Holder-of-Key Web Browser SSO Profile

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Technical Committee:
OASIS Security Services TC

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Related Work:
This specification is an alternative to the SAML V2.0 Web Browser SSO Profile in the SAML V2.0 Profiles specification [SAML2Prof].

Declared XML Namespace(s):
urn:oasis:names:tc:SAML:2.0:profiles:SSO:browser:holder-of-key

Abstract:
This profile allows for transport and validation of holder-of-key assertions by standard HTTP user agents with no modification of client software and maximum compatibility with existing deployments. Most of the flows are as in standard Web Browser SSO, but an X.509 certificate presented by the user agent supplies a valid keypair through client TLS authentication for HTTP

transactions. Cryptographic data resulting from TLS authentication is used for holder-of-key validation of a SAML assertion. This strengthens the assurance of the resulting authentication context and protects against credential theft, giving the service provider fresh authentication and attribute information without requiring it to perform successful validation of the certificate.

Status:

This document was last revised or approved by the SSTC on the above date. The level of approval is also listed above. Check the "Latest Version" or "Latest Approved Version" location noted above for possible later revisions of this document.

Technical Committee members should send comments on this specification to the Technical Committee's email list. Others should send comments to the Technical Committee by using the "Send A Comment" button on the Technical Committee's web page at http://www.oasis-open.org/committees/security.

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1 Introduction

In the scenario addressed by this profile, which is an extended version of the Web Browser SSO Profile in 4.1 of [SAML2Prof], a principal uses an HTTP user agent to either access a web-based resource at a service provider or access an identity provider such that the service provider and desired resource are understood or implicit. In either case, the user agent needs to acquire a SAML assertion from the identity provider. The user agent makes a request to the identity provider using client TLS authentication. The X.509 certificate supplied in this transaction is used primarily to supply a public key that is associated with the principal. The identity provider authenticates the principal by way of this TLS authentication or any other method of its choice. The identity provider then produces a response containing at least an assertion with holder-of-key subject confirmation and an authentication statement for the user agent to transport to the service provider. This assertion is presented by the user agent to the service provider over client TLS authentication to prove possession of the private key matching the holder-of-key confirmation in the assertion. The service provider should rely on no information from the certificate beyond the key; instead, it consumes the assertion to create a security context. The TLS key may then be used to persist the security context rather than a cookie or other application-layer session.

To implement this scenario, a profile of the SAML Authentication Request protocol is used in conjunction with the HTTP Redirect, HTTP POST and HTTP Artifact bindings. It is assumed that the user is using an HTTP user agent capable of presenting client certificates during TLS session establishment, such as a standard web browser.

1.1 Terminology

The keywords "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this specification are to be interpreted as described in [RFC 2119].

These keywords are thus capitalized when used to unambiguously specify requirements over protocol and application features and behavior that affect the interoperability and security of implementations. When these words are not capitalized, they are meant in their natural-language sense.

Conventional XML namespace prefixes are used throughout this specification to stand for their respective namespaces as follows:

Prefix	XML Namespace	Comments
`md:`	urn:oasis:names:tc:SAML:2.0:metadata	This is the SAML V2.0 metadata namespace defined in the SAML V2.0 metadata specification [SAML2Meta].
`saml:`	urn:oasis:names:tc:SAML:2.0:assertion	This is the SAML V2.0 assertion namespace defined in the SAML V2.0 core specification [SAML2Core].
`samlp:`	urn:oasis:names:tc:SAML:2.0:protocol	This is the SAML V2.0 protocol namespace defined in the SAML V2.0 core specification [SAML2Core].

This specification uses the following typographical conventions in text: `<namespace:Element>`, `Attribute`, **Datatype**, `OtherKeyword`.

1.2 Normative References

[DSig] D. Eastlake, J. Reagle, D. Solo. *XML-Signature Syntax and Processing*. World Wide Web Consortium Recommendation, 12 February 2002. See http://www.w3.org/TR/xmldsig-core/.

[IDPDisco] R. Widdowson, S. Cantor. Identity Provider Discovery Service Protocol and Profile, OASIS SSTC October 2007. Document ID sstc-saml-idp-discovery. See http://www.oasis-open.org/committees/security/.

