Web Services

1

How Do Web Services Relate to Course?

- Relatively novel XML-based distributed/network computing paradigm
- Supported by all major computing companies (Microsoft, IBM, Sun, Oracle, HP, …)
- Technical concepts are similar to other paradigms already discussed in the course
- The main difference is in “business issues”

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Service-Based Software Systems

- "Software is a service" business model
  - Software is not a product any more, but a service available over the network
  - Application Service Providers (ASPs)
- Service-Oriented Architecture (SOA)
  - Applications decomposed into distributed services
  - On-line access to libraries of composable components

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W3C Definition of a Web Service

- A software application that:
  - has a unique Uniform Resource Identifier (URI),
  - can be defined, described, and discovered using XML (Extensible Markup Language),
  - supports exchange of XML messages via Internet-based protocols.

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Microsoft .NET Definition of a Web Service

- A black-box programmable application logic that can be reused without worrying about how the service is implemented
- Defined strictly in terms of the messages the Web Service accepts and generates
- Simply and easily composed over the network, across domain boundaries
- Accessible using standard and ubiquitous Internet protocols and data formats (XML)

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Some Goals of the Work on Web Services

- Faster development and deployment of IT (Information Technology) systems
- Dynamic and ad hoc A2A (Application-to-Application) and B2B (Business-to-Business) integration
- Interoperability across programming languages and operation platforms
- Leveraging and compatibility with existing Internet/Web infrastructure

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Web Services vs. Distributed Objects

- Ad hoc & temporary vs. planned & stable integration
- “Loose coupling” vs. “tight coupling”
- Synchronous or asynchronous vs. synchronous communication
- RPC (Remote Procedure Call) or document-based vs. RPC interactions
- B2B or inter-enterprise vs. inter-enterprise integration

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Who Is Working in This Area?

- All major computing companies
  - Microsoft .NET, IBM Dynamic e-business, Sun ONE (Open Net Environment), Oracle, HP, …
- Several industrial “standardization” bodies
  - W3C (World Wide Web Consortium)
  - OASIS (Organization for the Advancement of Structured Information Standards)
  - WS-I (Web Services - Interoperability)
  - …

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Basic Technologies

- XML (Extensible Markup Language) - For data representations
- SOAP [a.k.a. Simple Object Access Protocol, XML Protocol] - An XML packaging protocol, defines message formats and encoding rules
- WSDL (Web Services Description Language) - An XML service description language

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Some Popular Technologies

- UDDI (Universal Description, Discovery, and Integration) - For discovering service providers if you do not know their URLs
- WS-Inspection - For discovering services located on a particular Web site (you need to know its URL)
- BPEL4WS (Business Process Execution Language for Web Services) - For describing Web Service compositions (orchestrations)

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And Many Other Technologies …

- WS-Policy - For specifying policies (e.g., security)
- WSLA (Web Service Level Agreements) - A way to to specify quality of service (QoS) guarantees and service level agreements
- Many WS-??? and WS?L technologies …

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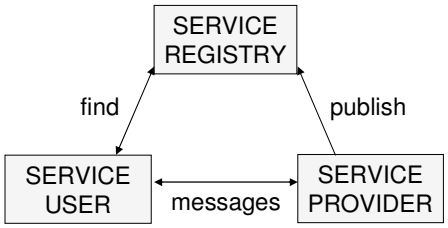
Web Service Standards

- SOAP
- WSDL
- UDDI



- WS-*
  - WS-Addressing
  - WS-ReliableMessaging
  - WS-Security, WS-Policy
  - WS-Resource
  - WS-Choreography (WS-CDL)
  - WS-BPEL (aka. BPEL4WS)
  - WS-Coordination, WS-AtomicTransaction, WS-CAF
  - ...

UNDER DEVELOPMENT!

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SOAP

- Used to be "**S**imple **O**bject **A**ccess **P**rotocol", but no longer an acronym...

