

Web 2.0

Lecture 2: REST Architecture 1

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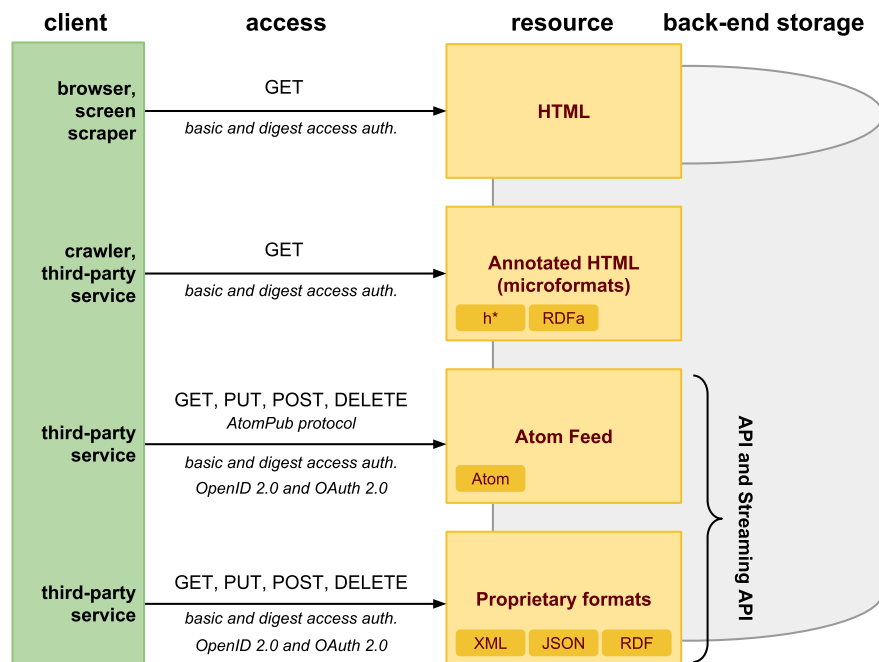


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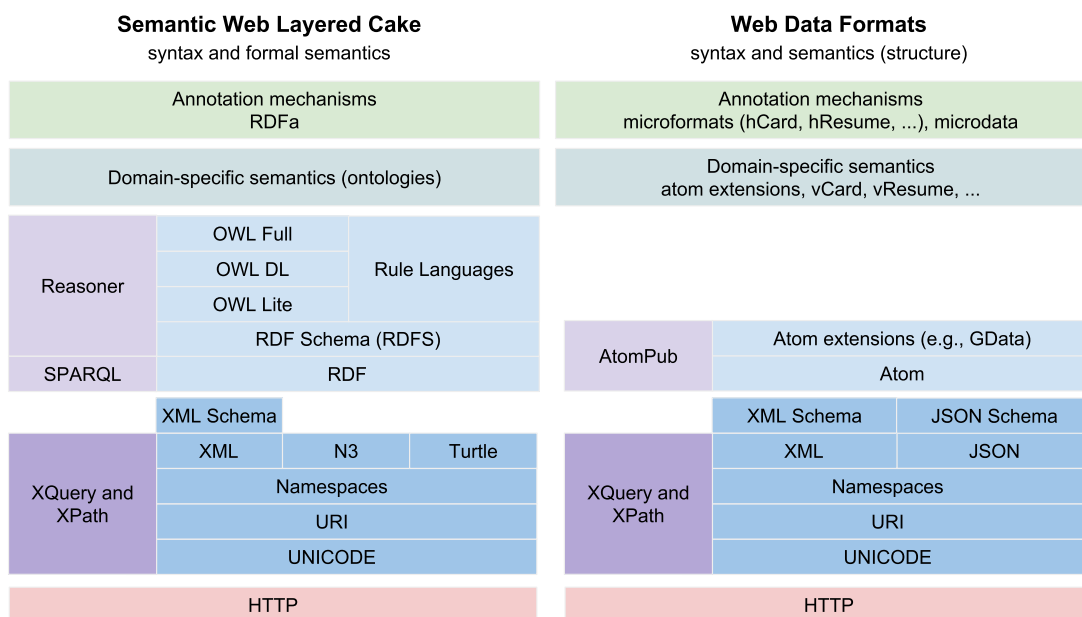
Overview

