Technical Brief

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Web Services and NIEM:
Realizing the Value of Available Tools

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Introduction

The National Information Exchange Model (NIEM) is an XML vocabulary that continues to gain popularity as a means to support cross-domain information sharing. NIEM is about the *semantics* of a message, not *transportation* of that message. **Web services** is a term for a group of industry standards that collectively provide a mechanism for exchanging XML-based messages, such as NIEM messages. One of these standards is the **Web Services Description Language** (WSDL), which standardizes the specification and description of a web services interface.

While WSDL is valuable in general as a way to describe the behavioral and information models of services, this brief focuses on the value of WSDL to software developers, who can use WSDL definitions to produce software code for the intersystem sharing of information. This *Technical Brief* will also demonstrate the ability of several available tools to create programming code based on NIEM schemas. In doing so, this brief also demonstrates that the web services tool space — on both the Java and Microsoft .NET platforms — has matured to the point that there are no longer significant barriers to the use of NIEM with web services and WSDL.

In order to effectively establish a web services-based information sharing environment, it is critical that systems have the ability to access and process XML data. A common and efficient way to do this is to leverage the WSDL definition of a service in order to automatically generate programming code (Java, .NET, etc.) that maps to XML constructs that define a service. Several tools exist that can —

- read a WSDL,

- automatically perform the mapping to XML constructs, and

- generate equivalent programming concepts that ultimately enable accessing and processing of XML data.

The code generated by these tools is commonly referred to as **stubs** and **skeletons**. Stubs and skeletons are critical concepts in supporting interaction between distributed systems by bridging the differences between XML structure and the object-orientation of languages such as Java, C#, and VB.NET:

Stubs   serve as a proxy on the service consumer side of an implementation and are responsible for marshalling data (converting from native format source code to an XML instance). Stubs help ensure that only schema-valid XML hits the wire, thus reducing or even eliminating the need to perform downstream XML validation.

Skeletons   serve as a proxy on the service provider side and are responsible for unmarshalling data (converting from an XML instance to native format source code).

Stub and skeleton code allows developers to focus on writing business logic, rather than focusing on low-level processing and parsing of XML messages. The generated code also assists with forming and sending the web services message that "wraps" the XML instance. This is a huge value-add since managing things like XML security headers and the overall SOAP envelope structure can be a tedious and error-prone task to program from scratch. Figure 1 provides a graphical illustration of how stubs and skeletons work.
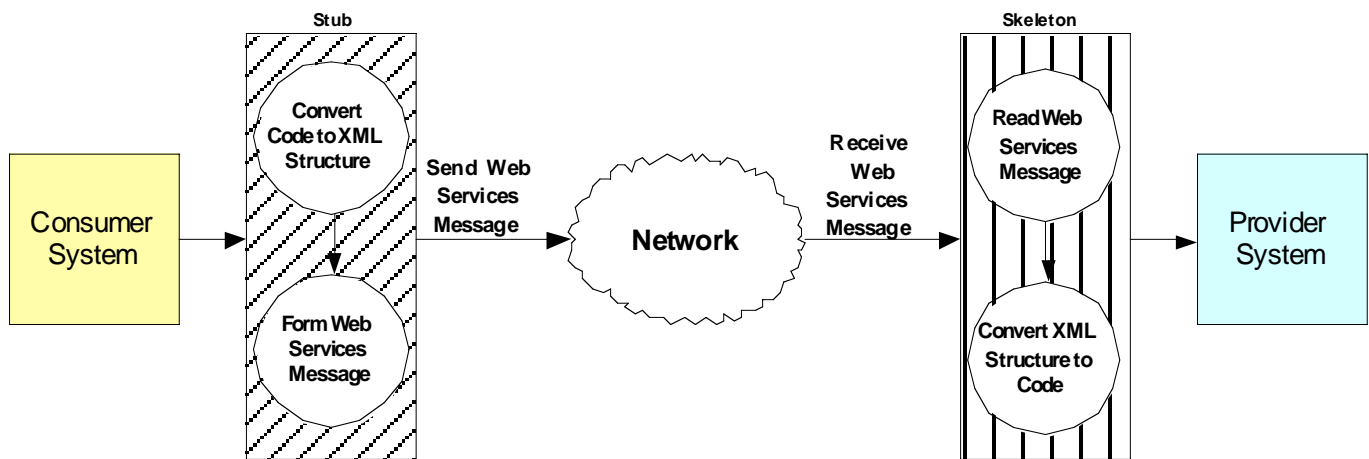

Figure 1: How Stubs and Skeletons Work

In the early days of the NIEM (and even the Global Justice XML Data Model [GJXDM]), some web services code generation tools did not support some of the complex XML schema concepts utilized by these standards. These schema concepts include:

- Substitution groups, including:
  - A substitution group and substitutable elements defined in a single namespace.
  - A substitution group and substitutable elements defined across multiple namespaces.

- Use of *xsd:any* as a means to define the content model of a given type.

