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A Very Short Introduction to Web Services

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BASIC CONCEPTS

e-Services, Web Services, Services … (1) - Historically

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- An e-Service is often defined as an application accessible via the Web, that provides a set of functionalities to businesses or individuals. What makes the e-Service vision attractive is the ability to automatically discover the e-Services that fulfill the users' needs, negotiate service contracts, and have the services delivered where and when users needs them

  Guest editorial. In [VLDBJ01]

- e-Service: an application component provided by an organization in order to be assembled and reused in a distributed, Internet-based environment; an application component is considered as an e-Service if it is: (i) open, that is independent, as much as possible, of specific platforms and computing paradigms; (ii) developed mainly for inter-organizations applications, not only for intra-organization applications; (iii) easily composable; its assembling and integration in an inter-organizations application does not require the development of complex adapters. e-Application: a distributed application which integrates in a cooperative way the e-Services offered by different organizations

  M. Mecella, B. Pernici: Designing Wrapper Components for e-Services in Integrating Heterogeneous Systems. In [VLDBJ01]

e-Services, Web Services, Services … (2) - Historically

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A Web service is a software system identified by a URI, whose public interfaces and bindings are defined and described using XML. Its definition can be discovered by other software systems. These systems may then interact with the Web service in a manner prescribed by its definition, using XML based messages conveyed by Internet protocols

Web Services Architecture Requirements, W3C Working Group Note, 11 Feb. 2004, http://www.w3.org/TR/wsa-reqs/

e-Services, Web Services, Services … (3) - Historically

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- Services are self-describing, open components that support rapid, low-cost composition of distributed applications. Services are offered by service providers — organizations that procure the service implementations, supply their service descriptions, and provide related technical and business support.

  Since services may be offered by different enterprises and communicate over the Internet, they provide a distributed computing infrastructure for both intra and cross-enterprise application integration and collaboration.

  Service descriptions are used to advertise the service capabilities, interface, behavior, and quality. Publication of such information about available services provides the necessary means for discovery, selection, binding, and composition of services. In particular, the service capability description states the conceptual purpose and expected results of the service (by using terms or concepts defined in an application-specific taxonomy). The service interface description publishes the service signature (its input/output/error parameters and message types). The (expected) behavior of a service during its execution is described by its service behavior description. Finally, the Quality of Service (QoS) description publishes important functional and nonfunctional service quality attributes […]. Service clients (end-user organizations that use some service) and service aggregators (organizations that consolidate multiple services into a new, single service offering) utilize service descriptions to achieve their objectives.
- The application on the Web (including several aspects of the SOA) is manifested by Web services

Guest editorial. In [CACM03]

And Today ?

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- e-Service
  - e-Service is the provision of a service via the Internet (the prefix "e" standing for "electronic")
  - True Web jargon, meaning just about anything done online
  - Basically whichever Web application usable by a human, through a user interface
- Web service
  - software component available on the Web, to be invoked by some other client application/component
  - A way of building Web-scale component-based distributed systems
- For building an e-Service, a designer may need to use/invoke many Web services

Two Architectures (and Middlewares) (1)

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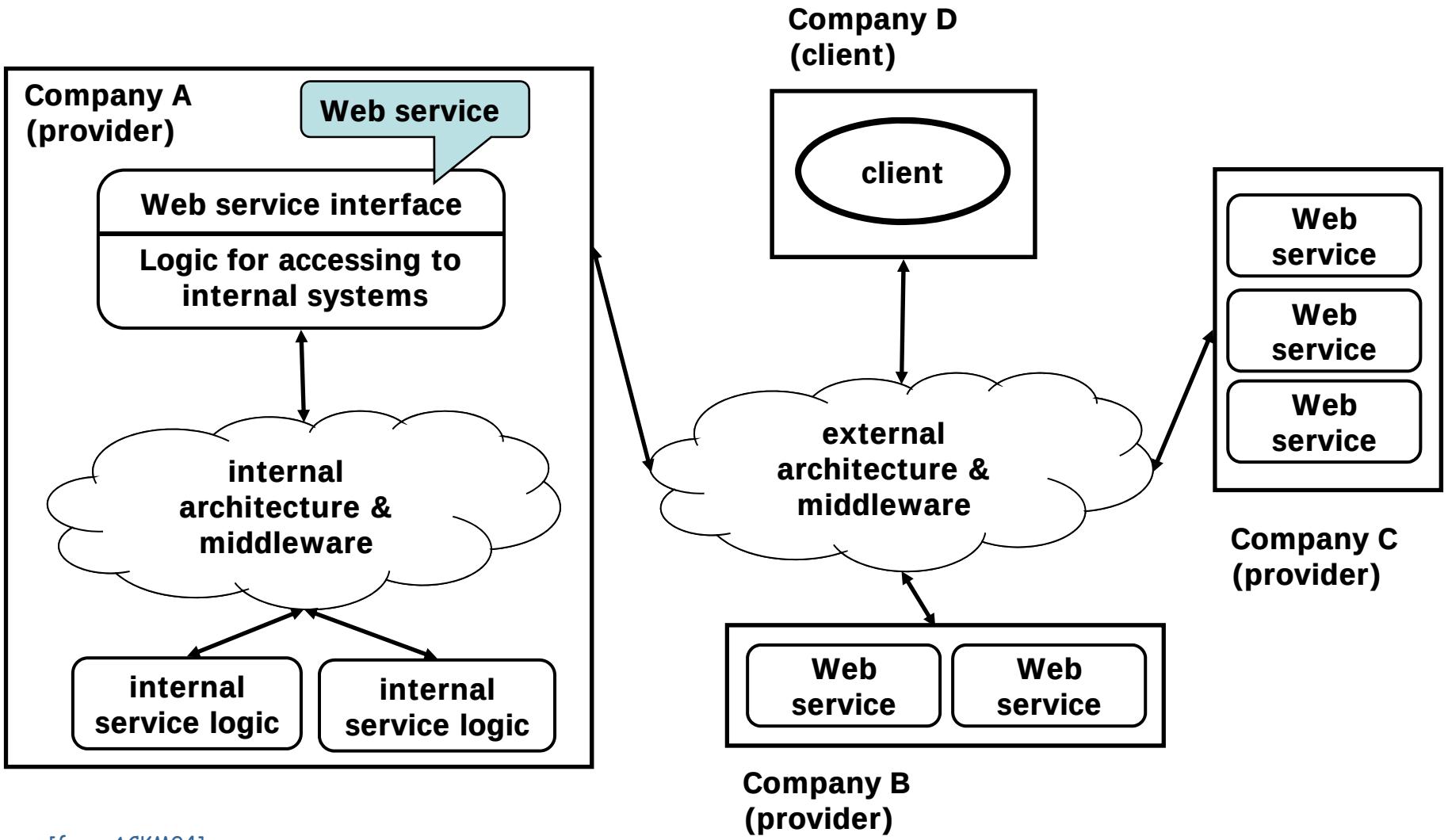

[from ACKM04]

Two Architectures (and Middlewares) (2)

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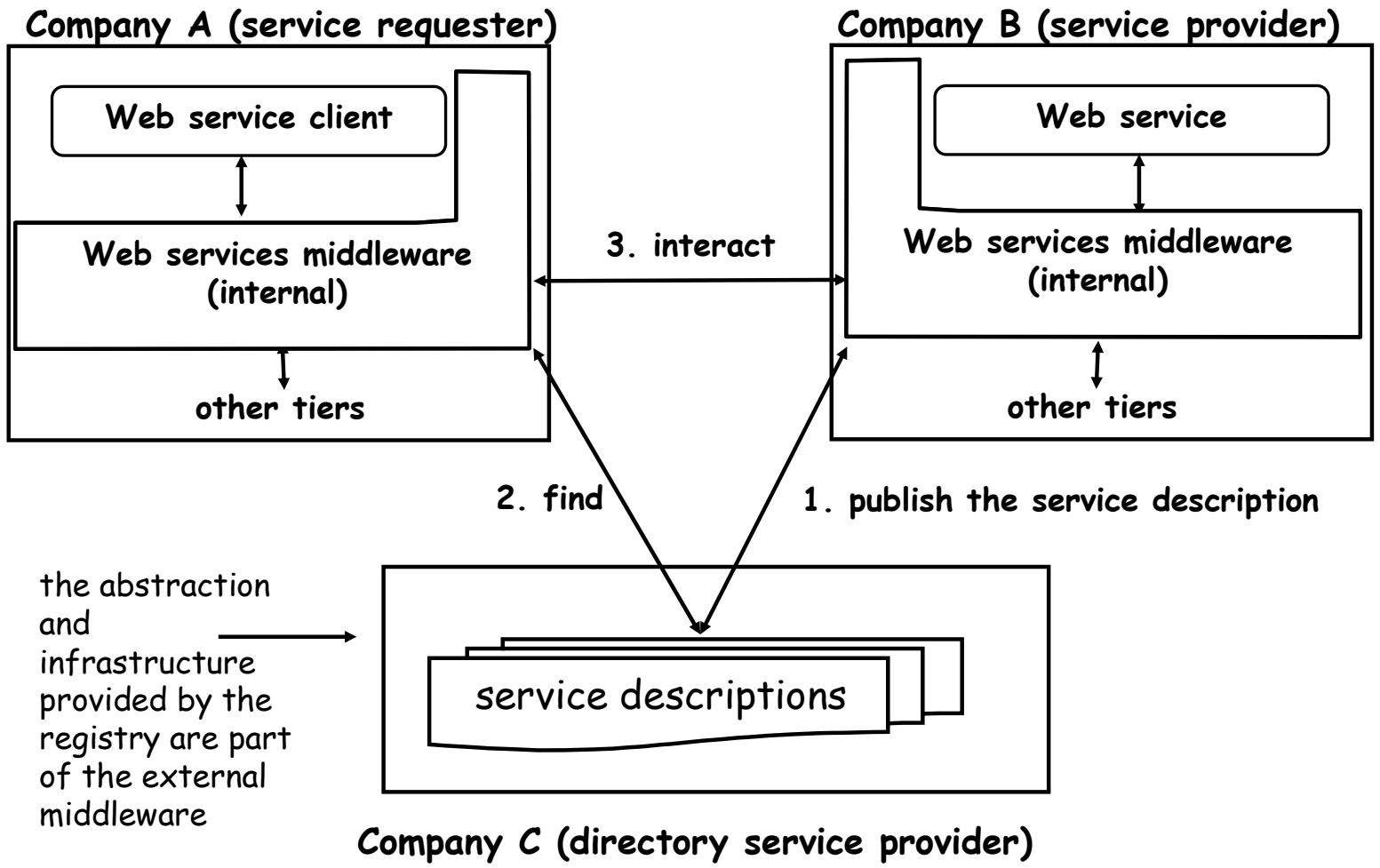

Two Architectures (and Middlewares) (3)

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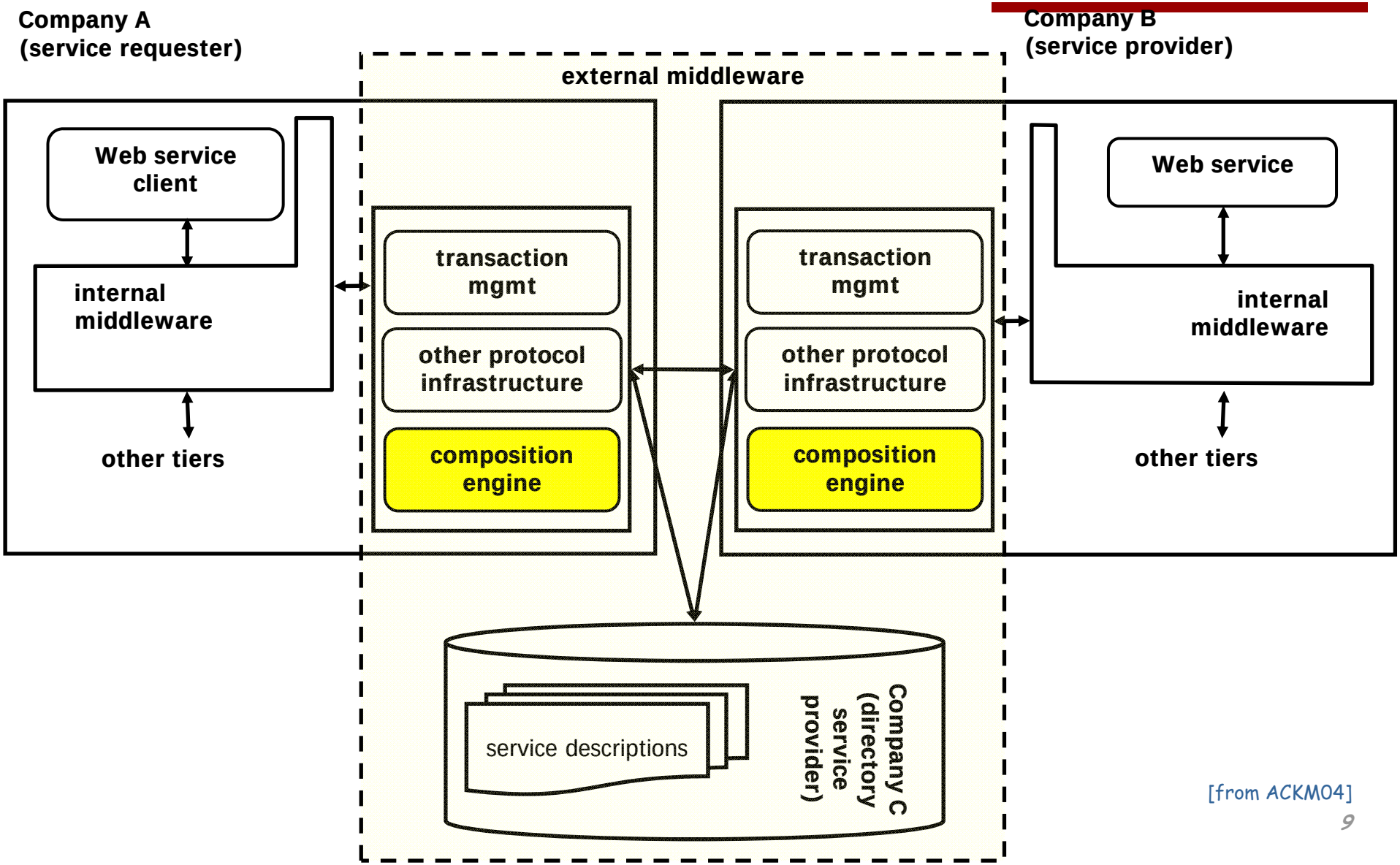
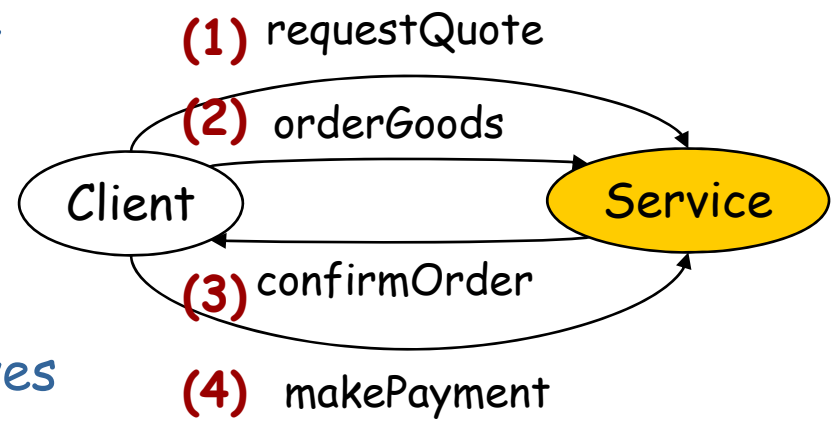
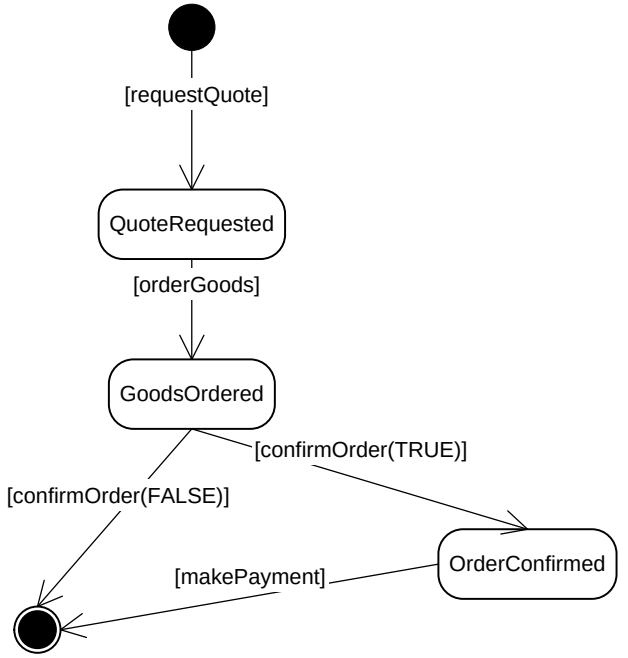