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

Data on the Web



Data Syntax, Structure and Semantics



Overview

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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 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

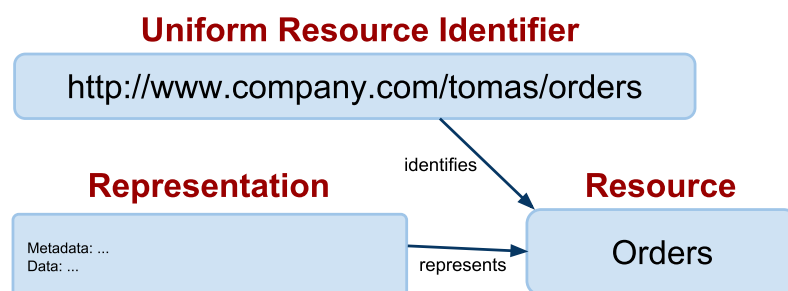
- Familiarity
 - *HTTP protocol is well-known and widely used*
- Interoperability
 - *All environments have HTTP client libraries*
 - *technical interoperability is thus no problem*
 - *no need to deal with vendor-specific interoperability issues*
 - *You can focus on the core of the integration problem*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

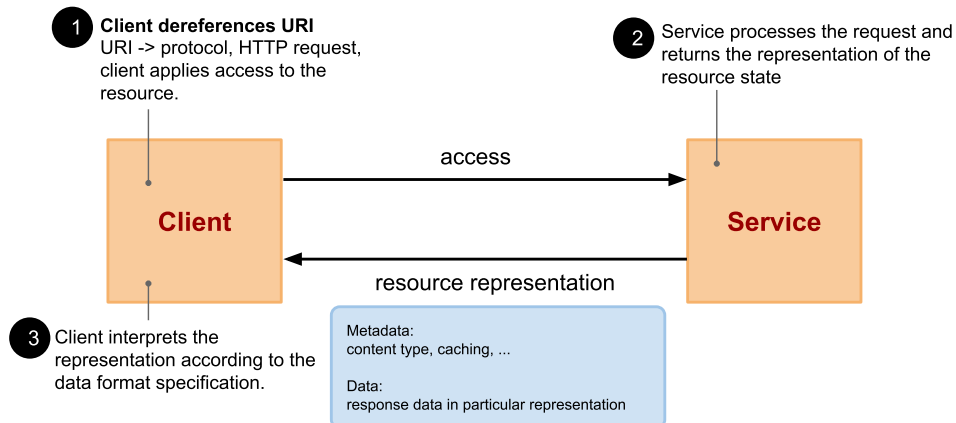
- REST architectural style defines constraints
 - *if you follow them, they help you to achieve a good design, interoperability and scalability.*
- Constraints
 - *Client/Server*
 - *Statelessness*
 - *Cacheability*
 - *Layered system*
 - *Uniform interface*
- Guiding principles
 - *Identification of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

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- **Uniform Resource Identifier**
 - *Resources and Application Data*
- 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

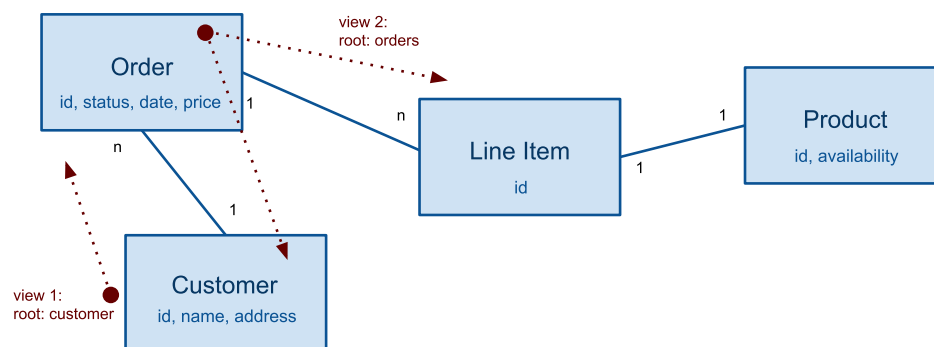
URI = scheme ":" ["//" authority] ["/" path] ["?" query] ["#" frag]
- Hierarchal sequence of components
 - **scheme**
 - refers to a spec that assigns IDs within that scheme
 - examples: **http**, **ftp**, **mailto**, **urn**
 - **scheme != protocol**
 - **authority**
 - registered name (domain name) 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

