Web 2.0

Lecture 3: REST Architecture 2

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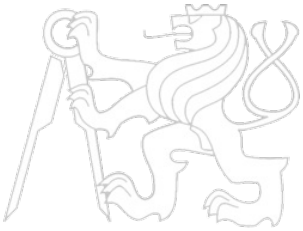

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REST Core Principles

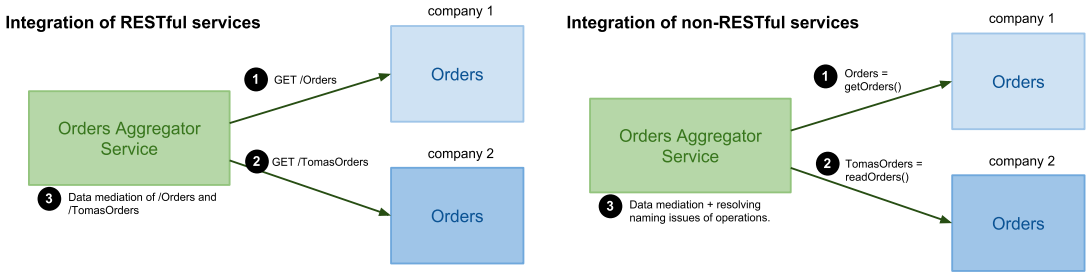
- REST architectural style defines constraints
  - *if you follow them, they help you to achieve a good design, interoperability and scalability.*
- Constraints
  - *Client/Server*
  - *Statelessness*
  - *Cacheability*
  - *Layered system*
  - ***Uniform interface***
- Guiding principles
  - *Identification of resources*
  - *Representations of resources and self-descriptive messages*
  - *Hypermedia as the engine of application state (HATEOAS)*

Overview

- Uniform Interface
  - *Basic operations*
  - *Handling Errors*
  - *Advanced Design Issues*
- Selected Protocols
- Selected Extensions

Uniform Interface

- Uniform interface = finite set of operations
  - *Resource manipulation*
    - → *CRUD – Create (POST/PUT), Read (GET), Update (PUT/PATCH), Delete (DELETE)*
  - *operations are not domain-specific*
    - → *For example,* `GET /orders` *and not* `getOrders()`
    - → *This reduces complexity when solving interoperability*
- Integration issues examples



Safe and Unsafe Operations

- Safe operations
  - *Do not change the resource state*
  - *Usually "read-only" or "lookup" operation*
  - *Clients can cache the results and refresh the cache freely*
- Unsafe operations
  - *May change the state of the resource*
  - *Transactions such as buy a ticket, post a message*
  - *Unsafe does not mean dangerous!*
- Unsafe interactions and transaction results
  - `POST` *response may include transaction results*
    - → *you buy a ticket and submit a purchase data*
    - → *you get transaction results*
    - → *and you cannot bookmark this..., why?*
  - *Should be referable with a persistent URI*

Idempotence

- Idempotent operation
  - *Invoking a method on the same resource always has the same effect*
  - *Operations* `GET`, `PUT`, `DELETE`
- Non-idempotent operation
  - *Invoking a method on the same resource may have different effects*
  - *Operation* `POST`
- Effect = a state change
  - *recall the effect definition in MDW*

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GET

- Reading
  - `GET` *retrieves a representation of a state of a resource*

```
> GET /orders HTTP/1.1
> Accept: application/xml

< HTTP/1.1 200 OK
< Content-Type: application/xml
<
< ...resource representation in xml...
```

  - *It is read-only operation*
  - *It is **safe***
  - *It is **idempotent***
  - `GET` *retrieves different states over time but the effect is always the same, cf. resource state hence it is idempotent.*
  - *Invocation of* `GET` *involves content negotiation*

PUT

- Updating or Inserting
  - `PUT` *updates a representation of a state of a resource or inserts a new resource*

```
> PUT /orders/4456 HTTP/1.1
> Content-Type: application/xml
>
> <order>...</order>

< HTTP/1.1 CODE
```

  - *where CODE is:*
    - → `200 OK` *or* `204 No Content` *for updating: A resource with id* `4456` ***exists****, the client sends an updated resource*
    - → `201 Created` *for inserting: A resource* ***does not exist****, the client generates the id* `4456` *and sends a representation of it.*
  - *It is* ***not safe*** *and it is* ***idempotent***

