REST: From GET to HATEOAS

... or how to create RESTful APIs

Who am I?

~ just some java guy ~

Jos Dirksen

Architect @ JPoint

- Live in Waalwijk
- Married
- Daughter (2.5 y/o)
- Blog at: www.smartjava.org

Interests

- Java & Scala
- REST, WS-*
- HTML5

- Snowboarding
- Reading
- Cooking

Books

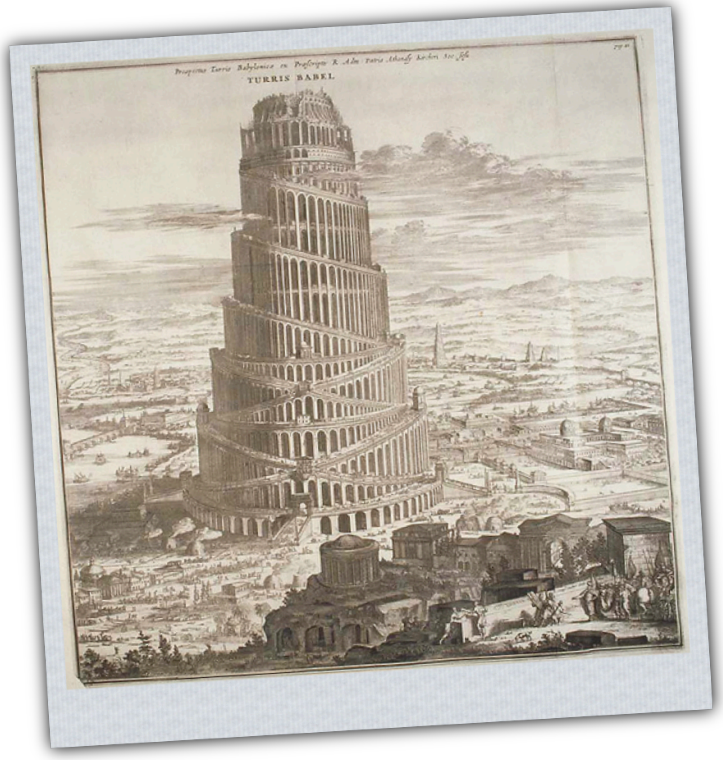
Shameless self promotion:

- SOA Governance in Action, Manning, 2012
- Open Source ESBs in Action, Manning, 2008

In the beginning...

~ It was a dark place ~

The world before REST!



Many different ‘standards’:

RMI, SOAP, Corba, DCE, DCOM

From many different parties:

Sun, Microsoft, IBM, OASIS, OMG

Caused many problems:

- Bad interoperability.
- Reinvent the wheel.
- Vendor ‘lock-in’.

And then came REST!

"Representational State Transfer (REST) is a style of software architecture for distributed hypermedia systems such as the World Wide Web"

REST is based on a set of constraints

~ Rest 101 ~

1. Client-server
Separate clients and servers.

2. Stateless server
Each request from a client contains all the information necessary to service the request.

3. Cacheable
Clients can cache responses, responses must indeticate if this is allowed.

4. Uniform interface
There is a uniform interface between clients and servers.

5. Layered System
Must allow concepts such as load balancers, proxies and firewalls.

6. Code-On-Demand (optional)
Client can request code from server and execute it.

Constraint 4: Uniform interface

~ Rest 101 ~

A. Identification of resources:
   E.g. by using an URI.
B. Manipulation of resources through representations:
   A representations allows user to modify/delete resource .
C. Self-descriptive messages:
   Process message based on message and meta-data.
D. Hypermedia as the engine of application state:
   State transitions are defined in representations.

And all was good!

Why do this? Why be RESTful?

- Scalable
- Fault-tolerant
- Recoverable
- Secure
- Loosely coupled

"Exactly what we want in the applications we are developing!"

But not everybody understood...