[RFC 2119] S. Bradner. *Key words for use in RFCs to Indicate Requirement Levels*. IETF RFC 2119, March 1997. http://www.ietf.org/rfc/rfc2119.txt.

[RFC 4346] T. Dierks, E. Rescorla. *The Transport Layer Security (TLS) Protocol*. IETF RFC 4346, April 2006. http://www.ietf.org/rfc/rfc4346.txt.

[SAML2Bind] S. Cantor et al. Assertions *and Protocols for the OASIS Security Assertion Markup Language (SAML) V2.0*. OASIS Standard, March 2005. Document ID saml-core-2.0-os. See http://docs.oasis-open.org/security/saml/v2.0/saml-bindings-2.0-os.pdf.

[SAML2Core] S. Cantor et al. *Assertions and Protocols for the OASIS Security Assertion Markup Language (SAML) V2.0*. OASIS Standard, March 2005. Document ID saml-core-2.0-os. See http://docs.oasis-open.org/security/saml/v2.0/saml-core-2.0-os.pdf.

[SAML2Meta] S. Cantor et al. *Metadata for the OASIS Security Assertion Markup Language (SAML) V2.0*. OASIS Standard, March 2005. Document ID saml-metadata-2.0-os. See http://docs.oasis-open.org/security/saml/v2.0/saml-metadata-2.0-os.pdf.

[SAML2Prof] S. Cantor et al. *Profiles for the OASIS Security Assertion Markup Language (SAML) V2.0*. OASIS Standard, March 2005. Document ID saml-profiles-2.0-os. See http:// docs.oasis-ope n.org/secur ity/saml/v2.0/saml-prof iles-2.0-os.pdf .

[SAML2Secure] F. Hirsch et al. *Security and Privacy Considerations for the OASIS Security Assertion Markup Language (SAML) v2.0*. OASIS SSTC, March 2005. Document ID saml-sec-consider-2.0-os. See http:// docs.oasis-open. org/security/saml /v2.0/saml-sec-consi der-2.0-os.pdf .

1.3 Conformance

1.3.1 Holder-of-Key Web Browser SSO Profile

A conforming implementation of a service provider and an identity provider MUST support holder-of-key assertions and the acquisition of client keys from TLS connections, for validation and issuance of these assertions, respectively.

2 Holder-of-Key Web Browser SSO Profile

2.1 Required Information

Identification: urn:oasis:names:tc:SAML:2.0:profiles:SSO:browser:holder-of-key

Contact information: security-services-comment@lists.oasis-open.org

SAML Confirmation Method Identifiers: The SAML V2.0 "holder-of-key" confirmation method identifier, urn:oasis:names:tc:SAML:2.0:cm:holder-of-key, is included in all assertions issued under this profile.

Description: Given below.

Updates: Provides an alternative to the SAML V2.0 Web Browser SSO Profile given in 4.1 of [SAML2Prof].

2.2 Background

This profile is designed to enhance the security of SAML assertion and message exchange without requiring modifications to client software. The amount of benefit depends on the alignment of the certificate with the discovery service and identity provider and the extent to which a service provider has been enabled. Deployments should minimize user interaction and avoid mutually conflicting CA requirements by coordinating certificate issuance and TLS configuration.

If both the identity provider and service provider use this profile, but assume no knowledge of the certificate's contents, enhanced security is the primary benefit. There is a small chance that a bearer token will be stolen in transit, as described in [SAML2Secure]. Confirming that the presenter of the token is the intended holder through public key cryptography virtually eliminates this chance, improving the viability of SAML-based HTTP SSO for sensitive applications. The session created by the service provider in the security context resulting from the Holder-of-Key Web Browser SSO Profile can be keyed by the TLS public key or session key. Application-layer sessions, such as maintained by cookies, are often poorly protected by user agents, allowing for theft of this session and impersonation of the user.

