Middleware Architectures 1

Lecture 4: HATEOAS, Caching and Concurrency

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Overview

- HATEOAS
- Caching, Revalidation, Concurrency Control
- Richardson Maturiy Model

HATEOAS

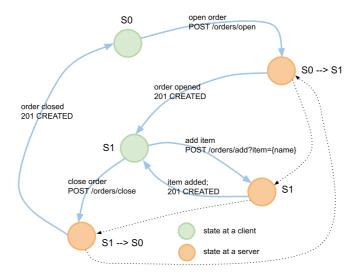
- HATEOAS = Hypertext as the Engine for Application State
 - The REST core principle
 - Hypertext
 - → Hypertext is a representation of a resource state with links
 - \rightarrow A link is an URI of a resource
 - → Applying an access (PUT, POST, DELETE) to a resource via its link = state transition
-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

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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



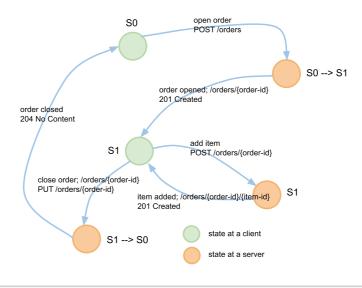
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Stateless server

• 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 the app data
- Data is serialized into resource representation formats
- All sessions may access the data via resource IDs

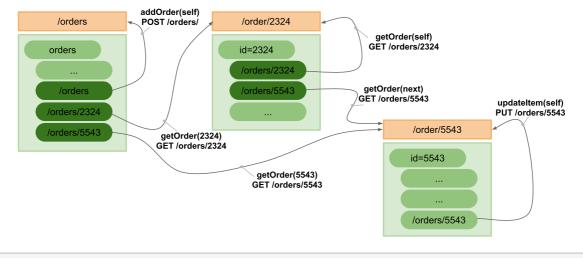
• Session Memory

- 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



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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

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

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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:

```
> HEAD /orders HTTP/1.1

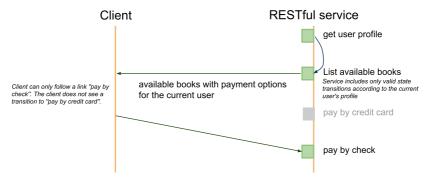
< Content-Type: application/xml
< Link: <http://company.com/orders/?page=2&size=10>; rel="next"
< Link: <http://company.com/orders/?page=10&size=10>; rel="last"
```

- 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



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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
- 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

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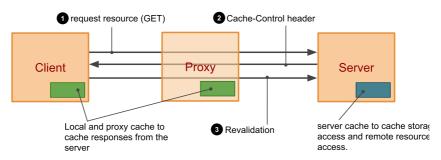
Scalability

- 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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Caching



• Your service should cache:

- anytime there is a static resource
- even there is a dynamic resource
 - \rightarrow 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 must not store persistently (this turns off caching)
- 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:

```
> GET /orders HTTP/1.1
> ...
< HTTP/1.1 200 OK
< Content-Type: application/xml
< Cache-Control: private, max-age=200
< Last-Modified: Sun, 7 Nov 2011, 09:40 CET
< ...data...</pre>
```

- only client can cache, 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, max-age=200
< Last-Modified: Sun, 7 Nov 2011, 09:40 CET</pre>
```

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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

```
< HTTP/1.1 200 OK
< Cache-Control: private, 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, max-age=200
< Last-Modified: Sun, 7 Nov 2011, 09:40 CET
< ETag: "4354a5f6423b43a54d"</pre>
```

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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**:

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

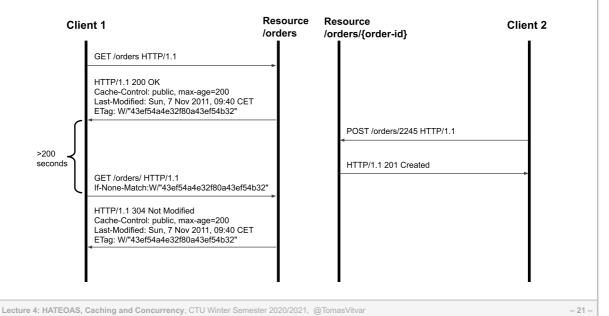
function computeWeakETag(orders) {
   var content = "";
   for (var i = 0; i < orders.length; i++)
        content += orders[i].id + orders[i].customer + orders[i].descr;
   return crypto.createHash('md5').update(content).digest("hex");
}</pre>
```

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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



Concurrency

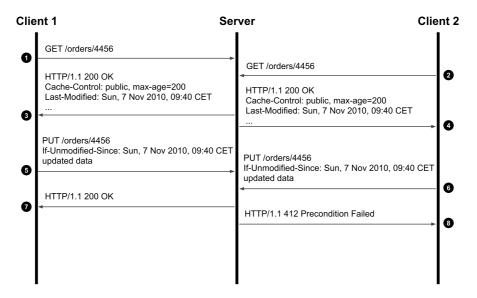
- Two clients may update the same resource
 - 1) a client GETs a resource GET /orders/5545
 - 2) the client modifies the resource
 - 3) the client updates the resource via PUT /orders/5545 HTTP/1.1

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
 - → 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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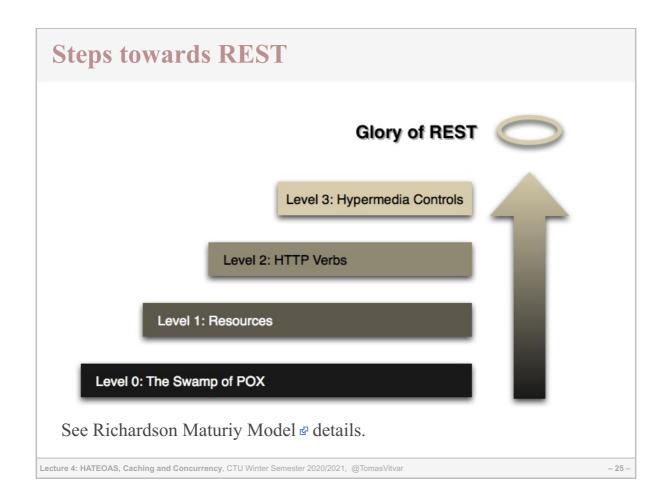
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Levels

- 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 resources and URIs
- LEVEL 2 HTTP Verbs
 - Use HTTP methods and respect their semantics
- LEVEL 3 Hypermedia Controls
 - HATEOAS

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