Middleware and Web Services

Lecture 2: Service Architecture and Technologies

doc. Ing. Tomáš Vitvar, Ph.D.
tomas@vitvar.com • @TomasVitvar • http://vitvar.com

Czech Technical University in Prague
Faculty of Information Technologies • Software and Web Engineering • http://vitvar.com/courses/mdw

Modified: Sun Oct 21 2018, 21:54:21
Humla v0.3

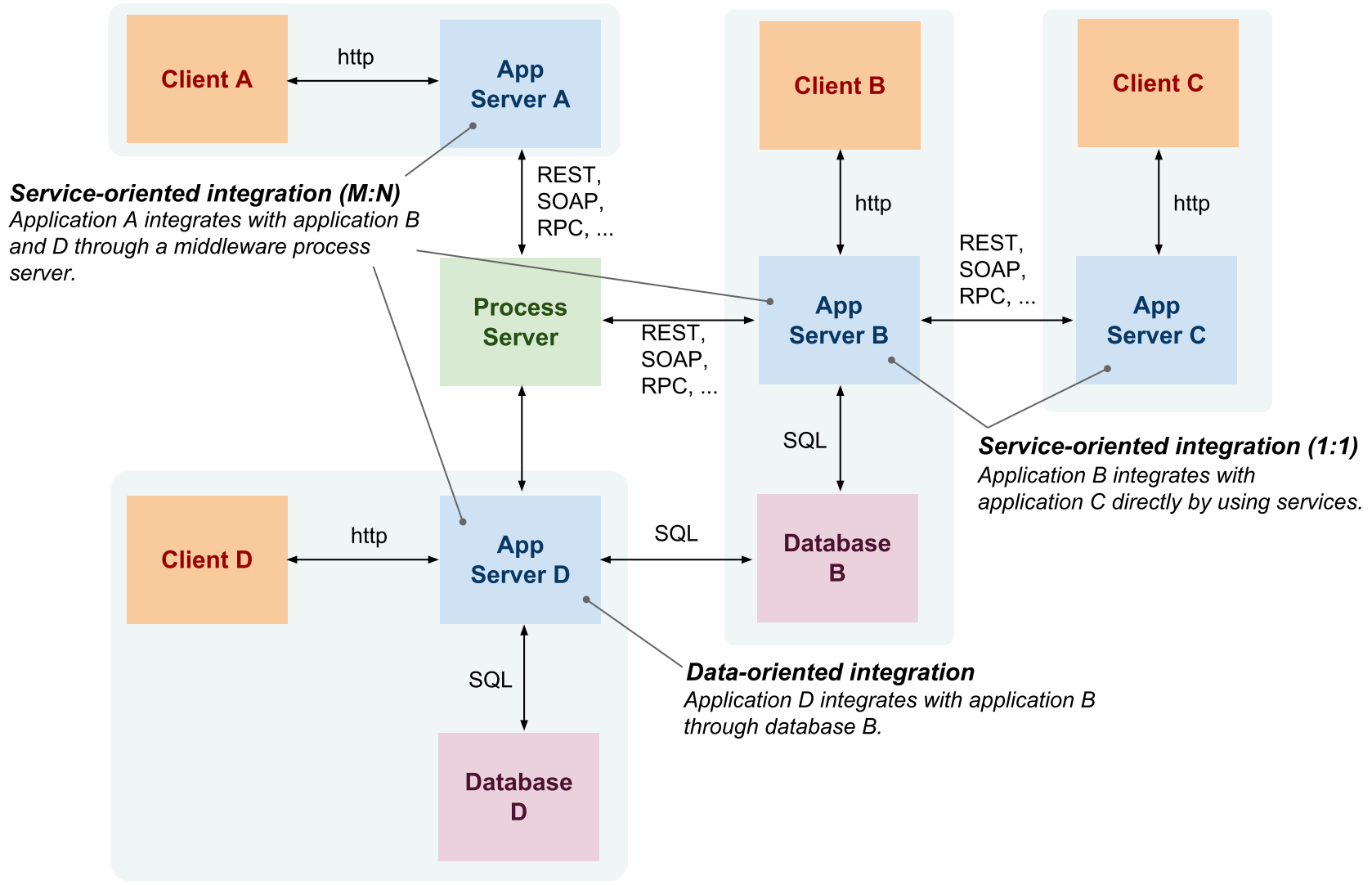
Overview

- Integrating Applications
- Service Definition
- Service Communication
- REST
- SOAP and WSDL

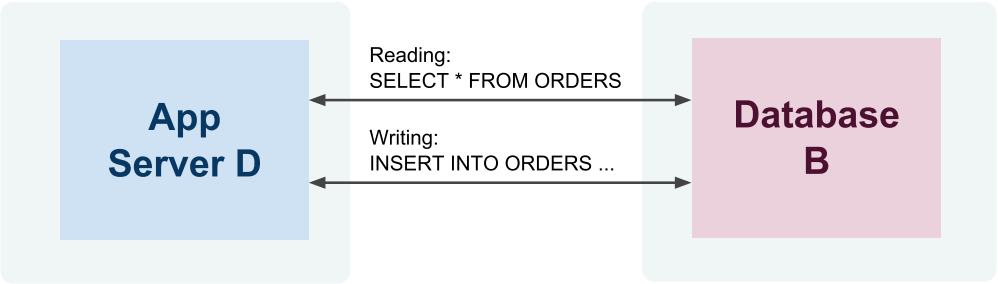
Integration and Interoperability

- Integration
  - *A process of connecting applications so that they can exchange and share capabilities, that is — information and functionalities.*
  - *Includes methodological approaches as well as technologies*
- Interoperability
  - *Ability of two or more applications to understand each other*
  - *Interoperability levels*
    - → *Data – syntax/structure and semantics*
    - → *Functions/Processes – syntax and semantics*
    - → *Technical aspects – protocols, network addresses, etc.*

Integration Approaches Overview

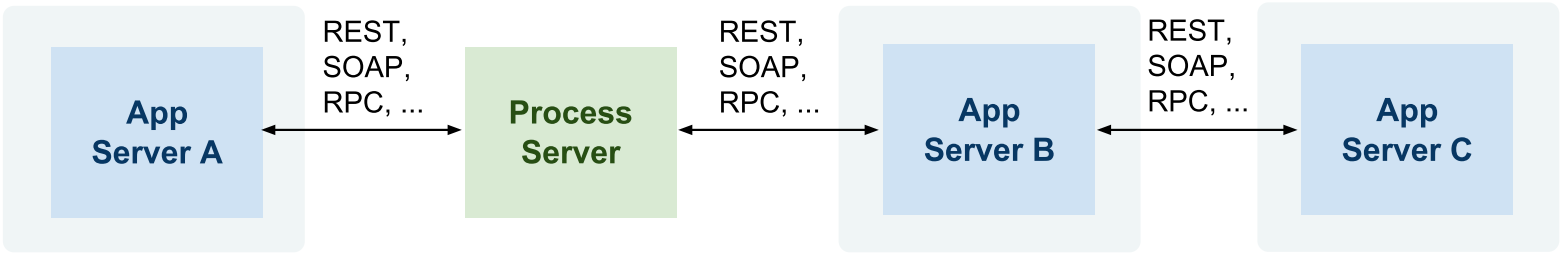


Data-oriented Integration



- Third-party database access
  - *Application D accesses a database of application B directly by using SQL and a knowledge of database B structure and constraints*
  - *In the past: monolithic and two-tier client/server architectures*
  - *Today: ETL (Extract, Transform, Load) technologies*
- Problems
  - *App D must understand complex structures and constraints*
    - → *Data – very complex, includes structure and integrity constraints*
    - → *Functions/processes – hidden in integrity constraints*
    - → *Technical – access mechanisms can vary*

Service-oriented Integration



- Integration at the application layer
  - *Application exposes services that other applications consume*
  - *Services hide implementation details but only define interfaces for integration*
- Problems
  - *Can become unmanageable if not properly designed*
  - *Interoperability*
    - → *Data – limited to input and output messages only*
    - → *Functions/processes – limited to semantics of services*
    - → *Technical – access mechanisms can vary*

Integration and Types of Data

- Transactional data – Web services
  - *Service-oriented integration*
  - *online, realtime communication between a client and a service*
  - *Usually small amount of data and small amount of service invocation in a process*
- Bulk data – ETL
  - *Data-oriented integration*
  - *processing of large amount of data in batches*
- **ESB provides both Web service and ETL capabilities**

Overview

- Integrating Applications
- Service Definition
- Service Communication
- REST
- SOAP and WSDL

Web Service Architecture

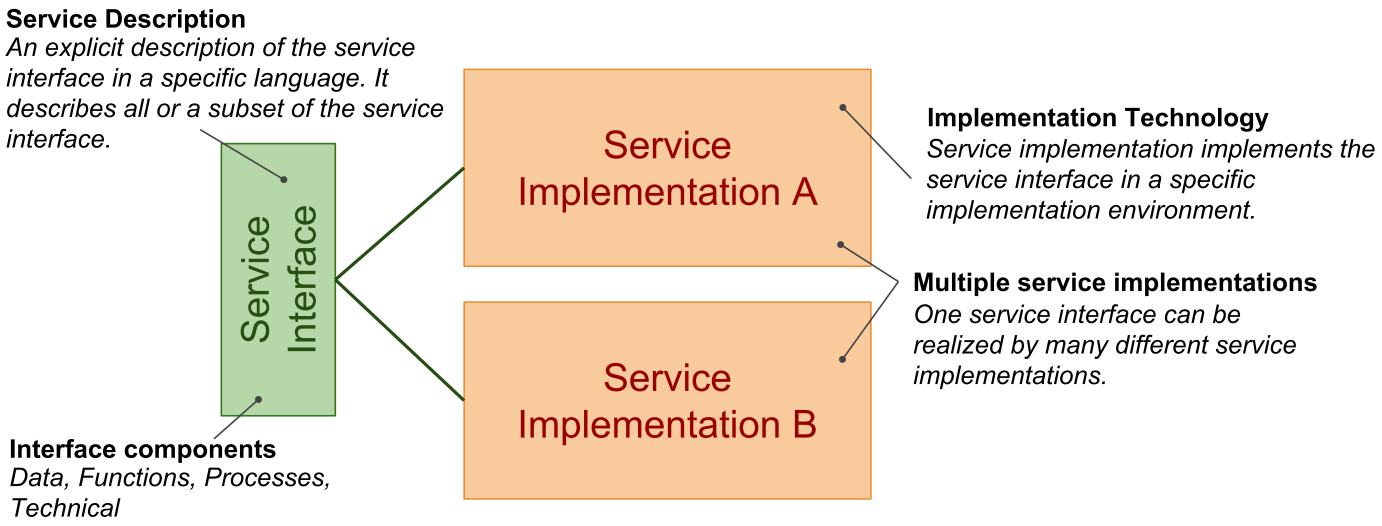
- Web Service Architecture
  - *Defined by W3C in Web Service Architecture Working Group Note*
  - *Defines **views***
    - → *message-oriented view (WSDL and SOAP)*
    - → *resource-oriented view (REST and HTTP)*
  - *Defines **architecture entities** and their **interactions***
    - → *Abstraction over underlying technology*
    - → *Basis for service usage processes and description languages*
- Service Oriented Architecture
  - *Collection of tools, methods and technologies*
  - *There is some implicit understanding of SOA in the community such as*
    - → *SOA provides advances over Enterprise Application Integration*
    - → *SOA is realized by using SOAP, WSDL, (and UDDI) technologies*
    - → *SOA utilizes Enterprise Service Bus (ESB)*

  ⇒ *~ a realization of Web Service Architecture message-oriented view*

Service

- Difficult to agree on one definition
- Business definition
  - *A service realizes an effect that brings a business value to a service consumer*
    - → *for example, to pay for and deliver a book*
- Conceptual definition
  - *service characteristics*
    - → *encapsulation, reusability, loose coupling, contracting, abstraction, discoverability, composability*
- Logical definition
  - *service interface, description and implementation*
  - *service usage process*
    - → *service use tasks, service types*
- Architectural definition
  - *business service (also application service)*
    - → *external, exposed functionality of an application*
  - *infrastructure service*
    - → *internal/technical, supports processing of requests*

Interface, Description and Implementation



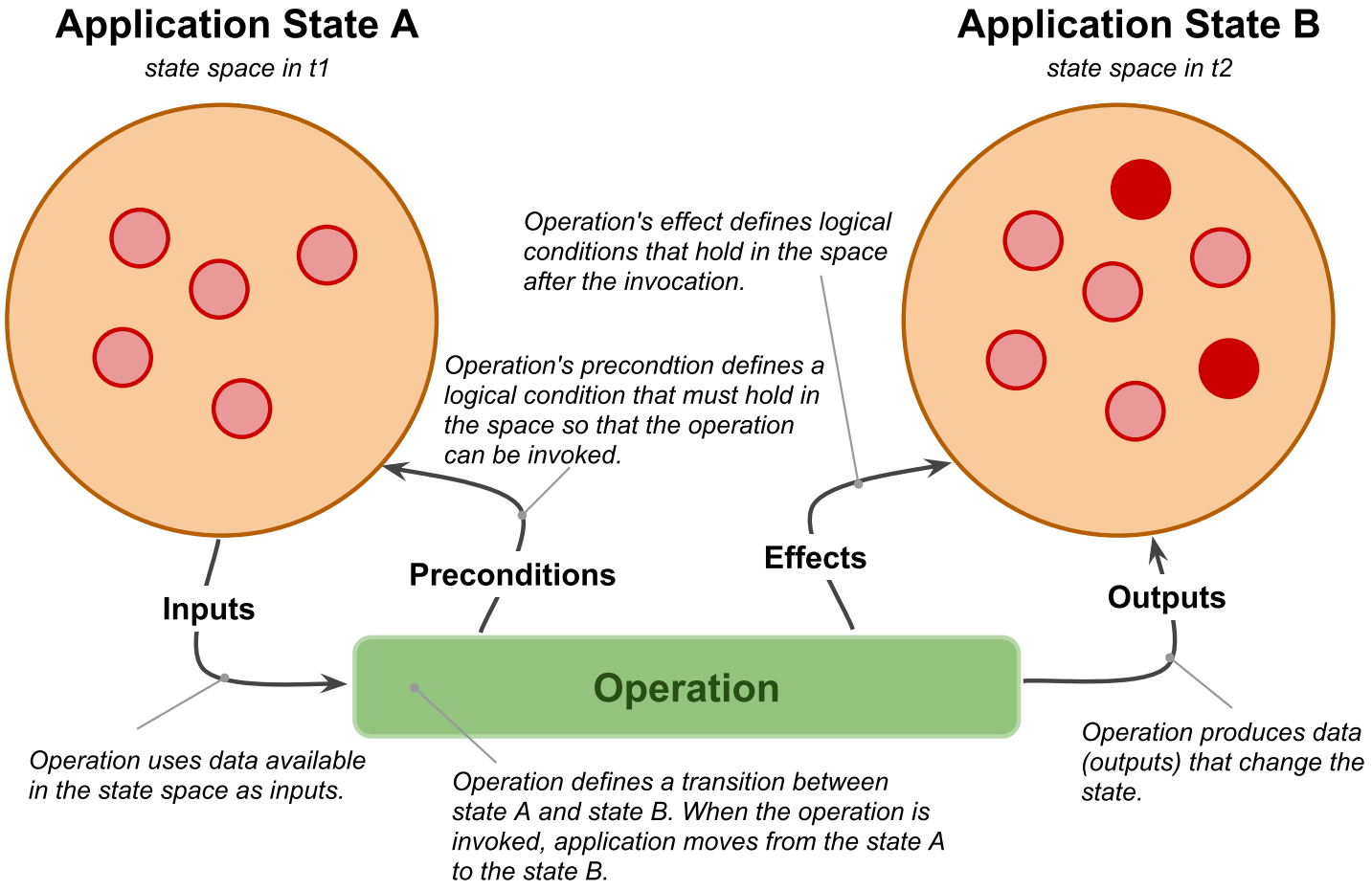
- Terminology clarification
  - *service ~ service interface + service implementation*
  - *WSDL service ~ service description in WSDL language*
  - *SOAP service ~ a service interface is possible to access through SOAP protocol; there is a WSDL description usually available too.*
  - *REST/RESTful service ~ service interface that conforms to REST architectural style and HTTP protocol*

Service Interface

- Service interface components
  - *Data*
    - → *Data model definition used by the service*
    - → *for example, input and output messages, representation of resources*
  - *Functions*
    - → *operations and input and output data used by operations*
  - *Process*
    - → *public process: how to consume the service's functionality*
    - → *orchestration: realization of the service's functionality by its implementation*
  - *Technical*
    - → *security, usage aspects (SLA-Service Level Agreement)*
    - → *other technical details such as IP addresses, ports, protocols, etc.*

Public Process

- A state diagram
  - *operation of a service defines a **state transition** between two states.*



Service Characteristics

Loose Coupling
The requester agent's implementation is independent from service usage. That is, there is no "hard-wired" knowledge required to use the service.

