# Service Oriented Architectures

# Styles, Technologies and Applications

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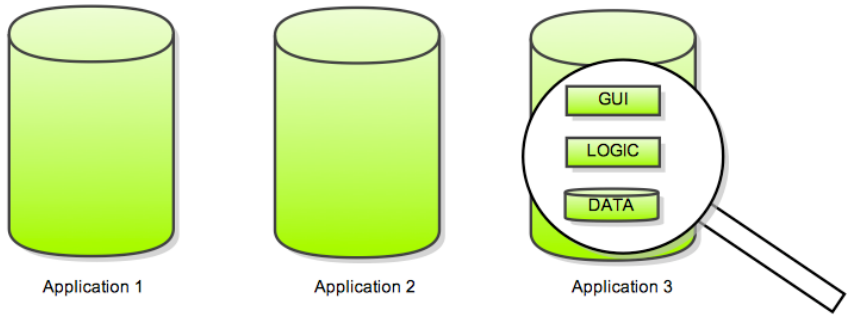
# Agenda

1. What problem are we trying to address ?
2. Evolution towards Distributed Applications
3. Software Services - definition
4. **Web** Services ?
5. Architectural Styles - RPC vs Service-Oriented vs Resource-Oriented (REST)
6. Real-World examples

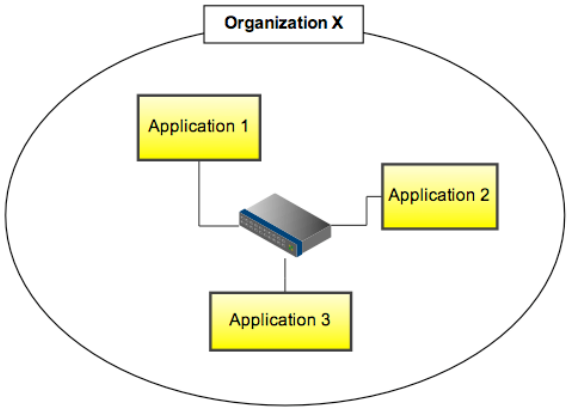
# 1. Problem

## Complete, closed, monolithic applications



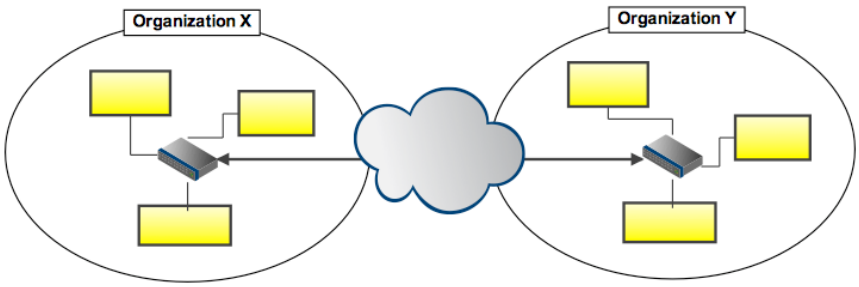