- GET: /getAllDogs
- GET: /saveDog?name=brian&age=7
- GET: /feedDog?food=123&dog=brian

instead of:

- GET: /dogs
- POST: /dogs/1234
- POST: /dogs/1234/food/12

"In your URLs – nouns are good; verbs are (usually) bad"

Twitter API

~ just saying your RESTful doesn't make it so ~

Bad URLs:

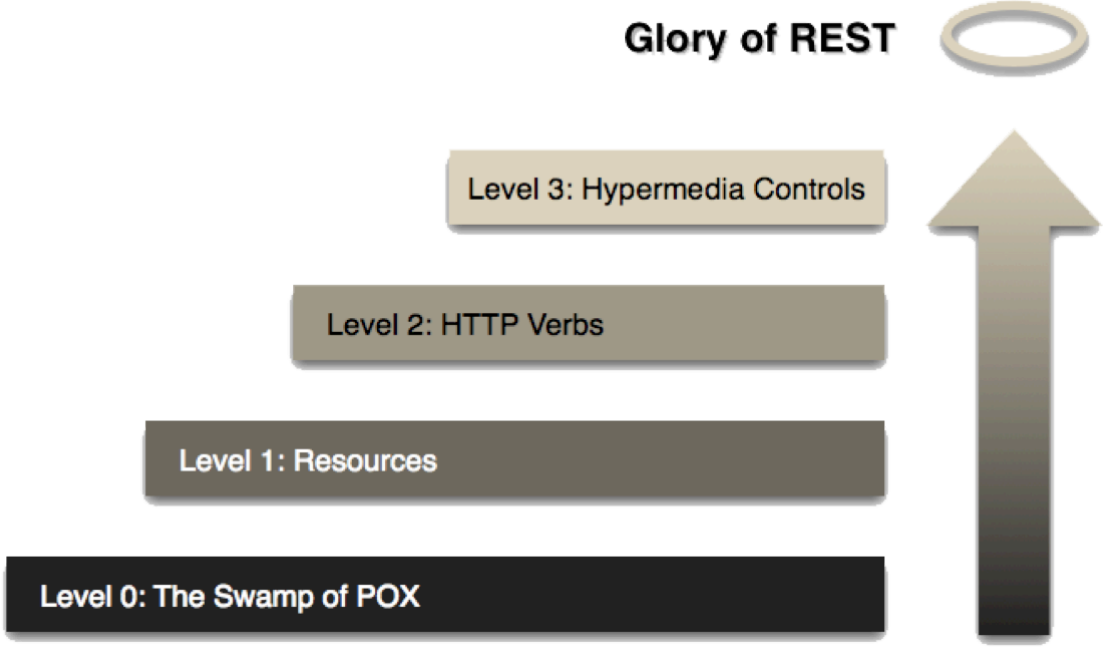
- POST statuses/destroy/:id
- GET statuses/show/:id
- POST direct_messages/new

Instead of:

- DELETE statuses/:id
- GET statuses/:id
- POST direct_messages or PUT direct_messages/:id

The maturity levels of REST

Richardson's Maturity Model



Level 0: The Swamp of Pox

~ nothing to do with REST ~

- One URI, one HTTP method
- XML-RPC / SOAP / POX
- Giant 'black box'

```
POST /appointmentService HTTP/1.1
[various other headers]

<appointmentRequest>
  <slot doctor = "mjones" start = "1400" end = "1450"/>
  <patient id = "jsmith"/>
</appointmentRequest>
```

Level 1: Resources

~ lots of APIs start out this way ~

- Each resource has an unique URI
- Single HTTP verb (usually POST or GET)
- Verbs have no meaning, used to tunnel over HTTP
- Early versions of Flickr, del.ico.us and Amazon

```
POST /slots/1234 HTTP/1.1
[various other headers]

<appointmentRequest>
  <patient id = "jsmith"/>
</appointmentRequest>
```

Level 2: HTTP Verbs

~ close but no sigar ~

- Many URIs, using multiple verbs.
- Correct use of response codes.
- Exposes state, not behavior.
- Crud services, can be useful e.g Amazon S3

```
GET /doctors/mjones/slots?date=20100104&status=open HTTP/1.1
Host: royalhope.nhs.uk

HTTP/1.1 200 OK
<openSlotList>
  <slot id = "1234" start = "1400" end = "1450"/>
  <slot id = "5678" start = "1600" end = "1650"/>
</openSlotList>
```

