Java Security

Web Services Security (Overview)

Lecture 9

Java 2 Cryptography

- Java provides API + SPI for crypto functions
  - Java Cryptography Architecture
    - Security related core classes
      - Access control and cryptography
  - Java Cryptography Extension
    - Other core classes
      - Message digest, digital signatures, certificate management
      - Key exchange, MAC

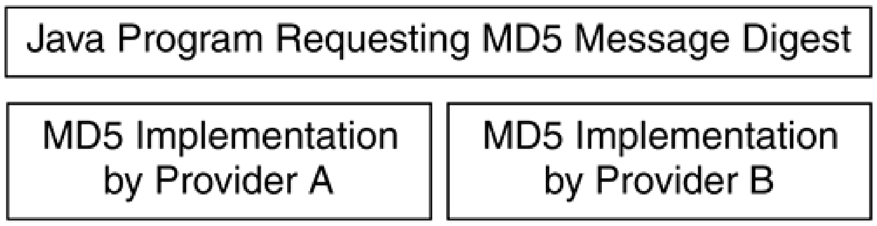
JCA + JCE

- Engine
  - Abstract cryptographic service: E.g., message digest, digital signatures
    - To provide cryptographic operations
    - To generate or supply the crypto material
    - To generate and manage data objects (certificates or keys – keystores)
      - Use instances of engine class for crypto operations
- Algorithm
  - Implementation of an engine: Eg. MD5 for MessageDigest
- Provider
  - (set of) packages that supply concrete implementation of a subset of the cryptographic services (DS, MD, etc.)

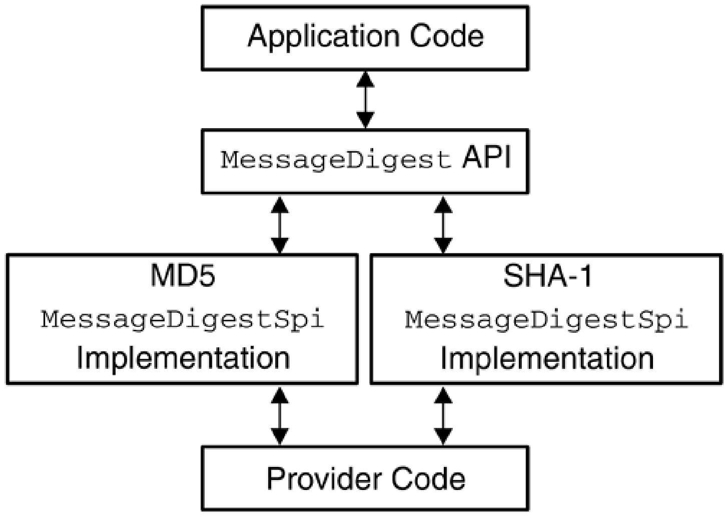
JCA + JCE Principles

- Provider based architecture
- Vendors can register implementations of algorithms
- Providers can be configured declaratively so the application code does not need to change
- Allows different implementations to be found at runtime

- Engine Class
- SPI class
  - Implementations expose the same API


Java Program Requesting MD5 Message Digest
MD5 Implementation by Provider A
MD5 Implementation by Provider B

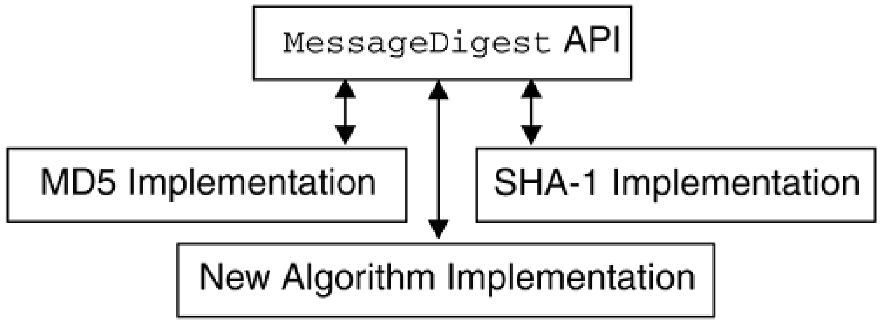
Implementation independence


Application Code
MessageDigest API
MD5 MessageDigestSpi Implementation
SHA-1 MessageDigestSpi Implementation
Provider Code

Algorithm Independence

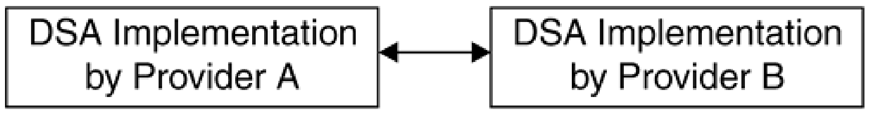
JCA + JCE Principles

- New algorithms can be easily plugged in
  - Has to be compliant with the MessageDigest API



Algorithm Extensibility

- Various implementation can
  - work with one another
  - Use one another's keys
  - Verify one another's messages



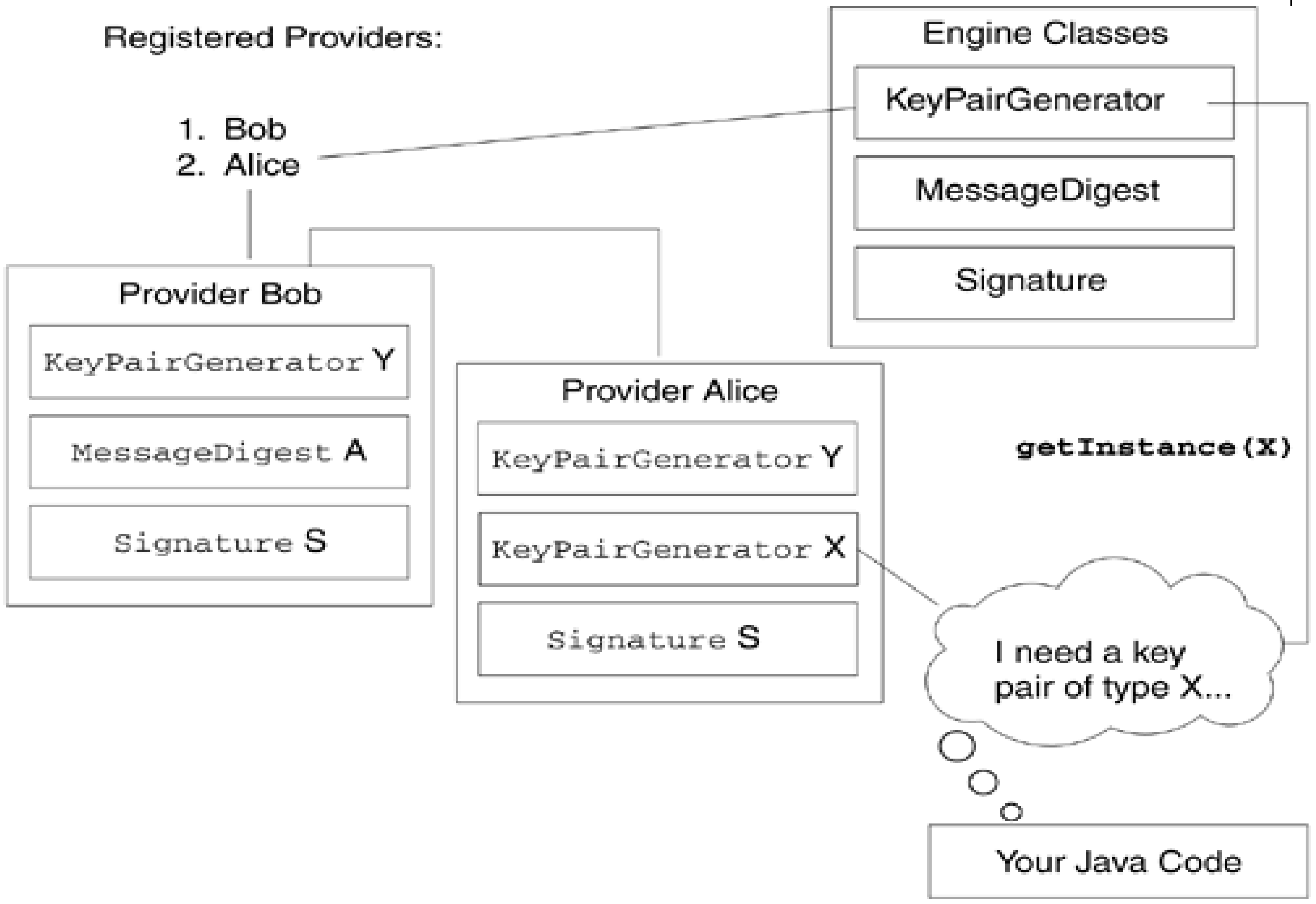
DSA Implementation by Provider A
DSA Implementation by Provider B

