**Script** **generated by TTT**

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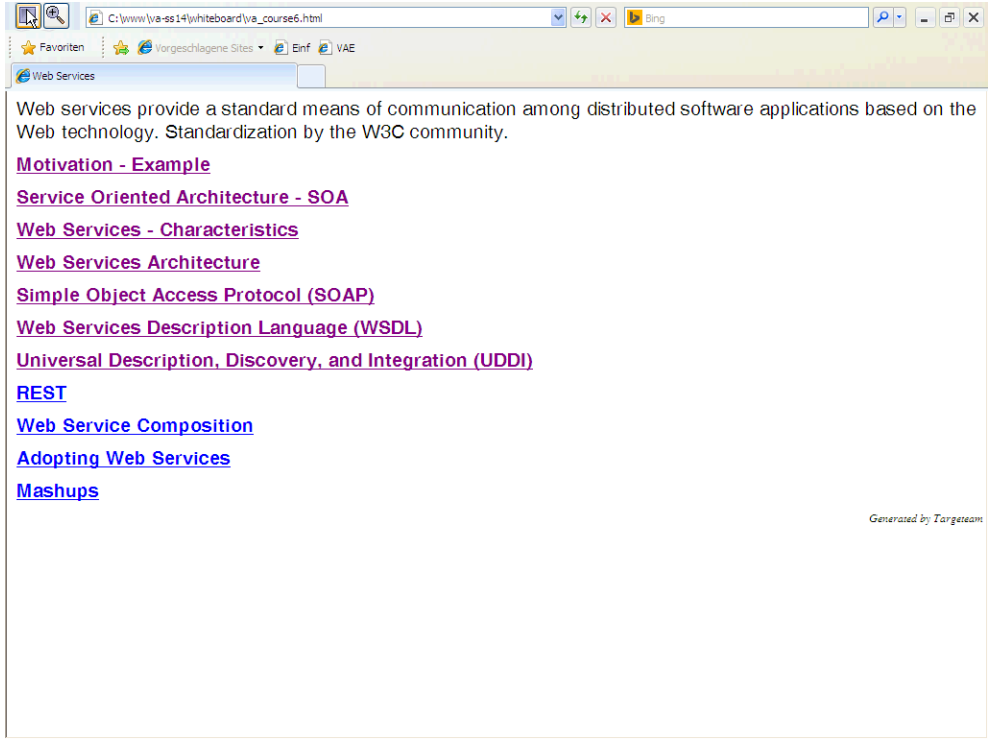



## REST

REST (Representational State Transfer) is an architectural style of distributed applications.

REST is not a standard; it is a set of principles how to use Web standards, such as HTTP, URIs and Mime Types.

The Web is a REST system.

REST is based on the following key principles

give every relevant resource an ID: use URIs to identify everything that is any item of interest.

URL: http://www.boeing.com/aircraft/747

A representation of the resource is returned (e.g., Boeing747.html). The representation places the client application in a state.

link resources together: navigating links results in state transfers of the client application.

use standard methods: such as get, post, put, delete.

communication is stateless.

resources with multiple representations: client may specify the formats which it accepts

GET /customers/1234 HTTP/1.1

Accept: text/x-vcard



## Web Services

Web services provide a standard means of communication among distributed software applications based on the Web technology. Standardization by the W3C community.

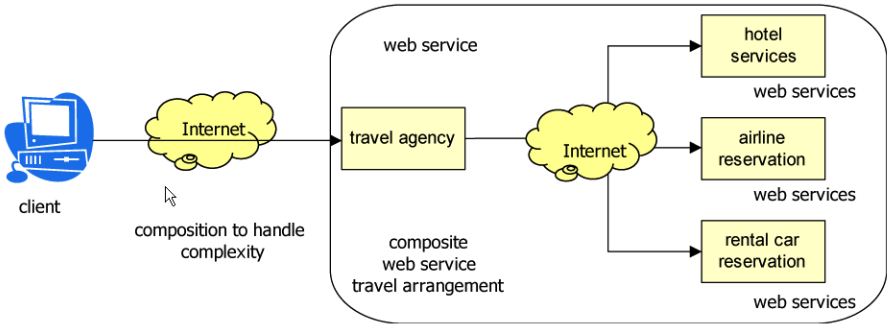
## Web Service Composition

an important issue is the choice of the appropriate granularity

small vs. large Web Services - thousands vs. a handful of Web Services

what are the appropriate reusable, shared business components

Composition of complex Web Services from smaller reusable Web Services




[Dimensions to handle complexity]

[Web Service Orchestration]



## Dimensions to handle complexity

component model: defines the sub-services.

orchestration model: defines the order in which the sub-services are invoked.

