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Abstract:

This specification describes enhancements to SOAP messaging to provide message integrity and confidentiality. The specified mechanisms can be used to accommodate a wide variety of security models and encryption technologies.

This specification also provides a general-purpose mechanism for associating security tokens with message content. No specific type of security token is required, the specification is designed to be extensible (i.e.. support multiple security token formats). For example, a client might provide one format for proof of identity and provide another format for proof that they have a particular business certification.

Additionally, this specification describes how to encode binary security tokens, a framework for XML-based tokens, and how to include opaque encrypted keys. It also includes extensibility mechanisms that can be used to further describe the characteristics of the tokens that are included with a message.

Status:

This is a technical committee document submitted for consideration by the OASIS Web Services Security (WSS) technical committee. Please send comments to the editors. If you are on the wss@lists.oasis-open.org list for committee members, send comments there. If you are not on that list, subscribe to the wss-comment@lists.oasis-open.org list and send comments there. To subscribe, send an email message to wss-comment-request@lists.oasis-open.org with the word "subscribe" as the body of the message. For patent disclosure information that may be essential to the implementation of this specification, and any offers of licensing terms, refer to the Intellectual Property Rights section of the OASIS Web Services Security Technical Committee (WSS TC) web page at http://www.oasis-open.org/committees/wss/ipr.php. General OASIS IPR information can be found at http://www.oasis-open.org/who/intellectualproperty.shtml.

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1 Introduction

This specification proposes a standard set of SOAP [SOAP11, SOAP12] extensions that can be used when building secure Web services to implement message content integrity and confidentiality. This specification refers to this set of extensions and modules as the "Web Services Security: SOAP Message Security" or "WSS: SOAP Message Security".

This specification is flexible and is designed to be used as the basis for securing Web services within a wide variety of security models including PKI, Kerberos, and SSL. Specifically, this specification provides support for multiple security token formats, multiple trust domains, multiple signature formats, and multiple encryption technologies. The token formats and semantics for using these are defined in the associated profile documents.

This specification provides three main mechanisms: ability to send security tokens as part of a message, message integrity, and message confidentiality. These mechanisms by themselves do not provide a complete security solution for Web services. Instead, this specification is a building block that can be used in conjunction with other Web service extensions and higher-level application-specific protocols to accommodate a wide variety of security models and security technologies.

These mechanisms can be used independently (e.g., to pass a security token) or in a tightly coupled manner (e.g., signing and encrypting a message or part of a message and providing a security token or token path associated with the keys used for signing and encryption).

1.1 Goals and Requirements

The goal of this specification is to enable applications to conduct secure SOAP message exchanges.

This specification is intended to provide a flexible set of mechanisms that can be used to construct a range of security protocols; in other words this specification intentionally does not describe explicit fixed security protocols.

As with every security protocol, significant efforts must be applied to ensure that security protocols constructed using this specification are not vulnerable to any one of a wide range of attacks. The examples in this specification are meant to illustrate the syntax of these mechanisms and are not intended as examples of combining these mechanisms in secure ways.

The focus of this specification is to describe a single-message security language that provides for message security that may assume an established session, security context and/or policy agreement.

The requirements to support secure message exchange are listed below.

1.1.1 Requirements

The Web services security language must support a wide variety of security models. The following list identifies the key driving requirements for this specification:

- Multiple security token formats
- Multiple trust domains
- Multiple signature formats
- Multiple encryption technologies
- End-to-end message content security and not just transport-level security

1.1.2 Non-Goals

The following topics are outside the scope of this document:

- Establishing a security context or authentication mechanisms.
- Key derivation.
- Advertisement and exchange of security policy.

- How trust is established or determined.
- Non-repudiation.

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, this specification uses a convention where each member of an element's [children] or [attributes] property is described using an XPath-like 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/>).

Readers are presumed to be familiar with the terms in the Internet Security Glossary [GLOS].

2.2 Namespaces

Namespace URIs (of the general form "some-URI") represents some application-dependent or context-dependent URI as defined in RFC 2396 [URI]. The XML namespace URIs that MUST be used by implementations of this specification are as follows (note that elements used in this specification are from various namespaces):

```
        http://www.docs.oasis-open.org/wss/2004/01/oasis-200401-wss-
wssecurity-secext-1.0.xsd
        http://www.docs.oasis-open.org/wss/2004/01/oasis-200401-wss-
wssecurity-utility-1.0.xsd
```

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
ds	http://www.w3.org/2000/09/xmldsig#
S11	http://schemas.xmlsoap.org/soap/envelope/
S12	http://www.w3.org/2003/05/soap-envelope
wsse	http://www.docs.oasis-open.org/wss/2004/01/oasis-200401-wss-wssecurity-secext-1.0.xsd
wsu	http://www.docs.oasis-open.org/wss/2004/01/oasis-200401-wss-wssecurity-utility-1.0.xsd

xenc	http://www.w3.org/2001/04/xmlenc#

The URLs provided for the *wsse* and *wsu* namespaces can be used to obtain the schema files.

2.3 Acronyms and Abbreviations

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

Term	Definition
HMAC	Keyed-Hashing for Message Authentication
SHA-1	Secure Hash Algorithm 1
SOAP	Simple Object Access Protocol
URI	Uniform Resource Identifier
XML	Extensible Markup Language

2.4 Terminology

Defined below are the basic definitions for the security terminology used in this specification.

Claim – A *claim* is a declaration made by an entity (e.g. name, identity, key, group, privilege, capability, etc).

Claim Confirmation – A *claim confirmation* is the process of verifying that a claim applies to an entity

Confidentiality – *Confidentiality* is the property that data is not made available to unauthorized individuals, entities, or processes.

Digest – A *digest* is a cryptographic checksum of an octet stream.

Digital Signature – In this document, digital signature and signature are used interchangeably and have the same meaning.

End-To-End Message Level Security – *End-to-end message level security* is established when a message that traverses multiple applications (one or more SOAP intermediaries) within and between business entities, e.g. companies, divisions and business units, is secure over its full route through and between those business entities. This includes not only messages that are initiated within the entity but also those messages that originate outside the entity, whether they are Web Services or the more traditional messages.

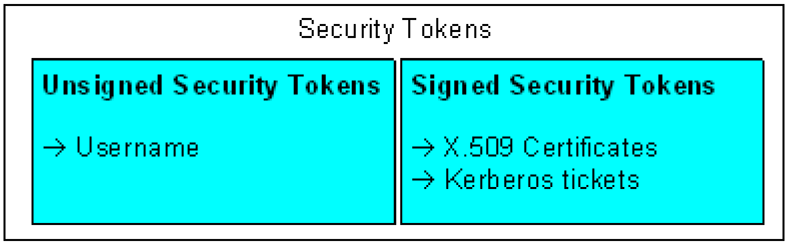
Integrity – *Integrity* is the property that data has not been modified.

Message Confidentiality - *Message Confidentiality* is a property of the message and encryption is the mechanism by which this property of the message is provided.

Message Integrity - *Message Integrity* is a property of the message and digital signature is a mechanism by which this property of the message is provided.

Signature - A *signature* is a value computed with a cryptographic algorithm and bound to data in such a way that intended recipients of the data can use the signature to verify that the data has not been altered and/or has originated from the signer of the message, providing message integrity and authentication. The signature can be computed and verified with symmetric key algorithms, where the same key is used for signing and verifying, or with asymmetric key algorithms, where different keys are used for signing and verifying (a private and public key pair are used).

Security Token – A *security token* represents a collection (one or more) of claims.



Signed Security Token – A *signed security token* is a security token that is asserted and cryptographically signed by a specific authority (e.g. an X.509 certificate or a Kerberos ticket).

Trust - *Trust is* the characteristic that one entity is willing to rely upon a second entity to execute a set of actions and/or to make set of assertions about a set of subjects and/or scopes.

3 Message Protection Mechanisms

When securing SOAP messages, various types of threats should be considered. This includes, but is not limited to:

- the message could be modified or read by antagonists or
- an antagonist could send messages to a service that, while well-formed, lack appropriate security claims to warrant processing.

To understand these threats this specification defines a message security model.

3.1 Message Security Model

This document specifies an abstract *message security model* in terms of security tokens combined with digital signatures to protect and authenticate SOAP messages.

Security tokens assert claims and can be used to assert the binding between authentication secrets or keys and security identities. An authority can vouch for or endorse the claims in a security token by using its key to sign or encrypt (it is recommended to use a keyed encryption) the security token thereby enabling the authentication of the claims in the token. An X.509 [X509] certificate, claiming the binding between one's identity and public key, is an example of a signed security token endorsed by the certificate authority. In the absence of endorsement by a third party, the recipient of a security token may choose to accept the claims made in the token based on its trust of the producer of the containing message.

Signatures are used to verify message origin and integrity. Signatures are also used by message producers to demonstrate knowledge of the key, typically from a third party, used to confirm the claims in a security token and thus to bind their identity (and any other claims occurring in the security token) to the messages they create.

It should be noted that this security model, by itself, is subject to multiple security attacks. Refer to the Security Considerations section for additional details.

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.

3.2 Message Protection

Protecting the message content from being disclosed (confidentiality) or modified without detection (integrity) are primary security concerns. This specification provides a means to protect a message by encrypting and/or digitally signing a body, a header, or any combination of them (or parts of them).

Message integrity is provided by XML Signature [XMLSIG] in conjunction with security tokens to ensure that modifications to messages are detected. The integrity mechanisms are designed to support multiple signatures, potentially by multiple SOAP actors/roles, and to be extensible to support additional signature formats.

Message confidentiality leverages XML Encryption [XMLENC] in conjunction with security tokens to keep portions of a SOAP message confidential. The encryption mechanisms are designed to support additional encryption processes and operations by multiple SOAP actors/roles.

This document defines syntax and semantics of signatures within a <wsse:Security> element.

This document does not specify any signature appearing outside of a <wsse:Security> element.

3.3 Invalid or Missing Claims

A message recipient SHOULD reject messages containing invalid signatures, messages missing necessary claims or messages whose claims have unacceptable values. Such messages are unauthorized (or malformed). This specification provides a flexible way for the message producer to make a claim about the security properties by associating zero or more security tokens with the message. An example of a security claim is the identity of the producer; the producer can claim that he is Bob, known as an employee of some company, and therefore he has the right to send the message.