Implementation interoperability

Providers

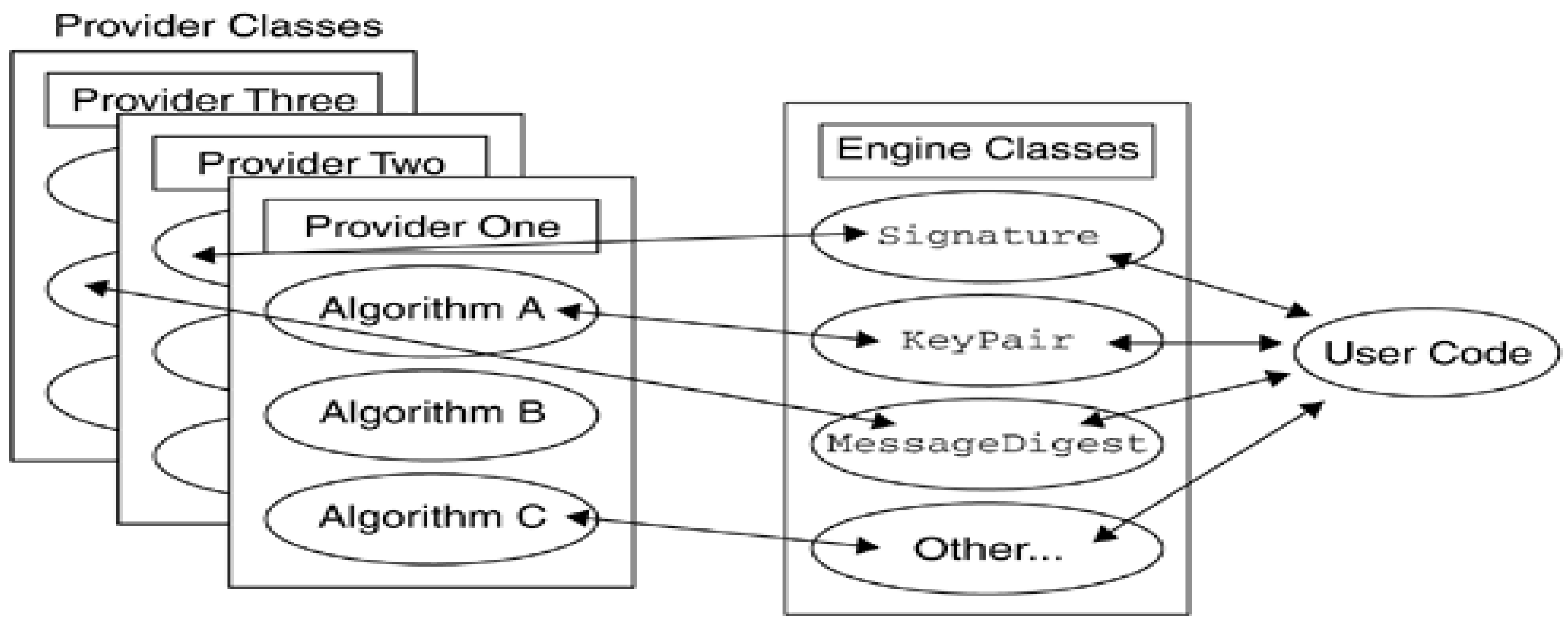
- SPI is
  - Key to pluggability, extensibility and module independence
  - It is a set of Java-language interfaces and abstract classes for cryptographic services
- A Provider is a pluggable modules
  - Provides concrete implementations of some SPI methods
    - java.security and javax.crypto and their subpackages contain many SPI interfaces that JCA and JCE providers can implement

Providers


Registered Providers:
1. Bob
2. Alice
Engine Classes
KeyPairGenerator
MessageDigest
Signature
Provider Bob
KeyPairGenerator Y
MessageDigest A
Signature S
Provider Alice
KeyPairGenerator Y
KeyPairGenerator X
Signature S
getInstance(X)
I need a key pair of type X...
Your Java Code

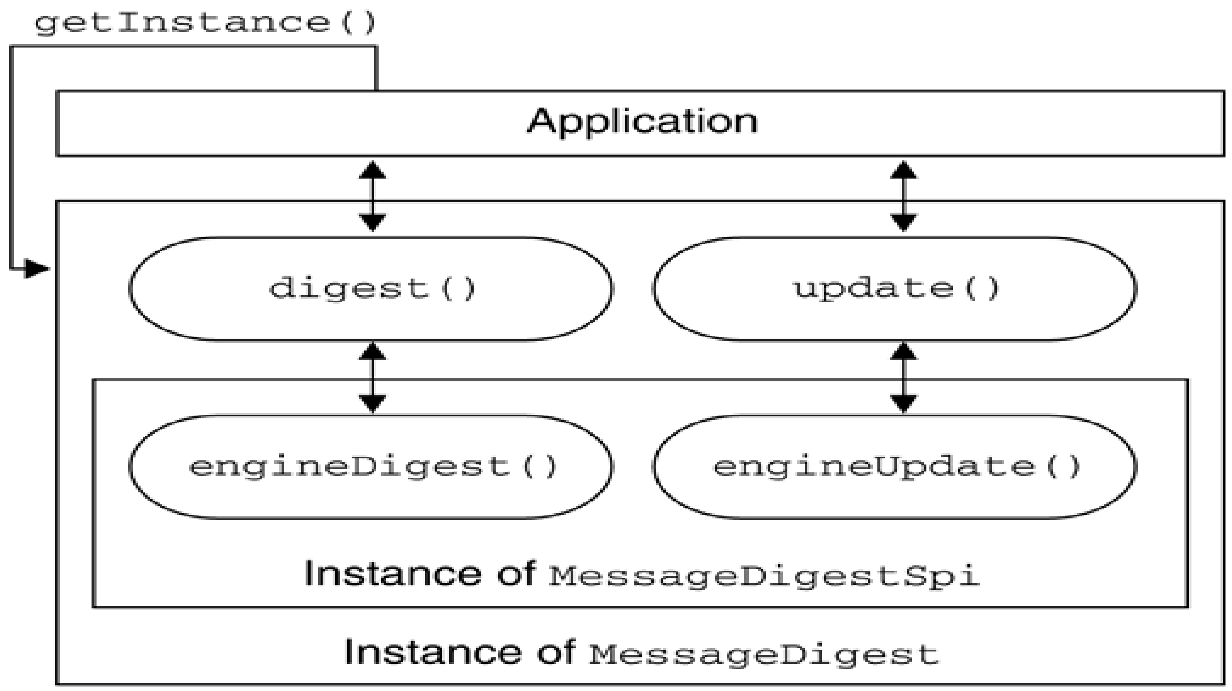
Engine and SPI

- Engine classes are the interfaces between the user code and the implementations
- Implementations are found at runtime



