2) (3)
 * 4.1. PublicKeyCredential Interface
 * 4.2.2. Web Authentication Assertion (interface
 AuthenticatorAssertionResponse)
 * 4.6. Options for Assertion Generation (dictionary
 PublicKeyCredentialRequestOptions)
 * 8. WebAuthn Extensions

#authenticatorReferenced in:
 * 1. Introduction (2) (3) (4)
 * 1.1. Use Cases
 * 2. Conformance
 * 3. Terminology (2) (3) (4) (5) (6) (7) (8) (9) (10) (11) (12)

#base64url-encodingReferenced in:
 * 4.1. PublicKeyCredential Interface
 * 4.1.3. Create a new credential - PublicKeyCredential's
 [[Create]](options) method (2)
 * 4.1.4. Use an existing credential to make an assertion -
 PublicKeyCredential's [[DiscoverFromExternalSource]](options)
 method (2)
 * 6.2. Verifying an authentication assertion

#cborReferenced in:
 * 4.1.3. Create a new credential - PublicKeyCredential's
 [[Create]](options) method
 * 4.1.4. Use an existing credential to make an assertion -
 PublicKeyCredential's [[DiscoverFromExternalSource]](options)
 method
 * 5.1. Authenticator data (2)
 * 8. WebAuthn Extensions (2) (3)
 * 8.2. Defining extensions (2)
 * 8.3. Extending request parameters
 * 8.4. Client extension processing (2)
 * 8.5. Authenticator extension processing (2) (3) (4) (5)

#attestationReferenced in:
 * 3. Terminology
 * 5. WebAuthn Authenticator model (2)
 * 5.3. Attestation (2) (3) (4)

#attestation-certificateReferenced in:
 * 3. Terminology (2)
 * 7.3.1. TPM attestation statement certificate requirements

#attestation-key-pairReferenced in:
 * 3. Terminology (2)
 * 5.3. Attestation

#attestation-private-keyReferenced in:
 * 5. WebAuthn Authenticator model
 * 5.3. Attestation

#attestation-public-keyReferenced in:
 * 5.3. Attestation

#authenticationReferenced in:
 * 1. Introduction (2)
 * 3. Terminology (2) (3) (4) (5) (6) (7)
 * 6.2. Verifying an authentication assertion

#authentication-assertionReferenced in:
 * 1. Introduction
 * 3. Terminology (2) (3)
 * 4.1. PublicKeyCredential Interface
 * 4.2.2. Web Authentication Assertion (interface
 AuthenticatorAssertionResponse)
 * 4.5. Options for Assertion Generation (dictionary
 PublicKeyCredentialRequestOptions)
 * 8. WebAuthn Extensions

#authenticatorReferenced in:
 * 1. Introduction (2) (3) (4)
 * 1.1. Use Cases
 * 2. Conformance
 * 3. Terminology (2) (3) (4) (5) (6) (7) (8) (9) (10) (11) (12) (13)
 (14) (15)

* 4.1. PublicKeyCredential Interface
* 4.1.3. Create a new credential - PublicKeyCredential's \[[Create]](options) method
* 4.1.4. Use an existing credential - PublicKeyCredential::[[DiscoverFromExternalSource]](options) method
* 4.2. Authenticator Responses (interface AuthenticatorResponse)
* 4.2.1. Information about Public Key Credential (interface AuthenticatorAttestationResponse) (2)
* 4.2.2. Web Authentication Assertion (interface AuthenticatorAssertionResponse)
* 4.5.3. Credential Attachment enumeration (enum Attachment)
* 4.6. Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions)
* 5. WebAuthn Authenticator model
* 5.1. Authenticator data
* 5.3. Credential Attestation
* 5.3.5.1. Privacy
* 5.3.5.2. Attestation Certificate and Attestation Certificate CA Compromise
* 6.1. Registering a new credential
* 7.2. Packed Attestation Statement Format
* 7.4. Android Key Attestation Statement Format
* 7.5. Android SafetyNet Attestation Statement Format
* 9.5. Supported Extensions Extension (exts)
* 9.6. User Verification Index Extension (uvi)
* 9.7. Location Extension (loc) (2) (3) (4)
* 9.8. User Verification Method Extension (uvm)
* 11. Sample scenarios

#authorization-gestureReferenced in:
* 1.1.1. Registration
* 1.1.2. Authentication
* 1.1.3. Other use cases and configurations
* 3. Terminology (2) (3) (4) (5) (6)

#biometric-recognitionReferenced in:
* 3. Terminology (2)

#ceremonyReferenced in:
* 1. Introduction
* 3. Terminology (2) (3) (4) (5) (6) (7)
* 6.1. Registering a new credential
* 6.2. Verifying an authentication assertion

#clientReferenced in:
* 3. Terminology

#conforming-user-agentReferenced in:
* 1. Introduction
* 2. Conformance (2) (3)
* 3. Terminology (2)

#credential-public-keyReferenced in:

* 4. Web Authentication API (2) (3)
* 4.1. PublicKeyCredential Interface
* 4.1.3. Create a new credential - PublicKeyCredential's [[Create]](options) method (2)
* 4.1.4. Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method (2) (3)
* 4.2. Authenticator Responses (interface AuthenticatorResponse)
* 4.2.1. Information about Public Key Credential (interface AuthenticatorAttestationResponse) (2)
* 4.2.2. Web Authentication Assertion (interface AuthenticatorAssertionResponse)
* 4.4.4. Authenticator Attachment enumeration (enum AuthenticatorAttachment)
* 4.5. Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions)
* 5. WebAuthn Authenticator model (2) (3) (4) (5) (6)
* 5.1. Authenticator data
* 5.2.1. The authenticatorMakeCredential operation
* 5.2.2. The authenticatorGetAssertion operation (2) (3)
* 5.3. Attestation (2) (3) (4) (5) (6) (7) (8) (9)
* 5.3.2. Attestation Statement Formats
* 5.3.4. Generating an Attestation Object (2)
* 5.3.5.1. Privacy
* 5.3.5.2. Attestation Certificate and Attestation Certificate CA Compromise
* 6.1. Registering a new credential
* 7.2. Packed Attestation Statement Format
* 7.4. Android Key Attestation Statement Format
* 7.5. Android SafetyNet Attestation Statement Format
* 9.5. Supported Extensions Extension (exts)
* 9.6. User Verification Index Extension (uvi)
* 9.7. Location Extension (loc) (2) (3) (4)
* 9.8. User Verification Method Extension (uvm)
* 11. Sample scenarios

#authorization-gestureReferenced in:
* 1.1.1. Registration
* 1.1.2. Authentication
* 1.1.3. Other use cases and configurations
* 3. Terminology (2) (3) (4) (5) (6)

#biometric-recognitionReferenced in:
* 3. Terminology (2)

#ceremonyReferenced in:
* 1. Introduction
* 3. Terminology (2) (3) (4) (5) (6) (7)
* 6.1. Registering a new credential
* 6.2. Verifying an authentication assertion

#clientReferenced in:
* 3. Terminology
* 4.1.5. Platform Authenticator Availability - PublicKeyCredential's isPlatformAuthenticatorAvailable() method (2) (3) (4)

#client-side-resident-credential-private-keyReferenced in:
* 3. Terminology (2)
* 4.1.3. Create a new credential - PublicKeyCredential's [[Create]](options) method
* 4.4.3. Authenticator Selection Criteria (dictionary AuthenticatorSelectionCriteria) (2)
* 5.2.1. The authenticatorMakeCredential operation

#conforming-user-agentReferenced in:
* 1. Introduction
* 2. Conformance (2) (3)
* 3. Terminology (2)

#credential-public-keyReferenced in:

* 3. Terminology
* 4.2.1. Information about Public Key Credential (interface
  AuthenticatorAttestationResponse)
* 5.1. Authenticator data
* 7.4. Android Key Attestation Statement Format
* 11.1. Registration (2)

#credential-key-pairReferenced in:
* 3. Terminology (2)
* 4.1.3. Create a new credential - PublicKeyCredential's
  \[[Create]](options) method

#credential-private-keyReferenced in:
* 3. Terminology (2)
* 4.1. PublicKeyCredential Interface
* 4.2.2. Web Authentication Assertion (interface
  AuthenticatorAssertionResponse)

#registrationReferenced in:
* 1. Introduction (2)
* 3. Terminology (2) (3) (4) (5) (6) (7)
* 6.1. Registering a new credential

#relying-partyReferenced in:
* 1. Introduction (2) (3) (4) (5)
* 1.1.3. Other use cases and configurations
* 3. Terminology (2) (3) (4) (5) (6) (7) (8) (9) (10) (11) (12) (13)
  (14)
* 4. Web Authentication API (2) (3)
* 4.2.1. Information about Public Key Credential (interface
  AuthenticatorAttestationResponse)
* 4.2.2. Web Authentication Assertion (interface
  AuthenticatorAssertionResponse)
* 4.5. Options for Credential Creation (dictionary
  MakeCredentialOptions) (2) (3) (4) (5)
* 4.5.1. Entity Description (2) (3) (4) (5)
* 4.5.2. Authenticator Selection Criteria (2)
* 4.5.3. Credential Attachment enumeration (enum Attachment) (2)
* 4.8.1. Client data used in WebAuthn signatures (dictionary
  CollectedClientData) (2) (3) (4)
* 4.8.4. Credential Transport enumeration (enum ExternalTransport)
  (2)
* 5. WebAuthn Authenticator model (2)
* 5.1. Authenticator data (2)
* 5.2.1. The authenticatorMakeCredential operation (2) (3) (4)
* 5.2.2. The authenticatorGetAssertion operation (2) (3)
* 5.3. Credential Attestation (2) (3)
* 5.3.5.1. Privacy
* 5.3.5.2. Attestation Certificate and Attestation Certificate CA
  Compromise (2) (3) (4) (5)
* 6. Relying Party Operations (2) (3) (4)
* 6.1. Registering a new credential (2) (3) (4) (5) (6) (7) (8) (9)
  (10) (11) (12) (13)
* 6.2. Verifying an authentication assertion (2) (3) (4)
* 7.4. Android Key Attestation Statement Format