[from ACKM04]

Services

- A service is characterized by the set of (atomic) operations that it exports …
- … and possibly by constraints on the possible conversations
  - Using a service typically involves performing sequences of operations in a particular order (conversations)
  - During a conversation, the client typically chooses the next operation to invoke (on the basis of previous results, etc.) among the ones that the service allows at that point





Choreography: Coordination of Conversations of N Services

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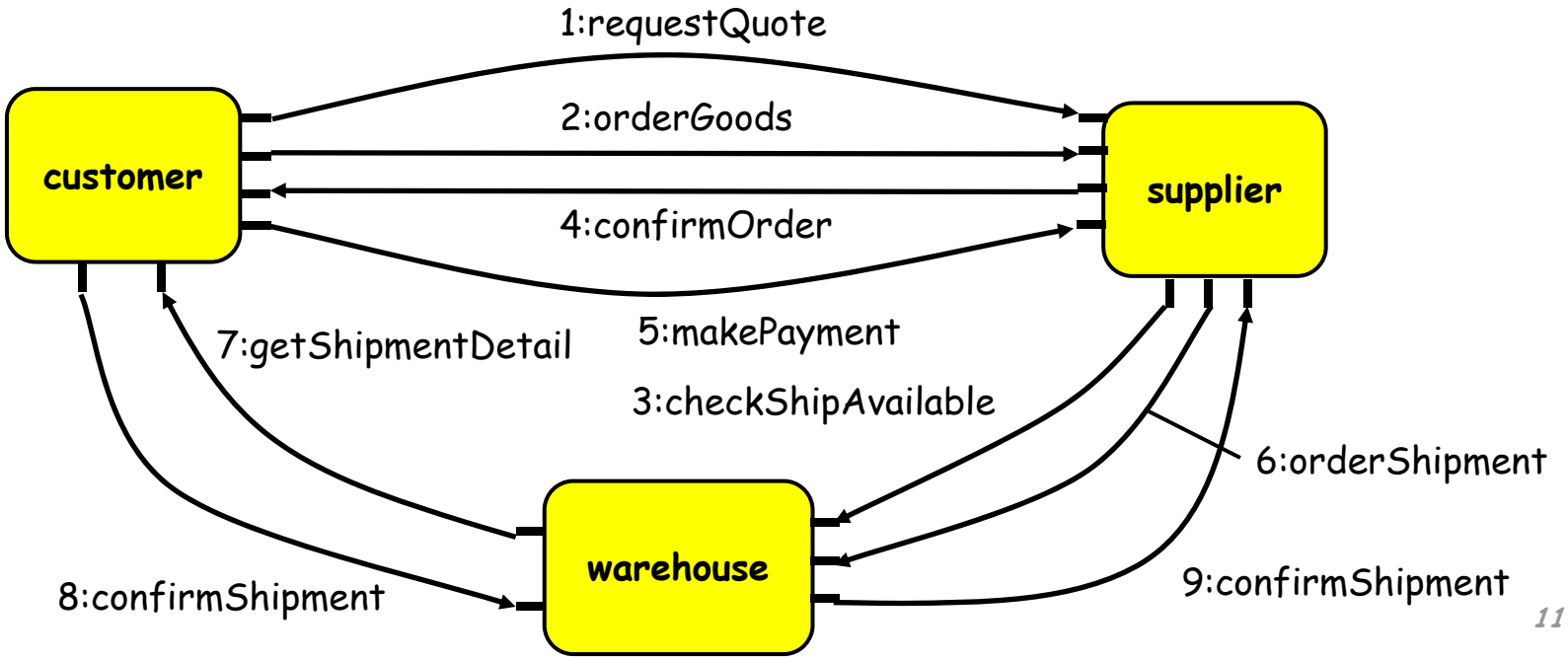
- Global specification of the conversations of N peer services (i.e., multi-party conversations)
  - Roles
  - Message exchanges
  - Constraints on the order in which such exchanges should occur



Choreography: Coordination of Conversations of N Services

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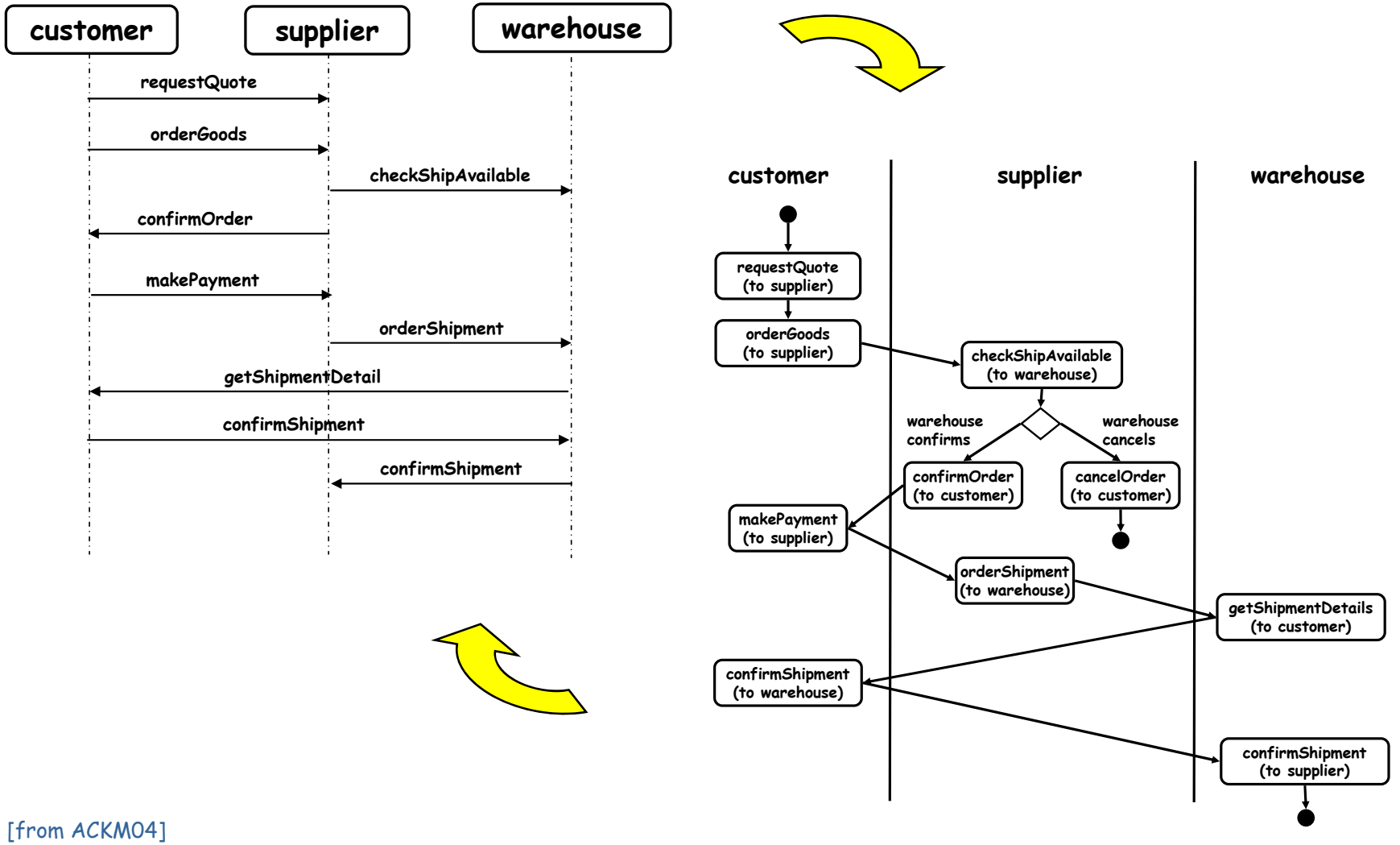

[from ACKM04]

Composition

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- Deals with the implementation of an application (in turn offered as a service) whose application logic involves the invocation of operations offered by other services
  - The new service is the *composite* service
  - The invoked services are the *component* services

The Composition Engine/Middleware

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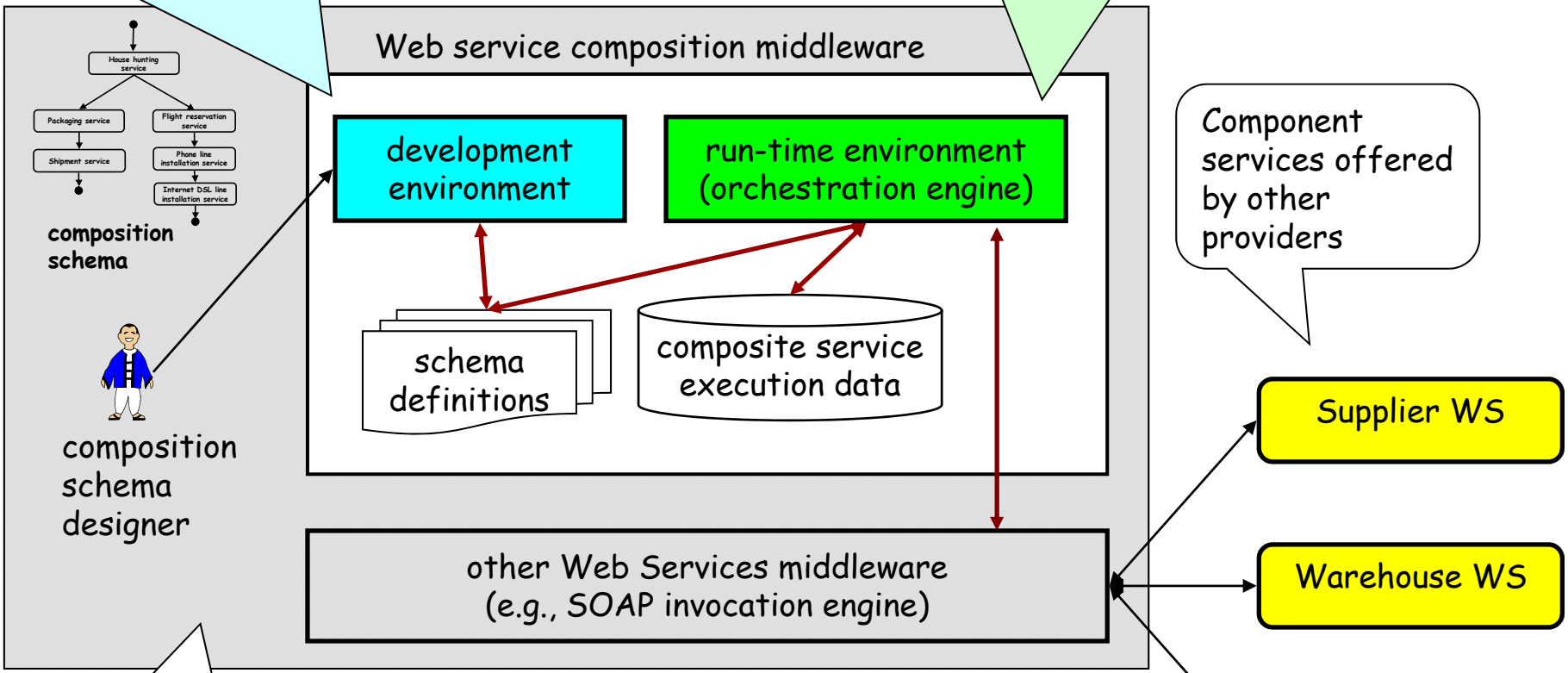
Through the development environment, a **composition schema** is **synthesized**, either manually or (semi-)automatically. A service composition model and a language (maybe characterized by a graphical and a textual representation) are adopted

Orchestration: the run-time environment executes the composite service business logic by invoking other services (through appropriate protocols)



[from ACKM04]

Synthesis and Orchestration

- (Composition) Synthesis: building the specification of the composite service (i.e., the composition schema)
  - Manual
  - Automatic
- Orchestration: the run-time management of the composite service (invoking other services, scheduling the different steps, etc.)
  - Composition schema is the "program" to be executed
  - Similarities with WfMSs (Workflow Management Systems)

Composition Schema

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- A composition schema specifies the "process" of the composite service
  - The "workflow" of the service
- Different clients, by interacting with the composite service, satisfy their specific needs (reach their goals)
  - A specific execution of the composition schema for a given client is an orchestration instance

Choreography (Coordination) vs. Composition (Orchestration)

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- Composition is about implementing new services
  - From the point of view of the client, a composite service and a basic (i.e., implemented in a traditional programming language) one are indistinguishable
- Choreography is about global modeling of N peers, for proving correctness, design-time discovery of possible partners and run-time bindings

- N.B.: There is a strong relationship between a service internal composition and the external choreographies it can participate in
  - if A is a composite service that invokes B, the A's composition schema must reflect the coordination protocol governing A – B interactions
  - in turn, the composition schema of A determines the coordination protocols that A is able to support (i.e., the choreographies it can participate in)

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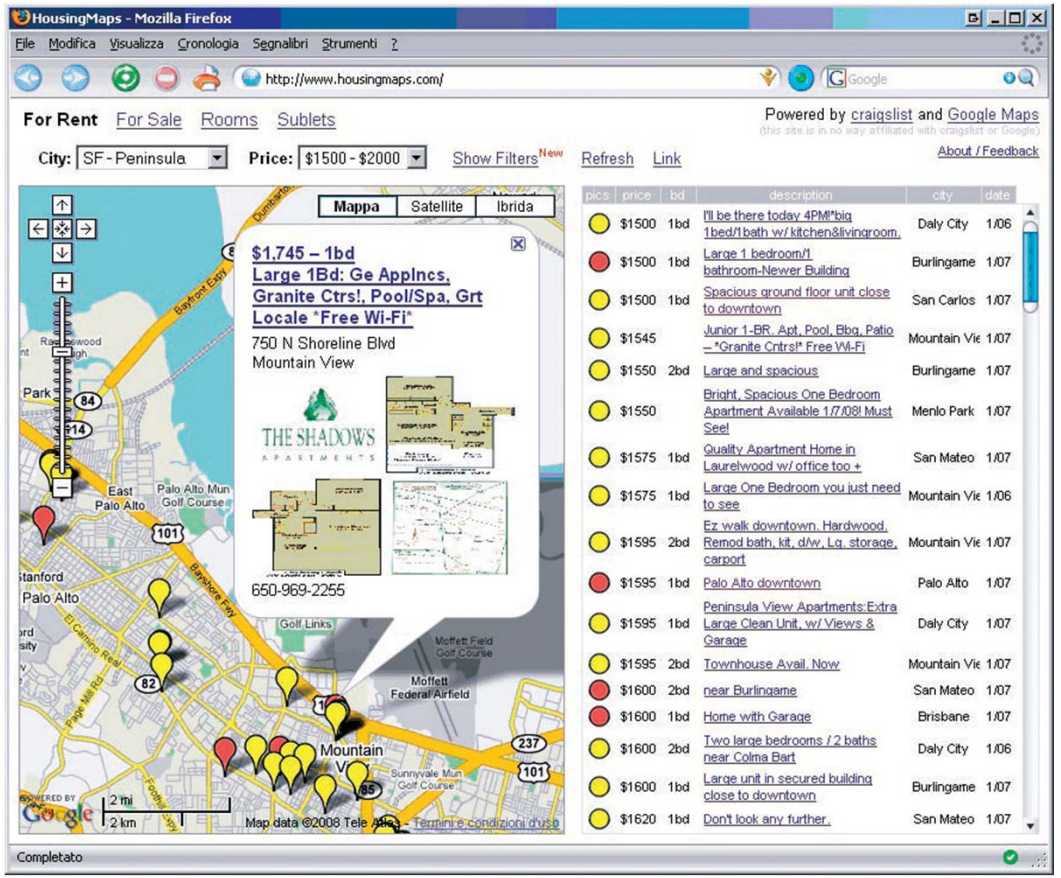
Services Mash-up (1)

Web application that combines data from one or more sources into a single integrated tool

- easy, fast integration, frequently done by access to open APIs and data sources to produce results that were not the original reason for producing the raw source data.
- E.g., cartographic data from Google Maps to add location information to real estate data, thereby creating a new and distinct e-Service that was not originally provided by either source
- Bottom-up, developers-driven approach



D. Benslimane, S. Dustdar, A. Sheth (eds.). Services Mashups – Special Issue. IEEE Internet Computing, vol. 12, no. 5, 2008.

