Chapter 5

Web Services Description Language

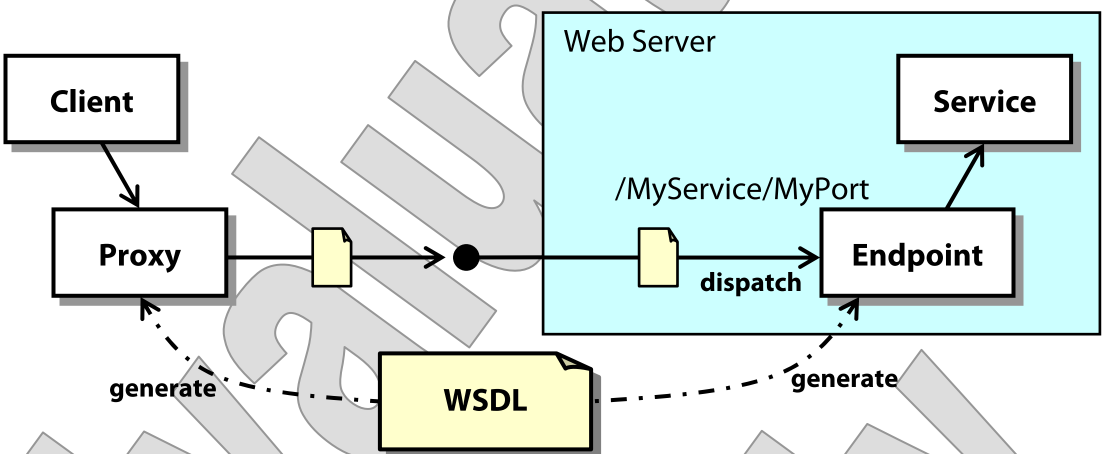
OBJECTIVES

After completing "Web Services Description Language," you will be able to:

- **Explain the importance of providing full metadata for a web service, and how WSDL accomplishes this.**
- **Describe the WSDL model for creating one's own**
  - Abstract service models
  - Concrete service models
- **Write WSDL documents to describe message and service types.**
- **Create bindings for a service description to a specific protocol, such as SOAP.**
- **Generate client code for a WSDL-described service.**

Metadata for Web Services

- As we discussed earlier, web services do not live by SOAP alone.
- Service **description** is a critical element of the architecture; there are several key benefits:
  - Developers can **understand the contract** in which their software will play a part – service, client, or intermediary.
  - One can **generate code** for either service or client development that handles the grunt-work of SOAP messaging:



  - It's possible to **validate** message content at runtime – though this is not necessarily something we'd want to do for each request and response, for performance reasons.
  - Metadata enables **dynamic invocation** and reception of messages, by general-purpose intermediaries or possibly as part of a rapid-application-development tool that helps users build composite applications from a set of available services.

Web Services Description Language

- Broad consensus has formed around the **Web Services Description Language**, or **WSDL**, as the best means of providing the metadata necessary to web services and SOAs.
- WSDL is an XML vocabulary for describing web services.
- A WSDL descriptor defines:
  - **Message types** and their valid content
  - **Operations**, which can include one or more possible message types, in a scenario such as one message type for a request and one for a response
  - Service **interfaces**, essentially compositions of operations
  - Service **implementations** – or perhaps "defines" is the wrong verb for this one; let's say WSDL "identifies" service implementations, which naturally will be written in some other language
  - **Bindings** between interfaces and implementations – in fact the choice of SOAP/HTTP is considered part of this binding, as the interface is not protocol-specific

WSDL Namespaces

- **The WSDL specification defines several namespaces for use in descriptors.**
- **The primary WSDL namespace URI is shown below; the common prefix is `wsdl:`, although descriptor documents often set this namespace as the default.**

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

  – Remember the warning from the SOAP chapter about the importance of that trailing slash ...

- **Each binding of WSDL to a possible messaging protocol is given its own namespace:**
  – The SOAP binding namespace, commonly prefixed **`soap:`**

