

The Web of (Linked) Data

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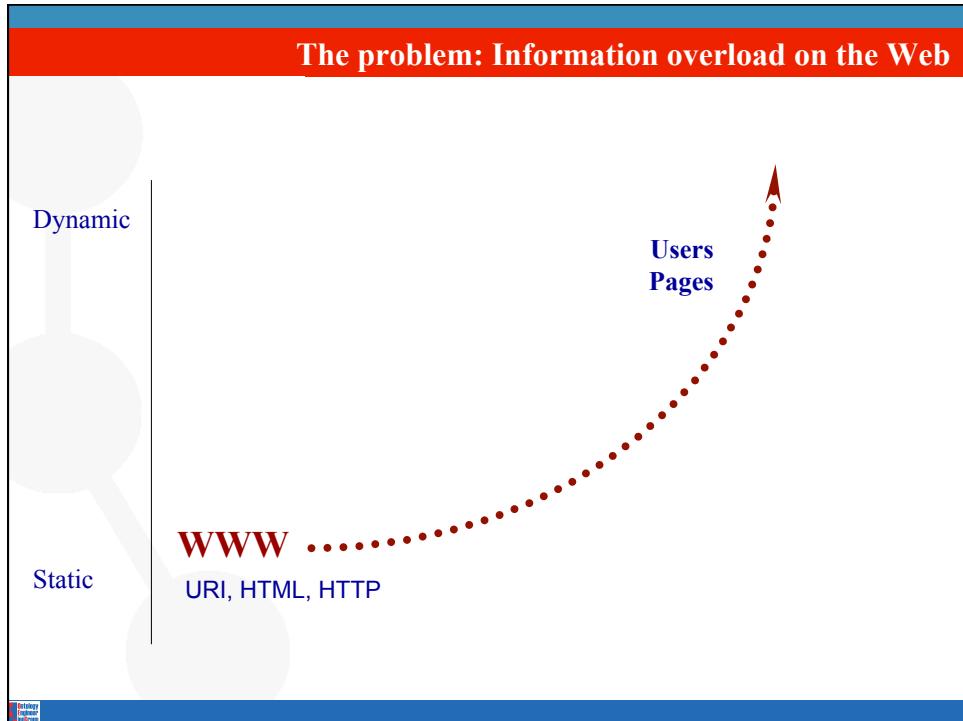
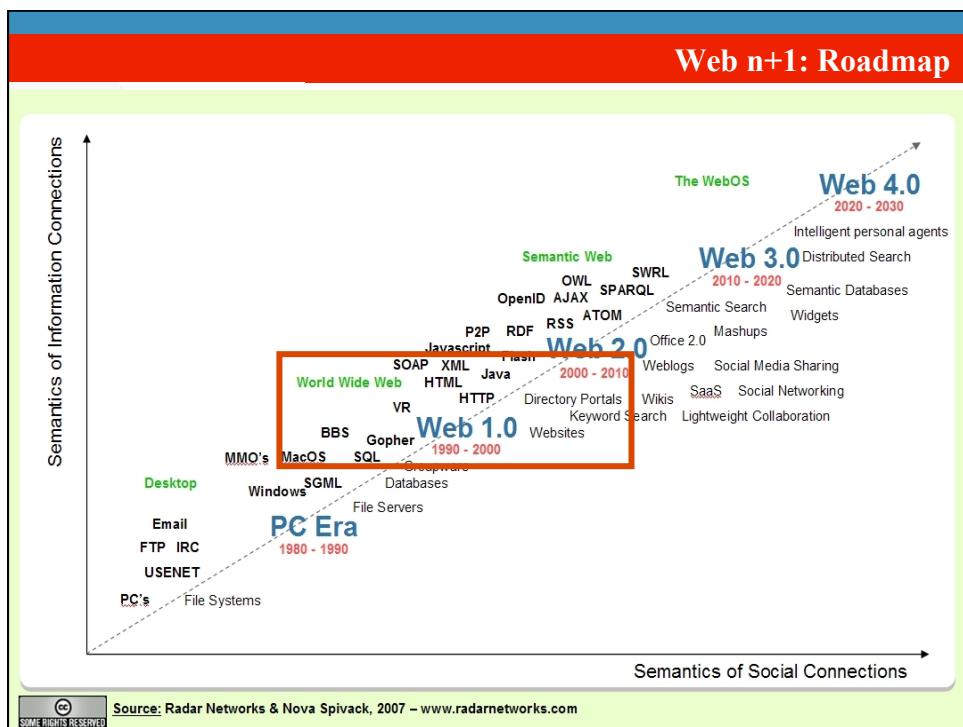
Acknowledgements: Luis M. Vilches, Victor Saquicela, Guillermo Alvaro Rey, Olaf Hartig, Juan Sequeda, and many others that we may have omitted.

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- Web 3.0 and the Semantic Web
- Linked Data
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Where we are Today: the *Syntactic Web*

The diagram illustrates the Syntactic Web. It features two computer monitors. The top monitor displays a web page with a navigation menu and several sections of text. The bottom monitor displays a similar web page with a different layout and content. A blue arrow originates from the top monitor and points to a central node in a network graph. This graph consists of several circular nodes, each labeled "Resource", connected by arrows labeled "href". The nodes are arranged in a cluster, with some nodes having multiple outgoing arrows pointing to other nodes.

- A place where computers do the presentation (easy) and people do the linking and interpreting (hard).
- Why not get computers to do more of the hard work?

What's the Problem?

- Typical web page markup consists of:
 - Rendering information (e.g., font size and colour)
 - Hyper-links to related content
- Semantic content is accessible to humans but not (easily) to computers...

A screenshot of a Mozilla Firefox browser window. The title bar reads "ISSGC'07 :: Semantic Grid introductory practical - Mozilla Firefox". The main content area displays a note titled "ISSGC'07: Semantic Grid introductory practical". The note includes sections such as "Introduction", "Document Style Conventions", and "Student Exercises: Build a Semantically-Aware Grid Service Using GT4". The note is written in a plain text format with some color-coded text and code snippets. At the bottom of the browser window, there is a status bar with the URL "http://www.cs.man.ac.uk/~oconch/oconch/Notes/ISSGC2006/" and the name "David Ferguson". Below the browser window, a Windows taskbar is visible, showing icons for "Windows Explorer", "Taskbar - Microsoft Out...", "Microsoft PowerPoint...", and "start".

Information a machine can see...



XML allows the creation of metadata with “meaning”



المندمة في علم الاتصاف: الاسم
آسن ميرون غومزبرز: المؤلفون
\$74.95: السعر
الفاتح: المتألّف

<العنوان><المؤلفون><العنوان><العنوان><المؤلفون><المؤلفون><المؤلفون>

mglés

Title: Ontological Engineering
Authors: Asunción Gómez-
Bárez

Perez...
Price: \$74.95

Product: Book

e>Ontological ex>Asunción Cá

```
<Title>Ontological Engineering</Title>
<Author>Asunción Gómez-Pérez...</Author>
<Price>$74.95</Price>
<Product>Book</Product>
```

What do the tags mean for the machine?



Solution: XML markup with “meaningful” tags?

But What About...?

The problem of choosing information

- Find the information
 - Extract relevant information
 - Interpretation by human users
 - Synthesis

The problem of content aggregation From Madrid to Tokyo

- Content in different languages (Spanish, English, Japanese)
 - Find out relevant information from heterogeneous sources
 - Extract
 - Interpretation
 - Aggregation
 - Consistency of the information

What was the Web intended to be?

