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Artix 5.6.4

Developing Artix® Applications with JAX-WS and JAX-RS

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Preface

What is Covered in This Book

This book describes:

- How to use the JAX-WS 2.1 APIs to develop applications with Artix
- How to use the JAX-RS 2.0 APIs to develop RESTful services

Who Should Read This Book

This book is intended for developers using Artix. It assumes that you have a good understanding of the following:

- General programming concepts.
- General SOA concepts.
- Java 6.
- The runtime environment into which you are deploying services.

How to Use This Book

This book is organized into the following parts:

- Part I describes how to develop SOA applications without using WSDL documents.
- Part II describes how to develop SOA applications using a WSDL document as a starting point.
- Part III describes how to use the Artix API's annotations to create RESTful services.
- Part IV describes common development tasks including how to publish a service using a standalone Java application.
- Part V describes how XML Schema data definitions are mapped into Java for use in developing services.
- *Developing Asynchronous Applications* describes how to develop service consumers that can interact with service providers asynchronously.
- *Using Raw XML Messages* describes how to use the `Dispatch` and `Provider` interfaces to develop applications that work with raw XML instead of JAXB objects.

- *Working with Contexts* describes how to manipulate message and transport properties programmatically.

The Artix Documentation Library

For information on the organization of the Artix library, the document conventions used, and where to find additional resources, see ***Using the Artix Library***.

Further Information and Product Support

Additional technical information or advice is available from several sources.

The product support pages contain a considerable amount of additional information, such as:

- The WebSync service, where you can download fixes and documentation updates.
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Part I

Starting from Java Code

One of the advantages of JAX-WS is that it does not require you to start with a WSDL document that defines their service. You can start with Java code that defines the features you want to expose as services. The code may be a class, or classes, from a legacy application that is being upgraded. It may also be a class that is currently being used as part of a non-distributed application and implements features that you want to use in a distributed manner. You annotate the Java code and generate a WSDL document from the annotated code. If you do not wish to work with WSDL at all, you can create the entire application without ever generating WSDL.

In this part

This part contains the following chapters:

Bottom-Up Service Development
Developing a Consumer Without a WSDL Contract

Bottom-Up Service Development

There are many instances where you have Java code that already implements a set of functionality that you want to expose as part of a service oriented application. You may also simply want to avoid using WSDL to define your interface. Using JAX-WS annotations, you can add the information required to service enable a Java class. You can also create a Service Endpoint Interface (SEI) that can be used in place of a WSDL contract. If you want a WSDL contract, Artix provides tools to generate a contract from annotated Java code.

To create a service starting from Java you must do the following:

1. Create a Service Endpoint Interface (SEI) that defines the methods you want to expose as a service.

NOTE: You can work directly from a Java class, but working from an interface is the recommended approach. Interfaces are better suited for sharing with the developers who are responsible for developing the applications consuming your service. The interface is smaller and does not provide any of the service's implementation details.

2. Add the required annotations to your code.
3. Generate the WSDL contract for your service.

TIP: If you intend to use the SEI as the service's contract, it is not necessary to generate a WSDL contract.

4. Publish the service as a service provider.

Creating the SEI

The *service endpoint interface* (SEI) is the piece of Java code that is shared between a service implementation and the consumers that make requests on that service. The SEI defines the methods implemented by the service and provides details about how the service will be exposed as an endpoint. When starting with a WSDL contract, the SEI is generated by the code generators. However, when starting from Java, it is the developer's responsibility to create the SEI.

There are two basic patterns for creating an SEI:

- Green field development — In this pattern, you are developing a new service without any existing Java code or WSDL. It is best to start by creating the SEI. You can then distribute the

SEI to any developers that are responsible for implementing the service providers and consumers that use the SEI.

NOTE: The recommended way to do green field service development is to start by creating a WSDL contract that defines the service and its interfaces. See Part II.

- Service enablement — In this pattern, you typically have an existing set of functionality that is implemented as a Java class, and you want to service enable it. This means that you must do two things:

  1. Create an SEI that contains only the operations that are going to be exposed as part of the service.
  2. Modify the existing Java class so that it implements the SEI.

Writing the interface

The SEI is a standard Java interface. It defines a set of methods that a class implements. It can also define a number of member fields and constants to which the implementing class has access.

In the case of an SEI the methods defined are intended to be mapped to operations exposed by a service. The SEI corresponds to a `wsdl:portType` element. The methods defined by the SEI correspond to `wsdl:operation` elements in the `wsdl:portType` element.

TIP: JAX-WS defines an annotation that allows you to specify methods that are not exposed as part of a service. However, the best practice is to leave those methods out of the SEI.

Example 1 shows a simple SEI for a stock updating service.

Example 1. Simple SEI

```
package com.iona.demo;

public interface quoteReporter
{
  public Quote getQuote(String ticker);
}
```

Implementing the interface

Because the SEI is a standard Java interface, the class that implements it is a standard Java class. If you start with a Java class you must modify it to implement the interface. If you start with the SEI, the implementation class implements the SEI.

Example 2 shows a class for implementing the interface in Example 1.

Example 2. Simple Implementation Class

```
package com.iona.demo;

import java.util.*;

public class stockQuoteReporter implements quoteReporter
{
   ...
  public Quote getQuote(String ticker)
  {
    Quote retVal = new Quote();
    retVal.setID(ticker);
    retVal.setVal(Board.check(ticker));
    Date retDate = new Date();
    retVal.setTime(retDate.toString());
    return(retVal);
  }
}
```

(`Board` is an assumed class whose implementation is left to the reader.)

Annotating the Code

JAX-WS relies on the annotation feature of Java 6. The JAX-WS annotations specify the metadata used to map the SEI to a fully specified service definition. Among the information provided in the annotations are the following:

- The target namespace for the service.
- The name of the class used to hold the request message
- The name of the class used to hold the response message
- If an operation is a one way operation
- The binding style the service uses
- The name of the class used for any custom exceptions
- The namespaces under which the types used by the service are defined

TIP: Most of the annotations have sensible defaults and it is not necessary to provide values for them. However, the more information you provide in the annotations, the better your service definition is specified. A well-specified service definition increases the likelihood that all parts of a distributed application will work together.

Required Annotations

In order to create a service from Java code you are only required to add one annotation to your code. You must add the `@WebService` annotation on both the SEI and the implementation class.

The @WebService annotation

The `@WebService` annotation is defined by the `javax.jws.WebService` interface and it is placed on an interface or a class that is intended to be used as a service. `@WebService` has the properties described in Table 1.

Table 1. @WebService Properties

Property	Description
name	Specifies the name of the service interface. This property is mapped to the `name` attribute of the `wsdl:portType` element that defines the service's interface in a WSDL contract. The default is to append `PortType` to the name of the implementation class. [a]
targetNamespace	Specifies the target namespace where the service is defined. If this property is not specified, the target namespace is derived from the package name.
serviceName	Specifies the name of the published service. This property is mapped to the `name` attribute of the `wsdl:service` element that defines the published service. The default is to use the name of the service's implementation class. [a]
wsdlLocation	Specifies the URL where the service's WSDL contract is stored. This must be specified using a relative URL. The default is the URL where the service is deployed.
endpointInterface	Specifies the full name of the SEI that the implementation class implements. This property is only specified when the attribute is used on a service implementation class.
portName	Specifies the name of the endpoint at which the service is published. This property is mapped to the `name` attribute of the `wsdl:port` element that specifies the endpoint details for a published service. The default is the append `Port` to the name of the service's implementation class. (When you generate WSDL from an SEI the interface's name is used in place of the implementation class' name.)

TIP: It is not necessary to provide values for any of the `@WebService` annotation's properties. However, it is recommended that you provide as much information as you can.

Annotating the SEI

The SEI requires that you add the `@WebService` annotation. Because the SEI is the contract that defines the service, you should specify as much detail as possible about the service in the `@WebService` annotation's properties.

Example 3 shows the interface defined in Example 1 with the `@WebService` annotation.

Example 3. Interface with the @WebService Annotation

```
package com.iona.demo;

import javax.jws.*;

@WebService(name="quoteUpdater", ❶
       targetNamespace="http://demos.iona.com", ❷
       serviceName="updateQuoteService", ❸
       wsdlLocation="http://demos.iona.com/quoteExampleService?wsdl", ❹
       portName="updateQuotePort") ❺
public interface quoteReporter
{
  public Quote getQuote(String ticker);
}
```

The `@WebService` annotation in Example 3 does the following:

❶ Specifies that the value of the `name` attribute of the `wsdl:portType` element defining the service interface is `quoteUpdater`.

❷ Specifies that the target namespace of the service is `http:\\demos.iona.com`.

❸ Specifies that the value of the `name` of the `wsdl:service` element defining the published service is `updateQuoteService`.

❹ Specifies that the service will publish its WSDL contract at `http:\\demos.iona.com\quoteExampleService?wsdl`.

❺ Specifies that the value of the `name` attribute of the `wsdl:port` element defining the endpoint exposing the service is `updateQuotePort`.

Annotating the service implementation

In addition to annotating the SEI with the `@WebService` annotation, you also must annotate the service implementation class with the `@WebService` annotation. When adding the annotation to the service implementation class you only need to

specify the endpointInterface property. As shown in Example 4 the property must be set to the full name of the SEI.

Example 4. Annotated Service Implementation Class

```
package org.eric.demo;

import javax.jws.*;


@WebService(endpointInterface="com.iona.demo.quoteReporter")
public class stockQuoteReporter implements quoteReporter
{
  public Quote getQuote(String ticker)
  {
  ...
  }
}
```

Optional Annotations

While the `@WebService` annotation is sufficient for service enabling a Java interface or a Java class, it does not fully describe how the service will be exposed as a service provider. The JAX-WS programming model uses a number of optional annotations for adding details about your service, such as the binding it uses, to the Java code. You add these annotations to the service's SEI.

NOTE: The more details you provide in the SEI the easier it is for developers to implement applications that can use the functionality it defines. It also makes the WSDL documents generated by the tools more specific.

Defining the Binding Properties with Annotations

If you are using a SOAP binding for your service, you can use JAX-WS annotations to specify a number of the bindings properties. These properties correspond directly to the properties you can specify in a service's WSDL contract. Some of the settings, such as the parameter style, can restrict how you implement a method. These settings can also effect which annotations can be used when annotating method parameters.

The @SOAPBinding annotation

The `@SOAPBinding` annotation is defined by the

`javax.jws.soap.SOAPBinding` interface. It provides details about the SOAP binding used by the service when it is deployed. If the `@SOAPBinding` annotation is not specified, a service is published using a wrapped doc/literal SOAP binding.

You can put the `@SOAPBinding` annotation on the SEI and any of the SEI's methods. When it is used on a method, setting of the method's `@SOAPBinding` annotation take precedence.

Table 2 shows the properties for the `@SOAPBinding` annotation.

Table 2. @SOAPBinding Properties

Property	Values	Description
style	`Style.DOCUMENT` (default) `Style.RPC`	Specifies the style of the SOAP message. If `RPC` style is specified, each message part within the SOAP body is a parameter or return value and appears inside a wrapper element within the `soap:body` element. The message parts within the wrapper element correspond to operation parameters and must appear in the same order as the parameters in the operation. If `DOCUMENT` style is specified, the contents of the SOAP body must be a valid XML document, but its form is not as tightly constrained.
use	`Use.LITERAL` (default) `Use.ENCODED`	Specifies how the data of the SOAP message is streamed. (Use.ENCODED is not currently supported.)
parameterStyle	`ParameterStyle.BARE` `ParameterStyle.WRAPPED` (default)	Specifies how the method parameters, which correspond to message parts in a WSDL contract, are placed into the SOAP message body. If `BARE` is specified, each parameter is placed into the message body as a child element of the message root. If `WRAPPED` is specified, all of the input parameters are wrapped into a single element on a request message and all of the output parameters are wrapped into a single element in the response message. If you set the style to RPC you must use the WRAPPED parameterStyle.

Document bare style parameters

Document bare style is the most direct mapping between Java code and the resulting XML representation of the service. When using this style, the schema types are generated directly from the input and output parameters defined in the operation's parameter list.

You specify that you want to use bare document/literal style by using the `@SOAPBinding` annotation with its style property set to `Style.DOCUMENT`, and its parameterStyle property set to `ParameterStyle.BARE`.

To ensure that an operation does not violate the restrictions of using document style when using bare parameters, your operations must adhere to the following conditions:

- The operation must have no more than one input or input/output parameter.
- If the operation has a return type other than void, it must not have any output or input/output parameters.
- If the operation has a return type of void, it must have no more than one output or input/output parameter.

NOTE: Any parameters that are placed in the SOAP header using the `@WebParam` annotation or the `@WebResult` annotation are not counted against the number of allowed parameters.

Document wrapped parameters

Document wrapped style allows a more RPC like mapping between the Java code and the resulting XML representation of the service. When using this style, the parameters in the method's parameter list are wrapped into a single element by the binding. The disadvantage of this is that it introduces an extra-layer of indirection between the Java implementation and how the messages are placed on the wire.

To specify that you want to use wrapped document\literal style use the `@SOAPBinding` annotation with its style property set to `Style.DOCUMENT`, and its parameterStyle property set to `ParameterStyle.WRAPPED`.

You have some control over how the wrappers are generated by using the `@RequestWrapper` annotation and the `@ResponseWrapper` annotation.

Example

Example 5 shows an SEI that uses document bare SOAP messages.

Example 5. Specifying a Document Bare SOAP Binding with the SOAP Binding Annotation

```
package org.eric.demo;

import javax.jws.*;
import javax.jws.soap.*;
import javax.jws.soap.SOAPBinding.*;

@WebService(name="quoteReporter")
@SOAPBinding(parameterStyle=ParameterStyle.BARE)
public interface quoteReporter
{
  ...
}
```

Defining Operation Properties with Annotations

When the runtime maps your Java method definitions into XML operation definitions it provides details such as:

- What the exchanged messages look like in XML
- If the message can be optimized as a one way message
- The namespaces where the messages are defined

The @WebMethod annotation The `@WebMethod` annotation is defined by the `javax.jws.WebMethod` interface. It is placed on the methods in the SEI. The `@WebMethod` annotation provides the information that is normally represented in the `wsdl:operation` element describing the operation to which the method is associated.

Table 3 describes the properties of the `@WebMethod` annotation.

Table 3. @WebMethod Properties

Property	Description
operationName	Specifies the value of the associated `wsdl:operation` element's `name`. The default value is the name of the method.
action	Specifies the value of the `soapAction` attribute of the `soap:operation` element generated for the method. The default value is an empty string.
exclude	Specifies if the method should be excluded from the service interface. The default is `false`.

The @RequestWrapper annotation

The `@RequestWrapper` annotation is defined by the `javax.xml.ws.RequestWrapper` interface. It is placed on the methods in the SEI. The `@RequestWrapper` annotation specifies the Java class implementing the wrapper bean for the method parameters of the request message starting a message exchange. It also specifies the element names, and namespaces, used by the runtime when marshaling and marshaling the request messages.

Table 4 describes the properties of the `@RequestWrapper` annotation.

Table 4. @RequestWrapper Properties

Property	Description
localName	Specifies the local name of the wrapper element in the XML representation of the request message. The default value is either the name of the method, or the value of the `@WebMethod` annotation's operationName property.
targetNamespace	Specifies the namespace under which the XML wrapper element is defined. The default value is the target namespace of the SEI.
className	Specifies the full name of the Java class that implements the wrapper element.

TIP: Only the className property is required.

IMPORTANT: If the method is also annotated with the `@SOAPBinding` annotation, and its parameterStyle property is set to `ParameterStyle.BARE`, this annotation is ignored.

The @ResponseWrapper annotation

The `@ResponseWrapper` annotation is defined by the `javax.xml.ws.ResponseWrapper` interface. It is placed on the methods in the SEI. The `@ResponseWrapper` specifies the Java class implementing the wrapper bean for the method parameters in the response message in the message exchange. It also specifies the element names, and namespaces, used by the runtime when marshaling and unmarshaling the response messages.

Table 5 describes the properties of the `@ResponseWrapper` annotation.

Table 5. @ResponseWrapper Properties

Property	Description
localName	Specifies the local name of the wrapper element in the XML representation of the response message. The default value is either the name of the method with Response appended, or the value of the @WebMethod annotation's operationName property with Response appended.
targetNamespace	Specifies the namespace where the XML wrapper element is defined. The default value is the target namespace of the SEI.
className	Specifies the full name of the Java class that implements the wrapper element.

TIP: Only the className property is required.

IMPORTANT: If the method is also annotated with the `@SOAPBinding` annotation, and its parameterStyle property is set to `ParameterStyle.BARE`, this annotation is ignored.

The @WebFault annotation

The `@WebFault` annotation is defined by the `javax.xml.ws.WebFault` interface. It is placed on exceptions that are thrown by your SEI. The `@WebFault` annotation is used to map the Java exception to a `wsdl:fault` element. This information is used to marshal the exceptions into a representation that can be processed by both the service and its consumers.

Table 6 describes the properties of the `@WebFault` annotation.

Table 6. @WebFault Properties

Property	Description
name	Specifies the local name of the fault element. Note that the *name* property is required.
targetNamespace	Specifies the namespace under which the fault element is defined. The default value is the target namespace of the SEI.
faultName	Specifies the full name of the Java class that implements the exception.

The @Oneway annotation

The `@Oneway` annotation is defined by the `javax.jws.Oneway` interface. It is placed on the methods in the SEI that will not require a response from the service. The `@Oneway` annotation tells the run time that it can optimize the execution of the method by not waiting for a response and by not reserving any resources to process a response.

This annotation can only be used on methods that meet the following criteria:

- They return void
- They have no parameters that implement the `Holder` interface
- They do not throw any exceptions that can be passed back to a consumer

Example

Example 6 shows an SEI with its methods annotated.

Example 6. SEI with Annotated Methods

```
package com.iona.demo;

import javax.jws.*;
import javax.xml.ws.*;

@WebService(name="quoteReporter")
public interface quoteReporter
{
       @WebMethod(operationName="getStockQuote")
       @RequestWrapper(targetNamespace="http://demo.iona.com/types",
className="java.lang.String")
       @ResponseWrapper(targetNamespace="http://demo.iona.com/types",
className="org.eric.demo.Quote")
       public Quote getQuote(String ticker);
}
```

Defining Parameter Properties with Annotations

The method parameters in the SEI correspond to the `wsdl:message` elements and their `wsdl:part` elements. JAX-WS provides annotations that allow you to describe the `wsdl:part` elements that are generated for the method parameters.

The @WebParam annotation

The `@WebParam` annotation is defined by the `javax.jws.WebParam` interface.

It is placed on the parameters of the methods defined in the SEI. The `@WebParam` annotation allows you to specify the direction of the parameter, if the parameter will be placed in the SOAP header, and other properties of the generated `wsdl:part`.

Table 7 describes the properties of the `@WebParam` annotation.

Table 7. @WebParam Properties

Property	Values	Description
name		Specifies the name of the parameter as it appears in the generated WSDL document. For RPC bindings, this is the name of the `wsdl:part` representing the parameter. For document bindings, this is the local name of the XML element representing the parameter. Per the JAX-WS specification, the default is `argN`, where `N` is replaced with the zero-based argument index (i.e., arg0, arg1, etc.).
targetNamespace		Specifies the namespace for the parameter. It is only used with document bindings where the parameter maps to an XML element. The default is to use the service's namespace.
mode	`Mode.IN` (default) `Mode.OUT` `Mode.INOUT`	Specifies the direction of the parameter. Any parameter that implements the Holder interface is mapped to `Mode.INOUT` by default.
header	`false` (default) `true`	Specifies if the parameter is passed as part of the SOAP header.
partName		Specifies the value of the `name` attribute of the `wsdl:part` element for the parameter. This property is used for document style SOAP bindings.

The @WebResult annotation

The `@WebResult` annotation is defined by the `javax.jws.WebResult` interface. It is placed on the methods defined in the SEI. The `@WebResult` annotation allows you to specify the properties of the `wsdl:part` that is generated for the method's return value.

Table 8 describes the properties of the `@WebResult` annotation.

Table 8. @WebResult Properties

Property	Description
name	Specifies the name of the return value as it appears in the generated WSDL document. For RPC bindings, this is the name of the `wsdl:part` representing the return value. For document bindings, this is the local name of the XML element representing the return value. The default value is `return`.
targetNamespace	Specifies the namespace for the return value. It is only used with document bindings where the return value maps to an XML element. The default is to use the service's namespace.
header	Specifies if the return value is passed as part of the SOAP header.
partName	Specifies the value of the `name` attribute of the `wsdl:part` element for the return value. This property is used for document style SOAP bindings.

Example

Example 7 shows an SEI that is fully annotated.

Example 7. Fully Annotated SEI

```
package com.iona.demo;

import javax.jws.*;
import javax.xml.ws.*;
import javax.jws.soap.*;
import javax.jws.soap.SOAPBinding.*;
import javax.jws.WebParam.*;

@WebService(targetNamespace="http://demo.iona.com",
       name="quoteReporter")
@SOAPBinding(style=Style.RPC, use=Use.LITERAL)
public interface quoteReporter
{
   @WebMethod(operationName="getStockQuote")
   @RequestWrapper(targetNamespace="http://demo.iona.com/types",
          className="java.lang.String")
   @ResponseWrapper(targetNamespace="http://demo.iona.com/types",
          className="org.eric.demo.Quote")
   @WebResult(targetNamespace="http://demo.iona.com/types",
          name="updatedQuote")
   public Quote getQuote(
          @WebParam(targetNamespace="http://demo.iona.com/types",
             name="stockTicker",
             mode=Mode.IN)
          String ticker
   );
}
```

Annotations added in Artix 5.6

Artix 5.6 adds the following new annotations:

- @WSDLDocumentation
- @SchemaValidation
- @DataBinding
- @GZIP
- @FastInfoset
- @Logging
- @EndpointProperty
- @Policy

The @WSDLDocumentation annotation

The `@WSDLDocumentation` annotation is intended for "java first" scenarios where the WSDL is derived from the Java interfaces/code. The `@WSDLDocumentation` annotations allow for adding `wsd:documentation` elements to various locations in the generated WSDL.

Example

Example 8 shows an `@WSDLDocumentation` annotation.

Example 8. An @WSDLDocumentation annotation

```
@WebService
@WSDLDocumentationCollection(
   {
     @WSDLDocumentation("My portType documentation"),
     @WSDLDocumentation(value = "My top level documentation",
     placement = WSDLDocumentation.Placement.TOP),
     @WSDLDocumentation(value = "My binding doc", placement =
     WSDLDocumentation.Placement.BINDING)
   }
)
public interface MyService {
       @WSDLDocumentation("The docs for echoString")
       String echoString(String s);
       }
}
```

The @SchemaValidation annotation

The `@SchemaValidation` annotation turns on SchemaValidation for messages. By default, for performance reasons, Artix does not validate messages against the schema. By turning on validation, problems with messages not matching the schema are easier to determine.

The @DataBinding annotation

The `@DataBinding` annotation sets the DataBinding class associated with the service. By default, Artix assumes you are using the JAXB data binding. However, Artix supports different databindings such as XMLBeans, Aegis, and SDO. The `@DataBinding` annotation can be used in place of configuration to select the databinding class.

Example

Example 9 shows an `@DataBindings` annotation.

Example 9. An @DataBinding annotation

```
@DataBinding(org.apache.cxf.sdo.SDODataBinding.class)
public interface MyService {
      public commonj.sdo.DataObject echoStruct(
       commonj.sdo.DataObject struct
       );
}
```

The @GZIP annotation

The `@GZIP` annotation enables GZIP compression of on-the-wire data. The `@GZIP` annotation supports the following attribute:

Attribute	Description
threshold	The threshold under which messages are not gzipped.

GZIP is a negotiated annotation. An initial request from a client is not gzipped, but an Accept header is added and if the server supports GZIP. If the server supports GZIP, the response is gzipped, and any subsequent requests are as well.

The @FastInfoset annotation

The `@FastInfoset` annotation enables FastInfoset of on-the-wire data. The `@FastInfoset` annotation supports the following attribute:

Attribute	Description
force	Forces the use of fastinfoset instead of negotiating. The default is false.

FastInfoset is a negotiated enhancement. An initial request from a client is not in fastinfoset, but an Accept header is added and if the server supports fastinfoset. If the server supports fastinfoset, the response is in fastinfoset and any subsequent requests are as well.

The @Logging annotation

The `@Logging` annotation turns on logging for the endpoint. The `@Logging` annotation can be used to control the size limits of what gets logged as well as the location. The `@Logging` annotation supports the following attributes:

Attribute	Description

limit	Sets the size limit after which the message is truncated in the logs. The default is 64K.
inLocation	Sets the location to log incoming messages. Can be <stderr>, <stdout>, <logger>, or a file: URL. The default is <logger>.
outLocation	Sets the location to log outgoing messages. Can be <stderr>, <stdout>, <logger>, or a file: URL. The default is <logger>.

Example

Example 10 shows an `@Logging` annotation.

Example 10. An @Logging annotation

```
@Logging(limit=16000, inLocation="<stdout>")
public interface MyService {

       String echoString(String s);

}
```

The @EndpointProperty annotation

The `@EndpointProperty` annotation adds a property to an endpoint. Many items, such as WS-Security related settings, can be configured via endpoint properties. Traditionally, these are set via the <jaxws:properties> element on the <jaxws:endpoint> element in the spring config, but the `@EndpointProperty` annotation allows these properties to be configured into the code.

Example

Example 11 shows an `@EndpointProperty` annotation.

Example 11. An `@EndpointProperty` annotation

```
@WebService
@EndpointProperties(
       {
           @EndpointProperty(key = "my.property",
                  value="some value"),
           @EndpointProperty(key = "my.other.property",
                  value="some other value"),
           })
>public interface MyService {
       String echoString(String s);
}
```

The @Policy annotation

The `@Policy` is used to attach WS-Policy fragments to a service or operation.

The `@Policy` annotation supports the following attributes:

Attribute	Description
uri	REQUIRED. The location of the file containing the Policy definition.
includeInWSDL	Determines whether to include the policy in the generated WSDL when generating a wsdl. The default it true.
placement	Specifies where to place the policy.
faultClass	If placement is a FAULT, `faultClass` specifies which fault the policy would apply to.

Example

Example 12 shows an `@Policy` annotation.

Example 12. An @Policy annotation

```
@Policies({
    @Policy(uri = "annotationpolicies/TestInterfacePol icy.xml"),
    @Policy(uri = "annotationpolicies/TestImplPolicy.xml", placement =
            Policy.Placement.SERVICE_PORT),
   @Policy(uri = "annotationpolicies/TestPortTypePolicy.xml",
                       placement = Policy.Placement.PORT_TYPE)
}
)
@WebService
public static interface TestInterface {
    @Policies({
        @Policy(uri = "annotationpolicies/TestOperation Policy.xml"),
        @Policy(uri = "annotationpolicies/TestOperationInput Policy.xml",
                placement = Policy.Placement.BINDING_OPERATION_INPUT),
       @Policy(uri = "annotationpolicies/TestOperationOutput Policy.xml",
                placement = Policy.Placement.BINDING_OPERATION_OUTPUT),
        @Policy(uri = "annotationpolicies/TestOperationPT Policy.xml",
                placement = Policy.Placement.PORT_TYPE_OPERATION),
        @Policy(uri = "annotationpolicies/TestOperationPTIn putPolicy.xml",
                placement = Policy.Placement.PORT_TYPE_OPERATION_INPUT),
        @Policy(uri = "annotationpolicies/TestOperationPTOut putPolicy.xml",
                placement = Policy.Placement.PORT_TYPE_OPERATION_OUTPUT)
    }
    )
    int echoInt(int i);
}
```

Generating WSDL

Using the command line tool

Once your code is annotated, you can generate a WSDL contract for your service using the **java2ws** command's `-wsdl` flag. For a

detailed listing of options for the **java2ws** command see *java2ws* in ***Artix Java Runtime Command Reference***.

Using Ant

To call the WSDL generator from Ant use the **java** task to execute the `org.apache.cxf.tools.java2ws.JavaToWS` class and pass `-wsdl` as one of its arguments. Example 13 shows a sample Ant target that calls the WSDL generator.

Example 13. Calling the WSDL Generator from Ant

```
<project name="java2ws" basedir=".">
   <property name="fsf.home" location ="/usr/myapps/fsf-trunk"/>
   <property name="build.classes.dir" location ="${basedir}/build/classes"/>

   <path id="fsf.classpath">
      <pathelement location="${build.classes.dir}"/>
      <fileset dir="${fsf.home}/lib">
         <include name="*.jar"/>
      </fileset>
   </path>

   <target name="WSDLGen">
      <java classname="org.apache.cxf.tools.java2ws.JavaToWS" fork="true">
         <arg value="-wsdl"/>
         <arg value="service.Greeter"/>
         <classpath>
            <path refid="fsf.classpath"/>
         </classpath>
      </java>
   </target>
</project>
```

NOTE: You must set the Java task's fork to true.

Example

Example 14 shows the WSDL contract that is generated for the SEI shown in Example 7.

Example 14. Generated WSDL from an SEI

```
<?xml version="1.0" encoding="UTF-8"?>
<wsdl:definitions targetNamespace="http://demo.eric.org/"
          xmlns:tns="http://demo.eric.org/"
    xmlns:ns1=""
    xmlns:xsd="http://www.w3.org/2001/XMLSchema"
    xmlns:ns2="http://demo.eric.org/types"
    xmlns:soap="http://schemas.xmlsoap.org/wsdl/soap/"
    xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/">
  <wsdl:types>
    <xsd:schema>
      <xs:complexType name="quote">
        <xs:sequence>
          <xs:element name="ID" type="xs:string" minOccurs="0"/>
          <xs:element name="time" type="xs:string" minOccurs="0"/>
          <xs:element name="val" type="xs:float"/>
        </xs:sequence>
      </xs:complexType>
    </xsd:schema>
  </wsdl:types>
  <wsdl:message name="getStockQuote">
    <wsdl:part name="stockTicker" type="xsd:string">
    </wsdl:part>
  </wsdl:message>
  <wsdl:message name="getStockQuoteResponse">
    <wsdl:part name="updatedQuote" type="tns:quote">
    </wsdl:part>
  </wsdl:message>
  <wsdl:portType name="quoteReporter">
    <wsdl:operation name="getStockQuote">
      <wsdl:input name="getQuote" message="tns:getStockQuote">
    </wsdl:input>
      <wsdl:output name="getQuoteResponse" message="tns:getStockQuoteResponse">
    </wsdl:output>
    </wsdl:operation>
  </wsdl:portType>
  <wsdl:binding name="quoteReporterBinding" type="tns:quoteReporter">
    <soap:binding style="rpc" transport="http://schemas.xmlsoap.org/soap/http" />
    <wsdl:operation name="getStockQuote">
      <soap:operation style="rpc" />
      <wsdl:input name="getQuote">
        <soap:body use="literal" />
      </wsdl:input>
      <wsdl:output name="getQuoteResponse">
        <soap:body use="literal"/>
      </wsdl:output>
    </wsdl:operation>
  </wsdl:binding>
  <wsdl:service name="quoteReporterService">
    <wsdl:port name="quoteReporterPort" binding="tns:quoteReporterBinding">
      <soap:address location="http://localhost:9000/quoteReporterService" />
    </wsdl:port>
  </wsdl:service>
</wsdl:definitions>
```

Developing a Consumer Without a WSDL Contract

You do not need a WSDL contract to develop a service consumer. You can create a service consumer from an annotated SEI. Along with the SEI you need to know the address at which the endpoint exposing the service is published, the QName of the service element that defines the endpoint exposing the service, and the QName of the port element defining the endpoint on which your consumer makes requests. This information can be specified in the SEI's annotations or provided separately.

To create a consumer without a WSDL contract you must do the following:

1. Create a Service object for the service on which the consumer will invoke operations.
2. Add a port to the `Service` object.
3. Get a proxy for the service using the `Service` object's `getPort()` method.
4. Implement the consumer's business logic.

Creating a Service Object

The `javax.xml.ws.Service` class represents the `wsdl:service` element which contains the definition of all of the endpoints that expose a service. As such, it provides methods that allow you to get endpoints, defined by `wsdl:port` elements, that are proxies for making remote invocations on a service.

NOTE: The `Service` class provides the abstractions that allow the client code to work with Java types as opposed to working with XML documents.

The create() methods

The `Service` class has two static `create()` methods that can be used to create a new `Service` object. As shown in Example 15, both of the `create()` methods take the QName of the `wsdl:service` element the `Service` object will represent, and one takes a URI specifying the location of the WSDL contract.

TIP: All services publish their WSDL contracts. For SOAP/HTTP services the URI is usually the URI for the service appended with `?wsdl`.

Example 15. Service create() Methods

```
public static Service create(URL wsdlLocation,
QName serviceName) throws WebServiceException;
public static Service create(QName serviceName) throws
WebServiceException;
```

The value of the `serviceName` parameter is a QName. The value of its namespace part is the target namespace of the service. The service's target namespace is specified in the targetNamespace property of the `@WebService` annotation. The value of the QName's local part is the value of `wsdl:service` element's `name` attribute. You can determine this value in one of the following ways:

- It is specified in the serviceName property of the `@WebService` annotation.
- You append `Service` to the value of the name property of the `@WebService` annotation.
- You append `Service` to the name of the SEI.

Example

Example 16 shows code for creating a `Service` object for the SEI shown in Example 7.

Example 16. Creating a Service Object

```
package com.iona.demo;

import javax.xml.namespace.QName; import javax.xml.ws.Service;

public class Client
{
  public static void main(String args[])
  {
❶    QName serviceName = new QName("http://demo.iona.com", "stockQuoteReporter");
❷    Service s = Service.create(serviceName);
    ...
  }
}
```

The code in Example 16 does the following:

❶ Builds the QName for the service using the targetNamespace property and the name property of the `@WebService` annotation.

❷ Calls the single parameter `create()` method to create a new `Service` object.

NOTE: Using the single parameter `create()` frees you from having any dependencies on accessing a WSDL contract.

Adding a Port to a Service

The endpoint information for a service is defined in a `wsdl:port` element, and the `Service` object creates a proxy instance for each of the endpoints defined in a WSDL contract, if one is specified. If you do not specify a WSDL contract when you create your `Service` object, the `Service` object has no information about the endpoints that implement your service, and therefore cannot create any proxy instances. In this case, you must provide the `Service` object with the information needed to represent a `wsdl:port` element using the `addPort()` method.

The addPort() method

The `Service` class defines an `addPort()` method, shown in Example 17, that is used in cases where there is no WSDL contract available to the consumer implementation. The `addPort()` method allows you to give a `Service` object the information, which is typically stored in a `wsdl:port` element, necessary to create a proxy for a service implementation.

Example 17. The addPort() Method

```
void addPort(QName portName,
    String bindingId,
    String endpointAddress)
throws WebServiceException;
```

The value of the `portName` is a QName. The value of its namespace part is the target namespace of the service. The service's target namespace is specified in the targetNamespace property of the `@WebService` annotation. The value of the QName's local part is the value of `wsdl:port` element's `name` attribute. You can determine this value in one of the following ways:

- Specify it in the portName property of the `@WebService` annotation.
- Append `Port` to the value of the name property of the `@WebService` annotation.
- Append `Port` to the name of the SEI.

The value of the `bindingId` parameter is a string that uniquely identifies the type of binding used by the endpoint. For a SOAP binding you use the standard SOAP namespace: http://schemas.xmlsoap.org/soap/. If the endpoint is not

using a SOAP binding, the value of the `bindingId` parameter is determined by the binding developer.

The value of the `endpointAddress` parameter is the address where the endpoint is published. For a SOAP/HTTP endpoint, the address is an HTTP address. Transports other than HTTP use different address schemes.

Example

Example 18 shows code for adding a port to the `Service` object created in Example 16.

Example 18. Adding a Port to a `Service` Object

```
package com.fusesource.demo;

import javax.xml.namespace.QName;
import javax.xml.ws.Service;

public class Client
{
  public static void main(String args[])
  {
    ...
❶    QName portName = new QName("http://demo.fusesource.com", "stockQuoteReporterPort");
❷    s.addPort(portName,
❸               "http://schemas.xmlsoap.org/soap/",
❹               "http://localhost:9000/StockQuote");
    ...
  }
}
```

The code in Example 18 does the following:

❶ Creates the QName for the `portName` parameter.

❷ Calls the `addPort()` method.

❸ Specifies that the endpoint uses a SOAP binding.

❹ Specifies the address where the endpoint is published.

Getting a Proxy for an Endpoint

A service proxy is an object that provides all of the methods exposed by a remote service and handles all of the details required to make the remote invocations. The `Service` object provides service proxies for all of the endpoints it is aware of through the `getPort()` method. Once you have a service proxy, you can invoke its methods. The proxy forwards the invocation to the remote service endpoint using the connection details specified in the service's contract.

The getPort() method

The `getPort()` method, shown in Example 19, returns a service proxy for the specified endpoint. The returned proxy is of the same class as the SEI.

Example 19. The getPort() Method

```
public <T> T getPort(QName portName,
        Class<T> serviceEndpointInterface)
throws WebServiceException;
```

The value of the `portName` parameter is a QName that identifies the `wsdl:port` element that defines the endpoint for which the proxy is created. The value of the `serviceEndpointInterface` parameter is the fully qualified name of the SEI.

TIP: When you are working without a WSDL contract the value of the `portName` parameter is typically the same as the value used for the `portName` parameter when calling `addPort()`.

Example

Example 20 shows code for getting a service proxy for the endpoint added in Example 18.

Example 20. Getting a Service Proxy

```
package com.fusesource.demo;

import javax.xml.namespace.QName; import javax.xml.ws.Service;

public class Client
{
  public static void main(String args[])
  {
    ...
    quoteReporter proxy = s.getPort(portName, quoteReporter.class);
    ...
  }
}
```

Implementing the Consumer's Business Logic

Once you instantiate a service proxy for a remote endpoint, you can invoke its methods as if it were a local object. The calls block until the remote method completes.

NOTE: If a method is annotated with the `@OneWay` annotation, the call returns immediately.

Example

Example 21 shows a consumer for the service defined in Example 7.

Example 21. Consumer Implemented without a WSDL Contract

```
package com.fusesource.demo;

import java.io.File; import java.net.URL;
import javax.xml.namespace.QName; import javax.xml.ws.Service;

public class Client
{
  public static void main(String args[])
  {
    QName serviceName = new QName("http://demo.eric.org", "stockQuoteReporter");
❶   Service s = Service.create(serviceName);

    QName portName = new QName("http://demo.eric.org", "stockQuoteReporterPort");
❷   s.addPort(portName, "http://schemas.xmlsoap.org/soap/",
"http://localhost:9000/EricStockQuote");

❸   quoteReporter proxy = s.getPort(portName, quoteReporter.class);

❹   Quote quote = proxy.getQuote("ALPHA");
    System.out.println("Stock "+quote.getID()+" is worth "+quote.getVal()+" as of
"+quote.getTime());
  }
}
```

The code in Example 21 does the following:

❶ Creates a `Service` object.

❷ Adds an endpoint definition to the `Service` object.

❸ Gets a service proxy from the `Service` object.

❹ Invokes an operation on the service proxy.

Part II

Starting from a WSDL Contract

The recommended way to develop service-oriented applications is to start from a WSDL contract. The WSDL contract provides an implementation neutral way of defining the operations a service exposes and the data that is exchanged with the service. Artix provides tools to generate JAX-WS annotated starting point code from a WSDL contract. The code generators create all of the classes needed to implement any abstract data types defined in the contract. This approach simplifies the development of widely distributed applications.

In this part

This part contains the following chapters:

A Starting Point WSDL Contract
Developing a Consumer From a WSDL Contract

A Starting Point WSDL Contract

Example 22 shows the HelloWorld WSDL contract. This contract defines a single interface, `Greeter`, in the `wsdl:portType` element. The contract also defines the endpoint which will implement the service in the `wsdl:port` element.

Example 22. HelloWorld WSDL Contract

```
<?xml version="1.0" encoding=";UTF-8"?>
<wsdl:definitions name="HelloWorld"
                  targetNamespace="http://apache.org/hello_world_soap_http
                  " xmlns="http://schemas.xmlsoap.org/wsdl/"
                  xmlns:soap="http://schemas.xmlsoap.org/wsdl/soap/"
                  xmlns:tns="http://apache.org/hello_world_soap_http"
                  xmlns:x1="http://apache.org/hello_world_soap_http/types"
                  xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
                  xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <wsdl:types>
    <schema
            targetNamespace="http://apache.org/hello_world_soap_http/types
            " xmlns="http://www.w3.org/2001/XMLSchema"
            elementFormDefault="qualified"><element name="sayHi">
      <element name="sayHi">
<complexType>
<sequence>
            <element name="requestType" type="string"/>
</sequence>
</complexType>
      </element>
      <element name="sayHiResponse">
<complexType>
<sequence>
            <element name="responseType" type="string"/>
</sequence>
</complexType>
      </element>
      <element name="greetMe">
<complexType>
<sequence>
            <element name="requestType" type="string"/>
</sequence>
</complexType>
      </element>
      <element name="greetMeResponse">
<complexType>
<sequence>
            <element name="responseType" type="string"/>
</sequence>
</complexType>
      </element>
      <element name="greetMeOneWay">
<complexType>
<sequence>
            <element name="requestType" type="string"/>
</sequence>
</complexType>
      </element>
      <element name="pingMe">
<complexType/>
      </element>
```

```
      <element name="pingMeResponse">
<complexType/>
      </element>
      <element name="faultDetail">
<complexType>
<sequence>
<element name="minor" type="short"/>
<element name="major" type="short"/>
</sequence>
</complexType>
      </element>
</schema>
  </wsdl:types>

  <wsdl:message name="sayHiRequest">
    <wsdl:part element="x1:sayHi" name="in"/>
  </wsdl:message>
  <wsdl:message name="sayHiResponse">
    <wsdl:part element="x1:sayHiResponse" name="out"/>
  </wsdl:message>
  <wsdl:message name="greetMeRequest">
    <wsdl:part element="x1:greetMe" name="in"/>
  </wsdl:message>
  <wsdl:message name="greetMeResponse">
    <wsdl:part element="x1:greetMeResponse" name="out"/>
  </wsdl:message>
  <wsdl:message name="greetMeOneWayRequest">
    <wsdl:part element="x1:greetMeOneWay" name="in"/>
  </wsdl:message>
  <wsdl:message name="pingMeRequest">
    <wsdl:part name="in" element="x1:pingMe"/>
  </wsdl:message>
  <wsdl:message name="pingMeResponse">
    <wsdl:part name="out" element="x1:pingMeResponse"/>
  </wsdl:message>
  <wsdl:message name="pingMeFault">
    <wsdl:part name="faultDetail" element="x1:faultDetail"/>
  </wsdl:message>

  <wsdl:portType name="Greeter">
❶    <wsdl:operation name="sayHi">
      <wsdl:input message="tns:sayHiRequest" name="sayHiRequest"/>
      <wsdl:output message="tns:sayHiResponse" name="sayHiResponse"/>
    </wsdl:operation>

❷    <wsdl:operation name="greetMe">
      <wsdl:input message="tns:greetMeRequest" name="greetMeRequest"/>
      <wsdl:output message="tns:greetMeResponse" name="greetMeResponse"/>
    </wsdl:operation>

❸    <wsdl:operation name="greetMeOneWay">
      <wsdl:input message="tns:greetMeOneWayRequest"
      name="greetMeOneWayRequest"/>
    </wsdl:operation>

❹    <wsdl:operation name="pingMe">
      <wsdl:input name="pingMeRequest" message="tns:pingMeRequest"/>
      <wsdl:output name="pingMeResponse" message="tns:pingMeResponse"/>
      <wsdl:fault name="pingMeFault" message="tns:pingMeFault"/>
    </wsdl:operation>
  </wsdl:portType>

  <wsdl:binding name="Greeter_SOAPBinding" type="tns:Greeter">
    ...
  </wsdl:binding>

  <wsdl:service name="SOAPService">
```

```
    <wsdl:port binding="tns:Greeter_SOAPBinding" name="SoapPort">
      <soap:address
      location="http://localhost:9000/SoapContext/SoapPort"/>
    </wsdl:port>
  </wsdl:service>
</wsdl:definitions>
```

The `Greeter` interface defined in Example 22 defines the following operations:

❶ sayHi — Has a single output parameter, of xsd:string.

❷ greetMe — Has an input parameter, of xsd:string, and an output parameter, of xsd:string.

❸ greetMeOneWay — Has a single input parameter, of xsd:string. Because this operation has no output parameters, it is optimized to be a oneway invocation (that is, the consumer does not wait for a response from the server).

❹ pingMe — Has no input parameters and no output parameters, but it can raise a fault exception.

Top-Down Service Development

In the top-down method of developing a service provider you start from a WSDL document that defines the operations and methods the service provider will implement. Using the WSDL document, you generate starting point code for the service provider. Adding the business logic to the generated code is done using normal Java programming APIs.

Once you have a WSDL document, the process for developing a JAX-WS service provider is as follows:

Generate starting point code.

Implement the service provider's operations.

Publish the implemented service.

Generating the Starting Point Code

JAX-WS specifies a detailed mapping from a service defined in WSDL to the Java classes that will implement that service as a service provider. The logical interface, defined by the `wsdl:portType` element, is mapped to a service endpoint interface (SEI). Any complex types defined in the WSDL are mapped into Java classes following the mapping defined by the Java Architecture for XML Binding (JAXB) specification. The endpoint defined by the `wsdl:service` element is also generated into a Java class that is used by consumers to access service providers implementing the service.

The **wsdl2java** command automates the generation of this code. It also provides options for generating starting point code for your implementation, along with an Ant based makefile to build the application. **wsdl2java** provides a number of arguments for controlling the generated code.

Running the code generator

You can generate the code needed to develop your service provider using the following command:

```
wsdl2java -ant -impl -server -d outputDir myService.wsdl
```

This command does the following:

- The `-ant` argument generates an Ant makefile, called `build.xml`, for your application.

- The `-impl` argument generates a shell implementation class for each `wsdl:portType` element in the WSDL contract.
- The `-server` argument generates a simple `main()` to run your service provider as a standalone application.
- The `-d outputDir` argument directs **wsdl2java** to write the generated code to a directory called `outputDir`.
- `myService.wsdl` is the WSDL contract from which code is generated.

For a complete list of the arguments for **wsdl2java** see *wsdl2java* in ***Artix Java Runtime Command Reference***.

Generating code from Ant

If you are using Apache Ant as your build system, you can call the code generator using Ant's **java** task as shown in Example 23.

Example 23. Generating Service Starting Point Code from Ant

```
<project name="myProject" basedir=".">
  <property name="fsf.home" location ="InstallDir"/>

   <path id="fsf.classpath">
     <fileset dir="${fsf.home}/lib">
 <include name="*.jar"/>
      </fileset>
   </path>

  <target  name="ServiceGen">
    <java classname="org.apache.cxf.tools.wsdlto.WSDLToJava" fork="true">
      <arg value="-ant"/>
      <arg value="-impl"/>
      <arg value="-server"/>
      <arg value="-d"/>
      <arg value="outputDir"/>
      <arg value="myService.wsdl"/>
      <classpath>
        <path refid="fsf.classpath"/>
      </classpath>
    </java>
    ...
  </target>
  ...
</project>
```

The command line options are passed to the code generator using the task's `arg` element. Arguments that require two strings, such as `-d`, must be split into two `arg` elements.

Generated code

Table 9 describes the files generated for creating a service provider.

Table 9. Generated Classes for a Service Provider

File	Description
portTypeName.java	The SEI. This file contains the interface your service provider implements. You should not edit this file.
serviceName.java	The endpoint. This file contains the Java class consumers use to make requests on the service.
*portTypeName*Impl.java	The skeleton implementation class. Modify this file to build your service provider.
*portTypeName*Server.java	A basic server mainline that allows you to deploy your service provider as a standalone process. For more information see *Publishing a Service*.

In addition, **wsdl2java** will generate Java classes for all of the types defined in the WSDL contract.

Generated packages

The generated code is placed into packages based on the namespaces used in the WSDL contract. The classes generated to support the service (based on the `wsdl:portType` element, the `wsdl:service` element, and the `wsdl:port` element) are placed in a package based on the target namespace of the WSDL contract. The classes generated to implement the types defined in the `types` element of the contract are placed in a package based on the `targetNamespace` attribute of the `types` element.

The mapping algorithm is as follows:

1. The leading `http://` or `urn://` are stripped off the namespace.
2. If the first string in the namespace is a valid Internet domain, for example it ends in `.com` or `.gov`, then the leading `www.` is stripped off the string, and the two remaining components are flipped.
3. If the final string in the namespace ends with a file extension of the pattern `.xxx` or `.xx`, then the extension is stripped.

4. The remaining strings in the namespace are appended to the resulting string and separated by dots.
5. All letters are made lowercase.

Implementing the Service Provider

Generating the implementation code

You generate the implementation class used to build your service provider with **wsdl2java**'s `-impl` flag.

TIP: If your service's contract includes any custom types defined in XML Schema, you must ensure that the classes for the types are generated and available.

For more information on using **wsdl2java** see *wsdl2java* in ***Artix Java Runtime Command Reference***.

Generated code

The implementation code consists of two files:

- `*portTypeName*.java` — The service interface(SEI) for the service.
- `*portTypeName*Impl.java` — The class you will use to implement the operations defined by the service.

Implement the operation's logic

To provide the business logic for your service's operations complete the stub methods in `*portTypeName*Impl.java`. You usually use standard Java to implement the business logic. If your service uses custom XML Schema types, you must use the generated classes for each type to manipulate them. There are also some Artix specific APIs that can be used to access some advanced features.

Example

For example, an implementation class for the service defined in Example 22 may look like Example 24. Only the code portions highlighted in bold must be inserted by the programmer.

