LINKING WEB DATA

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Quick reminder: Gigantic global graph & Web of (linked) data

GIGANTIC GLOBAL GRAPH

Phase 1: ***I**nternational **I**nformation **I**nfrastructure (III)*

- network/graph of computers known as *Internet* or *Net*
- "*It isn't the cables, it is the computers which are interesting*"

Phase 2: ***W**orld **W**ide **W**eb (WWW)*

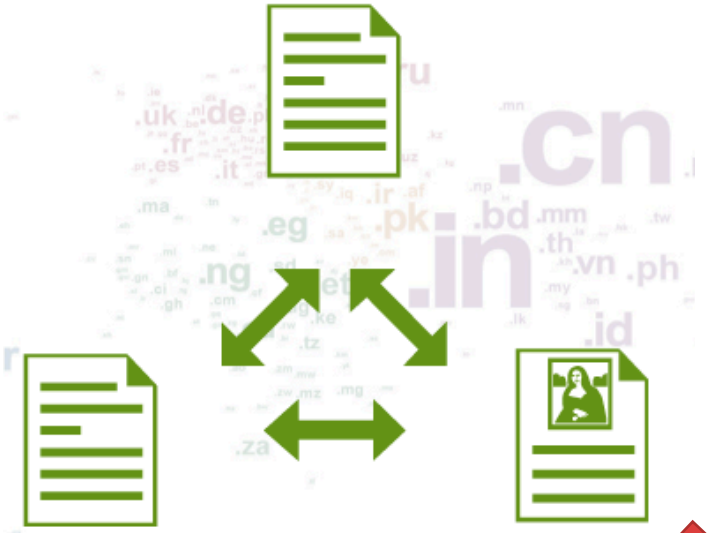
- network/graph of documents known as *Web*
- "*It isn't the computers, but the documents which are interesting*"

Phase 3: ***G**igantic **G**lobal **G**raph (GGG)*

- network/graph of entities (resources) and data that describe the entities
- "*It's not the documents, it is the things they are about which are important*"

TBL's blog post on GGG: http://dig.csail.mit.edu/breadcrumbs/node/215

WWW (= Web of documents)



GGG (= Web of data)