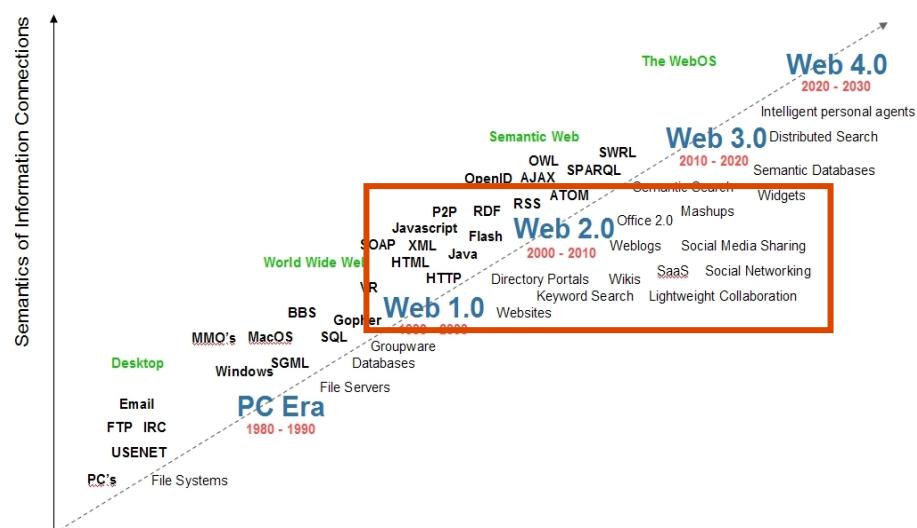


“... a goal of the Web was that, if the interaction between person and hypertext could be so intuitive that the **machine-readable** information space gave an accurate representation of the state of people's thoughts, interactions, and work patterns, then **machine analysis** could become a very powerful management tool, seeing patterns in our work and facilitating our working together through the typical problems which beset the management of large organizations.”

[Berners-Lee 1996]



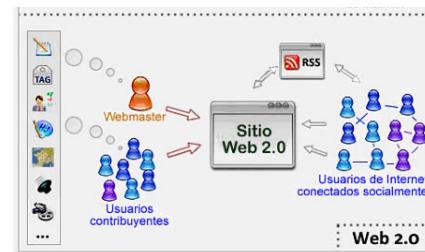
Web n+1: Roadmap



Source: Radar Networks & Nova Spivack, 2007 – www.radar-networks.com

Web 2.0

- **Users are both readers and writers**
 - Generate content
 - Control content
- **Ever-increasing amounts of content**
 - Dynamic content
- **Users participate**
 - Communication
 - Collaboration
- **Users add value to applications as they use it**
 - Collective intelligence by way of user participation
- **Rich user experience**
 - User-friendly interface
 - Personalized content
- **The Web as a programming platform**
 - Run applications entirely through a browser
 - Portability: software above the level of a single device
 - Openness



**- Find
- Understand
- Extract
- Compare
- Aggregate
- Publish
- Contextualise**

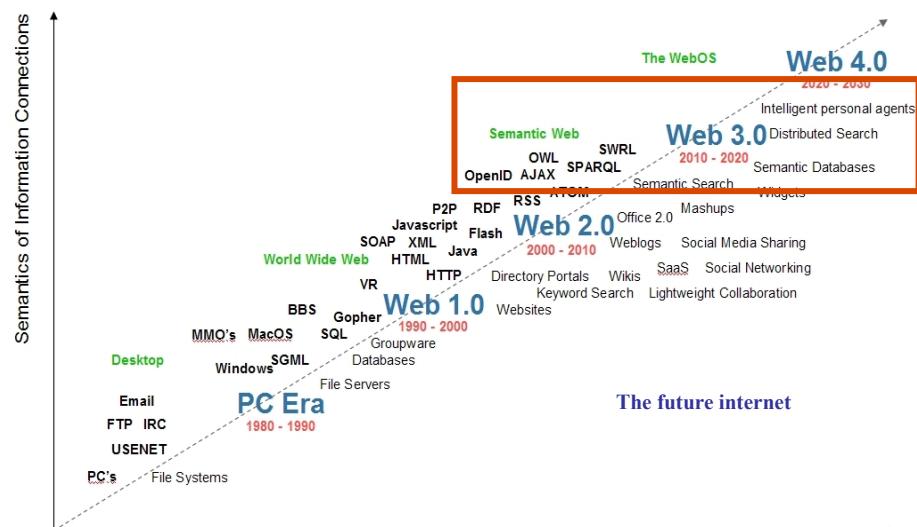
and Tim Berners-Lee [1996] sentence
is still valid for the Web 2.0



“... the machine-readable information space
... machine analysis could become a very
powerful management tool, ...
... facilitating our working together”

Internet
Radar

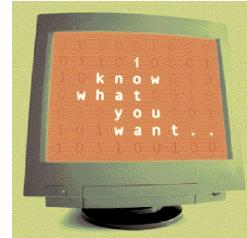
Web n+1: Roadmap



SOME RIGHTS RESERVED

Web 3.0

- **Intelligent Web**
 - Semantic Web technologies
 - The Data Web – a global database
 - Intelligent applications (NLP, machine learning, machine reasoning, autonomous agents)
- **Ubiquitous**
 - Broadband adoption
 - Mobile Internet access
 - Mobile devices
- **Cloud computing**
 - Software-as-a-service business models
 - Web services interoperability
 - Distributed computing (P2P, grid computing, hosted "cloud computing" server farms)
- **Openness**
 - Open APIs and protocols
 - Open data formats
 - Open-source software platforms
 - Open data (Creative Commons, Open Data License, etc.)
- **Open Identity**
 - Open identity (OpenID)
 - Open reputation
 - Portable identity and personal data

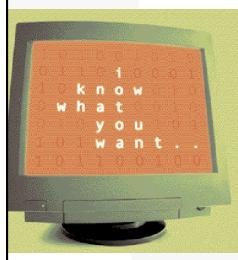


<http://lifeboat.com/ex/web.3.0>



What is the Semantic Web?

"The Semantic Web is an **extension** of the current Web in which information is given **well-defined meaning**, better enabling computers and people to work in **cooperation**. It is based on the idea of having data on the **Web** defined and linked such that it can be used for more **effective discovery, automation, integration, and reuse across various applications.**"



Ontologies
Annotation

Hendler, J., Berners-Lee, T., and Miller, E.
Integrating Applications on the Semantic Web, 2002,
<http://www.w3.org/2002/07/swint.html>

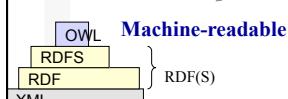


Need to Add “Semantics”

- External agreement on meaning of annotations
 - E.g., *Dublin Core* for annotation of library/bibliographic information
 - Agree on the meaning of a set of annotation tags
 - Problems with this approach
 - Inflexible
 - Limited number of things can be expressed
- Use **Ontologies** to specify meaning of annotations
 - Ontologies provide a vocabulary of terms
 - New terms can be formed by combining existing ones
 - “Conceptual Lego”
 - Meaning (**semantics**) of such terms is formally specified
 - Can also specify relationships between terms in multiple ontologies

Definition of Ontology

“An ontology is a formal, explicit specification of a shared conceptualization”

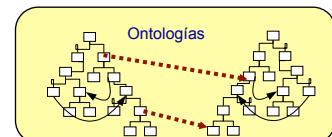
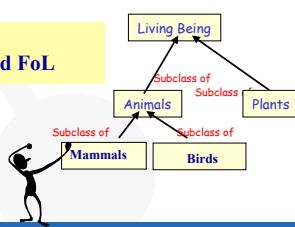