- Elements and types with the same name but defined in multiple namespaces.

As time has progressed, so have web services tools and their ability to understand and support the aforementioned complex XML schema concepts. This brief demonstrates how the tools have evolved to handle these XML schema features effectively, and identifies the few places where gaps remain. This information should prove useful to NIEM users who are contemplating using web services standards as the protocols by which they exchange NIEM data.

Intended Audience

This document assumes previous knowledge of using NIEM and web services together and serves as a sequel to the SEARCH *Technical Brief,* "Using NIEM with Web Services."[1] Please be sure that you have read and fully understand the concepts introduced in "Using NIEM with Web Services" before continuing with this document.

This document also assumes familiarity with Apache Ant[2] for those who are interested in recreating the tests mentioned throughout the document.
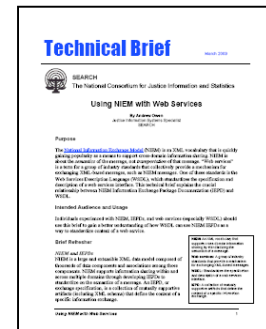
Web Services Tools

To illustrate the fact that certain web services tools support the usage of NIEM schemas in a web services environment, the next section will introduce several code generation tools and explain the outcomes of multiple tests. The tests were performed using a sample WSDL, NIEM schemas, and an Ant build file that are all available at http://www.search.org/programs/info/. The following section explains which targets in the Ant build file are required to test each code generation tool.

The NIEM schemas include the following concepts that have been known to cause code generation tools to fail in the past:

- **Substitution groups** – The example schemas contain the following substitution groups and substitutable elements:

  o `nc:ActivityDateRepresentation`[3] substitution group contains `nc:ActivityDate`.

  o `nc:AddressRepresentation` substitution group contains `nc:AddressFullText`.

  o `nc:DateRepresentation` substitution group contains `nc:Date`.

  o `nc:PersonEyeColor` substitution group contains `nc:PersonEyeColorText`, `nc:PersonEyeColorCode`, and `local:LocalPersonEyeColorText`[4] (this element illustrates an example of cross-namespace substitutions).

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[1] Andrew Owen, *Technical Brief,* "Using NIEM with Web Services" (Sacramento, CA: SEARCH, The National Consortium for Justice Information and Statistics, March 2009), available at http://www.search.org/files/pdf/WSandNIEM-IEPD.pdf.

[2] Apache Ant is a tool for automating software build processes. Read more about Ant at http://ant.apache.org/.

[3] "nc" is the namespace prefix assigned to the niem-core namespace (http://niem.gov/niem/niem-core/2.0) used in this example.

[4] "local" is the namespace prefix assigned to the extension namespace (http://local.gov/IS) used in this example.

- o *nc:PersonHairColor* substitution group contains *nc:PersonHairColorText* and *nc:PersonHairColorCode*.

- o *nc:RoleOf* substitution group contains *nc:RoleOfPersonReference*.

- *xsd:any* – The extension schema namespace defines a type *local:PersonOtherInformationType* with a content model that equals *s:ComplexObjectType* plus *xsd:any*.

- **Elements and types with the same name defined in different namespaces** – The extension schema namespace defines a type, *local:PersonType*, and an element, *local:Person*. The NIEM-core namespace also defines a type, *nc:PersonType*, and an element, *nc:Person*.

Code Generation Tools and Results

Several tools are available that automatically produce stub and skeleton code based on a given WSDL file. Each of these tools relies on particular bindings when generating programming code. A **binding** is essentially a mapping between specific programming concepts and XML schema concepts. Each binding has its own way of producing programming code based on XML schema concepts.

This section introduces three code generation tools — **wsimport**, **wsdl2java**, and **wsdl.exe**; describes the binding(s) those tools use; and describes each tool's ability to correctly react to the complex schema concepts identified earlier in this brief.

wsimport

Background
wsimport,[5] a core capability of the Glassfish Metro[6] project, is a Java-based utility that reads in a WSDL and automatically generates Java code required to implement a given service. Metro is a web services framework that consists of tools and infrastructure for developing web services, and is the reference implementation of the JAX-WS community standard for how to form, send, receive, and process web services messages in Java. More specifically, JAX-WS is a Java application programming interface (API) that supports the creation of Java-based web services.

Supported Binding(s)
wsimport only supports the Java Architecture for XML Binding (JAXB)[7] data binding.

Running the wsimport Example
To automatically generate Java code based on the sample WSDL and schemas, execute the **wsimport** target in the Ant build file included with the sample WSDL and schemas. The Ant build file is preconfigured to automatically run wsimport with the following parameters:

- *keep* – specifies whether to keep the generated source file.

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[5] See https://metro.dev.java.net/1.2/docs/wsimport.html.

[6] See https://metro.dev.java.net/.

[7] See http://java.sun.com/developer/technicalArticles/WebServices/jaxb/.

- *destdir* – specifies where to output generated code.