* 3. Terminology (2) (3)
* 4.2.1. Information about Public Key Credential (interface
  AuthenticatorAttestationResponse)
* 5. WebAuthn Authenticator model
* 5.1. Authenticator data
* 5.3. Attestation (2) (3)
* 5.3.1. Attestation data (2)
* 7.4. Android Key Attestation Statement Format
* 11.1. Registration (2)

#credential-key-pairReferenced in:
* 3. Terminology (2) (3)
* 4.1.3. Create a new credential - PublicKeyCredential's
  [[Create]](options) method

#credential-private-keyReferenced in:
* 3. Terminology (2) (3) (4)
* 4.1. PublicKeyCredential Interface
* 4.2.2. Web Authentication Assertion (interface
  AuthenticatorAssertionResponse)
* 5. WebAuthn Authenticator model
* 5.2.2. The authenticatorGetAssertion operation
* 5.3. Attestation (2)

#registrationReferenced in:
* 1. Introduction (2)
* 3. Terminology (2) (3) (4) (5) (6) (7) (8) (9)
* 6.1. Registering a new credential

#relying-partyReferenced in:
* 1. Introduction (2) (3) (4) (5) (6) (7)
* 1.1.3. Other use cases and configurations
* 3. Terminology (2) (3) (4) (5) (6) (7) (8) (9) (10) (11) (12) (13)
  (14) (15) (16) (17) (18) (19) (20) (21) (22)
* 4. Web Authentication API (2) (3) (4) (5) (6) (7)
* 4.1.4. Use an existing credential to make an assertion -
  PublicKeyCredential's [[DiscoverFromExternalSource]](options)
  method (2)
* 4.1.5. Platform Authenticator Availability - PublicKeyCredential's
  isPlatformAuthenticatorAvailable() method (2) (3)
* 4.2. Authenticator Responses (interface AuthenticatorResponse)
* 4.2.1. Information about Public Key Credential (interface
  AuthenticatorAttestationResponse) (2)
* 4.2.2. Web Authentication Assertion (interface
  AuthenticatorAssertionResponse)
* 4.4. Options for Credential Creation (dictionary
  MakePublicKeyCredentialOptions) (2) (3) (4) (5) (6) (7) (8)
* 4.4.1. Public Key Entity Description (dictionary
  PublicKeyCredentialEntity) (2) (3) (4) (5)
* 4.4.3. Authenticator Selection Criteria (dictionary
  AuthenticatorSelectionCriteria) (2) (3)
* 4.4.4. Authenticator Attachment enumeration (enum
  AuthenticatorAttachment) (2) (3) (4)
* 4.7.1. Client data used in WebAuthn signatures (dictionary
  CollectedClientData) (2) (3) (4)
* 4.7.4. Authenticator Transport enumeration (enum
  AuthenticatorTransport) (2)
* 5. WebAuthn Authenticator model (2)
* 5.1. Authenticator data (2)
* 5.2.1. The authenticatorMakeCredential operation (2) (3) (4)
* 5.2.2. The authenticatorGetAssertion operation (2) (3)
* 5.3. Attestation (2) (3) (4) (5) (6)
* 5.3.5.1. Privacy
* 5.3.5.2. Attestation Certificate and Attestation Certificate CA
  Compromise (2) (3) (4) (5) (6)
* 6. Relying Party Operations (2) (3) (4)
* 6.1. Registering a new credential (2) (3) (4) (5) (6) (7) (8) (9)
  (10) (11) (12) (13)
* 6.2. Verifying an authentication assertion (2) (3) (4) (5)
* 7.4. Android Key Attestation Statement Format

* 8. WebAuthn Extensions (2) (3)
* 8.2. Defining extensions (2)
* 8.3. Extending request parameters (2) (3) (4)
* 8.6. Example Extension (2) (3)

* 9.2. Simple Transaction Authorization Extension (txAuthSimple)
* 9.4. Authenticator Selection Extension (authnSel) (2)
* 9.5. Supported Extensions Extension (exts) (2)
* 9.6. User Verification Index Extension (uvi)
* 9.7. Location Extension (loc)
* 10.2. WebAuthn Extension Identifier Registrations
* 11.1. Registration (2) (3) (4)
* 11.2. Authentication (2) (3) (4) (5)
* 11.3. Decommissioning (2)

#relying-party-identifierReferenced in:
* 4.5. Options for Credential Creation (dictionary MakeCredentialOptions)
* 4.6. Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions)
* 5. WebAuthn Authenticator model

#rp-idReferenced in:
* 3. Terminology (2)

* 5. WebAuthn Authenticator model

#public-key-credentialReferenced in:
* 1. Introduction (2) (3) (4) (5)
* 3. Terminology (2) (3) (4) (5) (6)
* 4. Web Authentication API
* 4.1. PublicKeyCredential Interface
* 4.1.4. Use an existing credential - PublicKeyCredential::[[DiscoverFromExternalSource]](options) method

* 4.2.1. Information about Public Key Credential (interface AuthenticatorAttestationResponse)
* 4.5.2. Authenticator Selection Criteria
* 4.6. Options for Assertion Generation (dictionary

PublicKeyCredentialRequestOptions)
* 4.8. Supporting Data Structures
* 5. WebAuthn Authenticator model (2) (3)

* 5.3.3. Attestation Types

* 5.3.5.2. Attestation Certificate and Attestation Certificate CA Compromise (2)

* 8. WebAuthn Extensions (2) (3) (4)
* 8.2. Defining extensions (2)
* 8.3. Extending request parameters (2) (3) (4)
* 8.6. Example Extension (2) (3)
* 9.1. FIDO AppId Extension (appid) (2)
* 9.2. Simple Transaction Authorization Extension (txAuthSimple)
* 9.4. Authenticator Selection Extension (authnSel) (2) (3)
* 9.5. Supported Extensions Extension (exts) (2)
* 9.6. User Verification Index Extension (uvi)
* 9.7. Location Extension (loc) (2)
* 10.2. WebAuthn Extension Identifier Registrations (2)
* 11.1. Registration (2) (3) (4) (5)
* 11.2. Registration Specifically with Platform Authenticator (2) (3)
* 11.3. Authentication (2) (3) (4) (5)
* 11.4. Decommissioning (2)

#relying-party-identifierReferenced in:
* 4. Web Authentication API
* 4.4. Options for Credential Creation (dictionary MakePublicKeyCredentialOptions)
* 4.5. Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions)
* 5. WebAuthn Authenticator model

#rp-idReferenced in:
* 3. Terminology (2) (3) (4) (5) (6)
* 4. Web Authentication API (2) (3) (4) (5)
* 4.1.3. Create a new credential - PublicKeyCredential's [[Create]](options) method (2)
* 4.1.4. Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method (2)
* 4.4.1. Public Key Entity Description (dictionary PublicKeyCredentialEntity)
* 5. WebAuthn Authenticator model
* 5.1. Authenticator data (2) (3) (4) (5) (6)
* 5.2.1. The authenticatorMakeCredential operation (2) (3)
* 5.2.2. The authenticatorGetAssertion operation (2) (3)
* 6.1. Registering a new credential (2)
* 6.2. Verifying an authentication assertion (2)
* 7.4. Android Key Attestation Statement Format
* 7.6. FIDO U2F Attestation Statement Format (2) (3)

#public-key-credentialReferenced in:
* 1. Introduction (2) (3) (4) (5)
* 3. Terminology (2) (3) (4) (5) (6) (7) (8)
* 4. Web Authentication API (2) (3) (4)
* 4.1. PublicKeyCredential Interface
* 4.1.3. Create a new credential - PublicKeyCredential's [[Create]](options) method
* 4.1.4. Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method (2)
* 4.2.1. Information about Public Key Credential (interface AuthenticatorAttestationResponse)
* 4.4.1. Public Key Entity Description (dictionary PublicKeyCredentialEntity)
* 4.4.3. Authenticator Selection Criteria (dictionary AuthenticatorSelectionCriteria)
* 4.5. Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions)
* 4.7. Supporting Data Structures
* 5. WebAuthn Authenticator model (2) (3) (4) (5)
* 5.2.2. The authenticatorGetAssertion operation (2) (3)
* 5.3. Attestation (2)
* 5.3.2. Attestation Statement Formats
* 5.3.3. Attestation Types
* 5.3.4. Generating an Attestation Object
* 5.3.5.2. Attestation Certificate and Attestation Certificate CA Compromise (2)

* 6.1. Registering a new credential
* 8. WebAuthn Extensions (2)
* 11. Sample scenarios

#test-of-user-presenceReferenced in:
* 3. Terminology (2)
* 5.1. Authenticator data
* 9.2. Simple Transaction Authorization Extension (txAuthSimple)
* 9.3. Generic Transaction Authorization Extension (txAuthGeneric)

#tupReferenced in:
* 3. Terminology

#client-side-resident-credential-private-keyReferenced in:
* 3. Terminology (2)
* 4.1.3. Create a new credential - PublicKeyCredential's \[[Create]](options) method
* 4.5.2. Authenticator Selection Criteria (2)
* 5.2.1. The authenticatorMakeCredential operation

#user-consentReferenced in:
* 1. Introduction
* 3. Terminology (2)
* 4.1.3. Create a new credential - PublicKeyCredential's \[[Create]](options) method
* 4.2.2. Web Authentication Assertion (interface AuthenticatorAssertionResponse)

