RPC, RMI, SOA

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Komunikace v distribuovaných systémech

- z hlediska synchronnosti
  - synchronní – volající strana zastaví a čeká, dokud nedostane odpověď
  - asynchronní – volající strana pokračuje v práci, na příchod odpovědi je upozorněna
- z hlediska zajištění doručení zprávy
  - transientní (pomíjivá)
  - persistentní (vytrvalá)
- webové služby obvykle používají transientní synchronní komunikaci, ale lze použít všechny kombinace

RPC - Remote Procedure Calls

- distribuované systémy komunikují zasíláním zpráv
- vhodná abstrakce – RPC - Remote Procedure Calls
- např. DCE RPC, SUN RPC, …
- synchronní volání *požadavek-odpověď*
  - volaná procedura, parametry předávané hodnotou
  - návratové hodnoty
- IDL – Interface Definition Language
- klient a server *stubs*
  - volané jako běžné funkce v daném prog. jazyce
  - zajišťují marshalling/serializaci, komunikaci, unmarshaling/deserializaci

RMI - Remote Method Invocation

- distribuované objektově-orientované systémy potřebují předávat parametry odkazem
- distribuovaný objekt má stav a metody – **interface**, a **implementaci**
- Remote Method Invocation - např. CORBA, Java RMI, DCOM
- binární protokoly, Object Request Broker
- Java RMI umí předat objekt – stav i implementaci metod

SOA - Service Oriented Architecture

- RMI funguje jen v systémech pod centrální správou, neškáluje na Internet-size
  - synchronní komunikace neškáluje
  - tight coupling, verzování a evoluce jsou obtížné
  - distribuovanost nelze schovat (partial failure)
- SOA – Service Oriented Architecture
  - služby mají definovaný interface
  - interface je popsán zprávami, ne operacemi na datových typech
  - služby lze nalézt (např. v adresáři)

SOA (2)

- rozdíl mezi OO a SOA
  - přehrávač CD poskytuje službu přehrání CD
  - různá kvalita služby ve walkmanovi nebo HiFi věži
  - v objektově-orientovaném přístupu by každé CD bylo dodáno s vlastním přehrávačem, ze kterého by nešlo vyjmout
- SOA patrně lépe odpovídá způsobu, jímž jsou organizovány lidské aktivity

Web services

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

(W3C, Web Services Glossary)

Glossary

URL - Uniform Resource Locator

HTTP - Hypertext Transfer Protocol

HTML - Hypertext Markup Language

XML - Extensible Markup Language

GUI - Graphical User Interface

CGI - Common Gateway Interface

SSL/TLS - Secure Sockets Layer/Transport Layer Security

REST - Representational State Transfer

JSON - JavaScript Object Notation

AJAX - Asynchronous JavaScript and XML

Brief web services history

1989 - World Wide Web invented

1991 - HTTP 0.9 specified

1992 - Internet at Masaryk University :-)

1993 - first GUI web browser Mosaic

1993 - CGI interface for executing programs

1995 - JavaScript introduced by Netscape

1996 - SSL 3.0

1998 - XML 1.0

1998 - SOAP 1.1 by Microsoft

2003 - SOAP 1.2 by W3C (never used)

2004 - WS-Interoperability Basic Profile

Brief web services history (2)

2000 - REST defined by Roy Fielding

2001 - JSON format invented

2004 - GMail and Google Maps

2004 - Web 2.0 hype, wikis, mash-ups

2005 - AJAX (Asynchronous JavaScript)

2005 - Yahoo! offers JSON web services

2006 - OpenID 2.0

2008 - HTML5 (First Public Working Draft)

2010 - OAuth 1.0

2010 - mobile devices with Android

2012 - OAuth 2.0

Brief web services history (3)

2013 - responsive web design as answer to mobile devices with differing screen sizes

2006-2013 - cloud computing (Amazon 2006, Microsoft 2008, Google 2013)

2014 - HTML5 finalised

2014 - OpenID Connect

2015 - HTTP/2

2018 - TLS 1.3

My definition of a web service

web service client communicates with a web server providing a web resource identified by a URL, using HTTP protocol (optionally secured by SSL/TLS) exchanging messages in XML or JSON formats