- *sourcedestdir* – specifies where to place generated source files; this is only used if "*keep*" is set to true.

- *wsdl* – specifies the path location of the WSDL file.

wsimport Test Results

Test	Result	Explanation
Substitution group and substitutable elements defined in a single namespace	**Pass**	wsimport is able to generate code for all of the substitution groups and substitutable elements defined in a single namespace.
Substitution group and substitutable elements defined across multiple namespaces	**Pass**	wsimport is able to generate code for a substitution group when that group has a substitutable element defined in a namespace different than the head element of the substitution group.
Use of $xsd:any$ as a means to define the content model of a given type	**Pass**	wsimport is able to generate code for a complex type whose content model is defined using $xsd:any$.
Elements and types with the same name but defined in multiple namespaces	**Pass**	wsimport is able to generate code for elements and types with the same name but defined in multiple namespaces.

The following is command prompt output produced after successfully executing the **wsimport** target in the build file.

```
C:\code_generation_test\wsdl>ant wsimport
Buildfile: build.xml

wsimport:
 [wsimport] Consider using <depends>/<produces> so that wsimport won't do unnecessary
compilation
 [wsimport] command line: wsimport -d C:\code_generation_test\wsdl\temp\generated-classes
-keep -s C:\code_generation_test\wsdl\generated-src\wsimport -verbose
IncidentSummaryService.wsdl
 [wsimport] parsing WSDL...
 [wsimport]
 [wsimport]
 [wsimport] generating code...
 [wsimport]
 [wsimport] gov\niem\niem\domains\jxdm\_4\EnforcementOfficialType.java
 [wsimport] gov\niem\niem\domains\jxdm\_4\ObjectFactory.java
 [wsimport] gov\niem\niem\domains\jxdm\_4\package-info.java
 [wsimport] gov\niem\niem\niem_core\_2\ActivityType.java
 [wsimport] gov\niem\niem\niem_core\_2\AddressType.java
 [wsimport] gov\niem\niem\niem_core\_2\AssociationType.java
 [wsimport] gov\niem\niem\niem_core\_2\DateType.java
 [wsimport] gov\niem\niem\niem_core\_2\IdentificationType.java
 [wsimport] gov\niem\niem\niem_core\_2\IncidentType.java
 [wsimport] gov\niem\niem\niem_core\_2\LocationType.java
 [wsimport] gov\niem\niem\niem_core\_2\ObjectFactory.java
 [wsimport] gov\niem\niem\niem_core\_2\PersonNameTextType.java
 [wsimport] gov\niem\niem\niem_core\_2\PersonNameType.java
 [wsimport] gov\niem\niem\niem_core\_2\PersonType.java
 [wsimport] gov\niem\niem\niem_core\_2\ProperNameTextType.java
 [wsimport] gov\niem\niem\niem_core\_2\TextType.java
 [wsimport] gov\niem\niem\niem_core\_2\package-info.java
 [wsimport] gov\niem\niem\proxy\xsd\_2\Date.java
 [wsimport] gov\niem\niem\proxy\xsd\_2\ObjectFactory.java
 [wsimport] gov\niem\niem\proxy\xsd\_2\String.java
 [wsimport] gov\niem\niem\proxy\xsd\_2\package-info.java
 [wsimport] gov\local\is\IncidentAssociationType.java
 [wsimport] gov\local\is\IncidentSummaryType.java
 [wsimport] gov\local\is\ObjectFactory.java
 [wsimport] gov\local\is\PersonOtherInformationType.java
 [wsimport] gov\local\is\PersonType.java
 [wsimport] gov\local\is\package-info.java
 [wsimport] gov\local\ws\incidentsummary\IncidentSummaryPort.java
 [wsimport] gov\local\ws\incidentsummary\IncidentSummaryService.java
 [wsimport] gov\niem\niem\appinfo\_2\AppliesTo.java
 [wsimport] gov\niem\niem\appinfo\_2\Base.java
 [wsimport] gov\niem\niem\appinfo\_2\Deprecated.java
 [wsimport] gov\niem\niem\appinfo\_2\ObjectFactory.java
 [wsimport] gov\niem\niem\appinfo\_2\ReferenceTarget.java
 [wsimport] gov\niem\niem\appinfo\_2\Resource.java
 [wsimport] gov\niem\niem\appinfo\_2\package-info.java
 [wsimport] gov\niem\niem\structures\_2\AugmentationType.java
 [wsimport] gov\niem\niem\structures\_2\ComplexObjectType.java
 [wsimport] gov\niem\niem\structures\_2\MetadataType.java
 [wsimport] gov\niem\niem\structures\_2\ObjectFactory.java
 [wsimport] gov\niem\niem\structures\_2\ReferenceType.java
 [wsimport] gov\niem\niem\structures\_2\package-info.java
 [wsimport] gov\niem\niem\fbi\_2\EYECodeSimpleType.java
 [wsimport] gov\niem\niem\fbi\_2\EYECodeType.java
 [wsimport] gov\niem\niem\fbi\_2\HAICodeSimpleType.java
 [wsimport] gov\niem\niem\fbi\_2\HAICodeType.java
 [wsimport] gov\niem\niem\fbi\_2\ObjectFactory.java
 [wsimport] gov\niem\niem\fbi\_2\package-info.java
 [wsimport]
 [wsimport] compiling code...
 [wsimport]
 [wsimport] javac -d C:\code_generation_test\wsdl\temp\generated-classes -classpath
C:\Program
Files\Java\jdk1.6.0_11\lib\tools.jar;C:\GlassFishESBv21\glassfish\lib\activation.jar;C:\G
lassFishESBv21\glassf
ish\lib\javaee.jar;C:\GlassFishESBv21\glassfish\lib\webservices-
```

```
