Web Services Security UsernameToken Profile 1.1

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Abstract:

This document describes how to use the UsernameToken with the Web Services Security (WSS) specification.

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This section is non-normative.

Table of Contents

1 Introduction

This document describes how to use the UsernameToken with the WSS: SOAP Message Security specification [WSS]. More specifically, it describes how a web service consumer can supply a UsernameToken as a means of identifying the requestor by “username”, and optionally using a password (or shared secret, or password equivalent) to authenticate that identity to the web service producer.

This section is non-normative. Note that Sections 2.1, 2.2, all of 3, 4 and indicated parts of 6 are normative. All other sections are non-normative.

2 Notations and Terminology

This section specifies the notations, namespaces, and terminology used in this specification.

2.1 Notational Conventions

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

When describing abstract data models, this specification uses the notational convention used by the XML Infoset. Specifically, abstract property names always appear in square brackets (e.g., [some property]).

When describing concrete XML schemas [XML-Schema], this specification uses the notational convention of WSS: SOAP Message Security. Specifically, each member of an element’s [children] or [attributes] property is described using an XPath-like [XPath] notation (e.g., /x:MyHeader/x:SomeProperty/@value1). The use of {any} indicates the presence of an element wildcard (`<xs:any/>`). The use of @{any} indicates the presence of an attribute wildcard (`<xs:anyAttribute/>`).

Commonly used security terms are defined in the Internet Security Glossary [SECGLO]. Readers are presumed to be familiar with the terms in this glossary as well as the definition in the Web Services Security specification.

2.2 Namespaces

Namespace URIs (of the general form "some-URI") represents some application-dependent or context-dependent URI as defined in RFC 3986 [URI]. This specification is designed to work with the general SOAP [SOAP11, SOAP12] message structure and message processing model, and should be applicable to any version of SOAP. The current SOAP 1.1 namespace URI is used herein to provide detailed examples, but there is no intention to limit the applicability of this specification to a single version of SOAP.

The namespaces used in this document are shown in the following table (note that for brevity, the examples use the prefixes listed below but do not include the URIs – those listed below are assumed).

Prefix	Namespace
S11	`http://schemas.xmlsoap.org/soap/envelope/`
S12	`http://www.w3.org/2003/05/soap-envelope`
wsse	`http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-wssecurity-secext-1.0.xsd`
wsse11	`http://docs.oasis-open.org/wss/oasis-wss-wssecurity-secext-1.1.xsd`
wsu	`http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-wssecurity-utility-1.0.xsd`

The URLs provided for the *wsse* and *wsu* namespaces can be used to obtain the schema files. URI fragments defined in this specification are relative to a base URI of the following unless otherwise stated:

`http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-username-token-profile-1.0`

The following table lists the full URI for each URI fragment referred to in this specification.

URI Fragment	Full URI
#PasswordDigest	`http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-username-token-profile-1.0#PasswordDigest`
#PasswordText	`http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-username-token-profile-1.0#PasswordText`
#UsernameToken	`http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-username-token-profile-1.0#UsernameToken`

2.3 Acronyms and Abbreviations

The following (non-normative) table defines acronyms and abbreviations for this document.

Term	Definition
SHA	Secure Hash Algorithm
SOAP	Simple Object Access Protocol
URI	Uniform Resource Identifier
XML	Extensible Markup Language

3 UsernameToken Extensions

3.1 Usernames and Passwords

The `<wsse:UsernameToken>` element is introduced in the WSS: SOAP Message Security documents as a way of providing a username.

Within `<wsse:UsernameToken>` element, a `<wsse:Password>` element may be specified. Passwords of type `PasswordText and PasswordDigest` are not limited to actual passwords, although this is a common case. Any password equivalent such as a derived password or S/KEY (one time password) can be used. Having a type of `PasswordText` merely implies that the information held in the password is “in the clear”, as opposed to holding a “digest” of the information. For example, if a server does not have access to the clear text of a password but does have the hash, then the hash is considered a *password equivalent* and can be used anywhere where a "password" is indicated in this specification. It is not the intention of this specification to require that all implementations have access to clear text passwords.

Passwords of type `PasswordDigest` are defined as being the Base64 [XML-Schema] encoded, SHA-1 hash value, of the UTF8 encoded password (or equivalent). However, unless this digested password is sent on a secured channel or the token is encrypted, the digest offers no real additional security over use of `wsse:PasswordText`.