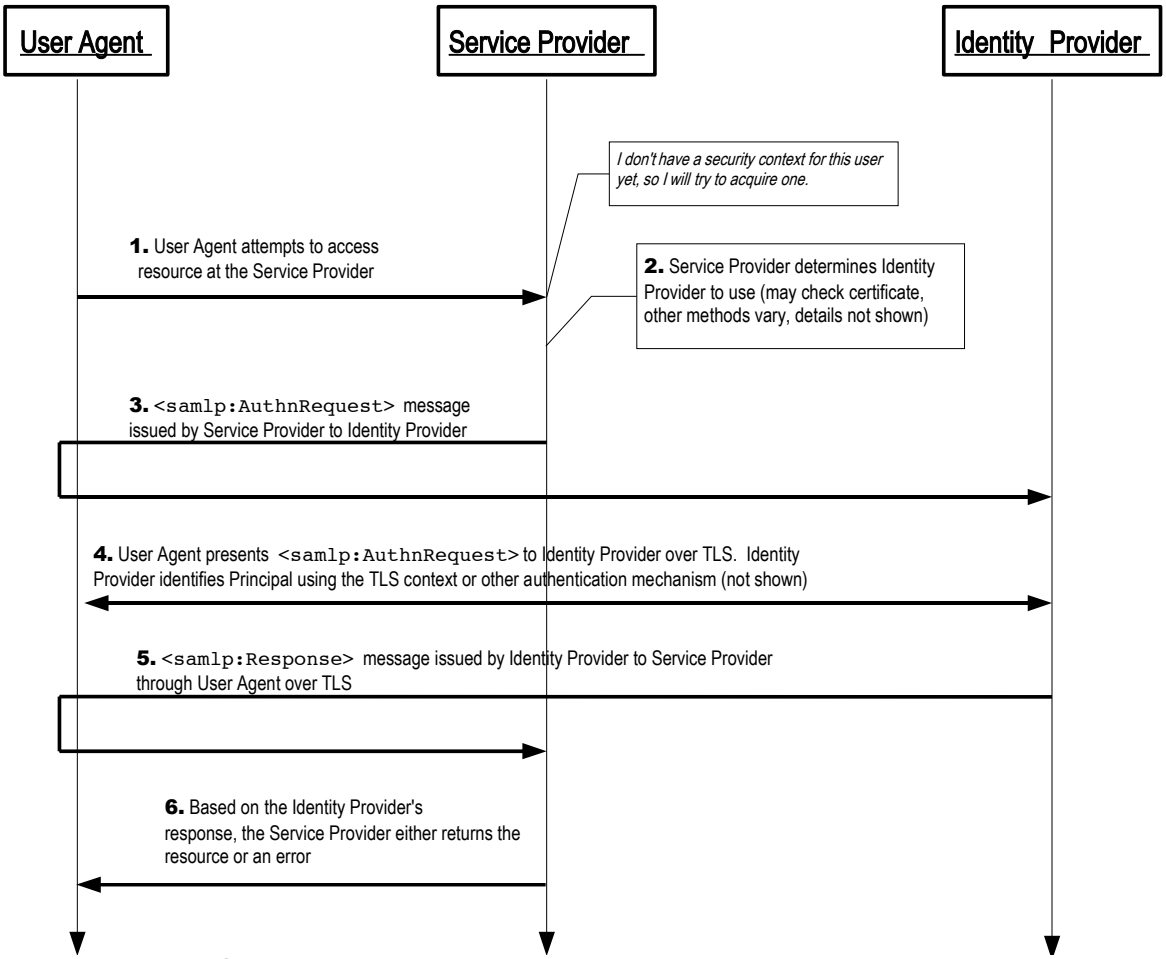
If a certificate can be used by the identity provider for principal authentication, there is no need for the user to further confirm its identity, and potentially no user interaction is needed.

Further, if the user accesses the service provider first, discovery of the user's identity provider may be performed by matching fields within the certificate presented; however, that is beyond the scope of this specification.

This profile offers meaningful advantages over traditional PKI, as well. There is no requirement for a mutually or universally trusted root, distributed OCSP or CRL-based revocation, a globally unique namespace, PKI validation (particularly by the SP), or for all participants in SSO to utilize X.509. The authentication token can be customized for every transaction, including fresh attributes and appropriate revelation of identity.

2.3 Profile Overview

Figure 1 illustrates the basic template for achieving SSO. The following steps are described by the profile. Within an individual step, there may be one or more actual message exchanges depending on the binding used for that step and other implementation-dependent behavior.