Example 24. Implementation of the Greeter Service

```
package demo.hw.server;

import org.apache.hello_world_soap_http.Greeter;

@javax.jws.WebService(portName = "SoapPort", serviceName = "SOAPService",
                      targetNamespace =
                      "http://apache.org/hello_world_soap_http",
                      endpointInterface =

"org.apache.hello_world_soap_http.Greeter") public class GreeterImpl

implements Greeter {

    public String greetMe(String me) {
       System.out.println("Executing operation greetMe");
       System.out.println("Message received: " + me + "\n");
       return "Hello " + me;
    }

    public void greetMeOneWay(String me) {
       System.out.println("Executing operation greetMeOneWay\n");
       System.out.println("Hello there " + me);
    }

    public String sayHi() {
       System.out.println("Executing operation sayHi\n");
       return "Bonjour";
    }

    public void pingMe() throws PingMeFault {
       FaultDetail faultDetail = new FaultDetail();
       faultDetail.setMajor((short)2);
       faultDetail.setMinor((short)1);
       System.out.println("Executing operation pingMe, throwing PingMeFault
       exception\n");

           throw new PingMeFault("PingMeFault raised by server", faultDetail);
    }
}
```

Developing a Consumer From a WSDL Contract

One way method of creating a consumer is to start from a WSDL contract. The contract defines the operations, messages, and transport details of the service on which a consumer makes requests. The starting point code for the consumer is generated from the WSDL contract. The functionality required by the consumer is added to the generated code.

Generating the Stub Code

The wsdl2java tool generates the stub code from the WSDL contract. The stub code provides the supporting code that is required to invoke operations on the remote service.

For consumers, the wsdl2java tool generates the following types of code:

- Stub code — Supporting files for implementing a consumer.
- Starting point code — Sample code that connects to the remote service and invokes every operation on the remote service.
- Ant build file — A `build.xml` file intended for use with the Ant build utility. It has targets for building and for running the sample consumer.

Generating the consumer code

To generate consumer code use the wsdl2java tool. Enter the following command at a command-line prompt:

```
wsdl2java -ant -client -d outptDir hello_world.wsdl
```

Where `outptDir` is the location of a directory where the generated files are placed and `hello_world.wsdl` is a file containing the contract shown in Example 22 on page 65. The `-ant` option generates an ant `build.xml` file, for use with the ant build utility. The `-client` option generates starting point code for the consumer's `main()` method.

For a complete list of the arguments available for the wsdl2java tool see wsdl2java in *Artix Java Runtime Command Reference*.

Generating code from Ant

If you are using Apache Ant as your build system, you can call the code generator using Ant's java task, as shown in Example 25.

Example 25. Generating Service Starting Point Code from Ant

```
<project name="myProject" basedir=".">
  <property name="fsf.home" location ="InstallDir"/>

   <path id="fsf.classpath">
     <fileset dir="${fsf.home}/lib">
         <include name="*.jar"/>
      </fileset>
   </path>

  <target  name="ServiceGen">
    <java classname="org.apache.cxf.tools.wsdlto.WSDLToJava" fork="true">
      <arg value="-ant"/>
      <arg value="-client"/>
      <arg value="-d"/>
      <arg value="outputDir"/>
      <arg value="myService.wsdl"/>
      <classpath>
        <path refid="fsf.classpath"/>
      </classpath>
    </java>
    ...
  </target>
  ...
</project>
```

The command line options are passed to the code generator using the task's `arg` element. Arguments that require two strings, such as `-d`, must be split into two `arg` elements.

Generated code

The preceding command generates the following Java packages:

- `org.apache.hello_world_soap_http` — This package is generated from the http://apache.org/hello_world_soap_http target namespace. All of the WSDL entities defined in this namespace (for example, the Greeter port type and the SOAPService service) map to Java classes this Java package.

- `org.apache.hello_world_soap_http.types` — This package is generated from the http://apache.org/hello_world_soap_http/types target namespace. All of the XML types defined in this namespace (that is, everything defined in the `wsdl:types` element of the HelloWorld contract) map to Java classes in this Java package.

The stub files generated by the **wsdl2java** tool fall into the following categories:

- Classes representing WSDL entities in the `org.apache.hello_world_soap_http` package. The following classes are generated to represent WSDL entities:
  - `Greeter` — A Java interface that represents the Greeter `wsdl:portType` element. In JAX-WS terminology, this Java interface is the service endpoint interface (SEI).
  - `SOAPService` — A Java service class (extending `javax.xml.ws.Service`) that represents the SOAPService `wsdl:service` element.
  - `PingMeFault` — A Java exception class (extending `java.lang.Exception`) that represents the pingMeFault `wsdl:fault` element.
- Classes representing XML types in the `org.objectweb.hello_world_soap_http.types` package. In the HelloWorld example, the only generated types are the various wrappers for the request and reply messages. Some of these data types are useful for the asynchronous invocation model.

Implementing a Consumer

To implement a consumer when starting from a WSDL contract, you must use the following stubs:

- Service class
- SEI

Using these stubs, the consumer code instantiates a service proxy to make requests on the remote service. It also implements the consumer's business logic.

Generated service class

Example 26 shows the typical outline of a generated service class, *`ServiceName`*`_Service`, which extends the `javax.xml.ws.Service` base class.

(If the `name` attribute of the `wsdl:service` element ends in `Service` the `_Service` is not used.)

Example 26. Outline of a Generated Service Class

```
@WebServiceClient(name="..." targetNamespace="..."
                  wsdlLocation="...")
public class ServiceName extends javax.xml.ws.Service
{
  ...
  public ServiceName(URL wsdlLocation, QName serviceName) { }

  public ServiceName() { }

  @WebEndpoint(name="...")
  public SEI getPortName() { }
  .
  .
  .
}
```

The `ServiceName` class in Example 26 defines the following methods:

- `ServiceName(URL wsdlLocation, QName serviceName)` — Constructs a service object based on the data in the `wsdl:service` element with the QName `ServiceName` service in the WSDL contract that is obtainable from `wsdlLocation`.
- `ServiceName()` — The default constructor. It constructs a service object based on the service name and the WSDL contract that were provided at the time the stub code was generated (for example, when running the **wsdl2java** tool). Using this constructor presupposes that the WSDL contract remains available at a specified location.
- `getPortName()` — Returns a proxy for the endpoint defined by the `wsdl:port` element with the `name` attribute equal to `PortName`. A getter method is generated for every `wsdl:port` element defined by the `ServiceName` service. A `wsdl:service` element that contains multiple endpoint definitions results in a generated service class with multiple `getPortName()` methods.

Service endpoint interface

For every interface defined in the original WSDL contract, you can generate a corresponding SEI. A service endpoint interface is the Java mapping of a `wsdl:portType` element. Each operation defined in the original `wsdl:portType` element maps to a corresponding method in the SEI. The operation's parameters are mapped as follows:

1. The input parameters are mapped to method arguments.
2. The first output parameter is mapped to a return value.
3. If there is more than one output parameter, the second and subsequent output parameters map to method arguments (moreover, the values of these arguments must be passed using Holder types).

For example, Example 27 shows the Greeter SEI, which is generated from the `wsdl:portType` element defined in Example 22. For simplicity, Example 27 omits the standard JAXB and JAX-WS annotations.

Example 27. The Greeter Service Endpoint Interface

```
package org.apache.hello_world_soap_http;
  ...
public interface Greeter
{
  public String sayHi();
  public String greetMe(String requestType);
  public void greetMeOneWay(String requestType);
  public void pingMe() throws PingMeFault;
}
```

Consumer main function

Example 28 shows the code that implements the HelloWorld consumer. The consumer connects to the SoapPort port on the SOAPService service and then proceeds to invoke each of the operations supported by the Greeter port type.

Example 28. Consumer Implementation Code

```
package demo.hw.client;

import java.io.File; import java.net.URL;
import javax.xml.namespace.QName;
import org.apache.hello_world_soap_http.Greeter;
import org.apache.hello_world_soap_http.PingMeFault;
import org.apache.hello_world_soap_http.SOAPService;

public final class Client {

  private static final QName SERVICE_NAME =
  new QName("http://apache.org/hello_world_soap_http",
            "SOAPService");

  private Client()
  {
  }

  public static void main(String args[]) throws Exception
  {
❶ if (args.length == 0)
    {
      System.out.println("please specify wsdl"); System.exit(1);
    }

❷ URL wsdlURL;
    File wsdlFile = new File(args[0]); if (wsdlFile.exists())
    {
      wsdlURL = wsdlFile.toURL();
    }
    else
    {
      wsdlURL = new URL(args[0]);
    }

    System.out.println(wsdlURL);
❸ SOAPService ss = new SOAPService(wsdlURL,SERVICE_NAME);
❹ Greeter port = ss.getSoapPort();
```

```
    String resp;

❺ System.out.println("Invoking sayHi..."); resp = port.sayHi();
    System.out.println("Server responded with: " + resp);
    System.out.println();

    System.out.println("Invoking greetMe...");
    resp = port.greetMe(System.getProperty("user.name"));
    System.out.println("Server responded with: " + resp);
    System.out.println();

    System.out.println("Invoking greetMeOneWay...");
    port.greetMeOneWay(System.getProperty("user.name"));
    System.out.println("No response from server as method is OneWay");
    System.out.println();

❻ try {
      System.out.println("Invoking pingMe, expecting exception...");
      port.pingMe();
    } catch (PingMeFault ex) {
      System.out.println("Expected exception: PingMeFault has occurred.");
      System.out.println(ex.toString());
    }
    System.exit(0);
  }
}
```

The `Client.main()` method from Example 28 proceeds as follows:

❶ Provided that the Artix runtime classes are on your classpath, the runtime is implicitly initialized. There is no need to call a special function to initialize Artix.

❷ The consumer expects a single string argument that gives the location of the WSDL contract for HelloWorld. The WSDL contract's location is stored in `wsdlURL`.

❸ You create a service object using the constructor that requires the WSDL contract's location and service name.

❹ Call the appropriate `get`*`PortName`*`()` method to obtain an instance of the required port. In this case, the SOAPService service supports only the SoapPort port, which implements the `Greeter` service endpoint interface.

❺ The consumer invokes each of the methods supported by the `Greeter` service endpoint interface.

❻ In the case of the `pingMe()` method, the example code shows how to catch the `PingMeFault` fault exception.

Part III

Developing RESTful Services

RESTful services take the concepts of loose coupling and coarse grained interfaces one step further than standard Web services. Built using the REST architectural style, they rely solely on the four HTTP verbs to access the operations provided by a service. Artix provides a robust mechanism for building RESTful services using straightforward Java classes and annotations.

In this part

This part contains the following chapters:

Introduction to RESTful Services
Developing RESTful applications using the JAX-RS APIs
Using the JAX-RS APIs

Introduction to RESTful Services

Representational State Transfer (REST)is a software architecture style that centers around the transmission of data over HTTP, using only the four basic HTTP verbs. It also eschews the use of any additional wrappers such as a SOAP envelope and the use of any state data.

Representational State Transfer (REST) is an architectural style first described in a doctoral dissertation by a researcher named Roy Fielding. In REST, servers expose resources using a URI, and clients access these resources using the four HTTP verbs. As clients receive representations of a resource they are placed in a state. When they access a new resource, typically by following a link, they change, or transition, their state. In order to work, REST assumes that resources are capable of being represented using a pervasive standard grammar.

The World Wide Web is the most ubiquitous example of a system designed on REST principles. Web browsers act as clients accessing resources hosted on Web servers. The resources are represented using HTML or XML grammars that all Web browsers can consume. The browsers can also easily follow the links to new resources.

The advantages of REST style systems is that they are highly scalable and highly flexible. Because the resources are accessed and manipulated using the four HTTP verbs, the resources are exposed using a URI, and the resources are represented using standard grammars, clients are not as affected by changes to the servers. Also, REST style systems can take full advantage of the scalability features of HTTP such as caching and proxies.

Basic REST principles

RESTful architectures adhere to the following basic principles:

- Application state and functionality are divided into resources.
- Resources are addressable using standard URIs that can be used as hypermedia links.
- All resources use only the four HTTP verbs:
  - `DELETE`
  - `GET`
  - `POST`
  - `PUT`

- All resources provide information using the MIME types supported by HTTP.
- The protocol is stateless.
- The protocol is cacheable.
- The protocol is layered.

Resources

Resources are central to REST. A resource is a source of information that can be addressed using a URI. In the early days of the Web, resources were largely static documents. In the modern Web, a resource can be any source of information. For example a Web service can be a resource if it can be accessed using a URI.

RESTful endpoints exchange *representations* of the resources they address. A representation is a document containing the data provided by the resource. For example, the method of a Web service that provides access to a customer record would be a resource, the copy of the customer record exchanged between the service and the consumer is a representation of the resource.

REST best practices

When designing RESTful services it is helpful to keep in mind the following:

- Provide a distinct URI for each resource you wish to expose.

  For example, if you are building a system that deals with driving records, each record should have a unique URI. If the system also provides information on parking violations and speeding fines, each type of resource should also have a unique base. For example, speeding fines could be accessed through `/speeding/`*`driverID`* and parking violations could be accessed through `/parking/`*`driverID`*.

- Use nouns in your URIs.

  Using nouns highlights the fact that resources are things and not actions. URIs such as `/ordering` imply an actions, whereas `/orders` implies a thing.

- Methods that map to `GET` should not change any data.

- Use links in your responses.

  Putting links to other resources in your responses makes it easier for clients to follow a chain of data. For example, if your service returns a collection of resources, it would be

easier for a client to access each of the individual resources using the provided links. If links are not included, a client needs to have additional logic to follow the chain to a specific node.

- Make your service stateless.

  Requiring the client or the service to maintain state information forces a tight coupling between the two. Tight couplings make upgrading and migrating more difficult. Maintaining state can also make recovery from communication errors more difficult.

Wrapped mode vs. unwrapped mode

RESTful services can only send or receive one XML element. To enable the mapping of methods that use more than one parameter, Artix can use *wrapped mode*. In wrapped mode, Artix wraps the parameters with a root element derived from the operation name. For example, the operation `Car findCar(String make, String model)` could not be mapped to an XML `POST` request like the one shown in Example 29.

Example 29. Invalid REST Request

```
<name>Dodge</name>
<model>Daytona</company>
```

Example 29 is invalid because it has two root XML elements, which is not allowed. Instead, the parameters would have to be wrapped with the operation name to make the `POST` valid. The resulting request is shown in Example 30.

Example 30. Wrapped REST Request

```
<findCar>
  <make>Dodge</make>
  <model>Daytona</model>
</findCar>
```

By default, Artix uses unwrapped mode, because, for cases where operations use a single parameter, it creates prettier XML. Using unwrapped mode, however, requires that you constrain your service interfaces to sending and receiving single elements. If your operation needs to take multiple parameters, you must combine them in an object. With the `findCar()`example above, you would want to create a `FindCar` class that holds the make and model data.

What's new in JAX-RS 2.0

Artix 5.6.3 for Java supports JAX-RS version 2.0. New features of JAX-RS version 2.0 affect the following areas:

- Filters
- Interceptors
- Dynamic Features
- Exceptions
- Suspended invocations
- Parameter converters
- Injection into subresources
- Updates to the matching algorithm
- Client API

Filters

Server Filters

`ContainerRequestFilter` and `ContainerResponseFilter` are new server-side request and response filters which can be used to customize various properties of a given request and response.

`ContainerRequestFilter` annotated with a PreMatching annotation will be run before the runtime has matched a request to a specific JAX-RS root resource and method. Prematching filters can be used to affect the matching process.

The request filters without the PreMatching annotation will run after the JAX-RS resource method has been selected.

`ContainerRequestFilter` can be used to block a request.

The filters can be bound to individual resource methods only with the help of custom NameBindings.

Multiple request and response filters can be executed in the specific order by using `javax.annotation.Priority` annotations. See https://jax-rs-spec.java.net/nonav/2.0-rev-a/apidocs/javax/ws/rs/Priorities.html for information on priorities. Request filters are sorted in ascending order, response filters in descending order.

Client Filters

`ClientRequestFilter` and `ClientResponseFilter` are new client-side request and response filters which can be used to customize various properties of a given request and response.

`ClientRequestFilter` can be used to block a request.

Request filters are sorted in ascending order, response filters in descending order. See https://jax-rs-spec.java.net/nonav/2.0-rev-a/apidocs/javax/ws/rs/Priorities.html for information on priorities.

Interceptors

`ReaderInterceptor` and `WriterInterceptor` can be used in addition to filters or on its own to customize requests and responses on server and client sides.

Interceptors can be useful to customize the reading/writing process and block JAX-RS `MessageBodyWriter` or `MessageBodyReader` providers.

The interceptors used on the server side can be bound to individual resource methods only with the help of custom NameBindings.

All interceptors are sorted in ascending order.

Dynamic Features

Dynamic Feature is a server side feature that can be used to attach request and response filters as well as reader and writer interceptors to specific resource methods. It is an alternative approach to using the NameBindings and offer a finer-grained control over the binding process.

Exceptions

Dedicated exception classes representing various HTTP error or redirect conditions have been introduced, see the `javax.ws.rs` *Exceptions* section at http://docs.oracle.com/javaee/7/api/javax/ws/rs/package-summary.html.

For example, instead of throwing a "`new WebApplicationException(404)`" it is better to do "`new NotFoundException()`". The finer-grained exception hierarchy allows for a finer-grained support of exception mappers. It also opens a way to check WebApplicationException and all of its subclasses when catching the HTTP exceptions on the client side.

Note that on the client side, `ProcessingException` can be used to catch client-related exceptions while `ResponseProcessingException` can be used to narrow down the client side exceptions specifically related to processing the response message.

Suspended invocations

One of the most useful new features of JAX-RS 2.0 is the support for server-side asynchronous invocations. See http://docs.oracle.com/javaee/7/api/javax/ws/rs/container/AsyncResponse.html which provides a very good overview of this feature.

Typically, the resource method accepting `AsyncResponse` will either store it and start a new thread to finish the request, the method will return and the invocation will be suspended, then eventually another thread (either the one which initiated an internal job or some other thread) will resume the suspended call. Note in this case the invocation will be suspended indefinitely until it is resumed.

Another approach is to have `AsyncResponse` suspended for a limited period of time only and also register a TimeoutHandler. The latter will be invoked when the invocation is resumed by the container after the timeout has expired and the handler will either complete the invocation or suspend it again till it is ready to finish it.

CompletionCallback can be registered with `AsyncResponse` to receive the notifications when the async response has been sent back.

This feature can help developers write very sophisticated asynchronous applications.

Parameter converters

ParamConverterProvider can be used to manage the conversion of custom Objects to String and vice versa on the server and client sides, when processing JAX-RS parameters representing URI parts or headers or form elements and when a default conversion mechanism does not work. For example, `java.util.Date` constructor accepting a String may have to be replaced a custom ParamConverter.

Bean parameters

BeanParam can be used to get JAX-RS parameters representing URI parts or headers or form elements and also contexts injected into a single bean container.

Note the runtime extension supporting the injection of all the parameters of specific JAX-RS type (example, `QueryParam("") MyBean`) is different, it only allows to get all the query parameters injected, but it also does not require that bean properties are annotated with `QueryParam/etc` annotations.

ResourceInfo

ResourceInfo is a new JAX-RS context which can be injected into filters and interceptors and checked which resource class and method are about to be invoked.

Injection into subresources

Subresources can get JAX-RS contexts injected directly into their fields with the help of ResourceContext.

When possible, having a parent resource injecting the contexts into a given sub-resource instance via a setter or constructor can offer a much simpler alternative.

Updates to the matching algorithm

JAX-RS 2.0 supports a proper resource method selection in cases where multiple root resource classes have the same Path value, for example:

Example 31. Updated Matching

```
@Path("/")
public class Root1 {
   @Path("/1")
   @GET
   public Response get() {...}
}

@Path("/")
public class Root2 {
   @Path("/2")
   @GET
   public Response get() {...}
}
```

In JAX-RS 1.1 a request with a URI such as "`/1`" is not guaranteed to be matched. The `Root1 get()` will always be correctly selected. Note ResourceComparator may still be of help in some cases.

Link

Link is a utility class for building HTTP links as HTTP Link headers or application data links.

UriInfo, UriBuilder, Response and ResponseBuilder classes have been enhanced to support Link.

Client API

The JAX-RS 2.0 Client API has been completely implemented in Artix for Java.

See the section JAX-RS Client API for more information.

Implementing REST with Artix for Java

Artix for Java uses the JAX-RS APIs for developing RESTful Webservices. The next chapter begins discussing how the JAX-RS APIs can be used to develop RESTful enabled applications.

Developing RESTful applications using the JAX-RS APIs

Artix recognizes a set of annotations that allow you to dictate the mappings of Java operations to a RESTful interface.

Artix provides a collection of annotations that allows you to define the mapping of an operation to an HTTP verb/URI combination. The REST annotations allow you to specify which verb to use for an operation and to specify a template for creating a URI for the exposed resource.

Specifying the HTTP verb

Artix uses four annotations for specifying the HTTP verb that will be used for a method:

- `javax.ws.rs.DELETE` specifies that the method maps to a `DELETE`.
- `javax.ws.rs.GET` specifies that the method maps to a `GET`.
- `javax.ws.rs.POST` specifies that the method maps to a `POST`.
- `javax.ws.rs.PUT` specifies that the method maps to a `PUT`.

When you map your methods to HTTP verbs, you must ensure that the mapping makes sense. For example, if you map a method that is intended to submit a purchase order, you would map it to a `PUT` or a `POST`. Mapping it to a `GET` or a `DELETE` would result in unpredictable behavior.

At the heart of JAX-RS lies the notion of the Resource class. JAX-RS emphasizes the manipulation of resources rather than issuing function calls. Resources have unique identifiers; this means that every resource is associated with one URL root. For example, `http://localhost:9000/customerservice` would signify a particular REST resource class.

This resource class relies on the use of Java annotations that describe how the various parts of the resource class are handled by the JAX-RS runtime.

Example 32. Specifying HTTP Verbs

```
package demo.jaxrs.server;

import javax.ws.rs.DELETE;
import javax.ws.rs.GET;
import javax.ws.rs.Path;
import javax.ws.rs.PathParam;
import javax.ws.rs.POST;
import javax.ws.rs.PUT;
import javax.ws.rs.Produces;
import javax.ws.rs.core.Response;

@Path("/customerservice/")
@Produces("application/json")
public class CustomerService {

    public CustomerService() {
    }

    @GET
    public Customers getCustomers() {
        ......
    }

    @GET
    @Path("/customers/{id}")
    @Produces("application/json")
    public Customer getCustomer(@PathParam("id") String id) {
        ......
    }

    @PUT
    @Path("/customers/{id}")
    @Consumes("application/xml")
    public Response updateCustomer(@PathParam("id") Long id,
          Customer customer) {
        ......
    }

    @POST
    @Path("/customers")
    public Response addCustomer(Customer customer) {
        ......
    }

    @DELETE
    @Path("/customers/{id}/")
    public Response deleteCustomer(@PathParam("id") String id)
{
        ......
    }
}
```

@Path annotation

The `@Path` annotation can be applied to resource classes or methods, and it is used to signify the root URL relative path. If for example the URL was `http://localhost:9000`, the url `http://localhost:9000/customerservice` would issue HTTP requests to our Resource class.

The value of `@Path` annotation is a relative URI path and follows the URI Template format and may include arbitrary regular expressions. When not available on the resource method, it is inherited from a class. For example:

Example 33. Using the @Path annotation

```
@Path("/customers/{id}")
public class CustomerResource {

    @GET
    public Customer getCustomer(@PathParam("id") Long id) {
        ......
    }

    @GET
    @Path("/order/{orderid}")
    public Order getOrder(@PathParam("id") Long customerId,
         @PathParam("orderid") Long orderId) {
        ......
    }

    @GET
    @Path("/order/{orderid}/{search:.*}")
    public Item findItem(@PathParam("id") Long customerId,
                         @PathParam("orderid") Long orderId,
                         @PathParam("search") String searchString,
                         @PathParam("search") List<PathSegment>
                             searchList) {
        ......
    }
}
```

This example is similar to the one above, but it also shows that an `{id}` template variable specified as part of the root `@Path` expression is reused by resource methods and a custom regular expression is specified by a `findItem()` method (note that a variable name is separated by '`:`' from an actual expression).

In this example, a request like '`GET /customers/1/order/2/price/2000/weight/2`' will be served by the `findItem()` method.

List<PathSegment> can be used to get to all the path segments in 'price/2000/weight/2' captured by the regular expression.

@Produces annotation

The @Produces annotation signifies the data format of the content that the Resource can produce, typical values are: application/xml, and application/json.

@Consumes annotation

The @Produces annotation signifies the data format of the content that the Resource can consume from HTTP based clients, typical values are application/xml, and application/json.

HTTP verb annotations

The JAX-RS specification defines a number of annotations such as GET, DELETE, PUT, and POST. Where GET will return a particular customer, the other verbs will make modifications: PUT will update a customer, POST will add a new customer, and DELETE will delete a customer's details.

Using an @HttpMethod designator, one can create a custom annotation such as @Update or @Patch. For example:

Example 34. Creating a Custom annotation

```
package org.apache.cxf.customverb;

import java.lang.annotation.ElementType;
import java.lang.annotation.Retention;
import java.lang.annotation.RetentionPolicy;
import java.lang.annotation.Target;

@Target({ElementType.METHOD})
@Retention(RetentionPolicy.RUNTIME)
@HttpMethod("PATCH")
public @interface PATCH {
  ...
}
```

Path parameters

With each resource method that has been annotated with a HTTP verb, we can further annotate the parameters to that method, and map them to values in the URL. In the following example, consider the GET method, and how it maps `{id}` in the URL/Path, to the parameter "`String id`":

Example 35. Mapping a Path Parameter

```
@GET
@Path("/customers/{id}")
@Produces("application/json")
public Customer getCustomer(@PathParam("id") String id) {
    ......
}
```

Using the JAX-RS APIs

Some guidance on how to get the best from the JAX-RS APIs.

Return types

Either `javax.ws.rs.core.Response` or custom type can be returned. `javax.ws.rs.core.Response` can be used to set the HTTP response code, headers and entity. JAX-RS `MessageBodyWriters` (see Message Body Providers) are in charge of serializing the response entities, those which are returned directly or as part of `javax.ws.rs.core.Response`.

Response Streaming

JAX-RS StreamingOutput

StreamingOutput can be used to stream the data to the client, for example:

Example 36. StreamingOutput

```
@GET
@Path("/books/pdf")
@Produces("application/pdf")
public StreamingOutput getPdf() {
  return new StreamingOutput() {
    public void write(final OutputStream os) {
     // read chunks of data from PDF and write to OutputStream
    }
  };
}
```

StreamingResponse

Artix 5.6.3 for Java introduces the `StreamingResponse` extension. This extension can be used with the WebSocket transport or as a possible replacement for the code working with StreamingOutput.

For example, consider that a number of resources need to be returned as they become available:

Example 37. StreamingResponse

```
@GET
@Path("/books")
@Produces("application/xml")
public StreamingResponse<Book> getBooks() {
  return new StreamingResponse<Book>() {
    public void writeTo(final Writer<Book> writer) {
     writer.getEntityStream().write("<Books>".getBytes());
     writer.write(new Book("CXF"));
     writer.write(new Book("JAX-RS"));
     writer.getEntityStream().write("</Books>".getBytes());
    }
  };
}
```

Exception handling

You can either throw an unchecked WebApplicationException, or return `Response` with a proper error code set.

The former option may be a better one when no JAX-RS types can be added to method signatures. For example :

Example 38. Throwing a WebApplication Exception

```
@Path("/customerservice/")
public class CustomerService {

    @PUT
    @Path("/customers/{id}")
    public Response updateCustomer(@PathParam("id") Long id, Customer customer)
    {
        return Response.status(errorCode).build();
    }

    @POST
    @Path("/customers")
    public Customer addCustomer(Customer customer) {
        throw new WebApplicationException(errorCode);
    }

}
```

Yet another option is to register an `ExceptionMapper` provider. For example:

Example 39. Using an ExceptionMapper Provider

```
public BookExceptionMapper implements ExceptionMapper<BookException> {
    public Response toResponse(BookException ex) {
        // convert to Response
    }
}
```

This allows for throwing a checked or runtime exception from an application code, and mapping it to an HTTP response in a registered provider.

Note that when no mappers are found for custom exceptions, they are propagated to the underlying container as required by the specification where they will typically be wrapped in ServletException, eventually resulting in HTTP 500 status being returned by default. Thus one option for intercepting the exceptions is to register a custom servlet filter which will catch ServletExceptions and handle the causes.

This propagation can be disabled by registering a boolean jaxrs property `'org.apache.cxf.propagate.exception'` with a false value. If such property is set and no exception mapper can be found for a given exception then it will be wrapped into an xml error response by the XMLFaultOutInterceptor.

You can also register a custom out fault interceptor which can handle all the exceptions by writing directly to the HttpServletResponse stream or XMLStreamWriter (as `XMLFaultOutInterceptor` does).

It is also possible to use registered ExceptionMappers to map the exceptions thrown from server in interceptors which are registered after JAXRSInInterceptor (Phase.UNMARSHAL) and out interceptors registered before JAXRSOutInterceptor (Phase.MARSHAL).

Mapping exceptions thrown from Artix Java interceptors

It is also possible to use registered ExceptionMappers to map the exceptions thrown from server in interceptors which are registered after `JAXRSInInterceptor` (`Phase.UNMARSHAL`) and out interceptors registered before `JAXRSOutInterceptor` (`Phase.MARSHAL`).

In order to get the exceptions thrown from Artix Java out interceptors mapped, add `org.apache.cxf.jaxrs.interceptor.JAXRSOutExceptionMapperInterceptor` to the list of out interceptors.

Customizing default WebApplicationException mapper

Artix Java ships a WebApplicationException mapper, `org.apache.cxf.jaxrs.impl.WebApplicationExceptionMapper`. By default it logs a stack trace at a warning level and returns Response available in the captured exception.

It can be configured to log a stack trace at a trace level, by setting a `'printStackTrace'` property to `'false'`. Alternatively, if `org.apache.cxf.logging.FaultListener` is registered (as a contextual property) and indicates that it handled a given exception, then no more logging is done.

A simple text error message can also be optionally reported, by setting an `'addMessageToResponse'` property to `'true'`.

Note that the custom WebApplicationException mapper, if registered, will be preferred to the default one.

Dealing with Parameters

The `PathParam` annotation is used to map a given Path template variable to a method parameter.

Example 40. Using the PathParam Annotation

```
@Path("/customer/{id}")
public class CustomerService {


  @PUT
  @Path("{name}")
  public Response updateCustomer(@PathParam("id") Long id,
          @PathParam("name") String name) {
      ...
  }
}
```

In this case a template variable `id` available from a root class annotation is mapped to a parameter of type Long, while a name variable is mapped to a parameter of type String.

`@QueryParam`, `@HttpHeader`, `@MatrixParam`, `@FormParam` and `@CookieParam` annotations are also supported.

Parameters can be of type String or of any type that have constructors accepting a String parameter or static `valueOf(String s)` methods.

Additionally JAX-RS checks for the static `fromString(String s)` method, so that types with no `valueOf(String)` factory methods can also be dealt with:

Example 41. Checking for types with no valueOf(String)

```
public enum Gender {
   MALE,
   FEMALE;

   public static Gender fromString(String s) {
       if ("1".equals(s)) {
           return FEMALE;
       } else if ("1".equals(s)) {
           return MALE;
       }
       return valueOf(s);
   }
}

@Path("/{g}")
public class Service {


  @PUT
  @Path("{id}")
  public Response update(@PathParam("g") Gender g, @PathParam("id") UUID u) {
        ...
  }
}
```

Note that on the trunk enums with `fromValue()` factory methods are also supported.

JAX-RS PathSegment is also supported. A sequence of identically named parameters (queries, headers, etc) can be mapped to List or Set or SortedSet.

JAX-RS supports ParameterHandler extensions which can be used to deal with method parameters annotated with one of the JAX-RS parameter annotations:

Example 42. Using ParameterHandler

```
public class MapHandler implements ParameterHandler<Map> {
    public Map fromString(String s) {...}
}

@Path("/map")
public class Service {

    @PUT
    @Path("/{mapvalue:(.)+}")
    public Response update(@PathParam("mapvalue") Map m, byte[] bytes) {
        ...
    }
}
```

Note that `ParameterHandlers` cannot be used to deal with parameters representing a message body, "`byte[] byte`" in this example. `MessageBodyReaders` have to deal with this task. That said, a given `MessageBodyReader` implementation can also implement `ParameterHandler`.

`ParameterHandlers` can be registered as providers either from Spring or programmatically.

Note that by default the handlers are checked last after all the other options recommended by the JAX-RS specification have been tried.

The handlers will always be checked first for `java.util.Date` and `java.util.Locale` parameters. Additionally, a "check.parameter.handlers.first" contextual property can be used to get the handlers checked first when the parameters of other types are processed.

All the parameters are automatically decoded. This can be disabled by using `@Encoded` annotation.

Parameters can have a default value set using a DefaultValue annotation :

```
public Response updateCustomer(@DefaultValue("123") @QueryParam("id")
     Long id, @PathParam("name") String name) { ... }
```

JAX-RS mandates that only a single method parameter which is not annotated with JAXRS annotations applicable to method parameters is allowed in a resource method. For example :

```
public Response do(@PathParam("id") String id, String body) {
}
```

Parameters like '`String body`' are expected to represent the request body/input stream. It's the job of JAX-RS MessageBodyReaders to deserialize the request body into an object of the expected type.

It is also possible to inject all types of parameters into fields or through dedicated setters. For example, the code in Example 40 can be rewritten like this:

Example 43. Injecting Parameters

```
@Path("/customer/{id}")
public class CustomerService {

    @PathParam("id")
    private Long id;

    private String name;

    @PathParam("name")
    public setName(String name) {
        this.name = name;
    }

    @PUT
    @Path("{name}")
    public Response updateCustomer() {
        // use id and name
    }
}
```

Parameter beans

There is an extension which makes it possible to inject a sequence of @PathParam, @QueryParam, @FormParam or @MatrixParam parameters into a bean. For example:

Example 44. Parameter Beans

```
@Path("/customer/{id}")
public class CustomerService {

    @PUT
    @Path("{name}")
    public Response updateCustomer(@PathParam("") Customer customer) {
        ...
    }

    @GET
    @Path("/order")
    public Response getCustomerOrder(@PathParam("id") int customerId,
                                     @QueryParam("") OrderBean bean,
                                     @MatrixParam("") OrderBean bean) {
        ...
    }

    @POST
    public Response addCustomerOrder(@PathParam("id") int customerId,
                                     @FormParam("") OrderBean bean) {
        ...
    }
}

public class Customer {
   public void setId(Long id) {...}
   public void setName(String s) {...}
}

public class OrderBean {
   public void setId(Long id) {...}
   public void setWeight(int w) {...}
}
```

Note that there is a single `@PathParam` with an empty value in `updateCustomer()` - this is an extension bit. The value for a template variable `'id'` is injected into `Customer.setId(Long id)`, while the value for `'name'` is injected into `Customer.setName(String s)`. The setter methods should have a single parameter, the conversion from the actual value to the parameter instance follows the same procedure as outlined above.

Similarly, in getCustomerOrder(), OrderBean can be injected with corresponding values from a query string like

`?id=1&weight=2` or from matrix parameters set as part of one of the path segments `/customer/1/order`, `id=1`, or `weight=2`. Likewise, in `addCustomerOrder()`, `FormParam("")` can capture all the values submitted from an HTML form and inject them into OrderBean.

Nested beans are also supported, which among other things, makes it possible to formulate advanced search queries. For example, given the following bean definitions:

Example 45. Searching Using Nested Beans

```
class Name {
    String first;
    String last;
}

class Address {
    String city;
    String state;
}

class Person {
    Name legalName;
    Address homeAddr;
    String race;
    String sex;
    Date birthDate;
}

class MyService
{
    @GET
    @Path("/getPerson")
    Person getPerson(@QueryParam("") Person person);
}
```

a query like:

```
> /getPerson?sex=M&legalName.first=John&legalName.last=
Doe&homeAddr.city=Reno&homeAddr.state=NV
```

will result in a Person bean being properly initialized and all the search criteria being captured and easily accessible. Note more enhancements are being planned in this area.

Resource lifecycles

The scopes which are supported by default are Singleton and Prototype(per-request).

Note that JAXRS `MessageBodyWriter` and `MessageBodyReader` providers are always singletons.

Classes with prototype scopes can get JAXRS contexts or parameters injected at construction time:

```
@Path("/")
public class PerRequestResourceClass {

   public PerRequestResourceClass(@Context HttpHeaders headers,
       @QueryParam("id") Long id) {}
}
```

Classes with singleton scopes can only have contexts injected at the construction time and it is only a `CXFNonSpringJaxrsServlet` which can do it. In most cases you can have contexts injected as bean properties immediately after construction time.

Overview of the selection algorithm

The JAX-RS Selection algorithm is used to select root resource classes, resource methods and subresource locators.

Selecting between multiple resource classes

When multiple resource classes match a given URI request, the following algorithm is used :

1. Prefer the resource class which has more literal characters in its `@Path` annotation.

   ```
   @Path("/bar/{id}")
   public class Test1 {}
   @Path("/bar/{id}/baz")
   public class Test2 {}
   @Path("/foo")
   public class Test3 {}
   @Path("/foo/")
   public class Test4 {}
   ```

   Both classes match `/bar/1/baz` requests but Test2 will be selected as it has nine Path literal characters compared to five in Test1. Similarly, Test4 wins against Test3 when a `/foo/` request arrives.

2. Prefer the resource class which has more capturing groups in its `@Path` annotation.

```
@Path("/bar/{id}/")
public class Test1 {}
@Path("/bar/{id}/{id2}")
public class Test2 {}
```

Both classes match `/bar/1/2` requests and both have the same number of literal characters but Test2 will be selected as it has two Path capturing groups (`id` and `id1`) as opposed to one in Test1.

3. Prefer the resource class which has more capturing groups with arbitrary regular expressions in its `@Path` annotation.

```
@Path("/bar/{id:.+}/baz/{id2}")
public class Test1 {}
@Path("/bar/{id}/bar/{id2}")
public class Test2 {}
```

Both classes match `/bar/1/baz/2` requests and both have the same number of literal characters and capturing groups but Test1 will be selected as it has one Path capturing group with the arbitrary regular expression (`id`) as opposed to none in Test2.

Selecting between multiple resource methods

Once the resource class has been selected, the next step is to choose a resource method. If multiple methods can be matched then the same rules which are used for selecting resource classes are applied. So one more rule is used:

4. Prefer a resource method to a subresource locator method

```
@Path("/")
public class Test1 {

 @Path("/bar")
 @GET
 public Order getOrder() {...}

 @Path("/bar")
 public Order getOrderFromSubresource() {...}
}

public class Order {

 @Path("/")
 @GET
 public Order getOrder() { return this; }
}
```

Both `getOrderFromSubresource()` and `getOrder()` methods can be used to serve a /bar request. However, `getOrder()` wins.

Resource methods and media types

Consider this resource class with two resource methods:

Example 46. Resource Class with Two Resource Methods

```
@Path("/")
public class Test1 {

 @Path("/bar")
 @POST
 @Consumes("application/json")
 @Produces("application/json")
 public Order addOrderJSON(OrderDetails details) {...}

 @Path("/bar")
 @POST
 @Consumes("application/xml")
 @Produces("application/xml")
 public Order getOrderXML(OrderDetails details) {...}
}
```

Both methods match `/bar` requests. If in a given request both Content-Type and Accept are set to `application/xml` then getOrderXML will be selected. If both Content-Type and Accept are set to `application/json` then `getOrderJSON` will be chosen instead.

For this specific example, in both cases either JAXB or JSON message body readers and writers will be selected to deserialize the input stream into `OrderDetails` and serialize `Order` into the output stream. Message body providers can have `@Produces` and `@Consumes` set too, and they have to match those on a chosen resource method.

The above code example can be replaced with this one:

Example 47. Using a Combined Resource Method

```
@Path("/")
public class Test1 {

 @Path("/bar")
 @POST
 @Consumes({"application/json", "application/xml"})
 @Produces({"application/json", "application/xml"})
 public Order addOrder(OrderDetails details) {...}

}
```

Custom selection between multiple resources

The JAX-RS selection algorithm has been designed with a lot of attention being paid to various possible cases, as far as the selection between multiple matching resource classes or methods is concerned.

However, in some cases, users have reported the algorithm being somewhat restrictive in the way multiple resource classes are selected. For example, by default, after a given resource class has been matched and if this class has no matching resource method, then the algorithm stops executing, without attempting to check the remaining matching resource classes.

It is possible to register a custom ResourceComparator implementation using a `jaxrs:server/jaxrs:resourceComparator` element, as shown in Example 48.

Example 48. Registering a Custom ResourceComparator

```
<!-- JAX-RS endpoint declaration fragment -->
<jaxrs:server address="/">
<!-- Usual elements, like serviceBeans or providers, etc -->

<!-- Custom ResourceComparator -->
<jaxrs:resourceComparator>
   <bean class="org.custom.CustomResourceComparator"/>
</jaxrs:resourceComparator>
</jaxrs:server>
```

Custom implementations can check the names of the resource classes or methods being compared and given the current request URI they can make sure that the required class or method is chosen by returning either `-1` or `1`, as needed. If `0` is returned then the runtime will proceed with executing the default selection algorithm. At the moment the easiest way to get to the details such as the current request URI is to create an instance of the JAX-RS `UriInfoImpl` using a constructor accepting a Message.

Note that by the time a custom `ResourceComparator` is called the provided resource classes or methods have already been successfully matched by the runtime.

For example, the optional HTTP request and URI parameters (query, matrix, headers, cookies) and form parameters do not affect the selection algorithm.

A custom `ResourceComparator` can be used when this limitation is considered to be problematic. Example 49 shows one such implementation.

Example 49. Implementing a Custom ResourceComparator

```
import java.io.UnsupportedEncodingException;
import java.net.URLDecoder;
import java.util.HashSet;
import java.util.List;
import java.util.Set;

import javax.ws.rs.core.MultivaluedMap;

import org.apache.cxf.jaxrs.ext.ResourceComparator;
import org.apache.cxf.jaxrs.model.ClassResourceInfo;
import org.apache.cxf.jaxrs.model.OperationResourceInfo;
import org.apache.cxf.jaxrs.model.OperationResourceInfoComparator;
import org.apache.cxf.jaxrs.model.Parameter;
import org.apache.cxf.jaxrs.util.JAXRSUtils;
import org.apache.cxf.message.Message;

public class QueryResourceInfoComperator extends
        OperationResourceInfoComparator implements ResourceComparator {

     public QueryResourceInfoComperator() {
         super(null, null);
     }

     @Override
     public int compare(ClassResourceInfo cri1, ClassResourceInfo cri2,
               Message message) {
         // Leave Class selection to CXF
         return 0;
     }

     @Override
     public int compare(OperationResourceInfo oper1,
               OperationResourceInfo oper2, Message message) {

         // Check if CXF can make a decision
         int cxfResult = super.compare(oper1, oper2);
         if (cxfResult != 0)
             return cxfResult;

         int op1Counter = getMatchingRate(oper1, message);
         int op2Counter = getMatchingRate(oper2, message);

         return op1Counter == op2Counter
                 ? 0
                 : op1Counter<  op2Counter
                         ? 1
                         : -1;
     }

    /**
     * This method calculates a number indicating a good or bad match between
     * values provided within the request and expected method parameters. A
```

```
 * higher number means a better match.
 *
 * @param operation
 *            The operation to be rated, based on contained parameterInfo
 *            values.
 * @param message
 *            A message containing query from user request
 * @return A positive or negative number, indicating a good match between
 *         query and method
 */
protected int getMatchingRate(OperationResourceInfo operation, Message
         message) {

      List<Parameter>  params = operation.getParameters();
      if (params == null || params.size() == 0)
          return 0;

      // Get Request QueryParams
      Set<String>  qParams = getParams((String)
               message.get(Message.QUERY_STRING));

      int rate = 0;
      for (Parameter p : params) {
          switch (p.getType()) {
          case QUERY:
              if (qParams.contains(p.getName()))
                  rate += 2;
              else if (p.getDefaultValue() == null)
                  rate -= 1;
              break;
         // optionally support other parameter types such as headers, etc
         // case HEADER:
         //  break;
         default:
              break;
          }
      }
      return rate;
  }

  /**
   * @param query
   *            URL Query Example: 'key=value&key2=value2'
   * @return A Set of all keys, contained within query.
   */
  protected Set<String>  getParams(String query) {
      Set<String>  params = new HashSet<String>();
      if (query == null || query.length() == 0)
          return params;

      MultivaluedMap<String, String> allQueries =
          JAXRSUtils.getStructuredParams(query, "&", false, false);
      return allQueries.keySet();
```

```
    }
}
```

Now consider this code:

```
@Path("/paramTest")
public class MySimpleService {

      @GET
      public String getFoo(@QueryParam("foo") String foo){
          return "foo:" + foo;
      }

      @GET
      public String getFooBar(@QueryParam("foo") String foo,
      @QueryParam("bar") String bar){
          return "foo:" + foo + " bar:" + bar;
      }
}
```

Using the custom comparator will lead to the `getFoo`() method accepting a single query parameter selected when a request URI has only one query parameter, and `getFoo()` method accepting multiple query parameters selected when a request URI has at least two query parameters. Further customizations may also be possible.

Context Annotations

A number of context types can be injected as parameters, in fields or through dedicated methods.

The following context types can be injected:

- UriInfo
- SecurityContext
- HttpHeaders
- Providers
- Request
- ContextResolver
- Servlet types:
    - HttpServletRequest
    - HttpServletResponse
    - ServletContext
    - ServletConfig

A specific composite context interface, *MessageContext*, is also supported in order to make it easier to deal with all the supported JAX-RS contexts (and indeed with future ones). It also lets you check the current message's properties.

Example 50. Using MessageContext

```
@Path("/customer")
public class CustomerService {

    @Context
    private org.apache.cxf.jaxrs.ext.MessageContext mc;
    @Context
    private ServletContext sc;
    private UriInfo ui;

    @Context
    public void setUriInfo(UriInfo ui) {
        this.ui = ui;
    }

    @PUT
    public Response updateCustomer(@Context HttpHeaders h, Customer c)
    {
        mc.getHttpHeaders();
    }
}
```

Note that all types of supported JAX-RS providers such as `MessageBodyWriter`, `MessageBodyReader`, `ExceptionMapper` and `ContextResolver`, as well as the list of body providers which can be provided by Providers can have contexts injected too. The only exception is that no parameter level injection is supported for providers due to methods of JAXRS providers being fixed.

Note that Providers and ContextResolver are likely to be of interest to message body providers rather than to the actual application code. You can also inject all the context types into `@Resource` annotated fields.

Custom Contexts

Registering a custom ContextProvider implementation such as `SearchContextProvider` lets you attach Context annotations to arbitrary classes which can be helpful when some of the information representing the current request needs to be optimized or specialized.

For example:

Example 51. Using Custom Contexts

```
package resources;
import org.apache.cxf.jaxrs.ext.search.SearchContext;
@Path("/")
public class RootResource {
    @Context
    private  SearchContext sc;
    // the rest of the code
}
```

And:

```
<jaxrs:server>
  <serviceBeans>
    <bean class="resources.RootResource"/>
  </serviceBeans>
  <jaxrs:providers>
    <bean
class="org.apache.cxf.jaxrs.ext.search.SearchContextProvider"/>
  </jaxrs:providers>
</jaxrs:server>
```

Custom Context implementations may get all the information about the HTTP request from the current message.

URI Calculation

UriInfo and UriBuilder can be used to determine URIs to present to a client.

Mapping of a particular URI to a service that returns some resource is straightforward using the `@Path` annotation. However RESTful services are often connected: one service returns data that is used as the key in another service.

Example 52 shows a tyical example, listing entities and accessing a particular entity.

Example 52. Accessing an Entity from a List

```
@Path("/customers")
public class CustomerService {

    @GET
    public Customers getCustomers() {
        ......
    }

    @GET
    @Path("/{id}")
    public Customer getCustomer(@PathParam("id") String id)
{
        ......
    }
}
```

For this service we can assume that the returned list of customers exposes only basic attributes and more details is returned using the second method which uses the customer ID as the key. Something like this:

```
GET http://foobar.com/api/customers

<customers>
    <customer id="1005">John Doe</customer>
    <customer id="1006">Jane Doe</customer>
    ...
</customers>

GET http://foobar.com/api/customers/1005

<customer id="1005">
    <first-name>John</first-name>
    <last-name>Doe</last-name>
    ...
</customer>
```

How does a client of this service know how to get from a list of customers to given customer? A trivial approach would be to expect the client to compute the proper URI. But wouldn't it be better to have the services provide full URIs in the response that can be used directly? This way the client would be more decoupled from the service itself (which may change URI format over time).

A client could be provided with the following on response:

```
GET http://foobar.com/api/customers

<customers-list>
    <customer id="1005" url="http://foobar.com/api/customers/1005">
              John Doe</customer>
    <customer id="1006" url="http://foobar.com/api/customers/1006">
              Jane Doe</customer>
    ...
</customers-list>
```

The problem for the service is how to determine these URIs when the paths come from `@Path` annotations. Paths with templates (variables) on multiple levels or sub-resources introducing dynamic routing to different URIs complicate the situation even further.

The core part of the solution is to inject the `UriInfo` object into method "`getCustomers`". This helper object allows for extracting useful information about the current URI context, but more importantly allows for getting the UriBuilder object. UriBuilder has multiple appender methods for building the URI for each object; in the current case to the stem URI y can append path in multiple ways, providing it as a string (which we actually want to avoid here) or a resource (class or method) to extract the `@Path` value. Finally `UriBuilder` must have values bound to its template variables to render the actual URI. This case in action looks like this:

```
@Path("/customers")
public class CustomerService {

    @GET
    public Customers getCustomers(@Context UriInfo ui) {
        ......
        // builder starts with current URI and has the path of the getCustomer
                 method appended to it
        UriBuilder ub = ui.getAbsolutePathBuilder().path(this.getClass(),
                 "getCustomer");
        for (Customer customer: customers) {
            // builder has {id} variable that must be filled in for each customer
            URI uri = ub.build(customer.getId());
            c.setUrl(uri);
        }
        return customers;
    }

    @GET
    @Path("/{id}")
    public Customer getCustomer(@PathParam("id") String id) {
        ......
    }
}
```

Annotation inheritance

Most of the JAX-RS annotations can be inherited from either an interface or a superclass, as in the followingr example.