rt.jar;C:\GlassFishESBv21\glassfish\lib\webservices-tools.jar -
Xbootclasspath/p:C:\Program Files\Java\jdk1.6.0_11\jre\lib\endorsed\webservice
s-api.jar;C:\Program Files\Java\jdk1.6.0_11\jre\lib\endorsed\webservices-api.jar
C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\domains\jxdm\_4\EnforcementOfficialType.java C:\code_gener
ation_test\wsdl\generated-src\wsimport\gov\niem\niem\domains\jxdm\_4\ObjectFactory.java
C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\domains\jxdm\_4\package-info.java C:\code_generatio
n_test\wsdl\generated-src\wsimport\gov\niem\niem\niem_core\_2\ActivityType.java
C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\niem_core\_2\AddressType.java C:\code_generation_test\wsdl\
generated-src\wsimport\gov\niem\niem\niem_core\_2\AssociationType.java
C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\niem_core\_2\DateType.java
C:\code_generation_test\wsdl\generated-sr
c\wsimport\gov\niem\niem\niem_core\_2\IdentificationType.java
C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\niem_core\_2\IncidentType.java
C:\code_generation_test\wsdl\generated-src\wsi
mport\gov\niem\niem\niem_core\_2\LocationType.java
C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\niem_core\_2\ObjectFactory.java
C:\code_generation_test\wsdl\generated-src\wsimport\gov\
niem\niem\niem_core\_2\PersonNameTextType.java C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\niem_core\_2\PersonNameType.java
C:\code_generation_test\wsdl\generated-src\wsimport\gov\nie
m\niem\niem_core\_2\PersonType.java C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\niem_core\_2\ProperNameTextType.java
C:\code_generation_test\wsdl\generated-src\wsimport\gov\niem\niem\
niem_core\_2\TextType.java C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\niem_core\_2\package-info.java
C:\code_generation_test\wsdl\generated-src\wsimport\gov\niem\niem\proxy\xsd\_2\Da
te.java C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\proxy\xsd\_2\ObjectFactory.java
C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\proxy\xsd\_2\String.java C:\code_
generation_test\wsdl\generated-src\wsimport\gov\niem\niem\proxy\xsd\_2\package-info.java
C:\code_generation_test\wsdl\generated-
src\wsimport\gov\local\is\IncidentAssociationType.java C:\code_generation_tes
t\wsdl\generated-src\wsimport\gov\local\is\IncidentSummaryType.java
C:\code_generation_test\wsdl\generated-src\wsimport\gov\local\is\ObjectFactory.java
C:\code_generation_test\wsdl\generated-src\wsimport\g
ov\local\is\PersonOtherInformationType.java C:\code_generation_test\wsdl\generated-
src\wsimport\gov\local\is\PersonType.java C:\code_generation_test\wsdl\generated-
src\wsimport\gov\local\is\package-info.ja
va C:\code_generation_test\wsdl\generated-
src\wsimport\gov\local\ws\incidentsummary\IncidentSummaryPort.java
C:\code_generation_test\wsdl\generated-
src\wsimport\gov\local\ws\incidentsummary\IncidentSummary
Service.java C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\appinfo\_2\AppliesTo.java
C:\code_generation_test\wsdl\generated-src\wsimport\gov\niem\niem\appinfo\_2\Base.java
C:\code_gener
ation_test\wsdl\generated-src\wsimport\gov\niem\niem\appinfo\_2\Deprecated.java
C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\appinfo\_2\ObjectFactory.java C:\code_generation_test\wsdl\
generated-src\wsimport\gov\niem\niem\appinfo\_2\ReferenceTarget.java
C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\appinfo\_2\Resource.java
C:\code_generation_test\wsdl\generated-src\ws
import\gov\niem\niem\appinfo\_2\package-info.java C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\structures\_2\AugmentationType.java
C:\code_generation_test\wsdl\generated-src\wsimport\g
ov\niem\niem\structures\_2\ComplexObjectType.java C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\structures\_2\MetadataType.java
C:\code_generation_test\wsdl\generated-src\wsimport\gov\n
iem\niem\structures\_2\ObjectFactory.java C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\structures\_2\ReferenceType.java
C:\code_generation_test\wsdl\generated-src\wsimport\gov\niem\nie
m\structures\_2\package-info.java C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\fbi\_2\EYECodeSimpleType.java
```

```
C:\code_generation_test\wsdl\generated-src\wsimport\gov\niem\niem\fbi\_2\EY
ECodeType.java C:\code_generation_test\wsdl\generated-
src\wsimport\gov\niem\niem\fbi\_2\HAICodeSimpleType.java
C:\code_generation_test\wsdl\generated-src\wsimport\gov\niem\niem\fbi\_2\HAICodeType.java
C:\c
ode_generation_test\wsdl\generated-src\wsimport\gov\niem\niem\fbi\_2\ObjectFactory.java
C:\code_generation_test\wsdl\generated-src\wsimport\gov\niem\niem\fbi\_2\package-
info.java

BUILD SUCCESSFUL
Total time: 2 seconds
```