Services Mash-up (2)

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- Based on various technologies
  - Web services
    - SOAP
    - RESTful
    - Atom/RSS
- Basically a lightweight form of composition

RELEVANT TECHNOLOGIES AND ABSTRACTIONS

The "Stacks" of Service Technologies

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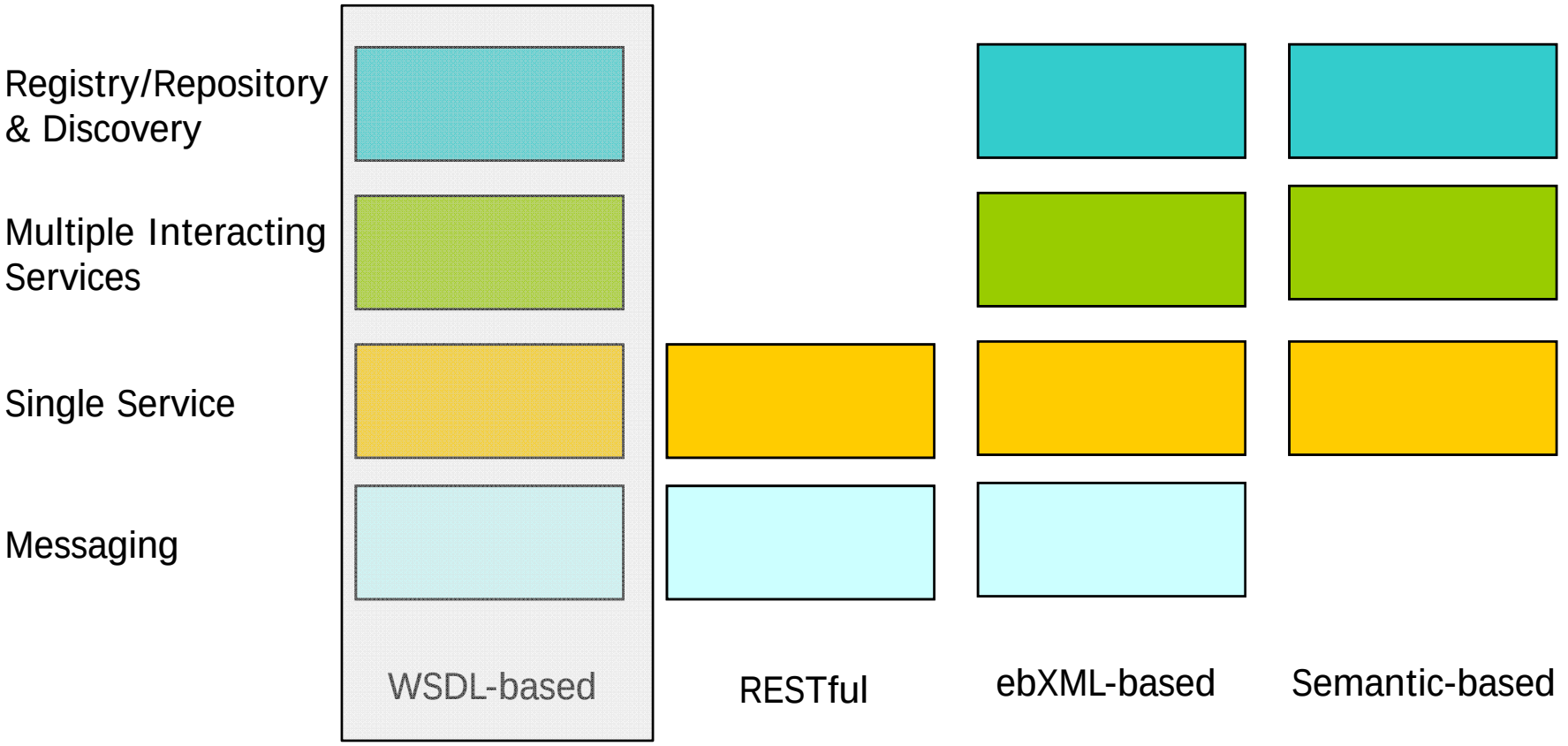

The WSDL-based "Stack"

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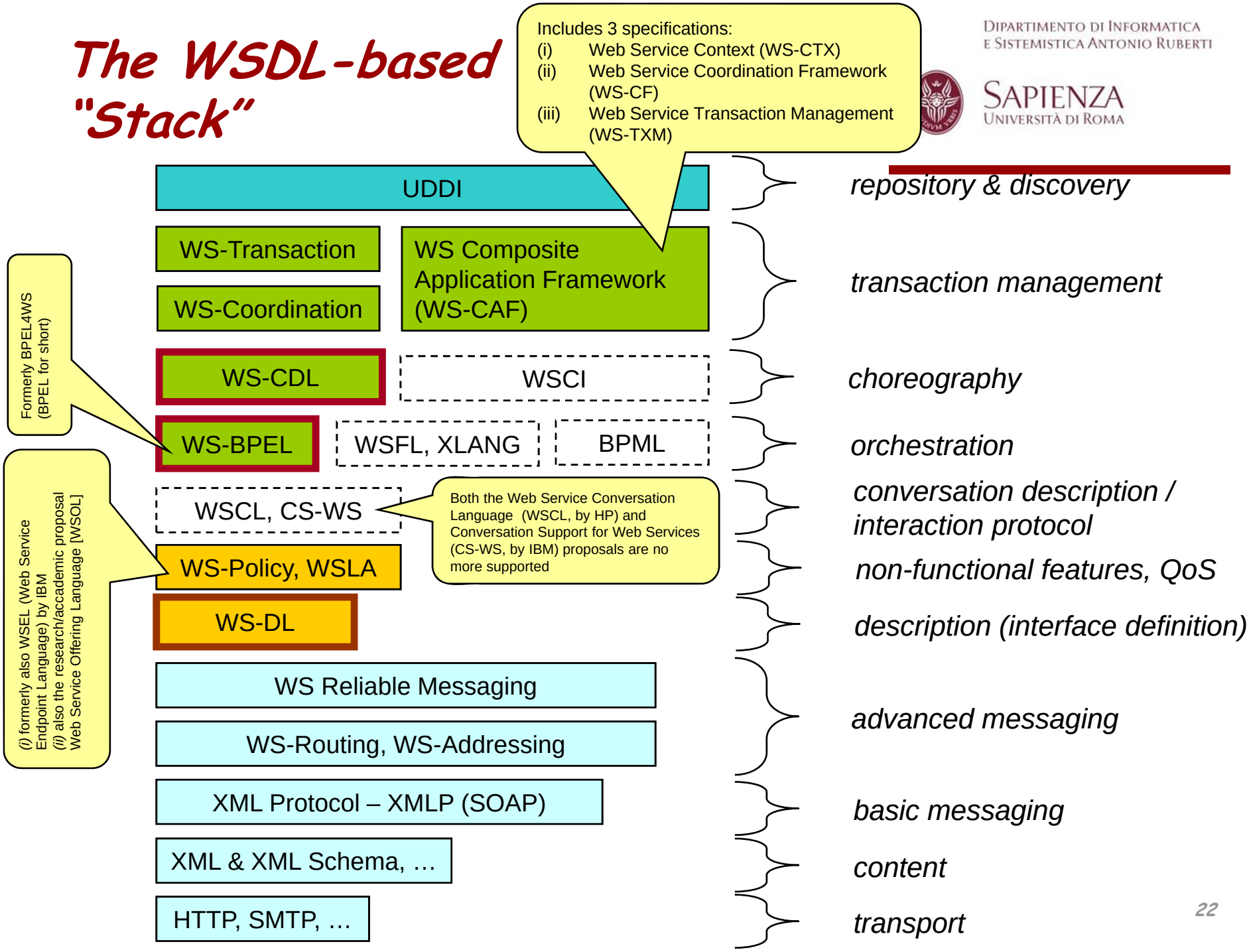

A Minimalist Infrastructure for Web Service

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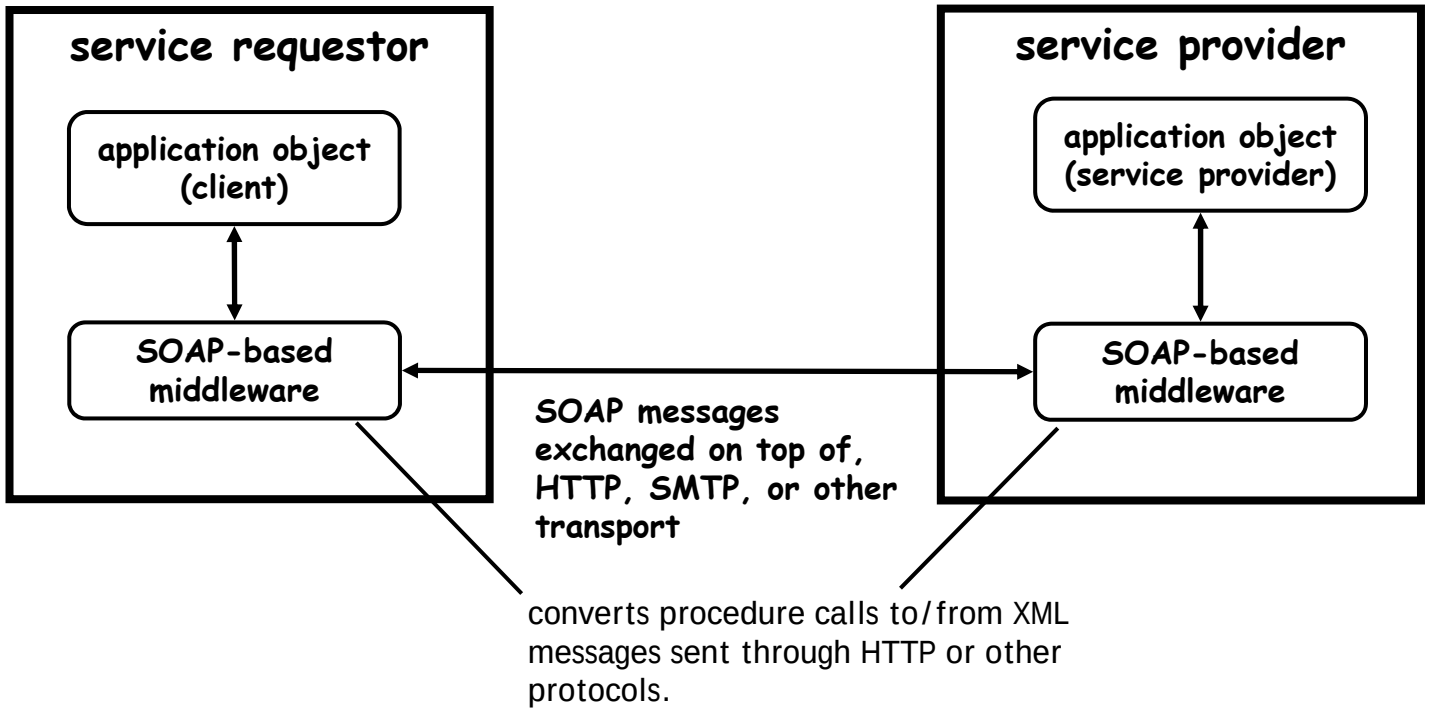

From Interfaces to Stub/Skeleton

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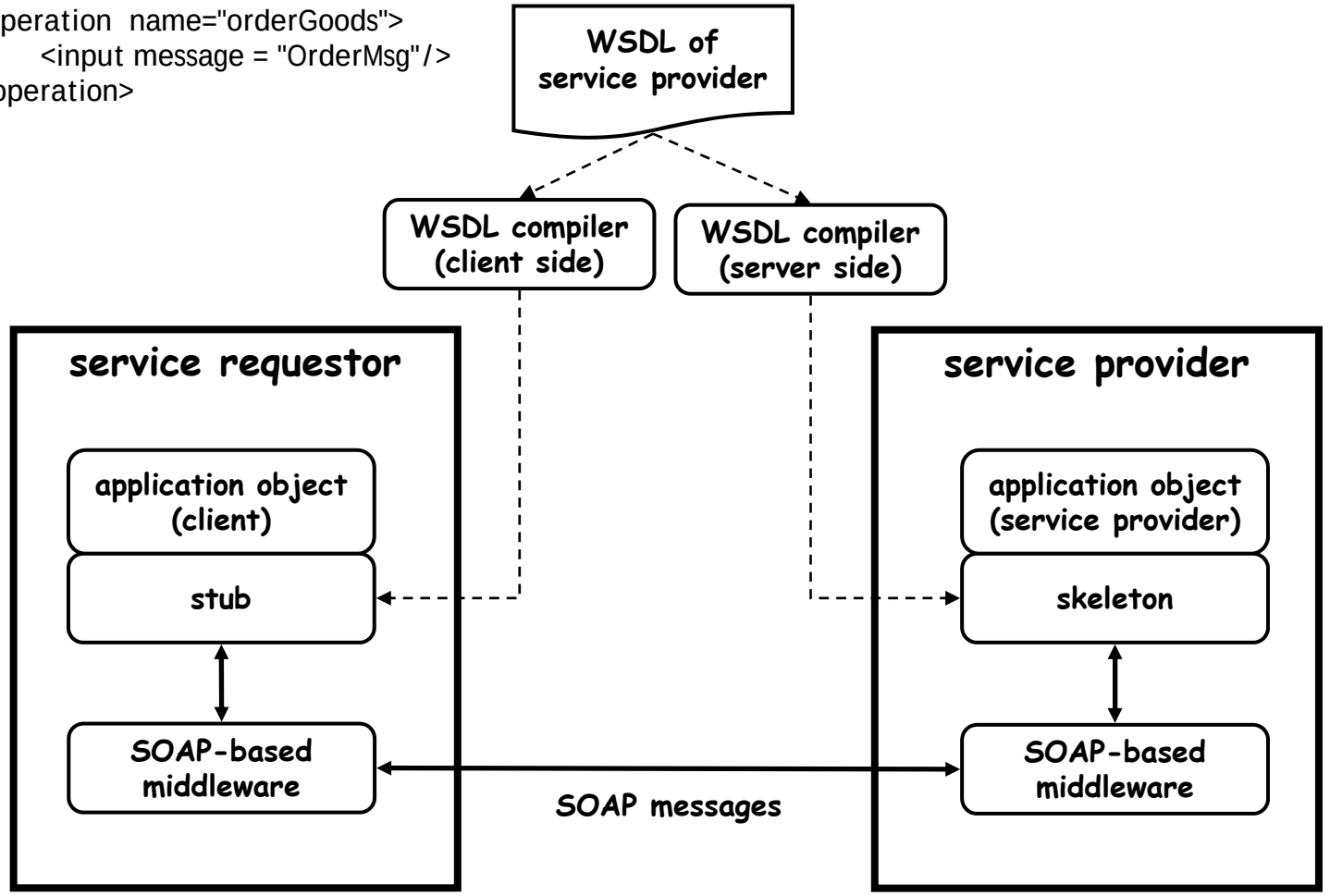
```
<operation  name="orderGoods">
        <input message = "OrderMsg"/>
</operation>
```



