

Web 2.0

Lecture 2: REST Architecture 1

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/w20>



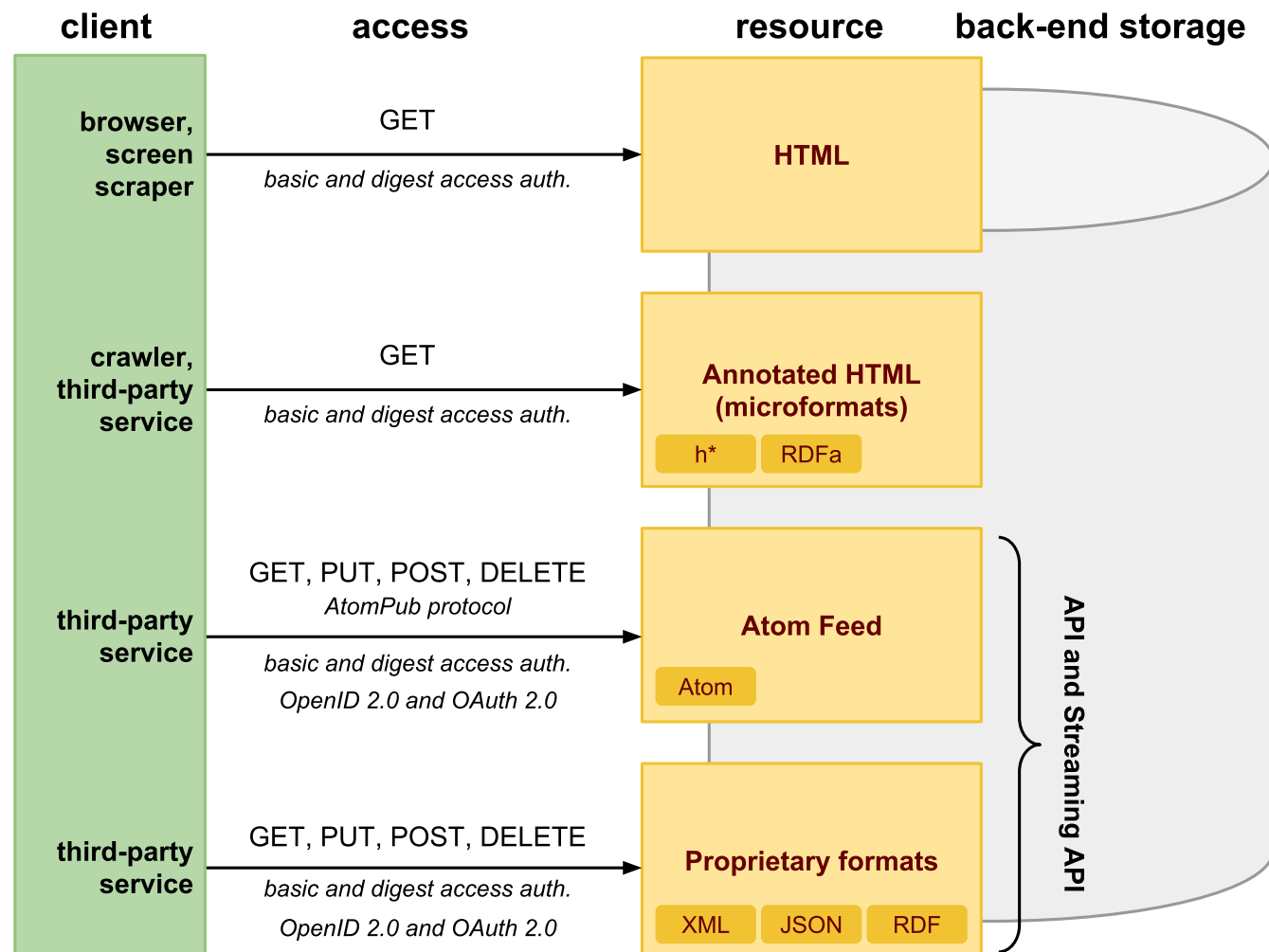
Evropský sociální fond
Praha & EU: Investujeme do vaší budoucnosti

Modified: Sun Mar 04 2018, 22:10:55
Humla v0.3

Overview

- Overview of Formats and Protocols
- Introduction to REST
- Uniform Resource Identifier
- Resource Representation
- HATEOAS