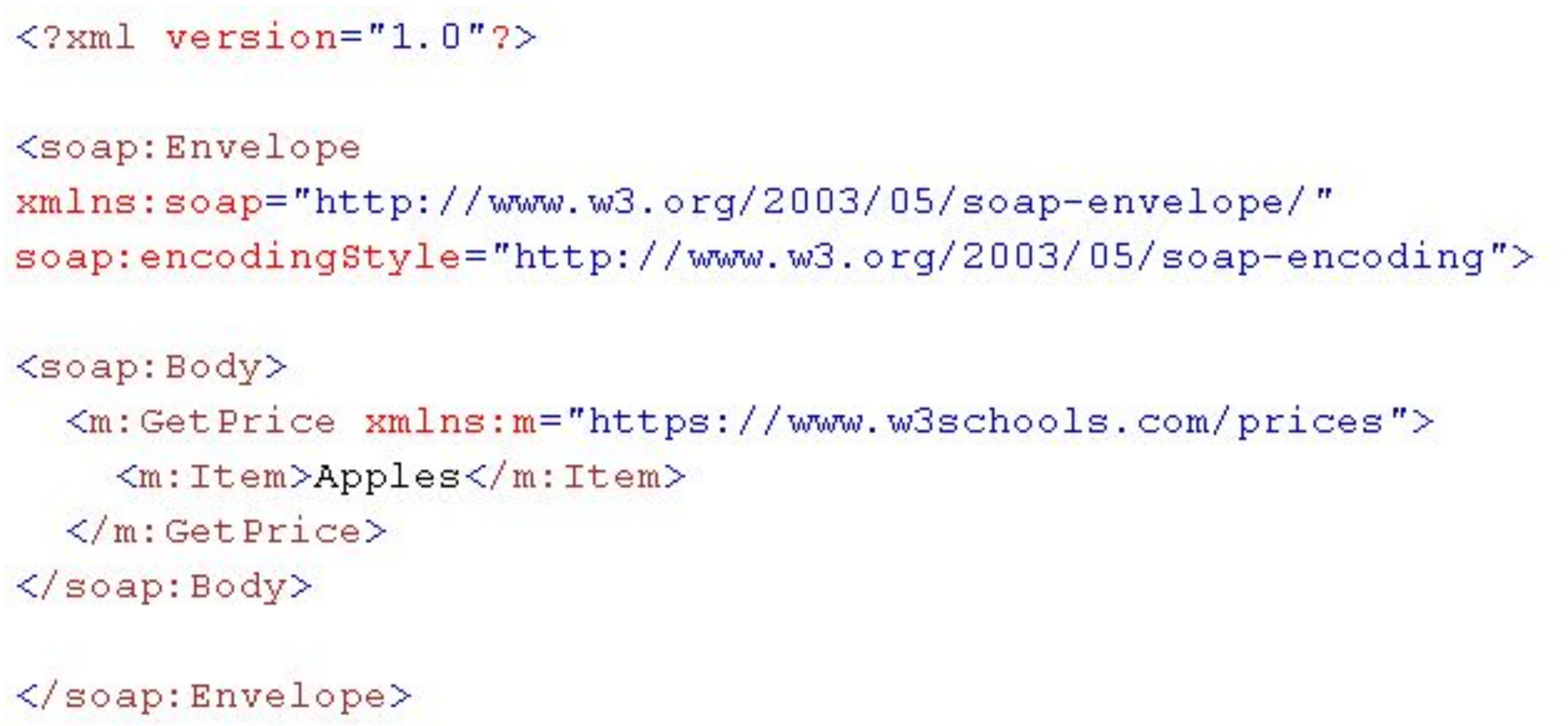
this definition covers

- SOAP/WSDL services
- REST APIs
- dynamic web pages using AJAX

SOAP/WSDL web services

- SOAP was **S**imple **O**bject **A**ccess **P**rotocol
- WSDL is **W**eb **S**ervice **D**escription **L**anguage
- technology for remote procedure calls using exchange of XML messages
- preferred in the enterprise world
- used in API of the Czech eGovernment’s "Data Boxes"
- WS-Interoperability Basic Profile needed to ensure interoperability
  - requires SOAP1.1
- many WS-* extensions

SOAP call



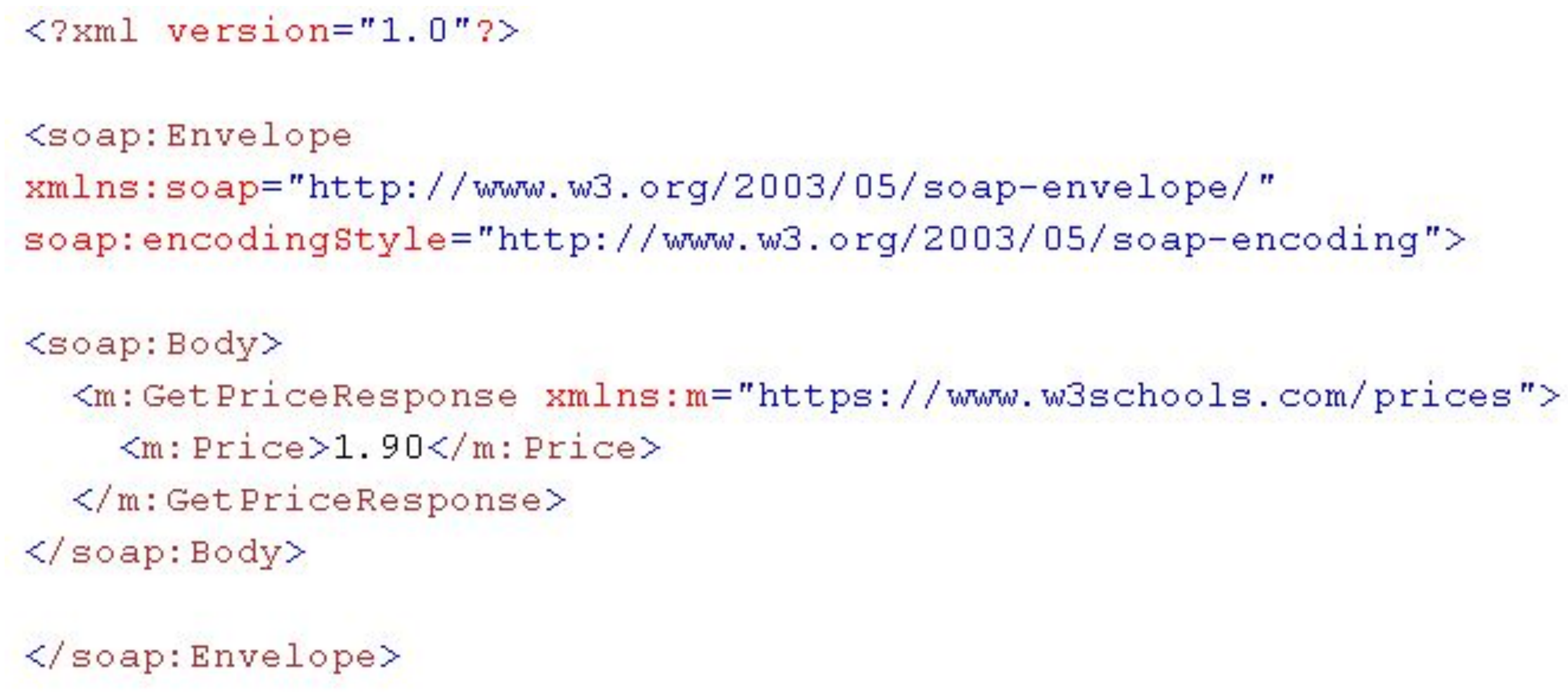
```
<?xml version="1.0"?>

<soap:Envelope
xmlns:soap="http://www.w3.org/2003/05/soap-envelope/"
soap:encodingStyle="http://www.w3.org/2003/05/soap-encoding">

<soap:Body>
  <m:GetPrice xmlns:m="https://www.w3schools.com/prices">
    <m:Item>Apples</m:Item>
  </m:GetPrice>
</soap:Body>

</soap:Envelope>
```