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

  – The HTTP binding namespace, commonly prefixed **`http:`**

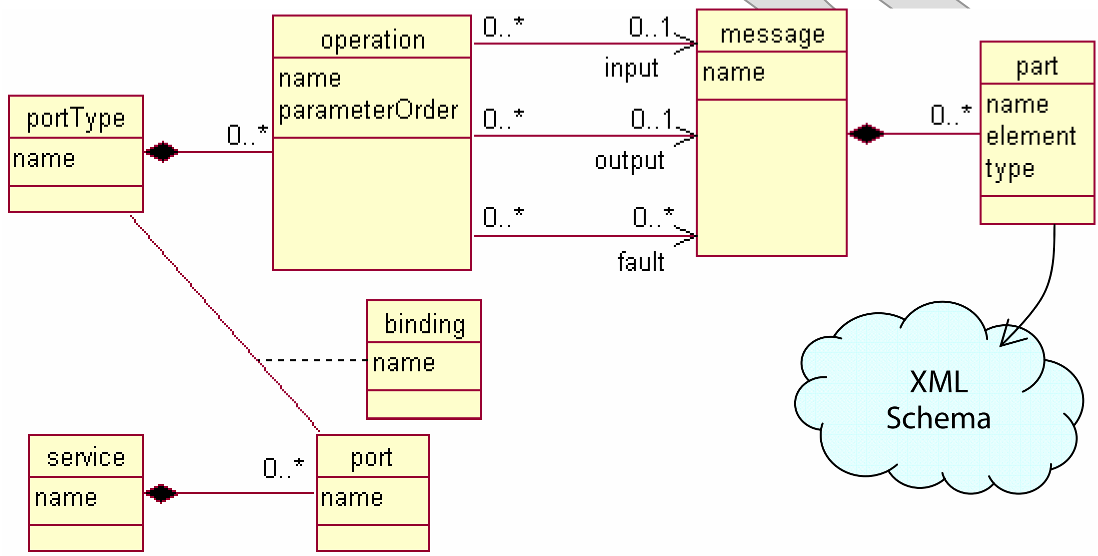
```
http://schemas.xmlsoap.org/wsdl/http/
```

  – The MIME binding namespace, commonly prefixed **`mime:`**

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

The Description Model

- WSDL is an XML vocabulary that uses seven main element types to describe a web service:



- There are components to define an **abstract model** of behavior:
  - A **<portType>** is a named interface to a set of **<operation>**s.
  - Each **<operation>** describes a messaging scenario in terms of **<input>**, **<output>**, and **<fault>** messages.
  - Those **<message>** definitions comprise **<part>**s, which in turn use XML Schema global element and type definitions to fully explain the model of expected message content.
- Then other components can define the **concrete model**:
  - The **<service>** component identifies a web service proper.
  - A service as envisioned by WSDL can offer multiple **<port>**s (though in practice almost all services are single-port).
  - A **<port>** is guaranteed to implement a given **<portType>**, in a specific way that is described by a **<binding>**.

A WSDL Document

EXAMPLE

- Here is a simple WSDL document – find this in **Examples/ Math/JAX-WS/Step2/Service/WSDL/Math.wsdl**:

```
<definitions name="Math"><!-- Namespaces elided.-->
  <types/>
  <message name="Math.Request" >
    <part name="x" type="xsd:double"/>
    <part name="y" type="xsd:double"/>
  </message>
  <message name="Math.Response">
    <part name="return" type="xsd:double"/>
  </message>

  <portType name="Calculator">
    <operation name="Add" parameterOrder="x y">
      <input message="tns:Math.Request"/>
      <output message="tns:Math.Response"/>
    </operation>
    ...
  </portType>

  <!-- We'll look at the binding later. -->

  <service name="Math">
    <port name="Calculator"
          binding="tns: CalculatorBinding">
      <soap:address
        location="SERVER_WILL_COMPLETE"
      />
    </port>
  </service>

</definitions>
```

WSDL and XML Schema

- **A WSDL descriptor is not a W3C XML Schema document.**
- **But it has a close relationship with XML Schema.**
  - A WSDL can embed an XML Schema, using its **`<types>`** component, and elements and types defined in that schema can be used in message **`<part>`**s.
  - A schema so embedded may also **import** other schema.
- **WSDL also follows a number of patterns from XML Schema, and really is of a similar nature.**
  - Both are **metamodels**: i.e. models for defining other models.
  - Both can be said to **populate a namespace** with type information: WSDL models govern web-service messaging interactions, and XML Schema models govern the XML content of a specific document or message.
  - Both WSDL's **`<definitions>`** and Schema's **`<schema>`** components have **targetNamespace** attributes

Associations Between Components

- **Another XML Schema pattern followed by WSDL is the use of both composition and association to connect components.**
  - A `<portType>` is **composed** of `<operation>`s: it has direct child elements that represent the operations it offers.
  - An `<operation>` is **associated** with a `<message>`: it identifies the message by name and that name is matched to the unique name of a message component.
- **You may notice something odd about the way names are matched, though – refer back to Math.wsdl to see this:**
  - The **message** attribute used by an operation's `<input>` component to identify the message will include a namespace prefix.
  - The corresponding `<message>`'s **name** attribute will not.
- **This is the rationale:**
  - When **defining** a component, we're implicitly populating the WSDL's **target namespace**.
  - When **identifying** another component for association, however, there is **no implicit namespace** – nor should there be.
  - One WSDL must populate one namespace, but it might refer to components from many namespaces.
  - This is why, even though it may seem redundant in many cases, attributes that seek to identify other components must be **qualified names**.