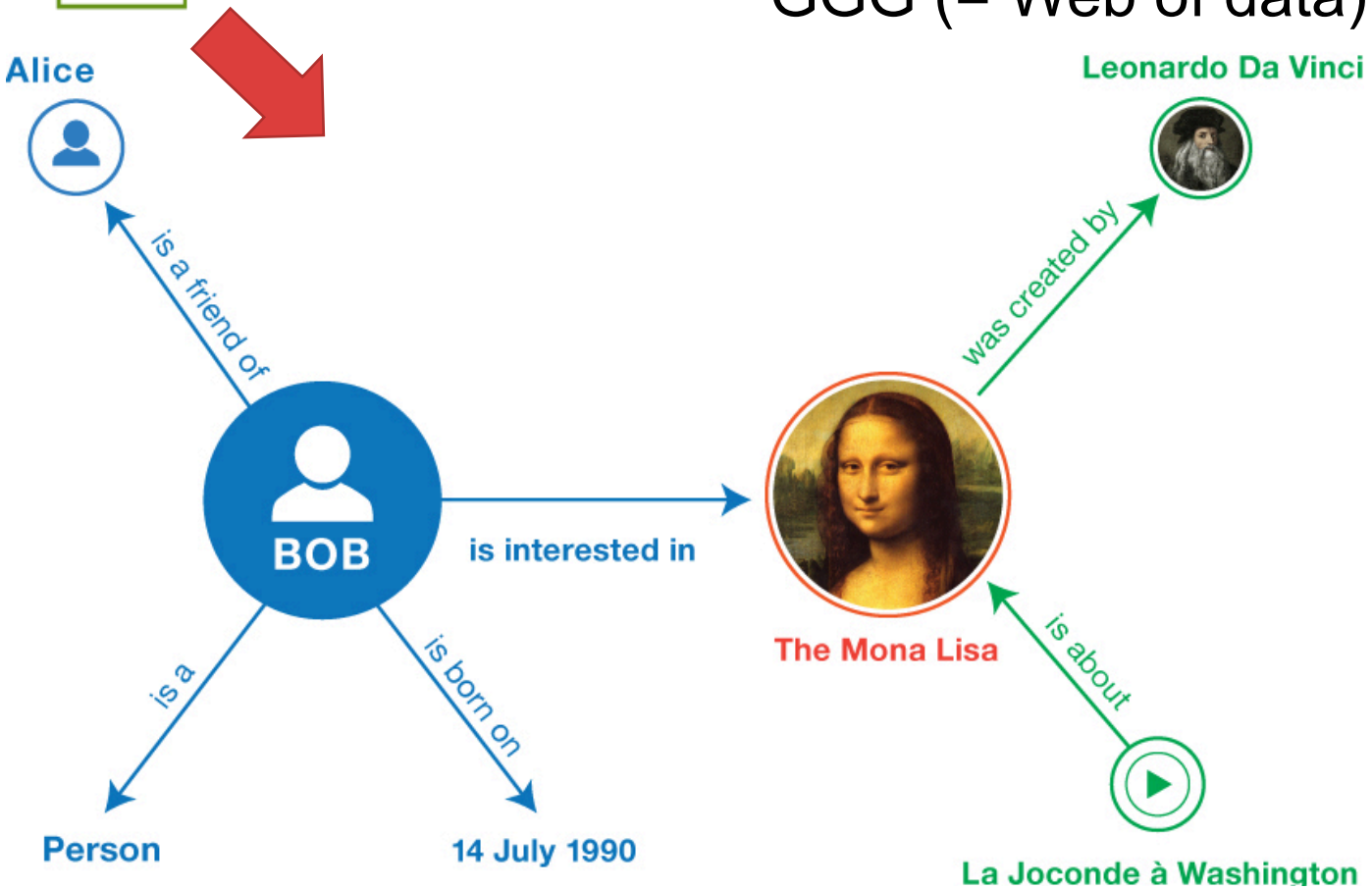


Image source: http://www.w3.org/TR/2014/NOTE-rdf11-primer-20140225/

WEB OF (LINKED) DATA: MAIN FEATURES

Web of data is based on the assumption that data have:

- well-defined structure (= structured data),
- explicitly defined meaning (= associated with machine intelligible semantics)

Two major data sources on the Web of Data:

- data embedded in Web pages
- data accessible through various kinds of program interfaces (RESTful APIs, query endpoints)

Data embedded in Web pages

Main idea:

make the content of the Web
'legible' to computers,
by presenting it
in the language they 'understand':
using structured data with
explicitly defined semantics

EXAMPLE

Traditional Web page

Links are presented in the same way regardless of the meaning of the established connection

```
Jane Doe
Professor
20341 Whitworth Institute
…
Graduated from <a href="http://www.umbc.edu/">UMBC</a>
…
Research associates:
<a href="http://www.xyz.edu/students/alicejones.html">Alice Jones</a>
…
```

Web page with embedded structured data

```
<div vocab="http://schema.org/" typeof="Person">
  <span property="name">Jane Doe</span>
  <span property="jobTitle">Professor</span>
…
Graduated from <a href="http://www.umbc.edu/"
    property="alumniOf">UMBC</a>
…
Research associates:
  <a href="http://www.xyz.edu/students/alicejones.html"
            property="colleague">Alice Jones</a>
…
</div>
```

Defining the type of an entity and its attributes

https://schema.org/jobTitle

Links have associated meaning

https://schema.org/colleague

Data embedded in Web pages

Numerous Web pages already contain structured data with explicitly defined semantics

A few examples:

- movies at RottenTomatoes.com
- events at Ticketmaster.com
- products at BestBuy.com
- recipes at AllRecipes.com

EXTRACTING DATA FROM WEB PAGES

Structured data testing tool

- https://developers.google.com/structured-data/testing-tool/
- Provides Web administrators with an insight into the data intelligible to programs that access the given Web page
- However, it does not allow for direct, program-based access to the embedded data
  - in other words, it cannot be called from a program to extract data from a Web page

EXTRACTING DATA FROM WEB PAGES

Microdata Distiller

- http://www.w3.org/2012/pyMicrodata/
- provides program-based access to the data embedded in Web pages
- main advantage: it allows you to easily pull data from Web pages – without page scraping or any other similar efforts – and use the extracted data in your program
- it can be called as a RESTfull service or installed and run locally

ADDING DATA TO WEB PAGES

To embed structured data in Web pages, we need:

- *vocabularies* for describing the content of the page in a machine-intelligible format
- a way to *extend HTML* to make those machine-intelligible descriptions an integral part of the Web page

To address the 1st requirement, we can use Schema.org or some other RDFS vocabulary

To address the 2nd requirement, we can use RDFa, Microdata, or JSON-LD – W3C recommendations for extending HTML with machine processable descriptions