- Processing Model
- Data Representation and RPC
- Binding to transport protocols (e.g. HTTP)

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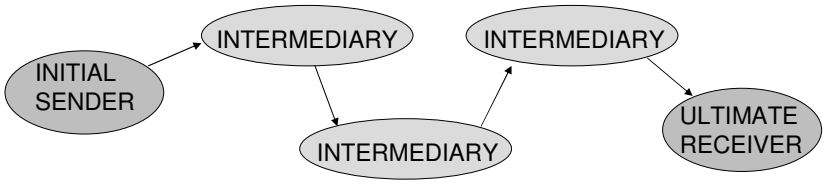
The SOAP Processing Model



SOAP Envelope:

```
<Envelope xmlns="http://www.w3.org/2003/05/soap-envelope">
  <Header>...</Header>
  <Body>...</Body>
</Envelope>
```

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Structure of a SOAP Message

SOAP Envelope

SOAP Header (optional)
- various management information

SOAP Body (mandatory)
- the transferred information in XML

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Envelope Headers

- Encryption information
- Access control
- Routing
- Auditing
- Data extensions
- ...

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A SOAP Message

```
<env:Envelope xmlns:env="http://www.w3.org/2003/05/soap-envelope"
              xmlns:w="http://www.widget.inc/shop"
              xmlns:n="http://notaries.example.org">
  <env:Header>
    <w:ticket>54B42CF401A</w:ticket>
    <n:token>
      <n:value>32158546</n:value>
      <n:issuer>http://notarypublic.example.com</n:issuer>
    </n:token>
  </env:Header>
  <env:Body>
    <w:buy>
      <w:product>light gadget</w:product>
      <w:amount>430</w:amount>
    </w:buy>
  </env:Body>
</env:Envelope>
```

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Special SOAP Header Attributes

- role
  - next
  - ultimateReceiver
  - none
- mustUnderstand
- relay
- encodingStyle

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Another Example

```
<env:Envelope xmlns:env="http://www.w3.org/2003/05/soap-envelope"
              xmlns:c="http://encodings.example.org"
              xmlns:r="http://routings.example.org">
  <env:Header>
    <c:encoding env:role="http://encodings.example.org/decoder"
                env:mustUnderstand="true">
      gzip+base64
    </c:encoding>
    <r:route env:relay="true"
             env:role=
             "http://www.w3.org/2003/05/soap-envelope/role/next">
      <r:node>130.225.16.12</r:node>
      <r:node>10.11.40.201</r:node>
    </r:route>
  </env:Header>
  <env:Body>
    H4sICACI/0EAA3EA80jNycnXUSjPL8pJUeQCABinVXsOAAAA
  </env:Body>
</env:Envelope>
```

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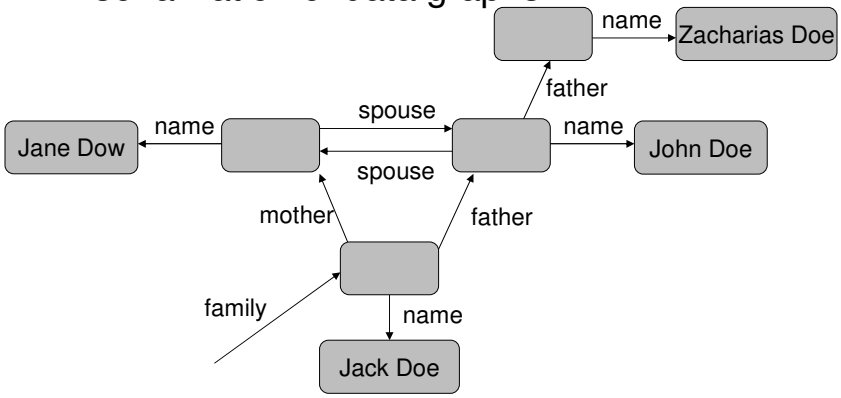
SOAP Encoding