The portType and operation Components

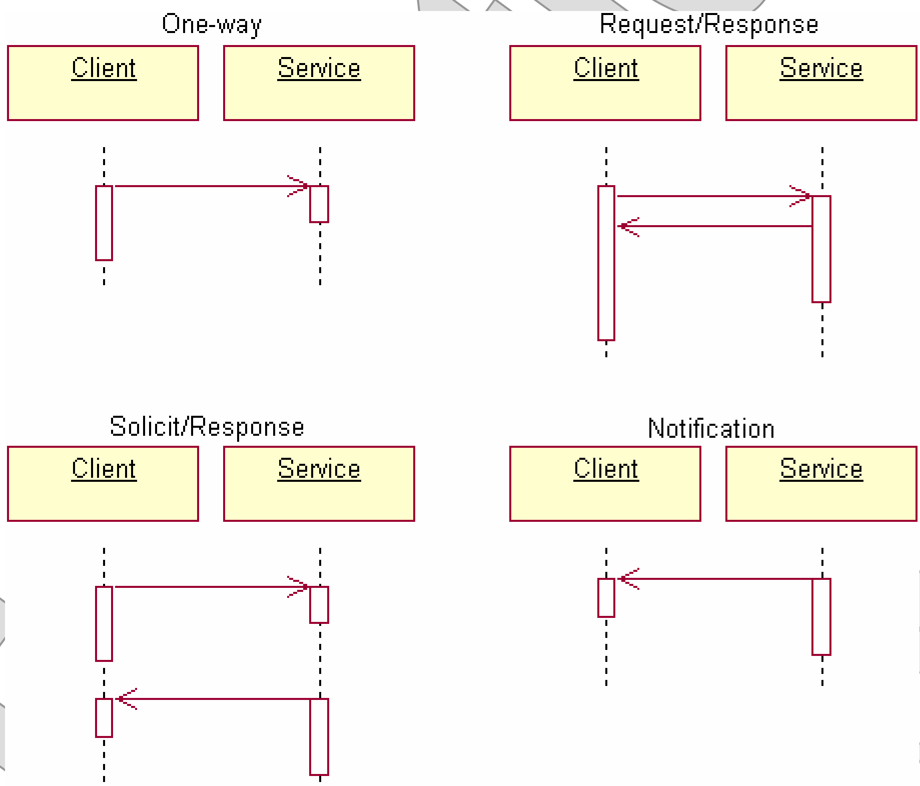
- **A `<portType>` includes any number of `<operation>`s, and it has a name – that's really the whole content model.**
- **`<operation>` is where the interesting stuff happens; it holds:**
  - An optional **`<input>`** message
  - An optional **`<output>`** message
  - Zero-to-many **`<fault>`** messages
- **As `<portType>` indicates an interface, `<operation>` is a method on that interface.**
- **Each input, output, or fault component identifies a `<message>`.**
  - Each can also carry its own unique **`name`**, but this is rarely done for input and output since they are unique by type.
  - Faults are almost always named, even if there's only one.
- **Consider a hypothetical method in a programming language:**

```
double calculateMedian (double[] values);
```

- **"calculateMedian" would be the name of a corresponding WSDL operation, and it would have input and output messages.**
  - One or more faults would correspond to exception signatures.
- **`<operation>` also has a parameterOrder attribute: this is a hint to processors – especially code generators – as to how the multiple parts of input and output messages might be arranged into a method signature.**
  - We'll consider this again when we look at mapping WSDL to Java.

Operation Modes

- You've noticed that both input and output messages are optional.
- WSDL defines four **operation modes**, each of which indicates a different combination of input and output messages and different synchronization characteristics between them.