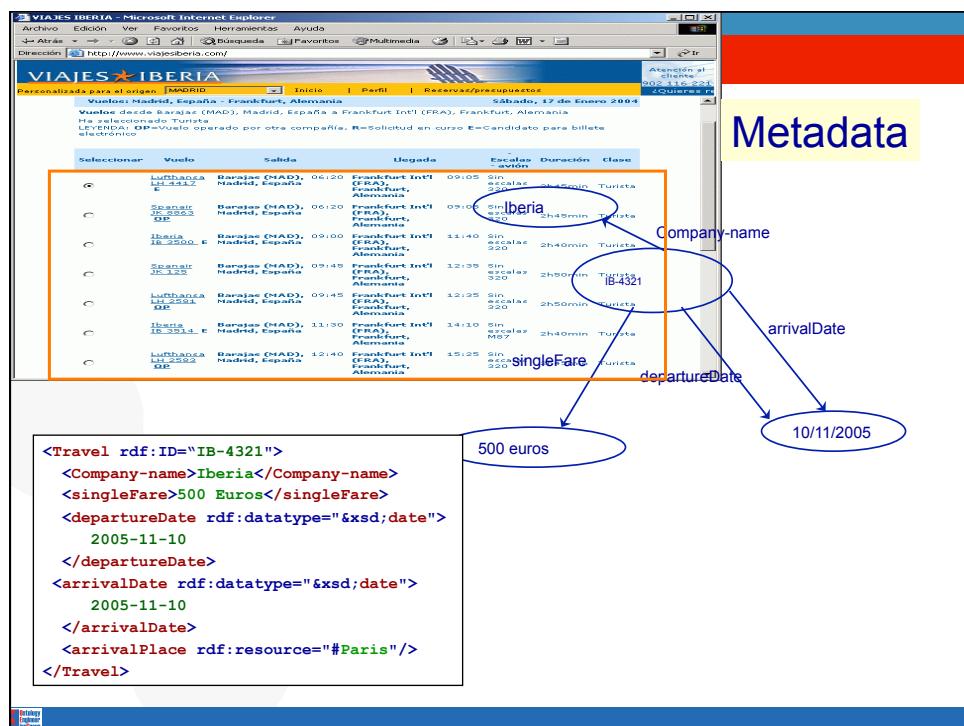
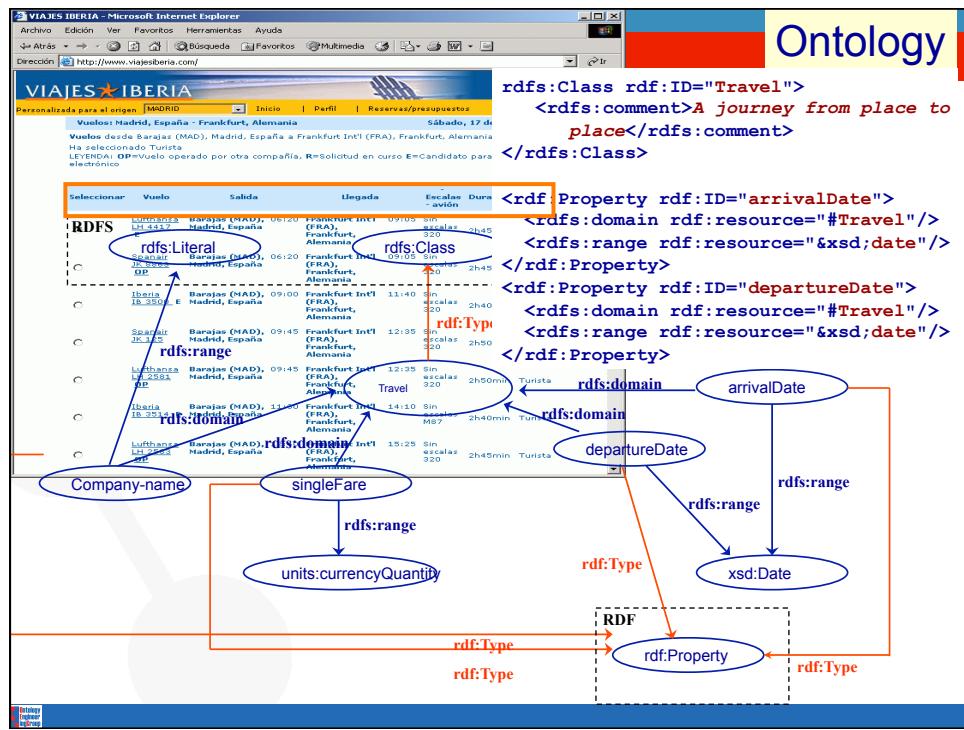
Concepts, properties
relations, functions,
constraints, axioms,
are explicitly defined

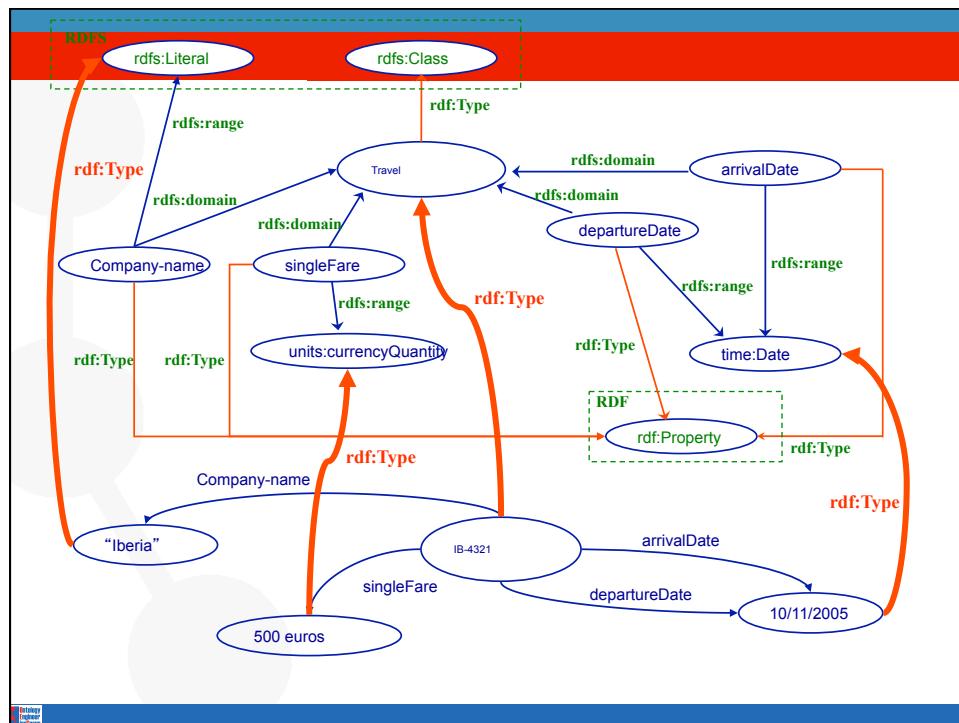
Consensual
Knowledge

Abstract model and
simplified view of some
phenomenon in the world
that we want to represent

Frames and FoL







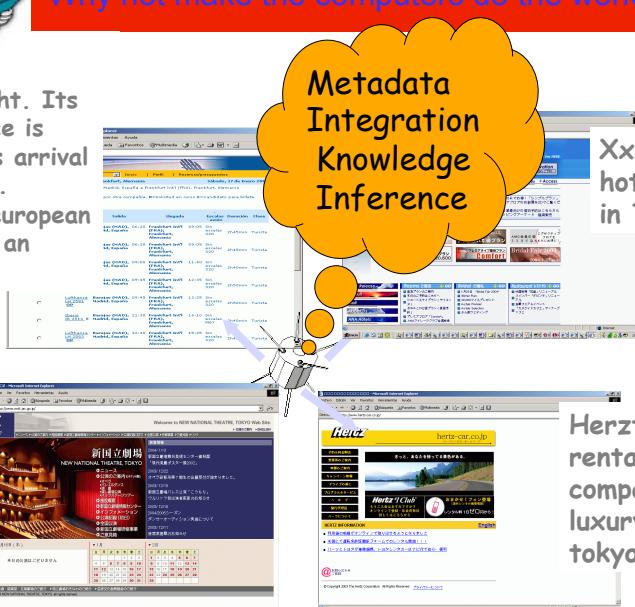
 Why not make the computers do the work?

IBXX is a flight. Its departure place is Madrid and its arrival place is Tokyo.
Madrid is an european city. Tokyo is an asian city.

The new national theater is a theater located in Tokyo. It has performances every Saturday.