3.4 Example

The following example illustrates the use of a custom security token and associated signature. The token contains base64 encoded binary data conveying a symmetric key which, we assume, can be properly authenticated by the recipient. The message producer uses the symmetric key with an HMAC signing algorithm to sign the message. The message receiver uses its knowledge of the shared secret to repeat the HMAC key calculation which it uses to validate the signature and in the process confirm that the message was authored by the claimed user identity.

```
(001) <?xml version="1.0" encoding="utf-8"?>
(002) <S11:Envelope xmlns:S11="..." xmlns:wsse="..." xmlns:wsu="..."
            xmlns:ds="...">
(003)   <S11:Header>
(004)      <wsse:Security
             xmlns:wsse="...">
(005)         <xxx:CustomToken wsu:Id="MyID"
                                 xmlns:xxx="http://fabrikam123/token">
(006)             FHUIORv...
(007)         </xxx:CustomToken>
(008)         <ds:Signature>
(009)            <ds:SignedInfo>
(010)               <ds:CanonicalizationMethod
                        Algorithm=
                          "http://www.w3.org/2001/10/xml-exc-c14n#"/>
(011)               <ds:SignatureMethod
                        Algorithm=
                        "http://www.w3.org/2000/09/xmldsig#hmac-sha1"/>
(012)               <ds:Reference URI="#MsgBody">
(013)                  <ds:DigestMethod
                          Algorithm=
                        "http://www.w3.org/2000/09/xmldsig#sha1"/>
(014)                  <ds:DigestValue>LyLsF0Pi4wPU...</ds:DigestValue>
(015)               </ds:Reference>
(016)            </ds:SignedInfo>
(017)            <ds:SignatureValue>DJbchm5gK...</ds:SignatureValue>
(018)            <ds:KeyInfo>
(019)                <wsse:SecurityTokenReference>
(020)                   <wsse:Reference URI="#MyID"/>
(021)                </wsse:SecurityTokenReference>
(022)            </ds:KeyInfo>
(023)         </ds:Signature>
(024)      </wsse:Security>
(025)   </S11:Header>
(026)   <S11:Body wsu:Id="MsgBody">
(027)     <tru:StockSymbol xmlns:tru="http://fabrikam123.com/payloads">
              QQQ
          </tru:StockSymbol>
(028)   </S11:Body>
(029) </S11:Envelope>
```

The first two lines start the SOAP envelope. Line (003) begins the headers that are associated with this SOAP message.

Line (004) starts the `<wsse:Security>` header defined in this specification. This header contains security information for an intended recipient. This element continues until line (024).

Lines (005) to (007) specify a custom token that is associated with the message. In this case, it uses an externally defined custom token format.

Lines (008) to (023) specify a digital signature. This signature ensures the integrity of the signed elements. The signature uses the XML Signature specification identified by the ds namespace declaration in Line (002).

Lines (009) to (016) describe what is being signed and the type of canonicalization being used.

Line (010) specifies how to canonicalize (normalize) the data that is being signed. Lines (012) to (015) select the elements that are signed and how to digest them. Specifically, line (012) indicates that the <S11:Body> element is signed. In this example only the message body is signed; typically all critical elements of the message are included in the signature (see the Extended Example below).

Line (017) specifies the signature value of the canonicalized form of the data that is being signed as defined in the XML Signature specification.

Lines (018) to (022) provides information, partial or complete, as to where to find the security token associated with this signature. Specifically, lines (019) to (021) indicate that the security token can be found at (pulled from) the specified URL.

Lines (026) to (028) contain the body (payload) of the SOAP message.

4 ID References

There are many motivations for referencing other message elements such as signature references or correlating signatures to security tokens. For this reason, this specification defines the `wsu:Id` attribute so that recipients need not understand the full schema of the message for processing of the security elements. That is, they need only "know" that the `wsu:Id` attribute represents a schema type of ID which is used to reference elements. However, because some key schemas used by this specification don't allow attribute extensibility (namely XML Signature and XML Encryption), this specification also allows use of their local ID attributes in addition to the `wsu:Id` attribute. As a consequence, when trying to locate an element referenced in a signature, the following attributes are considered:

- Local ID attributes on XML Signature elements
- Local ID attributes on XML Encryption elements
- Global wsu:Id attributes (described below) on elements

In addition, when signing a part of an envelope such as the body, it is RECOMMENDED that an ID reference is used instead of a more general transformation, especially XPath [XPATH]. This is to simplify processing.

4.1 Id Attribute

There are many situations where elements within SOAP messages need to be referenced. For example, when signing a SOAP message, selected elements are included in the scope of the signature. XML Schema Part 2 [XMLSCHEMA] provides several built-in data types that may be used for identifying and referencing elements, but their use requires that consumers of the SOAP message either have or must be able to obtain the schemas where the identity or reference mechanisms are defined. In some circumstances, for example, intermediaries, this can be problematic and not desirable.

Consequently a mechanism is required for identifying and referencing elements, based on the SOAP foundation, which does not rely upon complete schema knowledge of the context in which an element is used. This functionality can be integrated into SOAP processors so that elements can be identified and referred to without dynamic schema discovery and processing.

This section specifies a namespace-qualified global attribute for identifying an element which can be applied to any element that either allows arbitrary attributes or specifically allows a particular attribute.

4.2 Id Schema

To simplify the processing for intermediaries and recipients, a common attribute is defined for identifying an element. This attribute utilizes the XML Schema ID type and specifies a common attribute for indicating this information for elements.

The syntax for this attribute is as follows:

```
<anyElement wsu:Id="...">...</anyElement>
```

The following describes the attribute illustrated above:

.../@wsu:Id

   This attribute, defined as type `xsd:ID`, provides a well-known attribute for specifying the local ID of an element.

Two `wsu:Id` attributes within an XML document MUST NOT have the same value. Implementations MAY rely on XML Schema validation to provide rudimentary enforcement for intra-document uniqueness. However, applications SHOULD NOT rely on schema validation alone to enforce uniqueness.

This specification does not specify how this attribute will be used and it is expected that other specifications MAY add additional semantics (or restrictions) for their usage of this attribute. The following example illustrates use of this attribute to identify an element:

```
<x:myElement wsu:Id="ID1" xmlns:x="..."
           xmlns:wsu="..."/>
```

Conformant processors that do support XML Schema MUST treat this attribute as if it was defined using a global attribute declaration.

Conformant processors that do not support dynamic XML Schema or DTDs discovery and processing are strongly encouraged to integrate this attribute definition into their parsers. That is, to treat this attribute information item as if its PSVI has a [type definition] which {target namespace} is "`http://www.w3.org/2001/XMLSchema`" and which {name} is "Id." Doing so allows the processor to inherently know *how* to process the attribute without having to locate and process the associated schema. Specifically, implementations MAY support the value of the `wsu:Id` as the valid identifier for use as an XPointer [XPointer] shorthand pointer for interoperability with XML Signature references.

5 Security Header

The <wsse:Security> header block provides a mechanism for attaching security-related information targeted at a specific recipient in the form of a SOAPactor/role. This may be either the ultimate recipient of the message or an intermediary. Consequently, elements of this type may be present multiple times in a SOAP message. An active intermediary on the message path MAY add one or more new sub-elements to an existing <wsse:Security> header block if they are targeted for its SOAP node or it MAY add one or more new headers for additional targets.

As stated, a message MAY have multiple <wsse:Security> header blocks if they are targeted for separate recipients. However, only one <wsse:Security> header block MAY omit the S11:actor or S12:role attributes. Two <wsse:Security> header blocks MUST NOT have the same value for S11:actor or S12:role. Message security information targeted for different recipients MUST appear in different <wsse:Security> header blocks. This is due to potential processing order issues (e.g. due to possible header re-ordering). The <wsse:Security> header block without a specified S11:actor or S12:role MAY be processed by anyone, but MUST NOT be removed prior to the final destination or endpoint.

As elements are added to a <wsse:Security> header block, they SHOULD be prepended to the existing elements. As such, the <wsse:Security> header block represents the signing and encryption steps the message producer took to create the message. This prepending rule ensures that the receiving application can process sub-elements in the order they appear in the <wsse:Security> header block, because there will be no forward dependency among the sub-elements. Note that this specification does not impose any specific order of processing the sub-elements. The receiving application can use whatever order is required.

When a sub-element refers to a key carried in another sub-element (for example, a signature sub-element that refers to a binary security token sub-element that contains the X.509 certificate used for the signature), the key-bearing element SHOULD be ordered to precede the key-using Element:

```
<S11:Envelope>
    <S11:Header>
            ...
        <wsse:Security S11:actor="..." S11:mustUnderstand="...">
            ...
        </wsse:Security>
            ...
    </S11:Header>
    ...
</S11:Envelope>
```

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

/wsse:Security

This is the header block for passing security-related message information to a recipient.

/wsse:Security/@S11:actor

This attribute allows a specific SOAP 1.1 [SPOAP11] actor to be identified. This attribute is optional; however, no two instances of the header block may omit a actor or specify the same actor.

/wsse:Security/@S12:role

This attribute allows a specific SOAP 1.2 [SOAP12] role to be identified. This attribute is optional; however, no two instances of the header block may omit a role or specify the same role.

/wsse:Security/{any}

This is an extensibility mechanism to allow different (extensible) types of security information, based on a schema, to be passed. Unrecognized elements SHOULD cause a fault.

/wsse:Security/@{any}

This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the header. Unrecognized attributes SHOULD cause a fault.

All compliant implementations MUST be able to process a `<wsse:Security>` element.

All compliant implementations MUST declare which profiles they support and MUST be able to process a `<wsse:Security>` element including any sub-elements which may be defined by that profile. It is RECOMMENDED that undefined elements within the `<wsse:Security>` header not be processed.

The next few sections outline elements that are expected to be used within a `<wsse:Security>` header.

When a `<wsse:Security>` header includes a `mustUnderstand="true"` attribute:

- The receiver MUST generate a SOAP fault if does not implement the WSS: SOAP Message Security specification corresponding to the namespace. Implementation means ability to interpret the schema as well as follow the required processing rules specified in WSS: SOAP Message Security.
- The receiver must generate a fault if unable to interpret or process security tokens contained in the `<wsse:Security>` header block according to the corresponding WSS: SOAP Message Security token profiles.
- Receivers MAY ignore elements or extensions within the `<wsse:Security>` element, based on local security policy.

6 Security Tokens

This chapter specifies some different types of security tokens and how they are attached to messages.

6.1 Attaching Security Tokens

This specification defines the `<wsse:Security>` header as a mechanism for conveying security information with and about a SOAP message. This header is, by design, extensible to support many types of security information.

For security tokens based on XML, the extensibility of the `<wsse:Security>` header allows for these security tokens to be directly inserted into the header.

6.1.1 Processing Rules

This specification describes the processing rules for using and processing XML Signature and XML Encryption. These rules MUST be followed when using any type of security token. Note that if signature or encryption is used in conjunction with security tokens, they MUST be used in a way that conforms to the processing rules defined by this specification.

6.1.2 Subject Confirmation

This specification does not dictate if and how claim confirmation must be done; however, it does define how signatures may be used and associated with security tokens (by referencing the security tokens from the signature) as a form of claim confirmation.

6.2 User Name Token

6.2.1 Usernames

The `<wsse:UsernameToken>` element is introduced as a way of providing a username. This element is optionally included in the `<wsse:Security>` header.

The following illustrates the syntax of this element:

```
<wsse:UsernameToken wsu:Id="...">
    <wsse:Username>...</wsse:Username>
</wsse:UsernameToken>
```

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

/wsse:UsernameToken

This element is used to represent a claimed identity.

/wsse:UsernameToken/@wsu:Id

A string label for this security token.

/wsse:UsernameToken/wsse:Username

This required element specifies the claimed identity.

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

This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the `<wsse:Username>` element.

/wsse:UsernameToken/{any}

This is an extensibility mechanism to allow different (extensible) types of security information, based on a schema, to be passed. Unrecognized elements SHOULD cause a fault.

/wsse:UsernameToken/@{any}

This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the `<wsse:UsernameToken>` element. Unrecognized attributes SHOULD cause a fault.

All compliant implementations MUST be able to process a `<wsse:UsernameToken>` element.
The following illustrates the use of this:

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

6.3 Binary Security Tokens

6.3.1 Attaching Security Tokens

For binary-formatted security tokens, this specification provides a `<wsse:BinarySecurityToken>` element that can be included in the `<wsse:Security>` header block.