SCHEMA.ORG

Vocabulary for describing Web data in machine intelligible form; currently, the most widely used vocabulary of this kind

The initiative for its development came from the major Web companies: Google, Yahoo, Microsoft (Bing), Yandex

It is now developing within the W3C as a community effort: https://www.w3.org/community/schemaorg/

Initially it defined only a handful of types, but has significantly evolved over time

- list of all the types currently supported by Schema.org: http://schema.org/docs/full.html

SCHEMA.ORG

Recommendation:

- Video of the keynote talk by Google's R. Guha – leader of the W3C WebSchemas group – on the topic of structured data, Schema.org, and associated open technologies: http://videolectures.net/iswc2013_guha_tunnel/
- alternatively, or in addition, check this interview with R. Guha: http://semanticweb.com/schema-org-chat-googles-r-v-guha_b40607

EXTENDING HTML WITH MACHINE INTELLIGIBLE DESCRIPTIONS

W3C recommendations (de-facto standards) for embedding structured data in HTML pages:

- RDFa (RDF in attributes)
- Microdata
- JSON-LD

RDFa

Jane Doe Professor
20341 Whitworth Institute 405 N. Whitworth Seattle, WA 98052
(425) 123-4567
jane-doe@xyz.edu
Research associates: Alice Jones Bob Smith