Engine and SPI

- The engine class calls the SPI class methods
  - SPI class method names begins with “engine”
  - Implementation of abstract SPI done by providers



Enterprise Security for Web Services

- XML
  - Simplicity and flexibility
  - Facilitates B2B messaging
  - Security is a big concern
    - Structured semantics and schema-driven nature
- XML security technologies are available
  - Encryption
    - Elements, sections
  - Digital signatures
    - All or parts – by one or more entities
  - Access control

Web Service

- Web service
  - Is a an interface that describes a collection of network-accessible operations based on open internet standards
  - Potential to enable application integration at a higher level of the protocol stack
    - based on Web Services standards
    - XML
    - Simple Object Access Protocol
    - Web Services Description Lanaguage (WSDL)
    - Unversal Description, Discovery and Itnegration

SOAP

- Simple, lightweight and extensible XML-based mechanism for exchanging structured data between network applications
  - Consists of:
    - An envelop
      - What is in the message and who should deal with it
    - A set of coding rules
      - Serialization mechanism that be used to exchange instance of application defined data types

SOAP

- It supports modular architecture
  - Allows defining the following in separate documents
    - WS Addressing Specification (WS-Addressing)
    - WS Security Specification (WS-Security)
- A SOAP envelope is defined in
  - Envelope XML element
    - Consists of two parts:
      - Header: adds features to the messages
        - Meta information can be added to the message
        - E.g., transaction IDs, message routing information, message security
      - Body: mechanism for exchanging information

Security Technologies

- XML Signature
  - Validation of the messages and non-repudiation
- SAML
  - AuthM + Security Srvices ML
    - Authentication + Authorization profile information
  - Common language for sharing of security services between companies for B2B/B2C transacrtions
- XML Encryption
  - Encrypting of XML fragments
- WS-Security
  - Set of SOAP extensions that can be used when building WS to implement integrity and confidentiality

XML Signature

- IETF and W3C standard for digitally signing all or some part of the XML document
- XML Signature
  - Is itself a piece of XML – defined by a schema
  - Contain references – URIs – to what is being signed
    - URIs – within the document or external to it
  - A singled XML document may have multiple signatures

XML Signature Structure

- XML Signature contains four major items:
  - A set of pointers (references) to things to be signed
  - The actual signature
  - (Optional) The key (or a way to look up the key) for verifying the signature
  - (Optional) An Object tag that can contain miscellaneous items not included in the first three items

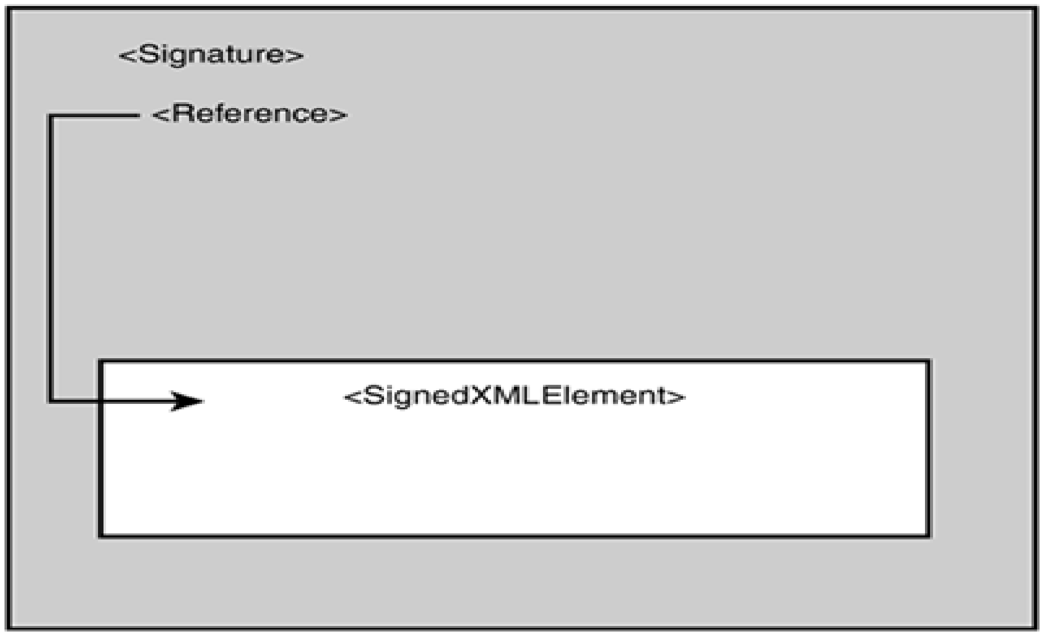
```
<Signature ID?>
    <SignedInfo>
        (CanonicalizationMethod)
        (SignatureMethod)
        (<Reference (URI=)? >
            (Transforms)?
            (DigestMethod)
            (DigestValue)
        </Reference>)+
    </SignedInfo>
    (SignatureValue)
    (KeyInfo)?
    (Object ID?)*
</Signature>
```

```
<Signature xmlns="http://www.w3.org/2000/09/xmldsig#">
    <SignedInfo>
        <Reference URI="http://www.foo.com/secureDocument.html" />
    </SignedInfo>
    <SignatureValue>...</SignatureValue>
    <KeyInfo>... </KeyInfo>
</Signature>
```

XML Signature: Enveloping Signature

```
<Signature xmlns="http://www.w3.org/2000/09/xmldsig#">
        <SignedInfo> <Reference URI="#111" /> </SignedInfo>
        <SignatureValue>...</SignatureValue>
        <KeyInfo>...</KeyInfo>
        <Object>
                <SignedItem id="111">Stuff to be signed</SignedItem>
        </Object>
</Signature>
```