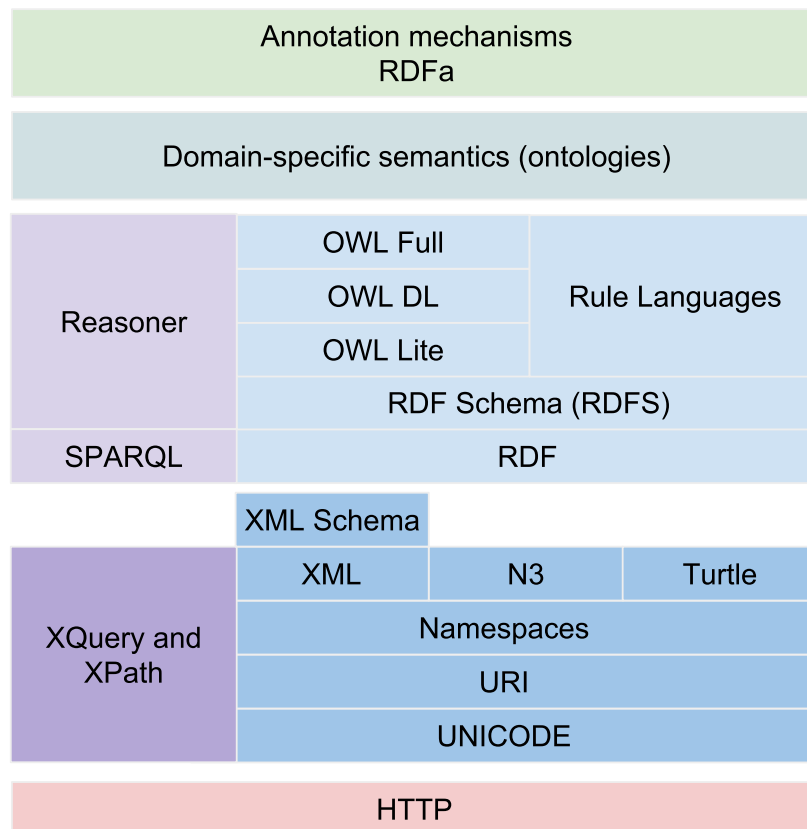
Data on the Web



Data Syntax, Structure and Semantics

Semantic Web Layered Cake

syntax and formal semantics



Web Data Formats

syntax and semantics (structure)



Overview

- Overview of Formats and Protocols
- **Introduction to REST**
- Uniform Resource Identifier
- Resource Representation
- HATEOAS

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

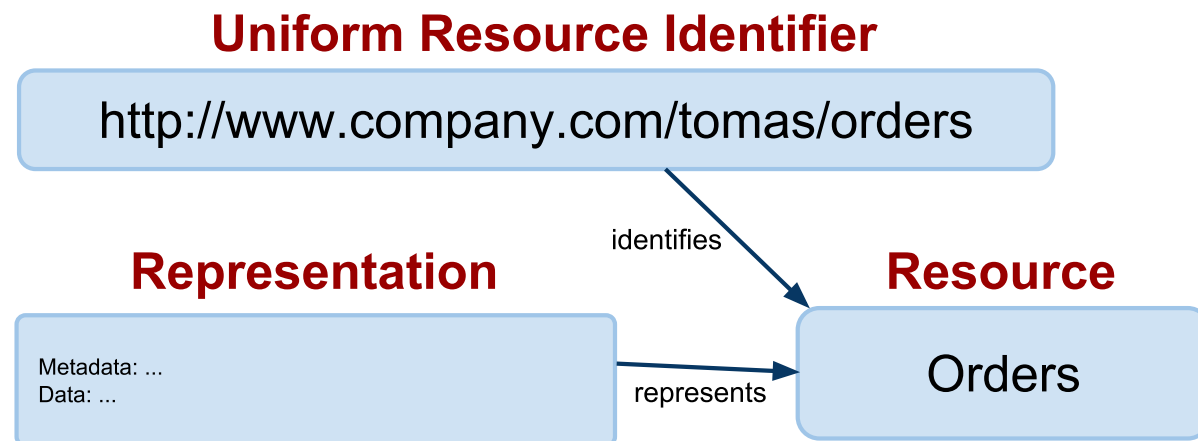
- Familiarity
 - *HTTP protocol is well-known and widely used*
- Interoperability
 - *All environments have HTTP client libraries*
 - *technical interoperability is thus no problem*
 - *no need to deal with vendor-specific interoperability issues*
 - *You can focus on the core of the integration problem*
 - *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