# 1. Objectives

## Integration across application boundaries



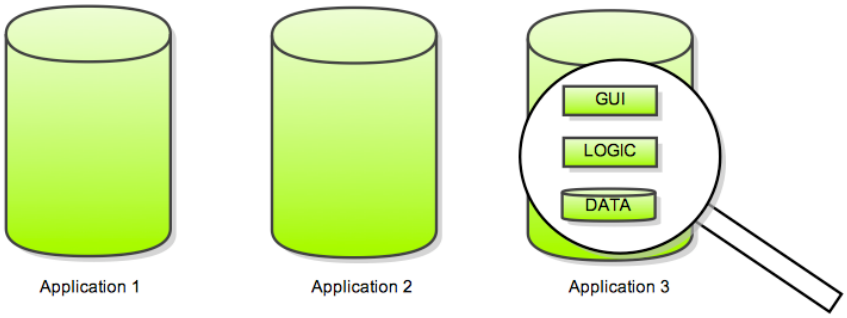
# 1. Objectives

## Integration across organizational boundaries



# 2. Evolution towards Distributed Applications

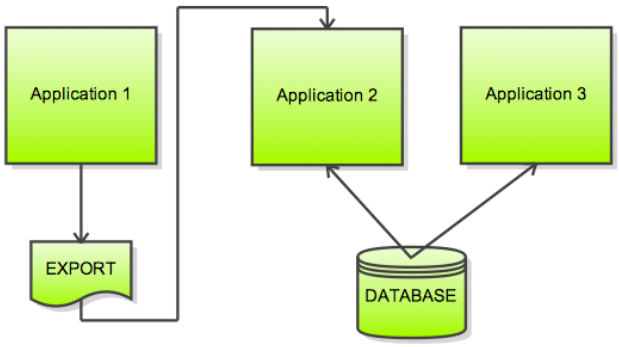
- **Monolithic Applications**




- duplication, high maintenance cost, no data sharing

# 2. Evolution towards Distributed Applications

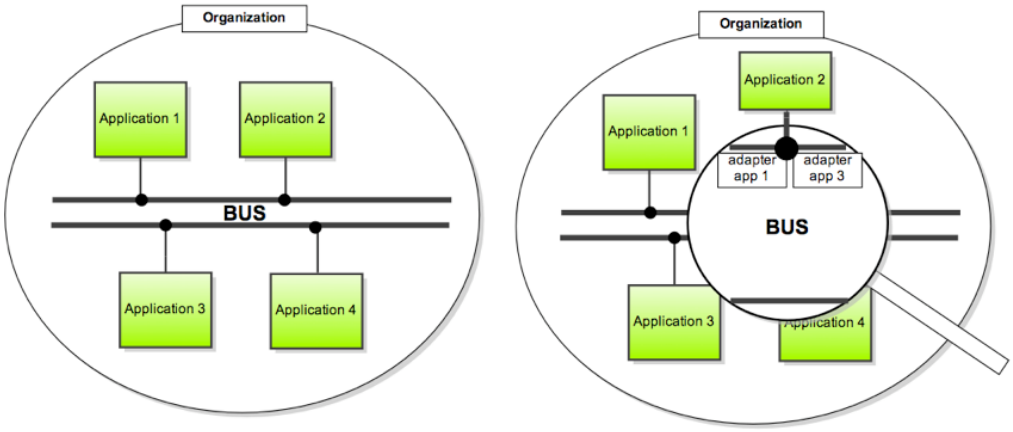
- **Applications sharing data**




- fragile, duplication

# 2. Evolution towards Distributed Applications

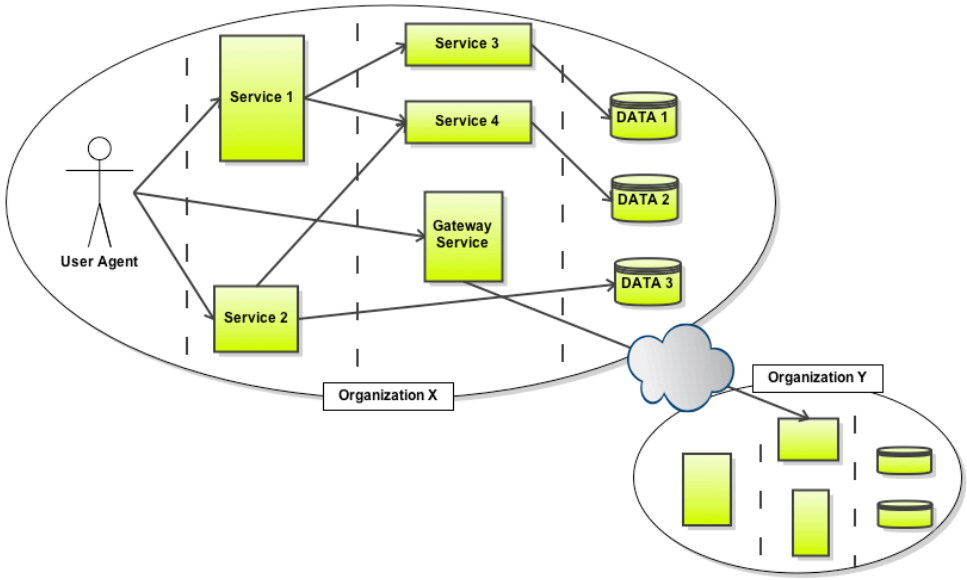
- **Applications sharing objects over the network**