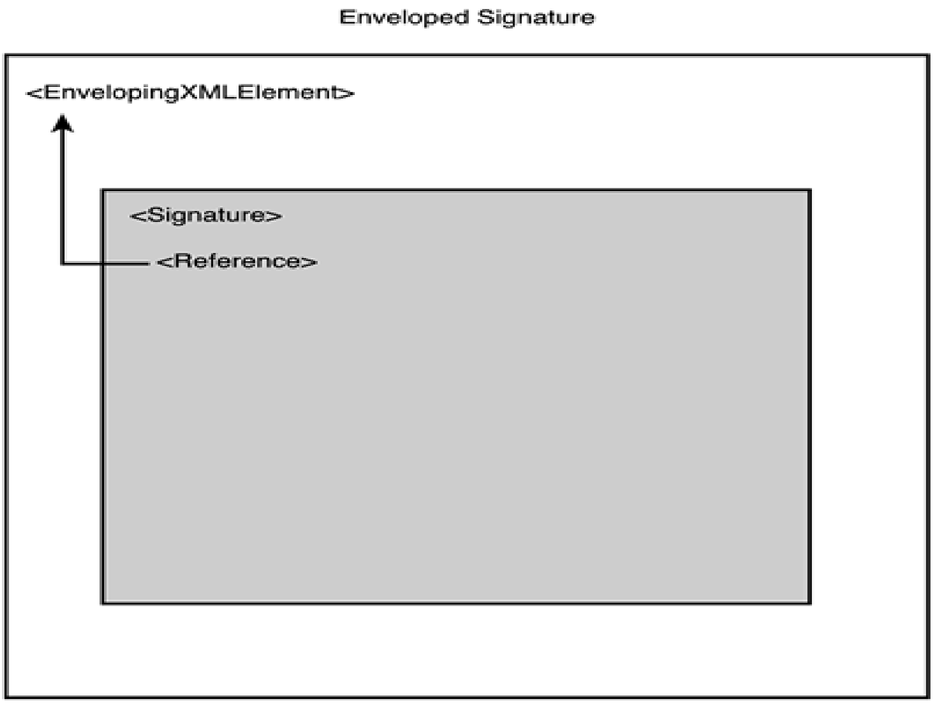
Enveloping Signature



XML Signature: Enveloped Signature

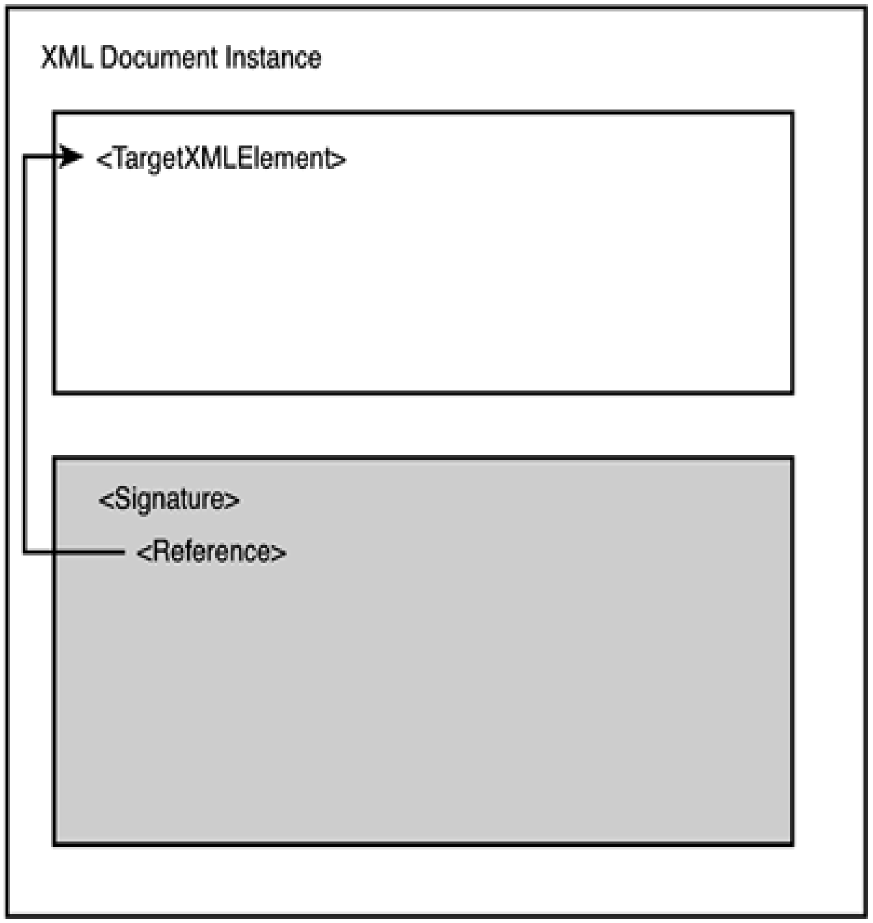
```
<PurchaseOrder id="po1">
        <SKU>125356</SKU>
        <Quantity>17</Quantity>
        <Signature xmlns="http://www.w3.org/2000/09/xmldsig#">
                    <SignedInfo> <Reference URI="#po1" /> </SignedInfo>
                    <SignatureValue>...</SignatureValue>
                    <KeyInfo>...</KeyInfo>
        </Signature>
</PurchaseOrder>
```

Parent element



XML Signature: Detached Signature

Detached Signature within same XML Document

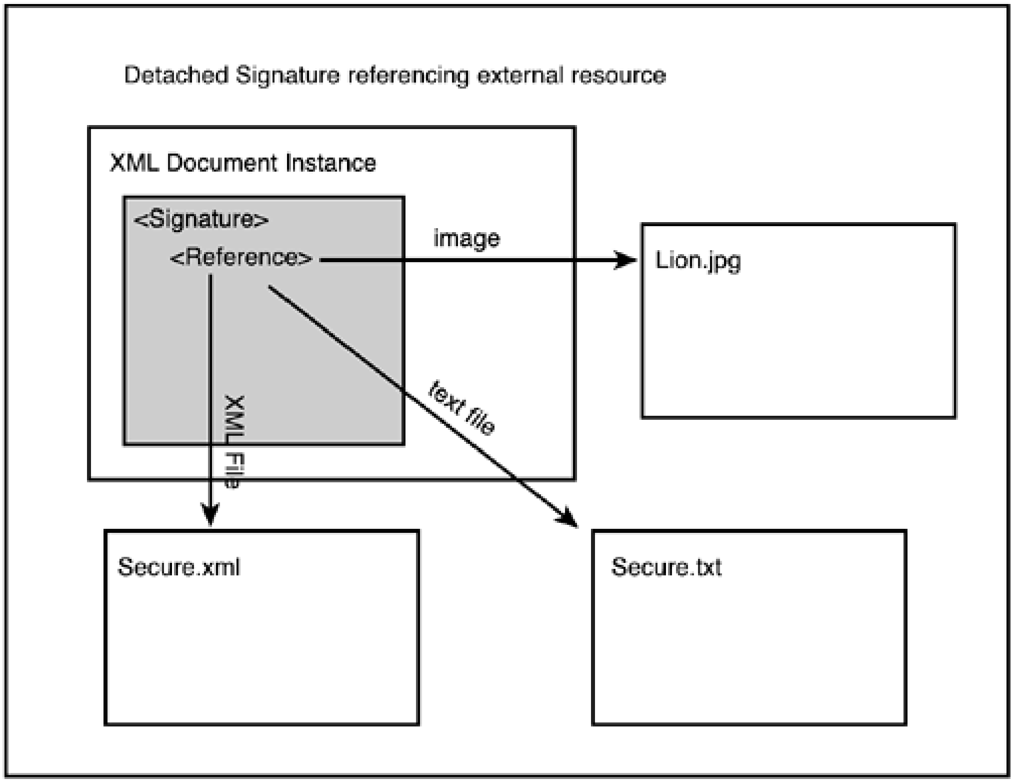


```
<PurchaseOrderDocument>
    <PurchaseOrder id="po1">
        <SKU>12366</SKU>
        <Quantity>17</Quantity>
    </PurchaseOrder>
    <Signature xmlns=
            "http://www.w3.org/2000/09/xmldsig#">
        <SignedInfo> <Reference URI="#po1" />
        </SignedInfo>
        <SignatureValue>...</SignatureValue>
        <KeyInfo>...</KeyInfo>
    </Signature>
</PurchaseOrderDocument>
```

XML Signature: Detached Signature

Can also reference external source

```
<Signature xmlns=
     "http://www.w3.org/2000/09/xmldsig#">
    <SignedInfo>
            <Reference URI=
            "http://www.foo.com/picture.jpg" />
    </SignedInfo>
    <SignatureValue>...</SignatureValue>
    <KeyInfo>...</KeyInfo>
</Signature>
```



XML Encryption Structure

```
<EncryptedData Id? Type? MimeType? Encoding?>
   <EncryptionMethod/>?
   <ds:KeyInfo>
       <EncryptedKey>?
       <AgreementMethod>?
       <ds:KeyName>?
       <ds:RetrievalMethod>?
       <ds:*>?
   </ds:KeyInfo>?
   <CipherData>
       <CipherValue>?
       <CipherReference URI?>?
   </CipherData>
   <EncryptionProperties>?
</EncryptedData>
```