Level 3: Hypermedia controls

~ True RESTful ~

- Resources are self-describing.
- Hypermedia As The Engine Of Application State (HATEOAS)
- Exposes state and behavior.

```
<appointment>
  <slot id = "1234" doctor = "mjones" start = "1400"
        end = "1450"/>
  <patient id = "jsmith"/>
  <link rel = "/linkrels/appointment/addTest"
        uri = "/slots/1234/appointment/tests"/>
  <link rel = "/linkrels/appointment/updateContactInfo"
        uri = "/patients/jsmith/contactInfo"/>
</appointment>
```

So, are level 0, 1 and 2 RESTful?

"What needs to be done to make the REST architectural style clear on the notion that hypertext is a constraint? In other words, if the engine of application state (and hence the API) is not being driven by hypertext, then it cannot be RESTful and cannot be a REST API. Period. Is there some broken manual somewhere that needs to be fixed?"

Roy T. Fielding

Level 2 is easy, how do we do HATEOAS?

~ Worst acronym ever! ~

HATEOAS?

"The next control state of an application resides in the representation of the first requested resource, ... The application state is controlled and stored by the user agent ... anticipate changes to that state (e.g., link maps and prefetching of representations) ... The model application is therefore an engine that moves from one state to the next by examining and choosing from among the alternative state transitions in the current set of representations."

Roy T. Fielding

Say what?

The key to HATEOAS is simple

- Hypermedia / Mime-types / Media-types :
  - Describes a current state
  - Compare it with a web page
  - Can be seen as the contract
- Links:
  - Describe the transition to the next state
  - Compare it with hyperlinks
- HATEOAS makes surfing the web possible
- Jim Webber: “Hypermedia Describes Protocols” (HYDEPR)

“In each response message, include the links for the next request message”

HATEOAS Part 1: Links

~ AtomPub ~

```
<feed xmlns="http://www.w3.org/2005/Atom">
        <title>Example Feed</title>
        <subtitle>A subtitle.</subtitle>
        <link href="http://example.org/feed/"
              rel="self" />
        <link href="http://example.org/" />
        <id>urn:uuid:60a76c80-d399-11d9-b91C-0003939e0af6</id>
        <updated>2003-12-13T18:30:02Z</updated>
        <author>
                <name>John Doe</name>
                <email>johndoe@example.com</email>
        </author>
        <entry>
                <title>Atom-Powered Robots Run Amok</title>
                <link href="http://example.org/2003/12/13/atom03" />
                <link rel="alternate" type="text/html"
                     href="http://example.org/2003/12/13/atom03.html"/>
```

HATEOAS Part 1: Links

~ Netflix API ~

```
<link
  href="http://.../catalog/titles/series/70023522/cast”
   rel="http://schemas.netflix.com/catalog/people"
 title="cast">
 <cast>
  <link href="http://api.netflix.com/catalog/people/30011713"
        rel="http://schemas.netflix.com/catalog/person"
      title="Steve Carell"/>
  <link href="http://api.netflix.com/catalog/people/30014922"
        rel="http://schemas.netflix.com/catalog/person"
      title="John Krasinski"/>
  <link href="http://api.netflix.com/catalog/people/20047634"
        rel="http://schemas.netflix.com/catalog/person"
      title="Jenna Fischer"/>
</cast>
</link>
```

HATEOAS Part 1: Twitter Example

~ Before using links~

```
GET .../followers/ids.json?cursor=-1&screen_name=josdirksen

{
 “previous_cursor”: 0,
 “previous_cursor_str”: 0,
 “ids”: [
   12345678,
   87654321,
   11223344
 ],
 “next_cursor”: 0,
 “next_cursor_str”: “0”
}
```