- complex, vendor lock in, tight coupling

# 2. Evolution towards Distributed Applications

- **Service Oriented Architectures**




- language independant, reusability, composability, loose-coupling

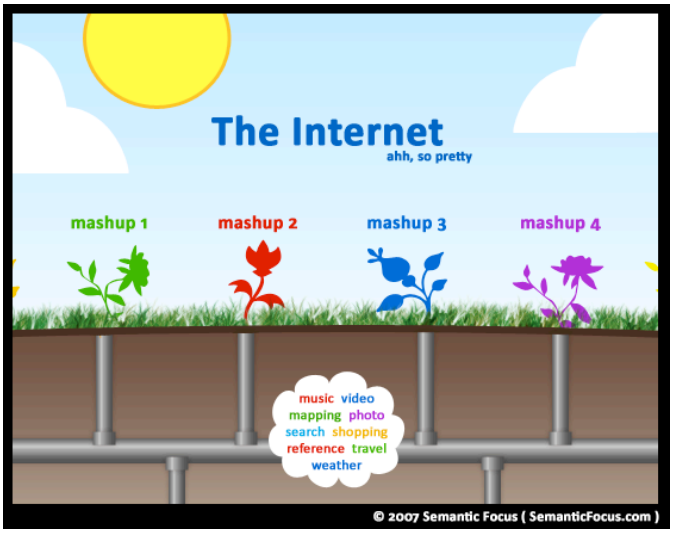
# 3. Software Services - definition

- Software services are units of functionality that exist at a service endpoint (**address**) that can be **remotely** accessed by clients.
- Clients can use the service by communicating with this endpoint without having direct access to the actual code files that implement the service.
- Loosely coupled
- Avoid fine-grained interactions patterns.

# 3. Software Services - benefits

- Operations across organizations
- Language independent
- Reusability
- Standardization, leading to better interoperability

# 4. Web Services ?




Term is often a catch-all for “services accessible on the web”

# 4. Web Services ?

W3C

> *a "web service" is "a **software system** designed to support **interoperable machine-to-machine interaction** over a **network**. It has an **interface** described in a **machine-processable format** (specifically Web Services Description Language WSDL). Other systems interact with the web service in a manner prescribed by its description using **SOAP messages**, typically **conveyed using HTTP** with an XML serialization in conjunction with other web-related standards."*

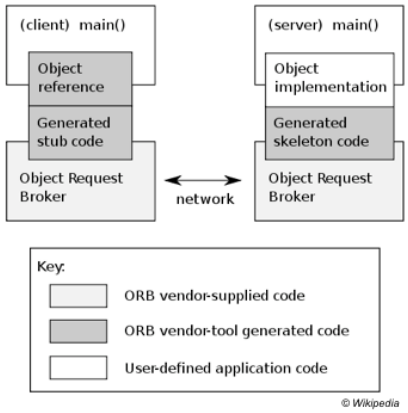
Web Services (WS) are just one of the technologies available to create distributed architectures. A software service may, but need not be exposed as a Web Service.

