

nehta

Example Technical Implementation of Interoperable Web Services

JAX-WS

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Release

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1 Introduction

1.1 Background

The National E-Health Transition Authority (NEHTA) has recommended Web services as the mechanism for communication between organisations in Australia's e-health environment.

NEHTA has published a number of technical documents to support the use of Web services. These include the *Web Services Profile* [WSP2008].

1.1.1 Document history

Version 1.0 of this document was written to explain how to conform to the *Web Services Standards Profile* [WSSP2006] and *Guidelines for Implementing Interoperable Web Services* [GIIWS2007] using the JAX-WS reference implementation.

The *Web Services Profile* [WSP2008] supersedes *Web Services Standards Profile* [WSSP2006] and *Guidelines for Implementing Interoperable Web Services* [GIIWS2007]. This document has been updated primarily to explain conformance to the *Web Services Profile* [WSP2008].

Since version 1.0 of this document, the Metro Web Services Stack was released, which includes the JAX-WS reference implementation. Changes to this document were made to align with the use of Metro 1.4.

1.2 Purpose

This document provides an example of how Web services conforming to the *Web Services Profile* [WSP2008] can be implemented using a specific toolkit: Metro [METRO].

The End-to-end security profile in the *Web Services Profile* [WSP2008] lists conformance criteria for Web services and clients that are secured from end to end. This document explains a way of building Web services and clients that meet these criteria using the Metro Web Services Stack [METRO] toolkit. Metro includes the Java API for XML Web Services (JAX-WS) [JAXWS].

The main purpose of this document is to support the understanding and interpretation of the conformance criteria in the *Web Services Profile* [WSP2008]. However, it can also assist programmers who are learning how to use Metro.

This document is provided for educational purposes only. The method it describes is only one approach; there might be other, equally valid approaches. The code samples in this document are designed for simplicity and ease of understanding, rather than robustness and reuse. They are not written for use in a production system.

1.3 Scope

This document only covers Metro. Also available are example technical implementation documents covering .NET Web Services Enhancements (WSE) 3.0 [WSE] and .NET Windows Communication Foundation (WCF) [WCF]. Those other example technical implementations can interoperate with this implementation, but they will not be discussed in this document.

These examples are not an endorsement of these platforms by NEHTA.

1.4 Intended audience

This document is intended for:

- Software developers; and
- System administrators.

It is expected that the reader is familiar with programming using Java, and has an understanding of Web services and Public Key Infrastructure (PKI) security using X.509 certificates.

The reader is also expected to be familiar with the *Web Services Profile* [WSP2008]. The criteria from [WSP2008] are referred to by their criterion number (e.g. "WS 3.1.1.1-1").

1.5 Definitions, acronyms, abbreviations

API	Application programming interface
CA	Certificate authority
DOM	Document Object Model
Glassfish	Open source JEE 5 application server from Sun. Previously distributed as the Sun Java System Application Server.
HTTP	Hypertext Transfer Protocol
Java SE	Java Standard Edition
Java EE	Java Enterprise Edition
JAR	Java Archive
JAXB	Java API for XML Binding
JAX-RPC	Java API for XML-based RPC
JAX-WS	Java API for XML Web Services
JDK	Java Development Kit
JRE	Java SE Runtime Environment
Metro	Open source Web services stack from Sun
RPC	Remote Procedure Call
SJSAS	Sun Java System Application Server
WAR	Web Archive
WCF	Windows Communication Foundation
WSDL	Web Service Definition Language
WSE	Web Services Enhancements
WSIT	Web Services Interoperability Technologies

1.5.1 Terminology

This document uses the following terms:

Web services	A technology for communicating between computer applications using SOAP, WSDL and other related standards.
Web service	A computer program that provides services and uses the Web services technologies to allow access to those services.
Web service client	A computer program that uses the services provided by a Web service. It invokes operations that are provided

by the Web service. The abbreviated term “client” can also be used.

Web server	A computer program that makes Web resources (predominantly HTML Web pages) available via Web protocols (predominantly HTTP).
Server	A computer that is hosting a Web server or other programs that provides a service to other programs.

1.6 Style Conventions

This document uses the following style conventions:

<i>Italics</i>	<ul style="list-style-type: none"> • Document titles • Program names, tool names • File names, directory paths • URLs • Keywords
Monospace	<ul style="list-style-type: none"> • XML fragments, namespaces, names of XML elements and types • Code fragments, names of classes, methods and fields • Assemblies, packages • Command-line calls and arguments • Configuration properties
Monospace + Bold	<ul style="list-style-type: none"> • Emphasis within XML and code fragments
“Double quotes”	<ul style="list-style-type: none"> • Graphical user interface options

1.7 Overview

Chapter 2 describes the service used as an example for this document.

Chapter 3 provides a brief overview of Metro.

Chapter 4 describes how to create a Web service client using Metro.

Chapter 5 describes how to create a Web service using Metro.

Appendix A lists references.

Appendix B provides instructions and notes on software installation.

Appendix C provides information on security key management.

Appendix D provides tips on debugging Metro programs.

2 Example service

This chapter describes the example service that will be implemented.¹

The specification of a service would normally be produced by an independent organisation, which brings together the requirements of all the stakeholders. This chapter is an abridged version of the service specification that would be produced—since this document is concerned with programming Web services, it focuses on the WSDL specification.

The example technical implementation described in this document assumes a WSDL-first approach, where the Web service implementation is developed using classes generated from the WSDL. This approach is in contrast to the implementation-first approach, where the WSDL is automatically generated from the implementation code. The WSDL-first approach is more applicable to an interoperable e-health environment, where standard WSDL specifications developed by independent organisations should be used to build Web services.

The structure of this chapter follows the approach described by the NEHTA *Interoperability Framework* [NIF2006] and uses concepts from the *Technical Architecture for Implementing Services* [TAIS2006].

2.1 Organisational

This example scenario is based on the exchange of discharge summaries. It has been simplified for ease of understanding—it is not intended to be a real world discharge summary scenario.

In the community for discharge summary exchange, there are two roles:

- Sending provider: the program that generates the discharge summary and sends it; and
- Receiving provider: the program that receives the discharge summary and tracks whether it has been acknowledged.

For the purpose of this example the business process for sending a discharge summary involves three activities:

- Testing if the receiving provider's discharge summary receiving service is operating;
- Sending discharge summaries from a sending provider to a receiving provider; and
- Checking the status of a discharge summary to see if the receiving provider has processed and acknowledged it.

2.1.1 Testing

In this activity, one party wishes to determine whether the receiving provider's service is operational or not. It can be used to check if the programs and the network have been correctly configured.

This activity illustrates the use of an operation that requires no parameters. It is implemented as an operation that does nothing, other than to return an empty result.

This operation is called "ping" after the program used to test if an internet protocol host is reachable across an IP network [PING].

¹ This chapter is identical to the corresponding chapter in the other *Example Technical Implementation of Interoperable Web Services* documents (i.e. for WCF and WSE 3.0.)

This is a request-response operation at the technical-level to comply with criterion WS 5.1.5.1-1 from the *Web Services Profile* [WSP2008].

2.1.2 Sending discharge summaries

In this activity, a sending provider creates a discharge summary and sends it to the receiving provider.

When the discharge summary has been received, the receiving provider keeps track of which discharge summary it has received and whether it has been acknowledged by a person at the receiving organisation. This behaviour is to support the checking operation described in section 2.1.3.

This is a one-way operation at the business-level, and no response data is returned to the sender. The only way the sender can discover if it was successfully received is to use the check discharge summary status operation.

At the technical-level, this operation is implemented as a request-response operation to comply with criterion WS 5.1.5.1-1. That is, a response is sent back, but it contains no business-level information.

2.1.3 Checking discharge summary status

In this activity, a sending provider queries the receiving provider about the status of a particular discharge summary. The receiving provider returns the result to the querying provider.

This is a request-response operation: a response containing the status is returned.

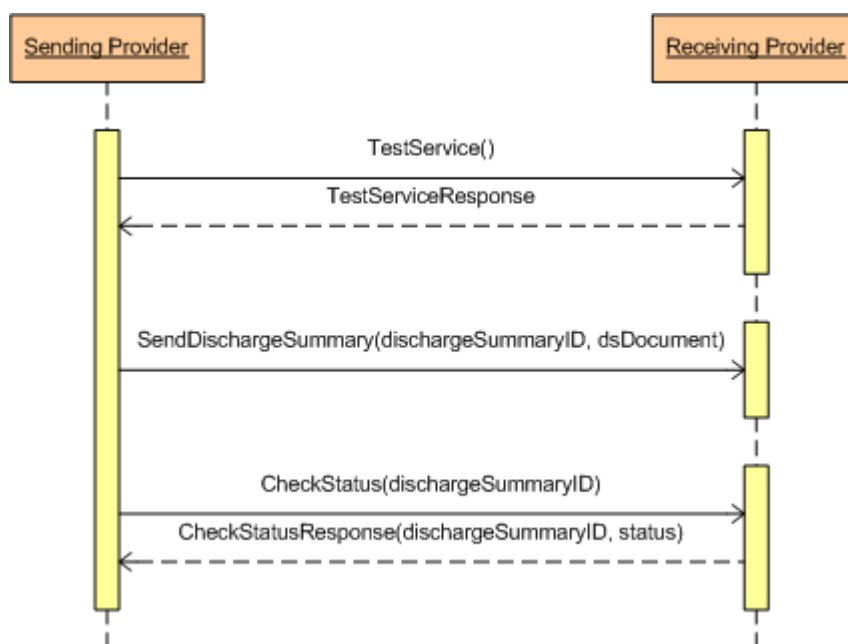


Figure 1: Example discharge summary business workflows

2.2 Informational

2.2.1 Discharge summary

The discharge summary is modelled as a document with an identifier and a notes field. The document identifier should be a globally unique string that is allocated by the sender of the discharge summary. The notes field contains unstructured text.

The discharge summary data model is simple since the aim of this example is to demonstrate Web services, rather than demonstrate a real discharge

summary scenario. NEHTA's *National Discharge Summary Data Content Specification* [NDS2006] contains much more structured data and metadata in the data model of a discharge summary.

2.2.2 Status

The possible status values for a discharge summary are:

- Not received: a discharge summary with the given document identifier has not been received;
- Pending acknowledgement: it has been received, but has not been acknowledged by the receiving party; and
- Acknowledged: it has been received and acknowledged.

The delay between receiving a discharge summary and it being acknowledged is not defined by the service. This is because acknowledgement is a manual process involving a person—it could take minutes or days to perform.

2.3 Technical

This section describes the technical aspects of the service interface specification. It is organised using the three types of attributes, as defined in the Technical Architecture: informational, behavioural and non-functional attributes [TAIS2006].

2.3.1 Informational attributes

The XML Schema used to define a discharge summary document is shown below. It defines a single complex type with 2 child elements: `documentId` and `notes`.

This XSD file will be stored in a file called *DischargeSummary.xsd*.

```
<?xml version="1.0"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema"
  targetNamespace="http://ns.nehta.gov.au/Example/WSP/DS/Xsd/DischargeSummary/1.0"
  elementFormDefault="qualified">

  <xsd:complexType name="DischargeSummaryType">
    <xsd:sequence>
      <xsd:element name="documentId" type="xsd:string"/>
      <xsd:element name="notes" type="xsd:string"/>
    </xsd:sequence>
  </xsd:complexType>

</xsd:schema>
```

2.3.2 Behavioural attributes

The WSDL file contains a formal specification of the behavioural aspects of the service interface.