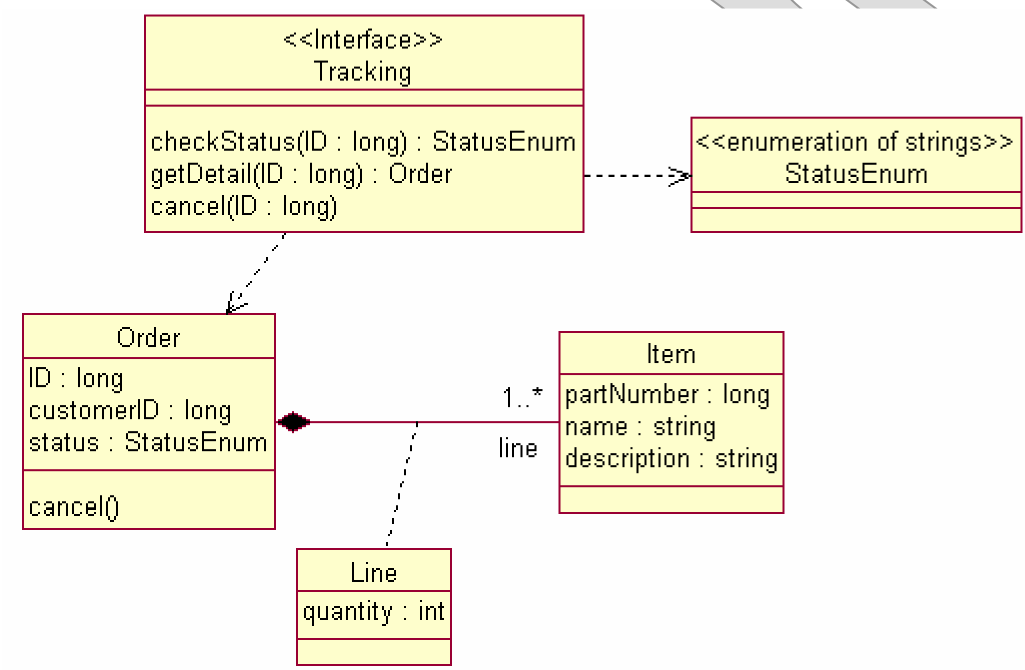
- The latter two are not intuitive, and they imply that the "client" can receive requests and is somehow registered with or known to the service.
- These two are really second-class citizens in the WSDL specification.
  - Bindings are only defined for **request/response** and **one-way**, and that's where most tools put their effort as well.

The message and part Components

- **The `<message>` element defines the exact information that's expected in a single message – whatever direction that message might travel, whatever it might be expected to mean.**
  - Notice that inputs and outputs on multiple **`<operation>`**s can (re)use a given **`<message>`** definition.
- **A `<message>` may have zero to many `<part>`s.**
  - The total message content is understood to include the content models of each of the parts, in sequence.
- **Each `<part>` has a `name` and must define its content in one of two ways:**
  - Using a **type** attribute to identify an XML Schema complex type – in this case the part **name** may appear in the actual message
  - Using an **element** attribute to identify a global element definition – in this case we're identifying an element with its own name and type, so the part's **name** is irrelevant to the message content

The Order-Tracking Service

- We'll look now at a new case study: an application that tracks information about product orders:



- The **Tracking** interface acts as a façade over a domain model:
  - **Order**s are composed of one or more **Line**s, each of which in turn defines some quantity of an **Item**.
  - An **Order** also has **status**, which is of an enumerated type.
  - The service is mostly concerned with checking order status and information, but has one mutator method that allows a customer to cancel an order, which of course changes the status field.
- In upcoming labs you'll build various pieces of this service – starting in this chapter, with its WSDL descriptor.

Validating WSDL

- **For our labs in this chapter we will need a WSDL-to-Java code generator.**
- **For this purpose we'll use the wsimport tool that's part of our JAX-WS implementation.**
- **At times during these labs, you'll run a script validate.bat that invokes wsimport:**

```
wsimport -d build/classes %1
```

  - This will result in some code generation as a by-product.
  - Feel free to review this code, of course, but know that we'll be using a different tool, starting in the next chapter, that generates different code.

An Abstract Model for Order Tracking

LAB 5A

Suggested time: 30 minutes

In this lab you will build the abstract WSDL model of messages for the Tracking service. For now, you will simply validate your descriptor; in a later lab you will use your completed descriptor to generate proxy classes which can be used by a prepared client application to invoke a prepared web service.

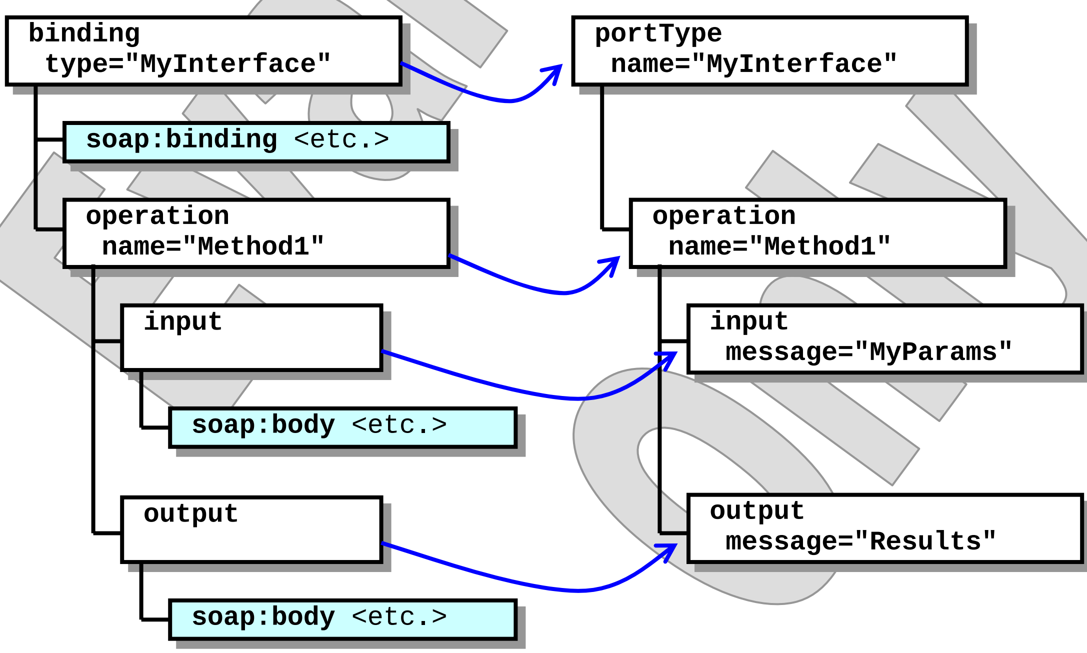
Detailed instructions are found at the end of the chapter.