# 5. Architectural Styles for Distributed Applications

- RPC (Remote Procedure Call)
- Service/Message Oriented
- Resource Oriented

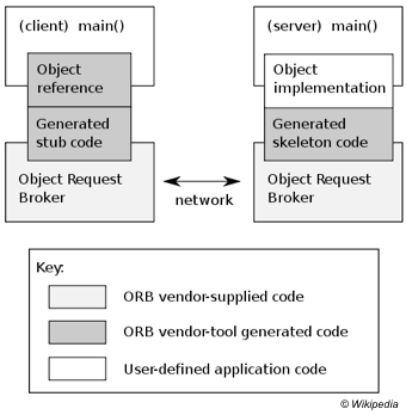
# 5A. RPC

- CORBA, DCOM, RMI, XML-RPC…
- Language independency
- Apparent simplicity



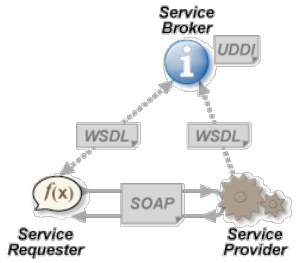
# 5A. RPC - drawbacks

- Tight coupling (generated client stub and server skeleton)
- No unique standard, leading to poor interoperability
- Poor scalability due to serialization/deserialization, but also:
- Hides the fact that objects are distributed, thus developer cannot make decisions according to objects locality.



# 5B. Message Oriented Architecture

- Most often implemented using the WS-* stack
- Web Services is a specific set of technologies for exposing Software Services:
  - *the WSDL language for service description*
  - *the SOAP language as the message format*
  - *the HTTP protocol as the transport layer*
  - *the UDDI interface for service discovery*



Java method:

```
1 public void myMethod(int x, float y);
```

## WSDL

```
01 <message name="myMethodRequest">
02     <part name="x" type="xsd:int"/>
03     <part name="y" type="xsd:float"/>
04 </message>
05 <message name="empty"/>
06
07 <portType name="PT">
08     <operation name="myMethod">
09         <input message="myMethodRequest"/>
10         <output message="empty"/>
11     </operation>
12 </portType>
13
14 <binding .../>
```

## SOAP

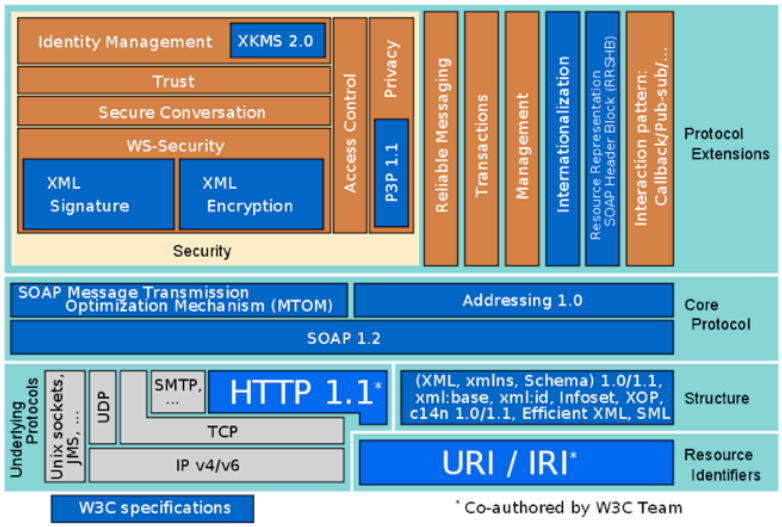
```
01 POST /service
02
03 <?xml version="1.0"?>
04 <soap:Envelope xmlns:soap="http://www.w3.org/2001/12
   /soap-envelope" soap:encodingStyle="http://www.w3.org
   /2001/12/soap-encoding">
05   <soap:Header>
06   ...
07   </soap:Header>
08   <soap:Body>
09     <myMethod>
10         <x xsi:type="xsd:int">5</x>
11         <y xsi:type="xsd:float">5.0</y>
12     </myMethod>
13   </soap:Body>
14 </soap:Envelope>
```

# 5B. Message Oriented Architecture - benefits

- Kind of standardized, leading to better interoperability
- Easier to change the interface without breaking old clients

