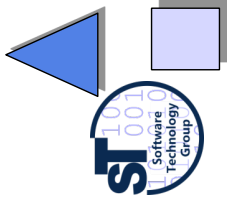


15. Web Services and Service-Oriented Architectures

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Multimediatechnik
<http://st.inf.tu-dresden.de>
Version 13-1-1, May 31, 2013



- 1) Web Services as a specific form of service-oriented architectures
- 2) SOAP
- 3) WSDL
- 4) BPEL
- 5) BPMN
- 6) Trust and security
- 7) Evaluation

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Obligatory Reading

- ▶ ISC, Chapter 2.4
- ▶ Lohmann, Niels, Verbeek, Eric, Dijkman, Remco. Petri Net Transformations for Business Processes – A Survey. In : Transactions on Petri Nets and Other Models of Concurrency II, Editor: Jensen, Kurt, van der Aalst, Wil, Lecture Notes in Computer Science 5460, 2009, Springer Berlin / Heidelberg
 - ▶ <http://www.springerlink.com/content/n7464131r6751453/>
- ▶ W.M.P. Van der Aalst. Don't go with the flow: Web services composition standards exposed. IEEE Intelligent Systems, Jan/Feb 2003. <http://tmitwww.tn.tue.nl/research/patterns/download/ieeewebflow.pdf>
- ▶ P. Wohed, W.M.P. Van der Aalst, M. Dumas, A. ter Hofstede. Analysis of Web Service Composition Languages: The Case of BPEL.
 - ▶ <http://www.bpmnforum.com/FAQ.htm> FAQ of BPMN

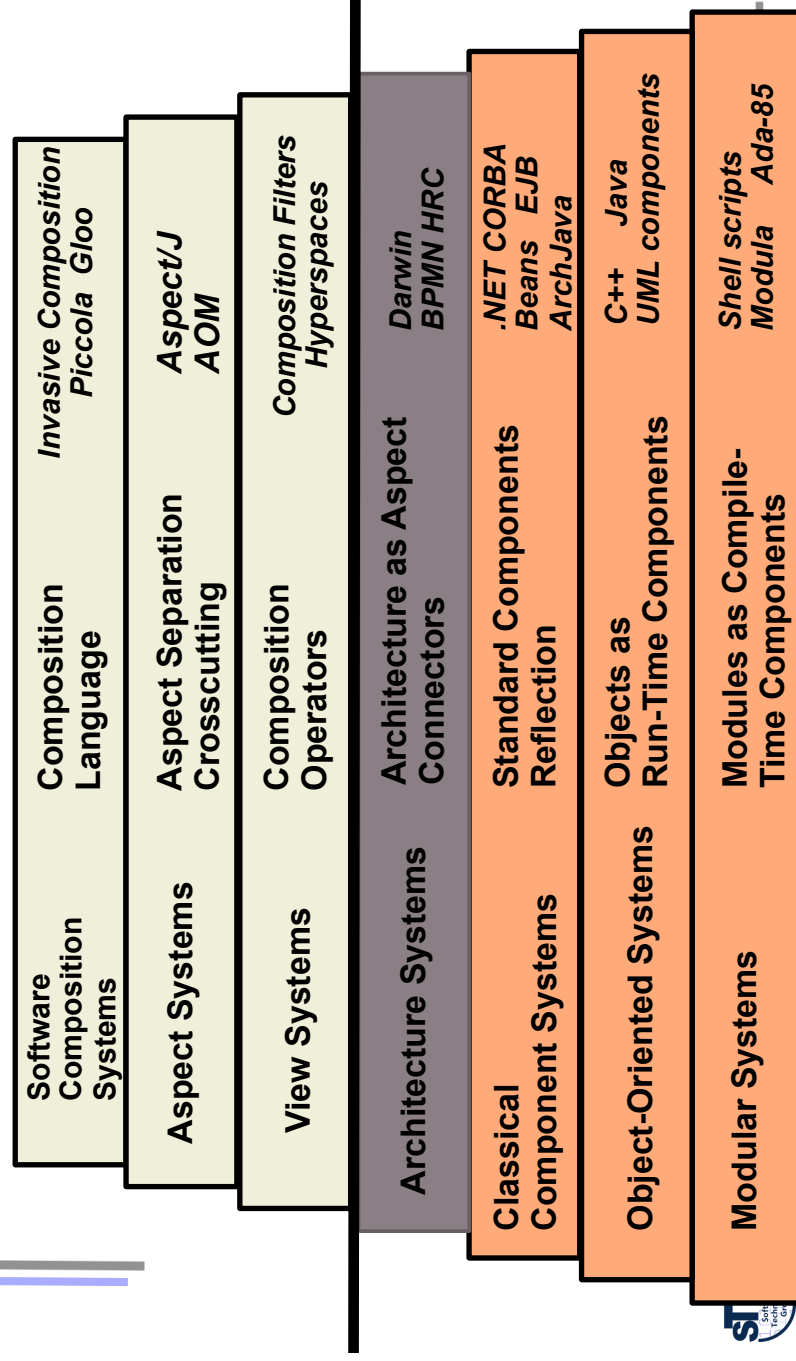


Literature

- ▶ Matthias Weske. Business Process Management – Concepts, Languages, Architectures. Springer. 2007
- ▶ YAWL <http://sourceforge.net/projects/yawl/>
- ▶ H. P. Alesso, C. F. Smith. Developing Semantic Web Services. A K Peters Ltd, Natick, Massachusetts, 2004.
- ▶ <http://www.bpmb.de/index.php/BPMNPoster>
- ▶ Liste der BPMN Werkzeug-Hersteller
http://www.bpmn.org/BPMN_Supporters.htm
- Scheer, A.-W. ARIS - Business Process Frameworks. Springer, Berlin, 1998, ISBN 3-540-64439-3
- Michael C. Jaeger. Modelling of Service Compositions: Relations to Business Process and Workflow Modelling. ICSOC 2007, LNCS 4652.



The Ladder of Composition Systems



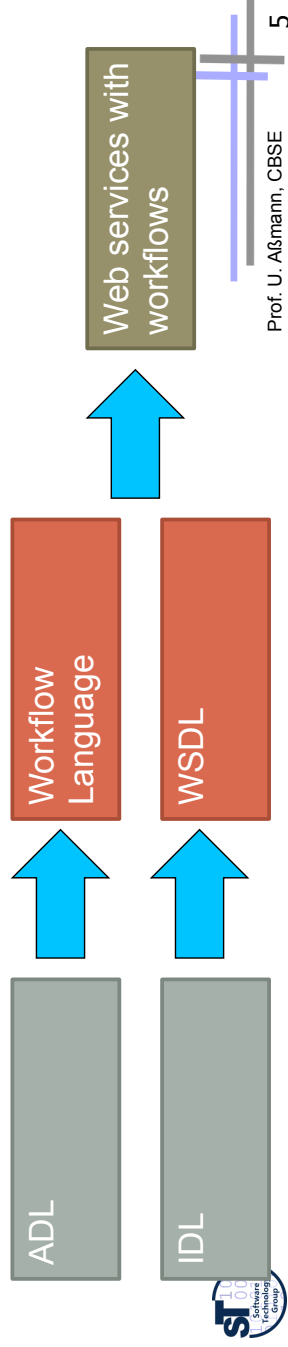
15.1 Web Services and Architecture Systems

Architecture systems may have different forms of architectural languages:

- Topology-based (Unicon, ACME, Darwin)
- Coordination schemes (CoSy)
- Imperative scripts (Darwin)

Web Service Systems and Languages (WSS) are a form of architectural system

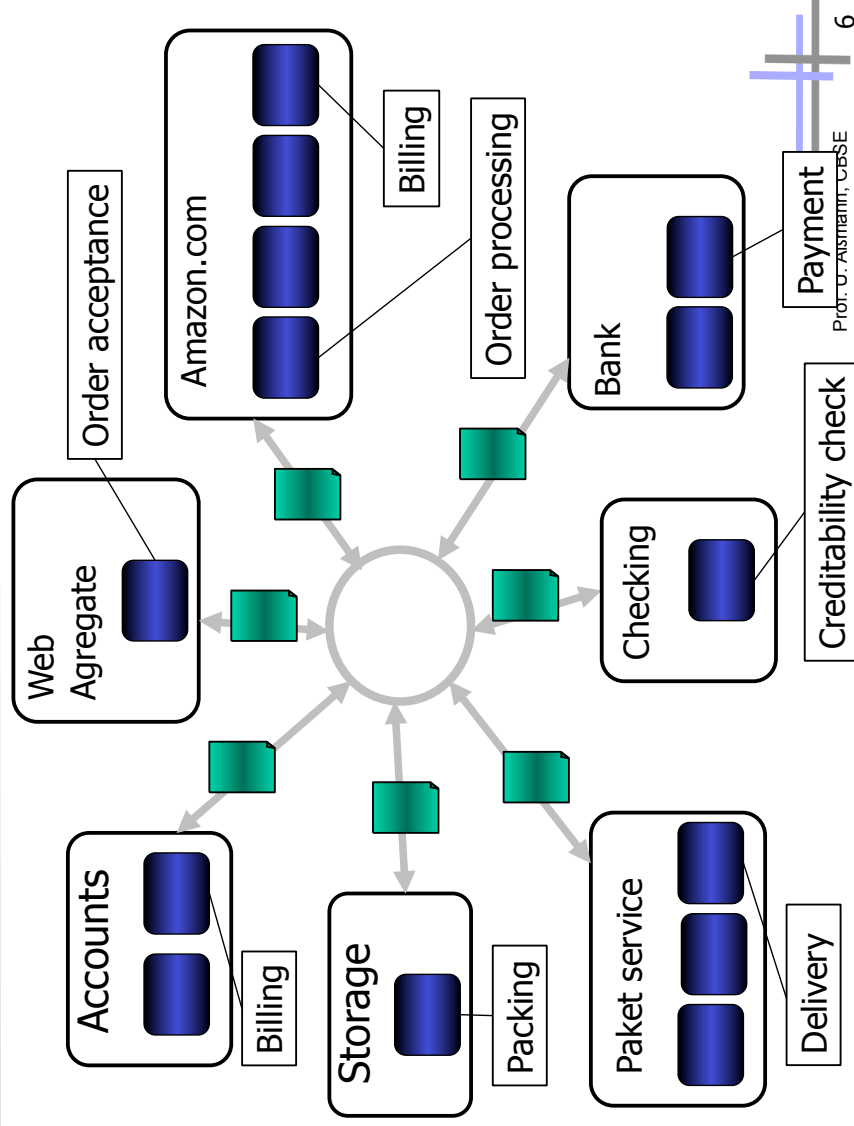
- They separate programming-in-the-small from programming-in-the-large (2-level programming)
 - Components encapsulate the service knowledge
 - The architectural level (orchestration, aggregation, composition) treats the big picture
- ▶ However, WSS have an imperative architectural language
 - ▶ They are based on XML standards (SOAP, WSDL, BPEL)