WS-Coordination is an extensible framework that describes how different Web Services work together reliably. Coordination framework contains

Activation, Registration and Coordination services

data access model: specifies the data exchange between the sub-services.

transactional model: transactional semantics of the composed service.

WS-Transaction specifies the protocols for each coordination type (used by WS-Coordination)

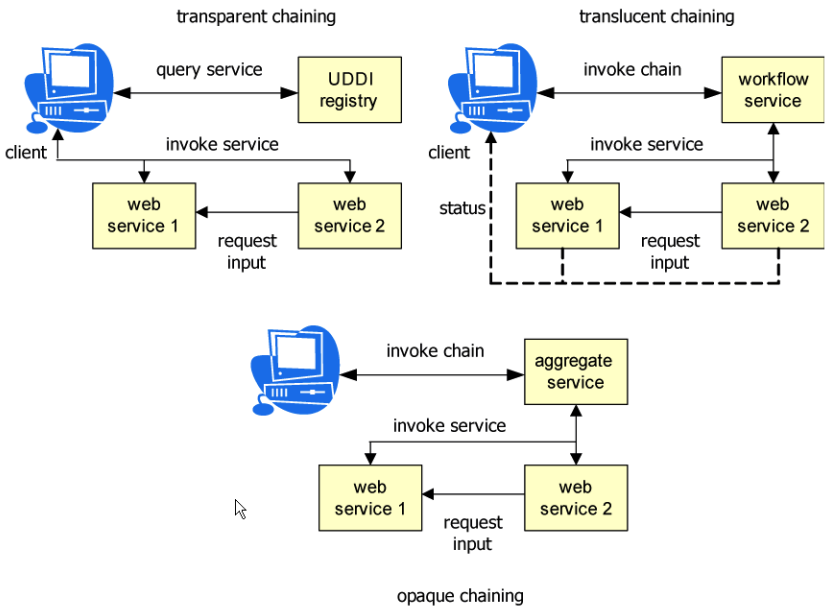
AtomicTransactions: all-or-nothing property, 2-phase-commit.

Business Activity: handle long-lived activities and to apply business logic to handle business exceptions; BusinessAgreement Protocol.

exception handling: handling of errors in the sub-services.



## Web Service Orchestration




transparent chaining

## Web Services

Web services provide a standard means of communication among distributed software applications based on the Web technology. Standardization by the W3C community.

[Motivation - Example]

[Service Oriented Architecture - SOA]

[Web Services - Characteristics]

[Web Services Architecture]

[Simple Object Access Protocol (SOAP)]

[Web Services Description Language (WSDL)]

[Universal Description, Discovery, and Integration (UDDI)]

[REST]

[Web Service Composition]

[Adopting Web Services]

[Mashups]

## Apache Axis

Apache Axis supports an environment to implement and provide Web services.

- set of client-side APIs for dynamically invoking SOAP Web services (with or without WSDL descriptions).
- tools to translate WSDL documents into Java frameworks.
- mechanisms for hosting Web services either within a servlet container (e.g. Tomcat) or via standalone server.
- a set of APIs for manipulating SOAP envelopes, bodies, and headers, and using them inside Message objects.
- data binding which enables mapping of Java classes into XML schemas and vice versa.
- a transport framework that allows usage of a variety of underlying transport mechanisms (e.g. JMS, email, etc).

**Axis2**

In the meantime there exists already Apache Axis2

- Java-based implementation of both the client and server sides of the Web services
- Axis2 is more flexible, efficient and configurable in comparison to Axis1.x
- Axis2 not only supports SOAP messages, but it also supports RESTful Web services.