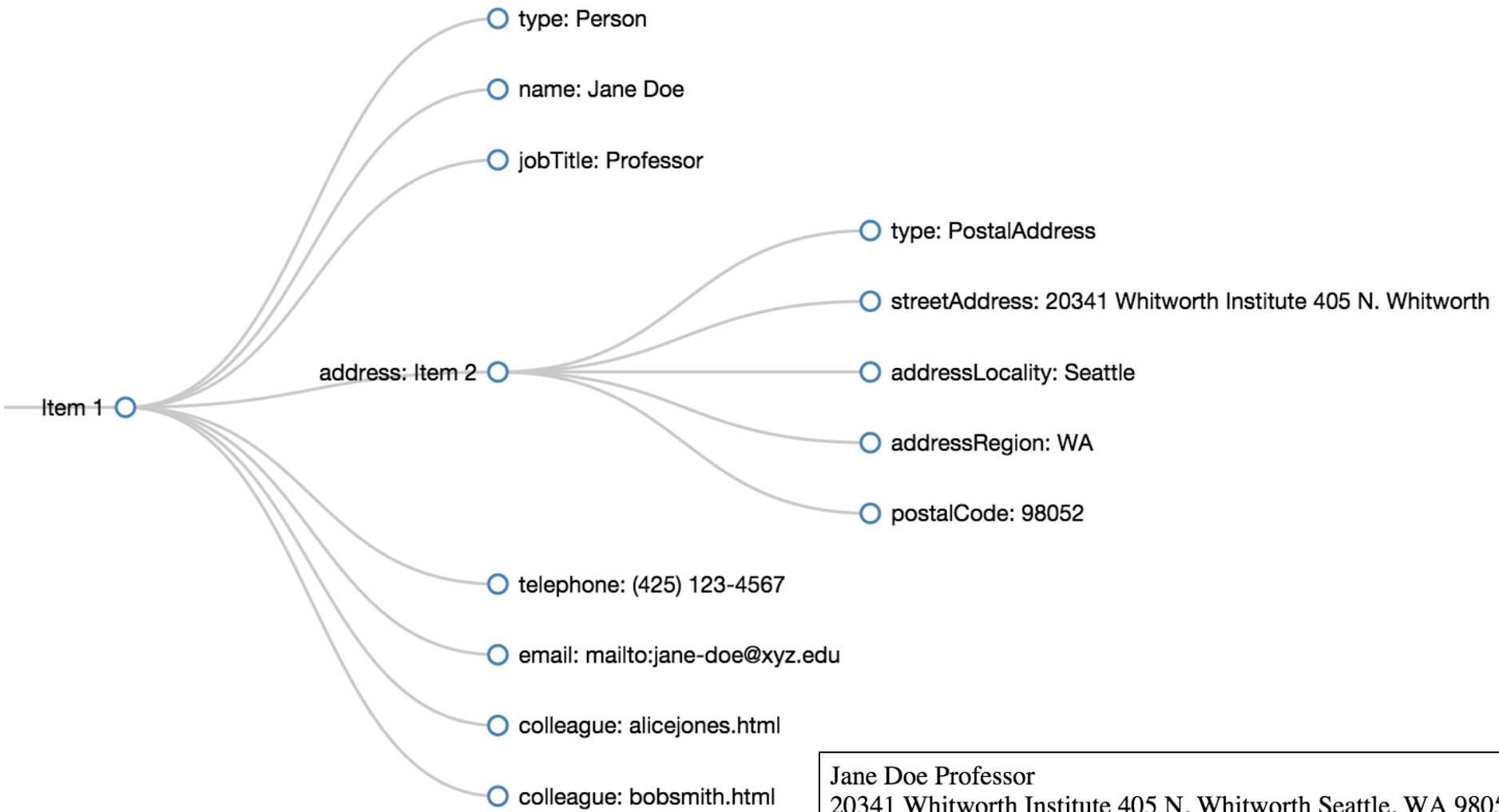
Presentation in a browser

HTML source (with embedded RDFa data)

```
<div vocab="http://schema.org/" typeof="Person">
  <span property="name">Jane Doe</span>
  <span property="jobTitle">Professor</span>
  <div property="address"  typeof="PostalAddress">
    <span property="streetAddress">
      20341 Whitworth Institute
      405 N. Whitworth
    </span>
    <span property="addressLocality">Seattle</span>,
    <span property="addressRegion">WA</span>
    <span property="postalCode">98052</span>
  </div>
  <span property="telephone">(425) 123-4567</span><br/>
  <a href="mailto:jane-doe@xyz.edu" property="email">
  jane-doe@xyz.edu</a><br/>
  Research associates:
  <a href="http://www.xyz.edu/students/alicejones.html" property="colleag
    Alice Jones</a>
  <a href="http://www.xyz.edu/students/bobsmith.html" property="colleague
    Bob Smith</a>
</div>
```

This code sample is created using the http://rdfa.info/play/ editor

Graph of data extracted from the Web page shown in the previous example



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(425) 123-4567
jane-doe@xyz.edu
Research associates: Alice Jones Bob Smith

MICRODATA

```
<div itemscope itemtype="http://schema.org/Person">
  <span itemprop="name">Jane Doe</span>
  <span itemprop="jobTitle">Professor</span>
  <div itemprop="address"
       itemscope itemtype="http://schema.org/PostalAddress">
    <span itemprop="streetAddress">
      20341 Whitworth Institute
      405 N. Whitworth
    </span>
    <span itemprop="addressLocality">Seattle</span>,
    <span itemprop="addressRegion">WA</span>
    <span itemprop="postalCode">98052</span>
  </div>
  <span itemprop="telephone">(425) 123-4567</span><br>
  <a href="mailto:jane-doe@xyz.edu" itemprop="email">
    jane-doe@xyz.edu</a><br>
  Research associates:
  <a href="http://www.xyz.edu/students/alicejones.html"
    itemprop="colleague">Alice Jones</a>
  <a href="http://www.xyz.edu/students/bobsmith.html"
    itemprop="colleague">Bob Smith</a>
</div>
```

The same example in Microdata notation; In fact, everything is (more or less) the same, the only difference is in the names of the used HTML attributes

JSON-LD

```
<script type="application/ld+json">
{
  "@context": "http://schema.org",
  "@type": "Person",
  "address": {
    "@type": "PostalAddress",
    "addressLocality": "Seattle",
    "addressRegion": "WA",
    "postalCode": "98052",
    "streetAddress": "20341 Whitworth Institute 405 N. Whitworth"
  },
  "colleague": [
    "http://www.xyz.edu/students/alicejones.html",
    "http://www.xyz.edu/students/bobsmith.html"
  ],
  "email": "mailto:jane-doe@xyz.edu",
  "image": "janedoe.jpg",
  "jobTitle": "Professor",
  "name": "Jane Doe",
  "telephone": "(425) 123-4567",
  "url": "http://www.janedoe.com"
}
</script>
```

Unlike RDFa and Microdata, JSON-LD data are not embedded in the body of an HTML page (the part that is rendered in the browser), but in the head of the page (the part for programs access only)

RDFa, Microdata, JSON-LD

RDFa:

- Relevant info, code, materials, etc. about RDFa: http://rdfa.info/
- Specification: http://www.w3.org/TR/xhtml-rdfa-primer/

Microdata:

- Specification: http://dev.w3.org/html5/md/

JSON-LD:

- Relevant info, code, materials, etc. about JSON-LD: http://json-ld.org/
- Specification: http://www.w3.org/TR/json-ld/

Good source of examples is Schema.org site where for each class, there is at least one example code segment given in each of the 3 standards