A WSDL file is not the complete documentation for a real service, which would require additional documentation to fully describe the service's behavioural attributes.

However, only the WSDL will be provided for this simple test service, because a complete description of the service is not required to achieve the level of interoperability testing that it will be used for in these examples.

2.3.2.1 WSDL containing service interface information

Criterion WS 3.1.2.1-1 recommends separating the service interface information from the service instance information. This section will go through the WSDL containing the service interface information for our sample Web service.

This WSDL file will be stored in a file called *DischargeSummaryReceiverInterface.wsdl*.

2.3.2.1.1 Header

The beginning of the WSDL file contains the start tag of the root element, which contains all the XML namespaces that this document will use.

It is a WSDL 1.1 document as required by criterion WS 3.1.1.1-1. The definitions root element belongs to the WSDL 1.1 XML namespace, namely:

```
http://schemas.xmlsoap.org/wsdl/
```

Following criterion WS 3.2.3.1-1, the addressing information in the WSDL is described using *WS-Addressing 1.0 – Metadata* [WSAM2007], whose namespace is:

```
http://www.w3.org/2007/05/addressing/metadata
```

The service namespace for this service was arbitrarily chosen to be:

```
http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0
```

It is a URL and uses a slash character as the separator, as recommended by criteria WS 3.1.3.1-2 and WS 3.1.3.1-3 respectively. This service namespace is used as the target namespace of the WSDL, following criterion WS 3.1.3.1.4. It is associated with the namespace prefix of `tns` so that it can be referenced in the document. The prefix of the target namespace does not necessarily have to be `tns`; it is just a commonly used convention.

```
<?xml version="1.0"?>
<wsdl:definitions xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
  xmlns:wsam="http://www.w3.org/2007/05/addressing/metadata"
  xmlns:tns="http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0"
  targetNamespace="http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0"
  name="DischargeSummaryReceiver">
```

2.3.2.1.2 Types

The types section of the WSDL declares the elements and data types of the messages used by the service. It contains a schema defined using the W3C XML Schema language [XSD2004].

The target namespace of the schema in the WSDL's `types` section is the service's namespace. Since the wrapper elements for the service's operations are declared in this schema, the wrapper elements will belong to the service's namespace, as required by criterion WS 3.1.3.1-8.

The definition of the discharge summary is imported from an external XML Schema file. This file was described in section 2.3.1.

```
<wsdl:types>
  <xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema"
    xmlns:tns="http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0"
    xmlns:ds="http://ns.nehta.gov.au/Example/WSP/DS/Xsd/DischargeSummary/1.0"
    targetNamespace="http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0"
    elementFormDefault="qualified">

    <xsd:import
      namespace="http://ns.nehta.gov.au/Example/WSP/DS/Xsd/DischargeSummary/1.0"
      schemaLocation="DischargeSummary.xsd"/>
```

The request and response elements for the ping operation are defined below. Since this operation takes no parameters and returns no results, both of these elements have an empty content model and no attributes.

To conform to criterion WS 5.1.4.1-1, this WSDL follows the wrapped convention. Thus, for all operations in this WSDL, the request element's name matches the operation's name, and the response element's name is the operation's name with a "Response" suffix.

```
<xsd:element name="ping">
```

```

    <xsd:complexType/>
  </xsd:element>

  <xsd:element name="pingResponse">
    <xsd:complexType/>
  </xsd:element>

```

The request and response elements for the send discharge summary operation are defined below.

The request is an element that contains the discharge summary document.

Although the send discharge summary operation requires no business-level response, it has a response element, which has an empty content model and no attributes. This operation is modelled as a request-response operation at the technical level to satisfy criterion WS 5.1.5.1-1.

```

<xsd:element name="sendDischargeSummary">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element name="document" type="ds:DischargeSummaryType"/>
    </xsd:sequence>
  </xsd:complexType>
</xsd:element>

<xsd:element name="sendDischargeSummaryResponse">
  <xsd:complexType/>
</xsd:element>

```

The request and response elements for the check status operation are defined below.

```

<xsd:element name="checkStatus">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element name="documentId" type="xsd:string"/>
    </xsd:sequence>
  </xsd:complexType>
</xsd:element>

<xsd:element name="checkStatusResponse">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element name="response" type="tns:ReceivedStatusType"/>
    </xsd:sequence>
  </xsd:complexType>
</xsd:element>

```

The following simple type defines the enumerated set of status values that could be returned by the check status operation.

```

<xsd:simpleType name="ReceivedStatusType">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="NotReceived"/>
    <xsd:enumeration value="PendingAcknowledgement"/>
    <xsd:enumeration value="Acknowledged"/>
  </xsd:restriction>
</xsd:simpleType>

```

The send discharge summary and check status operations can return a fault. The structure of this fault element is defined below.

```

<xsd:element name="invalidIdFault">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element name="faultDescription" type="xsd:string"/>
      <xsd:element name="documentId" type="xsd:string"/>
    </xsd:sequence>
  </xsd:complexType>
</xsd:element>
</xsd:schema>
</wsdl:types>

```

2.3.2.1.3 Messages

The messages section of the WSDL identifies the messages used by the three operations of the service.

The messages follow the wrapped convention to conform to criterion WS 5.1.4.1-1. The messages only have one part, where each part references an XML Schema element that was declared in the types section of the WSDL.

```
<wsdl:message name="pingInMsg">
  <wsdl:part name="body" element="tns:ping"/>
</wsdl:message>

<wsdl:message name="pingOutMsg">
  <wsdl:part name="body" element="tns:pingResponse"/>
</wsdl:message>

<wsdl:message name="sendDischargeSummaryInMsg">
  <wsdl:part name="body" element="tns:sendDischargeSummary"/>
</wsdl:message>

<wsdl:message name="sendDischargeSummaryOutMsg">
  <wsdl:part name="body" element="tns:sendDischargeSummaryResponse"/>
</wsdl:message>

<wsdl:message name="checkStatusInMsg">
  <wsdl:part name="body" element="tns:checkStatus"/>
</wsdl:message>

<wsdl:message name="checkStatusOutMsg">
  <wsdl:part name="body" element="tns:checkStatusResponse"/>
</wsdl:message>

<wsdl:message name="invalidIdFaultMsg">
  <wsdl:part name="fault" element="tns:invalidIdFault"/>
</wsdl:message>
```

2.3.2.1.4 Port Type

The portType section of the WSDL defines the three operations in the service. The operation definitions specify the structure of their input, output and fault messages by referencing the message definitions in the WSDL.

Following criterion WS 7.1.2.1-1, the input, output and fault messages of all operations are assigned WS-Addressing Action values. The WS-Addressing Action attributes belong to the namespace of *WS-Addressing 1.0 - Metadata* [WSAM2007]. The values used for the WS-Addressing Action conform to the scheme set out in the following criteria: WS 3.1.3.1-5, WS 3.1.3.1-6 and WS 3.1.3.1-7.

```
<wsdl:portType name="DischargeSummaryReceiver">

  <wsdl:operation name="ping">
    <wsdl:input message="tns:pingInMsg"
      wsam:Action="http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0/
DischargeSummaryReceiver/pingRequest"/>
    <wsdl:output message="tns:pingOutMsg"
      wsam:Action="http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0/
DischargeSummaryReceiver/pingResponse"/>
  </wsdl:operation>

  <wsdl:operation name="sendDischargeSummary">
    <wsdl:input message="tns:sendDischargeSummaryInMsg"
      wsam:Action="http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0/
DischargeSummaryReceiver/sendDischargeSummaryRequest"/>
    <wsdl:output message="tns:sendDischargeSummaryOutMsg"
      wsam:Action="http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0/
DischargeSummaryReceiver/sendDischargeSummaryResponse"/>
    <wsdl:fault name="invalidIdFault" message="tns:invalidIdFaultMsg"
      wsam:Action="http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0/
DischargeSummaryReceiver/sendDischargeSummary/Fault/invalidIdFault"/>
  </wsdl:operation>

  <wsdl:operation name="checkStatus">
    <wsdl:input message="tns:checkStatusInMsg"
      wsam:Action="http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0/
DischargeSummaryReceiver/checkStatusRequest"/>
    <wsdl:output message="tns:checkStatusOutMsg"
      wsam:Action="http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0/
DischargeSummaryReceiver/checkStatusResponse"/>
    <wsdl:fault name="invalidIdFault" message="tns:invalidIdFaultMsg"
      wsam:Action="http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0/
```

```

DischargeSummaryReceiver/checkStatus/Fault/InvalidIdFault"/>
  </wsdl:operation>

  </wsdl:portType>
</wsdl:definitions>

```

2.3.3 Non-functional attributes

The WSDL file can contain the non-functional attributes of a service in a formal specification. A WSDL file is not the complete documentation of a service however and some non-functional attributes of a service cannot be described formally within WSDL therefore requiring additional documentation.

2.3.3.1 WSDL containing service instance information

The non-functional attributes of a service are placed in a separate file as recommended by criterion WS 3.1.2.1-1. This second WSDL file contains the service instance information. It specifies the concrete aspects of the service interface, such as how data is transported and how it is secured.

This second WSDL will be stored in a file called *DischargeSummaryReceiver.wsdl*.

2.3.3.1.1 Header

In the second WSDL file, the start tag of the root element again contains all the XML namespaces that this document will use.

Criterion WS 5.1.1.1-1 recommends the use of SOAP 1.2 as the messaging protocol. This is specified in the WSDL by using the XML namespace for the SOAP 1.2 binding, which is namely:

```
http://schemas.xmlsoap.org/wsdl/soap12/
```

Following criterion WS 3.2.1.1-1, the WSDL uses the *WS-Policy 1.5 Framework* [WSPL2007] to define the non-functional attributes of the service that can be specified formally within the WSDL file. The *wsp* prefix is used to refer to the namespace of *WS-Policy 1.5*, namely:

```
http://www.w3.org/ns/ws-policy
```

The security policies of the service are specified using *WS-SecurityPolicy 1.2* [WSSPL2007], which follows criterion WS 3.2.2.1-1. The *sp* prefix is used to refer to the namespace of *WS-SecurityPolicy 1.2*, namely:

```
http://docs.oasis-open.org/ws-sx/ws-securitypolicy/200702
```

The addressing policies of the service are specified using *WS Addressing 1.0 - Metadata* [WSAM2007], which follows criterion WS 3.2.3.1-1. The *wsam* prefix is used to refer to the namespace of *WS-Addressing 1.0 - Metadata*, namely:

```
http://www.w3.org/2007/05/addressing/metadata
```

This second WSDL should have a target namespace that matches the service namespace, namely:

```
http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0
```

The *tns* prefix is again used to refer to the target namespace.

```

<?xml version="1.0"?>
<wsdl:definitions xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
  xmlns:soap="http://schemas.xmlsoap.org/wsdl/soap12/"
  xmlns:wsp="http://www.w3.org/ns/ws-policy"
  xmlns:sp="http://docs.oasis-open.org/ws-sx/ws-securitypolicy/200702"
  xmlns:wsam="http://www.w3.org/2007/05/addressing/metadata"
  xmlns:tns="http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0"
  targetNamespace="http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0"
  name="DischargeSummaryReceiver">

```

2.3.3.1.2 Addressing Policy

The addressing requirements of the service are declared using *WS-Addressing 1.0 - Metadata* [WSAM2007]. The addressing assertions are specified within a policy, defined using the *WS-Policy 1.5* [WSPL2007] policy language.