## Web Services and Java

Java provides a number of APIs implementing the Web Services standards

SAAJ ( SOAP with Attachments API for Java)

- SOAP messages as Java objects

JAX-WS (Java API for XML based Web-Services)

- programming model for Web Services; replaces JAX-RPC

JJWSDL: Accessing WSDL descriptions

JAXR (Java API for XML Registries)

- Accessing Web Services Registries, e.g. UDDI

JAXP (Java API for XML Processing)

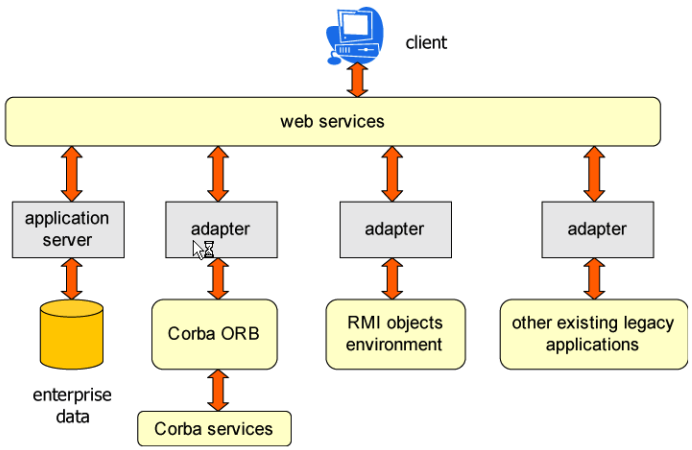
- Abstract XML-API-Specification implemented by e.g. Apache Xalan(XSLT), Apache Xerces2 (XML Parsing (DOM, SAX..)).

XWSS (Java Web-Services Security)

- Signatures, Encryption (roughly for SOAP what SSL is for HTTP)



## Distributed Process Architecture






## Semantic Web Services

In order to allow for ***automatic discovery of appropriate*** web services and of ***automatic interaction / chaining / incorporation*** with web services

- we need semantic meta-data for web services: Web-Service Ontologies, DataTypes with rich semantics....

Example: Map-Service

- Input: (int, int)
- Output: APPLICATION/GIF

Input: (int, int):

- (x,y) of center of map ?
- of corner of map ? which corner ?
- what coordinate system? Wgs84? Gauss-Krueger? ...

Output: APPLICATION/GIF:

- What kind of map? Topological? Political? POI? Traffic?
- Units of measure?

candidate technology: OWL-S (Ontology Web Language for Web Services)

- OWL-based Web service ontology, which supplies Web service providers with a core set of constructs for describing the properties and capabilities of their Web services in unambiguous, computer-interpretable form.

## Adopting Web Services

There exist already a variety of free of commercial Web services; provided especially by Internet companies, such as Google, Amazon or Yahoo.

**Example Web Services**

- Amazon E-Commerce Service (ECS)
  - XMethods : clearinghouse for Web Services
- Apache Axis
- Web Services and Java
- Distributed Process Architecture
- Semantic Web Services



## Mashups

**Definition: Mashup** simply indicates a way to create new Web applications by combining existing Web resources utilizing data and Web APIs.

**Mashup Techniques**

Work for the combination of data and services can be done on the server, the client or both of them.

1. Mashing on the Web Server
2. Mashing using Ajax
3. Mashing with JSON

**Development Support**

Yahoo Pipes are hosted and executed on a Yahoo server.

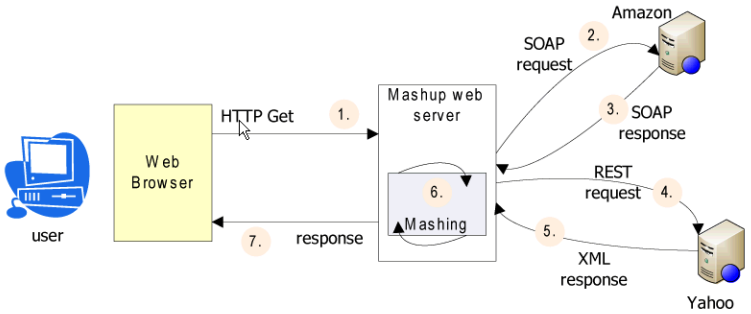
QedWiki was a Wiki-based mashup maker by IBM; pages are hosted on an IBM server; mostly executed on the client side.

ProgrammableWeb provides a mashup directory and marketplace which let users rank and discuss mashups.



## 1 Mashing on the Web Server

All the work of mashing is done on a Web server while the browser just waits for a response.



