HTTP, REST Web Services

Martin Ledvinka

martin.ledvinka@fel.cvut.cz

Winter Term 2018

Contents

What is a web service?

A Web service is a software system designed to support interoperable machine-to-machine interaction over a network.

— W3C, Web Services Glossary

We can identify two major classes of Web services:

- *REST-compliant Web services, in which the primary purpose of the service is to manipulate XML representations of Web resources using a uniform set of "stateless" operations; and*
- *arbitrary Web services, in which the service may expose an arbitrary set of operations.*

— W3C, Web Services Architecture (2004)

Web Service API Distribution

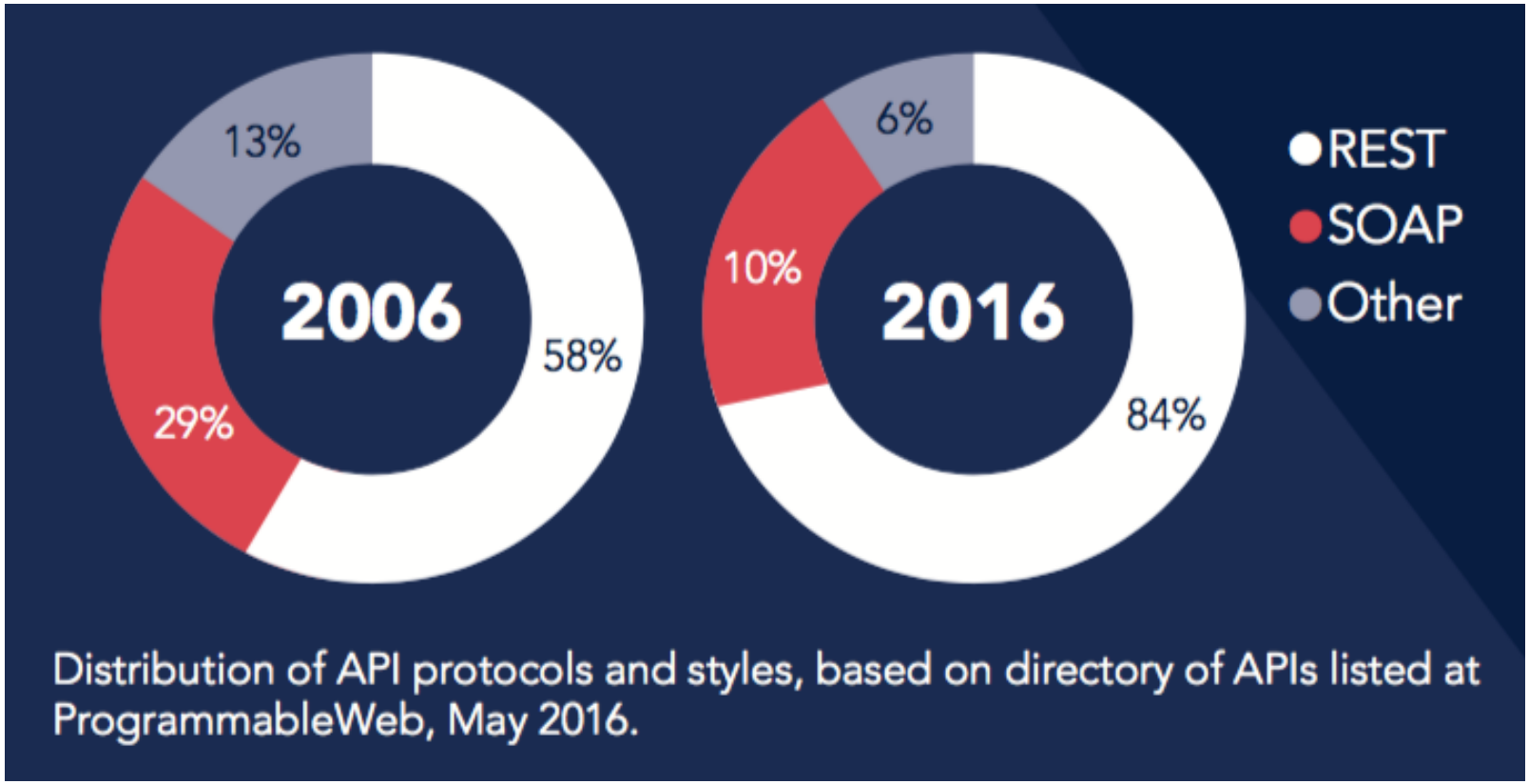


Figure : Interest in web service APIs. Source: `https://blog.wishtack.com/rest-apis-best-practices-and-security/`