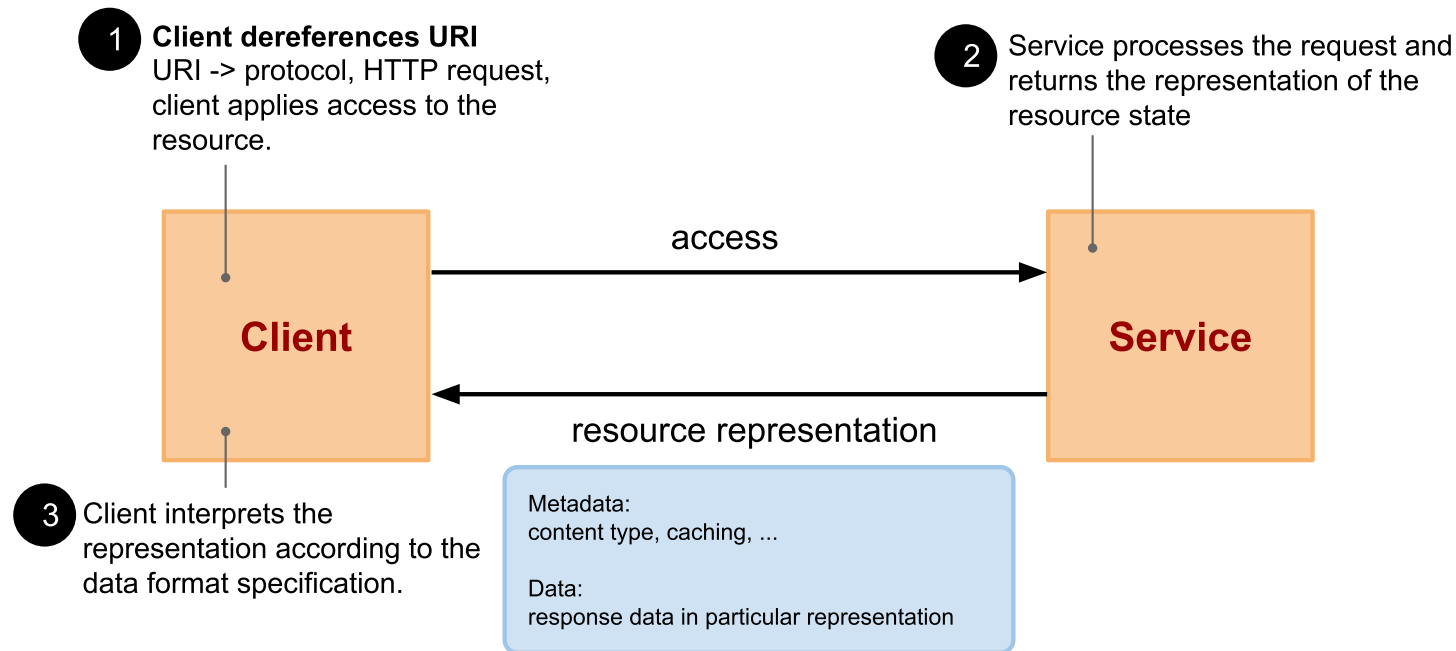
- REST architectural style defines constraints
 - *if you follow them, they help you to achieve a good design, interoperability and scalability.*
- Constraints
 - *Client/Server*
 - *Statelessness*
 - *Cacheability*
 - *Layered system*
 - *Uniform interface*
- Guiding principles
 - *Identification of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

- Overview of Formats and Protocols
- Introduction to REST
- **Uniform Resource Identifier**
 - *Resources and Application Data*
- Resource Representation
- HATEOAS