wsdl2java

Background

wsdl2java, a component of the Apache Axis2[8] project, is a Java utility that reads in a WSDL and automatically generates Java code required to implement a given service. Axis2 is a web services toolset that predates the release of JAX-WS by several years, and as such has an Axis-specific API as well as support for JAX-WS. There are two specific implementations of Axis2: one in the Java programming language and one in the C programming language. This brief focuses only on the Java implementation of Axis2.

Supported Binding(s)

wsdl2java currently supports four separate data bindings: *XMLBeans,*[9] JAXB*, Axis2 Data Binding* (ADB),[10] and JiBX.[11] Because this brief focuses on tools that generate code solely from WSDL and XML schema, and because JiBX requires development of a mapping artifact from XML schema to Java, the Axis JiBX binding is not included in the following analysis. A future brief may address use of JiBX with NIEM web services.

The Ant build file included with the sample files includes four targets to execute wsdl2java, one for each data binding. These targets are:

- *wsdl2java-xmlbeans* – enables the XMLBeans data binding.

- *wsdl2java-jaxbri* – enables the JAXB data binding.

- *wsdl2java-adb* – enables the ADB data binding.

- *wsdl2java-jibx* – enables the JiBX data binding.

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[8] See http://ws.apache.org/axis2/.

[9] See http://xmlbeans.apache.org/.

[10] See http://ws.apache.org/axis2/0_93/adb/adb-howto.html.

[11] See http://jibx.sourceforge.net/.

Running the wsdl2java Example

Each of the four wsdl2java targets in the build file is preconfigured to automatically run wsdl2java with the following parameters:

- **-d** – specifies the data binding; this can be set to **xmlbeans**, **jaxbri**, **adb**, or **jibx**.

- **-o** – specifies the output location for the generated Java code.

- **-uri** – specifies the path location of the WSDL file.

wsdl2java/XMLBeans Test Results

Test	Result	Explanation
Substitution group and substitutable elements defined in a single namespace	**Pass**	wsdl2java/XMLBeans is able to generate code for all of the substitution groups and substitutable elements defined in a single namespace.
Substitution group and substitutable elements defined across multiple namespaces	**Pass**	wsdl2java/XMLBeans is able to generate code for a substitution group when that group has a substitutable element defined in a namespace different than the head element of the substitution group.
Use of $xsd:any$ as a means to define the content model of a given type	**Pass**	wsdl2java/XMLBeans is able to generate code for a complex type whose content model is defined using $xsd:any$.
Elements and types with the same name but defined in multiple namespaces	**Pass**	wsdl2java/XMLBeans is able to generate code for elements and types with the same name but defined in multiple namespaces.