# 5B. Message Oriented Architecture - drawbacks

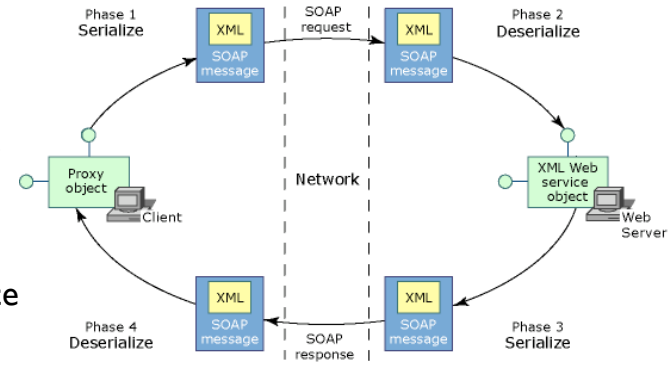
Complex, ever-changing specification




WS-Security, WS-Policy, WS-SecurityPolicy, WS-PolicyAssertions, WS-PolicyAttachment, WS-Trust, WS-Privacy, WS-Routing, WS-Referral, WS-Coordination, WS-Transaction, WS-SecureConversation, WS-Federation, WS-Authorization, WS-Attachments, WS-Transfer, WS-ResourceTransfer, WS-ReliableMessaging, WS-Addressing, …

# 5B. Message Oriented Architecture - drawbacks

- Specification written and pushed by big vendors (IBM, Microsoft, HP, Intel, SAP, Sun, etc.)
- Poor interoperability between vendor implementations, leading to vendor lock-in
- Most often, developers use early binding => stubs, proxy objects => tight-coupling
- Poor scalability: requires processing power to decode SOAP messages, difficult to load-balance or route requests based on the service endpoint (URI)




- UDDI is a failure
- Does not use HTTP as an application protocol, only as a transport protocol.

However, some advanced specs may be of interest (Security, QoS) if your environment requires it.

# 5C. RESTful Services - concepts

- Representational State Transfer, in Architectural Styles and the Design of Network-based Software Architectures Roy T. Fielding (2000)

  *The REST Web is the subset of the WWW (based on **HTTP**) in which agents provide **uniform interface** semantics – essentially create (POST), retrieve (GET), update (PUT) and delete (DELETE) – rather than **arbitrary or application-specific** interfaces, and manipulate **resources** only by the exchange of **representations**. Furthermore, the REST interactions are "**stateless**" in the sense that the meaning of a message does not depend on the state of the conversation.*

# 5C. RESTful Services - concepts

## Resources

- Functionalities offered by the service are exposed under the form of resources (e.g. jobs, users, payments, orders, friends…)

  *A resource can be anything that has identity (RFC 2396)*

- Real objects (user, site) or abstract concepts (status, payment)
- A resource may have **multiple representations**. E.g. a calendar may be represented using

```
image/png, text/html, application/pdf, application/xml, text/calendar
```

## URI

- Uniquely identifies each resource using a standardized syntax (http://server.com/users/crohr, https://bank.com/accounts, ftp://ftp-server/document, mailto:cyril.rohr@irisa.fr, xmpp://crohr@jabber.grid5000.fr…).
- Allow the use of **hypermedia** links to navigate from resource to resource.

# Unified interface

All resources share the same interface for transfering state between the client and the resource:

- a restricted set of well-defined operations (HTTP *verbs*)

```
GET             fetch a resource
POST            create a new resource
PUT             update a resource
DELETE          delete a resource
...
```

- a restricted set of standard media types

```
text/html, image/png, application/xml...
```

…but you can define your own.

