Middleware Architectures 1

Lecture 7: HATEOAS, Caching and Concurrency

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

Czech Technical University in Prague
Faculty of Information Technologies • Software and Web Engineering • https://vitvar.com/lectures

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Overview

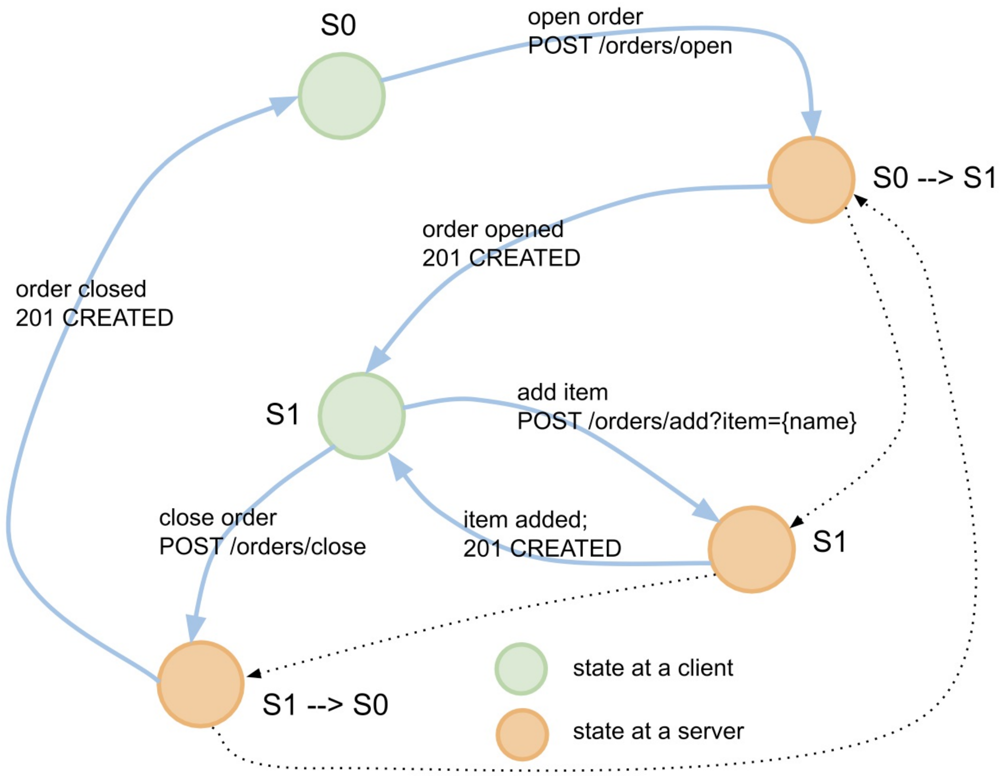
- HATEOAS
- Caching, Revalidation, Concurrency Control
- Richardson Maturiy Model

HATEOAS

- HATEOAS = Hypertext as the Engine for Application State
  - *The REST core principle*
  - ***Hypertext***
    - → *Hypertext is a representation of a resource state with **links***
    - → *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*

