WSDL 1.1 Overview

Marlon Pierce and Geoffrey Fox
Community Grids Lab
Indiana University
mpierce@cs.indiana.edu

What Is WSDL?

- Web Service Description Language
  - W3C specification
  - See http://www.w3.org/TR/wsdl for the official "note" for WSDL 1.1.
  - WSDL 1.1 never became a full "recommendation".
  - WSDL 2.0 working draft just completed it's public call for comments.
- This slide set will review WSDL 1.1, which is still the "standard".
  - WSDL 2.0 should replace this soon.
- We review 2.0 briefly.

Why Use WSDL?

- WSDL uses XML to describe interfaces
  - Programming language independent way to do this.
  - So you can use (for example) C++ programs to remotely invoke Java programs and vice versa.
- Consider Web browsers and Web servers:
  - All web browsers work pretty well with all web sites.
  - You don't care what kind of web server Amazon.com uses.
  - Amazon doesn't care if you use IE, Mozilla, Konqueror, Safari, etc.
  - You all speak HTTP.
- WSDL (and SOAP) are a generalization of this.
- Note I will describe WSDL from an Remote Procedure Call/Remote Method Invocation point of view.
  - But WSDL and SOAP also support more a more message-centric point of view.
  - C.f. Java Messaging System.
  - This is probably the way of the future for Web Services.

A Very Simple Example: Echo

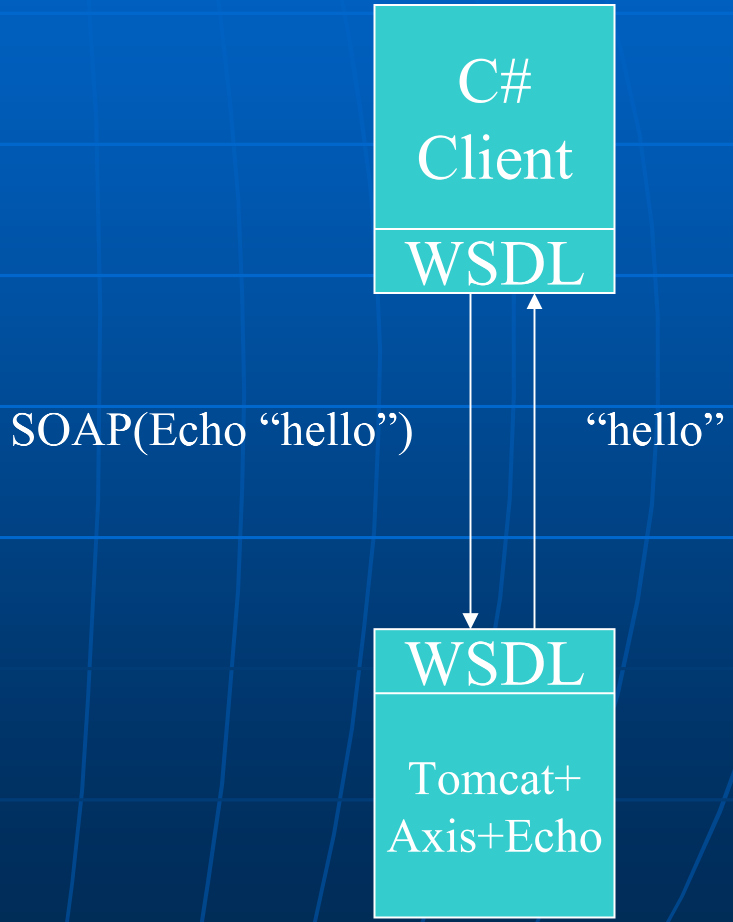
```
public class echoService implements
  echoServiceInterface{
  public String echo(String msg) {
      return msg;
  }
  public static void main(String[] args) {
      new echoService().echo(“hello”);
  }
}
```

The Echo Interface

```
/**
* All implementers of this interface
  must
* implement the echo() method.
*/
public interface echoServiceInterface {
  public String echo(String toEcho);
}
```

Now Use Echo As A Remote Service

- We can take the previous Java program and deploy it in Tomcat as a service.
- Clients can then invoke the echo service.
  - WSDL tells them how to do it.
  - Clients don't need to know anything about the service implementation or even language.
- WSDL is the latest IDL
  - DCE and CORBA IDL were two older examples.



What Does echoServiceInterface Look Like In WSDL?

```
<?xml version="1.0" encoding="UTF-8" ?>
<wsdl:definitions
    targetNamespace="http://grids.ucs.indiana.edu:8045/GCWS/services/Echo"
    xmlns="http://schemas.xmlsoap.org/wsdl/"
    xmlns:apachesoap="http://xml.apache.org/xml-soap"
    xmlns:impl="http://grids.ucs.indiana.edu:8045/GCWS/services/Echo"
    xmlns:intf="http://grids.ucs.indiana.edu:8045/GCWS/services/Echo"
    xmlns:soapenc="http://schemas.xmlsoap.org/soap/encoding/"
    xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
    xmlns:wsdlsoap="http://schemas.xmlsoap.org/wsdl/soap/"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <wsdl:types />
<wsdl:message name="echoResponse">
    <wsdl:part name="echoReturn" type="xsd:string" />
  </wsdl:message>
    <wsdl:message name="echoRequest">
    <wsdl:part name="in0" type="xsd:string" />
  </wsdl:message>
<wsdl:portType name="Echo">
    <wsdl:operation name="echo" parameterOrder="in0">
        <wsdl:input message="impl:echoRequest" name="echoRequest" />
        <wsdl:output message="impl:echoResponse" name="echoResponse" />
    </wsdl:operation>
  </wsdl:portType>
```

