Web 2.0

Lecture 4: HATEOAS, Scalability and Description

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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)

HATEOAS

- Stateful vs. Stateless
- Links and Preconditions
- Scalability

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HATEOAS

- HATEOAS = Hypertext as the Engine for Application State
 - The REST core principle
 - Hypertext
 - \rightarrow Hypertext is a representation of a resource with **links**
 - \rightarrow 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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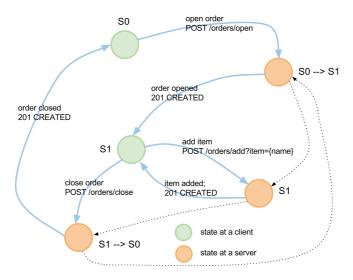
- HATEOAS
 - Stateful vs. Stateless
 - Links and Preconditions
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Stateful server

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



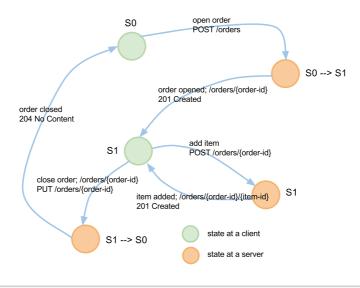
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Stateless server

• 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



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Persistent Storage and Session Memory

• Persistent Storage

- Contains app data
- Data is serialized into resource representation formats
- All sessions may access the data via resource IDs
- Note
 - → Our simple examples implement a storage in a server memory!

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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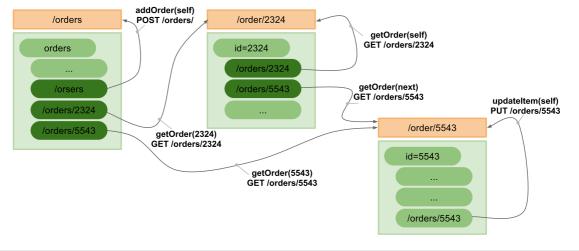
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Link

- 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



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Atom Links

Atom Syndication Format

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

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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

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Pagination

- Dividing a resource into a number of pages
 - A client retrieves a resource in pages to optimize interactions
 - Example: /orders?page={startPage}&size={numberReturned}
 - A client needs to ask for (or have default values for) a start page and a number of orders to return (must have a pre-defined knowledge)
- Example /orders resource:
 - client does not need to remember which page of orders it is viewing

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

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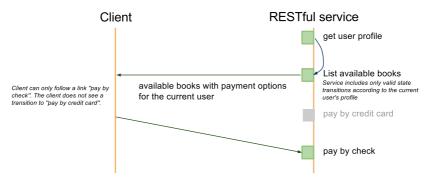
Preconditions and HATEOAS

Precondition

- Recall Preconditions and effects in MDW
 - → A conditions that must hold in a state before an operation can be executed.

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



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Advantages

Location transparency

- only "entry-level" links published to the World
- other links within documents can change without changing client's logic
- HATEOAS may reflect current user's rights in the app

Loose coupling

- no need for a logic to construct the links
- Clients know to which states they can move via links

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- HATEOAS
- Scalability
 - Caching and Revalidation
 - Concurrency Control

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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)
 - \rightarrow 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

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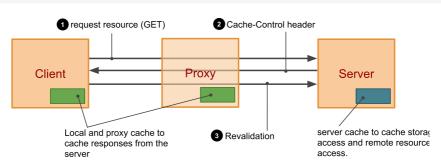
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Caching



• 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

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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)

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Example Date Revalidation

- Cache control example:
 - 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.

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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"
 - \rightarrow The app defines the meaning of its weak tags
- Example content revalidation with ETag

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Design Suggestions

- Composed resources use weak ETags
 - For example /orders
 - \rightarrow 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

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Weak ETag Example

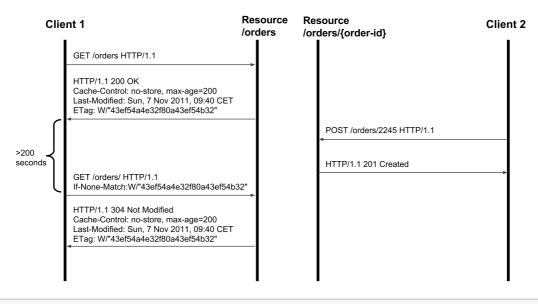
- App specific, /orders resource example
- Weak ETag compute function example
 - Any modification to an order's items is not significant for **/orders**:

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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



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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

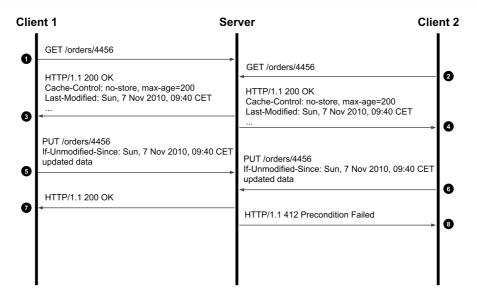
What happens if another client updates the resource between 1) and 3)?

- 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:
 - \rightarrow 200 OK if the PUT was successful
 - \rightarrow 412 Precondition Failed if the resource was updated in the meantime.

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Concurrency Control Protocol



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

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Overview

- HATEOAS
- Scalability
 - Documentation

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Documentation

RESTful API Documentation

- Until recently, not a standard way, only good practices
- and only textual, not in a formal language
 - \rightarrow there were attempts such as WADL, hREST
 - \rightarrow it is even possible to use WSDL 2.0
- Today, Swagger and Open API Specification
- Client libraries in major languages
 - JavaScript, Java, ...
 - these could be documented
 - they hide protocol details
- Best practices in RESTful API documentation
 - learn from Google, Twitter, and others

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Best Practices

- Include resource diagram
 - in UML, with links
- For each resource, describe
 - URI with parameters, such as
 http://company.com/orders/{order-id}
 - definition of the parameters
 - list of properties (attributes), with values, link to XML Schema
 - representations you support (XML, JSON)
 - sample request
 - sample response in representations you support
 - error codes
- Make sure
 - people can copy sample code and run it in a browser or by using curl

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Swagger Overview

• Emerging standard

- Started as a private company effort (SmartBear)
- Recently became so popular and evolved to a community effort
 - → Open API Specification under Apache Foundation
 - \rightarrow Google, IBM, 3Scale, ...

• Guiding Principles

- A minimal effort to describe an API
 - → API description should be generated, e.g. via code annotations
 - → It can always be written manually too
- A minimal effort to write clients
- Sanbox comes out-of-the-box

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Swagger API Description

- Server
 - Server provides a **Resource Listing** at /api-docs
 - For each resource, there is an API Declaration
- Resouce Listing
 - JSON Representation

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• API Declaration - JSON Representation

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