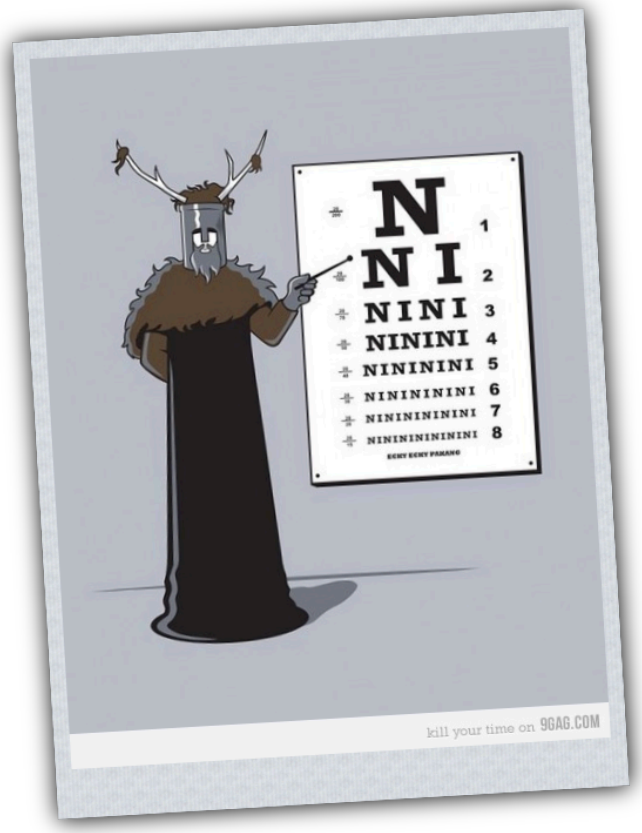
HATEOAS Part 1: Twitter Example

~ With links~

```
GET .../followers/ids.json?cursor=-1&screen_name=josdirksen

{
 “previous_cursor”: 0,
 “id”: {
   “name”: “John Smit”,
   “id”: “12345678”
   “links” : [
   { “rel”: “User info”,
     “href”: “https://.../users/12345678”},
   { “rel”: “Follow user”,
     “href”: “https://.../friendship/12345678”}
   ]
  } // and add other links: tweet to, send direct message,
  ..// block, report for spam, add or remove from list
}
```

HATEOAS Part 2: Media-types



WHERE:

People know **where** to find your resource using URIs.

HOW:

They know **how** to interact by following links.

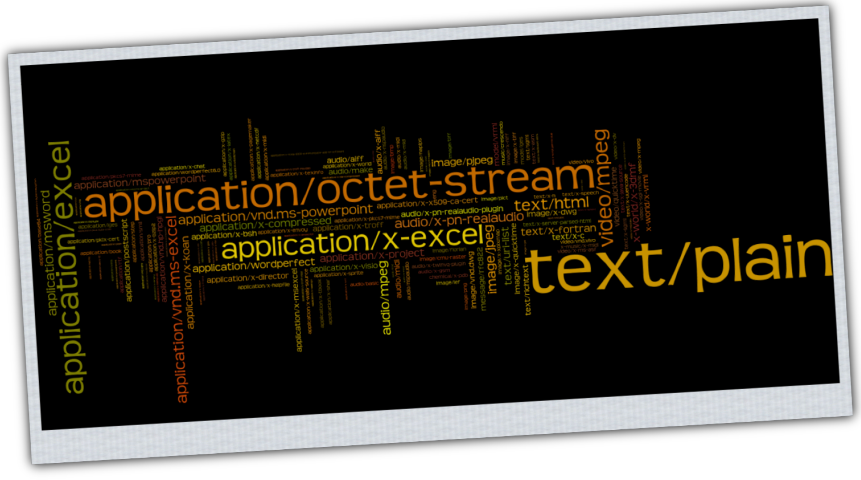
WHAT:

But **what** do the resources look like, **what** do they need to post?

HATEOAS Part 2: Media-types

~ not all media-types are equal, some are more equal than others ~

- Standard formats
  - Easy to use and understand.
  - Clients already know how to use them
  - Don't always match with what you want to do
  - XHTML and AtomPub
- Self created
  - Very domain specific
  - Can have rich semantics
  - Client specific implementation required
  - Often described using XML Schema
  - or in plain text, or not at all...