1. HTTP Request to Service Provider

The principal, via an HTTP user agent, makes an HTTP request for a secured resource at the service provider. The service provider determines that no security context exists, and attempts to create one.

2. Service Provider Determines Identity Provider

The service provider determines the proper identity provider to which to direct the user agent. This may be done through use of a discovery service as described in [IDPDisco], by examining fields in a certificate presented through client TLS authentication, such the X.509 subject or subjectAltName, or by any other means appropriate.

3. <samlp:AuthnRequest> issued by Service Provider to Identity Provider

The service provider issues a <samlp:AuthnRequest> message to be delivered by the user agent to the identity provider. The HTTP Redirect, HTTP POST, or HTTP Artifact binding can be used to transport the message to the identity provider through the user agent. URL size limits when using HTTP Redirect should be considered when issuing requests including keying information.

4. Identity Provider identifies Principal

The principal is identified by the identity provider. The identity provider identifies the principal using any authentication method at its discretion honoring any requirements imposed by the service provider in the <samlp:AuthnRequest>, including validation of the certificate presented in client

TLS authentication. However, the identity provider must establish that the private key corresponding to the keying material that will be included for holder-of-key proofing is held by this user agent, typically through a successful TLS handshake.

5. Identity Provider issues <samlp:Response> to Service Provider

The identity provider issues a <samlp:Response> message to be delivered by the user agent to the service provider. Either the HTTP POST or HTTP Artifact binding can be used to transfer the message to the service provider through the user agent. The message may indicate an error or will include at least an authentication statement in an assertion with holder-of-key <saml:SubjectConfirmation> containing keying information associated with the principal.

6. Service Provider grants or denies access to Principal

The response is received by the service provider, which can respond to the principal's user agent with its own error, an error passed by the identity provider, or establish a security context for the principal and return the requested resource.

Note that an identity provider can initiate this profile at step 5 by issuing a <samlp:Response> message to a service provider without the preceding steps. The user agent or a third party may also initiate this profile by spoofing the authentication request if there is no requirement it be signed.

2.4 Profile Description

If the profile is initiated by the service provider, start with Section 2.4.1. If the request is unsigned and spoofed by the user agent or a third party, start with Section 2.4.4. If initiated by the identity provider, start with Section 2.4.5. The descriptions refer to a Single Sign-On Service and Assertion Consumer Service in accordance with their use in section 4.1.3 of [SAML2Prof].

2.4.1 HTTP Request to Service Provider

The profile may be initiated by an arbitrary request to the service provider. The service provider is free to use any means it wishes to associate the subsequent interactions with the original request. Each of the bindings provides a RelayState mechanism that the service provider MAY use to associate the profile exchange with the original request. In particular, the TLS session itself MAY be used.

2.4.2 Service Provider Determines Identity Provider

The service provider determines the primary identity provider with which the principal is associated through a variety of mechanisms as selected by the service provider implementation or deployment. The service provider MAY check the certificate presented by the user agent, to attempt to use the X.509 subject, subjectAltName, or other field or extension in the certificate to determine the principal's identity provider or single sign-on service endpoint. The common domain cookie approach described in 4.3 of [SAML2Prof], a discovery service as described in [IDPDisco], or other mechanism MAY be used if the correct identity provider cannot be determined through inspection of the certificate.

2.4.3 <samlp:AuthnRequest> Issued by Service Provider to Identity Provider

Once an identity provider is selected, the location of a single sign-on service to which to send a <samlp:AuthnRequest> is determined based on the SAML binding chosen by the service provider. Metadata as described in [SAML2Meta] MAY be used for this purpose. Following an HTTP request by the user agent, an HTTP response is returned containing a <samlp:AuthnRequest> message or an

artifact, depending on the SAML binding used, to be delivered to the identity provider's single sign-on service.

Profile-specific rules for the contents of the <samlp:AuthnRequest> are defined in Section 2.5.1.

If the HTTP Redirect or POST binding is used, the <samlp:AuthnRequest> message is delivered directly to the identity provider in this step. If the HTTP Artifact binding is used, the Artifact Resolution profile defined in Section 5 of [SAML2Prof] is used by the identity provider, which makes a callback to the service provider to retrieve the <samlp:AuthnRequest> message using, for example, the SOAP binding.