The following is command prompt output produced after executing the **wsdl2java-xmlbeans** target in the build file.

```
C:\code_generation_test\wsdl>ant wsdl2java-xmlbeans
Buildfile: build.xml

wsdl2java-xmlbeans:
   [mkdir] Created dir: C:\code_generation_test\wsdl\generated-src\wsdl2java-xmlbeans
    [exec] Using AXIS2_HOME:  C:\axis2-1.5
    [exec] Using JAVA_HOME:  C:\Program Files\Java\jdk1.6.0_11
    [exec] Retrieving document at 'IncidentSummaryService.wsdl'.
    [exec] Retrieving schema at 'xsd/ExtensionSchema.xsd', relative to
'file:/C:/code_generation_test/wsdl/IncidentSummaryService.wsdl'.
    [exec] Retrieving schema at 'subset/niem/domains/jxdm/4.0/jxdm.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/ExtensionSchema.xsd'.
    [exec] Retrieving schema at '../../../niem-core/2.0/niem-core.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/domains/jxdm/4.0/jxdm.xsd'.
    [exec] Retrieving schema at '../../proxy/xsd/2.0/xsd.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/niem-core/2.0/niem-core.xsd'.
    [exec] Retrieving schema at '../../../appinfo/2.0/appinfo.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/proxy/xsd/2.0/xsd.xsd'.
    [exec] Retrieving schema at '../../../structures/2.0/structures.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/proxy/xsd/2.0/xsd.xsd'.
    [exec] Retrieving schema at '../../appinfo/2.0/appinfo.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/structures/2.0/structures.xsd'.
    [exec] Retrieving schema at '../../appinfo/2.0/appinfo.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/niem-core/2.0/niem-core.xsd'.
    [exec] Retrieving schema at '../../structures/2.0/structures.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/niem-core/2.0/niem-core.xsd'.
    [exec] Retrieving schema at '../../fbi/2.0/fbi.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/niem-core/2.0/niem-core.xsd'.
    [exec] Retrieving schema at '../../appinfo/2.0/appinfo.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/fbi/2.0/fbi.xsd'.
    [exec] Retrieving schema at '../../structures/2.0/structures.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/fbi/2.0/fbi.xsd'.
    [exec] Retrieving schema at '../../../appinfo/2.0/appinfo.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/domains/jxdm/4.0/jxdm.xsd'.
    [exec] Retrieving schema at '../../../structures/2.0/structures.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/domains/jxdm/4.0/jxdm.xsd'.
    [exec] Retrieving schema at 'subset/niem/niem-core/2.0/niem-core.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/ExtensionSchema.xsd'.
    [exec] Retrieving schema at 'subset/niem/structures/2.0/structures.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/ExtensionSchema.xsd'.
    [exec] [INFO] Resolving schema with publicId [http://local.gov/IS] and systemId
[xsd\ExtensionSchema.xsd]
    [exec] [INFO] Resolving schema with publicId [http://niem.gov/niem/structures/2.0]
and systemId [xsd\subset\niem\structures\2.0\structures.xsd]
    [exec] [INFO] Resolving schema with publicId [http://niem.gov/niem/niem-core/2.0]
and systemId [xsd\subset\niem\niem-core\2.0\niem-core.xsd]
    [exec] [INFO] Resolving schema with publicId [http://niem.gov/niem/domains/jxdm/4.0]
and systemId [xsd\subset\niem\domains\jxdm\4.0\jxdm.xsd]
    [exec] [INFO] Resolving schema with publicId [http://niem.gov/niem/appinfo/2.0]
and systemId [xsd\subset\niem\appinfo\2.0\appinfo.xsd]
    [exec] [INFO] Resolving schema with publicId [http://niem.gov/niem/fbi/2.0] and
systemId [xsd\subset\niem\fbi\2.0\fbi.xsd]
    [exec] [INFO] Resolving schema with publicId [http://niem.gov/niem/proxy/xsd/2.0]
and systemId [xsd\subset\niem\proxy\xsd\2.0\xsd.xsd]

BUILD SUCCESSFUL
Total time: 7 seconds
```

wsdl2java/JAXB Test Results

Test	Result	Explanation
Substitution group and substitutable elements defined in a single namespace	**Pass**	wsdl2java/JAXB is able to generate code for all of the substitution groups and substitutable elements defined in a single namespace.
Substitution group and substitutable elements defined across multiple namespaces	**Pass**	wsdl2java/JAXB is able to generate code for a substitution group when that group has a substitutable element defined in a namespace different than the head element of the substitution group.
Use of *xsd:any* as a means to define the content model of a given type	**Pass**	wsdl2java/JAXB is able to generate code for a complex type whose content model is defined using *xsd:any*.
Elements and types with the same name but defined in multiple namespaces	**Pass**	wsdl2java/JAXB is able to generate code for elements and types with the same name but defined in multiple namespaces.

The following is command prompt output produced after executing the **wsdl2java-jaxb** target in the build file.

```
C:\code_generation_test\wsdl>ant wsdl2java-jaxb
Buildfile: build.xml

wsdl2java-jaxb:
  [mkdir] Created dir: C:\code_generation_test\wsdl\generated-src\wsdl2java-jaxb
   [exec] Using AXIS2_HOME:   C:\axis2-1.5
   [exec] Using JAVA_HOME:   C:\Program Files\Java\jdk1.6.0_11
   [exec] Retrieving document at 'IncidentSummaryService.wsdl'.
   [exec] Retrieving schema at 'xsd/ExtensionSchema.xsd', relative to
'file:/C:/code_generation_test/wsdl/IncidentSummaryService.wsdl'.
   [exec] Retrieving schema at 'subset/niem/domains/jxdm/4.0/jxdm.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/ExtensionSchema.xsd'.
   [exec] Retrieving schema at '../../../niem-core/2.0/niem-core.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/domains/jxdm/4.0/jxdm.xsd'.
   [exec] Retrieving schema at '../../proxy/xsd/2.0/xsd.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/niem-core/2.0/niem-core.xsd'.
   [exec] Retrieving schema at '../../../appinfo/2.0/appinfo.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/proxy/xsd/2.0/xsd.xsd'.
   [exec] Retrieving schema at '../../../structures/2.0/structures.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/proxy/xsd/2.0/xsd.xsd'.
   [exec] Retrieving schema at '../../appinfo/2.0/appinfo.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/structures/2.0/structures.xsd'.
   [exec] Retrieving schema at '../../appinfo/2.0/appinfo.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/niem-core/2.0/niem-core.xsd'.
   [exec] Retrieving schema at '../../structures/2.0/structures.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/niem-core/2.0/niem-core.xsd'.
   [exec] Retrieving schema at '../../fbi/2.0/fbi.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/niem-core/2.0/niem-core.xsd'.
   [exec] Retrieving schema at '../../appinfo/2.0/appinfo.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/fbi/2.0/fbi.xsd'.
   [exec] Retrieving schema at '../../structures/2.0/structures.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/fbi/2.0/fbi.xsd'.
   [exec] Retrieving schema at '../../../appinfo/2.0/appinfo.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/domains/jxdm/4.0/jxdm.xsd'.
   [exec] Retrieving schema at '../../../structures/2.0/structures.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/domains/jxdm/4.0/jxdm.xsd'.
   [exec] Retrieving schema at 'subset/niem/niem-core/2.0/niem-core.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/ExtensionSchema.xsd'.
   [exec] Retrieving schema at 'subset/niem/structures/2.0/structures.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/ExtensionSchema.xsd'.

BUILD SUCCESSFUL
Total time: 3 seconds
```