SOAP response



```
<?xml version="1.0"?>

<soap:Envelope
xmlns:soap="http://www.w3.org/2003/05/soap-envelope/"
soap:encodingStyle="http://www.w3.org/2003/05/soap-encoding">

<soap:Body>
  <m:GetPriceResponse xmlns:m="https://www.w3schools.com/prices">
    <m:Price>1.90</m:Price>
  </m:GetPriceResponse>
</soap:Body>

</soap:Envelope>
```

SOAP/WSDL web services (2)

- started as XML-based Remote Method Invocation protocol
- changed to Remote Procedure Call protocol (no objects - SOAP is not abbreviation)
- introduced own type system
  - big problems with compatibility
- later replaced by XML Schema type system
- main lesson - remote interfaces should be defined by *messages*, not *operations*

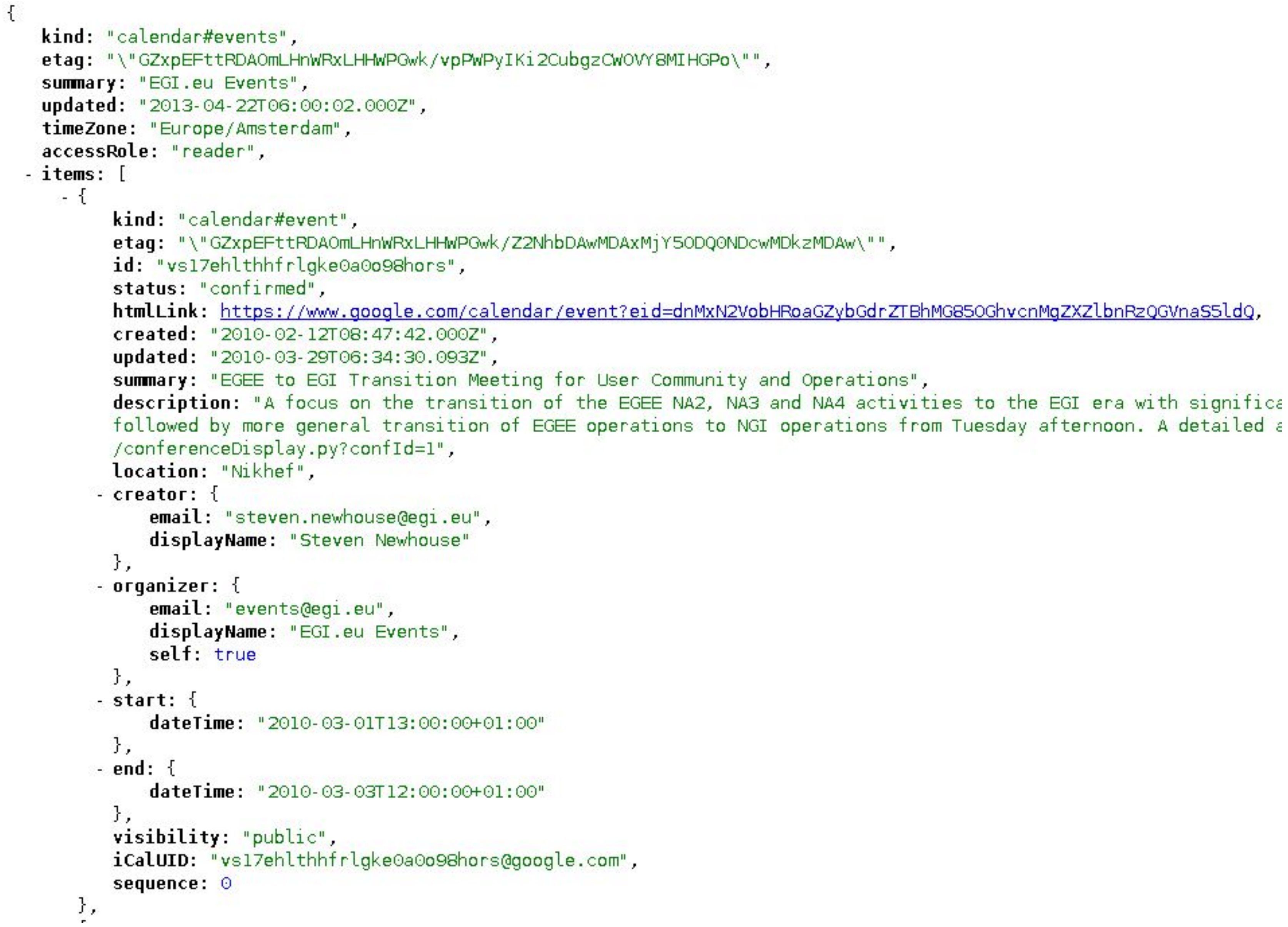
SOAP versus REST

- enterprises prefer complicated stack
  - XML
  - SOAP, WSDL, WS-Interoperability
  - WS-* (WS-Security, WS-Addressing, ...)
  - persistent connections - queues
  - RPC based
  - complex tools and frameworks
- Internet crowd prefers simplicity
  - JSON
  - web APIs described as HTTP requests to URLs
  - AJAX in browsers
  - transient connections - TCP/IP, HTTP
  - scalable using REST

Web APIs

- well-known APIs
  - Google APIs (Calendar, GMail, Maps, ...)
  - Facebook API
  - Twitter API
  - based on HTTP+JSON+SSL+OAuth
- third party clients
  - web, mobile (Android, iOS, ...), desktop, embedded
- OAuth
  - developer registers an application at API provider
  - user authorises the application to use certain operations in the API, giving the application a token
  - application uses the token to use the API on behalf of the user

JSON - JavaScript Object Notation



```
{
   kind: "calendar#events",
   etag: "\"GZxpEFttRDAOmLHnWRxLHHWPGwk/vpPWPyIKi2CubgzCWOVY8MIHGPo\"",
   summary: "EGI.eu Events",
   updated: "2013-04-22T06:00:02.000Z",
   timeZone: "Europe/Amsterdam",
   accessRole: "reader",
 - items: [
    - {
         kind: "calendar#event",
         etag: "\"GZxpEFttRDAOmLHnWRxLHHWPGwk/Z2NhbDAwMDAxMjY5ODQ0NDcwMDkzMDAw\"",
         id: "vs17ehlthhfrlgke0a0o98hors",
         status: "confirmed",
         htmlLink: https://www.google.com/calendar/event?eid=dnMxN2VobHRoaGZybGdrZTBhMG85OGhvcnMgZXZlbnRzQGVnaS5ldQ,
         created: "2010-02-12T08:47:42.000Z",
         updated: "2010-03-29T06:34:30.093Z",
         summary: "EGEE to EGI Transition Meeting for User Community and Operations",
         description: "A focus on the transition of the EGEE NA2, NA3 and NA4 activities to the EGI era with significa
         followed by more general transition of EGEE operations to NGI operations from Tuesday afternoon. A detailed a
         /conferenceDisplay.py?confId=1",
