Types of E-Business

Business To Consumer (B2C)	Business To Business (B2B)	Intra Business
•Relation between enterprise and Customers •Sales-related aspects are predominant, like product presentation, advertising, service advisory, shopping	•Relation between processes of different Enterprises •Predominant are relation to suppliers, and customer relations to other enterprises like industrial consumers, retailers, banks	•Electronic organization of internal business processes, like realization within workflow systems

B2B Integration – Conventional Middleware

- Middleware itself is (logically) centralized
  - usually controlled by a single company
  - now requires agreement on using, managing specific middleware platform across companies ("third party")
  - need to implement a "global workflow"
  - problems
    - lack of trust

    - autonomy needs to be preserved
    - business transactions are confidential
    - Point-to-point solutions
    - lack of standardization
  - many partners involved -> heterogeneity of middleware platforms
- Focus on LAN
  - insufficient support for internet protocols
  - problems with firewalls
  - cannot work with multiple trust domains

Web Services

- New distributed computing platform built on existing infrastructure including XML & HTTP
  - Web services are for B2B what browsers are for B2C
- Self-contained, self describing, modular service that can be published, located and invoked across the web
  - Refer to open standards and specifications:
    - component model (WSDL)
    - inter-component communication (SOAP)
    - discovery (UDDI)

    - Platform- and implementation-independent access
    - Described, searched, and executed based on XML
- Enable component-oriented applications
    - Loose coupling from client to service
    - Enable to integrate legacy systems into the web
    - Useful for other distributed computing frameworks such as CORBA, DCOM, EJBs

Web services as wrappers for existing IS-functionality

Service-Oriented Architecture (SOA)

Definition (given by OASIS SOA Reference Model):

- Service Requestor
  - Finds required services via Service Broker
  - Binds to services via Service Provider
- Service Provider
  - Provides e-business services
  - Publishes availability of these services through a registry
- Service Registry
  - Provides support for **publishing and locating** services
  - Like telephone yellow pages

Web Services - Definition

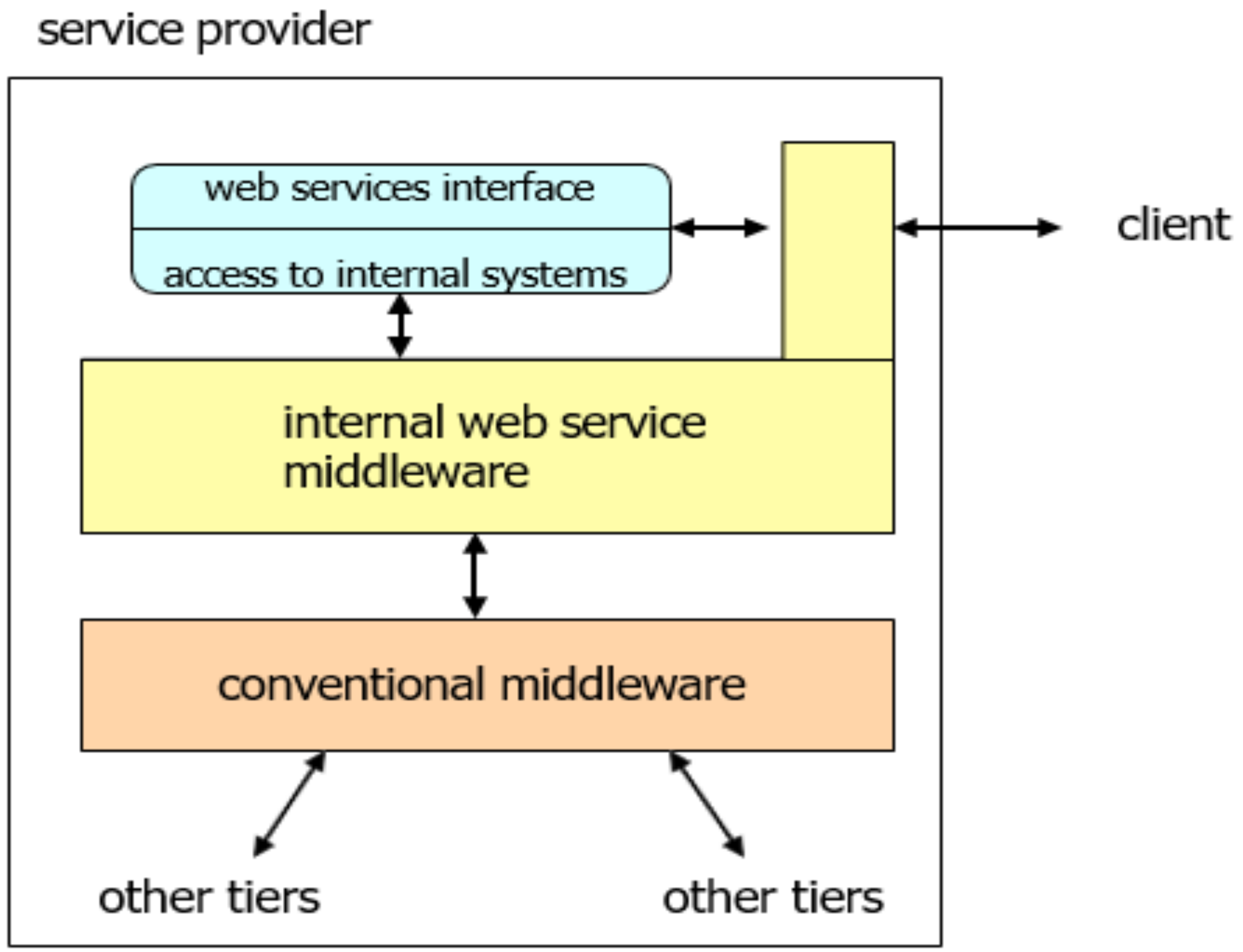
- W3C Web Services Architecture WG
  - produces WS Architecture Specification (working group note, 02/2004)
    - provide a common definition of a web service
    - define its place within a larger Web services framework to guide the community
- Definition
  - "A Web service is a software system designed to support interoperable machine-to- machine interaction over a network. It has an interface described in a machine- processable format (specifically WSDL). Other systems interact with the Web service in a manner prescribed by its description using SOAP messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web- related standards."

  - Earlier, more general definition:

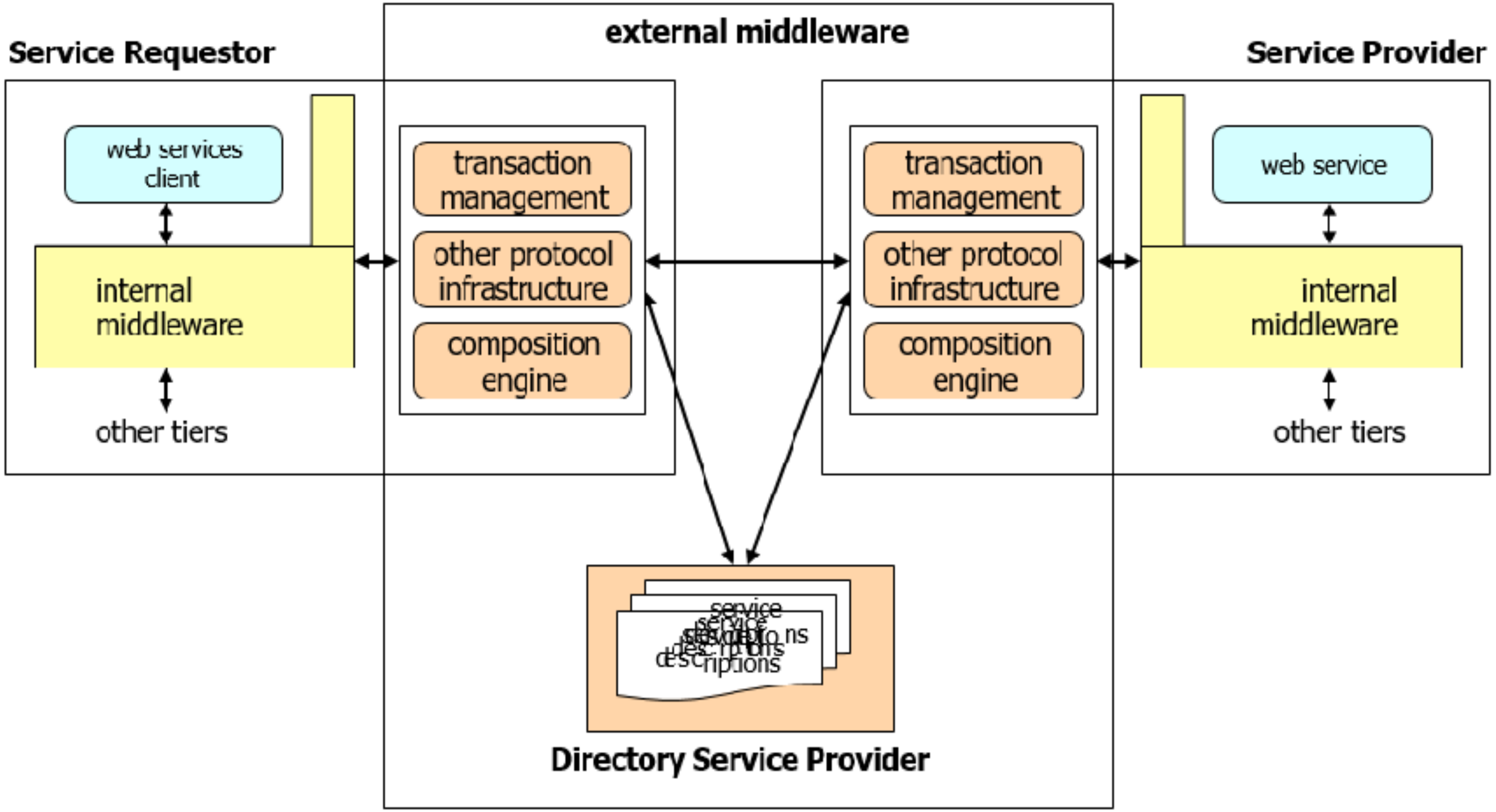
"A Web service is a software application identified by a URI, whose interfaces and bindings are capable of being defined, described, and discovered as XML artifacts. A Web service supports direct interactions with other software agents using XML based messages exchanged via internet-based protocols.

Web Service System Architecture

- Common internal architecture leveraging conventional middleware



External Web Services Architecture

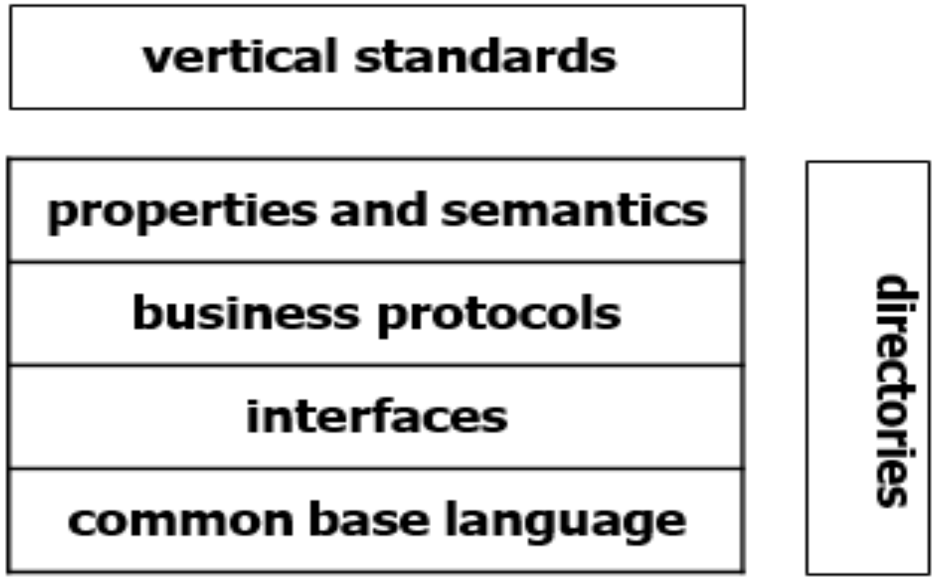


Technologies: Service Description & Discovery

- Service Description
  - Common Base Language (àXML)
  - Interfaces (àWSDL)
    - extend "traditional" IDLs
      - interaction mode
      - address/transport protocol info
  - Business Protocols (àWSCL, BPEL)
    - describe possible conversations
      - order of interactions
  - Properties and Semantics (àUDDI, WS-Policy)
    - descriptions to facilitate binding in a loosely-coupled, autonomous setting
      - e.g., non-functional properties (cost, transactional & security support)
      - textual descriptions
    - organize this information
  - Vertical Standards
    - interfaces, protocols, etc. specific to application domains

Service Description and Discovery Stack

- Service Discovery
  - Directory/Repository for WS descriptions
  - APIs and protocols for directory interaction at design-time or run-time

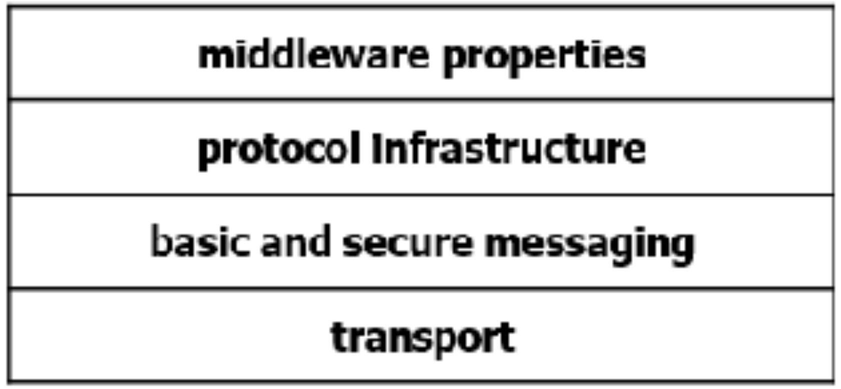


Technologies: Service Interaction & Composition

- Service Interaction
  - Transport
    - lots of possibilities
    - HTTP most common
  - Basic and Secure Messaging
    - standardize how to format/package information to be exchanged (àSOAP)
    - define how to extend basic mechanism to achieve additional capabilities (àWS- Security)

- Protocol Infrastructure (meta-protocols)
    - general infrastructure for business interactions
        - maintain state of conversation
        - meta-protocols
            - which protocols do we use?
            - who is coordinating?
- Middleware Properties (horizontal protocols)
    - properties similar to those of conventional middleware
        - reliability, transactions, …