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Reuse of Web Services as Black-Box Components

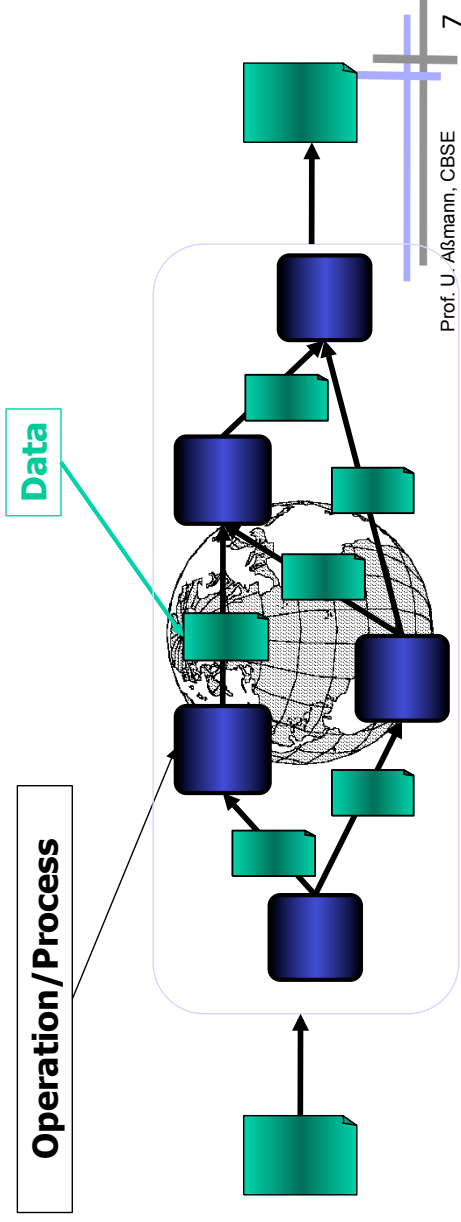


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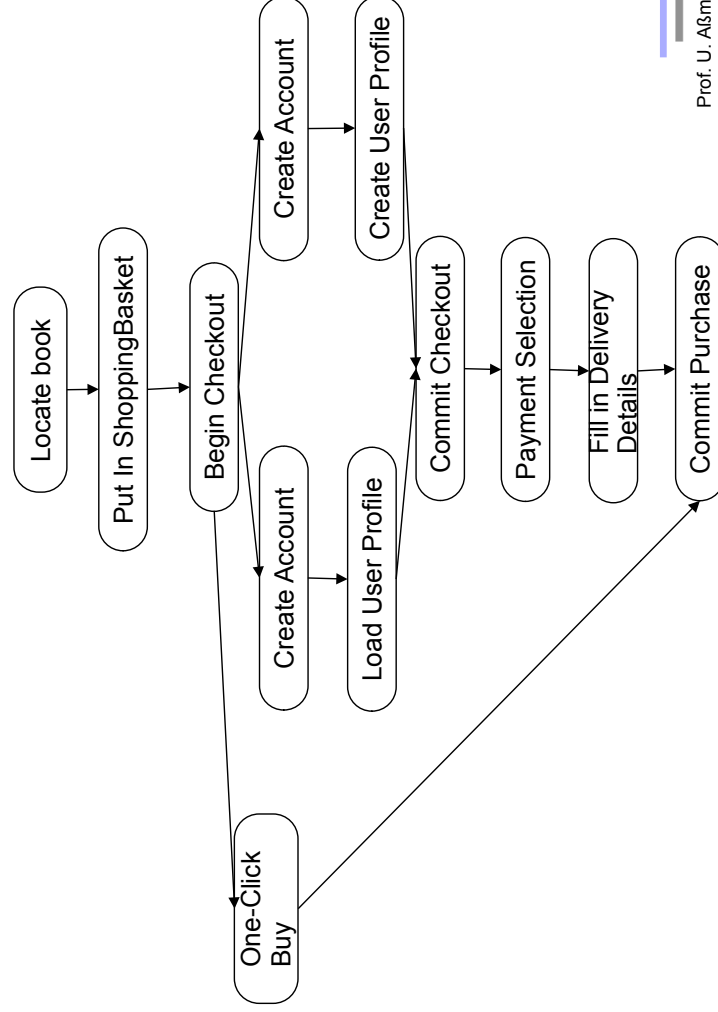
Web Service Architectures are Described by Workflows

- ▶ Workflow specifications combine control and data flow
- ▶ Web service architectures are the first step to service-oriented architectures (SOA), based on traders
 - Services will be offered, searched and discovered, downloaded, executed
- ▶ *Enterprise services* transfers web services to business systems
- ▶ *Customer services* serve the end-user of the web



Ex. Buying a Book from Amazon

- ▶ Workflows can be specified graphically
 - ▶ E.g., with UML activity diagram [Alesso/Smith]

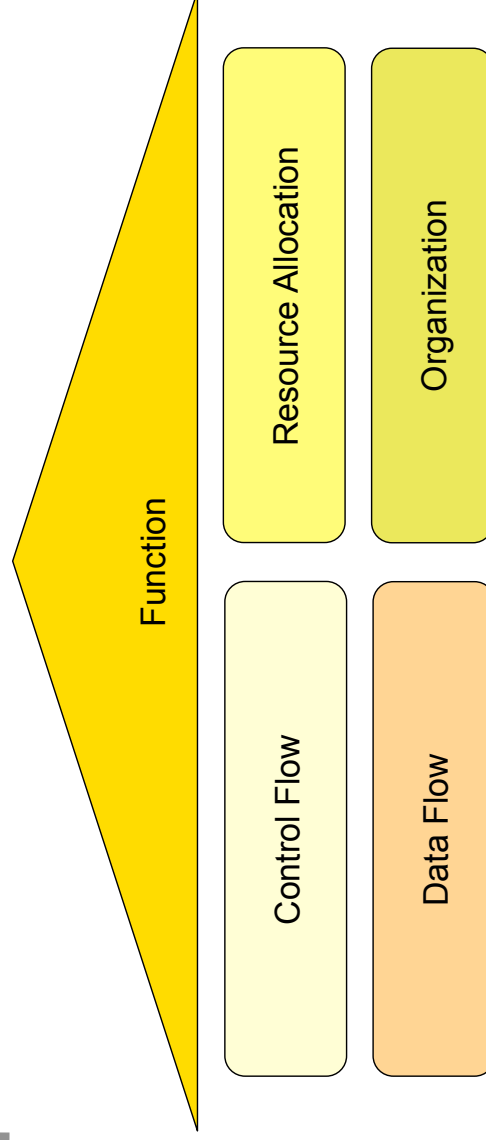


Which Types of Operational Specifications Exist?

- ▶ Data-flow graphs (data flow diagrams, DFD)
 - Data flows through operations
 - Activity diagrams: data flows through actions
 - See courses Softwaretechnologie II, Software-Entwicklungswerkzeuge
- ▶ Control-flow graphs (CFG)
 - Nodes are control-flow operations that start other operations on a state
 - The standard representation for imperative programs
- ▶ State systems
 - Finite State Machines (FSM): events trigger state transitions
 - Statecharts: Hierarchical FSM
 - Colored Petri nets: tokens mark control and data-flow, see course Softwaretechnologie II
- ▶ Mixed approaches
 - Cyclic data-flow graphs (also called static-single assignment graphs, SSA)
 - Cycles are marked by phi-nodes that contain control-flow guards
 - **Workflow languages:** mix control and data-flow
 - Provide specific split and join operators for control and data flow

Workflows Have Aspects

Standard workflow modeling discerns about 5 aspects
ex. ARIS house [Scheer's company IDS, now Software AG]



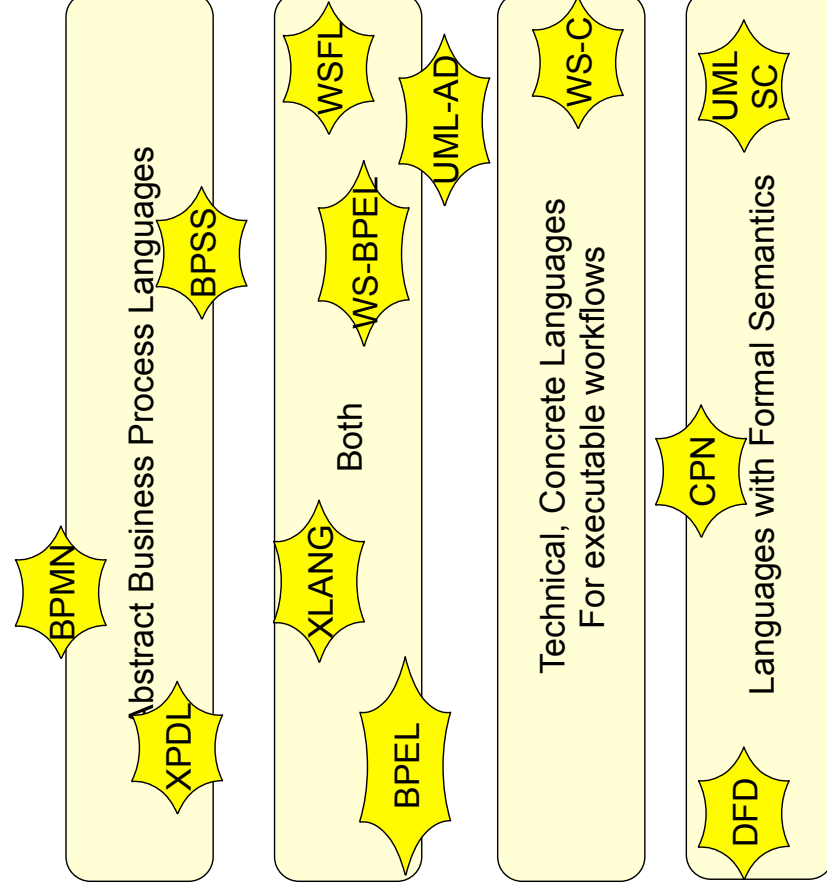


Workflow Languages

- ▶ A workflow language specifies control and data flow over a set of operations
 - ▶ The workflow is executable with an interpreter, the *workflow engine*
 - A single operation need not be executed automatically, but can be performed by humans (... for people)
 - The workflow runs in parallel
- Workflows are usually compiled to Colored Petri Nets or to Statecharts
 - YAWL (van der Aalst, Eindhoven)
 - Workflow Nets
- ▶ Industrial Examples:
 - Lotus Domino (IBM)
 - Business Process Execution Language (BPEL)
 - ARIS system for SAP, based on EPC (event process chains)
 - Business Process Modeling Notation (BPMN), also in use at SAP