         location: "Nikhef",
       - creator: {
            email: "steven.newhouse@egi.eu",
            displayName: "Steven Newhouse"
         },
       - organizer: {
            email: "events@egi.eu",
            displayName: "EGI.eu Events",
            self: true
         },
       - start: {
            dateTime: "2010-03-01T13:00:00+01:00"
         },
       - end: {
            dateTime: "2010-03-03T12:00:00+01:00"
         },
         visibility: "public",
         iCalUID: "vs17ehlthhfrlgke0a0o98hors@google.com",
         sequence: 0
      },
```

The same Google Cal event in XML

```
- <entry>
  - <id>
      http://www.google.com/calendar/feeds/events%40egi.eu/private/full/vs17ehlthhfrlgke0a0o98hors
    </id>
    <published>2010-02-12T08:47:42.000Z</published>
    <updated>2010-03-29T06:34:30.000Z</updated>
    <category scheme="http://schemas.google.com/g/2005#kind" term="http://schemas.google.com/g/2005#event"/>
  - <title type="text">
      EGEE to EGI Transition Meeting for User Community and Operations
    </title>
  - <content type="text">
      A focus on the transition of the EGEE NA2, NA3 and NA4 activities to the EGI era with significantly reduced EC funding during the firs
      to NGI operations from Tuesday afternoon. A detailed agenda is available - https://www.egi.eu/indico/conferenceDisplay.py?confId=1
    </content>
    <link rel="alternate" type="text/html" href="https://www.google.com/calendar/event?eid=dnMxN2VobHRoaGZybGdrZTBhMG85OGhvc
    <link rel="self" type="application/atom+xml" href="https://www.google.com/calendar/feeds/events%40egi.eu/private/full/vs17ehlthhfrlg
  - <author>
      <name>Steven Newhouse</name>
      <email>steven.newhouse@egi.eu</email>
    </author>
  - <gd:comments>
      <gd:feedLink href="https://www.google.com/calendar/feeds/events%40egi.eu/private/full/vs17ehlthhfrlgke0a0o98hors/comments"/>
    </gd:comments>
    <gd:eventStatus value="http://schemas.google.com/g/2005#event.confirmed"/>
    <gd:where valueString="Nikhef"/>
    <gd:who email="events@egi.eu" rel="http://schemas.google.com/g/2005#event.organizer" valueString="events@egi.eu"/>
    <gd:when endTime="2010-03-03T12:00:00.000+01:00" startTime="2010-03-01T13:00:00.000+01:00"/>
    <gd:transparency value="http://schemas.google.com/g/2005#event.opaque"/>
    <gd:visibility value="http://schemas.google.com/g/2005#event.public"/>
    <gCal:anyoneCanAddSelf value="false"/>
    <gCal:guestsCanInviteOthers value="true"/>
    <gCal:guestsCanModify value="false"/>
    <gCal:guestsCanSeeGuests value="true"/>
    <gCal:sequence value="0"/>
    <gCal:uid value="vs17ehlthhfrlgke0a0o98hors@google.com"/>
  </entry>
</feed>
```