The <samlp:AuthnRequest> message SHOULD be signed if authentication of the request issuer is required. If a certificate or public key is used as holder-of-key keying material in the request, the HTTP Redirect binding MUST NOT be used to transport the <samlp:AuthnRequest> due to size limitations.

It is REQUIRED that the <samlp:AuthnRequest> be presented to the identity provider over mutually authenticated TLS to supply the identity provider with keying information and establish the user agent's possession of the corresponding private key.

2.4.4 Identity Provider Identifies Principal and Verifies Key Possession

The identity provider must perform two functions in this step: identification of the principal presenting the <samlp:AuthnRequest>, and verification that the principal possesses the private key associated with the keying information that will be included in the <saml:SubjectConfirmation>.

The identity provider MUST establish the identity of the principal (unless it will return an error) prior to the issuance of the <samlp:Response>. If the <samlp:AuthnRequest> attribute ForceAuthn is present and true, the identity provider MUST freshly establish this identity rather than relying on any existing session it may have with the principal. Otherwise, and in all other respects, the identity provider may use any means to authenticate the user agent, subject to any requirements included in the <samlp:AuthnRequest>.

The identity provider MUST also establish that the keying information that will be included as a holder-of-key <saml:SubjectConfirmation> in the subsequent <samlp:Response> matches the private key presented by the user agent in step 2.4.3. The user agent MUST have demonstrated possession of this key through successful TLS authentication.

Preferably, both of these requirements will be simultaneously addressed by validation of an x.509 certificate presented by the user agent in TLS authentication from an issuer trusted by the identity provider, but this is not mandatory unless such an authentication context is requested by the service provider.

2.4.5 Identity Provider Issues <samlp:Response> to Service Provider

Regardless of the success or failure of the <samlp:AuthnRequest>, the identity provider SHOULD present an HTTP response to the user agent containing a <samlp:Response> message or an artifact, depending on the SAML binding used, to be delivered to the service provider's assertion consumer service.

The exact format of this HTTP response and the subsequent HTTP request to the assertion consumer service is defined by [SAML2Bind].

- If the HTTP POST binding is used, the <samlp:Response> message is delivered directly to the service provider in this step.

- If the HTTP Artifact binding is used, the Artifact Resolution profile defined in Section 5 of [SAML2Prof] is used by the service provider, which makes a callback to the identity provider to retrieve the <samlp:Response> message, using for example the SOAP binding. The TLS session could be used to persist client state during artifact resolution, or establish state afterwards by claiming a resolved assertion.

- The HTTP Redirect binding MUST NOT be used, as the response will typically exceed the URL length permitted by most user agents.

Profile-specific rules on the contents of the <samlp:Response> are included in section 2.5.3.

The location of the assertion consumer service MAY be determined using metadata defined in [SAML2Meta]. The identity provider MUST have some means to establish that this location is in fact controlled by the service provider. A service provider MAY indicate the SAML binding and the specific assertion consumer service to use in its <samlp:AuthnRequest> and the identity provider MUST honor them if it can.

It is REQUIRED that the HTTP requests in this step be made over mutually authenticated TLS to demonstrate possession of the private key corresponding to the keying information included in the assertion's <saml:SubjectConfirmation> as well as maintain confidentiality and message integrity. The <saml:Assertion> element(s) in the <samlp:Response> MUST be signed, if the HTTP POST binding is used, and MAY be signed if the HTTP Artifact binding is used.

The service provider MUST process the <samlp:Response> message and any enclosed <saml:Assertion> elements as described in [SAML2Core].

2.4.6 Service Provider Grants or Denies Access to Principal

To complete the profile, the service provider processes the <samlp:Response> and <saml:Assertion>(s) and grants or denies access to the resource. The service provider MAY establish a security context with the user agent using any session mechanism it chooses. Any subsequent use of the <saml:Assertion>(s) provided is at the discretion of the service provider and other relying parties, subject to any restrictions on use contained within them.

2.5 Use of Authentication Request Protocol

This profile is based upon the Web Browser SSO Profile defined in [SAML2Prof] and the Authentication Request protocol defined in [SAML2Core]. In the nomenclature of actors enumerated in Section 3.4 of that document, the service provider is the request issuer and the relying party, the user agent is the attesting entity and presenter, and the principal is the requested subject. There may be additional relying parties at the discretion of the identity provider.