REST vs SOAP Interest

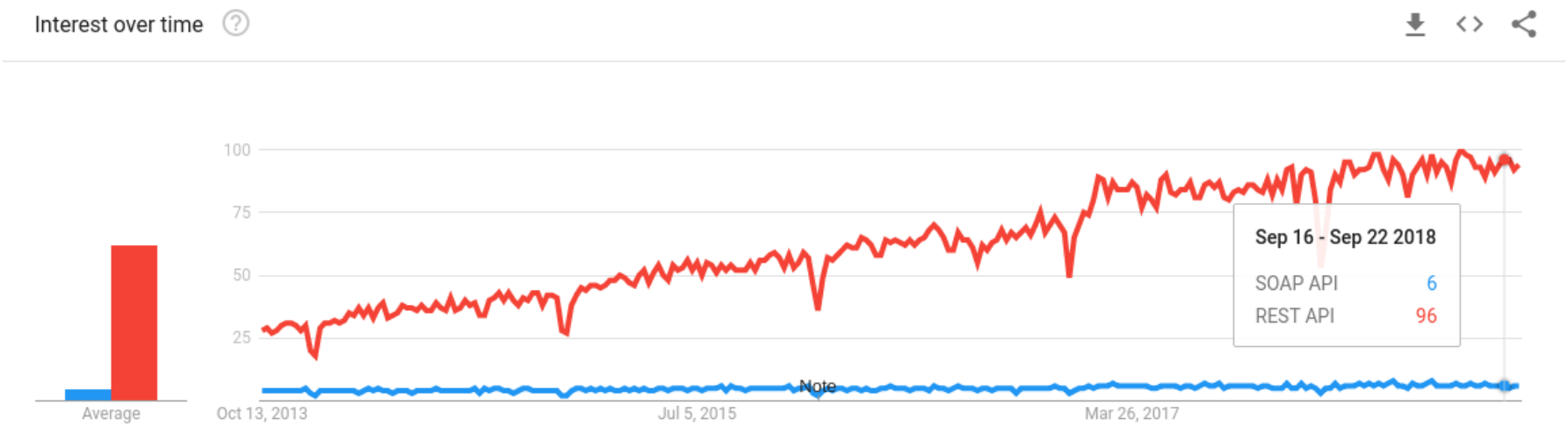


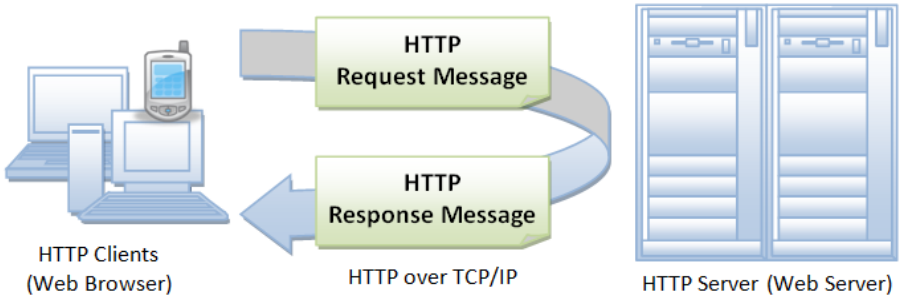
Figure : Interest over time for REST API versus SOAP API based on Google Insights for Search. Source: `https://www.google.com/trends`

Basic terms

- **Uniform Resource Identifier (URI)** is a string of characters used to identify a resource. (e.g., `http://www.fel.cvut.cz/cz/education/`)
- **The Hypertext Transfer Protocol (HTTP)** is an application *protocol* for distributed, collaborative, hypermedia information systems. It is the foundation of data communication for the World Wide Web.
  - initiated by Tim Berners-Lee at CERN in 1989
- **Representational State Transfer (REST)** is an *architectural style* for distributed hypermedia systems.
  - defined in 2000 by Roy Fielding in his doctoral dissertation

HTTP

HTTP protocol basics



- HTTP is a client-server application-level protocol
- Typically runs over a TCP/IP connection
- Extensible – e.g., video, image support
- Stateless
- Cacheable
- Requires *reliable* transport protocol – no UDP