wsdl2java/ADB Test Results

Test	Result	Explanation
Substitution group and substitutable elements defined in a single namespace	**Pass**	wsdl2java/ADB is able to generate code for all of the substitution groups and substitutable elements defined in a single namespace.
Substitution group and substitutable elements defined across multiple namespaces	**Pass**	wsdl2java/ADB is able to generate code for a substitution group when that group has a substitutable element defined in a namespace different than the head element of the substitution group.
Use of $xsd:any$ as a means to define the content model of a given type	**Pass**	wsdl2java/ADB is able to generate code for a complex type whose content model is defined using $xsd:any.$
Elements and types with the same name but defined in multiple namespaces	**Pass**	wsdl2java/ADB is able to generate code for elements and types with the same name but defined in multiple namespaces.

The ADB data binding for wsdl2java successfully produces Java code based on the given WSDL and NIEM schemas. Most importantly, ADB is able to understand and generate code based on the complex schema concepts mentioned earlier in this brief: substitution groups, $xsd:any$, and elements and types named the same but in different namespaces.

The following is command prompt output produced after executing the **wsdl2java-adb** target in the build file.

```
C:\code_generation_test\wsdl>ant wsdl2java-adb
Buildfile: build.xml

wsdl2java-adb:
  [mkdir] Created dir: C:\code_generation_test\wsdl\generated-src\wsdl2java-adb
   [exec] Using AXIS2_HOME:  C:\axis2-1.5
   [exec] Using JAVA_HOME:  C:\Program Files\Java\jdk1.6.0_11
   [exec] Retrieving document at 'IncidentSummaryService.wsdl'.
   [exec] Retrieving schema at 'xsd/ExtensionSchema.xsd', relative to
'file:/C:/code_generation_test/wsdl/IncidentSummaryService.wsdl'.
   [exec] Retrieving schema at 'subset/niem/domains/jxdm/4.0/jxdm.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/ExtensionSchema.xsd'.
   [exec] Retrieving schema at '../../../niem-core/2.0/niem-core.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/domains/jxdm/4.0/jxdm.xsd'.
   [exec] Retrieving schema at '../../proxy/xsd/2.0/xsd.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/niem-core/2.0/niem-core.xsd'.
   [exec] Retrieving schema at '../../../appinfo/2.0/appinfo.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/proxy/xsd/2.0/xsd.xsd'.
   [exec] Retrieving schema at '../../../structures/2.0/structures.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/proxy/xsd/2.0/xsd.xsd'.
   [exec] Retrieving schema at '../../appinfo/2.0/appinfo.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/structures/2.0/structures.xsd'.
   [exec] Retrieving schema at '../../appinfo/2.0/appinfo.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/niem-core/2.0/niem-core.xsd'.
   [exec] Retrieving schema at '../../structures/2.0/structures.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/niem-core/2.0/niem-core.xsd'.
   [exec] Retrieving schema at '../../fbi/2.0/fbi.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/niem-core/2.0/niem-core.xsd'.
   [exec] Retrieving schema at '../../appinfo/2.0/appinfo.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/fbi/2.0/fbi.xsd'.
   [exec] Retrieving schema at '../../structures/2.0/structures.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/fbi/2.0/fbi.xsd'.
   [exec] Retrieving schema at '../../../appinfo/2.0/appinfo.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/domains/jxdm/4.0/jxdm.xsd'.
   [exec] Retrieving schema at '../../../structures/2.0/structures.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/subset/niem/domains/jxdm/4.0/jxdm.xsd'.
```

```
   [exec] Retrieving schema at 'subset/niem/niem-core/2.0/niem-core.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/ExtensionSchema.xsd'.
   [exec] Retrieving schema at 'subset/niem/structures/2.0/structures.xsd', relative to
'file:/C:/code_generation_test/wsdl/xsd/ExtensionSchema.xsd'.
   [exec] [WARN] Type {http://niem.gov/niem/niem-core/2.0}DateRepresentation missing!
   [exec] [WARN] Type {http://niem.gov/niem/niem-core/2.0}PersonEyeColor missing!
   [exec] [WARN] Type {http://niem.gov/niem/niem-core/2.0}PersonHairColor missing!
   [exec] [WARN] Type {http://niem.gov/niem/niem-core/2.0}AddressRepresentation
missing!
   [exec] [WARN] Type {http://niem.gov/niem/niem-core/2.0}ActivityDateRepresentation
missing!
   [exec] [WARN] Could not find any schema type associated with the Element
'{http://niem.gov/niem/niem-core/2.0}PersonHairColor'
   [exec] [WARN] Could not find any schema type associated with the Element
'{http://niem.gov/niem/niem-core/2.0}RoleOf'
   [exec] [WARN] Could not find any schema type associated with the Element
'{http://niem.gov/niem/niem-core/2.0}DateRepresentation'
   [exec] [WARN] Could not find any schema type associated with the Element
'{http://niem.gov/niem/niem-core/2.0}PersonEyeColor'
   [exec] [WARN] Could not find any schema type associated with the Element
'{http://niem.gov/niem/niem-core/2.0}ActivityDateRepresentation'
   [exec] [WARN] Could not find any schema type associated with the Element
'{http://niem.gov/niem/niem-core/2.0}AddressRepresentation'

BUILD SUCCESSFUL
Total time: 2 seconds
```