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**

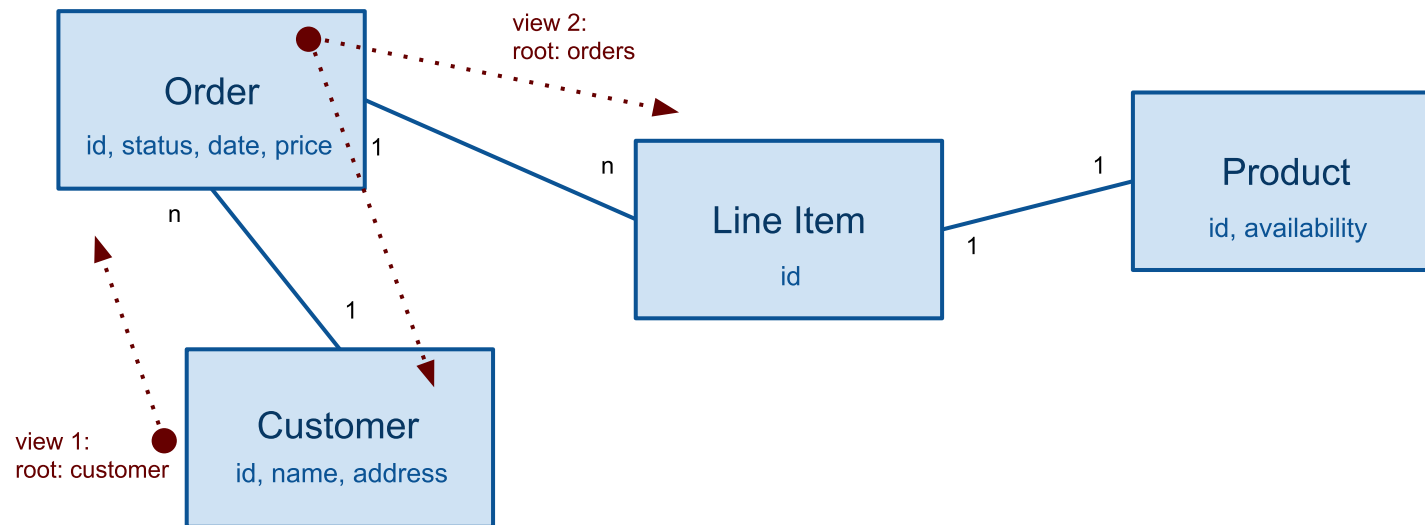
- *reference to a secondary resource within the primary resource*

Overview

- Overview of Formats and Protocols
- Introduction to REST
- Uniform Resource Identifier
 - *Resources and Application Data*
- Resource Representation
- HATEOAS

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`

- \Rightarrow *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

- Overview of Formats and Protocols
- Introduction to REST
- Uniform Resource Identifier
- **Resource Representation**
- HATEOAS

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

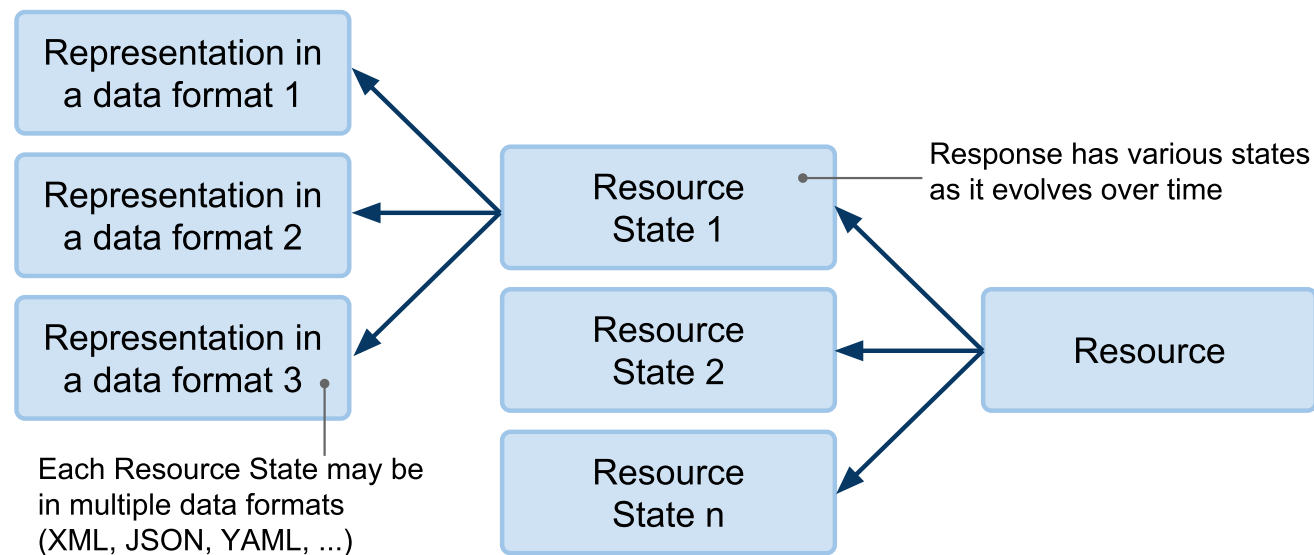
- Access
 - *to be retrieved (GET)*
 - *to be inserted or updated (PUT, POST)*
 - *to be deleted (DELETE)*
- Request
 - HTTP header **Accept**, part of content negotiation protocol
- Response
 - HTTP header **Content-Type: type/subtype; parameters**
 - Specifies an Internet Media Type [☞](#) of the resource 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)

```
1 <orders>
2   <order id="54467"/>
3   <order id="65432"/>
4 </orders>
```