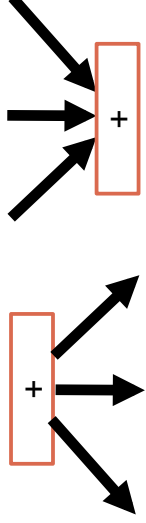
Web Service Languages Serve Different Abstraction Levels



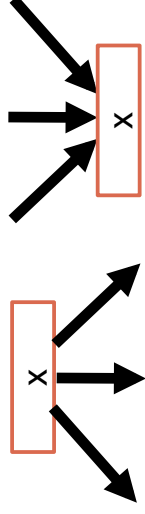
Typical Control-Flow Operators in Workflow Languages (Gateways)

Control-flow operators in Workflow languages are more complex than simple transitions in Petri Nets, which support only AND-split and -join

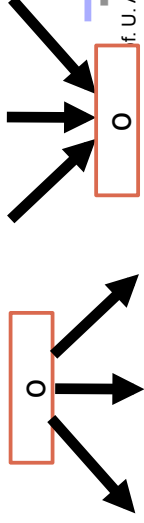
- ▶ AND-split: all
- ▶ AND-join: all of n



- ▶ XOR-split: 1 of n
- ▶ XOR-join: 1 of n



- ▶ OR-split: m of n
- ▶ OR-join: m of n

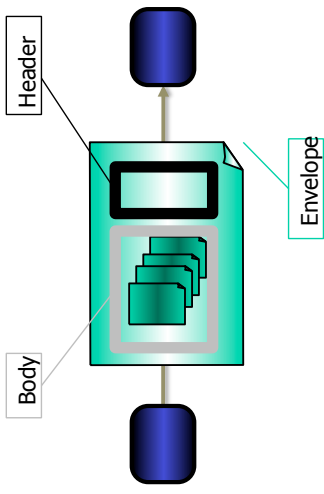


What are Workflow Engines?

- ▶ Workflow engines are interpreters of workflows
 - They maintain the parallelism in a workflow and synchronize all processes
- ▶ Usually, they also support for interactive applications
 - Undo
 - Transactions with rollback and commit
 - Compensation (in case of error)
- ▶ They are, for web services and component systems, *composition engines* that execute a composition program, the workflow

15.3 SOAP, An XML-based Interaction Protocol

- ▶ Simple Object Access Protocol (SOAP) defines the message format
- ▶ Message contains target address and an envelope
 - with name space, encoding attributes and
 - Header (fixed format) contains
 - Authentication (Sender, Receiver),
 - Transactions,
 - Error handling information,
 - Routing information ...
 - Body contains user data (free format)
- ▶ Transport is transparent, predefined channels:
 - HTTP (with back channel, de facto standard)
 - SMTP, TCP (with back channel)

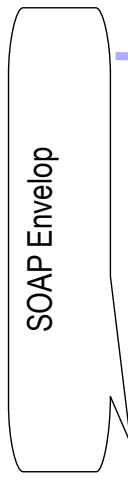


Example: SOAP Header

Message Header
HTTP

```
POST /TreatmentAdmin HTTP/1.1
HOST: www.hospital-admin.com
Content-Type: text/xml
Charset="utf-8"
Content-Length: nnnn
SOAPAction: http://localhost/TreatmentAdmin
```

```
<SOAP-ENV:Envelope
  xmlns:SOAP-ENV=http://schemas.xmlsoap.org/soap/envelope/
  SOAP-ENV:Encoding="http://.../encoding">
  <SOAP-ENV:Header>
    <a:Authentication
      xmlns:a=http://localhost/TreatmentAdmin ... >
      ...
    </a:Authentication>
  </SOAP-ENV:Header>
  <SOAP-ENV:Body> ... </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```



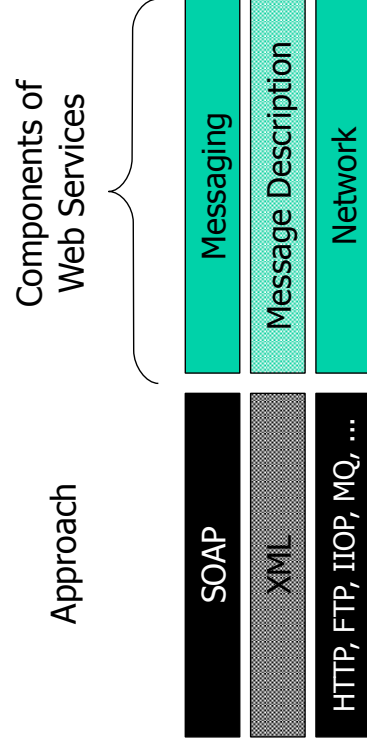
Example: SOAP Body

```
<SOAP-ENV:Body>  
<m:AddTreatment xmlns:a=http://localhost/TreatmentAdmin>  
<treatment>  
  <patient insurer="1577500" nr="0503760072" />  
  <doctor city = "HD" nr="4321" />  
<service>  
  <mkey>1234-A</mkey>  
  <date>2001-01-30</date>  
  <diagnosis>No complications.  
</diagnosis>  
</service>  
</treatment>  
</SOAP-ENV:Body>
```



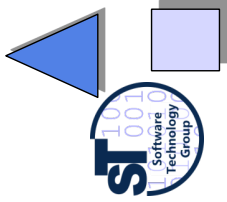
SOAP Interaction Protocol

- + W3C Recommendation (standard)
- + Implements RPC
- Untyped user data, types to encode in the message
- Interpretation of SOAP messages required
- High overhead / low performance



15.4 WSDL and The Interface

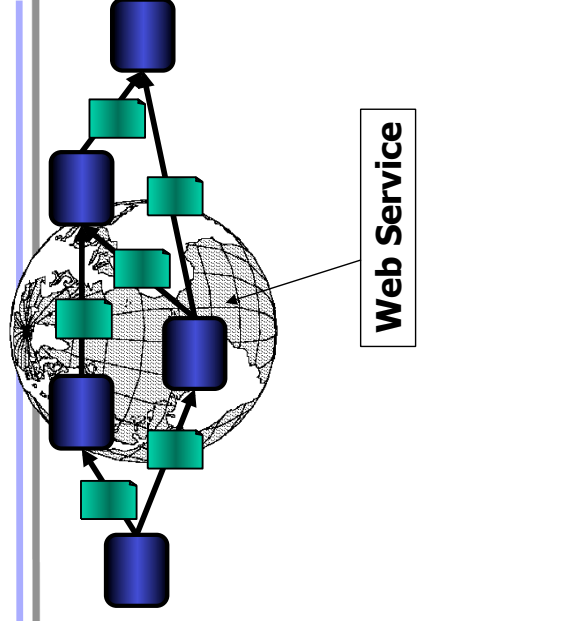
Concept of Web Services



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Service Interface



Web Services Description Language (WSDL)
defines a service interface



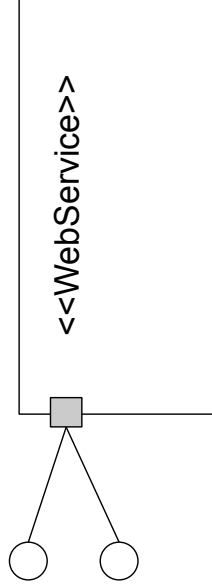
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WSDL Components and Their Interfaces

- ▶ A WSDL Interface consists of a set of ports
 - Functions with types of parameter and results in XML Schema
 - Event ports
 - Plays a similar role as ports of a UML component
- ▶ Advantages
 - WSDL abstracts from underlying protocol (http, SOAP, mime, IIOP)
 - Component model can be mapped to CORBA, EJB, DCOM, .NET
 - WSDL unifies call and event ports
 - WSDL abstracts from the underlying component model, introducing the component model as a *secret*



WSDL Specification Structure

- ▶ Types
 - In XML schema or another typing language
- ▶ Messages
 - The data that is communicated
- ▶ Operation
 - An interface of the service, with input and output, fault parameters
- ▶ Port type
 - A named set of operations (as in UML)
- ▶ Binding
 - A mapping of the port to underlying component models, e.g., http, soap, or mime
- ▶ Service
 - A set of related ports





WSDL Reuses Data Types of XSD Here: Type Definitions <schema> <element> <complexType>

```
<wsdl:types>
  <XMLSchema:schema ... [target name space definitions]>
    <XMLSchema:element name="addTreatment">
      <XMLSchema:complexType>
        <XMLSchema:sequence>
          <s:element minOccurs="1" maxOccurs="1" name="parameter"
            nullable="true" type="a:treatment"/>
        </XMLSchema:sequence>
      </XMLSchema:complexType>
    </XMLSchema:element>
    <XMLSchema:element name="addTreatmentResponse">
      <XMLSchema:sequence>
        <s:element minOccurs="1" maxOccurs="1" name="result"
          nullable="true" type="XMLSchema:boolean"/>
      </XMLSchema:sequence>
    </XMLSchema:complexType>
  </XMLSchema:schema>
</wsdl:types>
```



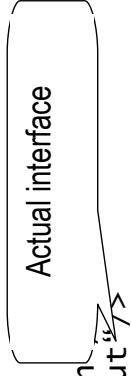
Port Types

- ▶ Event or message based:
 - Notification: data-out port
 - One-way: data-in port
- ▶ Call-based
 - Request-Response: procedure port
 - Solicit-Response: send, then receive (caller port)



Example: WSDL Ports, Typed by Message Types