Registry

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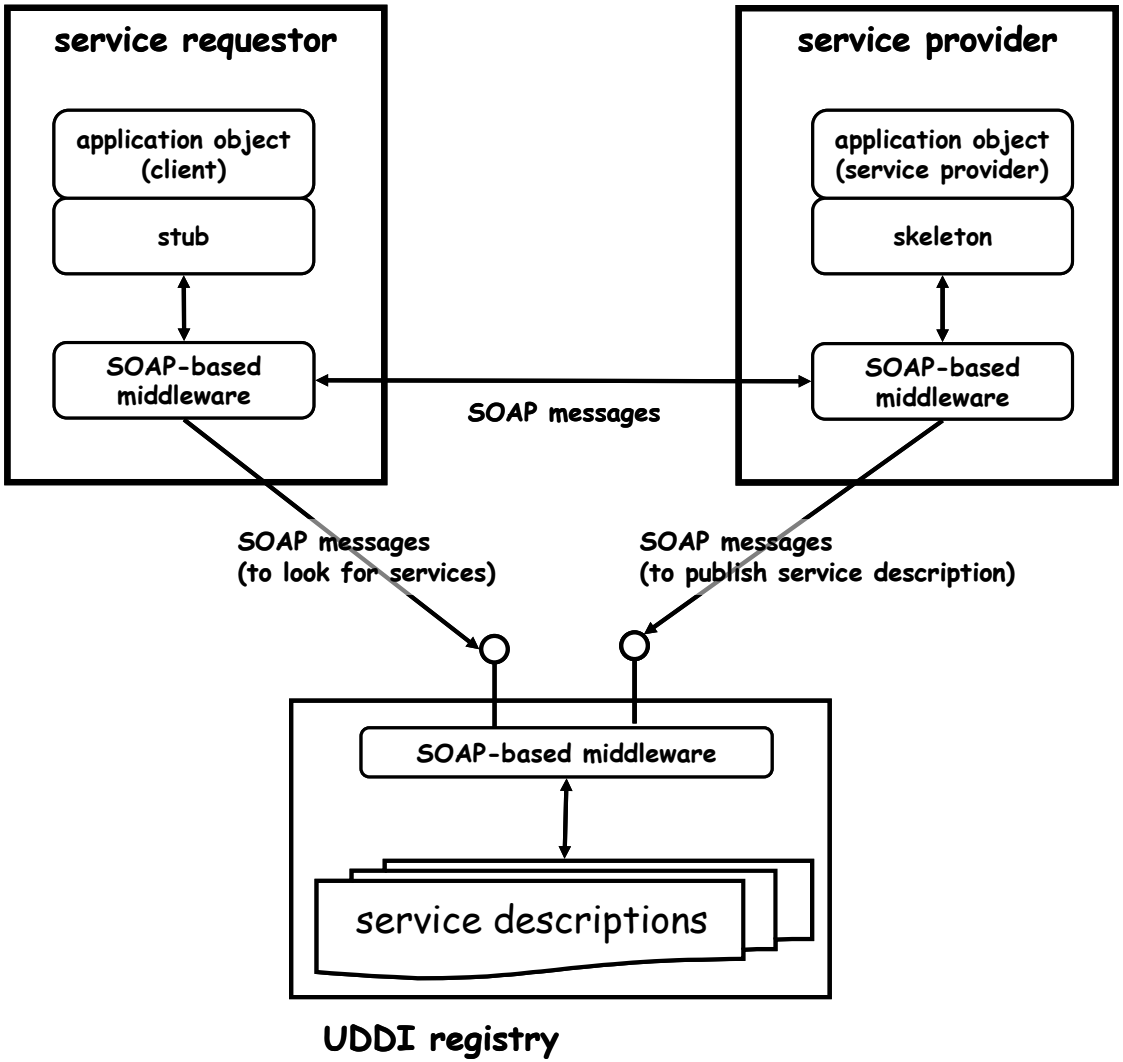

Web Service Definition Language (WS-DL)

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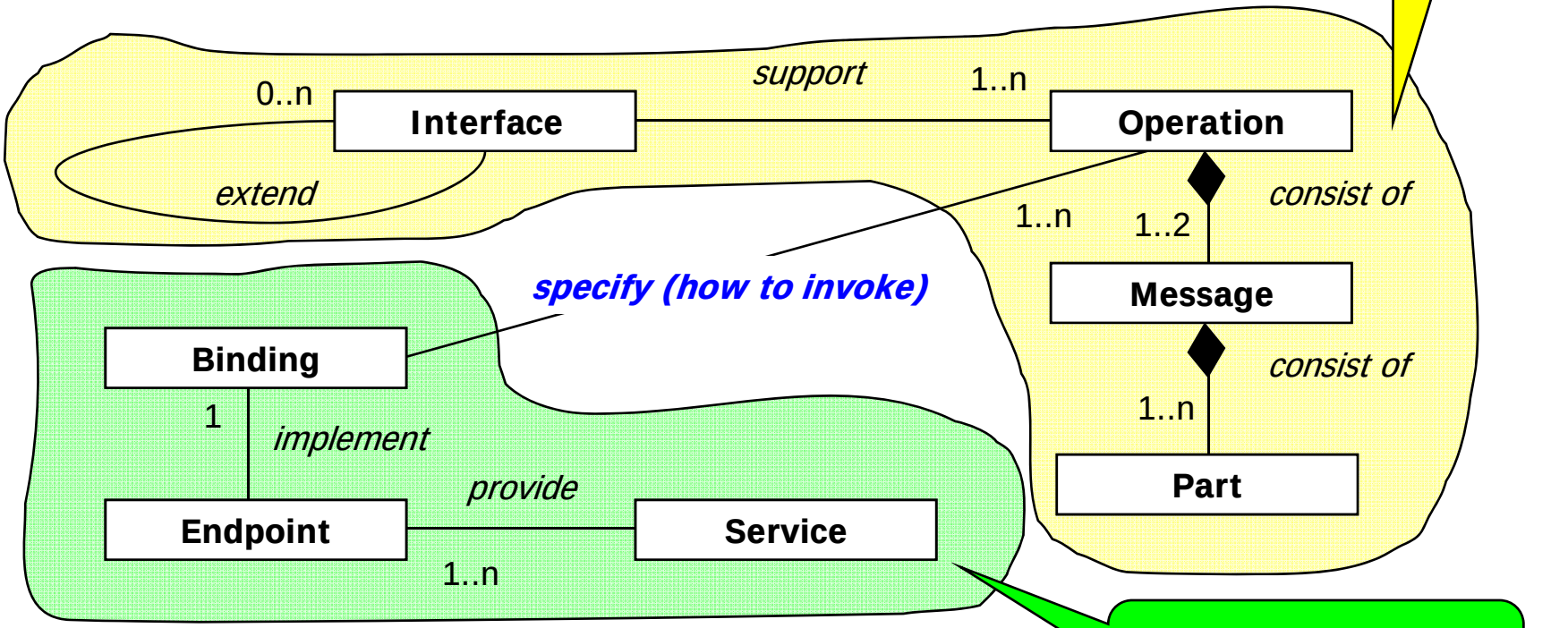
- WS-DL provides a framework for defining
  - Interface: operations and input/output formal parameters
  - Access specification: protocol bindings (e.g., SOAP)
  - Endpoint: the location of service



Message Exchange Patterns (1)

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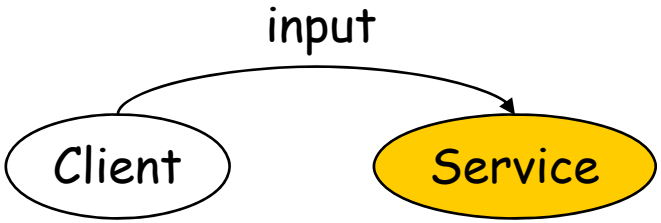
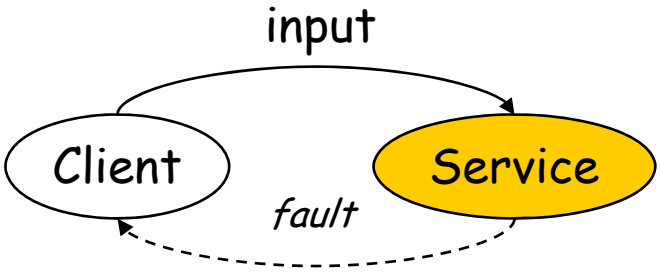
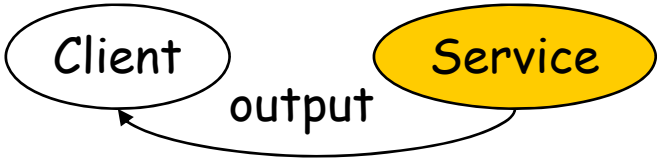


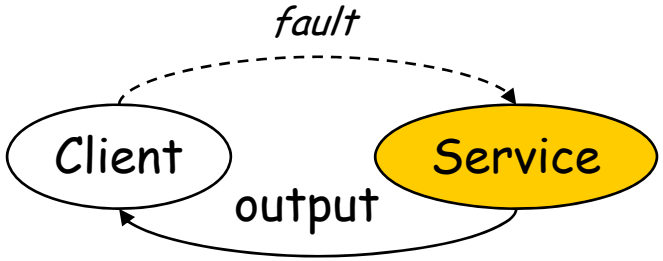
in-only (no faults)



robust in-only (message triggers fault)



out-only (no faults)



robust out-only (message triggers fault)

Message Exchange Patterns (2)

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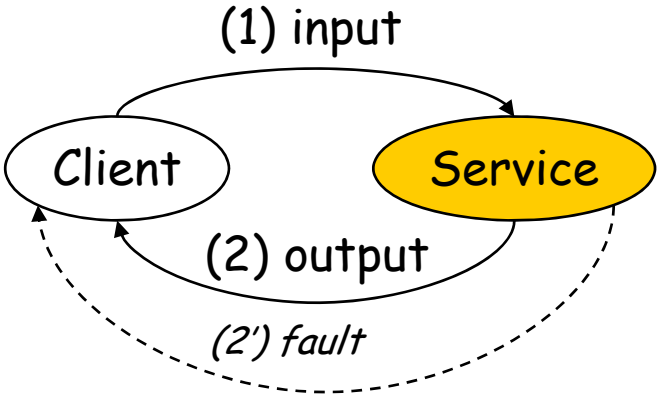
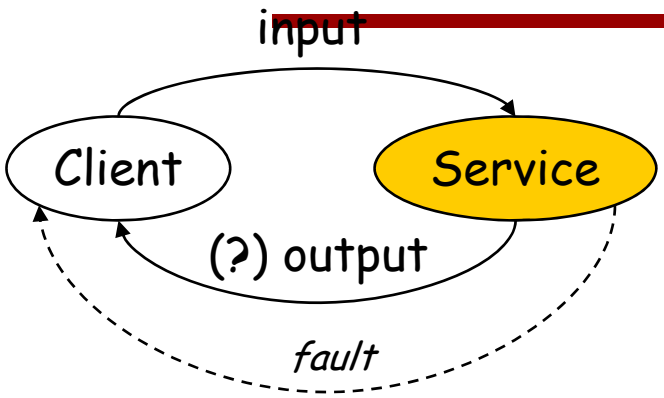
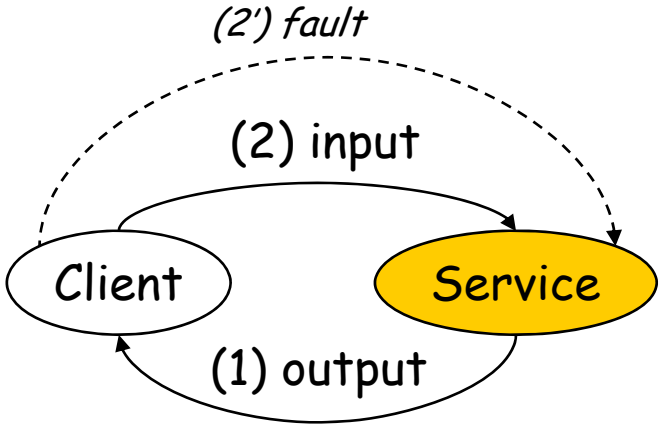


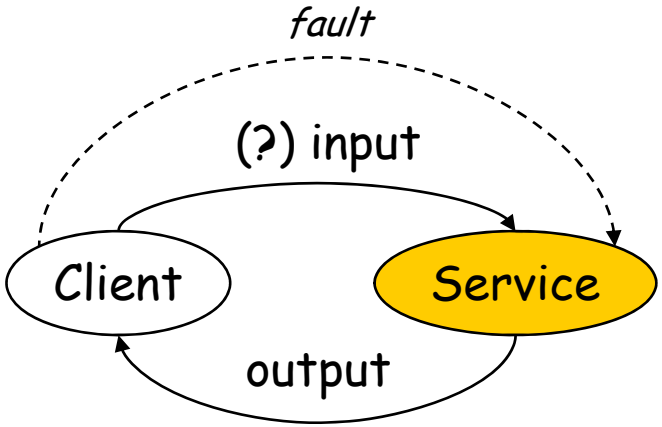
in-out (fault replaces message)



in-optional-out (message triggers fault)



out-in (fault replaces message)



out-optional-in (message triggers fault)

An Example (1)

```
<definitions … >
   <types>
        <element name="ListOfSong_Type">
               <complexType><sequence>
                      <element minOccurs="0" maxOccu   "unbound“
                             name="SongTitle" type=   s:string"/>
               </sequence></complexType>
        </element>
        <element name="SearchByTitleRequest">
               <complexType><all>
                      <element name="containedInTitle“
                             type="xs:string"/>
               </all></complexType>
        </element>
        <element name="SearchByTitleResponse">
               <complexType><all>
                      <element name="matchingSongs“
                             xsi:type="ListOfSong_Type"/>
               </all></complexType>
         </element>
```

Definition of a message and its formal parameters

An Example (2)

