Java Server-Side Programming

Web Services

Develop and Deploy Web Services in Tomcat 6

We shall develop web services in JDK and deploy in Tomcat first, and using IDE tools such as Eclipse and NetBeans later.

Server-Side

Step 1: Implement the Web Service

Let us begin by writing a web service, using JAX-WS (Java API for XML - Web Services) provided in JDK 1.6. JAX-WS is the technology for building web services in Java.

- Write a *web service end-point implementation* (SEI) class called `Hello`, in package `helloservice`. Save your source file as "`helloservice\Hello.java`". (You cannot use the default package for SEI.)

```
package helloservice;
import javax.jws.WebService;
import javax.jws.WebMethod;
/**
 * Web Service End-point implementation class
 */

@WebService
public class Hello {
   // Constructor
   public void Hello() {}

   @WebMethod
   public String sayHello(String name) {
      return "Hello, " + name + ".";
   }

   @WebMethod
   public int addNumbers(int number1, int number2) {
      return number1 + number2;
   }

   @WebMethod
   public double divideNumbers(int dividend, int divisor)
         throws DivideNumbersException {
      if (divisor == 0) {
         throw new DivideNumbersException("Divisor cannot be zero!");
      }
      return (double)dividend/divisor;
   }
}
```

  We also need to write the `DivideNumbersException` used in the above program:

```
package helloservice;
public class DivideNumbersException extends Exception {
   public DivideNumbersException(String message) {
      super(message);
   }
}
```

  Explanation:

  - The annotation `@WebService` specifies that this class is meant as a web service.
  - Three methods are annotated with `@WebMethod`. That is, these methods are accessible by the clients.

- Compile the source codes:

```
> cd package-base-directory
> javac helloservice\*.java
```

- Use JDK's `wsgen` tool to generate all the portable artifacts needed for web service deployment and invocation, as follows:

```
> cd package-base-directory
> wsgen -classpath . -keep helloservice.Hello
```

  The following classes will be generated in sub-directory `jaxws` (more precisely, in package `helloservice.jaxws`). The "-keep" option keeps the generated source files.

```
SayHello.class
SayHelloResponse.class
AddNumbers.class
AddNumbersResponse.class
DivideNumbers.class
DivideNumbersExceptionBean.class
DivideNumbersResponse.class
```

  Observe that for each web method exposed, two classes were generated: `*WebMethod*.class` and `*WebMethod*Response.class`. An exception bean was further created for the `DivideNumbersException`.

Step 2: Download and install JAX-WS Runtime for Tomcat

- Download the JAX-WS Runtime from https://jax-ws.dev.java.net. From the "Downloads" link, choose the latest version.
- Download the binary. Unpack the binary by double clicking the downloaded jar file (or run the JDK's `jar` tool).
- Copy all the jar files from the JAX-WS's "`lib`" directory to Tomcat's "`lib`" directory (i.e., "`$CATALINA_HOME\lib`").

Step 3: Deploy the Web Service in Tomcat

- First, create a context (or web application) called `hellows` for our web service in Tomcat, by creating a sub-directory called `hellows` under `$CATALINA_HOME\webapps`. Also create a subdirectory "`WEB-INF`" and sub-sub-directory "`WEB-INF\classes`" under the context root directory.
- Copy all the implementation and generated artifact classes (i.e., the directory `helloservice`) into "`WEB-INF\classes`". (Alternatively, you could create and deploy as a single WAR (Web Archive) file).
- Write the following web configuration file "`web.xml`" and save it in "`WEB-INF`".

```
<?xml version="1.0" encoding="UTF-8"?>
<web-app 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 http://java.sun.com/xml/ns/javaee/web-app_2_5.xsd"
   version="2.5">

  <listener>
    <listener-class>com.sun.xml.ws.transport.http.servlet.WSServletContextListener</listener-class>
  </listener>

  <servlet>
    <servlet-name>HelloService</servlet-name>
    <servlet-class>com.sun.xml.ws.transport.http.servlet.WSServlet</servlet-class>
    <load-on-startup>1</load-on-startup>
  </servlet>

  <servlet-mapping>
    <servlet-name>HelloService</servlet-name>
    <url-pattern>/hello</url-pattern>
  </servlet-mapping>

  <session-config>
    <session-timeout>60</session-timeout>
  </session-config>
</web-app>
```

- Write the following configuration file for JAX-WS called "`sun-jaxws.xml`" and save it in "`WEB-INF`" to define the end-points for the web service:

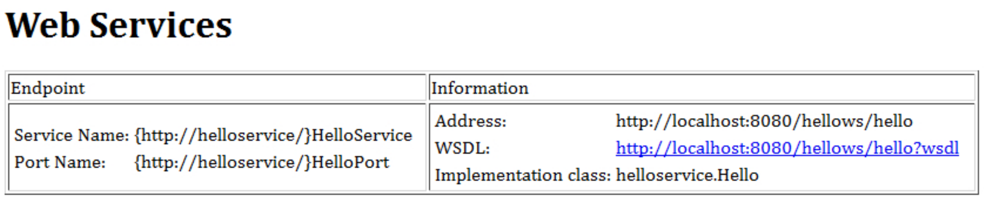
```
<?xml version="1.0" encoding="UTF-8"?>
<endpoints xmlns="http://java.sun.com/xml/ns/jax-ws/ri/runtime" version="2.0">
  <endpoint
    name="HelloService"
    implementation="helloservice.Hello"
    url-pattern="/hello" />
</endpoints>
```

- Start Tomcat. Observe these messages in Tomcat's console:

```
......
xxxxx com.sun.xml.ws.transport.http.servlet.WSServletContextListener contextInitialized
INFO: WSSERVLET12: JAX-WS context listener initializing
xxxxx com.sun.xml.ws.model.RuntimeModeler getRequestWrapperClass
INFO: Dynamically creating request wrapper Class helloservice.jaxws.Hello
xxxxx com.sun.xml.ws.model.RuntimeModeler getResponseWrapperClass
INFO: Dynamically creating response wrapper bean Class helloservice.jaxws.HelloResponse
xxxxx com.sun.xml.ws.transport.http.servlet.WSServletDelegate <init>
INFO: WSSERVLET14: JAX-WS servlet initializing
......
```

- Issue the following URL (assuming that Tomcat is running in port 8080):

```
http://localhost:8080/hellows/hello
```



Web Services

Endpoint	Information
Service Name: {http://helloservice/}HelloService Port Name: {http://helloservice/}HelloPort	Address: http://localhost:8080/hellows/hello WSDL: http://localhost:8080/hellows/hello?wsdl Implementation class: helloservice.Hello

- You could click on the WSDL (Web Service Description Language), to study the descriptions about this web service.

Client-Side

Now, a web service has been published. Let us write a client program (in Java) to access this web service.

- Write the following Java standalone program called `HelloClient`:

```
import javax.xml.ws.WebServiceRef;
import helloservice.HelloService;
import helloservice.Hello;

public class HelloClient {

   @WebServiceRef(wsdlLocation="http://localhost:8080/hellows/hello?wsdl")
   static HelloService service = new HelloService();
   //static HelloService service;

   public static void main(String[] args) {
      try {
         System.out.println("Retrieving the port from the following service: "
            + service);
         Hello port = service.getHelloPort();

         System.out.println("Invoking the sayHello operation on the port.");
         String response = port.sayHello("World");
         System.out.println(response);

         System.out.println("Invoking the addNumbers operation on the port.");
         int sum = port.addNumbers(55, 66);
         System.out.println(sum);
         System.out.println("Invoking the divideNumbers operation on the port.");
         double quotient = port.divideNumbers(1, 0);
         System.out.println(quotient);

      } catch(Exception e) {
         e.printStackTrace();
      }
   }
}
```

Notice that this client program imports some classes from the web service. You cannot compile unless you get these classes.

- Use JDK's `wsimport` tool to generate the client artifacts (i.e., the service endpoint interface and the service interface classes) (the "`-keep`" option keep the generated source files):

```
wsimport -keep http://localhost:8080/hellows/hello?wsdl
```

Observe that these classes (in package `helloservice`) are generated, in particular, `HelloService` and `Hello` class which we used in our client program:

```
AddNumbers.class
AddNumbersResponse.class
DivideNumbers.class
DivideNumbersException.class
DivideNumbersException_Exception.class
DivideNumbersResponse.class
Hello.class
HelloResponse.class
HelloService.class
Hello_Type.class
ObjectFactory.class
package-info.class
SayHello.class
SayHelloResponse.class
```

- Compile and run the client program:

```
Retrieving the port from the following service: helloservice.HelloService@xxxxxx
Invoking the sayHello operation on the port.
Hello, World.
Invoking the addNumbers operation on the port.
121
Invoking the divideNumbers operation on the port.
helloservice.DivideNumbersException_Exception: Divisor cannot be zero!
```

REFERENCES & RESOURCES

- "The Java EE 5 Tutorial for Sun Java System Application Server 9.1" @ http://java.sun.com/javaee/5/docs/tutorial/doc.

Latest version tested: JDK 1.6, Tomcat 6.0.20, JAX-WS 2.1.7
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