#user-verificationReferenced in:
* 1. Introduction
* 3. Terminology (2) (3) (4) (5) (6) (7)
* 9.2. Simple Transaction Authorization Extension (txAuthSimple)
* 9.3. Generic Transaction Authorization Extension (txAuthGeneric)

#webauthn-clientReferenced in:
* 3. Terminology (2)

#web-authentication-apiReferenced in:
* 1. Introduction (2) (3)
* 3. Terminology (2)

#publickeycredentialReferenced in:
* 1. Introduction
* 4.1. PublicKeyCredential Interface (2) (3) (4) (5) (6) (7) (8)
* 4.1.3. Create a new credential - PublicKeyCredential's \[[Create]](options) method (2) (3) (4) (5) (6)
* 4.1.4. Use an existing credential - PublicKeyCredential::[[DiscoverFromExternalSource]](options) method (2)
* 4.8.3. Credential Descriptor (dictionary

* 6.1. Registering a new credential
* 8. WebAuthn Extensions (2)
* 11. Sample scenarios

#test-of-user-presenceReferenced in:
* 3. Terminology (2) (3) (4) (5) (6)
* 9.2. Simple Transaction Authorization Extension (txAuthSimple)
* 9.3. Generic Transaction Authorization Extension (txAuthGeneric)

#user-consentReferenced in:
* 1. Introduction
* 3. Terminology (2)
* 4.1.3. Create a new credential - PublicKeyCredential's [[Create]](options) method
* 4.2.2. Web Authentication Assertion (interface AuthenticatorAssertionResponse)
* 5. WebAuthn Authenticator model (2) (3)
* 5.2.2. The authenticatorGetAssertion operation (2)

#user-verificationReferenced in:
* 1. Introduction
* 3. Terminology (2) (3) (4) (5) (6) (7) (8)
* 4.1.3. Create a new credential - PublicKeyCredential's [[Create]](options) method
* 9.2. Simple Transaction Authorization Extension (txAuthSimple)
* 9.3. Generic Transaction Authorization Extension (txAuthGeneric)

#concept-user-presentReferenced in:
* 3. Terminology
* 5.1. Authenticator data (2) (3)

#upReferenced in:
* 5.1. Authenticator data

#concept-user-verifiedReferenced in:
* 3. Terminology
* 5.1. Authenticator data (2) (3)

#uvReferenced in:
* 5.1. Authenticator data

#webauthn-clientReferenced in:
* 3. Terminology (2)

#web-authentication-apiReferenced in:
* 1. Introduction (2) (3)
* 3. Terminology (2)

#publickeycredentialReferenced in:
* 1. Introduction
* 4.1. PublicKeyCredential Interface (2) (3) (4) (5) (6) (7) (8)
* 4.1.3. Create a new credential - PublicKeyCredential's [[Create]](options) method (2) (3) (4) (5) (6)
* 4.1.4. Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method (2) (3)
* 4.1.5. Platform Authenticator Availability - PublicKeyCredential's isPlatformAuthenticatorAvailable() method
* 4.7.3. Credential Descriptor (dictionary

PublicKeyCredentialDescriptor)
* 5.2.1. The authenticatorMakeCredential operation (2)
* 6. Relying Party Operations
* 6.2. Verifying an authentication assertion

#dom-publickeycredential-rawidReferenced in:
* 4.1. PublicKeyCredential Interface
* 6.2. Verifying an authentication assertion

#dom-publickeycredential-responseReferenced in:
* 4.1. PublicKeyCredential Interface
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.1.4. Use an existing credential -
PublicKeyCredential::[[DiscoverFromExternalSource]](options) method
* 6.2. Verifying an authentication assertion

#dom-publickeycredential-clientextensionresultsReferenced in:
* 4.1. PublicKeyCredential Interface
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.1.4. Use an existing credential -
PublicKeyCredential::[[DiscoverFromExternalSource]](options) method
* 8.4. Client extension processing

#dom-publickeycredential-identifier-slotReferenced in:
* 4.1. PublicKeyCredential Interface (2)
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.1.4. Use an existing credential -
PublicKeyCredential::[[DiscoverFromExternalSource]](options) method

#dictdef-credentialrequestoptionsReferenced in:
* 4.1.1. CredentialRequestOptions Extension
* 4.1.4. Use an existing credential -
PublicKeyCredential::[[DiscoverFromExternalSource]](options) method

#dom-credentialrequestoptions-publickeyReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method (2)
* 4.1.4. Use an existing credential -
PublicKeyCredential::[[DiscoverFromExternalSource]](options) method

#dom-credentialcreationoptions-publickeyReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method

#dom-publickeycredential-create-slotReferenced in:
* 4.1. PublicKeyCredential Interface

#dom-publickeycredential-create-options-optionsReferenced in:
* 6.1. Registering a new credential

#dom-publickeycredential-discoverfromexternalsource-slotReferenced in:
* 4.1. PublicKeyCredential Interface

#authenticatorresponseReferenced in:
* 4.1. PublicKeyCredential Interface (2)
* 4.2. Authenticator Responses (interface AuthenticatorResponse) (2)
* 4.2.1. Information about Public Key Credential (interface
AuthenticatorAttestationResponse) (2)
* 4.2.2. Web Authentication Assertion (interface
AuthenticatorAssertionResponse) (2)

PublicKeyCredentialDescriptor)
* 5.2.1. The authenticatorMakeCredential operation
* 6. Relying Party Operations
* 6.2. Verifying an authentication assertion

#dom-publickeycredential-rawidReferenced in:
* 4.1. PublicKeyCredential Interface
* 6.2. Verifying an authentication assertion

#dom-publickeycredential-responseReferenced in:
* 4.1. PublicKeyCredential Interface
* 4.1.3. Create a new credential - PublicKeyCredential's
[[Create]](options) method
* 4.1.4. Use an existing credential to make an assertion -
PublicKeyCredential's [[DiscoverFromExternalSource]](options)
method
* 6.2. Verifying an authentication assertion

#dom-publickeycredential-clientextensionresultsReferenced in:
* 4.1. PublicKeyCredential Interface
* 4.1.3. Create a new credential - PublicKeyCredential's
[[Create]](options) method
* 4.1.4. Use an existing credential to make an assertion -
PublicKeyCredential's [[DiscoverFromExternalSource]](options)
method
* 8.4. Client extension processing

#dom-publickeycredential-identifier-slotReferenced in:
* 4.1. PublicKeyCredential Interface (2)
* 4.1.3. Create a new credential - PublicKeyCredential's
[[Create]](options) method
* 4.1.4. Use an existing credential to make an assertion -
PublicKeyCredential's [[DiscoverFromExternalSource]](options)
method

#dom-credentialcreationoptions-publickeyReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
[[Create]](options) method (2) (3)

#dom-credentialrequestoptions-publickeyReferenced in:
* 4.1.4. Use an existing credential to make an assertion -
PublicKeyCredential's [[DiscoverFromExternalSource]](options)
method (2) (3)

#dom-publickeycredential-create-slotReferenced in:
* 4.1. PublicKeyCredential Interface

#dom-publickeycredential-create-options-optionsReferenced in:
* 6.1. Registering a new credential

#dom-publickeycredential-discoverfromexternalsource-slotReferenced in:
* 4.1. PublicKeyCredential Interface

#authenticatorresponseReferenced in:
* 4.1. PublicKeyCredential Interface (2)
* 4.2. Authenticator Responses (interface AuthenticatorResponse) (2)
* 4.2.1. Information about Public Key Credential (interface
AuthenticatorAttestationResponse) (2)
* 4.2.2. Web Authentication Assertion (interface
AuthenticatorAssertionResponse) (2)

```
#dom-authenticatorresponse-clientdatajsonReferenced in:
  * 4.1.3. Create a new credential - PublicKeyCredential's
    \[[Create]](options) method (2)
  * 4.1.4. Use an existing credential -
    PublicKeyCredential::[[DiscoverFromExternalSource]](options) method
    (2)
  * 4.2. Authenticator Responses (interface AuthenticatorResponse)
  * 4.2.1. Information about Public Key Credential (interface
    AuthenticatorAttestationResponse)
  * 4.2.2. Web Authentication Assertion (interface
    AuthenticatorAssertionResponse)
  * 6.1. Registering a new credential (2)
  * 6.2. Verifying an authentication assertion

#authenticatorattestationresponseReferenced in:
  * 4.1. PublicKeyCredential Interface
  * 4.1.3. Create a new credential - PublicKeyCredential's
    \[[Create]](options) method (2)
  * 4.2.1. Information about Public Key Credential (interface
    AuthenticatorAttestationResponse) (2)
  * 6. Relying Party Operations
  * 6.1. Registering a new credential (2) (3)

#dom-authenticatorattestationresponse-attestationobjectReferenced in:
  * 4.1.3. Create a new credential - PublicKeyCredential's
    \[[Create]](options) method
  * 4.2.1. Information about Public Key Credential (interface
    AuthenticatorAttestationResponse)
  * 6.1. Registering a new credential

#authenticatorassertionresponseReferenced in:
  * 3. Terminology
  * 4.1. PublicKeyCredential Interface
  * 4.1.4. Use an existing credential -
    PublicKeyCredential::[[DiscoverFromExternalSource]](options) method

  * 4.2.2. Web Authentication Assertion (interface
    AuthenticatorAssertionResponse) (2)
  * 6. Relying Party Operations

#dom-authenticatorassertionresponse-authenticatordataReferenced in:
  * 4.1.4. Use an existing credential -
    PublicKeyCredential::[[DiscoverFromExternalSource]](options) method
    (2)
  * 4.2.2. Web Authentication Assertion (interface
    AuthenticatorAssertionResponse)
  * 6.2. Verifying an authentication assertion

#dom-authenticatorassertionresponse-signatureReferenced in:
  * 4.1.4. Use an existing credential -
    PublicKeyCredential::[[DiscoverFromExternalSource]](options) method
    (2)
  * 4.2.2. Web Authentication Assertion (interface
    AuthenticatorAssertionResponse)
  * 6.2. Verifying an authentication assertion

#dictdef-publickeycredentialparametersReferenced in:
  * 4.3. Parameters for Credential Generation (dictionary
    PublicKeyCredentialParameters)
  * 4.5. Options for Credential Creation (dictionary
    MakeCredentialOptions) (2)

#dom-publickeycredentialparameters-typeReferenced in:
  * 4.1.3. Create a new credential - PublicKeyCredential's
    \[[Create]](options) method (2)
  * 4.3. Parameters for Credential Generation (dictionary
    PublicKeyCredentialParameters)

#dom-publickeycredentialparameters-algorithmReferenced in:
```