AJAX

- Asynchronous JavaScript And XML
- does not need XML, uses JSON often
- based on introduction of **XMLHttpRequest** JavaScript object to web browsers around the year 2006
- asynchronous request to web server
- response processed in JavaScript
- same-origin policy (protocol,host,port)
- Cross-origin resource sharing (CORS)

REST

- Representational State Transfer
- software **architecture style** for creating **scalable web services**
- invented by Roy Fielding, author of HTTP 1.1
- resources identified by URIs
- representations of resources as JSON, XML or other formats
- uses HTTP methods GET, PUT, DELETE and POST for manipulating resources

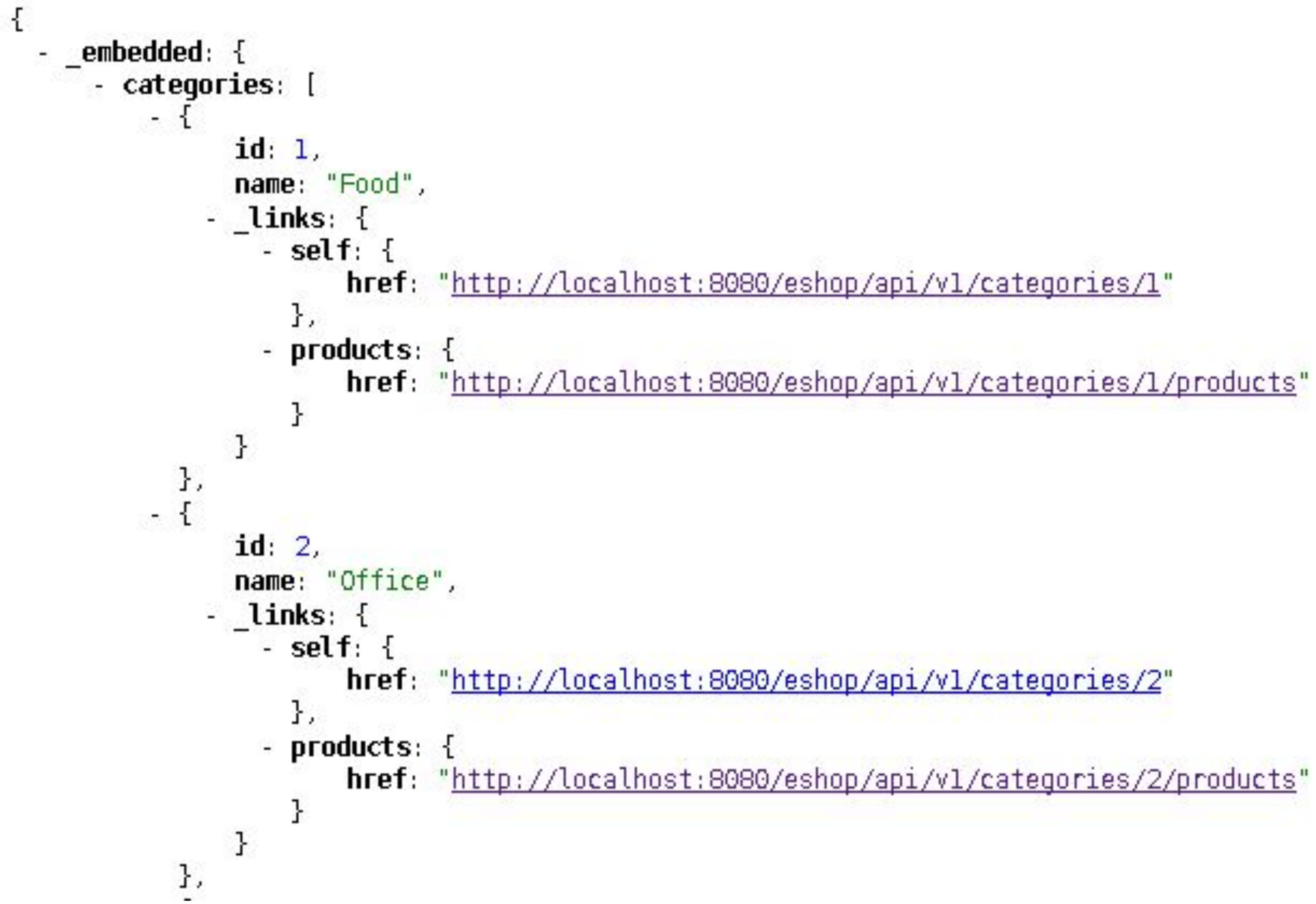
REST (2)

- no IDL (Interface Description Language) so far
- API described in human natural language
  - e.g. “image can be changed by HTTP PUT request to /image/{imageID}”
- Richardson Maturity Model
  - level 1 - resources identified by URIs
  - level 2 - use of HTTP methods as verbs
  - level 3 - HATEOAS (Hypertext As The Engine Of Application State)
  - level 3 introduces discoverability, making a protocol more self-documenting