POST

- Inserting
  - `POST` *inserts a new resource*
  - *A server generates a new resource ID, client only supplies a content and a resource URI where the new resource will be inserted.*

```
> POST /orders HTTP/1.1
> Content-Type: application/xml
>
> <order>...</order>

< HTTP/1.1 201 Created
< Location: /orders/4456
```

  - *It is* ***not safe*** *an it is* ***not idempotent***
  - *A client may "suggest" a resource's id using the* `Slug` *header*
    - → *Defined in AtomPub protocol*

DELETE

- Deleting
  - `DELETE` *deletes a resource with specified URI*

```
> DELETE /orders/4456 HTTP/1.1
< HTTP/1.1 CODE
```

  - *where CODE is:*
    - → `200 OK`*: the response body contains an entity describing a result of the operation.*
    - → `204 No Content`*: there is no response body.*
  - *It is* ***not safe*** *and it is* ***idempotent***
    - → *Multiple invocation of* `DELETE /orders/4456` *has always the same effect – the resource* `/orders/4456` *does not exist.*

Other

- HEAD
  - *same as* `GET` *but only retrieves HTTP headers*
  - *It is* ***safe*** *and* ***idempotent***
- OPTIONS
  - *queries the resource for resource configuration*
  - *It is* ***safe*** *and* ***idempotent***

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Types of Errors

- Client-side – status code `4xx`
  - `400 Bad Request`
    - → *generic client-side error*
    - → *invalid format, such as syntax or validation error*
  - `404 Not Found`
    - → *server can't map URI to a resource*
  - `401 Unauthorized`
    - → *wrong credentials (such as user/pass, or API key)*
    - → *the response contains* `WWW-Authenticate` *indicating what kind of authentication the service accepts*
  - `405 Method Not Allowed`
    - → *the resource does not support the HTTP method the client used*
    - → *the response contains* `Allow` *header to indicate methods it supports*
  - `406 Not Acceptable`
    - → *so many restrictions on acceptable content types (using* `Accept-*`*)*
    - → *server cannot serialize the resource to requested content types*

Types of Errors (Cont.)

- Server-side – status code `5xx`
  - `500 Internal Server Error`
    - → *generic server-side error*
    - → *usually not expressive, logs a message for system admins*
  - `503 Service Not Available`
    - → *server is overloaded or is under maintenance*
    - → *the response contains* `Retry-After` *header*

Use of Status Codes

- Service should respect semantics of status codes!

```
> GET /orders HTTP/1.1
> Accept: application/json

< HTTP/1.1 200 OK
< Content-Type: application/json
<
< { "error" :
<    { "error_text" :
<        "you do not have rights to access this resource " }
< }
```

  - *Client must understand the semantics of the response.*
  - *This breaks loose coupling and reusability service principles*
  - *The response should be:*

```
< HTTP/1.1 401 Unauthorized
< ...

< ...optional text describing the error...
```

Overview

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Respect HTTP Semantics

- Do not overload semantics of HTTP methods
  - *For example,* `GET` *is read-only method and idempotent*
  - *REST Anti-pattern:*

    `GET /orders/?add=new_order`

    → *This is not REST!*

    → *This breaks both safe and idempotent principles*
- Consequences
  - *Result of* `GET` *can be cached by proxy servers*
  - *They can revalidate their caches freely*
  - *You can end up with new entries in your storage without you knowing!*
- The same is true for other methods

Change Order Status

- `status` property of `/orders/{order-id}` resource
  - *reflects a state of the process*
  - *No need to use a stateful service, state is communicated through the order representation*
- How do you implement a canceling an order?
  - *You can delete it using* `DELETE`
  - *But you may want to cancel it in order to:*
    - → *maintain a list of canceled orders*
    - → *have a possibility to "roll-back" canceled orders*

DELETE to cancel

- A bad solution to cancel the order
  - *to cancel with DELETE*

    ```
    DELETE /orders/3454/?cancel=true
    ```
  - *you overload the meaning of DELETE*
  - *you violate the uniform interface principle*
- Always ask a question:
  - ***Is the operation a state of the resource?***
  - *if yes, the operation should be:*
    - → *modeled within the data format*
    - → *or as a separated resource (sub-resource)*
- No verbs in `path` and `query` components!
  - `/cancelOrder`, `/orders/{order-id}/?action=delete`, *etc.*
  - *Verbs in URIs indicate that a resource is actually an operation!*