There’s more…

What Does This Look Like In WSDL, Continued?

```
 <wsdl:binding name="EchoSoapBinding" type="impl:Echo">
    <wsdlsoap:binding style="rpc" transport="http://schemas.xmlsoap.org/soap/http" />
    <wsdl:operation name="echo">
             <wsdlsoap:operation soapAction="" />
             <wsdl:input name="echoRequest">
                           <wsdlsoap:body
             encodingStyle="http://schemas.xmlsoap.org/soap/encoding/"
             namespace="http://grids.ucs.indiana.edu:8045/GCWS/services/Echo"
             use="encoded" />
             </wsdl:input>
             <wsdl:output name="echoResponse">
                           <wsdlsoap:body
             encodingStyle="http://schemas.xmlsoap.org/soap/encoding

             namespace="http://grids.ucs.indiana.edu:8045/GCWS/services/Echo"
             use="encoded" />
             </wsdl:output>
    </wsdl:operation>
 </wsdl:binding>
<wsdl:service name="EchoService">
    <wsdl:port binding="impl:EchoSoapBinding" name="Echo">
             <wsdlsoap:address location="http://grids.ucs.indiana.edu:8045/GCWS/services/Echo"
    />
    </wsdl:port>
 </wsdl:service>
</wsdl:definitions>
```

Don’t strain your eyes. We will break this down

Writing WSDL

- I’m sure you are impressed with the previous two slides.
- One could write WSDL by hand, but this is not the usual way.
- It was automatically generated by Apache Axis. Most other Web service tools will do the same.
- We will go through the construction, though, for understanding.
- You should not think of WSDL (and SOAP) as programming languages.
  - They are just assertions, or descriptions.

WSDL Parts

- Types
  - Used to define custom message types
- Messages
  - Abstraction of request and response messages that my client and service need to communicate.
- PortTypes
  - Contains a set of operations.
  - Operations organize WSDL messages.
  - Operation->method name, PorType->java interface
- Bindings
  - Binds the PortType to a specific protocol (typically SOAP over http).
  - You can bind one PortType to several different protocols by using more than one port.
- Services
  - Gives you one or more URLs for the service.
  - Go here to execute “echo”.

Echo Service WSDL, Section by Section

The WSDL Schema

- See http://www.w3.org/TR/wsdl for the official recommendation.
- The full WSDL schema is given here.
  - Bryan Carpenter’s XML lectures cover everything you need to understand this schema.
  - But we will instead focus on a specific example.

Namespaces

- The WSDL document begins with several XML namespace definitions.
- Namespaces allow you to compose a single XML document from several XML schemas.
- Namespaces allow you to identify which schema an XML tag comes from.
  - Avoids name conflicts.
- See earlier XML lectures
- As we will see, the Axis namespace generator went overboard.
  - Not all of these are used.

Front Matters

```
<?xml version="1.0" encoding="UTF-8" ?>
<wsdl:definitions
    targetNamespace="http://grids.ucs.indiana.edu:8045/GCWS/services/Echo"
    xmlns="http://schemas.xmlsoap.org/wsdl/"
    xmlns:apachesoap="http://xml.apache.org/xml-soap"
    xmlns:impl="http://grids.ucs.indiana.edu:8045/GCWS/services/Echo"
    xmlns:intf="http://grids.ucs.indiana.edu:8045/GCWS/services/Echo"
    xmlns:soapenc="http://schemas.xmlsoap.org/soap/encoding/"
    xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/"
    xmlns:wsdlsoap="http://schemas.xmlsoap.org/wsdl/soap/"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema">

…
</wsdl:definitions>
```

Namespace Quiz

- What is the default namespace of our XML doc?
- What does <wsdl:definitions …> mean?
- What does xmlns:xsd=**http://www.w3.org/2001/XMLSchema** mean?
- Is http://www.w3c.org/2001/XMLSchema a URI or a URL?
- What is the target namespace of this document?
- What is the target namespace used for?

Quiz Answers

- http://schemas.xmlsoap.org/wsdl/
- This means <definitions> belongs to the schema named http://schemas.xmlsoap.org/wsdl/, labeled wsdl: in this doc.
- It means that elements from the XML schema that appear in this WSDL document will be labled by <xsd:…>
- Technically, it is used here as a URI; that is, it is a structured name. The URL does exist, however.
  - Recall URLs are special cases of URIs. URIs are names/identifiers. URLs also have a specific location on the web.
- http://grids.ucs.indiana.edu:8045/GCWS/services/Echo
- The target namespace is the namespace that will be used when we validate the document.
  - Note this isn't used in our document since we define no complex types of our own.
  - See next section.

WSDL Types

Use <types/> to declare local message structures.