2.5.1 <samlp:AuthnRequest> Usage

A service provider MAY include any message content described in [SAML2Core], Section 3.4.1. All processing rules are as defined in [SAML2Core]. The request MUST conform to the following:

- The <saml:Issuer> element MUST be present and MUST contain the unique identifier of the requesting service provider. The Format attribute MUST be omitted or have a value of urn:oasis:names:tc:SAML:2.0:nameid-format:entity.

- If the initial request was made over TLS and this message is signed, a <saml:Subject> element MAY be included in the request that includes keying information presented by the user agent for which the service provider wishes to receive an assertion in a holder-of-key

<saml:SubjectConfirmation> element. A <saml:NameID> SHOULD NOT be included, as the names used by the certificate authority may differ from those used by the identity provider. If the user agent fails this confirmation, then the identity provider MUST respond with a <samlp:Response> message containing an error status and no assertions.

- If the service provider wishes to permit the identity provider to establish a new identifier for the principal if none exists, it MUST include a <saml:NameIDPolicy> element with the AllowCreate attribute set to true.
- The <samlp:AuthnRequest> message MAY be signed (as directed by the SAML binding used). If the HTTP Artifact binding is used, authentication of the parties is OPTIONAL and any mechanism permitted by the binding MAY be used.

2.5.2 <samlp:AuthnRequest> Message Processing Rules

If the identity provider cannot or will not satisfy the request, it MUST respond with a message containing an appropriate error status code or codes.

If the <samlp:AuthnRequest> is not authenticated and/or integrity protected, the information in it MUST NOT be trusted except as advisory. The <samlp:AuthnRequest> must be processed as follows:

- It is RECOMMENDED that any AssertionConsumerServiceURL or AssertionConsumerServiceIndex attributes in the <samlp:AuthnRequest> are verified as belonging to the entityID to whom the response will be sent.
- It is NOT obligated to honor the requested set of <saml:Conditions> in the <samlp:AuthnRequest>, if any.

2.5.3 <samlp:Response> Usage

If the identity provider wishes to return an error for this request, it MUST NOT include any assertions in the <samlp:Response> message. Otherwise, if the request is successful or the response is not associated with a request, the <samlp:Response> element MUST conform to the following:

- The <saml:Issuer> element of the <samlp:Response> MAY be omitted, but if present it MUST contain the unique identifier of the issuing identity provider; the Format attribute MUST be omitted or have a value of urn:oasis:names:tc:SAML:2.0:nameid-format:entity.
- It MUST contain at least one <saml:Assertion>. Each assertion's <saml:Issuer> element MUST contain the unique identifier of the issuing identity provider, and the Format attribute MUST be omitted or have a value of urn:oasis:names:tc:SAML:2.0:nameid-format:entity.
- The set of one or more assertions MUST collectively contain one <saml:AuthnStatement> that reflects the authentication of the principal to the identity provider.
- The assertion containing a <saml:AuthnStatement> MUST also contain a <saml:Subject> element with at least one <saml:SubjectConfirmation> element with a Method of urn:oasis:names:tc:SAML:2.0:cm:holder-of-key. Its <saml:SubjectConfirmationData> MUST contain cryptographically secure keying material associated with the user's private key that will be available to the service provider as a result of TLS authentication, such as an X.509 certificate, a public key, or a collision resistant hash of the public key. Additional <saml:SubjectConfirmation> elements MAY be included, though

deployers should be aware of the implications of allowing weaker confirmation, as the processing is satisfy-any.

- If the identity provider supports the Single Logout profile, defined in Section 4.4 of [SAML2Prof], the `<saml:AuthnStatement>` MUST include a `SessionIndex` attribute to enable per-session logout requests by the service provider.
- Additional statements MAY be included in the assertion(s) at the discretion of the identity provider. The `<samlp:AuthnRequest>` MAY contain an `AttributeConsumingServiceIndex` XML attribute referencing information about desired or required attributes in [SAML2Meta]. The identity provider MAY ignore this, or send other attributes at its discretion.
- The assertion containing the `<saml:AuthnStatement>` MUST contain a `<saml:AudienceRestriction>` including the service provider's unique identifier as a `<saml:Audience>`.
- Other conditions (and other `<saml:Audience>` elements) MAY be included as requested by the service provider or at the discretion of the identity provider. All such conditions MUST be understood by and accepted by the service provider in order for the assertion to be considered valid.