XML serialization of data graphs



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SOAP Encoding, cont.

```
<family xmlns:env="http://www.w3.org/2003/05/soap-envelope"
        xmlns:enc="http://www.w3.org/2003/05/soap-encoding"
        env:encodingStyle=
               "http://www.w3.org/2003/05/soap-encoding"
        xmlns="http://www.widget.inc/encoding">
  <name>Jack Doe</name>
  <father enc:id="1">
    <name>John Doe</name>
    <father>
      <name>Zacharias Doe</name>
    </father>
    <spouse enc:ref="2"/>
  </father>
  <mother enc:id="2">
    <name>Jane Dow</name>
    <spouse enc:ref="1"/>
  </mother>
</family>
```

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RPC in SOAP

```
<env:Envelope
       xmlns:env="http://www.w3.org/2003/05/soap-envelope"
       xmlns:rs="http://www.brics.dk/ixwt/recipeserver"
       xmlns:rcp="http://www.brics.dk/ixwt/recipes">
  <env:Body>
    <rs:writeRecipe env:encodingStyle=
              "http://www.w3.org/2003/05/soap-encoding">
      <rs:lock>4DHX5ZV3D871AQ09</rs:lock>
      <rs:recipe env:encodingStyle=
              "http://xml.apache.org/xml-soap/literalxml">
        <rcp:recipe id="r105">
          <rcp:title>Cailles en Sarcophages</rcp:title>
          <rcp:date>Tue, 26 Sep 06</rcp:date>
         ...
        </rcp:recipe>
      </rs:recipe>
    </rs:writeRecipe>
  </env:Body>
</env:Envelope>
```

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Flexibility of SOAP

- SOAP can be used without using **SOAP Encoding**
- SOAP can be used with other conventions for RPC than **SOAP RPC**
- SOAP can be used with other communication patterns than **SOAP RPC**

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Protocol Binding

- Transmission protocols: HTTP, SMTP, ...
- Route from initial sender to ultimate receiver may involve different protocols
- RPC fits nicely into HTTP request–response

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HTTP Binding in SOAP

- Message exchange patterns:
  - request–response (for RPC) ⇒ POST
  - SOAP response ⇒ GET

```
HTTP/1.1 200 OK
Content-Type: application/soap+xml; charset="utf-8"
Content-Length: 273

<env:Envelope
    xmlns:env="http://www.w3.org/2003/05/soap-envelope"
    xmlns:rs="http://www.brics.dk/ixwt/recipeserver">
  <env:Body>
    <rs:writeRecipeResponse env:encodingStyle=
          "http://www.w3.org/2003/05/soap-encoding"/>
  </env:Body>
</env:Envelope>
```

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Summary of SOAP

- A transport neutral protocol for XML data interchange (but focusing on HTTP)
- Processing model (envelopes, intermediaries, ...)
- SOAP Encoding
- SOAP RPC
- Protocol Bindings
- Foundation of WS-*

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WSDL: Web Service Description Language

- Standard for describing Web services
  - Abstract interface for defining operations and their messages
    - Messages contain either document-oriented or procedure-oriented information
  - Bindings to message formats and protocols
  - Defines how to locate the endpoint for the service
    - Example: URLs for HTTP
  - Extensible (SOAP and HTTP extensions are defined)
  - Written in XML, leverages XML schema
- WSDL V1.1 Specification
  - http://www.w3.org/TR/wsdl

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Usage Scenarios

- As IDL (Interface Definition Language)
  - Allows tools to generate client access code for a service
  - Examples: IBM WebSphere Studio Application Developer, IBM Web Services Toolkit
- Standardized service interface descriptions
  - Allows advertisement and dynamic discovery of services
  - Enables dynamic binding to service
  - Complements UDDI registry

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Document Content

- Abstract Definitions
  - <types> data type definitions
  - <message> operation parameters
  - <portType> operation definitions
- Concrete Definitions
  - <binding> operation bindings
  - <service> location/address for each binding
- Also:
  - <import>used to reference other XML documents