6.3.2 Encoding Binary Security Tokens

Binary security tokens (e.g., X.509 certificates and Kerberos [KERBEROS] tickets) or other non-XML formats require a special encoding format for inclusion. This section describes a basic framework for using binary security tokens. Subsequent specifications MUST describe the rules for creating and processing specific binary security token formats.

The `<wsse:BinarySecurityToken>` element defines two attributes that are used to interpret it. The `ValueType` attribute indicates what the security token is, for example, a Kerberos ticket. The `EncodingType` tells how the security token is encoded, for example `Base64Binary`.

The following is an overview of the syntax:

```
<wsse:BinarySecurityToken wsu:Id=...
                          EncodingType=...
                          ValueType=.../>
```

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

/wsse:BinarySecurityToken

This element is used to include a binary-encoded security token.

/wsse:BinarySecurityToken/@wsu:Id

An optional string label for this security token.

/wsse:BinarySecurityToken/@ValueType

The `ValueType` attribute is used to indicate the "value space" of the encoded binary data (e.g. an X.509 certificate). The `ValueType` attribute allows a URI that defines the value type and space of the encoded binary data. Subsequent specifications MUST define the `ValueType` value for the tokens that they define. The usage of `ValueType` is RECOMMENDED.

/wsse:BinarySecurityToken/@EncodingType

The `EncodingType` attribute is used to indicate, using a URI, the encoding format of the binary data (e.g., `base64 encoded`). A new attribute is introduced, as there are issues with the current schema validation tools that make derivations of mixed simple and complex types difficult within XML Schema. The `EncodingType` attribute is interpreted to indicate the encoding format of the element. The following encoding formats are pre-defined (note that the URI fragments are relative to the URI for this specification):

URI	Description
#Base64Binary (default)	XML Schema base 64 encoding

/wsse:BinarySecurityToken/@{any}

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

All compliant implementations MUST be able to process a `<wsse:BinarySecurityToken>` element.

When a `<wsse:BinarySecurityToken>` is included in a signature—that is, it is referenced from a `<ds:Signature>` element--care should be taken so that the canonicalization algorithm (e.g., Exclusive XML Canonicalization [EXC-C14N]) does not allow unauthorized replacement of namespace prefixes of the QNames used in the attribute or element values. In particular, it is RECOMMENDED that these namespace prefixes be declared within the `<wsse:BinarySecurityToken>` element if this token does not carry the validating key (and consequently it is not cryptographically bound to the signature).

6.4 XML Tokens

This section presents framework for using XML-based security tokens. Profile specifications describe rules and processes for specific XML-based security token formats.

6.4.1 Identifying and Referencing Security Tokens

This specification also defines multiple mechanisms for identifying and referencing security tokens using the `wsu:Id` attribute and the `<wsse:SecurityTokenReference>` element (as well as some additional mechanisms). Please refer to the specific profile documents for the appropriate reference mechanism. However, specific extensions MAY be made to the `<wsse:SecurityTokenReference>` element.

7 Token References

This chapter discusses and defines mechanisms for referencing security tokens.

7.1 SecurityTokenReference Element

A security token conveys a set of claims. Sometimes these claims reside somewhere else and need to be "pulled" by the receiving application. The `<wsse:SecurityTokenReference>` element provides an extensible mechanism for referencing security tokens.

The `<wsse:SecurityTokenReference>` element provides an open content model for referencing security tokens because not all tokens support a common reference pattern. Similarly, some token formats have closed schemas and define their own reference mechanisms. The open content model allows appropriate reference mechanisms to be used when referencing corresponding token types.

If a `<wsse:SecurityTokenReference>` is used outside of the `<wsse:Security>` header block the meaning of the response and/or processing rules of the resulting references MUST be specified by the containing element and are out of scope of this specification.

The following illustrates the syntax of this element:

```
<wsse:SecurityTokenReference wsu:Id="...">
    ...
</wsse:SecurityTokenReference>
```

The following describes the elements defined above:

/wsse:SecurityTokenReference

This element provides a reference to a security token.

/wsse:SecurityTokenReference/@wsu:Id

A string label for this security token reference which names the reference. This attribute does not indicate the ID of what is being referenced, that SHOULD be done using a fragment URI in a `<wsse:Reference>` element within the `<wsse:SecurityTokenReference>` element.

/wsse:SecurityTokenReference/@wsse:Usage

This optional attribute is used to type the usage of the `<wsse:SecurityToken>`. Usages are specified using URIs and multiple usages MAY be specified using XML list semantics. No usages are defined by this specification.

/wsse:SecurityTokenReference/{any}

This is an extensibility mechanism to allow different (extensible) types of security references, based on a schema, to be passed. Unrecognized elements SHOULD cause a fault.

/wsse:SecurityTokenReference/@{any}

This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the header. Unrecognized attributes SHOULD cause a fault.

All compliant implementations MUST be able to process a `<wsse:SecurityTokenReference>` element.

This element can also be used as a direct child element of `<ds:KeyInfo>` to indicate a hint to retrieve the key information from a security token placed somewhere else. In particular, it is RECOMMENDED, when using XML Signature and XML Encryption, that a `<wsse:SecurityTokenReference>` element be placed inside a `<ds:KeyInfo>` to reference the security token used for the signature or encryption.

There are several challenges that implementations face when trying to interoperate. Processing the IDs and references requires the recipient to *understand* the schema. This may be an expensive task and in the general case impossible as there is no way to know the "schema location" for a specific namespace URI. As well, the primary goal of a reference is to uniquely identify the desired token. ID references are, by definition, unique by XML. However, other mechanisms such as "principal name" are not required to be unique and therefore such references may be not unique.

The following list provides a list of the specific reference mechanisms defined in WSS: SOAP Message Security in preferred order (i.e., most specific to least specific):

- **Direct References** – This allows references to included tokens using URI fragments and external tokens using full URIs.
- **Key Identifiers** – This allows tokens to be referenced using an opaque value that represents the token (defined by token type/profile).
- **Key Names** – This allows tokens to be referenced using a string that matches an identity assertion within the security token. This is a subset match and may result in multiple security tokens that match the specified name.
- **Embedded References -** This allows tokens to be embedded (as opposed to a pointer to a token that resides elsewhere).

7.2 Direct References

The `<wsse:Reference>` element provides an extensible mechanism for directly referencing security tokens using URIs.

The following illustrates the syntax of this element:

```
<wsse:SecurityTokenReference wsu:Id="...">
    <wsse:Reference URI="..." ValueType="..."/>
</wsse:SecurityTokenReference>
```

The following describes the elements defined above:

/wsse:SecurityTokenReference/wsse:Reference

This element is used to identify an abstract URI location for locating a security token.

/wsse:SecurityTokenReference/wsse:Reference/@URI

This optional attribute specifies an abstract URI for where to find a security token. If a fragment is specified, then it indicates the local ID of the token being referenced.

/wsse:SecurityTokenReference/wsse:Reference/@ValueType

This optional attribute specifies a URI that is used to identify the *type* of token being referenced. This specification does not define any processing rules around the usage of this attribute, however, specifications for individual token types MAY define specific processing rules and semantics around the value of the URI and how it SHALL be interpreted. If this attribute is not present, the URI MUST be processed as a normal URI. The usage of `ValueType` is RECOMMENDED for references with local URIs.

/wsse:SecurityTokenReference/wsse:Reference/{any}

This is an extensibility mechanism to allow different (extensible) types of security references, based on a schema, to be passed. Unrecognized elements SHOULD cause a fault.

/wsse:SecurityTokenReference/wsse:Reference/@{any}

This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the header. Unrecognized attributes SHOULD cause a fault.

The following illustrates the use of this element:

```
<wsse:SecurityTokenReference
          xmlns:wsse="...">
   <wsse:Reference
             URI="http://www.fabrikam123.com/tokens/Zoe"/>
</wsse:SecurityTokenReference>
```

7.3 Key Identifiers

Alternatively, if a direct reference is not used, then it is RECOMMENDED to use a key identifier to specify/reference a security token instead of a `<ds:KeyName>`. A `KeyIdentifier` is a value that can be used to uniquely identify a security token (e.g. a hash of the important elements of the security token). The exact value type and generation algorithm varies by security token type (and sometimes by the data within the token), Consequently, the values and algorithms are described in the token-specific profiles rather than this specification.

The `<wsse:KeyIdentifier>` element SHALL be placed in the `<wsse:SecurityTokenReference>` element to reference a token using an identifier. This element SHOULD be used for all key identifiers.

The processing model assumes that the key identifier for a security token is constant. Consequently, processing a key identifier is simply looking for a security token whose key identifier matches a given specified constant.

The following is an overview of the syntax:

```
<wsse:SecurityTokenReference>
   <wsse:KeyIdentifier wsu:Id="..."
                       ValueType="..."
                       EncodingType="...">
      ...
   </wsse:KeyIdentifier>
</wsse:SecurityTokenReference>
```

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

/wsse:SecurityTokenReference/wsse:KeyIdentifier

This element is used to include a binary-encoded key identifier.

/wsse:SecurityTokenReference/wsse:KeyIdentifier/@wsu:Id

An optional string label for this identifier.

/wsse:SecurityTokenReference/wsse:KeyIdentifier/@ValueType

The optional `ValueType` attribute is used to indicate the type of `KeyIdentifier` being used. Each specific token profile specifies the `KeyIdentifier` types that may be used to refer to tokens of that type. It also specifies the critical semantics of the identifier, such as whether the `KeyIdentifier` is unique to the key or the token. If no value is specified then the key identifier will be interpreted in an application-specific manner.

/wsse:SecurityTokenReference/wsse:KeyIdentifier/@EncodingType

The optional `EncodingType` attribute is used to indicate, using a URI, the encoding format of the `KeyIdentifier` (`#Base64Binary`). The base values defined in this specification are used (Note that URI fragments are relative to this document's URI):

URI	Description
#Base64Binary	XML Schema base 64 encoding (default)

/wsse:SecurityTokenReference/wsse:KeyIdentifier/@{any}

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

7.4 Embedded References

In some cases a reference may be to an embedded token (as opposed to a pointer to a token that resides elsewhere). To do this, the `<wsse:Embedded>` element is specified within a `<wsse:SecurityTokenReference>` element.

The following is an overview of the syntax:

```
<wsse:SecurityTokenReference>
   <wsse:Embedded wsu:Id="...">
      ...
   </wsse:Embedded>
</wsse:SecurityTokenReference>
```

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

/wsse:SecurityTokenReference/wsse:Embedded

This element is used to embed a token directly within a reference (that is, to create a *local* or *literal* reference).

/wsse:SecurityTokenReference/wsse:Embedded/@wsu:Id

An optional string label for this element. This allows this embedded token to be referenced by a signature or encryption.

/wsse:SecurityTokenReference/wsse:Embedded/{any}

This is an extensibility mechanism to allow any security token, based on schemas, to be embedded. Unrecognized elements SHOULD cause a fault.

/wsse:SecurityTokenReference/wsse:Embedded/@{any}

This is an extensibility mechanism to allow additional attributes, based on schemas, to be added. Unrecognized attributes SHOULD cause a fault.