PUT to cancel

- A RESTful solution to cancel an order
  1. *first, have an order's status*
     – *as part of the Order representation format*
     – *we extend "open" and "close" with "cancel"*
  2. *Use PUT to cancel an order*

```
> PUT /orders/{order-id}
> Content-Type: application/json
>
> { "status" : "cancel" }

< HTTP/1.1 204 No Content
```

- Clean-up all cancelled orders
  – *you can have a resource "all valid orders":* `/orders/valid`
  (~ all orders that are not canceled)
  → `GET /orders/valid` *will return all non-canceled orders*
  → `POST /orders/valid` *will purge all cancelled orders*

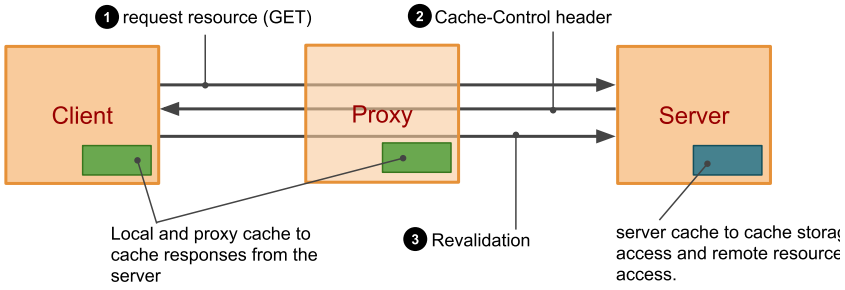
Overview

- Uniform Interface
- Selected Protocols
  – *Caching and Revalidation*
  – *Concurrency Control*
- Selected Extensions

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` – *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)*

Example Date Revalidation

- Cache control example:

```
> GET /orders HTTP/1.1
> ...

< HTTP/1.1 200 OK
< Content-Type: application/xml
< Cache-Control: private, no-store, max-age=200
< Last-Modified: Sun, 7 Nov 2011, 09:40 CET
<
< ...data...
```

  - *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.*

```
> GET /orders HTTP/1.1
> If-Modified-Since: Sun, 7 Nov 2011, 09:40 CET

< HTTP/1.1 304 Not Modified
< Cache-Control: private, no-store, 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, no-store, 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, no-store, 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"     : [...] }
        ]
}
```