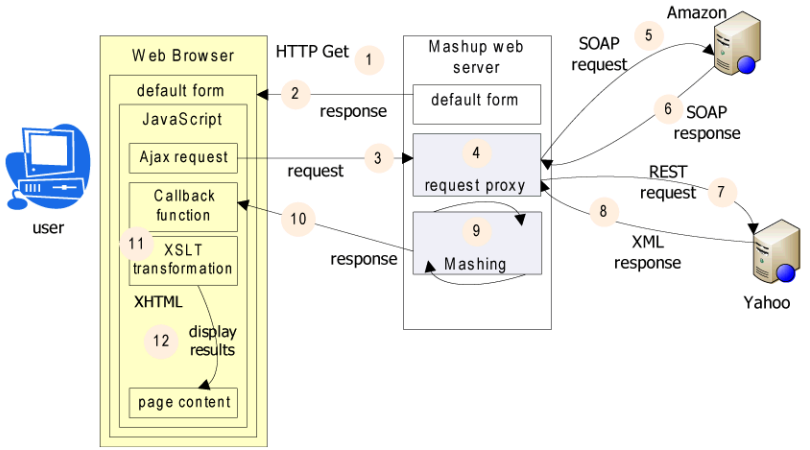

**Characteristics**

- Browser is decoupled from the partner sites supplying the data.
- Web server acts as a proxy and aggregator for the responses.
- Browser requests the entire page.
- Scalability problem because server does all the work.



## 2 Mashing using Ajax

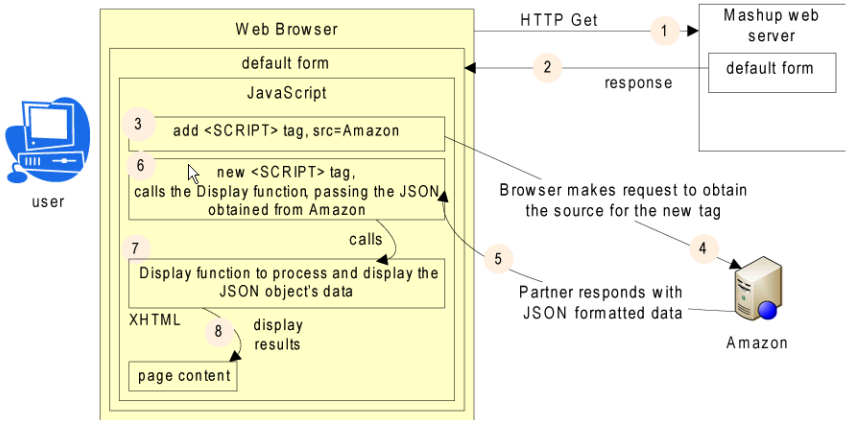
This approach allows a richer user experience; the work is divided between the server and the browser.




**Characteristics**

- more complex because developers face JavaScript challenges, server communication and asynchronicity.
- Ajax may refresh only a portion of the page.
- navigation mechanism of browser is bypassed.
- approach may result in a rich Internet application.

JSON (JavaScript Object Notation): lightweight data-interchange format that is gaining popularity in the mashup community.




**Characteristics**

- the browser communicates directly with the partner site.
- programmers must handle pre-made objects supplied in JSON.
- JSON objects are easier to read than XML.
- there is no data consolidation on the server.



in order to facilitate and speed up mashup development a number of tools and frameworks have recently emerged. Two dimensions may be distinguished

***component model*** : describes the characteristic properties of the mashup components

a well-defined component interface facilitates reusability of components

component properties:

type: a component can be data, application logic or user interface.

interface: create-read-update-delete (CRUD) interface, API for a specific programming language or IDL/WSDL.

extensibility: whether the user may extend the component model.

***composition model*** : specifies how the components are glued together to create the mashup application

flow-based: defines the orchestration as sequencing or partial order among components.

event-based: uses the publish-subscribe model.

Example for tool-assisted mashup development

Yahoo Pipes : mix data feeds to create data mashups using a visual editor.





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Software engineering of ***distributed applications*** raises interesting issues. In particular, the following problems must be considered:

1. Specification of a suitable software structure

   Applications must be decomposed into smaller, distributable components; encapsulation of data and functions.

   Which functionality is provided locally and which remotely?

   How should we test and debug distributed applications?