The following example illustrates embedding a SAML assertion:

```
<S11:Envelope xmlns:S11="..." xmlns:wsse="..." xmlns:wsu="...">
    <S11:Header>
        <wsse:Security>
            ...
            <wsse:SecurityTokenReference>
                <wsse:Embedded wsu:Id="tok1">
                    <saml:Assertion xmlns:saml="...">
                        ...
                    </saml:Assertion>
                </wsse:Embedded>
            </wsse:SecurityTokenReference>
            ...
        <wsse:Security>
    </S11:Header>
    ...
</S11:Body>
```

7.5 ds:KeyInfo

The `<ds:KeyInfo>` element (from XML Signature) can be used for carrying the key information and is allowed for different key types and for future extensibility. However, in this specification, the use of `<wsse:BinarySecurityToken>` is the RECOMMENDED mechanism to carry key material if the key type contains binary data. Please refer to the specific profile documents for the appropriate way to carry key material.

The following example illustrates use of this element to fetch a named key:

```
<ds:KeyInfo Id="..." xmlns:ds="http://www.w3.org/2000/09/xmldsig#">
    <ds:KeyName>CN=Hiroshi Maruyama, C=JP</ds:KeyName>
</ds:KeyInfo>
```

7.6 Key Names

It is strongly RECOMMENDED to use `<wsse:KeyIdentifier>` elements. However, if key names are used, then it is strongly RECOMMENDED that `<ds:KeyName>` elements conform to the attribute names in section 2.3 of RFC 2253 (this is recommended by XML Signature for `<ds:X509SubjectName>`) for interoperability.

Additionally, e-mail addresses, SHOULD conform to RFC 822:

```
    EmailAddress=ckaler@microsoft.com
```

8 Signatures

Message producers may want to enable message recipients to determine whether a message was altered in transit and to verify that the claims in a particular security token apply to the producer of the message.

Demonstrating knowledge of a confirmation key associated with a token key-claim confirms the accompanying token claims. Knowledge of a confirmation key may be demonstrated using that key to create an XML Signature, for example. The relying party acceptance of the claims may depend on its confidence in the token. Multiple tokens may contain a key-claim for a signature and may be referenced from the signature using a <wsse:SecurityTokenReference>. A key-claim may be an X.509 Certificate token, or a Kerberos service ticket token to give two examples.

Because of the mutability of some SOAP headers, producers SHOULD NOT use the *Enveloped Signature Transform* defined in XML Signature. Instead, messages SHOULD explicitly include the elements to be signed. Similarly, producers SHOULD NOT use the *Enveloping Signature* defined in XML Signature [XMLSIG].

This specification allows for multiple signatures and signature formats to be attached to a message, each referencing different, even overlapping, parts of the message. This is important for many distributed applications where messages flow through multiple processing stages. For example, a producer may submit an order that contains an orderID header. The producer signs the orderID header and the body of the request (the contents of the order). When this is received by the order processing sub-system, it may insert a shippingID into the header. The order sub-system would then sign, at a minimum, the orderID and the shippingID, and possibly the body as well. Then when this order is processed and shipped by the shipping department, a shippedInfo header might be appended. The shipping department would sign, at a minimum, the shippedInfo and the shippingID and possibly the body and forward the message to the billing department for processing. The billing department can verify the signatures and determine a valid chain of trust for the order, as well as who authorized each step in the process.

All compliant implementations MUST be able to support the XML Signature standard.

8.1 Algorithms

This specification builds on XML Signature and therefore has the same algorithm requirements as those specified in the XML Signature specification.

The following table outlines additional algorithms that are strongly RECOMMENDED by this specification:

Algorithm Type	Algorithm	Algorithm URI
Canonicalization	Exclusive XML Canonicalization	http://www.w3.org/2001/10/xml-exc-c14n#

As well, the following table outlines additional algorithms that MAY be used:

Algorithm Type	Algorithm	Algorithm URI
Transform	SOAP Message Normalization	http://www.w3.org/TR/2003/NOTE-soap12-n11n-20030328/

The Exclusive XML Canonicalization algorithm addresses the pitfalls of general canonicalization that can occur from *leaky* namespaces with pre-existing signatures.

Finally, if a producer wishes to sign a message before encryption, then following the ordering rules laid out in section 5, "Security Header", they SHOULD first prepend the signature element to the `<wsse:Security>` header, and then prepend the encryption element, resulting in a `<wsse:Security>` header that has the encryption element first, followed by the signature element:

<wsse:Security> header
[encryption element] [signature element] . .

Likewise, if a producer wishes to sign a message after encryption, they SHOULD first prepend the encryption element to the `<wsse:Security>` header, and then prepend the signature element. This will result in a `<wsse:Security>` header that has the signature element first, followed by the encryption element:

<wsse:Security> header
[signature element] [encryption element] . .

The XML Digital Signature WG has defined two canonicalization algorithms: XML Canonicalization and Exclusive XML Canonicalization. To prevent confusion, the first is also called Inclusive Canonicalization. Neither one solves all possible problems that can arise. The following informal discussion is intended to provide guidance on the choice of which one to use in particular circumstances. For a more detailed and technically precise discussion of these issues see: [XML-C14N] and [EXC-C14N].

There are two problems to be avoided. On the one hand, XML allows documents to be changed in various ways and still be considered equivalent. For example, duplicate namespace declarations can be removed or created. As a result, XML tools make these kinds of changes freely when processing XML. Therefore, it is vital that these equivalent forms match the same signature.

On the other hand, if the signature simply covers something like xx:foo, its meaning may change if xx is redefined. In this case the signature does not prevent tampering. It might be thought that the problem could be solved by expanding all the values in line. Unfortunately, there are mechanisms like XPATH which consider xx="http://example.com/"; to be different from yy="http://example.com/"; even though both xx and yy are bound to the same namespace.

The fundamental difference between the Inclusive and Exclusive Canonicalization is the namespace declarations which are placed in the output. Inclusive Canonicalization copies all the declarations that are currently in force, even if they are defined outside of the scope of the signature. It also copies any xml: attributes that are in force, such as `xml:lang` or `xml:base`. This guarantees that all the declarations you might make use of will be unambiguously specified. The problem with this is that if the signed XML is moved into another XML document which has other declarations, the Inclusive Canonicalization will copy then and the signature will be invalid. This can even happen if you simply add an attribute in a different namespace to the surrounding context.

Exclusive Canonicalization tries to figure out what namespaces you are actually using and just copies those. Specifically, it copies the ones that are "visibly used", which means the ones that are a part of the XML syntax. However, it does not look into attribute values or element content, so the namespace declarations required to process these are not copied. For example if you had an attribute like xx:foo="yy:bar" it would copy the declaration for xx, but not yy. (This can even happen without your knowledge because XML processing tools will add `xsi:type` if you use a schema subtype.) It also does not copy the xml: attributes that are declared outside the scope of the signature.

Exclusive Canonicalization allows you to create a list of the namespaces that must be declared, so that it will pick up the declarations for the ones that are not visibly used. The only problem is that the software doing the signing must know what they are. In a typical SOAP software environment, the security code will typically be unaware of all the namespaces being used by the application in the message body that it is signing.

Exclusive Canonicalization is useful when you have a signed XML document that you wish to insert into other XML documents. A good example is a signed SAML assertion which might be inserted as a XML Token in the security header of various SOAP messages. The Issuer who signs the assertion will be aware of the namespaces being used and able to construct the list. The use of Exclusive Canonicalization will insure the signature verifies correctly every time.

Inclusive Canonicalization is useful in the typical case of signing part or all of the SOAP body in accordance with this specification. This will insure all the declarations fall under the signature, even though the code is unaware of what namespaces are being used. At the same time, it is less likely that the signed data (and signature element) will be inserted in some other XML document. Even if this is desired, it still may not be feasible for other reasons, for example there may be Id's with the same value defined in both XML documents.

In other situations it will be necessary to study the requirements of the application and the detailed operation of the canonicalization methods to determine which is appropriate.

This section is non-normative.

8.2 Signing Messages

The `<wsse:Security>` header block MAY be used to carry a signature compliant with the XML Signature specification within a SOAP Envelope for the purpose of signing one or more elements in the SOAP Envelope. Multiple signature entries MAY be added into a single SOAP Envelope within one `<wsse:Security>` header block. Producers SHOULD sign all important elements of the message, and careful thought must be given to creating a signing policy that requires signing of parts of the message that might legitimately be altered in transit.

SOAP applications MUST satisfy the following conditions:

A compliant implementation MUST be capable of processing the required elements defined in the XML Signature specification.

To add a signature to a `<wsse:Security>` header block, a `<ds:Signature>` element conforming to the XML Signature specification MUST be prepended to the existing content of the `<wsse:Security>` header block, in order to indicate to the receiver the correct order of operations. All the `<ds:Reference>` elements contained in the signature SHOULD refer to a resource within the enclosing SOAP envelope as described in the XML Signature specification. However, since the SOAP message exchange model allows intermediate applications to modify the Envelope (add or delete a header block; for example), XPath filtering does not always result in the same objects after message delivery. Care should be taken in using XPath filtering so that there is no subsequent validation failure due to such modifications.

The problem of modification by intermediaries (especially active ones) is applicable to more than just XPath processing. Digital signatures, because of canonicalization and digests, present particularly fragile examples of such relationships. If overall message processing is to remain robust, intermediaries must exercise care that the transformation algorithms used do not affect the validity of a digitally signed component.

Due to security concerns with namespaces, this specification strongly RECOMMENDS the use of the "Exclusive XML Canonicalization" algorithm or another canonicalization algorithm that provides equivalent or greater protection.

For processing efficiency it is RECOMMENDED to have the signature added and then the security token pre-pended so that a processor can read and cache the token before it is used.

8.3 Signing Tokens

It is often desirable to sign security tokens that are included in a message or even external to the message. The XML Signature specification provides several common ways for referencing information to be signed such as URIs, IDs, and XPath, but some token formats may not allow tokens to be referenced using URIs or IDs and XPaths may be undesirable in some situations. This specification allows different tokens to have their own unique reference mechanisms which are specified in their profile as extensions to the `<wsse:SecurityTokenReference>` element. This element provides a uniform referencing mechanism that is guaranteed to work with all token formats. Consequently, this specification defines a new reference option for XML Signature: the STR Dereference Transform.

This transform is specified by the URI `#STR-Transform` (Note that URI fragments are relative to this document's URI) and when applied to a `<wsse:SecurityTokenReference>` element it means that the output is the token referenced by the `<wsse:SecurityTokenReference>` element not the element itself.

As an overview the processing model is to echo the input to the transform except when a `<wsse:SecurityTokenReference>` element is encountered. When one is found, the element is not echoed, but instead, it is used to locate the token(s) matching the criteria and rules defined by the `<wsse:SecurityTokenReference>` element and echo it (them) to the output. Consequently, the output of the transformation is the resultant sequence representing the input with any `<wsse:SecurityTokenReference>` elements replaced by the referenced security token(s) matched.

The following illustrates an example of this transformation which references a token contained within the message envelope:

```
...
<wsse:SecurityTokenReference wsu:Id="Str1">
     ...
</wsse:SecurityTokenReference>
...
<ds:Signature xmlns:ds="http://www.w3.org/2000/09/xmldsig#">
     <ds:SignedInfo>
      ...
       <ds:Reference URI="#Str1">
         <ds:Transforms>
           <ds:Transform
                Algorithm="...#STR-Transform">
             <wsse:TransformationParameters>
                <ds:CanonicalizationMethod
                       Algorithm="http://www.w3.org/TR/2001/REC-xml-
c14n-20010315" />
             </wsse:TransformationParameters>
          </ds:Transform>
         <ds:DigestMethod Algorithm=
                             "http://www.w3.org/2000/09/xmldsig#sha1"/>
         <ds:DigestValue>...</ds:DigestValue>
       </ds:Reference>
     </ds:SignedInfo>
     <ds:SignatureValue></ds:SignatureValue>
</ds:Signature>
...
```

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

/wsse:TransformationParameters

This element is used to wrap parameters for a transformation allows elements even from the XML Signature namespace.