Making it Real

- **These abstract models are nice, but when do we get to define an actual running service?**
- **We'll look at the concrete-model components now, starting with <service>, which has a name and a collection of <port>s.**
- **A <port> promises to implement a <portType>, which is identified by way of a <binding>.**
- **<port> and <binding> are both in the WSDL namespace – they are standard WSDL components – but they usually rely on extensibility elements to say what they really need to say.**
- **The WSDL vocabulary allows the inclusion of elements from non-WSDL namespaces at various points in a descriptor.**
  - These are called **extensibility elements**.
- **The WSDL 1.1 specification defines bindings for a few common protocols – SOAP, HTTP, and MIME attachments – and others are possible.**
- **Each defined binding will occupy its own namespace.**
  - Common usage is to set the WSDL namespace as the default and then use prefixes for the namespaces of various binding elements.
  - This leads to names such as **soap:binding** that, at first blush, may seem to be from the SOAP envelope namespace itself.
  - Remember that namespace prefixes can be assigned at the author's choice to any namespace URIs; SOAP is just an awfully common token in web services.

The binding Component

- One WSDL component, the **`<binding>`**, exists just for the purpose of extending the abstract service model by playing host to various extensibility elements.
  - A **`<port>`** refers to a **`<binding>`**.
  - That **`<binding>`**, in turn, refers to a **`<portType>`**.
- The **`<binding>`**s children are **`<operation>`**s – but these do <u>not</u> define new operations on the referenced port type.
  - Rather, each contains enough information to precisely **identify** an operation already defined in the port type.
  - These child elements are then combined with extensibility elements to **add** information specific to a target protocol.



The SOAP Binding

- **For SOAP-based services, the WSDL descriptor will include elements specific to SOAP messaging, which bind the abstract semantic definitions described thus far to a concrete SOAP implementation.**
- **Extensibility elements in this binding are:**
  - **`<soap:binding>`**, which extends the abstract binding by defining the specific SOAP transport (for instance, SOAP over HTTP), and the messaging style as either "document" (the default) or "rpc"
  - **`<soap:operation>`**, which extends the abstract operation with attributes such as the related SOAP action URI
  - **`<soap:body>`**, which can extend an abstract message type by defining "encoded" or "literal" use, encoding rules, namespaces, and other attributes
  - **`<soap:fault>`**, which extends abstract fault messages the same way **`<soap:body>`** extends input and output messages
  - **`<soap:address>`**, which can be used to assign a real URI to an abstract component such as a service
- **Remember that the WS-I BP requires**
  - Only literal use, meaning schema rather than encoding schemes
  - Document or RPC style is fine, but it must be consistent over the whole port/type – no mixing and matching at the operation level

Binding for the Math Model

EXAMPLE

- Here's the rest of the **Math.wsdl** from our earlier example:

```
<binding name="CalculatorBinding"
         type="tns:Calculator">
  <soap:binding
    style="rpc"
    transport=
      "http://schemas.xmlsoap.org/soap/http"
  />
  <operation name="Add">
    <input>
      <soap:body
        use="literal"
        namespace=".../WS/Math"
      />
    </input>
    <output>
      <soap:body
        use="literal"
          namespace=".../WS/Math"
      />
    </output>
  </operation>
  ...
```

- The binding reifies the abstract model as follows:
  - It identifies **SOAP over HTTP** as the messaging transport.
  - It says that all operations will be **RPC-style** – we'll talk about the practical impact of this in a moment.
  - It identifies the **namespace** in which the operation element is understood to exist.