Contracting
The service interface is a contract between the requester and the provider. They both agree to follow the service description in order to achieve interoperability.

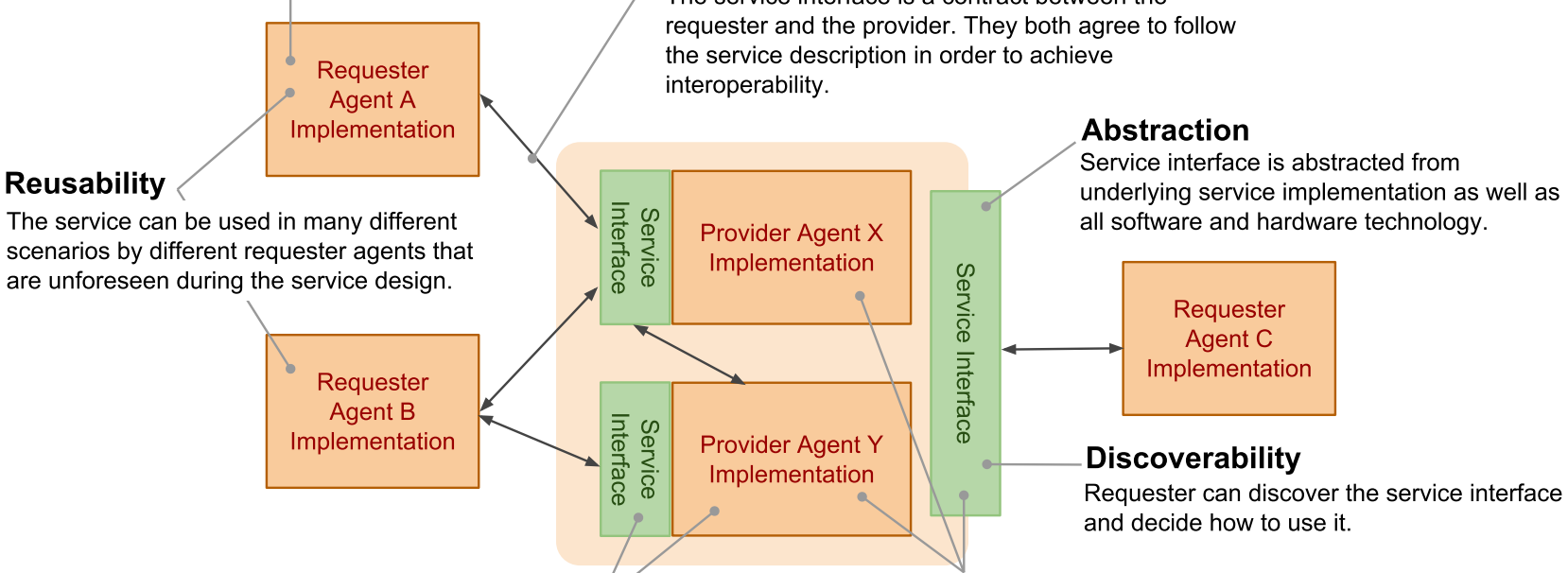
Abstraction
Service interface is abstracted from underlying service implementation as well as all software and hardware technology.

Reusability
The service can be used in many different scenarios by different requester agents that are unforeseen during the service design.

Discoverability
Requester can discover the service interface and decide how to use it.

Encapsulation
The provider agent implementation is hidden to the requester agent accessing the service. The requester agent only knows the service interface to consume its functionality.

Composability
It is possible to compose services into more complex processes. Such processes can again be accessed as services.

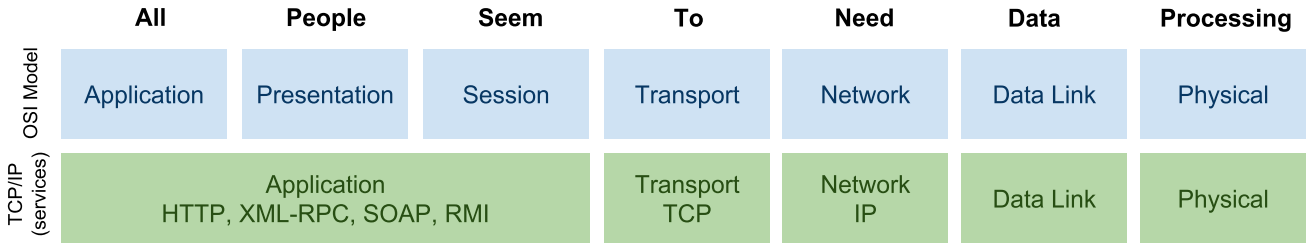


Overview

- Integrating Applications
- Service Definition
- Service Communication
- REST
- SOAP and WSDL

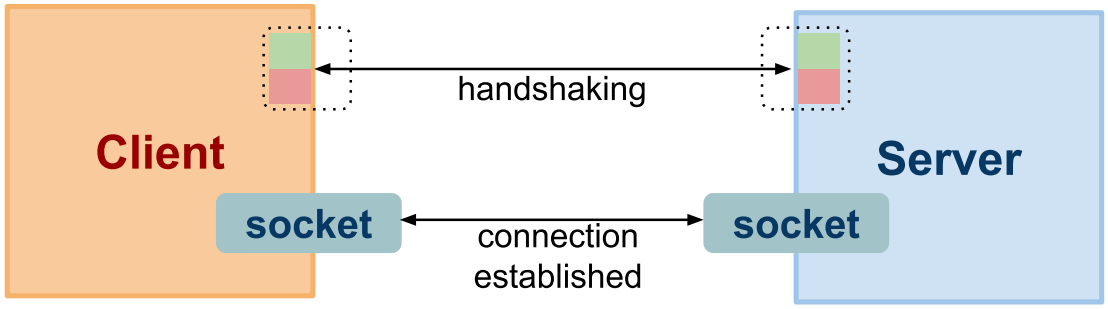
Application Protocols

- Remember this



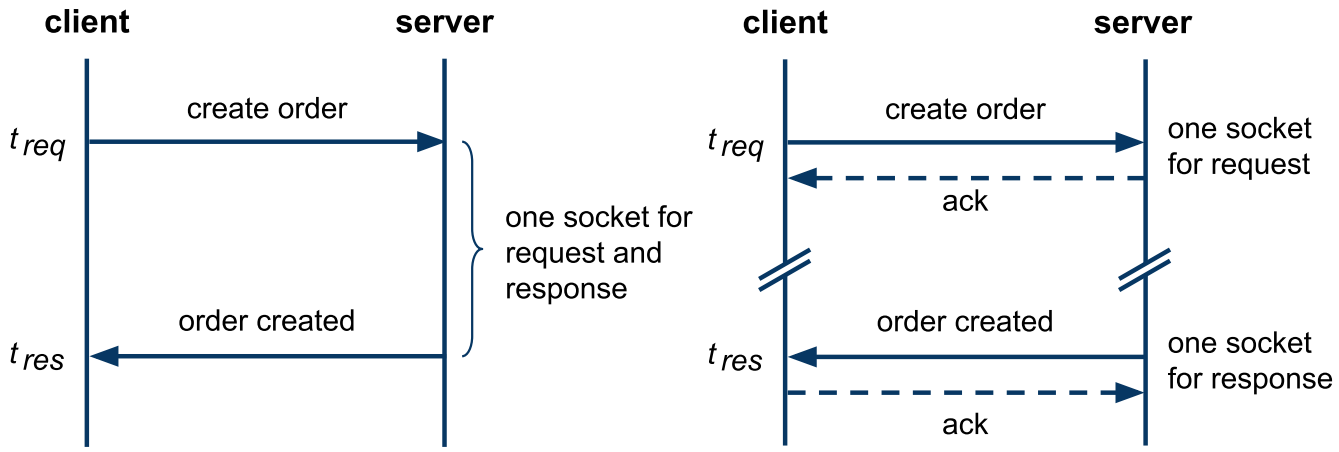
- App protocols mostly on top of the TCP Layer
  - *use TCP socket for communication*
- Major protocols
  - *HTTP – most of the app protocols layered on HTTP*
    → wide spread, but: implementors often break HTTP semantics
  - *RMI – Remote Method Invocation*
    → Java-specific, rather interface
    → may use HTTP underneath (among other things)
  - *XML-RPC – Remote Procedure Call and SOAP*
    → Again, HTTP underneath
  - *WebSocket – new protocol part of HTML5*

Socket



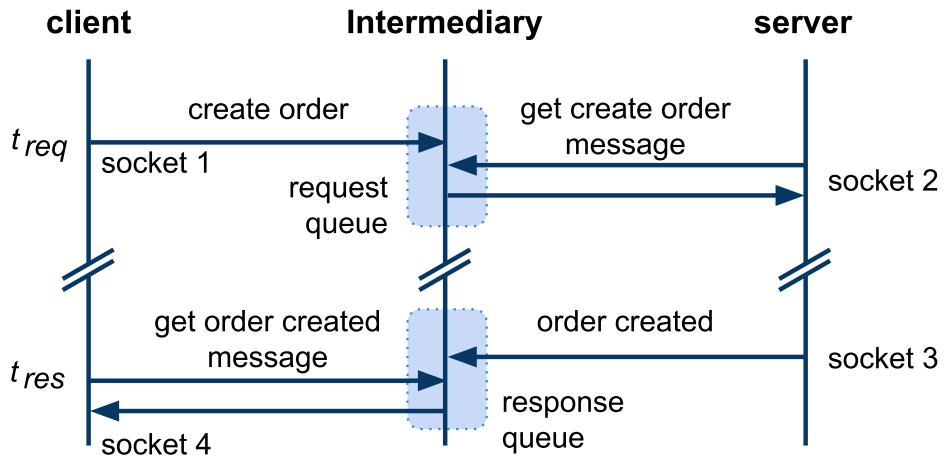
- Handshaking (connection establishment)
  - *The server listens at* `[dst_ip,dsp_port]`
  - *Three-way handshake:*
    - → *the client at* `[src_ip,src_port]` *sends a connection request*
    - → *the server responds*
    - → *the client acknowledges the response, can send data along*
  - *Result is a socket (virtual communication channel) with unique identification:*
    `socket=[src_ip,src_port;dst_ip,dst_port]`
- Data transfer (resource usage)
  - *Client/server writes/reads data to/from the socket*
  - *TCP features: reliable delivery, correct order of packets, flow control*
- Connection close

Synchronous and Asynchronous Communication



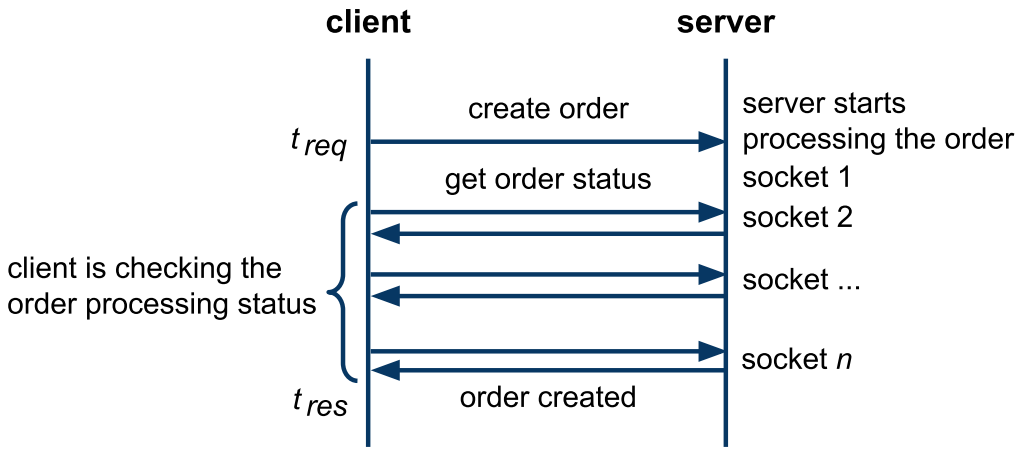
- Synchronous
  - *one socket, $|t_{req} - t_{res}|$ is small*
  - *easy to implement and deploy, only standard firewall config*
  - *only the server defines endpoint*
- Asynchronous
  - *request, response each has socket, client and server define endpoints*
  - *$|t_{req} - t_{res}|$ can be large (hours, even days)*
  - *harder to do across network elements (private/public networks issue)*

Asynchronous via Intermediary



- Intermediary
  - *A component that decouples a client-server communication*
  - *It increases reliability and performance*
    - → *The server may not be available when a client sends a request*
    - → *There can be multiple servers that can handle the request*
- Further Concepts
  - *Message Queues (MQ) – queue-based communication*
  - *Publish/Subscribe (P/S) – event-driven communication*