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```
<element name="SearchByAuthorRequest">
        <complexType><all>
                <element name="authorName“
                        type="xs:string"/>
        </all></complexType>
</element>
<element name="SearchByAuthorResponse">
        <complexType><all>
                <element name="matchingSongs“
                        xsi:type="ListOfSong_Type"/>
        </all></complexType>
</element>
<element name="ListenRequest">
        <complexType><all>
                <element name="selectedSong“
                        type="xs:string"/>
        </all></complexType>
</element>
```

An Example (3)

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```
    <element name="ListenResponse">
        <complexType><all>
            <element name="MP3fileURL" type="xs:string"/>
        </all></complexType>
    </element>
    <element name="ErrorMessage">
        <complexType><all>
            <element name="cause" type="xs:string"/>
        </all></complexType>
    </element>
</types>
```

An Example (4)

Definition of a service interface

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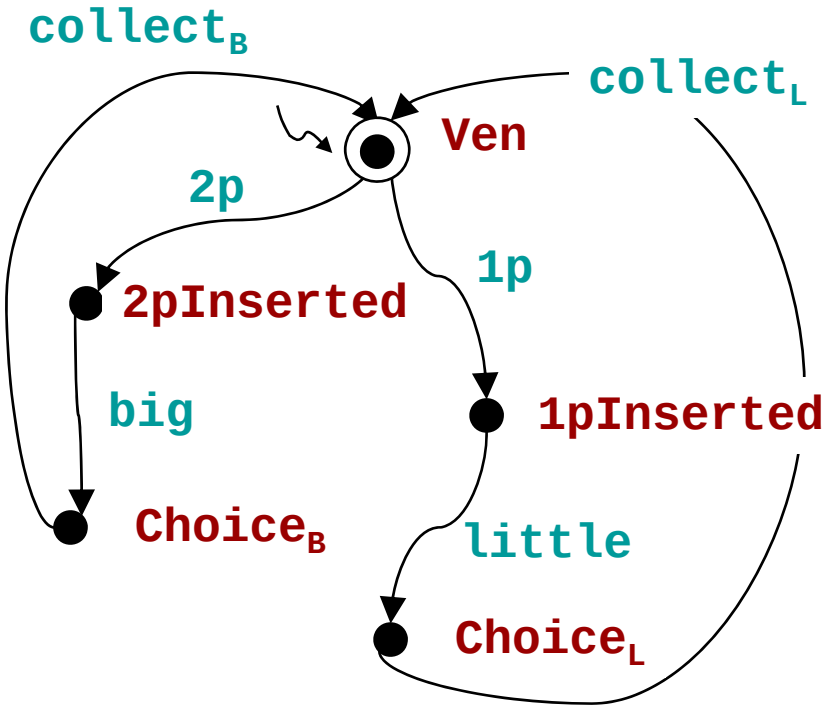
```
<interface name="MP3ServiceType">
     <operation name="search_by_title" pattern="in-out">
            <input message="SearchByTitleRequest"/>
            <output message="SearchByTitleResponse"/>
            <outfault message="ErrorMessage"/>
     </operation>
     <operation name="search_by_author" pattern="in-out">
            <input message="SearchByAuthorRequest"/>
            <output message="SearchByAuthorResponse"/>
            <outfault message="ErrorMessage"/>
     </operation>
     <operation name="listen" pattern="in-out">
            <input message="ListenRequest"/>
            <output message="ListenResponse"/>
            <outfault message="ErrorMessage"/>
     </operation>
</interface>
</definitions>
```

Definition of an operation and its message exchange pattern

Transition Systems

- A transition system (TS) is a tuple
  $T = \langle A, S, S^0, \delta, F \rangle$
  where:
  - A is the set of actions
  - S is the set of states
  - $S^0 \in S$ is the set of initial states
  - $\delta \subseteq S \times A \times S$ is the transition relation
  - $F \subseteq S$ is the set of final states



Automata vs. Transition Systems

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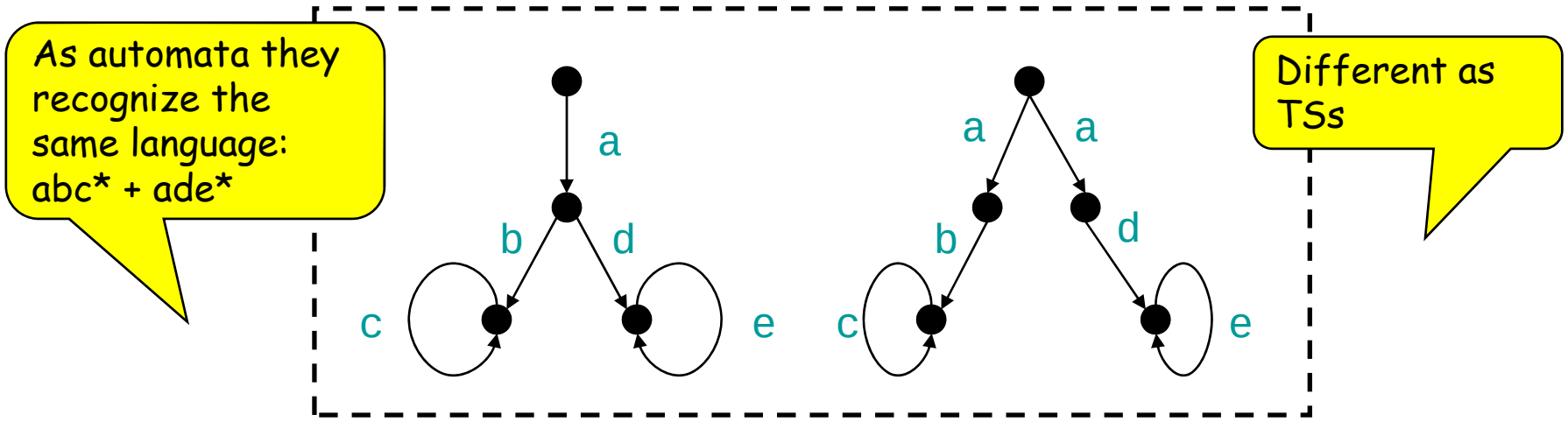
- Automata
  - define sets of runs (or traces or strings): (finite) length sequences of actions
- TSs
  - … but I can be interested also in the alternatives "encountered" during runs, as they represent client's "choice points"



WS-DL is the Set of Actions

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- A message exchange pattern (and the related operation) represents an interaction with the service client
  - an action that the service can perform by interacting with its client
- Abstracting from formal parameters, we can associate a different symbol to each operation …
- … thus obtaining the alphabet of actions

An Example

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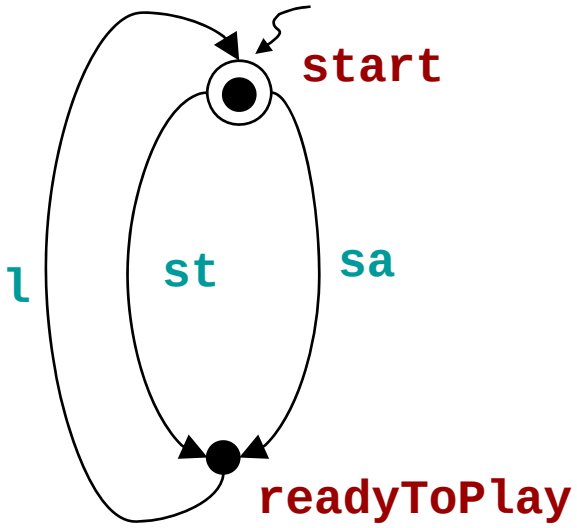
- The `MP3ServiceInterface` defines 3 actions:
  - search_by_title / st
  - search_by_author / sa
  - listen / l

- Formally $A = \{st, sa, l\}$



Putting All Together

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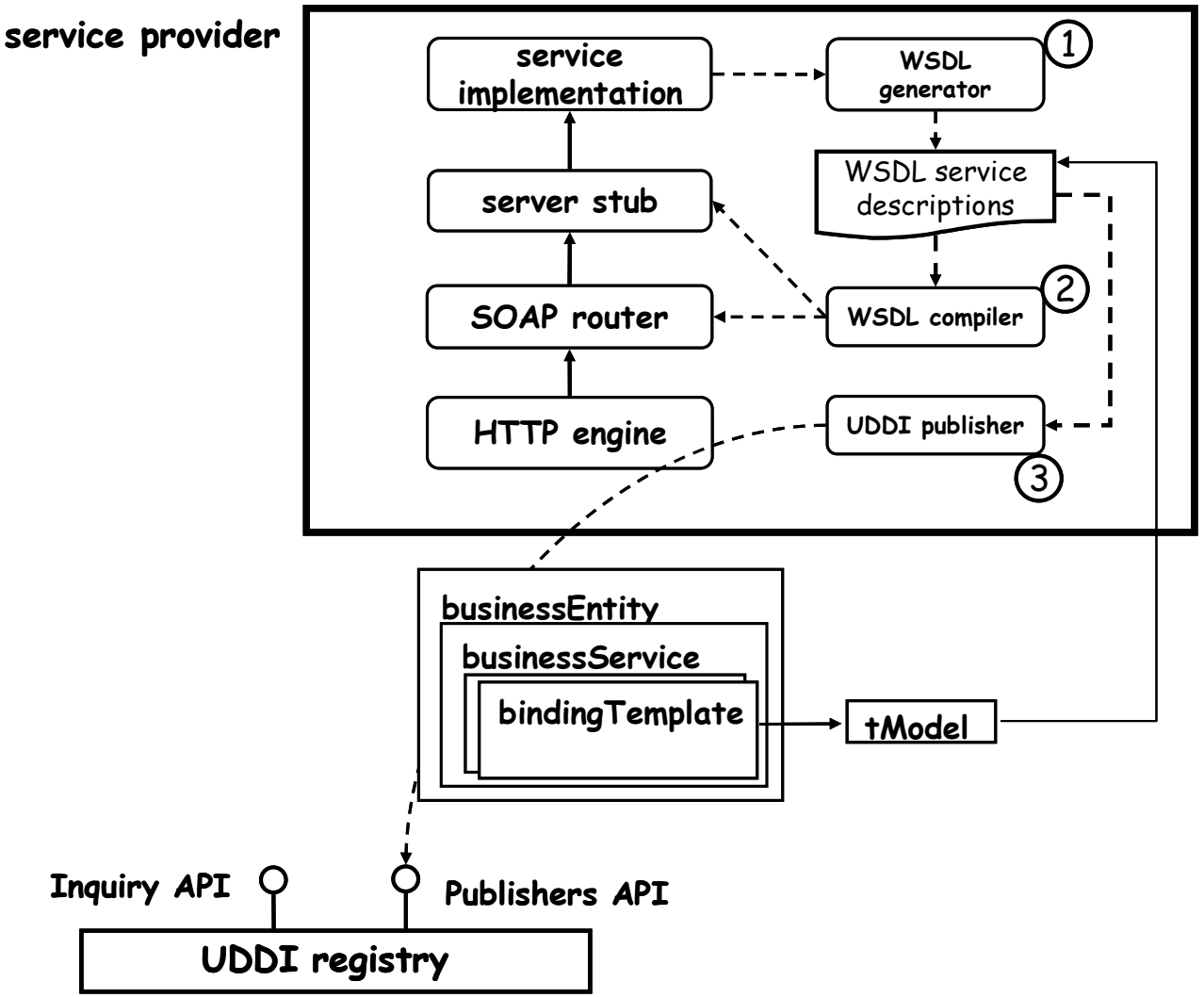

Business Process Execution Language for Web Services (WS-BPEL)

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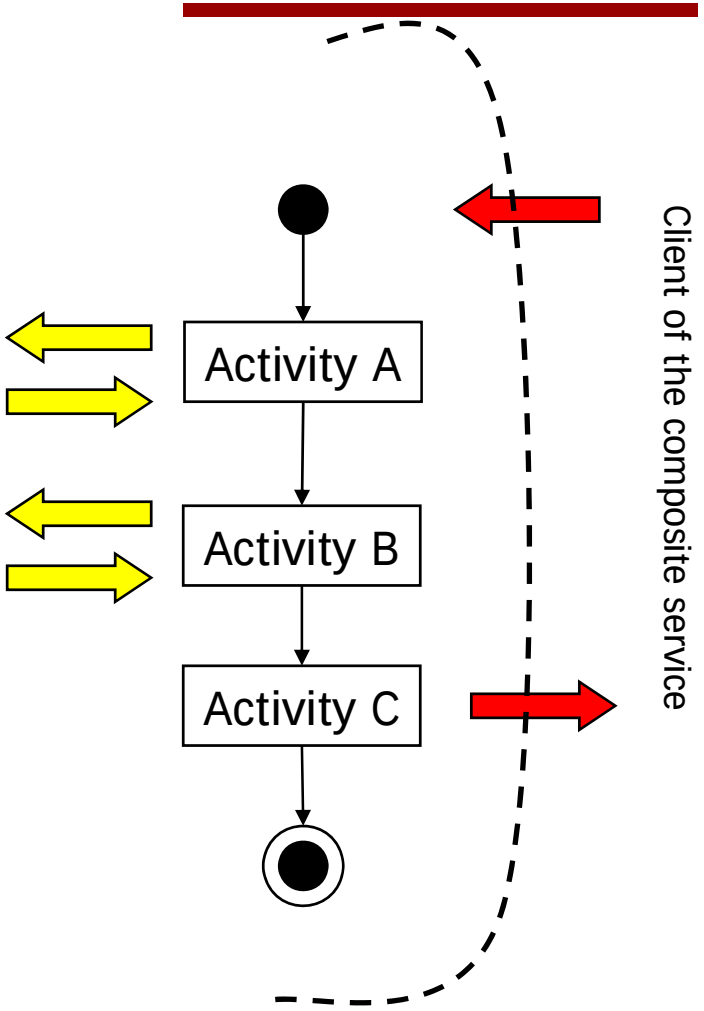
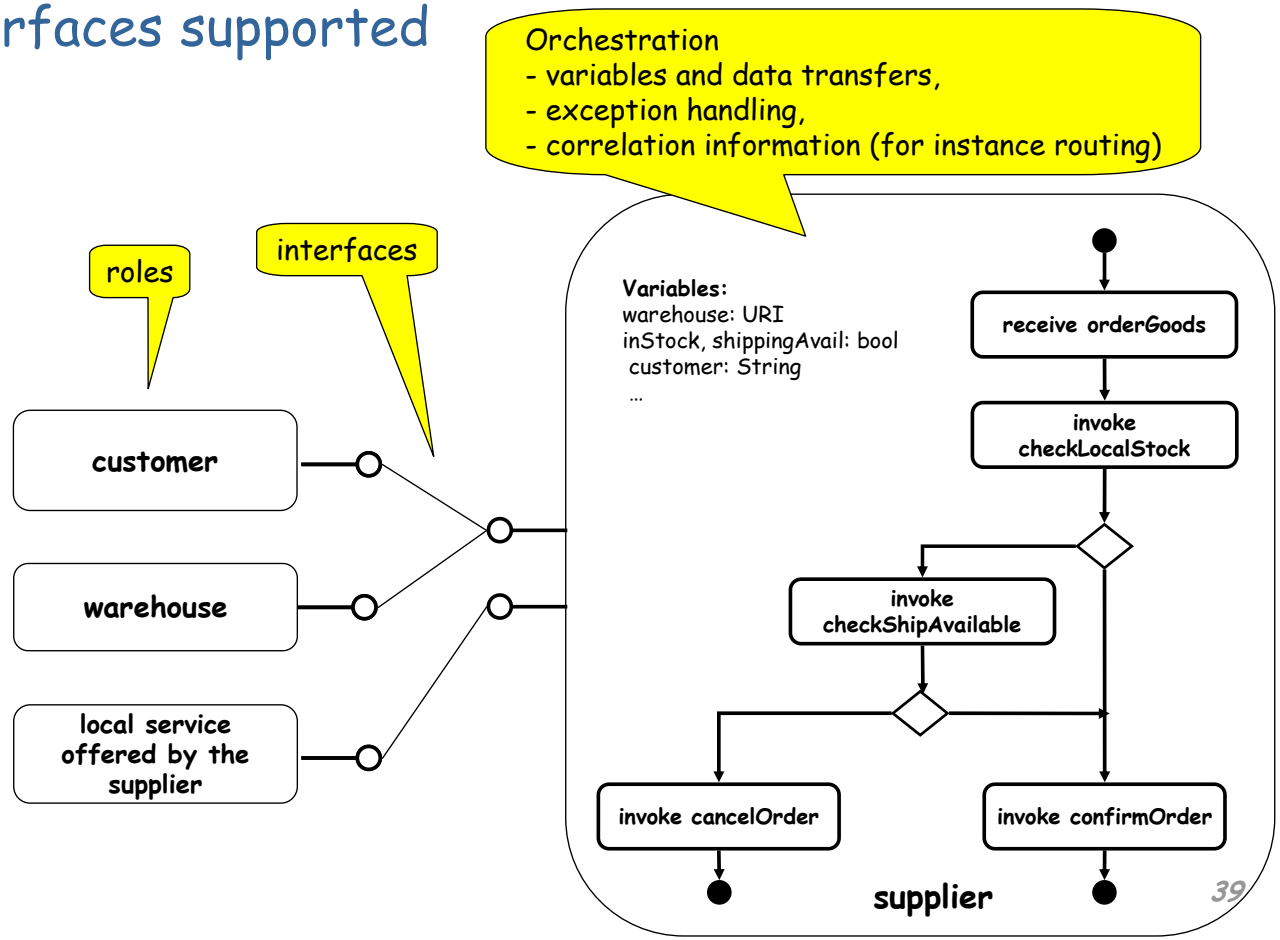
- Allows specification of composition schemas of Web Services
  - Business processes as coordinated interactions of Web Services
  - Business processes as Web Services
- Allows abstract and executable processes
- Influenced from
  - Traditional flow models
  - Structured programming
  - Successor of WSFL and XLANG
- Component Web Services described in WS-DL (v1.1)