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

```
1 <order>
2   ...
3 </order>
```

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

```
1 <orders>
2   <order id="54467"/>
3   <order id="65432"/>
4   <order id="74567"/>
5 </orders>
```

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

Overview

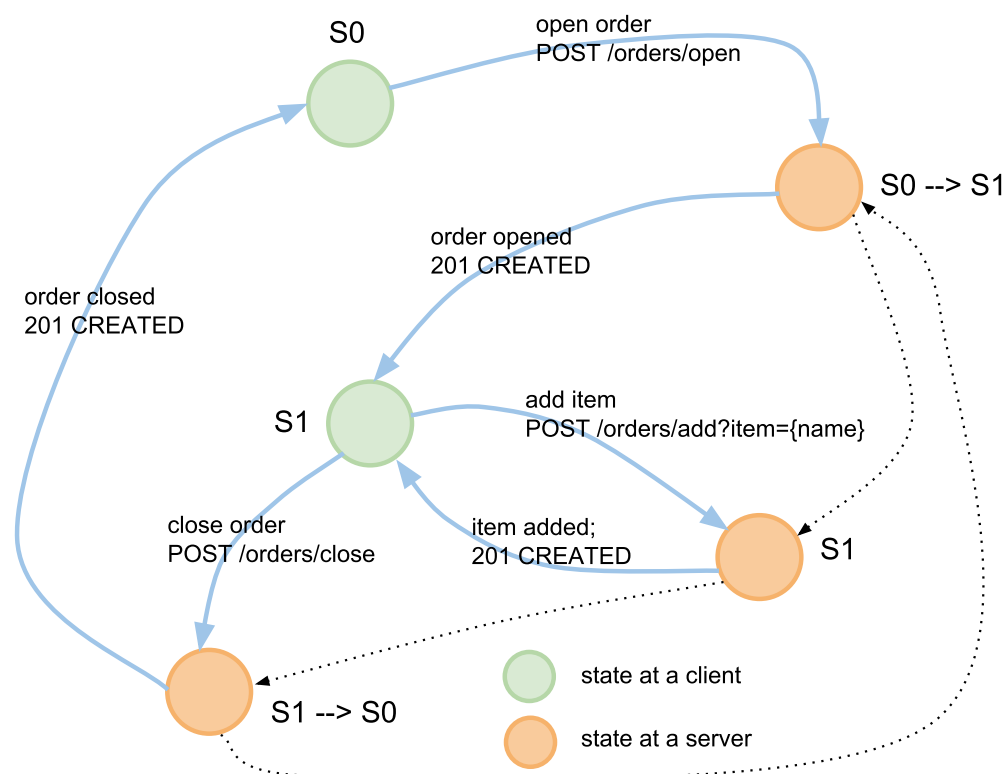
- Overview of Formats and Protocols
- Introduction to REST
- Uniform Resource Identifier
- Resource Representation
- **HATEOAS**