Asynchronous via Polling

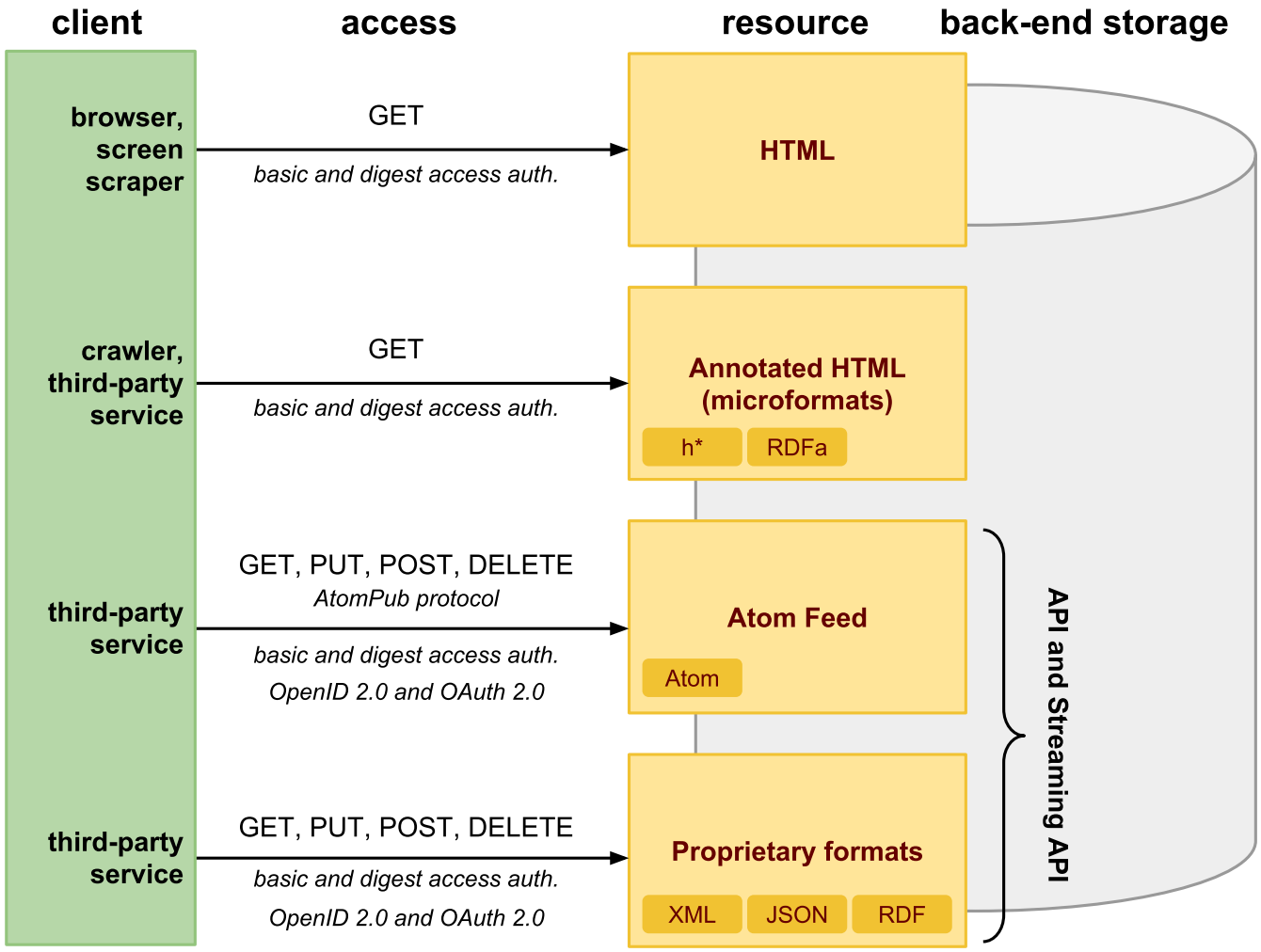


- Polling – only clients open sockets
  - *A client performs multiple request-response interactions*
    - → *The first interaction initiates a process on the server*
    - → *Subsequent interactions check for the processing status*
    - → *The last interaction retrieves the processing result*
- Properties of environments
  - *A server cannot open a socket with the client (network restrictions)*
  - *Typically on the Web (a client runs in a browser)*

Overview

- Integrating Applications
- Service Definition
- Service Communication
- REST
  - *Introduction to REST*
  - *Uniform Resource Identifier*
  - *Resource Representation*
  - *HATEOAS*
  - *Uniform Interface*
  - *Caching, Revalidation, Concurrency Control*
  - *Richardson Maturiy Model*
- SOAP and WSDL

Data on the Web



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 and Web Architecture

- Tim-Berners Lee
  - *"creator", father of the Web*
- Key Principles
  - *Separation of Concerns*
    → enables independent innovation
  - *Standards-based*
    → common agreement, big spread and adoption
  - *Royalty-free technology*
    → a lot of open source, no fees
- Architectural Basis
  - ***Identification:*** *universal linking of resources using URI*
  - ***Interaction:*** *protocols to retrieve resources – HTTP*
  - ***Formats:*** *resource representation (data and metadata)*

HTTP Advantages

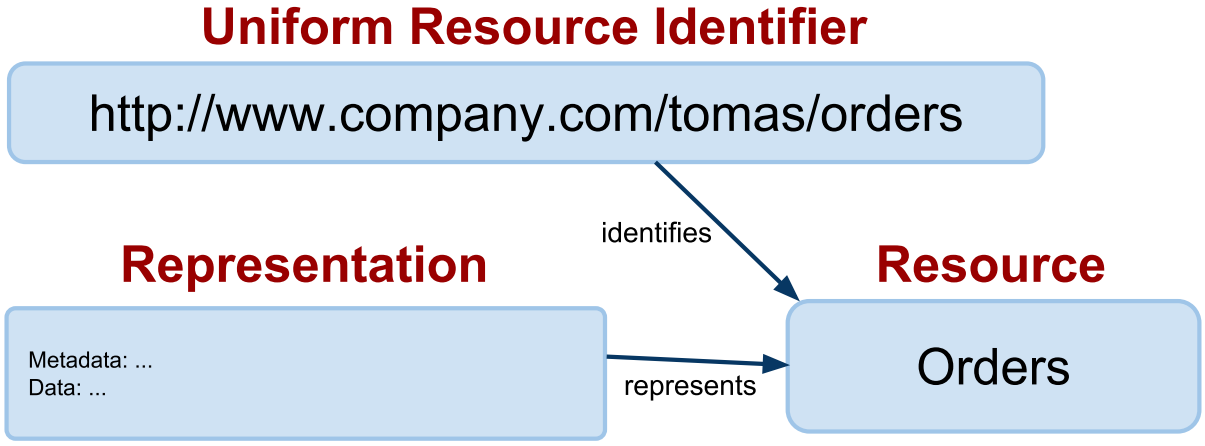
- Familiarity
  - *HTTP protocol is well-known and widely used*
- Interoperability
  - *All environments have HTTP client libraries*
    → technical interoperability is thus no problem
    → no need to deal with vendor-specific interoperability issues
  - *You can focus on the core of the integration problem*
    → application (domain, content) interoperability
- Scalability
  - *you can use highly scalable Web infrastructure*
    → caching servers, proxy servers, etc.
  - *HTTP features such as HTTP GET idempotence and safe allow you to use caching*

REST Core Principles

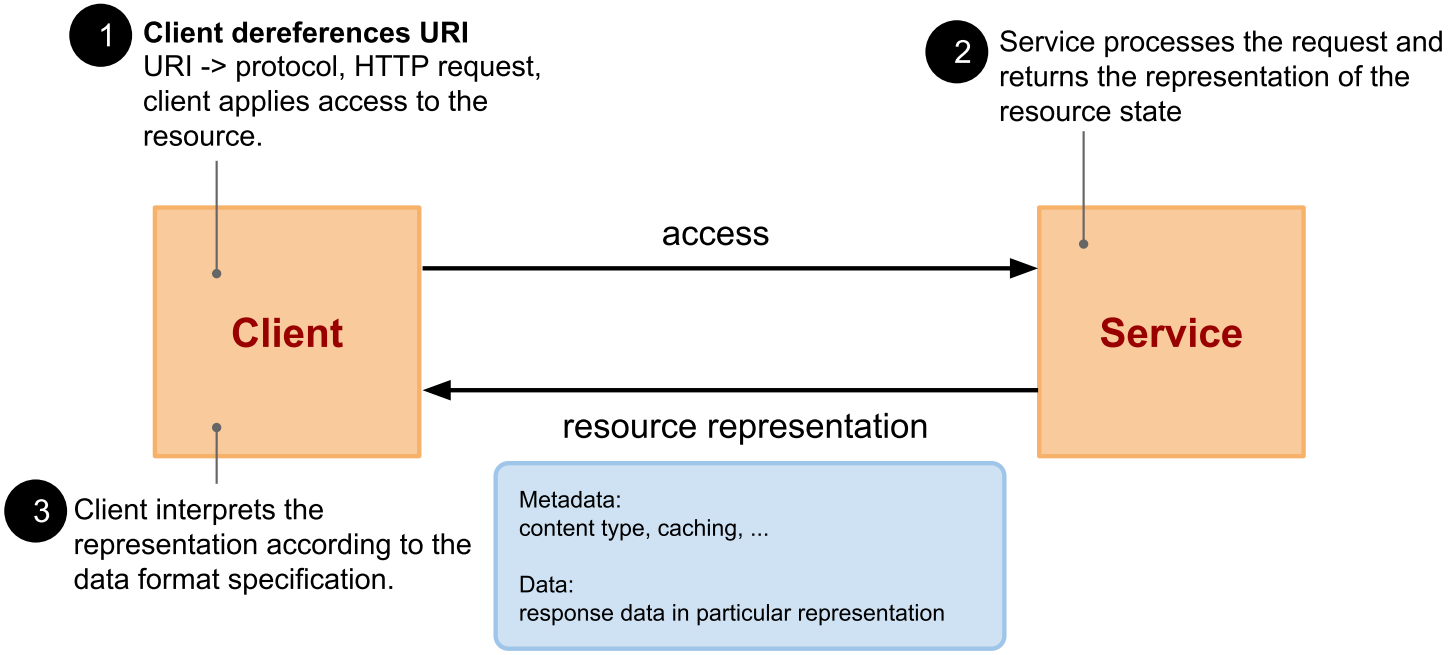
- REST architectural style defines constraints
  - *if you follow them, they help you to achieve a good design, interoperability and scalability.*
- Constraints
  - *Client/Server*
  - *Statelessness*
  - *Cacheability*
  - *Layered system*
  - *Uniform interface*
- Guiding principles
  - *Identification 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 and a representation and a client can apply an access to it*



Access to a Resource



- Terminology
  - *Client = User Agent*
  - ***Dereferencing URI** – a process of obtaining a protocol from the URI and creating a request.*
  - ***Access** – a process of sending a request and obtaining a response as a result; access usually realized through HTTP.*

Overview

- Integrating Applications
- Service Definition
- Service Communication
- REST
  - *Introduction to REST*
  - *Uniform Resource Identifier*
  - *Resource Representation*
  - *HATEOAS*
  - *Uniform Interface*
  - *Caching, Revalidation, Concurrency Control*
  - *Richardson Maturiy Model*
- SOAP and WSDL

URI, URL, URN

- URI – Uniform Resource Identifier
  - *URI only identifies a resource*
    → it does not imply the resource physically exists
  - *URI could be URL (locator) or URN (name)*
- URL – Uniform Resource Locator
  - *in addition allows to locate the resource*
    → that is — its network location
  - *every URL is URI but an URI does not need to be URL*
- URN – Uniform Resource Name
  - *refers to URI under "urn" scheme (RFC 2141)*
  - *require to be globally unique and persistent*
    → even if the resource cease to exist/becomes unavailable

URI

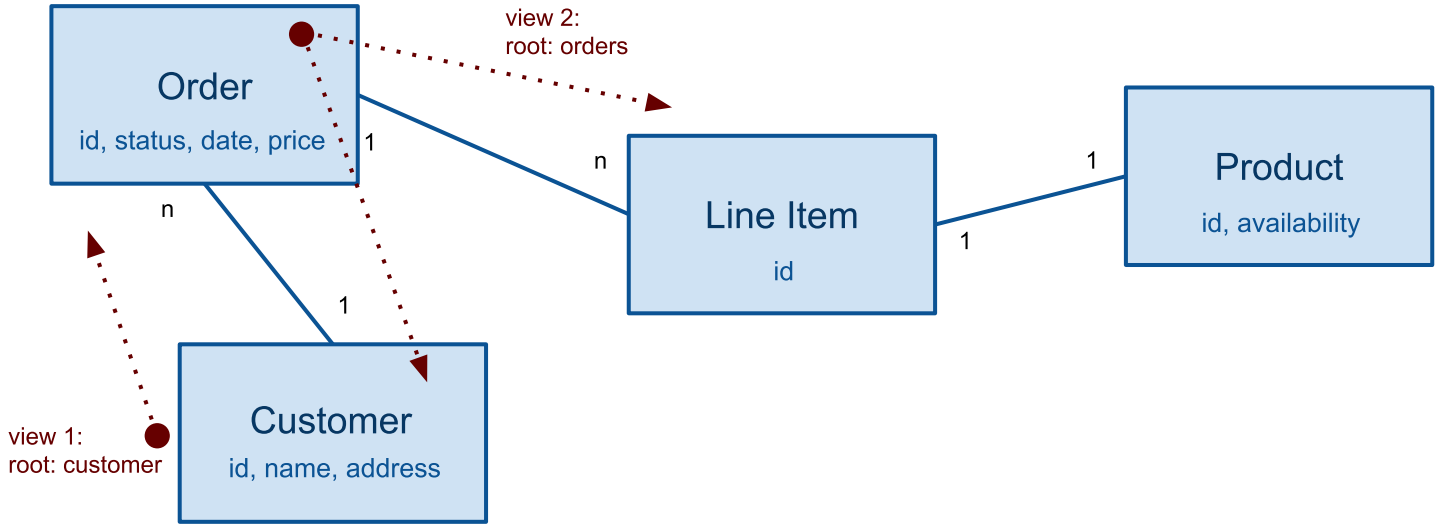
- Definition

```
URI = scheme ":" [ "//" authority ] [ "/" path ] [ "?" query ] [ "#" frag ]
```

- Hierarchal sequence of components
  - `scheme`
    - → *refers to a spec that assigns IDs within that scheme*
    - → *examples:* `http`, `ftp`, `mailto`, `urn`
    - → `scheme != protocol`
  - `authority`
    - → *registered name (domain name) or server address*
    - → *optional port and user*
  - `path and query`
    - → *identify resource within the scheme and authority scope*
    - → *path – hierarchal form*
    - → *query – non-hierarchal form (parameters key=value)*
  - `fragment`
    - → *reference to a secondary resource within the primary resource*

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}`

⇒ Design issues

- Good design practices
  - *No need for 1:1 relationship between resources and data entities*
    - → *A resource may aggregate data from two or more entities*
    - → *Thus only expose resources if it makes sense for the service*
  - *Try to limit URI aliases, make it simple and clear*

Path vs. Query

- Path
  - *Hierarchical component, a view on the data*
  - *The main identification of the resource*
- Query
  - *Can define selection, projection or other processing instructions*
  - *Selection*
    - → *filters entries of a resource by values of properties*

      `/customers/?status=valid`
  - *Projection*
    - → *filters properties of resource entries*

      `/customers/?properties=id,name`
  - *Processing instructions examples*
    - → *data format of the resource → cf. URI opacity*

      `/customers/?format=JSON`
    - → *Access keys such as API keys*

      `/customers/?key=3ae56-56ef76-34540aeb`

Fragment

- Primary resource
  - *Defined by URI path and query*
  - *could be complex, composed resources*
- Sub-resource/secondary resource
  - *Can be defined by a fragment*
  - *No explicit relationship between primary and sub-resource*
    → *For example, we cannot infer that the two resources are in* `part-of`*, or* `sub-class-of` *relationships.*
  - *Fragment semantics defined by a data format*
- Usage of fragment
  - *identification of elements in HTML*
  - *URI references in RDF*
  - *State of an application in a browser*

Fragment Semantics

- Fragment semantics for HTML
  - *assume that* `orders.html` *are in* `HTML` *format.*

```
1 http://company.com/tomas/orders.html#3456
```