Example 53. Annotation Inheritance

```
public interface CustomerService {

    @PUT
    @Path("/customers/{id}")
    Response updateCustomer(@PathParam("id") Long id, Customer customer);

    @POST
    @Path("/customers")
    Customer addCustomer(Customer customer);

}

@Path("/customerservice/")
public class Customers implements CustomerService {


    public Response updateCustomer(Long id, Customer customer) {
        return Response.status(errorCode).build();
    }

    public Customer addCustomer(Customer customer) {
        throw new WebApplicationException(errorCode);
    }
}
```

Similarly, annotations can be inherited from super-classes. In Artix for Java, the resource class inherits the class-level annotations from both its implemented interfaces and any class it extends.

Sub-Resource Locators

A method of a resource class that is annotated with `@Path` becomes a sub-resource locator when no annotation with an HttpMethod designator like @GET is present. Sub-resource locators are used to further resolve the object that will handle the request. They can delegate to other sub-resource locators, including themselves.

In Example 54, getOrder method is a sub-resource locator:

Example 54. Using Sub-Resource Locators

```
@Path("/customerservice/")
public class CustomerService {

    @Path("/orders/{orderId}/")
    public Order getOrder(@PathParam("orderId") String orderId) {
       ......
    }
}

@XmlRootElement(name = "Order")
public class Order {
    private long id;
    private Items items;

    public Order() {
    }

    public long getId() {
        return id;
    }


    @GET
    @Path("products/{productId}/")
    public Product getProduct(@PathParam("productId")int productId) {
       ......
    }

    @Path("products/{productId}/items")
    public Order getItems(@PathParam("productId") int productId) {
       return this;
    }

    @GET
    public Items getItems() {
       ......
    }
}
```

A HTTP GET request to `http://localhost:9000/customerservice/orders/223/products/323` is dispatched to `getOrder` method first. If the Order resource whose `id` is 223 is found, the Order 223 will be used to further resolve Product resource. Eventually, a Product 323 that belongs to Order 223 will be returned. Similarly, the request to `http://localhost:9000/customerservice/orders/223/products/323/items` will be delivered to the `getItems(productId)` method.

Note that a subresource class like Order often has no root `@Path` annotations which means that they are delegated to dynamically at runtime; in other words, they cannot be invoked upon before one of the root resource classes is invoked first. A root resource class (which has a root `@\Path` annotation) can become a subresource too if one of its subresource locator methods delegates to it, similar to `Order.getItems(productId)` above.

Note that a given subresource can be represented as an interface or some base class resolved to an actual class at runtime. In this case any resource methods which have to be invoked on an actual subresource instance are discovered dynamically at runtime.

Example 55. Representing a Sub-Resource as a Class

```
@Path("/customerservice/")
public class CustomerService {

    @Path("/orders/{orderId}/")
    public Order getOrder(@PathParam("orderId") String orderId) {
       ......
    }
}

public interface Order {
    @GET
    @Path("products/{productId}/")
    Product getProduct(@PathParam("productId")int productId);
}

@XmlRootElement(name = "Order")
public class OrderImpl implements Order {

    public Product getProduct(int productId) {
       ......
    }
}

@XmlRootElement(name = "Order")
public class OrderImpl2 implements Order {

    // overrides JAXRS annotations
    @GET
    @Path("theproducts/{productId}/")
    Product getProduct(@PathParam("id")int productId) {...}
}
```

Static resolution of subresources

By default, subresources are resolved dynamically at runtime. This is a slower procedure, partly due to the fact that a concrete subresource implementation may introduce some JAXRS annotations in addition to those which might be available at the interface typed by a subresource locator method and different to those available on another subresource instance implementing the same interface.

If you know that all the JAXRS annotations are available on a given subresource type (or one of its superclasses or interfaces) returned by a subresource locator method then you may want to disable the dynamic resolution as shown in the following example:

Example 56. Static Resolution of a Sub-Resource

```
<beans>
<jaxrs:server staticSubresourceResolution="true">
<!-- more configuration -->
</jaxrs:server>
</beans>
```

The injection of JAX-RS contexts and parameters will also be supported if this property has been enabled.

Message Body Providers

JAX-RS relies on *MessageBodyReader* and *MessageBodyWriter* implementations to serialize and de-serialize Java types. JAX-RS requires that certain types have to be supported out of the box.

By default, Artix for Java supports the following types:

- String
- byte[]
- InputStream
- Reader
- File
- JAXP Source
- JAX-RS StreamingOutput
- JAXB-annotated types with `application/xml`, `text/xml` and `application/json` formats as well as JAXBElement.
- JAX-RS MultivaluedMap is also supported for form contents.

See also Support for Data Bindings.

Custom Message Body Providers

It is likely that a given application may need to deal with types that are not supported by default. Alternatively, developers may want to provide a more efficient implementation for handling default types such as InputStream.

Example 57 shows a custom `MessageBodyReader` for `InputStream`.

Example 57. A Custom MessageBodyHeader

```
@Consumes("application/octet-stream")
@Provider
public class InputStreamProvider implements MessageBodyReader<InputStream>
{


    public boolean isReadable(Class<InputStream> type, Type genericType,
           Annotation[] annotations, MediaType mt) {
        return InputStream.class.isAssignableFrom(type);
    }

    public InputStream readFrom(Class<InputStream> clazz, Type t,
           Annotation[] a, MediaType mt, MultivaluedMap<String, String>
           headers, InputStream is)
        throws IOException {
        return new FilterInputStream(is) {
             @Override
             public int read(byte[] b) throws IOException {
                 // filter out some bytes
             }
        }
    }
}
```

Example 68 shows a custom `MessageBodyWriter` for `Long` objects:

Example 68. A Custom MessageBodyWriter

```
@Produces("text/plain")
@Provider
public class LongProvider implements MessageBodyWriter<Long> {

    public long getSize(Long l, Class<?> type, Type genericType,
Annotation[] annotations, MediaType mt) {
        return -1;
    }

    public boolean isWriteable(Class<?> type, Type genericType,
Annotation[] annotations, MediaType mt) {
        return long.class.isAssignableFrom(type) ||
        Long.class.isAssignableFrom(type);
    }

    public void writeTo(Long l, Class<?> clazz, Type type, Annotation[] a,
                        MediaType mt, MultivaluedMap<String, Object>
                        headers, OutputStream os)
        throws IOException {
        os.write(l.toString().getBytes());

    }
```

Artix 5.6.3 for Java ships with some custom providers too, for dealing with Atom (based on Apache Abdera) and XMLObjects. Artix Java also supports primitive types and their Number friends when text/plain media type is used, either on input or output.

Registering Custom Providers

You can easily register a provider either from Spring configuration or programmatically:

Example 69. Registering a Custom Provider

```
<beans>
<jaxrs:server id="customerService" address="/">
    <jaxrs:serviceBeans>
      <bean class="org.CustomerService" />
    </jaxrs:serviceBeans>

    <jaxrs:providers>
      <ref bean="isProvider" />
      <ref bean="longProvider" />
    </jaxrs:providers>
    <bean id="isProvider" class="com.bar.providers.InputStreamProvider"/>
    <bean id="longProvider" class="com.bar.providers.LongProvider"/>
</jaxrs:server>
</beans>
```

Note that instead of the older `<jaxrs:entityProviders>` the container `<jaxrs:providers>` is now used. JAX-RS supports different types of providers and having a single `<jaxrs:providers>` container is in line with the way other JAX-RS implementations discover providers by checking for `@Provider` annotations only.

While having `@Provider`-annotated providers automatically registered is a handy feature indeed, sometimes it might actually be problematic. For example, in a large project user providers from different libraries might clash.

When using the custom configuration (as shown above) provider instances of different types (handling the same format of request/response bodies) or differently configured instances of the same type can be registered with a different `jaxrs:server` instance. Yet another requirement might be to have only a given `jaxrs:server` endpoint among multiple available ones to handle requests with a given media type:

Example 70. Using a jaxrs.server endpoint to handle requests with a given media type

```
<beans>
<jaxrs:server id="customerService1" address="/1">
   <bean id="serviceBean" class="org.CustomerService" />

   <jaxrs:serviceBeans>
      <ref bean="serviceBean"/>
   </jaxrs:serviceBeans>

   <jaxrs:providers>
      <bean class="com.bar.providers.InputStreamProvider"/>
   </jaxrs:providers>
</jaxrs:server>
<jaxrs:server id="customerService2" address="/2">
    <jaxrs:serviceBeans>
      <ref bean="serviceBean"/>
    </jaxrs:serviceBeans>

    <jaxrs:providers>
      <bean id="isProvider" class=
            "baz.foo.jaxrsproviders.InputStreamProvider"/>
    </jaxrs:providers>
</jaxrs:server>

<jaxrs:server id="customerService3" address="/3">
    <jaxrs:serviceBeans>
      <ref bean="serviceBean"/>
```

Support for Data Bindings

JAX-RS `MessageBodyReader` and `MessageBodyWriter` can be used to create data bindings for reading and writing data in a number of different formats. Compliant JAX-RS implementations are expected to support JAXB-annotated beans, JAXP Source objects, InputStreams, and other formats. In addition, Artix for Java lets you re-use existing DataBindings for working with JAXB and other formats.

The following sections describe the support provided for JAXB abd JSON bindings. For further information, consult the Apache CXF online documentation at http://cxf.apache.org/docs/jax-rs-data-bindings.html.

JAXB Support

The request and response can be marshaled to and unmarshaled from a Java object using JAXB. There is a number of ways to tell the JAXB provider how objects can be serialized. The simplest way is to mark a given type with `@XmlRootElement` annotation.

Example 71. Using @XmlRootElement annotation

```
@XmlRootElement(name = "Customer")
public class Customer {
    private String name;
    private long id;

    public Customer() {
    }

    public void setName(String n) {
        name = n;
    }

    public String getName() {
        return name;
    }

    public void setId(long i) {
        id = i;
    }

    public long getId() {
        return id;
    }
}
```

In Example 72, the Customer object returned by `getCustomer` is marshaled using JAXB data binding:

Example 72. Marshaling an Object Using JAXB Data Binding

```
@Path("/customerservice/")
public class CustomerService {
    @GET
    @Path("/customers/{customerId}/")
    public Customer getCustomer(@PathParam("customerId") String id) {
        ....
    }
}
```

The wire representation of the `Customer` object is:

```
<Customer>
    <id>123</id>
    <name>John</name>
</Customer>
```

The simplest way to work with Collections is to define a type representing a Collection. For example:

Example 73. Defining a Type Representing a Collection

```
@XmlRootElement(name = "Customers")
public class Customers {
    private Collection<Customer> customers;

    public Collection<Customer> getCustomer() {
        return customers;
    }

    public void setCustomer(Collection<Customer> c) {
        this.customers = c;
    }
}
@Path("/customerservice/")
public class CustomerService {
    @GET
    @Path("/customers/")
    public Customers getCustomers() {
        ....
    }
}
```

As an alternative to using `@XmlRootElement` and `Collection` wrappers, one can provide an Object factory which will tell JAXB how to marshal a given type (in the case of Collections, its template type). Another option is to return or accept a JAXBElement directly from or in a given method.

Another option is to register one or more JAX-RS `ContextResolver` providers capable of creating JAXBContexts for a number of different types. The default `JAXBElementProvider` will check these resolvers first before attempting to create a JAXBContext on its own.

Finally, `JAXBProvider` provides a support for serializing response types and deserializing parameters of methods annotated with @XmlJavaTypeAdapter annotations.

Configuring the JAXB provider

The default JAXB provider can be configured in a number of ways. For example, here is how to set up marshal properties:

Example 74. Setting up Marshal Properties

```
<beans xmlns:util="http://www.springframework.org/schema/util">
<bean id="jaxbProvider" class="org.apache.cxf.jaxrs.provider.JAXBElementProvider">
<property name="marshalerProperties" ref="propertiesMap"/>
</bean>
<util:map id="propertiesMap">
<entry key="jaxb.formatted.output">
   <value type="java.lang.Boolean">true</value>
</entry>
</util:map>
/<beans>
```

Individual marshal properties can be injected as simple properties. At the moment, `Marshaler.JAXB_SCHEMA_LOCATION` can be injected as "`schemaLocation`" property. Schema validation can be enabled and custom `@Consume` and `@Produce` media types can be injected. See http://cxf.apache.org/docs/jax-rs-data-bindings.html for more information.

One issue which you may need to be aware of it is that an exception may occur during the JAXB serialization process, after some content has already been processed and written to the output stream. By default, the output goes directly to the output HTTP stream so if an exception occurs midway through the process then the output will likely be malformed. If you set `'enableBuffering'` property to `'true'` then a JAXB provider will write to the efficient `CachedOutputStream` instead and if an exception occurs then no text which has already been written will make it to the outside world and it will be only this exception that will be reported to the client.

When enabling buffering, you can also control how the data being serialized will be buffered. By default, an instance of CachedOutputStream will be used. If you set an "`enableStreaming`" property on the `JAXBElementProvider` then it will be a `CachingXMLEventWriter` that will cache the serialization events.

If you would like your own custom provider to write to a cached stream then you can either set an "`org.apache.cxf.output.buffering`" property to `'true'` on a jaxrs endpoint or "`enableBuffering`" property on the provider. If this provider deals with XML and has a "`getEnableStreaming`" method returning `'true'` then CachingXMLEventWriter will be used, in all other cases CachedOutputStream will be used.

Note that if you do not have wrapper types for your methods and the classloader you are using does not allow you to call `defineClass()`, you may need to set `-Dcom.sun.xml.bind.v2.bytecode.ClassTailor.noOptimize`.

JAXB Marshaler, Unmarshaler and context properties can be configured for both JAXB and JSON providers. Both providers can also be configured to skip the `isReadable()` and `isWriteable()` checks to do with asserting that a given instance is likely to be successfully read/written by setting a `'skipChecks'` property to `true`. This can be useful when it is known that only valid JAXB instances are read or written.

It is possible to have specific prefixes associated with XML namespaces. This might be needed to make legacy consumers able to consume the resulting XML. Use a "`namespacePrefixes`" map property (`namespace` is a key, the corresponding prefix is a value).

JSON Support

The following code returns a `Customer` object that is marshaled to JSON format:

Example 75. Marshaling an Object to JSON Format

```
@Path("/customerservice/")
public class CustomerService {
    @Produces("application/json")
    @GET
    @Path("/customers/{customerId}/")
    public Customer getCustomer(@PathParam("customerId") String id) {
        ....
    }
```

Configuring the JSON provider

The default JSON provider relies on Jettison 1.3 and it expects the types it deals with to follow the same techniques as described in JAXB support for them to be handled properly.

The default JSON provider can be configured in a number of ways. Example 76 shows how to set up namespace-to-prefix mappings.

Example 76. Setting up Namespace-to-Prefix Mappings in a JSON Provider

```
<beans xmlns:util="http://www.springframework.org/schema/util">
<bean id="jaxbProvider" class="org.apache.cxf.jaxrs.provider.json.JSONProvider">
<property name="namespaceMap" ref="jsonNamespaceMap"/>
</bean>
<util:map id="jsonNamespaceMap" map-class="java.util.Hashtable">
<entry key="http://www.example.org/books" value="b"/>
</util:map>
/<beans>
```

Schema validation can be enabled and custom `@Consume` and `@Produce` media types can be injected. See http://cxf.apache.org/docs/jax-rs-data-bindings.html for more information.

JAX-RS Client API

The JAX-RS client API is a Java based API used to access Web resources. It is not restricted to resources implemented using JAX-RS. It provides a higher-level abstraction compared to a plain HTTP communication API as well as integration with the JAX-RS extension providers, in order to enable concise and efficient implementation of reusable client-side solutions that leverage existing and well established client-side implementations of HTTP-based communication.

JAX-RS 2.0 Client API

Artix for Java implements the JAX-RS 2.0 Client API. Internally it is implemented in terms of WebClient.

The javax.ws.rs.client specification provides a short overview of how the JAX-RS 2.0 Client API works.

Typically, you can proceed as follows:

1. Start with ClientBuilder in order to create a Client.

2. Next create WebTarget and further customize the target as needed.

3. Next, initialize Invocation.Builder and the request can be made immediately using one of the SyncInvoker methods, with the builder directly implementing SyncInvoker.

```
Client client = ClientBuilder.newBuilder().newClient();
WebTarget target = client.target("http://localhost:8080/rs");
target = target.path("service").queryParam("a", "avalue");

Invocation.Builder builder = target.request();
Response response = builder.get();
Book book = builder.get(Book.class);
```

You can easily collapse this sequence into a single code sequence if preferred.

Note that SyncInvoker (and AsyncInvoker) expects Entity to represent the request body.

Invocation.Builderhas a shortcut to Invocation via its `build(...)` methods to further customize the invocation.

`Invocation.Builder.async()` links to AsyncInvoker.

Client and WebTarget can be individually configured. They implement the Configurable interface which can accept the providers and properties and return Configuration. Configuring the Client directly or indirectly via the `ClientBuilder.withConfig` method affects all the WebClients spawned by a given Client.

Proxy-based API

With the proxy-based API, you can reuse on the client side the interfaces or even the resource classes which have already been designed for processing the HTTP requests on the server side (note that a `cglib-nodeps` dependency will need to be available on the classpath for proxies created from concrete classes). When reused on the client side, they simply act as remote proxies.

`JAXRSClientFactory` is a utility class which wraps `JAXRSClientFactoryBean`. `JAXRSClientFactory` offers a number of utility methods but `JAXRSClientFactoryBean` can also be used directly if desired.

Example 77 Using Proxy-Based APIs

For example, given these class definitions:

```
@Path("/bookstore")
public interface BookStore {
   @GET
   Books getAllBooks();

   @Path("{id}")
   BookResource getBookSubresource(@PathParam("id") long id)
       throws NoBookFoundException;
}

public class BookStoreImpl implements BookStore {
   public Books getAllBooks() {}

   public Book getBookSubresource(long id) throws NoBookFoundException {}
}

public interface BookResource {
```

```
    @GET
    Book getBook();
}

public class BookResourceImpl implements BookResource {
    Book getBook() {}
}
```

the following client code retrieves a Book with id '1' and a collection of books:

```
BookStore store = JAXRSClientFactory.create("http://bookstore.com",
     BookStore.class);
// (1) remote GET call to http://bookstore.com/bookstore
Books books = store.getAllBooks();
// (2) no remote call
BookResource subresource = store.getBookSubresource(1);
// {3} remote GET call to http://bookstore.com/bookstore/1
Book b = subresource.getBook();
```

When proxies are created, initially or when subresource methods are invoked, the current URI is updated with corresponding `@Path`, `@PathParam`, `@QueryParam` or `@MatrixParam` values, while `@HttpHeader` and `@CookieParam` values contribute to the current set of HTTP headers. Same happens before the remote invocation is done.

It is important to understand that strictly speaking there is no direct relationship between a given method on the client side and the same one on the server side. The job of the proxy is to construct a correct URI according to given class and method specifications - it may or may not be the same method on the corresponding server class that will be invoked (provided of course that it is a JAX-RS annotated server resource class - but that may not be the case!) More often than not, you will see a method `foo()` invoked on a server resource class whenever the same method is invoked on the corresponding remote proxy - but in the presence of `@Path` annotations with arbitrary regular expressions this is not guaranteed, however this doesn't matter, as the most important thing is that a proxy will produce a correct URI and it will be matced as expected by a server class.

Client-side `MessageBodyReaders` and `MessageBodyWriters` are used to process request or response bodies just as they do on the server side. More specifically, method body writers are invoked whenever a remote method parameter is assumed to be a request body (that is, it has no JAX-RS annotations attached) or when a form submission is emulated with the help of either `@FormParams` or the JAX-RS `MultivaluedMap`.

You can make multiple remote invocations on the same proxy (initial or subresource), the current URI and headers will be updated properly for each call.

If you would like to proxify concrete classes such as `BookStoreImpl` for example (perhaps because you can not extract interfaces), then drop the `cglib-nodeps.jar` on a classpath. Such classes must have a default constructor. All methods which have nothing to do with JAX-RS will simply be ignored on the client side and marked as unsupported.

Customizing proxies

Proxies end up implementing not only the interface requested at proxy creation time but also a Client interface. In many cases one does not need to explicitly specify commonly used HTTP headers such as Content-Type or Accept as this information will likely be available from `@Consumes` or `@Produces` annotations. At the same time you may explicitly set either of these headers, or indeed some other header. You can use a simple WebClient utility method for converting a proxy to a base client:

Example 78 Converting a Proxy to a Base Client

```
BookStore proxy = JAXRSClientFactory.create("http://books",
         BookStore.class);
WebClient.client(proxy).accept("text/xml");
// continue using the proxy
```

You can also check a current set of headers, current and base URIs and a client Response.

Converting proxies to Web Clients and vice versa

Using proxies is just one way to consume a service. Proxies hide away the details of how URIs are being composed while HTTP-centric WebClients provide for an explicit URI creation. Both proxies and http clients rely on the same base data such as headers and the current URI, so at any time you can create a WebClient instance from the existing proxy:

Example 79 Converting a Proxy to a WebClient

```
BookStore proxy = JAXRSClientFactory.create("http://books",
      BookStore.class);
Client client = WebClient.client(proxy);
WebClient httpClient = WebClient.fromClient(client);
// continue using the http client
```

At any time you can convert an HTTP client into a proxy too:

Example 80 Converting a Proxy to an HTTP Client

```
BookStore proxy1 = JAXRSClientFactory.create("http://books",
      BookStore.class);
Client client = WebClient.client(proxy1);
BookStore proxy2 = JAXRSClientFactory.fromClient(client,
      BookStore.class);
```

Handling exceptions

There are a couple of ways you can handle remote exceptions with proxies.

One approach is to register a `ResponseExceptionMapper` as a provider either from Spring using a `jaxrs:client` or using a corresponding `JAXRSClientFactory` utility method. This way you can map remote error codes to expected checked exceptions or runtime exceptions if needed.

If no `ResponseExceptionMapper` is available when a remote invocation failed, an instance of `javax.ws.rs.WebApplicationException` is thrown. At this point you can check the actual `Response` and proceed from there.

Example 81 Handling Exceptions in a Proxy Client

```
BookStore proxy = JAXRSClientFactory.create("http://books",
    BookStore.class);
try {
    proxy.getBook();
} catch(WebApplicationException ex) {
  Response r = ex.getResponse();
  String message = ex.getMessage();
}
```

`javax.ws.rs.ProcessingException` will be thrown if the exception has occurred for one of two reasons:

- The remote invocation succeeded but no proper `MessageBodyReader` has been found on the client side; in this case the `Response` object representing the result of the invocation will still be available
- The remote invocation has failed for whatever reasons on the client side, example, no `MessageBodyWriter` is available.

Configuring proxies in Spring

When creating a proxy with JAXRSClientFactory, you can pass a Spring configuration location as one of the arguments. Or you can create a default bus using Spring configuration and all proxies will pick it up.

Example 82 Creating a Default Bus in Spring

```
SpringBusFactory bf = new SpringBusFactory();
Bus bus = bf.createBus("org/apache/cxf/systest/jaxrs/security/
        jaxrs-https.xml");
BusFactory.setDefaultBus(bus);
// BookStore proxy will get the configuration from Spring
BookStore proxy = JAXRSClientFactory.create("http://books",
        BookStore.class);
```

Injecting proxies

For injecting proxies via a Spring context, use the `jaxrs:client` element ss follows:

Example 83 Injecting a Proxy via a Spring Context

```
<jaxrs:client id="restClient"

address="http://localhost:${testutil.ports.BookServerRestSoap}/test/services/rest"
       serviceClass="org.apache.cxf.systest.jaxrs.BookStoreJaxrsJaxws"
       inheritHeaders="true">
       <jaxrs:headers>
           <entry key="Accept" value="text/xml"/>
       </jaxrs:headers>
</jaxrs:client>
```

Buffering Responses

One way to buffer proxy responses is to have a proxy method return JAX-RS `Response`, use its `bufferEntity()` method (available in JAX-RS 2.0) and use `Response.readEntity` which can return typed responses if preferred.

The other option is to have a "`buffer.proxy.response`" property enabled on a given proxy instance.

Limitations

Proxy sub-resource methods returning Objects can not be invoked. Prefer to have sub-resource methods returning typed classes: interfaces, abstract classes or concrete implementations.

Working with user models

Proxies can be created with the external user model being applied to a proxy class, for example:

```
JAXRSClientFactory.createFromModel("http://books",
    BookNoAnnotations.class,
    "classpath:/resources/model.xml", null);
```

`BookNoAnnotations` is either an interface or concrete class with no JAX-RS annotations. Both client proxies and server endpoints can 'turn' it into a RESTful resource by applying an external user model.

WebClient API

HTTP-centric clients are WebClient instances which also implement the Client interface. In addition to setting various Client request properties, you can also make an explicit HTTP

invocation with an HTTP verb being the name of a given operation:

Example 84. Explicit HTTP Invocation with a WebClient

```
WebClient client = WebClient.create("http://books");
Book book = client.path("bookstore/books").accept("text/xml").get(Book.class);
```

You can choose to get an explicit JAX-RS Response instead and check the response code, headers or entity body if any.

Example 85. Checking JAX-RS Response Code with a WebClient

```
WebClient client = WebClient.create("http://books");
client.path("bookstore/books");
client.type("text/xml").accept("text/xml")
Response r = client.post(new Book());
Book b = r.readEntity(Book.class);
```

WebClient lets you get back to a base URI or to a previous path segment and move forward. It can be handy for getting a number of individual entries from a service with IDs embedded in path segments.

Example 86. Listing Entries from a Service with a WebClient

```
WebClient client = WebClient.create("http://books");
List<Book> books = getBooks(client, 1L, 2L, 3L)

private List<Book> getBooks(WebClient client, Long ...ids) {
   List<Book> books = new ArrayList<Book>();
   for (Long id : ids) {
       books.add(client.path(id).get(Book.class));
       client.back();
   }
   return books;
}
```

The above code will send requests like "`GET http://books/1`", "`GET http://books/2`", and so on.

If the request URI can be parameterized then you may want to use the following code:

Example 87. Parameterized URI in a WebClient

```
Book book = WebClient.create("http://books").path("{year}/{id}", 2010,
          123).get(Book.class);
// as opposed to
// WebClient.create("http://books").path(2010).path(123).get(Book.class);
```

When reusing the same WebClient instance for multiple invocations, one may want to reset its state with the help of the `reset()` method, for example, when the Accept header value needs to be changed and the current URI needs to be reset to the baseURI (as an alternative to a `back(true)` call). The `resetQuery()` method may be used to reset the query values only. Both options are available for proxies too.

Asynchronous invocations

WebClient has several methods accepting JAX-RS 2.0 InvocationCallback and returning Future. Alternatively, you can also use `WebClient.async()` shortcut to work with a standard `AsyncInvoker`.

Working with explicit collections

WebClient supports `GenericEntity` and JAX-RS 2.0 GenericType directly and via JAX-RS 2.0 `SyncInvoker` and `AsyncInvoker` to make it easier to work with the explicit collections.

WebClient also has some collection-aware methods, for example:

Example 88. Collection-Aware Methods in WebClient

```
Collection<? extends Book> books = WebClient.getCollection(Book.class);
Collection<? extends Book> books = WebClient.postAndGetCollection(new
           ArrayList<Book>(), Book.class);
```

Handling exceptions

You can handle remote exceptions by either explicitly getting a Response object as shown above and handling error statuses as needed or you can catch either `javax.ws.rs.WebApplicationException` or `javax.ws.rs.ProcessingException` exceptions, the same way it can be done with proxies.

Configuring HTTP clients in Spring

Like proxies, HTTP clients can be created using a number of WebClient static utility methods: you can pass a location to a Spring configuration bean if needed or you can set up a default bus as shown above. For example:

Example 89. Using a Spring Configuration Bean

```
<bean id="myJsonProvider" class="org.apache.cxf.jaxrs.provider.JSONProvider" >
    <property name="supportUnwrapped" value="true" />
    <property name="wrapperName" value="nodeName" />
</bean>

<util:list id="webClientProviders">
    <ref bean="myJsonProvider"/>
</util:list>

<bean id="myWebClient" class="org.apache.cxf.jaxrs.client.WebClient"
               factory-method="create">
    <constructor-arg type="java.lang.String" value=
               "http://some.base.url.that.responds/" />
    <constructor-arg ref="webClientProviders" />
</bean>
```

It is possible to set-up WebClient instances the same way as proxies, using `jaxrs:client`.

Example 90. Using jaxrs.client to Set up a WebClient

```
<jaxrs:client id="webClient"
         address="https://localhost:${port}/services/rest"
         serviceClass="org.apache.cxf.jaxrs.client.WebClient">
    <jaxrs:headers>
        <entry key="Accept" value="text/xml"/>
    </jaxrs:headers>
</jaxrs:client>
```

The only limitation of using this option is that some of `jaxrs:client` attributes ("`inheritHeaders`", "`modelRef`") and elements ("`model`") are not really applicable to WebClient.

XML-centric clients

XML-centric clients are WebClients using an XMLSource utility class. XMLSource has a number of methods facilitating the retrieval of JAXB beans, individual properties or links with the help of XPath expressions. For example:

Example 91. Using an XML-Centric Client

```
WebClient wc = WebClient.create("http://aggregated/data");
XMLSource source = wc.get(XMLSource.class);
source.setBuffering(true);
Book b1 = source.getNode("/books/book[position() = 1]", Book.class);
Book b2 = source.getNode("/books/book[position() = 2]", Book.class);
```

Note that an XMLSource instance can be set to buffer the input stream thus allowing for executing multiple XPath queries.

XMlSource can also help with getting the URIs representing the links or XML instances as Strings.

Support for arbitrary HTTP methods for sync invocations.

To get the arbitrary HTTP methods supported with the synchronous client calls or bypass some known Java `HTTPUrlConnection` issues (for example, it will block empty DELETE requests) add the HttpClient-based transport dependency and set a "`use.async.http.conduit`" contextual property. This will work as is for asynchronous calls given that the HttpClient-based transport is required.

Thread Safety

Proxies and web clients (clients) are not thread safe by default. In some cases this can be a limitation, especially when clients are injected; synchronizing on them can cause performance side effects.

One way to 'make' clients thread-safe is to use `WebClient.fromClient(Client)` for web clients or `JAXRSClientFactoryBean.fromClient()` factory methods which copy all the original configuration properties and can be used to create new client instances per every request.

A single client doing multiple invocations without changing the current URI or headers is thread-safe. The only limitation in this case applies to proxies, in that they can not get "out of band" headers without synchronizing, for example:

Example 91. "Out of Band" Headers

```
// get some response headers passed to us 'out of band', which is not
     thread-safe for a plain proxy:
String bookHeader = WebClient.toClient(injectedBookStoreProxy)
     .getHeaders().getFirst("BookHeader");
```

The final option is to use a `'threadSafe'` boolean property when creating proxies or web clients (either from Spring or programmatically). Thread-safe clients created this way keep their state in a thread-local storage.

If a number of incoming threads is limited then one option is just do nothing, while the other option is to reset the thread local state.

Example 92. Reset the Thread Local State

```
try {
   webClient.path("bar")
   webClient.header("bar", baz);
   webClient.invoke(...);
} finally {
   // if using a proxy: WebClient.client(proxy).reset();
   webClient.reset();
}
```

Yet another option is to use `JAXRSClientFactoryBean` and a `'secondsToKeepState'` property for creating thread-safe clients. This will instruct clients to clean up the thread-local state periodically.

Configuring Clients at Runtime

Proxy and http-centric clients are typically created by `JAXRSClientFactory` or WebClient factory methods but `JAXRSClientFactoryBean` can also be used for pre-configuring clients before they are created.

Sometimes, you may want to configure a client instance after it is been created. For example, you may want to configure HTTPConduit programmatically, as opposed to setting its properties using Spring. `ClientConfiguration` represents a client-specific configuration state and can be accessed as shown in the following code:

```
Book proxy = JAXRSClientFactory.create("http://books", Book.class);
ClientConfiguration config = WebClient.getConfig(proxy);
HTTPConduit conduit1 = (HTTPConduit)config.getConduit();

WebClient webclient = WebClient.create("http://books");
HTTPConduit conduit2 =
       (HTTPConduit)WebClient.getConfig(webclient).getConduit();
```

Creating clients programmatically with no Spring dependencies

An example of creating a client programmatically is as follows:

Example 93. Creating a Client Programatically

```
JAXRSClientFactoryBean sf = new JAXRSClientFactoryBean();
sf.setResourceClass(CustomerService.class);
sf.setAddress("http://localhost:9000/");
BindingFactoryManager manager =
               sf.getBus().getExtension(BindingFactoryManager.class);
JAXRSBindingFactory factory = new JAXRSBindingFactory();
factory.setBus(sf.getBus());
manager.registerBindingFactory(JAXRSBindingFactory.JAXRS_BINDING_ID, factory);
CustomerService service = sf.create(CustomerService.class);
WebClient wc = sf.createWebClient();
```

Configuring an HTTP Conduit from Spring

There is a number of ways to configure HTTPConduits for proxies and WebClients.

It is possible to have an HTTPConduit configuration which will apply to all clients using different request URIs or only to those with using a specific URI. For example:

```
<http:conduit name="http://books:9095/bookstore.*"/>
```

This configuration will affect all proxies and WebClients which have requestURIs starting from `'http://books:9095/bookstore'`. Note the trailing '.*' suffix in the name of the `http:conduit` element.

Alternatively you can just use the following code:

```
<http:conduit name="*.http-conduit"/>
```

This configuration will affect all the clients, irrespective of the URIs being dealt with.

If you work with proxies then you can have the proxy-specific configuration using the expanded `QName` notation:

```
<http:conduit name="{http://foo.bar}BookService.http-conduit"/>
```

In this example, `'foo.bar'` is a reverse package name of the `BookService` proxy class.

Similarly, for WebClients you can do:

```
<http:conduit name="{http://localhost:8080}WebClient.http-conduit"/>
```

In this example, `'http://localhost:8080'` is the base service URI.

Clients and Authentication

Proxies and HTTP-centric clients can have the HTTP Authorization header set up explicitly:

Example 94. Specifying the HTTP Auhorization Header Explicitly

```
// Replace 'user' and 'password' by the actual values
String authorizationHeader = "Basic "
    + org.apache.cxf.common.util.Base64Utility.encode("user:password".getBytes());

// proxies
WebClient.client(proxy).header("Authorization", authorizationHeader);

// web clients
webClient.header("Authorization", authorizationHeader);
```

or by providing a username and password pair at client creation time, for example:

Example 95. Specifying the HTTP Auhorization Header via Username and Password

```
BookStore proxy = JAXRSClientFactory.create("http://books", BookStore.class,
"username", "password", "classpath:/config/https.xml");

WebClient client = WebClient.create("http://books", "username", "password",
"classpath:/config/https.xml");
```

When injecting clients from Spring, one can add 'username' and 'password' values as attributes to `jaxrs:client` elements or add them to WebClient factory create methods.

Part IV

Common Development Tasks

Aside from basic service provider and consumer implementation, there are a number of tasks that developers will commonly need to perform.

In this part

This part contains the following chapters:

Finding WSDL at Runtime
Publishing a Service
Generic Fault Handling

Finding WSDL at Runtime

Hard coding the location of WSDL documents into an application is not scalable. In real deployment environments, you will want to allow the WSDL document's location be resolved at runtime. Artix provides a number of tools to make this possible.

When developing consumers using the JAX-WS APIs you are must provide a hard coded path to the WSDL document that defines your service. While this is OK in a small environment, using hard coded paths does not translate to enterprise deployments.

To address this issue, Artix provides three mechanisms for removing the requirement of using hard coded paths:

- inject a configured proxy object
- a JAX-WS catalog
- the ServiceContractResolver interface

TIP: Injecting the proxy into your implementation code is generally the best option.

Instantiating a Proxy by Injection

Artix's use of the Spring Framework allows you to avoid the hassle of using the JAX-WS APIs to create service proxies. It allows you to define a client endpoint in a configuration file and then inject a proxy directly into the implementation code. When the runtime instantiates the implementation object, it will also instantiate a proxy for the external service based on the configuration. The implementation is handed a reference to the instantiated proxy.

Because the proxy is instantiated using information in the configuration file, the WSDL location does not need to be hard coded. It can be changed at deployment time. You can also specify that the runtime should search the application's classpath for the WSDL.

Procedure

To inject a proxy for an external service into a service provider's implementation do the following:

1. Deploy the required WSDL documents in a well known location that all parts of the application can access.

TIPS: If you are deploying the application as a WAR file, it is recommended that you place all of the WSDL documents and XML Schema documents in the `WEB-INF/wsdl` folder of the WAR.

If you are deploying the application as a JAR file, it is recommended that you place all of the WSDL documents and XML Schema documents in the `META-INF/wsdl` folder of the JAR.

2. Configure a JAX-WS client endpoint for the proxy that is being injected.

3. Inject the proxy into your service provide using the `@Resource` annotation.

Configuring the proxy

You configure a JAX-WS client endpoint using the `jaxws:client` element in your application's configuration file. This tells the runtime to instantiate a `org.apache.cxf.jaxws.JaxWsClientProxy` object with the specified properties. This object is the proxy that will be injected into the service provider.

At a minimum you need to provide values for the following attributes:

- `id`—Specifies the ID used to identify the client to be injected.
- `serviceClass`—Specifies the SEI of the service on which the proxy makes requests.
- Example 96 shows the configuration for a JAX-WS client endpoint.

Example 96. Configuration for a Proxy to be Injected into a Service Implementation

```
<beans ... xmlns:jaxws="http://cxf.apache.org/jaxws"
  ...
  schemaLocation="...
    http://cxf.apache.org/jaxws http://cxf.apache.org/schemas/jaxws.xsd
    ...">
  <jaxws:client id="bookClient"
                serviceClass="org.apache.cxf.demo.BookService"
                wsdlLocation="classpath:books.wsdl"/>
  ...
</beans>
```

NOTE: In Example 96 the `wsdlLocation` attribute instructs the runtime to load the WSDL from the classpath. If `books.wsdl` in on the classpath, the runtime will be able to find it.

For more information on configuring a JAX-WS client see *Configuring Consumer Endpoints* in ***Artix Deployment Guide: Java***.

Coding the provider implementation

You inject the configured proxy into a service implementation as a resource using the `@Resource` as shown in Example 97.

Example 97. Injecting a Proxy into a Service Implementation

```
package demo.hw.server;

import org.apache.hello_world_soap_http.Greeter;

@javax.jws.WebService(portName = "SoapPort", serviceName = "SOAPService",
              targetNamespace = "http://apache.org/hello_world_soap_http",
              endpointInterface = "org.apache.hello_world_soap_http.Greeter")
public class StoreImpl implements Store {

   @Resource(name="bookClient")
   private BookService proxy;

}
```

The annotation's name property corresponds to the value of the JAX-WS client's `id` attribute. The configured proxy is injected into the `BookService` object declared immediately after the annotation. You can use this object to make invocations on the proxy's external service.

Using a JAX-WS Catalog

The JAX-WS specification mandates the all implementations support:

> *support for a standard catalog facility to be used when resolving any Web service document that is part of the description of a Web service, specifically WSDL and XML Schema documents.*

This catalog facility uses the XML catalog facility specified by OASIS. All of the JAX-WS APIs and annotation that take a WSDL URI use the catalog to resolve the WSDL document's location.

This means that you can provide an XML catalog file that rewrites the locations of your WSDL documents to suit specific deployment environments.

Writing the catalog

JAX-WS catalogs are standard XML catalogs as defined by the OASIS XML Catalogs 1.1 specification. They allow you to specify mapping:

- a document's public identifier and/or a system identifier to a URI.
- the URI of a resource to another URI.
- Table 10 lists some common elements used for WSDL location resolution.

Table 10. Common JAX-WS Catalog Elements

Element	Description
`uri`	Maps a URI to an alternate URI.
`rewriteURI`	Rewrites the beginning of a URI. For example, this element allows you to map all URIs that start with `http://cxf.apache.org` to URIs that start with `classpath:`.
`uriSuffix`	Maps a URI to an alternate URI based on the suffix of the original URI. For example you could map all URIs that end in `foo.xsd` to `classpath:foo.xsd`.

Packaging the catalog The JAX-WS specification mandates that the catalog used to resolve WSDL and XML Schema documents is assembled using all available resources named `META-INF/jax-ws-catalog.xml`. If your application is packaged into a single JAR, or WAR, you can place the catalog into a single file.

If your application is packaged as multiple JARs, you can split the catalog into a number of files. Each catalog file could be modularized to only deal with WSDLs accessed by the code in the specific JARs.

Using a ServiceContractResolver Object

The most involved mechanism for resolving WSDL document locations at runtime is to implement your own custom contract resolver. This requires that you provide an implementation of the Artix specific `ServiceContractResolver` interface. You also need to register your custom resolver with the bus.

Once properly registered, the custom contract resolver will be used to resolve the location of any required WSDL and schema documents.

Implementing the contract resolver

A contract resolver is an implementation of the `org.apache.cxf.endpoint.ServiceContractResolver` interface.

As shown in Example 98, this interface has a single method, `getContractLocation()`, that needs to be implemented. `getContractLocation()` takes the QName of a service and returns the URI for the service's WSDL contract.

Example 98. ServiceContractResolver Interface

```
public interface ServiceContractResolver
{
  URI getContractLocation(QName qname);
}
```

The logic used to resolve the WSDL contract's location is application specific. You can add logic that to resolve contract locations from a UDDI registry, a database, a custom location on a file system, or any other mechanism you choose.

Registering the contract resolver programmatically

Before the Artix runtime will use your contract resolver, you must register it with a contract resolver registry. Contract resolver registries implement the `org.apache.cxf.endpoint.ServiceContractResolverRegistry` interface. However, you do not need to implement your own registry. Artix provides a default implementation in the `org.apache.cxf.endpoint.ServiceContractResolverRegistryImpl` class.

To register a contract resolver with the default registry you do the following:

1. Get a reference to the default bus object.
2. Get the service contract registry from the bus using the bus'
3. `getExtension()` method.
4. Create an instance of your contract resolver.
5. Register your contract resolver with the registry using the registry's `register()` method.

Example 99 shows the code for registering a contract resolver with the default registry.

Example 99. Registering a Contract Resolver

```
BusFactory bf=BusFactory.newInstance(); ❶
Bus bus=bf.createBus();

ServiceContractResolverRegistry registry =
     bus.getExtension(ServiceContractResolverRegistry); ❷

JarServiceContractResolver resolver = new JarServiceContractResolver(); ❸

registry.register(resolver); ❹
```

The code in Example 99 does the following:

❶ Gets a bus instance.

❷ Gets the bus' contract resolver registry.

❸ Creates an instance of a contract resolver.

❹ Registers the contract resolver with the registry.

Registering a contract resolver using configuration

You can also implement a contract resolver so that it can be added to a client through configuration. The contract resolver is implemented in such a way that when the runtime reads the configuration and instantiates the resolver, the resolver registers itself. Because the runtime handles the initialization, you can decide at runtime if a client needs to use the contract resolver.

To implement a contract resolver so that it can be added to a client through configuration do the following:

1. Add an `init()` method to your contract resolver implementation.
2. Add logic to your `init()` method that registers the contract resolver with the contract resolver registry as shown in Example 99.
3. Decorate the `init()` method with the `@PostConstruct` annotation.

Example 100 shows a contract resolver implementation that can be added to a client using configuration.

Example 100. Service Contract Resolver that can be Registered Using Configuration

```
import javax.annotation.PostConstruct;
import javax.annotation.Resource;
import javax.xml.namespace.QName;
import org.apache.cxf.Bus;
import org.apache.cxf.BusFactory;

public class UddiResolver implements ServiceContractResolver {
  private Bus bus;
  ...

  @PostConstruct
  public void init() {
    BusFactory bf=BusFactory.newInstance(); Bus bus=bf.createBus();
    if (null != bus) {
      ServiceContractResolverRegistry resolverRegistry =
          bus.getExtension(ServiceContract ResolverRegistry.class);
      if (resolverRegistry != null) {
        resolverRegistry.register(this);
      }
    }
  }
  public URI getContractLocation(QName serviceName) {
    ...
  }
}
```

To register the contract resolver with a client you need to add a `bean` element to the client's configuration. The `bean` element's `class` attribute is the name of the class implementing the contract resolver.

Example 101 shows a bean for adding a configuration resolver implemented by the `org.apache.cxf.demos.myContractResolver` class.

Example 101. Bean Configuring a Contract Resolver

```
<beansxmlns="http://www.springframework.org/schema/beans"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation=" http://www.springframework.org/schema/beans
http://www.springframe work.org/schema/beans/spring-beans.xsd">
...
<bean id="myResolver"
class="org.apache.cxf.demos.myContractResolver" />
...
</beans>
```

Contract resolution order

When a new proxy is created, the runtime uses the contract registry resolver to locate the remote service's WSDL contract. The contract resolver registry calls each contract resolver's `getContractLocation()` method in the order in which the resolvers were registered. It returns the first URI returned from one of the registered contract resolvers.

If you registered a contract resolver that attempted to resolve the WSDL contract at a well-known shared file system, it would be the only contract resolver used. However, if you subsequently registered a contract resolver that resolved WSDL locations using a UDDI registry, the registry could use both resolvers to locate a service's WSDL contract. The registry would first attempt to locate the contract using the shared file system contract resolver. If that contract resolver failed, the registry would then attempt to locate it using the UDDI contract resolver.

Publishing a Service

When you want to deploy a JAX-WS service as a standalone Java application or in an OSGi container without Spring-DM, you must to implement the code that publishes the service provider.

Artix for Java provides a number of ways to publish a service as a service provider. How you publish a service depends on the deployment environment you are using. Many of the containers supported by Artix do not require writing logic for publishing endpoints. There are two exceptions:

- deploying a server as a standalone Java application
- deploying a server into an OSGi container without Spring-DM

For detailed information in deploying applications into the supported containers see the ***Artix Deployment Guide: Java***.

APIs Used to Publish a Service

The `javax.xml.ws.Enddpoint` class does the work of publishing a JAX-WS service provider. To publishing an endpoint do the following:

1. Create an `Endpoint` object for your service provider.
2. Publish the endpoint.
3. Stop the endpoint when application shuts down.

The `Endpoint` class provides methods for creating and publishing service providers. It also provides a method that can create and publish a service provider in a single method call.

Instantiating a service provider

A service provider is instantiated using an `Endpoint` object. You instantiate an `Endpoint` object for your service provider using one of the following methods:

- `static Endpoint create(Object implementor);`

  This `create()` method returns an `Endpoint` for the specified service implementation. The `Endpoint` object is created using the information provided by the implementation class' `javax.xml.ws.BindingType` annotation, if it is present. If the annotation is not present, the `Endpoint` uses a default SOAP 1.1/HTTP binding.

- `static Endpoint create(URI bindingID, Object implementor);`

  This `create()` method returns an `Endpoint` object for the specified implementation object using the specified binding. This method overrides the binding information provided by the `javax.xml.ws.BindingType` annotation, if it is present. If the `bindingID` cannot be resolved, or it is `null`, the binding specified in the `javax.xml.ws.BindingType` is used to create the `Endpoint`. If neither the `bindingID` or the `javax.xml.ws.BindingType` can be used, the `Endpoint` is created using a default SOAP 1.1/HTTP binding.

- `static Endpoint publish(String address, Object implementor);`

  The `publish()` method creates an `Endpoint` object for the specified implementation, and publishes it. The binding used for the `Endpoint` object is determined by the URL scheme of the provided `address`. The list of bindings available to the implementation are scanned for a binding that supports the URL scheme. If one is found the `Endpoint` object is created and published. If one is not found, the method fails.

TIP: Using `publish()` is the same as invoking one of the `create()` methods, and then invoking the `publish()` method used in publish to an address.

IMPORTANT: The implementation object passed to any of the `Endpoint` creation methods must either be an instance of a class annotated with `javax.jws.WebService` and meeting the requirements for being an SEI implementation or it must be an instance of a class annotated with `javax.xml.ws.WebServiceProvider` and implementing the `Provider` interface.

Publishing a service provider

You can publish a service provider using either of the following `Endpoint` methods:

- `void publish(String address);`

  This `publish()` method publishes the service provider at the address specified.

IMPORTANT: The `address`'s URL scheme must be compatible with one of the service provider's bindings.

- `void publish(Object serverContext);`

This `publish()` method publishes the service provider based on the information provided in the specified server context. The server context must define an address for the endpoint, and the context must also be compatible with one of the service provider's available bindings.

Stopping a published service provider

When the service provider is no longer needed you should stop it using its `stop()` method. The `stop()` method, shown in Example 102, shuts down the endpoint and cleans up any resources it is using.

Example 102. Method for Stopping a Published Endpoint

```
void stop();
```

Once the endpoint is stopped it cannot be republished.

Publishing a Service in a Plain Java Application

When you want to deploy your application as a plain java application you need to implement the logic for publishing your endpoints in the application's `main()` method. Artix provides you two options for writing your application's `main()` method.

- use the `main()` method generated by the wsdl2java tool
- write a custom `main()` method that publishes the endpoints

Generating a Server Mainline

The wsdl2java tool's `-server` flag makes the tool generate a simple server mainline. The generated server mainline, as shown in Example 49, publishes one service provider for each `port` element in the specified WSDL contract.

For more information see *wsdl2java* in ***Artix Java Runtime Command Reference***.

Example 103 shows a generated server mainline.