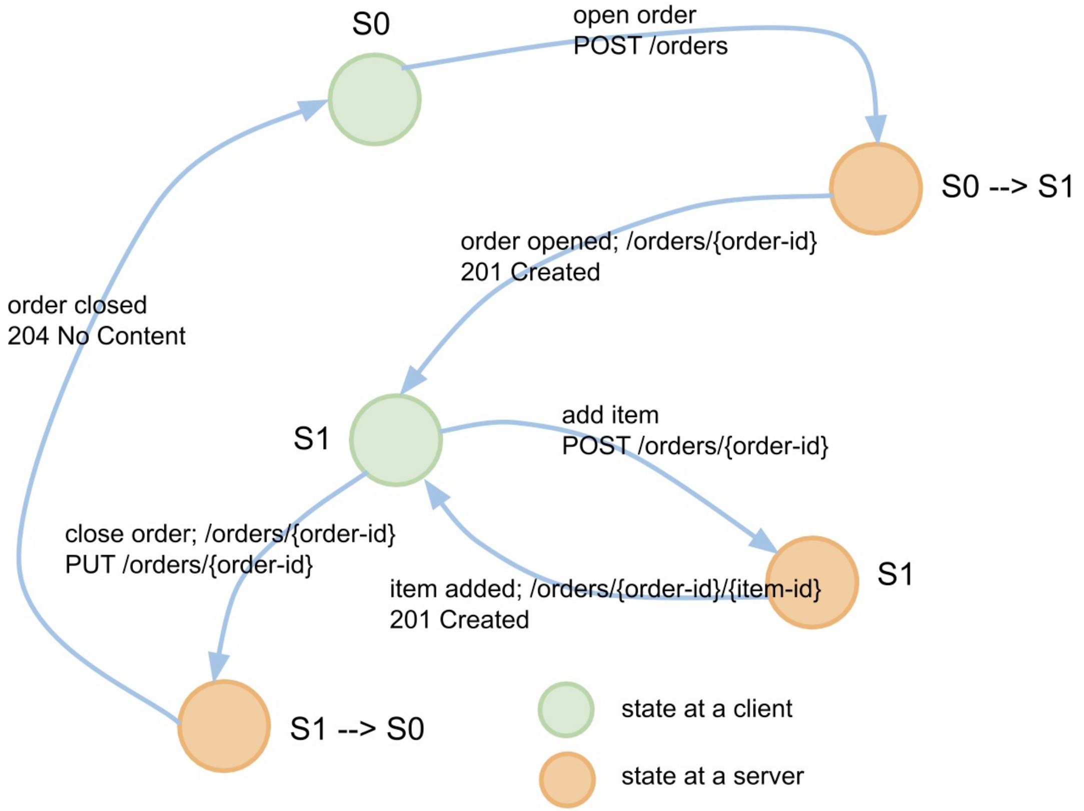
Stateful server

- 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*



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*

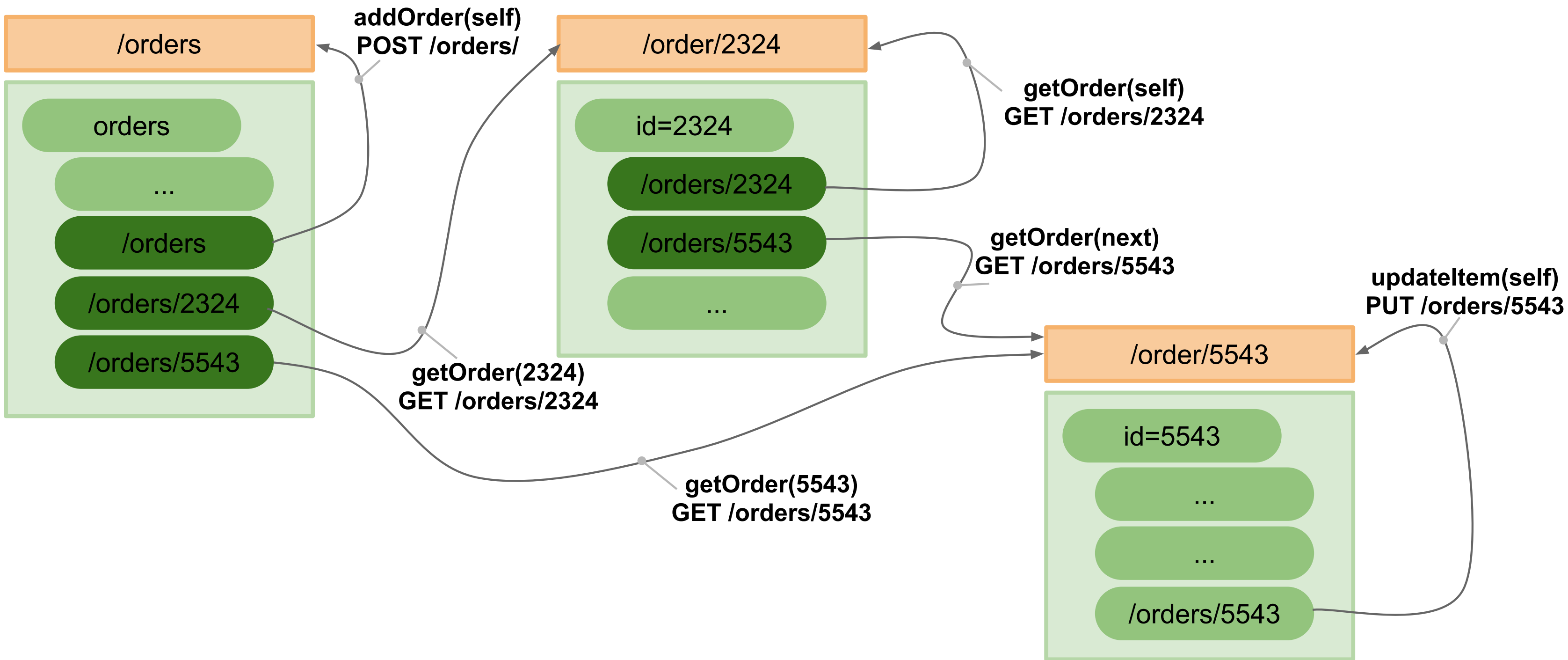


Persistent Storage and Session Memory

- 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*

```xml
<order a:xmlns="http://www.w3.org/2005/Atom" xmlns="...">
    <a:link
        rel="next"
        href="http://company.com/orders/5543"
        type="application/xml"/>
    <customer>Tomas</customer>
    <items>...</items>