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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" resources' IDs
 - Example:
`/customers/{customer-id}/orders/{order-id}/`
 - There can be more URIs identifying the same resource

Major characteristics

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

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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
 - AtomPub protocol such as **author**, **updated**, ...
 - HTML **http-equiv** meta tags
- Resource anatomy



Content-Type Metadata

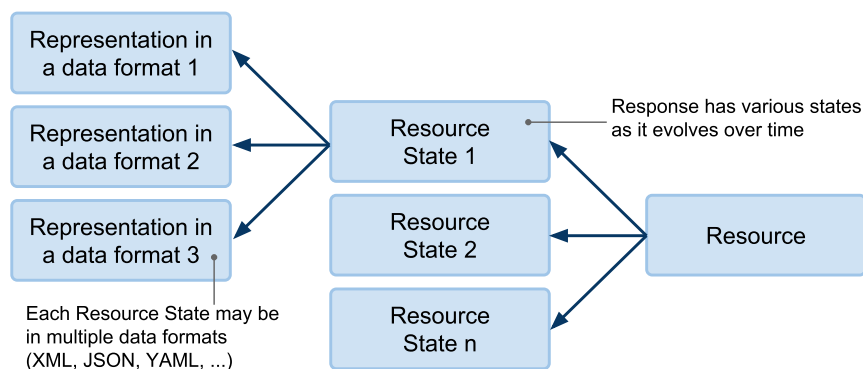
- Access
 - to be retrieved (*GET*)
 - to be inserted or updated (*PUT, POST*)
 - to be deleted (*DELETE*)
- Request
 - HTTP header **Accept**, part of content negotiation protocol
- Response
 - HTTP header **Content-Type: type/subtype; parameters**
 - Specifies an Internet Media Type [☞](#) of the resource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

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- **HATEOAS**
 - *Stateful vs. Stateless*
 - *Links and Preconditions*

HATEOAS

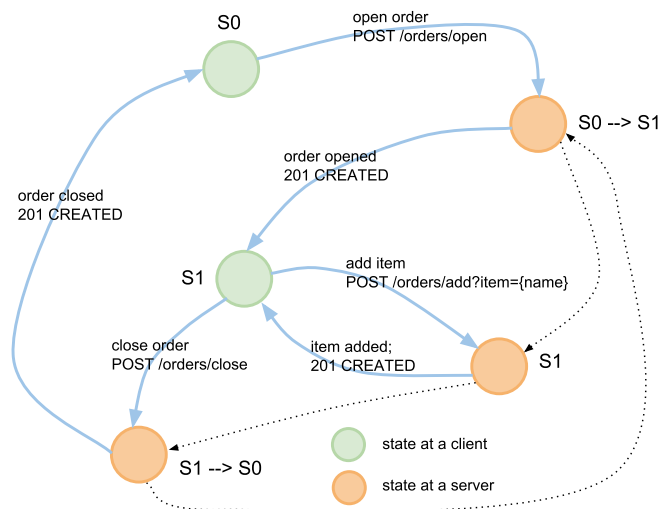
- HATEOAS = Hypertext as the Engine for Application State
 - *The REST core principle*
 - *Hypertext*
 - *Hypertext is a representation of a resource with **links***
 - *A link is an URI of a resource*
 - *Applying an access to a resource via its link = state transition*
- Statelessness
 - *A service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