Example 103. Generated Server Mainline

```
package org.apache.hello_world_soap_http; import
javax.xml.ws.Endpoint;
public class GreeterServer {

protected GreeterServer() throws Exception {
System.out.println("Starting Server");
❶      Object implementor = new GreeterImpl();
❷      String address = "http://localhost:9000/SoapContext/SoapPort";
❸      Endpoint.publish(address, implementor);
}

public static void main(String args[]) throws Exception {
       new GreeterServer();
       System.out.println("Server ready...");

       Thread.sleep(5 * 60 * 1000);
       System.out.println("Server exiting");
       System.exit(0);
       }
}
```

The code in Example 103 does the following:

❶ Instantiates a copy of the service implementation object.

❷ Creates the address for the endpoint based on the contents of the `address` child of the `wsdl:port` element in the endpoint's contract.

❸ Publishes the endpoint.

Writing a Server Mainline

If you used the Java first development model or you do not want to use the generated server mainline you can write your own. To write your server mainline you must do the following:

1. Instantiate an `javax.xml.ws.Endpoint` object for the service provider.
2. Create an optional server context to use when publishing the service provider.
3. Publish the service provider using one of the `publish()` methods.
4. Stop the service provider when the application is ready to exit.

Example 104 shows the code for publishing a service provider.

Example 104. Custom Server Mainline

```
package org.apache.hello_world_soap_http;

import javax.xml.ws.Endpoint;

public class GreeterServer
       {
       protected GreeterServer() throws Exception
       {
       }

       public static void main(String args[]) throws Exception
       {
❶      GreeterImpl impl = new GreeterImpl();
❷      Endpoint endpt.create(impl);
❸      endpt.publish("http://localhost:9000/SoapContext/SoapPort");

       boolean done = false;
❹      while(!done)
   {
   ...
   }
❺      endpt.stop();
       System.exit(0);
       }
}
```

The code in Example 104 does the following:

❶ Instantiates a copy of the service's implementation object.

❷ Creates an unpublished `Endpoint` for the service implementation.

❸ Publishes the service provider at `http://localhost:9000/SoapContext/SoapPort`.

❹ Loops until the server should be shutdown.

❺ Stops the published endpoint.

Generic Fault Handling

The JAX-WS specification defines two type of faults. One is a generic JAX-WS runtime exception. The other is a protocol specific class of exceptions that is thrown during message processing.

Runtime Faults

Most of the JAX-WS APIs throw a generic `javax.xml.ws.WebServiceException` exception.

APIs that throw WebServiceException

Table 11 lists some of the JAX-WS APIs that can throw the generic `WebServiceException` exception.

Table 11. APIs that Throw WebServiceException

API	Reason
`Binding.setHandlerChain()`	There is an error in the handler chain configuration.
`BindingProvider.getEndpointReference()`	The specified class is not assigned from a `W3CEndpointReference`.
`Dispatch.invoke()`	There is an error in the `Dispatch` instance's configuration or an error occurred while communicating with the service.
`Dispatch.invokeAsync()`	There is an error in the `Dispatch` instance's configuration.
`Dispatch.invokeOneWay()`	There is an error in the `Dispatch` instance's configuration or an error occurred while communicating with the service.
`LogicalMessage.getPayload()`	An error occurred when using a supplied `JAXBContext` to unmarshal the payload. The cause field of the `WebServiceException` contains the original `JAXBException`.
`LogicalMessage.setPayload()`	An error occurred when setting the payload of the message. If the exception is thrown when using a `JAXBContext`, the cause field of the `WebServiceException` contains the original `JAXBException`.

API	Reason
`WebServiceContext.getEndpointReference()`	The specified class is not assigned from a `W3CEndpointReference`.

Protocol Faults

Protocol exceptions are thrown when an error occurs during the processing of a request. All synchronous remote invocations can throw a protocol exception. The underlying cause occurs either in the consumer's message handling chain or in the service provider.

The JAX-WS specification defines a generic protocol exception. It also specifies a SOAP-specific protocol exception and an HTTP-specific protocol exception.

Types of protocol exceptions

The JAX-WS specification defines three types of protocol exception. Which exception you catch depends on the transport and binding used by your application.

Table 12 describes the three types of protocol exception and when they are thrown.

Table 12. Types of Generic Protocol Exceptions

Exception Class	When Thrown
`javax.xml.ws.ProtocolException`	This exception is the generic protocol exception. It can be caught regardless of the protocol in use. It can be cast into a specific fault type if you are using the SOAP binding or the HTTP binding. When using the XML binding in combination with the HTTP or JMS transports, the generic protocol exception cannot be cast into a more specific fault type.
`javax.xml.ws.soap.SOAPFaultException`	This exception is thrown by remote invocations when using the SOAP binding. For more information see Using the SOAP protocol exception.
`javax.xml.ws.http.HTTPException`	This exception is thrown when using the Artix HTTP binding to develop RESTful services. For more information see Part III.

Using the SOAP protocol exception

The `SOAPFaultException` exception wraps a SOAP fault. The underlying SOAP fault is stored in the `fault` field as a `javax.xml.soap.SOAPFault` object.

If a service implementation needs to throw an exception that does not fit any of the custom exceptions created for the application, it can wrap the fault in a `SOAPFaultException` using the exceptions creator and throw it back to the consumer. Example 105 shows code for creating and throwing a `SOAPFaultException` if the method is passed an invalid parameter.

Example 105. Throwing a SOAP Protocol Exception

```
public Quote getQuote(String ticker)
{
...
if(tickers.length()<3)
{
       SOAPFault fault =
       SOAPFactory.newInstance().createFault();

       fault.setFaultString("Ticker too short");
       throw new SOAPFaultException(fault);
       }
       ...
}
```

When a consumer catches a `SOAPFaultException` exception they can retrieve the underlying cause of the exception by examining the wrapped `SOAPFault` exception. As shown in Example 106, the `SOAPFault` exception is retrieved using the `SOAPFaultException` exception's `getFault()` method.

Example 106. Getting the Fault from a SOAP Protocol Exception

```
...
try
{
       proxy.getQuote(ticker);
}
catch (SOAPFaultException sfe)
{
       SOAPFault fault = sfe.getFault();
       ...
}
```

Part V

Working with Data Types

Service-oriented design abstracts data into a common exchange format. Typically, this format is an XML grammar defined in XML Schema. To save the developer from working directly with XML documents, the JAX-WS specification calls for XML Schema types to be marshaled into Java objects. This marshaling is done in accordance with the Java Architecture for XML Binding (JAXB) specification. JAXB defines bindings for mapping between XML Schema constructs and Java objects and rules for how to marshal the data. It also defines an extensive customization framework for controlling how data is handled.

In this part

This part contains the following chapters:

Basic Data Binding Concepts
Using XML Elements
Using Simple Types
Using Complex Types
Using Wild Card Types
Element Substitution
Customizing How Types are Generated
Using A JAXBContext Object

Basic Data Binding Concepts

There are a number of general topics that apply to how Artix handles type mapping.

Including and Importing Schema Definitions

Artix supports the including and importing of schema definitions, using the `<include/>` and `<import/>` schema tags. These tags enable you to insert definitions from external files or resources into the scope of a schema element. The essential difference between including and importing is:

- Including brings in definitions that belong to the same target namespace as the enclosing schema element.
- Importing brings in definitions that belong to a different target namespace from the enclosing schema element.

xsd:include syntax

The include directive has the following syntax:

```
<include schemaLocation="anyURI" />
```

The referenced schema, given by `anyURI`, must either belong to the same target namespace as the enclosing schema, or not belong to any target namespace at all. If the referenced schema does not belong to any target namespace, it is automatically adopted into the enclosing schema's namespace when it is included.

Example 107 shows an example of an XML Schema document that includes another XML Schema document.

Example 107. Example of a Schema that Includes Another Schema

```
<definitions targetNamespace="http://schemas.iona.com/tests/schema_parser"
       xmlns:tns="http://schemas.iona.com/tests/schema_parser"
       xmlns:xsd="http://www.w3.org/2001/XMLSchema"
       xmlns="http://schemas.xmlsoap.org/wsdl/">
<types>
   <schema targetNamespace="http://schemas.iona.com/tests/schema_parser"
          xmlns="http://www.w3.org/2001/XMLSchema">
   <include schemaLocation="included.xsd"/>
   <complexType name="IncludingSequence">
     <sequence>
       <element name="includedSeq" type="tns:IncludedSequence"/>
     </sequence>
   </complexType>
   </schema>
</types>
   ...
</definitions>
```

Example 108 shows the contents of the included schema file.

Example 108. Example of an Included Schema

```
<schema targetNamespace="http://schemas.iona.com/tests/schema_parser"
       xmlns="http://www.w3.org/2001/XMLSchema">
   <!-- Included type definitions -->
   <complexType name="IncludedSequence">
       <sequence>
             <element name="varInt" type="int"/>
             <element name="varString" type="string"/>
       </sequence>
   </complexType>
</schema>
```

xsd:import syntax

The import directive has the following syntax:

```
<import namespace="namespaceAnyURI"
       schemaLocation="schemaAnyURI" />
```

The imported definitions must belong to the `namespaceAnyURI` `target` namespace. If `namespaceAnyURI` is blank or remains unspecified, the imported schema definitions are unqualified.

Example 109 shows an example of an XML Schema that imports another XML Schema.

Example 109. Example of a Schema that Includes Another Schema

```
<definitions targetNamespace="http://schemas.iona.com/tests/schema_parser"
       xmlns:tns="http://schemas.iona.com/tests/schema_parser"
       xmlns:xsd="http://www.w3.org/2001/XMLSchema"
       xmlns="http://schemas.xmlsoap.org/wsdl/">
<types>
   <schema targetNamespace="http://schemas.iona.com/tests/schema_parser"
         xmlns="http://www.w3.org/2001/XMLSchema">
   <import namespace="http://schemas.iona.com/tests/imported_types"
         schemaLocation="included.xsd"/>
   <complexType name="IncludingSequence">
     <sequence>
       <element name="includedSeq" type="tns:IncludedSequence"/>
     </sequence>
   </complexType>
   </schema>
</types>
       ...
</definitions>
```

Example 110 shows the contents of the imported schema file.

Example 110. Example of an Included Schema

```
<schema targetNamespace="http://schemas.iona.com/tests/imported_types"
       xmlns="http://www.w3.org/2001/XMLSchema">
   <!-- Included type definitions -->
   <complexType name="IncludedSequence">
     <sequence>
       <element name="varInt" type="int"/>
       <element name="varString" type="string"/>
     </sequence>
   </complexType>
</schema>
```

Using non-referenced schema documents

Using types defined in a schema document that is not referenced in the service's WSDL document is a three step process:

1. Convert the schema document to a WSDL document using the **xsd2wsdl** tool.
2. Generate Java for the types using the **wsdl2java** tool on the generated WSDL document.
3. You will get a warning from the **wsdl2java** tool stating that the WSDL document does not define any services. You can ignore this warning.
4. Add the generated classes to your classpath.

XML Namespace Mapping

XML Schema type, group, and element definitions are scoped using namespaces. The namespaces prevent possible naming clashes between entities that use the same name. Java packages serve a similar purpose. Therefore, Artix maps the target namespace of a schema document into a package containing the classes necessary to implement the structures defined in the schema document.

Package naming

The name of the generated package is derived from a schema's target namespace using the following algorithm:

1. The URI scheme, if present, is stripped.

   For example, the namespace `http:\\www.widgetvendor.com\types\widgetTypes.xsd` becomes `\\widgetvendor.com\types\widgetTypes.xsd`.

   Note that Artix will only strip the `http:`, `https:`, and `urn:` schemes.

2. The trailing file type identifier, if present, is stripped.

   For example, `\\www.widgetvendor.com\types\widgetTypes.xsd` becomes `\\widgetvendor.com\types\widgetTypes`.

3. The resulting string is broken into a list of strings using `/` and `:` as separators.

   So, `\\www.widgetvendor.com\types\widgetTypes` becomes the list `{"www.widegetvendor.com", "types", "widgetTypes"}`.

4. If the first string in the list is an internet domain name, it is decomposed as follows:

   a. The leading `www.` is stripped.

   b. The remaining string is split into its component parts using the `.` as the separator.

   c. The order of the list is reversed.

   So, {"www.widegetvendor.com", "types", "widgetTypes"} becomes {"com", "widegetvendor", "types", "widgetTypes"}.

   Note that Internet domain names end in one of the following: `.com`, `.net`, `.edu`, `.org`, `.gov`, `.mil`; or in one of the two-letter country codes.

5. The strings are converted into all lower case.

   So, `{"com", "widegetvendor", "types", "widgetTypes"}` becomes `{"com", "widegetvendor", "types", "widgettypes"}`.

6. The strings are normalized into valid Java package name components as follows:

   a. If the strings contain any special characters, the special characters are converted to an underscore(_).

   b. If any of the strings are a Java keyword, the keyword is prefixed with an underscore(_).

   c. If any of the strings begin with a numeral, the string is prefixed with an underscore(_).

7. The strings are concatenated using `.` as a separator.

   So, `{"com", "widegetvendor", "types", "widgettypes"}` becomes the package name `com.widgetvendor.types.widgettypes`.

The XML Schema constructs defined in the namespace `http:\\www.widgetvendor.com\types\widgetTypes.xsd` are mapped to the Java package `com.widgetvendor.types.widgettypes`.

Package contents

A JAXB generated package contains the following:

- A class implementing each complex type defined in the schema. For more information on complex type mapping see Using Complex Types.
- An enum type for any simple types defined using the `enumeration` facet. For more information on how enumerations are mapped see Enumerations.
- A public `ObjectFactory` class that contains methods for instantiating objects from the schema. For more information on the `ObjectFactory` class see The Object Factory.
- A `package-info.java` file that provides metadata about the classes in the package.

The Object Factory

JAXB uses an object factory to provide a mechanism for instantiating instances of JAXB generated constructs. The object factory contains methods for instantiating all of the XML schema defined constructs in the package's scope. The only exception is that enumerations do not get a creation method in the object factory.

Complex type factory methods

For each Java class generated to implement an XML schema complex type, the object factory contains a method for creating an instance of the class. This method takes the form:

```
typeName createtypeName();
```

For example, if your schema contained a complex type named `widgetType`, Artix generates a class called `WidgetType` to implement it.

Example 111 shows the generated creation method in the object factory.

Example 111. Complex Type Object Factory Entry

```
public class ObjectFactory
{
       ...
       WidgetType createWidgetType()
       {
       return new WidgetType();
       }
       ...
}
```

Element factory methods

For elements that are declared in the schema's global scope, Artix inserts a factory method into the object factory. As discussed in Using XML Elements, XML Schema elements are mapped to `JAXBElement<T>` objects. The creation method takes the form:

```
public JAXBElement<elementType>
createelementName(elementType  value);
```

For example if you have an element named `comment` of type xsd:string, Artix generates the object factory method shown in Example 112.

Example 112. Element Object Factory Entry

```
public class ObjectFactory
{
   ...
   @XmlElementDecl(namespace = "...", name = "comment")
   public JAXBElement<String> createComment(String value) {
    return new JAXBElement<String>(_Comment_QNAME, String.class,
    null, value);
   }
   ...
}
```

Adding Classes to the Runtime Marshaler

When the Artix runtime reads and writes XML data it uses a map that associates the XML Schema types with their representative Java types. By default, the map contains all of the types defined in the target namespace of the WSDL contract's `schema` element. It also contains any types that are generated from the namespaces of any schemas that are imported into the WSDL contract.

The addition of types from namespaces other than the schema namespace used by an application's `schema` element is accomplished using the `@XmlSeeAlso` annotation. If your application needs to work with types that are generated outside the scope of your application's WSDL document, you can edit the `@XmlSeeAlso` annotation to add them to the JAXB map.

Using the @XmlSeeAlso

The `@XmlSeeAlso` annotation can be added to the SEI of your service. It contains a comma separated list of classes to include in the JAXB context. Example 113 shows the syntax for using the `@XmlSeeAlso` annotation.

Example 113. Syntax for Adding Classes to the JAXB Context

```
import javax.xml.bind.annotation.XmlSeeAlso;
@WebService()
@XmlSeeAlso({Class1.class,
             Class2.class,
             ...,
             ClassN.class})
      public class GeneratedSEI {
      ...
}
```

In cases where you have access to the JAXB generated classes, it is more efficient to use the `ObjectFactory` classes generated

to support the needed types. Including the `ObjectFactory` class includes all of the classes that are known to the object factory.

Example

Example 114 shows an SEI annotated with `@XmlSeeAlso`.

Example 114. Adding Classes to the JAXB Context

```
...
import javax.xml.bind.annotation.XmlSeeAlso;
...
@WebService()
@XmlSeeAlso(
  {org.apache.schemas.types.test.ObjectFactory.class,
  org.apache.schemas.tests.group_test.ObjectFactory.class})
      public interface Foo {
      ...
}
```

Using XML Elements

XML Schema elements are used to define an instance of an element in an XML document. Elements are defined either in the global scope of an XML Schema document, or they are defined as a member of a complex type. When they are defined in the global scope, Artix maps them to a JAXB element class that makes manipulating them easier.

An element instance in an XML document is defined by an XML Schema `element` element in the global scope of an XML Schema document To make it easier for Java developers to work with elements, Artix maps globally scoped elements to either a special JAXB element class or to a Java class that is generated to match its content type.

How the element is mapped depends on if the element is defined using a named type referenced by the `type` attribute or if the element is defined using an in-line type definition. Elements defined with in-line type definitions are mapped to Java classes.

TIP: It is recommended that elements are defined using a named type because in-line types are not reusable by other elements in the schema.

XML Schema mapping

In XML Schema elements are defined using `element` elements. `element` elements has one required attribute. The `name` specifies the name of the lement as it appears in an XML document.

In addition to the `name` attribute `element` elements have the optional attributes listed in Table 13.

Table 13. Attributes Used to Define an Element

Attribute	Description
`type`	Specifies the type of the element. The type can be any XML Schema primitive type or any named complex type defined in the contract. If this attribute is not specified, you will need to include an in-line type definition.
`nillable`	Specifies if an element can be left out of a document entirely. If nillable is set to true, the element can be omitted from any document generated using the schema.

Attribute	Description
`abstract`	Specifies if an element can be used in an instance document. `true` indicates that the element cannot appear in the instance document. Instead, another element whose `substitutionGroup` attribute contains the QName of this element must appear in this element's place. For information on how this attribute effects code generation see Java mapping of abstract elements.
`substitutionGroup`	Specifies the name of an element that can be substituted with this element. For more information on using type substitution see Element Substitution.
`default`	Specifies a default value for an element. For information on how this attribute effects code generation see Java mapping of elements with a default value.
`fixed`	Specifies a fixed value for the element.

Example 115 shows a simple element definition.

Example 115. Simple XML Schema Element Definition

```
<element name="joeFred" type="xsd:string" />
```

An element can also define its own type using an in-line type definition. In-line types are specified using either a `complexType` element or a `simpleType` element. Once you specify whether the type of data is complex or simple, you can define any type of data needed using the tools available for each type of data.

Example 116 shows an element definition with an in-line type definition.

Example 116. XML Schema Element Definition with an In-Line Type

```
<element name="skate">
   <complexType>
    <sequence>
     <element name="numWheels" type="xsd:int" />
     <element name="brand" type="xsd:string" />
    </sequence>
   </complexType>
</element>
```

Java mapping of elements with a named type

By default, globally defined elements are mapped to `JAXBElement<T>` objects where the template class is determined by the value of the `element` element's `type` attribute. For primitive types, the template class is derived using the wrapper

class mapping described in Wrapper classes. For complex types, the Java class generated to support the complex type is used as the template class.

To support the mapping and to relieve the developer of unnecessary worry about an element's QName, an object factory method is generated for each globally defined element, as shown in Example 117.

Example 117. Object Factory Method for a Globally Scoped Element

```
public class ObjectFactory {

   private final static QName _name_QNAME = new
   QName("targetNamespace", "localName");

...

   @XmlElementDecl(namespace = "targetNamespace", name =
   "localName") public JAXBElement<type> createname(type value);

}
```

For example, the element defined in Example 115 results in the object factory method shown in Example 118.

Example 118. Object Factory for a Simple Element

```
public class ObjectFactory {

   private final static QName _JoeFred_QNAME = new QName("...",
   "joeFred");

...

   @XmlElementDecl(namespace = "...", name = "joeFred") public
   JAXBElement<String> createJoeFred(String value);

}
```

Example 119 shows an example of using a globally scoped element in Java.

Example 119. Using a Globally Scoped Element

```
JAXBElement<String> element = createJoeFred("Green");
String color = element.getValue();
```

Using elements with named types in WSDL

If a globally scoped element is used to define a message part, the generated Java parameter is not an instance of `JAXBElement<T>`. Instead it is mapped to a regular Java type or class.

Given the WSDL fragment shown in Example 120, the resulting method has a parameter of type String.

Example 120. WSDL Using an Element as a Message Part

```
<?xml version="1.0" encoding=";UTF-8"?>
<wsdl:definitions name="HelloWorld"
       targetNamespace="http://apache.org/hello_world_soap_http"
       xmlns="http://schemas.xmlsoap.org/wsdl/"
       xmlns:soap="http://schemas.xmlsoap.org/wsdl/soap/"
       xmlns:tns="http://apache.org/hello_world_soap_http"
       xmlns:x1="http://apache.org/hello_world_soap_http/types"
       xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
       xmlns:xsd="http://www.w3.org/2001/XMLSchema">
<wsdl:types>
  <schema targetNamespace="http://apache.org/hello_world_soap_http/types"
       xmlns="http://www.w3.org/2001/XMLSchema"
       elementFormDefault="qualified">
       <element name="sayHi"> <element name="sayHi" type="string"/>
       <element name="sayHiResponse" type="string"/>
  </schema>
</wsdl:types>

<wsdl:message name="sayHiRequest">
  <wsdl:part element="x1:sayHi" name="in"/>
</wsdl:message>
<wsdl:message name="sayHiResponse">
  <wsdl:part element="x1:sayHiResponse" name="out"/>
</wsdl:message>

<wsdl:portType name="Greeter">
  <wsdl:operation name="sayHi">
    <wsdl:input message="tns:sayHiRequest" name="sayHiRequest"/>
    <wsdl:output message="tns:sayHiResponse" name="sayHiResponse"/>
  </wsdl:operation>
</wsdl:portType>
...
</wsdl:definitions>
```

Example 121 shows the generated method signature for the `sayHi` operation.

Example 121. Java Method Using a Global Element as a Part

```
String sayHi(String in);
```

Java mapping of elements with an in-line type

When an element is defined using an in-line type, it is mapped to Java following the same rules used for mapping other types to Java. The rules for simple types are described in Using Simple Types. The rules for complex types are described in Using Complex Types.

When a Java class is generated for an element with an in-line type definition, the generated class is decorated with the `@XmlRootElement` annotation. The `@XmlRootElement` annotation has two useful properties: name and namespace. These attributes are described in Table 14.

Table 14. Properties for the @XmlRootElement Annotation

Property	Description
`name`	Specifies the value of the XML Schema element element's name attribute.
`namespace`	Specifies the namespace in which the element is defined. If this element is defined in the target namespace, the property is not specified.

The `@XmlRootElement` annotation is not used if the element meets one or more of the following conditions:

- The element's `nillable` attribute is set to `true`
- The element is the head element of a substitution group

For more information on substitution groups see Element Substitution.

Java mapping of abstract elements

When the element's `abstract` attribute is set to `true` the object factory method for instantiating instances of the type is not generated. If the element is defined using an in-line type, the Java class supporting the in-line type is generated.

Java mapping of elements with a default value

When the element's `default` attribute is used the defaultValue property is added to the generated `@XmlElementDecl` annotation. For example, the element defined in Example 122 results in the object factory method shown in Example 123.

Example 122. XML Schema Element with a Default Value

```
<element name="size" type="xsd:int" default="7"/>
```

Example 123. Object Factory Method for an Element with a Default Value

```
@XmlElementDecl(namespace = "...", name = "size", defaultValue = "7")
  public JAXBElement<Integer> createUnionJoe(Integer value) {
    return new JAXBElement<Integer>(_Size_QNAME, Integer.class, null, value);
}
```

Using Simple Types

XML Schema simple types are either XML Schema primitive types like xsd:int, or are defined using the simpleType element. They are used to specify elements that do not contain any children or attributes. They are generally mapped to native Java constructs and do not require the generation of special classes to implement them.

Enumerated simple types do not result in generated code because they are mapped to Java enum types.

Primitive Types

When a message part is defined using one of the XML Schema primitive types, the generated parameter's type is mapped to a corresponding Java native type. The same pattern is used when mapping elements that are defined within the scope of a complex type. The resulting field is of the corresponding Java native type.

Mappings

Table 15 lists the mapping between XML Schema primitive types and Java native types.

Table 15. XML Schema Primitive Type to Java Native Type Mapping

XML Schema Type	Java Type
xsd:string	`String`
xsd:integer	`BigInteger`
xsd:int	int
xsd:long	long
xsd:short	short
xsd:decimal	`BigDecimal`
xsd:float	float
xsd:double	double
xsd:boolean	boolean
xsd:byte	byte
xsd:QName	`QName`
xsd:dateTime	`XMLGregorianCalendar`

XML Schema Type	Java Type
xsd:base64Binary	byte[]
xsd:hexBinary	byte[]
xsd:unsignedInt	long
xsd:unsignedShort	int
xsd:unsignedByte	short
xsd:time	XMLGregorianCalendar
xsd:date	XMLGregorianCalendar
xsd:g	XMLGregorianCalendar
xsd:anySimpleType [a]	Object
xsd:anySimpleType [b]	String
xsd:duration	Duration
xsd:NOTATION	QName

[a]For elements of this type

.[b]For attributes of this type.

Wrapper classes

Mapping XML Schema primitive types to Java primitive types does not work for all possible XML Schema constructs. Several cases require that an XML Schema primitive type is mapped to the Java primitive type's corresponding wrapper type. These cases include:

- An `element` element with its `nillable` attribute set to `true` as shown:

```
<element name="finned" type="xsd:boolean"
     nillable="true" />
```

- An `element` element with its `minOccurs` attribute set to `0` and its `maxOccurs` attribute set to `1`, or its `maxOccurs` attribute not specified, as shown :

```
<element name="plane" type="xsd:string" minOccurs="0" />
```

- An `attribute` element with its `use` attribute set to `optional`, or not specified, and having neither its `default` attribute nor its `fixed` attribute specified, as shown:

```
<element name="date">
   <complexType>
     <sequence/>
     <attribute name="calType" type="xsd:string"
             use="optional" />
   </complexType>
</element>
```

Table 16 shows how XML Schema primitive types are mapped Into Java wrapper classes in these cases.

Table 16. Primitive Schema Type to Java Wrapper Class Mapping

Schema Type	Java Type
xsd:int	`java.lang.Integer`
xsd:long	`java.lang.Long`
xsd:short	`java.lang.Short`
xsd:float	`java.lang.Float`
xsd:double	`java.lang.Double`
xsd:boolean	`java.lang.Boolean`
xsd:byte	`java.lang.Byte`
xsd:unsignedByte	`java.lang.Short`
xsd:unsignedShort	`java.lang.Integer`
xsd:unsignedInt	`java.lang.Long`
xsd:unsignedLong	`java.math.BigInteger`
xsd:duration	`java.lang.String`

Simple Types Defined by Restriction

XML Schema allows you to create simple types by deriving a new type from another primitive type or simple type. Simple types are described using a `simpleType` element.

The new types are described by restricting the *base type* with one or more facets. These facets limit the possible valid values that can be stored in the new type. For example, you could

define a simple type, SSN, which is a string of exactly 9 characters.

Each of the primitive XML Schema types has their own set of optional facets.

Procedure

To define your own simple type do the following:

1. Determine the base type for your new simple type.
2. Determine what restrictions define the new type based on the available facets for the chosen base type.
3. Using the syntax shown in this section, enter the appropriate `simpleType` element into the types section of your contract.

Defining a simple type in XML Schema

Example 124 shows the syntax for describing a simple type.

Example 124. Simple Type Syntax

```
<simpleType name="typeName">
   <restriction base="baseType">
     <facet value="value" />
     <facet value="value" />
     ...
   </restriction>
</simpleType>
```

The type description is enclosed in a `simpleType` element and identified by the value of the `name` attribute. The base type from which the new simple type is being defined is specified by the `base` attribute of the `xsd:restriction` element. Each facet element is specified within the `restriction` element. The available facets and their valid settings depend on the base type. For example, xsd:string has a number of facets including:

- `length`
- `minLength`
- `maxLength`
- `pattern`
- `whitespace`

Example 125 shows the definition for a simple type that represents the two-letter postal code used for US states. It can only contain two, uppercase letters. `TX` is a valid value, but `tx` or `tX` are not valid values.

Example 125. Postal Code Simple Type

```
<xsd:simpleType name="postalCode">
  <xsd:restriction base="xsd:string">
    <xsd:pattern value="[A-Z]{2}" />
  </xsd:restriction>
</xsd:simpleType>
```

Mapping to Java

Artix maps user-defined simple types to the Java type of the simple type's base type. So, any message using the simple type postalCode, shown in Example 125, is mapped to a `String` because the base type of postalCode is xsd:string. For example, the WSDL fragment shown in Example 126 results in a Java method, `state()`, that takes a parameter, `postalCode`, of `String`.

Example 126. Credit Request with Simple Types

```
<message name="stateRequest">
  <part name="postalCode" type="postalCode" />
</message>
...
<portType name="postalSupport">
  <operation name="state">
    <input message="tns:stateRequest" name="stateRec" />
    <output message="tns:stateResponse" name="credResp" />
  </operation>
</portType>
```

Enforcing facets

By default, Artix does not enforce any of the facets that are used to restrict a simple type. However, you can configure Artix endpoints to enforce the facets by enabling schema validation.

To configure Artix endpoints to use schema validation set the schema-validation-enabled property to `true`. Example 127 shows the configuration for a service provider that uses schema validation.

Example 127. Service Provider Configured to Use Schema Validation

```
<jaxws:endpoint
       name="{http://apache.org/hello_world_soap_http}SoapPort"
       wsdlLocation="wsdl/hello_world.wsdl"
       createdFromAPI="true">
  <jaxws:properties>
    <entry key="schema-validation-enabled" value="true" />
  </jaxws:properties>
</jaxws:endpoint>
```

For more information on configuring Artix see the ***Artix Deployment Guide: Java***.

Enumerations

In XML Schema, enumerated types are simple types that are defined using the `xsd:enumeration` facet. Unlike atomic simple types, they are mapped to Java enums.

Defining an enumerated type in XML Schema

Enumerations are a simple type using the `xsd:enumeration` facet. Each `xsd:enumeration` facet defines one possible value for the enumerated type.

Example 128 shows the definition for an enumerated type. It has the following possible values:

- `big`
- `large`
- `mungo`
- `gargantuan`

Example 128. XML Schema Defined Enumeration

```
<simpleType name="widgetSize">
  <restriction base="xsd:string">
    <enumeration value="big"/>
    <enumeration value="large"/>
    <enumeration value="mungo"/>
    <enumeration value="gargantuan"/>
  </restriction>
```

Mapping to Java

XML Schema enumerations where the base type is xsd:string are automatically mapped to Java enum type. You can instruct the code generator to map enumerations with other base types to Java enum types by using the customizations described in Customizing Enumeration Mapping.

The enum type is created as follows:

1. The name of the type is taken from the `name` attribute of the simple type definition and converted to a Java identifier.

   In general, this means converting the first character of the XML Schema's name to an uppercase letter. If the first character of the XML Schema's name is an invalid character, an underscrore (_) is prepended to the name.

2. For each `enumeration` facet, an enum constant is generated based on the value of the `value` attribute.

   The constant's name is derived by converting all of the lowercase letters in the value to their uppercase equivalent.

3. A constructor is generated that takes the Java type mapped from the enumeration's base type.

4. A public method called `value()` is generated to access the facet value that is represented by an instance of the type.

   The return type of the `value()` method is the base type of the XML Schema type.

5. A public method called `fromValue()` is generated to create an instance of the enum type based on a facet value.

   The parameter type of the `value()` method is the base type of the XML Schema type.

6. The class is decorated with the `@XmlEnum` annotation.

The enumerated type defined in Example 128 is mapped to the enum type shown in Example 129.

Example 129. Generated Enumerated Type for a String Bases XML Schema Enumeration

```
@XmlType(name = "widgetSize")
@XmlEnum
public enum WidgetSize {

   @XmlEnumValue("big")
   BIG("big"),
   @XmlEnumValue("large")
   LARGE("large"),
   @XmlEnumValue("mungo")
   MUNGO("mungo"),
   @XmlEnumValue("gargantuan")
   GARGANTUAN("gargantuan");
   private final String value;

   WidgetSize(String v)
     { value = v;
   }

   public String value() {
     return value;
   }

   public static WidgetSize fromValue(String v)
     { for (WidgetSize c: WidgetSize.values()) {
       if (c.value.equals(v)) {
          return c;
```

```
      }
    }
    throw new IllegalArgumentException(v);
    }

}
```

Lists

XML Schema supports a mechanism for defining data types that are a list of space separated simple types. An example of an element, `primeList`, using a list type is shown in Example 130.

Example 130. List Type Example

```
<primeList>1 3 5 7 9 11 13<\primeList>
```

XML Schema list types are generally mapped to Java `List<T>` objects. The only variation to this pattern is when a message part is mapped directly to an instance of an XML Schema list type.

Defining list types in XML Schema

XML Schema list types are simple types and as such are defined using a `simpleType` element. The most common syntax used to define a list type is shown in Example 131.

Example 131. Syntax for XML Schema List Types

```
<simpleType name="listType">
<list itemType="atomicType">
    <facet value="value" />
    <facet value="value" />
    ...
</list>
</simpleType>
```

The value given for `atomicType` defines the type of the elements in the list. It can only be one of the built in XML Schema atomic types, like xsd:int or xsd:string, or a user-defined simple type that is not a list.

In addition to defining the type of elements listed in the list type, you can also use facets to further constrain the properties of the list type.

Table 17 shows the facets used by list types.

Table 17. List Type Facets

Facet	Effect
`length`	Defines the number of elements in an instance of the list type.
`minLength`	Defines the minimum number of elements allowed in an instance of the list type.
`maxLength`	Defines the maximum number of elements allowed in an instance of the list type.
`enumeration`	Defines the allowable values for elements in an instance of the list type.
`pattern`	Defines the lexical form of the elements in an instance of the list type. Patterns are defined using regular expressions.

For example, the definition for the `simpleList` element shown in Example 130, is shown in Example 132.

Example 132. Definition of a List Type

```
<simpleType name="primeListType">
       <list itemType="int"/>
</simpleType>
<element name="primeList" type="primeListType"/>
```

In addition to the syntax shown in Example 131 you can also define a list type using the less common syntax shown in Example 133.

Example 133. Alternate Syntax for List Types

```
<simpleType name="listType">
   <list>
     <simpleType>
       <restriction base="atomicType">
         <facet value="value"/>
         <facet value="value"/>
         ...
       </restriction>
     </simpleType>
   </list>
</simpleType>
```

Mapping list type elements to Java

When an element is defined a list type, the list type is mapped to a collection property. A collection property is a Java `List<T>` object. The template class used by the `List<T>` is the wrapper

class mapped from the list's base type. For example, the list type defined in Example 132 is mapped to a `List<Integer>`.

For more information on wrapper type mapping see Wrapper classes.

Mapping list type parameters to Java

When a message part is defined as a list type, or is mapped to an element of a list type, the resulting method parameter is mapped to an array instead of a `List<T>` object. The base type of the array is the wrapper class of the list type's base class. For example, the WSDL fragment in Example 134 results in the method signature shown in Example 135.

Example 134. WSDL with a List Type Message Part

```
<definitions ...>
  ...
  <types ...>
    <schema ... >
      <simpleType name="primeListType">
        <list itemType="int"/>
      </simpleType>
      <element name="primeList" type="primeListType"/>
    </schemas>
  </types>
  <message name="numRequest">
    <part name="inputData" element="xsd1:primeList" />
  </message>
  <message name="numResponse">;
    <part name="outputData" type="xsd:int">
  ...
  <portType name="numberService">
    <operation name="primeProcessor">
      <input name="numRequest" message="tns:numRequest" />
      <output name="numResponse" message="tns:numResponse" />
    </operation>
    ...
  </portType>
  ...
</definitions>
```

Example 135. Java Method with a List Type Parameter

```
public interface NumberService {

    @XmlList
    @WebResult(name = "outputData", targetNamespace = "", partName = "outputData")
    @WebMethod
    public int primeProcessor(
        @WebParam(partName = "inputData", name = "primeList", targetNamespace = "...")
        java.lang.Integer[] inputData
    );
}
```

Unions

In XML Schema, a union is a construct that allows you to describe a type whose data can be one of a number of simple types. For example, you can define a type whose value is either the integer `1` or the string `first`. Unions are mapped to Java `String`s.

Defining in XML Schema

XML Schema unions are defined using a `simpleType` element. They contain at least one `union` element that defines the member types of the union. The member types of the union are the valid types of data that can be stored in an instance of the union. They are defined using the `union` element's `memberTypes` attribute. The value of the `memberTypes` attribute contains a list of one or more defined simple type names. Example 136 shows the definition of a union that can store either an integer or a string.

Example 136. Simple Union Type

```
<simpleType name="orderNumUnion">
  <union memberTypes="xsd:string xsd:int" />
</simpleType>
```

In addition to specifying named types as a member type of a union, you can also define an anonymous simple type as a member type of a union. This is done by adding the anonymous type definition inside of the `union` element.

Example 137 shows an example of a union containing an anonymous member type that restricts the possible values of a valid integer to the range 1 through 10.

Example 137. Union with an Anonymous Member Type

```
<simpleType name="restrictedOrderNumUnion">
  <union memberTypes="xsd:string">
    <simpleType>
      <restriction base="xsd:int">
        <minInclusive value="1" />
        <maxInclusive value="10" />
      </restriction>
    </simpleType>
  </union>
</simpleType>
```

Mapping to Java

XML Schema union types are mapped to Java `String` objects. By default, Artix does not validate the contents of the generated object. To have Artix validate the contents you will must configure the runtime to use schema validation as described in Enforcing facets.

Simple Type Substitution

XML allows for simple type substitution between compatible types using the `xsi:type` attribute. The default mapping of simple types to Java primitive types, however, does not fully support simple type substitution. The runtime can handle basic simple type substitution, but information is lost. The code generators can be customized to generate Java classes that facilitate lossless simple type substitution.

Default mapping and marshaling

Because Java primitive types do not support type substitution, the default mapping of simple types to Java primitive types presents problems for supporting simple type substitution. The Java virtual machine will balk if an attempt is made to pass a short into a variable that expects an int even though the schema defining the types allows it.

To get around the limitations imposed by the Java type system, Artix allows for simple type substitution when the value of the element's `xsi:type` attribute meets one of the following conditions:

- It specifies a primitive type that is compatible with the element's schema type.
- It specifies a type that derives by restriction from the element's schema type.
- It specifies a complex type that derives by extension from the element's schema type.

When the runtime does the type substitution it does not retain any knowledge of the type specified in the element's `xsi:type` attribute. If the type substitution is from a complex type to a simple type, only the value directly related to the simple type is preserved. Any other elements and attributes added by extension are lost.

Supporting lossless type substitution

You can customize the generation of simple types to facilitate lossless support of simple type substitution in the following ways:

- Set the `globalBindings` customization element's `mapSimpleTypeDef` to `true`.

  This instructs the code generator to create Java value classes for all named simple types defined in the global scope.

  For more information see Generating Java Classes for Simple Types.

- Add a `javaType` element to the `globalBindings` customization element.

  This instructs the code generators to map all instances of an XML Schema primitive type to s specific class of object.

  For more information see Specifying the Java Class of an XML Schema Primitive.

- Add a `baseType` customization element to the specific elements you want to customize.

  The `baseType` customization element allows you to specify the Java type generated to represent a property. To ensure the best compatibility for simple type substitution, use `java.lang.Object` as the base type.

  For more information see Specifying the Base Type of an Element or an Attribute.

Using Complex Types

Complex types can contain multiple elements and they can have attributes. They are mapped into Java classes that can hold the data represented by the type definition. Typically, the mapping is to a bean with a set of properties representing the elements and the attributes of the content model.

Basic Complex Type Mapping

XML Schema complex types define constructs containing more complex information than a simple type. The most simple complex types define an empty element with an attribute. More intricate complex types are made up of a collection of elements.

By default, an XML Schema complex type is mapped to a Java class, with a member variable to represent each element and attribute listed in the XML Schema definition. The class has setters and getters for each member variable.

Defining in XML Schema

XML Schema complex types are defined using the `complexType` element.

The `complexType` element wraps the rest of elements used to define the structure of the data. It can appear either as the parent element of a named type definition, or as the child of an `element` element anonymously defining the structure of the information stored in the element. When the `complexType` element is used to define a named type, it requires the use of the `name` attribute. The `name` attribute specifies a unique identifier for referencing the type.

Complex type definitions that contain one or more elements have one of the child elements described in Table 18. These elements determine how the specified elements appear in an instance of the type.

Table 18. Elements for Defining How Elements Appear in a Complex Type

Element	Description
`all`	All of the elements defined as part of the complex type must appear in an instance of the type. However, they can appear in any order.
`choice`	Only one of the elements defined as part of the complex type can appear in an instance of the type.

Element	Description
`sequence`	All of the elements defined as part of the complex type must appear in an instance of the type, and they must also appear in the order specified in the type definition.

NOTE: . If a complex type definition only uses attributes, you do not need one of the elements described in Table 18.

After deciding how the elements will appear, you define the elements by adding one or more `element` element children to the definition. Example 138 shows a complex type definition in XML Schema.

Example 138. XML Schema Complex Type

```
<complexType name="sequence">
  <sequence>
    <element name="name" type="xsd:string" />
    <element name="street" type="xsd:short" />
    <element name="city" type="xsd:string" />
    <element name="state" type="xsd:string" />
    <element name="zipCode" type="xsd:string" />
  </sequence>
</complexType>
```

Mapping to Java

XML Schema complex types are mapped to Java classes. Each element in the complex type definition is mapped to a member variable in the Java class. Getter and setter methods are also generated for each element in the complex type.

All generated Java classes are decorated with the `@XmlType` annotation. If the mapping is for a named complex type, the annotations name is set to the value of the `complexType` element's `name` attribute. If the complex type is defined as part of an element definition, the value of the `@XmlType` annotation's name property is the value of the `element` element's `name` attribute.

As described in Java mapping of elements with an in-line type, the generated class is decorated with the `@XmlRootElement` annotation if it is generated for a complex type defined as part of an element definition.

To provide the runtime with guidelines indicating how the elements of the XML Schema complex type should be handled, the code generators alter the annotations used to decorate the class and its member variables.

- All Complex Type

  All complex types are defined using the `all` element. They are annotated as follows:

  - The `@XmlType` annotation's propOrder property is empty.
  - Each element is decorated with the `@XmlElement` annotation.
  - The `@XmlElement` annotation's required property is set to `true`.

  Example 139 shows the mapping for an all complex type with two elements.

Example 139. Mapping of an All Complex Type

```
@XmlType(name = "all", propOrder = {

})
public class All {
    @XmlElement(required = true) protected BigDecimal amount;
    @XmlElement(required = true) protected String type;

    public BigDecimal getAmount() { return amount;
    }

    public void setAmount(BigDecimal value) { this.amount =
        value;
    }

    public String getType() { return type;
    }

    public void setType(String value) { this.type = value;
    }
}
```

- Choice Complex Type

  Choice complex types are defined using the `choice` element. They are annotated as follows:

  - The `@XmlType` annotation's propOrder property lists the names of the elements in the order they appear in the XML Schema definition.
  - None of the member variables are annotated.

  Example 140 shows the mapping for a choice complex type with two elements.

Example 140. Mapping of a Choice Complex Type

```
@XmlType(name = "choice", propOrder = {
    "address",
    "floater"
})
public class Choice {

    protected Sequence address;
    protected Float floater;

    public Sequence getAddress() {
        return address;
    }

    public void setAddress(Sequence value) {
        this.address = value;
    }

    public Float getFloater() {
        return floater;
    }

    public void setFloater(Float value) {
        this.floater = value;
    }

}
```

- Sequence Complex Type

  A sequence complex type is defined using the `sequence` element. It is annotated as follows:

  - The `@XmlType` annotation's propOrder property lists the names of the elements in the order they appear in the XML Schema definition.
  - Each element is decorated with the `@XmlElement` annotation.
  - The `@XmlElement` annotation's required property is set to `true`.

Example 141 shows the mapping for the complex type defined in Example 138.

Example 141. Mapping of a Sequence Complex Type

```
@XmlType(name = "sequence", propOrder = { "name",
    "street",
    "city",
    "state", "zipCode"
})
public class Sequence {

    @XmlElement(required = true) protected String name;
    protected short street;
    @XmlElement(required = true) protected String city;
    @XmlElement(required = true) protected String state;
    @XmlElement(required = true) protected String zipCode;

    public String getName() { return name;
    }

    public void setName(String value) { this.name = value;
    }

    public short getStreet() { return street;
    }

    public void setStreet(short value) { this.street = value;
    }

    public String getCity() { return city;
    }

    public void setCity(String value) { this.city = value;
    }

    public String getState() { return state;
    }
    public void setState(String value) { this.state = value;
    }

    public String getZipCode() { return zipCode;
    }

    public void setZipCode(String value) { this.zipCode = value;
    }
}
```

Attributes

Artix supports the use of `attribute` elements and `attributeGroup` elements within the scope of a `complexType` element. When defining structures for an XML document attribute declarations provide a means of adding information that is specified within the tag, not the value that the tag contains. For example, when describing the XML element <value currency="euro">410<\value> in XML Schema the `currency` attribute is described using an `attribute` element as shown in Example 142.

The `attributeGroup` element allows you to define a group of reusable attributes that can be referenced by all complex types

defined by the schema. For example, if you are defining a series of elements that all use the attributes `category` and `pubDate`, you could define an attribute group with these attributes and reference them in all the elements that use them. This is shown in Example 144.

When describing data types for use in developing application logic, attributes whose `use` attribute is set to either `optional` or `required` are treated as elements of a structure. For each attribute declaration contained within a complex type description, an element is generated in the class for the attribute, along with the appropriate getter and setter methods.

Defining an attribute in XML Schema

An XML Schema `attribute` element has one required attribute, `name`, that is used to identify the attribute. It also has four optional attributes that are described in Table 19.

Table 19. Optional Attributes Used to Define Attributes in XML Schema

Attribute	Description
`use`	Specifies if the attribute is required. Valid values are required, optional, or prohibited. optional is the default value.
`type`	Specifies the type of value the attribute can take. If it is not used the schema type of the attribute must be defined in-line.
`default`	Specifies a default value to use for the attribute. It is only used when the attribute element's use attribute is set to optional.
`fixed`	Specifies a fixed value to use for the attribute. It is only used when the attribute element's use attribute is set to optional.

Example 142 shows an attribute element defining an attribute, currency, whose value is a string.

Example 142. XML Schema Defining and Attribute

```
<element name="value">
  <complexType>
    <xsd:simpleContent>
      <xsd:extension base="xsd:integer">
        <xsd:attribute name="currency" type="xsd:string"
                       use="required"/>
      </xsd:extension>
    </xsd:simpleContent>
  </xsd:complexType>
</xsd:element>
```

If the `type` attribute is omitted from the `attribute` element, the format of the data must be described in-line. Example 143

shows an `attribute` element for an attribute, `category`, that can take the values `autobiography`, `non-fiction`, or `fiction`.

Example 143. Attribute with an In-Line Data Description

```
<attribute name="category" use="required">
  <simpleType>
    <restriction base="xsd:string">
      <enumeration value="autobiography"/>
      <enumeration value="non-fiction"/>
      <enumeration value="fiction"/>
    </restriction>
  </simpleType>
</attribute>
```

Using an attribute group in XML Schema

Using an attribute group in a complex type definition is a two step process:

1. Define the attribute group.

   An attribute group is defined using an `attributeGroup` element with a number of `attribute` child elements. The `attributeGroup` requires a `name` attribute that defines the string used to refer to the attribute group. The `attribute` elements define the members of the attribute group and are specified as shown in Defining an attribute in XML Schema. Example 144 shows the description of the attribute group `catalogIndecies`. The attribute group has two members: `category`, which is optional, and `pubDate`, which is required.

Example 144. Attribute Group Definition

```
<attributeGroup name="catalogIndices">
  <attribute name="category" type="catagoryType" />
  <attribute name="pubDate" type="dateTime"
             use="required" />
</attributeGroup>
```

2. Use the attribute group in the definition of a complex type.

   You use attribute groups in complex type definitions by using the `attributeGroup` element with the `ref` attribute. The value of the `ref` attribute is the name given the attribute group that you want to use as part of the type definition. For example if you want to use the attribute group `catalogIndecies` in the complex type dvdType, you would use <attributeGroup ref="catalogIndecies" /> as shown in Example 145.

Example 145. Complex Type with an Attribute Group

```
<complexType name="dvdType">
  <sequence>
    <element name="title" type="xsd:string" />
    <element name="director" type="xsd:string" />
    <element name="numCopies" type="xsd:int" />
  </sequence>
  <attributeGroup ref="catalogIndices" />
</complexType>
```

Mapping attributes to Java

Attributes are mapped to Java in much the same way that member elements

are mapped to Java. Required attributes and optional attributes are mapped to member variables in the generated Java class. The member variables are decorated with the `@XmlAttribute` annotation. If the attribute is required, the `@XmlAttribute` annotation's required property is set to `true`.

The complex type defined in Example 146 is mapped to the Java class shown in Example 147.