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#dom-authenticatorresponse-clientdatajsonReferenced in:
  * 4.1.3. Create a new credential - PublicKeyCredential's
    [[Create]](options) method (2)
  * 4.1.4. Use an existing credential to make an assertion -
    PublicKeyCredential's [[DiscoverFromExternalSource]](options)
    method (2)
  * 4.2. Authenticator Responses (interface AuthenticatorResponse)
  * 4.2.1. Information about Public Key Credential (interface
    AuthenticatorAttestationResponse)
  * 4.2.2. Web Authentication Assertion (interface
    AuthenticatorAssertionResponse)
  * 6.1. Registering a new credential (2)
  * 6.2. Verifying an authentication assertion

#authenticatorattestationresponseReferenced in:
  * 4.1. PublicKeyCredential Interface
  * 4.1.3. Create a new credential - PublicKeyCredential's
    [[Create]](options) method (2)
  * 4.2.1. Information about Public Key Credential (interface
    AuthenticatorAttestationResponse) (2)
  * 6. Relying Party Operations
  * 6.1. Registering a new credential (2) (3)

#dom-authenticatorattestationresponse-attestationobjectReferenced in:
  * 4.1.3. Create a new credential - PublicKeyCredential's
    [[Create]](options) method
  * 4.2.1. Information about Public Key Credential (interface
    AuthenticatorAttestationResponse)
  * 6.1. Registering a new credential

#authenticatorassertionresponseReferenced in:
  * 3. Terminology
  * 4.1. PublicKeyCredential Interface
  * 4.1.4. Use an existing credential to make an assertion -
    PublicKeyCredential's [[DiscoverFromExternalSource]](options)
    method
  * 4.2.2. Web Authentication Assertion (interface
    AuthenticatorAssertionResponse) (2)
  * 6. Relying Party Operations

#dom-authenticatorassertionresponse-authenticatordataReferenced in:
  * 4.1.4. Use an existing credential to make an assertion -
    PublicKeyCredential's [[DiscoverFromExternalSource]](options)
    method (2)
  * 4.2.2. Web Authentication Assertion (interface
    AuthenticatorAssertionResponse)
  * 6.2. Verifying an authentication assertion

#dom-authenticatorassertionresponse-signatureReferenced in:
  * 4.1.4. Use an existing credential to make an assertion -
    PublicKeyCredential's [[DiscoverFromExternalSource]](options)
    method (2)
  * 4.2.2. Web Authentication Assertion (interface
    AuthenticatorAssertionResponse)
  * 6.2. Verifying an authentication assertion

#dictdef-publickeycredentialparametersReferenced in:
  * 4.3. Parameters for Credential Generation (dictionary
    PublicKeyCredentialParameters)
  * 4.4. Options for Credential Creation (dictionary
    MakePublicKeyCredentialOptions) (2)

#dom-publickeycredentialparameters-typeReferenced in:
  * 4.1.3. Create a new credential - PublicKeyCredential's
    [[Create]](options) method (2)
  * 4.3. Parameters for Credential Generation (dictionary
    PublicKeyCredentialParameters)