  ⇒ *there is a HTML element with* `id=3456`

- But:
  - *Consider* `orders` *resource in* `application/xml`

```
1 <orders>
2     <order id="3456">...</order>
3     ...
4 </orders>
```

  - *Can't say that* `http://company.com/tomas/orders.xml#3456` *identifies an order element within the* `orders` *resource.*
  - `application/xml` *content type does not define fragment semantics*

Resource ID vs. Resource URI

- Resource ID
  - *Local ID, part of an entity in a data model*
  - *Unique within an application where the resource belongs*
  - *Usually generated on a server (cf. PUT to update and insert)*
  - *Exposed to the resource URI as a path element*

    `/orders/{order-id}`
- Resource URI
  - *Global identifier, valid on the whole Web*
  - *Corresponds to the view on the data model of the app*
  - *Include multiple higher-level resources' IDs*
  - *Example:*

    `/customers/{customer-id}/orders/{order-id}/`
  - *There can be more URIs identifying the same resource*

Major characteristics

- Capability URL
  - *Short lived URL generated for a specific purpose*
  - *For example, an user e-mail verification*
- URI Alias
  - *Two URIs identifying the same resource*
- URI Collision
  - *Two URIs identifying the same resource (misuse of an URI authority)*
- URI Opacity
  - *Content type encoded as part of an URI*
  - `http://www.example.org/customers.xml`
- Resource versions encoded in an URI
  - *Two URIs identifying the same resource of different versions*
  - `http://www.example.org/v1/customers.xml`
- Persistent URL
  - *URL is valid even when the resource is obsolete*
  - *For example, a redirection should be in place*

Overview

- Integrating Applications
- Service Definition
- Service Communication
- REST
  - *Introduction to REST*
  - *Uniform Resource Identifier*
  - *Resource Representation*
  - *HATEOAS*
  - *Uniform Interface*
  - *Caching, Revalidation, Concurrency Control*
  - *Richardson Maturiy Model*
- SOAP and WSDL

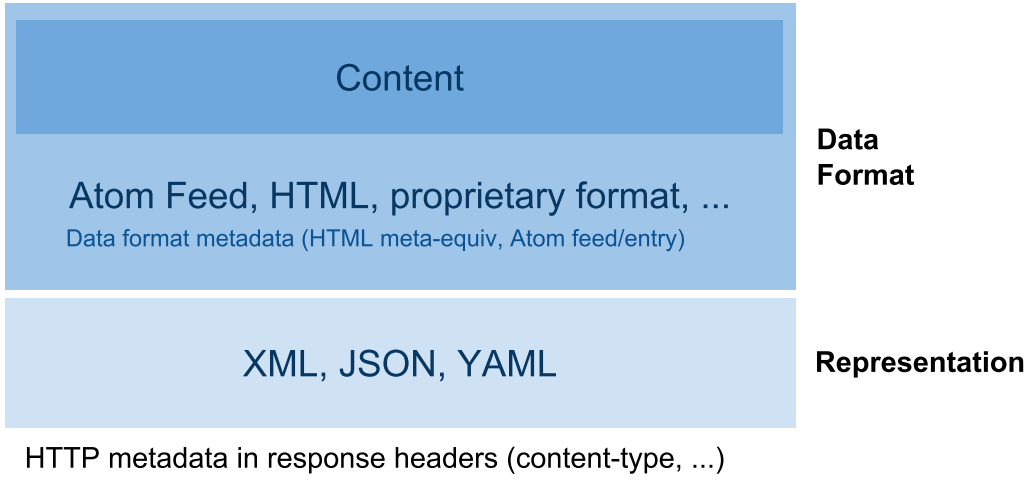
Representation and Data Format

- Representation
  - *Various languages, one resource can have multiple representations*
    → XML, HTML, JSON, YAML, RDF, ...
    → should conform to Internet Media Types
- Data format
  - *Format of resource data*
  - *Binary format*
    → specific data structures
    → pointers, numeric values, compressed, etc.
  - *Textual format*
    → in a defined encoding as a sequence of characters
    → HTML, XML-based formats are textual

Metadata

- Metadata ~ self-description
  - *Data about the resource*
  - *e.g., data format, representation, date the resource was created, ...*

  1. *Defined by HTTP response headers*
  2. *Can be part of the data format*
     - → *Atom Syndication Format such as* `author`, `updated`, ...
     - → *HTML* `http-equiv` *meta tags*
- Resource anatomy



Content-Type Metadata

- Access
  - *to be retrieved (GET)*
  - *to be inserted or updated (PUT, POST)*
  - *to be deleted (DELETE)*
- Request
  - *HTTP header* `Accept`*, part of content negotiation protocol*
- Response
  - *HTTP header* `Content-Type: type/subtype; parameters`
  - *Specifies an Internet Media Type of the resource representation.*
    - → *IANA (Internet Assigned Numbers Authority) manages a registry of media types and character encodings*
    - → *subtypes of* `text` *type have an optional charset parameter*

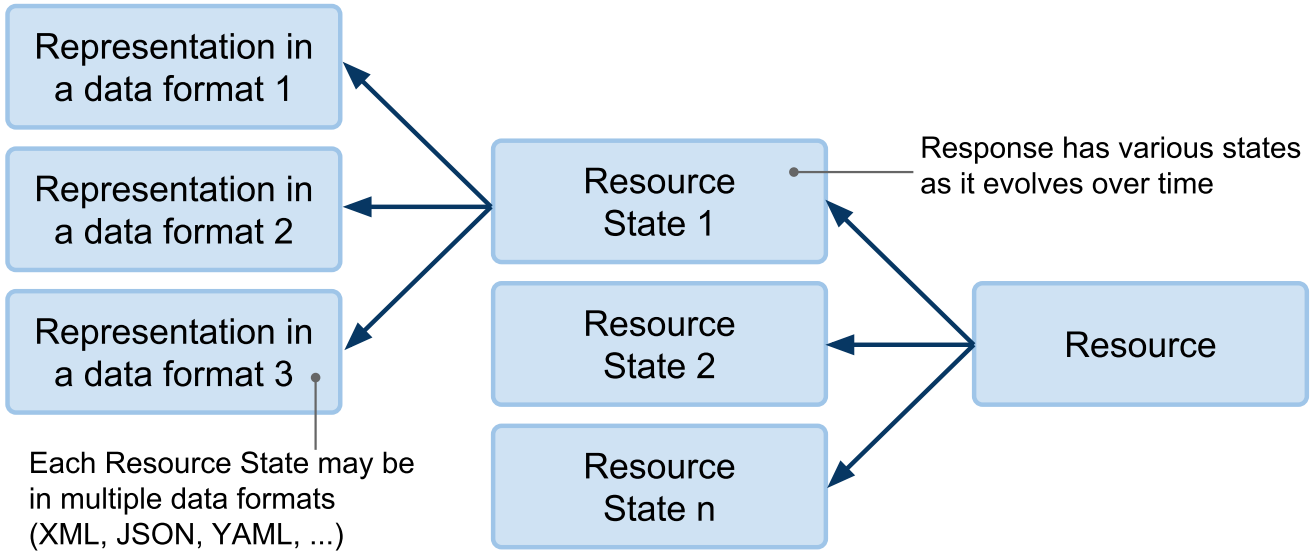
      `text/html; charset=iso-8859-1`
  - *A resource may provide more than one representations*
    - → *promotes services' loose coupling*

Major Media Types

- Common Standard Media Types
  - `text/plain`
    → *natural text in no formal structures*
  - `text/html`
    → *natural text embedded in HTML format*
  - `application/xml`, `application/json`
    → *XML-based/JSON-based, application specific format*
  - `application/wsdl+xml`
    → `+xml` *suffix to indicate a specific format*
- Non-standard media types
  - *Types or subtypes that begin with* `x-` *are not in IANA*
    `application/x-latex`
  - *subtypes that begin with* `vnd.` *are vendor-specific*
    `application/vnd.ms-excel`

Resource State

- State
  - *Resource representation is in fact a **representation of a resource state***
  - *Resource may be in different states over time*



- In REST resource states represent application states

Resource State Example

- Time `t1`: client A retrieves a resource `/orders` (GET)

```xml
<orders>
    <order id="54467"/>
    <order id="65432"/>
</orders>
```

- Time `t2`: client B adds a new order (POST)

```xml
<order>
    ...
</order>
```

- Time `t3`: client A retrieves a resource `/orders` (GET)

```xml
<orders>
    <order id="54467"/>
    <order id="65432"/>
    <order id="74567"/>
</orders>
```

- The resource `/orders` has different states in `t1` and `t3`.

Overview

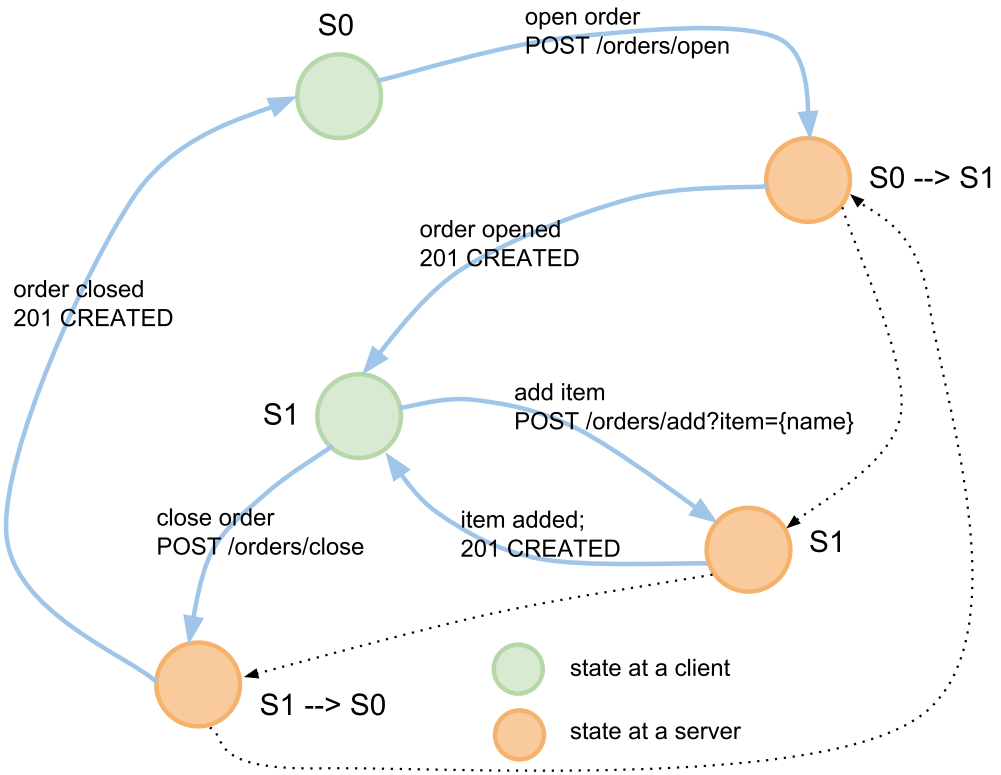
- Integrating Applications
- Service Definition
- Service Communication
- REST
  - *Introduction to REST*
  - *Uniform Resource Identifier*
  - *Resource Representation*
  - *HATEOAS*
  - *Uniform Interface*
  - *Caching, Revalidation, Concurrency Control*
  - *Richardson Maturiy Model*
- SOAP and WSDL

HATEOAS

- HATEOAS = Hypertext as the Engine for Application State
  - *The REST core principle*
  - ***Hypertext***
    - → *Hypertext is a representation of a resource with **links***
    - → *A link is an URI of a resource*
    - → *Applying an access to a resource via its link = state transition*
- Statelessness
  - *A service does not use a memory to remember a state*
  - *HATEOAS enables stateless implementation of services*

Stateful server

- Sessions to store the application state
  - *The app uses a server memory to remember the state*
  - *When the server restarts, the app state is lost*

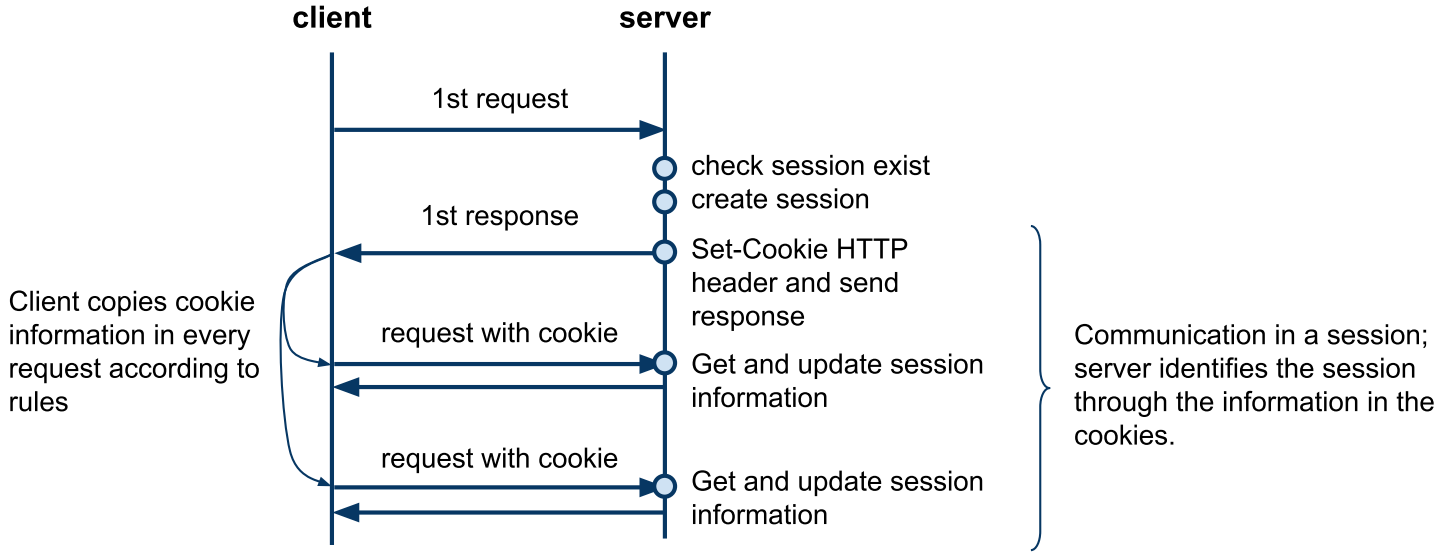


State Management

- HTTP is a stateless protocol – original design
  - *No information to relate multiple interactions at server-side*
    - → *Except* `Authorization` *header is copied in every request*
    - → *IP addresses do not work, one public IP can be shared by multiple clients*
- Solutions to check for a valid state at server-side
  - ***Cookies*** *– obvious and the most common workaround*
    - → *RFC 2109 – HTTP State Management Mechanism*
    - → *Allow clients and servers to talk in a context called* ***sessions***
  - ***Hypertext*** *– original HTTP design principle*
    - → *App states represented by resources (hypermedia), links define transitions between states*
    - → *Adopted by the REST principle* ***statelessness***

Interaction with Cookies

- Request-response interaction with cookies
  - *Session is a logical channel maintained by the server*



- Stateful Server
  - *Server remembers the session information in a server memory*
  - *Server memory is a non-persistent storage, when server restarts the memory content is lost!*