Example 146. techDoc Description

```
<complexType name="techDoc">
  <all>
    <element name="product" type="xsd:string" />
    <element name="version" type="xsd:short" />
  </all>
  <attribute name="usefullness" type="xsd:float"
             use="optional" default="0.01" />
</complexType>
```

Example 147. techDoc Java Class

```
@XmlType(name = "techDoc", propOrder = {

})
public class TechDoc {

    @XmlElement(required = true)
    protected String product;
    protected short version;
    @XmlAttribute
    protected Float usefullness;

    public String getProduct() {
       return product;
    }

    public void setProduct(String value) {
       this.product = value;
    }

    public short getVersion() {
       return version;
    }

    public void setVersion(short value) {
       this.version = value;
    }

    public float getUsefullness() {
        if (usefullness == null) {
            return  0.01F;
        } else {
            return usefullness;
        }
    }

    public void setUsefullness(Float value) { this.usefullness = value;
    }
}
```

As shown in Example 147, the `default` attribute and the `fixed` attribute instruct the code generators to add code to the getter method generated for the attribute. This additional code ensures that the specified value is returned if no value is set.

IMPORTANT: The `fixed` attribute is treated the same as the `default` attribute. If you want the `fixed` attribute to be treated as a Java constant you can use the customization described in Customizing Fixed Value Attribute Mapping.

Mapping attribute groups to Java

Attribute groups are mapped to Java as if the members of the group were explicitly used in the type definition. If the attribute group has three members, and it is used in a complex type, the generated class for that type will include a member variable, along with the getter and setter methods, for each member of the attribute group. For example, the complex type defined in Example 145, Artix generates a class containing the member variables `category` and `pubDate` to support the members of the attribute group as shown in Example 148.

Example 148. dvdType Java Class

```
@XmlType(name = "dvdType", propOrder = {
    "title",
    "director",
    "numCopies"
})
public class DvdType {

    @XmlElement(required = true)
    protected String title;
    @XmlElement(required = true)
    protected String director;
    protected int numCopies;
    @XmlAttribute
    protected CatagoryType category;
    @XmlAttribute(required = true)
    @XmlSchemaType(name = "dateTime")
    protected XMLGregorianCalendar pubDate;

    public String getTitle() {
        return title;
    }

    public void setTitle(String value) {
        this.title = value;
    }

    public String getDirector() {
        return director;
    }

    public void setDirector(String value) {
        this.director = value;
    }

    public int getNumCopies() {
        return numCopies;
    }

    public void setNumCopies(int value) {
        this.numCopies = value;
    }

    public CatagoryType getCatagory() {
        return catagory;
    }

    public void setCatagory(CatagoryType value) {
        this.catagory = value;
    }

    public XMLGregorianCalendar getPubDate() {
        return pubDate;
    }

    public void setPubDate(XMLGregorianCalendar value) {
        this.pubDate = value;
    }
}
```

Deriving Complex Types from Simple Types

Artix supports derivation of a complex type from a simple type. A simple type has, by definition, neither sub-elements nor attributes. Hence, one of the main reasons for deriving a complex type from a simple type is to add attributes to the simple type.

There are two ways of deriving a complex type from a simple type:

- By extension
- By restriction

Derivation by extension

Example 149 shows an example of a complex type, internationalPrice, derived by extension from the xsd:decimal primitive type to include a currency attribute.

Example 149. Deriving a Complex Type from a Simple Type by Extension

```
<complexType name="internationalPrice">
    <simpleContent>
        <extension base="xsd:decimal">
            <attribute name="currency" type="xsd:string"/>
        </extension>
    </simpleContent>
</complexType>
```

The `simpleContent` element indicates that the new type does not contain any sub-elements. The `extension` element specifies that the new type extends xsd:decimal.

Derivation by restriction

Example 150 shows an example of a complex type, idType, that is derived by restriction from xsd:string. The defined type restricts the possible values of xsd:stringto values that are ten characters in length. It also adds an attribute to the type.

Example 150. Deriving a Complex Type from a Simple Type by Restriction

```
<complexType name="idType">
  <simpleContent>
    <restriction base="xsd:string">
     <length value="10" />
     <attribute name="expires" type="xsd:dateTime" />
    </restriction>
  </simpleContent>
</complexType>
```

As in Example 149 the `simpleContent` element signals that the new type does not contain any children. This example uses a

`restriction` element to constrain the possible values used in the new type. The `attribute` element adds the element to the new type.

Mapping to Java

A complex type derived from a simple type is mapped to a Java class that is decorated with the `@XmlType` annotation. The generated class contains a member variable, `value`, of the simple type from which the complex type is derived. The member variable is decorated with the `@XmlValue` annotation. The class also has a `getValue()` method and a `setValue()` method. In addition, the generated class has a member variable, and the associated getter and setter methods, for each attribute that extends the simple type.

Example 151 shows the Java class generated for the idType type defined in Example 150.

Example 151. idType Java Class

```
@XmlType(name = "idType", propOrder = {
    "value"
})
public class IdType {

    @XmlValue
    protected String value;
    @XmlAttribute
    @XmlSchemaType(name = "dateTime")
    protected XMLGregorianCalendar expires;

    public String getValue() {
        return value;
    }

    public void setValue(String value) {
        this.value = value;
    }

    public XMLGregorianCalendar getExpires() {
        return expires;
    }

    public void setExpires(XMLGregorianCalendar value) {
        this.expires = value;
    }

}
```

Deriving Complex Types from Complex Types

Using XML Schema, you can derive new complex types by either extending or restricting other complex types using the `complexContent` element. When generating the Java class to represent the derived complex type, Artix extends the base type's class. In this way, the generated Java code preserves the inheritance hierarchy intended in the XML Schema.

Schema syntax

You derive complex types from other complex types by using the `complexContent` element, and either the `extension` element or the `restriction` element. The `complexContent` element specifies that the included data description includes more than one field. The `extension` element and the `restriction` element, which are children of the `complexContent` element, specify the base type being modified to create the new type. The base type is specified by the `base` attribute.

Extending a complex type

To extend a complex type use the `extension` element to define the additional elements and attributes that make up the new type. All elements that are allowed in a complex type description are allowable as part of the new type's definition. For example, you can add an anonymous enumeration to the new type, or you can use the `choice` element to specify that only one of the new fields can be valid at a time.

Example 152 shows an XML Schema fragment that defines two complex types, widgetOrderInfo and widgetOrderBillInfo. widgetOrderBillInfo is derived by extending widgetOrderInfo to include two new elements: `orderNumber` and `amtDue`.

Example 152. Deriving a Complex Type by Extension

```
<complexType name="widgetOrderInfo">
  <sequence>
    <element name="amount" type="xsd:int"/>
    <element name="order_date" type="xsd:dateTime"/>
    <element name="type" type="xsd1:widgetSize"/>
    <element name="shippingAddress" type="xsd1:Address"/>
  </sequence>
  <attribute name="rush" type="xsd:boolean" use="optional" />
</complexType>
<complexType name="widgetOrderBillInfo">
  <complexContent>
    <extension base="xsd1:widgetOrderInfo">
      <sequence>
        <element name="amtDue" type="xsd:decimal"/>
        <element name="orderNumber" type="xsd:string"/>
      </sequence>
      <attribute name="paid" type="xsd:boolean"
                 default="false" />
    </extension>
  </complexContent>
</complexType>
```

Restricting a complex type

To restrict a complex type use the `restriction` element to limit the possible values of the base type's elements or attributes. When restricting a complex type you must list all of the elements and attributes of the base type. For each element you can add restrictive attributes to the definition. For example, you can add a `maxOccurs` attribute to an element to limit the number of times it can occur. You can also use the `fixed` attribute to force one or more of the elements to have predetermined values.

Example 153 shows an example of defining a complex type by restricting another complex type. The restricted type, wallawallaAddress, can only be used for addresses in Walla Walla, Washington because the values for the `city` element, the `state` element, and the `zipCode` element are fixed.

Example 153. Defining a Complex Type by Restriction

```
<complexType name="Address">
  <sequence>
    <element name="name" type="xsd:string"/>
    <element name="street" type="xsd:short" maxOccurs="3"/>
    <element name="city" type="xsd:string"/>
    <element name="state" type="xsd:string"/>
    <element name="zipCode" type="xsd:string"/>
  </sequence>
</complexType>
<complexType name="wallawallaAddress">
  <complexContent>
    <restriction base="xsd1:Address">
      <sequence>
        <element name="name" type="xsd:string"/>
        <element name="street" type="xsd:short"
                 maxOccurs="3"/>
        <element name="city" type="xsd:string"
                 fixed="WallaWalla"/>
        <element name="state" type="xsd:string"
                 fixed="WA" />
        <element name="zipCode" type="xsd:string"
                 fixed="99362" />
      </sequence>
    </restriction>
  </complexContent>
</complexType>
```

Mapping to Java

As it does with all complex types, Artix generates a class to represent complex types derived from another complex type. The Java class generated for the derived complex type extends the Java class generated to support the base complex type. The base Java class is also modified to include the `@XmlSeeAlso` annotation. The base class' `@XmlSeeAlso` annotation lists all of the classes that extend the base class.

When the new complex type is derived by extension, the generated class will include member variables for all of the added elements and attributes. The new member variables will be generated according to the same mappings as all other elements.

When the new complex type is derived by restriction, the generated class will have no new member variables. The generated class will simply be a shell that does not provide any additional functionality. It is entirely up to you to ensure that the restrictions defined in the XML Schema are enforced.

For example, the schema in Example 152 results in the generation of two Java classes: `WidgetOrderInfo` and `WidgetBillOrderInfo`.

`WidgetOrderBillInfo` extends `WidgetOrderInfo` because widgetOrderBillInfo is derived by extension from widgetOrderInfo.

Example 154 shows the generated class for widgetOrderBillInfo.

Example 154. WidgetOrderBillInfo

```
@XmlType(name = "widgetOrderBillInfo", propOrder = {
    "amtDue",
    "orderNumber"
})
public class WidgetOrderBillInfo
    extends WidgetOrderInfo
{
    @XmlElement(required = true)
    protected BigDecimal amtDue;
    @XmlElement(required = true)
    protected String orderNumber;
    @XmlAttribute
    protected Boolean paid;

    public BigDecimal getAmtDue() {
        return amtDue;
    }

    public void setAmtDue(BigDecimal value) {
        this.amtDue = value;
    }

    public String getOrderNumber() {
        return orderNumber;
    }

    public void setOrderNumber(String value) {
        this.orderNumber = value;
    }

    public boolean isPaid() {
        if (paid == null) {
            return false;
        } else {
            return paid;
        }
    }

    public void setPaid(Boolean value) {
        this.paid = value;
    }
}
```

Occurrence Constraints

XML Schema allows you to specify the occurrence constraints on four of the XML Schema elements that make up a complex type definition:

- `all`
- `choice`
- `element`
- `sequence`

Occurrence Constraints on the All Element

XML Schema

Complex types defined with the `all` element do not allow for multiple occurrences of the structure defined by the `all` element. You can, however, make the structure defined by the `all` element optional by setting its `minOccurs` attribute to `0`.

Mapping to Java

Setting the `all` element's `minOccurs` attribute to `0` has no effect on the generated Java class.

Occurrence Constraints on the Choice Element

By default, the results of a `choice` element can only appear once in an instance of a complex type. You can change the number of times the element chosen to represent the structure defined by a `choice` element is allowed to appear using its `minOccurs` attribute and its `mxOccurs` attribute. Using these attributes you can specify that the choice type can occur zero to an unlimited number of times in an instance of a complex type. The element chosen for the choice type does not need to be the same for each occurrence of the type.

Using in XML Schema

The `minOccurs` attribute specifies the minimum number of times the choice type must appear. Its value can be any positive integer. Setting the `minOccurs` attribute to `0` specifies that the choice type does not need to appear inside an instance of the complex type.

The `maxOccurs` attribute specifies the maximum number of times the choice type can appear. Its value can be any non-zero, positive integer or `unbounded`. Setting the `maxOccurs` attribute to `unbounded` specifies that the choice type can appear an infinite number of times.

Example 155 shows the definition of a choice type, ClubEvent, with choice occurrence constraints. The choice type overall can be repeated 0 to unbounded times.

Example 155. Choice Occurrence Constraints

```
<complexType name="ClubEvent">
  <choice minOccurs="0" maxOccurs="unbounded">
    <element name="MemberName" type="xsd:string"/>
    <element name="GuestName" type="xsd:string"/>
  </choice>
</complexType>
```

Mapping to Java

Unlike single instance choice structures, XML Schema choice structures that can occur multiple times are mapped to a Java class with a single member variable. This single member variable is a `List<T>` object that holds all of the data for the multiple occurrences of the sequence. For example, if the sequence defined in Example 155 occurred two times, then the list would have two items.

The name of the Java class' member variable is derived by concatenating the names of the member elements. The element names are separated by `Or` and the first letter of the variable name is converted to lower case. For example, the member variable generated from Example 155 would be named `memberNameOrGuestName`.

The type of object stored in the list depends on the relationship between the types of the member elements. For example:

- If the member elements are of the same type the generated list will contain `JAXBElement<T>` objects. The base type of the `JAXBElement<T>` objects is determined by the normal mapping of the member elements' type.
- If the member elements are of different types and their Java representations implement a common interface, the list will contains objects of the common interface.
- If the member elements are of different types and their Java representations extend a common base class, the list will contains objects of the common base class.
- If none of the other conditions are met, the list will contain `Object` objects.

The generated Java class will only have a getter method for the member variable. The getter method returns a reference to the live list. Any modifications made to the returned list will effect the actual object.

The Java class is decorated with the `@XmlType` annotation. The annotation's name property is set to the value of the `name` attribute from the parent element of the XML Schema definition.

The annotation's propOrder property contains the single member variable representing the elements in the sequence.

The member variable representing the elements in the choice structure are decorated with the `@XmlElements` annotation. The `@XmlElements` annotation contains a comma separated list of `@XmlElement` annotations. The list has one `@XmlElement` annotation for each member element defined in the XML Schema definition of the type. The `@XmlElement` annotations in the list have their name property set to the value of the XML Schema `element` element's `name` attribute and their type property set to the Java class resulting from the mapping of the XML Schema `element` element's type.

Example 156 shows the Java mapping for the XML Schema choice structure defined in Example 155.

Example 156. Java Representation of Choice Structure with an Occurrence Constraint

```
@XmlType(name = "ClubEvent", propOrder = {
    "memberNameOrGuestName"
})
public class ClubEvent {

    @XmlElementRefs({
        @XmlElementRef(name = "GuestName", type = JAXBElement.class),
        @XmlElementRef(name = "MemberName", type = JAXBElement.class)
    })
    protected List<JAXBElement<String>> memberNameOrGuestName;

    public List<JAXBElement<String>> getMemberNameOrGuestName() {
        if (memberNameOrGuestName == null) {
            memberNameOrGuestName = new ArrayList<JAXBElement<String>>();
        }
        return this.memberNameOrGuestName;
    }

}
```

minOccurs set to 0

If only the `minOccurs` element is specified and its value is `0`, the code generators generate the Java class as if the `minOccurs` attribute were not set.

Occurrence Constraints on Elements

You can specify how many times a specific element in a complex type appears using the `element` element's `minOccurs` attribute and `maxOccurs` attribute. The default value for both attributes is `1`.

minOccurs set to 0

When you set one of the complex type's member element's `minOccurs` attribute to `0`, the `@XmlElement` annotation decorating the corresponding Java member variable is changed. Instead of

having its required property set to `true`, the `@XmlElement` annotation's required property is set to `false`.

minOccurs set to a value greater than 1

In XML Schema you can specify that an element must occur more than once in an instance of the type by setting the `element` element's `minOccurs` attribute to a value greater than one. However, the generated Java class will not support the XML Schema constraint. Artix generates the supporting Java member variable as if the `minOccurs` attribute were not set.

Elements with maxOccurs set

When you want a member element to appear multiple times in an instance of a complex type, you set the element's `maxOccurs` attribute to a value greater than 1. You can set the `maxOccurs` attribute's value to `unbounded` to specify that the member element can appear an unlimited number of times.

The code generators map a member element with the `maxOccurs` attribute set to a value greater than 1 to a Java member variable that is a `List<T>` object. The base class of the list is determined by mapping the element's type to Java. For XML Schema primitive types, the wrapper classes are used as described in Wrapper classes on page 149. For example, if the member element is of type xsd:int the generated member variable is a `List<Integer>` object.

Occurrence Constraints on Sequences

By default, the contents of a `sequence` element can only appear once in an instance of a complex type. You can change the number of times the sequence of elements defined by a `sequence` element is allowed to appear using its `minOccurs` attribute and its `maxOccurs` attribute. Using these attributes you can specify that the sequence type can occur zero to an unlimited number of times in an instance of a complex type.

Using XML Schema

The `minOccurs` attribute specifies the minimum number of times the sequence must occur in an instance of the defined complex type. Its value can be any positive integer. Setting the `minOccurs` attribute to `0` specifies that the sequence does not need to appear inside an instance of the complex type.

The `maxOccurs` attribute specifies the upper limit for how many times the sequence can occur in an instance of the defined complex type. Its value can be any non-zero, positive integer or `unbounded`. Setting the `maxOccurs` attribute to `unbounded` specifies that the sequence can appear an infinite number of times.

Example 157 shows the definition of a sequence type, CultureInfo, with sequence occurrence constraints. The sequence can be repeated 0 to 2 times.

Example 157. Sequence with Occurrence Constraints

```
<complexType name="CultureInfo">
  <sequence minOccurs="0" maxOccurs="2">
    <element name="Name" type="string"/>
    <element name="Lcid" type="int"/>
  </sequence>
</complexType>
```

Mapping to Java

Unlike single instance sequences, XML Schema sequences that can occur multiple times are mapped to a Java class with a single member variable. This single member variable is a `List<T>` object that holds all of the data for the multiple occurrences of the sequence. For example, if the sequence defined in Example 157 occurred two times, then the list would have four items.

The name of the Java class' member variable is derived by concatenating the names of the member elements. The element names are separated by `And` and the first letter of the variable name is converted to lower case. For example, the member variable generated from Example 157 is named `nameAndLcid`.

The type of object stored in the list depends on the relationship between the types of the member elements. For example:

- If the member elements are of the same type the generated list will contain `JAXBElement<T>` objects. The base type of the `JAXBElement<T>` objects is determined by the normal mapping of the member elements' type.
- If the member elements are of different types and their Java representations implement a common interface, the list will contains objects of the common interface.
- If the member elements are of different types and their Java representations extend a common base class, the list will contain objects of the common base class.
- If none of the other conditions are met, the list will contain `Object` objects.

The generated Java class only has a getter method for the member variable. The getter method returns a reference to the live list. Any modifications made to the returned list effects the actual object.

The Java class is decorated with the `@XmlType` annotation. The annotation's name property is set to the value of the `name` attribute from the parent element of the XML Schema definition.

The annotation's propOrder property contains the single member variable representing the elements in the sequence.

The member variable representing the elements in the sequence are decorated with the `@XmlElements` annotation. The `@XmlElements` annotation contains a comma separated list of `@XmlElement` annotations. The list has one `@XmlElement` annotation for each member element defined in the XML Schema definition of the type. The `@XmlElement` annotations in the list have their name property set to the value of the XML Schema `element` element's `name` attribute and their type property set to the Java class resulting from the mapping of the XML Schema `element` element's type.

Example 158 shows the Java mapping for the XML Schema sequence defined in Example 157.

Example 158. Java Representation of Sequence with an Occurrence Constraint

```
@XmlType(name = "CultureInfo", propOrder = {
    "nameAndLcid"
})
public class CultureInfo {

    @XmlElements({
        @XmlElement(name = "Name", type = String.class),
        @XmlElement(name = "Lcid", type = Integer.class)
    })
    protected List<Serializable> nameAndLcid;

    public List<Serializable> getNameAndLcid() {
        if (nameAndLcid == null) {
            nameAndLcid = new ArrayList<Serializable>();
        }
        return this.nameAndLcid;
    }

}
```

minOccurs set to 0

If only the `minOccurs` element is specified and its value is `0`, the code generators generate the Java class as if the `minOccurs` attribute is not set.

Using Model Groups

XML Schema model groups are convenient shortcuts that allows you to reference a group of elements from a user-defined complex type.For example, you can define a group of elements that are common to several types in your application and then reference the group repeatedly. Model groups are defined using the `group` element, and are similar to complex type definitions. The mapping of model groups to Java is also similar to the mapping for complex types.

Defining a model group in XML Schema

You define a model group in XML Schema using the `group` element with the `name` attribute. The value of the `name` attribute is a string that is used to refer to the group throughout the schema. The `group` element, like the `complexType` element, can have the `sequence` element, the `all` element, or the `choice` element as its immediate child.

Inside the child element, you define the members of the group using `element` elements. For each member of the group, specify one `element` element. Group members can use any of the standard attributes for the `element` element including `minOccurs` and `maxOccurs`. So, if your group has three elements and one of them can occur up to three times, you define a group with three `element` elements, one of which uses maxOccurs="3".

Example 159 shows a model group with three elements.

Example 159. XML Schema Model Group

```
<group name="passenger">
  <sequence>
    <element name="name" type="xsd:string" />
    <element name="clubNum" type="xsd:long" />
    <element name="seatPref" type="xsd:string"
             maxOccurs="3" />
  </sequence>
</group>
```

Using a model group in a type definition

Once a model group has been defined, it can be used as part of a complex type definition. To use a model group in a complex type definition, use the `group` element with the `ref` attribute. The value of the `ref` attribute is the name given to the group when it was defined. For example, to use the group defined in Example 159 you use <group ref="tns:passenger" /> as shown in Example 160.

Example 160. Complex Type with a Model Group

```
<complexType name="reservation">
  <sequence>
    <group ref="tns:passenger" />
    <element name="origin" type="xsd:string" />
    <element name="destination" type="xsd:string" />
    <element name="fltNum" type="xsd:long" />
  </sequence>
</complexType>
```

When a model group is used in a type definition, the group becomes a member of the type. So an instance of reservation has four member elements. The first element is the `passenger` element and it contains the member elements defined by the group shown in Example 159. An example of an instance of reservation is shown in Example 161.

Example 161. Instance of a Type with a Model Group

```
<reservation>
  <passenger>
    <name>A. Smart</name>
    <clubNum>99</clubNum>
    <seatPref>isle1</seatPref>
  </passenger>
  <origin>LAX</origin>
  <destination>FRA</destination>
  <fltNum>34567</fltNum>
</reservation>
```

Mapping to Java

By default, a model group is only mapped to Java artifacts when it is included in a complex type definition. When generating code for a complex type that includes a model group, Artix simply includes the member variables for the model group into the Java class generated for the type. The member variables representing the model group are annotated based on the definitions of the model group.

Example 162 shows the Java class generated for the complex type defined in Example 160.

Example 162. Type with a Group

```
@XmlType(name = "reservation", propOrder = {
    "name",
    "clubNum",
    "seatPref",
    "origin",
    "destination",
    "fltNum"
})
public class Reservation {
    @XmlElement(required = true)
    protected String name;
    protected long clubNum;
    @XmlElement(required = true)
    protected List<String> seatPref;
    @XmlElement(required = true)
    protected String origin;
    @XmlElement(required = true)
    protected String destination;
    protected long fltNum;

    public String getName() {
        return name;
    }

    public void setName(String value) {
        this.name = value;
    }

    public long getClubNum() {
        return clubNum;
    }

    public void setClubNum(long value) {
        this.clubNum = value;
    }

    public List<String> getSeatPref() {
        if (seatPref == null) {
            seatPref = new ArrayList<String>();
        }
        return this.seatPref;
    }

    public String getOrigin() {
        return origin;
    }

    public void setOrigin(String value) {
        this.origin = value;
    }

    public String getDestination() {
        return destination;
    }

    public void setDestination(String value) {
        this.destination = value;
    }

    public long getFltNum() {
        return fltNum;
    }

    public void setFltNum(long value) {
        this.fltNum = value;
    }
```

Multiple occurrences

You can specify that the model group appears more than once by setting the `group` element's `maxOccurs` attribute to a value greater than one. To allow for multiple occurrences of the model group Artix maps the model group to a `List<T>` object. The `List<T>` object is generated following the rules for the group's first child:

- If the group is defined using a `sequence` element see Occurrence Constraints on Sequences.
- If the group is defined using a `choice` element see Occurrence Constraints on the Choice Element.

Using Wild Card Types

There are instances when a schema author wants to defer binding elements or attributes to a defined type. For these cases, XML Schema provides three mechanisms for specifying wild card place holders. These are all mapped to Java in ways that preserve their XML Schema functionality.

Using Any Elements

The XML Schema `any` element is used to create a wild card place holder in complex type definitions. When an XML element is instantiated for an XML Schema `any` element, it can be any valid XML element. The `any` element does not place any restrictions on either the content or the name of the instantiated XML element.

For example, given the complex type defined in Example 163 you can instantiate either of the XML elements shown in Example 164.

Example 163. XML Schema Type Defined with an Any Element

```
<element name="FlyBoy">
  <complexType>
    <sequence>
      <any />
      <element name="rank" type="xsd:int" />
      </sequence>
  </complexType>
</element>
```

Example 164. XML Document with an Any Element

```
<FlyBoy>
  <learJet>CL-215</learJet>
  <rank>2</rank>
</element>
<FlyBoy>
  <viper>Mark II</viper>
  <rank>1</rank>
</element>
```

XML Schema `any` elements are mapped to either a Java `Object` object or a Java `org.w3c.dom.Element` object.

Specifying in XML Schema

The `any` element can be used when defining sequence complex types and choice complex types. In most cases, the `any` element is an empty element. It can, however, take an `annotation` element as a child.

Table 20 describes the `any` element's attributes.

Table 20. Attributes of the XML Schema Any Element

Attribute	Description

`namespace`	Specifies the namespace of the elements that can be used to instantiate the element in an XML document. The valid values are:
	`##any`
	Specifies that elements from any namespace can be used. This is the default.
	`##other`
	Specifies that elements from any namespace *other than the parent element's namespace* can be used.
	`##local`
	Specifies elements without a namespace must be used.
	`##targetNamespace`
	Specifies that elements from the parent element's namespace must be used.
	A space delimited list of URIs, `##local`, and `##targetNamespace`
	Specifies that elements from any of the listed namespaces can be used.

`maxOccurs`	Specifies the maximum number of times an instance of the element can appear in the parent element. The default value is `1`. To specify that an instance of the element can appear an unlimited number of times, you can set the attribute's value to `unbounded`.
`minOccurs`	Specifies the minimum number of times an instance of the element can appear in the parent element. The default value is `1`.
`processContents`	Specifies how the element used to instantiate the any element should be validated. Valid values are: strict Specifies that the element must be validated against the proper schema. This is the default value. lax Specifies that the element should be validated against the proper schema. If it cannot be validated, no errors are thrown. skip Specifies that the element should not be validated.

Example 165 shows a complex type defined with an `any` element

Example 165. Complex Type Defined with an Any Element

```
<complexType name="surprisePackage">
  <sequence>
    <any processContents="lax" />
    <element name="to" type="xsd:string" />
    <element name="from" type="xsd:string" />
  </sequence>
</complexType>
```

Mapping to Java

XML Schema `any` elements result in the creation of a Java property named `any`. The property has associated getter and setter methods. The type of the resulting property depends on the value of the element's `processContents` attribute. If the `any` element's `processContents` attribute is set to `skip`, the element is mapped to a `org.w3c.dom.Element` object. For all other values of the `processContents` attribute an `any` element is mapped to a Java `Object` object.

The generated property is decorated with the `@XmlAnyElement` annotation. This annotation has an optional lax property that instructs the runtime what to do when marshaling the data. Its default value is `false` which instructs the runtime to automatically marshal the data into a `org.w3c.dom.Element` object. Setting lax to `true` instructs the runtime to attempt to marshal the data into JAXB types. When the `any` element's `processContents` attribute is set to `skip`, the lax property is set to its default value. For all other values of the `processContents` attribute, lax is set to `true`.

Example 166 shows how the complex type defined in Example 165 is mapped to a Java class.

Example 166. Java Class with an Any Element

```
public class SurprisePackage {

    @XmlAnyElement(lax = true)
    protected Object any;
    @XmlElement(required = true)
    protected String to;
    @XmlElement(required = true)
    protected String from;

    public Object getAny() {
        return any;
    }

    public void setAny(Object value) {
        this.any = value;
    }

    public String getTo() {
        return to;
    }

    public void setTo(String value) {
        this.to = value;
    }

    public String getFrom() {
        return from;
    }

    public void setFrom(String value) {
        this.from = value;
    }
}
```

Marshaling

If the Java property for an `any` element has its lax set to `false`, or the property is not specified, the runtime makes no attempt to parse the XML data into JAXB objects. The data is always stored in a DOM `Element` object.

If the Java property for an `any` element has its lax set to `true`, the runtime attempts to marshal the XML data into the appropriate JAXB objects. The runtime attempts to identify the proper JAXB classes using the following procedure:

1. It checks the element tag of the XML element against the list of elements known to the runtime. If it finds a match, the runtime marshals the XML data into the proper JAXB class for the element.

2. It checks the XML element's `xsi:type` attribute. If it finds a match, the runtime marshals the XML element into the proper JAXB class for that type.

3. If it cannot find a match it marshals the XML data into a DOM `Element` object.

Usually an application's runtime knows about all of the types generated from the schema's included in its contract. This includes the types defined in the contract's `wsdl:types` element, any data types added to the contract through inclusion, and any types added to the contract through importing other schemas. You can also make the runtime aware of additional types using the `@XmlSeeAlso` annotation which is described in Adding Classes to the Runtime Marshaler.

Unmarshaling

If the Java property for an `any` element has its lax set to `false`, or the property is not specified, the runtime will only accept DOM `Element` objects. Attempting to use any other type of object will result in a marshaling error.

If the Java property for an `any` element has its lax set to `true`, the runtime uses its internal map between Java data types and the XML Schema constructs they represent to determine the XML structure to write to the wire. If the runtime knows the class and can map it to an XML Schema construct, it writes out the data and inserts an `xsi:type` attribute to identify the type of data the element contains.

If the runtime cannot map the Java object to a known XML Schema construct, it will throw a marshaling exception. You can add types to the runtime's map using the `@XmlSeeAlso` annotation which is described in Adding Classes to the Runtime Marshaler.

Using the XML Schema anyType Type

The XML Schema type xsd:anyType is the root type for all XML Schema types. All of the primitives are derivatives of this type, as are all user defined complex types. As a result, elements defined as being of xsd:anyType can contain data in the form of any of the XML Schema primitives as well as any complex type defined in a schema document.

In Java the closest matching type is the `Object` class. It is the class from which all other Java classes are sub-typed.

Using in XML Schema

You use the xsd:anyType type as you would any other XML Schema complex type. It can be used as the value of an `element` element's `type` element. It can also be used as the base type from which other types are defined.

Example 167 shows an example of a complex type that contains an element of type xsd:anyType.

Example 167. Complex Type with a Wild Card Element

```
<complexType name="wildStar">
  <sequence>
    <element name="name" type="xsd:string" />
    <element name="ship" type="xsd:anyType" />
  </sequence>
</complexType>
```

Mapping to Java

Elements that are of type xsd:anyType are mapped to `Object` objects.

Example 168 shows the mapping of Example 167 to a Java class.

Example 168. Java Representation of a Wild Card Element

```
public class WildStar {

    @XmlElement(required = true)
    protected String name;
    @XmlElement(required = true)
    protected Object ship;

    public String getName() {
        return name;
    }

    public void setName(String value) {
        this.name = value;
    }

    public Object getShip() {
        return ship;
    }

    public void setShip(Object value) {
        this.ship = value;
    }
}
```

This mapping allows you to place any data into the property representing the wild card element. The Artix runtime handles the marshaling and unmarshaling of the data into usable Java representation.

Marshaling

When Artix marshals XML data into Java types, it attempts to marshal anyType elements into known JAXB objects. To determine if it is possible to marshal an anyType element into a JAXB generated object, the runtime inspects the element's `xsi:type` attribute to determine the actual type used to construct the data in the element. If the `xsi:type` attribute is not present, the runtime attempts to identify the element's actual data type by introspection. If the element's actual data type is determined to be one of the types known by the application's JAXB context, the element is marshaled into a JAXB object of the proper type.

If the runtime cannot determine the actual data type of the element, or the actual data type of the element is not a known type, the runtime marshals the content into a `org.w3c.dom.Element` object. You will then need to work with the element's content using the DOM APIs.

An application's runtime usually knows about all of the types generated from the schema's included in its contract. This includes the types defined in the contract's `wsdl:types` element, any data types added to the contract through inclusion, and any types added to the contract through importing other schema documents. You can also make the runtime aware of additional types using the `@XmlSeeAlso` annotation which is described in Adding Classes to the Runtime Marshaler.

Unmarshaling

When Artix unmarshals Java types into XML data, it uses an internal map between Java data types and the XML Schema constructs they represent to determine the XML structure to write to the wire. If the runtime knows the class and can map the class to an XML Schema construct, it writes out the data and inserts an `xsi:type` attribute to identify the type of data the element contains. If the data is stored in a `org.w3c.dom.Element` object, the runtime writes the XML structure represented by the object but it does not include an `xsi:type` attribute.

If the runtime cannot map the Java object to a known XML Schema construct, it throws a marshaling exception. You can add types to the runtime's map using the `@XmlSeeAlso` annotation which is described in Adding Classes to the Runtime Marshaler.

Using Unbound Attributes

XML Schema has a mechanism that allows you to leave a place holder for an arbitrary attribute in a complex type definition. Using this mechanism, you can define a complex type that can have any attribute. For example, you can create a type that defines the elements <robot name="epsilon" />, <robot age="10000" />, or <robot type="weevil" /> without specifying the three attributes. This can be particularly useful when flexibility in your data is required.

Defining in XML Schema

Undeclared attributes are defined in XML Schema using the `anyAttribute` element. It can be used wherever an attribute element can be used. The `anyAttribute` element has no attributes, as shown in Example 169.

Example 169. Complex Type with an Undeclared Attribute

```
<complexType name="arbitter">
  <sequence>
    <element name="name" type="xsd:string" />
    <element name="rate" type="xsd:float" />
  </sequence>
  <anyAttribute />
</complexType>
```

The defined type, arbitter, has two elements and can have one attribute of any type. The three elements shown in Example 170 can all be generated from the complex type arbitter.

Example 170. Examples of Elements Defined with a Wild Card Attribute

```
<officer rank="12"><name>...</name><rate>...</rate></officer>
<lawyer type="divorce"><name>...</name><rate>...</rate></law yer>
<judge><name>...</name><rate>...</rate></judge>
```

Mapping to Java

When a complex type containing an `anyAttribute` element is mapped to Java, the code generator adds a member called `otherAttributes` to the generated class. `otherAttributes` is of type `java.util.Map<QName, String>` and it has a getter method that returns a live instance of the map. Because the map returned from the getter is live, any modifications to the map are automatically applied. Example 171 shows the class generated for the complex type defined in Example 169.

Example 171. Class for a Complex Type with an Undeclared Attribute

```
public class Arbitter {

    @XmlElement(required = true)
    protected String name;
    protected float rate;

    @XmlAnyAttribute
    private Map<QName, String> otherAttributes = new HashMap<QName, String>();

    public String getName() {
        return name;
    }

    public void setName(String value) {
        this.name = value;
    }

    public float getRate() {
        return rate;
    }

    public void setRate(float value) {
        this.rate = value;
    }

    public Map<QName, String> getOtherAttributes() {
        return otherAttributes;
    }

}
```

Working with undeclared attributes

The `otherAttributes` member of the generated class expects to be populated with a `Map` object. The map is keyed using `QNames`. Once you get the map, you can access any attributes set on the object and set new attributes on the object.

Example 172 shows sample code for working with undeclared attributes.

Example 172. Working with Undeclared Attributes

```
Arbitter judge = new Arbitter();
Map<QName, String> otherAtts = judge.getOtherAttributes(); ❶

QName at1 = new QName("test.apache.org", "house"); ❷
QName at2 = new QName("test.apache.org", "veteran");

otherAtts.put(at1, "Cape"); ❸
otherAtts.put(at2, "false");

String vetStatus = otherAtts.get(at2); ❹
```

The code in Example 172 does the following:

❶ Gets the map containing the undeclared attributes.

❷ Creates QNames to work with the attributes.

❸ Sets the values for the attributes into the map.

❷ Retrieves the value for one of the attributes.

Element Substitution

XML Schema substitution groups allow you to define a group of elements that can replace a top level, or head, element. This is useful in cases where you have multiple elements that share a common base type or with elements that need to be interchangeable.

Substitution Groups in XML Schema

A substitution group is a feature of XML schema that allows you to specify elements that can replace another element in documents generated from that schema. The replaceable element is called the head element and must be defined in the schema's global scope. The elements of the substitution group must be of the same type as the head element or a type that is derived from the head element's type.

In essence, a substitution group allows you to build a collection of elements that can be specified using a generic element. For example, if you are building an ordering system for a company that sells three types of widgets you might define a generic widget element that contains a set of common data for all three widget types. Then you can define a substitution group that contains a more specific set of data for each type of widget. In your contract you can then specify the generic widget element as a message part instead of defining a specific ordering operation for each type of widget. When the actual message is built, the message can contain any of the elements of the substitution group.

Syntax

Substitution groups are defined using the `substitutionGroup` attribute of the XML Schema `element` element. The value of the `substitutionGroup` attribute is the name of the element that the element being defined replaces. For example, if your head element is `widget`, adding the attribute substitutionGroup="widget" to an element named `woodWidget` specifies that anywhere a `widget` element is used, you can substitute a `woodWidget` element. This is shown in Example 173.

Example 173. Using a Substitution Group

```
<element name="widget" type="xsd:string" />
<element name="woodWidget" type="xsd:string"
         substitutionGroup="widget" />
```

Type restrictions

The elements of a substitution group must be of the same type as the head element or of a type derived from the head element's type. For example, if the head element is of type

xsd:int all members of the substitution group must be of type xsd:int or of a type derived from xsd:int. You can also define a substitution group similar to the one shown in Example 174 where the elements of the substitution group are of types derived from the head element's type.

Example 174. Substitution Group with Complex Types

```
<complexType name="widgetType">
  <sequence>
    <element name="shape" type="xsd:string" />
    <element name="color" type="xsd:string" />
  </sequence>
</complexType>
<complexType name="woodWidgetType">
  <complexContent>
    <extension base="widgetType">
      <sequence>
        <element name="woodType" type="xsd:string" />
      </sequence>
</extension>
</complexContent>
</complexType>
<complexType name="plasticWidgetType">
  <complexContent>
    <extension base="widgetType">
<sequence>
        <element name="moldProcess" type="xsd:string" />
</sequence>
</extension>
</complexContent>
</complexType>
<element name="widget" type="widgetType" />
<element name="woodWidget" type="woodWidgetType"
         substitutionGroup="widget" />
<element name="plasticWidget" type="plasticWidgetType"
         substitutionGroup="widget" />
<complexType name="partType">
  <sequence>
    <element ref="widget" />
  </sequence>
</complexType>
<element name="part" type="partType" />
```

The head element of the substitution group, `widget`, is defined as being of type widgetType. Each element of the substitution group extends widgetType to include data that is specific to ordering that type of widget.

Based on the schema in Example 174, the `part` elements in Example 175 are valid.

Example 175. XML Document using a Substitution Group

```
<part>
  <widget>
    <shape>round</shape>
    <color>blue</color>
  </widget>
</part>
<part>
  <plasticWidget>
    <shape>round</shape>
    <color>blue</color>
    <moldProcess>sandCast</moldProcess>
  </plasticWidget>
</part>
<part>
  <woodWidget>
    <shape>round</shape>
    <color>blue</color>
    <woodType>elm</woodType>
  </woodWidget>
</part>
```

Abstract head elements

You can define an abstract head element that can never appear in a document produced using your schema. Abstract head elements are similar to abstract classes in Java because they are used as the basis for defining more specific implementations of a generic class. Abstract heads also prevent the use of the generic element in the final product.

You declare an abstract head element by setting the `abstract` attribute of an `element` element to `true`, as shown in Example 176. Using this schema, a valid `review` element can contain either a `positiveComment` element or a `negativeComment` element, but cannot contain a `comment` element.

Example 176. Abstract Head Definition

```
<element name="comment" type="xsd:string" abstract="true" />
<element name="positiveComment" type="xsd:string"
         substitutionGroup="comment" />
<element name="negtiveComment" type="xsd:string"
         substitutionGroup="comment" />
<element name="review">
  <complexContent>
    <all>
      <element name="custName" type="xsd:string" />
      <element name="impression" ref="comment" />
    </all>
  </complexContent>
</element>
```

Substitution Groups in Java

Artix, as specified in the JAXB specification, supports substitution groups using Java's native class hierarchy in combination with the ability of the `JAXBElement` class's support for wildcard definitions. Because the members of a substitution group must all share a common base type, the classes generated to support

the elements' types also share a common base type. In addition, Artix maps instances of the head element to `JAXBElement<? extends T>` properties.

Generated object factory methods The object factory generated to support a package containing a substitution

group has methods for each of the elements in the substitution group. For each of the members of the substitution group, except for the head element, the `@XmlElementDecl` annotation decorating the object factory method includes two additional properties, as described in Table 21.

Table 21. Properties for Declaring a JAXB Element is a Member of a Substitution Group

Property	Description
substitutionHeadNamespace	Specifies the namespace where the head element is defined.
substitutionHeadName	Specifies the value of the head element's name attribute.

The object factory method for the head element of the substitution group's `@XmlElementDecl` contains only the default namespace property and the default name property.

In addition to the element instantiation methods, the object factory contains a method for instantiating an object representing the head element. If the members of the substitution group are all of complex types, the object factory also contains methods for instantiating instances of each complex type used.

Example 177 shows the object factory method for the substitution group defined in Example 174.

Example 177. Object Factory Method for a Substitution Group

```
public class ObjectFactory {

    private final static QName _Widget_QNAME = new QName(...);
    private final static QName _PlasticWidget_QNAME = new QName(...);
    private final static QName _WoodWidget_QNAME = new QName(...);
    public ObjectFactory() {
    }

    public WidgetType createWidgetType() { return new WidgetType();
    }

    public PlasticWidgetType createPlasticWidgetType() {
       return new PlasticWidgetType();
    }

    public WoodWidgetType createWoodWidgetType() {
       return new WoodWidgetType();
    }

    @XmlElementDecl(namespace="...", name = "widget")
    public JAXBElement<WidgetType> createWidget(WidgetType value) {
        return new JAXBElement<WidgetType>(_Widget_QNAME,
        WidgetType.class, null, value);
    }

    @XmlElementDecl(namespace = "...", name = "plasticWidget",
 substitutionHeadNamespace = "...", substitutionHeadName = "widget")
    public JAXBElement<PlasticWidgetType>
        createPlasticWidget(PlasticWidgetType value) { return new
        JAXBElement<PlasticWidgetType>(_PlasticWidget_QNAME, PlasticWidget
Type.class, null, value);
    }

    @XmlElementDecl(namespace = "...", name = "woodWidget",
substitutionHeadNamespace = "...", substitutionHeadName = "widget")
    public JAXBElement<WoodWidgetType> createWoodWidget(WoodWidgetType
    value) {
        return new JAXBElement<WoodWidgetType>(_WoodWidget_QNAME,
WoodWidgetType.class, null, value);
    }

}
```

Substitution groups in interfaces

If the head element of a substitution group is used as a message part in one of an operation's messages, the resulting method parameter will be an object of the class generated to support that element. It will not necessarily be an instance of the `JAXBElement<? extends T>` class. The runtime relies on Java's native type hierarchy to support the type substitution, and Java will catch any attempts to use unsupported types.

To ensure that the runtime knows all of the classes needed to support the element substitution, the SEI is decorated with the `@XmlSeeAlso` annotation. This annotation specifies a list of classes required by the runtime for marshaling. Fore more

information on using the `@XmlSeeAlso` annotation see Adding Classes to the Runtime Marshaler.

Example 179 shows the SEI generated for the interface shown in Example 178. The interface uses the substitution group defined in Example 174.

Example 178. WSDL Interface Using a Substitution Group

```
<message name="widgetMessage">
    <part name="widgetPart" element="xsd1:widget" />
  </message>
  <message name="numWidgets">
    <part name="numInventory" type="xsd:int" />
  </message>
  <message name="badSize">
    <part name="numInventory" type="xsd:int" />
  </message>
  <portType name="orderWidgets">
    <operation name="placeWidgetOrder">
      <input message="tns:widgetOrder" name="order" />
      <output message="tns:widgetOrderBill" name="bill" />
      <fault message="tns:badSize" name="sizeFault" />
    </operation>
    <operation name="checkWidgets">
      <input message="tns:widgetMessage" name="request" />
      <output message="tns:numWidgets" name="response" />
    </operation>
  </portType>
```

Example 179. Generated Interface Using a Substitution Group

```
@WebService(targetNamespace = "...", name = "orderWidgets")
@XmlSeeAlso({com.widgetvendor.types.widgettypes.ObjectFactory.class})
public interface OrderWidgets {

    @SOAPBinding(parameterStyle = SOAPBinding.ParameterStyle.BARE)
    @WebResult(name = "numInventory", targetNamespace = "", partName = "numInventory")
    @WebMethod
    public int checkWidgets(
        @WebParam(partName = "widgetPart", name = "widget", targetNamespace = "...")
        com.widgetvendor.types.widgettypes.WidgetType widgetPart
    );
}
```

TIP: The SEI shown in Example 169 lists the object factory in the `@XmlSeeAlso` annotation. Listing the object factory for a namespace provides access to all of the generated classes for that namespace.

Substitution groups in complex types

When the head element of a substitution group is used as an element in a complex type, the code generator maps the element to a `JAXBElement<? extends T>` property. It does not map it to a property containing an instance of the generated class generated to support the substitution group.

For example, the complex type defined in Example 180 results in the Java class shown in Example 181. The complex type uses the substitution group defined in Example 174.

Example 180. Complex Type Using a Substitution Group

```
<complexType name="widgetOrderInfo">
  <sequence>
    <element name="amount" type="xsd:int"/>
    <element ref="xsd1:widget"/>
  </sequence>
</complexType>
```

Example 181. Java Class for a Complex Type Using a Substitution Group

```
@XmlAccessorType(XmlAccessType.FIELD)
@XmlType(name = "widgetOrderInfo", propOrder =
{"amount","widget",})
public class WidgetOrderInfo {

    protected int amount;
    @XmlElementRef(name = "widget", namespace = "...", type
= JAXBElement.class)
    protected JAXBElement<? extends WidgetType> widget;
    public int getAmount() { return amount;
    }

    public void setAmount(int value) {
        this.amount = value;
    }

    public JAXBElement<? extends WidgetType> getWidget() {
        return widget;
    }

    public void setWidget(JAXBElement<? extends WidgetType> value) {
        this.widget = ((JAXBElement<? extends WidgetType> ) value);
    }
}
```

Setting a substitution group property

How you work with a substitution group depends on whether the code generator mapped the group to a straight Java class or to a `JAXBElement<? extends T>` class. When the element is simply mapped to an object of the generated value class, you work with the object the same way you work with other Java objects that are part of a type hierarchy. You can substitute any of the subclasses for the parent class. You can inspect the object to determine its exact class, and cast it appropriately.

TIP: . The JAXB specification recommends that you use the object factory methods for instantiating objects of the generated classes.

When the code generators create a `JAXBElement<? extends T>` object to hold instances of a substitution group, you must wrap the element's value in a `JAXBElement<? extends T>` object. The best method to do this is to use the element creation methods provided by the object factory. They provide an easy means for creating an element based on its value.

Example 182 shows code for setting an instance of a substitution group.

Example 182. Setting a Member of a Substitution Group

```
ObjectFactory of = new ObjectFactory(); ❶
PlasticWidgetType pWidget = of.createPlasticWidgetType(); ❷
pWidget.setShape = "round';
pWidget.setColor = "green";
pWidget.setMoldProcess = "injection";

JAXBElement<PlasticWidgetType> widget = of.createPlasticWidget(pWidget); ❸
WidgetOrderInfo order = of.createWidgetOrderInfo(); ❹
order.setWidget(widget); ❺
```

The code in Example 182 does the following:

❶ Instantiates an object factory.

❷ Instantiates a `PlasticWidgetType` object.

❸ Instantiates a `JAXBElement<PlasticWidgetType>` object to hold a plastic widget element.

❹ Instantiates a `WidgetOrderInfo` object.

❺ Sets the `WidgetOrderInfo` object's widget to the `JAXBElement` object holding the plastic widget element.

Getting the value of a substitution group property

The object factory methods do not help when extracting the element's value from a `JAXBElement<? extends T>` object. You must to use the `JAXBElement<? extends T>` object's `getValue()` method. The following options determine the type of object returned by the `getValue()` method:

- Use the `isInstance()` method of all the possible classes to determine the class of the element's value object.
- Use the `JAXBElement<? extends T>` object's `getName()` method to determine the element's name.

  The `getName()` method returns a QName. Using the local name of the element, you can determine the proper class for the value object.
- Use the `JAXBElement<? extends T>` object's `getDeclaredType()` method to determine the class of the value object.
- The `getDeclaredType()` method returns the `Class` object of the element's value object.

WARNING: There is a possibility that the `getDeclaredType()` method will return the base class for the head element regardless of the actual class of the value object.

Example 183 shows code retrieving the value from a substitution group. To determine the proper class of the element's value object the example uses the element's `getName()` method.

Example 183. Getting the Value of a Member of the Substitution Group

```
String elementName = order.getWidget().getName().getLocalPart();
if (elementName.equals("woodWidget")
{
  WoodWidgetType widget=order.getWidget().getValue();
}
else if (elementName.equals("plasticWidget")
{
  PlasticWidgetType widget=order.getWidget().getValue();
}
else
{
  WidgetType widget=order.getWidget().getValue();
}
```

Widget Vendor Example

This section shows an example of substitution groups being used in Artix to solve a real world application. A service and consumer are developed using the widget substitution group defined in Example 174. The service offers two operations: `checkWidgets` and `placeWidgetOrder`.