- Could encompass an entire document of other XML structure (similar to Enveloping structure
- Could contain a pointer to a detached resource

XML Encryption: Example

```
<Employee>
   <Name>Dave Remy</Name>
   <SocialSecurityNumber>
        <EncryptedData Type=
          "http://www.w3.org/2000/09/xmldsig#content">
        <EncryptionMethod Algorithm=". . .">
                  <CipherData><CipherValue>. . .</CipherValue>
                  </CipherData>
        </EncryptedData> </SocialSecurityNumber>
   <Salary>
        <EncryptedData Type=
             "http://www.w3.org/2000/09/xmldsig#content">
             <EncryptionMethod Algorithm=". . .">
                  <CipherData><CipherValue>. . .</CipherValue>
                  </CipherData>
        </EncryptedData>
   </Salary>
</Employee>
```

XML Encryption: Example

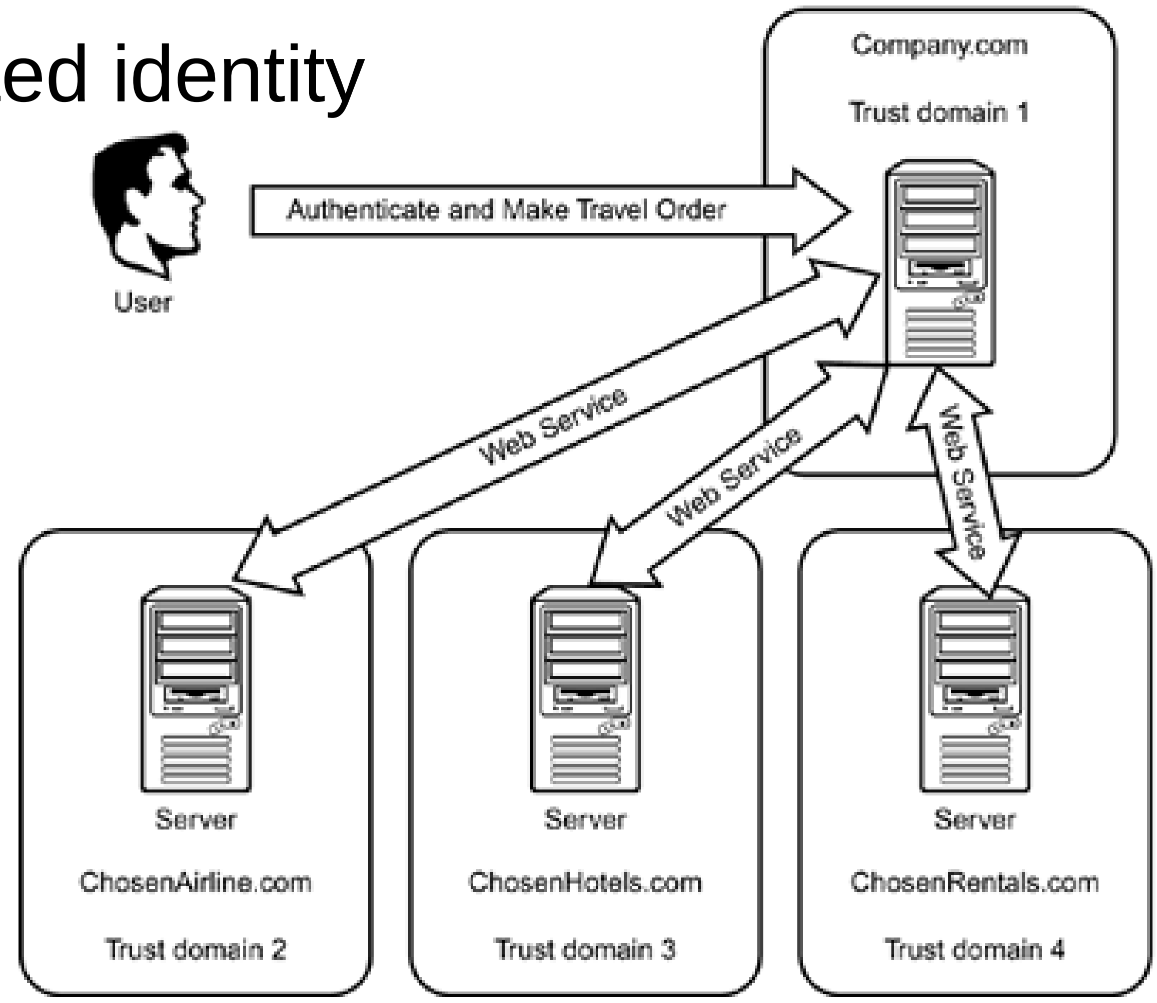
```
<Employee>
   <Name>Dave Remy</Name>
   <SocialSecurityNumber>
        <EncryptedData id="socsecnum" Type="http://www.w3.org/2000/09/ xmldsig#content">
            <EncryptionMethod Algorithm=". . ." />
            <CipherData><CipherValue>. . .</CipherValue></CipherData>
   </EncryptedData>
   </SocialSecurityNumber>
   <Salary>
        <EncryptedData id="salary" Type="http://www.w3.org/2000/09/ xmldsig#content">
            <EncryptionMethod Algorithm=". . .">
            <CipherData><CipherValue>. . .</CipherValue></CipherData>
        </EncryptedData>
   </Salary>
   <EncryptedKey>
        <EncryptionMethod Algorithm=". . ." />
        <CipherData> <CipherValue>. . .</CipherValue> </CipherData>
        <ReferenceList>
            <DataReference URI="#socsecnum" />
            <DataReference URI="#salary" /> </ReferenceList>
   </EncryptedKey>
</Employee>
```

SAML

- Enables portable identities and the assertions that these identities want to make
  - Assertion: authentication; authorization
- SAML is important for WS
  - is a standard XML format – all normal XML tools apply to SAML
  - Includes a standard message exchange protocol
  - Specifies the rules for how it is transported – making interoperability explicit at the specification level
  - Expression of security in the form of assertions about subjects (different from Certification authority based approach) – facilitated Single-Sign ON

