Web Services

Nicoleta Preda

November 22, 2017

Web Evolution

Technology	TCP/IP	HTML	XML
Purpose	Connectivity	Presentation	Programmability
Applications	E-Mail, FTP…	Web Pages	Web Services
Outcome	Create the Web	Browse the Web	Program the Web

Web Service (WS)

- A way of publishing/exporting data in the Internet
- A Web Service consists of several functions (methods, operations)
- Observation: We sometimes use Web Service to refer to a function

XML Overview

- XML is a language for building languages.
- Basic rules: be well formed and be valid
- Particular XML "dialects" are defined by an XML Schema.
- XML itself is defined by its own schema
- XML is extensible via namespaces

Advantage: Many basic tools available:

- parsers: SAX, DOM
- query languages: XPath and XQuery
- transformation languages: XSLT

XML & Web services

XML provides a natural substrate for distributed computing

- Its just a data description
- Programming language independent of the platform

Plan

SOAP Services

REST Services

Chapter Plan

- Web Services Architecture
- SOAP (messaging)
- WSDL (service description)
- UDDI (registry)

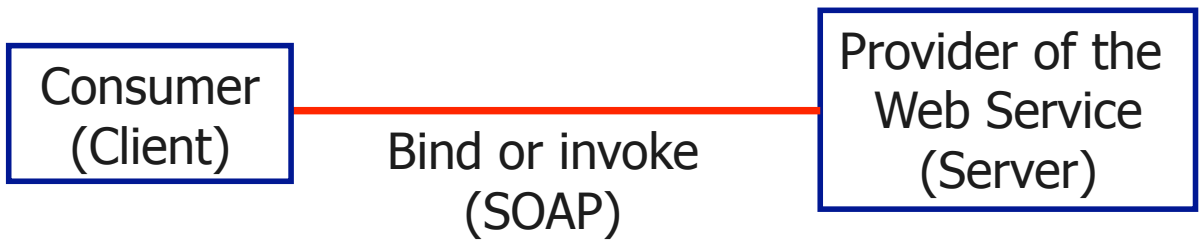
Web Services: Basic Architecture

The simplest Web service system has two participants:

A service producer (provider) - server

A service consumer (requester) - client

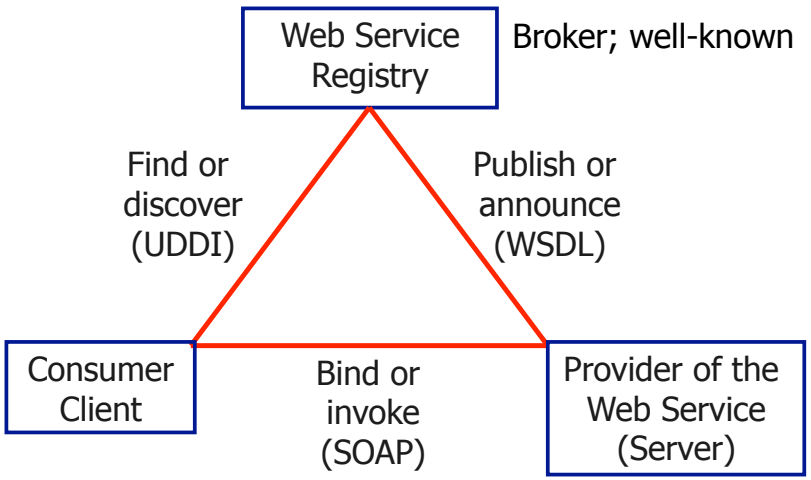
The provider presents the interface and implementation of the service, and the requester uses the Web service.