Xxx is a hotel placed in Tokyo

Metadata Integration Knowledge Inference

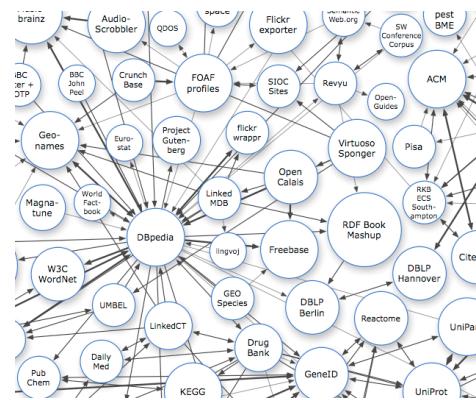


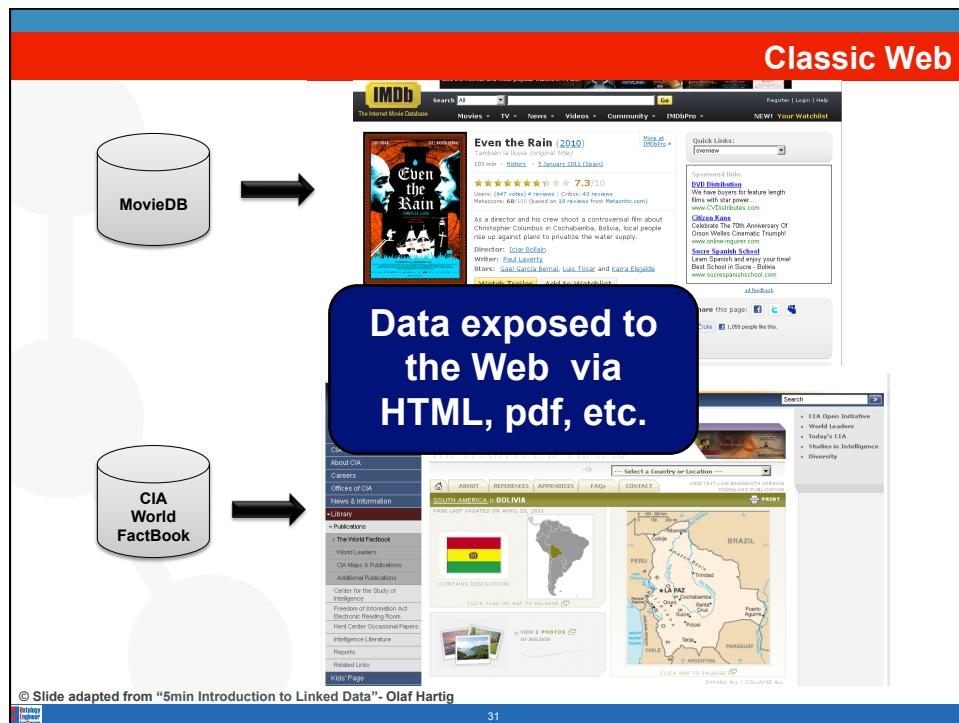
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What is the Web of Linked Data?

- An extension of the current Web...
 - ... where **i** data given **well-defined and explicitly represented meaning**, ...
 - ... so that it can be **shared** and used by **humans and machines**, ...
 - ... better enabling them to work in cooperation
- How?
 - Promoting information exchange by **tagging web content** with machine processable descriptions of its meaning.
 - And **technologies** and **infrastructure** to do this
 - And **clear principles** on how to publish data





What do we actually want?

- Use the Web like a single global database
 - Move from a Web of documents to a **Web of Data**

© Slide adapted from "5min Introduction to Linked Data"- Olaf Hartig

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Let's try an example...

- Tell me which football players, born in the province of Albacete, in Spain, have scored a goal in the World Cup final

La Web [Imágenes](#) [Videos](#) [Maps](#) [Libros](#) [Traductor](#) [Gmail](#) [Más ▾](#)

Google

Jugadores de fútbol de la provincia de Albacete

Aproximadamente 1,790 resultados (0.50 segundos)

Mundial Sudáfrica 2010 Los nombres de la jornada
Un gol de Sergio y un tanto de David, que también es... el del empate, además de haber sido, como ya sabes... Perú vs. Paraguay, que este hombre vale para anotar la **final de un Mundial** si los últimos "nombres de la jornada" en ... www.paraisodelfutbol.com/ /mundial-sudafica-2010-los-nombres-de-la-jornada.html

Tanque! - Delantero argentino Mundial 2010
El **jugador** alemán Mesut Özil celebra el gol enciagado en la **partido** final de la **temporada** 2004/2005 contra el **Albacete B** en el **Estadio** **Manzanares**. El futbolista, nacido el 2 de marzo de ... en ... máxima goleada de dicho torneo. www.tanque.net/ /Delantero-argentino-Mundial-2010.html

Ozil celebra con sus compañeros alemanes el gol m
El **jugador** alemán Mesut Özil celebra el gol enciagado en la **partido** final de la **temporada** 2004/2005 contra el **Albacete B** en el **Estadio** **Manzanares**. El futbolista, nacido el 2 de marzo de ... en ... máxima goleada de dicho torneo. www.tanque.net/ /Delantero-argentino-Mundial-2010.html

En cada

Puedes elegir a los héroes de La Roja? - Qué
13 Jul 2010 ... En la mayoría de los equipos de fútbol son las salvedades, muchas veces el solo contra el mundo ... Los 2 intenta para describir sus cualidades ... Mete el gol de la victoria ... Hoy es el día y ya no se sabe quién va a ganar. Puedes elegir a los héroes de La Roja? - Qué ... www.abc.es/deportes/2010/07/13/130924-puedes-elegir-a-los-heros-de-la-roja.html

Mostrar más resultados de www.que.es

Deportes | Man Guerrero
Hoy a las 12:30 gran final del mundial de basket: España VS pugna por el título de campeón de Europa. Hoy a las 12:30 gran final del mundial de basket: España VS pugna por el título de campeón de Europa. Hoy a las 12:30 gran final del mundial de basket: España VS pugna por el título de campeón de Europa. Hoy a las 12:30 gran final del mundial de basket: España VS pugna por el título de campeón de Europa.

Historial web | Configuración de búsqueda | Acceder

New features Log in / create account

Article Discussion Read Edit View history Search

Andrés Iniesta

From Wikipedia, the free encyclopedia

This is a Spanish name; the first family name is Iniesta and the second is Luján.

Andrés Iniesta (Spanish pronunciation: [an̪dɾe̪s iñje̪sta]; born 11 May 1984 in Fuentelbilla, Albacete, Castile-La Mancha) is a World Cup winning Spanish international football midfielder who currently plays for Spanish La Liga club FC Barcelona. His willingness to play anywhere on the pitch, coupled with a natural humility, has earned him the sobriquet *El Iusónista* (The Dreamer), *El Anti-Galáctico* (The Anti-Galactic), *Cerebro* (The Brain) and most recently *Don Andrés* from the Spanish press.^[1] After the 2009 UEFA Champions League Final, Manchester United striker Wayne Rooney asserted that he believed the midfielder to be the best player in the world.^[2] His current contract with Barcelona runs until 2015. He scored the winning goal for Spain in the 116th minute of the 2010 FIFA World Cup Final against the Netherlands and was the Man of the Match for the game.

Personal information

Full name	Andrés Iniesta Luján
Date of birth	11 May 1984 (age 26)
Place of birth	Fuentelbilla, Spain
Height	1.70 m (5 ft 7 in)
Playing position	Midfielder /Winger

Adapted from: Guillermo Alvaro Rey

It would be better to make a data query...

SPARQL Explorer for <http://dbpedia.org/sparql>

```

PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX dbpedia: <http://dbpedia.org/resource/>
PREFIX dbpedia2: <http://dbpedia.org/property/>
PREFIX dbpedia: <http://dbpedia.org/>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>

SELECT DISTINCT ?player ?village {
  ?s foaf:page ?player .
  ?s rdf:type <http://dbpedia.org/ontology/SoccerPlayer> .
  ?s skos:subject <http://dbpedia.org/resource/Category:UEFA_Euro_2008_players> .
  ?s <http://dbpedia.org/ontology/birthPlace> ?village .
  ?village skos:subject <http://dbpedia.org/resource/Category:Municipalities_in_Albacete> .
}

```

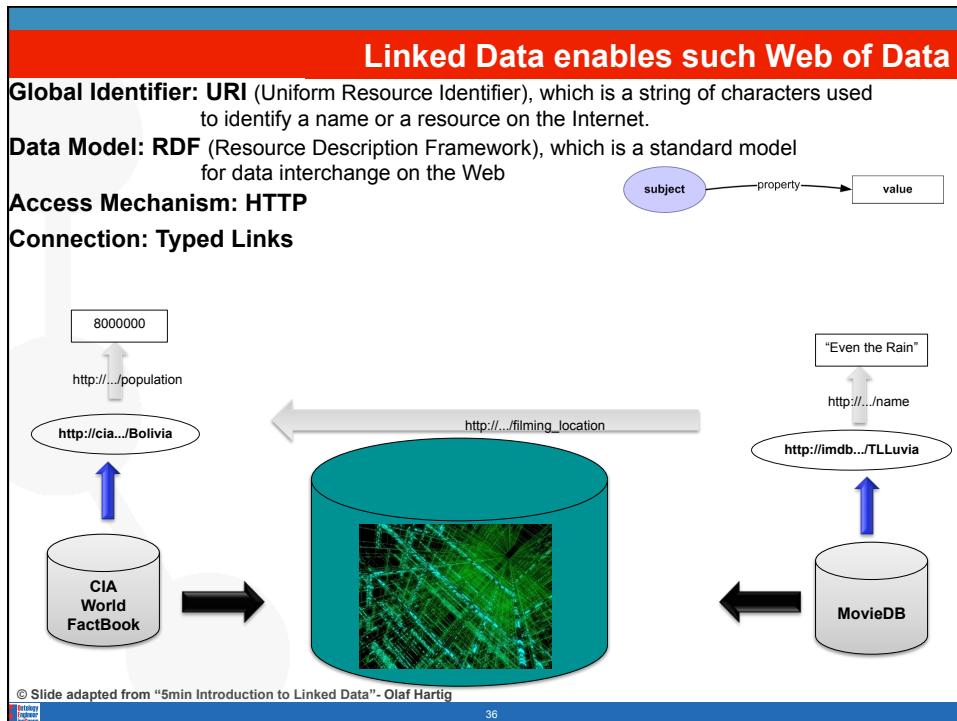
Results: Browse Go! Reset

SPARQL results:

player	village
http://en.wikipedia.org/wiki/Andr%C3%A9s_Iniesta	Fuentebilla



Taken from: Guillermo Alvaro Rey



What is Linked Data?