```
<wsdl:definitions [name space definitions]>
  <wsdl:types> ... </wsdl:types>
  <wsdl:message name="addTreatmentSOAPIn">
    <part name="parameters" element="addTreatment"/>
  </wsdl:message>
  <wsdl:message name="addTreatmentSOAPOut">
    <part name="parameters" element="addTreatmentResponse"/>
  </wsdl:message>
  <wsdl:porttype name="TreatmentAdminSOAP">
    <wsdl:operation name="addTreatment">
      <wsdl:input message="addTreatmentSOAPIn">
        <wsdl:output message="addTreatmentSOAPOut">
          </wsdl:operation>
        </wsdl:porttype>
      </wsdl:operation>
    </wsdl:porttype>
  </wsdl:porttype>
  <binding [binding to SOAP / HTTP Protocols] ...
</wsdl:definitions>
```

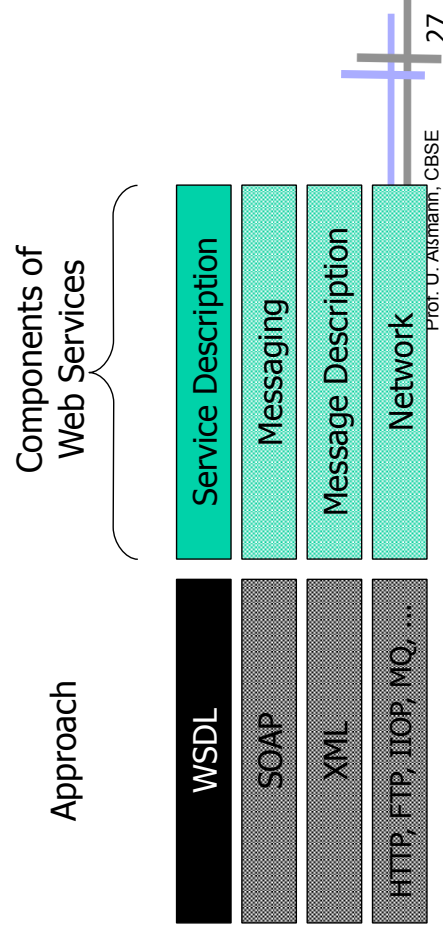


Example: Binding WSDL to SOAP

```
<wsdl:binding name="livetoken" type="Token">
  <soap:binding style="document"
    transport="http://schemas.xmlsoap.org/html">
    <operation name="getLastPrice">
      <soap:operation
        soapAction="http://www.stocktrade.com/GetPrice">
        <input> <soap:body use="literal"> </input>
        <output> <soap:body use="literal"> </output>
      </operation>
    </wsdl:binding>
```

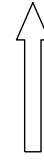
WSDL Service Interface

- ▶ WSDL is a Interface Definition Language (IDL)
 - Part of BPEL (see later)
 - No inheritance on WSDL
 - No standard mapping to data in programming languages
 - No web service as parameters/results
- ▶ W3C Recommendation (standard)

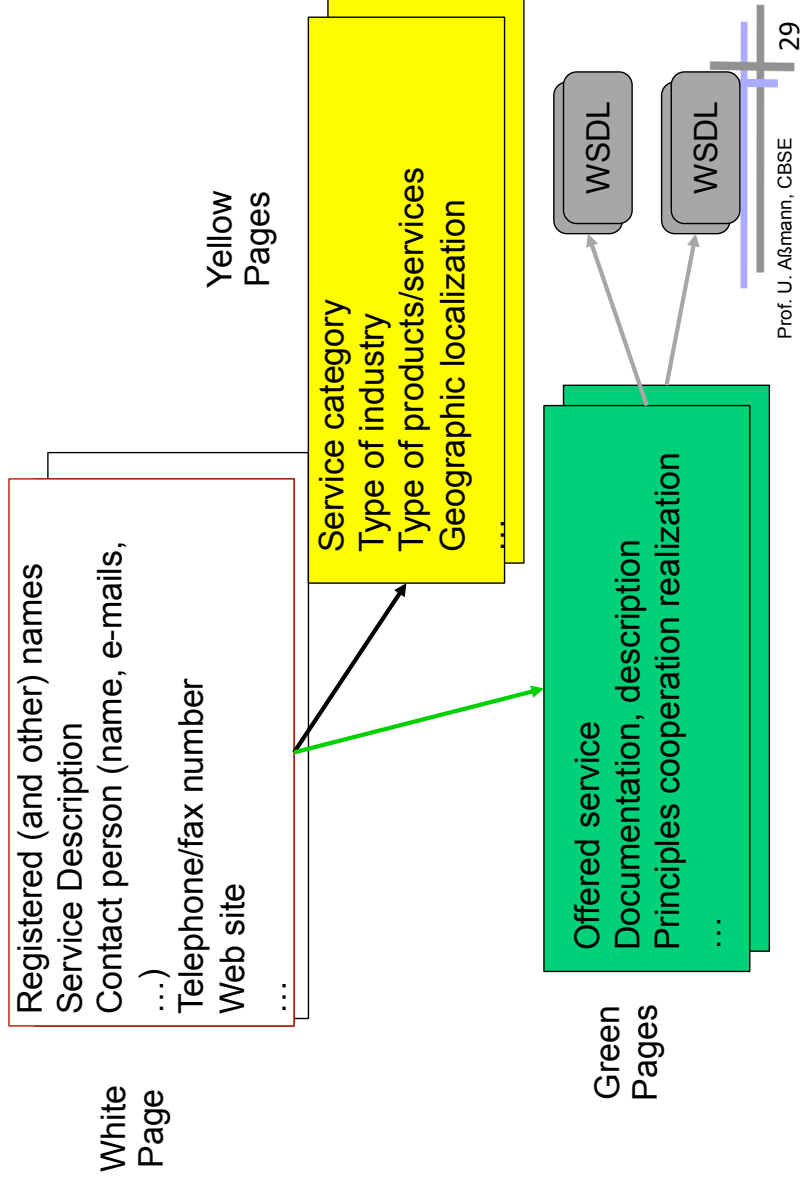


Trading on the Web: Offer and Find Services

- ▶ Standardized publishing, advertisement ...
- ▶ Extended name server, describing interface and properties
- ▶ XML Descriptor
 - White Page: Address
 - Yellow Page: Semantics (based on standard taxonomy)
 - Green Page: Technical specification of service
- ▶ Logically central, physically distributed data base



Universal Description, Discovery and Integration
(UDDI) defines service properties for service
trading



White Page

Yellow Pages

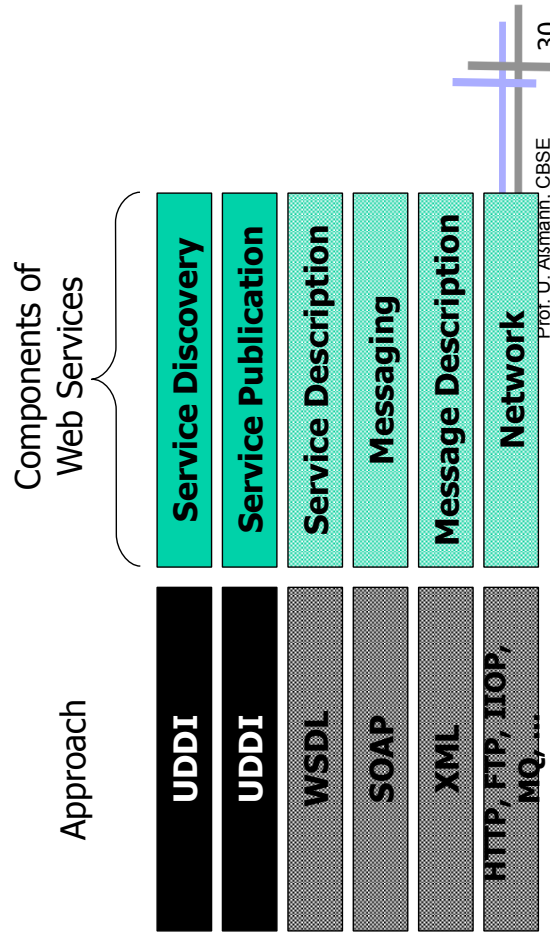
Green Pages



UDDI: Offer and Find Services



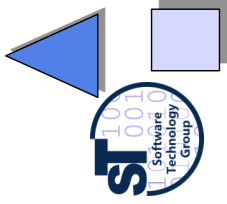
- Required and approached
- **No** search strategies
- **No** no trader or market place



15.5 Business Process Execution and Web Service Workflows with BPEL



BPEL, a web service composition language



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What is a Business Process?



“A collection of related, structured activities--a chain of events--that produce a specific service or product for a particular customer or customers.”

www.gao.gov/policy/itguide/glossary.htm

“A business process is a recipe for achieving a commercial result. Each business process has inputs, method and outputs. The inputs are a prerequisite that must be in place before the method can be put into practice. When the method is applied to the inputs then certain outputs will be created.”

en.wikipedia.org/wiki/Business_process

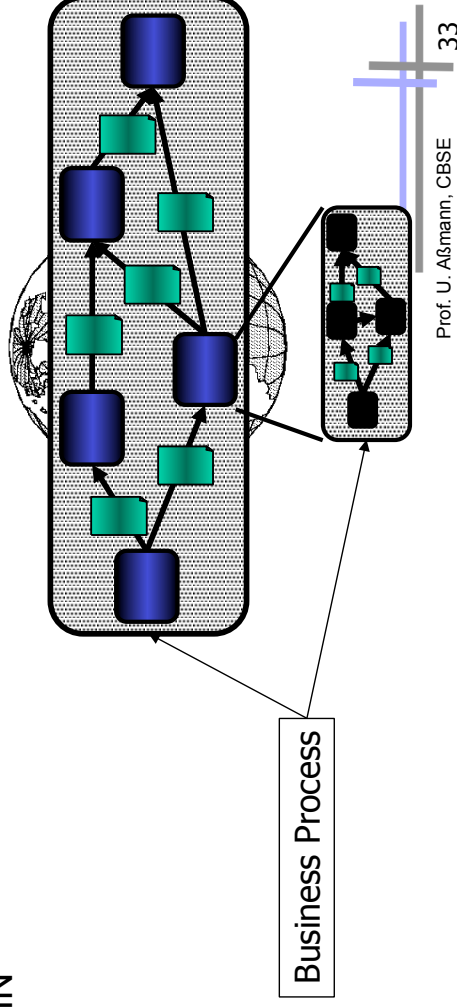
A business process is described on the modeling level, can be abstract, underspecified and need not be executable

A business process can be refined iteratively to become executable.

An executable business process is called a *workflow (executable business process)*.

Business Process Definition

- ▶ How to define a business process on the web
- ▶ There are many languages proposed today:
 - WSFL, WSCL, WSCI, XLANG, WSEL, UML, WSUI, WSXL, BPML, BPMN ...
- ▶ **IBM & Microsoft:** BPEL, BPEL4WS
- ▶ **OASIS:** WS BPEL
- ▶ **W3C:** OWL-S, SML (Service Modeling Language)
- ▶ **SAP:** BPMN



Ingredients of BPEL

- ▶ BPEL is an *executable language for workflows*, executable business processes
 - ▶ An architectural language for web services
 - Based on workflow languages
 - Mixing control and data flow operators
- ▶ BPEL is a *composition language*
 - Composing web services, using their ports
 - Relying on messages (events) and calls
- ▶ BPEL uses WSDL for service interface descriptions, as IDL
- ▶ BPEL adds connections (*partner link types*)



BPEL Made Simple

- ▶ BPEL is a activity-diagram like language,
 - with parallelism and transactions
 - with different kind of join and split operators
 - with ports and connections
 - BPEL can be edited graphically, and has an XML abstract syntax
- ▶ To create a web service, becomes a similar activity as editing an UML activity diagram or Petri Net
- ▶ BPEL uses WSDL definitions to define types, message types, and port types
 - WSDL definitions can be without binding
 - Bindings can be added when the BPEL process is deployed
 - That increases reuse of the process
 - This achieves *component model transparency* (independence of the underlying component model)
 - ▶ *Partner link types* (connector types) describing typed connections



BPEL Specification Structure

- ▶ **Process definition:** Header with namespace declarations
- ▶ **Variables:** global variables of the process
- ▶ **PartnerLink declarations:** interface declaration
 - with whom is the process connected?
- ▶ **Partners:** actual partners of the communication
- ▶ **Correlation sets:** Which instance of a process is talking to which other instance?
- ▶ **Fault handler:** What happens in the case of an exception?
- ▶ **Compensation handler:** compensation actions
- ▶ **Event handler:** what happens in case of a certain event?
- ▶ A (structured) **main operation**
 - e.g., sequence or flow



A Simple Pizza Order

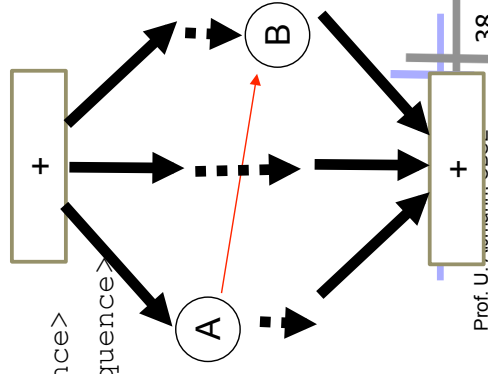
```
<!-- Process definition -->
<process name="OrderPizza" suppressJoinFailure="yes"
xmlns="http://schema.xmlsoap.org/ws/2003/03/business-process"
pns="http://www.pizza.org/schema">
<partnerLinks>
<partnerLink name="PizzaService" partnerLinkType="pns:OrderChannel"
myRole="PizzaOrderer">
</partnerLinks>
<!-- Global Variables -->
<variables>
<variable name="input" messageType="PizzaOrder"/>
<variable name="output" messageType="PizzaDelivery"/>
</variables>
<faultHandlers> ... </faultHandlers>
<sequence name="body">
<invoke name="order" partnerLink="PizzaService" portType="PizzaOrder"
operation="body" variable="output">
<receive name="acknowledgement" partnerLink="PizzaService" portType="Pizza"
operation="body" variable="input">
</sequence>
</process>
```

Connector

Flow Operations are Workflow Graphs

- ▶ The <flow> operation is structured as a workflow graphs
 - The names of messages, ports, partner links help to span up the graph
 - <flow> executes its sequences in parallel
 - <links> can synchronize parallel tasks