/wsse:TransformationParameters/ds:Canonicalization

This specifies the canolicalization algorithm to apply to the selected data.

/wsse:TransformationParameters/{any}

This is an extensibility mechanism to allow different (extensible) parameters to be specified in the future. Unrecognized parameters SHOULD cause a fault.

/wsse:TransformationParameters/@{any}

This is an extensibility mechanism to allow additional attributes, based on schemas, to be added to the element in the future. Unrecognized attributes SHOULD cause a fault.

The following is a detailed specification of the transformation.
The algorithm is identified by the URI: #STR-Transform
Transform Input:

- The input is a node set. If the input is an octet stream, then it is automatically parsed; cf. XML Digital Signature [XMLSIG].

Transform Output:

- The output is an octet steam.

Syntax:

- The transform takes a single mandatory parameter, a `<ds:CanonicalizationMethod>` element, which is used to serialize the input node set. Note, however, that the output may not be strictly in canonical form, per the canonicalization algorithm; however, the output is canonical, in the sense that it is unambiguous. However, because of syntax requirements in the XML Signature definition, this parameter MUST be wrapped in a `<wsse:TransformationParameters>` element.

Processing Rules:

- Let N be the input node set.
- Let R be the set of all `<wsse:SecurityTokenReference>` elements in N.
- For each Ri in R, let Di be the result of dereferencing Ri.
- If Di cannot be determined, then the transform MUST signal a failure.
- If Di is an XML security token (e.g., a SAML assertion or a `<wsse:BinarySecurityToken>` element), then let Ri' be Di.Otherwise, Di is a raw binary security token; i.e., an octet stream. In this case, let Ri' be a node set consisting of a `<wsse:BinarySecurityToken>` element, utilizing the same namespace prefix as the `<wsse:SecurityTokenReference>` element Ri, with no `EncodingType` attribute, a `ValueType` attribute identifying the content of the security token, and text content consisting of the binary-encoded security token, with no white space.
- Finally, employ the canonicalization method specified as a parameter to the transform to serialize N to produce the octet stream output of this transform; but, in place of any dereferenced `<wsse:SecurityTokenReference>` element Ri and its descendants, process the dereferenced node set Ri' instead. During this step, canonicalization of the replacement node set MUST be augmented as follows:
    - Note: A namespace declaration `xmlns=""` MUST be emitted with every apex element that has no namespace node declaring a value for the default namespace; cf. XML Decryption Transform.

8.4 Signature Validation

The validation of a `<ds:Signature>` element inside an `<wsse:Security>` header block SHALL fail if:

- the syntax of the content of the element does not conform to this specification, or
- the validation of the signature contained in the element fails according to the core validation of the XML Signature specification [XMLSIG], or

- the application applying its own validation policy rejects the message for some reason (e.g., the signature is created by an untrusted key – verifying the previous two steps only performs cryptographic validation of the signature).

If the validation of the signature element fails, applications MAY report the failure to the producer using the fault codes defined in Section 12 Error Handling.

8.5 Example

The following sample message illustrates the use of integrity and security tokens. For this example, only the message body is signed.

```
<?xml version="1.0" encoding="utf-8"?>
<S11:Envelope xmlns:S11="..." xmlns:wsse="..." xmlns:wsu="..."
xmlns:ds="...">
   <S11:Header>
      <wsse:Security>
         <wsse:BinarySecurityToken
                     ValueType="...#X509v3"
                     EncodingType="...#Base64Binary"
                     wsu:Id="X509Token">
                  MIIEZzCCA9CgAwIBAgIQEmtJZc0rqrKh5i...
         </wsse:BinarySecurityToken>
         <ds:Signature>
            <ds:SignedInfo>
               <ds:CanonicalizationMethod Algorithm=
                     "http://www.w3.org/2001/10/xml-exc-c14n#"/>
               <ds:SignatureMethod Algorithm=
                     "http://www.w3.org/2000/09/xmldsig#rsa-sha1"/>
               <ds:Reference URI="#myBody">
                  <ds:Transforms>
                     <ds:Transform Algorithm=
                           "http://www.w3.org/2001/10/xml-exc-c14n#"/>
                  </ds:Transforms>
                  <ds:DigestMethod Algorithm=
                       "http://www.w3.org/2000/09/xmldsig#sha1"/>
                  <ds:DigestValue>EULddytSo1...</ds:DigestValue>
               </ds:Reference>
            </ds:SignedInfo>
            <ds:SignatureValue>
              BL8jdfToEb1l/vXcMZNNjPOV...
            </ds:SignatureValue>
            <ds:KeyInfo>
                <wsse:SecurityTokenReference>
                    <wsse:Reference URI="#X509Token"/>
                </wsse:SecurityTokenReference>
            </ds:KeyInfo>
         </ds:Signature>
      </wsse:Security>
   </S11:Header>
   <S11:Body wsu:Id="myBody">
      <tru:StockSymbol xmlns:tru="http://www.fabrikam123.com/payloads">
        QQQ
      </tru:StockSymbol>
   </S11:Body>
</S11:Envelope>
```

9 Encryption

This specification allows encryption of any combination of body blocks, header blocks, and any of these sub-structures by either a common symmetric key shared by the producer and the recipient or a symmetric key carried in the message in an encrypted form.

In order to allow this flexibility, this specification leverages the XML Encryption standard. Specifically what this specification describes is how three elements (listed below and defined in XML Encryption) can be used within the `<wsse:Security>` header block. When a producer or an active intermediary encrypts portion(s) of a SOAP message using XML Encryption they MUST prepend a sub-element to the `<wsse:Security>` header block. Furthermore, the encrypting party MUST either prepend the sub-element to an existing `<wsse:Security>` header block for the intended recipients or create a new `<wsse:Security>` header block and insert the sub-element. The combined process of encrypting portion(s) of a message and adding one of these sub-elements is called an encryption step hereafter. The sub-element MUST contain the information necessary for the recipient to identify the portions of the message that it is able to decrypt.

All compliant implementations MUST be able to support the XML Encryption standard [XMLENC].

9.1 xenc:ReferenceList

The `<xenc:ReferenceList>` element from XML Encryption [XMLENC] MAY be used to create a manifest of encrypted portion(s), which are expressed as `<xenc:EncryptedData>` elements within the envelope. An element or element content to be encrypted by this encryption step MUST be replaced by a corresponding `<xenc:EncryptedData>` according to XML Encryption. All the `<xenc:EncryptedData>` elements created by this encryption step SHOULD be listed in `<xenc:DataReference>` elements inside one or more `<xenc:ReferenceList>` element.

Although in XML Encryption [XMLENC], `<xenc:ReferenceList>` was originally designed to be used within an `<xenc:EncryptedKey>` element (which implies that all the referenced `<xenc:EncryptedData>` elements are encrypted by the same key), this specification allows that `<xenc:EncryptedData>` elements referenced by the same `<xenc:ReferenceList>` MAY be encrypted by different keys. Each encryption key can be specified in `<ds:KeyInfo>` within individual `<xenc:EncryptedData>`.

A typical situation where the `<xenc:ReferenceList>` sub-element is useful is that the producer and the recipient use a shared secret key. The following illustrates the use of this sub-element:

```
<S11:Envelope xmlns:S11="..." xmlns:wsse="..." xmlns:wsu="..."
xmlns:ds="..." xmlns:xenc="...">
    <S11:Header>
        <wsse:Security>
            <xenc:ReferenceList>
                <xenc:DataReference URI="#bodyID"/>
            </xenc:ReferenceList>
        </wsse:Security>
    </S11:Header>
    <S11:Body>
        <xenc:EncryptedData Id="bodyID">
          <ds:KeyInfo>
            <ds:KeyName>CN=Hiroshi Maruyama, C=JP</ds:KeyName>
          </ds:KeyInfo>
          <xenc:CipherData>
            <xenc:CipherValue>...</xenc:CipherValue>
          </xenc:CipherData>
```

```
        </xenc:EncryptedData>
    </S11:Body>
</S11:Envelope>
```

9.2 xenc:EncryptedKey

When the encryption step involves encrypting elements or element contents within a SOAP envelope with a symmetric key, which is in turn to be encrypted by the recipient's key and embedded in the message, `<xenc:EncryptedKey>` MAY be used for carrying such an encrypted key. This sub-element SHOULD have a manifest, that is, an `<xenc:ReferenceList>` element, in order for the recipient to know the portions to be decrypted with this key. An element or element content to be encrypted by this encryption step MUST be replaced by a corresponding `<xenc:EncryptedData>` according to XML Encryption. All the `<xenc:EncryptedData>` elements created by this encryption step SHOULD be listed in the `<xenc:ReferenceList>` element inside this sub-element.

This construct is useful when encryption is done by a randomly generated symmetric key that is in turn encrypted by the recipient's public key. The following illustrates the use of this element:

```
<S11:Envelope xmlns:S11="..." xmlns:wsse="..." xmlns:wsu="..."
xmlns:ds="..." xmlns:xenc="...">
    <S11:Header>
        <wsse:Security>
              <xenc:EncryptedKey>
                ...
                <ds:KeyInfo>
                  <wsse:SecurityTokenReference>
                    <ds:X509IssuerSerial>
                      <ds:X509IssuerName>
                        DC=ACMECorp, DC=com
                       </ds:X509IssuerName>
<ds:X509SerialNumber>12345678</ds:X509SerialNumber>
                    </ds:X509IssuerSerial>
                  </wsse:SecurityTokenReference>
                </ds:KeyInfo>
                 ...
              </xenc:EncryptedKey>
  ...
        </wsse:Security>
    </S11:Header>
    <S11:Body>
        <xenc:EncryptedData Id="bodyID">
            <xenc:CipherData>
              <xenc:CipherValue>...</xenc:CipherValue>
            </xenc:CipherData>
        </xenc:EncryptedData>
    </S11:Body>
</S11:Envelope>
```

While XML Encryption specifies that `<xenc:EncryptedKey>` elements MAY be specified in `<xenc:EncryptedData>` elements, this specification strongly RECOMMENDS that `<xenc:EncryptedKey>` elements be placed in the `<wsse:Security>` header.

9.3 Processing Rules

Encrypted parts or using one of the sub-elements defined above MUST be in compliance with the XML Encryption specification. An encrypted SOAP envelope MUST still be a valid SOAP envelope. The message creator MUST NOT encrypt the `<S11:Envelope>`, `<S12:Envolope>`,, `<S11:Header>`, `<S12:Header>`, or `<S11:Body>`, `<S12:Body>` elements but MAY encrypt child elements of either the `<S11:Header>`, `<S12:Header>` and

<S11:Body> or <S12:Body> elements. Multiple steps of encryption MAY be added into a single <wsse:Security> header block if they are targeted for the same recipient.
When an element or element content inside a SOAP envelope (e.g. the contents of the <S11:Body> or <S12:Body> elements) are to be encrypted, it MUST be replaced by an <xenc:EncryptedData>, according to XML Encryption and it SHOULD be referenced from the <xenc:ReferenceList> element created by this encryption step.