Set-Cookie and Cookie Headers

- `Set-Cookie` response header

```
set-cookie = "Set-Cookie:" cookie ("," cookie)*
  cookie     = NAME "=" VALUE (";" cookie-av)*
  cookie-av = "Comment" "=" value
            | "Domain" "=" value
            | "Max-Age" "=" value
            | "Path" "=" value
```

  - `domain` – *a domain for which the cookie is applied*
  - `Max-Age` – *number of seconds the cookie is valid*
  - `Path` – *URL path for which the cookie is applied*

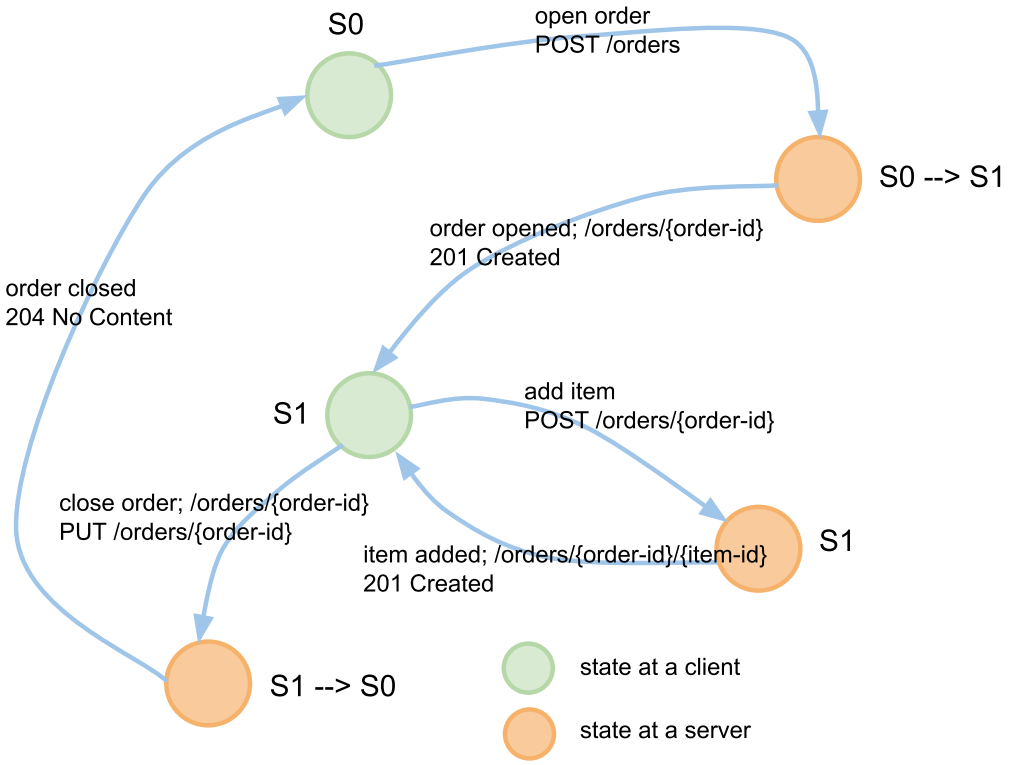
- `Cookie` request header. A client sends the cookie in a request if:
  - `domain` *matches the origin server's fully-qualified host name*
  - `path` *matches a prefix of the request-URI*
  - `Max-Age` *has not expired*

```
cookie  = "Cookie:" cookie-value (";" cookie-value)*
  cookie-value    = NAME "=" VALUE [";" path] [";" domain]
  path            = "$Path" "=" value
  domain          = "$Domain" "=" value
```

  - `domain`*, and* `path` *are values from corresponding attributes of the* `Set-Cookie` *header*

Stateless server

- HTTP and hypermedia to transfer the app state
  - *Does not use a server memory to remember the app state*
  - *State transferred between a client and a service via HTTP metadata and resources' representations*

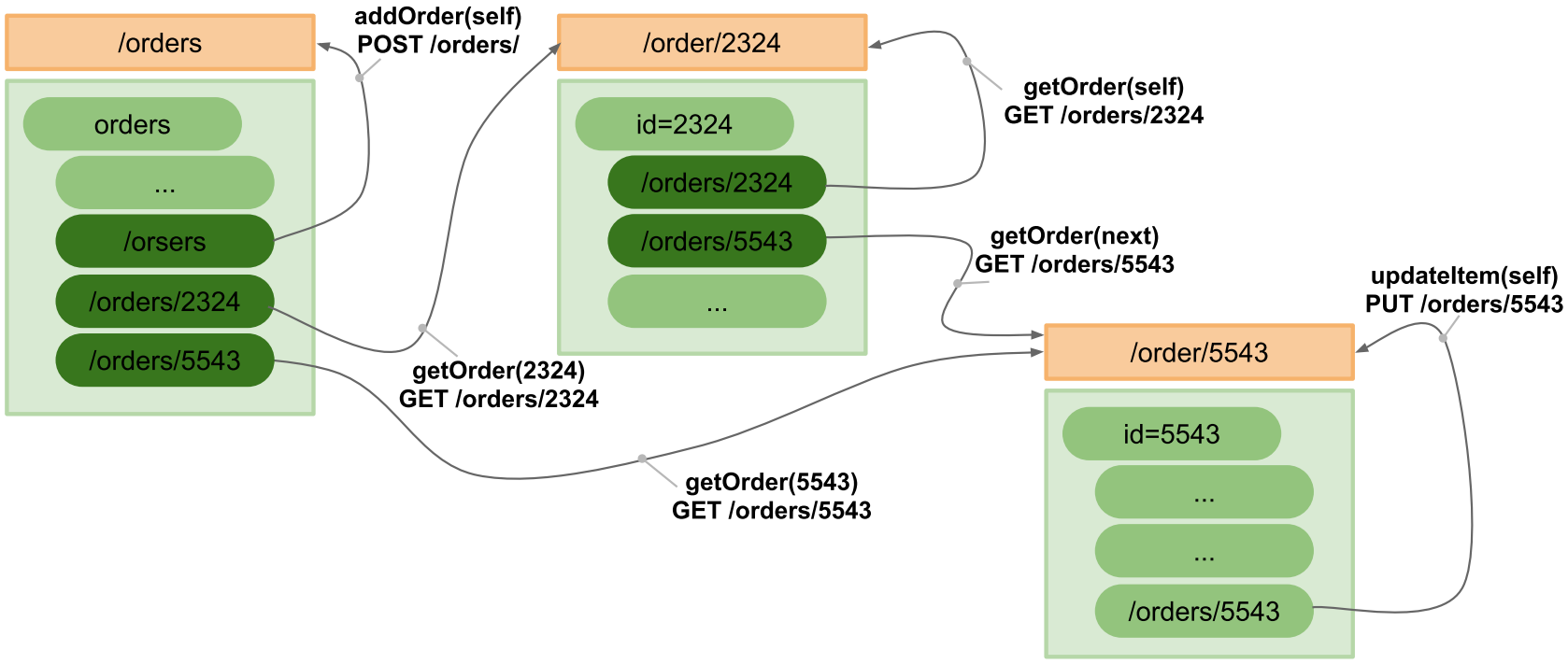


Persistent Storage and Session Memory

- Persistent Storage
  - *Contains the app data*
  - *Data is serialized into resource representation formats*
  - *All sessions may access the data via resource IDs*
- Session Memory
  - *Server memory that contains a state of the app*
  - *A session may only access its session memory*
  - *Access through cookies*
  - *Note*
    → *A session memory may be implemented via a persistent storage (such as in Google AppEngine)*

Link

- Service operation
  - *Applying an access to a link (GET, PUT, POST, DELETE)*
  - *Link: HTTP method + resource URI + optional link semantics*
- Example: `getOrder`, `addOrder`, and `updateItem`



Atom Links

- Atom Syndication Format
  - *XML-based document format; Atom feeds*
  - *Atom links becoming popular for RESTful applications*

```
1  <order a:xmlns="http://www.w3.org/2005/Atom" xmlns="...">
2      <a:link
3          rel="next"
4          href="http://company.com/orders/5543"
5          type="application/xml"/>
6      <customer>Tomas</customer>
7      <items>...</items>
8  </order>
```

  - *Link structure*

    `rel` – *name of the link*

    ~ semantics of an operation behind the link

    `href` – *URI to the resource described by the link*

    `type` – *media type of the resource the link points to*

Link Semantics

- Standard `rel` values
  - *Navigation:* `next`, `previous`, `self`
  - *Does not reflect a HTTP method you can use*
- Extension `rel` values
  - *You can use* `rel` *to indicate a semantics of an operation*
  - *Example: add item, delete order, update order, etc.*
  - *A client associates this semantics with an operation it may apply at a particular state*
  - *The semantics should be defined by using an URI*

```
<order a:xmlns="http://www.w3.org/2005/Atom" xmlns="...">
    <id>2324</id>
    <a:link rel="http://company.com/op/addItem"
        href="http://company.com/orders/2324"/>
    <a:link rel="http://company.com/op/deleteOrder"
        href="http://company.com/orders/2324"/>
</order>
```

Link Headers

- An alternative to Atom links in resource representations
  - *links defined in HTTP Link header, Web Linking IETF spec*
  - *They have the same semantics as Atom Links*
  - *Example:*

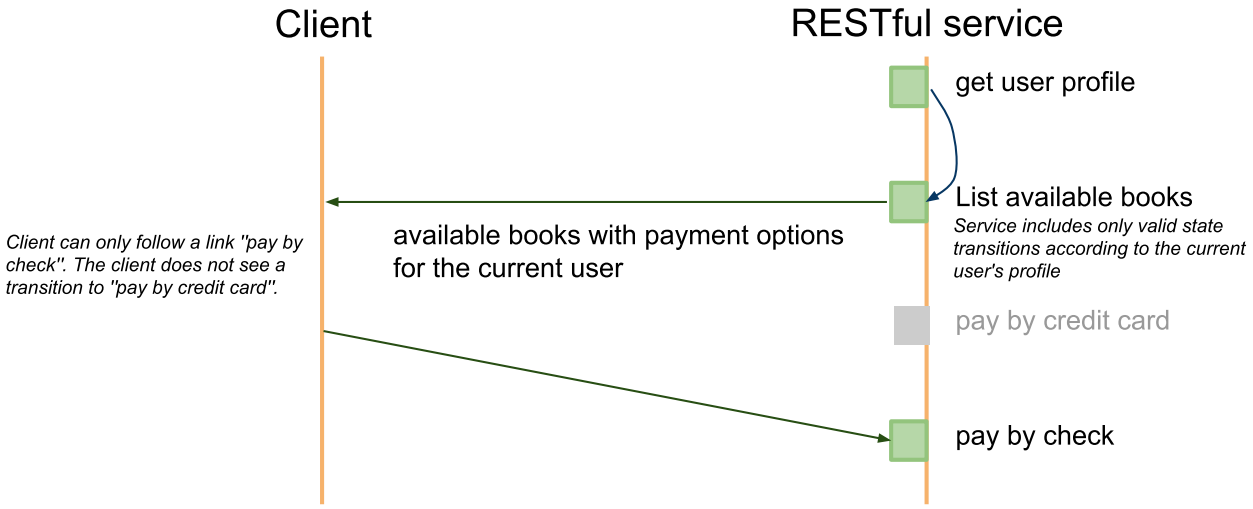
```
> HEAD /orders HTTP/1.1

< Content-Type: application/xml
< Link: <http://company.com/orders/?page=2&size=10>; rel="next"
< Link: <http://company.com/orders/?page=10&size=10>; rel="last"
```

- Advantages
  - *no need to get the entire document*
  - *no need to parse the document to retrieve links*
  - *use HTTP HEAD only*

Preconditions and HATEOAS

- Preconditions in HATEOAS
  - *Service in a current state generates only valid transitions that it includes in the representation of the resource.*
  - *Transition logic is realized at the server-side*



Advantages

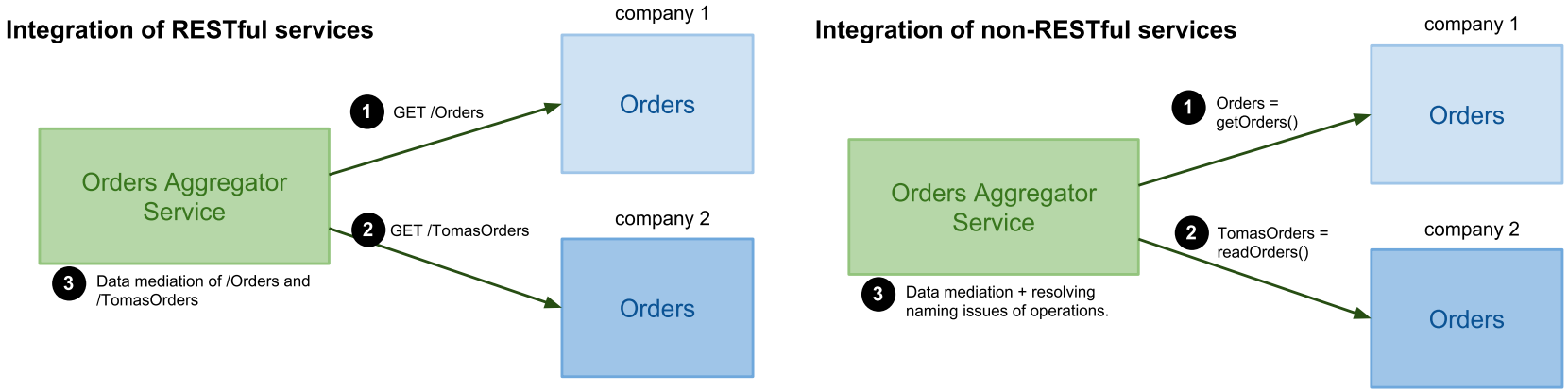
- Location transparency
  - *only "entry-level" links published to the World*
  - *other links within documents can change without changing client's logic*
  - *Hypertext represents the current user's view, i.e. rights or other context*
- Loose coupling
  - *no need for a logic to construct the links*
  - *Clients know to which states they can move via links*
- Statelessness and Cloud
  - *Better implementation of scalability*

Overview

- Integrating Applications
- Service Definition
- Service Communication
- REST
  - *Introduction to REST*
  - *Uniform Resource Identifier*
  - *Resource Representation*
  - *HATEOAS*
  - *Uniform Interface*
  - *Caching, Revalidation, Concurrency Control*
  - *Richardson Maturiy Model*
- SOAP and WSDL

Uniform Interface

- Uniform interface = finite set of operations
  - *Resource manipulation*
    - → *CRUD – Create (POST/PUT), Read (GET), Update (PUT/PATCH), Delete (DELETE)*
  - *operations are not domain-specific*
    - → *For example,* `GET /orders` *and not* `getOrders()`
    - → *This reduces complexity when solving interoperability*
- Integration issues examples



Safe and Unsafe Operations

- Safe operations
  - *Do not change the resource state*
  - *Usually "read-only" or "lookup" operation*
  - *Clients can cache the results and refresh the cache freely*
- Unsafe operations
  - *May change the state of the resource*
  - *Transactions such as buy a ticket, post a message*
  - *Unsafe does not mean dangerous!*
- Unsafe interactions and transaction results
  - `POST` *response may include transaction results*
    → *you buy a ticket and submit a purchase data*
    → *you get transaction results*
    → *and you cannot bookmark this..., why?*
  - *Should be referable with a persistent URI*