</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*

```xml
<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:*

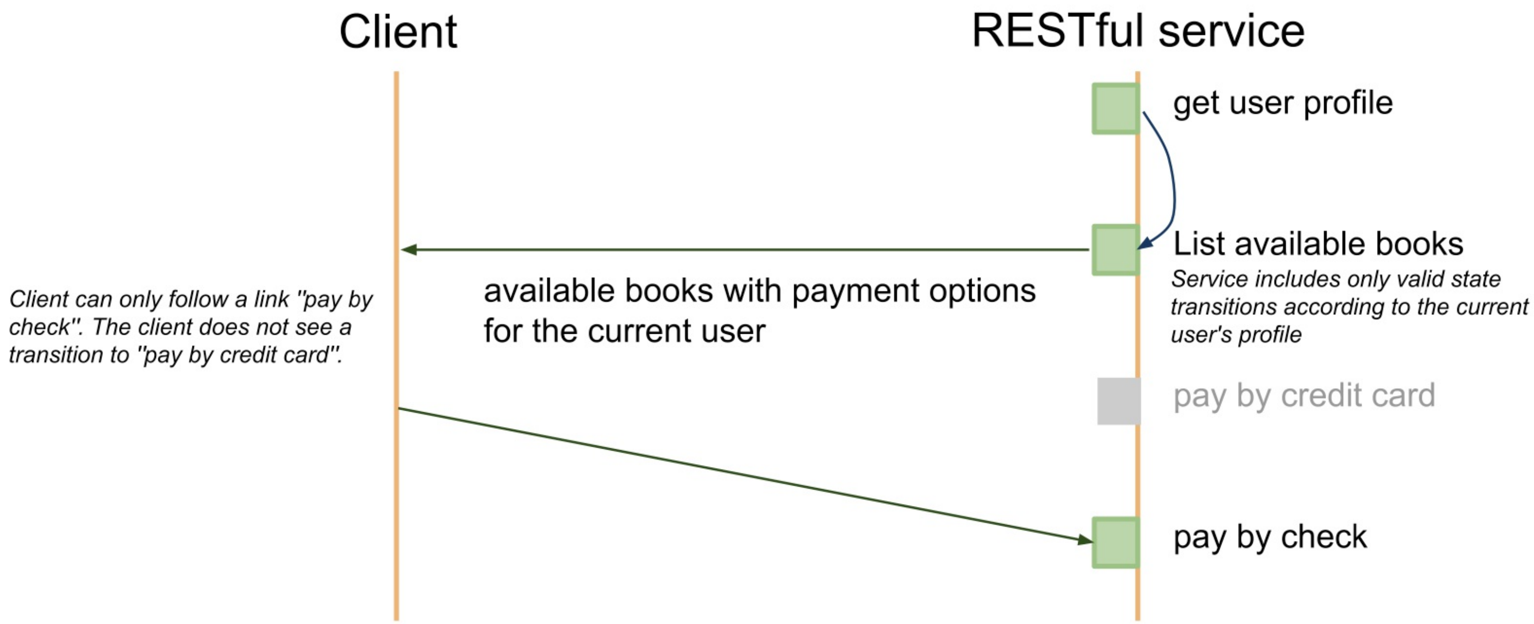
```
> HEAD /orders HTTP/1.1

< 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*

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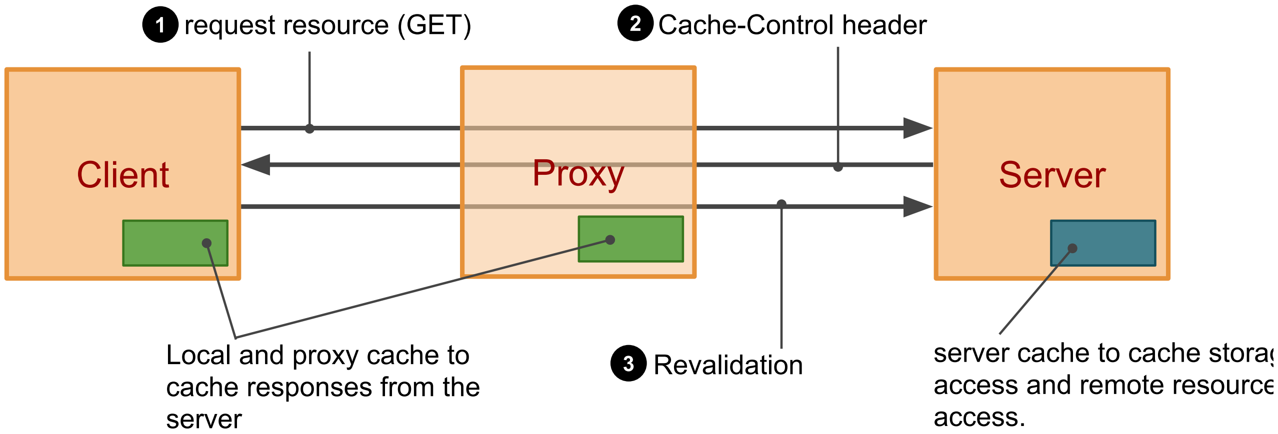
Scalability

- 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)*
    → 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` – *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)*

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...
```