- Linked Data is a term used to describe a recommended **best practice** for exposing, sharing, and connecting pieces of data, information, and knowledge on the Semantic Web using URIs and RDF.
- Part of the Semantic Web
- Exposing, sharing and connecting data
- Technologies: URIs and RDF (although others are also important)

Linked Open Data evolution

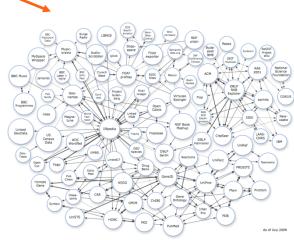
■ 2007



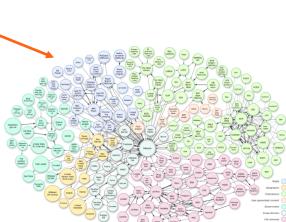
■ 2008

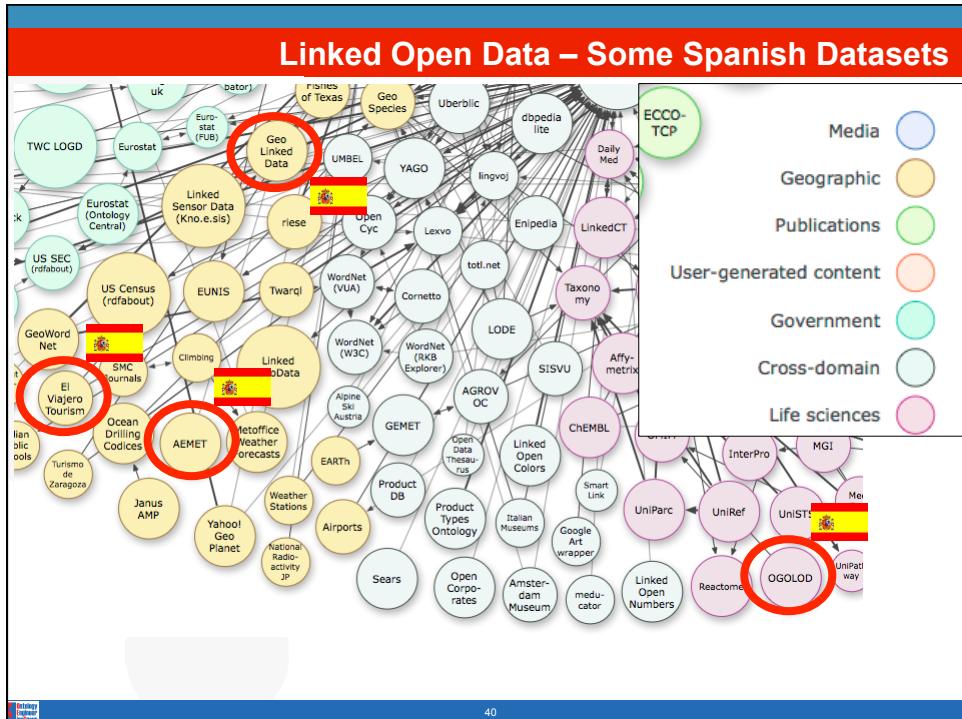
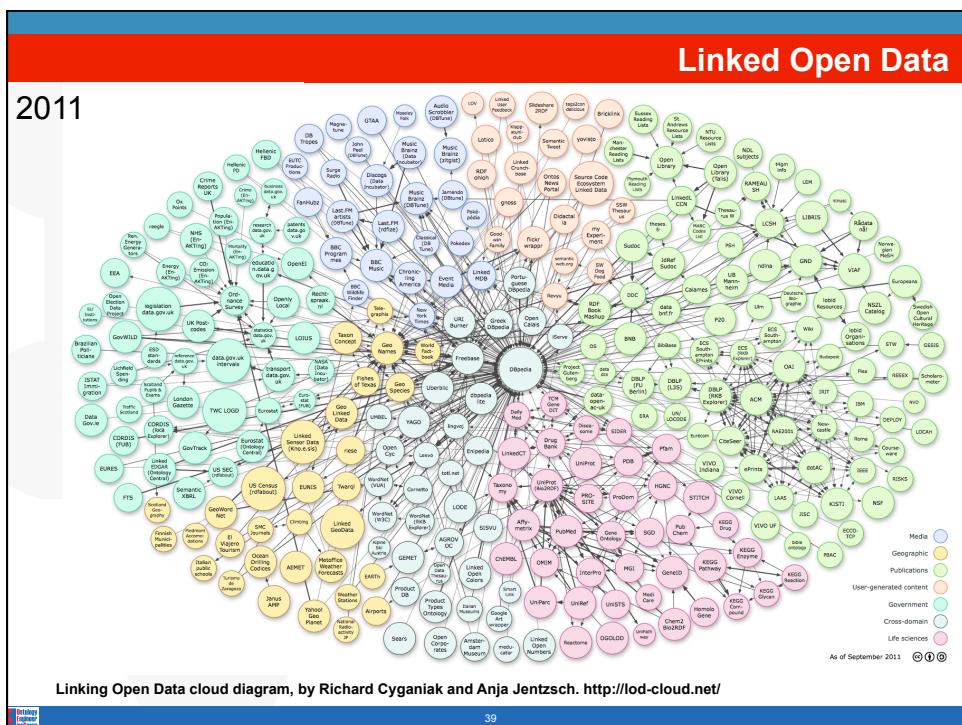


■ 2009



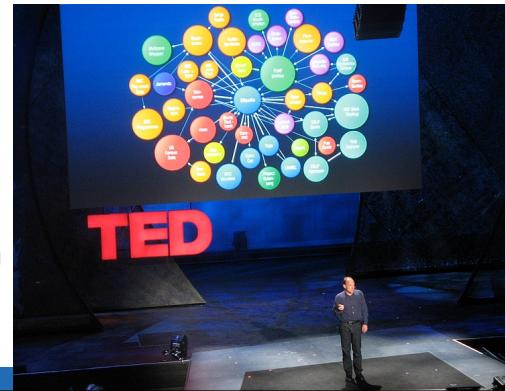
■ 2010





The four principles (Tim Berners Lee, 2006)

1. Use URIs as names for things
 2. Use HTTP URIs so that people can look up those names.
 3. When someone looks up a URI, provide useful information, using the standards (RDF*, SPARQL)
 4. Include links to other URIs, so that they can discover more things.
- <http://www.w3.org/DesignIssues/LinkedData.html>