HTTP Request

- Message header
  - Request line – identifies HTTP method, URI and protocol version
  - Request headers
- Message body

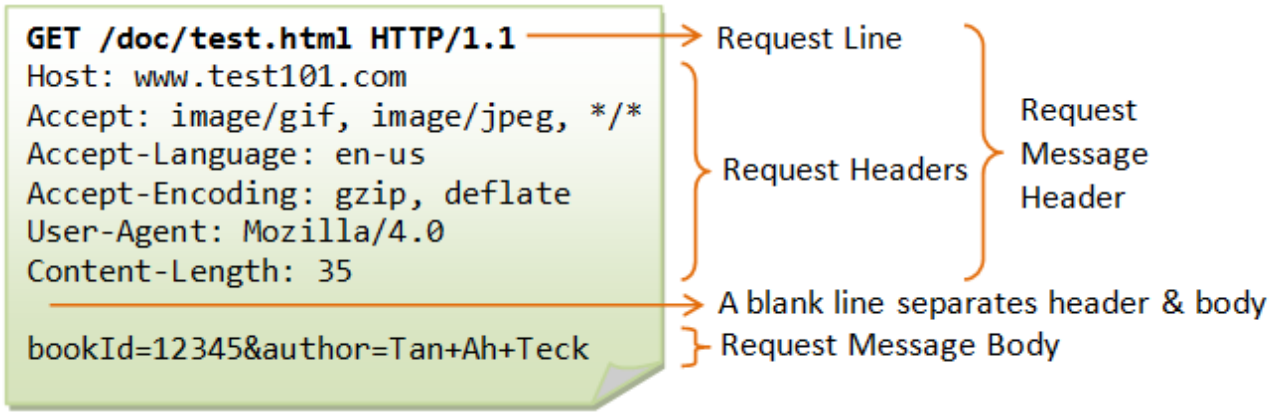


Figure : HTTP request example. Source: `https://www.ntu.edu.sg/home/ehchua/programming/webprogramming/HTTP_Basics.html`

HTTP Response

- Message header
  - Status line – identifies protocol version and response status code
  - Response headers
- Message body

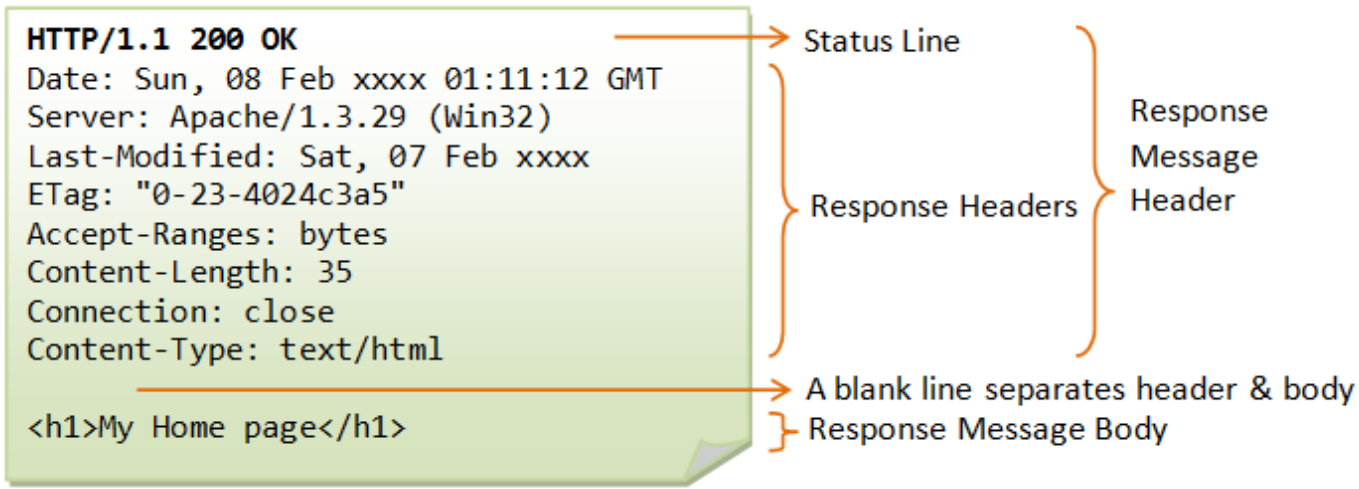


Figure : HTTP request example. Source: `https://www.ntu.edu.sg/home/ehchua/programming/webprogramming/HTTP_Basics.html`