```
<flow>
<links><link name="A"></link>
<link>name="B"></link>
</links>
<sequence>..<invoke> <target name="A">..</sequence>
<sequence>...<target name = "B">.....</sequence>
</flow>
```





Other Operations in BPEL

▶ Structured control-flow operators

- sequence
- switch
- while
- flow
- pick (XOR join)
- terminate

▶ Compensate

- ▶ Error compensation

▶ scope

▶ assign



BPEL Tools

▶ <http://en.wikipedia.org/wiki/BPEL>

▶ Eclipse BPEL project

- ▶ <http://www.eclipse.org/bpel/>

▶ Orchestra tool

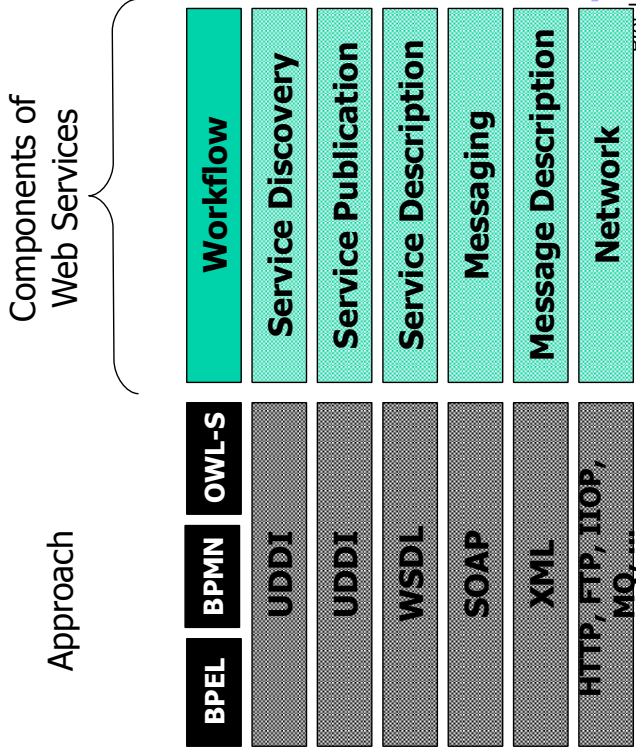
- ▶ <http://orchestra.ow2.org/xwiki/bin/view/Main/WebHome>

▶ People work on the translation of Colored Petri Nets and UML activity diagrams from and to BPEL

- CPN have good formal features (see ST-2)
- Can be used for deadlock checking, resource control, etc.
- YAWL is such a nice language, see the work of [van der Aalst]



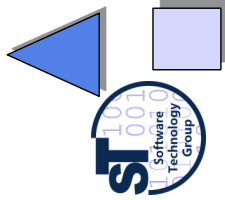
Business Process



15.6 Business Process Modeling Notation (BPMN)



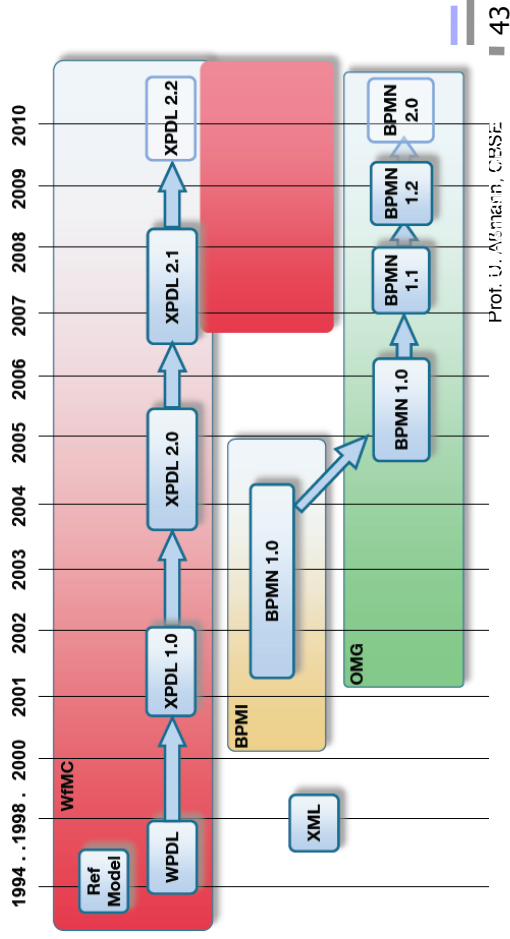
Another composition language





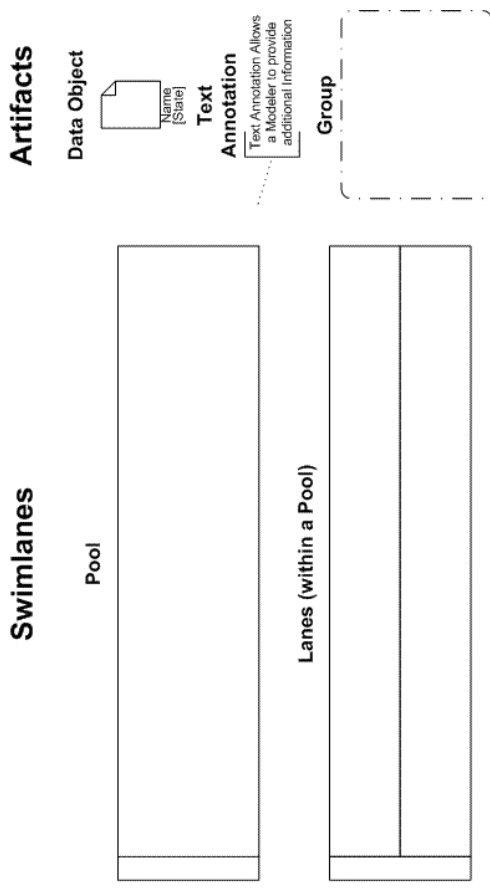
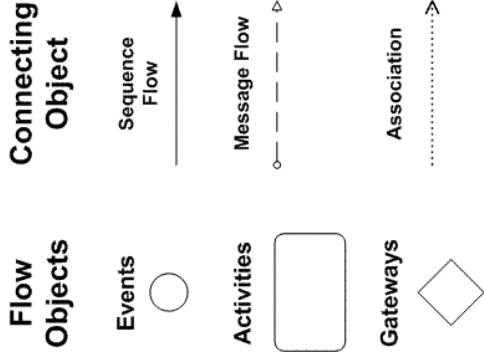
History

- The Business Process Modelling Notation (BPMN)
- Graphical notation for conceptual business processes
- Covers control, data, authorization, exception
- Standardized by OMG



Core Elements

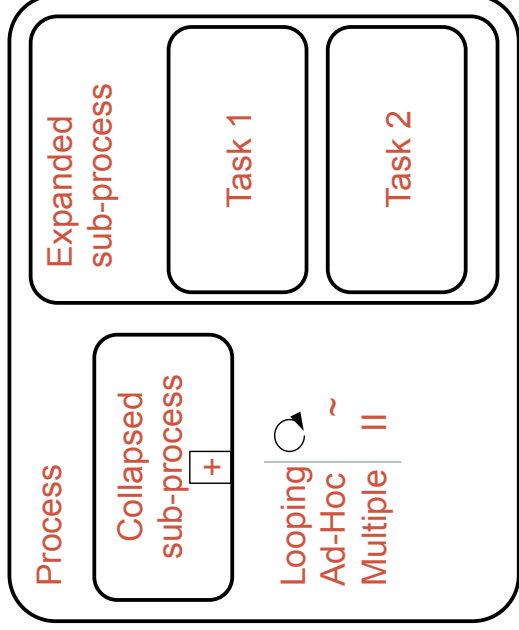
Core Set of BPMN Elements





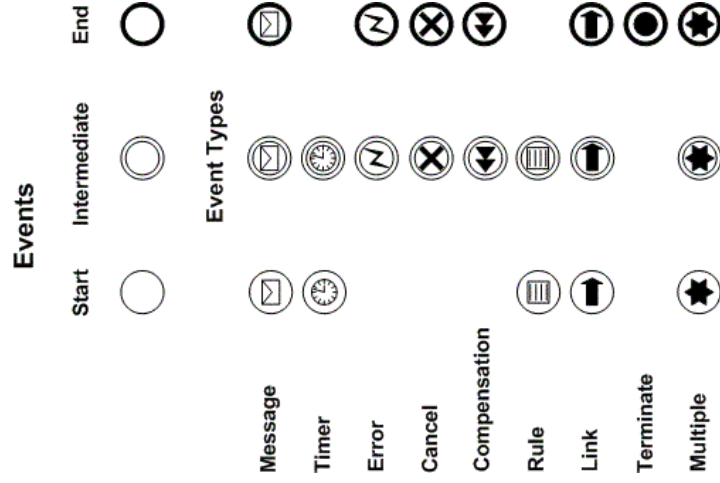
Activities and Processes

An **activity** is a generic type of work that a company performs. An activity can be atomic (task) or compound (process, sub-process).



Events and Activities

Events affect the flow of the process and usually have a cause (trigger) or an impact (result): 'Email received', 'Warehouse empty'





Gateways and Connections

A gateway is used to split or merge multiple process flows. It will determine branching, forking, merging and joining of paths.

Gateway control types

XOR (DATA)		Data based exclusive decision or merging. Both symbols have equal meaning. See also Conditional flow.
XOR (EVENT)		Event based exclusive decision only.
OR		Data based inclusive decision or merging.
COM- PLEX		Complex condition (a combination of basic conditions)
AND		Parallel forking and joining (synchronization).

Graphical connectors

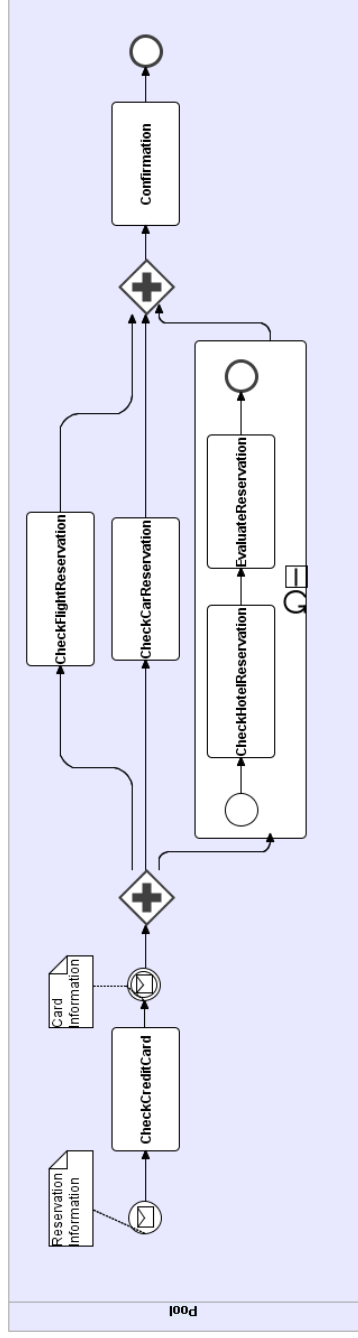
Normal sequence flow	
Conditional sequence flow	
Default sequence flow	
Message flow	
Association	



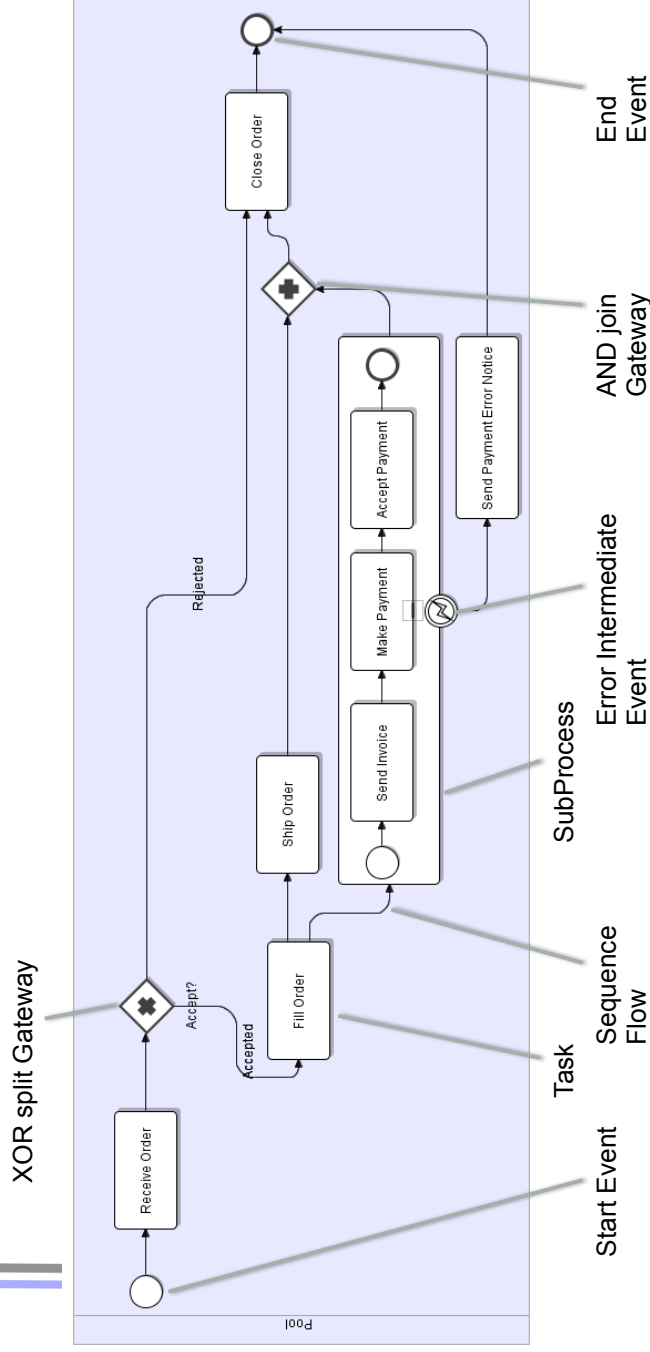
Example: Travel Process Control Flow



More refinement leads to business process specifications (with control and data flow)



Example



Why BPMN?

BPMN v1.x

Modeling language, no execution semantics

