

# Web 2.0

## Lecture 3: REST Architecture 2

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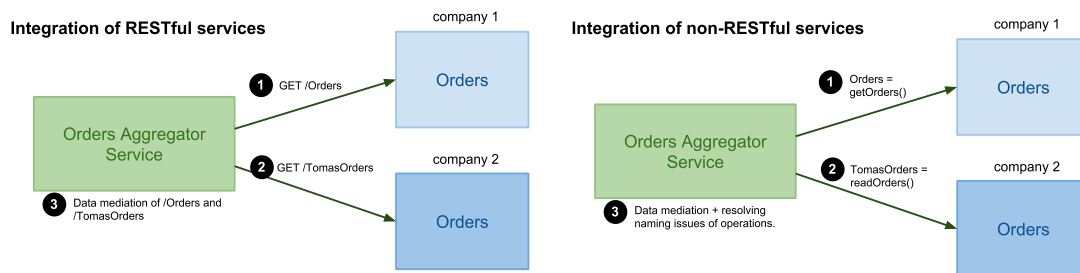
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## Overview

- **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 or inserts a representation of a state of a resource*
- *Updating the resource is a **complete replacement of the 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***

# PATCH

- **PATCH** to partial update a resource
  - IETF specification, see *PATCH Method for HTTP* [↗](#)
- Use in GData Protocol
  - To add, modify or delete selected elements of an Atom feed entry
  - Example to delete a description element and add a new title element

**gd:fields** uses the 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

# 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** and 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...



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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*

```
1 > PUT /orders/{order-id}
2 > Content-Type: application/json
3 >
4 > { "status" : "cancel" }
5
6 < 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

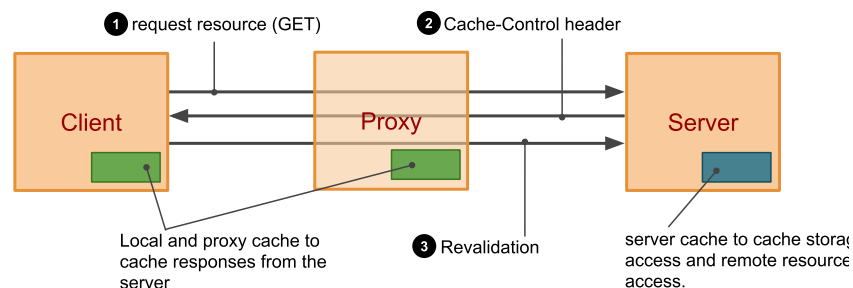
## Overview

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  - *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

```
1  {
2    "orders" :
3    [
4      { "id"      : 2245,
5        "customer" : "Tomas",
6        "descr"    : "Stuff to build a house.",
7        "items"    : [...] },
8      { "id"      : 5546,
9        "customer" : "Peter",
10       "descr"    : "Things to build a pipeline.",
11       "items"    : [...] }
12    ]
13  }
```

- Weak ETag compute function example

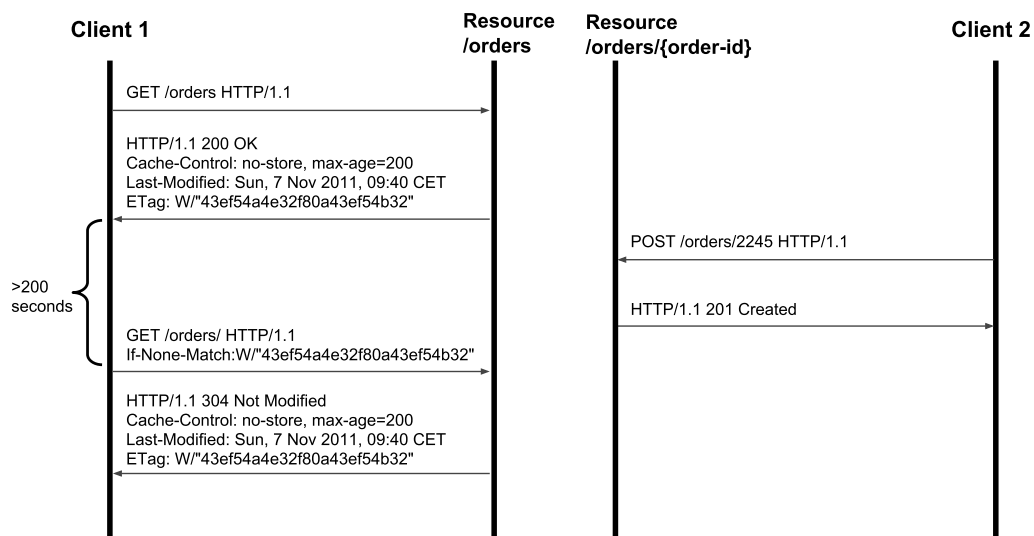
– Any modification to an order's items is not significant for **/orders**:

```
1  var crypto = require("crypto");
2
3  function computeWeakETag(orders) {
4    var content = "";
5    for (var i = 0; i < orders.length; i++)
6      content += orders[i].id + orders[i].customer + orders[i].descr;
7    return crypto.createHash('md5').update(content).digest("hex");
8  }
```

## 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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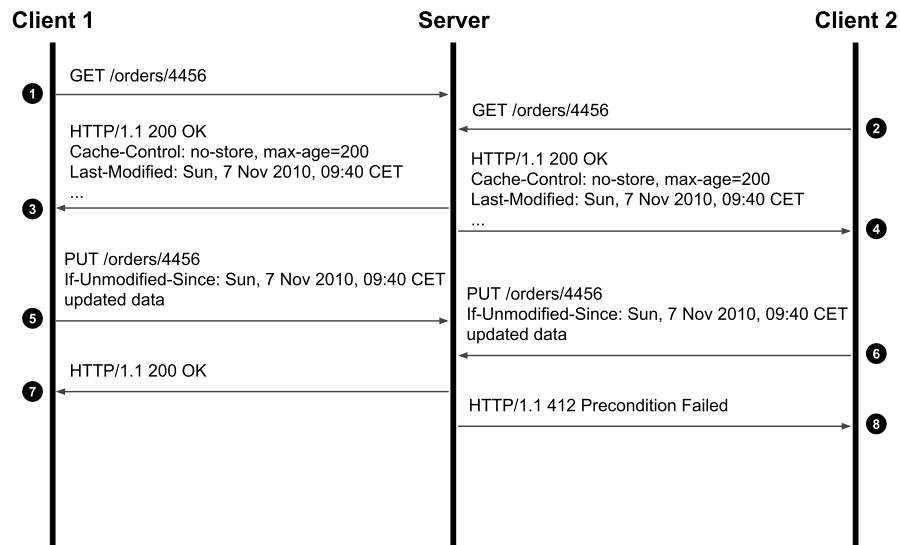
## Concurrency

- 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**:
    - **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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## GData Protocol: Entity Tags

- Resource Versioning
  - *Conditional GET and PUT (concurrency control)*
  - *Etags 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  ...
```