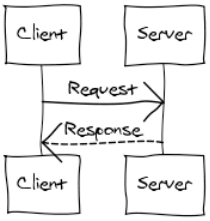
- a restricted set of status codes

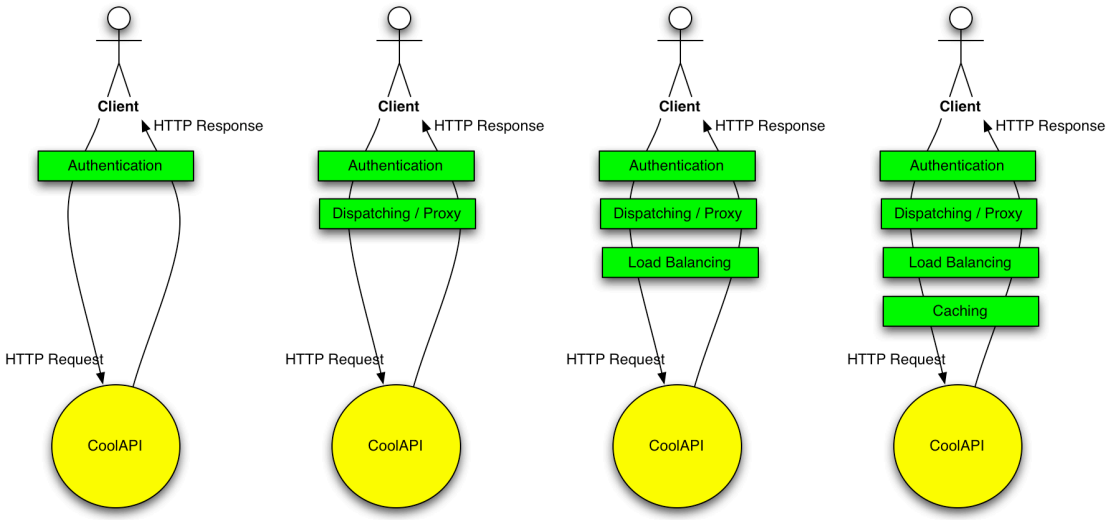
```
200 (OK), 201 (Created), 202 (Accepted),
303 (See Other), 304 (Not Modified),
400 (Bad Request), 404 (Not Found), 409 (Conflict),
500 (Internal Server Error)
...
```

# 5C. RESTful Services - concepts

## HTTP

- Client-Server protocol
- Stateless (each operation is self-sufficient)
- Cacheable
- Layered (intermediaries can be inserted between client and server, such as proxy, firewall, load-balancer, etc.)



# 5C. RESTful Services - benefits

- **Scalability** thanks to: cacheable requests (GET » POST,PUT,DELETE), and statelessness (requests are not bound to a specific server).
- **Interoperability**: the only thing that changes is the name of resources. Available HTTP verbs, status codes, etc. are always identical from one service to another => "given a URI, anyone already knows how to access it".
- **Addressability**: each resource is uniquely identified.

```
https://api.grid5000.fr/sid/grid5000/sites/rennes
```

- **Versioning** is easy: insert a version number in the URI (or use a custom HTTP Header), and dispatch accordingly to the correct server.
- **Control** meta-data (HTTP headers, both in Request and Response)

```
Accept: application/json [format]
Cache-Control: max-age=120 [cache]
Accept-Encoding: gzip, deflate [compression]
Accept-Language: us,en;q=0.5 [language]
Accept-Charset: ISO-8859-15,utf-8;q=0.7,*;q=0.7 [charset]
...
You can define your own: X-Api-Version, X-Api-User...
```

- Removes unnecessary complexity: headers, methods, status codes, media types are already standardized. The protocol is well documented, and in use since the Web exists. It's not another protocol on top of another protocol on top of another protocol on top of…

# 5C. RESTful Services - benefits

- **Security**: uses the inherent HTTP security model, certain methods to certain URIs can easily be restricted by firewall/proxy configuration.
- **Ubiquity**: every programming language can speak HTTP
- **Layered** architecture

# 5C. RESTful Services - constraints

- Requires to **carefully choose** the HTTP verb among those available

```
GET     safe         (doesn't change the state of the resource on the server)
        idempotent   (same operation can be applied multiple times
                      and will always return the same result)
        cacheable
PUT     idempotent
DELETE  idempotent
POST
...
```

- **Stateless**: each communication must include all the material required for the server to understand the context.