  – *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
```

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, 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"
```

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"       : [...] }
        ]
}
```

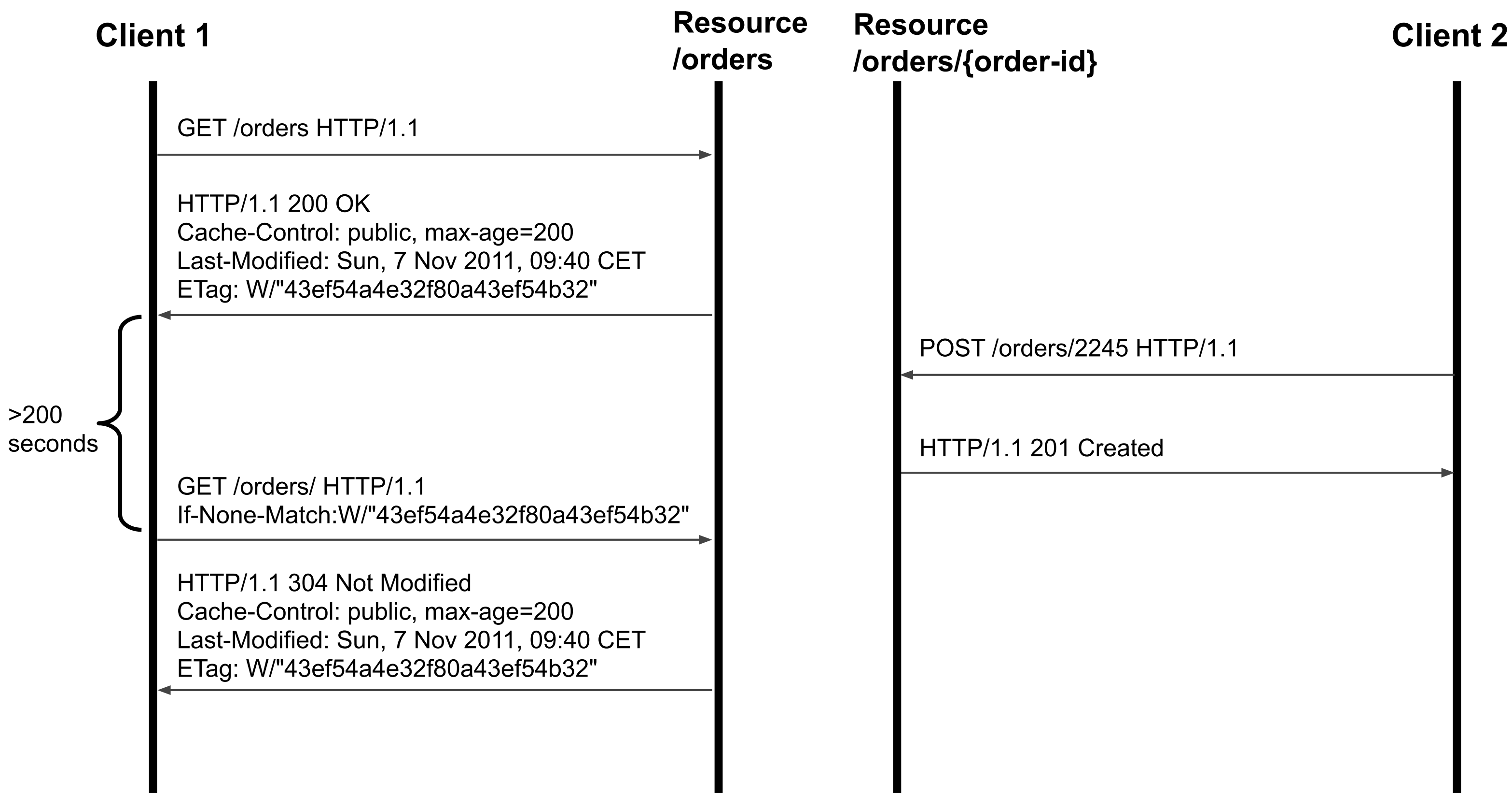
- Weak ETag compute function example
  - *Any modification to an order's items is not significant for* `/orders`*:*