9.3.1 Encryption

The general steps (non-normative) for creating an encrypted SOAP message in compliance with this specification are listed below (note that use of <xenc:ReferenceList> is RECOMMENDED).

- Create a new SOAP envelope.
- Create a <wsse:Security> header
- When an <xenc:EncryptedKey> is used, create a <xenc:EncryptedKey> sub-element of the <wsse:Security> element. This <xenc:EncryptedKey> sub-element SHOULD contain an <xenc:ReferenceList> sub-element, containing a <xenc:DataReference> to each <xenc:EncryptedData> element that was encrypted using that key.
- Locate data items to be encrypted, i.e., XML elements, element contents within the target SOAP envelope.
- Encrypt the data items as follows: For each XML element or element content within the target SOAP envelope, encrypt it according to the processing rules of the XML Encryption specification [XMLENC]. Each selected original element or element content MUST be removed and replaced by the resulting <xenc:EncryptedData> element.
- The optional <ds:KeyInfo> element in the <xenc:EncryptedData> element MAY reference another <ds:KeyInfo> element. Note that if the encryption is based on an attached security token, then a <wsse:SecurityTokenReference> element SHOULD be added to the <ds:KeyInfo> element to facilitate locating it.
- Create an <xenc:DataReference> element referencing the generated <xenc:EncryptedData> elements. Add the created <xenc:DataReference> element to the <xenc:ReferenceList>.
- Copy all non-encrypted data.

9.3.2 Decryption

On receiving a SOAP envelope containing encryption header elements, for each encryption header element the following general steps should be processed (non-normative):
Identify any decryption keys that are in the recipient's possession, then identifying any message elements that it is able to decrypt.
Locate the <xenc:EncryptedData> items to be decrypted (possibly using the <xenc:ReferenceList>).
Decrypt them as follows:
For each element in the target SOAP envelope, decrypt it according to the processing rules of the XML Encryption specification and the processing rules listed above.
If the decryption fails for some reason, applications MAY report the failure to the producer using the fault code defined in Section 12 Error Handling of this specification.
It is possible for overlapping portions of the SOAP message to be encrypted in such a way that they are intended to be decrypted by SOAP nodes acting in different Roles. In this case, the <xenc:ReferenceList> or <xenc:EncryptedKey> elements identifying these encryption operations will necessarily appear in different <wsse:Security> headers. Since SOAP does not provide any means of specifying the order in which different Roles will process their respective headers, this order is not specified by this specification and can only be determined by a prior agreement.

9.4 Decryption Transformation

The ordering semantics of the `<wsse:Security>` header are sufficient to determine if signatures are over encrypted or unencrypted data. However, when a signature is included in one `<wsse:Security>` header and the encryption data is in another `<wsse:Security>` header, the proper processing order may not be apparent.

If the producer wishes to sign a message that MAY subsequently be encrypted by an intermediary then the producer MAY use the Decryption Transform for XML Signature to explicitly specify the order of decryption.

10 Security Timestamps

It is often important for the recipient to be able to determine the *freshness* of security semantics. In some cases, security semantics may be so *stale* that the recipient may decide to ignore it. This specification does not provide a mechanism for synchronizing time. The assumption is that time is trusted or additional mechanisms, not described here, are employed to prevent replay. This specification defines and illustrates time references in terms of the `xsd:dateTime` type defined in XML Schema. It is RECOMMENDED that all time references use this type. It is further RECOMMENDED that all references be in UTC time. Implementations MUST NOT generate time instants that specify leap seconds. If, however, other time types are used, then the `ValueType` attribute (described below) MUST be specified to indicate the data type of the time format. Requestors and receivers SHOULD NOT rely on other applications supporting time resolution finer than milliseconds.

The <wsu:Timestamp> element provides a mechanism for expressing the creation and expiration times of the security semantics in a message.

All times MUST be in UTC format as specified by the XML Schema type (dateTime). It should be noted that times support time precision as defined in the XML Schema specification.

The <wsu:Timestamp> element is specified as a child of the <wsse:Security> header and may only be present at most once per header (that is, per SOAP actor/role).

The ordering within the element is as illustrated below. The ordering of elements in the <wsu:Timestamp> element is fixed and MUST be preserved by intermediaries.

The schema outline for the <wsu:Timestamp> element is as follows:

```
<wsu:Timestamp wsu:Id="...">
    <wsu:Created ValueType="...">...</wsu:Created>
    <wsu:Expires  ValueType="...">...</wsu:Expires>
    ...
</wsu:Timestamp>
```

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

/wsu:Timestamp

This is the element for indicating message timestamps.

/wsu:Timestamp/wsu:Created

This represents the creation time of the security semantics. This element is optional, but can only be specified once in a <wsu:Timestamp> element. Within the SOAP processing model, creation is the instant that the infoset is serialized for transmission. The creation time of the message SHOULD NOT differ substantially from its transmission time. The difference in time should be minimized.

/wsu:Timestamp/wsu:Expires

This element represents the expiration of the security semantics. This is optional, but can appear at most once in a <wsu:Timestamp> element. Upon expiration, the requestor asserts that its security semantics are no longer valid. It is strongly RECOMMENDED that recipients (anyone who processes this message) discard (ignore) any message whose security semantics have passed their expiration. A Fault code (`wsu:MessageExpired`) is provided if the recipient wants to inform the requestor that its security semantics were expired. A service MAY issue a Fault indicating the security semantics have expired.

/wsu:Timestamp/{any}

This is an extensibility mechanism to allow additional elements to be added to the element. Unrecognized elements SHOULD cause a fault.

/wsu:Timestamp/@wsu:Id

This optional attribute specifies an XML Schema ID that can be used to reference this element (the timestamp). This is used, for example, to reference the timestamp in a XML Signature.

/wsu:Timestamp/@{any}

This is an extensibility mechanism to allow additional attributes to be added to the element. Unrecognized attributes SHOULD cause a fault.

The expiration is relative to the requestor's clock. In order to evaluate the expiration time, recipients need to recognize that the requestor's clock may not be synchronized to the recipient’s clock. The recipient, therefore, MUST make an assessment of the level of trust to be placed in the requestor's clock, since the recipient is called upon to evaluate whether the expiration time is in the past relative to the requestor's, not the recipient’s, clock. The recipient may make a judgment of the requestor’s likely current clock time by means not described in this specification, for example an out-of-band clock synchronization protocol. The recipient may also use the creation time and the delays introduced by intermediate SOAP roles to estimate the degree of clock skew.

The following example illustrates the use of the <wsu:Timestamp> element and its content.

```
<S11:Envelope xmlns:S11="..." xmlns:wsse="..." xmlns:wsu="...">
  <S11:Header>
    <wsse:Security>
      <wsu:Timestamp wsu:Id="timestamp">
         <wsu:Created>2001-09-13T08:42:00Z</wsu:Created>
         <wsu:Expires>2001-10-13T09:00:00Z</wsu:Expires>
      </wsu:Timestamp>
      ...
    </wsse:Security>
    ...
  </S11:Header>
  <S11:Body>
    ...
  </S11:Body>
</S11:Envelope>
```

11 Extended Example

The following sample message illustrates the use of security tokens, signatures, and encryption. For this example, the timestamp and the message body are signed prior to encryption. The decryption transformation is not needed as the signing/encryption order is specified within the <wsse:Security> header.

```
(001) <?xml version="1.0" encoding="utf-8"?>
(002) <S11:Envelope xmlns:S11="..." xmlns:wsse="..." xmlns:wsu="..."
xmlns:xenc="..." xmlns:ds="...">
(003)   <S11:Header>
(004)      <wsse:Security>
(005)         <wsu:Timestamp wsu:Id="T0">
(006)           <wsu:Created>
(007)                   2001-09-13T08:42:00Z</wsu:Created>
(008)         </wsu:Timestamp>
(009)
(010)         <wsse:BinarySecurityToken
                     ValueType="...#X509v3"
                     wsu:Id="X509Token"
                     EncodingType="...#Base64Binary">
(011)         MIIEZzCCA9CgAwIBAgIQEmtJZc0rqrKh5i...
(012)         </wsse:BinarySecurityToken>
(013)         <xenc:EncryptedKey>
(014)             <xenc:EncryptionMethod Algorithm=
                        "http://www.w3.org/2001/04/xmlenc#rsa-1_5"/>
(015)             <ds:KeyInfo>
(016)                <wsse:KeyIdentifier
                         EncodingType="...#Base64Binary"
                   ValueType="...#X509v3">MIGfMa0GCSq...
(017)                </wsse:KeyIdentifier>
(018)             </ds:KeyInfo>
(019)             <xenc:CipherData>
(020)                <xenc:CipherValue>d2FpbmdvbGRfE0lm4byV0...
(021)                </xenc:CipherValue>
(022)             </xenc:CipherData>
(023)             <xenc:ReferenceList>
(024)                 <xenc:DataReference URI="#enc1"/>
(025)             </xenc:ReferenceList>
(026)         </xenc:EncryptedKey>
(027)         <ds:Signature>
(028)            <ds:SignedInfo>
(029)               <ds:CanonicalizationMethod
                  Algorithm="http://www.w3.org/2001/10/xml-exc-c14n#"/>
(030)               <ds:SignatureMethod
               Algorithm="http://www.w3.org/2000/09/xmldsig#rsa-sha1"/>
(031)               <ds:Reference URI="#T0">
(032)                  <ds:Transforms>
(033)                     <ds:Transform
                  Algorithm="http://www.w3.org/2001/10/xml-exc-c14n#"/>
(034)                  </ds:Transforms>
(035)                  <ds:DigestMethod
                   Algorithm="http://www.w3.org/2000/09/xmldsig#sha1"/>
(036)                  <ds:DigestValue>LyLsF094hPi4wPU...
(037)                   </ds:DigestValue>
(038)               </ds:Reference>
(039)               <ds:Reference URI="#body">
(040)                  <ds:Transforms>
(041)                     <ds:Transform
```

```
                  Algorithm="http://www.w3.org/2001/10/xml-exc-c14n#"/>
(042)                  </ds:Transforms>
(043)                  <ds:DigestMethod
                   Algorithm="http://www.w3.org/2000/09/xmldsig#sha1"/>
(044)                  <ds:DigestValue>LyLsF094hPi4wPU...
(045)                   </ds:DigestValue>
(046)               </ds:Reference>
(047)            </ds:SignedInfo>
(048)            <ds:SignatureValue>
(049)                     Hp1ZkmFZ/2kQLXDJbchm5gK...
(050)            </ds:SignatureValue>
(051)            <ds:KeyInfo>
(052)                <wsse:SecurityTokenReference>
(053)                    <wsse:Reference URI="#X509Token"/>
(054)                </wsse:SecurityTokenReference>
(055)            </ds:KeyInfo>
(056)         </ds:Signature>
(057)      </wsse:Security>
(058)   </S11:Header>
(059)   <S11:Body wsu:Id="body">
(060)      <xenc:EncryptedData
                  Type="http://www.w3.org/2001/04/xmlenc#Element"
                  wsu:Id="enc1">
(061)         <xenc:EncryptionMethod
              Algorithm="http://www.w3.org/2001/04/xmlenc#tripledes-
cbc"/>
(062)         <xenc:CipherData>
(063)            <xenc:CipherValue>d2FpbmdvbGRfE0lm4byV0...
(064)            </xenc:CipherValue>
(065)         </xenc:CipherData>
(066)      </xenc:EncryptedData>
(067)   </S11:Body>
(068) </S11:Envelope>
```

Let's review some of the key sections of this example:

Lines (003)-(058) contain the SOAP message headers.