MORE ABOUT VOCABULARIES

Schema Actions

- Schema.org classes and attributes aimed at
  - describing (in machine intelligible way) different kinds of actions that a Web site offers to its visitors, and how those actions can be invoked by a (third party) program
  - integrating data about users' actions from different Web sites
- To learn how to use this feature, check the following articles:
  - an article (http://goo.gl/9zkeUK) explaining why this feature is relevant, and another one (http://goo.gl/xPRpQz) illustrating its use in the music domain
  - document describing Schema.org actions and offering instructions for their use (https://goo.gl/D7oxrw)

More about vocabularies

GoodRelations

- http://www.heppnetz.de/projects/goodrelations/
- vocabulary for describing products, offers, shops, and the like
- already in wide use in the e-commerce domain
  - E.g. Kmart.com, Sears.com, BestBuy.com
- a number of tools have been developed to facilitate its use
  - check: http://wiki.goodrelations-vocabulary.org/Tools
- it has been integrated into Schema.org
  - http://schema.org/Product ; http://schema.org/Offer …

More about vocabularies

Open Graph Protocol (OGP)

- http://ogp.me/
- introduced by Facebook to obtain more information about the things people ‘Like’ outside the Facebook’s domain
  - RDFa + OGP data embedded in the page provide a formal description of the “liked” item
  - thus obtained information is used for further extending Facebook’s Entity Graph
- OGP supports the description of several popular domains: music, video, articles, books, websites and user profiles

TOOLS FOR WORKING WITH EMBEDDED STRUCTURED DATA

Google has developed a set of supporting tools for

- embedding structured data in Web pages
- tracking and management of Web pages with embedded data,
- detecting errors in how the data is embedded in a page

Some of these tools:

- Structured Data Dashboard (https://goo.gl/V8NZ8L)
- Data Highlighter (https://goo.gl/P5SZOc)
- Structured Data Markup Helper (https://goo.gl/1Ywtfg)

Video from Google IO 2013 conference introduces and describes these tools: https://developers.google.com/events/io/sessions/351340935

LINKING DATA ON THE WEB

5 STAR (LINKED) OPEN DATA

Linked Open Data star scheme by example:

http://5stardata.info/

LINKED DATA PRINCIPLES

1) Use URIs as names for things

ISBN: 9781775411840

2) Use HTTP URIs so that people can look up those names

```
<http://www.worldcat.org/title/north-and-south/oclc/606818482>
```

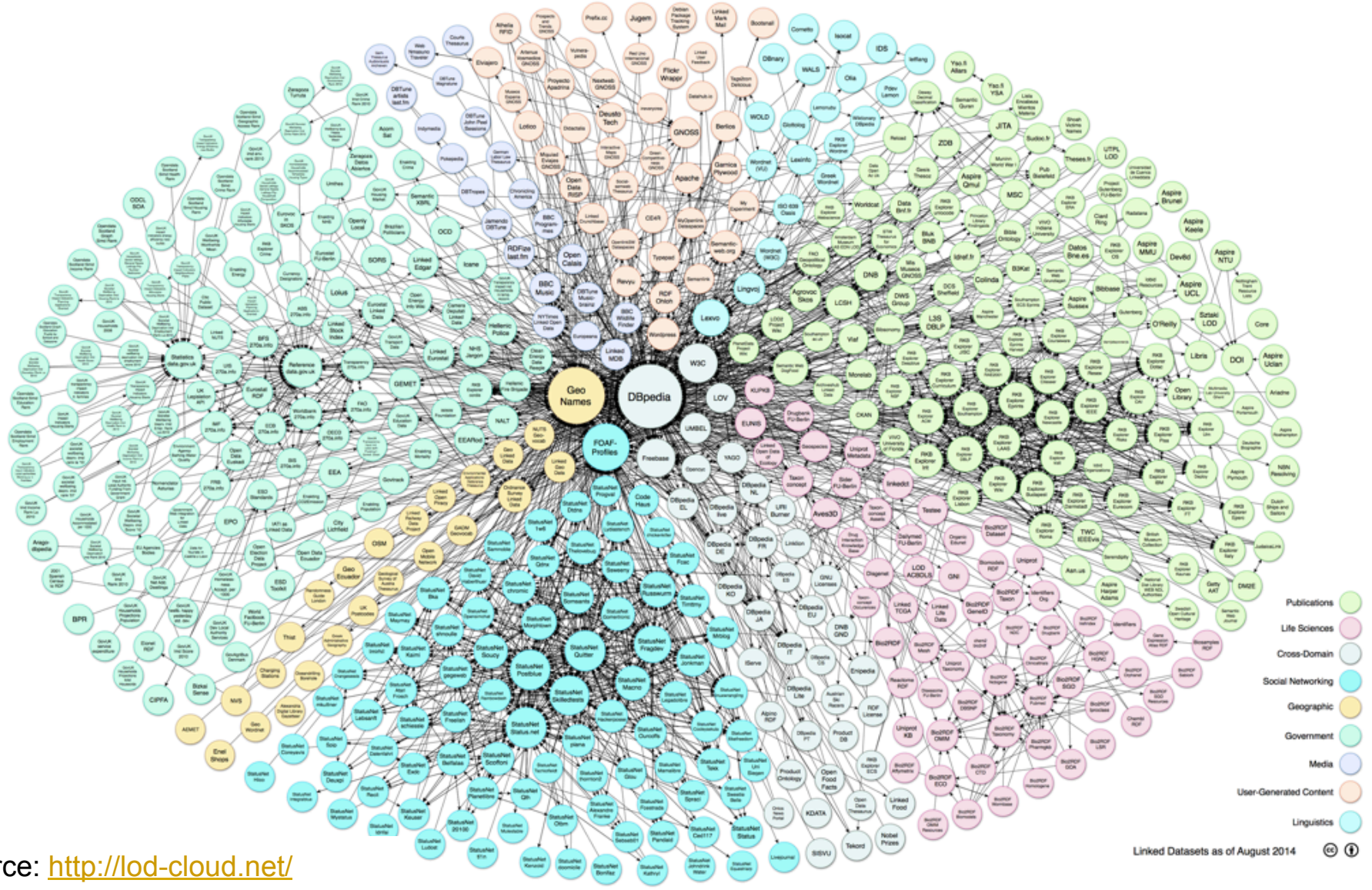
3) Provide useful information for each URI, using the Linked Data standards (RDF(S), SPARQL)

```
<http://www.worldcat.org/title/north-and-south/oclc/606818482>
rdf:type schema:Book
```