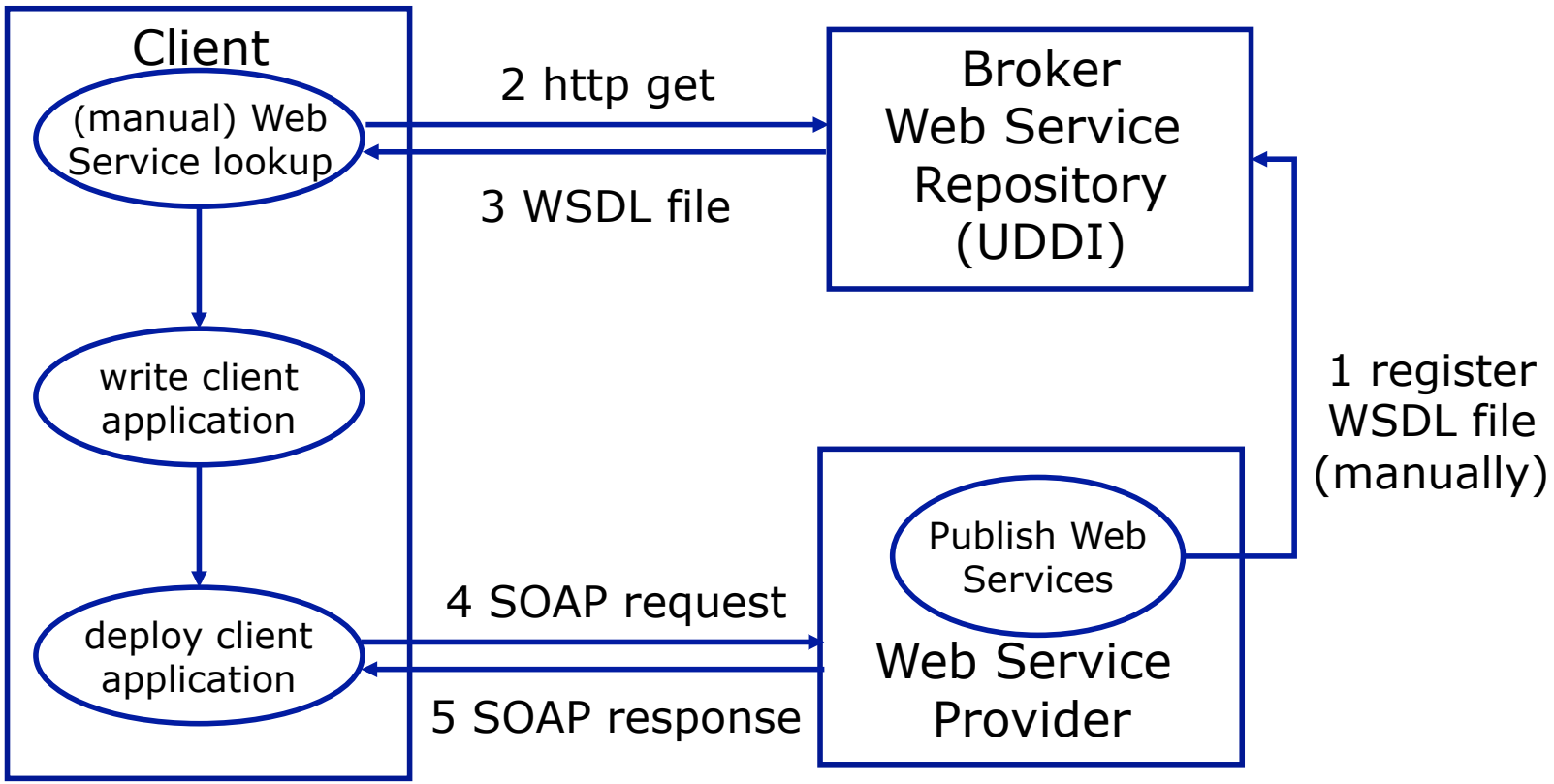
Web Services Architecture

A more sophisticated system:

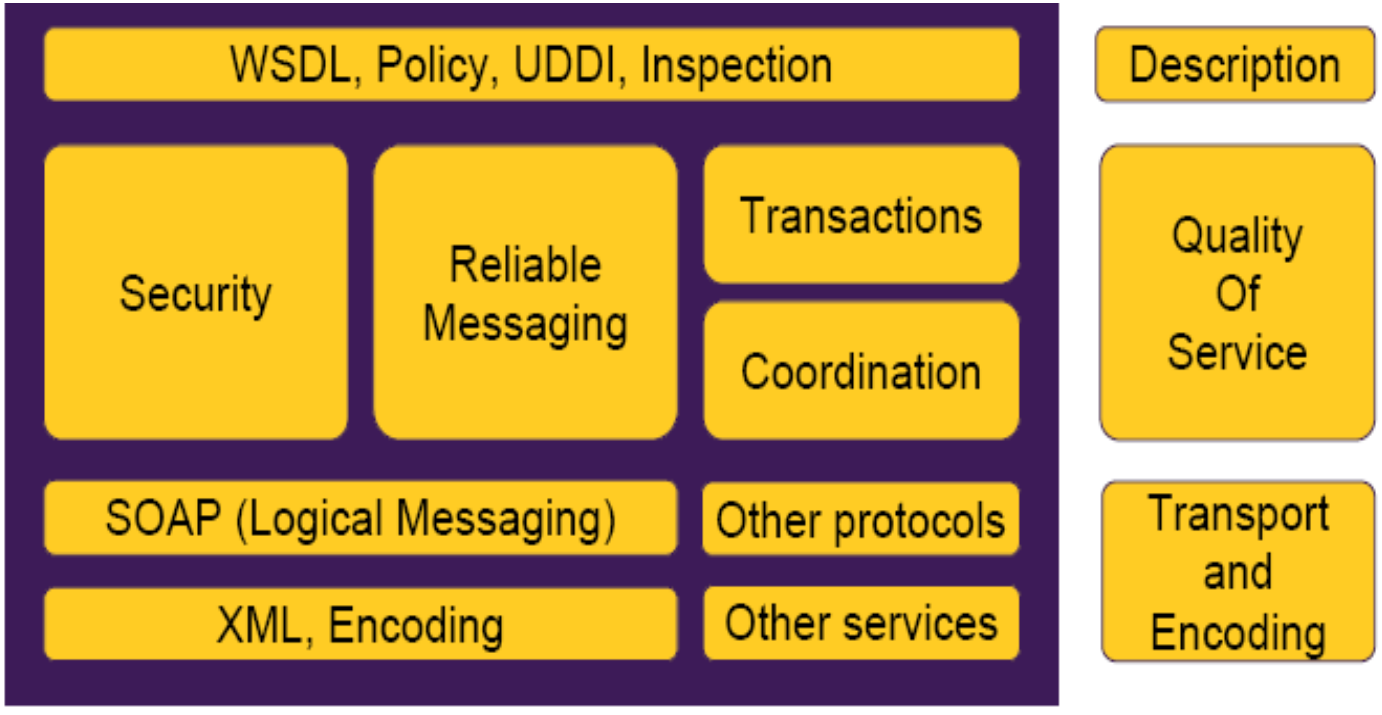
- A registry - acts as a broker for Web Services
- A provider - can publish services to the registry
- A consumer - can then discover services in the registry



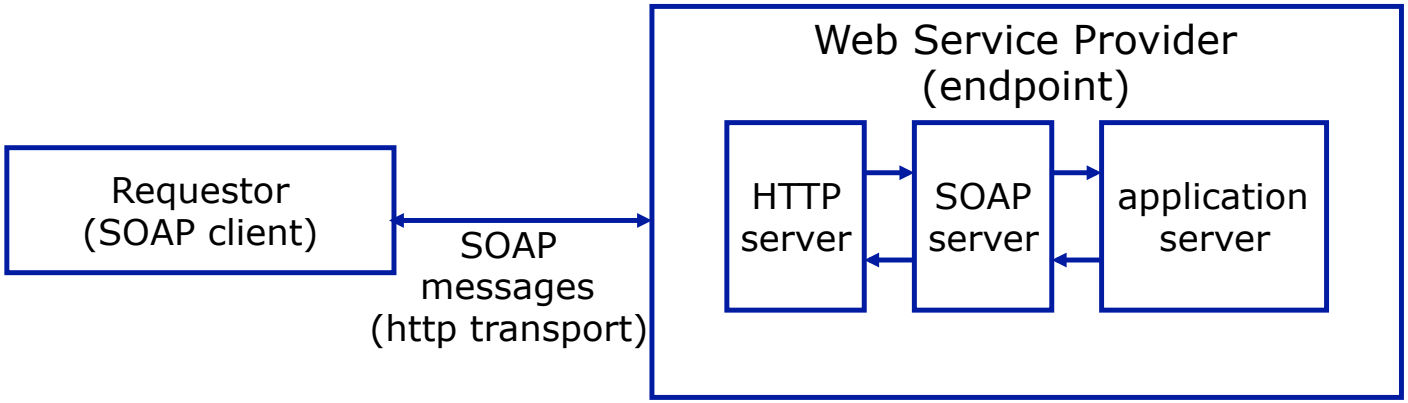
Basic Web Service Usage Scenario



Stack of Web Service Standards



Web Services Implementation



- Application Server (Web Service-enabled)

  provides implementation of services and exposes it through WSDL/SOAP
  implementation in Java, as EJB, as .NET (C#) etc.