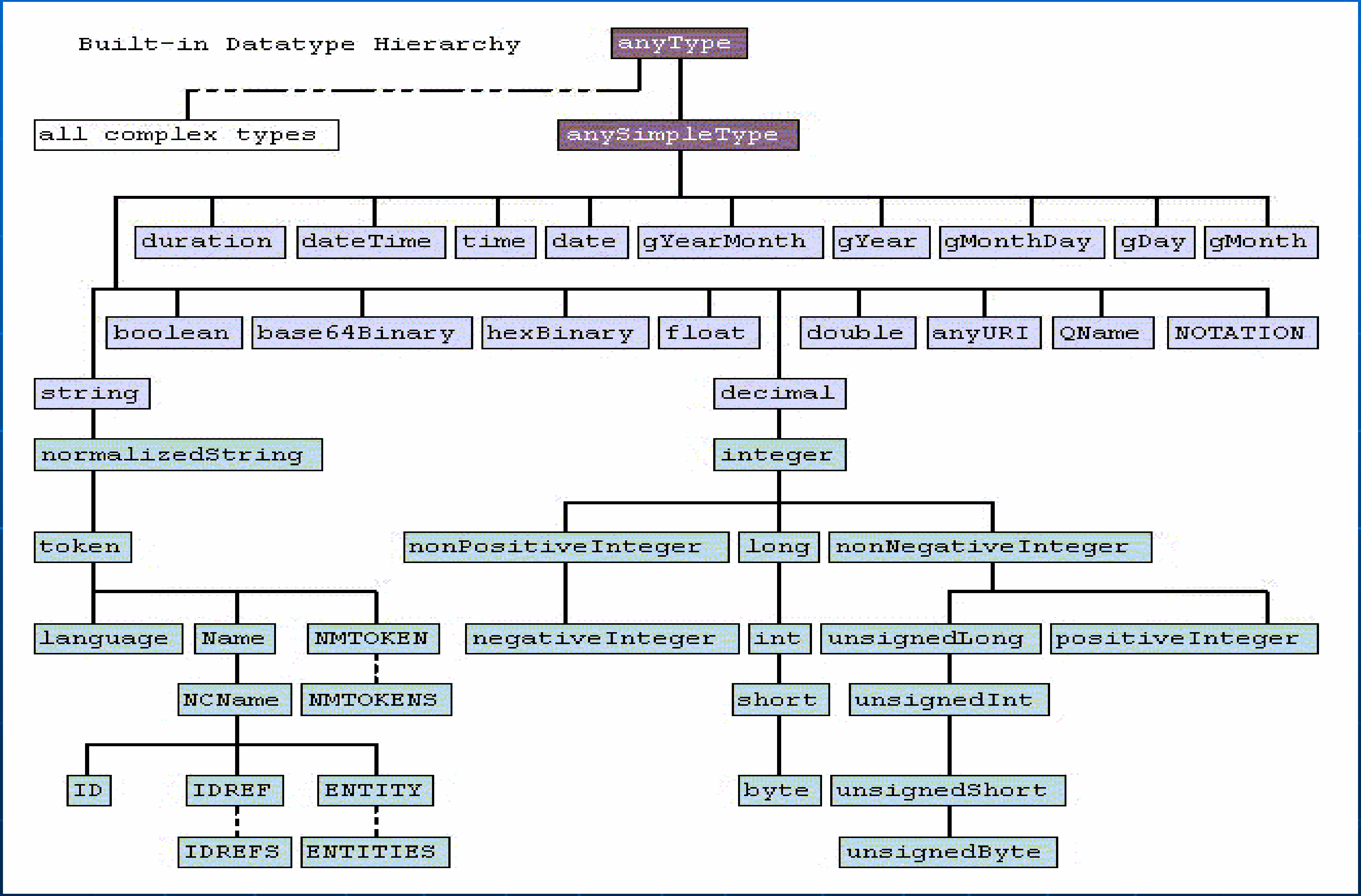
What Does echoServiceInterface Look Like In WSDL?

```
<?xml version="1.0" encoding="UTF-8" ?>
<wsdl:definitions ...>
 <wsdl:types />
<wsdl:message name="echoResponse">
  <wsdl:part name="echoReturn"
  type="xsd:string" />
 </wsdl:message>
  <wsdl:message name="echoRequest">
  <wsdl:part name="in0" type="xsd:string" />
 </wsdl:message>
...
</wsdl:definitions>
```

WSDL Types

- WSDL messages don’t need to declare types when just sending XML Schema primitive objects.
- EchoService just has string messages.
  - So no special types definitions are needed in our WSDL.
- Strings are an XML schema built-in type.
  - See earlier XML lectures.
  - Or next slide…

Schema Built In Types



When Would I Need A Type?

- Any time your Web Service needs to send data formatted by anything other than XML Schema built-in types, you must define the type in WSDL.
- Example: Arrays are not built-in types!
    - Arrays of strings, ints, etc., must be defined in the WSDL <type></type> structure.

How Does WSDL Encode String Arrays?

- Imagine that my echo service actually echoes back an array of strings.
- Arrays are not part of the built-in types, so I will have to define them myself.
- Luckily for us, SOAP defines arrays, so we can import this definition.
- Next slide shows what this looks like.

String Array Example

```
<wsdl:types>
   <schema
        targetNamespace="http://grids.ucs.indiana.edu:8045/G
   CWS/services/EchoArray"
        xmlns="http://www.w3.org/2001/XMLSchema">
     <import
        namespace="http://schemas.xmlsoap.org/soap/encodi
   ng/" />
     <complexType name="ArrayOf_xsd_string">
        <complexContent>
          <restriction base="soapenc:Array">
            <attribute ref="soapenc:arrayType"
                          wsdl:arrayType="xsd:string[]" />
          </restriction>
        </complexContent>
     </complexType>
     <element name="ArrayOf_xsd_string" nillable="true"
        type="impl:ArrayOf_xsd_string" />
   </schema>
  </wsdl:types>
```

WSDL String Array Types

- WSDL <type/> is nothing more than an extensibility placeholder in WSDL.
- Technically, the WSDL schema specifies that <type> </type> can contain a <sequence> of 0 or more <any> tags.
  - Look at the WSDL schema.
- And note that the <any/> tag acts like wildcard.
  - You can insert any sort of xml here.
- See slides from XML lectures.

Inserting a Type

- Between <type></type>, we insert a <schema>.
- Since arrays are defined in SOAP encoding rules, I next *import* the appropriate schema.
    - I import the definition of the SOAP Array and extend it to a String array.
    - Typically imports also have "location" attributes
        - "This namespace is located here for download."
- Next, insert our own local definition of a type called "ArrayOf_xsd_string".
- This is a restricted extension of the SOAP Array complex type.
    - We only allow 1 dimensional string arrays
    - It is also nillable—I am allowed to returna "null" value for the string.

Handling Other XML Types

- You can also express other message arguments as XML.
  - Examples: a purchase order, an SVG description of an image, a GML description of a map.
- In practice, these are handled by automatic Bean serializers/deserializers.
  - Castor is an example: http://www.castor.org/
  - XMLBeans is another http://xml.apache.org/xmlbeans/
- These are tools that make it easy to convert between XML and JavaBeans.
- By "JavaBeans" I mean objects that associate simple get/set methods with all data.
- Implementation dependent.