WS-BPEL Specification

An XML document specifying

- Roles exchanging messages with the composite service/process
- The (WSDL) interfaces supported by such roles
- The orchestration of the process
  - Variables and data transfer
  - Exception handling
  - Correlation information



Process Model
(Activities)

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- Primitive
  - **invoke**: to invoke a Web Service (in-out) operation
  - **receive**: to wait for a message from an external source
  - **reply**: to reply to an external source message
  - **wait**: to remain idle for a given time period
  - **assign**: to copy data from one variable to another
  - **throw**: to raise exception errors
  - **empty**: to do nothing
- Structured
  - **sequence**: sequential order
  - **switch**: conditional routing
  - **while**: loop iteration
  - **pick**: choices based on events
  - **flow**: concurrent execution (synchronized by **links**)
  - **scope**: to group activities to be treated "transactionally" (managed by the same fault handler, within the same transactional context)

A link connects exactly one source activity S to exactly one target activity T; T starts only after S ends. An activity can have multiple incoming (possibly with join conditions) and outgoing links. Links can be guarded

Process Model
(Data Manipulation and Exception Handling)

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- Blackboard approach
  - a blackboard of variables is associated to each orchestration instance (i.e., a shared memory within an orchestration instance)
  - variables are not initialized at the beginning; they are modified (read/write) by assignments and messages
  - manipulation through XPath
- Try-catch-throw approach
  - definition of fault handlers
  - … but also event handlers and compensation handlers (for managing transactionality as in the SAGA model)

From a TS to WS-BPEL (1)

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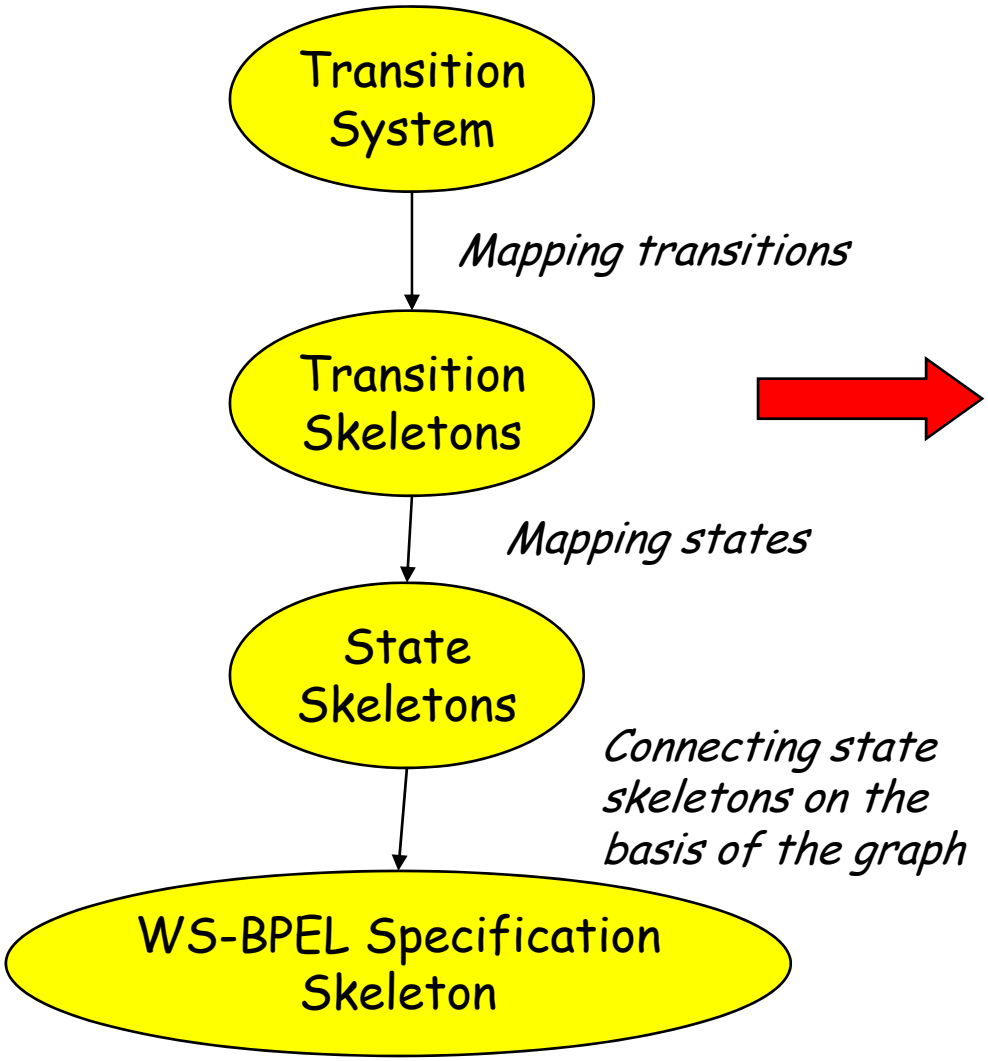


```
<process name = "…">
    <partnerLinks>
     …
    </partnerLinks>

    <variables>
     …
    </variables>

    <flow>
       <links>
         …
       </links>
       <!-- state skel. -->
       …
       <!-- state skel. -->
    </flow>

</process>
```

From a TS to WS-BPEL (2)

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***Intuition* [Baina etal CAISE04, Berardi etal VLDB-TES04]**

1. Each transition corresponds to a WS-BPEL pattern consisting of *(i)* an **<onMessage>** operation (in order to wait for the input from the client of the composite service), *(ii)* followed by the effective logic of the transition, and then *(iii)* a final operation for returning the result to the client. Of course both before the effective logic and before returning the result, messages should be copied forth and back in appropriate variables
2. All the transitions originating from the same state are collected in a **<pick>** operation, having as many **<onMessage>** clauses as transitions originating from the state
3. The WS-BPEL file is built visiting all the nodes of the graph, starting from the initial state and applying the previous rules.

N.B.: (1) and (2) works for in-out interactions (the ones shown in the following). Simple modifications are needed for in-only, robust-in-only and in-optional-out. The other kinds of interactions implies a proactive behaviour of the composite service, possibly guarded by **<onAlarm>** blocks.

Transition Skeletons

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```
<onMessage … >
      <sequence>
            <assign>
               <copy>
                  <from variable="input" … />
                  <to variable="transitionData" … />
               </copy>
            </assign>
            < !-- logic of the transition -->
            <assign>
               <copy>
                  <from variable="transitionData" … />
                  <to variable="output" … />
               </copy>
            </assign>
            <reply … />
      </sequence>
</onMessage>
```

State Skeletons

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- N transitions from state S_i are mapped onto:

```
<pick name = "Si">
      <!-- transition #1 -->
      <onMessage … >
            <!-- transition skeleton -->
      </onMessage>
      … … …
      <!-- transition #N -->
      <onMessage … >
            <!-- transition skeleton -->
      </onMessage>
</pick>
```

Mapping the TS

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- All the **<pick>** blocks are enclosed in a surrounding **<flow>**; the dependencies are modeled as **<link>**s
  - **<link>**s are controlled by specific variables **S_i-to-S_j** that are set to TRUE iff the transition S_i ! S_j is executed
  - Each state skeleton has many outgoing **<link>**s as states connected in output, each going to the appropriate **<pick>** block
  - Transitions going back into the initial state should not be considered, as they can be represented as the start of a new instance

An Example (1)

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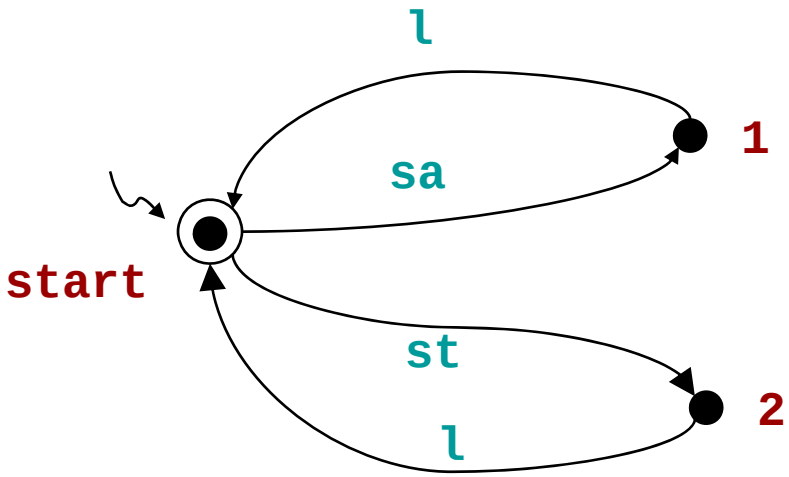


```
<partnerLinks>
  <!-- The "client" role represents the requester of this composite service -->
      <partnerLink name="client"
                partnerLinkType="tns:Transition"
                myRole="MP3ServiceTypeProvider"
                partnerRole="MP3ServiceTypeRequester"/>
      <partnerLink name="service"
                partnerLinkType="nws:MP3CompositeService"
                myRole="MP3ServiceTypeRequester"
                partnerRole="MP3ServiceTypeProvider"/>
</partnerLinks>
```

An Example (2)

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```
<variables>
      <variable name="input" messageType="tns:listen_request"/>
      <variable name="output" messageType="tns:listen_response"/>
      <variable name="dataIn" messageType="nws:listen_request"/>
      <variable name="dataOut" messageType="nws:listen_response"/>
</variables>

       <pick>
          <onMessage partnerLink="client"
                     portType="tns:MP3ServiceType"
                     operation="listen"
                     variable="input">
                     <sequence>
                          <assign>
                              <copy>
                                  <from variable="input" part="selectedSong"/>
                                  <to variable="dataIn" part="selectedSong"/>
                              </copy>
                          </assign>
                          … …
                          <assign>
                              <copy>
                                  <from variable="dataOut" part="MP3FileURL"/>
                                  <to variable="output" part="MP3FileURL"/>
                              </copy>
                          </assign>
                          <reply name="replyOutput"
                                 partnerLink="client"
                                 portType="tns:MP3ServiceType"
                                 operation="listen"
                                 variable="output"/>
                     </sequence>
          </onMessage>
          … …
       </pick>
```

An Example (3)

```
<process suppressJoinFailure = "no">
   <flow>
   <links>
      <link name="start-to-1"/>
      <link name="start-to-2"/>
    </links>

    <pick createInstance = "yes">
       <onMessage="sa">
          <sequence>
             <copy>...</copy>
             … …
             <copy>...</copy>
             <reply ... />

          </sequence>
       </onMessage>
       <onMessage="st">
          <sequence>
             <copy>...</copy>
             … …
             <copy>...</copy>
             <reply ... />
          </sequence>
       </onMessage>
       <source linkName="start-to-1" transitionCondition = "bpws:getVariableData('start-to-1') = 'TRUE' " />
       <source linkName="start-to-2" transitionCondition = "bpws:getVariableData('start-to-2') = 'TRUE' " />
    </pick>
```

A new instance is created in the initial state. This resolve also the presence of the cycles without the need of enclosing <while>

The <sa> transition skeleton should set variables:
start-to-1 = TRUE
start-to-2 = FALSE

The <st> transition skeleton should set variables:
start-to-1 = FALSE
start-to-2 = TRUE

An Example (4)