Document vs. RPC Style

- We've discussed the differences between document-style and RPC-style services already, but more in the abstract: you know it when you see it.
- In WSDL's SOAP binding, each style implies different arrangement of elements in the actual SOAP message – this is an entirely practical matter.
- In RPC style, the conformant SOAP message will have a single body element which represents the operation itself.
  - The element name will be that of the WSDL **<operation>**.
  - The namespace is defined by the corresponding **<soap:body>** element's **namespace** attribute.
- So, the conformant SOAP request for the **Add** operation as defined in the **Math.wsdl** would look like this:

```
<soap-env:Envelope ...  >
  <soap-env:Body>
    <math:Add>
      <x>6.0</x>
      <y>3</y>
    </math:Add>
  </soap-env:Body>
</soap-env:Envelope>
```

- In a document-style binding of the same abstract model, the **<math:Add>** element would disappear, and the **<x>** and **<y>** elements would be direct children of the SOAP body.
  - Or we'd re-express this same model, using a different message type supported by an XML schema complex type – we'll try this later.

The HTTP Binding

- **Strictly as an example of WSDL's extensibility, we'll survey the HTTP GET/POST binding.**
  - This binding can be used to describe interactions with a web application or service using HTTP GET/POST requests.
  - It is more aptly used with REST-based web services than with those that use SOAP.
- **HTTP extensibility elements are:**
  - `<http:binding>`, which identifies the HTTP binding itself and indicates which verb, GET or POST, is to be used
  - `<http:operation>`, which can define a URI relative to the address (below) for each abstract operation
  - `<http:address>`, which identifies the service location as a URI
  - `<http:urlEncoded>` and `<http:urlReplacement>`, which define two mutually-exclusive means of encoding the abstract message parts into the CGI string for GET requests
- **The HTTP binding also uses parts of the MIME binding, to define message parts that travel as attachments.**
- **We will not consider non-SOAP bindings any further in this course.**

Dynamic Invocation

EXAMPLE

- **In the next few chapters we'll be looking at JAX-WS, which of course relies on a WSDL compiler to generate Java code.**
  - That code is then **statically bound** to a specific WSDL model.
- **WSDL also enables dynamic binding, and as a rough illustration of this capability we'll now try out a dynamic web-services client application, found in Examples/Dynamic.**
- **This application reads a WSDL descriptor and dynamically populates choosers based on the components it finds there.**
  - The user can select a **service**, and per service a **port**, and per port an **operation**.
  - The application then **populates** an area of the **GUI** with input controls based on the chosen operation's message signature. (The application can only handle input of single-value types.)
  - The user can enter argument values and **send a message** that should be valid according to the WSDL.
  - The **response** is interpreted into another dynamically-built GUI.
- **The application is actually rather low-tech: it uses JAXP to parse the WSDL descriptor as XML, and SAAJ to perform SOAP messaging.**
  - But it gives an idea what more ambitious APIs such as JAXB and JAX-WS can do (and JAX-WS does have some dynamic invocation capabilities).