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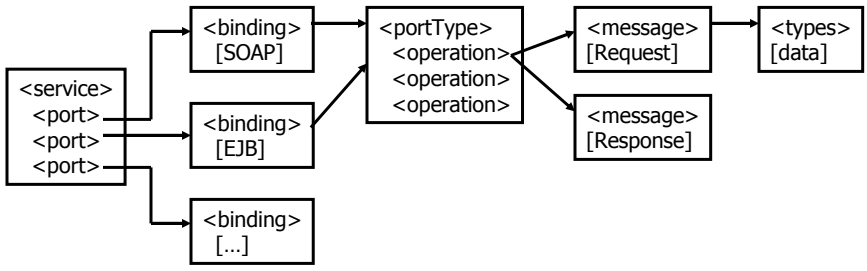
Document Structure



Service(s) Supported Protocol(s) Java class method method method SOAP Request/ response

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SOAP Binding - RPC Style

- Indicates that the Web service is accessed using SOAP V1.1 protocol
- Use style="rpc" attribute on SOAP binding element
- Example SOAP service method signature:
  - public float getQuote (String symbol)

SOAP	Java	Description
Operation	getQuote	Method name
Input Message	String symbol	Input parameter
Output Message	float	Return type

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Example: Stock Quote Service [1]

```
<definitions name="StockQuoteService"
   targetNamespace="http://tempuri.org/StockQuoteService"
   xmlns:tns="http://tempuri.org/StockQuoteService" ...>

 <message name="SymbolRequest">
   <part name="symbol" type="xsd:string" />
 </message>
 <message name="QuoteResponse">
   <part name="quote" type="xsd:float" />
 </message>
 <portType name="StockQuoteService">
   <operation name="getQuote">
     <input message="tns:SymbolRequest" />
     <output message="tns:QuoteResponse" />
   </operation>
 </portType>
 ...
```

```
public float getQuote (String symbol)
```

```
public float getQuote (String symbol)
```

```
public float getQuote (String symbol)
```

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Example: Stock Quote Service [2]

```
...
<binding name="SoapBinding" type="tns:StockQuoteService">
  <soap:binding style="rpc"
     transport="http://schemas.xmlsoap.org/soap/http" />
  <operation name="getQuote">
    <soap:operation soapAction="http://tempuri.org/GetQuote" />
    <input>
      <soap:body use="encoded"
        namespace="http://tempuri.org/live-stock-quotes"
        encodingStyle="http://schemas.xmlsoap.org/soap/encoding/"/>
    </input>
    <output>
      <soap:body use="encoded" namespace="..." encodingStyle="..."/>
    </output>
  </operation>
</binding>
...
```

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Example: Stock Quote Service [3]

```
...
<service name="StockQuoteService">
  <documentation>Stock Quote Service</documentation> -
  <port name="Demo"  binding="tns:SoapBinding">
    <soap:address
      location="http://tempuri.org/services/StockQuoteService" />
  </port>
</service>
</definitions>
```

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WSDL4J

- WSDL Java API
  - WSDL object model
  - Parse contents of a WSDL document
  - Programmatically create new WSDL documents
- Open source project sponsored by IBM and HP
  - http://sourceforge.net/projects/wsdl4j/
- Is the reference implementation for JSR 110
  - Primarily a set of Java interfaces that can be implemented by anyone
  - Java package name: javax.wsdl

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WSDL4J Example - Find Port

```
// Get WSDLReader
WSDLReader wsdlReader = WSDLFactory.newInstance().newWSDLReader();

// Read WSDL service implementation document
Definition wsdlDefinition = wsdlReader.readWSDL(null, wsdlURL);

// Get the service elements
Map services = definition.getServices();

// Get an iterator for the list of services
Iterator serviceIterator = services.values().iterator();

boolean bPortFound = false;
while ((serviceIterator.hasNext()) && !(bPortFound)) {
  // Get next service element
  Service service = (Service) serviceIterator.next();

  // Determine if this service element contains the specified port
  if ((port = service.getPort(portName)) != null)
     bPortFound = true;
}
```

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Summary of WSDL

Description of **interfaces** of Web services:

- message types
- operations
- encodings and communication protocols
- location

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UDDI

- **U**niversal **D**escription, **D**iscovery, and **I**ntegration

- static / dynamic discovery
- public / private registries

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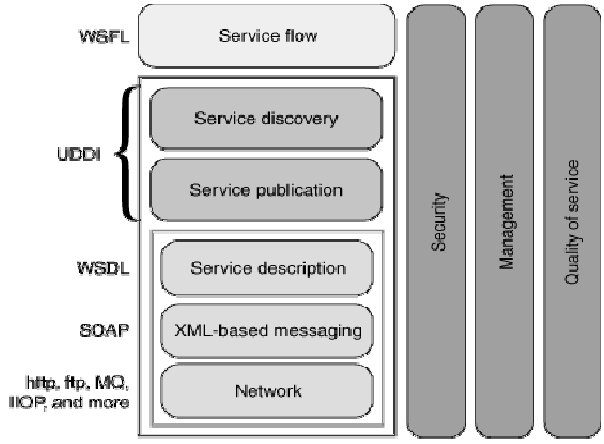
Web Services Protocol Stack



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UDDI Descriptions

- `publisherAssertion`
  (describes relations between businesses)
- `businessEntity`
  (describes a concrete business)
- `businessService`
  (describes a Web service)
- `bindingTemplate`
  (describes invocation information)
- `tModel`
  (technical details, e.g. reference to WSDL description)

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UDDI Operations

Inquiry Operations:
Find
- find_business
- find_service
- find_binding
- find_tModel

Get details
- get_businessDetail
- get_serviceDetail
- get_bindingDetail
- get_tModelDetail
- get_registeredInfo

Publishing Operations:
Save
- save_business
- save_service
- save_binding
- save_tModel

Delete
- delete_business
- delete_service
- delete_binding
- delete_tModel

Security
- get_authToken
- discard_authToken

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Summary

- **SOAP** – a transport neutral protocol for XML data interchange (but focusing on HTTP)
- **WSDL** – description of Web service interfaces
- **UDDI** – registries and discovery of Web services

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Semantic Web Services: the ultimate vision for the WWW

The Vision

- 500 million users
- more than 3 billion pages

Static

WWW
URI, HTML, HTTP

The Vision

Serious Problems in

- information finding,
- information extracting,
- information representing,
- information interpreting and
- and information maintaining.

Static

WWW
URI, HTML, HTTP

Semantic Web
RDF, RDF(S), OWL

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Why RDF/OWL, why not simply XML and related technologies

- XML provides a surface syntax for structured documents, but imposes no semantic constraints on the meaning of these documents.
- XML Schema is a language for restricting the structure of XML documents and also extends XML with datatypes.
- RDF is a datamodel for objects ("resources") and relations between them, provides a simple semantics for this datamodel, and these datamodels can be represented in an XML syntax.
- RDF Schema is a vocabulary for describing properties and classes of RDF resources, with a semantics for generalization-hierarchies of such properties and classes.
- OWL adds more vocabulary for describing properties and classes: among others, relations between classes (e.g. disjointness), cardinality (e.g. "exactly one"), equality, richer typing of properties, characteristics of properties (e.g. symmetry), and enumerated classes.