The service's addressing policies are specified in a policy called *AddressingPolicy*. The name *AddressingPolicy* is arbitrary - any unique name could have been used.

The Addressing assertion element indicates the use of WS-Addressing [WSAM2007], as per criterion WS 7.1.1.1-1.

```
<wsp:Policy xml:id="AddressingPolicy">
  <wsam:Addressing/>
</wsp:Policy>
```

2.3.3.1.3 Security Policy

The security requirements of the service are specified within a policy, defined using the *WS-Policy 1.5* [WSPL2007] policy language. The *WS-SecurityPolicy 1.2* [WSSPL2007] is used to formally describe the security requirements.

The service's security policies are specified in a policy called *SecurityPolicy*.

```
<wsp:Policy xml:id="SecurityPolicy">
```

The Wss11 assertion element declares the use of *WS-Security 1.1* as per criterion WS 6.2.1.1-1.

```
<sp:Wss11>
  <wsp:Policy>
```

The `MustSupportRefKeyIdentifier` element requires service providers and service clients to support key identifier references. This is needed because some certificates in the request and response messages have to be referenced using their subject key identifiers to conform to criteria: WS 6.2.7.1-2, WS 6.2.7.2-1 and WS 6.2.7.2-2.

```
<sp:MustSupportRefKeyIdentifier/>
</wsp:Policy>
</sp:Wss11>
```

Criterion WS 6.2.3.1-1 requires that the SOAP body, the SOAP headers and the WS-Security timestamp be signed. The digital signature requirements of this criterion are met by providing the `SignedParts` assertion element in the policy.

The `SignedParts` element is used to indicate which parts of the SOAP messages are to be signed. When this element has no children, it specifies that the body and all headers targeted to the Ultimate Receiver role are to be signed [WSSPL2007].

An explicit assertion is not needed for signing the timestamp because if the timestamp is included, it implies that it must be signed [WSSPL2007].

```
<sp:SignedParts/>
```

Criterion WS 6.2.4.2-1 requires that the entire SOAP body is encrypted, while criterion WS 6.2.4.2-3 recommends that no SOAP headers are to be encrypted. These encryption requirements are met by providing the `EncryptedParts` assertion element in the policy.

The `EncryptedParts` element indicates which parts of a message should be encrypted. When this element has no children, it specifies that the body is to be encrypted. By default, SOAP headers are excluded from encryption.

```
<sp:EncryptedParts/>
```

The `AsymmetricBinding` element declares the use of public key cryptography as per criterion WS 6.1.1.1-1. It permits a child policy within itself to configure additional properties of the public key cryptography.

```
<sp:AsymmetricBinding>
  <wsp:Policy>
```

Criterion WS 6.2.2.2-1 requires that SOAP messages provide a Created timestamp in the WS-Security Timestamp element. The closest translation of this criterion is the `IncludeTimestamp` assertion, which requires the WS-Security Timestamp be provided in SOAP messages [WSSPL2007]. The Created element is optional within the WS-Security Timestamp element [WSS2006].

```
<sp:IncludeTimestamp/>
```

Criterion WS 6.2.3.1-2 stipulates that the digital signatures must be calculated over the entire element (i.e. including the start and end tags of the element). This behaviour is declared by the `OnlySignEntireHeadersAndBody` assertion element.

```
<sp:OnlySignEntireHeadersAndBody/>
```

The `EncryptSignature` assertion element declares that the digital signatures in messages must be encrypted, which matches criterion WS 6.2.4.2-2.

```
<sp:EncryptSignature/>
```

Criterion WS 6.2.5.2-2 requires the use of the Lax "Security Header Layout" property of *WS-SecurityPolicy* [WSSPL2007].

```
<sp:Layout>
  <wsp:Policy>
    <sp:Lax/>
  </wsp:Policy>
</sp:Layout>
```

An explicit assertion element is not required to declare the behaviour of signing before encrypting as per criterion WS 6.2.5.1-1. The default value of the "Protection Order" property of *WS-SecurityPolicy* [WSSPL2007] is "SignBeforeEncrypting".

The `Basic256Rsa15` assertion element declares the use of the *Basic256Rsa15* algorithm suite, as required by criterion WS 6.2.6.1-1.

```
<sp:AlgorithmSuite>
  <wsp:Policy>
    <sp:Basic256Rsa15/>
  </wsp:Policy>
</sp:AlgorithmSuite>
```

The `InitiatorToken` assertion element provides configuration properties for the service invoker's certificate.

In *WS-SecurityPolicy 1.2* [WSSPL2007], the initiator role belongs to the entity who sends the initial message and the recipient role belongs to the entity that is the target of the initial message. Using the terminology of this document, the service invoker is the initiator, and the service provider is the recipient.

Specifying an `AlwaysToRecipient` inclusion policy in the `IncludeToken` attribute on the `X509Token` element will meet criteria: WS 6.2.7.1-1 and WS-6.2.7.2-2. This token inclusion policy means that the service invoker's certificate is included in the messages to the service provider, which are namely the SOAP requests. In the other messages, namely the SOAP responses, the service invoker's certificate is not in the message itself, and is referenced indirectly.

The `wssX509V3Token10` element indicates that an X.509v3 token should be used for the service invoker's certificate, which follows criterion WS 6.1.2.1-1.

The `RequireKeyIdentifierReference` element specifies a key identifier reference should be used when the token is indirectly referenced. For an X.509v3 certificate, the key identifier reference is the subject key identifier. This assertion element is needed because criterion WS-6.2.7.2-2 requires that the subject key identifier be used to reference the service invoker's certificate in responses.

```
<sp:InitiatorToken>
  <wsp:Policy>
    <sp:X509Token sp:IncludeToken="http://docs.oasis-open.org/ws-sx/
ws-securitypolicy/200702/IncludeToken/AlwaysToRecipient">
      <wsp:Policy>
        <sp:RequireKeyIdentifierReference/>
        <sp:WssX509V3Token10/>
      </wsp:Policy>
    </sp:X509Token>
  </wsp:Policy>
</sp:InitiatorToken>
```

The `RecipientToken` assertion element is similar to the `InitiatorToken`, except that it applies to the security token of the service provider.

In the WSDL, the `RecipientToken` element has almost the same content as that of the `InitiatorToken` element, except that a *Never* inclusion policy is set on the `IncludeToken` attribute on the `X509Token` element. This token inclusion policy will meet criteria: WS 6.2.7.1-2 and WS 6.2.7.2-1. The service provider's certificate is never included in requests and responses, and is indirectly referenced.

```
<sp:RecipientToken>
  <wsp:Policy>
    <sp:X509Token sp:IncludeToken="http://docs.oasis-open.org/ws-sx/
ws-securitypolicy/200702/IncludeToken/Never">
      <wsp:Policy>
        <sp:RequireKeyIdentifierReference/>
        <sp:WssX509V3Token10/>
      </wsp:Policy>
    </sp:X509Token>
  </wsp:Policy>
</sp:RecipientToken>
</wsp:Policy>
</sp:AsymmetricBinding>
</wsp:Policy>
```

2.3.3.1.4 *Import*

Since the second WSDL file refers to the port type defined in the WSDL containing the service interface information, it must import the first WSDL file.

```
<wsdl:import location="DischargeSummaryReceiverInterface.wsdl"
namespace="http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0"/>
```

2.3.3.1.5 *Binding*

The binding section indicates the message format and protocol details for the abstract port types.

The addressing and security policies that were defined in sections 2.3.3.1.2 and 2.3.3.1.3 have to be applied to the service. This is done using `wsp:PolicyReference` elements. The `wsp:PolicyReference` elements are applied to the WSDL binding element as recommended by criterion WS 3.2.1.1-2.

Criterion WS 4.1.1.1-1 recommends the use of HTTP 1.1 as the transport protocol. Although the particular HTTP version cannot be specified in the WSDL, the use of HTTP as the transport protocol can be specified by setting the `transport` attribute of the SOAP binding element to:

```
http://schemas.xmlsoap.org/soap/http
```

To comply with criterion WS 5.1.2.1-1, the *document/literal* style is used. This is done by setting the *style* attributes of SOAP operation elements to *document* and the use attributes of SOAP body and fault elements to *literal*.

To comply with criterion WS 5.1.3.1-1, *soapAction* values are not assigned to any operation. The *soapActionRequired* attributes are set to *false* to indicate that the service does not need *soapAction* values in the requests.

```
<wsdl:binding name="DischargeSummaryReceiverBinding"
  type="tns:DischargeSummaryReceiver">

  <wsp:PolicyReference URI="#AddressingPolicy"/>
  <wsp:PolicyReference URI="#SecurityPolicy"/>

  <soap:binding style="document"
    transport="http://schemas.xmlsoap.org/soap/http"/>

  <wsdl:operation name="Ping">
    <soap:operation style="document" soapActionRequired="false"/>
    <wsdl:input>
      <soap:body use="literal"/>
    </wsdl:input>
    <wsdl:output>
      <soap:body use="literal"/>
    </wsdl:output>
  </wsdl:operation>

  <wsdl:operation name="SendDischargeSummary">
    <soap:operation style="document" soapActionRequired="false"/>
    <wsdl:input>
      <soap:body use="literal"/>
    </wsdl:input>
    <wsdl:output>
      <soap:body use="literal"/>
    </wsdl:output>
    <wsdl:fault name="invalidIdFault">
      <soap:fault name="invalidIdFault" use="literal"/>
    </wsdl:fault>
  </wsdl:operation>

  <wsdl:operation name="CheckStatus">
    <soap:operation style="document" soapActionRequired="false"/>
    <wsdl:input>
      <soap:body use="literal"/>
    </wsdl:input>
    <wsdl:output>
      <soap:body use="literal"/>
    </wsdl:output>
    <wsdl:fault name="invalidIdFault">
      <soap:fault name="invalidIdFault" use="literal"/>
    </wsdl:fault>
  </wsdl:operation>

</wsdl:binding>
```

2.3.3.1.6 Service

The service part of the WSDL defines a service with concrete ports that are associated with a particular binding.

An address must be provided for the Web service instance. However, it is not necessary to provide an actual hard-coded URL. This address value can be overridden by the toolkit.

```
<wsdl:service name="DischargeSummaryReceiverService">
  <wsdl:port name="DischargeSummaryReceiver"
    binding="tns:DischargeSummaryReceiverBinding">
    <soap:address location="http://dummy.example.com"/>
  </wsdl:port>
</wsdl:service>

</wsdl:definitions>
```

3 Overview of Metro

3.1 General background

Metro [METRO] is a Web services stack made up of 3 primary components, namely JAX-WS, JAXB and WSIT.

JAX-WS [JAXWS], the Java API for XML-Based Web Services, is a standard Java API for Web services, which was developed by the *Java Community Process JSR-224* [JSR224]. Metro contains an open-source reference implementation of the JAX-WS specification.

JAXB [JAXB], the Java Architecture for XML Binding, is a standard Java technology that maps Java objects to and from XML. It is a critical component of the implementation of Java-based Web services. It was developed by the *Java Community Process JSR-222* [JSR222]. A JAXB reference implementation is in Metro.