4) Include links to other URIs so that more things could be discovered.

```
<http://www.worldcat.org/title/north-and-south/oclc/606818482>
schema:author <http://viaf.org/viaf/39377536/>
```

Data published on the Web following the Linked Data principles

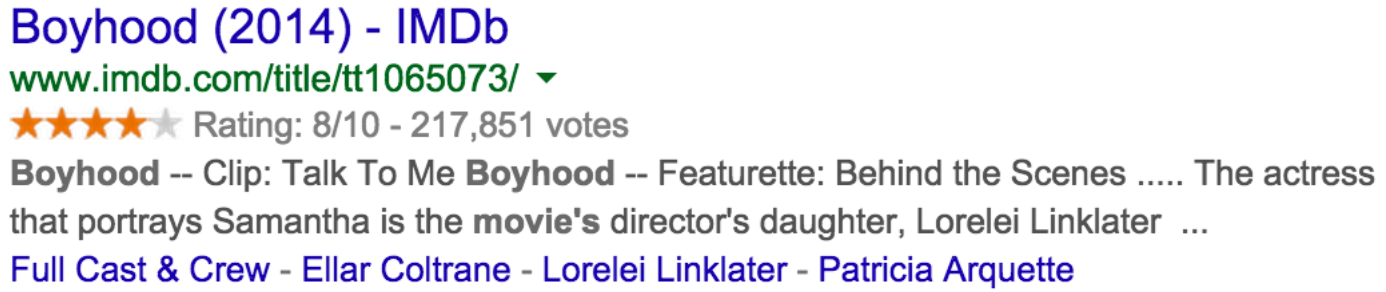


Source: http://lod-cloud.net/

Application examples

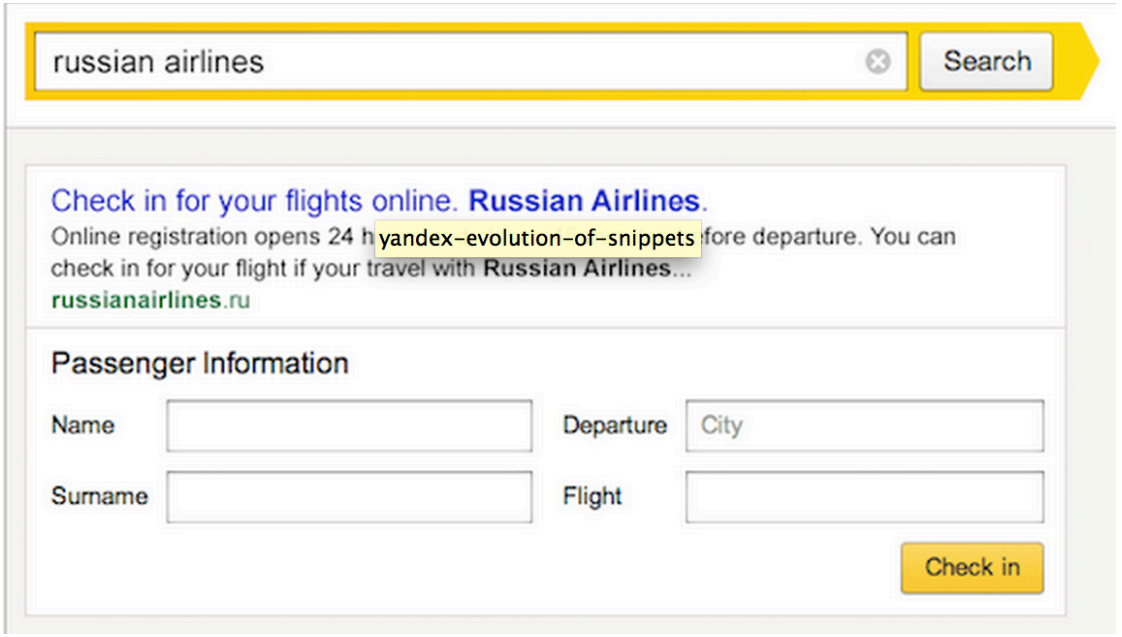
Rich Snippets

- Richer rendering of Google search results for those pages that embed structured and semantically described data
- Try it yourself by searching Google for any movie, concert, recipe, mobile phone app, Sourceforge project, …
- Detailed insight into Rich Snippets is available at: https://goo.gl/6JBY9k



Interactive Snippets (Yandex Islands)

- Feature of the Yandex search engine, similar to Rich Snippets, but more interactive
  - E.g., allows one to check-in for a flight