2. Mechanisms for name resolution

   How can an application localize and make use of a remotely provided service?

   Assignment of names to addresses.

   What should happen if a client cannot contact the localized server subsystem?

3. Communication mechanisms

   Selection of the desired communication model, e.g. client-server model, group communication or peer-to-peer.

   How does the application (both client and server) handle network communication errors?

4. Consistency

   How can the data be kept consistent, particularly for replicated data?



   Assignment of names to addresses.

   What should happen if a client cannot contact the localized server subsystem? alternative

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   How can the data be kept consistent, particularly for replicated data?

   If a cache is used for performance improvement, then it must be kept consistent with the stored data.

   User interface consistency for the individual components.

5. User requirements
   - Functionality and reconfigurability of the distributed application and its components.
   - Service quality, such as security, reliability, fault tolerance and performance.
   - What kind of security mechanisms are provided? Is authentication an issue?
   - Which actions will be triggered if a client cannot communicate with its server?
   - What type of heterogeneity is necessary?
   - What efficiency (performance) is expected?



   What should happen if a client cannot contact the localized server subsystem? alternative

3. Communication mechanisms

   Selection of the desired communication model, e.g. client-server model, group communication or peer-to-peer.

   How does the application (both client and server) handle network communication errors?

4. Consistency

   How can the data be kept consistent, particularly for replicated data? voting approaches

   If a cache is used for performance improvement, then it must be kept consistent with the stored data. client/server maintained cache

   User interface consistency for the individual components. multi-user editing

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   - Which actions will be triggered if a client cannot communicate with its server?
   - What type of heterogeneity is necessary?
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## Open Distributed Processing (ODP)

introduced by ISO with the goal of defining a reference model for distributed applications

integrating a wide range of standards for distributed systems, e.g. ISO/OSI reference model

Reduction of complexity by specifying different levels of abstractions of the distributed system ("viewpoints").

Enterprise viewpoint: deals with the overall goals that the distributed system should reach within the organization.

Information viewpoint: focus on aspects of the structure, the control of and the access to information

Computation viewpoint: aspects of the logical distribution of data and subsystems.

Engineering viewpoint: physical distribution of data and subsystems

Technology viewpoint: the different physical and technical subsystems, e.g. network, hardware platforms.



## Design - Development environment

use of Software Engineering concepts, methods and tools to design and development distributed applications

software development cycle is divided into phases

requirements analysis, specification, design, implementation, test and integration, maintenance

for details see Software Engineering courses

**Open Distributed Processing (ODP)**

**Model Driven Architecture (MDA)**

**AutoFocus**



## 1. Step: development of PIM

PIM models the functionality and behavior of software system

specifies components, classes, pre-/post conditions, semantics

no technological details, e.g. type of communication (such as SOAP)

- use of UML (Unified Modeling Language) to model information in diagrams.
  - use case diagrams
  - class and component diagrams
  - sequence diagrams
  - state diagrams

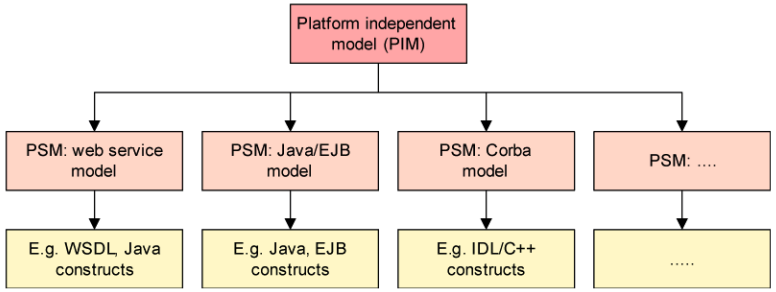


## 3. Step: code generation

generation of specific technological constructs, e.g. Java packages

implementation of system functionality

use of tools for automatic code generation



AutoFocus is a platform to specify distributed systems

- developed by the group of Prof. Broy, TU München
- based on formal methods of systems engineering
- integrates hierarchical description techniques
- allows distributed and platform independent development
- project advanced to **AutoFocus 2** supporting the following functionality
  - requirement analysis tool (AutoRAID), such as use-cases and scenarios, business and application requirements
  - Design modelling views and editors, such as system structure diagram, state transition diagram, message sequence charts
  - interactive simulation environment, code generation, consistency maintenance support,