SAML - scenario

- Federated identity



SAML

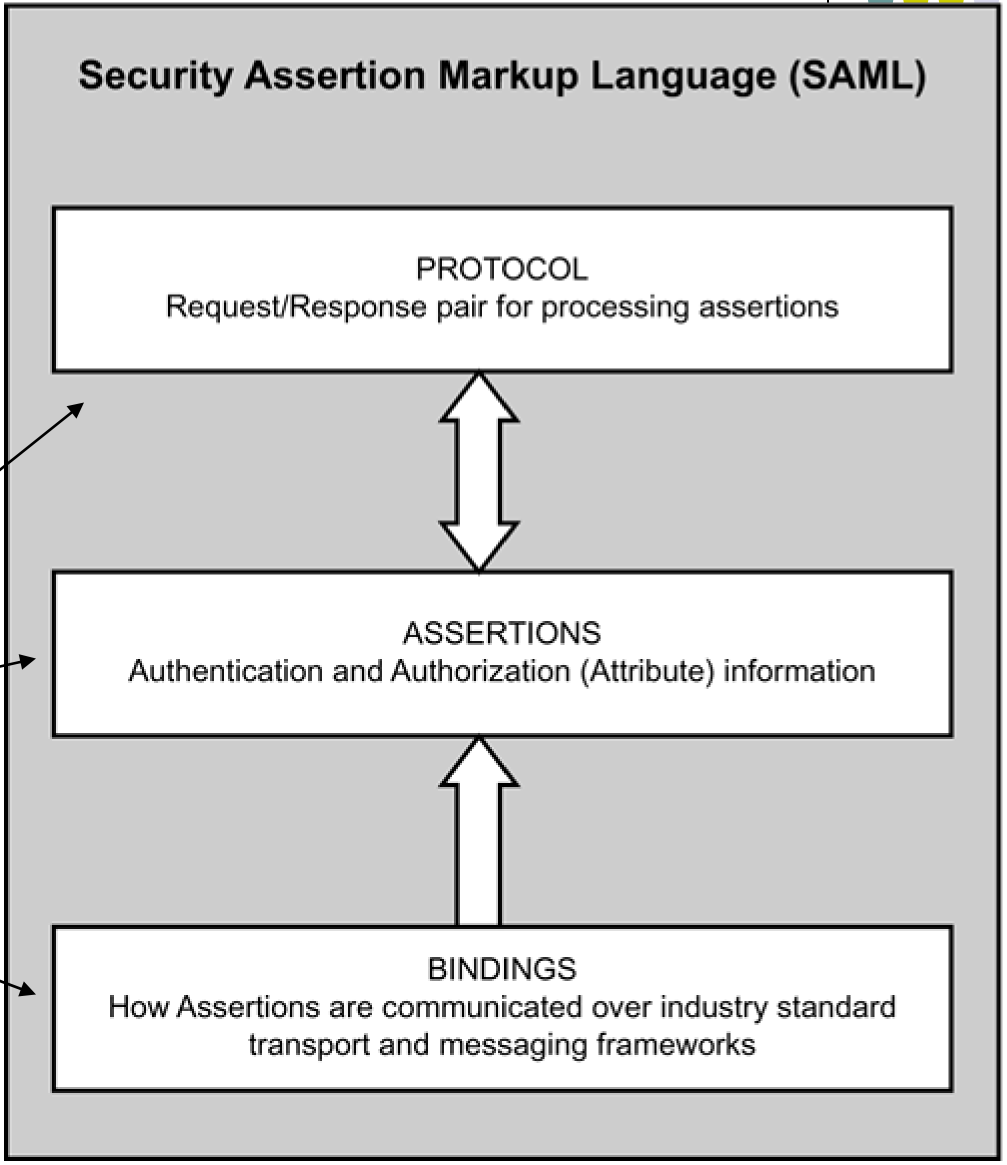
- Defines three types of assertions
  - Authentication
    - States that a particular auth. authority has authenticated the subject
      - Using a particular process
      - At a particular time (+ validity)
  - Authorization
    - States that a particular authority has granted/denied permissions on particular resource (+time)
  - Attributes
    - Provides qualifying information about either an authentication or authorization assertion

SAML – how it works

- Three XML based mechanisms and their relationship

XML schema + definition

Rules on using assertions

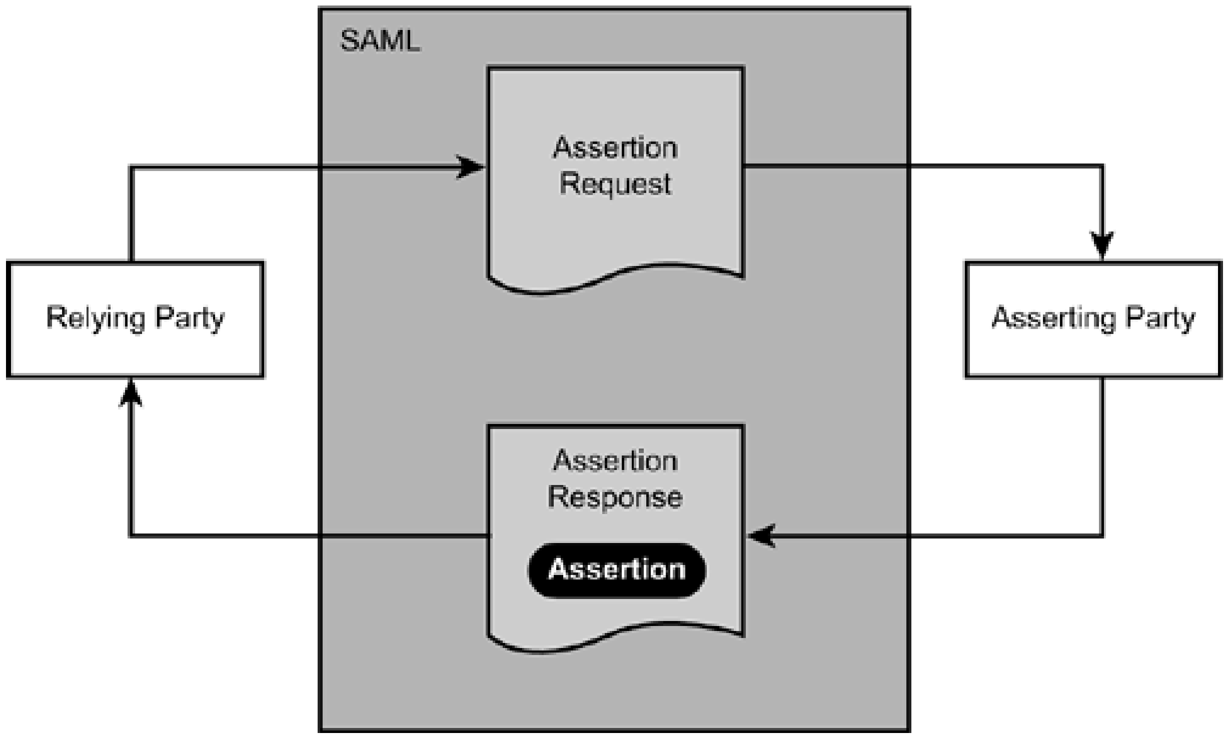

Security Assertion Markup Language (SAML)
PROTOCOL
Request/Response pair for processing assertions
ASSERTIONS
Authentication and Authorization (Attribute) information
BINDINGS
How Assertions are communicated over industry standard transport and messaging frameworks

SAML Example

```
<saml:Assertion>
  MajorVersion="1" MinorVersion="0"
  AssertionID="192.168.0.1.12345"
  Issuer="Company.com"
  IssueInstant="2004-01-21T10:02:00Z">
  <saml:Conditions>
    NotBefore="2004-01-21T10:02:00Z"
    NotAfter="2004-01-21T10:09:00Z" />
  <saml:AuthenticationStatement>
    AuthenticationMethod="password"
    AuthenticationInstant="2004-01-21T10:02:00Z">
    <saml:Subject>
      <saml:NameIdentifier
        SecurityDomain="Company.com"
        Name="jothy" />
    </saml:Subject>
  </saml:AuthenticationStatement>
</saml:Assertion>
```