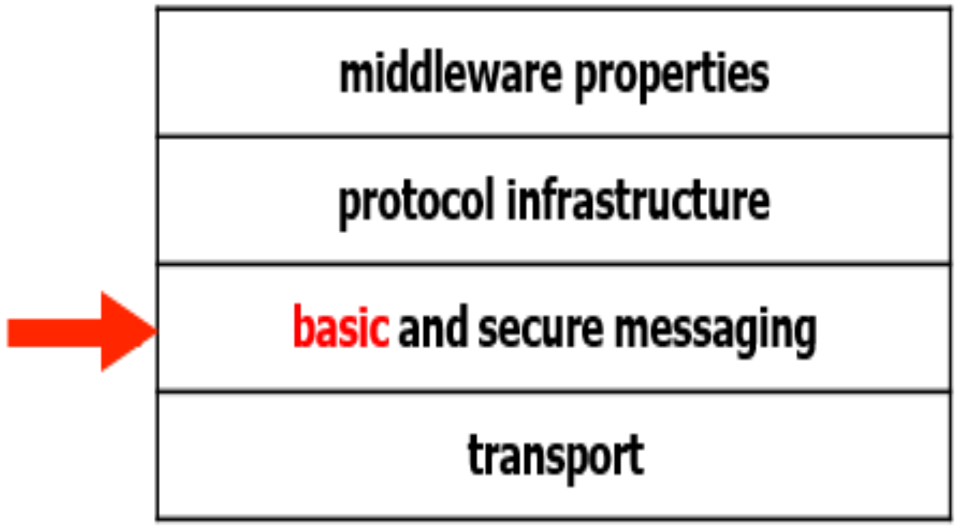
Service Interaction Stack



- Service Composition
- Implement web service by invoking other web services
- Similar to workflow management, only for web services

SOAP – Simple Object Access Protocol

Service Interaction Stack



- Defines how to format information in XML so that it can be exchanged between peers
  - message format for stateless, one-way communication
    - support loosely-coupled applications
    - conventions for interaction patterns (RPC)
    - implement "on top of" one-way messaging
    - first message encodes the call, second (reply) message the result
  - processing rules for SOAP messages
  - how to transport SOAP messages on top of HTTP, SMTP

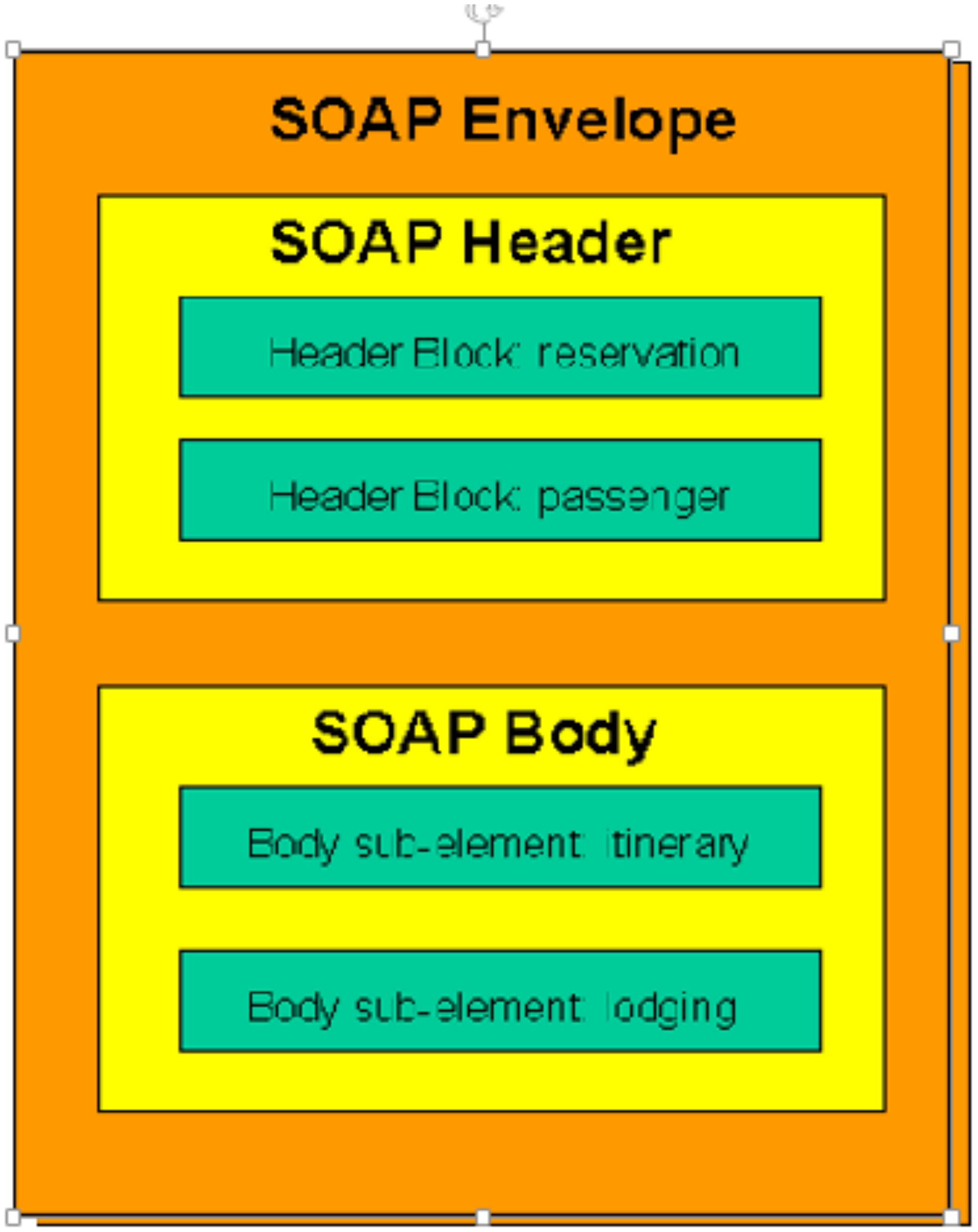
SOAP Envelope Framework

- Defines mechanism for identifying
  - What information is in the message
  - Who should deal with the information
  - Whether this is optional or mandatory
- Envelope element is the root element of the SOAP message, contains
  - Optional header element
  - Mandatory body element

- Body element
    - Contains arbitrary XML
        - application-specific
    - Child elements are called body entries (or bodies)
- Some consequences
    - Message body cannot contain general XML **document**, only elements
    - Validation of application data (i.e., the body) requires separation from the surrounding SOAP-specific XML
        - Many web service engines support that

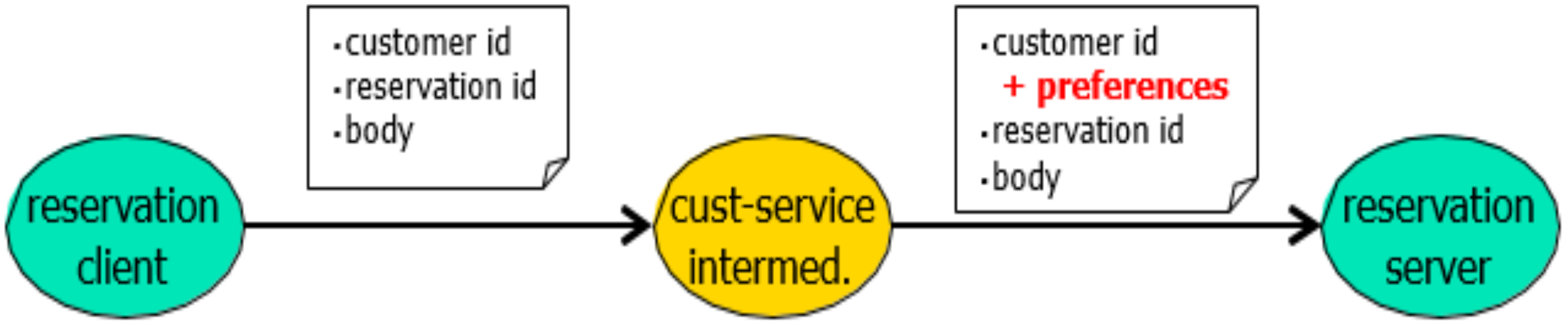
Sample SOAP Message

```
<?xml version='1.0' ?>
<env:Envelope  xmlns:env="http://www.w3.org/2003/05/soap-envelope">
<env:Header>
   <m:reservation xmlns:m="http://travelcompany.example.org/reservation"
                  env:role="http://www.w3.org/2003/05/soap-envelope/role/next "
                  env:mustUnderstand="true">
      <m:reference>uuid:093a2da1 q345 739r ba5d pqff98fe8j7d</m:reference>
      <m:dateAndTime>2001-11-29T13:20:00.000-05:00</m:dateAndTime>
   </m:reservation>
   <n:passenger xmlns:n="http://mycompany.example.com/employees"         env:role="http://
      www.w3.org/2003/05/soap-envelope/role/next"
                    env:mustUnderstand="true">
       <n:name>Åke Jógvan Øyvind</n:name>
   </n:passenger>
 </env:Header>
 <env:Body>
   <p:itinerary  xmlns:p="http://travelcompany.example.org/reservation/travel">
      <p:departure>
        <p:departing>New York</p:departing>
        <p:arriving>Los Angeles</p:arriving>
        <p:departureDate>2001-12-14</p:departureDate>
      </p:departure>
      <p:return>
        <p:departing>Los Angeles</p:departing>
        <p:arriving>New York</p:arriving>
        <p:departureDate>2001-12-20</p:departureDate>
      </p:return>
    </p:itinerary>
   <q:lodging  xmlns:q="http://travelcompany.example.org/reservation/hotels">
      <q:preference>none</q:preference>
   </q:lodging>
 </env:Body>
</env:Envelope>
```


