Middleware and Web Services

Lecture 8: SOAP and REST

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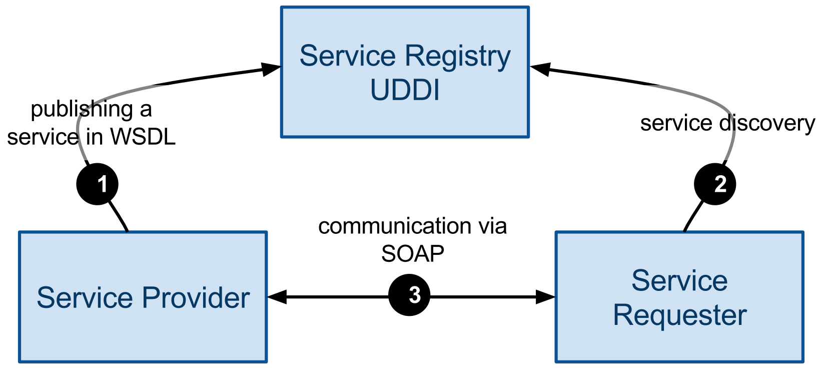
Overview

- SOAP
  - *Message Path*
- Representational State Transfer
- SOAP and REST Comparision

Web Service Architecture

- WSDL, SOAP and UDDI



– *Realization of SOA*

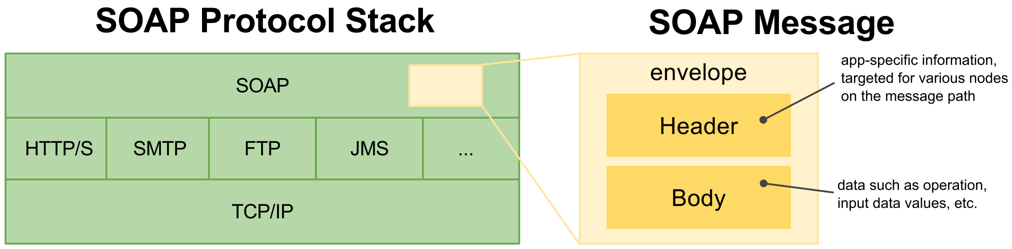
– *Message-Oriented view*

→ *SOAP messaging (header, body)*

→ *types of messages – input, output, fault*

SOAP Protocol

- SOAP defines a messaging framework



app-specific information, targeted for various nodes on the message path

data such as operation, input data values, etc.

– *XML-based protocol*

– *a layer over transport protocols*

→ *binding to HTTP, SMTP, JMS, ...*

– *involves multiple nodes (message path)*

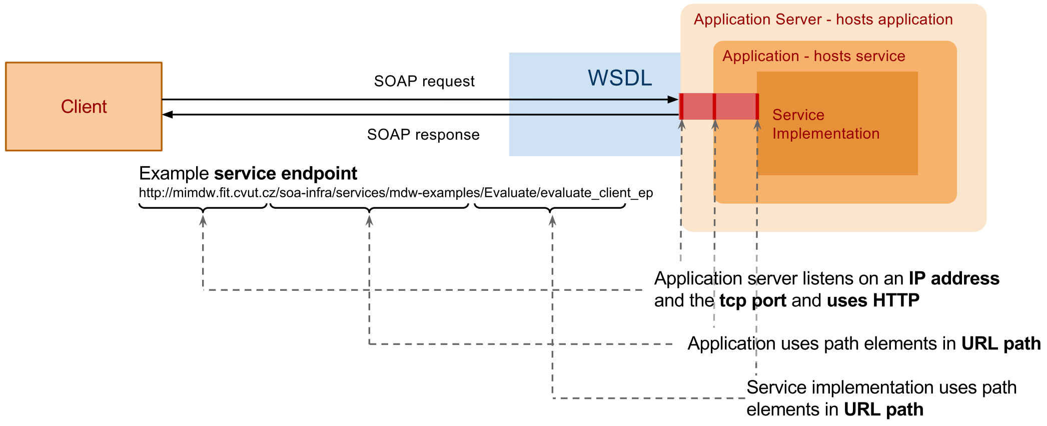
→ *sender, receiver, intermediary*

SOAP Message

- Envelope
  - *A container of a message*
- Header
  - *Metadata – describe a message, organized in header blocks*
    - *→ routing information*
    - *→ security measures implemented in the message*
    - *→ reliability rules related to delivery of the message*
    - *→ context and transaction management*
    - *→ correlation information (request and response message relation)*
  - *WS extensions (WS-*) utilize the message header*
- Body (payload)
  - *Actual contents of the message, XML formatted*
  - *Contains also faults for exception handling*
- Attachment
  - *Data that cannot be serialized into XML such as binary data*