WSIT [WSIT], Sun's Web Services Interoperability Technologies, were developed to ensure interoperability between the Java platform and the *Windows Communication Foundation (WCF)* [WCF], from Microsoft.

3.2 Technical overview

3.2.1 Client

Using Metro, a Web service client does not have to create and manipulate XML SOAP messages directly. The client can invoke an operation on a remote Web service by making a Java method call.

Metro comes with a tool called *wsimport*, which generates Java classes from a given WSDL. It generates:

- Java class for the service declared in the WSDL;
- Java interfaces containing methods for the Web service operations of the ports defined in the WSDL;
- Java beans for the XML Schema types defined in the WSDL; and
- Exceptions for the SOAP faults declared in the WSDL.

This document will refer to these Java interfaces and classes generated by *wsimport* as "service interface classes".

When the client makes a method call using these generated service interface classes, JAX-WS uses JAXB to marshal the Java method call and its parameters as a SOAP request. JAX-WS might also manipulate the SOAP request before it is sent, based on configuration details. For instance, it can add addressing and security headers to the request, and sign and encrypt the request. When a SOAP response is returned to the client, JAX-WS verifies and decrypts the response if security is configured. JAXB then unmarshals the SOAP response into a Java object that is returned to the client.

3.2.2 Server

On the server-side, the *wsimport* tool is also used to generate service interface classes. The Web service developer then codes a Java class that implements the generated Java interface containing the Web service methods. These classes and other supporting files are packaged into a Web archive (WAR) and deployed in a Web container.

When a SOAP request comes in, a servlet provided by the JAX-WS implementation processes the request. If security is configured, JAX-WS will

verify and decrypt the SOAP request. JAXB unmarshals the SOAP request. The appropriate method is then called on the Web service implementation class. The method's return value is marshalled by JAXB as a SOAP response, which might be signed and encrypted, before it is passed to the servlet to return over the network.

3.3 Recommended version

The implementation described in this document was tested against version 1.4 of Metro, Sun's open source Web services stack. Metro is developed under the Glassfish project umbrella. Metro (version 1.4) includes the JAX-WS reference implementation (version 2.1.5), the JAXB reference implementation (version 2.1.9), and WSIT (version 1.4).

This document describes how to build and configure Web services and clients for the Metro 1.4 version. The code and configuration samples in this document might not work for other Metro versions.

3.4 Requirements

This section lists the software requirements. See *Appendix B*: for installation instructions and notes.

3.4.1 Client deployment

- Metro Version 1.4
- Java Runtime Environment (JRE) 6 Update 4
- Java Cryptography Extension (JCE) Unlimited Strength Jurisdiction Policy Files

3.4.2 Web service deployment

The same software is required as the client deployment but also requires a servlet container to host the Web service.

Note: This document describes hosting a Web service in terms of the Glassfish Application Server because it is part of the platform used in testing the code and configuration fragments in the document. However, Glassfish is not required to host Metro Web services. Metro can be used with lightweight Java Web containers, such as Apache Tomcat, as well as other Java Enterprise Edition application servers.

3.4.3 Client development

- Metro 1.4
- Java Standard Edition Development Kit (JDK) 6 Update 4

3.4.4 Web service development

The same software is required as the client development.

3.5 Platform used

The code and configuration fragments in this document were tested using the following software:

- Metro Version 1.4
- Glassfish Version 2 UR2
- JDK 6 Update 4
- JCE Unlimited Strength Jurisdiction Policy Files 6
- Ant 1.7.0
- Windows XP Professional SP2 and Ubuntu 7.10

4 Web service client

This chapter describes how to build a Web service client using Metro. The aim of a Web service client is to invoke an operation on a service instance.

The process of creating a Web service client simply involves generating the service interface classes from the WSDL files and then using those classes in the client program.

The steps for building a Web service client are:

1. Modify the WSDL files;
2. Generate the service interface classes from the WSDL files;
3. Implement the client application; and
4. Specify the keys and certificates.

4.1 Modify the WSDL files

4.1.1 WSDL containing the service interface information

No modifications need to be made to the standard WSDL containing the service interface information from section 2.3.2.1.

4.1.2 WSDL containing the service instance information

Metro 1.4 has two issues with interpreting the policies in the standard WSDL file containing the service instance information from section 2.3.3.1. However, there are workarounds for these issues.

When the `SignedParts` element has no children [WSSPL2007], it signifies that the body and all headers targeted to the Ultimate Receiver role are to be signed. However, Metro 1.4 creates incorrect signature references for custom SOAP headers unless the headers are explicitly listed in the `SignedParts` element. Although this example service does not have custom SOAP headers, the explicit children under the `SignedParts` element are declared to show the workaround. The explicit children under the `EncryptedParts` element are declared for consistency.

```
<wsdl:definitions xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
  xmlns:sp="http://schemas.xmlsoap.org/ws/2005/07/securitypolicy"
  ...>
  <wsp:Policy xml:id="SecurityPolicy">
    ...
    <sp:SignedParts>
      <sp:Body />
      <sp:Header Namespace="http://www.w3.org/2005/08/addressing" />
    </sp:SignedParts>
    <sp:EncryptedParts>
      <sp:Body />
    </sp:EncryptedParts>
    ...
  </wsp:Policy>
  ...
</wsdl:definitions>
```

When a policy that is applied to a service's binding has the `SignedParts` and `EncryptedParts` assertion elements, all the messages must be signed and encrypted. However, Metro 1.4 does not sign and encrypt faults unless the `SignedParts` and `EncryptedParts` assertions are in a policy that is applied at the message level. For this reason, the example fragment below places the

SignedParts and EncryptedParts assertions in a separate policy called *SecureMessagePolicy*.

```
<wsdl:definitions xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
  xmlns:sp="http://schemas.xmlsoap.org/ws/2005/07/securitypolicy"
  ...>
  ...
  <wsp:Policy xml:id="SecurityPolicy">
    <sp:Wss11>
      ...
    </sp:Wss11>
    <!-- Removed sp:SignedParts and sp:EncryptedParts elements -->
    <sp:AsymmetricBinding>
      ...
    </sp:AsymmetricBinding>
  </wsp:Policy>
  <wsp:Policy xml:id="SecureMessagePolicy">
    <sp:SignedParts>
      <sp:Body />
      <sp:Header Namespace="http://www.w3.org/2005/08/addressing" />
    </sp:SignedParts>
    <sp:EncryptedParts>
      <sp:Body />
    </sp:EncryptedParts>
  </wsp:Policy>
  ...
</wsdl:definitions>
```

The *SecureMessagePolicy* policy is applied to all messages of each operation. Although the issue is only with fault messages, the SignedParts and EncryptedParts assertions are applied at the message-level for input and output messages for consistency.

```
<wsdl:definitions xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
  xmlns:sp="http://schemas.xmlsoap.org/ws/2005/07/securitypolicy"
  ...>
  ...
  <wsdl:binding name="..." type="...">
    ...
    <wsp:PolicyReference URI="#SecurityPolicy"/>
    ...
    <wsdl:operation name="sendDischargeSummary">
      <soap:operation style="document" soapActionRequired="false"/>
      <wsdl:input>
        <wsp:PolicyReference URI="#SecureMessagePolicy" />
        <soap:body use="literal"/>
      </wsdl:input>
      <wsdl:output>
        <wsp:PolicyReference URI="#SecureMessagePolicy" />
        <soap:body use="literal"/>
      </wsdl:output>
      <wsdl:fault name="invalidIdFault">
        <wsp:PolicyReference URI="#SecureMessagePolicy" />
        <soap:fault name="invalidIdFault" use="literal"/>
      </wsdl:fault>
    </wsdl:operation>
    ...
  </wsdl:binding>
  ...
</wsdl:definitions>
```

4.2 Generate the service interface classes from the WSDL files

The service interface classes are generated by running the *wsimport* tool over the WSDL [WSIMPORT]. The *wsimport* tool comes as a command-line application as well as an Ant task. Ant is a Java build tool. The examples below are based on calling *wsimport* from Ant.

The *wsimport* Ant task must be declared before using it. The Java class for this Ant task comes with the Metro distribution. The code below assumes that there is a METRO_HOME environment variable that points to the root directory of the Metro toolkit.

```
<!-- Define path to Metro JAR files -->
```

```

<property environment="env"/>
<path id="metro.path">
  <fileset dir="${env.METRO_HOME}/lib" includes="*.jar"/>
</path>

<!-- Define wsimport task -->
<taskdef name="wsimport" classname="com.sun.tools.ws.ant.WsImport">
  <classpath refid="metro.path"/>
</taskdef>

```

The following are commonly useful parameters that should be passed to *wsimport*:

- `wsdl`: WSDL file from which to generate classes;
 - This file is the WSDL containing the service instance information.
- `wsdllocation`: value that will be in the `@WebServiceClient.wsdlLocation` annotation in the generated service interface;
- `package`: package name that the generated classes should be in;
- `destdir`: location to place the generated compiled classes;
- `keep`: set to true to keep the source files of the generated classes;
- `sourcedestdir`: location to place the generated source files; and
- `extension`: set to true to enable custom extensions.

The Metro toolkit regards the SOAP 1.2 binding as an extension. Thus, this parameter must be set to true to use SOAP 1.2, which is recommended by the *Web Services Profile* [WSP2008].

```

<wsimport wsdl="wsdl/DischargeSummaryReceiver.wsdl"
  wsdllocation="DischargeSummaryReceiver.wsdl"
  package="com.example.ds.client"
  destdir="gen/classes"
  keep="true"
  sourcedestdir="gen/src"
  extension="true"/>

```

4.3 Implement the client application

The steps for a client to invoke a Web service operation are:

- Load the configuration;
- Create a service object;
- Get a port object from the service object;
- Set the request context properties on the port object; and
- Invoke Web service operations on the port object.

```

package com.example.ds.client;

import java.io.FileReader;
import java.net.URL;
import java.util.Map;
import java.util.Properties;
import javax.xml.namespace.QName;
import javax.xml.ws.BindingProvider;
import javax.xml.ws.WebServiceClient;
import com.example.common.client.RequestContextConstants;

public class ClientApp {

    public static void main(String[] args) throws Exception {
        if (args.length != 1) {
            System.out.println("Usage: java ClientApp [properties-file]");
        } else {
            // Load configuration properties
            String configFile = args[0];

```

```

Properties configProperties = new Properties();
configProperties.load(new FileReader(configFile));

// Create service
DischargeSummaryReceiverService service = createService();

// Create port
DischargeSummaryReceiver port = service.getDischargeSummaryReceiver();

// Set request context properties on the port
setRequestContextProperties(port, configProperties);

// Invoke Web service operations
ReceivedStatusType status = port.checkStatus("1234");
}
}
...
}

```

4.3.1 Load the configuration

To call a particular Web service, the client application needs to know the Web service's URL and certificate. Since the client application in the example scenario is simple, it gets this information from a properties file that was specified in an argument.

```

public class ClientApp {

    public static void main(String[] args) throws Exception {
        if (args.length != 1) {
            System.out.println("Usage: java ClientApp [properties-file]");
        } else {
            // Load configuration properties
            String configFile = args[0];
            Properties configProperties = new Properties();
            configProperties.load(new FileReader(configFile));
            ...
        }
    }
    ...
}