HAL - Hypertext Application Language

- one of proposed standards for HATEOAS (level 3 in Richardson Maturity Model)
- format for JSON messages in REST APIs
  - every object has **_links** property with links to operations on the object or to other objects
  - collections are wrapped in **_embedded**
- supported by Spring HATEOAS Java library

HAL example

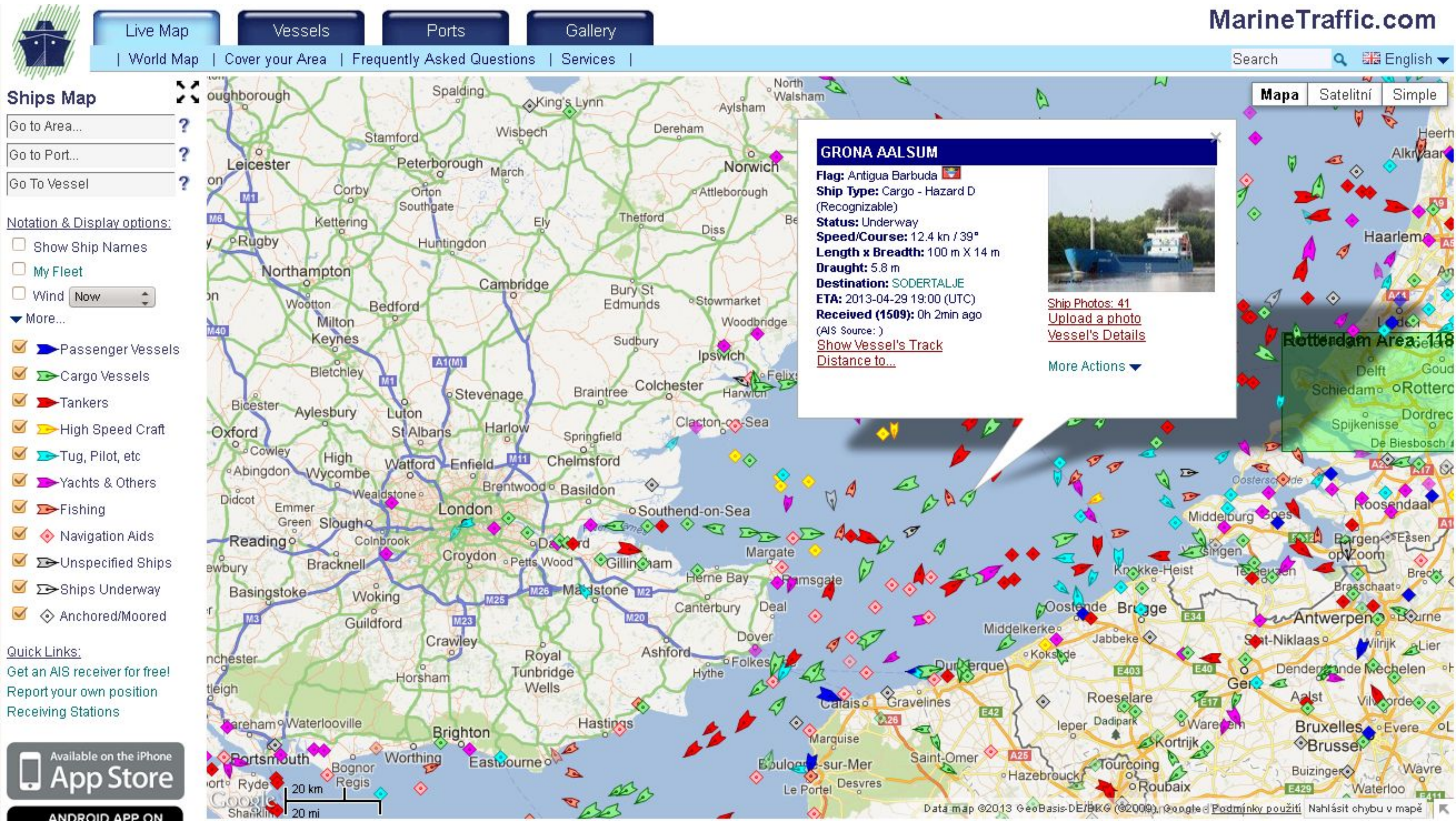


```
{
 - _embedded: {
     - categories: [
         - {
               id: 1,
               name: "Food",
             - _links: {
                 - self: {
                       href: "http://localhost:8080/eshop/api/v1/categories/1"
                   },
                 - products: {
                       href: "http://localhost:8080/eshop/api/v1/categories/1/products"
                   }
               }
           },
         - {
               id: 2,
               name: "Office",
             - _links: {
                 - self: {
                       href: "http://localhost:8080/eshop/api/v1/categories/2"
                   },
                 - products: {
                       href: "http://localhost:8080/eshop/api/v1/categories/2/products"
                   }
               }
           },
         -
```

Mash ups

- combine data from various sources
- typically a Google map with some geospatial data
  - ships - http://www.marinetraffic.com/
  - aircrafts - http://www.flightradar24.com/