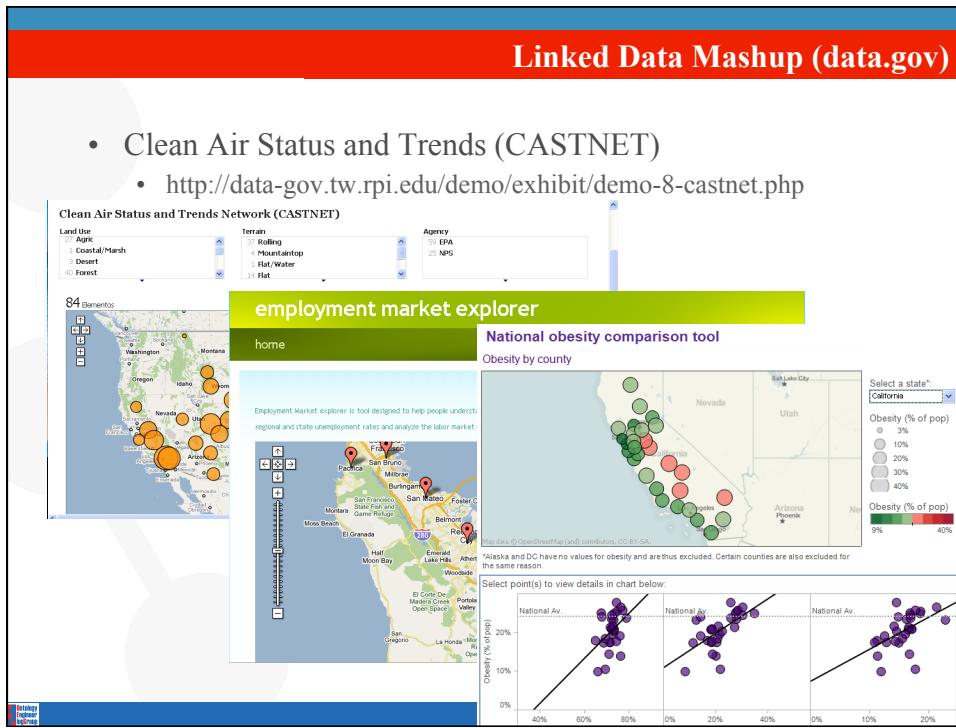


Open Government. USA and UK

A screenshot of the DATA.GOV website, which is celebrating its 1st anniversary. The page features a large cupcake graphic and a banner for the "HAPPY 1ST ANNIVERSARY DATA.GOV". The navigation bar includes links for Home, Data, SPARQL, Apps, Ideas, Forum, Wiki, Resources, and About. A search bar is prominently displayed. The main content area shows "Latest datasets" and a "Community" section. A large green overlay box contains the words "TOP-DOWN" and "BOTTOM-UP" in white, suggesting a comparison between different approaches to open government data.

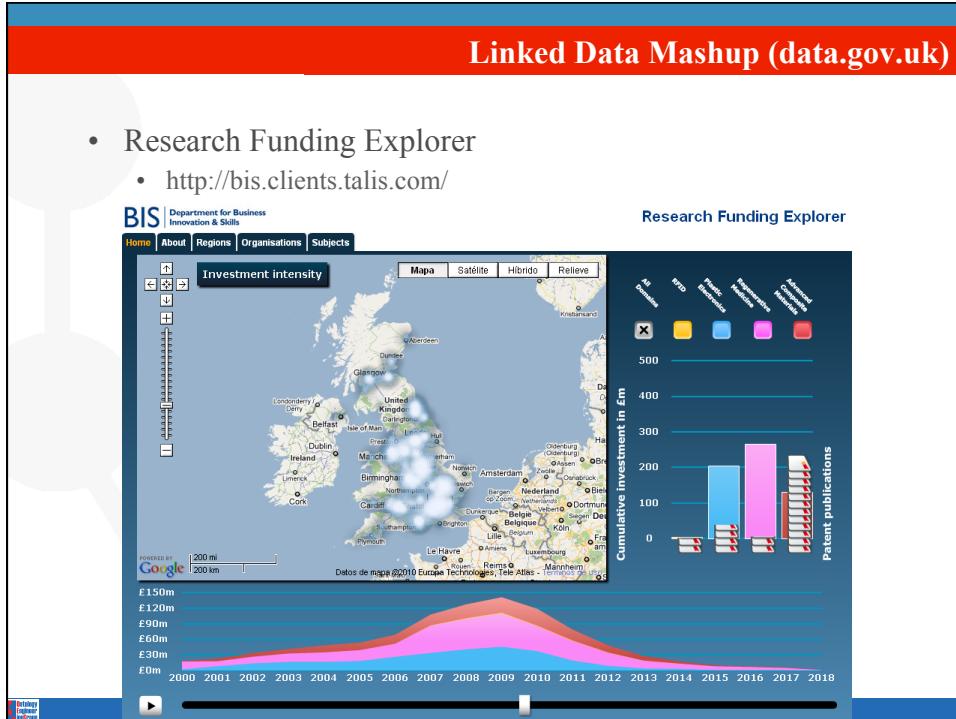
Linked Data Mashup (data.gov)

- Clean Air Status and Trends (CASTNET)
 - <http://data-gov.tw.rpi.edu/demo/exhibit/demo-8-castnet.php>



Linked Data Mashup (data.gov.uk)

- Research Funding Explorer
 - <http://bis.clients.talis.com/>



Designing URI sets for the Public Sector (UK)

- http://www.cabinetoffice.gov.uk/media/301253/public_sector_uri.pdf

URI Type	URI structure	Examples
Identifier	http://(domain)/id/(concept)/(reference) or http://(domain)/(concept)/(reference)#id	http://education.data.gov.uk/id/school/78 http://education.data.gov.uk/school/78#id http://transport.data.gov.uk/id/road/M5/junction/24
Document	http://(domain)/doc/(concept)/(reference)	http://education.data.gov.uk/doc/school/78
Representation	http://(domain)/doc/(concept)/(reference)/(doc_file-extension)	http://education.data.gov.uk/doc/school/78/doc.rdf
Definition of the scheme concept	http://(domain)/def/(concept)	http://education.data.gov.uk/def/school
List of scheme identifiers	http://(domain)/doc/(concept)	http://education.data.gov.uk/doc/school
Set	http://(domain)/set/(concept)	http://education.data.gov.uk/set/school



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So does that mean I have to publish my data as Linked Data, now?



- But, why?
 - What was your incentive to publish an HTML page in 1990?
 - Share data in documents and because your neighbor was doing it
 - So, why should we publish Linked Data in 2011?
 - Share data as data and because your neighbor is doing it



Open Government Initiatives

- W3C eGovernment Activity
 - Improving Access to Government through Better Use of the Web
 - Publishing Open Government Data
 - W3C Government Linked Data WG
- Open Knowledge Foundation
 - Open Data Manual
- 5-star deployment scheme for Linked Open Data
 - ★ make your stuff available on the Web (whatever format) under an open license¹
 - ★★ make it available as structured data (e.g., Excel instead of image scan of a table)²
 - ★★★ use non-proprietary formats (e.g., CSV instead of Excel)³
 - ★★★★ use URLs to identify things, so that people can point at your stuff⁴
 - ★★★★★ link your data to other data to provide context⁵



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Linked Data in the UK

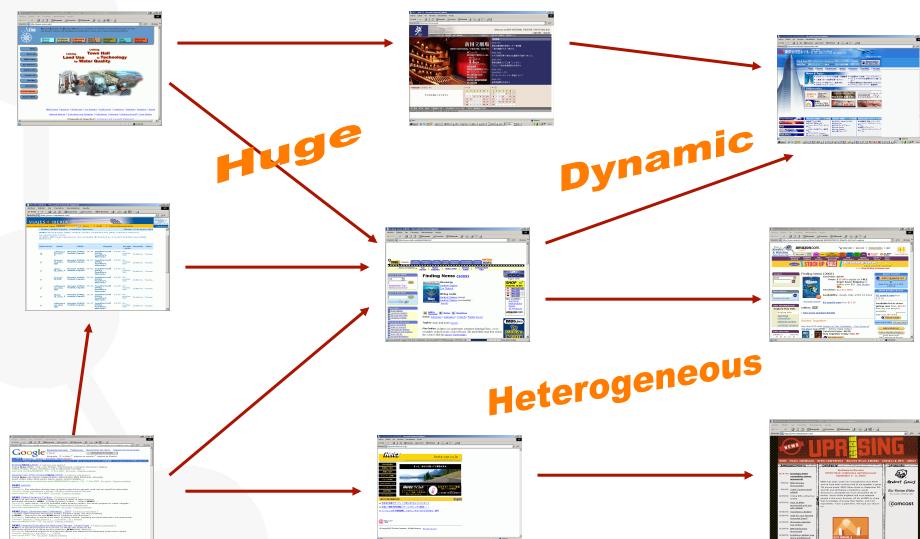
- Education
 - <http://education.data.gov.uk/id/school/106661>
- Parliament
 - <http://parliament.psi.enacting.org/id/member/1227>
- Maps
 - E.g., London:
<http://data.ordnancesurvey.co.uk/id/7000000000041428>
 - <http://map.psi.enacting.org>
- Transport
 - <http://www.dft.gov.uk/naptan/>
- SameAs service
 - <http://www.sameas.org>
- Challenges
 - <http://gov.tso.co.uk/openup/sparql/gov-transport>