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*

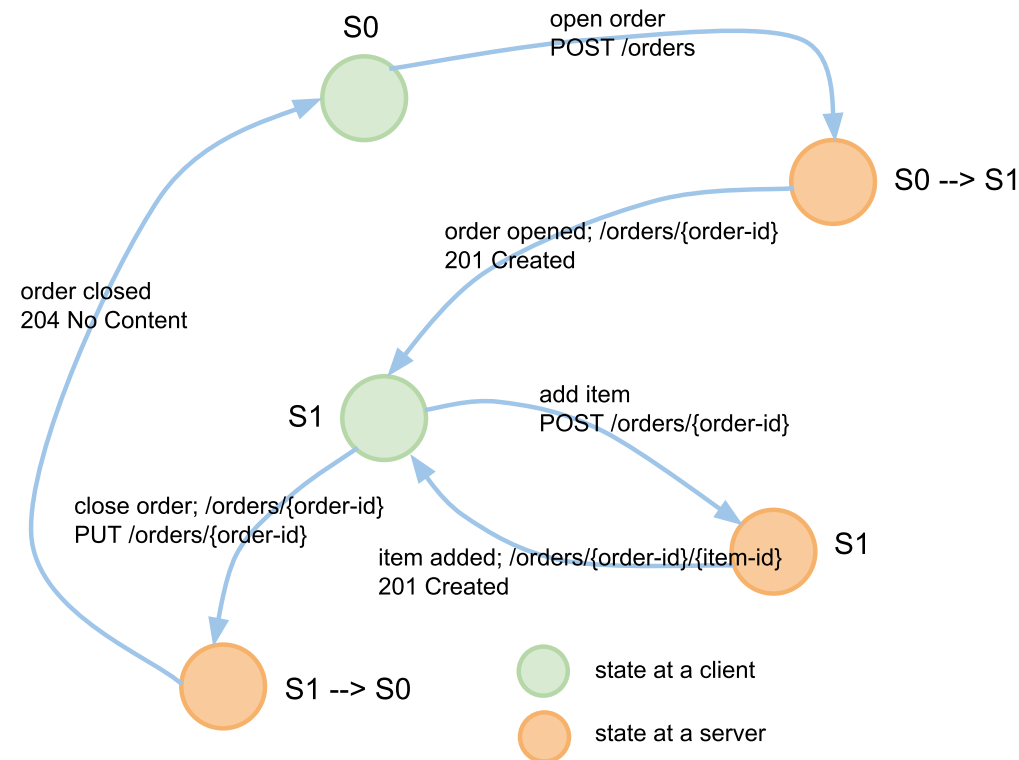
Stateful server

- Sessions to store the application state
 - Recall HTTP state management in MDW
 - The app uses a server memory to remember the state
 - When the server restarts, the app state is lost