Example 184 shows the interface for the ordering service.

Example 184. Widget Ordering Interface

```
<message name="widgetOrder">
  <part name="widgetOrderForm" type="xsd1:widgetOrderInfo"/>
</message>
<message name="widgetOrderBill">
  <part name="widgetOrderConformation" type="xsd1:widgetOrderBillInfo"/>
</message>
<message name="widgetMessage">
  <part name="widgetPart" element="xsd1:widget" />
</message>
<message name="numWidgets">
  <part name="numInventory" type="xsd:int" />
</message>
<portType name="orderWidgets">
  <operation name="placeWidgetOrder">
    <input message="tns:widgetOrder" name="order"/>
    <output message="tns:widgetOrderBill" name="bill"/>
  </operation>
  <operation name="checkWidgets">
    <input message="tns:widgetMessage" name="request" />
    <output message="tns:numWidgets" name="response" />
  </operation>
</portType>
```

Example 185 shows the generated Java SEI for the interface.

Example 185. Widget Ordering SEI

```
@WebService(targetNamespace = "http://widgetVendor.com/widgetOrderForm", name = "orderWid
gets")
@XmlSeeAlso({com.widgetvendor.types.widgettypes.ObjectFactory.class})
public interface OrderWidgets {

    @SOAPBinding(parameterStyle = SOAPBinding.ParameterStyle.BARE)
    @WebResult(name = "numInventory", targetNamespace = "", partName = "numInventory")
    @WebMethod
    public int checkWidgets(
        @WebParam(partName = "widgetPart", name = "widget", targetNamespace = "http://wid
getVendor.com/types/widgetTypes")
        com.widgetvendor.types.widgettypes.WidgetType widgetPart
    );

    @SOAPBinding(parameterStyle = SOAPBinding.ParameterStyle.BARE)
    @WebResult(name = "widgetOrderConformation", targetNamespace = "", partName = "widget
OrderConformation")
    @WebMethod
    public com.widgetvendor.types.widgettypes.WidgetOrderBillInfo placeWidgetOrder(
        @WebParam(partName = "widgetOrderForm", name = "widgetOrderForm", targetNamespace
= "")
        com.widgetvendor.types.widgettypes.WidgetOrderInfo widgetOrderForm
    ) throws BadSize;
}
```

NOTE: Because the example only demonstrates the use of substitution groups, some of the business logic is not shown.

The checkWidgets Operation

`checkWidgets` is a simple operation that has a parameter that is the head member of a substitution group. This operation demonstrates how to deal with individual parameters that are members of a substitution group. The consumer must ensure that the parameter is a valid member of the substitution group. The service must properly determine which member of the substitution group was sent in the request.

Consumer implementation

The generated method signature uses the Java class supporting the type of the substitution group's head element. Because the member elements of a substitution group are either of the same type as the head element or of a type derived from the head element's type, the Java classes generated to support the members of the substitution group inherit from the Java class generated to support the head element. Java's type hierarchy natively supports using subclasses in place of the parent class.

Because of how Artix generates the types for a substitution group and Java's type hierarchy, the client can invoke `checkWidgets()` without using any special code. When

developing the logic to invoke `checkWidgets()` you can pass in an object of one of the classes generated to support the widget substitution group.

Example 186 shows a consumer invoking `checkWidgets()`.

Example 186. Consumer Invoking checkWidgets()

```
System.out.println("What type of widgets do you want to order?");
System.out.println("1 - Normal");
System.out.println("2 - Wood");
System.out.println("3 - Plastic");
System.out.println("Selection [1-3]");
String selection = reader.readLine();
String trimmed = selection.trim();
char widgetType = trimmed.charAt(0);
switch (widgetType)
{
  case '1':
  {
    WidgetType widget = new WidgetType();
    ...
    break;
  }
  case '2':
  {
    WoodWidgetType widget = new WoodWidgetType();
    ...
    break;
  }
  case '3':
  {
    PlasticWidgetType widget = new PlasticWidgetType();
    ...
    break;
  }
  default :
    System.out.println("Invaid Widget Selection!!");
}

proxy.checkWidgets(widgets);
```

Service implementation

The service's implementation of `checkWidgets()` gets a widget description as a `WidgetType` object, checks the inventory of widgets, and returns the number of widgets in stock. Because all of the classes used to implement the substitution group inherit from the same base class, you can implement `checkWidgets()` without using any JAXB specific APIs.

All of the classes generated to support the members of the substitution group for `widget` extend the `WidgetType` class. Because of this fact, you can use `instanceof` to determine what type of widget was passed in and simply cast the `widgetPart` object into the more restrictive type if appropriate. Once you have the proper type of object, you can check the inventory of the right kind of widget.

Example 187 shows a possible implementation.

Example 187. Service Implementation of checkWidgets()

```
public int checkWidgets(WidgetType widgetPart)
{
  if (widgetPart instanceof WidgetType)
  {
                 return checkWidgetInventory(widgetType);
  }
  else if (widgetPart instanceof WoodWidgetType)
  {
    WoodWidgetType widget = (WoodWidgetType)widgetPart;
    return checkWoodWidgetInventory(widget);
  }
  else if (widgetPart instanceof PlasticWidgetType)
  {
    PlasticWidgetType widget = (PlasticWidgetType)widgetPart;
    return checkPlasticWidgetInventory(widget);
  }
}
```

The placeWidgetOrder Operation

`placeWidgetOrder` uses two complex types containing the substitution group. This operation demonstrates to use such a structure in a Java implementation. Both the consumer and the service must get and set members of a substitution group.

Consumer implementation

To invoke `placeWidgetOrder()` the consumer must construct a widget order containing one element of the widget substitution group. When adding the widget to the order, the consumer should use the object factory methods generated for each element of the substitution group. This ensures that the runtime and the service can correctly process the order. For example, if an order is being placed for a plastic widget, the `ObjectFactory.createPlasticWidget()` method is used to create the element before adding it to the order.

Example 188 shows consumer code for setting the widget property of the `WidgetOrderInfo` object.

Example 188. Setting a Substitution Group Member

```
ObjectFactory of = new ObjectFactory();

WidgetOrderInfo order = new of.createWidgetOrderInfo();
...
System.out.println();
System.out.println("What color widgets do you want to order?");
String color = reader.readLine();
System.out.println();
System.out.println("What shape widgets do you want to order?");
String shape = reader.readLine();
System.out.println();
System.out.println("What type of widgets do you want to order?");
System.out.println("1 - Normal");
System.out.println("2 - Wood");
System.out.println("3 - Plastic");
System.out.println("Selection [1-3]");
String selection = reader.readLine();
```

```
String trimmed = selection.trim();
char widgetType = trimmed.charAt(0);
switch (widgetType)
{
  case '1':
  {
    WidgetType widget = of.createWidgetType();
    widget.setColor(color);
    widget.setShape(shape);
    JAXB<WidgetType> widgetElement = of.createWidget(widget);
    order.setWidget(widgetElement);
    break;
  }
  case '2':
  {
    WoodWidgetType woodWidget = of.createWoodWidgetType();
    woodWidget.setColor(color); woodWidget.setShape(shape);
    System.out.println();
    System.out.println("What type of wood are your widgets?");
    String wood = reader.readLine(); woodWidget.setWoodType(wood);
    JAXB<WoodWidgetType> widgetElement = of.createWoodWidget(woodWidget);
    order.setWoodWidget(widgetElement);
    break;
  }
  case '3':
  {
    PlasticWidgetType plasticWidget = of.createPlasticWidgetType();
    plasticWidget.setColor(color);
    plasticWidget.setShape(shape);
    System.out.println();
    System.out.println("What type of mold to use for your widgets?");
    String mold = reader.readLine(); plasticWidget.setMoldProcess(mold);
    JAXB<WidgetType> widgetElement =
    of.createPlasticWidget(plasticWidget);
    order.setPlasticWidget(widgetElement);
    break;
  }
  default :
    System.out.println("Invaid Widget Selection!!");
    }
```

Service implementation

The `placeWidgetOrder()` method receives an order in the form of a `WidgetOrderInfo` object, processes the order, and returns a bill to the consumer in the form of a `WidgetOrderBillInfo` object. The orders can be for a plain widget, a plastic widget, or a wooden widget. The type of widget ordered is determined by what type of object is stored in `widgetOrderForm` object's widget property. The widget property is a substitution group and can contain a `widget` element, a `woodWidget` element, or a `plasticWidget` element.

The implementation must determine which of the possible elements is stored in the order. This can be accomplished using the `JAXBElement<? extends T>` object's `getName()` method to determine the element's QName. The QName can then be used to determine which element in the substitution group is in the order. Once the element included in the bill is known, you can extract its value into the proper type of object.

Example 189 shows a possible implementation.

Example 189. Implementation of placeWidgetOrder()

```
public com.widgetvendor.types.widgettypes.WidgetOrderBillInfo placeWidgetOrder(WidgetOrderInfo
 widgetOrderForm)
{
  ObjectFactory of = new ObjectFactory(); ❶

  WidgetOrderBillInfo bill = new WidgetOrderBillInfo() ❷

   // Copy the shipping address and the number of widgets
   // ordered from widgetOrderForm to bill
   ...

  int numOrdered = widgetOrderForm.getAmount(); ❸

  String elementName = widgetOrderForm.getWidget().getName().getLocalPart(); ❹
  if (elementName.equals("woodWidget") ❺
  {
    WoodWidgetType widget=order.getWidget().getValue(); ❻
    buildWoodWidget(widget, numOrdered);

    // Add the widget info to bill
    JAXBElement<WoodWidgetType> widgetElement = of.createWoodWidget(widget); ❼
    bill.setWidget(widgetElement); ❽

    float amtDue = numOrdered * 0.75; bill.setAmountDue(amtDue); ❾
  }
  else if (elementName.equals("plasticWidget")
  {
    PlasticWidgetType widget=order.getWidget().getValue();
    buildPlasticWidget(widget, numOrdered);

    // Add the widget info to bill
    JAXBElement<PlasticWidgetType> widgetElement =
    of.createPlasticWidget(widget); bill.setWidget(widgetElement);

    float amtDue = numOrdered * 0.90;
    bill.setAmountDue(amtDue);
  }
  else
  {
    WidgetType widget=order.getWidget().getValue();
    buildWidget(widget, numOrdered);

    // Add the widget info to bill
    JAXBElement<WidgetType> widgetElement =
    of.createWidget(widget); bill.setWidget(widgetElement);

    float amtDue = numOrdered * 0.30;
    bill.setAmountDue(amtDue);
  }

  return(bill);
}
```

The code in Example 189 does the following:

❶ Instantiates an object factory to create elements.

❷ Instantiates a `WidgetOrderBillInfo` object to hold the bill.

❸ Gets the number of widgets ordered.

❹ Gets the local name of the element stored in the order.

❺ Checks to see if the element is a `woodWidget` element.

❻ Extracts the value of the element from the order to the proper type of object.

❼ Creates a `JAXBElement<T>` object placed into the bill.

❽ Sets the bill object's widget property.

❾ Sets the bill object's amountDue property.

Customizing How Types are Generated

The JAXB default mappings cover most uses of XML Schema used when using service-oriented design to create Java applications. For instances where the default mappings are insufficient, JAXB provides an extensive customization mechanism.

IMPORTANT: JAXB customizations are ignored if you are using the **wsdlgen** tool.

Basics of Customizing Type Mappings

The JAXB specification defines a number of XML elements that customize how Java types are mapped to XML Schema constructs. These elements can be specified in-line with XML Schema constructs. If you cannot, or do not want to, modify the XML Schema definitions, you can specify the customizations in external binding document.

Namespace

The elements used to customize the JAXB data bindings are defined in the namespace http://java.sun.com/xml/ns/jaxb. You must add a namespace declaration similar to the one shown in Example 190. This is added to the root element of all XML documents defining JAXB customizations.

Example 190. JAXB Customization Namespace

```
xmlns:jaxb="http://java.sun.com/xml/ns/jaxb"
```

Version declaration

When using the JAXB customizations, you must indicate the JAXB version being used. This is done by adding a `jaxb:version` attribute to the root element of the external binding declaration. If you are using in-line customization, you must include the `jaxb:version` attribute in the `schema` element containing the customizations. The value of the attribute is always `2.0`.

Example 191 shows an example of the `jaxb:version` attribute used in a `schema` element.

Example 191. Specifying the JAXB Customization Version

```
< schema ...
        jaxb:version="2.0">
```

Using in-line customization

The most direct way to customize how the code generators map XML Schema constructs to Java constructs is to add the customization elements directly to the XML Schema definitions. The JAXB customization elements are placed inside the `xsd:appinfo` element of the XML schema construct that is being modified.

Example 192 shows an example of a schema containing an in-line JAXB customization.

Example 192. Customized XML Schema

```
<schema targetNamespace="http://widget.com/types/widgetTypes"
        xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:jaxb="http://java.sun.com/xml/ns/jaxb"
        jaxb:version="2.0">
  <complexType name="size">
    <annotation>
      <appinfo>
        <jaxb:class name="widgetSize" />
       </appinfo>
   </annotation>
    <sequence>
      <element name="longSize" type="xsd:string" />
      <element name="numberSize" type="xsd:int" />
    </sequence>
  </complexType>
<schema>
```

Using an external binding declaration

When you cannot, or do not want to, make changes to the XML Schema document that defines your type, you can specify the customizations using an external binding declaration. An external binding declaration consists of a number of nested `jaxb:bindings` elements. Example 193 shows the syntax of an external binding declaration.

Example 193. JAXB External Binding Declaration Syntax

```
<jaxb:bindings xmlns:jaxb="http://java.sun.com/xml/ns/jaxb"
               xmlns:xsd="http://www.w3.org/2001/XMLSchema"
               jaxb:version="2.0">
  <jaxb:bindings [schemaLocation="schemaUri" | wsdlLocation="wsdlUri">
    <jaxb:bindings node="nodeXPath"> binding declaration
    </jaxb:bindings>
    ...
  </jaxb:bindings>
<jaxb:bindings>
```

The `schemaLocation` attribute and the `wsdlLocation` attribute are used to identify the schema document to which the modifications are applied. Use the `schemaLocation` attribute if you are generating code from a schema document. Use the `wsdlLocation` attribute if you are generating code from a WSDL document.

The `node` attribute is used to identify the specific XML schema construct that is to be modified. It is an XPath statement that resolves to an XML Schema element.

Given the schema document `widgetSchema.xsd`, shown in Example 194, the external binding declaration shown in Example 195 modifies the generation of the complex type size.

Example 194. XML Schema File

```
<schema targetNamespace="http://widget.com/types/widgetTypes"
        xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
        version="1.0">
  <complexType name="size">
    <sequence>
      <element name="longSize" type="xsd:string" />
      <element name="numberSize" type="xsd:int" />
    </sequence>
  </complexType>
<schema>
```

Example 195. External Binding Declaration

```
<jaxb:bindings xmlns:jaxb="http://java.sun.com/xml/ns/jaxb"
               xmlns:xsd="http://www.w3.org/2001/XMLSchema"
               jaxb:version="2.0">
  <jaxb:bindings schemaLocation="wsdlSchema.xsd">
    <jaxb:bindings node="xsd:complexType[@name='size']">
        <jaxb:class name="widgetSize" />
    </jaxb:bindings>
  </jaxb:bindings>
<jaxb:bindings>
```

To instruct the code generators to use the external binging declaration use the wsdl2java tool's `-b` *`binding-file`* option, as shown below:

```
wsdl2java -b widgetBinding.xml widget.wsdl
```

Specifying the Java Class of an XML Schema Primitive

By default, XML Schema types are mapped to Java primitive types. While this is the most logical mapping between XML Schema and Java, it does not always meet the requirements of the application developer. You might want to map an XML Schema primitive type to a Java class that can hold extra information, or you might want to map an XML primitive type to a class that allows for simple type substitution.

The JAXB `javaType` customization element allows you to customize the mapping between an XML Schema primitive type and a Java primitive type. It can be used to customize the mappings at both the global level and the individual instance level. You can use the `javaType` element as part of a simple type definition or as part of a complex type definition.

When using the `javaType` customization element you must specify methods for converting the XML representation of the primitive type to and from the target Java class. Some mappings have default conversion methods. For instances where there are no default mappings, Artix provides JAXB methods to ease the development of the required methods.

Syntax

The `javaType` customization element takes four attributes, as described in Table 22.

Table 22. Attributes for Customizing the Generation of a Java Class for an XML Schema Type

Attribute	Required	Description
`name`	Yes	Specifies the name of the Java class to which the XML Schema primitive type is mapped. It must be either a valid Java class name or the name of a Java primitive type. You must ensure that this class exists and is accessible to your application. The code generator does not check for this class.
`xmlType`	No	Specifies the XML Schema primitive type that is being customized. This attribute is only used when the javaType element is used as a child of the globalBindings element.
`parseMethod`	No	Specifies the method responsible for parsing the string-based XML representation of the data into an instance of the Java class. For more information see Specifying the converters.
`printMethod`	No	Specifies the method responsible for converting a Java object to the string-based XML representation of the data. For more information see Specifying the converters.

The `javaType` customization element can be used in three ways:

- To modify all instances of an XML Schema primitive type — The `javaType` element modifies all instances of an XML Schema type in the schema document when it is used as a child of the `globalBindings` customization element. When it is used in this manner, you must specify a value for the `xmlType` attribute that identifies the XML Schema primitive type being modified.

  Example 196 shows an in-line global customization that instructs the code generators to use `java.lang.Integer` for all instances of xsd:short in the schema.

Example 196. Global Primitive Type Customization

```
<schema targetNamespace="http://widget.com/types/widgetTypes"
        xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
        xmlns:jaxb="http://java.sun.com/xml/ns/jaxb" jaxb:version="2.0">
  <annotation>
    <appinfo>
      <jaxb:globalBindings ...>
        <jaxb:javaType name="java.lang.Integer"
                       xmlType="xsd:short" />
      </globalBindings
    </appinfo>
  </annotation>
  ...
</schema>
```

- To modify a simple type definition — The `javaType` element modifies the class generated for all instances of an XML simple type when it is applied to a named simple type definition. When using the `javaType` element to modify a simple type definition, do not use the `xmlType` attribute.

  Example 197 shows an external binding file that modifies the generation of a simple type named zipCode.

Example 197. Binding File for Customizing a Simple Type

```
<jaxb:bindings xmlns:jaxb="http://java.sun.com/xml/ns/jaxb"
               xmlns:xsd="http://www.w3.org/2001/XMLSchema"
               jaxb:version="2.0">
  <jaxb:bindings wsdlLocation="widgets.wsdl">
    <jaxb:bindings node="xsd:simpleType[@name='zipCode']">
        <jaxb:javaType name="com.widgetVendor.widgetTypes.zipCodeType"
           parseMethod="com.widgetVendor.widgetTypes.support.parseZipCode"
           printMethod="com.widgetVendor.widgetTypes.support.printZipCode" />
    </jaxb:bindings>
  </jaxb:bindings>
<jaxb:bindings>
```

- To modify an element or attribute of a complex type definition — The `javaType` can be applied to individual parts of a complex type definition by including it as part of a JAXB property customization. The `javaType` element is placed as a child to the property's `baseType` element. When using the `javaType` element to modify a specific part of a complex type definition, do not use the `xmlType` attribute.
- Example 198 shows a binding file that modifies an element of a complex type.

Example 198. Binding File for Customizing an Element in a Complex Type

```
<jaxb:bindings xmlns:jaxb="http://java.sun.com/xml/ns/jaxb"
               xmlns:xsd="http://www.w3.org/2001/XMLSchema"
               jaxb:version="2.0">
  <jaxb:bindings schemaLocation="enumMap.xsd">
    <jaxb:bindings node="xsd:ComplexType[@name='widgetOrderInfo']">
      <jaxb:bindings node="xsd:element[@name='cost']">
        <jaxb:property>
          <jaxb:baseType>
            <jaxb:javaType name="com.widgetVendor.widgetTypes.costType"
                           parseMethod="parseCost"
                           printMethod="printCost" >
          </jaxb:baseType>
        </jaxb:property>
      </jaxb:bindings>
    </jaxb:bindings>
  </jaxb:bindings>
<jaxb:bindings>
```

For more information on using the `baseType` element see Specifying the Base Type of an Element or an Attribute.

Specifying the converters

The Artix cannot convert XML Schema primitive types into random Java classes. When you use the `javaType` element to customize the mapping of an XML Schema primitive type, the code generator creates an adapter class that is used to marshal and unmarshal the customized XML Schema primitive type. A sample adapter class is shown in Example 199.

Example 199. JAXB Adapter Class

```
public class Adapter1 extends XmlAdapter<String, javaType>
{
  public javaType unmarshal(String value)
  {
    return(parseMethod(value));
  }

  public String marshal(javaType value)
  {
    return(printMethod(value));
  }
}
```

`parseMethod` and `printMethod` are replaced by the value of the corresponding `parseMethod` attribute and `printMethod` attribute. The values must identify valid Java methods. You can specify the method's name in one of two ways:

- A fully qualified Java method name in the form of `packagename.ClassName.methodName`
- A simple method name in the form of `methodName`

When you only provide a simple method name, the code generator assumes that the method exists in the class specified by the `javaType` element's `name` attribute.

IMPORTANT: The code generators **do not** generate parse or print methods. You are responsible for supplying them. For information on developing parse and print methods see Implementing converters.

If a value for the `parseMethod` attribute is not provided, the code generator assumes that the Java class specified by the `name` attribute has a constructor whose first parameter is a Java `String` object. The generated adapter's `unmarshal()` method uses the assumed constructor to populate the Java object with the XML data.

If a value for the `printMethod` attribute is not provided, the code generator assumes that the Java class specified by the `name` attribute has a `toString()` method. The generated adapter's `marshal()` method uses the assumed `toString()` method to convert the Java object to XML data.

If the `javaType` element's `name` attribute specifies a Java primitive type, or one of the Java primitive's wrapper types, the code generators use the default converters. For more information on default converters see Default primitive type converters.

What is generated

As mentioned in Specifying the converters, using the `javaType` customization element triggers the generation of one adapter class for each customization of an XML Schema primitive type. The adapters are named in sequence using the pattern `AdapterN`. If you specify two primitive type customizations, the code generators create two adapter classes: `Adapter1` and `Adapter2`.

The code generated for an XML schema construct depends on whether the effected XML Schema construct is a globally defined element or is defined as part of a complex type.

When the XML Schema construct is a globally defined element, the object factory method generated for the type is modified from the default method as follows:

- The method is decorated with an `@XmlJavaTypeAdapter` annotation.

  The annotation instructs the runtime which adapter class to use when processing instances of this element. The adapter class is specified as a class object.

- The default type is replaced by the class specified by the `javaType` element's `name` attribute.

Example 200 shows the object factory method for an element affected by the customization shown in Example 196.

Example 200. Customized Object Factory Method for a Global Element

```
@XmlElementDecl(namespace = "http://widgetVendor.com/types/wid
getTypes", name = "shorty")
   @XmlJavaTypeAdapter(org.w3._2001.xmlschema.Adapter1 .class)

    public JAXBElement<Integer> createShorty(Integer value)
{
        return new JAXBElement<Integer>(_Shorty_QNAME, In
teger.class, null, value);
    }
```

When the XML Schema construct is defined as part of a complex type, the generated Java property is modified as follows:

- The property is decorated with an `@XmlJavaTypeAdapter` annotation.

  The annotation instructs the runtime which adapter class to use when processing instances of this element. The adapter class is specified as a class object.

- The property's `@XmlElement` includes a type property.

  The value of the type property is the class object representing the generated object's default base type. In the case of XML Schema primitive types, the class is `String`.

- The property is decorated with an `@XmlSchemaType` annotation.

  The annotation identifies the XML Schema primitive type of the construct.

- The default type is replaced by the class specified by the `javaType` element's `name` attribute.

- Example 201 shows the object factory method for an element affected by the customization shown in Example 196.

Example 201. Customized Complex Type

```
public class NumInventory {

    @XmlElement(required = true, type = String.class)
    @XmlJavaTypeAdapter(Adapter1 .class)
    @XmlSchemaType(name = "short")
    protected Integer numLeft;
    @XmlElement(required = true)
    protected String size;

    public Integer getNumLeft() {
        return numLeft;
    }

    public void setNumLeft(Integer value) {
        this.numLeft = value;
    }

    public String getSize() {
        return size;
    }

    public void setSize(String value) {
        this.size = value;
    }

}
```

Implementing converters

The Artix runtime has does not know how to convert XML primitive types to and from the Java class specified by the `javaType` element, except that it should call the methods specified by the `parseMethod` attribute and the `printMethod` attribute. You are responsible for providing implementations of the methods the runtime calls. The implemented methods must be capable of working with the lexical structures of the XML primitive type.

To simplify the implementation of the data conversion methods, Artix provides the `javax.xml.bind.DatatypeConverter` class. This class provides methods for parsing and printing all of the XML Schema primitive types. The parse methods take string representations of the XML data and they return an instance of the default type defined in Table 15. The print methods take an instance of the default type and they return a string representation of the XML data.

The Java documentation for the `DatatypeConverter` class can be found at http://java.sun.com/webservices/docs/1.6/api/javax/xml/bind/ DatatypeConverter.html.

Default primitive type converters

When specifying a Java primitive type, or one of the Java primitive type

Wrapper classes, in the `javaType` element's `name` attribute, it is not necessary to specify values for the `parseMethod` attribute or

the `printMethod` attribute. The Artix runtime substitutes default converters if no values are provided.

The default data converters use the JAXB `DatatypeConverter` class to parse the XML data. The default converters will also provide any type casting necessary to make the conversion work.

Generating Java Classes for Simple Types

By default, named simple types do not result in generated types unless they are enumerations. Elements defined using a simple type are mapped to properties of a Java primitive type.

There are instances when you need to have simple types generated into Java classes, such as is when you want to use type substitution.

To instruct the code generators to generate classes for all globally defined simple types, set the `globalBindings` customization element's `mapSimpleTypeDef` to `true`.

Adding the customization

To instruct the code generators to create Java classes for named simple types add the `globalBinding` element's `mapSimpleTypeDef` attribute and set its value to `true`.

Example 202 shows an in-line customization that forces the code generator to generate Java classes for named simple types.

Example 202. in-Line Customization to Force Generation of Java Classes for SimpleTypes

```
<schema targetNamespace="http://widget.com/types/widgetTypes"
        xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
        xmlns:jaxb="http://java.sun.com/xml/ns/jaxb"
        jaxb:version="2.0">
  <annotation>
    <appinfo>
      <jaxb:globalBindings mapSimpleTypeDef="true" />
    </appinfo>
  </annotation>
  ...
</schema>
```

Example 203 shows an external binding file that customizes the generation of simple types.

Example 203. Binding File to Force Generation of Constants

```
<jaxb:bindings xmlns:jaxb="http://java.sun.com/xml/ns/jaxb"
               xmlns:xsd="http://www.w3.org/2001/XMLSchema"
               jaxb:version="2.0">
  <jaxb:bindings schemaLocation="types.xsd">
    <jaxb:globalBindings mapSimpleTypeDef="true" />
  <jaxb:bindings>
<jaxb:bindings>
```

IMPORTANT: This customization only affects *named* simple types that are defined in the *global* scope.

Generated classes

The class generated for a simple type has one property called value. The value property is of the Java type defined by the mappings in Primitive Types. The generated class has a getter and a setter for the value property.

Example 205 shows the Java class generated for the simple type defined in Example 204.

Example 204. Simple Type for Customized Mapping

```
<simpleType name="simpleton">
  <restriction base="xsd:string">
    <maxLength value="10"/>
  </restriction>
</simpleType>
```

Example 205. Customized Mapping of a Simple Type

```
@XmlAccessorType(XmlAccessType.FIELD)
@XmlType(name = "simpleton", propOrder = {"value"})
public class Simpleton {

    @XmlValue
    protected String value;

    public String getValue() {
        return value;
    }

    public void setValue(String value) {
        this.value = value;
    }

}
```

Customizing Enumeration Mapping

If you want enumerated types that are based on a schema type other than xsd:string, you must instruct the code generator to map it. You can also control the name of the generated enumeration constants.

The customization is done using the `jaxb:typesafeEnumClass` element along with one or more `jaxb:typesafeEnumMember` elements.

There might also be instances where the default settings for the code generator cannot create valid Java identifiers for all of the members of an enumeration. You can customize how the code generators handle this by using an attribute of the `globalBindings` customization.

Member name customizer

If the code generator encounters a naming collision when generating the members of an enumeration or if it cannot create a valid Java identifier for a member of the enumeration, the code generator, by default, generates a warning and does not generate a Java enum type for the enumeration.

You can alter this behavior by adding the `globalBinding` element's `typesafeEnumMemberName` attribute. The `typesafeEnumMemberName` attribute's values are described in Table 23.

Table 23. Values for Customizing Enumeration Member Name Generation

Value	Description
`skipGeneration`(default)	Specifies that the Java enum type is not generated and generates a warning.
`generateName`	Specifies that member names will be generated following the pattern VALUE_N. N starts off at one, and is incremented for each member of the enumeration.
`generateError`	Specifies that the code generator generates an error when it cannot map an enumeration to a Java enum type.

Example 206 shows an in-line customization that forces the code generator to generate type safe member names.

Example 206. Customization to Force Type Safe Member Names

```
<schema targetNamespace="http://widget.com/types/widgetTypes"

        xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
        xmlns:jaxb="http://java.sun.com/xml/ns/jaxb"
        jaxb:version="2.0">
  <annotation>
    <appinfo>
      <jaxb:globalBindings typesafeEnumMemberName="generate
Name" />
    </appinfo>
  </annotation>
  ...
</schema>
```

Class customizer

The `jaxb:typesafeEnumClass` element specifies that an XML Schema enumeration should be mapped to a Java enum type. It has two attributes that are described in Table 24. When the `jaxb:typesafeEnumClass` element is specified in-line, it must be placed inside the `xsd:annotation` element of the simple type it is modifying.

Table 24. Attributes for Customizing a Generated Enumeration Class

Attribute	Description
`name`	Specifies the name of the generated Java enum type. This value must be a valid Java identifier.
`map`	Specifies if the enumeration should be mapped to a Java enum type. The default value is `true`.

Member customizer

The `jaxb:typesafeEnumMember` element specifies the mapping between an XML Schema `enumeration` facet and a Java enum type constant. You must use one `jaxb:typesafeEnumMember` element for each `enumeration` facet in the enumeration being customized.

When using in-line customization, this element can be used in one of two ways:

- It can be placed inside the `xsd:annotation` element of the `enumeration` facet it is modifying.
- They can all be placed as children of the `jaxb:typesafeEnumClass` element used to customize the enumeration.

The `jaxb:typesafeEnumMember` element has a `name` attribute that is required. The `name` attribute specifies the name of the generated Java enum type constant. It's value must be a valid Java identifier.

The `jaxb:typesafeEnumMember` element also has a `value` attribute. The `value` is used to associate the `enumeration` facet with the proper `jaxb:typesafeEnumMember` element. The value of the `value` attribute must match one of the values of an `enumeration` facets' `value` attribute. This attribute is required when you use an external binding specification for customizing the type generation, or when you group the `jaxb:typesafeEnumMember` elements as children of the `jaxb:typesafeEnumClass` element.

Example 207 shows an enumerated type that uses in-line customization and has the enumeration's members customized separately.

Example 207. In-line Customization of an Enumerated Type

```
<schema targetNamespace="http://widget.com/types/widgetTypes"
        xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
        xmlns:jaxb="http://java.sun.com/xml/ns/jaxb"
        jaxb:version="2.0">
<simpleType name="widgetInteger">
<annotation>
      <appinfo>
        <jaxb:typesafeEnumClass />
      </appinfo>
</annotation>
<restriction base="xsd:int">
      <enumeration value="1">
<annotation>
<appinfo>
            <jaxb:typesafeEnumMember name="one" />
</appinfo>
</annotation>
      </enumeration>
      <enumeration value="2">
<annotation>
<appinfo>
            <jaxb:typesafeEnumMember name="two" />
</appinfo>
</annotation>
      </enumeration>
      <enumeration value="3">
<annotation>
<appinfo>
            <jaxb:typesafeEnumMember name="three" />
</appinfo>
</annotation>
      </enumeration>
      <enumeration value="4">
<annotation>
<appinfo>
            <jaxb:typesafeEnumMember name="four" />
</appinfo>
</annotation>
      </enumeration>
    </restriction>
  </simpleType>
<schema>
```

Example 208 shows an enumerated type that uses in-line customization and combines the member's customization in the class customization.

Example 208 In-line Customization of an Enumerated Type Using a Combined Mapping

```
<schema targetNamespace="http://widget.com/types/widgetTypes"
        xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
        xmlns:jaxb="http://java.sun.com/xml/ns/jaxb"
        jaxb:version="2.0">
<simpleType name="widgetInteger">
  <annotation>
      <appinfo>
        <jaxb:typesafeEnumClass>
            <jaxb:typesafeEnumMember value="1" name="one" />
            <jaxb:typesafeEnumMember value="2" name="two" />
            <jaxb:typesafeEnumMember value="3" name="three" />
```

```
            <jaxb:typesafeEnumMember value="4" name="four" />
        </jaxb:typesafeEnumClass>
      </appinfo>
  </annotation>
  <restriction base="xsd:int">
      <enumeration value="1" />
      <enumeration value="2" />
      <enumeration value="3" />
      <enumeration value="4" >
  </restriction>
</simpleType>
<schema>
```

Example 209 shows an external binding file that customizes an enumerated type.

Example 209. Binding File for Customizing an Enumeration

```
<jaxb:bindings xmlns:jaxb="http://java.sun.com/xml/ns/jaxb"
               xmlns:xsd="http://www.w3.org/2001/XMLSchema"
               jaxb:version="2.0">
  <jaxb:bindings schemaLocation="enumMap.xsd">
    <jaxb:bindings node="xsd:simpleType[@name='widgetInteger']">
        <jaxb:typesafeEnumClass>
            <jaxb:typesafeEnumMember value="1" name="one" />
            <jaxb:typesafeEnumMember value="2" name="two" />
            <jaxb:typesafeEnumMember value="3" name="three" />
            <jaxb:typesafeEnumMember value="4" name="four" />
        </jaxb:typesafeEnumClass>
    </jaxb:bindings>
  </jaxb:bindings>
<jaxb:bindings>
```

Customizing Fixed Value Attribute Mapping

By default, the code generators map attributes defined as having a fixed value to normal properties. When using schema validation, Artix can enforce the schema definition. However, using schema validation increases message processing time.

Another way to map attributes that have fixed values to Java is to map them to Java constants. You can instruct the code generator to map fixed value attributes to Java constants using the `globalBindings` customization element. You can also customize the mapping of fixed value attributes to Java constants at a more localized level using the `property` element.

Global customization

You can alter this behavior by adding the `globalBinding` element's `fixedAttributeAsConstantProperty` attribute. Setting this attribute to `true` instructs the code generator to map any attribute defined using `fixed` attribute to a Java constant.

Example 210 shows an in-line customization that forces the code generator to generate constants for attributes with fixed values.

Example 210. in-Line Customization to Force Generation of Constants

```
<schema targetNamespace="http://widget.com/types/widgetTypes"

        xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
        xmlns:jaxb="http://java.sun.com/xml/ns/jaxb"
        jaxb:version="2.0">
        <annotation>
          <appinfo>
      <jaxb:globalBindings fixedAttributeAsConstantProp erty="true" />
          </appinfo>
        </annotation>
  ...
</schema>
```

Example 211 shows an external binding file that customizes the generation of fixed attributes.

Example 211. Binding File to Force Generation of Constants

```
<jaxb:bindings xmlns:jaxb="http://java.sun.com/xml/ns/jaxb"
               xmlns:xsd="http://www.w3.org/2001/XMLSchema"
               jaxb:version="2.0">
  <jaxb:bindings schemaLocation="types.xsd">
    <jaxb:globalBindings fixedAttributeAsConstantProperty="true" />
  <jaxb:bindings>
<jaxb:bindings>
```

Local mapping

You can customize attribute mapping on a per-attribute basis using the `property` element's `fixedAttributeAsConstantProperty` attribute. Setting this attribute to `true` instructs the code generator to map any attribute defined using `fixed` attribute to a Java constant.

Example 212 shows an in-line customization that forces the code generator to generate constants for a single attribute with a fixed value.

Example 212. In-Line Customization to Force Generation of Constants

```
<schema targetNamespace="http://widget.com/types/widgetTypes"
        xmlns="http://www.w3.org/2001/XMLSchema"
        xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
        xmlns:jaxb="http://java.sun.com/xml/ns/jaxb" jaxb:version="2.0">
  <complexType name="widgetAttr">
    <sequence>
      ...
    </sequence>
    <attribute name="fixer" type="xsd:int" fixed="7">
      <annotation>
        <appinfo>
          <jaxb:property fixedAttributeAsConstantProperty="true" />
        </appinfo>
      </annotation>
     </attribute>
  </complexType>
  ...
</schema>
```

Example 213 shows an external binding file that customizes the generation of a fixed attribute.

Example 213. Binding File to Force Generation of Constants

```
<jaxb:bindings xmlns:jaxb="http://java.sun.com/xml/ns/jaxb"
        xmlns:xsd="http://www.w3.org/2001/XMLSchema" jaxb:version="2.0">
  <jaxb:bindings schemaLocation="types.xsd">
    <jaxb:bindings node="xsd:complexType[@name='widgetAttr']">
      <jaxb:bindings node="xsd:attribute[@name='fixer']">
            <jaxb:property fixedAttributeAsConstantProperty="true" />
        </jaxb:bindings>
    </jaxb:bindings>
  </jaxb:bindings>
<jaxb:bindings>
```

Java mapping

In the default mapping, all attributes are mapped to standard Java properties with getter and setter methods. When this customization is applied to an attribute defined using the `fixed` attribute, the attribute is mapped to a Java constant, as shown in Example 214.

Example 214. Mapping of a Fixed Value Attribute to a Java Constant

```
@XmlAttribute
public final static type NAME = value;
```

- `type` is determined by mapping the base type of the attribute to a Java type using the mappings described in Primitive Types.
- `NAME` is determined by converting the value of the `attribute` element's `name` attribute to all capital letters.

- `value` is determined by the value of the `attribute` element's `fixed` attribute.

For example, the attribute defined in Example 212 is mapped as shown in Example 215.

Example 215. Fixed Value Attribute Mapped to a Java Constant

```
@XmlRootElement(name = "widgetAttr")
public class WidgetAttr {

    ...

  @XmlAttribute
  public final static int FIXER = 7;

  ...

}
```

Specifying the Base Type of an Element or an Attribute

Occasionally you need to customize the class of the object generated for an element, or for an attribute defined as part of an XML Schema complex type. For example, you might want to use a more generalized class of object to allow for simple type substitution.

One way to do this is to use the JAXB base type customization. It allows a developer, on a case by case basis, to specify the class of object generated to represent an element or an attribute. The base type customization allows you to specify an alternate mapping between the XML Schema construct and the generated Java object. This alternate mapping can be a simple specialization or a generalization of the default base class. It can also be a mapping of an XML Schema primitive type to a Java class.

Customization usage

To apply the JAXB base type property to an XML Schema construct use the JAXB `baseType` customization element. The `baseType` customization element is a child of the JAXB `property` element, so it must be properly nested.

Depending on how you want to customize the mapping of the XML Schema construct to Java object, you add either the `baseType` customization element's `name` attribute, or a `javaType` child element. The `name` attribute is used to map the default class of the generated object to another class within the same class hierarchy. The `javaType` element is used when you want to map XML Schema primitive types to a Java class.

IMPORTANT: You cannot use both the `name` attribute and a `javaType` child element in the same `baseType` customization element.

Specializing or generalizing the default mapping

The `baseType` customization element's `name` attribute is used to redefine the class of the generated object to a class within the same Java class hierarchy. The attribute specifies the fully qualified name of the Java class to which the XML Schema construct is mapped. The specified Java class **must** be either a super-class or a sub-class of the Java class that the code generator normally generates for the XML Schema construct. For XML Schema primitive types that map to Java primitive types, the wrapper class is used as the default base class for the purpose of customization.

For example, an element defined as being of xsd:int uses `java.lang.Integer` as its default base class. The value of the `name` attribute can specify any super-class of `Integer` such as `Number` or `Object`.

TIP: For simple type substitution, the most common customization is to map the primitive types to an `Object` object.

Example 216 shows an in-line customization that maps one element in a complex type to a Java `Object` object.

Example 216. In-Line Customization of a Base Type

```
<complexType name="widgetOrderInfo">
  <all>
    <element name="amount" type="xsd:int" />
     <element name="shippingAdress" type="Address>
      <annotation>
        <appinfo>
           <jaxb:property>
             <jaxb:baseType name="java.lang.Object" />
           </jaxb:property>
        </appinfo>
      </annotation>
    </element>
    <element name="type" type="xsd:string"/>
  </all>
</complexType>
```

Example 217 shows an external binding file for the customization shown in Example 216.

Example 217. External Binding File to Customize a Base Type

```
<jaxb:bindings xmlns:jaxb="http://java.sun.com/xml/ns/jaxb"
               xmlns:xsd="http://www.w3.org/2001/XMLSchema"
               jaxb:version="2.0">
  <jaxb:bindings schemaLocation="enumMap.xsd">
    <jaxb:bindings node="xsd:ComplexType[@name='widgetOrderInfo']">
      <jaxb:bindings node="xsd:element[@name='shippingAddress']">
        <jaxb:property>
          <jaxb:baseType name="java.lang.Object" />
        </jaxb:property>
      </jaxb:bindings>
    </jaxb:bindings>
  </jaxb:bindings>
<jaxb:bindings>
```

The resulting Java object's `@XmlElement` annotation includes a type property. The value of the type property is the class object representing the generated object's default base type. In the case of XML Schema primitive types, the class is the wrapper class of the corresponding Java primitive type.

Example 218 shows the class generated based on the schema definition in Example 217.

Example 218. Java Class with a Modified Base Class

```
public class WidgetOrderInfo {

    protected int amount;
    @XmlElement(required = true) protected String type;
    @XmlElement(required = true, type = Address.class)
    protected Object shippingAddress;

    ...
    public Object getShippingAddress() {
        return shippingAddress;
    }

    public void setShippingAddress(Object value) {
        this.shippingAddress = value;
    }

}
```

Usage with javaType

The `javaType` element can be used to customize how elements and attributes defined using XML Schema primitive types are mapped to Java objects. Using the `javaType` element provides a lot more flexibility than simply using the `baseType` element's `name` attribute. The `javaType` element allows you to map a primitive type to any class of object.

For a detailed description of using the `javaType` element, see Specifying the Java Class of an XML Schema Primitive.

Using A JAXBContext Object

The `JAXBContext` object allows the Artix's runtime to transform data between XML elements and Java object. Application developers need to instantiate a `JAXBContext` object they want to use JAXB objects in message handlers and when implementing consumers that work with raw XML messages.

The `JAXBContext` object is a low-level object used by the runtime. It allows the runtime to convert between XML elements and their corresponding Java representations. An application developer generally does not need to work with `JAXBContext` objects. The marshaling and unmarshaling of XML data is typically handled by the transport and binding layers of a JAX-WS application.

However, there are instances when an application will need to manipulate the XML message content directly. In two of these instances:

- Implementing consumers that use raw XML data
- Working with messages in a handler

You will need to instantiate a `JAXBContext` object using one of the two available `JAXBContext.newInstance()` methods.

Best practices

`JAXBContext` objects are resource intensive to instantiate. It is recommended that an application create as few instances as possible. One way to do this is to create a single `JAXBContext` object that can manage all of the JAXB objects used by your application and share it among as many parts of your application as possible.

TIP: `JAXBContext` objects are thread safe.

Getting a JAXBContext object using an object factory

The `JAXBContext` class provides a `newInstance()` method, shown in Example 219, that takes a list of classes that implement JAXB objects.

Example 219. Getting a JAXB Context Using Classes

```
static JAXBContext newInstance(Class... classesToBeBound)
    throws JAXBException;
```

The returned `JAXBObject` object will be able to marshal and unmarshal data for the JAXB object implemented by the classes

passed into the method. It will also be able to work with any classes that are statically referenced from any of the classes passed into the method.

While it is possible to pass the name of every JAXB class used by your application to the `newInstance()` method it is not efficient. A more efficient way to accomplish the same goal is to pass in the object factory, or object factories, generated for your application. The resulting `JAXBContext` object will be able to manage any JAXB classes the specified object factories can instantiate.

Getting a JAXBContext object using package names

The `JAXBContext` class provides a `newInstance()` method, shown in Example 220, that takes a colon (`:`) seperated list of package names. The specified packages should contain JAXB objects derived from XML Schema.

Example 220. Getting a JAXB Context Using Classes

```
static JAXBContext newInstance(String contextPath)
    throws JAXBException;
```

The returned `JAXBContext` object will be able to marshal and unmarshal data for all of the JAXB objects implemented by the classes in the specified packages.

Part VI
Advanced Programming Tasks

The JAX-WS programming model offers a number of advanced features.

In this part

This part contains the following chapters:

Developing Asynchronous Application
Using Raw XML Messages
Working with Contexts
Writing Handlers

Developing Asynchronous Applications

JAX-WS provides an easy mechanism for accessing services asynchronously. The SEI can specify additional methods that can be used to access a service asynchronously. The Artix code generators generate the extra methods for you. You simply add the business logic.

In addition to the usual synchronous mode of invocation, Artix supports two forms of asynchronous invocation:

- Polling approach — To invoke the remote operation using the polling approach, you call a method that has no output parameters, but returns a `javax.xml.ws.Response` object. The `Response` object (which inherits from the `javax.util.concurrency.Future` interface) can be polled to check whether or not a response message has arrived.
- Callback approach — To invoke the remote operation using the callback approach, you call a method that takes a reference to a callback object (of `javax.xml.ws.AsyncHandler` type) as one of its parameters. When the response message arrives at the client, the runtime calls back on the `AsyncHandler` object, and gives it the contents of the response message.

WSDL for Asynchronous Examples

Example 221 shows the WSDL contract that is used for the asynchronous examples. The contract defines a single interface, `GreeterAsync`, which contains a single operation, greetMeSometime.

Example 221. WSDL Contract for Asynchronous Example

```
<?xml version="1.0" encoding="UTF-8"?><wsdl:definitions xmlns="http://schem
as.xmlsoap.org/wsdl/"
          xmlns:soap="http://schemas.xmlsoap.org/wsdl/soap/"
          xmlns:tns="http://apache.org/hello_world_async_soap_http"
          xmlns:x1="http://apache.org/hello_world_async_soap_http/types"
          xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
          xmlns:xsd="http://www.w3.org/2001/XMLSchema"
          targetNamespace="http://apache.org/hello_world_async_soap_http"
          name="HelloWorld">
  <wsdl:types>
    <schema
          targetNamespace="http://apache.org/hello_world_async_soap_http/types"
          xmlns="http://www.w3.org/2001/XMLSchema"
          xmlns:x1="http://apache.org/hello_world_async_soap_http/types"
          elementFormDefault="qualified">
      <element name="greetMeSometime">
<complexType>
<sequence>
            <element name="requestType" type="xsd:string"/>
</sequence>
</complexType>
      </element>
      <element name="greetMeSometimeResponse">
<complexType>
<sequence>
            <element name="responseType"
type="xsd:string"/>
</sequence>
</complexType>
      </element>
    </schema>
  </wsdl:types>

  <wsdl:message name="greetMeSometimeRequest">
    <wsdl:part name="in" element="x1:greetMeSometime"/>
  </wsdl:message>
  <wsdl:message name="greetMeSometimeResponse">
<wsdl:part name="out"
               element="x1:greetMeSometimeResponse"/>
  </wsdl:message>
  <wsdl:portType name="GreeterAsync">
    <wsdl:operation name="greetMeSometime">
      <wsdl:input name="greetMeSometimeRequest"
                  message="tns:greetMeSometimeRequest"/>
      <wsdl:output name="greetMeSometimeResponse"
                   message="tns:greetMeSometimeResponse"/>
    </wsdl:operation>
  </wsdl:portType>

  <wsdl:binding name="GreeterAsync_SOAPBinding"
                type="tns:GreeterAsync">
    ...
  </wsdl:binding>

  <wsdl:service name="SOAPService">
    <wsdl:port name="SoapPort"
               binding="tns:GreeterAsync_SOAPBinding">
      <soap:address location="http://localhost:9000/SoapContext/SoapPort"/>
    </wsdl:port>
  </wsdl:service>
</wsdl:definitions>
```

Generating the Stub Code

The asynchronous style of invocation requires extra stub code for the dedicated asynchronous methods defined on the SEI. This special stub code is not generated by default. To switch on the asynchronous feature and generate the requisite stub code, you must use the mapping customization feature from the WSDL 2.0 specification.

Customization enables you to modify the way the **wsdl2java** generates stub code. In particular, it enables you to modify the WSDL-to-Java mapping and to switch on certain features. Here, customization is used to switch on the asynchronous invocation feature. Customizations are specified using a binding declaration, which you define using a `jaxws:bindings` tag (where the jaxws prefix is tied to the http://java.sun.com/xml/ns/jaxws namespace). There are two ways of specifying a binding declaration:

- External Binding BDeclaration

  When using an external binding declaration the `jaxws:bindings` element is defined in a file separatel from the WSDL contract. You specify the location of the binding declaration file to **wsdl2java** when you generate the stub code.

- Embedded Binding Declaration

  When using an embedded binding declaration you embed the `jaxws:bindings` element directly in a WSDL contract, treating it as a WSDL extension. In this case, the settings in `jaxws:bindings` apply only to the immediate parent element.

Using an external binding declaration

The template for a binding declaration file that switches on asynchronous invocations is shown in Example 222.