SOAP Envelope
SOAP Header
Header Block: reservation
Header Block: passenger
SOAP Body
Body sub-element: itinerary
Body sub-element: lodging

SOAP Intermediaries

- SOAP intermediaries provide "value-added services"
  - SOAP message can travel through multiple SOAP nodes
    - Sender [-> Intermediary …] -> ultimate Receiver
  - Intermediaries process one or more SOAP headers
    - Header is removed from the message after processing (default behavior)
      - can be reinserted by the intermediary, possibly with modified values
    - Intermediary does not need to understand message body



- Relay attribute (optional)
  - relayable headers that were targeted at the intermediary but were not processed have to be forwarded
  - non-relayable headers that were targeted at the intermediary but were not processed have to be removed

SOAP Processing Model

- Describes logical actions taken by a node when receiving a SOAP message
- Every node has to
  - check message for syntactical correctness
  - analyze SOAP-specific parts
    - envelope, header, body elements
- Role attribute (optional)
  - governs further processing of header blocks
  - node assumes one or more roles, selects headers targeted at these roles
    - every node must assume the role "next"
  - predefined roles ("next", "ultimate_receiver", …) vs. user-defined roles
- MustUnderstand attribute (optional)
  - if set to "true" for a selected header, a node assuming the target role MUST understand and be able to process it
    - generate fault if header cannot be processed, before any processing is started

SOAP-based RPCs

- SOAP is fundamentally a stateless, one-way message exchange paradigm
  - …but applications can create more complex interaction patterns
    - Request/response, request/multiple responses
- SOAP-based RPC
- Employs request/response message exchange pattern (MEP)
- MEPs define "templates" for more complex message eschanges
  - Invocation is modeled as a struct of in/inout parameters
    - <doCheck>

<product> … </product>

<quantity> … </quantity>
</doCheck>

    - Response is modeled as a struct as well
        - <doCheckResponse> … </doCheckResponse>
    - All data is passed by-value
    - Endpoint (address of target node) to be provided in a protocol binding-specific manner
- Protocol Bindings and RPC
    - RPC not predicated to any protocol binding
    - Binding to HTTP (synchronous protocol) makes RPC-style “natural”
        - One-way exchange will use simple acknowledgement as HTTP response

A Simple SOAP/HTTP RPC

```
POST /StockQuote HTTP/1.1
Host: www.stockquoteserver.com
Content-Type: application/soap+xml ;
charset="utf-8"
Content-Length: nnnn

<SOAP-ENV:Envelope
 xmlns:SOAP-ENV=http://schemas.xmlsoap.org/soap/envelope/
 SOAP-ENV:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
  <SOAP-ENV:Body>
   <m:GetLastTradePrice xmlns:m="Some-URI">
        <symbol>DIS</symbol>
   </m:GetLastTradePrice>
  </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

Object Endpoint

Method Name

Input Parameter

A Simple SOAP Response

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

<SOAP-ENV:Envelope
  xmlns:SOAP-ENV=http://schemas.xmlsoap.org/soap/envelope/
  SOAP-ENV:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/"/>
  <SOAP-ENV:Body>
    <m:GetLastTradePriceResponse xmlns:m="Some-URI">
          <Price>34.5</Price>
    </m:GetLastTradePriceResponse>
  </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

Standard Suffix

More SOAP

- SOAP protocol bindings
  - SOAP standard defines a binding to HTTP
  - SOAP is transport-independent, can be bound to any protocol type
- E.g., SMTP, message queuing systems, …
- SOAP with Attachments
  - XML isn’t good at carrying non-XML things within it
  - Introduces an outer multipart MIME envelope
  - Root part is SOAP envelope
  - Other parts can be anything: XML, images, …

Beyond SOAP – WS-Addressing

- Source and Destination information
  - SOAP does not define them as part of the message itself
    - relies on protocol-specific bindings
  - Example: SOAP/HTTP
    - endpoint reference is a URL encoded in the HTTP transport header
    - destination of the response is determined by the return transport address
  - Information might be lost
    - transport connection terminates (timeout)
    - message forwarded by an intermediary (e.g., a firewall)
  - Response always goes to sender
    - not possible to have response go somewhere else
- WS-Addressing
  - provides a mechanism to place the target, source and other important address information directly within the Web service message
    - decouples address information from any specific transport model
  - w3c recommendation

WS-Addressing Constructs

- Endpoint reference
  - uniquely identifies WS endpoint
- Message information headers
  - describe end-to-end message characteristics such as
    - source and destination endpoints
    - message identity

- Example

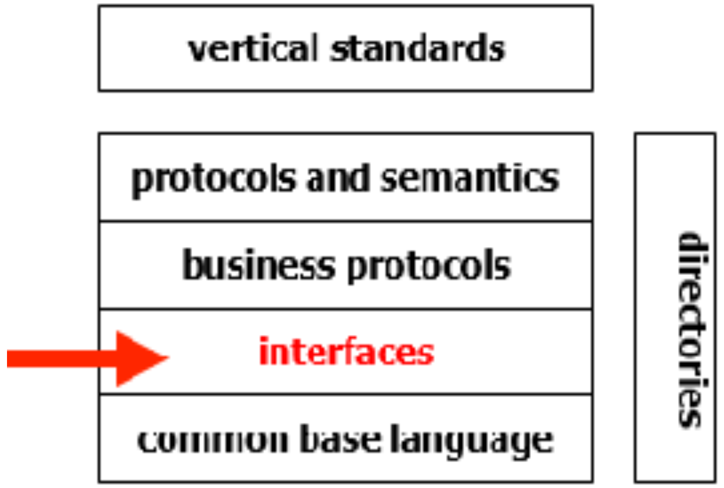
```xml
<S:Envelope xmlns:S="http://www.w3.org/2002/12/soap-envelope"
xmlns:wsa="http://schemas.xmlsoap.org/ws/2003/03/addressing">
<S:Header>
<wsa:MessageID>
http://example.com/6B29FC40-CA47-1067-B31D-00DD010662DA
</wsa:MessageID>
<wsa:ReplyTo>
<wsa:Address>http://business456.com/client1</wsa:Address>
</wsa:ReplyTo>
```