Lines (004)-(057) represent the `<wsse:Security>` header block. This contains the security-related information for the message.

Lines (005)-(008) specify the timestamp information. In this case it indicates the creation time of the security semantics.

Lines (010)-(012) specify a security token that is associated with the message. In this case, it specifies an X.509 certificate that is encoded as Base64. Line (011) specifies the actual Base64 encoding of the certificate.

Lines (013)-(026) specify the key that is used to encrypt the body of the message. Since this is a symmetric key, it is passed in an encrypted form. Line (014) defines the algorithm used to encrypt the key. Lines (015)-(018) specify the identifier of the key that was used to encrypt the symmetric key. Lines (019)-(022) specify the actual encrypted form of the symmetric key. Lines (023)-(025) identify the encryption block in the message that uses this symmetric key. In this case it is only used to encrypt the body (Id="enc1").

Lines (027)-(056) specify the digital signature. In this example, the signature is based on the X.509 certificate. Lines (028)-(047) indicate what is being signed. Specifically, line (039) references the message body.

Lines (048)-(050) indicate the actual signature value – specified in Line (043).

Lines (052)-(054) indicate the key that was used for the signature. In this case, it is the X.509 certificate included in the message. Line (053) provides a URI link to the Lines (010)-(012).

The body of the message is represented by Lines (059)-(067).

Lines (060)-(066) represent the encrypted metadata and form of the body using XML Encryption. Line (060) indicates that the "element value" is being replaced and identifies this encryption. Line (061) specifies the encryption algorithm – Triple-DES in this case. Lines (063)-(064) contain the actual cipher text (i.e., the result of the encryption). Note that we don't include a reference to the key as the key references this encryption – Line (024).

12 Error Handling

There are many circumstances where an *error* can occur while processing security information. For example:

- Invalid or unsupported type of security token, signing, or encryption
- Invalid or unauthenticated or unauthenticatable security token
- Invalid signature
- Decryption failure
- Referenced security token is unavailable
- Unsupported namespace

If a service does not perform its normal operation because of the contents of the Security header, then that MAY be reported using SOAP's Fault Mechanism. This specification does not mandate that faults be returned as this could be used as part of a denial of service or cryptographic attack. We combine signature and encryption failures to mitigate certain types of attacks.

If a failure is returned to a producer then the failure MUST be reported using the SOAP Fault mechanism. The following tables outline the predefined security fault codes. The "unsupported" classes of errors are as follows. Note that the reason text provided below is RECOMMENDED, but alternative text MAY be provided if more descriptive or preferred by the implementation. The tables below are defined in terms of SOAP 1.1. For SOAP 1.2, the Fault/Code/Value is env:Sender (as defined in SOAP 1.2) and the Fault/Code/Subcode/Value is the *faultcode* below and the Fault/Reason/Text is the *faultstring* below.

Error that occurred (faultstring)	Faultcode
An unsupported token was provided	wsse:UnsupportedSecurityToken
An unsupported signature or encryption algorithm was used	wsse:UnsupportedAlgorithm

The "failure" class of errors are:

Error that occurred (faultstring)	faultcode
An error was discovered processing the <wsse:Security> header.	wsse:InvalidSecurity
An invalid security token was provided	wsse:InvalidSecurityToken
The security token could not be authenticated or authorized	wsse:FailedAuthentication
The signature or decryption was invalid	wsse:FailedCheck
Referenced security token could not be retrieved	wsse:SecurityTokenUnavailable

13 Security Considerations

As stated in the Goals and Requirements section of this document, this specification is meant to provide extensible framework and flexible syntax, with which one could implement various security mechanisms. This framework and syntax by itself *does not provide any guarantee of security.* When implementing and using this framework and syntax, one must make every effort to ensure that the result is not vulnerable to any one of a wide range of attacks.

13.1 General Considerations

It is not feasible to provide a comprehensive list of security considerations for such an extensible set of mechanisms. A complete security analysis MUST be conducted on specific solutions based on this specification. Below we illustrate some of the security concerns that often come up with protocols of this type, but we stress that this *is not an exhaustive list of concerns.*

- freshness guarantee (e.g., the danger of replay, delayed messages and the danger of relying on timestamps assuming secure clock synchronization)
- proper use of digital signature and encryption (signing/encrypting critical parts of the message, interactions between signatures and encryption), i.e., signatures on (content of) encrypted messages leak information when in plain-text)
- protection of security tokens (integrity)
- certificate verification (including revocation issues)
- the danger of using passwords without outmost protection (i.e. dictionary attacks against passwords, replay, insecurity of password derived keys, ...)
- the use of randomness (or strong pseudo-randomness)
- interaction between the security mechanisms implementing this standard and other system component
- man-in-the-middle attacks
- PKI attacks (i.e. identity mix-ups)

There are other security concerns that one may need to consider in security protocols. The list above should not be used as a "check list" instead of a comprehensive security analysis. The next section will give a few details on some of the considerations in this list.

13.2 Additional Considerations

13.2.1 Replay

Digital signatures alone do not provide message authentication. One can record a signed message and resend it (a replay attack).It is strongly RECOMMENDED that messages include digitally signed elements to allow message recipients to detect replays of the message when the messages are exchanged via an open network. These can be part of the message or of the headers defined from other SOAP extensions. Four typical approaches are: Timestamp, Sequence Number, Expirations and Message Correlation. Signed timestamps MAY be used to keep track of messages (possibly by caching the most recent timestamp from a specific service) and detect replays of previous messages. It is RECOMMENDED that timestamps be cached for a given period of time, as a guideline, a value of five minutes can be used as a minimum to detect replays, and that timestamps older than that given period of time set be rejected in interactive scenarios.

13.2.2 Combining Security Mechanisms

This specification defines the use of XML Signature and XML Encryption in SOAP headers. As one of the building blocks for securing SOAP messages, it is intended to be used in conjunction with other security techniques. Digital signatures need to be understood in the context of other security mechanisms and possible threats to an entity.

Implementers should also be aware of all the security implications resulting from the use of digital signatures in general and XML Signature in particular. When building trust into an application based on a digital signature there are other technologies, such as certificate evaluation, that must be incorporated, but these are outside the scope of this document.

As described in XML Encryption, the combination of signing and encryption over a common data item may introduce some cryptographic vulnerability. For example, encrypting digitally signed data, while leaving the digital signature in the clear, may allow plain text guessing attacks.

13.2.3 Challenges

When digital signatures are used for verifying the claims pertaining to the sending entity, the producer must demonstrate knowledge of the confirmation key. One way to achieve this is to use a challenge-response type of protocol. Such a protocol is outside the scope of this document. To this end, the developers can attach timestamps, expirations, and sequences to messages.

13.2.4 Protecting Security Tokens and Keys

Implementers should be aware of the possibility of a token substitution attack. In any situation where a digital signature is verified by reference to a token provided in the message, which specifies the key, it may be possible for an unscrupulous producer to later claim that a different token, containing the same key, but different information was intended.

An example of this would be a user who had multiple X.509 certificates issued relating to the same key pair but with different attributes, constraints or reliance limits. Note that the signature of the token by its issuing authority does not prevent this attack. Nor can an authority effectively prevent a different authority from issuing a token over the same key if the user can prove possession of the secret.

The most straightforward counter to this attack is to insist that the token (or its unique identifying data) be included under the signature of the producer. If the nature of the application is such that the contents of the token are irrelevant, assuming it has been issued by a trusted authority, this attack may be ignored. However because application semantics may change over time, best practice is to prevent this attack.

Requestors should use digital signatures to sign security tokens that do not include signatures (or other protection mechanisms) to ensure that they have not been altered in transit. It is strongly RECOMMENDED that all relevant and immutable message content be signed by the producer. Receivers SHOULD only consider those portions of the document that are covered by the producer's signature as being subject to the security tokens in the message. Security tokens appearing in `<wsse:Security>` header elements SHOULD be signed by their issuing authority so that message receivers can have confidence that the security tokens have not been forged or altered since their issuance. It is strongly RECOMMENDED that a message producer sign any `<wsse:SecurityToken>` elements that it is confirming and that are not signed by their issuing authority.

When a requester provides, within the request, a Public Key to be used to encrypt the response, it is possible that an attacker in the middle may substitute a different Public Key, thus allowing the attacker to read the response. The best way to prevent this attack is to bind the encryption key in some way to the request. One simple way of doing this is to use the same key pair to sign the request as to encrypt the response. However, if policy requires the use of distinct key pairs for signing and encryption, then the Public Key provided in the request should be included under the signature of the request.

13.2.5 Protecting Timestamps and Ids

In order to *trust* wsu:Id attributes and <wsu:Timestamp> elements, they SHOULD be signed using the mechanisms outlined in this specification. This allows readers of the IDs and timestamps information to be certain that the IDs and timestamps haven't been forged or altered in any way. It is strongly RECOMMENDED that IDs and timestamp elements be signed.

This section is non-normative.

14 Interoperability Notes

Based on interoperability experiences with this and similar specifications, the following list highlights several common areas where interoperability issues have been discovered. Care should be taken when implementing to avoid these issues. It should be noted that some of these may seem "obvious", but have been problematic during testing.

- **Key Identifiers:** Make sure you understand the algorithm and how it is applied to security tokens.
- **EncryptedKey:** The <xenc:EncryptedKey> element from XML Encryption requires a Type attribute whose value is one of a pre-defined list of values. Ensure that a correct value is used.
- **Encryption Padding:** The XML Encryption random block cipher padding has caused issues with certain decryption implementations; be careful to follow the specifications exactly.
- **IDs:** The specification recognizes three specific ID elements: the global wsu:Id attribute and the local Id attributes on XML Signature and XML Encryption elements (because the latter two do not allow global attributes). If any other element does not allow global attributes, it cannot be directly signed using an ID reference. Note that the global attribute `wsu:Id` MUST carry the namespace specification.
- **Time Formats:** This specification uses a restricted version of the XML Schema `xsd:dateTime` element. Take care to ensure compliance with the specified restrictions.
- **Byte Order Marker (BOM):** Some implementations have problems processing the BOM marker. It is suggested that usage of this be optional.
- **SOAP, WSDL, HTTP:** Various interoperability issues have been seen with incorrect SOAP, WSDL, and HTTP semantics being applied. Care should be taken to carefully adhere to these specifications and any interoperability guidelines that are available.

This section is non-normative.

15 Privacy Considerations

In the context of this specification, we are only concerned with potential privacy violation by the security elements defined here. Privacy of the content of the payload message is out of scope. Producers or sending applications should be aware that claims, as collected in security tokens, are typically personal information, and should thus only be sent according to the producer's privacy policies. Future standards may allow privacy obligations or restrictions to be added to this data. Unless such standards are used, the producer must ensure by out-of-band means that the recipient is bound to adhering to all restrictions associated with the data, and the recipient must similarly ensure by out-of-band means that it has the necessary consent for its intended processing of the data.