Idempotence

- Idempotent operation
  - *Invoking a method on the same resource always has the same effect*
  - *Operations* `GET`, `PUT`, `DELETE`
- Non-idempotent operation
  - *Invoking a method on the same resource may have different effects*
  - *Operation* `POST`
- Effect = a state change
  - *recall the effect definition in MDW*

GET

- Reading
  - `GET` *retrieves a representation of a state of a resource*

```
> GET /orders HTTP/1.1
> Accept: application/xml

< HTTP/1.1 200 OK
< Content-Type: application/xml
<
< ...resource representation in xml...
```

  - *It is read-only operation*
  - *It is **safe***
  - *It is **idempotent***
  - `GET` *retrieves different states over time but the effect is always the same, cf. resource state hence it is idempotent.*
  - *Invocation of* `GET` *involves content negotiation*

PUT

- Updating or Inserting
  - `PUT` *updates or inserts a representation of a state of a resource*
  - *Updating the resource is a* ***complete replacement of the resource***

```
> PUT /orders/4456 HTTP/1.1
> Content-Type: application/xml
>
> <order>...</order>

< HTTP/1.1 CODE
```

  - *where CODE is:*
    - → `200 OK` *or* `204 No Content` *for updating: A resource with id* `4456` ***exists****, the client sends an updated resource*
    - → `201 Created` *for inserting: A resource* ***does not exist****, the client generates the id* `4456` *and sends a representation of it.*
  - *It is* ***not safe*** *and it is* ***idempotent***

PATCH

- `PATCH` to partial update a resource
  - *IETF specification, see PATCH Method for HTTP*
- Use in GData Protocol
  - *To add, modify or delete selected elements of an Atom feed entry*
  - *Example to delete a description element and add a new title element* `gd:fields` *uses the partial response syntax*

```
1  PATCH /myFeed/1/1/
2  Content-Type: application/xml
3
4  <entry xmlns='http://www.w3.org/2005/Atom'
5      xmlns:gd='http://schemas.google.com/g/2005'
6      gd:fields='description'>
7    <title>New title</title>
8  </entry>
```

  - *Rules*
    - → *Fields not already present are added*
    - → *Non-repeating fields already present are updated*
    - → *Repeating fields already present are appended*

POST

- Inserting
  - `POST` *inserts a new resource*
  - *A server generates a new resource ID, client only supplies a content and a resource URI where the new resource will be inserted.*

```
> POST /orders HTTP/1.1
> Content-Type: application/xml
>
> <order>...</order>

< HTTP/1.1 201 Created
< Location: /orders/4456
```

  - *It is **not safe** an it is **not idempotent***
  - *A client may "suggest" a resource's id using the* `Slug` *header*
    → *Defined in AtomPub protocol*

DELETE

- Deleting
  - `DELETE` *deletes a resource with specified URI*

```
> DELETE /orders/4456 HTTP/1.1

< HTTP/1.1 CODE
```

  - *where CODE is:*
    - → `200 OK`*: the response body contains an entity describing a result of the operation.*
    - → `204 No Content`*: there is no response body.*
  - *It is* ***not safe*** *and it is* ***idempotent***
    - → *Multiple invocation of* `DELETE /orders/4456` *has always the same effect – the resource* `/orders/4456` *does not exist.*

Other

- HEAD
  - *same as* `GET` *but only retrieves HTTP headers*
  - *It is* ***safe*** *and* ***idempotent***
- OPTIONS
  - *queries the resource for resource configuration*
  - *It is* ***safe*** *and* ***idempotent***

Types of Errors

- Client-side – status code `4xx`
  - `400 Bad Request`
    - → *generic client-side error*
    - → *invalid format, such as syntax or validation error*
  - `404 Not Found`
    - → *server can't map URI to a resource*
  - `401 Unauthorized`
    - → *wrong credentials (such as user/pass, or API key)*
    - → *the response contains* `WWW-Authenticate` *indicating what kind of authentication the service accepts*
  - `405 Method Not Allowed`
    - → *the resource does not support the HTTP method the client used*
    - → *the response contains* `Allow` *header to indicate methods it supports*
  - `406 Not Acceptable`
    - → *so many restrictions on acceptable content types (using* `Accept-*`*)*
    - → *server cannot serialize the resource to requested content types*

Types of Errors (Cont.)

- Server-side – status code `5xx`
  - `500 Internal Server Error`
    - → *generic server-side error*
    - → *usually not expressive, logs a message for system admins*
  - `503 Service Not Available`
    - → *server is overloaded or is under maintenance*
    - → *the response contains* `Retry-After` *header*

Use of Status Codes

- Service should respect semantics of status codes!

```
> GET /orders HTTP/1.1
> Accept: application/json

< HTTP/1.1 200 OK
< Content-Type: application/json
<
< { "error" :
<    { "error_text" :
<        "you do not have rights to access this resource " }
< }
```

  - *Client must understand the semantics of the response.*
  - *This breaks loose coupling and reusability service principles*
  - *The response should be:*

```
< HTTP/1.1 401 Unauthorized
< ...

< ...optional text describing the error...
```

Respect HTTP Semantics

- Do not overload semantics of HTTP methods
  - *For example,* `GET` *is read-only method and idempotent*
  - *REST Anti-pattern:*

    ```
    GET /orders/?add=new_order
    ```

    → *This is not REST!*

    → *This breaks both safe and idempotent principles*
- Consequences
  - *Result of* `GET` *can be cached by proxy servers*
  - *They can revalidate their caches freely*
  - *You can end up with new entries in your storage without you knowing!*
- The same is true for other methods

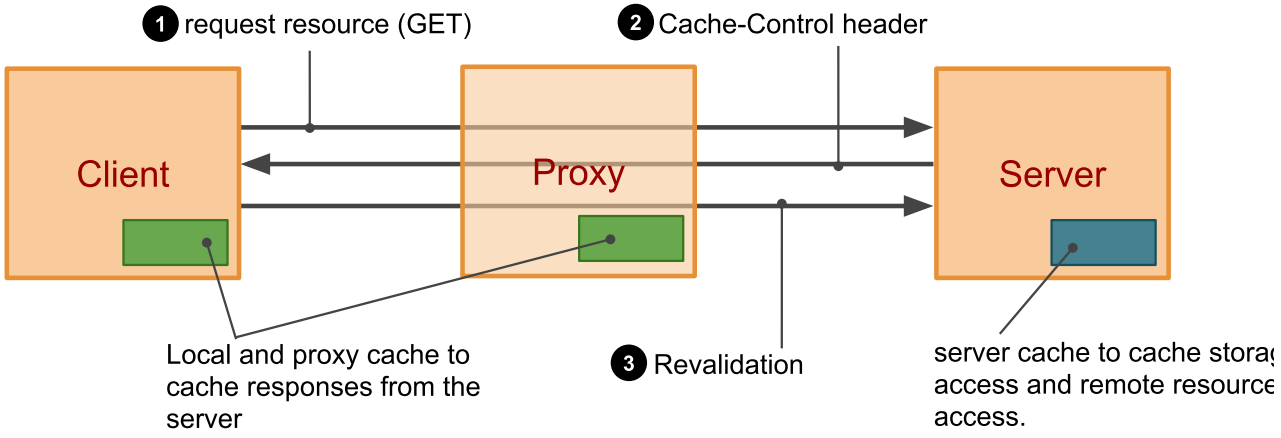
Overview

- Integrating Applications
- Service Definition
- Service Communication
- REST
  - *Introduction to REST*
  - *Uniform Resource Identifier*
  - *Resource Representation*
  - *HATEOAS*
  - *Uniform Interface*
  - *Caching, Revalidation, Concurrency Control*
  - *Richardson Maturiy Model*
- SOAP and WSDL

Scalability

- Need for scalability
  - *Huge amount of requests on the Web every day*
  - *Huge amount of data downloaded*
- Some examples
  - *Google, Facebook: 5 billion API calls/day*
  - *Twitter: 3 billions of API calls/day (75% of all the traffic)*
    → 50 million tweets a day
  - *eBay: 8 billion API calls/month*
  - *Bing: 3 billion API calls/month*
  - *Amazon WS: over 100 billion objects stored in S3*
- Scalability in REST
  - *Caching and revalidation*
  - *Concurrency control*

Caching



- Your service should cache:
  - *anytime there is a static resource*
  - *even there is a dynamic resource*
    - → *with chances it updates often*
    - → *you can force clients to always revalidate*
- three steps:
  - *client GETs the resource representation*
  - *server controls how it should cache through* `Cache-Control` *header*
  - *client revalidates the content via conditional GET*

Cache Headers

- `Cache-Control` response header
  - *controls over local and proxy caches*
  - `private` – *no proxy should cache, only clients can*
  - `public` – *any intermediary can cache (proxies and clients)*
  - `no-cache` – *the response should not be cached. If it is cached, the content should always be revalidated.*
  - `no-store` – *can cache but should not store persistently. When a client restarts, content is lost*
  - `no-transform` – *no transformation of cached data; e.g. compressions*
  - `max-age`, `s-maxage` *a time in seconds how long the cache is valid;* `s-maxage` *for proxies*
- `Last-Modified` and `ETag` response headers
  - *Content last modified date and a content entity tag*
- `If-Modified-Since` and `If-None-Match` request headers
  - *Content revalidation (conditional GET)*

Example Date Revalidation

- Cache control example:

```
> GET /orders HTTP/1.1
> ...

< HTTP/1.1 200 OK
< Content-Type: application/xml
< Cache-Control: private, no-store, max-age=200
< Last-Modified: Sun, 7 Nov 2011, 09:40 CET
<
< ...data...
```

  - *only client can cache, must not be stored on the disk, the cache is valid for 200 seconds.*

- Revalidation (conditional GET) example:
  - *A client revalidates the cache after* `200` *seconds.*

```
> GET /orders HTTP/1.1
> If-Modified-Since: Sun, 7 Nov 2011, 09:40 CET

< HTTP/1.1 304 Not Modified
< Cache-Control: private, no-store, max-age=200
< Last-Modified: Sun, 7 Nov 2011, 09:40 CET
```

Entity Tags

- Signature of the response body
  - *A hash such as MD5*
  - *A sequence number that changes with any modification of the content*
- Types of tag
  - *Strong ETag: reflects the content bit by bit*
  - *Weak ETag: reflects the content "semantically"*
    - *→ The app defines the meaning of its weak tags*
- Example content revalidation with `ETag`

```
< HTTP/1.1 200 OK
< Cache-Control: private, no-store, max-age=200
< Last-Modified: Sun, 7 Nov 2011, 09:40 CET
< ETag: "4354a5f6423b43a54d"

> GET /orders HTTP/1.1
> If-None-Match: "4354a5f6423b43a54d"

< HTTP/1.1 304 Not Modified
< Cache-Control: private, no-store, max-age=200
< Last-Modified: Sun, 7 Nov 2011, 09:40 CET
< ETag: "4354a5f6423b43a54d"
```

Design Suggestions

- Composed resources use weak ETags
  - *For example* `/orders`
    → *a composed resource that contains a summary information*
    → *changes to an order's items will not change semantics of* `/orders`
  - *It is usually not possible to perform updates on these resources*
- Non-composed resources use strong ETags
  - *For example* `/orders/{order-id}`
  - *They can be updated*
- Further notes
  - *Server should send both* `Last-Modified` *and* `ETag` *headers*
  - *If client sends both* `If-Modified-Since` *and* `If-None-Match`, `ETag` *validation takes preference*

Weak ETag Example

- App specific, `/orders` resource example

```
{
    "orders" :
        [
            { "id"        : 2245,
              "customer"  : "Tomas",
              "descr"     : "Stuff to build a house.",
              "items"     : [...] },
            { "id"        : 5546,
              "customer"  : "Peter",
              "descr"     : "Things to build a pipeline.",
              "items"     : [...] }
        ]
}
```

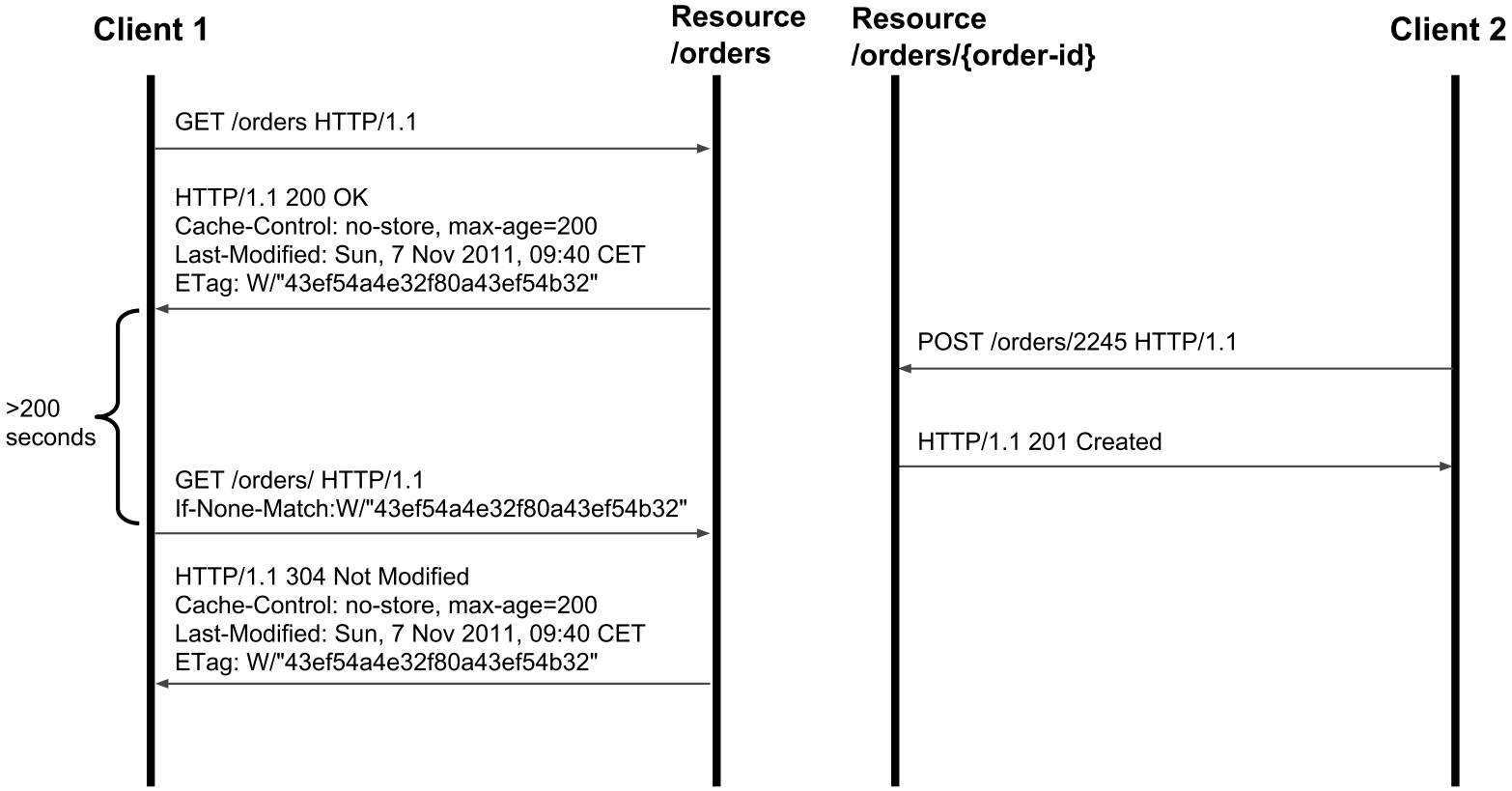
- Weak ETag compute function example
  - *Any modification to an order's items is not significant for* `/orders`*:*

```
var crypto = require("crypto");

function computeWeakETag(orders) {
    var content = "";
    for (var i = 0; i < orders.length; i++)
        content += orders[i].id + orders[i].customer + orders[i].descr;
    return crypto.createHash('md5').update(content).digest("hex");
}
```