- SOAP server

  implements the SOAP protocol

- HTTP server

  standard Web server

- SOAP client

  implements the SOAP protocol on the client site

Chapter Plan

- Web Services Architecture
- SOAP (messaging)
- WSDL (service description)
- UDDI (registry)

SOAP: Simple Object Access Protocol

- Lightweight messaging framework based on XML
- Supports simple messaging and RPC
- SOAP consists of:
  - Envelope construct: defines the overall structure of messages
  - Encoding rules: define the serialization of application data types
  - SOAP RPC: defines representation of remote procedure calls and responses
  - Binding framework: binding to protocols such as HTTP, SMTP
  - Fault handling
- Soap supports advanced message processing:
  - forwarding intermediaries: route messages based on the semantics of message
  - active intermediaries: do additional processing before forwarding messages, may modify message

SOAP messages

- SOAP messages consist of

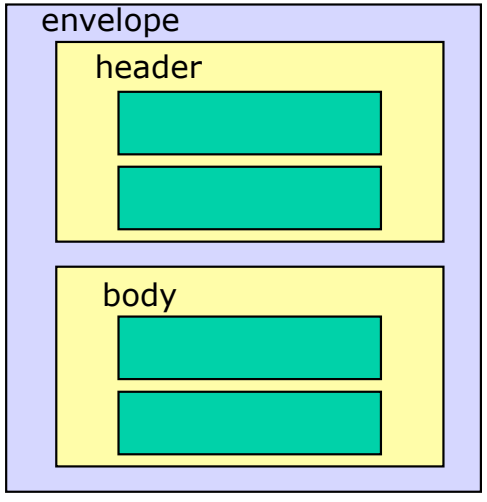
  Envelope: top element of XML message (required)
  Header: general information on message such as security (optional)
  Body: data exchanged (required)

- Header

  elements are application-specific
  may be processed and changed
  by intermediaries or recipient

- Body

  elements are application-specific
  processed by recipient only



Skeleton SOAP Message

```
<?xml version="1.0"?>
<soap:Envelope
    xmlns:soap="http://www.w3.org/2001/12/soap-envelope"
    soap:encodingStyle="http://www.w3.org/2001/12/soap-encoding">
<soap:Header>
  ...
  ...
</soap:Header>
<soap:Body>
  ...
  ...
  <soap:Fault>
    ...
    ...
  </soap:Fault>
</soap:Body>
</soap:Envelope>
```

SOAP RPC: Remote Procedure Call

Encapsulate RPC into SOAP messages

- procedure name and arguments
- response (return value)
- processing instructions (transactional RPC!)

```
<?xml version='1.0' ?>
<env:Envelope xmlns:env="http://www.w3.org/2002/12/soap envelope">
<env:Header>
  <t:transaction xmlns:t="http://thirdparty.example.org.transaction"
                 env:encodingStyle="http://example.com/encoding" env:mustUnderstand="true">
   5</t:transaction>
</env:Header>
<env:Body>

  <m:chargeReservation env:encodingStyle="http://www.w3.org/2002/12/soap-encoding"
                      xmlns:m="http://travelcompany.org/">
     <m:reservation xmlns:m="http://travelcompany.org/reservation"> <m:code>DDXZF</m:code>
     </m:reservation>
   <o:creditCard xmlns:o="http://travelcompany.com/financia">
         <n:name xmlns:n="http://travelcompany.com/employee"> Alice Ruberg </n:name>
         <o:number>1473484265576</o:number> <o:expiration>2016-02</o:expiration>
     </o:creditCard>
  </m:chargeReservation>

</env:Body>
</env:Envelope>
```

SOAP RPC: Remote Procedure Call

Encapsulate RPC into SOAP messages

- procedure name and arguments
- response (return value)
- processing instructions (transactional RPC!)

```
<?xml version='1.0' ?>
<env:Envelope xmlns:env="http://www.w3.org/2002/12/soap envelope">
<env:Header>
  <t:transaction xmlns:t="http://thirdparty.example.org.transaction"
                 env:encodingStyle="http://example.com/encoding" env:mustUnderstand="true">
   5</t:transaction>
</env:Header>
<env:Body>
```

```
chargeReservation(code:DDXZF,
                  creditCard{name:  Alice Ruberg,
                             number:  1473484265576,
                             expiration:  2016-02}
                 )
```

```
</env:Body>
</env:Envelope>
```