Example 222. Template for an Asynchronous Binding Declaration

```
<bindings xmlns:xsd="http://www.w3.org/2001/XMLSchema"
          xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
          wsdlLocation="AffectedWSDL"
          xmlns="http://java.sun.com/xml/ns/jaxws">
  <bindings node="AffectedNode">
    <enableAsyncMapping>true</enableAsyncMapping>
  </bindings>
</bindings>
```

Where `AffectedWSDL` specifies the URL of the WSDL contract that is affected by this binding declaration. The `AffectedNode` is an XPath value that specifies which node (or nodes) from the WSDL contract are affected by this binding declaration. You can set `AffectedNode` to `wsdl:definitions`, if you want the entire

WSDL contract to be affected. The `jaxws:enableAsyncMapping` element is set to `true` to enable the asynchronous invocation feature.

For example, if you want to generate asynchronous methods only for the `GreeterAsync` interface, you can specify <bindings node="wsdl:definitions/wsdl:portType[@name='GreeterAsync']"> in the preceding binding declaration.

Assuming that the binding declaration is stored in a file, `async_binding.xml`, you generate the requisite stub files with asynchronous support by entering the following command:

```
wsdl2java -client -b async_binding.xml hello_world.wsdl
```

When you run **wsdl2java**, you specify the location of the binding declaration file using the `-b` option.

For more information on wsdl2java see *wsdl2java* in ***Artix Java Runtime Command Reference***.

Using an embedded binding declaration

You can also embed the binding customization directly into the WSDL document defining the service by placing the `jaxws:bindings` element and its associated `jaxws:enableAsynchMapping` child directly into the WSDL.

You also must add a namespace declaration for the jaxws prefix.

Example 223 shows a WSDL file with an embedded binding declaration that activates the asynchronous mapping for an operation.

Example 223. WSDL with Embedded Binding Declaration for Asynchronous Mapping

```
<wsdl:definitions xmlns="http://schemas.xmlsoap.org/wsdl/"
                  ...
                  xmlns:jaxws="http://java.sun.com/xml/ns/jaxws"
                  ...>
  ...
     <wsdl:portType
  name="GreeterAsync">
    <wsdl:operation name="greetMeSometime">
      <jaxws:bindings>
        <jaxws:enableAsyncMapping>true</jaxws:enableAsyncMapping>
      </jaxws:bindings>
      <wsdl:input name="greetMeSometimeRequest"
                  message="tns:greetMeSometimeRequest"/>
      <wsdl:output name="greetMeSometimeResponse"
                   message="tns:greetMeSometimeResponse"/>
    </wsdl:operation>
  </wsdl:portType>
  ...
</wsdl:definitions>
```

When embedding the binding declaration into the WSDL document you can control the scope affected by the declaration by changing where you place the declaration. When the declaration is placed as a child of the `wsdl:definitions` element the code generator creates asynchronous methods for all of the operations defined in the WSDL document. If it is placed as a child of a `wsdl:portType` element the code generator creates asynchronous methods for all of the operations defined in the interface. If it is placed as a child of a `wsdl:operation` element the code generator creates asynchronous methods for only that operation.

It is not necessary to pass any special options to the code generator when using embedded declarations. The code generator will recognize them and act accordingly.

Generated interface

After generating the stub code in this way, the `GreeterAsync` SEI (in the file `GreeterAsync.java`) is defined as shown in Example 224.

Example 224. Service Endpoint Interface with Methods for Asynchronous Invocations

```
package org.apache.hello_world_async_soap_http;

import org.apache.hello_world_async_soap_http.types.GreetMeSometimeResponse;
...

public interface GreeterAsync
{
  publicFuture<?> greetMeSometimeAsync(
        java.lang.String requestType,
        AsyncHandler<GreetMeSometimeResponse> asyncHandler
    );

    public Response<GreetMeSometimeResponse>
        greetMeSometimeAsync( java.lang.String
        requestType
    );

    public java.lang.String
        greetMeSometime(
        java.lang.String
        requestType
    );
}
```

In addition to the usual synchronous method, `greetMeSometime()`, two asynchronous methods are also generated for the greetMeSometime operation:

- Callback approach

  ```
  public Future<?> greetMeSomtimeAsync(java.lang.String
  requestType, AsyncHandler<GreetMeSomtimeResponse>
  asyncHandler);
  ```

- Polling approach

```
public Response<GreetMeSomeTimeResponse>
greetMeSometimeAsync(java.lang.String requestType);
```

Implementing an Asynchronous Client with the Polling Approach

The polling approach is the more straightforward of the two approaches to developing an asynchronous application. The client invokes the asynchronous method called `OperationNameAsync()` and is returned a `Response<T>` object that it polls for a response. What the client does while it is waiting for a response is depends on the requirements of the application. There are two basic patterns for handling the polling:

- Non-blocking polling — You periodically check to see if the result is ready by calling the non-blocking `Response<T>.isDone()` method. If the result is ready, the client processes it. If it not, the client continues doing other things.
- Blocking polling — You call `Response<T>.get()` right away, and block until the response arrives (optionally specifying a timeout).

Using the non-blocking pattern

Example 225 illustrates using non-blocking polling to make an asynchronous invocation on the greetMeSometime operation defined in Example 221. The client invokes the asynchronous operation and periodically checks to see if the result is returned.

Example 225. Non-Blocking Polling Approach for an Asynchronous Operation Call

```
package demo.hw.client;

import java.io.File;
import java.util.concurrent.Future;

import javax.xml.namespace.QName;
import javax.xml.ws.Response;

import org.apache.hello_world_async_soap_http.*; public final class Client

{
  private static final QName SERVICE_NAME
    = new QName("http://apache.org/hello_world_async_soap_http",
                "SOAPService");

  private Client() {}
  public static void main(String args[]) throws Exception {

    // set up the proxy for the client

❶     Response<GreetMeSometimeResponse> greetMeSomeTimeResp =
```

```
       port.greetMeSometimeAsync(System.getProperty("user.name"));

❷       while (!greetMeSomeTimeResp.isDone()) {
        // client does some work
      }
❸       GreetMeSometimeResponse reply = greetMeSomeTimeResp.get();
        // process the response

        System.exit(0);
      }
}
```

The code in Example 225 does the following:

❶ Invokes the `greetMeSometimeAsync()` on the proxy.

The method call returns the `Response<GreetMeSometimeResponse>` object to the client immediately. The Artix runtime handles the details of receiving the reply from the remote endpoint and populating the `Response<GreetMeSometimeResponse>` object.

NOTE: The runtime transmits the request to the remote endpoint's `greetMeSometime()` method and handles the details of the asynchronous nature of the call transparently. The endpoint, and therefore the service implementation, never worries about the details of how the client intends to wait for a response..

❷ Checks to see if a response has arrived by checking the `isDone()` of the returned `Response` object.

If the response has not arrived, the client continues working before checking again.

❸ When the response arrives, the client retrieves it from the `Response` object using the `get()` method.

Using the blocking pattern

When using the block polling pattern, the `Response` object's `isDone()` is never called. Instead, the `Response` object's `get()` method is called immediately after invoking the remote operation. The `get()` blocks until the response is available.

TIP: You can also pass a timeout limit to the `get()` method.

Example 226 shows a client that uses blocking polling.

Example 226. Blocking Polling Approach for an Asynchronous Operation Call

```
package demo.hw.client;

import java.io.File;
import java.util.concurrent.Future;

import javax.xml.namespace.QName;
import javax.xml.ws.Response;

import org.apache.hello_world_async_soap_http.*;

public final class Client {
  private static final QName SERVICE_NAME
    = new QName("http://apache.org/hello_world_async_soap_http",
                "SOAPService");

  private Client() {}

  public static void main(String args[]) throws Exception {

    // set up the proxy for the client Response<GreetMeSometimeResponse>

    greetMeSomeTimeResp =
      port.greetMeSometimeAsync(System.getProperty("user.name"));
    GreetMeSometimeResponse reply = greetMeSomeTimeResp.get();
      // process the response System.exit(0);
  }
}
```

Implementing an Asynchronous Client with the Callback Approach

An alternative approach to making an asynchronous operation invocation is to implement a callback class. You then call the asynchronous remote method that takes the callback object as a parameter. The runtime returns the response to the callback object.

To implement an application that uses callbacks, do the following:

1. Create a callback class that implements the `AsyncHandler` interface.

   Your callback object can perform any amount of response processing required by your application.

2. Make remote invocations using the *operationName*`Async()` that takes the callback object as a parameter and returns a `Future<?>` object.

3. If your client requires access to the response data, you can poll the returned `Future<?>` object's `isDone()` method to see if the remote endpoint has sent the response.

TIP: If the callback object does all of the response processing, it is not necessary to check if the response has arrived.

Implementing the callback

The callback class must implement the `javax.xml.ws.AsyncHandler` interface. The interface defines a single method:

```
void handleResponse(Response<T> res);
```

The Artix runtime calls the `handleResponse()` method to notify the client that the response has arrived. Example 227 shows an outline of the `AsyncHandler` interface that you must implement.

Example 227. The javax.xml.ws.AsyncHandler Interface

```
public interface javax.xml.ws.AsyncHandler
{
   void handleResponse(Response<T> res)
}
```

Example 228 shows a callback class for the greetMeSometime operation defined in Example 221.

Example 228. Callback Implementation Class

```
package demo.hw.client;

import javax.xml.ws.AsyncHandler;
import javax.xml.ws.Response;

import org.apache.hello_world_async_soap_http.types.*;

public class GreeterAsyncHandler implements AsyncHandler<GreetMeSometimeResponse>
{
❶  private GreetMeSometimeResponse reply;
❷  public void handleResponse(Response<GreetMeSometimeResponse>
                               response)
  {
    try
      {
        reply = response.get();
      }
    catch (Exception ex)
      {
        ex.printStackTrace();
      }
  }
❸  public String getResponse()
  {
    return reply.getResponseType();
  }
}
```

The callback implementation shown in Example 228 does the following:

❶ Defines a member variable, `response`, that holds the response returned from the remote endpoint.

❷ Implements `handleResponse()`.

This implementation simply extracts the response and assigns it to the member variable `reply`.

❸ Implements an added method called `getResponse()`.

This method is a convenience method that extracts the data from `reply` and returns it.

Implementing the consumer

Example 229 illustrates a client that uses the callback approach to make an asynchronous call to the GreetMeSometime operation defined in Example 221.

Example 229. Callback Approach for an Asynchronous Operation Call

```
package demo.hw.client;

import java.io.File;
import java.util.concurrent.Future;

import javax.xml.namespace.QName;
import javax.xml.ws.Response;

import org.apache.hello_world_async_soap_http.*;

public final class Client {
...

  public static void main(String args[]) throws Exception
  {
    ...
    // Callback approach
❶     GreeterAsyncHandler callback = new GreeterAsyncHandler();
❷     Future<?> response =
           port.greetMeSometimeAsync(System.getProperty("user.name"),callback);
❸     while (!response.isDone())
      {
        // Do some work
      }
❹     resp = callback.getResponse();
    ...
    System.exit(0);
  }
}
```

The code in Example 229 does the following:

❶ Instantiates a callback object.

❷ Invokes the greetMeSometimeAsync() that takes the callback object on the proxy.

The method call returns the Future<?> object to the client immediately. The Artix runtime handles the details of receiving the reply from the remote endpoint, invoking the callback object's handleResponse() method, and populating the Response<GreetMeSometimeResponse> object.

NOTE: The runtime transmits the request to the remote endpoint's greetMeSometime() method and handles the details of the asynchronous nature of the call without the remote endpoint's knowledge. The endpoint, and therefore the service implementation, does not need to worry about the details of how the client intends to wait for a response.

❸ Uses the returned Future<?> object's isDone() method to check if the response has arrived from the remote endpoint.

❹ Invokes the callback object's getResponse() method to get the response data.

Catching Exceptions Returned from a Remote Service

Consumers making asynchronous requests will not receive the same exceptions returned than when they make synchronous requests. Any exceptions returned to the consumer asynchronously are wrapped in an ExecutionException exception. The actual exception thrown by the service is stored in the ExecutionException exception's cause field.

Catching the exception

Exceptions generated by a remote service are thrown locally by the method that passes the response to the consumer's business logic. When the consumer makes a synchronous request, the method making the remote invocation throws the exception. When the consumer makes an asynchronous request, the Response<T> object's get() method throws the exception. The consumer will not discover that an error was encountered in processing the request until it attempts to retrieve the response message.

Unlike the methods generated by the JAX-WS framework, the Response<T> object's get() method does not throw either user modeled exceptions nor the generic JAX-WS exceptions. Instead, it throws a java.util.concurrent.ExecutionException exception.

Getting the exception details

The framework stores the exception returned from the remote service in the `ExecutionException` exception's `cause` field. The details about the remote exception are extracted by getting the value of the `cause` field and examining the stored exception. The stored exception can be any user defined exception or one of the generic JAX-WS exceptions.

Example

Example 230 shows an example of catching an exception using the polling approach.

Example 230. Catching an Exception using the Polling Approach

```
package demo.hw.client;

import java.io.File;
import java.util.concurrent.Future;

import javax.xml.namespace.QName;
import javax.xml.ws.Response;

import org.apache.hello_world_async_soap_http.*;

public final class Client
{
  private static final QName SERVICE_NAME
    = new QName("http://apache.org/hello_world_async_soap_http",
                "SOAPService");

  private Client() {}

  public static void main(String args[]) throws Exception
  {
    ...
    // port is a previously established proxy object.
    Response<GreetMeSometimeResponse> resp =
       port.greetMeSometimeAsync(System.getProperty("user.name"));

    while (!resp.isDone())
    {
      // client does some work
    }
    try ❶
    {
      GreetMeSometimeResponse reply = greetMeSomeTimeResp.get();
      // process the response
    }
    catch (ExecutionException ee) ❷
    {
       Throwable cause = ee.getCause(); ❸
       System.out.println("Exception "+cause.getClass().getName()+" thrown
by the remote service.");
    }
  }
}
```

The code in Example 230 does the following:

❶ Wraps the call to the `Response<T>` object's `get()` method in a try/catch block.

❷ Catches a `ExecutionException` exception.

❸ Extracts the `cause` field from the exception.

If the consumer was using the callback approach the code used to catch the exception would be placed in the callback object where the service's response is extracted.

Using Raw XML Messages

The high-level JAX-WS APIs shield the developer from using native XML messages by marshaling the data into JAXB objects. However, there are cases when it is better to have direct access to the raw XML message data that is passing on the wire. The JAX-WS APIs provide two interfaces that provide access to the raw XML: the `Dispatch` interface is the client-side interface, and the `Provider` interface is the server-side interface.

Using XML in a Consumer

The `Dispatch` interface is a low-level JAX-WS API that allows you work directly with raw messages. It accepts and returns messages, or payloads, of a number of types including DOM objects, SOAP messages, and JAXB objects. Because it is a low-level API, the `Dispatch` interface does not perform any of the message preparation that the higher-level JAX-WS APIs perform. You must ensure that the messages, or payloads, that you pass to the `Dispatch` object are properly constructed, and make sense for the remote operation being invoked.

Usage Modes

`Dispatch` objects have two *usage modes*:

- Message mode
- Message Payload mode (Payload mode)

The usage mode you specify for a `Dispatch` object determines the amount of detail that is passed to the user level code.

Message mode

In *message mode*, a `Dispatch` object works with complete messages. A complete message includes any binding specific headers and wrappers. For example, a consumer interacting with a service that requires SOAP messages must provide the `Dispatch` object's `invoke()` method a fully specified SOAP message. The `invoke()` method also returns a fully specified SOAP message. The consumer code is responsible for completing and reading the SOAP message's headers and the SOAP message's envelope information.

TIP: Message mode is not ideal when working with JAXB objects.

To specify that a `Dispatch` object uses message mode provide the value `java.xml.ws.Service.Mode.MESSAGE` when creating the `Dispatch` object. For more information about creating a `Dispatch` object see Creating a Dispatch object.

Payload mode

In *payload mode*, also called message payload mode, a `Dispatch` object works with only the payload of a message. For example, a `Dispatch` object working in payload mode works only with the body of a SOAP message. The binding layer processes any binding level wrappers and headers. When a result is returned from the `invoke()` method the binding level wrappers and headers are already striped away, and only the body of the message is left.

TIP: When working with a binding that does not use special wrappers, such as the Artix XML binding, payload mode and message mode provide the same results.

To specify that a `Dispatch` object uses payload mode provide the value `java.xml.ws.Service.Mode.PAYLOAD` when creating the `Dispatch` object. For more information about creating a `Dispatch` object see Creating a Dispatch object.

Data Types

Because `Dispatch` objects are low-level objects, they are not optimized for using the same JAXB generated types as the higher level consumer APIs. `Dispatch` objects work with the following types of objects:

- `javax.xml.transform.Source`
- `javax.xml.soap.SOAPMessage`
- `javax.activation.DataSource`
- JAXB

Using Source objects

A `Dispatch` object accepts and returns objects that are derived from the `javax.xml.transform.Source` interface. `Source` objects are supported by any binding, and in either message mode or payload mode.

`Source` objects are low level objects that hold XML documents. Each `Source` implementation provides methods that access the stored XML documents and then manipulate its contents. The following objects implement the `Source` interface:

* `DOMSource`

  Holds XML messages as a Document Object Model(DOM) tree. The XML message is stored as a set of `Node` objects that are accessed using the `getNode()` method. Nodes can be either updated or added to the DOM tree using the `setNode()` method.

* `SAXSource`

  Holds XML messages as a Simple API for XML (SAX) object. SAX objects contain an `InputSource` object that holds the raw data and an `XMLReader` object that parses the raw data.

* `StreamSource`

  Holds XML messages as a data stream. The data stream can be manipulated the same as any other data stream.

Using SOAPMessage objects

`Dispatch` objects can use `javax.xml.soap.SOAPMessage` objects when the following conditions are true:

* The `Dispatch` object is using the SOAP binding
* The `Dispatch` object is using message mode

A `SOAPMessage` object holds a SOAP message. They contain one `SOAPPart` object and zero or more `AttachmentPart` objects. The `SOAPPart` object contains the SOAP specific portions of the SOAP message including the SOAP envelope, any SOAP headers, and the SOAP message body. The `AttachmentPart` objects contain binary data that is passed as an attachment.

Using DataSource objects

`Dispatch` objects can use objects that implement the `javax.activation.DataSource` interface when the following conditions are true:

* The `Dispatch` object is using the HTTP binding
* The `Dispatch` object is using message mode

`DataSource` objects provide a mechanism for working with MIME typed data from a variety of sources, including URLs, files, and byte arrays.

Using JAXB objects While `Dispatch` objects are intended to be low level APIs that allow you to work with raw messages, they also allow you to work with JAXB objects. To work with JAXB objects a `Dispatch` object must be passed a `JAXBContext` that can marshal and unmarshal the JAXB objects in use. The `JAXBContext` is passed when the `Dispatch` object is created.

You can pass any JAXB object understood by the JAXBContext object as the parameter to the invoke() method. You can also cast the returned message into any JAXB object understood by the JAXBContext object.

For information on creating a JAXBContext object see Using A JAXBContext Object.

Working with Dispatch Objects

Procedure

To use a Dispatch object to invoke a remote service the following sequence should be followed:

1. Create a Dispatch object.
2. Construct a request message.
3. Call the proper invoke() method.
4. Parse the response message.

Creating a Dispatch object

To create a Dispatch object do the following:

- Create a Service object to represent the wsdl:service element that defines the service on which the Dispatch object will make invocations. See Creating a Service Object on page 54.
- Create the Dispatch object using the Service object's createDispatch() method, shown in Example 231.

Example 231. The createDispatch() Method

```
public Dispatch<T> createDispatch(QName portName,
      java.lang.Class<T> type,
      Service.Mode mode)
throws WebServiceException;
```

NOTE: If you are using JAXB objects the method signature for createDispatch() is:

```
public Dispatch<T> createDispatch(QName portName,
      javax.xml.bind.JAXBCont
      Service.Mode mode)
throws WebServiceException;
```

Table 25 describes the parameters for the createDispatch() method.

Table 25. Parameters for createDispatch()

Parameter	Description
portName	Specifies the QName of the wsdl:port element that represents the service provider where the Dispatch object will make invocations.
type	Specifies the data type of the objects used by the Dispatch object. See Data Types. When working with JAXB objects, this parameter specifies the JAXBContext object used to marshal and unmarshal the JAXB objects.
mode	Specifies the usage mode for the Dispatch object. See Usage Modes.

Example 232 shows the code for creating a `Dispatch` object that works with `DOMSource` objects in payload mode.

Example 232. Creating a Dispatch Object

```
package com.iona.demo;

import javax.xml.namespace.QName; import javax.xml.ws.Service;

public class Client
{
  public static void main(String args[])
  {
    QName serviceName = new QName("http://org.apache.cxf", "stockQuoteReporter");
    Service s = Service.create(serviceName);

    QName portName = new QName("http://org.apache.cxf", "stockQuoteReporterPort");
    Dispatch<DOMSource> dispatch = s.createDispatch(portName,
                                              DOMSource.class,
                                              Service.Mode.PAYLOAD);
    ...
```

Constructing request messages

When working with `Dispatch` objects, requests must be built from scratch.

The developer is responsible for ensuring that the messages passed to a `Dispatch` object match a request that the targeted service provider can process. This requires precise knowledge about the messages used by the service provider and what, if any, header information it requires.

This information can be provided by a WSDL document or an XML Schema document that defines the messages. While service providers vary greatly there are a few guidelines to be followed:

- The root element of the request is based in the value of the `name` attribute of the `wsdl:operation` element corresponding to the operation being invoked.

WARNING: If the service being invoked uses doc/literal bare messages, the root element of the request is based on the value of the `name` attribute of the `wsdl:part` element referred to by the `wsdl:operation` element.

IMPORTANT: The children of top-level elements may be namespace qualified. To be certain you must check their schema definitions.

- If the service being invoked uses rpc/literal messages, none of the top-level elements can be null.

- If the service being invoked uses doc/literal messages, the schema definition of the message determines if any of the elements are namespace qualified.

For more information about how services use XML messages see the WS-I Basic Profile at http://www.ws-i.org/Profiles/BasicProfile-1.0-2004-04-16.html.

Synchronous invocation

For consumers that make synchronous invocations that generate a response, use the `Dispatch` object's `invoke()` method shown in Example 233.

Example 233. The Dispatch.invoke() Method

```
T invoke(T msg) throws WebServiceException;
```

The type of both the response and the request passed to the `invoke()` method are determined when the `Dispatch` object is created. For example if you create a `Dispatch` object using `createDispatch(portName, SOAPMessage.class, Service.Mode.MESSAGE)`, both the response and the request are `SOAPMessage` objects.

NOTE: When using JAXB objects, both the response and the request can be of any type the provided `JAXBContext` object can marshal and unmarshal. Also, the response and the request can be different JAXB objects.

Example 234 shows code for making a synchronous invocation on a remote service using a `DOMSource` object.

Example 234. Making a Synchronous Invocation Using a Dispatch Object

```
// Creating a DOMSource Object for the request
DocumentBuilder db = DocumentBuilderFactory.newDocumentBuilder();
Document requestDoc = db.newDocument();
Element root = requestDoc.createElementNS("http://org.apache.cxf/stockExample",
            "getStockPrice");
root.setNodeValue("DOW");
DOMSource request = new DOMSource(requestDoc);

// Dispatch disp created previously DOMSource response = disp.invoke(request);
```

Asynchronous invocation

`Dispatch` objects also support asynchronous invocations. As with the higher level asynchronous APIs discussed in Developing Asynchronous Applications, `Dispatch` objects can use both the polling approach and the callback approach.

When using the polling approach, the `invokeAsync()` method returns a `Response<t>` object that can be polled to see if the response has arrived. Example 235 shows the signature of the method used to make an asynchronous invocation using the polling approach.

Example 235. The Dispatch.invokeAsync() Method for Polling

```
Response <T> invokeAsync(T msg)
             throws WebServiceException;
```

For detailed information on using the polling approach for asynchronous invocations see Implementing an Asynchronous Client with the Polling Approach.

When using the callback approach, the `invokeAsync()` method takes an `AsyncHandler` implementation that processes the response when it is returned. Example 236 shows the signature of the method used to make an asynchronous invocation using the callback approach.

Example 236. The Dispatch.invokeAsync() Method Using a Callback

```
Future<?> invokeAsync(T msg, AsyncHandler<T> handler)
            throws WebServiceException;
```

For detailed information on using the callback approach for asynchronous invocations see Implementing an Asynchronous Client with the Callback Approach.

NOTE: As with the synchronous `invoke()` method, the type of the response and the type of the request are determined when you create

the `Dispatch` object.

Oneway invocation

When a request does not generate a response, make remote invocations using the `Dispatch` object's `invokeOneWay()`. Example 237 shows the signature for this method.

Example 237. The Dispatch.invokeOneWay() Method

```
void invokeOneWay(T msg)
                  throws WebServiceException;
```

The type of object used to package the request is determined when the `Dispatch` object is created. For example if the `Dispatch` object is created using `createDispatch(portName, DOMSource.class, Service.Mode.PAYLOAD)`, then the request is packaged into a `DOMSource` object.

NOTE: When using JAXB objects, the response and the request can be of any type the provided `JAXBContext` object can marshal and unmarshal.

Example 238 shows code for making a oneway invocation on a remote service using a JAXB object.

Example 238. Making a One Way Invocation Using a Dispatch Object

```
// Creating a JAXBContext and an Unmarshaler for the request
JAXBContext jbc = JAXBContext.newInstance("org.apache.cxf.StockExample");
Unmarshaler u = jbc.createUnmarshaler();

// Read the request from disk
File rf = new File("request.xml");
GetStockPrice request = (GetStockPrice)u.unmarshal(rf);

// Dispatch disp created previously
disp.invokeOneWay(request);
```

Using XML in a Service Provider

The `Provider` interface is a low-level JAX-WS API that allows you to implement a service provider that works directly with messages as raw XML. The messages are not packaged into JAXB objects before being passed to an object that implements the `Provider` interface.

Messaging Modes

Objects that implement the `Provider` interface have two *messaging modes*:

- Message mode
- Payload mode

The messaging mode you specify determines the level of messaging detail that is passed to your implementation.

Message mode

When using *message mode*, a `Provider` implementation works with complete messages. A complete message includes any binding specific headers and wrappers. For example, a `Provider` implementation that uses a SOAP binding receives requests as fully specified SOAP message. Any response returned from the implementation must be a fully specified SOAP message.

To specify that a `Provider` implementation uses message mode provide the value `java.xml.ws.Service.Mode.MESSAGE` as the value to the `javax.xml.ws.ServiceMode` annotation, as shown in Example 239.

Example 239. Specifying that a Provider Implementation Uses Message Mode

```
@WebServiceProvider
@ServiceMode(value=Service.Mode.MESSAGE)
public class stockQuoteProvider implements Provider<SOAPMes sage>
{
  ...
}
```

Payload mode In payload mode a `Provider` implementation works with only the payload of a message. For example, a `Provider` implementation working in payload mode works only with the body of a SOAP message. The binding layer processes any binding level wrappers and headers.

TIP: When working with a binding that does not use special wrappers, such as the Artix XML binding, payload mode and message mode provide the same results.

To specify that a `Provider` implementation uses payload mode by provide the value `java.xml.ws.Service.Mode.PAYLOAD` as the value to the `javax.xml.ws.ServiceMode` annotation, as shown in Example 240.

Example 240. Specifying that a Provider Implementation Uses Payload Mode

```
@WebServiceProvider
@ServiceMode(value=Service.Mode.PAYLOAD)
public class stockQuoteProvider implements Provider<DOMSource>
{
  ...
}
```

TIP: If you do not provide a value for the `@ServiceMode` annotation, the `Provider` implementation uses payload mode..

Data Types

Because they are low-level objects, `Provider` implementations cannot use the same JAXB generated types as the higher level consumer APIs. `Provider` implementations work with the following types of objects:

- `javax.xml.transform.Source`
- `javax.xml.soap.SOAPMessage`
- `javax.activation.DataSource`

Using Source objects

A `Provider` implementation can accept and return objects that are derived from the `javax.xml.transform.Source` interface. `Source` objects are low level objects that hold XML documents. Each `Source` implementation provides methods that access the stored XML documents and manipulate its contents. The following objects implement the `Source` interface:

- `DOMSource` Holds XML messages as a Document Object Model(DOM) tree. The XML message is stored as a set of `Node` objects that are accessed using the `getNode()` method. Nodes can be either updated or added to the DOM tree using the `setNode()` method.
- `SAXSource` Holds XML messages as a Simple API for XML (SAX) object. SAX objects contain an `InputSource` object that holds the raw data and an `XMLReader` object that parses the raw data.

- `StreamSource` Holds XML messages as a data stream. The data stream can be manipulated the same as any other data stream.

IMPORTANT:

When using `Source` objects the developer is responsible for ensuring that all required binding specific wrappers are added to the message. For example, when interacting with a service expecting SOAP messages, the developer must ensure that the required SOAP envelope is added to the outgoing request and that the SOAP envelope's contents are correct.

Using SOAPMessage objects

`Provider` implementations can use `javax.xml.soap.SOAPMessage` objects when the following conditions are true:

- The `Provider` implementation is using the SOAP binding
- The `Provider` implementation is using message mode

A `SOAPMessage` object holds a SOAP message. They contain one `SOAPPart` object and zero or more `AttachmentPart` objects. The `SOAPPart` object contains the SOAP specific portions of the SOAP message including the SOAP envelope, any SOAP headers, and the SOAP message body. The `AttachmentPart` objects contain binary data that is passed as an attachment.

Using DataSource objects

`Provider` implementations can use objects that implement the `javax.activation.DataSource` interface when the following conditions are true:

- The implementation is using the HTTP binding
- The implementation is using message mode

`DataSource` objects provide a mechanism for working with MIME typed data from a variety of sources, including URLs, files, and byte arrays.

Implementing a Provider Object

The `Provider` interface is relatively easy to implement. It only has one method, `invoke()`, that must be implemented. In addition it has three simple requirements:

- An implementation must have the `@WebServiceProvider` annotation.
- An implementation must have a default public constructor.

- An implementation must implement a typed version of the `Provider` interface.

In other words, you cannot implement a `Provider<T>` interface. You must implement a version of the interface that uses a concrete data type as listed in Data Types. For example, you can implement an instance of a `Provider<SAXSource>`.

The complexity of implementing the `Provider` interface is in the logic handling the request messages and building the proper responses.

Working with messages

Unlike the higher-level SEI based service implementations, `Provider` implementations receive requests as raw XML data, and must send responses as raw XML data. This requires that the developer has intimate knowledge of the messages used by the service being implemented. These details can typically be found in the WSDL document describing the service.

- WS-I Basic Profile (http://www.ws-i.org/Profiles/BasicProfile-1.0-2004-04-16.html) provides guidelines about the messages used by services, including:

  The root element of a request is based in the value of the `name` attribute of the `wsdl:operation` element that corresponds to the operation that is invoked.

WARNING: If the service uses doc/literal bare messages, the root element of the request is based on the value of `name` attribute of the `wsdl:part` element referred to by the `wsdl:operation` element.

- The root element of all messages is namespace qualified.
- If the service uses rpc/literal messages, the top-level elements in the messages are not namespace qualified.

IMPORTANT: The children of top-level elements might be namespace qualified, but to be certain you will must check their schema definitions.

- If the service uses rpc/literal messages, none of the top-level elements can be null.
- If the service uses doc/literal messages, then the schema definition of the message determines if any of the elements are namespace qualified.

The @WebServiceProvider annotation

To be recognized by JAX-WS as a service implementation, a `Provider` implementation must be decorated with the `@WebServiceProvider` annotation.

Table 26 describes the properties that can be set for the `@WebServiceProvider` annotation.

Table 26. @WebServiceProvider Properties

Property	Description
portName	Specifies the value of the name attribute of the wsdl:port element that defines the service's endpoint.
serviceName	Specifies the value of the name attribute of the wsdl:service element that contains the service's endpoint.
targetNamespace	Specifies the targetname space of the service's WSDL definition.
wsdlLocation	Specifies the URI for the WSDL document defining the service.

All of these properties are optional, and are empty by default. If you leave them empty, Artix creates values using information from the implementation class.

Implementing the invoke() method

The `Provider` interface has only one method, `invoke()`, that must be implemented. The `invoke()` method receives the incoming request packaged into the type of object declared by the type of `Provider` interface being implemented, and returns the response message packaged into the same type of object. For example, an implementation of a `Provider<SOAPMessage>` interface receives the request as a `SOAPMessage` object and returns the response as a `SOAPMessage` object.

The messaging mode used by the `Provider` implementation determines the amount of binding specific information the request and the response messages contain. Implementations using message mode receive all of the binding specific wrappers and headers along with the request. They must also add all of the binding specific wrappers and headers to the response message. Implementations using payload mode only receive the body of the request. The XML document returned by an implementation using payload mode is placed into the body of the request message.

Examples

Example 241 shows a `Provider` implementation that works with `SOAPMessage` objects in message mode.

Example 241. Provider<SOAPMessage> Implementation

```
import javax.xml.ws.Provider;
import javax.xml.ws.Service;
import javax.xml.ws.ServiceMode;
import javax.xml.ws.WebServiceProvider;

❶@WebServiceProvider(portName="stockQuoteReporterPort"
      serviceName="stockQuoteReporter")
❷@ServiceMode(value="Service.Mode.MESSAGE")
public class  stockQuoteReporterProvider implements Provider<SOAPMessage>
{
❸public stockQuoteReporterProvider()
  {
  }

❹public SOAPMessage invoke(SOAPMessage request)
  {
❺   SOAPBody requestBody = request.getSOAPBody();
❻   if(requestBody.getElementName.getLocalName.equals("getStockPrice"))
    {
❼     MessageFactory mf = MessageFactory.newInstance();
      SOAPFactory sf = SOAPFactory.newInstance();

❽     SOAPMessage response = mf.createMessage();
      SOAPBody respBody = response.getSOAPBody();
      Name bodyName = sf.createName("getStockPriceResponse");
      respBody.addBodyElement(bodyName);
      SOAPElement respContent = respBody.addChildElement("price");
      respContent.setValue("123.00");
      response.saveChanges();
❾     return response;
    }
    ...
  }
}
```

The code in Example 241 does the following:

❶ Specifies that the following class implements a `Provider` object that implements the service whose `wsdl:service` element is named stockQuoteReporter, and whose `wsdl:port` element is named stockQuoteReporterPort.

❷ Specifies that this `Provider` implementation uses message mode.

❸ Provides the required default public constructor.

❹ Provides an implementation of the `invoke()` method that takes av`SOAPMessage` object and returns a `SOAPMessage` object.

❺ Extracts the request message from the body of the incoming SOAP message.

❻ Checks the root element of the request message to determine how to process the request.

❼ Creates the factories required for building the response.

❽ Builds the SOAP message for the response.

❾ Returns the response as a `SOAPMessage` object.

Example 242 shows an example of a `Provider` implementation using `DOMSource` objects in payload mode.

Example 242. Provider<DOMSource> Implementation

```
import javax.xml.ws.Provider;
import javax.xml.ws.Service;
import javax.xml.ws.ServiceMode;
import javax.xml.ws.WebServiceProvider;

❶@WebServiceProvider(portName="stockQuoteReporterPort"
serviceName="stockQuoteReporter")
❷@ServiceMode(value="Service.Mode.PAYLOAD")
public class  stockQuoteReporterProvider implements Provider<DOMSource>
❸public stockQuoteReporterProvider()
  {
  }

❹public DOMSource invoke(DOMSource request)
  {
    DOMSource response = new DOMSource();
    ...
    return response;
  }
}
```

The code in Example 242 does the following:

❶ Specifies that the class implements a `Provider` object that implements the service whose `wsdl:service` element is named stockQuoteReporter, and whose `wsdl:port` element is named stockQuoteReporterPort.

❷ Specifies that this `Provider` implementation uses payload mode.

❸ Provides the required default public constructor.

❹ Provides an implementation of the `invoke()` method that takes a `DOMSource` object and returns a `DOMSource` object.

Working with Contexts

JAX-WS uses contexts to pass metadata along the messaging chain. This metadata, depending on its scope, is accessible to implementation level code. It is also accessible to JAX-WS handlers that operate on the message below the implementation level.

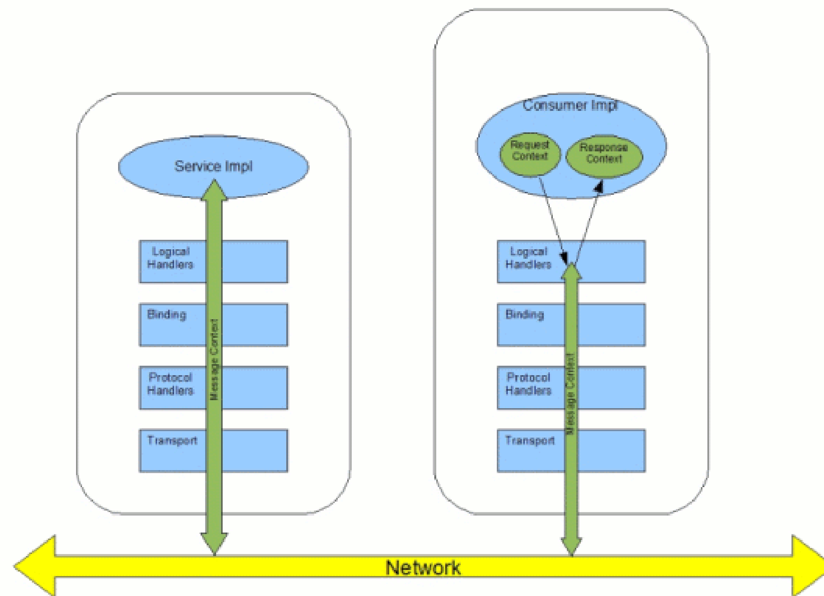
Understanding Contexts

In many instances it is necessary to pass information about a message to other parts of an application. Artix does this using a context mechanism. Contexts are maps that hold properties relating to an outgoing or an incoming message. The properties stored in the context are typically metadata about the message, and the underlying transport used to communicate the message. For example, the transport specific headers used in transmitting the message, such as the HTTP response code or the JMS correlation ID, are stored in the JAX-WS contexts.

The contexts are available at all levels of a JAX-WS application. However, they differ in subtle ways depending upon where in the message processing stack you are accessing the context. JAX-WS `Handler` implementations have direct access to the contexts and can access all properties that are set in them. Service implementations access contexts by having them injected, and can only access properties that are set in the `APPLICATION` scope. Consumer implementations can only access properties that are set in the `APPLICATION` scope.

Figure 1 shows how the context properties pass through Artix. As a message passes through the messaging chain, its associated message context passes along with it.

Figure 1. Message Contexts and Message Processing Path



How properties are stored in a context

The message contexts are all implementations of the `javax.xml.ws.handler.MessageContext` interface. The `MessageContext` interface extends the `java.util.Map<String key, Object value>` interface. `Map` objects store information as key value pairs.

In a message context, properties are stored as name/value pairs. A property's key is a `String` that identifies the property. The value of a property can be any value stored in any Java object. When the value is returned from a message context, the application must know the type to expect and cast accordingly. For example, if a property's value is stored in a `UserInfo` object it is still returned from a message context as an `Object` object that must be cast back into a `UserInfo` object.

Properties in a message context also have a scope. The scope determines where a property can be accessed in the message processing chain.

Property scopes

Properties in a message context are scoped. A property can be in one of the following scopes:

- `APPLICATION`

  Properties scoped as `APPLICATION` are available to JAX-WS `Handler` implementations, consumer implementation code,

and service provider implementation code. If a handler needs to pass a property to the service provider implementation, it sets the property's scope to `APPLICATION`.

All properties set from either the consumer implementation or the service provider implementation contexts are automatically scoped as `APPLICATION`.

- `HANDLER`

  Properties scoped as `HANDLER` are only available to JAX-WS `Handler` implementations. Properties stored in a message context from a `Handler` implementation are scoped as `HANDLER` by default.

  You can change a property's scope using the message context's `setScope()` method. Example 243 shows the method's signature.

Example 243. The MessageContext.setScope() Method

```
void setScope(String key, MessageContext.Scope scope)
   throws java.lang.IllegalArgumentException;
```

The first parameter specifies the property's key. The second parameter specifies the new scope for the property. The scope can be either:

- `MessageContext.Scope.APPLICATION`
- `MessageContext.Scope.HANDLER`

Overview of contexts in handlers

Classes that implement the JAX-WS `Handler` interface have direct access to a message's context information. The message's context information is passed into the `Handler` implementation's `handleMessage()`, `handleFault()`, and `close()` methods.

`Handler` implementations have access to all of the properties stored in the message context, regardless of their scope. In addition, logical handlers use a specialized message context called a `LogicalMessageContext`.

`LogicalMessageContext` objects have methods that access the contents of the message body.

Overview of contexts in service implementations

Service implementations can access properties scoped as `APPLICATION` from the message context. The service provider's implementation object accesses the message context through the `WebServiceContext` object.

For more information see Working with Contexts in a Service Implementation.

Overview of contexts in consumer implementations

Consumer implementations have indirect access to the contents of the message context. The consumer implementation has two separate message contexts:

- Request context — holds a copy of the properties used for outgoing requests
- Response context — holds a copy of the properties from an incoming response

The dispatch layer transfers the properties between the consumer implementation's message contexts and the message context used by the `Handler` implementations.

When a request is passed to the dispatch layer from the consumer implementation, the contents of the request context are copied into the message context that is used by the dispatch layer. When the response is returned from the service, the dispatch layer processes the message and sets the appropriate properties into its message context. After the dispatch layer processes a response, it copies all of the properties scoped as `APPLICATION` in its message context to the consumer implementation's response context.

For more information see Working with Contexts in a Consumer Implementation.

Working with Contexts in a Service Implementation

Context information is made available to service implementations using the `WebServiceContext` interface. From the `WebServiceContext` object you can obtain a `MessageContext` object that is populated with the current request's context properties in the application scope. You can manipulate the values of the properties, and they are propagated back through the response chain.

NOTE: The `MessageContext` interface inherits from the `java.util.Map` interface. Its contents can be manipulated using the `Map` interface's methods.

Obtaining a context To obtain the message context in a service implementation do the following:

1. Declare a variable of type `WebServiceContext`.

2. Decorate the variable with the `javax.annotation.Resource` annotation to indicate that the context information is being injected into the variable.

3. Obtain the `MessageContext` object from the `WebServiceContext` object using the `getMessageContext()` method.

IMPORTANT: `getMessageContext()` can only be used in methods that are decorated with the `@WebMethod` annotation.

Example 244 shows code for obtaining a context object.

Example 244. Obtaining a Context Object in a Service Implementation

```
import javax.xml.ws.*;
import javax.xml.ws.handler.*;
import javax.annotation.*;

@WebServiceProvider
public class WidgetServiceImpl
{
  @Resource WebServiceContext wsc;

  @WebMethod
  public String getColor(String itemNum)
  {
    MessageContext context = wsc.getMessageContext();
  }

  ...
}
```

Reading a property from a context

Once you have obtained the `MessageContext` object for your implementation, you can access the properties stored there using the `get()` method shown in Example 245.

Example 245. The MessageContext.get() Method

```
V get(Object key);
```

This `get()` is inherited from the `Map` interface.

The `key` parameter is the string representing the property you want to retrieve from the context. The `get()` returns an object that must be cast to the proper type for the property. Table 27 lists a number of the properties that are available in a service implementation's context.

IMPORTANT: . Changing the values of the object returned from the context also changes the value of the property in the context.

Example 246 shows code for getting the name of the WSDL `operation` element that represents the invoked operation.

Example 246. Getting a Property from a Service's Message Context

```
import javax.xml.ws.handler.MessageContext;
import org.apache.cxf.message.Message;

  ...
  // MessageContext context retrieved in a previous example
  QName wsdl_operation = (QName)context.get(Message.WSDL_OPERATION);
```

Setting properties in a context

Once you have obtained the `MessageContext` object for your implementation, you can set properties, and change existing properties, using the `put()` method shown in Example 247.

Example 247. The MessageContext.put() Method

```
V put(K key,
      V value)
throws ClassCastException, IllegalArgumentException, NullPointerException;
```

If the property being set already exists in the message context, the `put()` method replaces the existing value with the new value and returns the old value. If the property does not already exist in the message context, the `put()` method sets the property and returns `null`.

Example 248 shows code for setting the response code for an HTTP request.

Example 248. Setting a Property in a Service's Message Context

```
import javax.xml.ws.handler.MessageContext;
import org.apache.cxf.message.Message;

  ...
  // MessageContext context retrieved in a previous example
  context.put(Message.RESPONSE_CODE, new Integer(404));
```

Supported contexts

Table 27 lists the properties accessible through the context in a service implementation object.

Table 27. Properties Available in the Service Implementation Context

Base Class	
Property Name	**Description**
org.apache.cxf.message.Message	
PROTOCOL_HEADERS See note A at foot of table	Specifies the transport specific header information. The value is stored as a java.util.Map<String, List<String>>.
RESPONSE_CODE See note A at foot of table	Specifies the response code returned to the consumer. The value is stored as an Integer object.
ENDPOINT_ADDRESS	Specifies the address of the service provider. The value is stored as a String.
HTTP_REQUEST_METHOD See note A at foot of table	Specifies the HTTP verb sent with a request. The value is stored as a String.
PATH_INFO See note A at foot of table	Specifies the path of the resource being requested. The value is stored as a String. The path is the portion of the URI after the hostname and before any query string. For example, if an endpoint's URI is http://cxf.apache.org/demo/widgets the path is /demo/widgets.
QUERY_STRING See note A at foot of table	Specifies the query, if any, attached to the URI used to invoke the request. The value is stored as a String. Queries appear at the end of the URI after a ?. For example, if a request is made to http://cxf.apache.org/demo/widgets?color the query is color.
MTOM_ENABLED	Specifies whether or not the service provider can use MTOM for SOAP attachments. The value is stored as a Boolean.
SCHEMA_VALIDATION_ENABLED	Specifies whether or not the service provider validates messages against a schema. The value is stored as a Boolean.

Base Class	
Property Name	**Description**
FAULT_STACKTRACE_ENABLED	Specifies if the runtime provides a stack trace along with a fault message. The value is stored as a Boolean.
CONTENT_TYPE	Specifies the MIME type of the message. The value is stored as a String.
BASE_PATH	Specifies the path of the resource being requested. The value is stored as a java.net.URL. The path is the portion of the URI after the hostname and before any query string. For example, if an endpoint's URL is http://cxf.apache.org/demo/widgets the base path is /demo/widgets.
ENCODING	Specifies the encoding of the message. The value is stored as a String.
FIXED_PARAMETER_ORDER	Specifies whether the parameters must appear in the message in a particular order. The value is stored as a Boolean.
MAINTAIN_SESSION	Specifies if the consumer wants to maintain the current session for future requests. The value is stored as a Boolean.
WSDL_DESCRIPTION See note A at foot of table	Specifies the WSDL document that defines the service being implemented. The value is stored as a org.xml.sax.InputSource object.
WSDL_SERVICE See note A at foot of table	Specifies the qualified name of the wsdl:service element that defines the service being implemented. The value is stored as a QName.
WSDL_PORT See note A at foot of table	Specifies the qualified name of the wsdl:port element that defines the endpoint used to access the service. The value is stored as a QName.
WSDL_INTERFACE See note A at foot of table	Specifies the qualified name of the wsdl:portType element that defines the service being implemented. The value is stored as a QName.
WSDL_OPERATION See note A at foot of table	Specifies the qualified name of the wsdl:operation element that corresponds to the operation invoked by the consumer. The value is stored as a QName.

Base Class	
Property Name	**Description**
javax.xml.ws.handler.MessageContext	
MESSAGE_OUTBOUND_PROPERTY	Specifies if a message is outbound. The value is stored as a Boolean. true specifies that a message is outbound.
INBOUND_MESSAGE_ATTACHMENTS	Contains any attachments included in the request message. The value is stored as a java.util.Map<String, DataHandler>. The key value for the map is the MIME Content-ID for the header.
OUTBOUND_MESSAGE_ATTACHMENTS	Contains any attachments for the response message. The value is stored as a java.util.Map<String, DataHandler>. The key value for the map is the MIME Content-ID for the header.
WSDL_DESCRIPTION	Specifies the WSDL document that defines the service being implemented. The value is stored as a org.xml.sax.InputSource object.
WSDL_SERVICE	Specifies the qualified name of the wsdl:service element that defines the service being implemented. The value is stored as a QName.
WSDL_PORT	Specifies the qualified name of the wsdl:port element that defines the endpoint used to access the service. The value is stored as a QName.
WSDL_INTERFACE	Specifies the qualified name of the wsdl:portType element that defines the service being implemented. The value is stored as a QName.
WSDL_OPERATION	Specifies the qualified name of the wsdl:operation element that corresponds to the operation invoked by the consumer. The value is stored as a QName.
HTTP_RESPONSE_CODE	Specifies the response code returned to the consumer. The value is stored as an Integer object.
HTTP_REQUEST_HEADERS	Specifies the HTTP headers on a request. The value is stored as a java.util.Map<String, List<String>>.

Base Class	
Property Name	**Description**
HTTP_RESPONSE_HEADERS	Specifies the HTTP headers for the response. The value is stored as a java.util.Map<String, List<String>>.
HTTP_REQUEST_METHOD	Specifies the HTTP verb sent with a request. The value is stored as a String.
SERVLET_REQUEST	Contains the servlet's request object. The value is stored as a javax.servlet.http.HttpServletRequest.
SERVLET_RESPONSE	Contains the servlet's response object. The value is stored as a javax.servlet.http.HttpResponse.
SERVLET_CONTEXT	Contains the servlet's context object. The value is stored as a javax.servlet.ServletContext.
PATH_INFO	Specifies the path of the resource being requested. The value is stored as a String. The path is the portion of the URI after the hostname and before any query string. For example, if an endpoint's URL is http://cxf.apache.org/demo/widgets the path is /demo/widgets.
QUERY_STRING	Specifies the query, if any, attached to the URI used to invoke the request. The value is stored as a String. Queries appear at the end of the URI after a ?. For example, if a request is made to http://cxf.apache.org/demo/widgets?color the query string is color.
REFERENCE_PARAMETERS	Specifies the WS-Addressing reference parameters. This includes all of the SOAP headers whose wsa:IsReferenceParameter attribute is set to true. The value is stored as a java.util.List.
org.apache.cxf.transport.jms.JMSConstants	
JMS_SERVER_HEADERS	Contains the JMS message headers. For more information see Working with JMS Message Properties.