```
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) ?

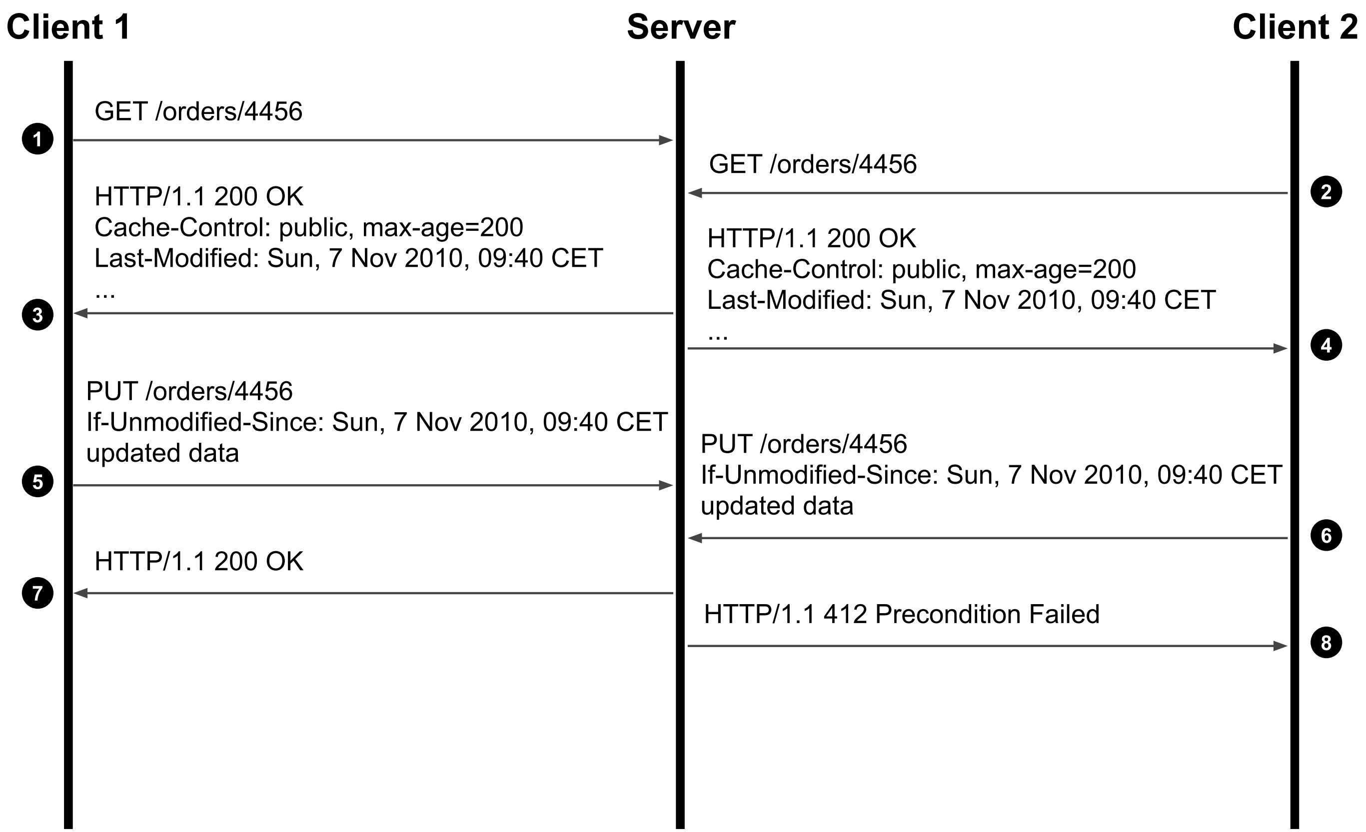
- Concurrency control
  - *Conditional* `PUT`