BPMN includes a partial mapping to Business Process Execution Language (BPEL)

Changes in the BPMN model do not update in the BPEL code

BPMN v2.x

Execution semantics

Explicit service mapping

First engines are available (jBPM for jBoss)

BPMN geared towards business analysts:

BPMN constructs are simplified

UML notation too bloated

BPMN is on the platform-independent level, BPEL nearer the platform-specific level

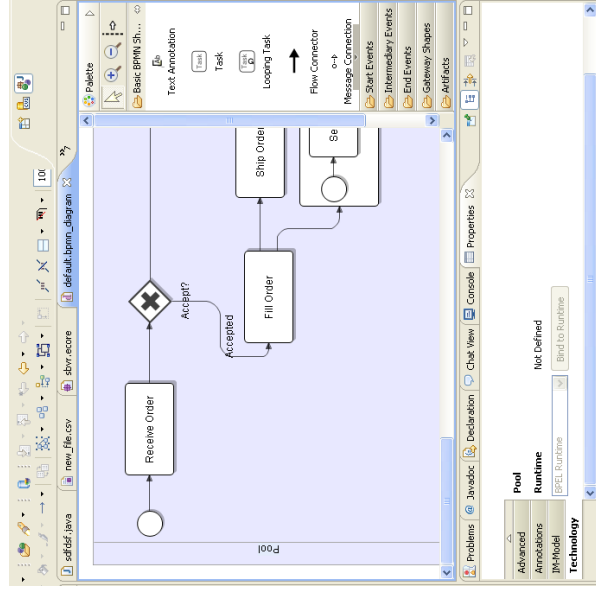
Give BPMN a try

Free BPMN Editor
from Eclipse
Included in the SOA
Tools Project

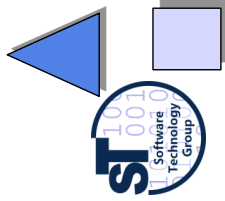
<http://www.eclipse.org/bpmn/>

<http://www.eclipse.org/bpmn2-modeler/>

SAP has decided to use BPMN
in their products



15.7 Trust and Security



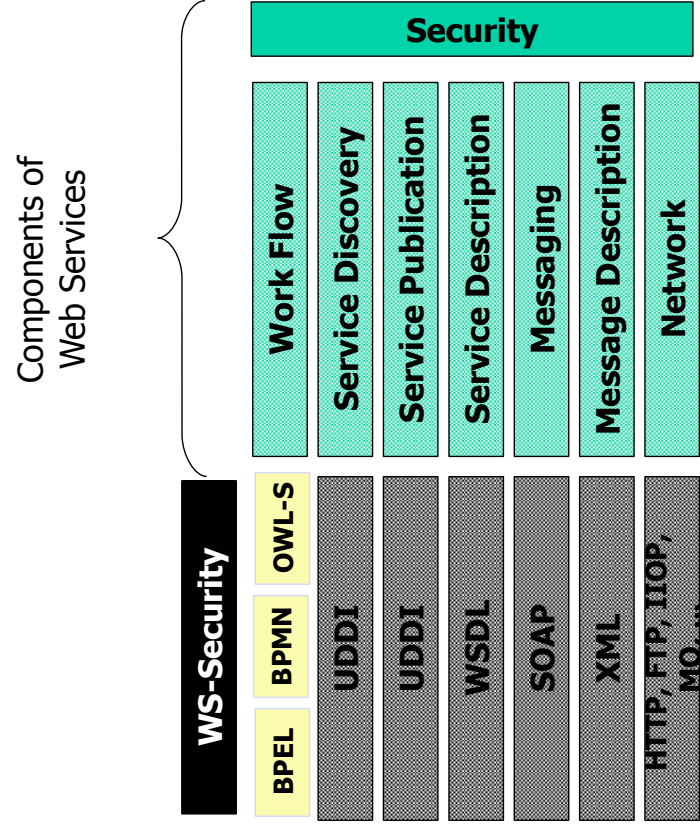


Trust and Security

- ▶ Policies: when do I allow somebody to do something
- ▶ Integrity: intact, unchanged
- ▶ Confidentiality: cryptification policy
- ▶ Authentication: proof of identity
- ▶ Authorization: access to execute certain services
- ▶ Non-Repudiation: warranty on failiior
- ▶ Legal Rights: copy rights, reselling rights, ...
- ▶ Privacy: handling personal data
- ▶ ...



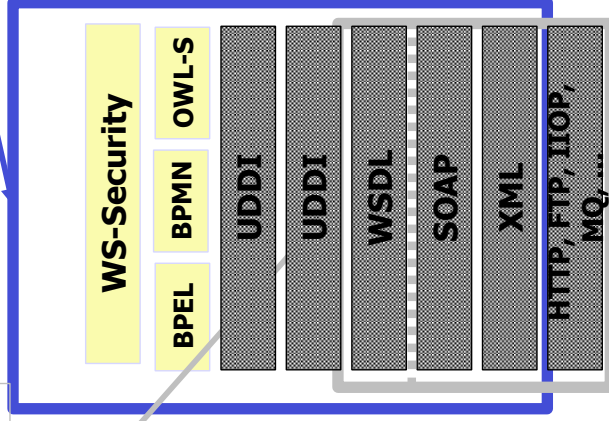
Trust and Security



Technical Conclusion

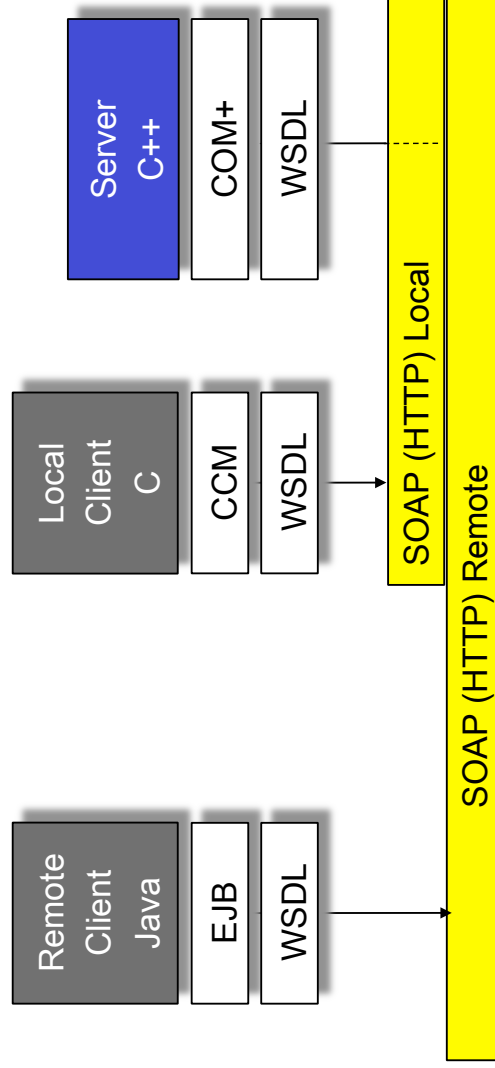
Defined with XML

Web Services minimum



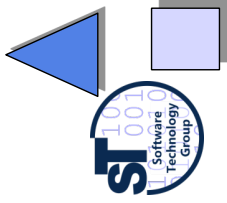
Web Services – Component Model Transparency

- ▶ Language adaptation: XML Schema + WSDL
- ▶ Remote transparency: SOAP (+ HTTP)
- ▶ Component model transparency (EJB, COM+, CORBA, CCM, Beans, etc...)



15.7 Evaluation of Web Services

as composition system



CBSE, © Prof. Uwe Alsmann

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Component Model

- ▶ Mechanisms for secrets and transparency: very good
 - Location, language, component model transparency
 - Communication protocol transparency
 - Interface specification is flexible with WSDL
- ▶ Different black-box component models can be hidden under WSDL specifications
- ▶ Generic BPEL Web Services are possible (without bound WSDL ports)
- ▶ BPMN Web Services can be stepwise refined from abstract to concrete



Composition Technique

- ▶ Mechanisms for connection
 - Protocol transparency allows for flexible connections
 - WSDL binding is flexible
- ▶ Mechanisms for aspect separation
 - Separate modeling from execution (abstract business processes from workflows)
- ▶ Scalability: Better
 - Changes of protocol possible
 - Changes of distribution easy
 - Changes of workflow easy

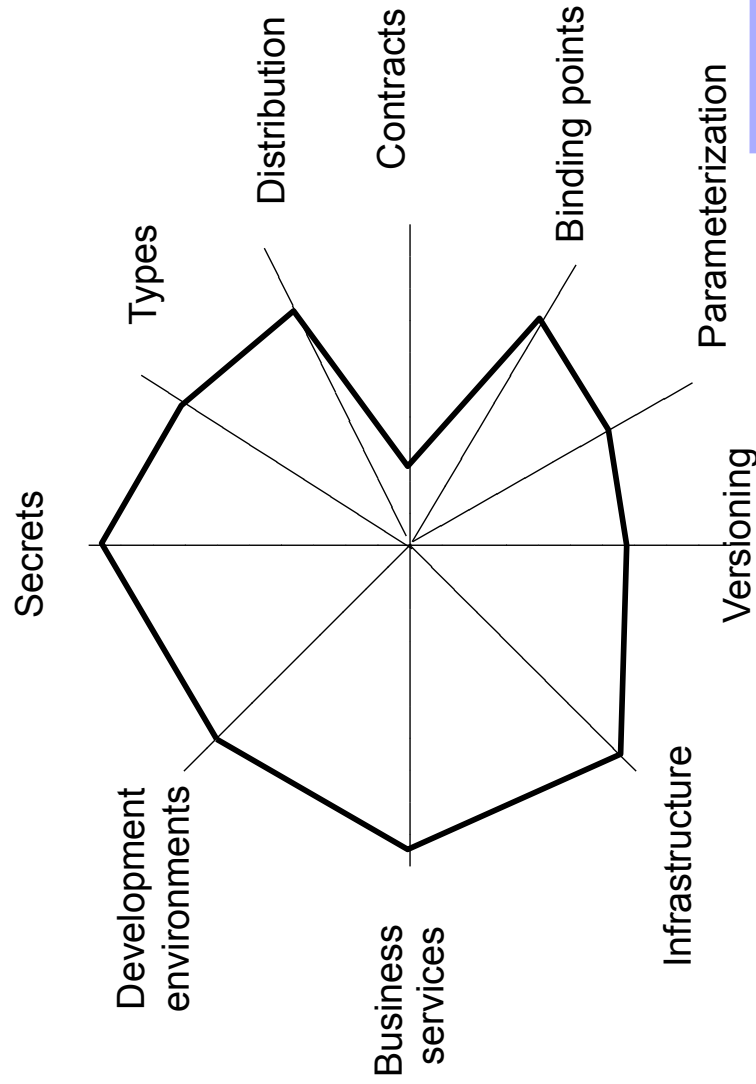


Composition Language

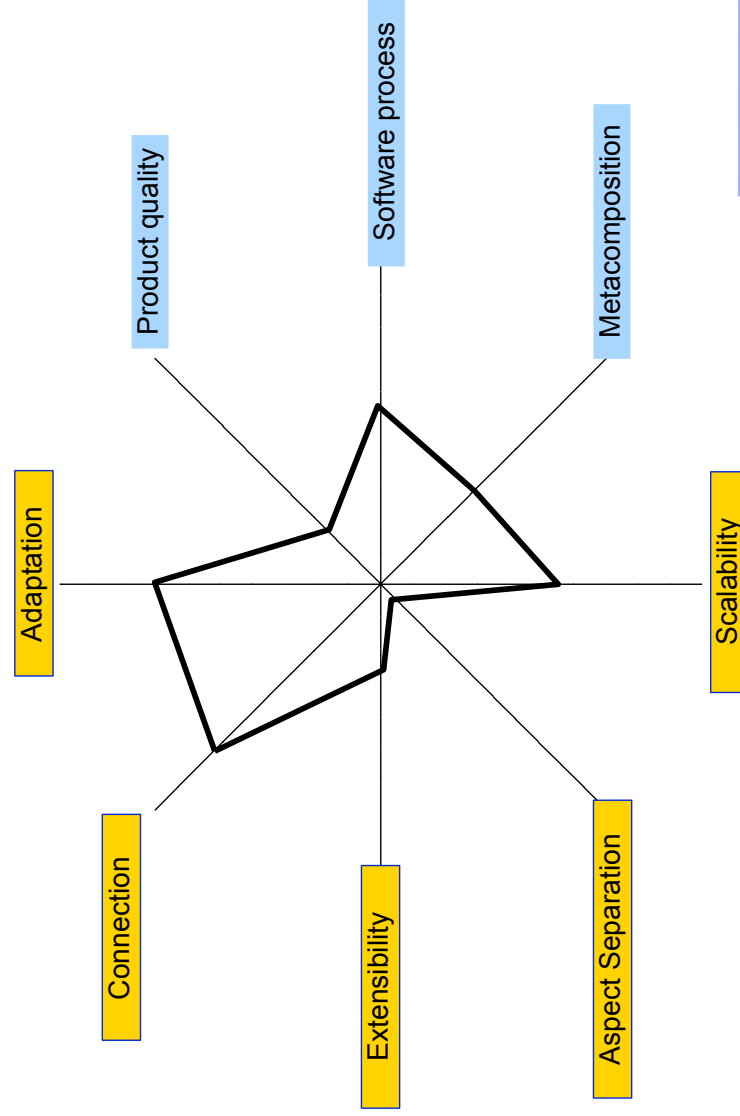
- ▶ BPEL, BPMN are flexible composition languages
