Web 2.0
Lecture 3: Uniform Interface

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REST Core Principles

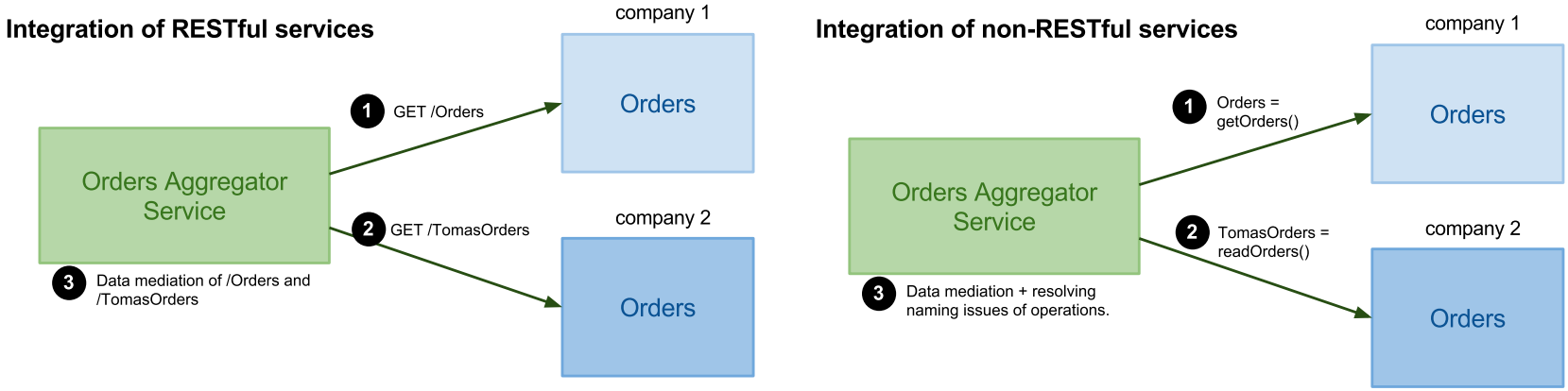
- REST architectural style defines constraints
  - *if you follow them, they help you to achieve a good design, interoperability and scalability.*
- Constraints
  - *Client/Server*
  - *Statelessness*
  - *Cacheability*
  - *Layered system*
  - ***Uniform interface***
- Guiding principles
  - *Identification 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), 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

- Uniform Interface
- Asynchronous Communication
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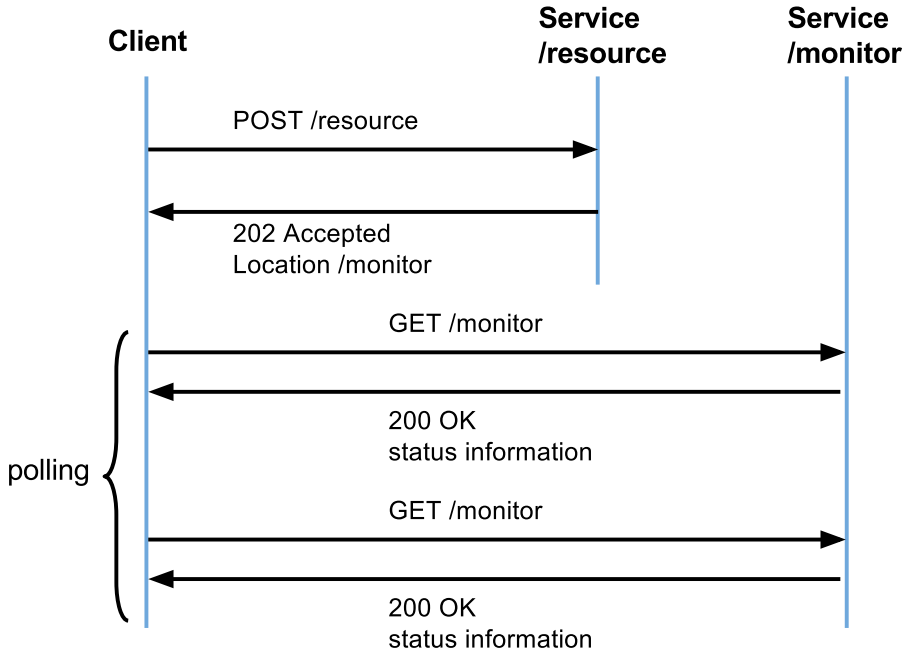
Asynchronous Communication

- 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

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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"*

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

Task

- *Implement the remaining methods listed above*

Testing

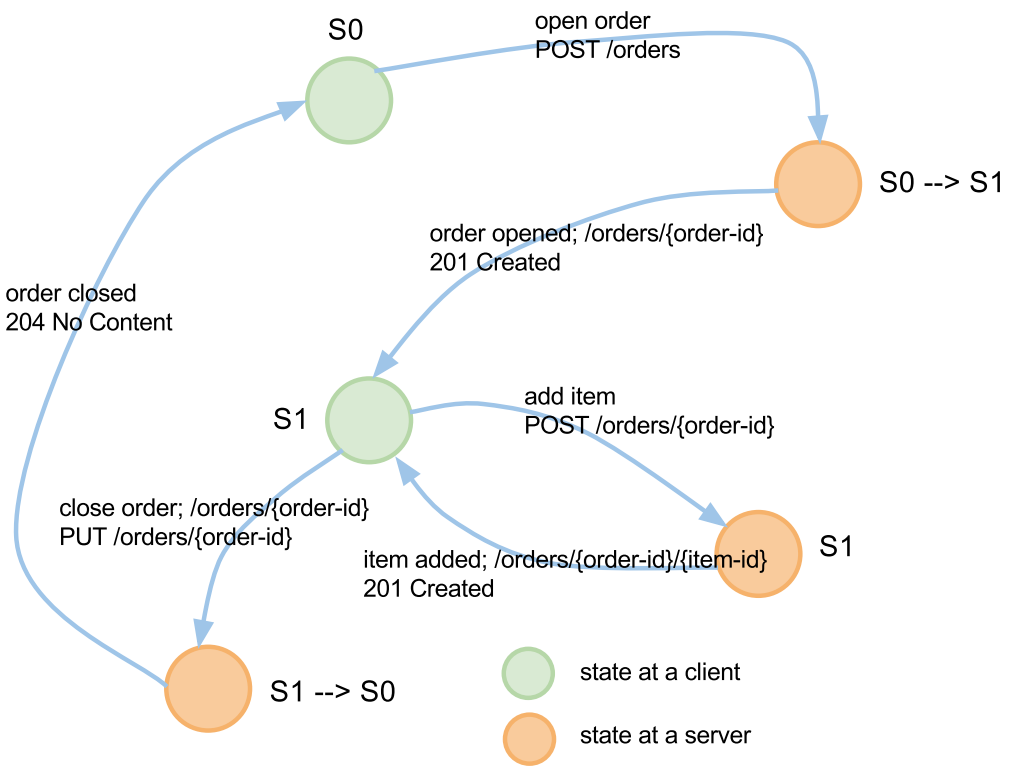
- Test the service using a bash script `test.sh`

```
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*

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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*

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.