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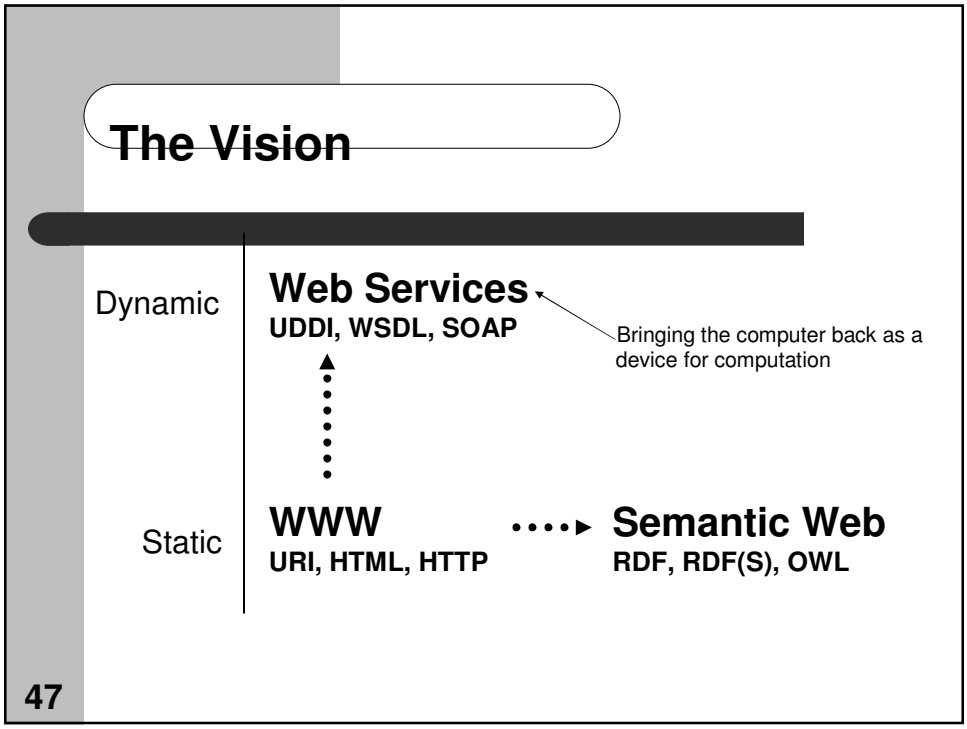
The Vision
Dynamic
Web Services
UDDI, WSDL, SOAP
Bringing the computer back as a device for computation
Static
WWW
URI, HTML, HTTP
Semantic Web
RDF, RDF(S), OWL
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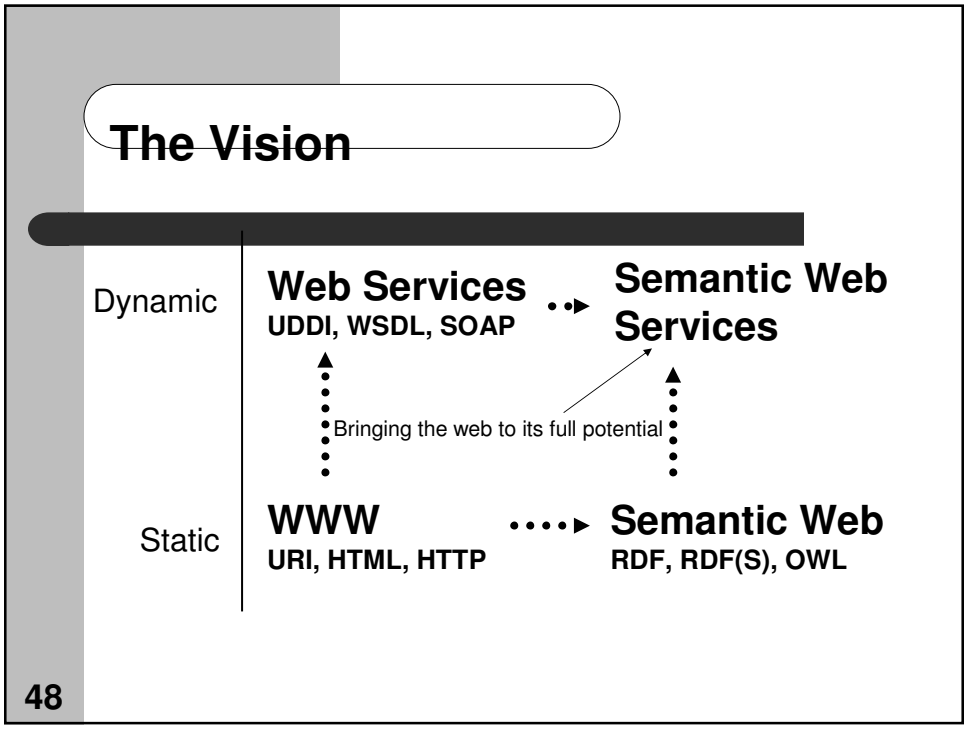
The Vision
Dynamic
Web Services
UDDI, WSDL, SOAP
Semantic Web Services
Bringing the web to its full potential
Static
WWW
URI, HTML, HTTP
Semantic Web
RDF, RDF(S), OWL
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The Semantic Web