Weak ETag Revalidation

- Updating `/orders` resource
  - `POST /orders/{order-id}` *inserts a new item to an order*
  - *Any changes to orders' items will not change the Weak ETag*



Concurrency

- Two clients may update the same resource

  1) a client GETs a resource `GET /orders/5545`

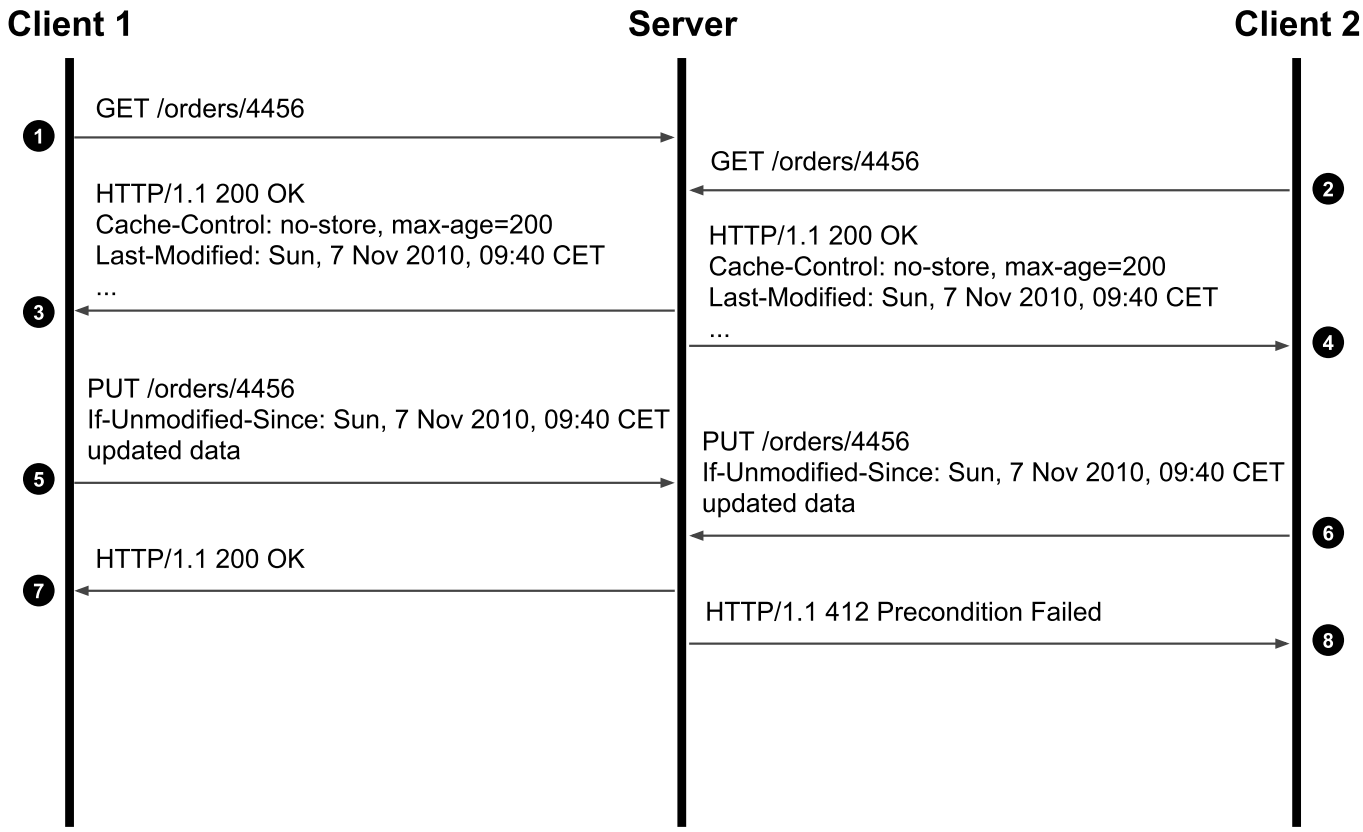
  2) the client modifies the resource

  3) the client updates the resource via `PUT /orders/5545 HTTP/1.1`

  What happens if another client updates the resource between 1) and 3) ?

- Concurrency control
  - *Conditional* `PUT`
    - → *Update the resource only if it has not changed since a specified date or a specified ETag matches the resource content*
  - `If-Unmodified-Since` *and* `If-Match` *headers*
  - *Response to conditional* `PUT`*:*
    - → `200 OK` *if the* `PUT` *was successful*
    - → `412 Precondition Failed` *if the resource was updated in the meantime.*

Concurrency Control Protocol

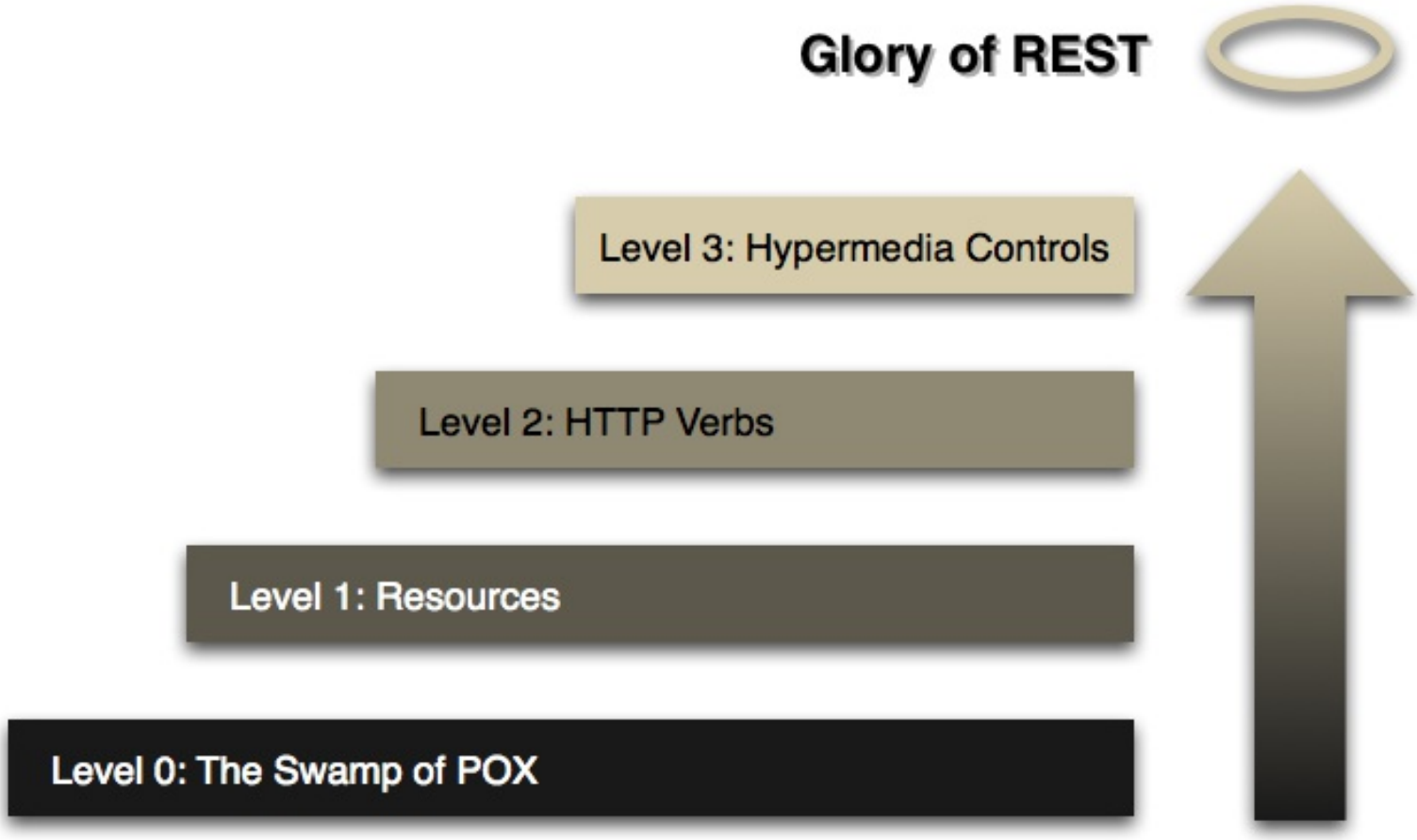


- Conditional PUT and ETags
  - *Conditional PUT must always use strong entity tags or date validation*

Overview

- Integrating Applications
- Service Definition
- Service Communication
- REST
  - *Introduction to REST*
  - *Uniform Resource Identifier*
  - *Resource Representation*
  - *HATEOAS*
  - *Uniform Interface*
  - *Caching, Revalidation, Concurrency Control*
  - *Richardson Maturiy Model*
- SOAP and WSDL

Steps towards REST



See Richardson Maturiy Model details.

Levels

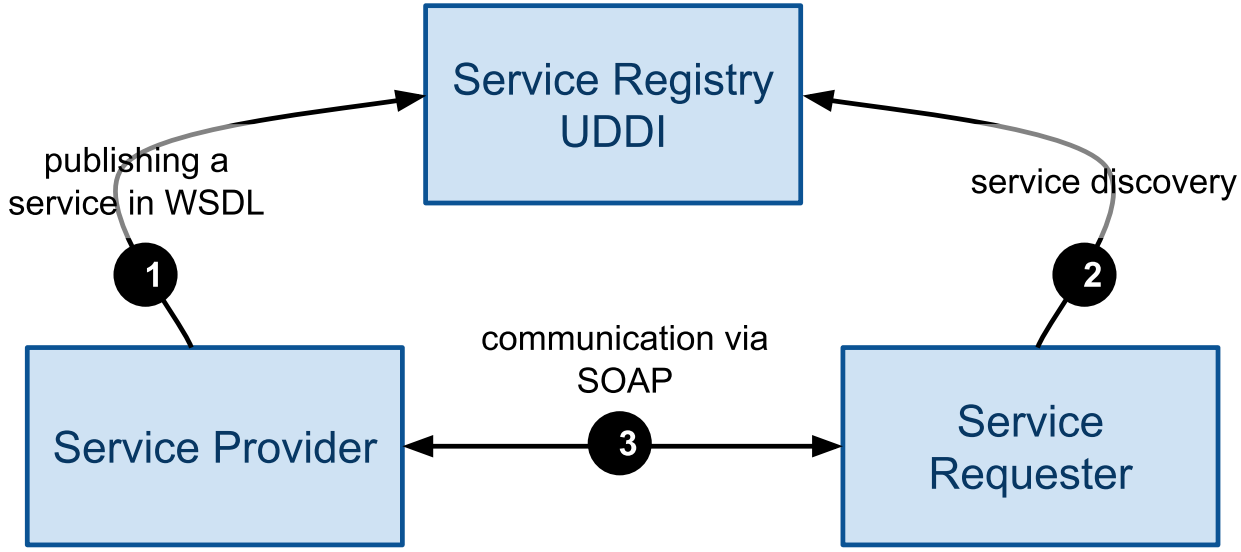
- LEVEL 0 – POX (Plain Old XML)
  - *HTTP as a tunneling mechanism*
  - *URL defines a service endpoint*
  - *No Web principles*
- LEVEL 1 – Resources
  - *Take advantages of reosources and URIs*
- LEVEL 2 – HTTP Verbs
  - *Use HTTP methods and respect their semantics*
- LEVEL 3 – Hypermedia Conrols
  - *HATEOS*

Overview

- Integrating Applications
- Service Definition
- Service Communication
- REST
- SOAP and WSDL
  - *Introduction to SOAP*
  - *WSDL*
  - *WS-Addressing*

Web Service Architecture

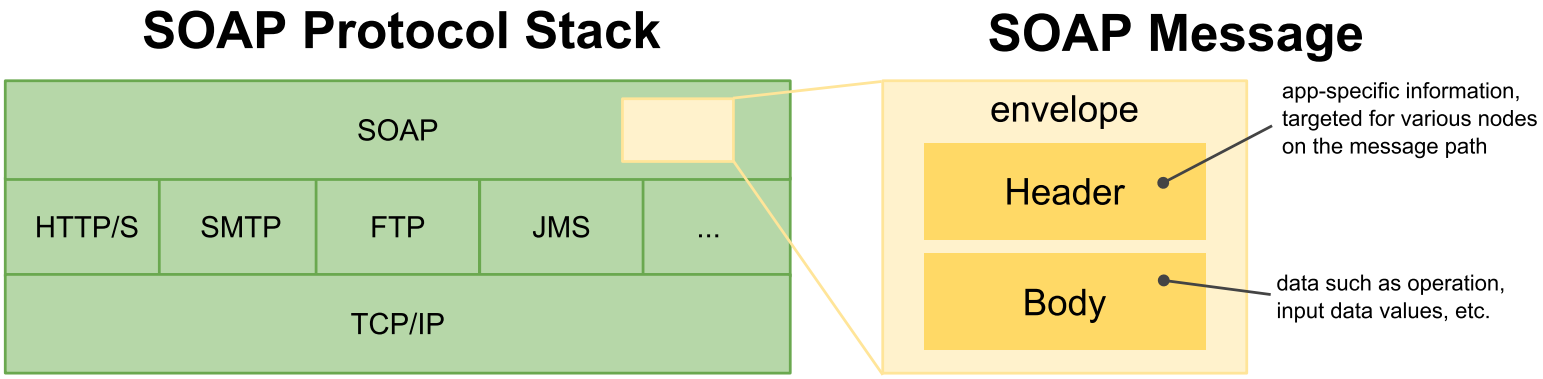
- WSDL, SOAP and UDDI



  - *Realization of SOA*
  - *Message-Oriented view*
    - → *SOAP messaging (header, body)*
    - → *types of messages – input, output, fault*