HTTP Headers

Typical, often used HTTP headers

	Request	**Response**
Content	• Content-Type • Content-Length • Content-Encoding • Accept	• Content-Type • Content-Length • Content-Encoding
Caching	• If-Modified-Since • If-Match	• Last-Modified • ETag
Miscellaneous	• Cookie • Host • Authorization • User-Agent	• Set-Cookie • Location

HTTP Methods

GET

- Used to retrieve resource at request URI
- Safe and idempotent
- Cacheable
- Can have side effects, but not expected
- Can be conditional or partial (If-Modified-Since, Range)

POST

- Requests server to create new resource from the specified body
- Can be used also to update resources
- Should respond with 201 status and location of newly created resource on success
- Neither safe nor idempotent
- No caching

HTTP Methods

PUT

- Requests server to store the specified entity under the request URI
- Server may possibly create a resource if it does not exist
- Usually used to update resources
- Idempotent, unsafe

DELETE

- Used to ask server to delete resource at the request URI
- Idempotent, unsafe
- Deletion does not have to be immediate

HTTP Response Status Codes

- **1xx** – rarely used
- **2xx** – success
  - 200 OK – requests succeeded, usually contains data
  - 201 Created – returns a *Location* header for new resource
  - 202 Accepted – server received request and started processing
  - 204 No Content – request succeeded, nothing to return
- **3xx** – redirection
  - 304 Not Modified – resource not modified, cached version can be used

HTTP Response Status Codes

- **4xx** – client error
  - 400 Bad Request – malformed syntax
  - 401 Unauthorized – authentication required
  - 403 Forbidden – server has understood, but refuses request
  - 404 Not Found – resource not found
  - 405 Method Not Allowed – specified method is not supported
  - 409 Conflict – resource conflicts with client data
  - 415 Unsupported Media Type – server does not support media type
- **5xx** – server error
  - 500 Internal Server Error – server encountered error and failed to process request

RESTful web services

Understanding REST

- REST is an architectural style, not standard
- It was designed for distributed systems to address *architectural properties* such as performance, scalability, simplicity, modifiability, visibility, portability, and reliability
- REST architectural style is defined by 6 *principles/architectural constraints* (e.g., client-server, stateless)
- System/API that conforms to the constraints of REST can be called *RESTful*

REST principles

1. Client-server
2. Uniform interface
   - Resource-based
   - Manipulation of resource through representation
   - Self-descriptive messages
   - Hypermedia as the engine of application state
3. Stateless interactions
4. Cacheable
5. Layered system
6. Code on demand (optional)

Building RESTful API

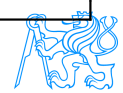
- Can be build on top of existing web technologies
- Reusing semantics of HTTP 1.1 methods
  - Safe and idempotent methods
  - Typically called HTTP verbs in context of services
  - Resource oriented, correspond to CRUD operations
  - Satisfies **uniform interface** constraint
- HTTP Headers to describe requests & responses
- Content negotiation

HTTP GET

```
GET /eshop/rest/categories HTTP/1.1
Host: localhost:8080
Accept: application/json
Cache-Control: no-cache
```

```
HTTP/1.1 200
Cache-Control: no-cache, no-store, max-age=0, must-revalidate
Content-Type: application/json;charset=UTF-8

[{
   "id": 2,
   "name": "CPU"
}, {
   "id": 7,
   "name": "Graphic card"
}, {
   "id": 11,
   "name": "RAM"
}]
```



HTTP verbs – POST

```
POST /eshop/rest/categories HTTP/1.1
Host: localhost:8080
Content-Type: application/json
Cookie: EAR_JSESSIONID=18162708908C126C0BA5A3D3081CCAC9
Cache-Control: no-cache

{
   "name": "Motherboard"
}
```

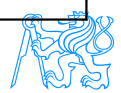
```
HTTP/1.1 201
Cache-Control: no-cache, no-store, max-age=0, must-revalidate
Location: http://localhost:8080/eshop/rest/categories/151
```