WSDL Messages

The echoServiceInterface messages

```
<?xml version="1.0" encoding="UTF-8" ?>
<wsdl:definitions>
 <wsdl:types />
<wsdl:message name="echoResponse">
   <wsdl:part name="echoReturn" type="xsd:string" />
</wsdl:message>
<wsdl:message name="echoRequest">
   <wsdl:part name="in0" type="xsd:string" />
</wsdl:message>
<wsdl:portType name="Echo">
   <wsdl:operation name="echo" parameterOrder="in0">
         <wsdl:input message="impl:echoRequest"
   name="echoRequest" />
         <wsdl:output message="impl:echoResponse"
   name="echoResponse" />
   </wsdl:operation>
 </wsdl:portType>
...
</wsdl:definitions>
```

Our Echo Messages

```
<wsdl:message
      name="echoResponse">
  <wsdl:part name="echoReturn"
      type="xsd:string" />
</wsdl:message>
<wsdl:message
      name="echoRequest">
  <wsdl:part name="in0"
      type="xsd:string" />
</wsdl:message>
```

Remember the Echo Service implementation?

- Our echo service takes a string argument and returns a string answer.
- In WSDL, I first abstract these as *messages.*
  - Echo needs two messages.
- Note we have not yet said message is the request and which is the response.
  - That is the job of the portType operations, coming up.

Structure of a Message

- WSDL <message> elements have name attributes and one or more *parts*.
  - The message name should be unique for the document.
  - <operation> elements will refer to messages by name.
- I need one <part> for each piece of data I need to send in that message.
- Each <part> is given a name and specifies its type.
  - <part> types can point to <wsdl:type> definitions if necessary.
  - Our service just needs xsd:strings, so no problem.

More Messages

- Our simple service only has one method.
  - What if it had echoEnglish(), echoSpanish(), and echoFrench()?
  - Each takes a string in English and echoes back the string in another language.
- Then we would need 6 messages, each with one part.

portTypes and operations

The echoServiceInterface portType

```
<?xml version="1.0" encoding="UTF-8" ?>
<wsdl:definitions>
 <wsdl:types />
<wsdl:message name="echoResponse">
   <wsdl:part name="echoReturn" type="xsd:string" />
 </wsdl:message>
   <wsdl:message name="echoRequest">
   <wsdl:part name="in0" type="xsd:string" />
 </wsdl:message>
<wsdl:portType name="Echo">
   <wsdl:operation name="echo" parameterOrder="in0">
         <wsdl:input message="impl:echoRequest"
   name="echoRequest" />
         <wsdl:output message="impl:echoResponse"
   name="echoResponse" />
   </wsdl:operation>
 </wsdl:portType>
…
</wsdl:definition>
```

EchoService portType

```
<wsdl:portType name="Echo">
  <wsdl:operation name="echo"
      parameterOrder="in0">
      <wsdl:input
      message="impl:echoRequest"
      name="echoRequest" />
      <wsdl:output
      message="impl:echoResponse"
      name="echoResponse" />
      </wsdl:operation>
 </wsdl:portType>
```

WSDL portTypes

- WSDL messages are only abstract messages.
  - We bind them to *operations* within the portType.
- The structure of the portType specifies (still abstractly) how the messages are to be used.
  - Think of operations->java methods and portTypes->java interfaces.

portType Message Patterns

- PortTypes support four types of messaging:
  - One way: Client send a message to the service and doesn't want a response.
    - <input> only.
  - Request-Response: Client sends a message and waits for a response.
    - <input>, then <output>
  - Solicit-Response: Service sends a message to the client first, then the client responds.
    - <output>, then <input>
  - Notification: <output> only.
- These still are abstract. We must implement them using some message protocol.
  - HTTP units of transmission are request and response, so mapping Solicit-Response to HTTP will take some work.

portType for EchoService

- The echo service has one method, echo.
- It takes one string argument and returns one string.
- In WSDL, the portType is “Echo”, the operation is “echo”.
- The messages are organized into input and output.
  - Messages are placed here as appropriate.
  - That is, <input> takes the <echoRequest> message.

Parameter Order

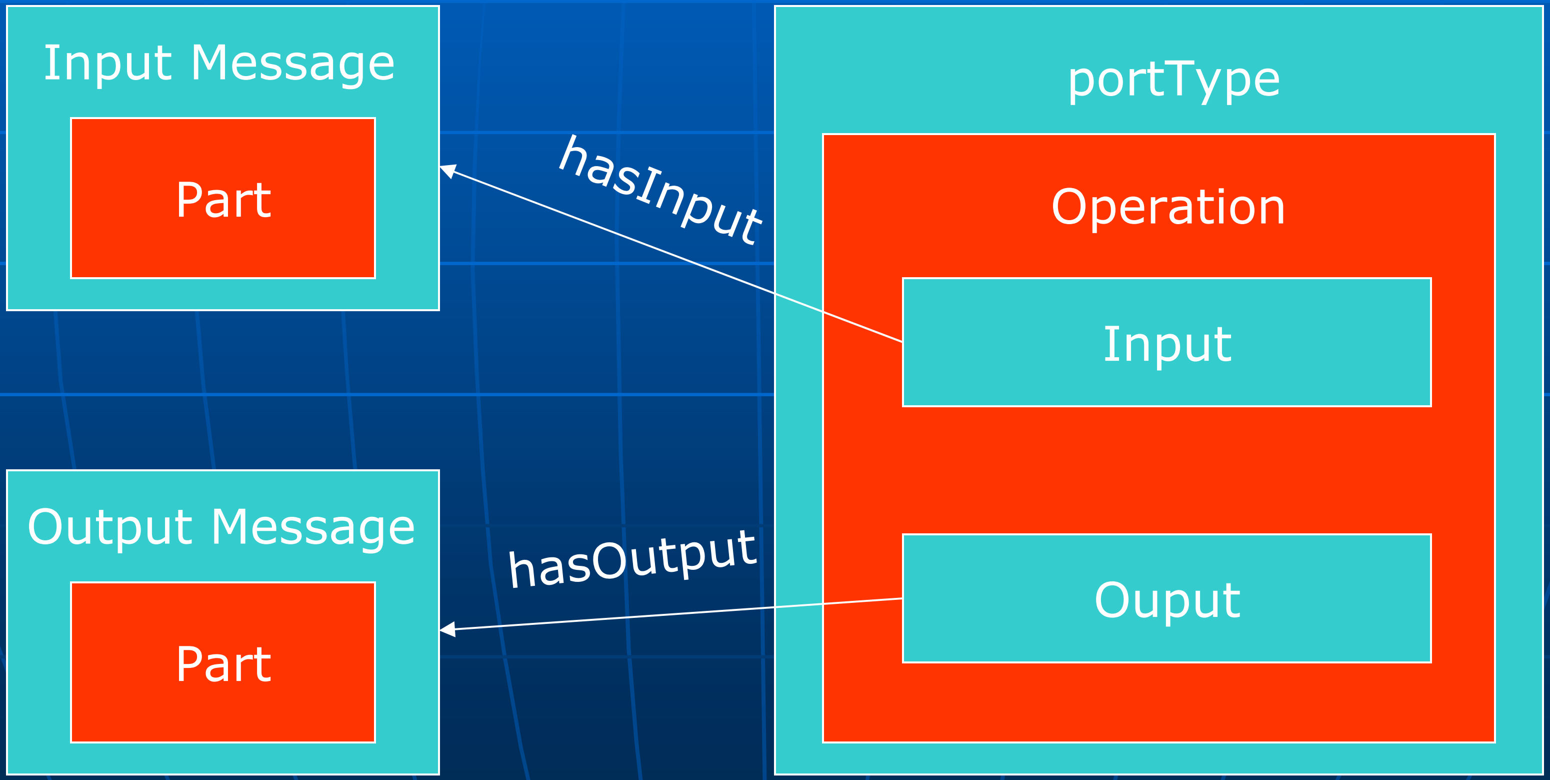
- This attribute of operation is used to specify zero or more space-separated values.
- The values give the order that the input messages must be sent.
- Echo is a bad example, since it only has one input parameter, named ***in0***.