```
<wsa:To>http://fabrikam123.com/
Purchasing</wsa:To>
<wsa:Action>http://fabrikam123.com/
SubmitPO</wsa:Action>
</S:Header>
<S:Body>
...</S:Body>
</S:Envelope>
```

Web Services Description Language (WSDL)

- Provides all information necessary to programmatically access a service
  - documentation for distributed systems
  - recipe for automating the details involved in applications communication
- Description of the logical web service interface
  - operations, parameters, …
  - similar to IDL in conventional middleware

- Describes mechanism to access the web service
  - which protocol is used
  - SOAP, …
  - service location
  - WSDL standardization pursued by w3c
  - V1.1 specification is a w3c note
    - not an official standard, but most widely used
  - WSDL 2.0 is a w3c recommendation

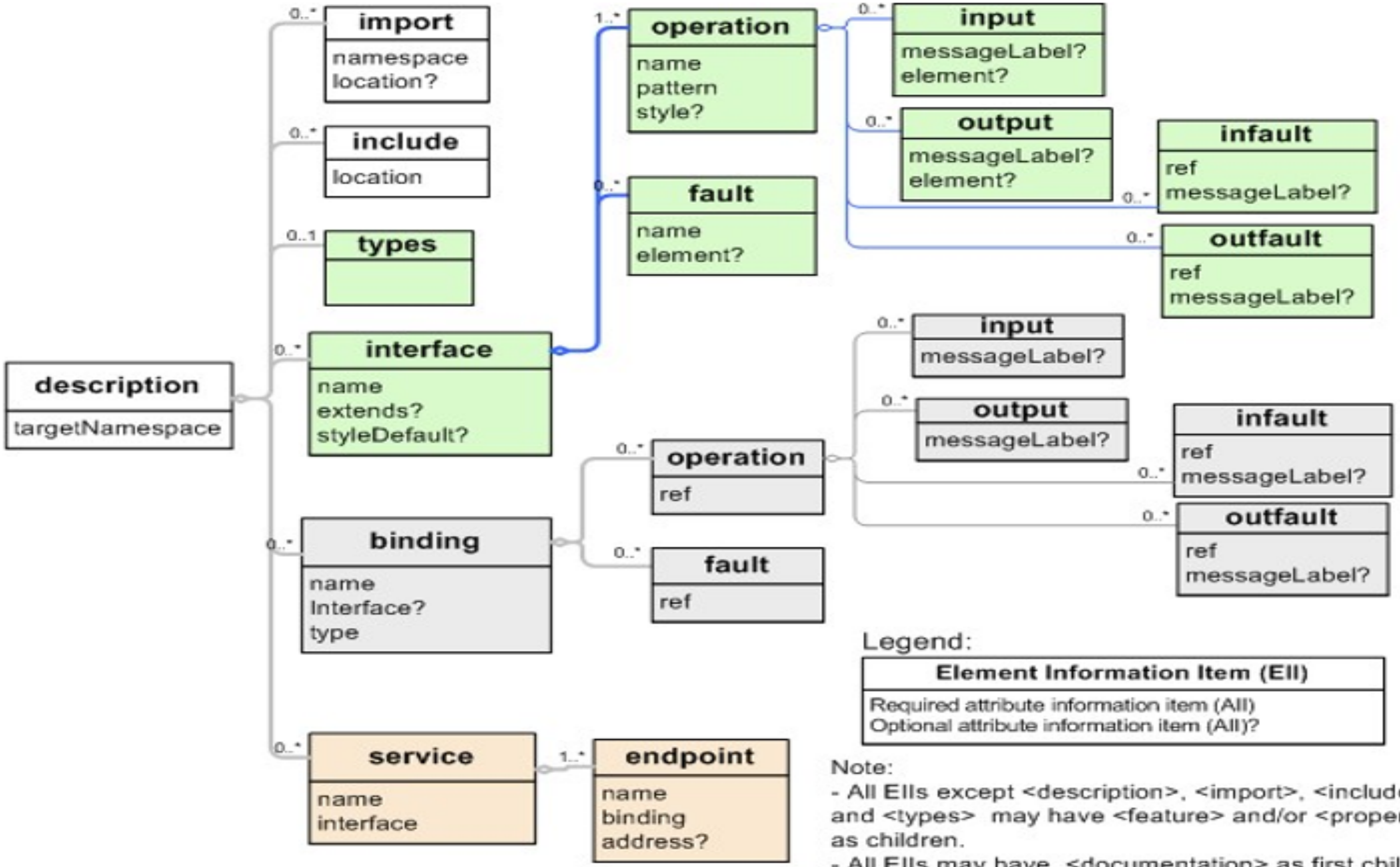


Service Description and Discovery Stack

Ingredients of WSDL

- Abstract part
  - Types: Definitions of data types needed
  - Message Exchange Pattern: Abstract definition of data exchanged
  - Operation: Abstract actions supported by the service
  - Interface: Interface defined as set of operations
- Concrete part
  - Binding: Concrete protocol and data format used to implement an interface
  - Endpoint: Single individual "end point" identified by a network address supporting a particular binding
  - Service: Collection of related "end points"

WSDL 2.0 Document Structure



Legend:

Element Information Item (EII)
Required attribute information item (AII) Optional attribute information item (AII)?

Note:
- All EIIs except <description>, <import>, <include>, and <types> may have <feature> and/or <property> as children.
- All EIIs may have <documentation> as first child

Modularizing Service Definitions

- WSDL document defines a target namespace
  - similar to XML Schema target namespace
- Import/Include

<description>
[<**import** namespace="uri" location="uri"/> | <**include** location="uri"/>]*
</description>

- Can be used to factor out any kind of definitions
  - Types, Interface, Bindings,... or any combination of these
  - Example:
    - Import Interface and specify Binding
    - Import Binding and specify Service
- Import, include differ regarding namespaces
  - include: referenced WSDL document needs to have same target namespace
  - import: referenced WSDL can have different target namespace
    - components are referenced in importing document using qualified names

Message Exchange Patterns

- Defines interaction paradigms
  - exchange of several asynchronous messages
  - sequence and cardinality of messages in an operation
    - abstract: no message types, no binding-specific information is specified
    - minimal contract
- Standard MEPs defined by WSDL specification
  - in-bound MEPs
    - In-Only, Robust In-Only, In-Out, In-Optional-Out
  - out-bound MEPs
    - Out-Only, Robust Out-Only, Out-In, Out-Optional-In
    - Where to send to? Outside scope of WSDL
      - Information could be provided through another (subscribe) operation or defined at deployment time
- Extensibility – possible to define new MEPs

Types

```
<description…>
<types>
<xsd:schema…/>*
</types>
</description>
```

- Type clause used to define types used in message exchange
- all message types (normal, fault) are single, top-level elements

▪ Default type system is XML Schema

▪ Special extensibility element foreseen to refer to other type system

- Example

```
<description targetNamespace= …> …
<types>
<xsd:schema …>
<xsd:complexType name=“registration”>
… </xsd:complexType>
<xsd:element name="registrationRequest"
type="registration"/>
</xsd:schema>
</types>
…
```

Interface

- Interface is a set of abstract operations
  - may extend other interfaces (i.e., multiple interface inheritance)
    - faults, operations, etc. are inherited
    - overloading of operations is not supported
    - inheritance conflicts must not occur
  - default style for operations can be specified
- Operation groups a set of abstract messages involved
  - references a MEP that defines sequence of messages
  - defines the structure of input, output, infault, outfault messages by referencing the appropriate (schema) types
  - optionally declares a style
    - rules used for generating messages, e.g., RPC style
  - may optionally be declared "safe"
    - no further obligations result from an invocation
- Interface Fault
  - definition of faults that can occur in the scope of this interface

Binding

- Interface, type elements define the abstract, reusable portion of the WSDL definition
- The binding element tells the service requestor **how to format the message in a protocol-specific manner**
  - interface can have one or more bindings
- Protocol-specific aspects are provided using binding extensions

<**binding** name="…" interface="…"?>

<-- extensibility element (1) -->*

<**operation** ref="…">*

<-- extensibility element (2) -->*

