Web 2.0
Lecture 3: Uniform Interface

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

Czech Technical University in Prague
Faculty of Information Technologies • Software and Web Engineering • http://vitvar.com/courses/w20
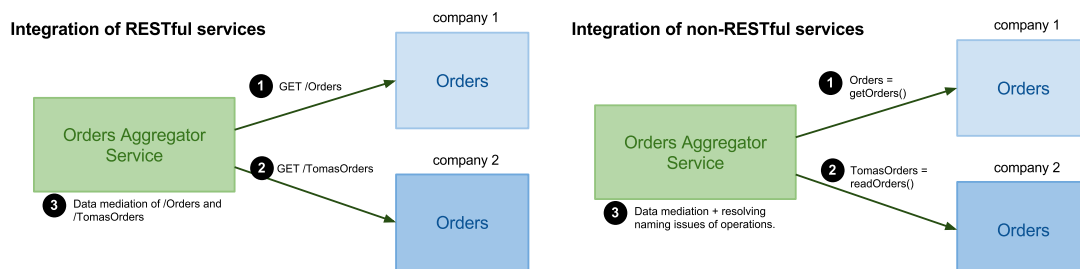

REST Core Principles

- 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), Delete (DELETE)*
  - *operations are not domain-specific*
    - → *For example,* `GET /orders` *and not* `getOrders()`
    - → *This reduces complexity when solving interoperability*
- Integration issues examples

Integration of RESTful services

company 1

Orders

❶ GET /Orders

Orders Aggregator Service

❷ GET /TomasOrders

company 2

Orders

❸ Data mediation of /Orders and /TomasOrders

Integration of non-RESTful services

company 1

Orders

❶ Orders = getOrders()

Orders Aggregator Service

❷ TomasOrders = readOrders()

company 2

Orders

❸ Data mediation + resolving naming issues of operations.

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*

Overview

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

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***

Overview

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

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
- Advanced Design Issues

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*
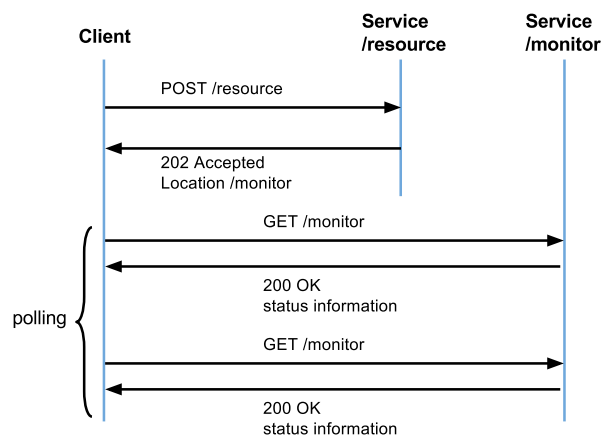
Asynchronous and Polling/Pushing

- 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
- ## Asynchronous Communication
- ## Implementing a RESTful Service
  – Basic Implementation
- ## Advanced Design Issues

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"*

```
45   if (method == "POST") { // open order
46       // create a new order object
47       var order = {
48           id : storage.getOrderSeqId(),
49           status : "open",
50           items : []
51       };
52
53       // add the order to the list of orders and return the result
54       storage.orders.push(order);
55       return {
56           status : "201", // created
57           headers : { Location: "http://" + host + "/orders/" + order.id }
58       };
59   }
```

  - → 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

```
74  if ((id = uri.match("^/orders/([0-9]+)$"))) {
75      if (method == "POST") {
76          // get the order object
77          var order = storage.getOrder(id[1]);
78          if (order && order.status == "open") {
79              // get the item object from the request data and set it's id
80              var item = JSON.parse(data);
81              item.id = storage.getItemSeqId(order);
82
83              // store the item in the order and return the result
84              // location is the URI of the newly created item
85              order.items.push(item);
86              return {
87                  status : "201", // created
88                  headers : { Location: "http://" + host + "/orders/" +
89                      order.id + "/" + item.id }
90              };
91          } else
92              // not found or bad request (the order is not open)
93              return { status : (order ? "400" : "404") };
94      }
```

Close Order

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

```
97   // update the order status
98   if (method == "PUT") {
99       // get the order object
100      var order = storage.getOrder(id[1]);
101      if (order && order.status == "open") {
102          var o2 = JSON.parse(data);
103
104          // check for the valid status
105          if (o2.status && (s = o2.status.match("(close)"))) {
106              order.status = s[1];
107              return {
108                  status : "204", // no content
109              };
110          } else
111              // bad request
112              return { status : "400" };
113      } else
114          // not found or bad request (the order is not open)
115          return { status : (order ? "400" : "404") };
116  }
```

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 != "DELET
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

```
3   # set your server address here
4   SERVER_URL="http://mdw-examples.tomvit.cloud9ide.com"
5
6   # add an order and get the new location; assume everything went ok
7   order_uri=$(curl -v -X POST $SERVER_URL/orders 2>&1 | \
8       awk '/Location/ {print $3}')
9
10  # remove whitespace
11  order_uri=${order_uri//[[:space:]]}
12
13  echo "New order with URI $order_uri has been created"
14
15  # add items to the order
16  curl -X POST -d "{ \"name\" : \"socks\", \"price\" : 5 }" $order_uri
17  curl -X POST -d "{ \"name\" : \"t-shirt\", \"price\" : 20  }" $order_uri
18  curl -X POST -d "{ \"name\" : \"jumper\", \"price\" : 45  }" $order_uri
19
20  # close the order
21  curl -X PUT -d "{ \"status\" : \"close\" }" $order_uri
22
23  # list the items in the order and the order's status
24  curl $order_uri
```

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

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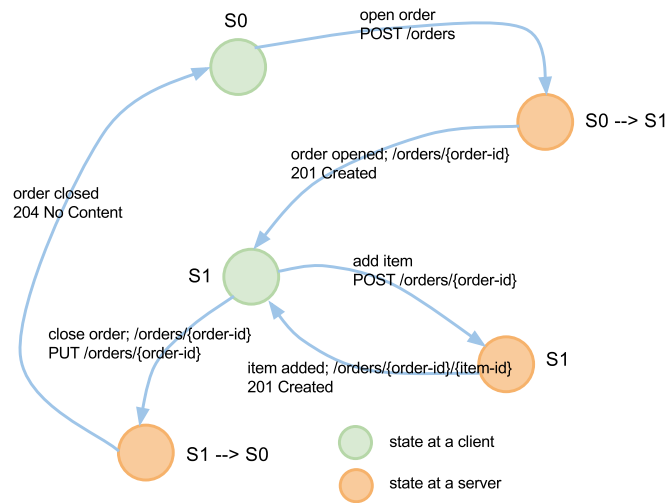
- Note
  - *client, service communicate through metadata and representations*
  - *There is no need for a stateful server*

Overview

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

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*

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.
Encapsulation	+	Distinguishes interface from implementation, processing logic is not exposed to clients through the interface.