- Do NOT disguise RPC calls as HTTP requests (Flickr API):

```
GET /service?action=getUser&id=crohr&...

POST /service
{
  "action": "getUser",
  "id": "crohr",
  ...
}
```

# 5C. RESTful Services - HowTo

- A bit of specification:
  - *Choose your resources*
  - *Choose the supported HTTP verbs for each resource*
  - *Choose the supported media types*
  - *Choose the status codes that will be returned*
  - *Think about the link relationships between your resources*
- Use frameworks that encourage REST style: Sinatra (ruby), Restlet (java), Django & web.py (python)…
- Think about non-functional aspects
  - *Authentication: use Basic-Auth, Digest or SSL Client Certificates. Avoid sessions and tokens stored in cookies.*
  - *Caching: max-age, public/private, ETags, Last-Modified*
  - *Request dispatching & Load balancing, based on URI/IP/Geolocation/Traffic congestion…*

# 5C. RESTful Services - Client Side Code

- Ruby

```ruby
require 'restclient'
response = RestClient.get
"https://api.grid5000.fr/sid/grid5000", :user
=> "crohr", :password => "whatever"
```

- cURL

```
$ curl -X GET -kni https://api.grid5000.fr
/sid/grid5000
```

- Javascript (jQuery)

```
  $.ajax({
    url: "http://some/url",
    dataType: "json",
    success: function(data) {
      // do something
    },
    error: function() {},
    ...
  })
{:class="brush: ruby"}
```

- Example of a response

```
HTTP/1.1 200 OK
Date: Fri, 29 Jan 2010 12:12:14 GMT
ETag:
"ca5998adb91af61b9f9c57f2a26f71edebea5ffc"
Allow: GET
Cache-Control: public, must-revalidate
Last-Modified: Mon, 25 Jan 2010 15:31:30 GMT
Content-Length: 998
Status: 200
Content-Type:
application/vnd.fr.grid5000.api.grid+json;level=1
Age: 15023
X-Cache: HIT from api-proxy.rennes.grid5000.fr

{
  "uid": "grid5000",
  "type": "grid",
  "version":
"1cd3a84ff0c25d269cb24ac294e29b0fe8c111c5",
  "links": [
```

```
    {
      "href": "/sid/grid5000/versions
/1cd3a84ff0c25d269cb24ac294e29b0fe8c111c5",
      "title": "version",
      "rel": "member",
      "type":
"application/vnd.fr.grid5000.api.Version+json;level
    },
    {
      "href": "/sid/grid5000/versions",
      "title": "versions",
      "rel": "collection",
      "type":
"application/vnd.fr.grid5000.api.Collection+json;le
    },
    {
      "href": "/sid/grid5000",
      "rel": "self",
      "type":
"application/vnd.fr.grid5000.api.Grid+json;level=1"
    },
    {
      "href": "/sid/grid5000/environments",
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    },
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      "title": "sites",
      "rel": "collection",
      "type":
"application/vnd.fr.grid5000.api.Collection+json;le
    }
  ]
}
```

# 5C. RESTful Services - Server Side Code

```ruby
require 'rubygems'
require 'sinatra/base'  # gem install sinatra
require 'json'          # gem install json

class API < Sinatra::Base

  configure do
    # some configuration here
  end

  get         '/URI'   { do_something }
  post        '/URI'   { do_something }
  put         '/URI'   { do_something }
  delete      '/URI'   { do_something }

end
API.run! :host => "localhost", :port => 4567
```

# 5C. RESTful Services - Example: library of scientific publications

## Specification

- root

```
METHOD  URI,MEDIA-TYPES,CODES        DESCRIPTION
GET     /                            API entry-point
        json
```

- authors

```
GET     /authors?affiliations=x,y,z  fetch the list of authors,
        json                            optionally filtered by affiliations
        200,304,406,500
GET     /authors/:author_id          fetch a specific author
        json
        200,304,404,406,500
POST    /authors                     create a new author
        json
        201,400,406,415,500
DELETE  /authors/:author_id          delete the author
        204,500
PUT     /authors/:author_id          update an author
        json
        200,400,406,415,500
```