SOAP Response

```
<?xml version='1.0' ?>
<env:Envelope xmlns:env="http://www.w3.org/2002/12/soap-envelope" >
<env:Header>
  <t:transaction xmlns:t=http://thirdparty.example.org/transaction
                 env:encodingStyle=http://example.com/encoding
                 env:mustUnderstand="true">5</t:transaction>
</env:Header>
<env:Body>
```

```
 <m:chargeReservationResponse
                env:encodingStyle=http://www.w3.org/2002/12/soap-encoding
                xmlns:m="http://travelcompany.example.org/">
   <m:code>FT35ZBQ</m:code>
   <m:viewAt> http://travelcompany.example.org/reservations?code=FT35ZBQ
   </m:viewAt>
 </m:chargeReservationResponse>
```

```
</env:Body>
</env:Envelope>
```

The *fault* element

Carries an error message
If present, must appear as a child of `<Body>`
Must only appear once
Has the following sub-elements:

Sub Element	Description
<faultcode>	A code for identifying the fault (VersionMismatch, MustUnderstand, Client, Server)
`<faultstring>`	A human readable explanation of the fault
`<faultactor>`	Information about who caused the fault to happen
`<detail>`	Holds application specific error information related to the Body element

Protocol Binding

- Bindings to different protocols possible: HTTP, SMTP
- Different HTTP bindings:
  - HTTP POST (for request-response communications)
  - HTTP GET

Request

```
POST /Reservations?code=FT35ZBQ HTTP/1.1
Host: travelcompany.example.org
Content-Type: application/soap+xml; charset="utf-8"
Content-Length: nnnn
<?xml version='1.0' ?>
<env:Envelope xmlns:env="http://www.w3.org/2002/12/soap-envelope">
 ...SOAP request message...
</env:Envelope>
```

Response

```
HTTP/1.1 200 OK
Content-Type: application/soap+xml; charset="utf-8"
Content-Length: nnnn
<?xml version='1.0' ?>
<env:Envelope xmlns:env="http://www.w3.org/2002/12/soap-envelope">
... SOAP response message ...
</env:Envelope>
```

Chapter Plan

- Web Services Architecture
- SOAP (messaging)
- WSDL (service description)
- UDDI (registry)

WSDL: Web Service Definition Language

Define a Web Service in WSDL by

Writing an XML document conforming to the WSDL specs

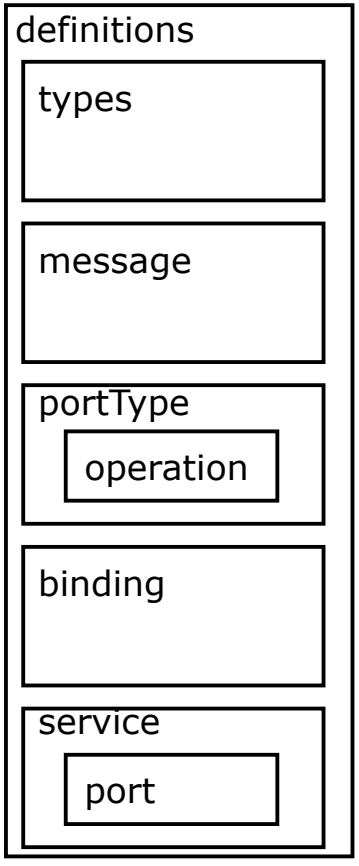
Describes three fundamental properties:

- What are the operations (functions, methods) provided by the service
- How a service is accessed

  Data format and protocol details
- Where a service is located

  Address (URL) details

WSDL Document Structure



All the data types used by the Web service

Parameters and messages used by method

Abstract interface definition: each operation element defines a method signature

Binds abstract methods to specific protocols

A service is a collection of ports.