WSDL Self-Referencing

- The WSDL <input> and <output> tags need to point back to the <message> definitions above:

```
<wsdl:message name="echoResponse">
    <wsdl:part name="echoReturn" type="xsd:string" />
 </wsdl:message>
…
<wsdl:portType name="Echo">
    <wsdl:operation name="echo" parameterOrder="in0">
          …
          <wsdl:output message="impl:echoResponse"
                     name="echoResponse" />
    </wsdl:operation>
  </wsdl:portType>
```

The Picture So Far…



Bindings

Binding Section of WSDL

```
<wsdl:definitions>
…
 <wsdl:binding name="EchoSoapBinding" type="impl:Echo">
      <wsdlsoap:binding style="rpc" transport="http://schemas.xmlsoap.org/soap/http" />
      <wsdl:operation name="echo">
            <wsdlsoap:operation soapAction="" />
            <wsdl:input name="echoRequest">
               <wsdlsoap:body
                     encodingStyle="http://schemas.xmlsoap.org/soap/encoding/"
                     namespace="http://grids.ucs.indiana.edu:8045/GCWS/services/Echo"
                     use="encoded" />
            </wsdl:input>
            <wsdl:output name="echoResponse">
              <wsdlsoap:body
                     encodingStyle="http://schemas.xmlsoap.org/soap/encoding
                     namespace="http://grids.ucs.indiana.edu:8045/GCWS/services/Echo"
                     use="encoded" />
            </wsdl:output>
      </wsdl:operation>
  </wsdl:binding>
<wsdl:service name="EchoService">
      <wsdl:port binding="impl:EchoSoapBinding" name="Echo">
            <wsdlsoap:address location="http://grids.ucs.indiana.edu:8045/GCWS/services/Echo"
      />
      </wsdl:port>
  </wsdl:service>
</wsdl:definitions>
```

Don’t strain your eyes--we will zoom in.

So Far…

- We have defined abstract messages, which have XML values.
  - Simple or custom-defined types.
- We have grouped messages into operations and operations into portTypes.
- We are now ready to bind the portTypes to specific protocols.

The Binding for Echo

```
<wsdl:binding name="EchoSoapBinding" type="impl:Echo">
 <wsdlsoap:binding style="rpc"
    transport="http://schemas.xmlsoap.org/soap/http" />
 <wsdl:operation name="echo">
    <wsdlsoap:operation soapAction="" />
    <wsdl:input name="echoRequest">
      <wsdlsoap:body
          encodingStyle="http://schemas.xmlsoap.org/soap/encoding/"
          namespace="[echo service namespace URI]"
          use="encoded" />
    </wsdl:input>
    <wsdl:output name="echoResponse">
      <wsdlsoap:body
          encodingStyle="http://schemas.xmlsoap.org/soap/encoding/"
          namespace="[echo service namespace URI]"
          use="encoded" />
    </wsdl:output>
  </wsdl:operation>
</wsdl:binding>
```

The highlighted "wsdlsoap:" tags are extensions for SOAP message binding and not part of the WSDL schema.