HTTP verbs – PUT

```
PUT /eshop/rest/products/8 HTTP/1.1
Host: localhost:8080
Content-Type: application/json
Cookie: EAR_JSESSIONID=18162708908C126C0BA5A3D3081CCAC9

{
   "id":8,
   "name":"MSI GeForce GTX 1050 Ti 4GT OC",
   "amount":50,
   "price":4490.0,
   "categories":[{
      "id":7,
      "name":"Graphic card"
   }],
   "removed":false
}
```

```
HTTP/1.1 204
Cache-Control: no-cache, no-store, max-age=0, must-revalidate
```



HTTP verbs – DELETE

```
DELETE /eshop/rest/products/8 HTTP/1.1
Host: localhost:8080
Cookie: EAR_JSESSIONID=18162708908C126C0BA5A3D3081CCAC9
Cache-Control: no-cache
```

```
HTTP/1.1 204
Cache-Control: no-cache, no-store, max-age=0, must-revalidate
```

Recommended Interaction of HTTP Methods w.r.t. URIs

HTTP Verb	**CRUD**	**Collection (e.g. /categories)**	**Specific Item (e.g. /categories/{id})**
POST	Create	201 Created[1]	405 Method Not Allowed /409 Conflict[3]
GET	Read	200 OK, list of categories	200 OK, single category/404 Not Found[4]
PUT	Update/Replace	405 Method Not Allowed[2]	200 OK/**204 No Content**/404 Not Found[4]
PATCH	Update/Modify	405 Method Not Allowed[2]	200 OK/**204 No Content**/404 Not Found[4]
DELETE	Delete	405 Method Not Allowed[2]	200 OK/**204 No Content**/404 Not Found[4]

Table : Recommended return values of HTTP methods in combination with the resource URIs.

- [1] – returns *Location* header with link to /categories/{id} containing new ID
- [2] – unless you want to update/replace/modify/delete whole collection
- [3] – if resource already exists
- [4] – if ID is not found or invalid

Naming conventions

- resources should have name as nouns, not as verbs or actions
- plural if possible to apply
- URI should follow a predictable (i.e., consistent usage) and hierarchical structure (based on structure-relationships of data)

Correct usages

POST /customers/12345/orders/121/items
GET /customers/12345/orders/121/items/3
GET|PUT|DELETE /customers/12345/configuration

Anti-patterns

GET /services?op=update_customer&id=12345&format=json
PUT /customers/12345/update

Demo

Let's examine SpaceX REST API.

