Holder-of-Key Web Browser SSO Profile

Working Draft 03

17 June 2008

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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):

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.

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This document was last revised or approved by the SSTC on the above date. The level of
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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 access a web-based resource at a service provider. To do so, the user agent needs to acquire a SAML assertion from the identity provider. The user may first acquire a request for authentication from the service provider or a third party. The user agent then 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 choosing. 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 relies 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:

<table>
<thead>
<tr>
<th>Prefix</th>
<th>XML Namespace</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>md:</td>
<td>urn:oasis:names:tc:SAML:2.0:metadata</td>
<td>This is the SAML V2.0 metadata namespace defined in the SAML V2.0 metadata specification [SAML2Meta].</td>
</tr>
<tr>
<td>ds:</td>
<td><a href="http://www.w3.org/2000/09/xmldsig#">http://www.w3.org/2000/09/xmldsig#</a></td>
<td>This is the XML digital signature namespace defined in the XML Signature Syntax and Processing specification [DSig].</td>
</tr>
<tr>
<td>saml:</td>
<td>urn:oasis:names:tc:SAML:2.0:assertion</td>
<td>This is the SAML V2.0 assertion namespace defined in the SAML V2.0 core specification [SAML2Core].</td>
</tr>
<tr>
<td>samlp:</td>
<td>urn:oasis:names:tc:SAML:2.0:protocol</td>
<td>This is the SAML V2.0 protocol namespace defined in the SAML V2.0 core specification [SAML2Core].</td>
</tr>
</tbody>
</table>

For purposes of this document, Transport Layer Security (TLS) includes Secure Sockets Layer V3.0.

This specification uses the following typographical conventions in text: <namespace:Element>, Attribute, Datatype, OtherKeyword.
## 1.2 Normative References


## 1.3 Conformance

### 1.3.1 Identity Provider

A conforming implementation of an identity provider MUST support the following normative text of this profile: Sections 2.4.3, 2.4.4, 2.4.5, 2.5.2, and 2.5.3.

In addition to the typical requirements for a SAML implementation, a conforming identity provider MUST support the following functionality to support interoperability:

- Retrieving a certificate presented by a user agent and validating that the user agent possesses the corresponding private key through TLS; and
- Encoding this certificate using Base64 as `<ds:KeyInfo>` in a `<saml:SubjectConfirmationData>` element.

Implementations MAY additionally support the substitution of certificate fingerprints, public keys, and public key fingerprints for this certificate. Matches against `<ds:KeyName>` are discouraged because of the associated need for coordinated namespaces and certificate authorities. These alternatives SHOULD NOT be used unless the identity provider is specifically aware of the service provider's support for them.
1.3.2 Service Provider

A conforming implementation of a service provider MUST support the following normative text of this profile: Sections 2.4.1, 2.4.2, 2.4.3, 2.4.6, 2.5.1, and 2.5.4.

In addition to the typical requirements for a SAML implementation, a conforming service provider MUST support the following functionality to support interoperability:

- Retrieving a certificate presented by a user agent and validating that the user agent possesses the corresponding private key through TLS; and
- Decoding a Base64-encoded certificate within a `<ds:KeyInfo>` in a `<saml:SubjectConfirmationData>` element and matching it against a presented certificate.

Implementations MAY additionally support the substitution of certificate fingerprints, public keys, and public key fingerprints for this certificate. Matches against `<ds:KeyName>` are discouraged because of the associated need for coordinated namespaces and certificate authorities. A service provider SHOULD NOT trust assertions received through this profile unless it can confidently interpret and match the `<saml:SubjectConfirmationData>`.
2 Holder-of-Key Web Browser SSO Profile

2.1 Required Information


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.

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.

4. Identity Provider identifies Principal

The user agent makes a request to the identity provider using TLS. 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.
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. The user agent presents this response to the service provider using TLS. 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 by either establishing a security context for the principal and returning the requested resource or returning its own error or an error passed by the identity provider.

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]. Processing rules for all messages are specified in Section 2.5.

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.

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.
The <samlp:AuthnRequest> message MUST be signed if the identity provider requires the request issuer to be verified and the HTTP Redirect or HTTP POST bindings are used; if the HTTP Artifact binding is used, then the request issuer MAY be verified through other means.

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.

### 2.4.4 Identity Provider Identifies Principal and Verifies Key Possession

If the HTTP Redirect or POST binding is used, a <samlp:AuthnRequest> message is delivered directly to the identity provider to begin 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 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>.

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. Keying information resulting from this process MUST match information included as holder-of-key <saml:SubjectConfirmation> in the subsequent <samlp:Response>.

These requirements can 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>

The identity provider presents 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.
- 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.
2.4.6 Service Provider Grants or Denies Access to Principal

The HTTP request presenting the message resulting from Section 2.4.5 to the service provider MUST 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.

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.

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

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 uses 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 the <samlp:AuthnRequest> is to be 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 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.
- If the user agent fails to meet a <saml:SubjectConfirmation> present in the <samlp:AuthnRequest>, the identity provider MUST respond with a <samlp:Response> message containing an error status and no assertions.
- The identity provider 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 and only one <saml:AuthnStatement> that reflects the authentication of the principal to the identity provider.
- The assertion containing the <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. See Section 1.3.1 for minimal conformance requirements. 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 <samlp:Response> 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 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 according to processing rules in [SAML2Core].

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.

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

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.

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.
This profile is based on the Web Browser SSO Profile in [SAML2Prof]. The primary difference is the mandatory <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.
4 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].

- 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 validity period of an assertion issued with holder-of-key confirmation can be significantly longer than that of a bearer assertion, and replay detection less important, because the risk of assertion theft is mitigated by key possession confirmation. The lack of a meaningful assertion revocation mechanism establishes an upper cap on advisable validity periods.

- 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. Deployers should consider the limited benefits and significant complexity resulting from authentication request signing. There is no significant known attack associated with a spoofed authentication request that is processed in accordance with this profile, with the possible exception of deliberate omission of `forceAuthn="true"`, which can be mitigated by checking `AuthnInstant`.

- 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.
Appendix A. Acknowledgments

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