```

An example configuration file for the client application is provided below. Section 4.3.4 will explain how the properties are used to configure the calls to the Web service.

```

service.url=http://localhost:8080/dsreceiver
service.certSubject=CN=jaxws_server

```

4.3.2 Create a service object

The *wsimport* tool generates a class that corresponds to each service declaration in the WSDL, which this document will call a "service class". In the example implementation, this service class is named `DischargeSummaryReceiverService`. The first step in invoking Web service calls is to create an instance of this service class, which is done in `createService()` method in the code listing below.

```

public class ClientApp {

    public static void main(String[] args) throws Exception {
        ...
        // Create service
        DischargeSummaryReceiverService service = createService();
        ...
    }

    private static DischargeSummaryReceiverService createService() {
        // Get annotation from wsimport-generated DischargeSummaryReceiverService
        // class
        WebServiceClient annotation = DischargeSummaryReceiverService.class

```

```

        .getAnnotation(WebServiceClient.class);

    // Get details from the Web service's annotation
    String wsdlLocStr = annotation.wsdlLocation();
    String serviceName = annotation.name();
    String serviceNamespace = annotation.targetNamespace();

    // Search for the WSDL in the class path. Assume that the Web service's WSDL
    // files are in the JAR file containing the client app.
    URL wsdlLocUrl = getURLFromClasspath(wsdlLocStr);

    // Create the service
    QName serviceQName = new QName(serviceNamespace, serviceName);
    return new DischargeSummaryReceiverService(wsdlLocUrl, serviceQName);
}
...
private static URL getURLFromClasspath(String filePath) {
    URL result = null;
    if (filePath != null) {
        ClassLoader loader = Thread.currentThread().getContextClassLoader();
        result = loader.getResource(filePath);
    }
    return result;
}
}
}

```

The generated `DischargeSummaryReceiverService` class has a constructor that has no parameters. It is advisable not to call this constructor when instantiating a new service object. It uses a hard-coded value for the WSDL location, which corresponds to the location of the WSDL file when the classes were generated by the `wsimport` tool. Calling this constructor when a local WSDL file is used to generate the classes will mean that the client application is not portable. If a remote WSDL location is used to generate the classes, the client application will stop working if the remote WSDL location is changed (e.g. the WSDL file is moved to a new remote location).

The generated service class also has a constructor that takes a WSDL location. This constructor should be used since it gives the flexibility to choose the location of the WSDL file at run-time. In the example client, the WSDL location is retrieved from the classpath. Section 4.5 will show where to place the WSDL files when packaging the example client. The WSDL used to create the Service object should contain the policy modifications specified in section 4.1 .

The constructor also requires passing the qualified name of the service in the WSDL. Instead of using hard-coded values, the namespace and the name of the service can be retrieved from the `WebServiceClient` annotation in the generated service class.

4.3.3 Get a port object

The service class has a getter method for each port declared in the WSDL. These getter methods return a port object that allows the client application to invoke operations defined for that port in the WSDL.

```

public static void main(String[] args) throws Exception {
    ...
    // Get port
    DischargeSummaryReceiver port = service.getDischargeSummaryReceiver();
    ...
}

```

4.3.4 Set request context properties on the port

The request context properties allow the client's main application to specify values that are used by other parts of the program. In the example client, the configuration values are retrieved from a properties file specified in a command-line argument.

The `BindingProvider.ENDPOINT_ADDRESS_PROPERTY` property should be set in the request context. This is a built-in property of the Metro toolkit. When it is set, its value will override the value of the endpoint address in the WSDL. This feature enables the client to dynamically select the service that it wishes to invoke.

In order for the client to dynamically select a Web service, it needs to also be able to dynamically select the service's certificate, which is used to encrypt requests. This is also done using request context properties, which are made available to the certificate selector class. Section 4.4.2 will explain what configure security keys and certificates and how to implement the certificate selector class. The client application passes the Subject name of the certificate to select in a request context property to the certificate selector class. This is a custom request context property.

```
public static void main(String[] args) throws Exception {
    ...
    // Set request context properties on the port
    setRequestContextProperties(port, configProperties);
    ...
}

private static void setRequestContextProperties(
    DischargeSummaryReceiver port, Properties configProperties)
    throws URISyntaxException {
    // Get request context properties
    BindingProvider bindingProvider = (BindingProvider) port;
    Map<String, Object> requestContext = bindingProvider.getRequestContext();

    // Set endpoint address URL
    String endpointAddress = configProperties.getProperty("service.url");
    requestContext.put(BindingProvider.ENDPOINT_ADDRESS_PROPERTY,
        endpointAddress);

    // Set service's certificate
    String serviceCertificate = configProperties
        .getProperty("service.certSubject");
    requestContext.put(RequestContextConstants.SERVICE_CERT_SUBJECT_KEY,
        serviceCertificate);
}
```

The custom request context properties can have arbitrary names, as long as they are agreed upon between the client's main application and the handlers. In addition, the custom property names should not clash with Metro property names. The names of the custom request context properties can be specified in constants in a class.

```
package com.example.common.client;

public class RequestContextConstants {
    public static final String SERVICE_CERT_SUBJECT =
        "com.example.common.security.certificate.service";
}
```

4.3.5 Invoke Web service operations

The client application invokes Web service operations on the port object.

Although the example WSDL defined in section 2.3.2.1 uses the document-literal style, since it follows the wrapped convention, the *wsimport* tool recognises this convention and generates RPC style method signatures.

```
public static void main(String[] args) throws Exception {
    ...
    // Invoke Web service operations
    ReceivedStatus status = port.checkStatus("1234");
}
```

4.4 Specify the keys and certificates

In order to sign and encrypt messages, the Metro toolkit needs to know which keys and certificates to use to perform those actions.

4.4.1 Create client-security-env.properties

The Metro toolkit looks for a security configuration file called *client-security-env.properties* in the classpath of the client application. Section 4.5 will explain where the *client-security-env.properties* file should be placed so that it is in the classpath.

An example *client-security-env.properties* is given below.

```
keystore.url=C:\\certs\\client_key.jks
keystore.type=JKS
keystore.password=password
truststore.url=C:\\certs\\others_certs.jks
truststore.type=JKS
truststore.password=password
key.password=password2key
truststore.certselector=com.example.common.security.client.ClientTrustStoreCertSelector
```

4.4.1.1 Properties to select the key store and trust store

A key store is a security key database file that contains the certificate and private key for the entity. In this case, the entity is the client. A trust store is a security key database file that contains the public certificates of others, such as the certificate authority and Web services. *Appendix C*: contains more information about these security key database files.

The Metro toolkit will be able to open the key store and trust store files when the following properties are set in *client-security-env.properties*:

- `keystore.url`: file location of the key store;
- `keystore.type`: type of the key store (*pkcs12*, *jks* or *jceks*);
- `keystore.password`: password for the key store;
- `truststore.url`: file location of the trust store;
- `truststore.type`: type of the trust store (*pkcs12*, *jks* or *jceks*); and
- `truststore.password`: password for the trust store.

4.4.1.2 Properties to select the keys

After opening the key store and trust store files, the Metro toolkit needs to know which particular keys must be used for securing the messages.

SOAP requests are signed using the private key of the Web service client. The Metro toolkit selects the particular key to use from the key store by looking at the `my.alias` configuration property. If this property is not set, then the toolkit will select the first key it finds. The example scenario assumes that the client has only one set of public and private keys; thus, the toolkit's default behaviour of selecting the first key is acceptable.

A private key has its own password. The `key.password` configuration property specifies the password for the private key. If this property is not specified, then the Metro toolkit assumes that the password of the private key matches that of the key store.

SOAP requests are encrypted using the public key of the Web service. The public key to use can be specified using the `peer.alias` configuration property. However, this approach will tie the client to a particular service when the client is running. To change the service's certificate will involve closing the client, editing the configuration, and restarting the client.

A more flexible approach is to provide a Java class that can dynamically select the public key to use. To implement this approach, the `truststore.certselector` configuration property should be provided and set to the fully qualified name of the custom `CertSelector` class. The implementation of this class is provided in section 4.4.2.

In addition to the properties described in section 4.4.1.1, the following properties should be specified in `client-security-env.properties` to enable Metro to sign and encrypt requests.

- `key.password`: password for the private key; and
- `truststore.certselector`: class that selects the public key.

No additional configuration properties are needed for selecting keys to decrypt and verify the signature of SOAP responses. Metro automatically finds the certificates and private keys in the key store and trust store from the key references in the responses. For example, to verify the signature in a response, the Subject Key Identifier value of the signature key in the response is used to look up the matching public key in the trust store.

4.4.1.3 Avoiding absolute file locations

An issue with the original example `client-security-env.properties` file is that absolute locations are provided for the key store and trust store files. This affects the portability of the client application.

The Metro toolkit can also look in the classpath to find key store and trust store files. If file names are specified, instead of absolute locations, as shown below, Metro will look for the security key files in the `META-INF/` directory in the classpath. Section 4.5 will explain where the security key files are to be placed when packaging the Web service client.

```
keystore.url=client_key.jks
keystore.type=JKS
keystore.password=password
truststore.url=others_certs.jks
truststore.type=JKS
truststore.password=password
key.password=password2key
truststore.certselector=com.example.common.security.client.ClientTrustStoreCertSelector
```

4.4.1.4 Avoiding hard-coded password values

Another issue with the original example `client-security-env.properties` file is that passwords are stored in clear text, which compromises the security of the client application.

Instead of specifying the password values in the `keystore.password`, `truststore.password` and `key.password` configuration properties, a password callback class can be specified in these properties as shown in the example `client-security-env.properties` file below. This class will be instantiated and called by the Metro toolkit when it requires a password value. Its implementation is given in section 4.4.3.

```
keystore.url=client_key.jks
keystore.type=JKS
keystore.password=com.example.common.security.client.ClientPasswordCallback
truststore.url=others_certs.jks
truststore.type=JKS
truststore.password=com.example.common.security.client.ClientPasswordCallback
key.password=com.example.common.security.client.ClientPasswordCallback
truststore.certselector=com.example.common.security.client.ClientTrustStoreCertSelector
```

4.4.2 Implement the certificate selector

An example implementation of the trust store `CertSelector` class is provided below. This Java class will be called by the Metro toolkit to select the public key to use from the trust store to encrypt SOAP requests.

```

package com.example.common.security.client;

import java.security.Principal;
import java.security.cert.CertSelector;
import java.security.cert.Certificate;
import java.security.cert.X509Certificate;
import java.util.HashMap;
import java.util.Map;
import com.example.common.client.ClientProperty;

public class ClientTrustStoreCertSelector implements CertSelector {
    private Map context;
    private String serviceCert;

    public ClientTrustStoreCertSelector(Map contextParam) {
        this.context = contextParam;
        if (context != null) {
            this.serviceCert = (String) context.get(
                RequestContextConstants.SERVICE_CERT_SUBJECT);
        }
    }

    public boolean match(Certificate certificate) {
        boolean result = false;
        if ((this.serviceCert != null) && (this.serviceCert.length() > 0)
            && (certificate instanceof X509Certificate)) {
            // The certificate's subject name must match what has been specified
            String certSubj = getCertificateSubject((X509Certificate) certificate);
            result = this.serviceCert.equals(certSubj);
        }
        return result;
    }

    @Override
    public Object clone() {
        return new ClientTrustStoreCertSelector(new HashMap(this.context));
    }

    private String getCertificateSubject(X509Certificate certificate) {
        String result = null;
        Principal subject = certificate.getSubjectDN();
        if (subject != null) {
            result = subject.getName();
        }
        return result;
    }
}

```

This class implements the `CertSelector` interface. It should have a constructor that takes in a `Map` object. This `Map` object is passed by the `DefaultCallbackHandler` and contains the request context properties set by the client's main application. Section 4.3.4 discussed how these request context properties are set. One of these properties should be the Subject name of the certificate for the Web service that the client's main application will invoke.