 - Not yet full exchangeability of connector types
 - But graphic support for workflow specifications
 - Control- and data-flow operators (gateways)
 - Parallel execution semantics
 - Abstract (business processes) and executable level (workflows)
- ▶ Metacomposition fully supported
 - The generation of a BPEL or BPMN script is easy, because it is XML based
 - Environments generate workflow from other specifications
 - Generic workflow architectures will be possible



Web Services - Component Model



Web Services – Composition Technique and Language



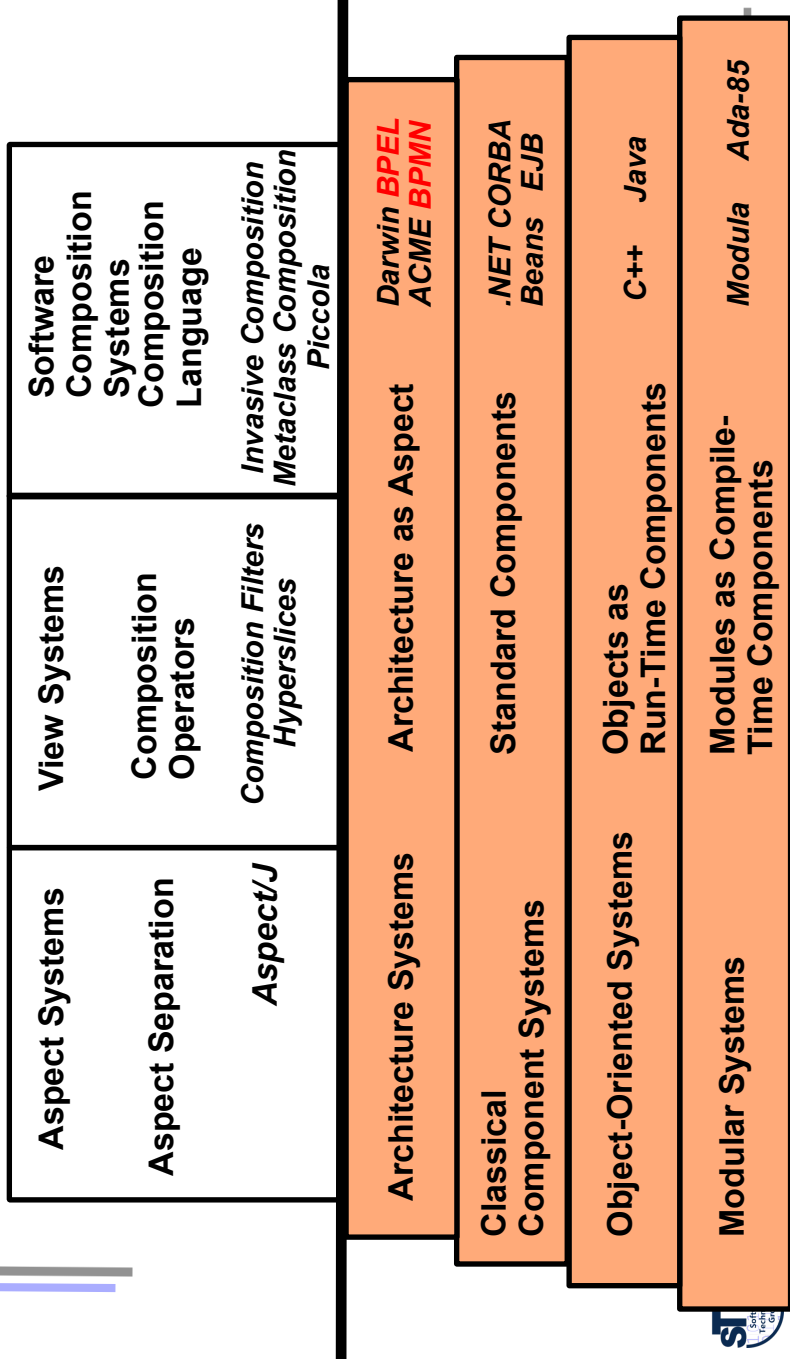
Web Services as Composition Systems



So Far: *Blackbox* Composition

- ▶ Standard middleware
 - CORBA, DCOM
- ▶ Implicit middleware
 - EJB
- ▶ Architecture systems
 - Web services

The Ladder of Component and Composition Systems



The Second Part of the Course: Greybox Composition

- Generic programming Invasive software
- Generic program elements composition
- Home-made connectors Slots and hooks
- View-based programming Novel Forms of
- Formal foundations (lambda Composition
- N, pi-calculus) Uniform composition
- Record calculi, Scala Active document composition:
- Hyperspace programming Architectural styles for
- Aspect-oriented active documents and web
- development systems
- Aspect-oriented programming Roundtrip engineering and
- Aspect-oriented design composition



Some Abbreviations

- ▶ ebXML: Electronic Business XML
- ▶ UDDI: Universal Description, Discovery and Integration
- ▶ OAG: Open Applications Group
- ▶ OASIS: Organization for the Advancement of Structured Information Standards
- ▶ SOAP: Simple Object Access Protocol
- ▶ HTTP: Hypertext Transfer Protocol
- ▶ tpaML: Trading Partner Agreement Markup Language
- ▶ UML: Unified Modeling Language
- ▶ UN/CEFACT: United Nations Centre for the Facilitation of Procedures and Practices in Administration, Commerce and Transport
- ▶ WSFL: Web Services Flow Language
- ▶ WSDL: Web Services Description Language
- ▶ WSIL: Web Services Inspection Language
- ▶ WSXL: Web Services Experience Language
- ▶ WSCL: Web Services Conversation Language
- ▶ WSUI: Web Services User Interface
- ▶ WSML: Web Services Meta Language
- ▶ WSCM: (Web Services Component Model) Numer omdöpt till WSIA
- ▶ WSIA: Web Services for Interactive Applications
- ▶ WSEL: Web Services Endpoint Language
- ▶ WSRP: Web Services for Remote Portals



Some URLs

- ▶ www.ebxml.org
- ▶ www.uddi.org
- ▶ www.oasis-open.org
- ▶ www.uncefact.org
- ▶ www.w3.org
- ▶ www.omg.org
- ▶ www.biztalk.org
- ▶ www.soapclient.com
- ▶ www.soapware.org
- ▶ www.xml.com
- ▶ www.xml.org
- ▶ www.webservices.org
- ▶ www.webservicesarchitect.com
- ▶ www.ws-i.org