- the next generation of the WWW
- information has machine-processable and machine-understandable semantics
- not a separate Web but an augmentation of the current one
- Ontologies as basic building block

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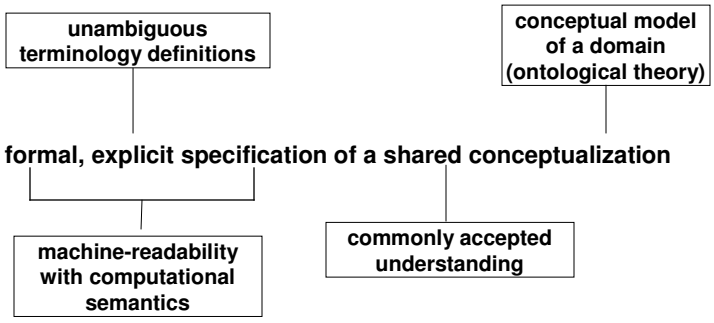
Ontology Definition



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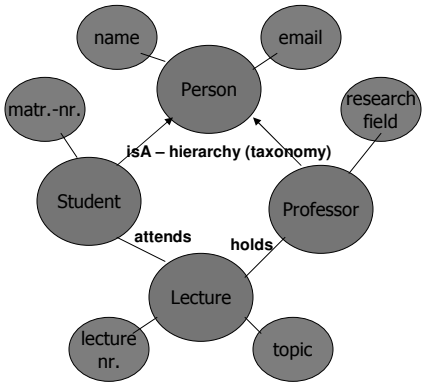
Ontology Example

Concept
conceptual entity of the domain

Property
attribute describing a concept

Relation
relationship between concepts or properties

Axiom
coherency description between Concepts / Properties / Relations via logical expressions



holds(Professor, Lecture) =>
Lecture.topic = Professor.researchField

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Web Services

- loosely coupled, reusable components
- encapsulate discrete functionality
- distributed
- programmatically accessible over standard internet protocols
- add new level of functionality on top of the current web

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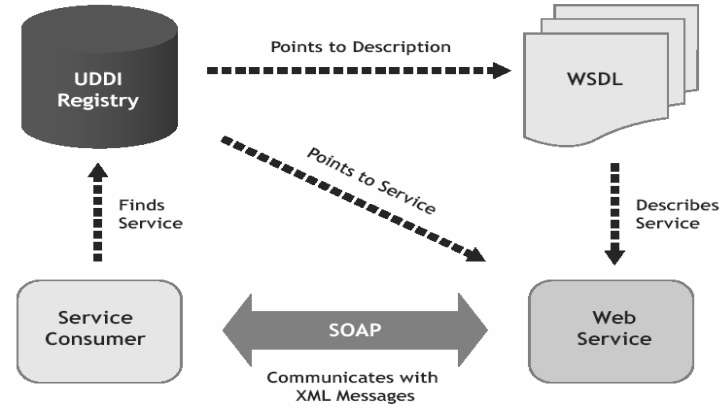
The Promise of Web Services

web-based SOA as new system design paradigm



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Deficiencies of WS Technology

- current technologies allow usage of Web Services
- but:
  - only syntactical information descriptions
  - syntactic support for discovery, composition and execution
  - => Web Service usability, usage, and integration needs to be inspected manually
  - no semantically marked up content / services
  - no support for the Semantic Web

=> current Web Service Technology Stack failed to realize the promise of Web Services

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Semantic Web Services

Semantic Web Technology

- allow machine supported data interpretation
- ontologies as data model

+

Web Service Technology

automated discovery, selection, composition,
and web-based execution of services

=> Semantic Web Services as integrated solution for realizing the vision of the next generation of the Web

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