Two optional elements are introduced in the `<wsse:UsernameToken>` element to provide a countermeasure for replay attacks: `<wsse:Nonce>` and `<wsu:Created>`. A nonce is a random value that the sender creates to include in each UsernameToken that it sends. Although using a nonce is an effective countermeasure against replay attacks, it requires a server to maintain a cache of used nonces, consuming server resources. Combining a nonce with a creation timestamp has the advantage of allowing a server to limit the cache of nonces to a "freshness" time period, establishing an upper bound on resource requirements. If either or both of `<wsse:Nonce>` and `<wsu:Created>` are present they MUST be included in the digest value as follows:

Password_Digest = Base64 (SHA-1 (nonce + created + password))

That is, concatenate the nonce, creation timestamp, and the password (or shared secret or password equivalent), digest the combination using the SHA-1 hash algorithm, then include the Base64 encoding of that result as the password (digest). This helps obscure the password and offers a basis for preventing replay attacks. For web service producers to effectively thwart replay attacks, three counter measures are RECOMMENDED:

1. It is RECOMMENDED that web service producers reject any UsernameToken *not* using *both* nonce *and* creation timestamps.
2. It is RECOMMENDED that web service producers provide a timestamp “freshness” limitation, and that any UsernameToken with “stale” timestamps be rejected. As a guideline, a value of five minutes can be used as a minimum to detect, and thus reject, replays.
3. It is RECOMMENDED that used nonces be cached for a period at least as long as the timestamp freshness limitation period, above, and that UsernameToken with nonces that have already been used (and are thus in the cache) be rejected.

Note that the nonce is hashed using the octet sequence of its decoded value while the timestamp is hashed using the octet sequence of its UTF8 encoding as specified in the contents of the element.

Note that `PasswordDigest` can only be used if the plain text password (or password equivalent) is available to both the requestor and the recipient.

Note that the secret is put at the end of the input and not the front. This is because the output of SHA-1 is the function's complete state at the end of processing an input stream. If the input stream happened to fit neatly into the block size of the hash function, an attacker could extend the input with additional blocks and generate new/unique hash values knowing only the hash output for the original stream. If the secret is at the end of the stream, then attackers are prevented from arbitrarily extending it -- since they have to end the input stream with the password which they don't know. Similarly, if the nonce/created was put at the end, then an attacker could update the nonce to be nonce+created, and add a new created time on the end to generate a new hash.

The countermeasures above do not cover the case where the token is replayed to a different receiver. There are several (non-normative) possible approaches to counter this threat, which may be used separately or in combination. Their use requires pre-arrangement (possibly in the form of a separately published profile which introduces new password type) among the communicating parties to provide interoperability:

- including the username in the hash, to thwart cases where multiple user accounts have matching passwords (e.g. passwords based on company name)

- including the domain name in the hash, to thwart cases where the same username/password is used in multiple systems
- including some indication of the intended receiver in the hash, to thwart cases where receiving systems don't share nonce caches (e.g., two separate application clusters in the same security domain).

The following illustrates the XML syntax of this element:

```
<wsse:UsernameToken wsu:Id="Example-1">
   <wsse:Username> ... </wsse:Username>
   <wsse:Password Type="..."> ... </wsse:Password>
   <wsse:Nonce EncodingType="..."> ... </wsse:Nonce>
   <wsu:Created> ... </wsu:Created>
</wsse:UsernameToken>
```

The following describes the attributes and elements listed in the example above:

/wsse:UsernameToken/wsse:Password

This optional element provides password information (or equivalent such as a hash). It is RECOMMENDED that this element only be passed when a secure transport (e.g. HTTP/S) is being used or if the token itself is being encrypted.

/wsse:UsernameToken/wsse:Password/@Type

This optional URI attribute specifies the type of password being provided. The table below identifies the pre-defined types (note that the URI fragments are relative to the URI for this specification).

URI	Description
#PasswordText (default)	The actual password for the username, the password hash, or derived password or S/KEY. This type should be used when hashed password equivalents that do not rely on a nonce or creation time are used, or when a digest algorithm other than SHA1 is used.
#PasswordDigest	The digest of the password (and optionally nonce and/or creation timestamp) for the username using the algorithm described above.

/wsse:UsernameToken/wsse:Password/@{any}

This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the element.

/wsse:UsernameToken/wsse:Nonce

> This optional element specifies a cryptographically random nonce. Each message including a <wsse:Nonce> element MUST use a new nonce value in order for web service producers to detect replay attacks.

