Web 2.0

Lecture 3: Uniform Interface

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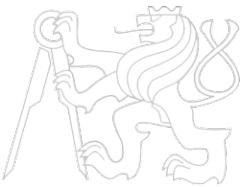

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REST Core Principles

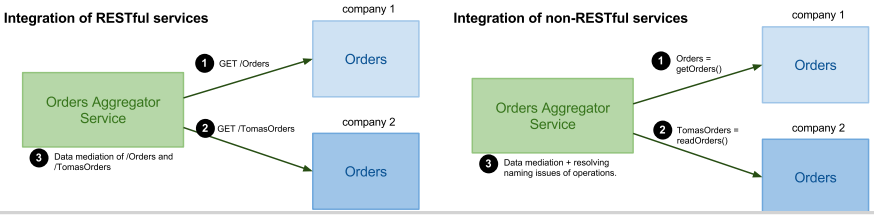
- REST architectural style defines constraints
  - *if you follow them, they help you to achieve a good design, interoperability and scalability.*
- Constraints
  - *Client/Server*
  - *Statelessness*
  - *Cacheability*
  - *Layered system*
  - ***Uniform interface***
- Guiding principles
  - *Identification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

Overview

- Uniform Interface
  - *Basic operations*
  - *Handling Errors*
- Asynchronous Communication
- Implementing a RESTful Service
- Advanced Design Issues

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?*

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

- Uniform Interface
- Asynchronous Communication
- Implementing a RESTful Service
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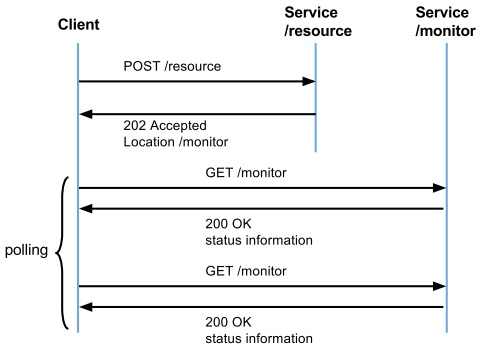
Asynchronous Communication

- Recall asynchronous communication from MDW
- Asynchronous communication in HTTP
  - *Server cannot establish a connection, always clients need to*
    → clients are browsers behind firewalls



Asynchronous and Polling/Pushing

- Submit request for processing
  - *Always through HTTP request and* 202 Accepted *response and* Location *header with a monitor resource*
  - *Methods:* PUT, POST, DELETE
- Getting the status from the monitor resource
  - ***polling*** *– a client periodically checks for changes via* GET
    - → *Most natural solution, not a real-time solution*
  - ***pushing*** *– a server pushes changes back to the client*
    - → *Part of real-time Web efforts*
  - *More details in Lecture 8: Protocols for the Realtime Web*

Overview

- Uniform Interface
- Asynchronous Communication
- Implementing a RESTful Service
  - *Basic Implementation*
- Advanced Design Issues

Service Description

- Example service: Oder processing

  https://github.com/tomvit/w20/tree/master/examples/restful-service

```
1  * the service provides three operations: 'open', 'add', 'close'
2  * operation 'open' opens the order
3      - input: none
4      - output: text informing that the order was opened
5
6  * operation 'add' adds an item to the order
7      - input: an item name, the syntax is [0-9A-Za-z\-]+
8      - output: text informing that the item was added to the order
9
10 * operation 'close' closes the order and returns all items in the order
11     - input: none
12     - output: list of all items previously added to the order
13
14 * the public process is: S0--open--S1, S1--add--S1, S1--close--S0, where
15   S0, S1 are states such that S0 = order is closed, and S1 = order is opened.
16
17 * protocol is HTTP, RESTful service
18   running at ec2.vitvar.com, tcp/9900
```

- Basic steps to define a RESTful service
  1. *identify resources and URIs*
  2. *specify resources' representations*
  3. ***define service operations*** *(methods and status codes)*

Overview

- Uniform Interface
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  - *Basic Implementation*
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Resources, URIs and Representations

- There are three resources
  - *Resource* /orders *is a container of all orders*
  - *Resource* /orders/{order-id} *is an order with resource id* order-id.
  - *Resource* /orders/{order-id}/{item-id} *is an item that belongs to the order* order-id *and that has a resource id* item-id.
- Structure
  - /orders
    - → *list of all orders*
  - /orders/{order-id}
    - → *status, order id, list of all items in the order*
  - /orders/{order-id}/{item-id}
    - → *item id, name, price*
- Resource representations
  - *We define representations in JSON*

Open Order

- To open an order
  - *Insert a new order to* /orders *using* POST
  - *Set the new order's status to "open"*

- → storage.getOrderSeqId() *returns the order ID*
- → storage.orders *(line 37) is an array of all orders in a storage*

Add Item to Order

- To add an item to the order
  - *Insert a new item to the order* `/orders/{order-id}` *using* `POST`

Close Order

- To close an order
  - *Update the status of the order* `/orders/{order-id}` *using* `PUT`

Other Operations

- To get, delete an order and get, delete and update an item
  - *Delete an order* /orders/{order-id} *using* DELETE
  - *Get an order's item* /orders/{order-id}/{item-id} *using* GET
  - *Update an order's item* /orders/{order-id}/{item-id} *using* PUT
  - *Delete an order's item* /orders/{order-id}/{item-id} *using* DELETE
- Other methods are not allowed
  - *Send* 405 Not Allowed *status with* Allow *header to indicate which methods are allowed on a resource*

```
1 if (method != "GET" && method != "PUT" && method != "POST" && method != "
2    return {
3       status: "405", // method not allowed
4       headers : { "Allow" : "GET, PUT, POST, DELETE" }
5    };
```

Task

- *Implement the remaining methods listed above*

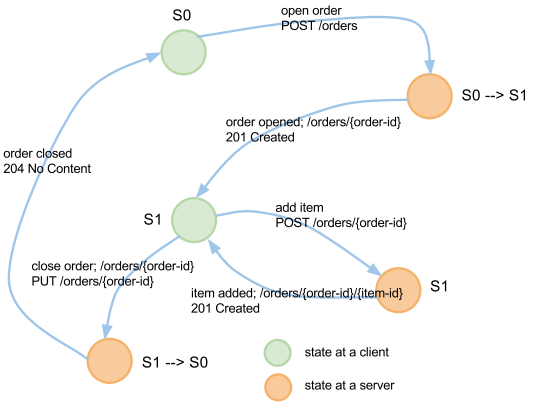
Testing

- Test the service using a bash script test.sh

Task

- *Run service and test it using the* test.sh *script.*

RESTful Public Process



- Note
  - *client, service communicate through metadata and representations*
  - *There is no need for a stateful server*

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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*

Evaluation

- How "good" is our Order Book service?
  - *Analysis of the service by service characteristics (see MDW for details) and HTTP principles.*

Principle	+/–	Comment
Loose Coupling	+	Uses standard response codes.
	+	Uses representation of resources and HTTP Location header to implement the public process.
	–	Does not use hypermedia; client needs to construct links for some resources.
	+	Properly models resource URIs and resource IDs; they have hierarchical nature; does not use verbs.
	+	Respects semantics of HTTP methods and extensively uses them.
Reusability	+	Unforeseen clients will likely use the service as the application state is communicated through HTTP.
	–	Only offers one representation format (JSON).
Contracting and Discoverability	–	Does not describe content type nor public process such as by using Internet Media Types.
Composability	+	Does not obstruct composition.
Abstraction	+	Service description can be implemented by various implementation technologies.
		Distinguishes interface from implementation, processing logic is not exposed to clients