    → *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*

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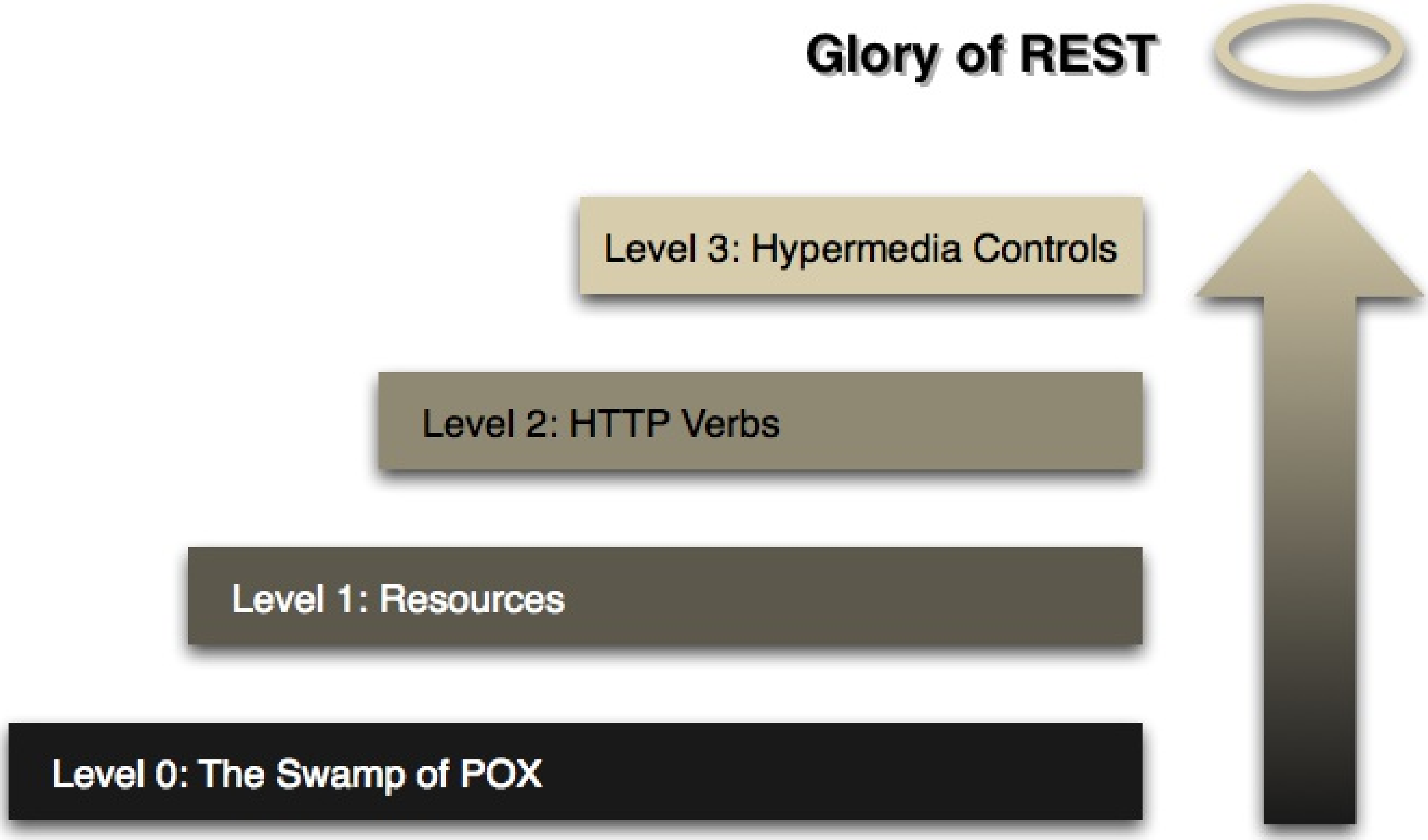
Steps towards REST



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