A port is a specific method and has its own URI

WSDL to Code

- Convert WSDL document to code
  E.g., Apache AXIS WSDL2java
- Derive WSDL from Java classes
  E.g., Apache WSDL, Eclipse plug-in

XML Schema

- Grammar (data definition language) for specifying valid documents
- Uses same syntax as regular XML documents: verbose and difficult to read
- Provides local scoping of subelement names
- Incorporates namespaces
- Types
  - primitive types: string, integer, float, date, ...
  - simpleType constructors: list, union
  - restrictions: intervals, lengths, enumerations, regex patterns,
- Flexible ordering of elements
- Key and referential integrity constraints

Example Type Element

```
<types>
<xsd:schema targetNamespace="http://travelcompany.com/ns"
   xmlns:xsd="http://www.w3.org/2001/XMLSchema">
   <xsd:complexType name="creditCard">
       <xsd:sequence>
           <xsd:element name="name" type="xsd:string">
           <xsd:element name="number" type="xsd:integer">
           <xsd:element name="expiration" type="xsd:date">
    </xsd:sequence>
  </xsd:complexType>
</xsd:schema>
</types>
```

Overview of Defining WSDL Services

1. Define in XML Schema the message types used when invoking the service:

   MT1, MT2 etc.

2. Define (named) messages by using these types, e.g.

   message m1 has type MT1, message m2 has type MT2 etc.

3. Define Services that consist of one or more operations; each operation is implemented by the exchange of messages

   service S offers operation O1;
   for executing O1 first send a request message m1,
   then a response message m2 is returned

4. Define a Binding B to a specific protocol, e.g.

   SOAP service S is implemented in SOAP;
   the SOAP messages are constructed from the abstract messages m1 and m2 by, e.g. inlining the messages as body of SOAP message

5. Service S is provided with binding B at the following URI's (called ports)

Example WSDL

```
<definitions name="TravelAgency">
<types>
  <schema> definition of types in XML Schema ... </schema>
</types>
<message name="ChargeReservation"> XML-schema definition </message>
<message name="ChargeReservationResponse"> XML-schema definition </message>
<portType name="TravelAgencyPortType">
  <operation name="ChargeReservation"> definition of an operation ... </operation>
</portType>
<binding name="TravelAgencySoapBinding"> definition of a binding ... </binding>
<service name="TravelAgencyService">
    <port name="TravelAgencyPort"> definition of a port ... </port>
</service>
</definitions>
```

Chapter Plan

- Web Services Architecture
- SOAP (messaging)
- WSDL (service description)
- UDDI (registry)

UDDI: Initial Goals and Final Use

- Goal: provide access to WSDL descriptions registered to a broker
- UDDI is an open industry initiative (IBM, Microsoft, SAP)
- The work at UDDI was stopped in 2006 due to the lack of wide acceptance
- Nowadays, UDDI systems are most commonly found inside companies

UDDI: Universal Description Discovery and Integration

- Standard for describing, publishing and finding web services

  Use XML-based description files for services

- Main components

  White pages: basic contact information about an organization

  Yellow pages: classification of organization based on industrial categorization

  Green pages: technical description of services offered by registered organizations

- Access to UDDI Registry

  Standard UDDI API (accessible via SOAP)

  Web browser

- Data Structures (XML)