The `CertSelector` interface has two methods to implement: `match()` and `clone()`. The `match()` method is called as the `DefaultCallbackHandler` iterates through the certificates in the trust store. This method should return true when it is passed the certificate to select – namely the certificate whose Subject name matches the value of the client's request context property. The `clone()` method implementation provides a duplicate copy of the `CertSelector`. The `@Override` annotation marks that this method implementation overrides the protected `Object.clone()` method.

4.4.3 Implement the password callback

An example implementation of a password callback, `com.example.common.security.client.ClientPasswordCallback`, is given below. The Metro toolkit will call this class to obtain passwords for the key store, the trust store and the private key of the client.

```

package com.example.common.security.client;

import java.io.IOException;

import javax.security.auth.callback.Callback;
import javax.security.auth.callback.CallbackHandler;
import javax.security.auth.callback.PasswordCallback;
import javax.security.auth.callback.UnsupportedCallbackException;

/**
 * An example implementation of a password callback handler.
 * When configured to do so, this class will be called by the security
 * framework when a password is needed.
 */
public class ClientPasswordCallback implements CallbackHandler {

    // Prompt for trust store password
    private static final String TRUSTSTORE_PASSWORD_PROMPT = "TrustStorePassword";

    // Prompt for key store password
    private static final String KEYSTORE_PASSWORD_PROMPT = "KeyStorePassword";

    // Prompt for key password
    private static final String KEY_PASSWORD_PROMPT = "KeyPassword";

    /**
     * @see CallbackHandler#handle(Callback[])
     */
    public void handle(Callback[] callbacks) throws IOException,
        UnsupportedCallbackException {
        for (int i = 0; i < callbacks.length; i++) {
            Callback callback = callbacks[i];
            if (callback instanceof PasswordCallback) {
                PasswordCallback pwdCallback = (PasswordCallback) callback;

                String password = null;
                String prompt = pwdCallback.getPrompt();
                if (TRUSTSTORE_PASSWORD_PROMPT.equals(prompt)) {
                    // Retrieve trust store password (not shown)
                    password = "...";
                }
                else if (KEYSTORE_PASSWORD_PROMPT.equals(prompt)) {
                    // Retrieve key store password (not shown)
                    password = "...";
                }
                else if (KEY_PASSWORD_PROMPT.equals(prompt)) {
                    // Retrieve key password (not shown)
                    password = "...";
                }
                else {
                    // Unknown password prompt
                    // Throw an UnsupportedCallbackException
                    String errMsg = "Unsupported password prompt: " + prompt;
                    throw new UnsupportedCallbackException(callback, errMsg);
                }

                // Check password
                if (password == null) {
                    String errMsg = "Couldn't retrieve " + prompt;
                    throw new IOException(errMsg);
                }

                // Set password
                char[] passwordChars = password.toCharArray();
                pwdCallback.setPassword(passwordChars);
            }
            else {
                // Not a PasswordCallback
                // Throw an UnsupportedCallbackException
                throw new UnsupportedCallbackException(callback);
            }
        }
    }
}

```

```
}

```

The password callback class implements the `javax.security.auth.callback.Callback` interface, which defines one method called `handle()`. This method is called by the Metro toolkit when it requires a password to the key store, the trust store or the private key used for signing requests.

Metro will pass a `javax.security.auth.callback.PasswordCallback` object to the `handle()` method. The type of password required is specified by calling the `getPrompt()` method in the `PasswordCallback` object. For instance, if the callback is to get the key password, the prompt will be "KeyPassword".

Once the type of the password required is known, it can be retrieved. The retrieval of passwords is not shown in the example listing because it will depend on how passwords are securely stored, which is outside the scope of this document.

The retrieved password value is set in the `PasswordCallback` object as a character array using the `setPassword()` method. When the `handle()` method exits, the toolkit will read this password value from the `PasswordCallback` object.

4.5 Package the Web service Client

4.5.1 Directory structure

The Web service client should be packaged in a JAR file. The listing below shows the directory structure of the client's JAR file.

```
(Java class files)
(WSDL and XSD files)
client-security-env.properties
META-INF/
  (Key store and trust store files)

```

The Java classes, including the stubs generated by the `wsimport` tool, should be placed in the root directory of the JAR file.

Since the code of the example client in section 4.3.2 looks for the WSDL file from the classpath, the WSDL and XSD files must be placed in the root directory of the JAR file.

The `client-security-env.properties` file should be placed in the root directory of the client JAR file. The Metro toolkit will look for this file in the classpath to configure the keys and certificates used by the Web service client. Since the client JAR file will be in the classpath in order for the client code to be executed, placing the `client-security-env.properties` file in the client JAR file will allow the toolkit to read it and set the security configuration based on its values.

The key store and trust store files must be in the `META-INF` directory if absolute file locations are not specified in the `client-security-env.properties` configuration file.

4.5.2 Create the JAR file

The JAR file for the client can be created using the `jar` Ant task or the `jar` command-line tool. An example call to the `jar` Ant task is given below.

```
<jar destfile="dsreceiverClient.jar">
  <fileset dir="${classes.dir}">
    <include name="**/*.class" />
  </fileset>
  <fileset dir="${wsdl.dir}">
    <include name="*.wsdl" />
  </fileset>
</jar>

```

```
<include name="*.xsd" />
</fileset>
<fileset dir="${conf.dir}">
  <include name="client-security-env.properties" />
</fileset>
<metainf dir="${certificates.dir}">
  <include name="*.jks" />
</metainf>
</jar>
```

4.6 Run the Web service client

To run the client application, the client JAR file and the JAR files in `<METRO_HOME>/lib` directory should be in the classpath.

5 Web service

This chapter describes how to build a Web service using Metro. The aim of a Web service is to provide a service instance that makes available service operations for clients to invoke.

The steps for building a Web service are:

1. Modify the WSDL files;
2. Generate the service interface classes from the WSDL files;
3. Implement the Web service;
4. Specify the keys and certificates;
5. Create the deployment descriptors;
6. Package the Web service; and
7. Deploy the Web service.

In some steps, there are several similarities with the steps in building a Web service client. For these steps, this section is written describing what additional actions or modifications need to be done on the step described on the client-side to adapt it to the server-side.

5.1 Modify the WSDL files

The same modifications to the standard WSDL file for the service instance information will have to be made for the server-side as described in section 4.1.

5.2 Generate the service interface classes from the WSDL files

The *wsimport* tool is also used to generate the service interface classes for the server. The information for this step in the client-side, explained in section 4.2, also applies to the server-side.

5.3 Implement the Web service

A Web service implementation class provides concrete method implementations for the operations in the WSDL. Although it is not necessary, it is a good idea for the Web service implementation class to implement the generated port interface, which is the `DischargeSummaryReceiver` interface in this example. Using this approach, some discrepancies, such as missing method implementations, can be discovered at compile-time.

The Web service implementation class must have a `WebService` annotation with an `endpointInterface` attribute. The value of this `endpointInterface` attribute must be the fully-qualified name of the generated port interface. The `WebMethod` annotation must be used to mark the methods that implement the operations in the WSDL.

```
package com.example.ds.server;

import javax.jws.WebMethod;
import javax.jws.WebService;

@WebService (endpointInterface="com.example.ds.server.DischargeSummaryReceiver")
public class DischargeSummaryReceiverImpl implements DischargeSummaryReceiver {
    @WebMethod
    public void ping() {
        ...
    }
}
```

```

@WebMethod
public void sendDischargeSummary(DischargeSummaryType document)
    throws InvalidIdFaultMsg{
    ...
}

@WebMethod
public ReceivedStatusType checkStatus(String documentId)
    throws InvalidIdFaultMsg {
    ...
}
}

```

5.4 Specify the keys and certificates

Section 4.4 discussed how to specify the keys and certificates to secure messages on the client-side. Keys and certificates are specified in a similar way on the client-side, except that the security configuration file is called *server-security-env.properties*. Section 5.6 will explain where this file is to be placed when packaging the Web service. The listing below provides an example *server-security-env.properties*.

```

keystore.url=server_key.jks
keystore.type=JKS
keystore.password=password
truststore.url=others_certs.jks
truststore.type=JKS
truststore.password=password
key.password=password2key

```

Like the client-side, values should be provided for the properties to locate and open the key store and trust store, namely: `keystore.url`, `keystore.type`, `keystore.password`, `truststore.url`, `truststore.type` and `truststore.password`. If the password for the Web service's private key is different from that of the key store, then it should be set in the `key.password` configuration property.

Unlike the client-side configuration, a custom trust store *CertSelector* is not always necessary. By default, Metro will use the client's certificate in the request message to encrypt the response message. Generally, this default behaviour is appropriate, but there are cases when it will have to be changed. For example, if the client's certificate in the request only permits *Digital Signature* usage, it cannot be used to encrypt the response. In that case, a custom trust store *CertSelector* is necessary to look up the client's certificate that permits encryption.

5.5 Create the deployment descriptors

Deployment descriptors are configuration files for server-side engines and containers. A Web service needs to provide a number of deployment descriptors.

5.5.1 sun-jaxws.xml

A *sun-jaxws.xml* file configures the Web service's endpoints in Metro. This file is specific to the JAX-WS reference implementation in Metro, and is not standardised. An example configuration file is provided below.

```

<endpoints xmlns="http://java.sun.com/xml/ns/jax-ws/ri/runtime" version="2.0">
  <endpoint name="DischargeSummaryReceiver"
    implementation="com.example.ds.server.DischargeSummaryReceiverImpl"
    wsdl="WEB-INF/wsdl/DischargeSummaryReceiverService.wsdl"
    service="{http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0}DischargeSummaryReceiverService"
    port="{http://ns.nehta.gov.au/Example/WSP/DS/Svc/Receiver/1.0}DischargeSummaryReceiver"
    url-pattern="/*"

```

```

        binding="http://java.sun.com/xml/ns/jaxws/2003/05/soap/bindings/HTTP/"
      />
</endpoints>

```

A Web service endpoint is declared using an `endpoint` XML element. The following XML attributes should be provided in the `endpoint` element:

- *name*: descriptive name of the endpoint;
- *implementation*: qualified name of the Web service implementation class written in section 5.3;
- *wsdl*: location of the root WSDL;

The root WSDL is the WSDL containing the service declaration. The example assumes the directory structure described in section 5.6. All WSDL and XSD files are in the `WEB-INF/wsdl` directory.

- *service*: qualified name of the service;
The namespace should match WSDL's target namespace. The local name should match the service's name defined in the WSDL.
- *port*: qualified name of the port;
The namespace should match WSDL's target namespace. The local name should match the port's name defined in the WSDL.
- *url-pattern*: specifies which URLs will map to this endpoint; and
- *binding*: which SOAP binding to use.