```
<input messageLabel="…"?>?
<-- extensibility element (3) -->*
</input>
<output messageLabel="…"?>?
<-- extensibility element (4) -->*
</output>
<infault ref="…" messageLabel="…"?>*
<-- extensibility element (5) -->*
</infault>
<outfault ref="…" messageLabel="…"?>*
<-- extensibility element (6) -->*
</outfault>
</operation>
</binding>
```

- Standard binding extensions for SOAP/HTTP, HTTP GET/POST, SOAP w/MIME attachments

SOAP Binding - Details

- <soap:binding>
  - protocol: HTTP, SMTP, FTP, …
  - mep: default SOAP message exchange pattern for operations
- <soap:operation>
  - action: value of SOAPAction HTTP header (SOAP over HTTP only!)
  - mep: actual mep for the operation
- e.g., soap-response for implementing an in-out WSDL MEP

Endpoint and Service

- Endpoint
  - Specifies the network address of the endpoint hosting the web service
- Service
  - Contains a set of related endpoint elements
    - Group endpoints related to the same service interface but expressed by different protocols (bindings)
- Example

```
<service name="StockQuoteService"
   interface="StockQuoteInterface"
<endpoint name="StockQuoteEndpoint"
   binding="tns:StockQuoteSoapBinding">
   <address="http://myservice.com/stockquote"/
   >
</port>
</service>
```

implemented binding

address of the endpoint

Web Service Policies

- Web service capabilities and requirements need to be described as (machine-readable) metadata
  - examples: addressing, security, transactions, reliability
  - allows tools to check for service compatibility, generate code
- WS-Policy
  - express capabilities, characteristics of entities in a WS-based system
    - policy assertions, expressions, statements
    - example:

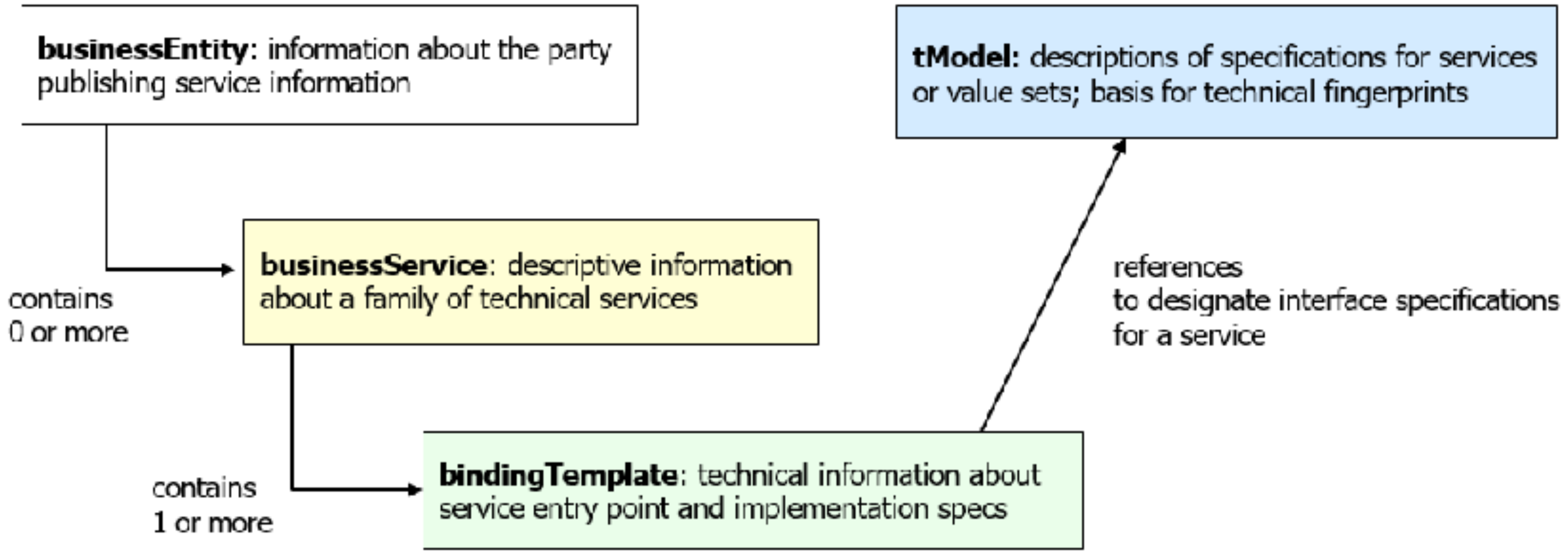
```
<All>
<wsam:Addressing>…</wsam:Addressing>
<ExactlyOne>
<sp:TransportBinding>…</sp:TransportBinding>
<sp:AsymmetricBinding>…</sp:AsymmetricBinding>
</ExactlyOne>
</All>
```

  - allows senders, receivers to specify their security requirements and capabilities
- WS-PolicyAttachment
  - associate policy expressions with subjects
    - reference policies from WSDL definitions or inline them in bindings
    - associate policies with UDDI entities

Universal Description Discovery and Integration (UDDI)

- Goal: enable service discovery
  - catalogue services based on published information of service providers
  - maintain taxonomy(ies) to support searching for appropriate services in business terms
  - specify technical binding information to actually communicate with the selected service
- UDDI registry serves as a directory of web services
  - Allows searching “by what” and “by how” instead of just “by name”
- UDDI defines
  - Set of schemas for describing businesses and their services
    - UDDI data model
  - SOAP API for accessing a UDDI registry
- UDDI initiative
  - Involves more than 300 companies
  - http://www.uddi.org

UDDI Core Data Structures


businessEntity: information about the party publishing service information
tModel: descriptions of specifications for services or value sets; basis for technical fingerprints
businessService: descriptive information about a family of technical services
contains 0 or more
references to designate interface specifications for a service
bindingTemplate: technical information about service entry point and implementation specs
contains 1 or more

- UDDI key
  - uniquely identifies each instance of core data structures within a registry
  - basis for realizing the containment/referencing relationships (using foreign keys)
- XML Schema definition for UDDI Data Model

Entities, Services, Binding Templates

- Business entity offering services
  - (multiple) name(s) and textual description(s), possibly in multiple languages
  - contact info, discovery URLs referring to other documents
  - known identifiers
    - list of identifiers that a business may be known by (tax number, D-U-N-S, …)
    - business categories describing specific business aspects
    - categorization by industry, product, geographic region, …
- Business Service: logical service
  - (multiple) name(s), textual description(s), business categories

- Binding Template: instance of a web service
  - (multiple) textual description(s), possibly in multiple languages
  - access point representing the network address (e.g., URL) for invoking the service
  - categories describing specific aspects of the service
- tModelInstanceDetails
  - points to one or more tModel information elements
  - goal: provide a technical "fingerprint" for identifying compatible services

What Are tModels?

- A tModel (technology model) represents a concept, an idea, a well accepted technical specification (taxonomy, interface…)...
  - Its semantics should be clearly described
  - UDDI comes with a set of predefined tModels
- Examples
  - Taxonomies
    - NAICS (industry codes), UNSPC (product & service codes), ISO3166 (geographic locations) …
  - Technical specifications
    - RosettaNet, ebXML, EDI, standard ERP system interface,...

    - Identifiers
        - D&B numbers, US tax codes,...
- When registering a tModel it gets a globally unique identifier: tModelKey
- tModel data structure
    - tModelKey, name, overviewDoc, descriptions, categories, identifiers, …
        - overviewDoc may contain a URL child element that points to a WSDL file describing the interface …

Using tModelKeys

- tModelKey is used to give references a semantics