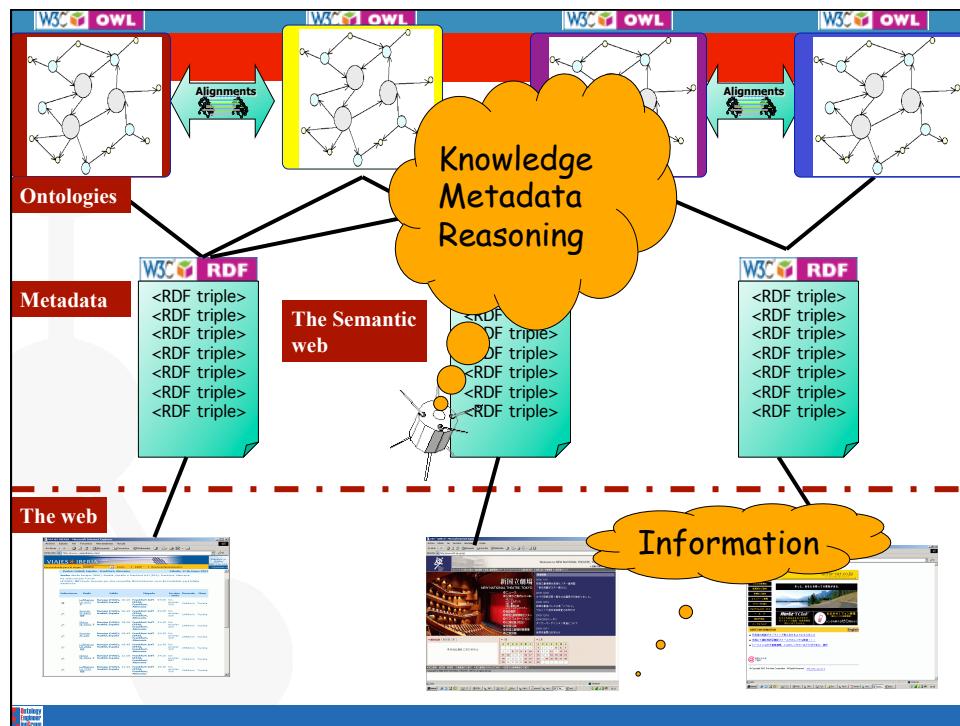
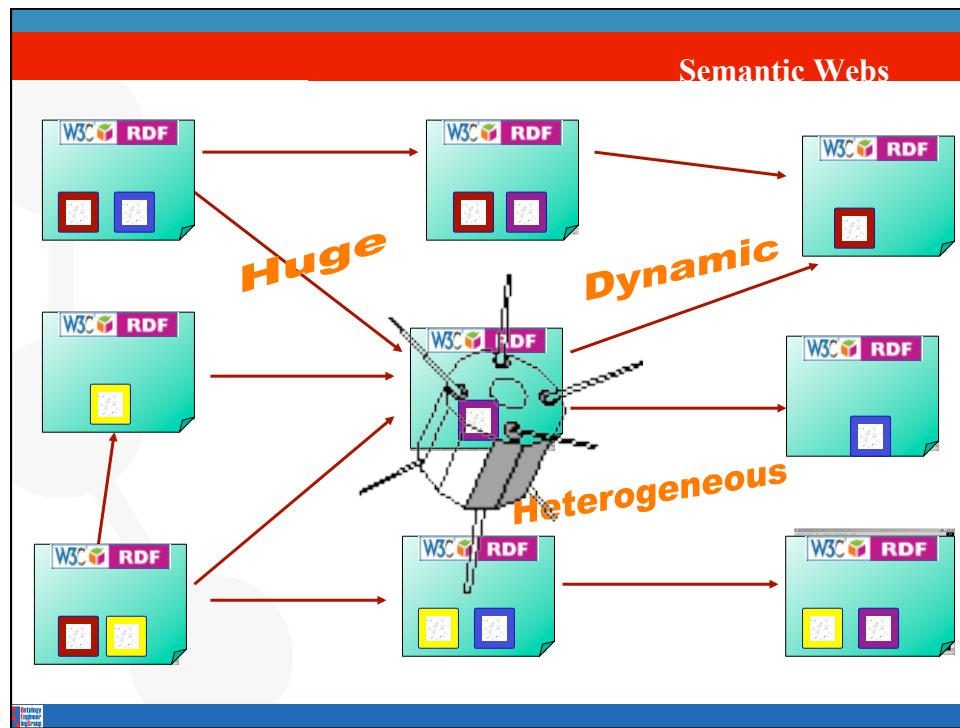


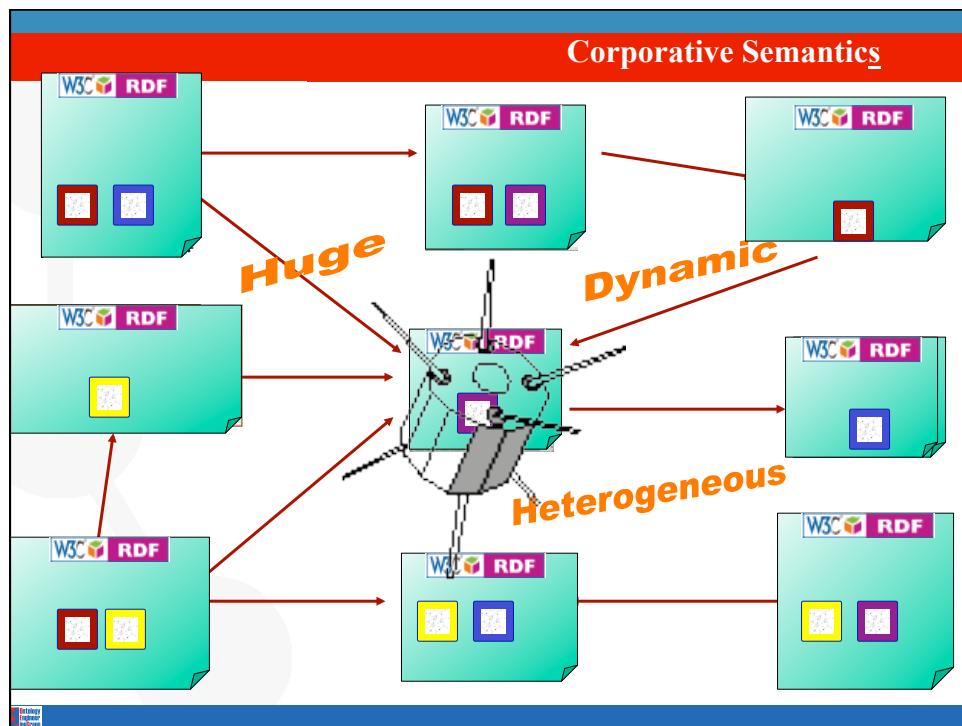
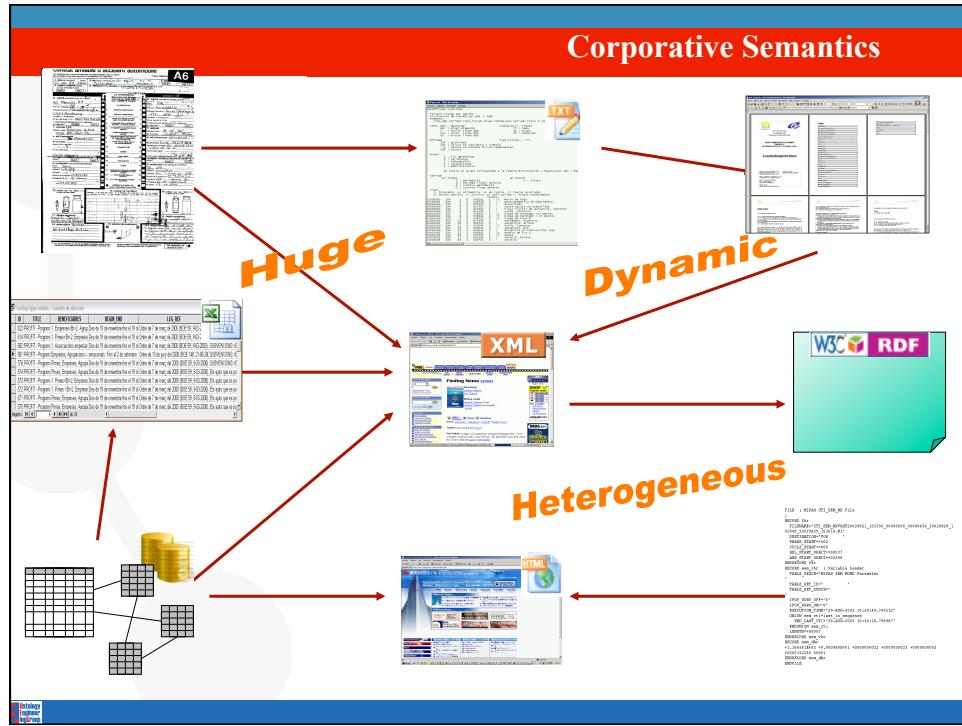
48