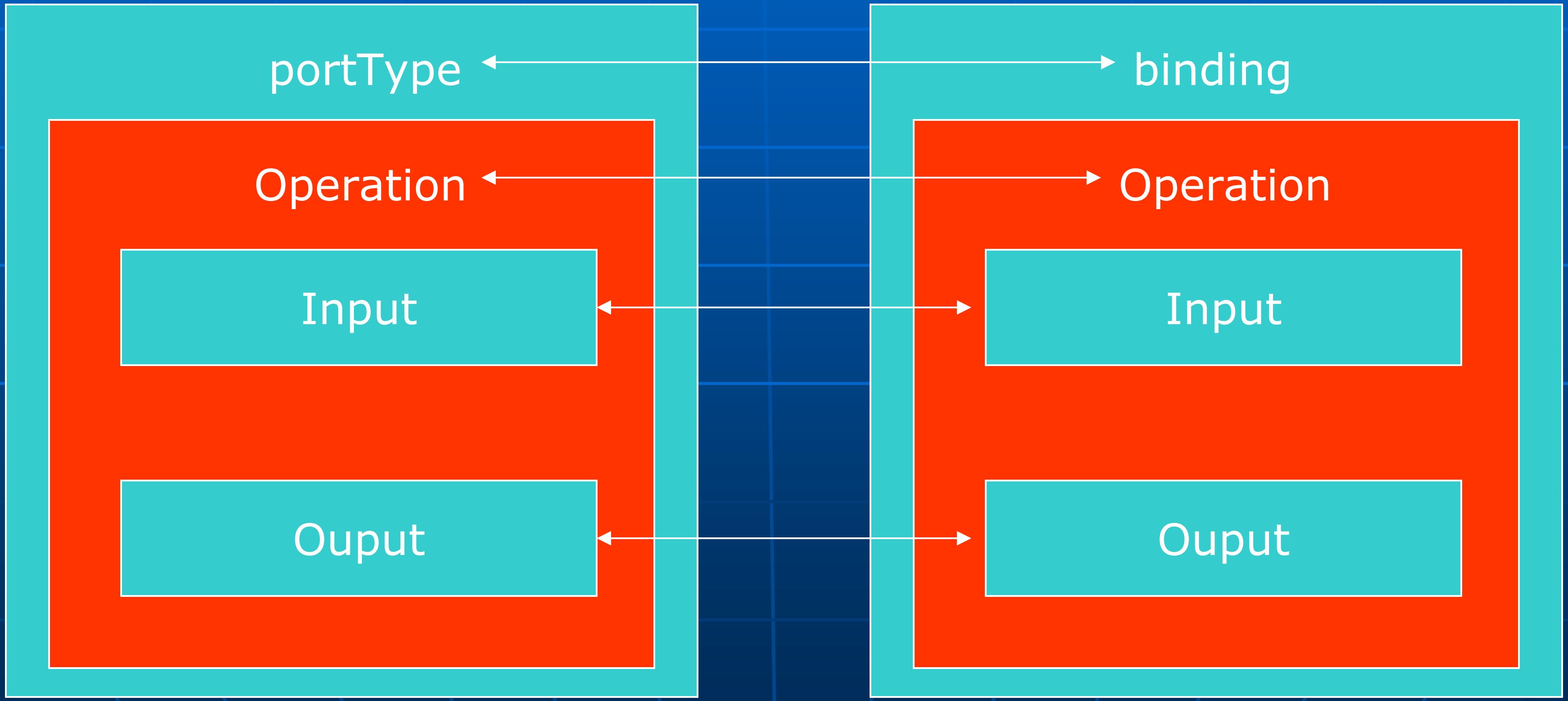
WSDL SOAP Bindings

- In the previous slide, we specify several things:
  - We will use SOAP/HTTP
  - We will use RPC encoding style
    - Other choice is literal “document” style.
  - We specify the namespace associated with the Echo service input and output messages.
- All of this corresponds to SOAP message parts.
  - We will expand this in the next lecture.

Binding tags

- Binding tags are meant to bind the parts of portTypes to sections of specific protocols.
  - SOAP, HTTP GET/POST, and MIME are provided in the WSDL specification.
- Bindings refer back to portTypes by name, just as operations point to messages.