SAML protocol

- SAML assertions are sent to the authentication and authorization authorities

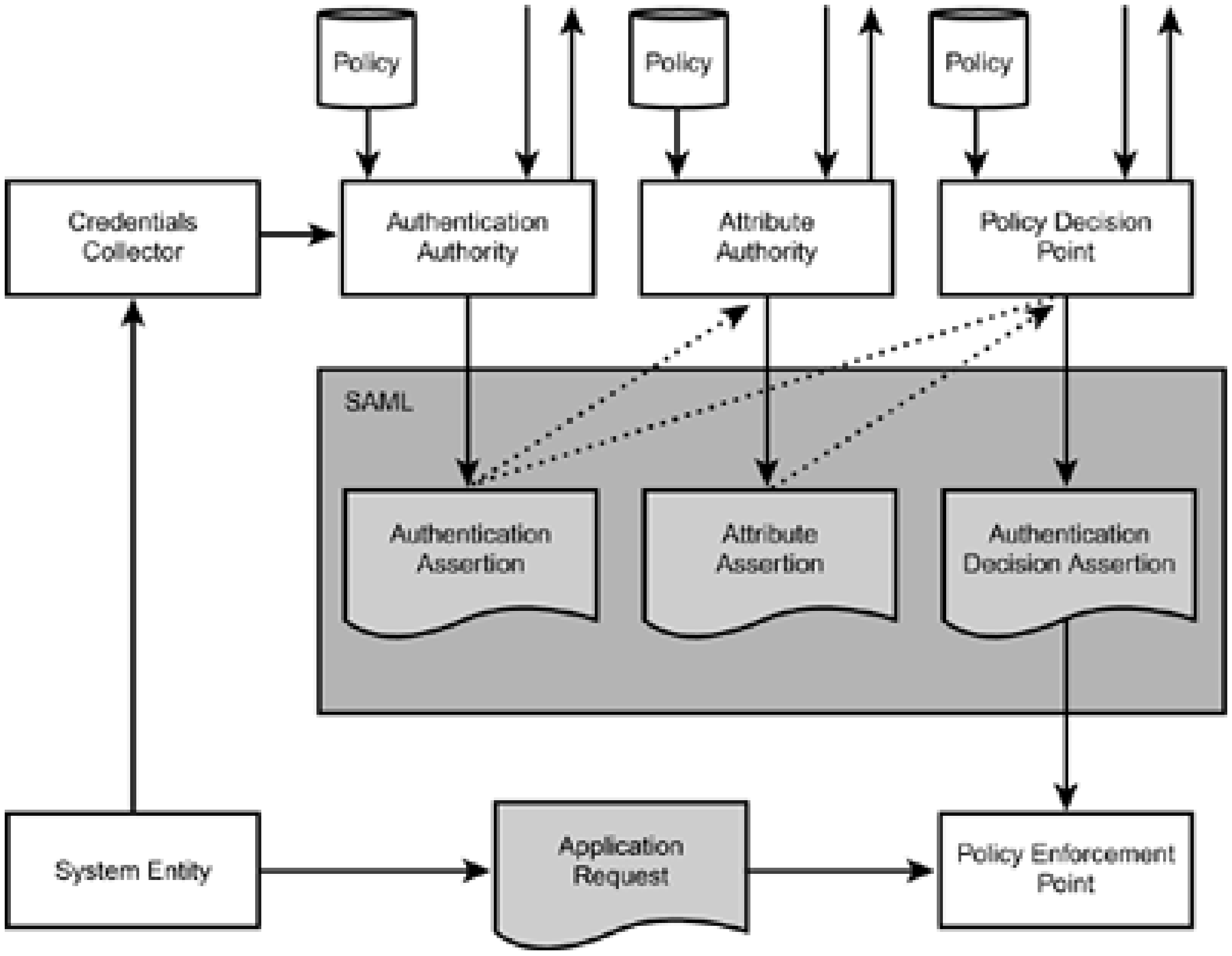


SAML Authorization/Attribute Assertions

```
<saml:Assertion ...>
  <saml:AttributeStatement>
    <saml:Subject>...</saml:Subject>
    <saml:Attribute
      AttributeName="PaidStatus"
      AttributeNamespace="http://smithco.com">
      <saml:AttributeValue>
        PaidUp
      </saml:AttributeValue>
    </saml:Attribute>
    <saml:Attribute
      AttributeName="CreditLimit"
      AttributeNamespace="http://smithco.com">
      <saml:AttributeValue xsi:type="my:type">
        <my:amount currency="USD">500.00
        </my:amount>
      </saml:AttributeValue>
    </saml:Attribute>
  </saml:AttributeStatement>
</saml:Assertion>
```

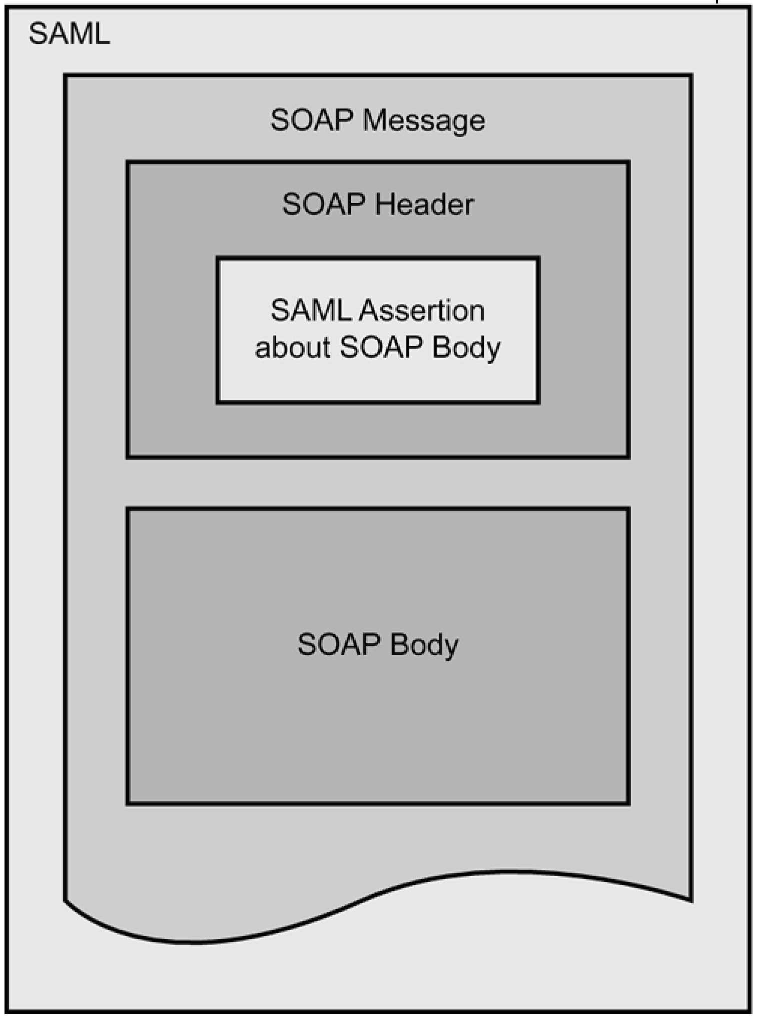
```
<saml:Assertion ...>
  <saml:AuthorizationStatement
    Decision="Permit"
    Resource="http://jonesco.com/doit.cgi">
    <saml:Subject>...</saml:Subject>
    <saml:Action Namespace=
"urn:oasis:names:tc:SAML:1.0:action:rwedc">Execute
    </saml:Action>
  </saml:AuthorizationStatement>
</saml:Assertion>
```

SAML Architecture



SAML Binding

- Requires SOAP over HTTP as one binding
- SOAP Binding
  - SAML information is contained inside the SOAP
- SAML Profile
  - Describes how SAML assertions are embedded into and extracted from a framework/protocol
    - Browser profile of SAML
    - SAML profile SOAP
    - WS-Security