Endpoint

- SOAP service endpoint definition


Client
SOAP request
SOAP response
WSDL
Application Server - hosts application
Application - hosts service
Service Implementation

Example **service endpoint**
http://mimdw.fit.cvut.cz/soa-infra/services/mdw-examples/Evaluate/evaluate_client_ep

Application server listens on an **IP address** and the **tcp port** and **uses HTTP**

Application uses path elements in **URL path**

Service implementation uses path elements in **URL path**

  - *Endpoint – a network address used for communication*
  - *Communication – request-response, SOAP messages over a communication (application) protocol*
  - *Synchronous communication – only service defines endpoint*
  - *Asynchronous communication – service and client define endpoints*

Service Invocation Example (1)

- Example service implementation
  - *A service that evaluates an expression*
  - *Uses SOAP over HTTP*
    - *→ We can use standard HTTP tools to invoke the service*
- SOAP request message

evaluate-input.xml

```
<soap:Envelope xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/">
        <soap:Body>
                <ns1:evaluateRequest
                xmlns:ns1="http://xmlns.oracle.com/mdw_examples/Evaluate/evalu
                        <ns1:x>12</ns1:x>
                        <ns1:y>18</ns1:y>
                </ns1:evaluateRequest>
        </soap:Body>
</soap:Envelope>
```

- Invoking the service using curl

```
curl -s -X POST --header "Content-Type: text/xml;charset=UTF-8" \
--header "SOAPAction: \"evaluate\"" --data @evaluate-input.xml \
http://mimdw.fit.cvut.cz/soa-infra/services/mdw-examples/Evaluate/evaluate_cli
```

Service Invocation Example (2)

- Invocation result

```
* About to connect() to mimdw.fit.cvut.cz port 80 (#0)
*   Trying 147.32.233.55... connected
* Connected to sb.vitvar.com (147.32.233.55) port 80 (#0)
> POST /soa-infra/services/mdw-examples/Evaluate/evaluate_client_ep HTTP/1.1
> User-Agent: curl/7.19.7 (x86_64-redhat-linux-gnu) libcurl/7.19.7 NSS/3.14.0.
> Host: mimdw.fit.cvut.cz
> Accept: */*
> Content-Type: text/xml;charset=UTF-8
> SOAPAction: "evaluate"
> Content-Length: 302
>
} [data not shown]
< HTTP/1.1 200 OK
< Date: Sun, 17 Nov 2013 11:24:59 GMT
< Server: Oracle-Application-Server-11g
< Content-Length: 569
< X-ORACLE-DMS-ECID: 004upqiWhdD0zkWVLybQ8A0005uX0004Y^
< SOAPAction: ""
< X-Powered-By: Servlet/2.5 JSP/2.1
< Content-Type: text/xml; charset=UTF-8
< Content-Language: en
```

Service Invocation Example (3)

- SOAP response message

```
<?xml version="1.0"?>
<env:Envelope xmlns:env="http://schemas.xmlsoap.org/soap/envelope/"
    xmlns:wsa="http://www.w3.org/2005/08/addressing">
  <env:Header>
    <wsa:MessageID>urn:E42018C04F7A11E3BFD5D1953058407C</wsa:MessageID>
  </env:Header>
  <env:Body>
    <evaluateResponse
        xmlns="http://xmlns.oracle.com/mdw_examples/Evaluate/evaluate">
      <result>30</result>
    </evaluateResponse>
  </env:Body>
</env:Envelope>
```