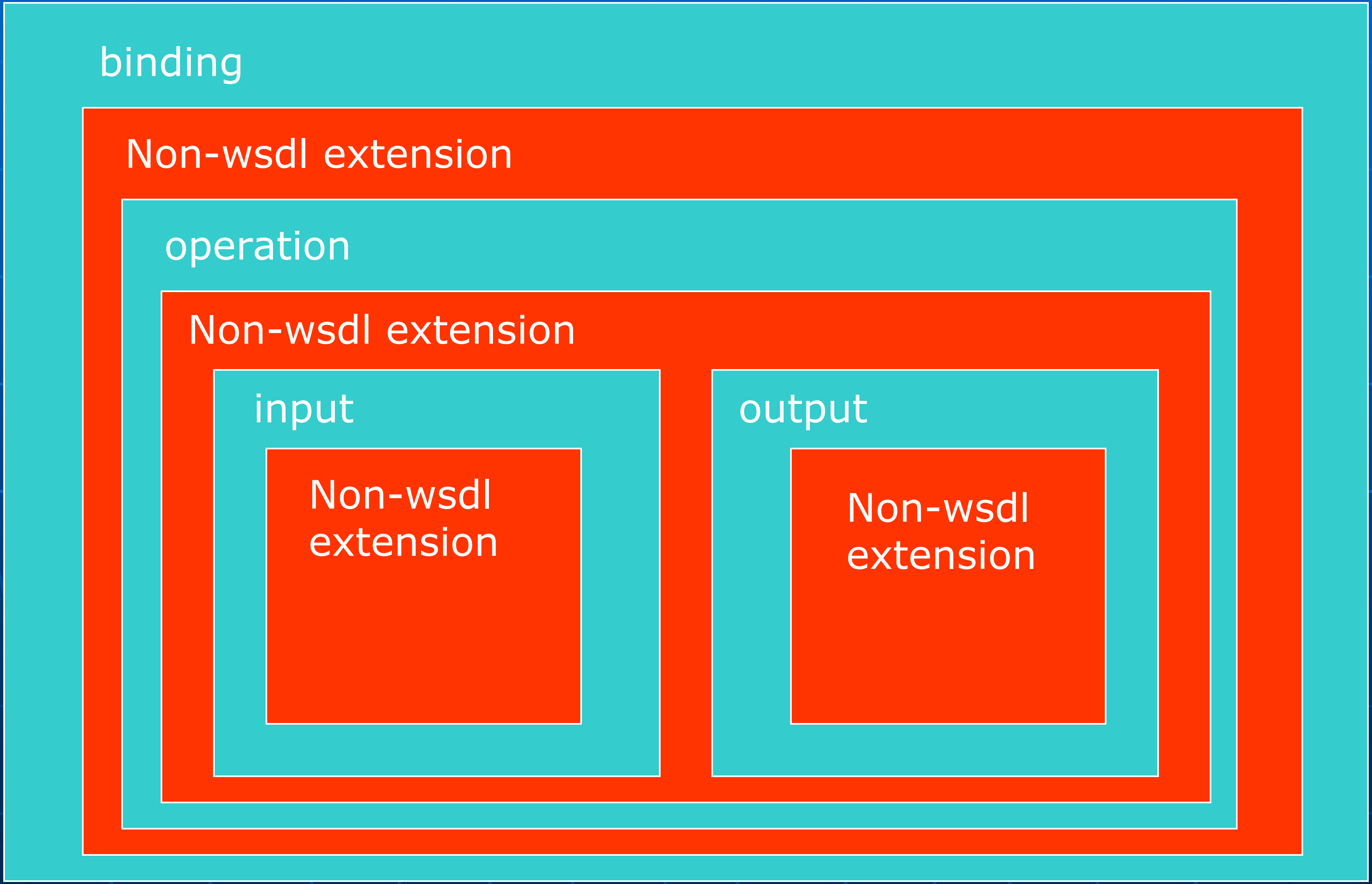
WSDL Internal References



Structure of the Binding

- <binding> tags are really just placeholders.
- They are meant to be extended at specific places by wsdl protocol bindings.
  - These protocol binding rules are defined in supplemental schemas.
- The following box figure summarizes these things
  - Green boxes are part of WSDL
    - From the wsdl namespace, that is.
  - Red boxes are parts of the document from other schemas
    - From wsdlsoap namespace in the echo example.

Binding Structure



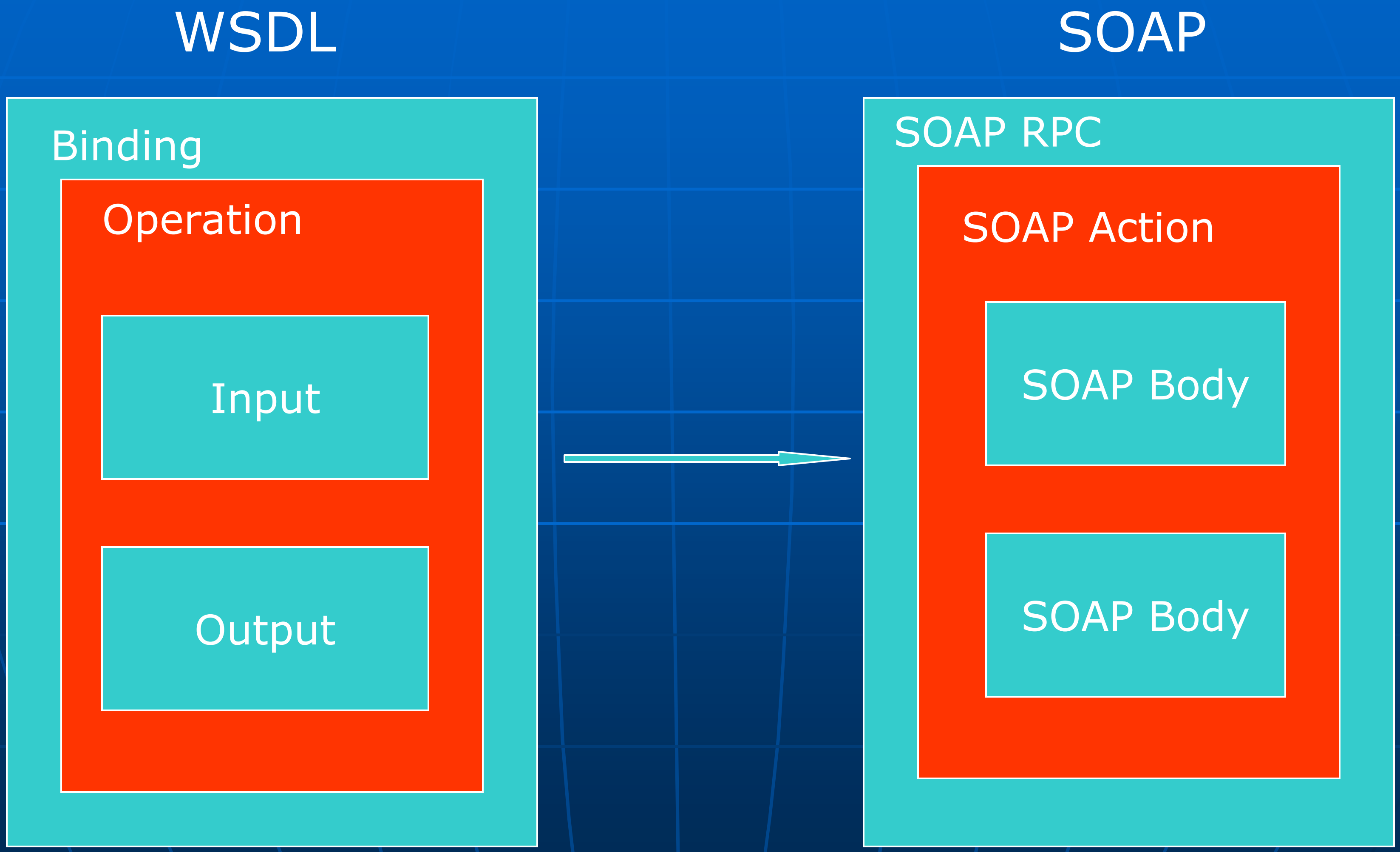
SOAP Bindings

- The WSDL bindings are meant to prescribe how the parts of the portType get transported.
- All the given bindings are to parts of SOAP messaging formats.
  - WSDL’s SOAP bindings define mappings.
  - We will look at these in upcoming lectures.

For now, note the following

- We specify SOAP encoding
- SOAP is a message format and needs a transport protocol, so we specify HTTP.
- Operation styles may be either "RPC" or "Document".
  - We use RPC.
- SOAP Body elements will be used to actually convey message payloads.
  - RPC requires "encoded" payloads.
    - Each value (echo strings) is wrapped in an element named after the operation.
    - Useful RPC processing on the server side.
  - Documents are literal (unencoded)
    - Use to just send a payload of XML inside SOAP.

Binding Associations to SOAP



Binding Restrictions

- Binding elements point by name to portTypes.
- WSDL allows more than one binding element to point to the same port type.
  - Why?
  - Because a service may support multiple, alternative protocol bindings.