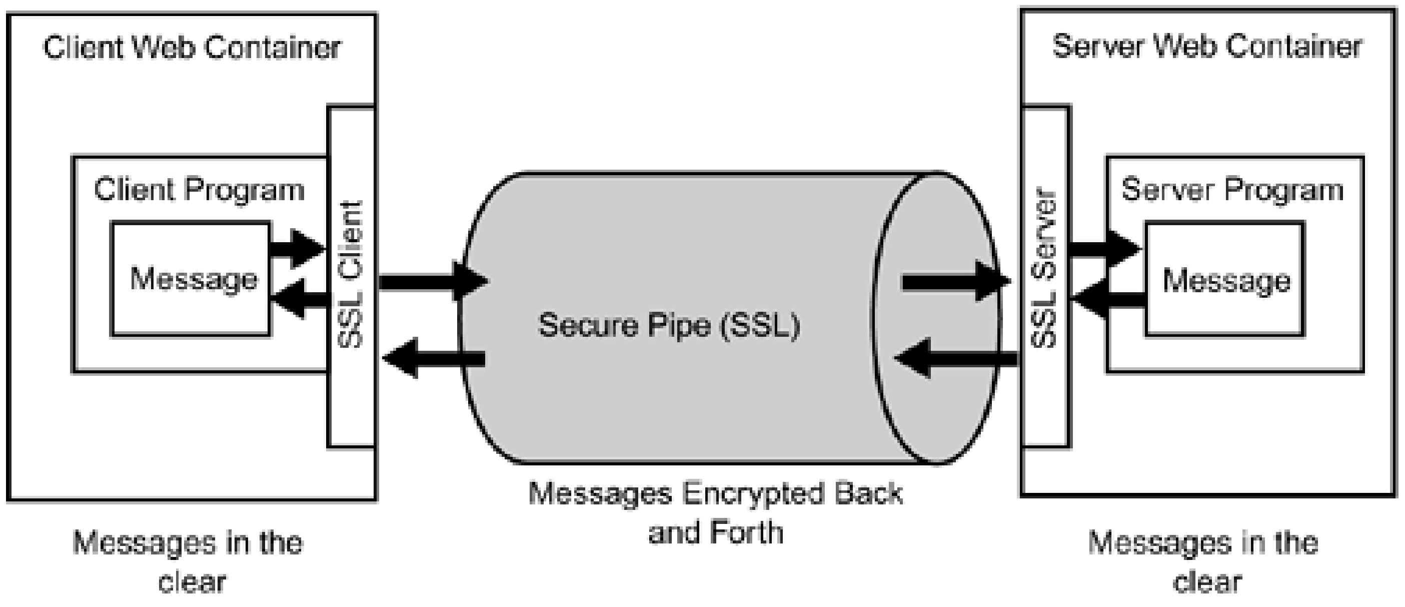
WS-Security

- Focuses on applying on applying existing security technologies to SOAP message
    - X.509 certificates
    - SAML assertions
    - XML Signatures
    - XML Encryption

- GOAL: Secure the SOAP
    - No matter where it goes
    - No matter how long it lives

HTTP Transport Security Versus Message Security

- HTTP Transport Security
  - Authentication at the time secure pipe is created
  - Confidentiality/Integrity in the pipe only



HTTP-TS Pros and Cons

Pros

- **Mature**: Tried and true
- **Support**: Supported by most servers and clients
- **Understood**: Understood by most system administrators
- **Simpler**: Generally simpler than message-level security alternatives

Cons

- **Point to Point**: Messages are in the clear after reaching SSL endpoint
- **Waypoint visibility**: Cannot have partial visibility into the message
- **Granularity**: Cannot have different security for messages in and messages out
- **Transport dependent**: Applies only to HTTP

Message Security Pros and Cons

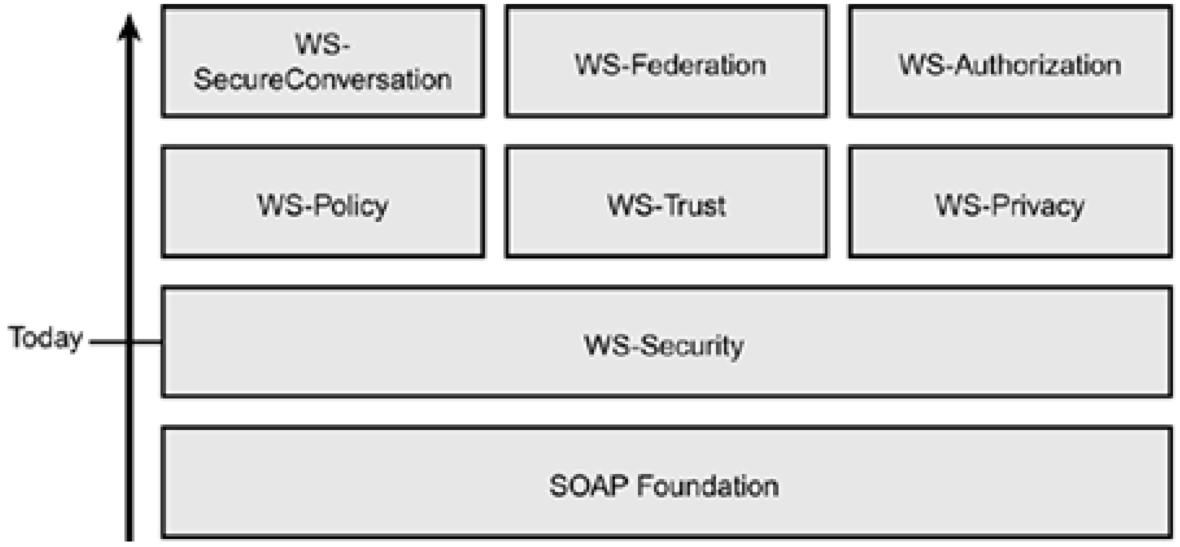
Pros

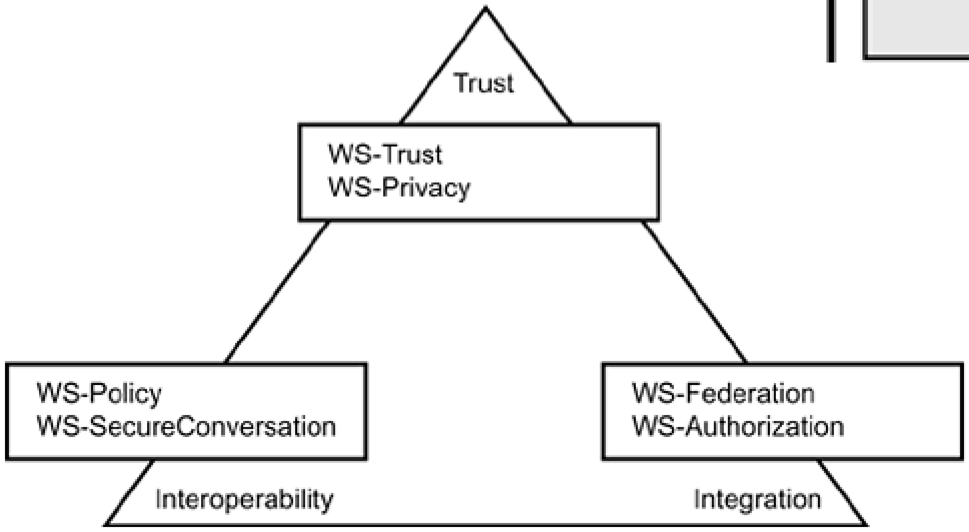
- **Persistent**: Allows the message to be self-protecting
- **Selective**: Portions of the message can be secured to different parties
- **Flexible**: Different security policy can be applied to request and response - Transport independent

Cons

- **Immature**: standard, tools
- **Complex**: encompasses many other standards including XML Encryption, XML Signature, X.509 certificates, and many more

Web Services Security Stack


WS-SecureConversation
WS-Federation
WS-Authorization
WS-Policy
WS-Trust
WS-Privacy
Today
WS-Security
SOAP Foundation


Trust
WS-Trust
WS-Privacy
WS-Policy
WS-SecureConversation
WS-Federation
WS-Authorization
Interoperability
Integration