2.5.4 <samlp:Response> Message Processing Rules

Regardless of the SAML binding used, the service provider MUST do the following:

- Verify any signatures present on the assertion(s) or the response.
- Verify that cryptographic data resulting from the mutual TLS authentication to the service provider matches the keying information in the holder-of-key `<saml:SubjectConfirmationData>`. The service provider SHOULD NOT rely on any other data in the certificate to process the assertion.
- Verify that any assertions relied upon are valid in other respects.

Any assertion which is not valid, or whose subject confirmation requirements cannot be met, SHOULD be discarded and SHOULD NOT be used to establish a security context for the principal.

2.5.4.1 Artifact-Specific <samlp:Response> Message Processing Rules

If the HTTP Artifact binding is used to deliver the `<samlp:Response>`, the dereferencing of the artifact using the Artifact Resolution profile MUST be mutually authenticated, integrity protected, and confidential.

If the assertion is not encrypted, it is RECOMMENDED that the identity provider ensure that only the service provider to whom the `<samlp:Response>` message has been issued is given the message as the result of a `<samlp:ArtifactResolve>` request.

Either the SAML binding used to dereference the artifact or message signatures can be used to authenticate the parties and protect the messages.

2.5.4.2 POST-Specific <samlp:Response> Message Processing Rules

If the HTTP POST binding is used to deliver the `<samlp:Response>`, the enclosed assertion(s) MUST be signed.

2.6 Compatibility

This profile is based on the Web Browser SSO Profile in [SAML2Prof]. The primary difference is the mandatory holder-of-key `<saml:SubjectConfirmation>` and the resulting mandate of client TLS authentication for user agent interactions. Because of its satisfy-any nature, inclusion of additional (in particular, bearer) `<saml:SubjectConfirmation>` must be done cautiously in order to preserve the security benefits.

The `urn:oasis:names:tc:SAML:2.0:profiles:SSO:browser:holder-of-key` profile is technically compatible with the `urn:oasis:names:tc:SAML:2.0:profiles:SSO:browser` profile, but it is RECOMMENDED that separate endpoints be used to remove any potential ambiguity.

2.7 Security and Privacy Considerations

The holder-of-key assertions and protocols supporting their issuance and verification in this profile have some different security and privacy characteristics from the bearer assertions used in the Web Browser SSO Profile.

- If a certificate is used by the identity provider for principal authentication, phishing is eliminated, as there are greater challenges and no benefits to tricking the user into authenticating with legitimate credentials to a fraudulent party.
- There are limitations on the degree to which users can remain private under this profile, since the X.509 certificate is presented to the service provider. Most end-user X.509 certificates have a unique distinguished name for the subject regularly containing personally identifying information. Additional information about the subject may be implicitly revealed through other fields. Furthermore, unless a new keypair is issued for every transaction, the public key is a de-facto persistent ID, as discussed in [SAML2Secure].
- It is REQUIRED that the HTTP requests in this step be made over mutually authenticated TLS to demonstrate possession of the private key corresponding to the keying information included in the assertion's <saml:SubjectConfirmation> as well as maintain confidentiality and message integrity.
- Holder-of-key confirmation of the assertion issued eliminates the potential for assertion theft and encryption prevents privacy loss, eliminating attacks that would have required a check of the request issuer in Section 2.5.2.
- The use of holder-of-key verification and encryption eliminate man-in-the-middle attacks. Without checking `<saml:AudienceRestriction>` in Section 2.5.3, there is the possibility of collusion between the principal and the intended recipient to re-encrypt and replay the assertion to another service provider.
- The `<md:IDPSSODescriptor>` element's `WantAuthnRequestsSigned` attribute MAY be used by an identity provider to indicate a requirement that requests be signed. The `<md:SPSSODescriptor>` element's `AuthnRequestsSigned` attribute MAY be used by a service provider to indicate the intention to sign all of its requests. If one of these attributes is present, the requirement SHOULD be met by counterparties.

Appendix A. Acknowledgments

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