Client Implementation

- WSDL – Web Service Description Language
  – *definitions for the client to know how to communicate with the service*
    → *which operations it can use*
    → *data formats for input (request), output (response) and fault messages*
    → *how to serialize the data as payloads of a communication protocol (binding)*
    → *where the service is physically present on the network*
- Clients' environments
  – *Clients implemented in a language such as Java*
    → *Tools to generate service API for the client, e.g. WSDL2Java*
    → *Can be written manually too, e.g. our example in bash*
  – *Clients reside on the middleware, e.g. on an Enterprise Service Bus*
    → *They provide added values in end-to-end communication, proxy services, SOAP intermediaries*

Overview

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- SOAP and REST Comparision

SOAP Node

- A program that services use to transmit SOAP messages
  - *Element of SOAP messaging infrastructure*
  - *Realized by a SOAP communication server*
    - → *Every vendor has its own implementation*
    - → *Must conform to SOAP standard*
    - → *Sometimes causes vendor interoperability problem*
- SOAP node types
  - ***SOAP sender*** *– a node that transmits a message*
  - ***SOAP receiver*** *– a node that received a message*
  - ***SOAP intermediary*** *– a node that receives and transmits a message and optionally processes the message*
  - ***initial SOAP sender*** *– the first node transmitting the message*
  - ***ultimate SOAP receiver*** *– the last node receiving the message*

Message Path

- A path from a service requester to a service consumer over a number of SOAP nodes.

  `S → (I)* → R`, *where*

  `S` *is an initial sender,*

  `I` *is an intermediary,*

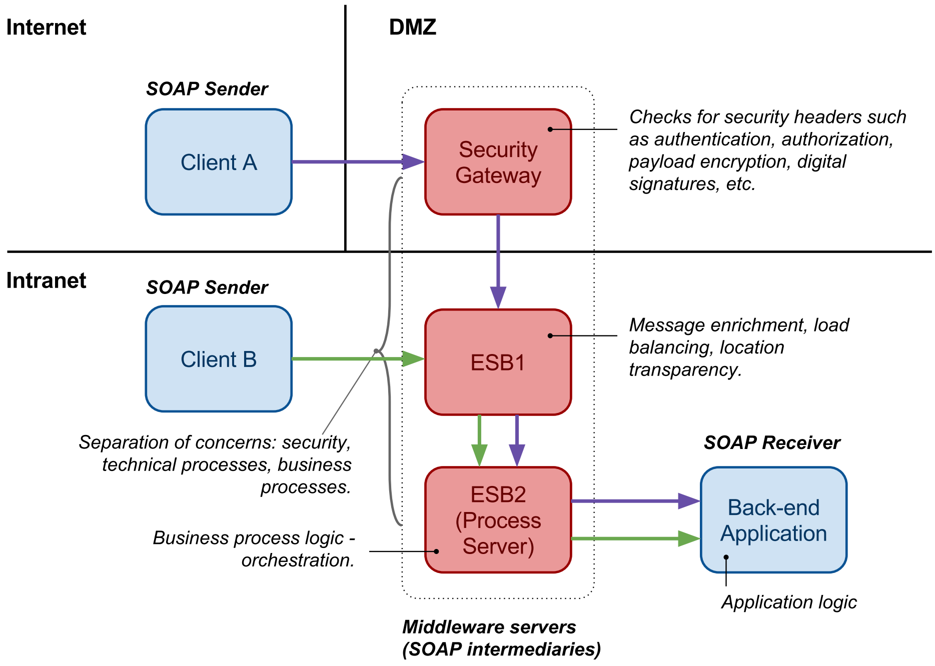
  `R` *is an ultimate receiver.*

- A path may have zero or more intermediaries
  - ***Passive intermediary*** *– such as a load balancing server*

    → only forwards the message, does not rewrite headers
  - ***Active intermediary*** *– such as a policy enforcement server*

    → May modify headers

SOAP Message Paths Example



Checks for security headers such as authentication, authorization, payload encryption, digital signatures, etc.

Message enrichment, load balancing, location transparency.

Separation of concerns: security, technical processes, business processes.

Business process logic - orchestration.