#dom-publickeycredentialparameters-algReferenced in:
```

* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.3. Parameters for Credential Generation (dictionary
PublicKeyCredentialParameters)

#dictdef-publickeycredentialuserentityReferenced in:
* 4.4. User Account Parameters for Credential Generation (dictionary
PublicKeyCredentialUserEntity)
* 4.5. Options for Credential Creation (dictionary
MakeCredentialOptions) (2)

#dom-publickeycredentialuserentity-displaynameReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.4. User Account Parameters for Credential Generation (dictionary
PublicKeyCredentialUserEntity)
* 4.5. Options for Credential Creation (dictionary
MakeCredentialOptions)

#dictdef-makecredentialoptionsReferenced in:
* 4.1.2. CredentialCreationOptions Extension
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.5. Options for Credential Creation (dictionary
MakeCredentialOptions)

#dom-makecredentialoptions-rpReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method (2) (3) (4) (5)
* 4.5. Options for Credential Creation (dictionary
MakeCredentialOptions)

#dom-makecredentialoptions-userReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method (2) (3) (4)
* 4.5. Options for Credential Creation (dictionary
MakeCredentialOptions)
* 5.2.1. The authenticatorMakeCredential operation (2)
* 6.1. Registering a new credential

#dom-makecredentialoptions-challengeReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.5. Options for Credential Creation (dictionary
MakeCredentialOptions)

#dom-makecredentialoptions-parametersReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method (2)
* 4.5. Options for Credential Creation (dictionary
MakeCredentialOptions)

#dom-makecredentialoptions-timeoutReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method (2)
* 4.5. Options for Credential Creation (dictionary
MakeCredentialOptions)

#dom-makecredentialoptions-excludelistReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.5. Options for Credential Creation (dictionary
MakeCredentialOptions)

#dom-makecredentialoptions-authenticatorselectionReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.5. Options for Credential Creation (dictionary
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* 4.1.3. Create a new credential - PublicKeyCredential's
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* 4.3. Parameters for Credential Generation (dictionary
PublicKeyCredentialParameters)

#dictdef-makepublickeycredentialoptionsReferenced in:
* 4.1.1. CredentialCreationOptions Extension
* 4.1.3. Create a new credential - PublicKeyCredential's
[[Create]](options) method
* 4.4. Options for Credential Creation (dictionary
MakePublicKeyCredentialOptions)

#dom-makepublickeycredentialoptions-rpReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
[[Create]](options) method (2) (3) (4) (5) (6)
* 4.4. Options for Credential Creation (dictionary
MakePublicKeyCredentialOptions)

#dom-makepublickeycredentialoptions-userReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
[[Create]](options) method (2) (3) (4)
* 4.4. Options for Credential Creation (dictionary
MakePublicKeyCredentialOptions)
* 5.2.1. The authenticatorMakeCredential operation (2)
* 6.1. Registering a new credential

#dom-makepublickeycredentialoptions-challengeReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
[[Create]](options) method
* 4.4. Options for Credential Creation (dictionary
MakePublicKeyCredentialOptions)

#dom-makepublickeycredentialoptions-pubkeycredparamsReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
[[Create]](options) method (2)
* 4.4. Options for Credential Creation (dictionary
MakePublicKeyCredentialOptions)

#dom-makepublickeycredentialoptions-timeoutReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
[[Create]](options) method (2)
* 4.4. Options for Credential Creation (dictionary
MakePublicKeyCredentialOptions)

#dom-makepublickeycredentialoptions-excludecredentialsReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
[[Create]](options) method
* 4.4. Options for Credential Creation (dictionary
MakePublicKeyCredentialOptions)

#dom-makepublickeycredentialoptions-authenticatorselectionReferenced
in:
* 4.1.3. Create a new credential - PublicKeyCredential's
[[Create]](options) method (2)
* 4.4. Options for Credential Creation (dictionary
MakePublicKeyCredentialOptions)

* 5.2.1. The authenticatorMakeCredential operation

#dom-makecredentialoptions-extensionsReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
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* 4.5. Options for Credential Creation (dictionary
MakeCredentialOptions)
* 8.3. Extending request parameters

#dictdef-publickeycredentialentityReferenced in:
* 4.4. User Account Parameters for Credential Generation (dictionary
PublicKeyCredentialUserEntity)
* 4.5. Options for Credential Creation (dictionary
MakeCredentialOptions) (2)
* 4.5.1. Entity Description
* 5.2.1. The authenticatorMakeCredential operation (2)

#dom-publickeycredentialentity-idReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method (2) (3) (4)
* 4.5. Options for Credential Creation (dictionary
MakeCredentialOptions) (2) (3)
* 4.5.1. Entity Description

* 5.2.1. The authenticatorMakeCredential operation (2)

#dom-publickeycredentialentity-nameReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method (2)
* 4.5. Options for Credential Creation (dictionary
MakeCredentialOptions) (2)
* 4.5.1. Entity Description

#dom-publickeycredentialentity-iconReferenced in:
* 4.5.1. Entity Description

#dictdef-authenticatorselectioncriteriaReferenced in:
* 4.5. Options for Credential Creation (dictionary
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* 4.5.2. Authenticator Selection Criteria

#dom-authenticatorselectioncriteria-attachmentReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.5.2. Authenticator Selection Criteria

#dom-authenticatorselectioncriteria-requireresidentkeyReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.5.2. Authenticator Selection Criteria

* 5.2.1. The authenticatorMakeCredential operation (2)

#dom-makepublickeycredentialoptions-extensionsReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
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* 4.4. Options for Credential Creation (dictionary
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* 8.3. Extending request parameters

#dictdef-publickeycredentialentityReferenced in:
* 4.4. Options for Credential Creation (dictionary
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* 4.4.1. Public Key Entity Description (dictionary
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* 5.2.1. The authenticatorMakeCredential operation

#dom-publickeycredentialentity-idReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
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* 4.4. Options for Credential Creation (dictionary
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* 4.4.1. Public Key Entity Description (dictionary
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* 5.2.1. The authenticatorMakeCredential operation (2)

#dom-publickeycredentialentity-nameReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
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* 4.4. Options for Credential Creation (dictionary
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* 4.4.1. Public Key Entity Description (dictionary
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#dom-publickeycredentialentity-iconReferenced in:
* 4.4.1. Public Key Entity Description (dictionary
PublicKeyCredentialEntity)

#dictdef-publickeycredentialuserentityReferenced in:
* 4.4. Options for Credential Creation (dictionary
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* 4.4.2. User Account Parameters for Credential Generation
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* 5.2.1. The authenticatorMakeCredential operation

#dom-publickeycredentialuserentity-displaynameReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
[[Create]](options) method
* 4.4. Options for Credential Creation (dictionary
MakePublicKeyCredentialOptions)
* 4.4.2. User Account Parameters for Credential Generation
(dictionary PublicKeyCredentialUserEntity)

#dictdef-authenticatorselectioncriteriaReferenced in:
* 4.4. Options for Credential Creation (dictionary
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* 4.4.3. Authenticator Selection Criteria (dictionary
AuthenticatorSelectionCriteria) (2)

#dom-authenticatorselectioncriteria-aaReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
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* 4.4.3. Authenticator Selection Criteria (dictionary
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#dom-authenticatorselectioncriteria-rkReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
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* 4.4.3. Authenticator Selection Criteria (dictionary

#enumdef-attachmentReferenced in:
* 4.5.2. Authenticator Selection Criteria (2)
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#platform-authenticatorsReferenced in:
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* 4.5.3. Credential Attachment enumeration (enum Attachment) (2)

#platform-attachmentReferenced in:
* 4.5.3. Credential Attachment enumeration (enum Attachment)

#cross-platform-attachedReferenced in:
* 4.5.3. Credential Attachment enumeration (enum Attachment) (2)

#dictdef-publickeycredentialrequestoptionsReferenced in:
* 4.1.1. CredentialRequestOptions Extension
* 4.6. Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions) (2)
* 6.2. Verifying an authentication assertion

#dom-publickeycredentialrequestoptions-challengeReferenced in:
* 4.1.4. Use an existing credential - PublicKeyCredential::[[DiscoverFromExternalSource]](options) method
* 4.6. Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions) (2)

#dom-publickeycredentialrequestoptions-timeoutReferenced in:
* 4.1.4. Use an existing credential - PublicKeyCredential::[[DiscoverFromExternalSource]](options) method (2)
* 4.6. Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions)

#dom-publickeycredentialrequestoptions-rpidReferenced in:
* 4.1.4. Use an existing credential - PublicKeyCredential::[[DiscoverFromExternalSource]](options) method (2) (3)
* 4.6. Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions)
* 9.1. FIDO AppId Extension (appid)

#dom-publickeycredentialrequestoptions-allowlistReferenced in:
* 4.1.4. Use an existing credential - PublicKeyCredential::[[DiscoverFromExternalSource]](options) method (2) (3) (4)
* 4.6. Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions)

AuthenticatorSelectionCriteria)

#dom-authenticatorselectioncriteria-uvReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's [[Create]](options) method
* 4.4.3. Authenticator Selection Criteria (dictionary AuthenticatorSelectionCriteria)

#enumdef-authenticatorattachmentReferenced in:
* 4.4.3. Authenticator Selection Criteria (dictionary AuthenticatorSelectionCriteria) (2)
* 4.4.4. Authenticator Attachment enumeration (enum AuthenticatorAttachment) (2)

#platform-authenticatorsReferenced in:
* 4.1.5. Platform Authenticator Availability - PublicKeyCredential's isPlatformAuthenticatorAvailable() method (2) (3) (4) (5)
* 4.4.4. Authenticator Attachment enumeration (enum AuthenticatorAttachment) (2)
* 11.1. Registration
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#roaming-authenticatorsReferenced in:
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* 4.4.4. Authenticator Attachment enumeration (enum AuthenticatorAttachment) (2)
* 11.1. Registration

#platform-attachmentReferenced in:
* 4.4.4. Authenticator Attachment enumeration (enum AuthenticatorAttachment)

#cross-platform-attachedReferenced in:
* 4.4.4. Authenticator Attachment enumeration (enum AuthenticatorAttachment) (2)

#dictdef-publickeycredentialrequestoptionsReferenced in:
* 4.1.2. CredentialRequestOptions Extension
* 4.5. Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions) (2)
* 6.2. Verifying an authentication assertion

#dom-publickeycredentialrequestoptions-challengeReferenced in:
* 4.1.4. Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method
* 4.5. Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions) (2)

#dom-publickeycredentialrequestoptions-timeoutReferenced in:
* 4.1.4. Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method (2)
* 4.5. Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions)

#dom-publickeycredentialrequestoptions-rpidReferenced in:
* 4.1.4. Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method (2) (3) (4)
* 4.5. Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions)
* 9.1. FIDO AppId Extension (appid)

#dom-publickeycredentialrequestoptions-allowcredentialsReferenced in:
* 4.1.4. Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method (2) (3) (4)
* 4.5. Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions)

#dom-publickeycredentialrequestoptions-extensionsReferenced in:
* 4.1.4. Use an existing credential -
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* 4.6. Options for Assertion Generation (dictionary
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#typedefdef-authenticationextensionsReferenced in:
* 4.1. PublicKeyCredential Interface (2)
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.1.4. Use an existing credential -
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* 4.5. Options for Credential Creation (dictionary
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* 4.8.1. Client data used in WebAuthn signatures (dictionary
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#dictdef-collectedclientdataReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.1.4. Use an existing credential -
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* 4.8.1. Client data used in WebAuthn signatures (dictionary

CollectedClientData) (2)

#client-dataReferenced in:
* 4.2. Authenticator Responses (interface AuthenticatorResponse)
* 5. WebAuthn Authenticator model (2) (3)
* 5.1. Authenticator data (2)
* 6.1. Registering a new credential
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#dom-collectedclientdata-challengeReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
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* 4.1.4. Use an existing credential -
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* 4.8.1. Client data used in WebAuthn signatures (dictionary

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* 6.1. Registering a new credential
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#dom-collectedclientdata-originReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.1.4. Use an existing credential -
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* 4.8.1. Client data used in WebAuthn signatures (dictionary

CollectedClientData)
* 6.1. Registering a new credential
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#dom-collectedclientdata-hashalgReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.1.4. Use an existing credential -
PublicKeyCredential::[[DiscoverFromExternalSource]](options) method
* 4.8.1. Client data used in WebAuthn signatures (dictionary

#dom-publickeycredentialrequestoptions-extensionsReferenced in:
* 4.1.4. Use an existing credential to make an assertion -
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* 4.5. Options for Assertion Generation (dictionary
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#typedefdef-authenticationextensionsReferenced in:
* 4.1. PublicKeyCredential Interface (2)
* 4.1.3. Create a new credential - PublicKeyCredential's
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* 4.1.4. Use an existing credential to make an assertion -
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* 4.4. Options for Credential Creation (dictionary
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* 4.7.1. Client data used in WebAuthn signatures (dictionary
CollectedClientData) (2)

#dictdef-collectedclientdataReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
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* 4.1.4. Use an existing credential to make an assertion -
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* 4.7.1. Client data used in WebAuthn signatures (dictionary
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#client-dataReferenced in:
* 4.2. Authenticator Responses (interface AuthenticatorResponse)
* 5. WebAuthn Authenticator model (2) (3) (4)
* 5.1. Authenticator data (2)
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* 8. WebAuthn Extensions
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#dom-collectedclientdata-challengeReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
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* 4.1.4. Use an existing credential to make an assertion -
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* 4.7.1. Client data used in WebAuthn signatures (dictionary
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* 6.1. Registering a new credential
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#dom-collectedclientdata-originReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
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* 4.1.4. Use an existing credential to make an assertion -
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* 4.7.1. Client data used in WebAuthn signatures (dictionary
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* 6.1. Registering a new credential
* 6.2. Verifying an authentication assertion

#dom-collectedclientdata-hashalgorithmReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
[[Create]](options) method
* 4.1.4. Use an existing credential to make an assertion -
PublicKeyCredential's [[DiscoverFromExternalSource]](options)
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* 4.7.1. Client data used in WebAuthn signatures (dictionary

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#dom-collectedclientdata-tokenbindingReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.1.4. Use an existing credential -
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* 4.8.1. Client data used in WebAuthn signatures (dictionary

CollectedClientData)
* 6.1. Registering a new credential
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#dom-collectedclientdata-clientextensionsReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.1.4. Use an existing credential -
PublicKeyCredential::[[DiscoverFromExternalSource]](options) method
* 4.8.1. Client data used in WebAuthn signatures (dictionary

CollectedClientData)
* 6.1. Registering a new credential
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* 8.4. Client extension processing

#dom-collectedclientdata-authenticatorextensionsReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.1.4. Use an existing credential -
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* 4.8.1. Client data used in WebAuthn signatures (dictionary

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* 6.1. Registering a new credential
* 6.2. Verifying an authentication assertion

#collectedclientdata-json-serialized-client-dataReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method
* 4.1.4. Use an existing credential -
PublicKeyCredential::[[DiscoverFromExternalSource]](options) method

* 4.2. Authenticator Responses (interface AuthenticatorResponse)
* 4.2.1. Information about Public Key Credential (interface
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* 4.2.2. Web Authentication Assertion (interface
AuthenticatorAssertionResponse)
* 4.8.1. Client data used in WebAuthn signatures (dictionary
CollectedClientData)

#collectedclientdata-hash-of-the-serialized-client-dataReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
\[[Create]](options) method (2)
* 4.1.4. Use an existing credential -
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* 4.2.1. Information about Public Key Credential (interface
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* 5.3.2. Attestation Statement Formats (2)
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#dom-collectedclientdata-tokenbindingidReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
[[Create]](options) method
* 4.1.4. Use an existing credential to make an assertion -
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* 4.7.1. Client data used in WebAuthn signatures (dictionary
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* 6.1. Registering a new credential
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#dom-collectedclientdata-clientextensionsReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
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* 4.1.4. Use an existing credential to make an assertion -
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* 4.7.1. Client data used in WebAuthn signatures (dictionary
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* 6.1. Registering a new credential
* 6.2. Verifying an authentication assertion
* 8.4. Client extension processing

#dom-collectedclientdata-authenticatorextensionsReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
[[Create]](options) method
* 4.1.4. Use an existing credential to make an assertion -
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method
* 4.7.1. Client data used in WebAuthn signatures (dictionary
CollectedClientData)
* 6.1. Registering a new credential
* 6.2. Verifying an authentication assertion

#collectedclientdata-json-serialized-client-dataReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
[[Create]](options) method
* 4.1.4. Use an existing credential to make an assertion -
PublicKeyCredential's [[DiscoverFromExternalSource]](options)
method
* 4.2. Authenticator Responses (interface AuthenticatorResponse)
* 4.2.1. Information about Public Key Credential (interface
AuthenticatorAttestationResponse) (2)
* 4.2.2. Web Authentication Assertion (interface
AuthenticatorAssertionResponse)
* 4.7.1. Client data used in WebAuthn signatures (dictionary
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#collectedclientdata-hash-of-the-serialized-client-dataReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's
[[Create]](options) method (2)
* 4.1.4. Use an existing credential to make an assertion -
PublicKeyCredential's [[DiscoverFromExternalSource]](options)
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* 4.2.1. Information about Public Key Credential (interface
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* 4.2.2. Web Authentication Assertion (interface
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* 4.7.1. Client data used in WebAuthn signatures (dictionary
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* 5. WebAuthn Authenticator model
* 5.2.1. The authenticatorMakeCredential operation (2)
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* 5.3.2. Attestation Statement Formats (2)
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* 7.2. Packed Attestation Statement Format (2)
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* 7.4. Android Key Attestation Statement Format (2)
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* 7.6. FIDO U2F Attestation Statement Format (2)

#enumdef-publickeycredentialtypeReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's \[[Create]](options) method (2)
* 4.3. Parameters for Credential Generation (dictionary PublicKeyCredentialParameters)
* 4.8.2. Credential Type enumeration (enum PublicKeyCredentialType)
* 4.8.3. Credential Descriptor (dictionary PublicKeyCredentialDescriptor)