The SOAP 1.2 binding should be used in order to conform to the *Web Services Profile* [WSP2008]. The value for the SOAP 1.2 binding is:

```
http://java.sun.com/xml/ns/jaxws/2003/05/soap/bindings/HTTP/
```

5.5.2 web.xml

The standard deployment descriptor for Java EE Web applications is a `web.xml` file. A Web service requires a `web.xml` deployment descriptor since it is a Web application. An example file is provided below.

```

<web-app>
  <listener>
    <listener-class>
      com.sun.xml.ws.transport.http.servlet.WSServletContextListener
    </listener-class>
  </listener>
  <servlet>
    <servlet-name>DischargeSummaryReceiver</servlet-name>
    <servlet-class>com.sun.xml.ws.transport.http.servlet.WSServlet</servlet-class>
    <load-on-startup>1</load-on-startup>
  </servlet>
  <servlet-mapping>
    <servlet-name>DischargeSummaryReceiver</servlet-name>
    <url-pattern>/*</url-pattern>
  </servlet-mapping>
  <session-config>
    <session-timeout>60</session-timeout>
  </session-config>
</web-app>

```

The `web.xml` file specifies the servlet that will handle the HTTP requests, `com.sun.xml.ws.transport.http.servlet.WSServlet`, and its context listener, `com.sun.xml.ws.transport.http.servlet.WSServletContextListener`. These classes are part of the Metro toolkit.

5.5.3 sun-web.xml

The Glassfish server uses a deployment descriptor called *sun-web.xml* for configurations that are specific to it. Since the example Web service is simple, it doesn't require additional Glassfish-specific configuration and this deployment descriptor is not needed. More complex Web services may require the additional configuration features available in a *sun-web.xml* file, such as having class loading controlled by the application. See [SUNWEBXML] for the structure of the *sun-web.xml* file and [SUNWEBAPP] for information on how to configure Glassfish using the *sun-web.xml* file.

5.6 Package the Web service

5.6.1 Directory structure

The directory structure of a Web service, which is given below, follows the standard structure of a Web application.

```

/WEB-INF
  (Deployment descriptors, e.g. web.xml, sun-jaxws.xml, sun-web.xml)
  classes/
    (Java class files)
    META-INF/
      (Key store and trust store files)
  lib/
    (JAR files)
  wsdl/
    (WSDL and XSD files)

```

Since there is no visible aspect to a Web service, all files are located within the *WEB-INF* directory. The deployment descriptors, which are discussed in section 5.5, must be in this directory.

All Java classes, namely the generated stubs, the Web service implementation class and other classes, must be in the *classes* sub-directory.

If the *server-security-env.properties* configuration does not use absolute file locations, then the key store and trust store files must be in a *META-INF* directory that is in the classpath. In a Web application, the *WEB-INF/classes* directory is in the classpath.

Any JAR files used by the Web service implementation must be in the *lib* sub-directory. The Metro JAR files should not be included.

There is no prescribed location for the WSDL and XSD files of a Web service. Metro locates the service's WSDL from what is specified in the *sun-jaxws.xml* configuration file. The WSDL and XSD files should be placed in a single directory to create a clean directory structure for the Web service.

5.6.2 Create the WAR file

Since the Web service is a Web application, it must be packaged in a Web Archive (WAR) file. The WAR file can be created using the *war* Ant task or the *jar* command-line tool. An example call to the *war* Ant task is given below.

```

<war warfile="dsreceiver.war" webxml="${conf.dir}/web.xml">
  <webinf dir="${conf.dir}">
    <include name="sun-*.xml"/>
  </webinf>
  <classes dir="${classes.dir}">
    <include name="**/*.class"/>
  </classes>
  <classes dir="${conf.dir}">
    <include name="server-security-env.properties" />
  </classes>
  <zipfileset dir="${wsdl.dir}" prefix="WEB-INF/wsdl">
    <include name="*.wsdl"/>
    <include name="*.xsd"/>
  </zipfileset>

```

```
<zipfileset dir="{security.dir}" prefix="WEB-INF/classes/META-INF">
  <include name="*.jks" />
</zipfileset>
</war>
```

5.7 Deploy the Web service

5.7.1 Install Metro on the server

Appendix B: contains instructions and notes on installing Metro on the server. It has specific details on Glassfish, which is Sun's Open Source Java EE reference implementation.

5.7.2 Deploy the WAR file

Deploying the Web service will depend on the chosen server software. Read the server's user guide on how to deploy a Web application.

Several Java servers have an auto-deploy or hot deploy feature. The server will automatically deploy WAR files copied to a particular directory. For Glassfish, this directory is: `$AS_HOME/domains/domain1/autodeploy` for the default domain. Copy the WAR file created in section 5.6.2 to the auto-deploy directory.

5.7.3 Accessing the Web service

The Web service should be available at: `http://<host>:<port>/<application name>`, where the `<application name>` matches the prefix of the WAR file. For example, if the `dsreceiver.war` file was deployed on a server XYZ running on port 8080, the URL would be `http://XYZ:8080/dsreceiver`.

The Web service's WSDL is available by appending a `"?wsdl"` on the service's URL, e.g. `http://XYZ:8080/dsreceiver?wsdl`. In the published WSDL, the server will automatically replace the dummy value for the address in the original WSDL (namely `"http://dummy.example.com"`) with the actual address of the service.

Appendix A: References

- [EJBICA] EJBICA, *EJBICA – The Java EE Certificate Authority*, <http://ejbca.sourceforge.net>.
- [GIIWS2007] NEHTA, *Guidelines for Implementing Interoperable Web Services*, version 1.0, 28 March 2007.
- [HANDLER] Sun Microsystems, *Metro 1.4 FCS – Handler*, <https://metro.dev.java.net/nonav/1.4/docs/handlers.html>.
- [JCA] Sun Microsystems, *Java Cryptography Architecture (JCA)*, <http://java.sun.com/javase/6/docs/technotes/guides/security/crypto/CryptoSpec.html>.
- [JAXB] Sun Microsystems, *Java Architecture for XML Binding (JAXB)*, <https://jaxb.dev.java.net>.
- [JAXWS] Sun Microsystems, *Java API for XML Web Services (JAX-WS)*, <https://jax-ws.dev.java.net>.
- [JSR224] JCP, *Java API for XML-Based Web Services*, 2.0, JSR-000224, <http://jcp.org/aboutJava/communityprocess/pfd/jsr224/>.
- [JSR222] JCP, *Java API for XML Binding*, 2.0, JSR-000222, <http://jcp.org/aboutJava/communityprocess/pfd/jsr222/>.
- [KEYTOOL] Sun Microsystems, *keytool - Key and Certificate Management Tool*, <http://java.sun.com/javase/6/docs/technotes/tools/windows/keytool.html>.
- [METRO] Sun Microsystems, *Metro*, <https://metro.dev.java.net>.
- [NDS2006] NEHTA, *National Discharge Summary: Data Content Specifications*, version 1.0, 21 December 2006.
- [NIF2006] NEHTA, *Interoperability Framework*, version 1.0, 1 April 2006.
- [OPENSSL] OpenSSL, *OpenSSL: The Open Source toolkit for SSL/TLS*, <http://www.openssl.org>.
- [PING] Muus, *The Story of the PING Program*, <http://ftp.arl.mil/~mike/ping.html>.
- [PKCS1999] RSA Laboratories, *PKCS 12: Personal Information Exchange Syntax*, version 1.0, 24 June 1999, <ftp://ftp.rsasecurity.com/pub/pkcs/pkcs-12/pkcs-12v1.pdf>.
- [SUNWEBAPP] Sun Microsystems, *Sun Java System Application Server 9.1: sun-web-app*, <http://docs.sun.com/app/docs/doc/819-3673/6n5sk1due?a=view#indexterm-467>.
- [SUNWEBXML] Sun Microsystems, *Sun Java System Application Server 9.1: The sun-web.xml File*, <http://docs.sun.com/app/docs/doc/819-3673/6n5sk1d5a?a=view#beaql>.
- [TAIS2006] NEHTA, *Technical Architecture for Implementing Services: Concepts and Patterns*, version 1.0, 21 December 2006.
- [WCF] Microsoft, *Windows Communication Foundation (WCF)*, <http://netfx3.com/content/WCFHome.aspx>.
- [WSAM2007] W3C, *Web Services Addressing 1.0 – Metadata*, W3C Recommendation, 4 September 2007, <http://www.w3.org/TR/2007/REC-ws-addr-metadata-20070904>.

- [WSE] Microsoft, *Web Services Enhancements (WSE)*, <http://msdn2.microsoft.com/en-us/webservices/aa740663.aspx>.
- [WSIMPORT] Sun Microsystems, *Java API for XML Web Services (JAX-WS) – wsimport*, version 2.1, revision 1.1, <https://jax-ws.dev.java.net/nonav/2.1/docs/wsimport.html>.
- [WSIT] Sun Microsystems, *Web Services Interoperability Technologies (WSIT)*, <https://wsit.dev.java.net/>.
- [WSP2008] NEHTA, *Web Services Profile*, version 3.0, 1 September 2008.
- [WSPL2007] W3C, *Web Services Policy 1.5 – Framework*, W3C Recommendation, 4 September 2007, <http://www.w3.org/TR/2007/REC-ws-policy-20070904>.
- [WSS2006] OASIS, *Web Services Security: SOAP Message Security 1.1*, OASIS Standard, 1 February 2006, <http://www.oasis-open.org/committees/download.php/16790/wss-v1.1-spec-os-SOAPMessageSecurity.pdf>.
- [WSSP2006] NEHTA, *Web Services Standards Profile*, version 2.0, 20 November 2006.
- [WSSPL2007] OASIS, *WS-SecurityPolicy 1.2*, OASIS Standard, 1 July 2007, <http://docs.oasis-open.org/ws-sx/ws-securitypolicy/v1.2/ws-securitypolicy.pdf>.
- [XSD2004] W3C, *XML Schema Part 1: Structures*, W3C Recommendation, 28 October 2004, <http://www.w3.org/TR/2004/REC-xmlschema-1-20041028/>.

Appendix B: Installation

B.1 Java Development Kit

1. Download and install JDK 6 Update 4 or later.

URL: <http://java.sun.com/javase/downloads/index.jsp>

<JDK_HOME> will be used in this document to refer to the root directory of the JDK installation.

<JRE_HOME> will be used in this document to refer to <JDK_HOME>/jre.

2. Add <JDK_HOME>/bin to the path.
3. Create a JAVA_HOME environment variable pointing to <JDK_HOME>.

B.2 Java Cryptography Extension Unlimited Strength Jurisdiction Policy Files

The Java Cryptography Extension (JCE) provides cryptography services in the JDK. The JCE policy files in the JDK download are limited in strength due to the import control restrictions for some countries. The “unlimited strength” capabilities are enabled by installing certain policy files into the JRE.

1. Download the JCE Unlimited Strength Jurisdiction Policy Files for the installed JDK version.

URL: <http://java.sun.com/javase/downloads/index.jsp>

2. Unpack the downloaded zip file.
3. Copy the two JAR files (*local_policy.jar* and *US_export_policy.jar*) to the <JRE_HOME>/lib/security directory.

Overwrite the existing JAR files in the directory.

B.3 Ant

Ant is a Java-based build tool. Metro comes with Ant scripts to simplify its installation. To use these scripts, the Ant tool must be installed.