HATEOAS Part 2: Media-types

~ Custom media types ~

```
200 OK
Content-Type: application/vnd.bank.org.account+xml;charset=UTF-8

<accounts xmlns="urn:org:bank:accounts">
    <account>
        <id>AZA12093</id>
        <link href="http://bank.org/account/AZA12093" rel="self"/>
        <link rel="http://bank.org/rel/transfer"
              type="application/vnd.bank.org.transfer+xml"
              href="http://bank.org/transfers"/>
        <link rel="http://bank.org/rel/customer"
              type="application/vnd.bank.org.customer+xml"
              href="http://bank.org/customer/7t676323a"/>
        <balance currency="USD">993.95</balance>
    </account>
</accounts>
```

And that is what HATEOAS means!

- Media-types describe the resources.
- Actions are executed by following links.
- Each new response reflects a state.

- It is good to create custom media-types.
- Creates self-describing APIs.
- Clients 'explore' your API just as they browse the web.

"Media-types describes a domain specific application protocol"

HATEOAS Part 2: Twitter Example

~ With links, but no media-type ~

```
GET .../followers/ids.json?cursor=-1&screen_name=josdirksen

{
 “previous_cursor”: 0,
 “id”: {
   “name”: “John Smit”,
   “id”: “12345678”
   “links” : [
   { “rel”: “User info”,
     “href”: “https://.../users/12345678”},
   { “rel”: “Follow user”,
     “href”: “https://.../friendship/12345678”}
   ]
  }
  ...
}
```

HATEOAS Part 2: Twitter Example

~ With links & media-type ~

```
GET .../followers/ids.json?cursor=-1&screen_name=josdirksen

{
 “previous_cursor”: 0,
 “id”: {
   “name”: “John Smit”,
   “id”: “12345678”
   “links” : [
   { “type: “application/vnd.twitter.com.user”,
     “rel”: “User info”,
     “href”: “https://.../users/12345678”},
   { “type”: “application/vnd.twitter.com.user.follow”,
     “rel”: “Follow user”,
     “href”: “https://.../friendship/12345678”}
   ] // and add other options: tweet to, send direct message,
     // block, report for spam, add or remove from list
  }  // This is how you create a self-describing API.
}
```

Versioning without breaking

Three options for versioning

~ Media-types ~

- Media-type is versioned, directly in its name

```
Request:
GET /opengov/garbageschedule?location=Main%20Street HTTP/1.1
Accept: application/vnd.opengov.org.garbageschedule-v2+json

Response:
HTTP/1.1 200 OK
Content-Type: application/vnd.opengov.org.garbageschedule-v2+json

{"schedule"
     "self": "schedule-2423",
     "dayOfWeek": "Monday",
     "oddOrEvenWeeks": "Odd"}
```

Three options for versioning

~ Add version qualifier ~

- Media-type stays the same, add a qualifier.

```
Request:
GET /opengov/garbageschedule?location=Main%20Street HTTP/1.1
Accept: application/vnd.opengov.org.garbageschedule+json;v=1

Response:
HTTP/1.1 200 OK
Content-Type: application/vnd.opengov.org.garbageschedule+json;v=1

{"schedule"
     "self": "schedule-2423",
     "dayOfWeek": "Monday",
     "oddOrEvenWeeks": "Odd"}
```

Three options for versioning

~ The URI is versioned ~

- The version is added in the URI path

```
Request:
GET /opengov/v1/garbageschedule?location=Main%20Street HTTP/1.1
Accept: application/vnd.opengov.org.garbageschedule+json

Response:
HTTP/1.1 200 OK
Content-Type: application/vnd.opengov.org.garbageschedule+json

{"schedule"
     "self": "schedule-2423",
     "dayOfWeek": "Monday",
     "oddOrEvenWeeks": "Odd"}
```

Which one is the best?