wsdl.exe

Background
wsdl.exe is a .NET utility distributed with the .NET software development kit (SDK). wsdl.exe reads a WSDL and automatically generates .NET stubs and skeletons for a service. It has the ability to produce C#, Visual Basic, JScript, and Visual J# code.

Supported Binding(s)
There is no standard data binding definition behind wsdl.exe that defines how stub and skeleton code is generated.

Running the wsdl.exe Example
To automatically generate code based on the sample WSDL and schemas, execute the **wsdl-exe** target in the Ant build file included with the sample WSDL and schemas. The Ant build file is preconfigured to automatically run wsdl.exe with the following parameters:

- *wsdl location* – specifies the path location of the wsdl.

- */o:* – specifies output location for generated code.

- */l:* – specifies output programming language; the build file is configured to output C#.

- This target also specifies the location of each XML schema that exists in the NIEM Information Exchange Package Documentation (IEPD); this is necessary, as wsdl.exe does not completely understand `xsd:import` statements in the schemas.

wsdl.exe Test Results

Test	Result	Explanation
Substitution group and substitutable elements defined in a single namespace	**Pass**	wsdl.exe is able to generate code for all of the substitution groups and substitutable elements defined in a single namespace.
Substitution group and substitutable elements defined across multiple namespaces	**Fail**	wsdl.exe is not able to generate code for a substitution group when that group has a substitutable element defined in a namespace different than the head element of the substitution group. This is evident because the generated code does not include an equivalent for the XML element *local:LocalPersonEyeColorText*, which according to schema is substitutable for *nc:PersonEyeColor*.
Use of *xsd:any* as a means to define the content model of a given type	**Pass**	wsdl.exe is able to generate code for a complex type whose content model is defined using *xsd:any*.
Elements and types with the same name but defined in multiple namespaces	**Pass**	wsdl.exe is able to generate code for elements and types with the same name but defined in multiple namespaces.

wsdl.exe is able to handle substitution groups defined in the same namespace, *xsd:any*, and elements and types named the same but in different namespaces.

The following is command prompt output produced after executing the **wsdl-exe** target in the build file.

```
C:\code_generation_test\wsdl>ant wsdl-exe
Buildfile: build.xml

wsdl-exe:
    [exec] Microsoft (R) Web Services Description Language Utility
    [exec] [Microsoft (R) .NET Framework, Version 2.0.50727.42]
    [exec] Copyright (C) Microsoft Corporation. All rights reserved.
    [exec] Writing file 'generated-src/wsdl-exe/IncidentSummaryService.cs'.

BUILD SUCCESSFUL
Total time: 0 seconds
```

Conclusion

Current web services tools, in both the Java and .NET platform worlds, have excellent support for even the more "complex" features that NIEM uses. While there are many factors that go into selection of messaging protocols, lack of tool availability should not be a barrier to selecting web services as a means to transport NIEM messages.

These tools' ability to effectively work with web services supports The Global Justice Information Sharing Initiative's[12] direction with the Global Justice Reference Architecture[13] (JRA), which recommends web services as the set of standard protocols for implementing Service Oriented Architecture (SOA).

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[12] For more background on Global, see http://it.ojp.gov/default.aspx?area=globalJustice.

[13] For more background on the JRA, see http://it.ojp.gov/default.aspx?area=nationalInitiatives&page=1015.

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