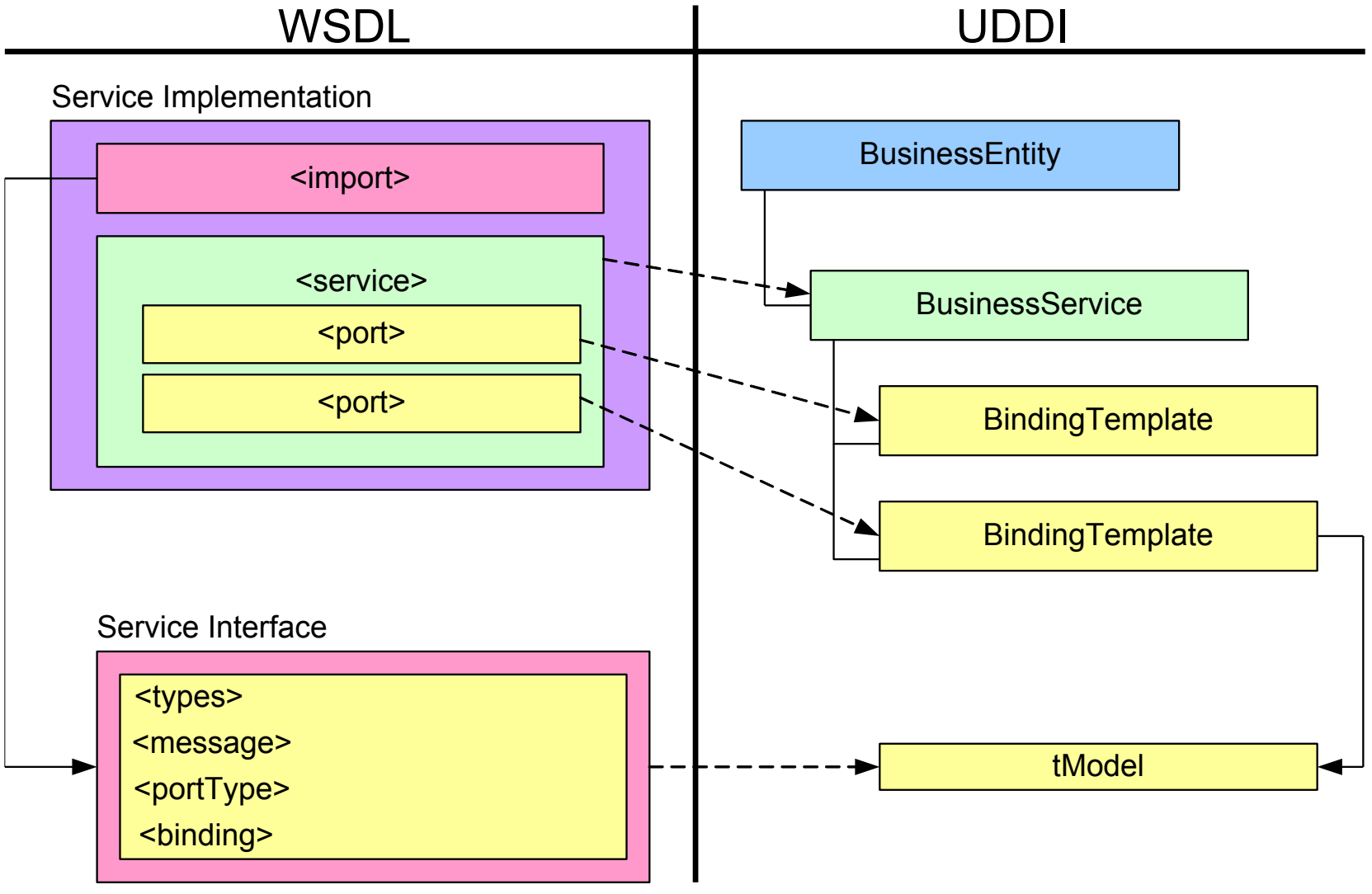
  Business entity: general information + business services

  Business services: business level description + binding templates

  Binding templates: access point + tModel (service types)

  tModel: abstract definition of a web service

WSDL – UDDI


WSDL
UDDI
Service Implementation
<import>
<service>
<port>
<port>
BusinessEntity
BusinessService
BindingTemplate
BindingTemplate
Service Interface
<types>
<message>
<portType>
<binding>
tModel

Web Services within the Distributed Computing Environment

- Loosely Coupled

  Each service exists independently of the other services that make up the application.
  Individual pieces of the application to be modified without impacting unrelated areas.

- Ease of Interface

  Data is isolated between applications creating "silos".
  Web Services act as glue between these and enable easier communications within and across organisations.

Plan

REST: REpresentational State Transfer

- Introduced in Roy Fielding's doctoral dissertation (2000)
- Fielding contributed also to the design of HTTP and URI's

Real REST-based Web Services

ProgramableWeb.com:

- references more than 12000 APIs from various domains (in 2015)
- $>$ 70% of the publicly available Web Services are REST

Search (3200 APIs)
Traveling (1200 APIs)
Social (3000 APIs)
Music (1000 APIs)
Financial (1200 APIs)
Science (600 APIs)
Weather (300 APIs)

A Call to a Real Web Service

Web site: MusicBrainz
Web Service function: “get album by artist name”
Web call for for input “Rihanna”: `http://musicbrainz.com?artist=Rihanna`