The End

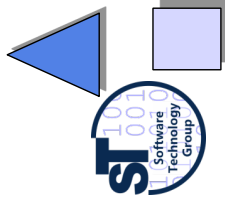
- ▶ Many slides inherited from
- ▶ Stig Berild's talk on the Nordic Conference on Web Services, Nov. 2002
- ▶ Prof. Welf Löwe, Web Service Competence Center (WSCC), Växjö Linnaeus University



15.9 OWL-S (Web Ontology Language for Services)

Additional material

- ▶ OWL-S definition at
<http://www.w3.org/Submission/OWL-S/>
- ▶ <http://daml.semanticweb.org/services/owl-s/1.0>





OWL Web Ontology Language

- ▶ Classes and relationships
- ▶ Expressions to compute (derive) new classes and relationships (*derived model*)
 - Union, intersection of relations and classes
 - Cardinality restrictions
 - Existential quantifiers
- ▶ Roughly speaking, OWL corresponds to UML-class diagrams without methods + OCL + class expressions
- ▶ Instead of plain XML, OWL can be used to type data
 - Beyond trees and context-free structures, graphs, knowledge webs, semantic nets can be described (context-sensitive structures)



OWL-S

- ▶ Based on OWL, a language for specification of web services has been developed by the OWL-S coalition
- ▶ Specification has three parts:
 - *Service profile*: semantic service description, service offer, service functionality (*what does the service provide?*)
 - Based on domain ontologies in OWL, i.e., OWL-specified attributes
 - *Service model*: service realization, decomposition of a service (*how does the service work?*)
 - Service is also called a *process*
 - Here, OWL-S provides a process ontology
 - *Service grounding*: service mapping to underlying mechanisms (*how is the service mapped to a component model and transport protocol?*) Similar to WSDL grounding





OWL-S Processes

▶ Atomic

- Cannot be decomposed
- Can be called and executed
- Can be mapped to WSDL process descriptions (*grounding*), and hence, to SOAP

▶ Simple

- Cannot be decomposed
- Can be executed, but not be called from outside

▶ Composite

- Build from atomic and simple processes



Service Model (Process Model) of OWL-S



▶ Process Ontology

- Describes a service (process) with an *I/OPE* specification
 - Inputs
 - Outputs
 - Parameters
 - Effects

▶ Process control ontology (for composite processes)

- Internal realization with state, activation, execution, completion (control-flow specification)





Creating an OWL-S specification

- ▶ Describe atomic processes
- ▶ Describe grounding of atomic processes
- ▶ Describe compositions
- ▶ Describe simple processes
- ▶ Describe profile of service



OWL-S Statements of a Composite Process

- ▶ Unordered (unspecified order)
- ▶ Sequence
- ▶ Split
- ▶ Split+Join (fork and join)
- ▶ Concurrent
- ▶ Choice
- ▶ If-then-else
- ▶ Repeat-until
- ▶ Repeat-while