* 5.2.1. The authenticatorMakeCredential operation (2) (3)

#dom-publickeycredentialtype-public-keyReferenced in:
* 4.8.2. Credential Type enumeration (enum PublicKeyCredentialType)

#dictdef-publickeycredentialdescriptorReferenced in:
* 4.5. Options for Credential Creation (dictionary MakeCredentialOptions) (2)
* 4.6. Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions) (2) (3)
* 4.8.3. Credential Descriptor (dictionary PublicKeyCredentialDescriptor)

#dom-publickeycredentialdescriptor-transportsReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's \[[Create]](options) method (2)
* 4.1.4. Use an existing credential - PublicKeyCredential::[[DiscoverFromExternalSource]](options) method (2)

#dom-publickeycredentialdescriptor-typeReferenced in:
* 4.1.4. Use an existing credential - PublicKeyCredential::[[DiscoverFromExternalSource]](options) method
* 4.8.3. Credential Descriptor (dictionary PublicKeyCredentialDescriptor)

#dom-publickeycredentialdescriptor-idReferenced in:
* 4.1.4. Use an existing credential - PublicKeyCredential::[[DiscoverFromExternalSource]](options) method
* 4.8.3. Credential Descriptor (dictionary PublicKeyCredentialDescriptor)

#enumdef-transportReferenced in:
* 4.8.3. Credential Descriptor (dictionary PublicKeyCredentialDescriptor)

#dom-transport-usbReferenced in:
* 4.8.4. Credential Transport enumeration (enum ExternalTransport)

#dom-transport-nfcReferenced in:
* 4.8.4. Credential Transport enumeration (enum ExternalTransport)

#dom-transport-bleReferenced in:
* 4.8.4. Credential Transport enumeration (enum ExternalTransport)

* 7.2. Packed Attestation Statement Format (2)
* 7.3. TPM Attestation Statement Format (2)
* 7.4. Android Key Attestation Statement Format (2)
* 7.5. Android SafetyNet Attestation Statement Format
* 7.6. FIDO U2F Attestation Statement Format (2)

#enumdef-publickeycredentialtypeReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's [[Create]](options) method (2)
* 4.3. Parameters for Credential Generation (dictionary PublicKeyCredentialParameters)
* 4.7.2. Credential Type enumeration (enum PublicKeyCredentialType)
* 4.7.3. Credential Descriptor (dictionary PublicKeyCredentialDescriptor)
* 5.2.1. The authenticatorMakeCredential operation (2) (3)

#dom-publickeycredentialtype-public-keyReferenced in:
* 4.7.2. Credential Type enumeration (enum PublicKeyCredentialType)

#dictdef-publickeycredentialdescriptorReferenced in:
* 4.4. Options for Credential Creation (dictionary MakePublicKeyCredentialOptions) (2)
* 4.5. Options for Assertion Generation (dictionary PublicKeyCredentialRequestOptions) (2) (3)
* 4.7.3. Credential Descriptor (dictionary PublicKeyCredentialDescriptor)
* 5.2.1. The authenticatorMakeCredential operation

#dom-publickeycredentialdescriptor-transportsReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's [[Create]](options) method (2)
* 4.1.4. Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method (2)

#dom-publickeycredentialdescriptor-typeReferenced in:
* 4.1.4. Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method
* 4.7.3. Credential Descriptor (dictionary PublicKeyCredentialDescriptor)

#dom-publickeycredentialdescriptor-idReferenced in:
* 4.1.4. Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method
* 4.7.3. Credential Descriptor (dictionary PublicKeyCredentialDescriptor)

#enumdef-authenticatortransportReferenced in:
* 4.7.3. Credential Descriptor (dictionary PublicKeyCredentialDescriptor)
* 4.7.4. Authenticator Transport enumeration (enum AuthenticatorTransport)

#dom-authenticatortransport-usbReferenced in:
* 4.7.4. Authenticator Transport enumeration (enum AuthenticatorTransport)

#dom-authenticatortransport-nfcReferenced in:
* 4.7.4. Authenticator Transport enumeration (enum AuthenticatorTransport)

#dom-authenticatortransport-bleReferenced in:
* 4.7.4. Authenticator Transport enumeration (enum AuthenticatorTransport)

#typedefdef-cosealgorithmidentifierReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's [[Create]](options) method

#authenticator-dataReferenced in:
  * 4.2.1. Information about Public Key Credential (interface
    AuthenticatorAttestationResponse) (2)
  * 4.2.2. Web Authentication Assertion (interface
    AuthenticatorAssertionResponse)
  * 5. WebAuthn Authenticator model (2)
  * 5.1. Authenticator data (2) (3) (4) (5) (6) (7) (8)
  * 5.2.1. The authenticatorMakeCredential operation (2)
  * 5.2.2. The authenticatorGetAssertion operation (2) (3) (4)
  * 5.3. Credential Attestation (2)
  * 5.3.1. Attestation data
  * 5.3.2. Attestation Statement Formats (2)
  * 5.3.4. Generating an Attestation Object (2) (3)
  * 5.3.5.3. Attestation Certificate Hierarchy
  * 6.1. Registering a new credential (2)
  * 7.5. Android SafetyNet Attestation Statement Format
  * 8.5. Authenticator extension processing (2)
  * 8.6. Example Extension (2)
  * 9.6. User Verification Index Extension (uvi)
  * 9.7. Location Extension (loc)
  * 9.8. User Verification Method Extension (uvm)

#authenticatormakecredentialReferenced in:
  * 3. Terminology (2) (3)
  * 4.1.3. Create a new credential - PublicKeyCredential's
    \[[Create]](options) method (2)
  * 5.2.3. The authenticatorCancel operation (2)
  * 8. WebAuthn Extensions
  * 8.2. Defining extensions

#authenticatorgetassertionReferenced in:
  * 3. Terminology (2) (3)
  * 4.1.4. Use an existing credential -
    PublicKeyCredential::[[DiscoverFromExternalSource]](options) method
    (2) (3)
  * 5. WebAuthn Authenticator model
  * 5.1. Authenticator data
  * 5.2.3. The authenticatorCancel operation (2)
  * 8. WebAuthn Extensions
  * 8.2. Defining extensions

#authenticatorcancelReferenced in:
  * 4.1.3. Create a new credential - PublicKeyCredential's
    \[[Create]](options) method (2) (3)
  * 4.1.4. Use an existing credential -
    PublicKeyCredential::[[DiscoverFromExternalSource]](options) method
    (2) (3)

#attestation-statement-formatReferenced in:

  * 4.3. Parameters for Credential Generation (dictionary
    PublicKeyCredentialParameters)
  * 4.7.5. Cryptographic Algorithm Identifier (typedef
    COSEAlgorithmIdentifier)
  * 5.2.1. The authenticatorMakeCredential operation
  * 5.3.1. Attestation data

#attestation-signatureReferenced in:
  * 3. Terminology
  * 5. WebAuthn Authenticator model (2) (3)
  * 5.3. Attestation
  * 7.6. FIDO U2F Attestation Statement Format

#assertion-signatureReferenced in:
  * 5. WebAuthn Authenticator model (2)
  * 5.2.2. The authenticatorGetAssertion operation (2) (3) (4) (5) (6)

#authenticator-dataReferenced in:
  * 4.2.1. Information about Public Key Credential (interface
    AuthenticatorAttestationResponse) (2)
  * 4.2.2. Web Authentication Assertion (interface
    AuthenticatorAssertionResponse)
  * 5. WebAuthn Authenticator model (2)
  * 5.1. Authenticator data (2) (3) (4) (5) (6) (7) (8)
  * 5.2.1. The authenticatorMakeCredential operation (2)
  * 5.2.2. The authenticatorGetAssertion operation (2) (3) (4)
  * 5.3. Attestation (2)
  * 5.3.1. Attestation data
  * 5.3.2. Attestation Statement Formats (2)
  * 5.3.4. Generating an Attestation Object (2) (3)
  * 5.3.5.3. Attestation Certificate Hierarchy
  * 6.1. Registering a new credential (2)
  * 7.5. Android SafetyNet Attestation Statement Format
  * 8.5. Authenticator extension processing (2)
  * 8.6. Example Extension (2)
  * 9.6. User Verification Index Extension (uvi)
  * 9.7. Location Extension (loc)
  * 9.8. User Verification Method Extension (uvm)

#authenticatormakecredentialReferenced in:
  * 3. Terminology (2) (3)
  * 4.1.3. Create a new credential - PublicKeyCredential's
    [[Create]](options) method (2)
  * 5. WebAuthn Authenticator model
  * 5.2.3. The authenticatorCancel operation (2)
  * 8. WebAuthn Extensions
  * 8.2. Defining extensions

#authenticatorgetassertionReferenced in:
  * 3. Terminology (2) (3)
  * 4.1.4. Use an existing credential to make an assertion -
    PublicKeyCredential's [[DiscoverFromExternalSource]](options)
    method (2) (3) (4)
  * 5. WebAuthn Authenticator model
  * 5.1. Authenticator data
  * 5.2.3. The authenticatorCancel operation (2)
  * 8. WebAuthn Extensions
  * 8.2. Defining extensions

#authenticatorcancelReferenced in:
  * 4.1.3. Create a new credential - PublicKeyCredential's
    [[Create]](options) method (2) (3)
  * 4.1.4. Use an existing credential to make an assertion -
    PublicKeyCredential's [[DiscoverFromExternalSource]](options)
    method (2) (3)

#attestation-objectReferenced in:
  * 3. Terminology
  * 4. Web Authentication API
  * 4.2.1. Information about Public Key Credential (interface

* 3. Terminology
* 4.2.1. Information about Public Key Credential (interface
  AuthenticatorAttestationResponse)
* 5.3.4. Generating an Attestation Object (2)

#attestation-typeReferenced in:
* 3. Terminology

#attestation-dataReferenced in:
* 5.1. Authenticator data (2) (3) (4) (5) (6) (7)
* 5.2.1. The authenticatorMakeCredential operation
* 5.2.2. The authenticatorGetAssertion operation
* 5.3. Credential Attestation (2)
* 5.3.3. Attestation Types
* 6.1. Registering a new credential (2)
* 7.3. TPM Attestation Statement Format
* 7.4. Android Key Attestation Statement Format

#authenticator-data-for-the-attestationReferenced in:
* 7.2. Packed Attestation Statement Format
* 7.3. TPM Attestation Statement Format
* 7.4. Android Key Attestation Statement Format (2)
* 7.5. Android SafetyNet Attestation Statement Format
* 7.6. FIDO U2F Attestation Statement Format

#authenticator-data-claimed-to-have-been-used-for-the-attestationRefere
nced in:
* 7.2. Packed Attestation Statement Format
* 7.3. TPM Attestation Statement Format
* 7.4. Android Key Attestation Statement Format (2)
* 7.6. FIDO U2F Attestation Statement Format

#basic-attestationReferenced in:
* 5.3.5.1. Privacy

#self-attestationReferenced in:
* 3. Terminology (2) (3) (4)
* 5.3. Credential Attestation
* 5.3.5.2. Attestation Certificate and Attestation Certificate CA
  Compromise

  AuthenticatorAttestationResponse) (2)
* 4.4. Options for Credential Creation (dictionary
  MakePublicKeyCredentialOptions) (2)
* 5.2.1. The authenticatorMakeCredential operation (2)
* 5.3. Attestation (2) (3)
* 5.3.1. Attestation data
* 5.3.4. Generating an Attestation Object (2) (3) (4)
* 6.1. Registering a new credential

#attestation-statementReferenced in:
* 3. Terminology
* 4.2.1. Information about Public Key Credential (interface
  AuthenticatorAttestationResponse) (2) (3)
* 5.3. Attestation (2) (3) (4) (5) (6) (7) (8)
* 5.3.2. Attestation Statement Formats (2) (3)

#attestation-statement-formatReferenced in:
* 4.2.1. Information about Public Key Credential (interface
  AuthenticatorAttestationResponse)
* 4.7.4. Authenticator Transport enumeration (enum
  AuthenticatorTransport)
* 5.3. Attestation (2) (3) (4) (5) (6) (7)
* 5.3.2. Attestation Statement Formats (2) (3) (4)
* 5.3.4. Generating an Attestation Object (2)

#attestation-typeReferenced in:
* 5.3. Attestation (2) (3) (4) (5) (6)
* 5.3.2. Attestation Statement Formats

#attestation-dataReferenced in:
* 5.1. Authenticator data (2) (3) (4) (5) (6) (7)
* 5.2.1. The authenticatorMakeCredential operation
* 5.2.2. The authenticatorGetAssertion operation
* 5.3. Attestation (2)
* 5.3.3. Attestation Types
* 6.1. Registering a new credential (2)
* 7.3. TPM Attestation Statement Format
* 7.4. Android Key Attestation Statement Format

#signing-procedureReferenced in:
* 5.3.2. Attestation Statement Formats

#authenticator-data-for-the-attestationReferenced in:
* 7.2. Packed Attestation Statement Format
* 7.3. TPM Attestation Statement Format
* 7.4. Android Key Attestation Statement Format (2)
* 7.5. Android SafetyNet Attestation Statement Format
* 7.6. FIDO U2F Attestation Statement Format

#authenticator-data-claimed-to-have-been-used-for-the-attestationRefere