https://documenter.getpostman.com/view/2025350/RWaEzAiG#intro

The Richardson Maturity Model

- provides a way to evaluate compliance of API to REST constraints

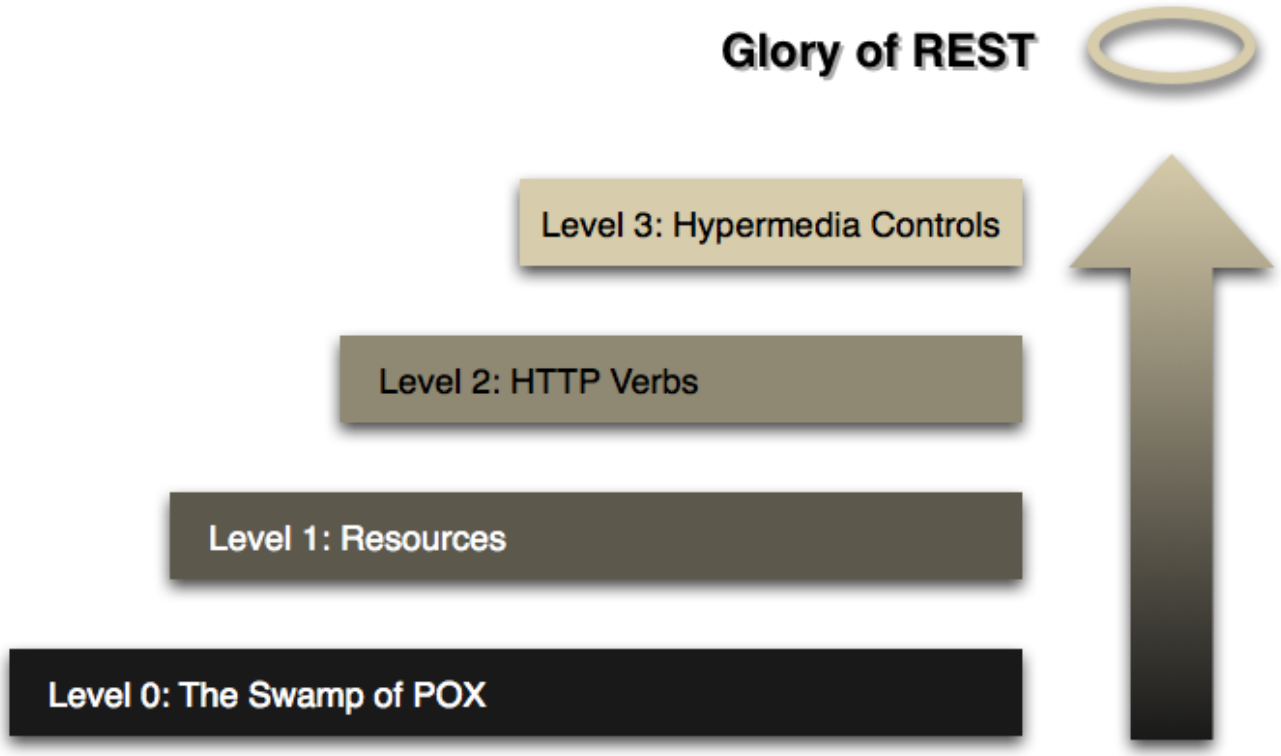


Figure : A model (developed by Leonard Richardson) that breaks down the principal elements of a REST approach into three steps about *resources*, *http verbs*, and *hypermedia controls*. Source: `http://martinfowler.com/articles/richardsonMaturityModel.html`

HATEOAS

- *Hypermedia as the Engine of Application State*
- Final level of the Richardson Maturity Model
- Client needs zero or little prior knowledge of an API
- Client just needs to understand hypermedia
- Server provides links to further endpoints
- Often difficult to implement
  - Not many usable libraries

HATEOAS Example

**EAR e-shop does not support HATEOAS.*

```
{
   "id": 2,
   "name": "CPU",
   "links": [{
      "rel": "self",
      "href": "http://localhost:8080/eshop/rest/categories/2"
   }, {
      "rel": "edit",
      "href": "http://localhost:8080/eshop/rest/categories/2"
   }, {
      "rel": "products",
      "href": "http://localhost:8080/eshop/rest/categories/2/products"
   }]
}
```

We are using the *Atom* link format.

Linked Data

Linked Data

- Method of publishing structured data allowing to interlink them with other data
- Builds upon the original ideas of the Web
  - Interconnected resources, but this time, machine-readable
- Knowledge-based systems, context-aware applications, precise domain description, knowledge inference
- Still possible to build REST APIs, but resources have global identifiers now
- Attributes and relationships also globally identifiable and may have well-defined meaning

Linked Data Example

```
{
  "@context": {
    "name": "http://www.w3.org/2000/01/rdf-schema#label",
    "description": "http://purl.org/dc/terms/description",
    "products": "http://onto.fel.cvut.cz/ontologies/eshop/has-product"
  },
  "@id": "http://onto.fel.cvut.cz/eshop/categories/cpu",
  "products": {
    "@id": "https://ark.intel.com/products/97455/Intel-Core-i3-7100-
        Processor-3M-Cache-3-90-GHz",
    "name": "Intel Core i3-7100"
  },
  "description": "Category of Central Processing Units for computers.",
  "name": "CPU"
}
```

Conclusions

REST

Pros

- Easy to build
- Easy to use
- Standard technologies – HTTP, JSON, XML
- Platform-independent
- Stateless, cacheable

Cons

- No standard for REST itself – APIs build in various ways
- No standard for documentation and publishing REST API description
- No “registry” of REST services

The End

Thank You

Resources

- Fielding, R.T., 2000. Architectural styles and the design of network-based software architectures (Doctoral dissertation, University of California, Irvine),
- Fowler, M., 2010. Richardson Maturity Model: steps toward the glory of REST. Online at `http://martinfowler.com/articles/richardsonMaturityModel.html`.
- Lanthaler, M. and Gütl, C., 2012, April. On using JSON-LD to create evolvable RESTful services. In Proceedings of the Third International Workshop on RESTful Design (pp. 25-32). ACM.
- `https://spring.io/understanding/REST`
- `https://developer.mozilla.org/en-US/docs/Web/HTTP/Overview`
- `http://linkeddata.org/`