Application logic

Middleware servers (SOAP intermediaries)

SOAP Message Example 1

- Client A → Security Gateway
  - *Client needs to authenticate with a username and a password*

```
<s:envelope
    xmlns:tns="http://company.com/2011/wsdl/order"
    xmlns:s="http://schemas.xmlsoap.org/soap/envelope/">
  <s:header>
    <wss:security
         xmlns:wss="http://schemas.xmlsoap.org/ws/2002/04/secext"
         s:mustUnderstand="1">
      <wss:UsernameToken>
        <wss:username>username</wsse:Username>
        <wss:password Type="#PasswordText">pswd</wsse:Password>
      </wss:UsernameToken>
    </wss:security>
  </s:header>
  <s:body>
    <tns:getOrderStatus xmlns:m="http://company.com/2011/schemas/order">
        <m:orderId>2345</m:orderId>
        <m:customerId>2234</m:customerId>
    </tns:getOrderStatus>
  </s:body>
</s:envelope>
```

SOAP Message Example 2

- Client B → Proxy Server
  - *Client directly invokes a proxy service without authentication*

```
<s:envelope
    xmlns:tns="http://company.com/2011/wsdl/order"
    xmlns:s="http://schemas.xmlsoap.org/soap/envelope/">
  <s:header/>
  <s:body>
    <tns:getOrderStatus xmlns:m="http://company.com/2011/schemas/order">
        <m:orderId>2345</m:orderId>
        <m:customerId>2234</m:customerId>
    </tns:getOrderStatus>
  </s:body>
</s:envelope>
```

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REST

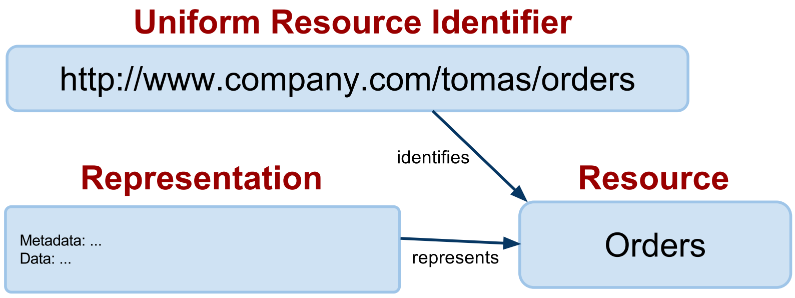
- REST
  – *Representational State Transfer*
- Architecture Style
  – *Roy Fielding – co-author of HTTP*
  – *He coined REST in his PhD thesis* ↗.
    → *The thesis abstracts from HTTP technical details*
    → *HTTP is one of the REST implementation* → ***RESTful***
    → *REST is a leading programming model for Web APIs*
- REST (RESTful) proper design
  – *people break principles often*
  – *See REST Anti-Patterns* ↗ *for some details.*
- REST and Web Service Architecture
  – *REST is a realization of WSA resource-oriented model*

REST Core Principles

- REST architectural style defines constraints
  - *if you follow them, they help you to achieve a good design, interoperability and scalability.*
- Constraints
  - *Client/Server*
  - *Statelessness*
  - *Cacheability*
  - *Layered system*
  - *Uniform interface*
- Guiding principles
  - *Identification of resources*
  - *Representations of resources and self-descriptive messages*
  - *Hypermedia as the engine of application state (HATEOAS)*

Resource

- A resource can be anything such as
  - *A real object: car, dog, Web page, printed document*
  - *An abstract thing such as address, name, etc. → RDF*
- A resource in REST
  - *A resource corresponds to one or more entities of a data model*
  - *A representation of a resource can be conveyed in a message electronically (information resource)*
  - *A resource has an identifier (URI) and a representation (XML, JSON, ...) and a client can apply an access to it (use HTTP methods)*



Uniform Resource Identifier

http://www.company.com/tomas/orders

identifies

Representation

Metadata: ...
Data: ...

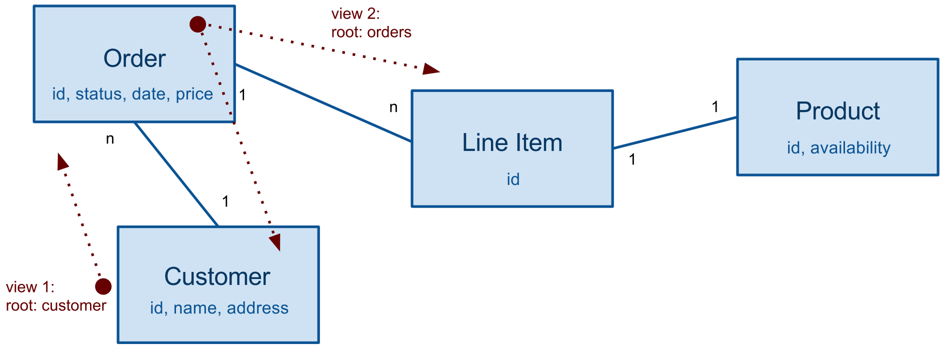
represents

Resource

Orders

Resources over Entities

- Application's data model
  - *Entities and properties that the app uses for its data*