Result for the Web call:

```
<release-group id="a7753ec7-2fea-3621-a73b-e5d3462d4741"
  <primary-type>Album</primary-type>
</release-group>
<date>2002-09-16</date>
<country>GB</country>
<release-event-list>
  <release-event>
    <date>2002-09-16</date>
    <area id="8a754a16-0027-3a29-b6d7-2b40ea0481ed">
      <name>United Kingdom</name>
      <sort-name>United Kingdom</sort-name>
      <iso-3166-1-code-list>
        <iso-3166-1-code>GB</iso-3166-1-code>
      </iso-3166-1-code-list>
    </area>
```

REST Architecture

- REST is not protocol specific
- However, it is usually associated with HTTP

HTTP

- Synchronous request/response network protocol
- Used for collaborative distributed document-based systems
- The documents are encoded using different formats:
  - XML
  - JSON
  - Binary data may be included in the documents bodies
- Browsers usually use only a small part of HTTP

REST Architectural Principles

- The web has addressable resources:
  - Each resource has a URI.
- The web has a uniform interface. E.g,
  - HTTP has a small number of methods.
  - Use these to manipulate resources.
- The Web is representation oriented - providing diverse formats:
  - XML
  - JSON
- Stateless communication: using features of the Web methods
- Hypermedia is used as the engine of application state

Principle: Addressability

Addressability (not restricted to HTTP)
Each HTTP request uses a URI.
The format of a URI is well defined:

`scheme://host:port/path?queryString#fragment`

`scheme`	- not necessarily HTTP; may be FTP or HTTPS
`host`	- field may be a DNS name or a IP address
`port`	- may be derived from the scheme; HTTP implies port 80
`path`	- set of text segments delimited by the "/"
`queryString`	- list of parameters represented as `name=value` pairs
	- each pair is delimited by an "&"
	- space is represented with the '+' characters
	- for special characters use % followed by two hex digits
`fragment`	- used to point to a particular place in the document.

Principle: Uniform Interface

- HTTP GET
  - read only operation
  - idempotent (once same as many)
  - safe (no important change to server's state)
  - may include parameters in the URI

```
http://www.travelagency.com/flights?source=Bucharest&dest=Paris
```

- HTTP PUT
  - store the message body
  - insert or update
  - idempotent
  - not safe

Principle: Uniform Interface

- HTTP POST
  - not idempotent
  - each method call may modify the resource in a unique way
  - the request may or may not contain additional information
  - the parameters are found within the request body (not in the URI)
- HTTP DELETE
  - remove the resource
  - each method call may modify the resource in a unique way

Advantages of the Uniform Interface

- Familiarity
  - No need to use a complicated syntax to describe methods signatures.
  - We already know the methods.
- Interoperability
  - SOAP-WS has been a moving target.
  - HTTP is widely supported.
- Scalability
  - Since GET is idempotent and safe.
  - Results may be cached by clients or proxy servers.

Principle: Representation Oriented

- Representations of resources are exchanged
- Representations may be in many formats: XML, JSON, YAML, etc
- GET returns a representation
- PUT and POST passes representations to the server so that underlying resources may change

How the representation mode is specified?

- HTTP uses the CONTENT-TYPE header for the call results
- The value of the CONTENT-TYPE is a MIME typed string. Versioning information may be included

Principle: Communicate Statelessly

- The application may have a state but there is no client session data stored on the server.
- If there is any session-specific data it should be held and maintained by the client and transferred to the server with each request as needed.
- The server is easier to scale. No replication of session data concerns.

Hypermedia as the Engine of Application State

- Hypermedia consists of documents with links
- Hence, a REST Web service can use links in call results to encode
  - the interactions that can be preformed next
  - possible transitions of the current state of the application

```
<order id = "111">
    <customer> http://travelagency.com/customers/customer/1234
    </customer>
    <cancel> http://travelagency.com/canceling?orderId=111
    </cancel>
    <booking>
        <booking>
            <persons>2
            <train>
                http://travelagency.com/trains/trains/8754
            </train>
```

SOAP-based vs. REST-based Web services

- SOAP-WSs use HTTP strictly as a transport protocol
- REST-WSs used the application protocol to express calls to operations:

SOAP

Request	Response
XML (SOAP)	XML (SOAP)

REST

Request	Response
URI	XML

- SOAP-WSs: requests/responses are typed using XML-Schema
  the error response is specified
- REST-WSs: the service does not communicate the schema
  that it used to encode the responses