1. Download Ant 1.7.0 or later.

URL: <http://ant.apache.org/bindownload.cgi>

2. Unpack the downloaded zip file to the desired location.

<ANT_HOME> will be used in this document to refer to the root directory of Ant.

3. Add <ANT_HOME>/bin to the path.

B.4 Metro

1. Download *Metro 1.4*.

URL: <https://metro.dev.java.net/1.4/>

2. Unpack the downloaded JAR file with the command: `java -jar metro-installer.jar`

A dialog box for the license agreement will appear. Read this license agreement. The *Accept* button will only be enabled when the scroll bar reaches the bottom.

If you accept the license agreement, the files will be unpacked to a *metro* sub-directory within the directory containing the Metro installation JAR file.

3. Move the *metro* directory to the desired location.

`<METRO_HOME>` will be used in this document to refer to this *metro* directory.

JDK 6 Update 4 includes an older version of the JAX-WS reference implementation than the version of Metro 1.4. However, the API jars provided with JDK 6 Update 4 are compatible with those in Metro 1.4.

B.5 Servlet container

This section describes in general terms setting up a servlet container to host a Metro Web service. How these steps are carried out will depend on the server software.

1. Install the server software.
2. Install *Metro 1.4* on the server.

This step involves making the server load the JAR files in the *lib* directory of the Metro installation. For instance, for some server software, this step involves copying the Metro JAR files to the server's own *lib* directory.

3. Turn off capture stack trace feature of Metro by setting the following System property: `com.sun.xml.ws.fault.SOAPFaultBuilder.disableCaptureStackTrace=true`

If the capture stack trace feature is turned on, which it is by default, when a fault or exception occurs, Metro will place the stack trace of the fault or exception in the `Details` element of the SOAP fault message that is returned to the client. This feature is undesirable for two reasons.

It exposes the Web service to unknown clients.

It causes interoperability issues with Microsoft WCF clients. WCF expects only one child element within the `Details` element of a SOAP fault. When a fault is raised and the capture stack trace feature is turned on, Metro will place 2 child elements within the `Details` element: one for the fault (whose structure is defined in the WSDL) and another for the stack trace. WCF clients then cannot recognise the fault that was returned. Another exception about the SOAP fault being invalid will be raised on the client.

B.6 Glassfish

This section explains how to do the steps described in the previous section in terms of Glassfish, Sun's Java Open Source EE reference implementation.

To install the server software:

1. Download Glassfish V2 UR2 or later.

URL: <http://java.sun.com/javaee/downloads/index.jsp>

2. Run the downloaded file by double-clicking on it.

A wizard should step you through the installation process, such as selecting the directory to install in and the ports to use.

`<AS_HOME>` will be used in this document to refer to the root directory of Glassfish.

3. Read the Quick Start Guide at: `<AS_HOME>/docs/QuickStart.html` on starting and stopping the server.

The following steps will install Metro on a Glassfish server:

1. Create an `AS_HOME` environment variable pointing to `<AS_HOME>`.
2. Run in the `<METRO_HOME>` directory: `ant -f wsit-on-glassfish.xml install`

This command copies the `webservices-rt.jar` and `webservices-tools.jar` files from the `<METRO_HOME>/lib` directory to the `<AS_HOME>/lib` directory.

It also copies the `webservices-api.jar` file from the `<METRO_HOME>/lib` directory to the `<AS_HOME>/lib/endorsed` directory.

To turn off the capture stack trace feature of Metro, do the steps described in the next section for the property: `com.sun.xml.ws.fault.SOAPFaultBuilder.disableCaptureStackTrace=true`.

B.6.1 Specify System properties

1. Start the application server if it is not running.
2. Log into the *Admin Console* for the application server.
3. Click on the *Application Server* link in the left-hand frame.
4. Click on the *JVM Settings* tab in the right-hand frame.
5. Click on the *JVM Options* tab.
6. For each system property, click on the *Add JVM Option* button and in the empty *Value* text field that appears, type in the `-D` option and then the property, e.g.:
`-DpropertyName=propertyValue`
7. Click on the *Save* button. The application server has to be re-started for it to recognise the changes.

Appendix C: Key management

The term, *key store*, has 2 meanings in Java depending on the context. The first meaning refers to files containing security tokens, such as certificates and private keys. It is used in relation to general security tools and APIs. The second meaning is more specific, referring to the file containing an entity's own certificate and private key. It is differentiated from a *trust store*, which refers to the file containing other entities' public certificates. It is used in relation to Web service and SSL (Secure Sockets Layer) APIs. This appendix section uses the first meaning.

C.1 Key store types

The standard Java distribution supports 3 key store types:

- PKCS #12
 - PKCS #12 belongs to the Public-Key Cryptography Standards (PKCS) group of specifications developed by RSA Laboratories. PKCS #12 is a standard format for storing and transferring identity information, such as certificates and private keys [PKCS1999].
 - The standard name for this key store type is *pkcs12*.
- Java Key Store (JKS)
 - JKS is a proprietary Java format for storing security tokens [JCA].
 - The standard name for this key store type is *jks*.
- Java Cryptography Extension Key Store (JCEKS)
 - JCEKS is another proprietary Java format, but it has stronger protection for private keys than JKS [JCA].
 - The standard name for this key store type is *jceks*.

Other key store types can be supported in Java using the extensible mechanisms of the Java Cryptography Architecture (JCA) [JCA].

C.2 Tools

The Java Development Kit (JDK) comes with a *keytool* command-line tool for managing keys and certificates [KEYTOOL]. This tool is found in the `<JDK_HOME>/bin` directory. It allows you to create key stores, import certificates into the key stores, list the keys in a key store, create self-signed certificates and more. Read the documentation for the *keytool* tool for the installed JDK. The functionality and command-line arguments for the tool can differ between JDK versions.

There are also open source tools, like openSSL [OPENSSL] and EJBCA [EJBCA], which allows you to create keys and certificates.

Appendix D: Debugging

This appendix contains some hints about debugging Web services.

An important first step to debugging Web service problems is to identify the failure point.

- *Was a SOAP request sent by the client?* If not, there could be problems with the client-side configuration. For example, the key store's password can be wrong.
- *Did the SOAP request reach the Web service implementation class?* If not, the server might have problems with the SOAP request. For example, the request can be encrypted with a certificate that the server does not have a private key for.
- *Was a SOAP response sent by the server?* If not, the server-side configuration might have errors. For example, the server cannot find the encryption key for the client.

Although the error messages will help indicate the problems, there are additional mechanisms to further identify the failure point.

D.1 Use a SOAP handler

SOAP handlers are a programmatic mechanism that provides access to SOAP messages before they are sent and after they are received [HANDLER]. The SOAP handler mechanism is one way to see the incoming and outgoing SOAP messages for Metro clients and services.

The code below provides an example of a SOAP handler that logs incoming and outgoing SOAP messages.

```
package com.example.common;

import java.io.ByteArrayOutputStream;
import java.io.IOException;
import java.util.Set;
import java.util.logging.Level;
import java.util.logging.Logger;
import javax.xml.namespace.QName;
import javax.xml.soap.SOAPException;
import javax.xml.soap.SOAPMessage;
import javax.xml.ws.handler.MessageContext;
import javax.xml.ws.handler.soap.SOAPHandler;
import javax.xml.ws.handler.soap.SOAPMessageContext;

public class LoggingHandler implements SOAPHandler<SOAPMessageContext> {

    private static final Logger LOG = Logger.getLogger(LoggingHandler.class
        .getName());

    public boolean handleMessage(SOAPMessageContext context) {
        try {
            if (isOutboundMessage(context)) {
                LOG.info("Outgoing message: ");
            }
            else {
                LOG.info("Incoming message: ");
            }
            LOG.info(getSOAPXML(context.getMessage()));
        }
        catch (Exception e) {
            // Handle exception
        }
        return true;
    }

    public boolean handleFault(SOAPMessageContext context) {
        try {
            if (isOutboundMessage(context)) {
                LOG.info("Outgoing fault: ");
            }
        }
    }
}
```

```

        else {
            LOG.info("Incoming fault: ");
        }
        LOG.info(getSOAPXML(context.getMessage()));
    }
    catch (Exception e) {
        // Handle exception
    }
    return true;
}

... // Empty implementations of methods for the SOAPHandler interface

private String getSOAPXML(SOAPMessage message) throws Exception {
    ByteArrayOutputStream out = new ByteArrayOutputStream();
    message.writeTo(out);
    out.flush();
    return new String(out.toByteArray());
}

private boolean isOutboundMessage(MessageContext context) {
    Boolean result = (Boolean) context
        .get(MessageContext.MESSAGE_OUTBOUND_PROPERTY);
    return result.booleanValue();
}
}

```

On the client-side SOAP handlers are declared in a binding file that is passed to the *wsimport* tool using the *binding* attribute. The example below shows a *wsimport* call that provides a binding file called *handlers.xml*.

```

<wsimport wsdl="wsdl/DischargeSummaryReceiver.wsdl"
  wsdllocation="DischargeSummaryReceiver.wsdl"
  package="com.example.ds.client"
  destdir="gen/classes"
  keep="true"
  sourcedestdir="gen/src"
  extension="true"
  binding="handlers.xml"/>

```

The contents of the *handlers.xml* binding file are shown in the example below. It declares the use of the logging SOAP handler.

```

<bindings xmlns="http://java.sun.com/xml/ns/jaxws"
  xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
  wsdlLocation="DischargeSummaryReceiver.wsdl">
  <bindings node="wsdl:definitions">
    <jws:handler-chains xmlns:jws="http://java.sun.com/xml/ns/javaee">
      <jws:handler-chain>
        <jws:handler>
          <jws:handler-class>com.example.common.LoggingHandler</jws:handler-class>
        </jws:handler>
      </jws:handler-chain>
    </jws:handler-chains>
  </bindings>
</bindings>

```

On the server-side, SOAP handlers are declared in the *sun-jaxws.xml* configuration file, which was described in section 5.5.1. The example below shows the declaration of the logging SOAP handler in the *sun-jaxws.xml* file.

```

<endpoints xmlns="http://java.sun.com/xml/ns/jax-ws/ri/runtime" version="2.0">
  <endpoint ... >
    <jws:handler-chains xmlns:jws="http://java.sun.com/xml/ns/javaee">
      <jws:handler-chain>
        <jws:handler>
          <jws:handler-class>com.example.common.LoggingHandler</jws:handler-class>
        </jws:handler>
      </jws:handler-chain>
    </jws:handler-chains>
  </endpoint>
</endpoints>

```

D.2 Use an HTTP tool

A SOAP handler will only provide access to unsecured messages (e.g. without signatures and encryption). An HTTP debugging proxy tool or an HTTP monitor can be used to see the SOAP messages that are actually sent back and forth between client and server.

To send SOAP messages to an HTTP proxy tool, set the `http.proxyHost` and `http.proxyPort` system properties to the proxy's host and port when running the client application.

Note If the Web service URL uses `localhost` as the host name, Metro does not route the SOAP messages through the specified proxy. To use a debugging proxy tool when the client and server are on the same machine, use another way of referring to the machine, such as the IP address or the computer name in Windows, in the Web service URL.

D.3 View server logs

The error message in the SOAP fault that is returned to the client might not indicate the root cause of the error. Remember to check the server logs for more detailed information. The server log for Glassfish's default domain is at: `<AS_HOME>/domains/domain1/logs/server.log`