- The following article provides more information: http://goo.gl/uxjb6g



Pinterest's Rich Pins

- Rich Pins are pins with additional, advanced features
  - E.g., for products, they provide information about the current price, availability, current discounts, special deals
- An overview of different types of Rich Pins is available at: https://business.pinterest.com/en/rich-pins
- Documentation for developers gives detailed information on the use of structured data for the creation of Rich Pins: https://developers.pinterest.com/docs/rich-pins/

PERSONAL DIGITAL ASSISTENTS

Some well known examples:

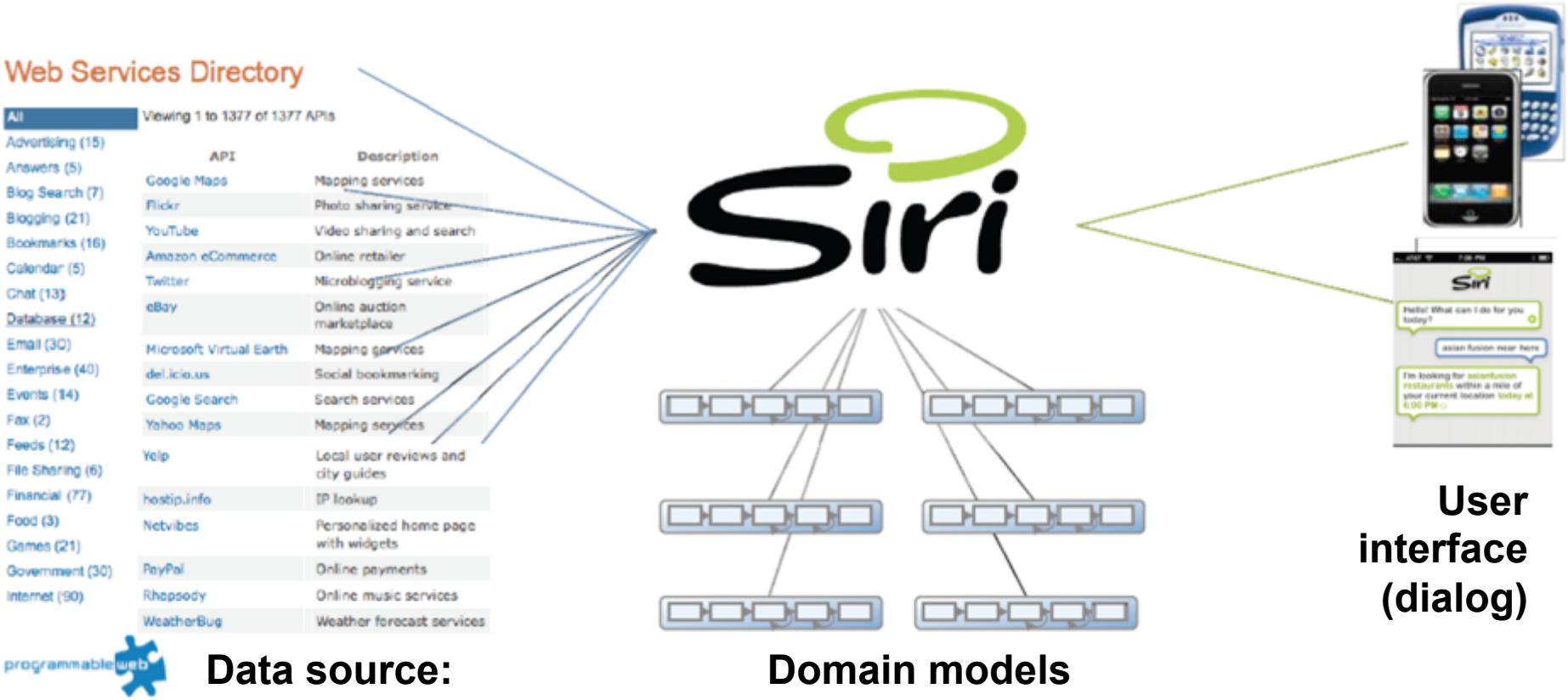
- Siri (http://www.apple.com/ios/siri/)
- Google Now (http://www.google.com/landing/now/)
- Evi (http://www.evi.com/)
- Skyvi (http://www.skyviapp.com/)
  - bought by Google; ceased to exist as a standalone app in Sept 2015; the technology behind it is integrated into Google Now