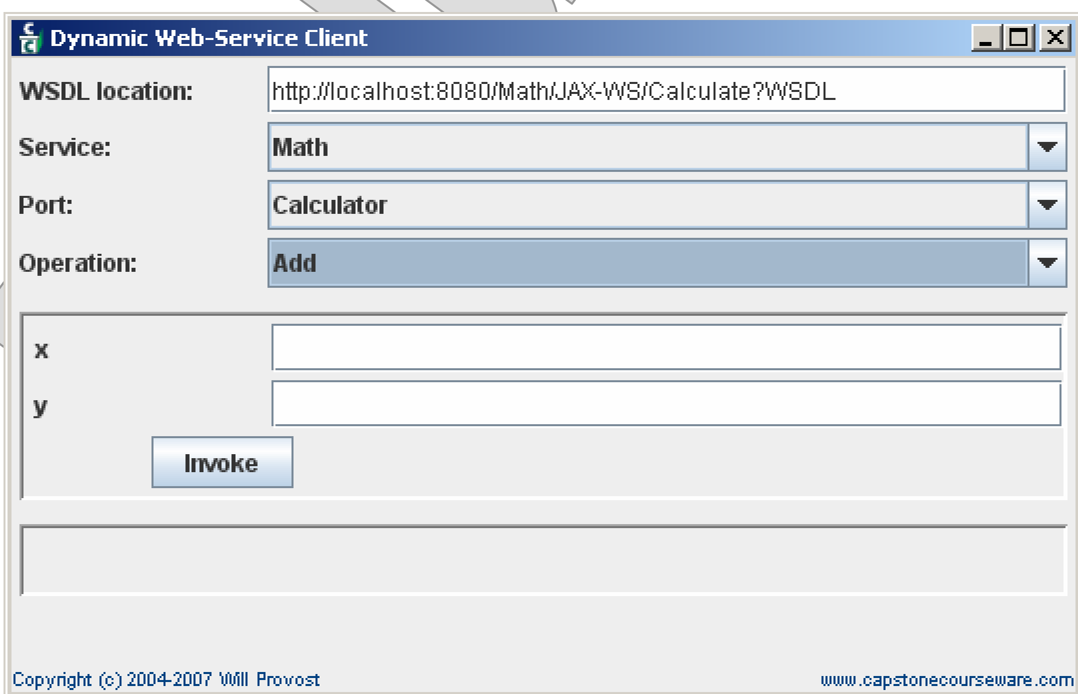
Dynamic Invocation

EXAMPLE

- We'll need some target services, so if you haven't already built these, run **ant** from each of the following directories:
  - **Examples/Math/JAX-WS/Step2/Service**
  - **Examples/Ellipsoid/JAX-WS/Service**
- Run the dynamic client application using the **run** script.
- Enter the URI for the Math service descriptor, and hit TAB.

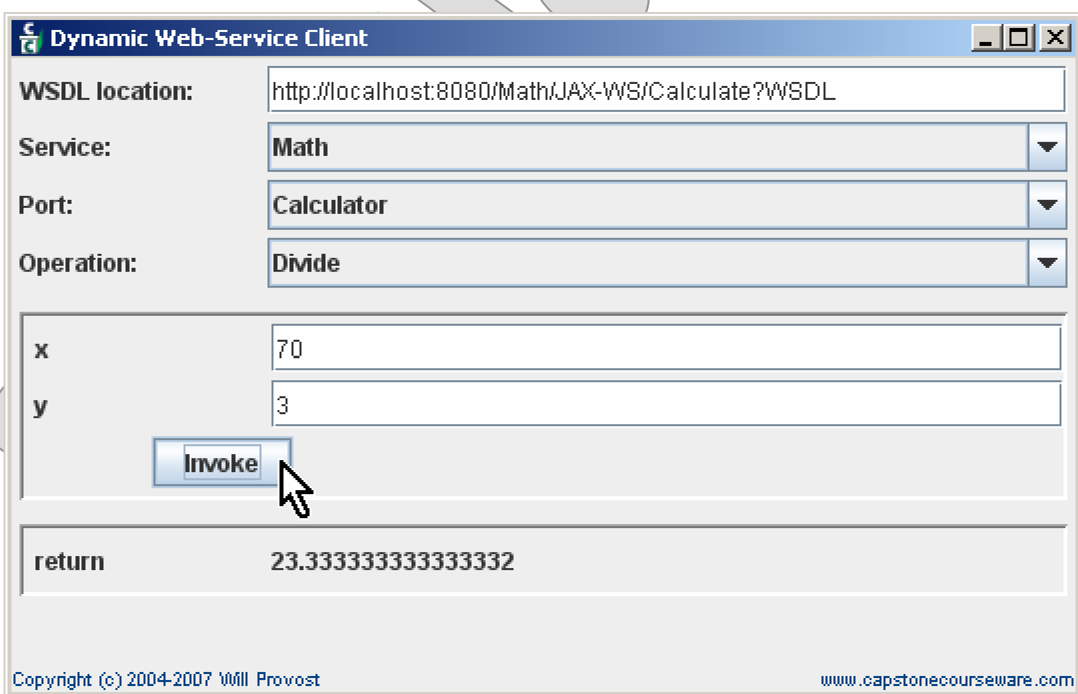
`http://localhost:8080/Math/JAX-WS/Calculate?WSDL`

  - The application will pause while it downloads the WSDL file, and then will populate the combo boxes with information on available services, ports, and operations:



Dynamic Invocation

- Tab through the combo boxes, choosing whichever operation you like in the third one.
- Whenever you select from this combo box, the GUI will be populated with text fields labeled appropriately for the request message parts – in this case **x** and **y** arguments.
- You can enter values in these text fields and click the **Invoke** button.
  - When the service has responded, the result will appear in another addition to the GUI:



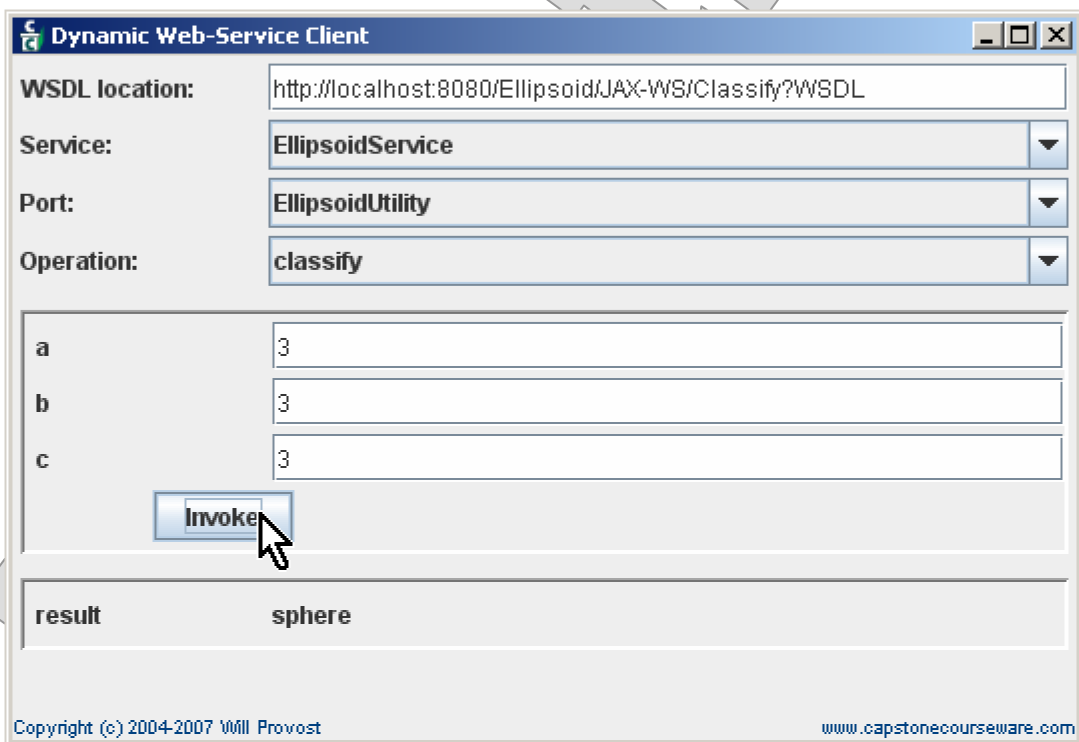
  - You can also see the raw SOAP messages that were exchanged on your behalf by the application – these are echoed to the console.

Dynamic Invocation

- **Now we'll try the Ellipsoid service.**
  - Enter the URI for the WSDL file, as shown below, and hit TAB.

```
http://localhost:8080/Ellipsoid/JAX-WS/Classify?WSDL
```

  - Here you have no choice of service, port, or operation, but the input and output GUI sections do adjust to the different semantics for the **classify** operation.



A Concrete Model for Order Tracking

LAB 5B

Suggested time: 30 minutes

In this lab you will complete the WSDL document from Lab 5A by adding concrete information on service, port, and SOAP/HTTP binding. You will again validate your descriptor, and then you will use it in a full Ant build of the client application, using it to generate proxy classes on which a pre-written client application will depend for its SOAP messaging.

Detailed instructions are found at the end of the chapter.

Publishing WSDL Descriptors

- **How can potential clients find our service?**
  - A WSDL is essential, but then where can clients find that?
- **There are a few options, from simple to SOA-ambitious.**
- **WSDL documents are often published on a website alongside the services that they describe.**
- **A consensus has emerged recently on where to locate a service's WSDL document(s): simply add "?WSDL" to the service URI.**

```
http://localhost:8080/Tracking/Track?WSDL
```

  - Application servers implement this automatically – and they fix up the **location** attribute of the SOAP address component while they're at it, so that generated client proxies will find the service without help from the hand-written client software.
  - There's a bit of a **chicken-and-egg problem** here, though: how would a client know the service URI, unless they'd see the WSDL?
  - This address will also fall under any **security constraints** that you set on the service URI itself – you can't force authentication and authorization over the service endpoint without effectively hiding the WSDL, too.
  - So it is sometimes good to deploy the WSDL in duplicate, at a sibling path such as the following:

```
http://localhost:8080/Tracking/WSDL/Track.wsdl
```

- **In proper SOAs, WSDL addresses will also be published in UDDI repositories, naming services, and the like.**

SUMMARY

- **WSDL is the consensus solution to the problem of web-service description.**
  - It relies on XML Schema to express precise models for the content of individual messages.
  - It adds its own type information describing the service as a whole, including messaging scenarios (operations) and protocol specifics (bindings) that are gathered into service descriptions.
- **A WSDL description often becomes the "document of record" for a web service or system of services and client software.**
- **Again, it defines a contract, and this allows multiple parties to carry out their part of a larger business collaboration with confidence that**
  - The other roles are being filled
  - All parties will be able to interoperate when they need to
- **It's a business question, rather than a technical question, who writes or owns the WSDL and who simply uses it.**
  - Several scenarios are possible, and we'll be visiting many of them in the upcoming chapters.