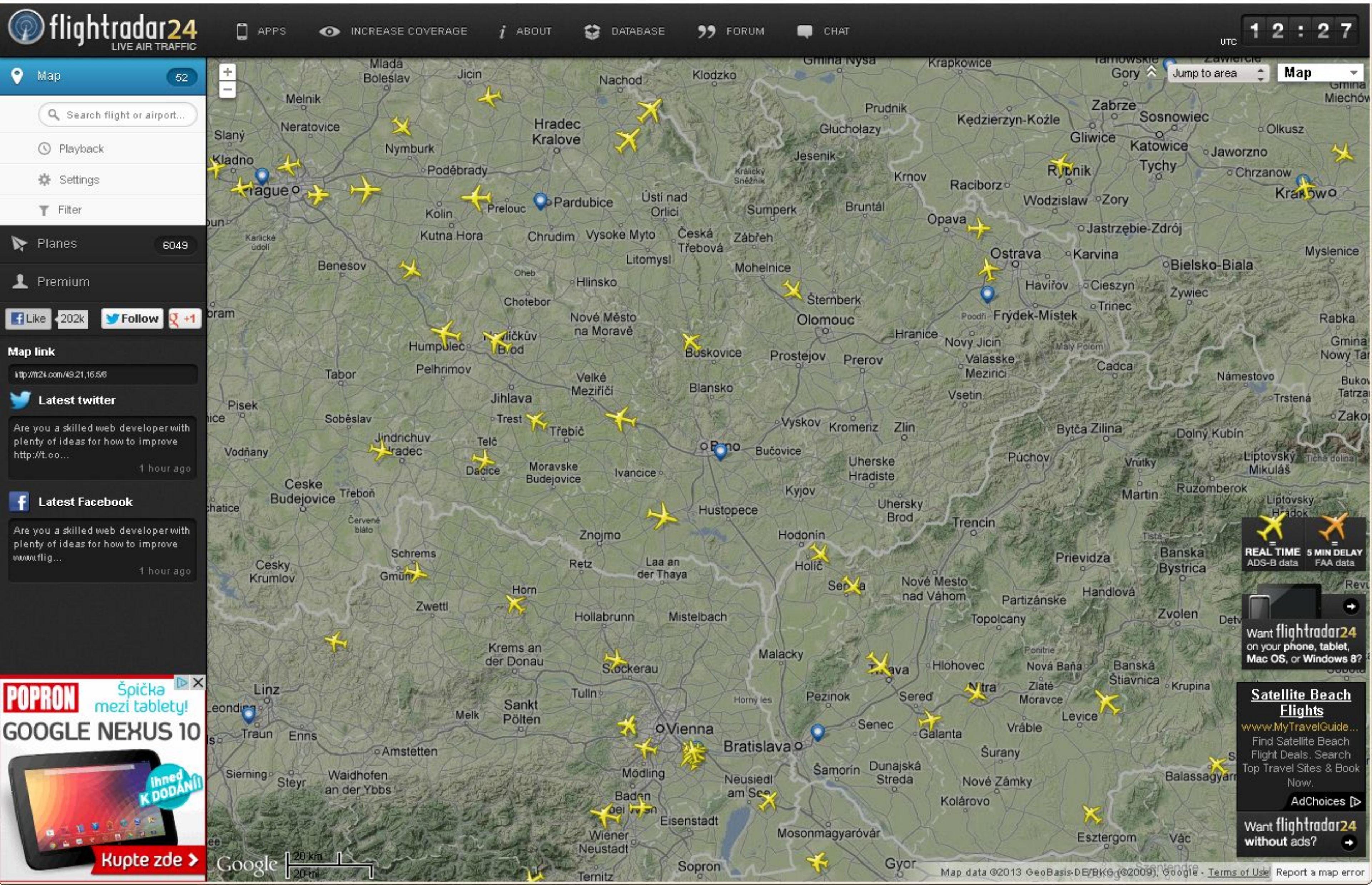
www.marinetraffic.com



GRONA AALSUM
Flag: Antigua Barbuda
Ship Type: Cargo - Hazard D (Recognizable)
Status: Underway
Speed/Course: 12.4 kn / 39°
Length x Breadth: 100 m X 14 m
Draught: 5.8 m
Destination: SODERTALJE
ETA: 2013-04-29 19:00 (UTC)
Received (1509): 0h 2min ago
(AIS Source:)
Show Vessel's Track
Distance to...
Ship Photos: 41
Upload a photo
Vessel's Details
More Actions

Data map ©2013 GeoBasis-DE/BKG (©2009), Google

www.flightradar24.com


flightradar24
LIVE AIR TRAFFIC
APPS
INCREASE COVERAGE
ABOUT
DATABASE
FORUM
CHAT
UTC 12:27
Map 52
Search flight or airport...
Playback
Settings
Filter
Planes 6049
Premium
Like 202k
Follow
+1
Map link
http://fr24.com/49.21,16.5/8
Latest twitter
Latest Facebook
Jump to area
Map
REAL TIME ADS-B data
5 MIN DELAY FAA data
Want flightradar24 on your phone, tablet, Mac OS, or Windows 8?
Want flightradar24 without ads?
POPRON Špička mezi tablety! GOOGLE NEXUS 10 ihned K DODÁNÍ! Kupte zde
Satellite Beach Flights
www.MyTravelGuide...
Find Satellite Beach Flight Deals. Search Top Travel Sites & Book Now.
AdChoices
Map data ©2013 GeoBasis-DE/BKG (©2009), Google - Terms of Use
Report a map error

Are you a skilled web developer with plenty of ideas for how to improve http://t.co...
1 hour ago

Are you a skilled web developer with plenty of ideas for how to improve www.flig...
1 hour ago