/wsse:UsernameToken/wsse:Nonce/@EncodingType

> This optional attribute URI specifies the encoding type of the nonce (see the definition of <wsse:BinarySecurityToken> for valid values). If this attribute isn't specified then the default of Base64 encoding is used.

/wsse:UsernameToken/wsu:Created

> The optional <wsu:Created> element specifies a timestamp used to indicate the creation time. It is defined as part of the <wsu:Timestamp> definition.

All compliant implementations MUST be able to process the <wsse:UsernameToken> element. Where the specification requires that an element be "processed" it means that the element type MUST be recognized to the extent that an appropriate error is returned if the element is not supported.

Note that <wsse:KeyIdentifier> and <ds:KeyName> elements as described in the WSS: SOAP Message Security specification are not supported in this profile.

The following example illustrates the use of this element. In this example the password is sent as clear text and therefore this message should be sent over a confidential channel:

```
<S11:Envelope xmlns:S11="..." xmlns:wsse="...">
   <S11:Header>
      ...
      <wsse:Security>
         <wsse:UsernameToken>
            <wsse:Username>Zoe</wsse:Username>
            <wsse:Password>IloveDogs</wsse:Password>
         </wsse:UsernameToken>
      </wsse:Security>
      ...
   </S11:Header>
   ...
</S11:Envelope>
```

The following example illustrates using a digest of the password along with a nonce and a creation timestamp:

```
<S11:Envelope xmlns:S11="..." xmlns:wsse="..." xmlns:wsu= "...">
   <S11:Header>
      ...
      <wsse:Security>
         <wsse:UsernameToken>
            <wsse:Username>NNK</wsse:Username>
            <wsse:Password Type="...#PasswordDigest">
               weYI3nXd8LjMNVksCKFV8t3rgHh3Rw==
            </wsse:Password>
            <wsse:Nonce>WScqanjCEAC4mQoBE07sAQ==</wsse:Nonce>
            <wsu:Created>2003-07-16T01:24:32Z</wsu:Created>
         </wsse:UsernameToken>
      </wsse:Security>
      ...
   </S11:Header>
   ...
</S11:Envelope>
```

3.2 Token Reference

When a UsernameToken is referenced using `<wsse:SecurityTokenReference>` the `ValueType` attribute is not required. If specified, the value of `#UsernameToken` MUST be specified.

The following encoding formats are pre-defined (note that the URI fragments are relative to `http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-username-token-profile-1.0`):

URI	Description
#UsernameToken	UsernameToken

When a UsernameToken is referenced from a `<ds:KeyInfo>` element, it can be used to derive a key for a message authentication algorithm as described in Section 4 Key Derivation

There is no definition of a `KeyIdentifier` for a UsernameToken. Consequently, KeyIdentifier references MUST NOT used when referring to a UsernameToken.

Similarly, there is no definition of a `KeyName` for a UsernameToken. Consequently, `KeyName` references MUST NOT be used when referring to a UsernameToken.

All references refer to the `wsu:Id` for the token.

3.3 Error Codes

Implementations may use custom error codes defined in private namespaces if needed. But it is RECOMMENDED that they use the error handling codes defined in the WSS: SOAP Message Security specification for signature, decryption, and encoding and token header errors to improve interoperability.

When using custom error codes, implementations should be careful not to introduce security vulnerabilities that may assist an attacker in the error codes returned.

4 Key Derivation

The password associated with a username may be used to derive a shared secret key for the purposes of integrity or confidentiality protecting message contents. This section defines schema extensions and a procedure for deriving such keys. This procedure MUST be employed when keys are to be derived from passwords in order in ensure interoperability.

It must be noted that passwords are subject to several kinds of attack, which in turn will lead to the exposure of any derived keys. This key derivation procedure is intended to minimize the risk of attacks on the keys, to the extent possible, but it is ultimately limited by the insecurity of a password that it is possible for a human being to remember and type on a standard keyboard. This is discussed in more detail in the security considerations section of this document.

Two additional elements are required to enable to derivation of a key from a password. They are `<wsse11:Salt>` and `<wsse11:Iteration>`. These values are not secret and MUST be conveyed in the UsernameToken when key derivation is used. When key derivation is used the password MUST NOT be included in the UsernameToken. The receiver will use its knowledge of the password to derive the same key as the sender.

The following illustrates the syntax of the `<wsse11:Salt>` and `<wsse11:Iteration>` elements.

```
<wsse:UsernameToken wsse:Id=”…”>
    <wsse:Username>…</wsse:Username>
    <wsse11:Salt>…</wsse11:Salt>
    <wsse11:Iteration>…</wsse11:Iteration>
</wsse:UsernameToken>
```

The following describes these elements.