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*

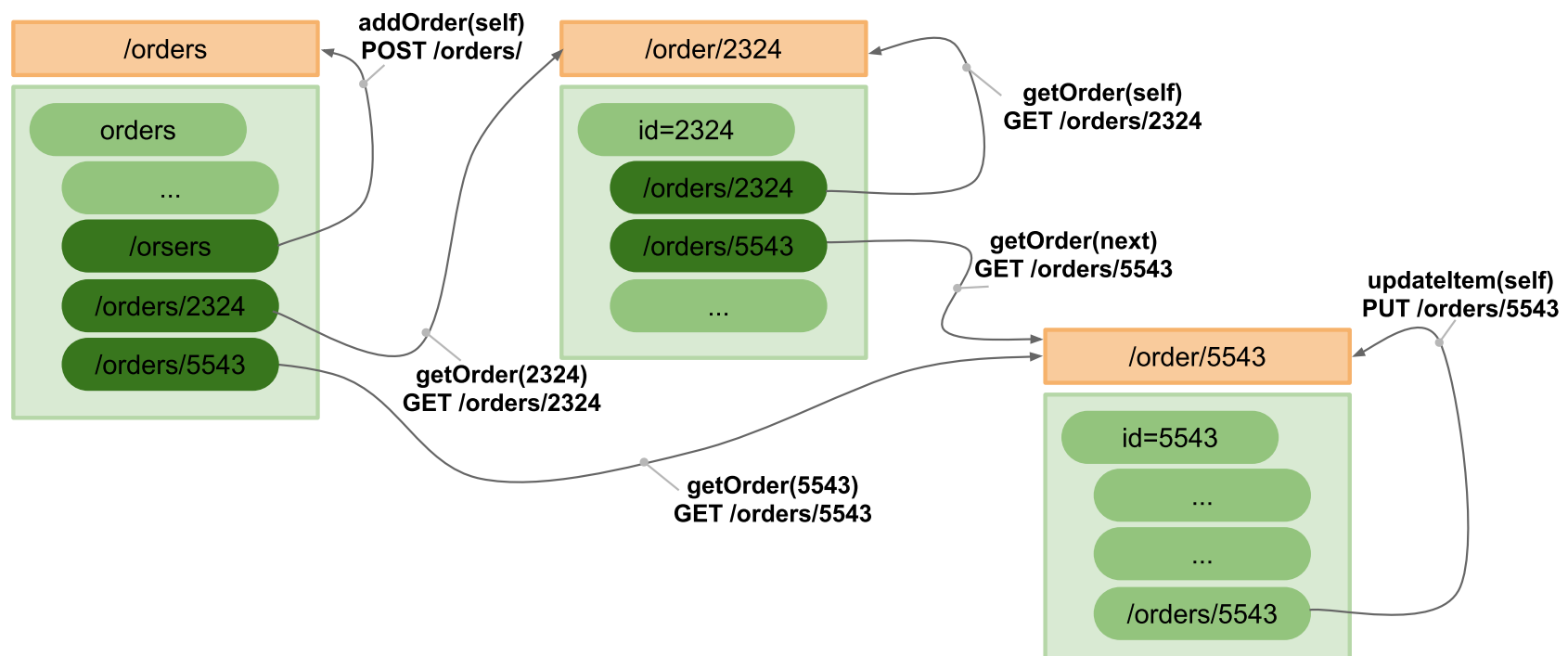


Persistent Storage and Session Memory

- 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*

```
1 <order a:xmlns="http://www.w3.org/2005/Atom" xmlns="...">
2   <id>2324</id>
3   <a:link rel="http://company.com/op/addItem"
4     href="http://company.com/orders/2324"/>
5   <a:link rel="http://company.com/op/deleteOrder"
6     href="http://company.com/orders/2324"/>
7 </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
```

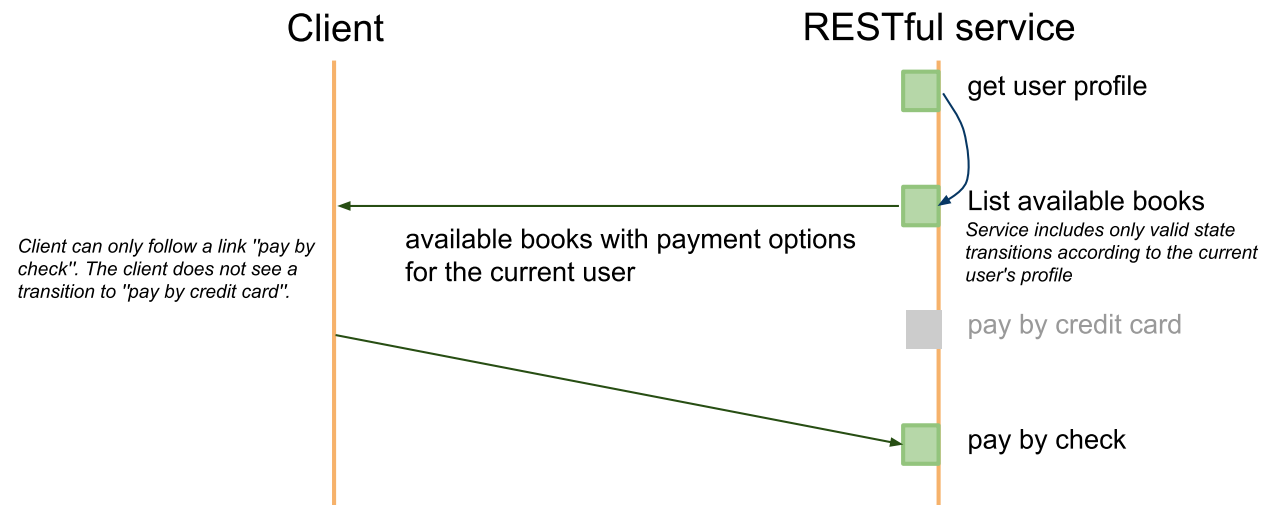
```
< Link: <http://company.com/orders/?page=2&size=10>; rel="next"
```

```
< 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*