```
<element name = "keyedReference">
<type content = "empty">
<attribute name = "tModelKey" type = "string"/>
<attribute name = "keyName" minOccurs = "1" type = "string"/>
<attribute name = "keyValue" minOccurs = "1" type = "string"/>
</type>
</element>
```

- This allows to specify the semantics of a name-value pair, e.g.: Is the identifier a US Tax Number, is it D&B number, is the name of an interface of the system of a particular ERP vendor,...?
  - Example: identify SAP AG by its Dun & Bradstreet D-U-N-S® Number, using the corresponding tModelKey within the UDDI Business Registry

```
<keyedReference  tModelKey=”uddi:ubr.uddi.org:identifier:dnb.com:D-U-N-S”  keyName=”SAP
  AG”
keyValue=”31-626-8655” />
```

Important Registry APIs

- Inquiry API
  - Find things
    - find_business
    - find_service
    - find_binding
    - find_tModel
  - Get Details about things
    - get_businessDetail
    - get_serviceDetail
    - get_bindingDetail
    - get_tModelDetail

Provided as SOAP-based web services

- Publishers API
  - Save things
    - save_business
    - save_service
    - save_binding
    - save_tModel
  - Delete things
    - delete_business
    - delete_service
    - delete_binding
    - delete_tModel
  - security…
    - get_authToken
    - discard_authToken

Inquiry API

- FIND APIs
  - Basic browsing/searching
- Can return a set of results
  - Limited search capabilities
- Query is specified in an XML element with subelements for
    - Values of properties to match (e.g., business name starts with ‘S’)
    - Qualifiers that modify the search behavior (e.g., exactNameMatch, sortByNameDesc, …)

- Example: Find the latest two businesses that registered, and whose name starts with an ‘S’
- <find_business generic=“1.0” maxRows=“2” xmlns=“urn:uddi-org:api”>

```
<findQualifiers>
<findQualifier>sortByDateDesc</findQualifier>
</findQualifiers>
<name>S</name>
</find_business>
```

  - Return unique reference keys identifying the result “elements”
- GET APIs
  - Based on unique reference keys, retrieve detailed information

Registry Types

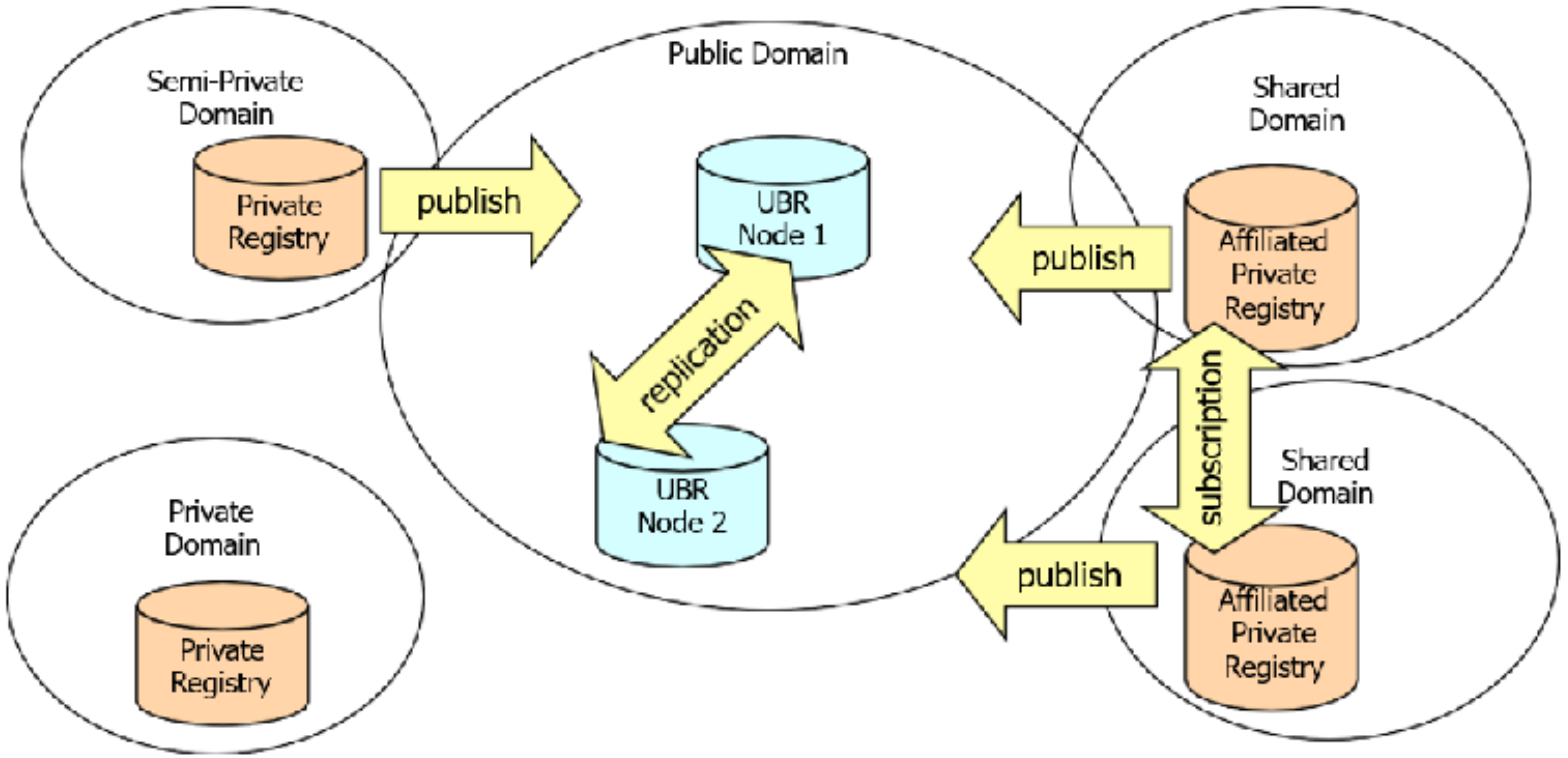
- Different types of registries
  - corporate/private (e.g., enterprise web service registry)
    - operates within the boundaries of a single company (or for a restricted number of partners)
    - data is not shared with other registries
  - affiliated (e.g., trading partner network)
    - registry is deployed in a controlled environment
    - limited access by authorized clients
    - data may be shared with other registries in a controlled manner

    - public (e.g., UDDI Business Registry)
        - open, public access to registry data
        - secured administrative access, content may be moderated
        - data may shared, transferred among registries
- UDDI Business Registry
    - public, global registry of businesses and their services
    - master directory of publicly available e-commerce services
    - was initial focus of UDDI effort

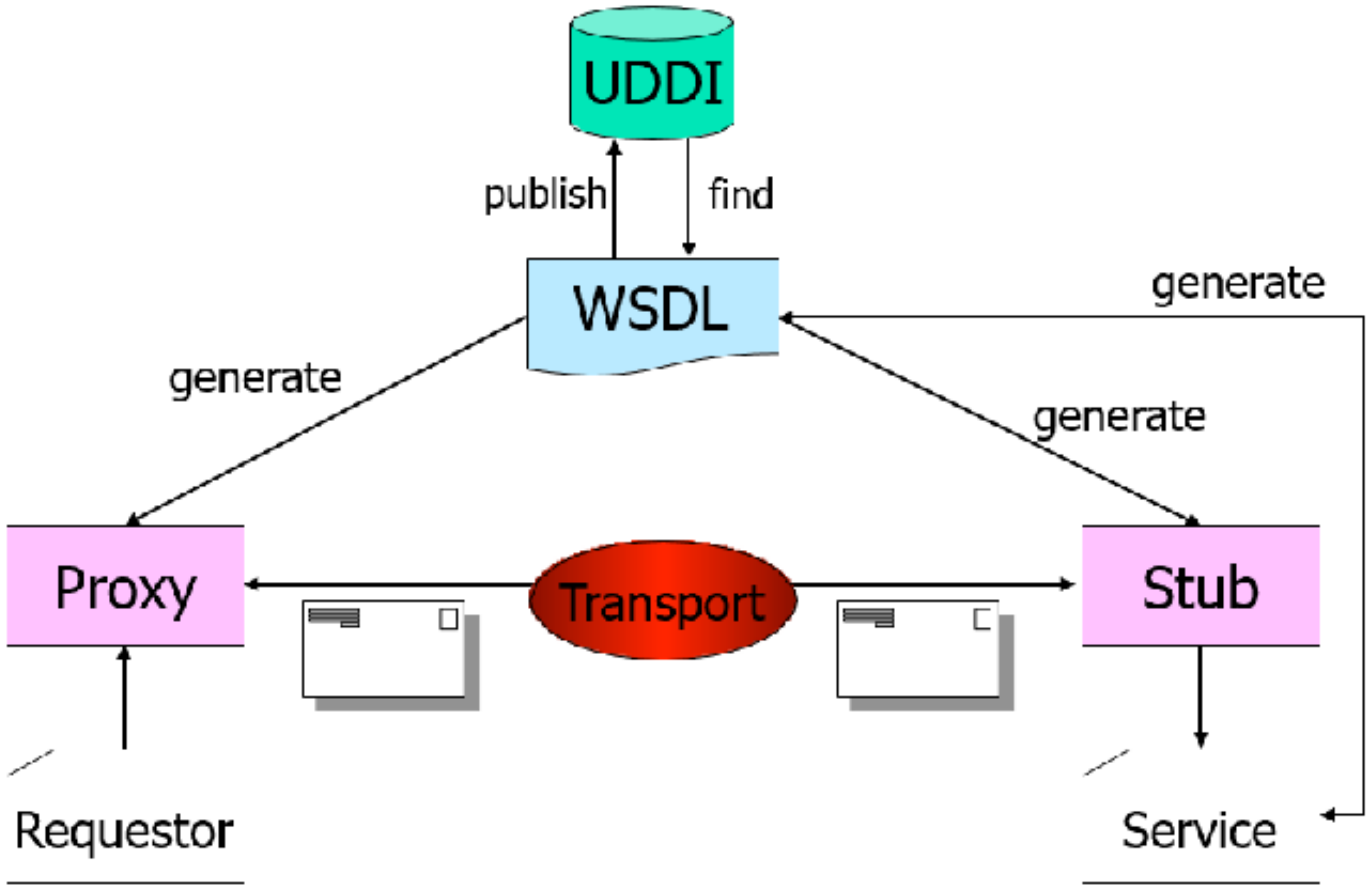
Registry Architecture

- UDDI registry may consist of multiple UDDI nodes
- UDDI node
  - supports interaction with UDDI data through (subset of) UDDI APIs
  - belongs to exactly one UDDI registry
  - interacts with other nodes in the same registry (through replication) to maintain a single, complete logical copy of the registry data
- Affiliation of registries
  - consists of multiple registries
  - registries define policies for controlled copying of subsets of registry data among each other
  - registries share a common namespace for UDDI keys, have compatible policies for assigning key values
- Enhanced set of APIs to support registry architecture, types of registries
  - security, custody transfer, subscription, replication

Registry Affiliation – Example



Tooling Principles



Java API for XML Web Services (JAX-WS)

- API for building web services and clients based on remote procedure calls and XML
  - Goal: hide all the complexities of SOAP message processing
  - APIs for supporting XML based RPC for the Java platform
    - Define web service
    - Use web service
  - Defines
    - WSDL/XML to Java mapping
    - Java to XML/WSDL mapping
    - Core APIs
    - SOAP support (including attachments)
    - Client and Server Programming models involving generated stub classes

- Client side invocation (standard programming model)
    - Application invokes web service through generated stub class
    - JAX-WS runtime maps the invocation to SOAP, builds the SOAP message, processes the HTTP request
- Server side processing
    - JAX-WS runtime processes HTTP, SOAP message, maps to RPC and dispatches to target (class implementing the web service)

Mapping WSDL <-> Java – Example

WSDL 1.1 interface definition:

```
<!-- WSDL Extract -->
<message name=”getLastTradePrice”>
<part name=”tickerSymbol”  type=”
xsd:string”/>
</message>
<message
name=”getLastTradePriceResponse”>
<part name=”result”
type=”xsd:float”/>
</message>
```

Java service endpoint interface:

```
//Java
public interface StockQuoteProvider
extends java.rmi.Remote {
float getLastTradePrice(  String
tickerSymbol)
throws java.rmi.RemoteException;
}
```

```
<portType
name=”StockQuoteProvider”>
<operation name=”getLastTradePrice”
parameterOrder=”tickerSymbol”>
<input message=
”tns:getLastTradePrice”/>
<output message=  ”
tns:getLastTradePriceResponse”/>
</operation>
</portType>
```

Summary

- Service-oriented architectures
  - definition, access, discovery of (web) services
- SOAP
  - defines SOAP message structure and messaging framework
    - stateless, one-way
    - more complex patterns "on top" (e.g., request/response)
  - provides convention for doing RPCs using SOAP
  - support for extensibility, error-handling, flexible data representation
  - independent of transport protocols
    - binding framework for defining protocol-specific bindings
      - SOAP/HTTP
  - extensions beyond SOAP for addressing, reliable messaging (see next chapter)

Summary (cont.)

- WSDL
  - supports description of all information needed to access a web service
    - interface, operation, message types
    - binding to specific protocol (e.g., SOAP)
      - protocol extensions
    - endpoint, service
- UDDI
  - registry

- publish information about business, services provided, and the way to use them
    - white, yellow, green pages
- tModels provide infrastructure for business and service "name space"
    - identification, classification of business, services, protocols, …
    - can "point to" detailed service descriptions such as WSDL files
    - APIs for manipulating and inquiring about registry content
- provided as web services

Summary (cont.)

- Application development
  - Integration with programming languages, existing middleware
  - Tooling support
- Programming language binding
  - WSDL as the "IDL for web services"
  - Mapping WSDL to PL (e.g., Java)
    - enables generation of client proxies, server stubs for web services invocation
  - Mapping PL to WSDL
    - "publish" existing functionality as a web service
  - Example: JAX-RPC

- Web services support based on conventional middleware
  - define standards for reusing/extending existing programming models and middleware infrastructure to support web service
  - J2EE: use/publish servlets, stateless session beans to implement web services
    - JAX-WS and SAAJ APIs
      - basic web services interoperability support
    - Web Services for J2EE specification
      - describes the packaging and deployment requirements for J2EE applications that provide and use web services
    - EJB specification
      - extended to support implementing web services using stateless session beans.
    - JAXR API
      - access to registries and repositories.
    - JAXP API
      - processing XML documents
        - Java interfaces to XSLT, SAX, DOM-parsers