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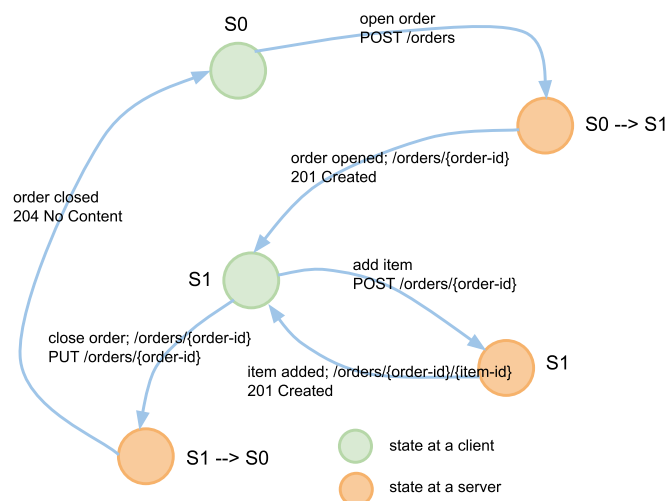
Stateful server

- 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

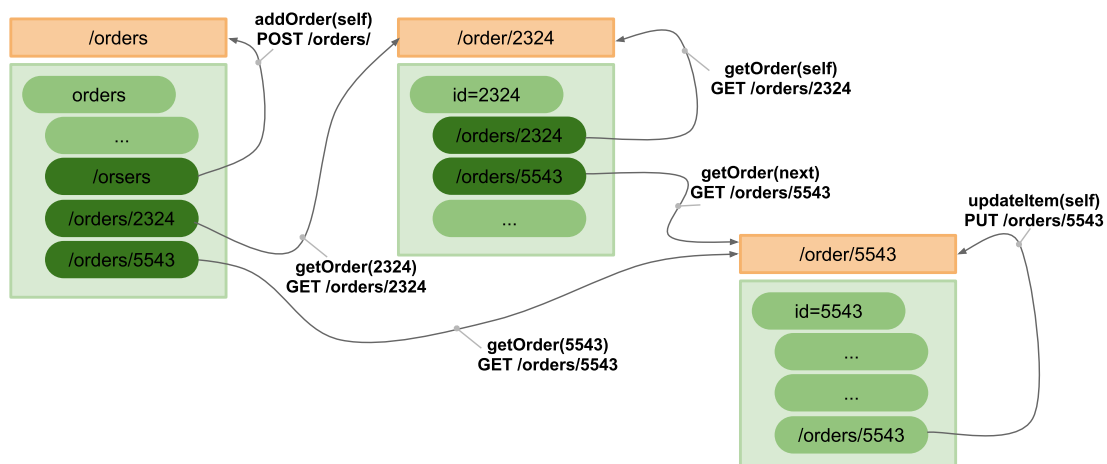
- Persistent Storage
 - *Contains the app data*
 - *Data is serialized into resource representation formats*
 - *All sessions may access the data via resource IDs*
- Session Memory
 - *Server memory that contains a state of the app*
 - *A session may only access its session memory*
 - *Access through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

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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*

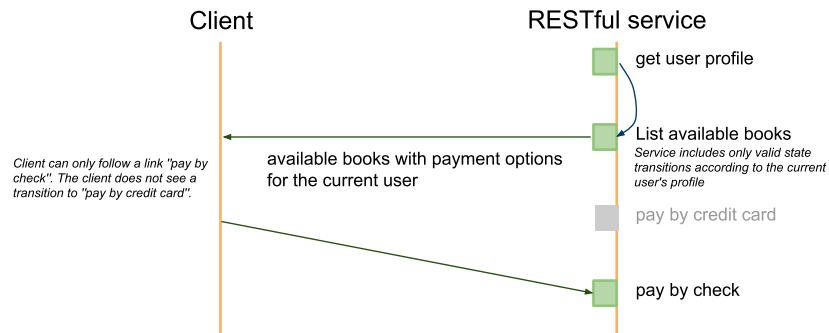
```
1 <order a:xmlns="http://www.w3.org/2005/Atom" xmlns="...">
2   <id>2324</id>
3   <a:link rel="http://company.com/op/addItem"
4     href="http://company.com/orders/2324"/>
5   <a:link rel="http://company.com/op/deleteOrder"
6     href="http://company.com/orders/2324"/>
7 </order>
```

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