~ personal opinion ~

Matter of taste:

1. Media-type approach most RESTful, but requires work on client and server side.

2. Qualifier, second best, easier to implement. Less media-types to keep track off.

3. URL, most often used. Personally don't like it. Can have two URIs point to same resource.

When HTTPS isn't enough

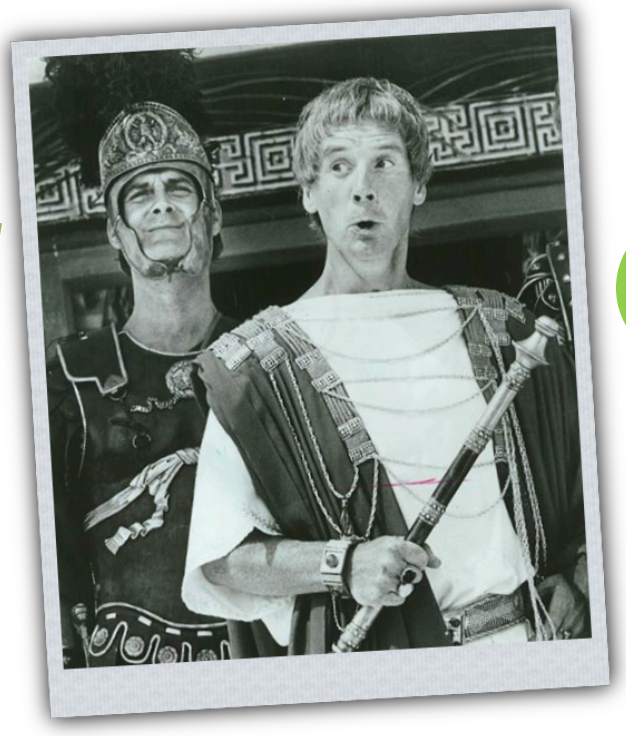
General idea about authentication in REST

"REST means working with the standards of the web, and the standard for 'secure' transfer on the web is SSL. Anything else is going to be kind of funky and require extra deployment effort for clients, which will have to have encryption libraries available."

Highest rated answer on stackoverflow regarding REST authentication schemes

Why do we need more?

- HTTPS doesn't fix man-in-the-middle attack
- It provides only transport level security
- Has no support for message integrity or authenticity
- REST assumes "Layered System"
- OAuth is nice (and complex) for authentication doesn't handle message integrity.
- REST doesn't have a WS-Security standard



HMAC based authentication

~ de facto standard ~

- Used by Google, Amazon AWS, Yahoo etc.
- Create a signature of the complete request, using shared secret.
- Add custom header with signature and signing user.
- Encrypt the following with this shared secret:
  - URI, to avoid executing on different resource,
  - Verb, indicates what we want to do with a resource,
  - MD5-Header, to detect changes to the content body
  - Content-type, indicates the type of resource
  - Date header, to avoid replay

HMAC based authentication

~ example ~

```
POST /resources/rest/geo/comment HTTP/1.1[\r][\n]
hmac: jos:+9tnOCLfxXFbzPmbYwq/KYuUSUI=[\r][\n]
Date: Mon, 26 Mar 2012 21:34:33 CEST[\r][\n]
Content-Md5: r52FDQv6V2GHN4neZBvXLQ==[\r][\n]
Content-Length: 69[\r][\n]
Content-Type: application/vnd.geo.comment+json;
charset=UTF-8[\r][\n]
Host: localhost:9000[\r][\n]
Connection: Keep-Alive[\r][\n]
User-Agent: Apache-HttpClient/4.1.3 (java 1.5)[\r][\n]
[\r][\n]
{"comment" : {"message":"blaat" , "from":"blaat" , "commentFor":
123}}
```

Parting guidelines

~ you may forget everything else I said ~

- Just doing URIs and Verbs doesn't make it RESTful
  - But that isn't necessary a bad thing.
- Use "Links" to describe "HOW" your service is used.
- Describe "WHAT" is expected using media-types.
  - This isn't a complete replacement of documentation
  - Don't use WADL
- Use media-types for versioning.
- Forget what HATEOAS stands for.

Pop Quiz

~ have you been paying attention ~

- Is this request RESTful? Why? Why Not?

```
Request:
GET /opengov/garbageschedule?location=Main%20Street HTTP/1.1
Accept: application/vnd.opengov.org.garbageschedule+json

Response:
HTTP/1.1 200 OK
Content-Type: application/vnd.opengov.org.garbageschedule+json

{"schedule"
     "self": ”/schedules/schedule-2423",
     "dayOfWeek": "Monday",
     "oddOrEvenWeeks": "Odd"}
```

Q&A

THANKS FOR COMING

More information; look at http://www.jpoint.nl or contact me.