[A] When using HTTP this property is the same as the standard JAX-WS defined property.

Working with Contexts in a Consumer Implementation

Consumer implementations have access to context information through the `BindingProvider` interface. The `BindingProvider` instance holds context information in two separate contexts:

- Request Context

  The *request context* enables you to set properties that affect outbound messages. Request context properties are applied to a specific port instance and, once set, the properties affect every subsequent operation invocation made on the port, until such time as a property is explicitly cleared. For example, you might use a request context property to set a connection timeout or to initialize data for sending in a header.

- Response Context

  The *response context* enables you to read the property values set by the response to the last operation invocation made from the current thread. Response context properties are reset after every operation invocation. For example, you might access a response context property to read header information received from the last inbound message.

IMPORTANT: Only information that is placed in the application scope of a message context can be accessed by the consumer implementation.

Obtaining a context

Contexts are obtained using the `javax.xml.ws.BindingProvider` interface.

The `BindingProvider` interface has two methods for obtaining a context:

- `getRequestContext()`

  The `getRequestContext()` method, shown in Example 249, returns the request context as a `Map` object. The returned `Map` object can be used to directly manipulate the contents of the context.

Example 249. The getRequestContext() Method

```
Map<String, Object> getRequestContext();
```

- `getResponseContext()`

  The `getResponseContext()`, shown in Example 250, returns the response context as a `Map` object. The returned `Map` object's contents reflect the state of the response context's contents from the most recent successful request on a remote service made in the current thread.

Example 240. The getResponseContext() Method

```
Map<String, Object> getResponseContext();
```

Since proxy objects implement the `BindingProvider` interface, a `BindingProvider` object can be obtained by casting a proxy object. The contexts obtained from the `BindingProvider` object are only valid for operations invoked on the proxy object used to create it.

Example 251 shows code for obtaining the request context for a proxy.

Example 251. Getting a Consumer's Request Context

```
// Proxy widgetProxy obtained previously BindingProvider bp =
(BindingProvider)widgetProxy;
Map<String, Object> responseContext = bp.getResponseContext();
```

Reading a property from a context

Consumer contexts are stored in `java.util.Map<String, Object>` objects.

The map has keys that are String objects and values that contain arbitrary objects. Use `java.util.Map.get()` to access an entry in the map of response context properties.

To retrieve a particular context property, `ContextPropertyName`, use the code shown in Example 252.

Example 252. Reading a Response Context Property

```
// Invoke an operation. port.SomeOperation();

// Read response context property.
java.util.Map<String, Object> responseContext =
  ((javax.xml.ws.BindingProvider)port).getResponseContext();
PropertyType propValue = (PropertyType) responseContext.get(ContextPropertyName);
```

Setting properties in a context

Consumer contexts are hash maps stored in `java.util.Map<String, Object>` objects. The map has keys that are String objects and values that are arbitrary objects. To set a property in a context use the `java.util.Map.put()` method.

TIP: While you can set properties in both the request context and the response context, only the changes made to the request context have any impact on message processing. The properties in the response context are reset when each remote invocation is completed on the current thread.

Example 253. Setting a Request Context Property

```
// Set request context property. java.util.Map<String, Object>
requestContext =
     ((javax.xml.ws.BindingProvider)port).getRequestContext();
requestContext.put(BindingProvider.ENDPOINT_ADDRESS_PROPERTY,
"http://localhost:8080/wid gets");

// Invoke an operation.
port.SomeOperation();
```

IMPORTANT: Once a property is set in the request context its value is used for all subsequent remote invocations. You can change the value and the changed value will then be used.

Supported contexts

Artix supports the following context properties in consumer implementations:

Table 28. Consumer Context Properties

Base Class	
Property Name	**Description**
`javax.xml.ws.BindingProvider`	
`ENDPOINT_ADDRESS_PROPERTY`	Specifies the address of the target service. The value is stored as a `String`.
`USERNAME_PROPERTY` See note A	Specifies the username used for HTTP basic authentication. The value is stored as a `String`.
`PASSWORD_PROPERTY` See note B	Specifies the password used for HTTP basic authentication. The value is stored as a `String`.
`SESSION_MAINTAIN_PROPERTY` See note C	Specifies if the client wants to maintain session information. The value is stored as a `Boolean` object.

Base Class	
Property Name	**Description**
org.apache.cxf.ws.addressing.JAXWSAConstants	
CLIENT_ADDRESSING_PROPERTIES	Specifies the WS-Addressing information used by the consumer to contact the desired service provider. The value is stored as a org.apache.cxf.ws.addressing.AddressingProperties.
org.apache.cxf.transports.jms.context.JMSConstants	
JMS_CLIENT_REQUEST_HEADERS	Contains the JMS headers for the message. For more information see Working with JMS Message Properties.

A This property is overridden by the username defined in the HTTP security settings.

B This property is overridden by the password defined in the HTTP security settings.

C The Artix ignores this property.

Working with JMS Message Properties

The Artix JMS transport has a context mechanism that can be used to inspect a JMS message's properties. The context mechanism can also be used to set a JMS message's properties.

Inspecting JMS Message Headers

Consumers and services use different context mechanisms to access the JMS message header properties. However, both mechanisms return the header properties as a `org.apache.cxf.transports.jms.context.JMSMessageHeadersType` object.

Getting the JMS Message Headers in a Service

To get the JMS message header properties from the `WebServiceContext` object, do the following:

1. Obtain the context as described in Obtaining a context.

2. Get the message headers from the message context using the message context's `get()` method with the parameter `org.apache.cxf.transports.jms.JMSConstants.JMS_SERVER_HEADERS`.

Example 254 shows code for getting the JMS message headers from a service's message context:

Example 254. Getting JMS Message Headers in a Service Implementation

```
import org.apache.cxf.transport.jms.JMSConstants;
import org.apache.cxf.transports.jms.context.JMSMessageHeadersType;

@WebService(serviceName = "HelloWorldService",
                           portName = "HelloWorldPort", endpointInterface
                           = "org.apache.cxf.hello_world_jms.HelloWorld
                           PortType", targetNamespace =
                           "http://cxf.apache.org/hello_world_jms") public
                           class GreeterImplTwoWayJMS implements
                           HelloWorldPortType
  {
    @Resource
    protected WebServiceContext wsContext;
    ...

    @WebMethod
    public String greetMe(String me)
    {
      MessageContext mc = wsContext.getMessageContext();
      JMSMessageHeadersType headers = (JMSMessageHeadersType)
mc.get(JMSConstants.JMS_SERV ER_HEADERS);
.
.
.
     }
      ...
}
```

Getting JMS Message Header Properties in a Consumer

Once a message is successfully retrieved from the JMS transport you can inspect the JMS header properties using the consumer's response context. In addition, you can see how long the client waits for a response before timing out.

You can To get the JMS message headers from a consumer's response context do the following:

1. Get the response context as described in Obtaining a context.

2. Get the JMS message header properties from the response context using the context's `get()` method with `org.apache.cxf.transports.jms.JMSConstants.JMS_CLIENT_RESPONSE_HEADERS` as the parameter.

Example 255 shows code for getting the JMS message header properties from a consumer's response context.

Example 255. Getting the JMS Headers from a Consumer Response Header

```
import org.apache.cxf.transports.jms.context.*;
// Proxy greeter initialized previously
❶BindingProvider  bp = (BindingProvider)greeter;
❷Map<String, Object> responseContext = bp.getResponseContext();
❸JMSMessageHeadersType responseHdr = (JMSMessageHeadersType)
                   responseContext.get(JMSConstants.JMS_CLIENT_REQUEST_HEADERS);
...
}
```

The code in Example 255 does the following:

❶ Casts the proxy to a `BindingProvider`.

❷ Gets the response context.

❸ Retrieves the JMS message headers from the response context.

Inspecting the Message Header Properties

Standard JMS Header Properties

Table 29 lists the standard properties in the JMS header that you can inspect.

Table 29. JMS Header Properties

Property Name	Property Type	Getter Method
Correlation ID	string	`getJMSCorralationID()`
Delivery Mode	int	`getJMSDeliveryMode()`
Message Expiration	long	`getJMSExpiration()`
Message ID	string	`getJMSMessageID()`
Priority	int	`getJMSPriority()`
Redelivered	boolean	`getJMSRedlivered()`
Time Stamp	long	`getJMSTimeStamp()`
Type	string	`getJMSType()`
Time To Live	long	`getTimeToLive()`

Optional Header Properties

In addition, you can inspect any optional properties stored in the JMS header using `JMSMessageHeadersType.getProperty()`. The optional properties are returned as a `List` of `org.apache.cxf.transports.jms.context.JMSPropertyType`. Optional properties are stored as name/value pairs.

Example

Example 256 shows code for inspecting some of the JMS properties using the response context.

Example 256. Reading the JMS Header Properties

```
// JMSMessageHeadersType messageHdr retrieved previously
❶System.out.println("Correlation ID: "+messageHdr.getJMSCorrelationID());
❷System.out.println("Message Priority: "+messageHdr.getJMSPriority());
❸System.out.println("Redelivered: "+messageHdr.getRedelivered());

JMSPropertyType prop = null;
❹List<JMSPropertyType> optProps = messageHdr.getProperty();
❺Iterator<JMSPropertyType> iter = optProps.iterator();
❻while (iter.hasNext())
{
  prop = iter.next();
   System.out.println("Property name: "+prop.getName());
   System.out.println("Property value: "+prop.getValue());
}
```

The code in Example 256 does the following:

❶ Prints the value of the message's correlation ID.

❷ Prints the value of the message's priority property.

❸ Prints the value of the message's redelivered property.

❹ Gets the list of the message's optional header properties.

❺ Gets an `Iterator` to traverse the list of properties.

❻ Iterates through the list of optional properties and prints their name and value.

Setting JMS Properties

Using the request context in a consumer endpoint, you can set a number of the JMS message header properties and the consumer endpoint's timeout value. These properties are valid for a single invocation. You must reset them each time you invoke an operation on the service proxy.

NOTE: You cannot set header properties in a service.

JMS Header Properties

Table 30 lists the properties in the JMS header that can be set using the consumer endpoint's request context.

Table 30. Settable JMS Header Properties

Property Name	Property Type	Setter Method
Correlation ID	string	`setJMSCorralationID()`
Delivery Mode	int	`setJMSDeliveryMode()`
Priority	int	`setJMSPriority()`
Time To Live	long	`setTimeToLive()`

To set these properties do the following:

1. Create an `org.apache.cxf.transports.jms.context.JMSMessageHeadersType` object.
2. Populate the values you want to set using the appropriate setter methods described in Table 30.
3. Set the values to the request context by calling the request context's `put()` method using `org.apache.cxf.transports.jms.JMSConstants.JMS_CLIENT_REQUEST_HEADERS` as the first argument, and the new `JMSMessageHeadersType` object as the second argument.

Optional JMS Header Properties

You can also set optional properties to the JMS header. Optional JMS header properties are stored in the `JMSMessageHeadersType` object that is used to set the other JMS header properties. They are stored as a `List` object containing `org.apache.cxf.transports.jms.context.JMSPropertyType` objects. To add optional properties to the JMS header do the following:

1. Create a `JMSPropertyType` object.
2. Set the property's name field using `setName()`.
3. Set the property's value field using `setValue()`.
4. Add the property to the JMS message header using `JMSMessageHeadersType.getProperty().add(JMSPropertyType)`.

5. Repeat the procedure until all of the properties have been added to the message header.

Client Receive Timeout

In addition to the JMS header properties, you can set the amount of time a consumer endpoint waits for a response before timing out. You set the value by calling the request context's `put()` method with `org.apache.cxf.transports.jms.JMSConstants.JMS_CLIENT_RECEIVE_TIMEOUT` as the first argument and a long representing the amount of time in milliseconds that you want the consumer to wait as the second argument.

Example

Example 257 shows code for setting some of the JMS properties using the request context.

Example 257. Setting JMS Properties using the Request Context

```
import org.apache.cxf.transports.jms.context.*;
 // Proxy greeter initialized previously
❶InvocationHandler handler = Proxy.getInvocationHandler(greeter);


BindingProvider bp= null;
❷if (handler instanceof BindingProvider)
{
❸bp = (BindingProvider)handler;
❹Map<String, Object> requestContext = bp.getRequestContext();

❺JMSMessageHeadersType requestHdr = new JMSMessageHeadersType();
❻requestHdr.setJMSCorrelationID("WithBob");
❼requestHdr.setJMSExpiration(3600000L);


❽JMSPropertyType prop = new JMSPropertyType;
   prop.setName("MyProperty");
   prop.setValue("Bluebird");
❾requestHdr.getProperty().add(prop);
❿requestContext.put(JMSConstants.CLIENT_REQUEST_HEADERS, requestHdr);
 requestContext.put(JMSConstants.CLIENT_RECEIVE_TIMEOUT, new Long(1000));
```

The code in Example 257 does the following:

❶ Gets the `InvocationHandler` for the proxy whose JMS properties you want to change.

❷ Checks to see if the `InvocationHandler` is a `BindingProvider`.

❸ Casts the returned `InvocationHandler` object into a `BindingProvider` object to retrieve the request context.

❹ Gets the request context.

❺ Creates a `JMSMessageHeadersType` object to hold the new message header values.

❻ Sets the Correlation ID.

❼ Sets the Expiration property to 60 minutes.

❽ Creates a new `JMSPropertyType` object.

❾ Sets the values for the optional property, and adds the optional property to the message header.

❿ Sets the JMS message header values into the request context; and xets the client receive timeout property to 1 second.

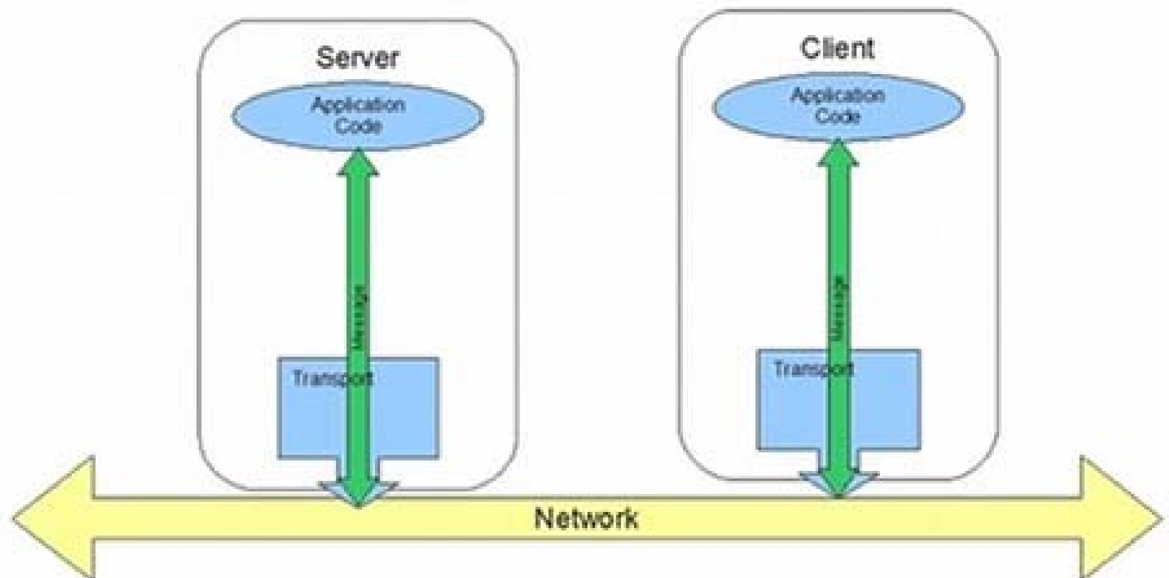
Writing Handlers

JAX-WS provides a flexible plug-in framework for adding message processing modules to an application. These modules, known as handlers, are independent of the application level code and can provide low-level message processing capabilities.

Handlers: An Introduction

When a service proxy invokes an operation on a service, the operation's parameters are passed to Artix where they are built into a message and placed on the wire. When the message is received by the service, Artix reads the message from the wire, reconstructs the message, and then passes the operation parameters to the application code responsible for implementing the operation. When the application code is finished processing the request, the reply message undergoes a similar chain of events on its trip to the service proxy that originated the request. This is shown in Figure 2.

Figure 2. Message Exchange Path

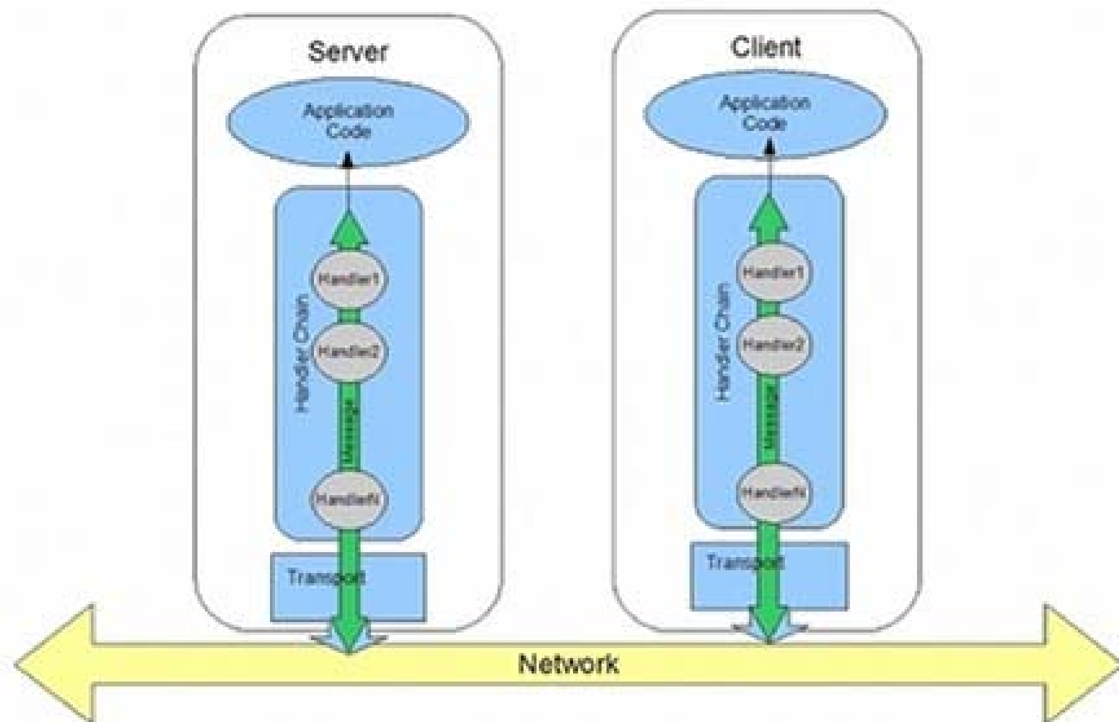


JAX-WS defines a mechanism for manipulating the message data between the application level code and the network. For example, you might want the message data passed over the open network to be encrypted using a proprietary encryption mechanism. You could write a JAX-WS handler that encrypted

and decrypted the data. Then you could insert the handler into the message processing chains of all clients and servers.

As shown in Figure 3, the handlers are placed in a chain that is traversed between the application level code and the transport code that places the message onto the network.

Figure 3. Message Exchange Path with Handlers



Handler types

The JAX-WS specification defines two basic handler types:
Logical Handler

Logical handlers can process the message payload and the properties stored in the message context. For example, if the application uses pure XML messages, the logical handlers have access to the entire message. If the application uses SOAP messages, the logical handlers have access to the contents of the SOAP body. They do not have access to either the SOAP headers or any attachments unless they were placed into the message context.

Logical handlers are placed closest to the application code on the handler chain. This means that they are executed first when a message is passed from the application code to the transport. When a message is received from the network and passed back to the application code, the logical handlers are executed last.

Protocol Handler

Protocol handlers can process the entire message received from the network and the properties stored in the message context. For example, if the application uses SOAP messages, the protocol handlers would have access to the contents of the SOAP body, the SOAP headers, and any attachments.

Protocol handlers are placed closest to the transport on the handler chain. This means that they are executed first when a message is received from the network. When a message is sent to the network from the application code, the protocol handlers are executed last.

TIP: The only protocol handler supported by Artix is specific to SOAP.

Implementation of handlers

The differences between the two handler types are very subtle and they share a common base interface. Because of their common parentage, logical handlers and protocol handlers share a number of methods that must be implemented, including:

- handleMessage()

  The `handleMessage()` method is the central method in any handler. It is the method responsible for processing normal messages.

- handleFault()

  `handleFault()` is the method responsible for processing fault messages.

- close()

  `close()` is called on all executed handlers in a handler chain when a message has reached the end of the chain. It is used to clean up any resources consumed during message processing.

The differences between the implementation of a logical handler and the implementation of a protocol handler revolve around the following:

- The specific interface that is implemented

All handlers implement an interface that derives from the `Handler` interface. Logical handlers implement the `LogicalHandler` interface. Protocol handlers implement protocol specific extensions of the `Handler` interface. For example, SOAP handlers implement the `SOAPHandler` interface.

- The amount of information available to the handler

  Protocol handlers have access to the contents of messages and all of the protocol specific information that is packaged with the message content. Logical handlers can only access the contents of the message. Logical handlers have no knowledge of protocol details.

Adding handlers to an application

To add a handler to an application you must do the following:

1. Determine whether the handler is going to be used on the service providers, the consumers, or both.
2. Determine which type of handler is the most appropriate for the job.
3. Implement the proper interface.

   To implement a logical handler see Implementing a Logical Handler.

   To implement a protocol handler see Implementing a Protocol Handler.
4. Configure your endpoint(s) to use the handlers.

Implementing a Logical Handler

Logical handlers implement the `javax.xml.ws.handler.LogicalHandler` interface. The `LogicalHandler` interface, shown in Example 258 passes a `LogicalMessageContext` object to the `handleMessage()` method and the `handleFault()` method. The context object provides access to the *body* of the message and to any properties set into the message exchange's context.

Example 268. LogicalHandler Synopsis

```
public interface LogicalHandler extends Handler
{
  boolean handleMessage(LogicalMessageContext context);
  boolean handleFault(LogicalMessageContext context);
  void close(LogicalMessageContext context);
}
```

Procedure

To implement a logical hander you do the following:

1. Implement any initialization logic required by the handler.
2. Implement the message handling logic.
3. Implement the fault handling logic.
4. Implement the logic for closing the handler when it is finished.
5. Implement any logic for cleaning up the handler's resources before it is destroyed.

Handling Messages in a Logical Handler

Normal message processing is handled by the `handleMessage()` method.

The `handleMessage()` method receives a `LogicalMessageHandler` object that provides access to the message body and any properties stored in the message context.

The `handleMessage()` method returns either `true` or `false` depending on how message processing is to continue. It can also throw an exception.

Getting the message data

The `LogicalMessageContext` object passed into logical message handlers allows access to the message body using the context's `getMessage()` method.

The `getMessage()` method, shown in Example 259, returns the message payload as a `LogicalMessage` object.

Example 259. Method for Getting the Message Payload in a Logical Handler

```
LogicalMessage getMessage();
```

Once you have the `LogicalMessage` object, you can use it to manipulate the message body. The `LogicalMessage` interface, shown in Example 260, has getters and setters for working with the actual message body.

Example 260. Logical Message Holder

```
LogicalMessage {
  Source getPayload();
  Object getPayload(JAXBContext context);
  void setPayload(Object payload, JAXBContext context);
  void setPayload(Source payload);
}
```

IMPORTANT: The contents of the message payload are determined by the type of binding in use. The SOAP binding only allows access to the SOAP body of the message. The XML binding allows access to the entire message body.

Working with the message body as an XML object

One pair of getters and setters of the logical message work with the message payload as a `javax.xml.transform.dom.DOMSource` object.

The `getPayload()` method that has no parameters returns the message payload as a `DOMSource` object. The returned object is the actual message payload. Any changes made to the returned object change the message body immediately.

You can replace the body of the message with a `DOMSource` object using the `setPayload()` method that takes the single `Source` object.

Working with the message body as a JAXB object

The other pair of getters and setters allow you to work with the message payload as a JAXB object. They use a `JAXBContext` object to transform the message payload into JAXB objects.

To use the JAXB objects you do the following:

1. Get a `JAXBContext` object that can manage the data types in the message body.

   For information on creating a `JAXBContext` object see *Using A* JAXBContext Object.

2. Get the message body as shown in Example 261.

Example 261. Getting the Message Body as a JAXB Object

```
JAXBContext jaxbc = JAXBContext(myObjectFactory.class);
Object body = message.getPayload(jaxbc);
```

3. Cast the returned object to the proper type.

4. Manipulate the message body as needed.

5. Put the updated message body back into the context as shown in Example 262.

Example 262. Updating the Message Body Using a JAXB Object

```
message.setPayload(body, jaxbc);
```

Working with context properties

The logical message context passed into a logical handler is an instance of the application's message context and can access all of the properties stored in it. Handlers have access to properties at both the `APPLICATION` scope and the `HANDLER` scope.

Like the application's message context, the logical message context is a subclass of Java `Map`. To access the properties stored in the context, you use the `get()` method and `put()` method inherited from the `Map` interface.

By default, any properties you set in the message context from inside a logical handler are assigned a scope of `HANDLER`. If you want the application code to be able to access the property you need to use the context's `setScope()` method to explicitly set the property's scope to `APPLICATION`.

For more information on working with properties in the message context see Understanding Contexts.

Determining the direction of the message

It is often important to know the direction a message is passing through the handler chain. For example, you would want to retrieve a security token from incoming requests and attach a security token to an outgoing response.

The direction of the message is stored in the message context's outbound message property. You retrieve the outbound message property from the message context using the `MessageContext.MESSAGE_OUTBOUND_PROPERTY` key as shown in Example 263.

Example 263. Getting the Message's Direction from the SOAP Message Context

```
Boolean outbound;
outbound = (Boolean)smc.get(MessageContext.MESSAGE_OUT BOUND_PROPERTY);
```

The property is stored as a `Boolean` object. You can use the object's `booleanValue()` method to determine the property's value. If the property is set to `true`, the message is outbound. If the property is set to `false` the message is inbound.

Determining the return value

How the `handleMessage()` method completes its message processing has a direct impact on how message processing proceeds. It can complete by doing one of the following actions:

1. Return `true`—Returning `true` signals to the Artix runtime that message processing should continue normally. The next handler, if any, has its `handleMessage()` invoked.

2. Return `false`—Returning `false` signals to the Artix runtime that normal message processing must stop. How the runtime proceeds depends on the message exchange pattern in use for the current message.

   For request-response message exchanges the following happens:

   a. The direction of message processing is reversed.

      For example, if a request is being processed by a service provider, the message stops progressing toward the service's implementation object. Instead, it is sent back towards the binding for return to the consumer that originated the request.

   b. Any message handlers that reside along the handler chain in the new processing direction have their `handleMessage()` method invoked in the order in which they reside in the chain.

   c. When the message reaches the end of the handler chain it is dispatched.

   For one-way message exchanges the following happens:

   a. Message processing stops.

   b. All previously invoked message handlers have their `close()` method invoked.

   c. The message is dispatched.

3. Throw a `ProtocolException` exception—Throwing a `ProtocolException` exception, or a subclass of this exception, signals the Artix runtime that fault message processing is beginning. How the runtime proceeds depends on the message exchange pattern in use for the current message.

   For request-response message exchanges the following happens:

   a. If the handler has not already created a fault message, the runtime wraps the message in a fault message.

   b. The direction of message processing is reversed.

      For example, if a request is being processed by a service provider, the message stops progressing toward the service's implementation object. Instead, it is sent back towards the binding for return to the consumer that originated the request.

c. Any message handlers that reside along the handler chain in the new processing direction have their `handleFault()` method invoked in the order in which they reside in the chain.

d. When the fault message reaches the end of the handler chain it is dispatched.

For one-way message exchanges the following happens:

a. If the handler has not already created a fault message, the runtime wraps the message in a fault message.

b. Message processing stops.

c. All previously invoked message handlers have their `close()` method invoked.

d. The fault message is dispatched.

4. Throw any other runtime exception—Throwing a runtime exception other than a `ProtocolException` exception signals the Artix runtime that message processing is to stop. All previously invoked message handlers have the `close()` method invoked and the exception is dispatched. If the message is part of a request-response message exchange, the exception is dispatched so that it is returned to the consumer that originated the request.

Example

Example 264 shows an implementation of `handleMessage()` message for a logical message handler that is used by a service consumer. It processes requests before they are sent to the service provider.

Example 264. Logical Message Handler Message Processing

```
public class SmallNumberHandler implements LogicalHandler<LogicalMessageContext>
{
    public final boolean handleMessage(LogicalMessageContext messageContext)
    {
        try
        {
            boolean outbound = (Boolean)messageContext.get(MessageContext.MESSAGE_OUT
BOUND_PROPERTY);
            if (outbound) ❶
            {
                LogicalMessage msg = messageContext.getMessage(); ❷

                JAXBContext jaxbContext =
                JAXBContext.newInstance(ObjectFactory.class);
                Object payload = msg.getPayload(jaxbContext); ❸
                if (payload instanceof JAXBElement)
                {
                    payload = ((JAXBElement)payload).getValue();
                }
                if (payload instanceof AddNumbers) ❹
                {
                    AddNumbers req = (AddNumbers)payload;
```

```
                int a = req.getArg0(); int b = req.getArg1(); int answer = a + b;
                if (answer < 20) ❺
                {
                  AddNumbersResponse resp = new AddNumbersResponse(); ❻
                  resp.setReturn(answer);
                  msg.setPayload(new
                  ObjectFactory().createAddNumbersResponse(resp),
                                                jaxbContext);
                  return false; ❼
                }
            }
            else
            {
               throw new WebServiceException("Bad Request"); ❽
            }
        }
        return true; ❾
    }
    catch (JAXBException ex) ❿
    {
        throw new ProtocolException(ex);
    }
  }
...
}
```

The code in Example 264 does the following:

❶ Checks if the message is an outbound request. If the message is an outbound request, the handler does additional message processing.

❷ Gets the `LogicalMessage` representation of the message payload from the message context.

❸ Gets the actual message payload as a JAXB object.

❹ Checks to make sure the request is of the correct type. If it is, the handler continues processing the message.

❺ Checks the value of the sum. If it is less than the threshold of 20 then it builds a response and returns it to the client.

❻ Builds the response.

❼ Returns `false` to stop message processing and return the response to the client.

❽ Throws a runtime exception if the message is not of the correct type. This exception is returned to the client.

❾ Returns `true` if the message is an inbound response or the sum does not meet the threshold. Message processing continues normally.

➓ Throws a `ProtocolException` if a JAXB marshaling error is encountered. The exception is passed back to the client after it is processed by the `handleFault()` method of the handlers between the current handler and the client.

Implementing a Protocol Handler

Protocol handlers are specific to the protocol in use. Artix provides the SOAP protocol handler as specified by JAX-WS. A SOAP protocol handler implements the `javax.xml.ws.handler.soap.SOAPHandler` interface.

The `SOAPHandler` interface, shown in Example 265, uses a SOAP specific message context that provides access to the message as a `SOAPMessage` object. It also allows you to access the SOAP headers.

Example 265. SOAPHandler Synopsis

```
public interface SOAPHandler extends Handler
{
  boolean handleMessage(SOAPMessageContext context);
  boolean handleFault(SOAPMessageContext context);
  void close(SOAPMessageContext context);
  Set<QName> getHeaders()
}
```

In addition to using a SOAP specific message context, SOAP protocol handlers require that you implement an additional method called `getHeaders()`. This additional method returns the QNames of the header blocks the handler can process.

Procedure

To implement a logical hander do the following:

1. Implement any initialization logic required by the handler.
2. Implement the message handling logic.
3. Implement the fault handling logic.
4. Implement the `getHeaders()` method.
5. Implement the logic for closing the handler when it is finished.
6. Implement any logic for cleaning up the handler's resources before it is destroyed.

Implementing the getHeaders() method

The `getHeaders()`, shown in Example 266, method informs the Artix runtime what SOAP headers the handler is responsible for processing. It returns the QNames of the outer element of each SOAP header the handler understands.

Example 266. The SOAPHander.getHeaders() Method

```
Set<QName> getHeaders();
```

For many cases simply returning `null` is sufficient. However, if the application uses the `mustUnderstand` attribute of any of the SOAP headers, then it is important to specify the headers understood by the application's SOAP handlers. The runtime checks the set of SOAP headers that all of the registered handlers understand against the list of headers with the `mustUnderstand` attribute set to `true`. If any of the flagged headers are not in the list of understood headers, the runtime rejects the message and throws a SOAP must understand exception.

Handling Messages in a SOAP Handler

Normal message processing is handled by the `handleMessage()` method.

The `handleMessage()` method receives a `SOAPMessageHandler` object that provides access to the message body as a `SOAPMessage` object and the SOAP headers associated with the message. In addition, the context provides access to any properties stored in the message context.

The `handleMessage()` method returns either `true` or `false` depending on how message processing is to continue. It can also throw an exception.

Working with the message body

You can get the SOAP message using the SOAP message context's `getMessage()` method. It returns the message as a live `SOAPMessage` object. Any changes to the message in the handler are automatically reflected in the message stored in the context.

If you wish to replace the existing message with a new one, you can use the context's `setMessage()` method. The `setMessage()` method takes a `SOAPMessage` object.

Getting the SOAP headers

You can access the SOAP message's headers using the `SOAPMessage` object's `getHeader()` method. This will return the SOAP header as a `SOAPHeader` object that you will need to inspect to find the header elements you wish to process.

The SOAP message context provides a `getHeaders()` method, shown in Example 267, that will return an array containing JAXB objects for the specified SOAP headers.

Example 267. The SOAPMessageContext.getHeaders() Method

```
Object[] getHeaders(QName header,
                    JAXBContext context,
                    boolean allRoles);
```

You specify the headers using the QName of their element. You can further limit the headers that are returned by setting the `allRoles` parameter to `false`. That instructs the runtime to only return the SOAP headers that are applicable to the active SOAP roles.

If no headers are found, the method returns an empty array.

For more information about instantiating a `JAXBContext` object see *Using A* JAXBContext Object.

Working with context properties

The SOAP message context passed into a logical handler is an instance of the application's message context and can access all of the properties stored in it. Handlers have access to properties at both the `APPLICATION` scope and the `Handler` scope.

Like the application's message context, the SOAP message context is a subclass of Java `Map`. To access the properties stored in the context, you use the `get()` method and `put()` method inherited from the `Map` interface.

By default, any properties you set in the context from inside a logical handler will be assigned a scope of `HANDLER`. If you want the application code to be able to access the property you need to use the context's `setScope()` method to explicitly set the property's scope to `APPLICATION`.

For more information on working with properties in the message context see Understanding Contexts.

Determining the direction of the message

It is often important to know the direction a message is passing through the handler chain. For example, you would want to add headers to an outgoing message and strip headers from an incoming message.

The direction of the message is stored in the message context's outbound message property. You retrieve the outbound message property from the message context using the `MessageContext.MESSAGE_OUTBOUND_PROPERTY` key as shown in Example 268.

Example 268. Getting the Message's Direction from the SOAP Message Context

```
Boolean outbound;
outbound = (Boolean)smc.get(MessageContext.MESSAGE_OUT
BOUND_PROPERTY);
```

The property is stored as a `Boolean` object. You can use the object's `booleanValue()` method to determine the property's value. If the property is set to `true`, the message is outbound. If the property is set to `false` the message is inbound.

Determining the return value

How the `handleMessage()` method completes its message processing has a direct impact on how message processing proceeds. It can complete by doing one of the following actions:

1. return `true`—Returning `true` signals to the Artix runtime that message processing should continue normally. The next handler, if any, has its `handleMessage()` invoked.

2. return `false`—Returning `false` signals to the Artix runtime that normal message processing is to stop. How the runtime proceeds depends on the message exchange pattern in use for the current message.

   For request-response message exchanges the following happens:

   a. The direction of message processing is reversed.

      For example, if a request is being processed by a service provider, the message will stop progressing toward the service's implementation object. It will instead be sent back towards the binding for return to the consumer that originated the request.

   b. Any message handlers that reside along the handler chain in the new processing direction have their `handleMessage()` method invoked in the order in which they reside in the chain.

   c. When the message reaches the end of the handler chain it is dispatched.

   For one-way message exchanges the following happens:

   a. Message processing stops.

   b. All previously invoked message handlers have their `close()` method invoked.

   c. The message is dispatched.

3. throw a `ProtocolException` exception—Throwing a `ProtocolException` exception, or a subclass of this exception, signals the Artix runtime that fault message processing is to start. How the runtime proceeds depends on the message exchange pattern in use for the current message.

   For request-response message exchanges the following happens:

   a. If the handler has not already created a fault message, the runtime wraps the message in a fault message.

   b. The direction of message processing is reversed.

      For example, if a request is being processed by a service provider, the message will stop progressing toward the service's implementation object. It will be sent back towards the binding for return to the consumer that originated the request.

   c. Any message handlers that reside along the handler chain in the new processing direction have their `handleFault()` method invoked in the order in which they reside in the chain.

   d. When the fault message reaches the end of the handler chain it is dispatched.

   For one-way message exchanges the following happens:

   a. If the handler has not already created a fault message, the runtime wraps the message in a fault message.

   b. Message processing stops.

   c. All previously invoked message handlers have their `close()` method invoked.

   d. The fault message is dispatched.

4) throw any other runtime exception—Throwing a runtime exception other than a `ProtocolException` exception signals the Artix runtime that message processing is to stop. All previously invoked message handlers have the `close()` method invoked and the exception is dispatched. If the message is part of a request-response message exchange the exception is dispatched so that it is returned to the consumer that originated the request.

Example

Example 269 shows a `handleMessage()` implementation that prints the SOAP message to the screen.

Example 269. Handling a Message in a SOAP Handler

```
public boolean handleMessage(SOAPMessageContext smc)
{
  PrintStream out;
  Boolean outbound = (Boolean)smc.get(MessageContext.MESSAGE_OUTBOUND_PROPERTY); ❶
  if (outbound.booleanValue()) ❷
  {
    out.println("\nOutbound message:");
  }
  else
  {
    out.println("\nInbound message:");
  }
  SOAPMessage message = smc.getMessage(); ❸
  message.writeTo(out); ❹
  out.println();

  return true;
}
```

The code in Example 269 does the following:

❶ Retrieves the outbound property from the message context.

❷ Tests the messages direction and prints the appropriate message.

❸ Retrieves the SOAP message from the context.

❹ Prints the message to the console.

Initializing a Handler

When the runtime creates an instance of a handler, it creates all of the resources the hander needs to process messages. While you can place all of the logic for doing this in the handler's constructor, it may not be the most appropriate place. The handler framework performs a number of optional steps when it instantiates a handler. You can add resource injection and other initialization logic that will be executed during the optional steps.

TIP: You do not have to provide any initialization methods for a handler.

Order of initialization

The Artix runtime initializes a handler in the following manner:

1. The handler's constructor is called.
2. Any resources that are specified by the `@Resource` annotation are injected.
3. The method decorated with `@PostConstruct` annotation, if it is present, is called.

   Methods decorated with the `@PostConstruct` annotation must have a void return type and have no parameters.
4. The handler is place in the `Ready` state.

Handling Fault Messages

Handlers use the `handleFault()` method for processing fault messages when a `ProtocolException` exception is thrown during message processing.

The `handleFault()` method receives either a `LogicalMessageContext` object or `SOAPMessageContext` object depending on the type of handler. The received context gives the handler's implementation access to the message payload.

The `handleFault()` method returns either `true` or `false`, depending on how fault message processing is to proceed. It can also throw an exception.

Getting the message payload

The context object received by the `handleFault()` method is similar to the one received by the `handleMessage()` method. You use the context's `getMessage()` method to access the message payload in the same way. The only difference is the payload contained in the context.

For more information on working with a `LogicalMessageContext` see Handling Messages in a Logical Handler.

For more information on working with a `SOAPMessageContext` see Handling Messages in a SOAP Handler.

Determining the return value

How the `handleFault()` method completes its message processing has a direct impact on how message processing proceeds. It completes by performing one of the following actions:

- Return `true`

  Returning `true` signals that fault processing should continue normally. The `handleFault()` method of the next handler in the chain will be invoked.

- Return `false`

  Returning `false` signals that fault processing stops. The `close()` method of the handlers that were invoked in processing the current message are invoked and the fault message is dispatched.

- Throw an exception

  Throwing an exception stops fault message processing. The `close()` method of the handlers that were invoked in processing the current message are invoked and the exception is dispatched.

Example

Example 270 shows an implementation of `handleFault()` that prints the message body to the screen.

Example 270. Handling a Fault in a Message Handler

```
public final boolean handleFault(LogicalMessageContext message Context)
{
  System.out.println("handleFault() called with message:");

  LogicalMessage msg=messageContext.getMessage();
  System.out.println(msg.getPayload());

  return true;
}
```

Closing a Handler

When a handler chain is finished processing a message, the runtime calls each executed handler's `close()` method. This is the appropriate place to clean up any resources that were used by the handler during message processing or resetting any properties to a default state.

If a resource needs to persist beyond a single message exchange, you should not clean it up during in the handler's `close()` method.

Releasing a Handler

The runtime releases a handler when the service or service proxy to which the handler is bound is shutdown. The runtime will invoke an optional release method before invoking the handler's destructor. This optional release method can be used to release any resources used by the handler or perform other actions that would not be appropriate in the handler's destructor.

TIP: You do not have to provide any clean-up methods for a handler.

Order of release

The following happens when the handler is released:

1. The handler finishes processing any active messages.
2. The runtime invokes the method decorated with the `@PreDestroy` annotation.
3. This method should clean up any resources used by the handler.
4. The handler's destructor is called.

Configuring Endpoints to Use Handlers

Programmatic Configuration

IMPORTANT: Any handler chains configured using the Spring configuration override the handler chains configured programmaticaly.

Adding a Handler Chain to a Consumer

Adding a handler chain to a consumer involves explicitly building the chain of handlers. Then you set the handler chain directly on the service proxy's `Binding` object.

Procedure

To add a handler chain to a consumer you do the following:

1. Create a `List<Handler>` object to hold the handler chain.
2. Create an instance of each handler that will be added to the chain.
3. Add each of the instantiated handler objects to the list in the order they are to be invoked by the runtime.
4. Get the `Binding` object from the service proxy.

TIP: Artix provides an implementation of the `Binding` interface called `org.apache.cxf.jaxws.binding.DefaultBindingImpl`.

5. Set the handler chain on the proxy using the `Binding` object's `setHandlerChain()` method.

Example

Example 271 shows code for adding a handler chain to a consumer.

Example 271. Adding a Handler Chain to a Consumer

```
import javax.xml.ws.BindingProvider;
import javax.xml.ws.handler.Handler;
import java.util.ArrayList;
import java.util.List;

import org.apache.cxf.jaxws.binding.DefaultBindingImpl;
...
❶ SmallNumberHandler sh = new SmallNumberHandler();
❷ List<Handler> handlerChain = new ArrayList<Handler>();
❸ handlerChain.add(sh);
❹ DefaultBindingImpl binding = ((BindingProvider)proxy).getBinding();
❺ binding.getBinding().setHandlerChain(handlerChain);
```

The code in Example 271 does the following:

❶ Instantiates a handler.

❷ Creates a `List` object to hold the chain.

❸ Adds the handler to the chain.

❹ Gets the `Binding` object from the proxy as a `DefaultBindingImpl` object.

❺ Assigns the handler chain to the proxy's binding.

Adding a Handler Chain to a Service Provider

You add a handler chain to a service provider by decorating either the SEI or the implementation class with the `@HandlerChain` annotation. The annotation points to a meta-data file defining the handler chain used by the service provider.

Procedure

To add handler chain to a service provider you do the following:

1. Decorate the provider's implementation class with the `@HandlerChain` annotation.
2. Create a handler configuration file that defines the handler chain.

The @HandlerChain annotation

The `javax.jws.HandlerChain` annotation decorates service provider's implementation class. It instructs the runtime to load the handler chain configuration file specified by its file property.

The annotation's file property supports two methods for identifying the handler configuration file to load:

- a URL
- a relative path name

Example 272 shows a service provider implementation that will use the handler chain defined in a file called `handlers.xml`. `handlers.xml` must be located in the directory from which the service provider is run.

Example 272. Service Implementation that Loads a Handler Chain

```
import javax.jws.HandlerChain;
import javax.jws.WebService;
...

@WebService(name = "AddNumbers",
            targetNamespace = "http://apache.org/handlers",
            portName = "AddNumbersPort",
            endpointInterface = "org.apache.handlers.AddNumbers",
            serviceName = "AddNumbersService")
@HandlerChain(file = "handlers.xml")
public class AddNumbersImpl implements AddNumbers
{
...
}
```

Handler configuration file

The handler configuration file defines a handler chain using the XML grammar that accompanies JSR 109(Web Services for Java EE, Version 1.2). This grammar is defined in the document at http://java.sun.com/xml/ns/javaee.

The root element of the handler configuration file is the `handler-chains` element. The `handler-chains` element has one or more `handler-chain` elements.

The `handler-chain` element define a handler chain. Table 31 describes the `handler-chain` element's children.

Table 31. Elements Used to Define a Server-Side Handler Chain

Element	Description
`handler`	Contains the elements that describe a handler.
`service-name-pattern`	Specifies the QName of the WSDL service element defining the service to which the handler chain is bound. You can use * as a wildcard when defining the QName.
`port-name-pattern`	Specifies the QName of the WSDL port element defining the endpoint to which the handler chain is bound. You can use * as a wildcard when defining the QName.
`protocol-binding`	Specifies the message binding for which the handler chain is used. The binding is specified as a URI or using one of the following aliases: ##SOAP11_HTTP, ##SOAP11_HTTP_MTOM, ##SOAP12_HTTP, ##SOAP12_HTTP_MTOM, ##XML_HTTP. For more information about message binding URIs see the ***Artix Deployment Guide***.

The `handler-chain` element is only required to have a single `handler` element as a child. It can, however, support as many `handler` elements as needed to define the complete handler chain. The handlers in the chain are executed in the order they specified in the handler chain definition.

IMPORTANT: The final order of execution will be determined by sorting the specified handlers into logical handlers and protocol handlers. Within the groupings, the order specified in the configuration will be used.

The other children, such as `protocol-binding`, are used to limit the scope of the defined handler chain. For example, if you use the `service-name-pattern` element, the handler chain will only be attached to service providers whose WSDL `port` element is a child of the specified WSDL `service` element. You can only use one of these limiting children in a `handler` element.

The `handler` element defines an individual handler in a handler chain. Its `handler-class` child element specifies the fully qualified name of the class implementing the handler. The `handler` element can also have an optional `handler-name` element that specifies a unique name for the handler.

Example 273 shows a handler configuration file that defines a single handler chain. The chain is made up of two handlers.

Example 273. Handler Configuration File

```
<handler-chains xmlns="http://java.sun.com/xml/ns/javaee"
                xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                xsi:schemaLocation="http://java.sun.com/xml/ns/javaee">
<handler-chain>
  <handler>
      <handler-name>LoggingHandler</handler-name>
      <handler-class>demo.handlers.common.LoggingHandler</handler-class>
  </handler>
  <handler>
      <handler-name>AddHeaderHandler</handler-name>
      <handler-class>demo.handlers.common.AddHeaderHandler</handler-class>
  </handler>
</handler-chain>
</handler-chains>
```

Spring Configuration

The easiest way to configure an endpoint to use a handler chain is to define the chain in the endpoint's configuration. This is done by adding a `jaxwxs:handlers` child to the element configuring the endpoint.

IMPORTANT: A handler chain added through the configuration file takes precedence over a handler chain configured programatically.

Procedure

To configure an endpoint to load a handler chain you do the following:

1. If the endpoint does not already have a configuration element, add one.

   For more information on configuring Artix endpoints see *Configuring Artix Endpoints* in ***Artix Deployment Guide***.

2. Add a `jaxws:handlers` child element to the endpoint's configuration element.

3. For each handler in the chain, add a `bean` element specifying the class that implements the handler.

TIP: If your handler implementation is used in more than one place you can reference a `bean` element using the `ref` element.

The handlers element

The `jaxws:handlers` element defines a handler chain in an endpoint's configuration. It can appear as a child to all of the JAX-WS endpoint configuration elements. These are:

- `jaxws:endpoint` configures a service provider.
- `jaxws:server` also configures a service provider.
- `jaxws:client` configures a service consumer.

You add handlers to the handler chain in one of two ways:

- add a `bean` element defining the implementation class
- use a `ref` element to refer to a named `bean` element from elsewhere in the configuration file

The order in which the handlers are defined in the configuration is the order in which they will be executed. The order may be modified if you mix logical handlers and protocol handlers. The run time will sort them into the proper order while maintaining the basic order specified in the configuration.

Example

Example 274 shows the configuration for a service provider that loads a handler chain.

Example 274. Configuring an Endpoint to Use a Handler Chain In Spring

```
<beans ...
  xmlns:jaxws="http://cxf.apache.org/jaxws"
  ...
  schemaLocation="...
    http://cxf.apache.org/jaxws http://cxf.apache.org/schemas/jaxws.xsd...">
  <jaxws:endpoint id="HandlerExample"
                  implementor="org.apache.cxf.example.DemoImpl"
                  address="http://localhost:8080/demo">
    <jaxws:handlers>
       <bean class="demo.handlers.common.LoggingHandler" />
       <bean class="demo.handlers.common.AddHeaderHandler" />
    </jaxws:handlers>
  </jaws:endpoint>
</beans>
```