Federated identity

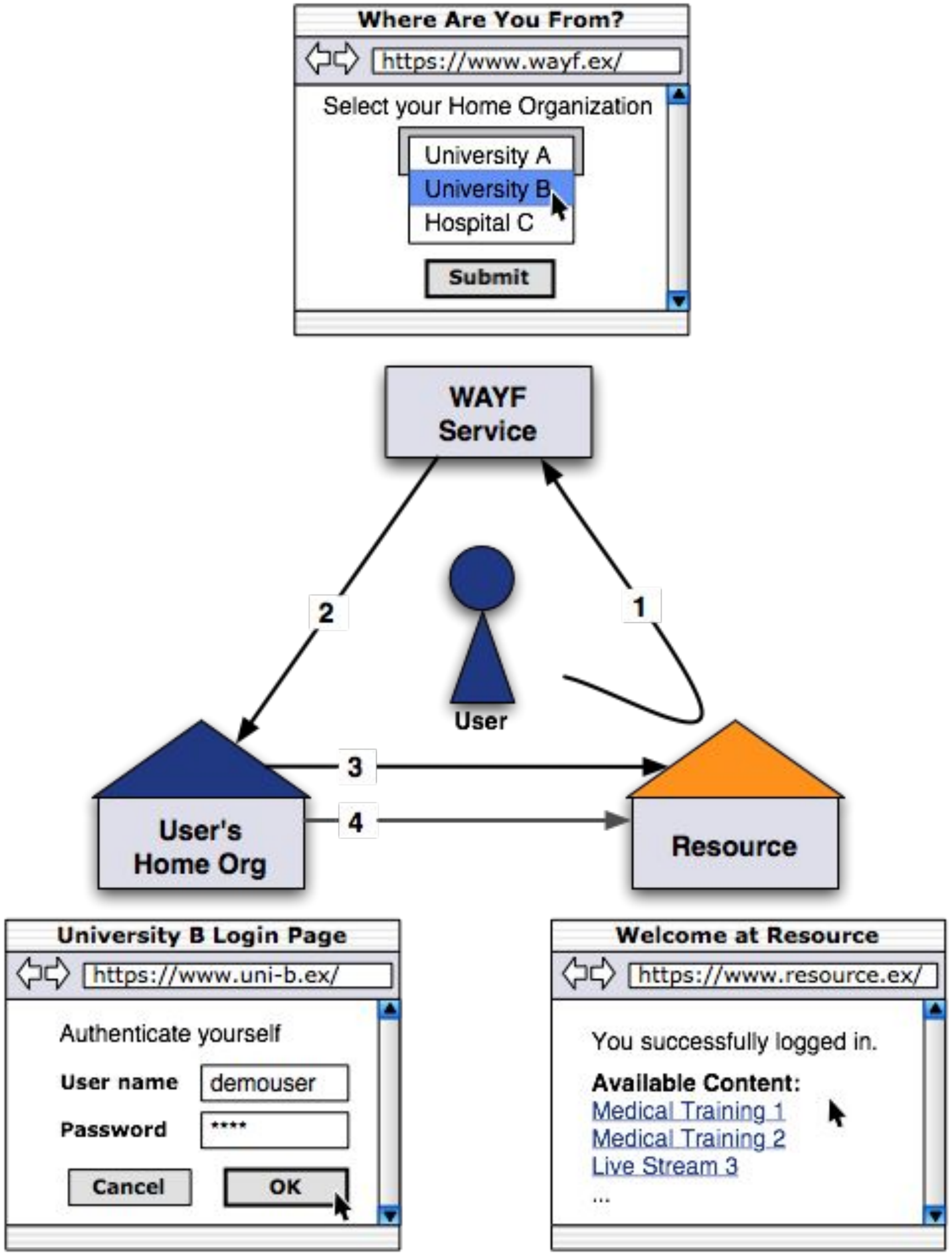
- many authentication mechanisms were developed for the web
    - username+password (hard to remember)
    - X509 digital certificate (complicated to get)
    - digest, Kerberos etc. (not much support in browsers)
- users forget passwords to rarely used accounts
- in federated identity, account from one organisation can be reused at others
- identity providers
    - OpenID - MojeID.cz, anybody
    - SAML - in academia, Microsoft O365, Google Apps
    - OAuth - Google, Facebook, Twitter, ...
    - OpenID Connect - mix of OpenID and OAuth

OpenID versions 1 and 2

- obsolete
- introduced the idea of decentralized authentication protocol
- users were identified by URLs
- anybody could run an identity provider
- problem of trust
- only large identity providers like Google were trusted by service providers

SAML

- Security Assertion Markup Language
- introduced in 2001
- provides **web browser single sign-on**
- SAML document is XML containing user attributes signed by identity provider
- trust between identity providers and service providers is established using federations
- a federation publishes lists of trusted IdPs and SPs complying with federation’s policy
- WAYF -Where Are Your From? service



Select your Home Organization

Authenticate yourself

User name	demouser
Password	****

You successfully logged in.

Available Content:
Medical Training 1
Medical Training 2
Live Stream 3
...

OAuth

- open standard for **authorization**, commonly used as a way for Internet users to authorize websites or applications to access their information on other websites but without giving them the passwords
- can be also used for authentication
- more in separate slides

OpenID Connect

- promoted as third version of OpenID
- authentication layer built on top of OAuth 2.0
- OAuth used for authorization
- standardized UserInfo API
- OpenID used for user data items (email, full name, etc.)