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```
<pick>
   <onMessage="l">
         <sequence>
            <copy>...</copy>
            … …
           <copy>...</copy>
           <reply ... />
         </sequence>
   </onMessage>
   <target linkName="start-to-1" />
</pick>
<pick>
   <onMessage="l">
         <sequence>
            <copy>...</copy>
            … …
           <copy>...</copy>
           <reply ... />
         </sequence>
   </onMessage>
   <target linkName="start-to-2" />
</pick>
</process>
```

Choreography

(As Reported in Literature: Classical Ballet Style)

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- Consider a dance with more than one dancer
  - Each dancer has a set of steps that they will perform. They orchestrate their own steps because they are in complete control of their domain (their body)
  - A choreographer ensures that the steps all of the dancers make is according to some overall, pre-defined scheme. This is a choreography
  - The dancers have no control over the steps they make: their steps must conform to the choreography
  - The dancers have a single view-point of the dance
  - The choreographer has a multi-party or global view-point of the dance

Choreography
(A Possible Evolution: Jam Session Style)

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- Consider a jazz band with many players
  - There is a rhythm and a main theme. This is the choreography
  - Each player executes his piece by improvising variations over the main theme and following the given rhythm
  - The players still have a single view-point of the music; in addition they have full control over the music they play
  - There is a multi-party or global view-point of the music, but this is only a set of "sketchy" guidelines

WS-BPEL vs. WS-CDL

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- Orchestration/WS-BPEL is about describing and executing a single peer
- Choreography/WS-CDL is about describing and guiding a global model (N peers)
- You should derive the single peer from the global model by projecting based on participant

The "Stacks" of Service Technologies

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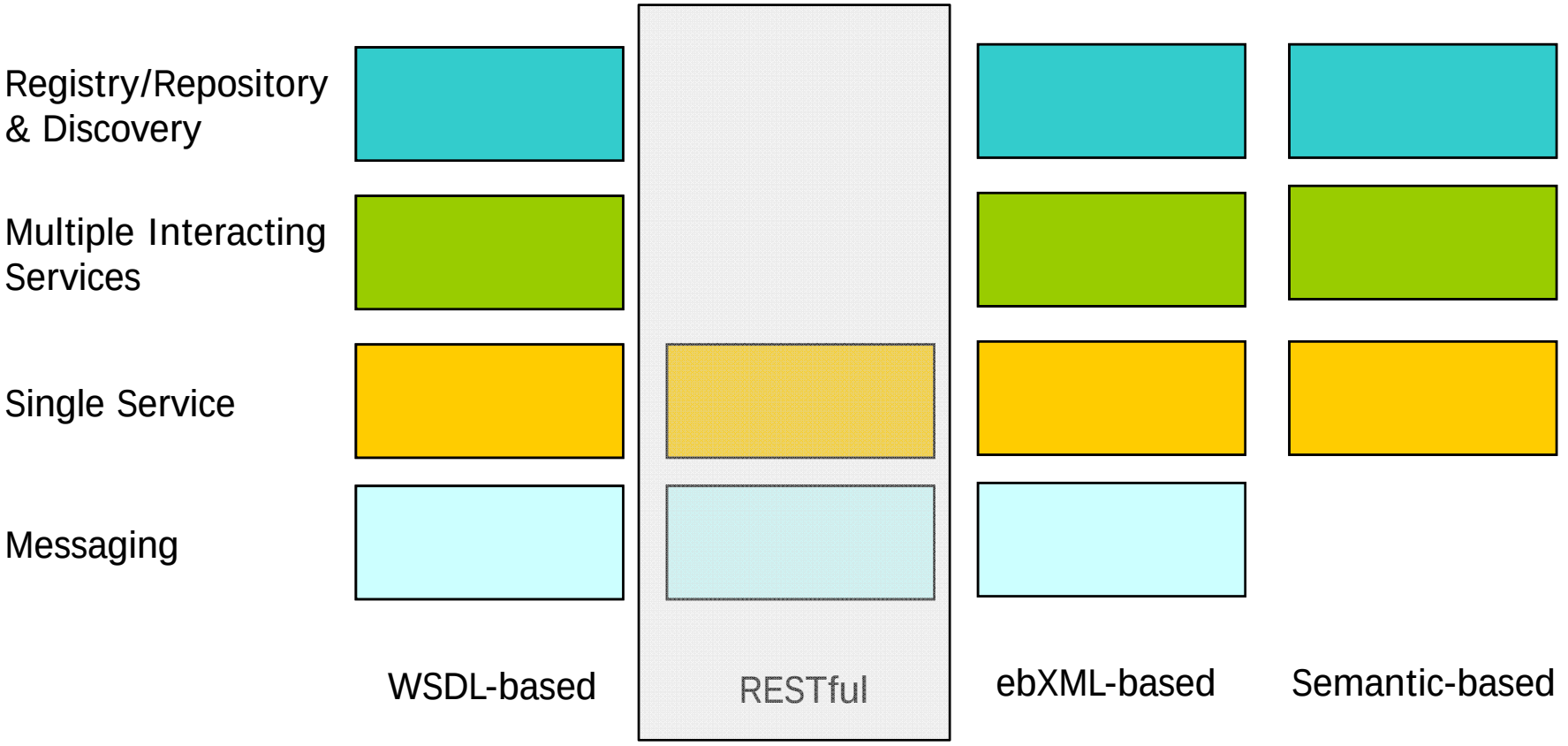

RESTful Services (1)

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- REST refers to simple application interfaces transmitting data over HTTP without additional layers as SOAP
  - Web page meant to be consumed by program as opposed to a Web browser or similar UI tool
  - require an architectural style to make sense of them (the REST one), because there's no smart human being on the client end to keep track

RESTful Services (2)

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- Metaphor based on nouns and verbs
  - URIs ~ nouns
  - Verbs describe actions that are applicable to nouns
    - GET -- retrieve information / READ, SELECT
    - POST (PUT) – add/update new information / CREATE, INSERT, UPDATE
    - DELETE -- discard information / DELETE
- State means the application/session state, maintained as part of the content transferred (in XML) from client to server back to client

RESTful Services (3)

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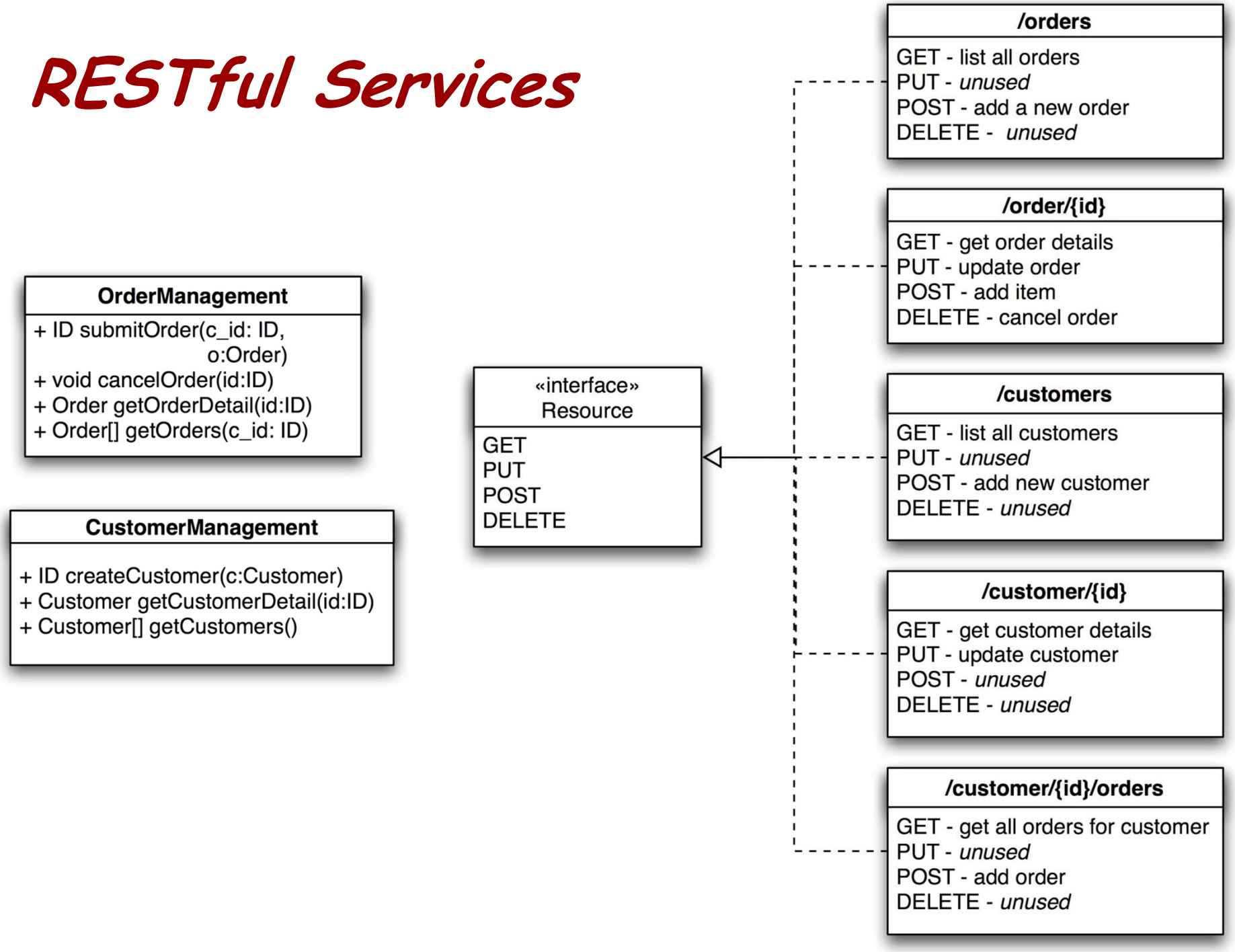
- REST is, in a sense, a kind of RPC, except the methods have been defined in advance
  - Consider the stock example of a remote procedure called "getStockPrice"
  - It's not clear what what it means to GET, PUT, and POST to something called "getStockPrice"
  - But if we change the name from "getStockPrice" to "CurrentStockPrice" all is well !!

RESTful Services



RESTful Services (4)

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- REST is incompatible with "end-point" RPC -- Either you address data objects or you address "software components"
  - REST does the former
  - End-point RPC does the latter

```
POST /purchase_orders HTTP/1.1
Host: accounting.mycompany.com
content-type:
application/purchase-order+xml
....
<po>...</po>
```

```
POST /generic_message_handler
content-type: application/SOAP+XML
<soap:envelope>
   <soap:body>
     <submit-purchase-order>
       <destination>accounting.mycompany.com
       </destination>
       <po>...</po>
     </submit-purchase-order>
   </soap:body>
<soap:envelope>
```

Example (1)

Operation	HTTP Request	HTTP Response	Java Technology Method
Create	POST /restfulwebservice-war/poservice/ HTTP/1.0 Accept: */* Connection: close Content-Type: text/xml Content-Length: 618 Pragma: no-cache <tns:PurchaseOrderDocument xmlns:tns="urn:PurchaseOrderDocument"> <billTo> <street>1 Main Street</street> <city>Beverly Hills</city> <state>CA</state> <zipCode>90210</zipCode> </billTo> <createDate>2004-03-27T12:21:02.055-05:00</createDate> <poID>ABC-CO-19282</poID> <items> <itemname>Copier Paper</itemname> <price>10</price> <quantity>2</quantity> </items> <items> <itemname>Toner</itemname> <price>920</price> <quantity>1</quantity> </items> <shipTo> <street>1 Main Street</street> <city>Beverly Hills</city> <state>CA</state> <zipCode>90210</zipCode> </shipTo> </tns:PurchaseOrderDocument>	HTTP/1.1 200 OK X-Powered-By: Servlet/2.5 Content-Type: text/xml Date: Fri, 21 Jul 2006 17:07:15 GMT Connection: close <?xml version="1.0" encoding="UTF-8"?> <ns2:Status xmlns:ns2="urn:Status" xmlns:ns3="urn:PurchaseOrderDocument" xmlns:ns4="urn:POProcessingFault"> <orderid>ABC1153501634787</orderid> <timestamp>Fri Jul 21 13:07:14 EDT 2006</timestamp> </ns2:Status>	public PurchaseOrderStatus acceptPO(PurchaseOrder order)

Example (2)

Read	GET /restfulwebservice-war/poservice/ABC1153501634787 HTTP/1.0 Connection: close Content-Type: text/xml	HTTP/1.1 200 OK X-Powered-By: Servlet/2.5 Content-Type: text/xml Connection: close <?xml version="1.0" encoding="UTF-8"?><ns3:PurchaseOrderDocument xmlns:ns3="urn:PurchaseOrderDocument" xmlns:ns2="urn:Status" xmlns:ns4="urn:POProcessingFault"><billTo><street>1 Main Street</street><city>Beverly Hills</city><state>CA</state><zipCode>90210</zipCode></billTo><createDate>2006-07-21T13:08:37.505-04:00</createDate><items><itemname>Copier Paper</itemname><price>10</price><quantity>2</quantity></items><items><itemname>Toner</itemname><price>920</price><quantity>1</quantity></items><poID>/ABC1153501634787</poID><shipTo><street>1 Main Street</street><city>Beverly Hills</city><state>CA</state><zipCode>90210</zipCode></shipTo></ns3:PurchaseOrderDocument>	public PurchaseOrder retreivePO (String orderID)
	GET /restfulwebservice-war/poservice/ HTTP/1.1 Connection: keep-alive	HTTP/1.1 400 Bad Request X-Powered-By: Servlet/2.5 Content-Type: text/xml <?xml version="1.0" encoding="UTF-8"?><ns4:POProcessingFault xmlns:ns4="urn:POProcessingFault" xmlns:ns2="urn:Status" xmlns:ns3="urn:PurchaseOrderDocument"><message>Unable to retrieve the order associated with the orderid you specified</message></ns4:POProcessingFault>	Indicates a problem finding the order

Example (3)

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Update	PUT /restfulwebservice-war/poservice/ HTTP/1.0 Connection: close Content-Type: text/xml Content-Length: 620 Pragma: no-cache <tns:PurchaseOrderDocument xmlns:tns="urn:PurchaseOrderDocument"> <billTo> <street>1 Main Street</street> <city>Beverly Hills</city> <state>CA</state> <zipCode>90210</zipCode> </billTo> <createDate>2004-03-27T12:21:02.055-05:00</createDate> <poID>ABC-CO-19282</poID> <items> <itemname>Copier Paper</itemname> <price>10</price> <quantity>2</quantity> </items> <items> <itemname>Toner</itemname> <price>920</price> <quantity>1</quantity> </items> <shipTo> <street>1 Main Street</street> <city>Beverly Hills</city> <state>CA</state> <zipCode>90210</zipCode> </shipTo> </tns:PurchaseOrderDocument>	HTTP/1.1 200 OK X-Powered-By: Servlet/2.5 Content-Type: text/xml <?xml version="1.0" encoding="UTF-8"?><ns3:PurchaseOrderDocument xmlns:ns3="urn:PurchaseOrderDocument" xmlns:ns2="urn:Status" xmlns:ns4="urn:POProcessingFault"> <billTo><street>1 Main Street</street><city>Beverly Hills</city><state>CA</state><zipCode>90210</zipCode> </billTo> <createDate>2004-03-27T12:21:02.055-05:00</createDate> <items><itemname>Copier Paper</itemname> <price>10</price><quantity>2</quantity></items> <items><itemname>Toner</itemname><price>920</price> <quantity>1</quantity></items> <poID>ABC-CO-19282</poID><shipTo><street>1 Main Street</street><city>Beverly Hills</city> <state>CA</state><zipCode>90210</zipCode></shipTo> </ns3:PurchaseOrderDocument>	public PurchaseOrder updatePO(PurchaseOrder order)
Delete	DELETE /restfulwebservice-war/poservice/ABC-CO-19282 HTTP/1.0 Connection: close Content-Type: text/xml Content-Length: 0 Pragma: no-cache	HTTP/1.1 200 OK X-Powered-By: Servlet/2.5 Content-Type: text/xml Date: Fri, 21 Jul 2006 17:10:38 GMT Server: Sun Java System Application Server Platform Edition 9.1 Connection: close <?xml version="1.0" encoding="UTF-8"?>	public void cancelPO(String orderID)

Why so trendy ?

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- Easy and lightweight
- Amazon, Yahoo, Google offer their Web services as RESTful

- … but nothing really new for us, basically the same abstractions apply, you can consider the operations as a whole or you can start modeling the data flowing through the service

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PRACTICAL DEVELOPMENT

JAX-WS 2.0 – Java API for XML Web Services

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- Specifica basata su **annotazioni**
- Applicata su classi ed interfacce in modo da definire e gestire automaticamente
  - il protocollo di comunicazione remota
    - **SOAP**
  - il *marshalling*
    - **XML**
  - lo scambio di messaggi previsto
    - **WSDL / XML-Schema**
- Condiziona anche la codifica client (se Java)
- Alternativa a **JAX-RPC** (*Java API for XML Remote Procedure Calls*)
  - basata su file di mapping e descrittori XML

Premesse ed osservazioni

- Il file WSDL verrà automaticamente generato dal framework
  - JBossWS
- Non è previsto il mantenimento di alcuno stato conversazionale !!
  - I Web Service, per propria natura, sono **stateless**
    - La realizzazione di **Web Service conversazionali** è ottenibile tramite estensioni dello standard
      - **WS-Addressing**
- Occorre ricordare che i Web Service sono creati per essere ***platform-independent***
  - Moduli client e server possono essere codificati in linguaggi differenti
  - Non è richiesta *alcuna* importazione di file bytecode nel client che siano residenti nel server

Implementazione basata su POJO/Servlet

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1. Creare un'interfaccia che dichiari le operazioni offerte dal Web Service