SOAP Protocol

- SOAP defines a messaging framework



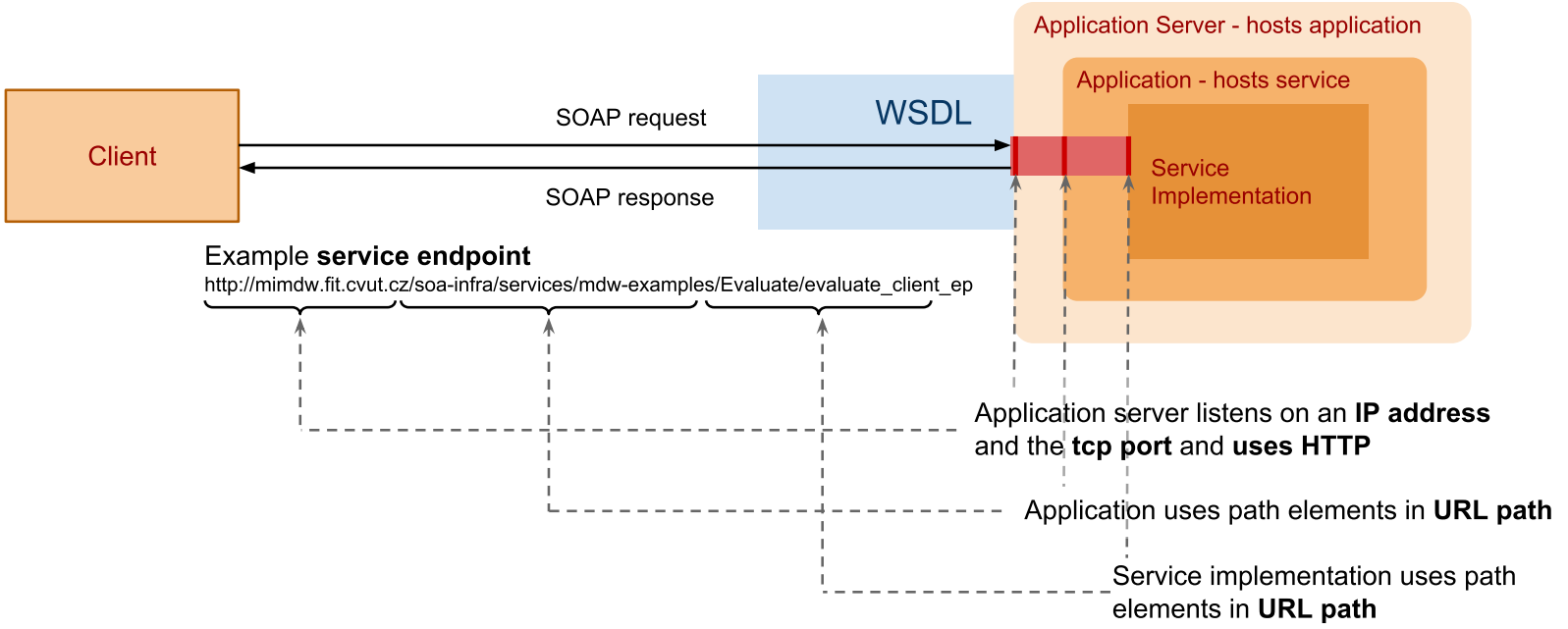
– *XML-based protocol*
– *a layer over transport protocols*
  → binding to HTTP, SMTP, JMS, ...
– *involves multiple nodes (message path)*
  → sender, receiver, intermediary

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



  - *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`

```xml
<soap:Envelope xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/">
        <soap:Body>
                <ns1:evaluateRequest
                xmlns:ns1="http://xmlns.oracle.com/mdw_examples/Evaluate/evaluate"
                        <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_client_
```

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/3.14.0.0 zl
> 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

- Integrating Applications
- Service Definition
- Service Communication
- REST
- SOAP and WSDL
  - *Introduction to SOAP*
  - *WSDL*
  - *WS-Addressing*

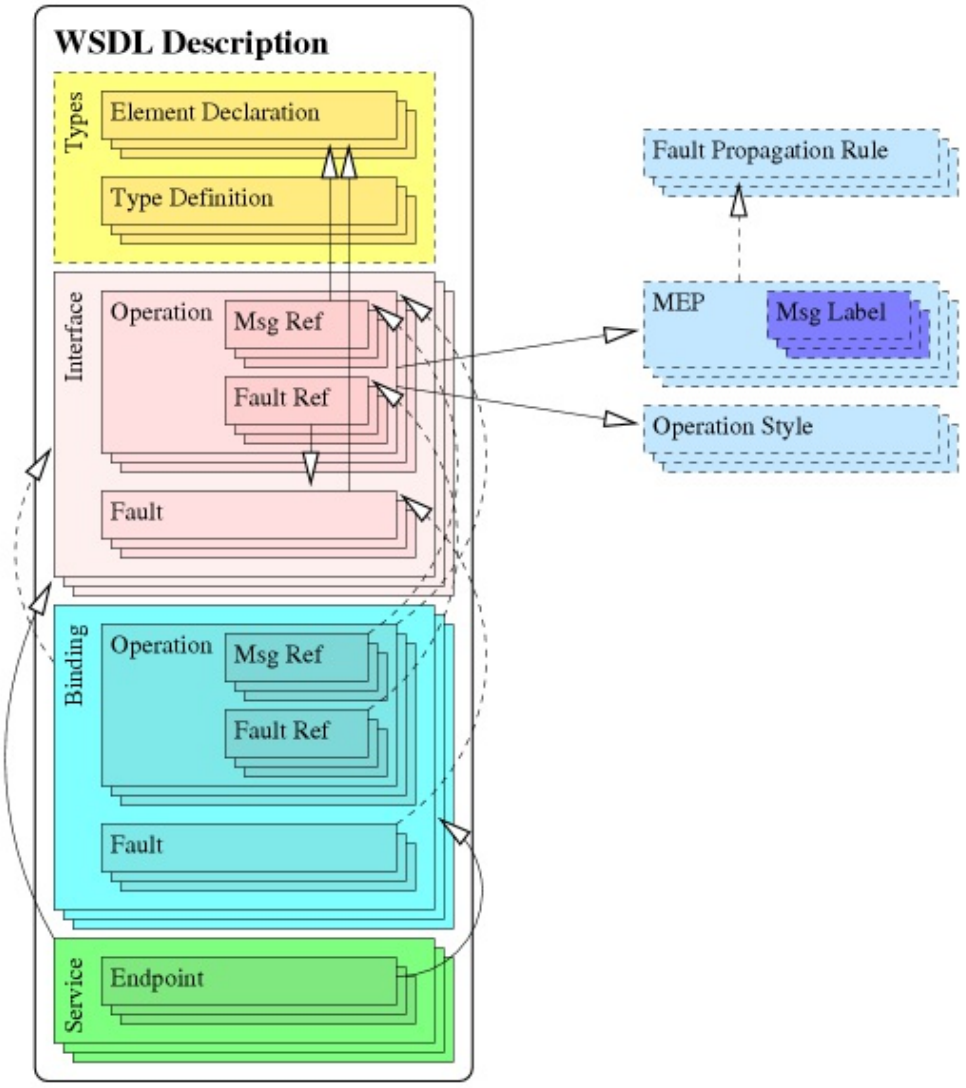
Specifications

- WSDL = Web Service Description Language
  - *A standard that allows to describe Web services explicitly (main aspects)*
  - *A contract between a requester and a provider*
- Specifications
  - *WSDL 1.1 – still widely used*
    - → *Web Service Description Language 1.1*
  - *WSDL 2.0 – An attempt to address several issues with WSDL 1.1*
    - → *SOAP vs. REST, naming, exrpessivity*
    - → *WSDL 2.0 Primer (part 0)*
    - → *WSDL 2.0 Core Language (part 1)*

WSDL Overview and WSDL 1.1 Syntax

- Components of WSDL
  - *Information model (`types`)*
    - → *Element types, message declarations (XML Schema)*
  - *Set of operations (`portType`)*
    - → *A set of operations is "interface" in the WSDL terminology*
    - → *operation name, input, output, fault*
  - *Binding (`binding`)*
    - → *How messages are transfered over the network using a concrete transport protocol*
    - → *Transport protocols: HTTP, SMTP, FTP, JMS, ...*
  - *Endpoint (`service`)*
    - → *Where the service is physically present on the network*
- Types of WSDL documents
  - ***Abstract WSDL*** *– only information model and a set of operations*
  - ***Concrete WSDL*** *– everything, a concrete service available in the environment*

WSDL Components and Dependencies



Overview

- Integrating Applications
- Service Definition
- Service Communication
- REST
- SOAP and WSDL
  - *Introduction to SOAP*
  - *WSDL*
  - *WS-Addressing*

Overview

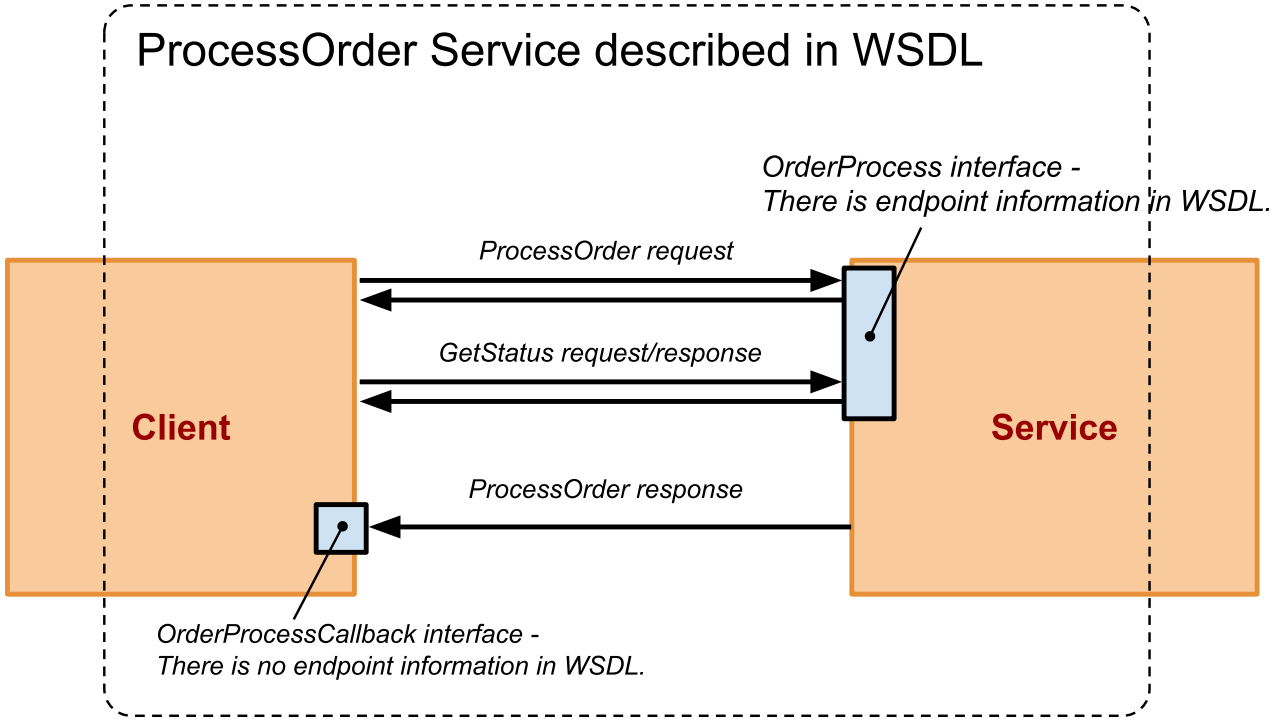
- WS-Addressing
  - *W3C Recommendation, May 2006*
  - *A transport-independent mechanisms for web services to communicate addressing information*
  - *WSDL describes WS-Addressing as a policy attached to a WSDL binding*

```
1  <binding name="OrderProcessBinding" type="op:OrderProcess">
2      <soap:binding transport="http://schemas.xmlsoap.org/soap/http"/>
3      <PolicyReference xmlns:wsp="http://schemas.xmlsoap.org/ws/2004/09/policy"
4          URI="#wsaddr_policy" wsdl:required="false"/>
```

- Two main purposes
  1. *Asynchronous communication*
     - *Client sends an endpoint where the server should send a response asynchronously*
  2. *Relating interactions to a conversation*
     - *Client and service communicate conversation ID*

Order Processing Example

- Asynchronous communication via callback, steps:
  - *Client submits an order request*
  - *Service starts processing of the order (CRM, OMS, back-office)*
  - *Client can retrieve the order status*
  - *Service responds asynchronously with an order response message*



Interface Example (1)

- Order process complex conversation
  1. *The client invokes* `processOrder`.
  2. *The service responses back* ***synchronously*** *with order status.*
  3. *The client gets the status of order processing by invoking synchronous* `getStatus` *operation (this can be invoked serveral times).*
  4. *The service responses back* ***asynchronously*** *by invoking* `processOrderResponse` *– callback on client's interface*
- Interface implemented by the order process service
  - `getStatus` *operation must be executed in the same* ***conversation*** *as* `processOrder` *operation*

```
1  <portType name="OrderProcess">
2      <operation name="processOrder">
3          <input message="op:OrderProcessRequestMessage"/>
4          <output message="op:OrderStatusResponseMessage"/>
5      </operation>
6      <operation name="getStatus">
7          <input message="op:OrderStatusRequestMessage"/>
8          <output message="op:OrderStatusResponseMessage"/>
```

Interface Example (2)

- Interface implemented by the client

```
<portType name="OrderProcessCallback">
    <operation name="processOrderResponse">
        <input message="op:OrderProcessResponseMessage"/>
        <fault message="op:OrderProcessFaultMessage"/>
    <operation>
</portType>
```

ProcessOrder Request Message

- Client sends process order request – `processOrder`
  - *it sends addressing information where the client listens for the callback*
  - *it sends conversation ID (message ID) to start the conversation on the server*

```
> POST /soa-infra/services/mdw-examples/ProcessOrder/orderprocess_client_ep HTTP/1.1
> Host: mimdw.fit.cvut.cz
> Content-Type: text/xml;charset=UTF-8
> SOAPAction: "processOrder"
> Content-Length: 810

<soap:Envelope xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/"
    xmlns:ord="http://mimdw.fit.cvut.cz/mdw-examples/cdm/order">
     <soap:Header xmlns:wsa='http://www.w3.org/2005/08/addressing'>
        <wsa:ReplyTo>
            <wsa:Address>http://192.168.94.110:2233/path/to/service</wsa:Address>
        </wsa:ReplyTo>
        <wsa:MessageID>urn:AXYYBA00531111E3BFACA780A7E5AF64</wsa:MessageID>
     </soap:Header>
     <soap:Body>
        <ord:Order>
            <ord:CustomerId>1</ord:CustomerId>
            <ord:LineItems>
                <ord:item>
                    <ord:label>Apple MacBook Pro</ord:label>
                    <ord:action>ADD</ord:action>
                </ord:item>
            </ord:LineItems>
        </ord:Order>
    </soap:Body>
</soap:Envelope>
```

GetStatus Request Message

- Client sends get status request – `getStatus`
  - *after it invokes* `processOrder` *with conversation ID (message ID)*
  - *it uses the same conversation ID for get status request too*
    - → *the request will be procesessed by the running service instance*

```
1  > POST /soa-infra/services/mdw-examples/ProcessOrder/orderprocess_client_ep HTTP/1.1
2  > Host: mimdw.fit.cvut.cz
3  > Content-Type: text/xml;charset=UTF-8
4  > SOAPAction: "getStatus"
5  > Content-Length: 472
6
7  <soap:Envelope xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/">
8      <soap:Header xmlns:wsa="http://www.w3.org/2005/08/addressing">
9          <wsa:RelatesTo>urn:AXYYBA00531111E3BFACA780A7E5AF64</wsa:RelatesTo>
10     </soap:Header>
11     <soap:Body>
12         <ns1:StatusRequest
13             xmlns:ns1="http://mimdw.fit.cvut.cz/mdw_examples/ProcessOrder/OrderProcess
14             <ns1:process-id>18a9baec2d5ac0a2:64d155de:1425c4185f1:-7ff2</ns1:process-i
15         </ns1:StatusRequest>
16     </soap:Body>
17 </soap:Envelope>
```