What Does It Mean?

- WSDL is not a programming language.
- A service that exposes an WSDL interface is just telling a client what it needs to do to communicate with the service.
  - Send me strings and I will return strings.
  - I expect SOAP messages that include the strings in the body.
  - I expect this body to be RPC encoded with the operation name so that I will know which operation the body contents belong to.
  - I will return SOAP messages that include Strings in the body.
  - These will also be encoded so that you know what to do with them.

Ports and Services

What Does This Look Like In WSDL, Continued?

```
<wsdl:definitions>
   …
   <wsdl:binding>
   …
  </wsdl:binding>
<wsdl:service name="EchoService">
   <wsdl:port binding="impl:EchoSoapBinding"
   name="Echo">
        <wsdlsoap:address
   location="http://grids.ucs.indiana.edu:8045/G
   CWS/services/Echo" />
   </wsdl:port>
  </wsdl:service>
</wsdl:definitions>
```

Ports and Services

```
<wsdl:service name="EchoService">
  <wsdl:port
     binding="impl:EchoSoapBinding"
     name="Echo">
    <wsdlsoap:address
         location="http://..../"/>
  </wsdl:port>
</wsdl:service>
```

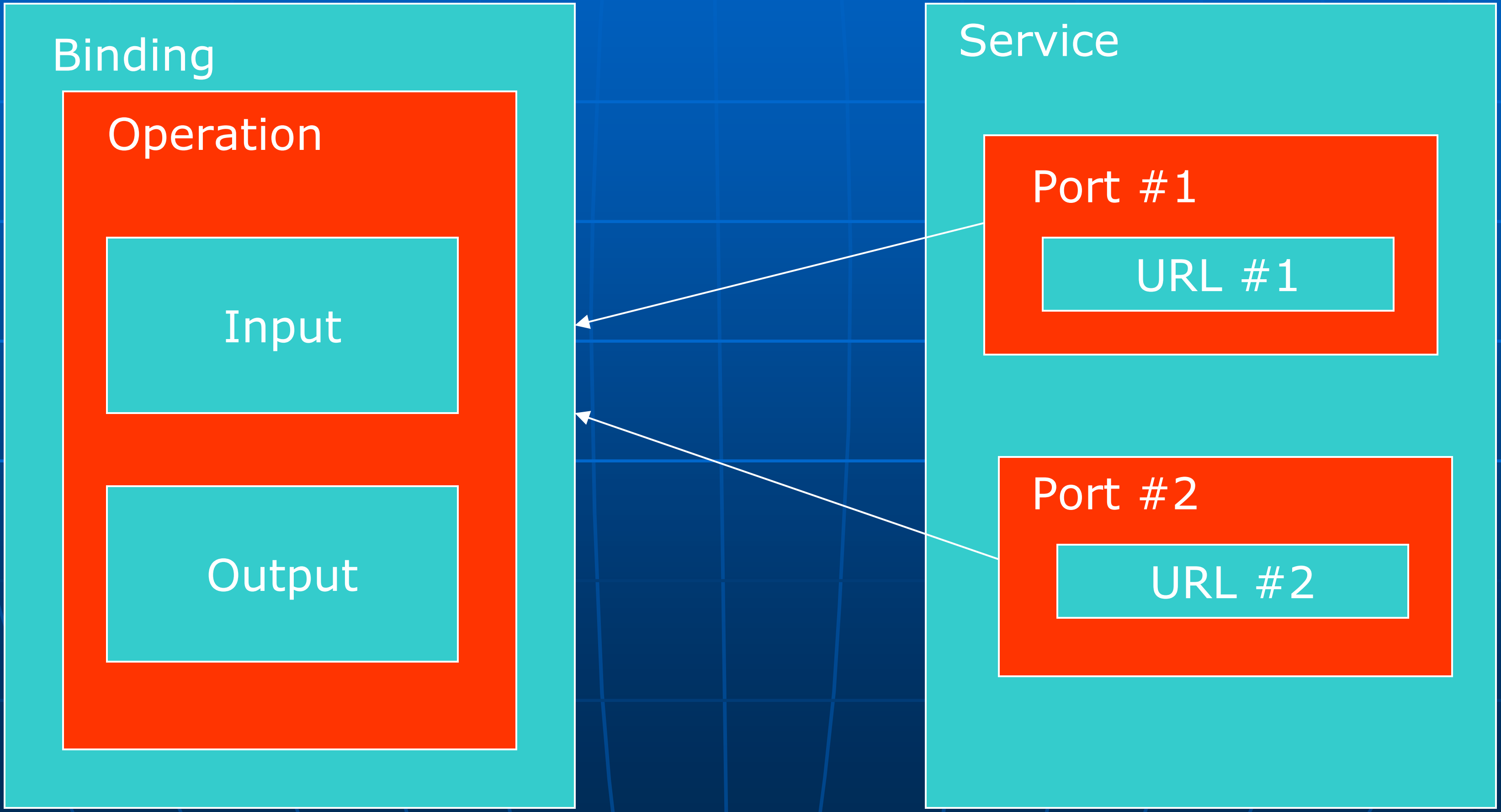
Port and Service Tags

- The service element is a collection of ports.
  - That’s all it is for.
- Ports are intended to point to actual Web service locations
  - The location depends on the binding.
  - For SOAP bindings, this is a URL.

Ports and Services

- A service can have more than one port.
- Two ports can point back to the same binding element.
  - Ports refer to bindings by name
  - This allows you to provide alternative service locations.
- The figure on next slide conceptually depicts associating two ports to a single binding.
  - The ports differ only in the URLs of their services.

Port Associations to Bindings



Summary of WSDL

- WSDL decouples remote service operations.
  - Types=custom message definitions.
    - Any data types not in the XML schema.
  - Message=name the messages that must be exchanged and their data types, possibly defined by <type>.
  - PortTypes=service interfaces
    - Operations=remote method signatures.
  - Bindings=mappings of portType operations to real message formats
  - Ports=locations (URLs) of real services.