```
package it.uniroma1.dis.pseudoinfostud.control;

public interface ElencoUtentiAttiviService {
    public String[] getElencoUtentiAttivi();
}
```

Implementazione basata su POJO/Servlet

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2. Dichiarare, per mezzo di annotazioni, le caratteristiche del Web Service

```
package it.uniroma1.dis.pseudoinfostud.control;

import javax.jws.WebMethod;
import javax.jws.WebResult;
import javax.jws.WebService;

@WebService(targetNamespace =
"http://www.dis.uniroma1.it/master/pseudoinfostud/ElencoUtenti")

public interface ElencoUtentiAttiviService {

@WebMethod(operationName="getElencoUtentiAttivi")
@WebResult(name="elencoUtentiAttivi")
        public String[] getElencoUtentiAttivi();
}
```

Implementazione basata su POJO/Servlet

3. Codificare una classe che implementi quei metodi (**endpoint**)

```
package it.uniroma1.dis.pseudoinfostud.control;

public class ElencoUtentiAttiviEndpoint
implements ElencoUtentiAttiviService {

@Override
public String[] getElencoUtentiAttivi() {
        List<String> utentiAttivi =
                new ArrayList<String>();
         ...
        return utentiAttivi.toArray();
}
}
```

Implementazione basata su POJO/Servlet

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4. Dichiarare, per mezzo di annotazioni, le caratteristiche dell'endpoint

```
package it.uniroma1.dis.pseudoinfostud.control;

import javax.jws.WebService;

@WebService(
        name = "ElencoUtentiAttiviEndpoint",
        serviceName = "ElencoUtentiAttivi",
        targetNamespace = "http://www.dis.uniroma1.it/asos/pseudoinfostud/ElencoUtenti",
        endpointInterface = "it.uniroma1.dis.pseudoinfostud.control.ElencoUtentiAttiviService")

public class ElencoUtentiAttiviEndpoint implements ElencoUtentiAttiviService {
        public String[] getElencoUtentiAttivi() {
        // ...
        }
}
```

Implementazione basata su POJO/Servlet

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5. Impostare, su web.xml, i riferimenti remoti verso l'endpoint

```
<?xml version="1.0" encoding="UTF-8"?>
<web-app xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns="http://java.sun.com/xml/ns/javaee"
xmlns:web="http://java.sun.com/xml/ns/javaee/web-app_2_5.xsd"
xsi:schemaLocation="http://java.sun.com/xml/ns/javaee
http://java.sun.com/xml/ns/javaee/web-app_2_5.xsd" id="WebApp_ID" version="2.5">
  <display-name>PseudoInfostudWSServer</display-name>
  <servlet>
    <display-name>ElencoUtentiAttiviEndpoint</display-name>
    <servlet-name>ElencoUtentiAttiviEndpoint</servlet-name>
    <servlet-class>
it.uniroma1.dis.pseudoinfostud.control.ElencoUtentiAttiviEndpoint
    </servlet-class>
  </servlet>
  <servlet-mapping>
    <servlet-name>ElencoUtentiAttiviEndpoint</servlet-name>
    <url-pattern>/ElencoUtentiAttivi</url-pattern>
  </servlet-mapping>
</web-app>
```

Implementazione basata su POJO/Servlet

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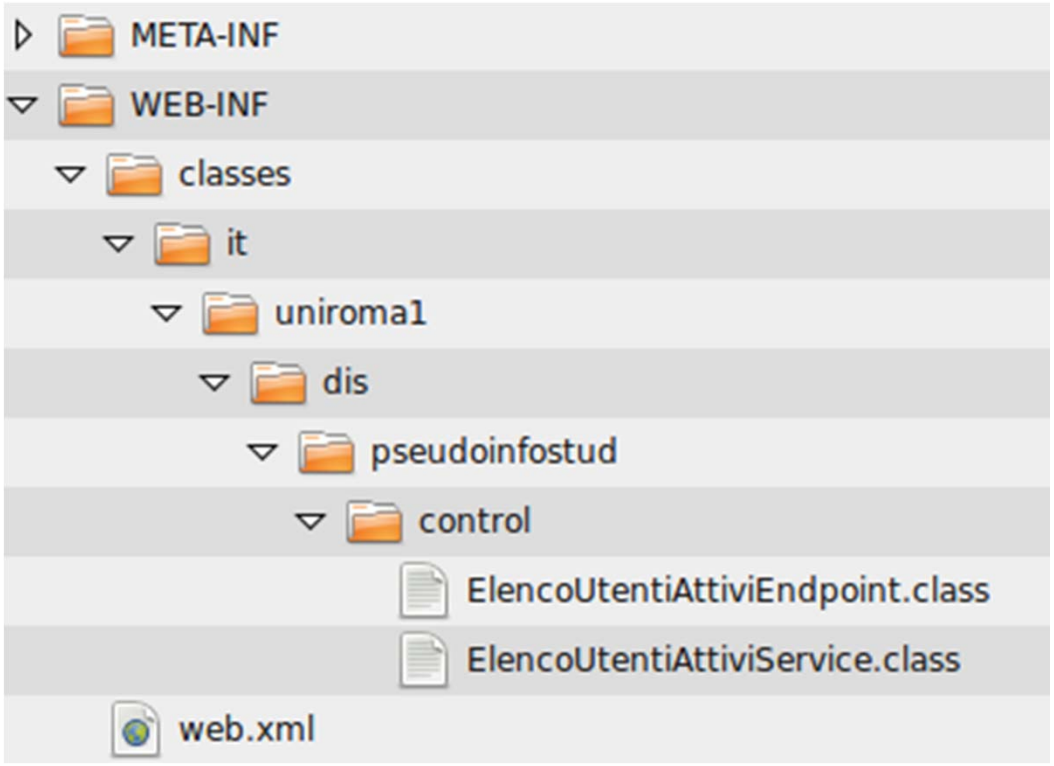
6. Dispiegare sull'Application Server il **WAR** contenente bytecode e metadati creati



Implementazione basata su POJO/Servlet

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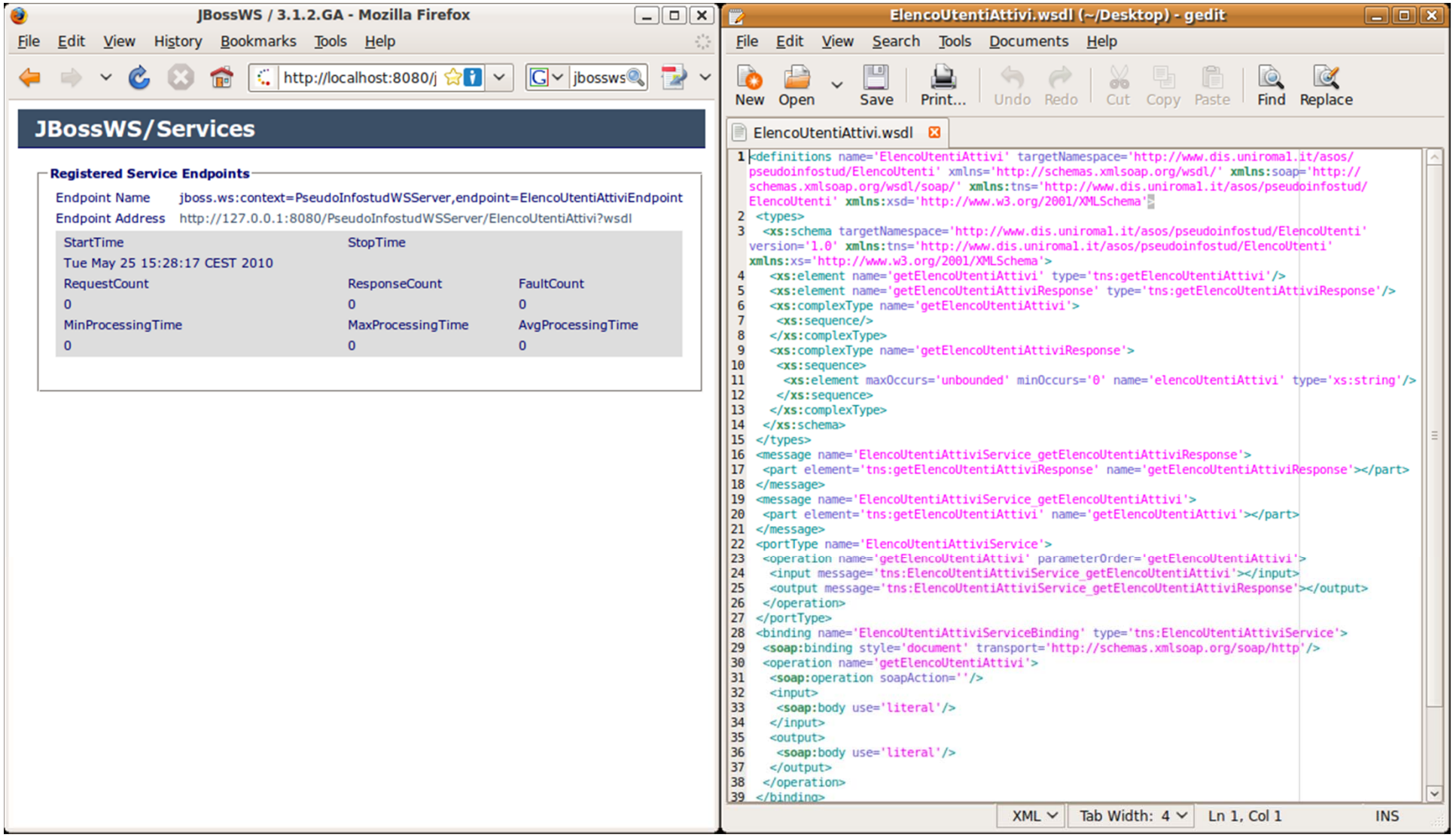

Osservazioni POJO / Servlet

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- Sebbene si compili un'applicazione web basata su Servlet, la classe che implementa il Web Service non deve dichiarare esplicitamente l'estensione della classe javax.servlet.GenericServlet
- L'implementazione è estremamente semplice
- Qualunque classe può divenire l'endpoint di un Web Service, una volta apposte opportunamente le annotazioni

Il client

- Non è necessario che il client sia codificato in Java
  - Esula dagli scopi di questo corso l'integrazione con altre tecnologie...
    - ... dunque nel resto della lezione considereremo la codifica in Java!
- Occorre ricordare che non solo i valori e le istanze, ma anche la definizione degli stessi, sono basati su XML
  - WSDL contiene tutte le informazioni, con riferimenti a XML-Schema interni o esterni
- Nel progetto client, anche se codificato in Java, non si devono importare direttamente le classi definite sul server!
  - L'esperienza insegna che, provando, si ottengono a run-time errori alquanto criptici...
    com.sun.xml.ws.model.RuntimeModelerException: runtime modeler error: Wrapper class *bla.bla.bla.Bla* is not found. Have you run APT to generate them?

Gli stub

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- Occorre generare gli **stub** delle classi presenti sul server
  - Gli stub devono essere prodotti sulla base del solo WSDL
- Il comando per ottenere da shell (prompt) la codifica e la compilazione di tali stub è wsimport
  - Esempio d'uso

```
wsimport
    -d ‹directory_destinazione_file_compilati›
    -s ‹directory_destinazione_file_sorgente_generati›
    -keep
    -p ‹package_classi_stub›
    ‹uri_wsdl›
```

Gli stub

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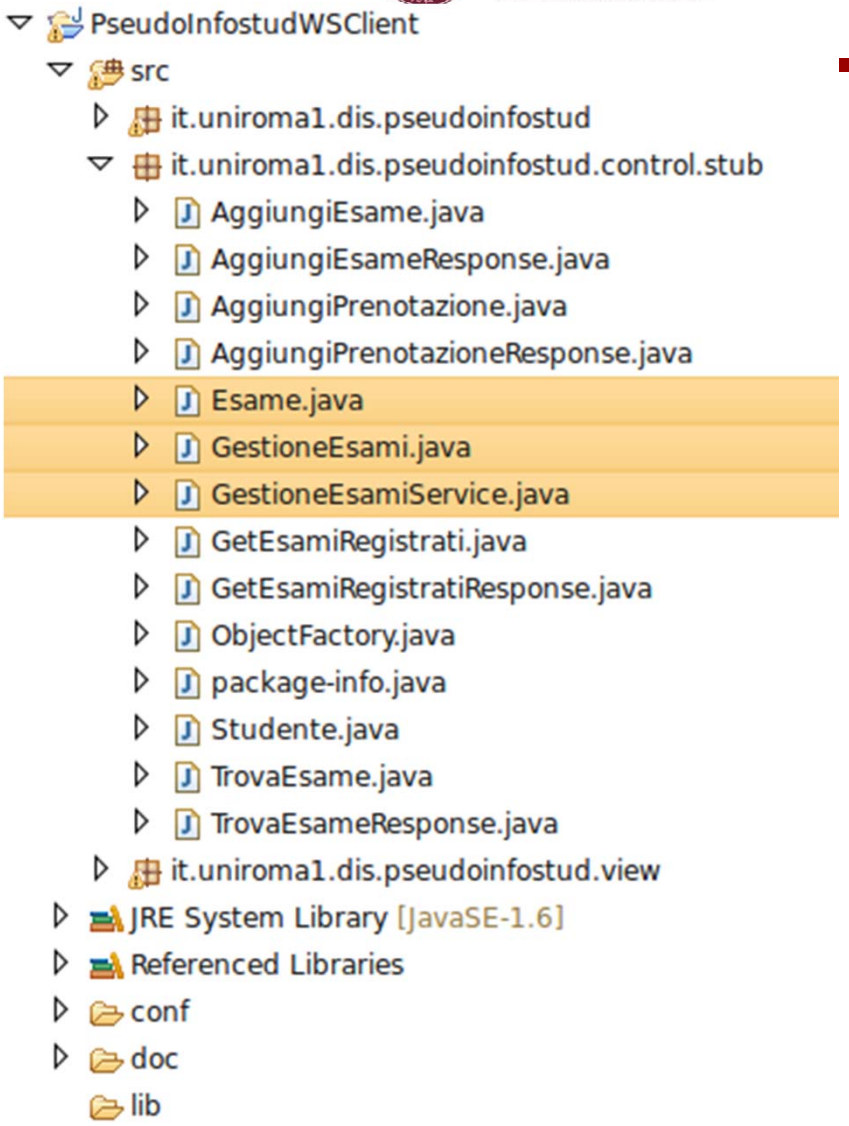
- Occorre generare gli **stub** delle classi presenti sul server
  - Gli stub devono essere prodotti sulla base del solo WSDL
- Il comando per ottenere da shell (prompt) la codifica e la compilazione di tali stub è wsimport
  - Caso reale

```
wsimport
-d /home/mobidis/workspace/SimpleWSClient/bin
-s /home/mobidis/workspace/SimpleWSClient/src
-keep
-p stub
http://127.0.0.1:8080/ElencoUtentiAttivi/ElencoUtentiAttivi?wsdl
```

Gli stub

- Le classi di Stub vanno aggiunte al progetto Java del client
  - Il mantenimento dei sorgenti è opzionale...
  - ... ma molto utile a scopo didattico
- Attenzione: sono classi diverse dalla controparte sul server



Invocazione di operazioni del WS

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- Dati gli stub (importati nella classe client), per ottenere un riferimento locale all'endpoint (proxy):
  ‹EndpointInterfaceName› endpoint =
  new **‹ServiceName›**()
  .get**‹ServicePortName›**();

Invocazione di operazioni del WS

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- Su tale classe, potranno essere invocati i metodi dichiarati tramite annotazione @WebService
  - Il nome dei metodi corrisponderà al nome specificato come attributo name dell'annotazione, se presente!

Web Services and WS-BPEL