If claim data are visible to intermediaries, then the policies must also allow the release to these intermediaries. As most personal information cannot be released to arbitrary parties, this will typically require that the actors are referenced in an identifiable way; such identifiable references are also typically needed to obtain appropriate encryption keys for the intermediaries.

If intermediaries add claims, they should be guided by their privacy policies just like the original producers.

Intermediaries may also gain traffic information from a SOAP message exchange, e.g., who communicates with whom at what time. Producers that use intermediaries should verify that releasing this traffic information to the chosen intermediaries conforms to their privacy policies.

This section is non-normative.

16 References

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Appendix A: Utility Elements and Attributes

These specifications define several elements, attributes, and attribute groups which can be re-used by other specifications. This appendix provides an overview of these *utility* components. It should be noted that the detailed descriptions are provided in the specification and this appendix will reference these sections as well as calling out other aspects not documented in the specification.

A.1. Identification Attribute

There are many situations where elements within SOAP messages need to be referenced. For example, when signing a SOAP message, selected elements are included in the signature. XML Schema Part 2 provides several built-in data types that may be used for identifying and referencing elements, but their use requires that consumers of the SOAP message either have or are able to obtain the schemas where the identity or reference mechanisms are defined. In some circumstances, for example, intermediaries, this can be problematic and not desirable.

Consequently a mechanism is required for identifying and referencing elements, based on the SOAP foundation, which does not rely upon complete schema knowledge of the context in which an element is used. This functionality can be integrated into SOAP processors so that elements can be identified and referred to without dynamic schema discovery and processing.

This specification specifies a namespace-qualified global attribute for identifying an element which can be applied to any element that either allows arbitrary attributes or specifically allows this attribute. This is a general purpose mechanism which can be re-used as needed.

A detailed description can be found in Section 4.0 ID References.

This section is non-normative.

A.2. Timestamp Elements

The specification defines XML elements which may be used to express timestamp information such as creation and expiration. While defined in the context of message security, these elements can be re-used wherever these sorts of time statements need to be made.

The elements in this specification are defined and illustrated using time references in terms of the *dateTime* type defined in XML Schema. It is RECOMMENDED that all time references use this type for interoperability. It is further RECOMMENDED that all references be in UTC time for increased interoperability. If, however, other time types are used, then the `ValueType` attribute MUST be specified to indicate the data type of the time format.

The following table provides an overview of these elements:

Element	Description
<wsu:Created>	This element is used to indicate the creation time associated with the enclosing context.
<wsu:Expires>	This element is used to indicate the expiration time associated with the enclosing context.

A detailed description can be found in Section 10.

This section is non-normative.

A.3. General Schema Types

The schema for the utility aspects of this specification also defines some general purpose schema elements. While these elements are defined in this schema for use with this specification, they are general purpose definitions that may be used by other specifications as well.

Specifically, the following schema elements are defined and can be re-used:

Schema Element	Description
wsu:commonAtts attribute group	This attribute group defines the common attributes recommended for elements. This includes the wsu:Id attribute as well as extensibility for other namespace qualified attributes.
wsu:AttributedDateTime type	This type extends the XML Schema dateTime type to include the common attributes.
wsu:AttributedURI type	This type extends the XML Schema anyURI type to include the common attributes.

This section is non-normative.

Appendix B: SecurityTokenReference Model

This appendix provides a non-normative overview of the usage and processing models for the `<wsse:SecurityTokenReference>` element.

There are several motivations for introducing the `<wsse:SecurityTokenReference>` element:

The XML Signature reference mechanisms are focused on "key" references rather than general token references.

The XML Signature reference mechanisms utilize a fairly closed schema which limits the extensibility that can be applied.

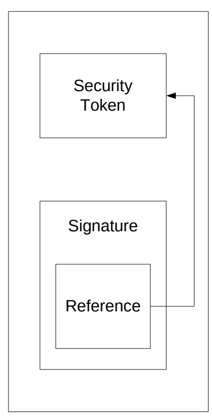
There are additional types of general reference mechanisms that are needed, but are not covered by XML Signature.

There are scenarios where a reference may occur outside of an XML Signature and the XML Signature schema is not appropriate or desired.

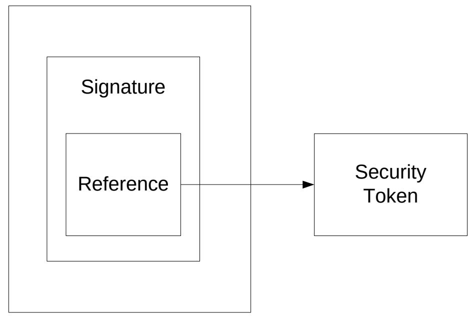
The XML Signature references may include aspects (e.g. transforms) that may not apply to all references.

The following use cases drive the above motivations:

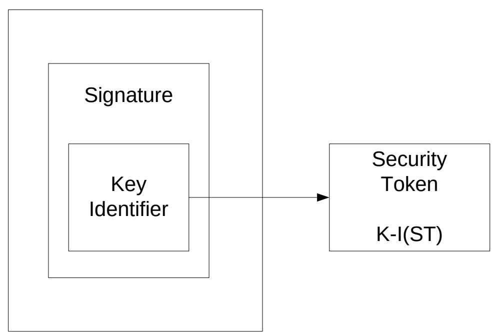
Local Reference – A security token, that is included in the message in the `<wsse:Security>` header, is associated with an XML Signature. The figure below illustrates this:



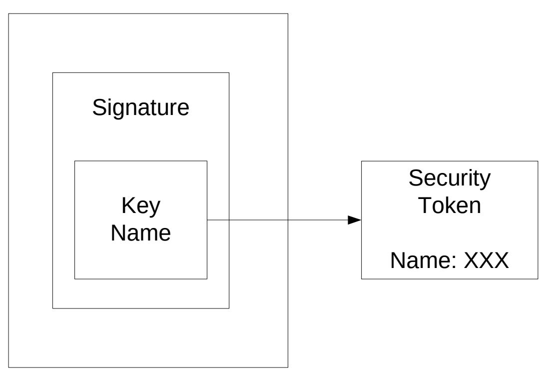
Remote Reference – A security token, that is not included in the message but may be available at a specific URI, is associated with an XML Signature. The figure below illustrates this:



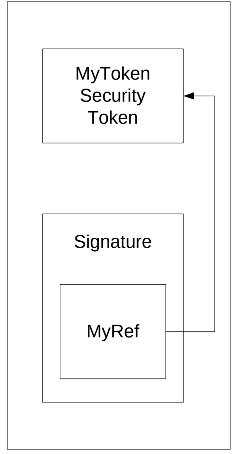
Key Identifier – A security token, which is associated with an XML Signature and identified using a known value that is the result of a well-known function of the security token (defined by the token format or profile). The figure below illustrates this where the token is located externally:



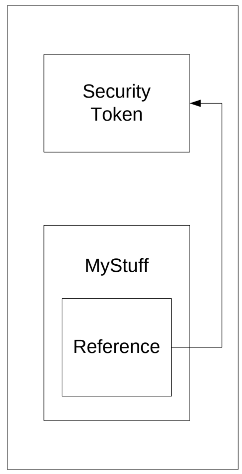
Key Name – A security token is associated with an XML Signature and identified using a known value that represents a "name" assertion within the security token (defined by the token format or profile). The figure below illustrates this where the token is located externally:



Format-Specific References – A security token is associated with an XML Signature and identified using a mechanism specific to the token (rather than the general mechanisms described above). The figure below illustrates this:



Non-Signature References – A message may contain XML that does not represent an XML signature, but may reference a security token (which may or may not be included in the message). The figure below illustrates this:



All conformant implementations MUST be able to process the `<wsse:SecurityTokenReference>` element. However, they are not required to support all of the different types of references.

The reference MAY include a *`ValueType`* attribute which provides a "hint" for the type of desired token.

If multiple sub-elements are specified, together they describe the reference for the token.

There are several challenges that implementations face when trying to interoperate:

ID References – The underlying XML referencing mechanism using the XML base type of ID provides a simple straightforward XML element reference. However, because this is an XML type, it can be bound to *any* attribute. Consequently in order to process the IDs and references requires the recipient to *understand* the schema. This may be an expensive task and in the general case impossible as there is no way to know the "schema location" for a specific namespace URI.

Ambiguity – The primary goal of a reference is to uniquely identify the desired token. ID references are, by definition, unique by XML. However, other mechanisms such as "principal name" are not required to be unique and therefore such references may be unique.

The XML Signature specification defines a `<ds:KeyInfo>` element which is used to provide information about the "key" used in the signature. For token references within signatures, it is RECOMMENDED that the `<wsse:SecurityTokenReference>` be placed within the `<ds:KeyInfo>`. The XML Signature specification also defines mechanisms for referencing keys by identifier or passing specific keys. As a rule, the specific mechanisms defined in WSS: SOAP Message Security or its profiles are preferred over the mechanisms in XML Signature.

The following provides additional details on the specific reference mechanisms defined in WSS: SOAP Message Security:

Direct References – The `<wsse:Reference>` element is used to provide a URI reference to the security token. If only the fragment is specified, then it references the security token within the document whose wsu:Id matches the fragment. For non-fragment URIs, the reference is to a [potentially external] security token identified using a URI. There are no implied semantics around the processing of the URI.

Key Identifiers – The <wsse:KeyIdentifier> element is used to reference a security token by specifying a known value (identifier) for the token, which is determined by applying a special *function* to the security token (e.g. a hash of key fields). This approach is typically unique for the specific security token but requires a profile or token-specific function to be specified. The ValueType attribute defines the type of key identifier and, consequently, identifies the type of token referenced. The EncodingType attribute specifies how the unique value (identifier) is encoded. For example, a hash value may be encoded using base 64 encoding (the default).

Key Names – The <ds:KeyName> element is used to reference a security token by specifying a specific value that is used to *match* an identity assertion within the security token. This is a subset match and may result in multiple security tokens that match the specified name. While XML Signature doesn't imply formatting semantics, WSS: SOAP Message Security RECOMMENDS that X.509 names be specified.

It is expected that, where appropriate, profiles define if and how the reference mechanisms map to the specific token profile. Specifically, the profile should answer the following questions:

- What types of references can be used?
- How "Key Name" references map (if at all)?
- How "Key Identifier" references map (if at all)?
- Are there any additional profile or format-specific references?

This section is non-normative.

Appendix C: Revision History

Rev	Date	What
01	20-Sep-02	Initial draft based on input documents and editorial review
02	24-Oct-02	Update with initial comments (technical and grammatical)
03	03-Nov-02	Feedback updates
04	17-Nov-02	Feedback updates
05	02-Dec-02	Feedback updates
06	08-Dec-02	Feedback updates
07	11-Dec-02	Updates from F2F
08	12-Dec-02	Updates from F2F
14	03-Jun-03	Completed these pending issues - 62, 69, 70, 72, 74, 84, 90, 94, 95, 96, 97, 98, 99, 101, 102, 103, 106, 107, 108, 110, 111
15	18-Jul-03	Completed these pending issues – 78, 82, 104, 105, 109, 111, 113
16	26-Aug-03	Completed these pending issues - `99, 128, 130, 132, 134`
18	15-Dec-03	Editorial Updates based on Issue List #30
19	29-Dec-03	Editorial Updates based on Issue List #31
20	14-Jan-04	Completed issue 241 and feedback updates
21	19-Jan-04	Editorial corrections for name space and document name

This section is non-normative.

Appendix D: Notices

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