- papers

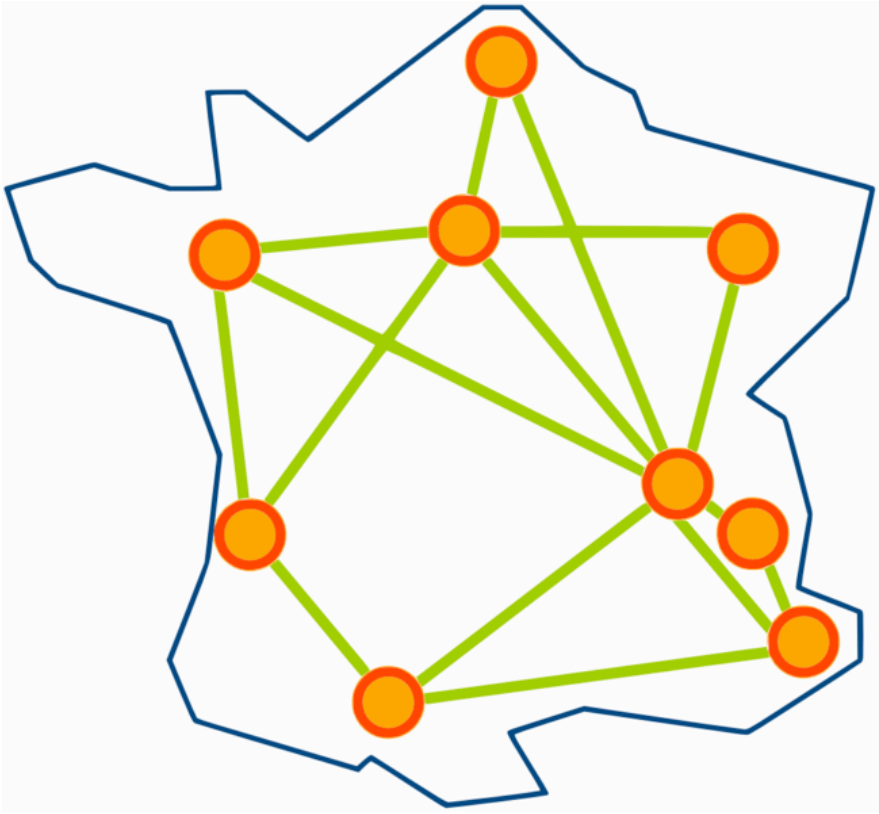
```
GET     /papers?tags=x,y,z           fetch the list of papers,
        json                            optionally filtered by tags
        200,304,406,500
GET     /papers/:paper_id            fetch a specific author
        json,text,html,pdf,latex
        200,304,404,406,500
POST    /papers                      create a new paper
        json
        201,400,406,415,500
DELETE  /papers/:paper_id            delete the paper
        204,500
PUT     /papers/:paper_id            update a paper. deal with conflicts.
        json
        200,400,406,409,415,500
```

- convenience collections

```
GET     /authors/:author_id/papers   fetch the papers of a specific author
        json
GET     /papers/:paper_id/authors    fetch the authors of a specific paper
        json
```

See http://github.com/crohr/rest-presentation/tree/master/app for the implementation.

# 6. RESTful Services - Real-World examples - Grid5000



http://www.grid5000.fr

# 6. RESTful Services - Real-World examples - In the wild

## RESTful

- Amazon S3 API: http://docs.amazonwebservices.com/AmazonS3/latest/API/
- Netflix API: http://developer.netflix.com/docs/REST_API_Reference
- Sun Cloud API: http://kenai.com/projects/suncloudapis/pages/Home
- Google Data API: http://code.google.com/apis/gdata/docs/2.0/basics.html

## Not RESTful

- Digg API: http://digg.com/api/docs/overview
- Flickr API: http://www.flickr.com/services/api/

# References


- RESTful Web Services, by Leonard Richardson and Sam Ruby, ISBN#978-0-596-52926-0
- http://tech.groups.yahoo.com/group/rest-discuss
- http://code.google.com/p/implementing-rest
- HTTP/1.1 Method Definitions - http://www.w3.org/Protocols/rfc2616/rfc2616-sec9.html
- HTTP/1.1 Status Code Definitions - http://www.w3.org/Protocols/rfc2616/rfc2616-sec10.html
- HTTP/1.1 Header Field Definitions - http://www.w3.org/Protocols/rfc2616/rfc2616-sec14.html
- http://www.subbu.org/
- Web Services architecture
- Sinatra Ruby framework: http://www.sinatrarb.com

# Questions

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