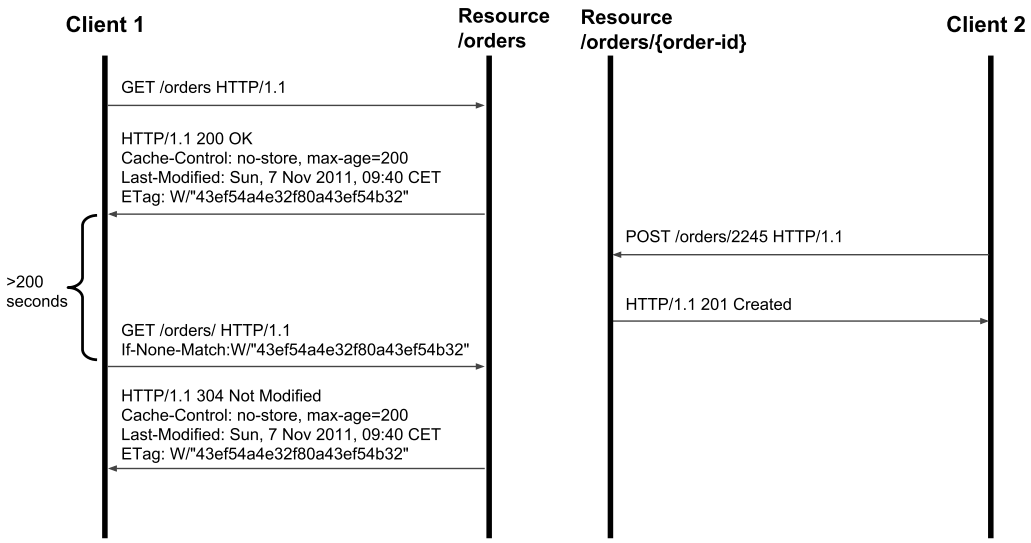
- Weak ETag compute function example
  - *Any modification to an order's items is not significant for* `/orders`*:*

```
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*



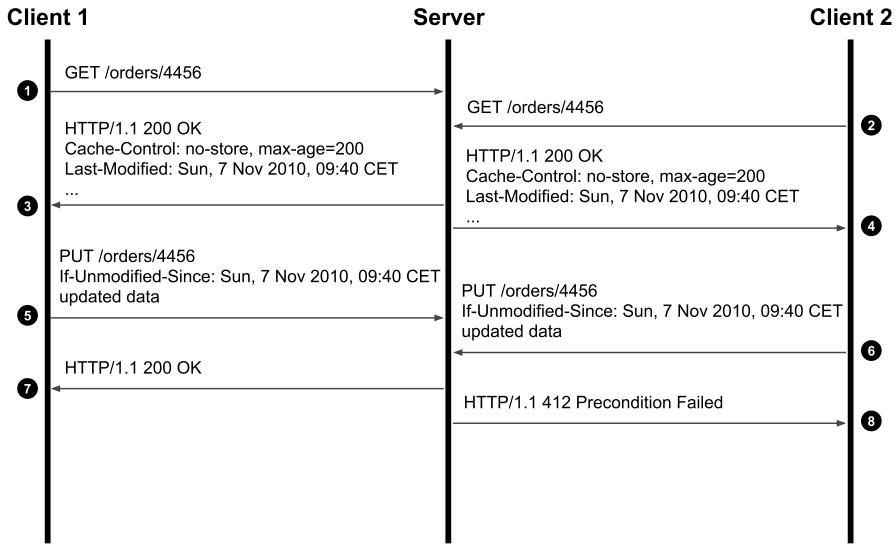
Overview

- Uniform Interface
- Selected Protocols
  - *Caching and Revalidation*
  - *Concurrency Control*
- Selected Extensions

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*

Overview

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GData Protocol: Partial Update

- `PATCH` HTTP Method
  - *IETF specification, see PATCH Method for HTTP*
  - *Add, modify or delete selected elements of an entry*
- Examples
  - *To delete a description element and add a new title element*
  - `gd:fields` *uses partial response syntax*

```
1  PATCH /myFeed/1/1/
2  Content-Type: application/xml
3
4  <entry xmlns='http://www.w3.org/2005/Atom'
5      xmlns:gd='http://schemas.google.com/g/2005'
6      gd:fields='description'>
7    <title>New title</title>
8  </entry>
```

- Rules
  - *Fields not already present are added*
  - *Non-repeating fields already present are updated*
  - *Repeating fields already present are appended*

GData Protocol: Entity Tags

- Resource Versioning
  - *Conditional GET and PUT (concurrencyl control)*
    → *See Lecture 4 – scalability*
  - *Etgas on atom and entry elements*
- Example

```
1  GData-Version: 2.0
2  ETag: W/"C0QBRXcycSp7ImA9WxRVFUk."
3  ...
4  <?xml version='1.0' encoding='utf-8'?>
5  <feed xmlns='http://www.w3.org/2005/Atom'
6      xmlns:gd='http://schemas.google.com/g/2005'
7      gd:etag='W/"C0QBRXcycSp7ImA9WxRVFUk."'>
8    ...
9    <entry gd:etag='"CUUEQX47eCp7ImA9WxRVEkQ."'>
10     ...
11   </entry>
12 </feed>
```

  - *It is possible to do a conditional GET/PUT on the entry by using the ETag* `"CUUEQX47eCp7ImA9WxRVEkQ."`

GData Protocol: HTTP Methods Overriding

- Firewall restrictions
  - *Some firewall configurations do not allow to send HTTP request other than GET and POST*
- HTTP methods overriding through `POST`

```
X-HTTP-Method-Override: PUT
X-HTTP-Method-Override: DELETE
X-HTTP-Method-Override: PATCH
```

- Example

```
1  POST /myfeed/1/1/
2  X-HTTP-Method-Override: PATCH
3  Content-Type: application/xml
4  ...
```