nced in:
* 7.2. Packed Attestation Statement Format
* 7.3. TPM Attestation Statement Format
* 7.4. Android Key Attestation Statement Format (2)
* 7.6. FIDO U2F Attestation Statement Format

#basic-attestationReferenced in:
* 5.3.5.1. Privacy

#self-attestationReferenced in:
* 3. Terminology (2) (3) (4)
* 5.3. Attestation (2)
* 5.3.2. Attestation Statement Formats
* 5.3.3. Attestation Types
* 5.3.5.2. Attestation Certificate and Attestation Certificate CA
  Compromise
* 6.1. Registering a new credential (2) (3)
* 7.2. Packed Attestation Statement Format (2)
* 7.6. FIDO U2F Attestation Statement Format

#privacy-caReferenced in:
 * 5.3.5.1. Privacy

#elliptic-curve-based-direct-anonymous-attestationReferenced in:
 * 5.3.5.1. Privacy

#ecdaaReferenced in:
 * 5.3.2. Attestation Statement Formats
 * 5.3.3. Attestation Types
 * 5.3.5.2. Attestation Certificate and Attestation Certificate CA
 Compromise
 * 6.1. Registering a new credential
 * 7.2. Packed Attestation Statement Format (2)
 * 7.3. TPM Attestation Statement Format (2)

#attestation-statement-format-identifierReferenced in:
 * 5.3.2. Attestation Statement Formats
 * 5.3.4. Generating an Attestation Object

#identifier-of-the-ecdaa-issuer-public-keyReferenced in:
 * 6.1. Registering a new credential
 * 7.2. Packed Attestation Statement Format
 * 7.3. TPM Attestation Statement Format (2)

#ecdaa-issuer-public-keyReferenced in:
 * 5.3.2. Attestation Statement Formats
 * 5.3.5.1. Privacy
 * 6.1. Registering a new credential
 * 7.2. Packed Attestation Statement Format (2) (3)

#registration-extensionReferenced in:
 * 4.1.3. Create a new credential - PublicKeyCredential's
 \[[Create]](options) method
 * 8. WebAuthn Extensions (2) (3) (4) (5) (6)
 * 8.6. Example Extension
 * 9.2. Simple Transaction Authorization Extension (txAuthSimple)
 * 9.3. Generic Transaction Authorization Extension (txAuthGeneric)
 * 9.4. Authenticator Selection Extension (authnSel)
 * 9.5. Supported Extensions Extension (exts)
 * 9.6. User Verification Index Extension (uvi)
 * 9.7. Location Extension (loc)
 * 9.8. User Verification Method Extension (uvm)
 * 10.2. WebAuthn Extension Identifier Registrations (2) (3) (4) (5)
 (6) (7)

#authentication-extensionReferenced in:
 * 4.1.4. Use an existing credential -
 PublicKeyCredential::[[DiscoverFromExternalSource]](options) method
 * 8. WebAuthn Extensions (2) (3) (4) (5) (6)
 * 8.6. Example Extension
 * 9.1. FIDO AppId Extension (appid)
 * 9.2. Simple Transaction Authorization Extension (txAuthSimple)
 * 9.3. Generic Transaction Authorization Extension (txAuthGeneric)
 * 9.6. User Verification Index Extension (uvi)
 * 9.7. Location Extension (loc)
 * 9.8. User Verification Method Extension (uvm)
 * 10.2. WebAuthn Extension Identifier Registrations (2) (3) (4) (5)
 (6)

#client-extensionReferenced in:
 * 4.1.3. Create a new credential - PublicKeyCredential's
 \[[Create]](options) method
 * 4.1.4. Use an existing credential -
 PublicKeyCredential::[[DiscoverFromExternalSource]](options) method
 * 4.7. Authentication Extensions (typedef AuthenticationExtensions)
 * 8. WebAuthn Extensions
 * 8.2. Defining extensions
 * 8.4. Client extension processing

#privacy-caReferenced in:
 * 5.3.5.1. Privacy

#elliptic-curve-based-direct-anonymous-attestationReferenced in:
 * 5.3.5.1. Privacy

#ecdaaReferenced in:
 * 5.3.2. Attestation Statement Formats
 * 5.3.3. Attestation Types
 * 5.3.5.2. Attestation Certificate and Attestation Certificate CA
 Compromise
 * 6.1. Registering a new credential
 * 7.2. Packed Attestation Statement Format (2)
 * 7.3. TPM Attestation Statement Format (2)

#attestation-statement-format-identifierReferenced in:
 * 5.3.2. Attestation Statement Formats
 * 5.3.4. Generating an Attestation Object

#identifier-of-the-ecdaa-issuer-public-keyReferenced in:
 * 6.1. Registering a new credential
 * 7.2. Packed Attestation Statement Format
 * 7.3. TPM Attestation Statement Format (2)

#ecdaa-issuer-public-keyReferenced in:
 * 5.3.2. Attestation Statement Formats
 * 5.3.5.1. Privacy
 * 6.1. Registering a new credential
 * 7.2. Packed Attestation Statement Format (2) (3)

#registration-extensionReferenced in:
 * 4.1.3. Create a new credential - PublicKeyCredential's
 [[Create]](options) method
 * 8. WebAuthn Extensions (2) (3) (4) (5) (6)
 * 8.6. Example Extension
 * 9.2. Simple Transaction Authorization Extension (txAuthSimple)
 * 9.3. Generic Transaction Authorization Extension (txAuthGeneric)
 * 9.4. Authenticator Selection Extension (authnSel)
 * 9.5. Supported Extensions Extension (exts)
 * 9.6. User Verification Index Extension (uvi)
 * 9.7. Location Extension (loc)
 * 9.8. User Verification Method Extension (uvm)
 * 10.2. WebAuthn Extension Identifier Registrations (2) (3) (4) (5)
 (6) (7)

#authentication-extensionReferenced in:
 * 4.1.4. Use an existing credential to make an assertion -
 PublicKeyCredential's [[DiscoverFromExternalSource]](options)
 method
 * 8. WebAuthn Extensions (2) (3) (4) (5) (6)
 * 8.6. Example Extension
 * 9.1. FIDO AppId Extension (appid)
 * 9.2. Simple Transaction Authorization Extension (txAuthSimple)
 * 9.3. Generic Transaction Authorization Extension (txAuthGeneric)
 * 9.6. User Verification Index Extension (uvi)
 * 9.7. Location Extension (loc)
 * 9.8. User Verification Method Extension (uvm)
 * 10.2. WebAuthn Extension Identifier Registrations (2) (3) (4) (5)
 (6)

#client-extensionReferenced in:
 * 4.1.3. Create a new credential - PublicKeyCredential's
 [[Create]](options) method
 * 4.1.4. Use an existing credential to make an assertion -
 PublicKeyCredential's [[DiscoverFromExternalSource]](options)
 method
 * 4.6. Authentication Extensions (typedef AuthenticationExtensions)
 * 8. WebAuthn Extensions
 * 8.2. Defining extensions
 * 8.4. Client extension processing

#authenticator-extensionReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's \[[Create]](options) method
* 4.1.4. Use an existing credential - PublicKeyCredential::[[DiscoverFromExternalSource]](options) method
* 4.7. Authentication Extensions (typedef AuthenticationExtensions)
* 8. WebAuthn Extensions (2) (3)
* 8.2. Defining extensions (2)
* 8.3. Extending request parameters
* 8.5. Authenticator extension processing

#extension-identifierReferenced in:
* 4.1. PublicKeyCredential Interface
* 4.1.3. Create a new credential - PublicKeyCredential's \[[Create]](options) method
* 4.1.4. Use an existing credential - PublicKeyCredential::[[DiscoverFromExternalSource]](options) method
* 5.1. Authenticator data
* 8. WebAuthn Extensions (2)
* 8.2. Defining extensions
* 8.3. Extending request parameters
* 8.4. Client extension processing (2)
* 8.5. Authenticator extension processing (2)
* 8.6. Example Extension
* 9.5. Supported Extensions Extension (exts) (2)
* 9.7. Location Extension (loc)
* 10.2. WebAuthn Extension Identifier Registrations

#client-extension-inputReferenced in:
* 8. WebAuthn Extensions (2) (3)
* 8.2. Defining extensions
* 8.3. Extending request parameters (2) (3) (4) (5) (6)
* 8.4. Client extension processing (2) (3) (4)
* 8.6. Example Extension

#authenticator-extension-inputReferenced in:
* 8. WebAuthn Extensions (2) (3) (4) (5)
* 8.2. Defining extensions
* 8.3. Extending request parameters (2) (3)
* 8.4. Client extension processing
* 8.5. Authenticator extension processing (2) (3)

#client-extension-processingReferenced in:
* 4.1. PublicKeyCredential Interface
* 4.1.3. Create a new credential - PublicKeyCredential's \[[Create]](options) method (2)
* 4.1.4. Use an existing credential - PublicKeyCredential::[[DiscoverFromExternalSource]](options) method (2)
* 8. WebAuthn Extensions (2) (3) (4)
* 8.2. Defining extensions

#client-extension-outputReferenced in:
* 4.1. PublicKeyCredential Interface
* 4.1.3. Create a new credential - PublicKeyCredential's \[[Create]](options) method (2)
* 4.1.4. Use an existing credential - PublicKeyCredential::[[DiscoverFromExternalSource]](options) method (2)
* 8. WebAuthn Extensions (2) (3)
* 8.2. Defining extensions (2) (3)
* 8.4. Client extension processing (2) (3)
* 8.6. Example Extension

#authenticator-extension-processingReferenced in:
* 8. WebAuthn Extensions
* 8.2. Defining extensions

#authenticator-extensionReferenced in:
* 4.1.3. Create a new credential - PublicKeyCredential's [[Create]](options) method
* 4.1.4. Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method
* 4.6. Authentication Extensions (typedef AuthenticationExtensions)
* 8. WebAuthn Extensions (2) (3)
* 8.2. Defining extensions (2)
* 8.3. Extending request parameters
* 8.5. Authenticator extension processing

#extension-identifierReferenced in:
* 4.1. PublicKeyCredential Interface
* 4.1.3. Create a new credential - PublicKeyCredential's [[Create]](options) method
* 4.1.4. Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method
* 5.1. Authenticator data
* 8. WebAuthn Extensions (2)
* 8.2. Defining extensions
* 8.3. Extending request parameters
* 8.4. Client extension processing (2)
* 8.5. Authenticator extension processing (2)
* 8.6. Example Extension
* 9.5. Supported Extensions Extension (exts) (2)
* 9.7. Location Extension (loc)
* 10.2. WebAuthn Extension Identifier Registrations

#client-extension-inputReferenced in:
* 8. WebAuthn Extensions (2) (3)
* 8.2. Defining extensions
* 8.3. Extending request parameters (2) (3) (4) (5) (6)
* 8.4. Client extension processing (2) (3) (4)
* 8.6. Example Extension

#authenticator-extension-inputReferenced in:
* 8. WebAuthn Extensions (2) (3) (4) (5)
* 8.2. Defining extensions
* 8.3. Extending request parameters (2) (3)
* 8.4. Client extension processing
* 8.5. Authenticator extension processing (2) (3)

#client-extension-processingReferenced in:
* 4.1. PublicKeyCredential Interface
* 4.1.3. Create a new credential - PublicKeyCredential's [[Create]](options) method (2)
* 4.1.4. Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method (2)
* 8. WebAuthn Extensions (2) (3) (4)
* 8.2. Defining extensions

#client-extension-outputReferenced in:
* 4.1. PublicKeyCredential Interface
* 4.1.3. Create a new credential - PublicKeyCredential's [[Create]](options) method (2)
* 4.1.4. Use an existing credential to make an assertion - PublicKeyCredential's [[DiscoverFromExternalSource]](options) method (2)
* 8. WebAuthn Extensions (2) (3)
* 8.2. Defining extensions (2) (3)
* 8.4. Client extension processing (2) (3)
* 8.6. Example Extension

#authenticator-extension-processingReferenced in:
* 8. WebAuthn Extensions
* 8.2. Defining extensions

* 8.5. Authenticator extension processing

#authenticator-extension-outputReferenced in:
* 5.1. Authenticator data
* 8. WebAuthn Extensions (2) (3)
* 8.2. Defining extensions (2) (3)
* 8.4. Client extension processing
* 8.5. Authenticator extension processing
* 8.6. Example Extension
* 9.5. Supported Extensions Extension (exts)
* 9.6. User Verification Index Extension (uvi)
* 9.7. Location Extension (loc)
* 9.8. User Verification Method Extension (uvm)

#typedefdef-authenticatorselectionlistReferenced in:
* 9.4. Authenticator Selection Extension (authnSel)

#typedefdef-aaguidReferenced in:
* 9.4. Authenticator Selection Extension (authnSel)

* 8.5. Authenticator extension processing

#authenticator-extension-outputReferenced in:
* 5.1. Authenticator data
* 8. WebAuthn Extensions (2) (3)
* 8.2. Defining extensions (2) (3)
* 8.4. Client extension processing
* 8.5. Authenticator extension processing
* 8.6. Example Extension
* 9.5. Supported Extensions Extension (exts)
* 9.6. User Verification Index Extension (uvi)
* 9.7. Location Extension (loc)
* 9.8. User Verification Method Extension (uvm)

#typedefdef-authenticatorselectionlistReferenced in:
* 9.4. Authenticator Selection Extension (authnSel)

#typedefdef-aaguidReferenced in:
* 9.4. Authenticator Selection Extension (authnSel)