/wsse11:UsernameToken/wsse:Salt

This element is combined with the password as described below. Its value is a 128 bit number serilized as `xs:base64Binary`. It MUST be present when key derivation is used.

/wsse11:UsernameToken/wsse11:Iteration

> This element indicates the number of times the hashing operation is repeated when deriving the key. It is expressed as a `xs:unsignedInteger` value. If it is not present, a value of 1000 is used for the iteration count.

A key derived from a password may be used either in the calculation of a Message Authentication Code (MAC) or as a symmetric key for encryption. When used in a MAC, the key length will always be 160 bits. When used for encryption, an encryption algorithm MUST NOT be used which requires a key of length greater than 160 bits. A sufficient number of the high order bits of the key will be used for encryption. Unneeded low order bits will be discarded. For example, if the AES-128 algorithm is used, the high order 128 bits will be used and the low order 32 bits will be discarded from the derived 160 bit value.

The `<wsse11:Salt>` element is constructed as follows. The high order 8 bits of the Salt will have the value of 01 if the key is to be used in a MAC and 02 if the key is to be used for encryption. The remaining 120 low order bits of the Salt should be a random value.

The key is derived as follows. The password (which is UTF-8 encoded) and Salt are concatenated in that order. Only the actual octets of the password are used, it is not padded or zero terminated. This value is hashed using the SHA1 algorithm. The result of this operation is also hashed using SHA1. This process is repeated until the total number of hash operations equals the Iteration count.

In other words: K1 = SHA1(password + Salt)
K2 = SHA1(K1)
…
Kn = SHA1 (Kn-1)
Where + means concatenation and n is the iteration count.

The resulting 160 bit value is used in a MAC function or truncated to the appropriate length for encryption

5 Security Considerations

The use of the UsernameToken introduces no additional threats beyond those already identified for other types of SecurityTokens. Replay attacks can be addressed by using message timestamps, nonces, and caching, as well as other application-specific tracking mechanisms. Token ownership is verified by use of keys and man-in-the-middle attacks are generally mitigated. Transport-level security may be used to provide confidentiality and integrity of both the UsernameToken and the entire message body.

When a password (or password equivalent) in a `<UsernameToken>` is used for authentication, the password needs to be properly protected. If the underlying transport does not provide enough protection against eavesdropping, the password SHOULD be digested as described in this document. Even so, the password must be strong enough so that simple password guessing attacks will not reveal the secret from a captured message.

When a password is encrypted, in addition to the normal threats against any encryption, two password-specific threats must be considered: replay and guessing. If an attacker can impersonate a user by replaying an encrypted or hashed password, then learning the actual password is not necessary. One method of preventing replay is to use a nonce as mentioned previously. Generally it is also necessary to use a timestamp to put a ceiling on the number of previous nonces that must be stored. However, in order to be effective the nonce and timestamp must be signed. If the signature is also over the password itself, prior to encryption, then it would be a simple matter to use the signature to perform an offline guessing attack against the password. This threat can be countered in any of several ways including: don't include the password under the signature (the password will be verified later) or sign the encrypted password.

The reader should also review Section 13 of WSS: SOAP Message Security document for additional discussion on threats and possible counter-measures.

The security of keys derived from passwords is limited by the attacks available against passwords themselves, such as guessing and brute force. Because of the limited size of password that human beings can remember and limited number of octet values represented by keys that can easily be typed, a typical password represents the equivalent of an entropy source of a maximum of only about 50 bits. For this reason a maximum key size of only 160 bits is supported. Longer keys would simply increase processing without adding to security.

The key derivation algorithm specified here is based on one described in RFC 2898. It is referred to in that document as PBKDF1. It is used instead of PBKDF2, because it is simpler and keys longer than 160 bits are not required as discussed previously.

The purpose of the salt is to prevent the bulk pre-computation of key values to be tested against distinct passwords. The Salt value is defined so that MAC and encryption keys are guaranteed to have distinct values even when derived from the same password. This prevents certain cryptanalytic attacks.

The iteration count is intended to increase the work factor of a guessing or brute force attack, at a minor cost to normal key derivation. An iteration count of at least 1000 (the default) SHOULD always be used.

This section is non-normative.

6 References

The following are normative references:

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Appendix B. Revision History

Rev	Date	By Whom	What