- URI identifies a resource within the app's data model
  - `path` *– a "view" on the data model*
    - → *data model is a graph*
    - → *URI identifies a resource using a path in a tree with some root*

Examples of Views

- View 1
  - *all customers:* `/customers`
  - *a particular customer:* `/customers/{customer-id}`
  - *All orders of a customer:* `/customers/{customer-id}/orders`
  - *A particular order:* `/customers/{customer-id}/orders/{order-id}`
- View 2
  - *all orders:* `/orders`
  - *All orders of a customer:* `/orders/{customer-id}`
  - *A particular order:* `/orders/{customer-id}/{order-id}`
- Various views represented by **URL path**

Uniform Interface

- Finite set of operations
  – *They are not dependent on the domain semantics*
  – *They only define how to manipulate with resources*
- RESTful service – HTTP methods
  – *GET – reads a resource (+ HEAD, OPTIONS)*
  – *PUT – updates or creates a resource (+ PATCH)*
  – *POST – creates a new resource*
  – *DELETE – deletes a resource*
- HTTP methods' properties
  – *a method is* ***safe***
    → *It does not change the application state (it does not modify the data)*
    → *GET, OPTIONS, HEAD*
    → *Results can be cached by intermediaries (e.g. proxy servers)*
  – *a method is* ***idempotent***
    → *Every method invocation will always have the same effect*
    → *GET, PUT, DELETE*

Examples

- Operation `getCustomerOrder(customerId, OrderId)`
  – *Retrieves a representation of the order resource that belongs to a particular customer*

```
> GET /customers/{cutomerId}/orders/{orderId}
```

- Operation `openOrder(customerId)`
  – *Creates a new order for a customer*

```
> POST /customers/{cutomerId}/orders
< Location: /customers/{customerId}/orders/{orderId}

> GET /customers/{customerId}/orders/{orderId}
```

- Operation `addLineItem(customerId, orderId)`
  – *Adds a new item to the order*

```
> POST /customers/{customerId}/orders/{orderId}
< Location: /customers/{customerId}/orders/{orderId}/items/{itemId}

> GET /customers/{customerId}/orders/{orderId}/items/{itemId}
```

- Operation `closeOrder(customerId, orderId)`
  – *Closes the order (i.e., changes a state of the order resource)*

```
> PUT /customers/{customerId}/orders/{orderId}
> <status>CLOSED</status>
```

Examples – evaluate operation

- Example REST implementation of the SOAP service evaluate
- Operation `evaluate(n1, n2)`
  - *Evaluates expression such that the result is* `n1+n2`

```
> POST /evaluate/additions/
> <parameters>
>   <n1>{n1}</n1>
>   <n2>{n2}</n2>
> </parameters>
< Location: /evaluations/additions/{n1}+{n2}

> GET /evaluations/additions/{n1}+{n2}
```

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SOAP vs. REST

- SOAP uses input and output messages in operations
- REST uses resources and defines access on them

- SOAP can use more protocols
- REST uses HTTP
  - *Pratically, most of the SOAP implementations use SOAP over HTTP*

- Operations in SOAP are domain-specific
- HTTP operations are independent on domain semantics
  - *REST operations' semantics is defined by HTTP method + resource semantics*

- SOAP uses XML and XML Schema
- REST can use many representation formats
  - *For example, XML, JSON, YAML, etc.*

- SOAP is defined by WSDL
- REST is described in text or HTML

- Client libraries can be generated from WSDL
- REST vendor provides client libraries

SOAP vs. REST

- SOAP clients must hard-code service's public process
- REST clients can follow links in hypertext for application states

- SOAP services are used for inter/intra-enterprise integration
- REST services are used for Web APIs for integration on the Web