PERSONAL DIGITAL ASSISTENTS

*"Thanks to **Google Now**, as I stroll around San Francisco, **live bus times** are offered to me whenever I pull my phone from my pocket at a bus stop. And when I get up in the morning, Google Now presents a panel summarizing my **optimum transit journey** to work along with specific buses and an **estimate of the time** the trip will take…"*

Source: Google's Answer to Siri Thinks Ahead, MIT Technology Review

Web (RESTful) APIs for Data Access



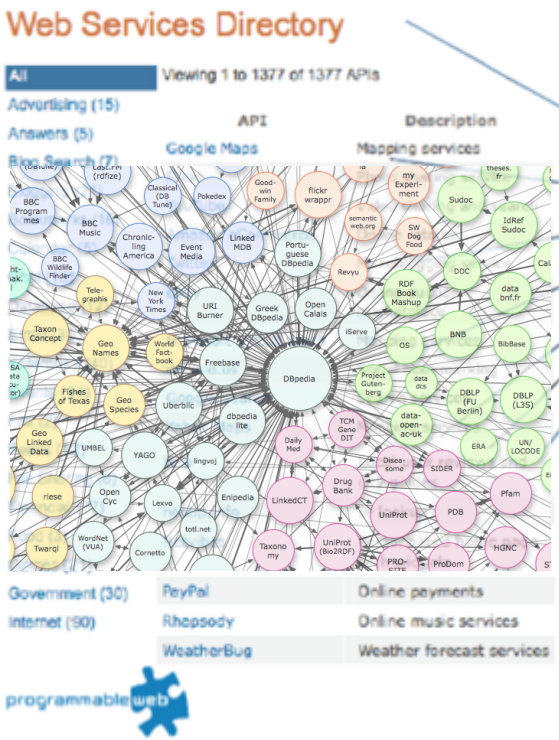
Tom Gruber. *Siri: A Virtual Personal Assistant.* Keynote presentation at Semantic Technologies conference, June 2009. http://tomgruber.org/writing/semtech09.htm

Web (RESTful) APIs for Data Access

Sole reliance on Web APIs for data collection has drawbacks :

- To collect data from different sources, one needs to
  - get acquainted with the specificities of different APIs that provide access to the required data
  - resolve the heterogeneity in the data collected from different sources
- APIs tend to change, causing the need to update the code that relies on them for data access
- Change in the conditions for accessing the data
  - changes in the quantity and/or kinds of the data that can be pulled through the API

New (additional) data source: Linked (open) data on the Web



Data sources:

Web APIs + **Linked Data**

Siri

Domain models
(**RDFS vocabularies**)
and program logic

User interface (dialog)