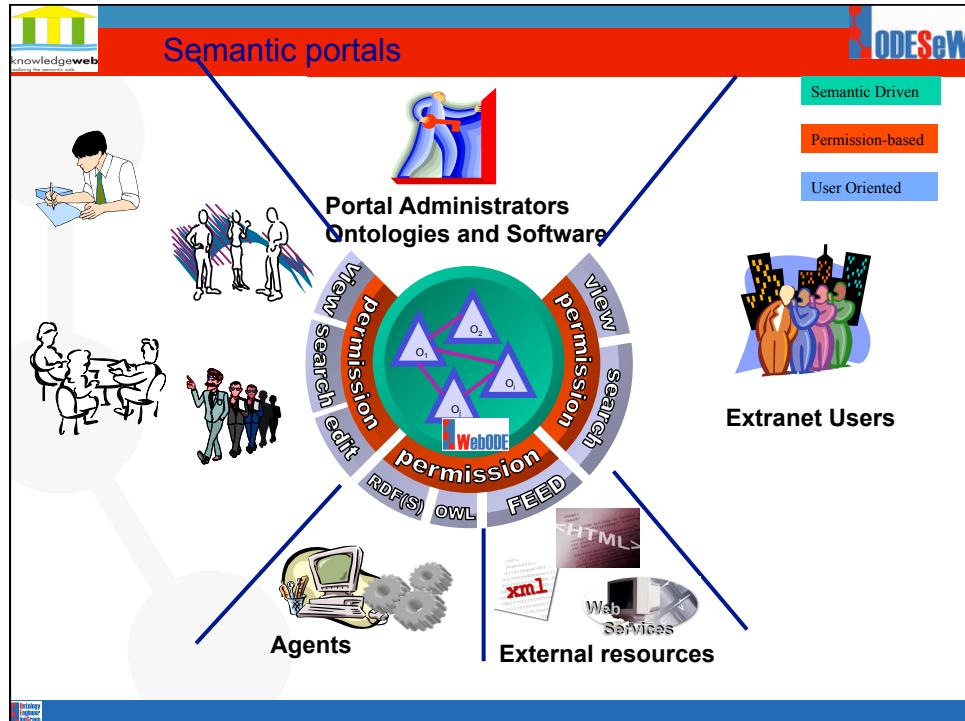
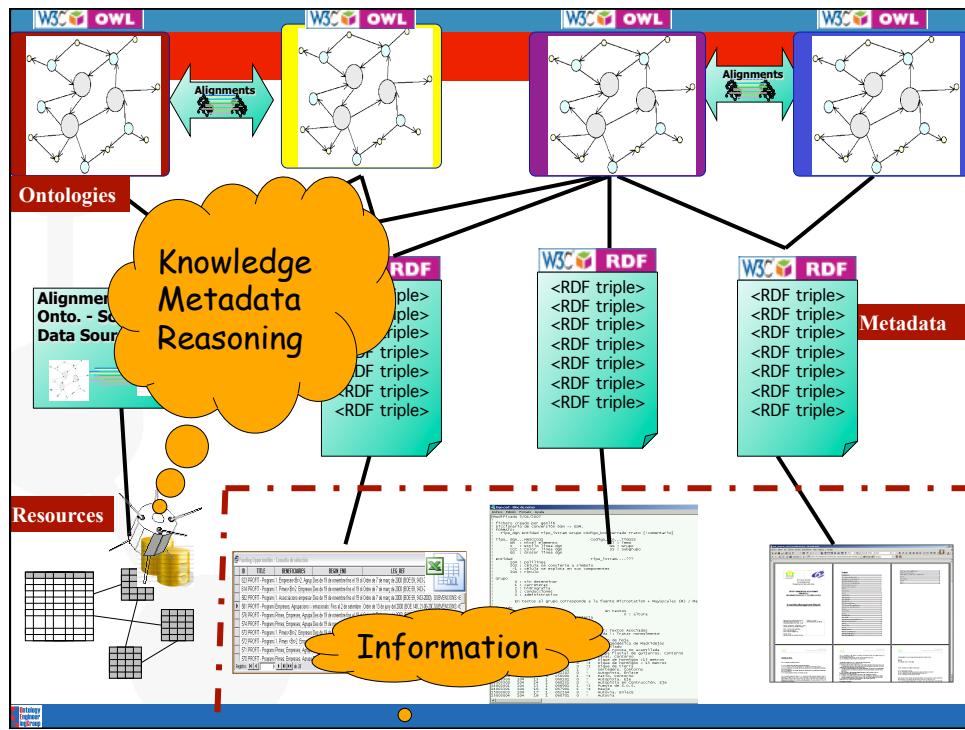
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 - Semantic Information exchange between heterogeneous data sources

The Web









Edición de los contenidos del portal (Atributos)

KnowledgeWeb Project FP6-507482

Person

Instance Name:	Angel Lopez-Cima
Instance Attribute:	Full Name
Range:	String (1,1)
Cardinality:	
Value:	Angel Lopez-Cima
Enter an URL [http://] or upload a file upload	
Angel.jpg	
alopez@l.upm.es	
Homepage	
URL:	(0,1)
Date:	(1,N)
String (1,1):	16/10/1976
City:	String (1,1): Madrid
Zip code:	String (0,1): 28860
Street Address:	String (1,1): Campus Montegancedo, s/n
Telephone:	String (0,1): +34 91 336 6604
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Student

Master Student
PhD Student
Undergraduate

ROFS

Documentation Event Organization Person Project Administration Logout

Continue to relations >>

Semantic-based Visualisation

Status of the Deliverables

Workpackage	Deliverable	Generated By	Q.A. Responsibility	Delivery Date	Project Month	Status
WP1: Ontologies	D1.1: State of the art in ontologies from the SW perspective	UPM	IFI	11/08/2002	2	Final
	D1.2: Kernel Ontology Specification, knowledge architecture	UPM	UDS	09/24/2003	27	Final
	D1.3: Ontology Workbench Specification	UPM	Uniliv	09/26/2003	27	Final
WP2: Window on Semantic Web languages	D1.4: Ontology Alignment Solution	IFI	UPM	09/12/2003	27	Final
	D2.1: State of the art on Semantic Web languages	IFI	UPM	09/17/2003	9	Final
	D2.2: Report on SW languages evolution	IFI	ISOCO	08/28/2003	30	Final
WP3: Annotation services	D3.1: State of the art on annotation tools and services	ISOCO	UDS	02/28/2003	2	---
	D3.2: Methodology for the development of wrappers and annotation tools	ISOCO	UPM	09/17/2003	9	Final
	D3.3: Annotation services for static resources	ISOCO	UPM	09/15/2003	10	---
WP4: Semantic indexation and routing	D3.4: Annotation services for dynamic resources	ISOCO	Uniliv	---	23	---
	D3.5: Annotation services for multimedia content	ISOCO	Uniliv	---	---	---
	D3.6: Annotation services for web services	ISOCO	Uniliv	---	---	---
WP5: Multilinguality	D4.1: State of the art on indexation, routing techniques and annotation tools required for multilingual environments	ISOCO	Uniliv	---	---	---
	D5.1: State of the art on multilinguality for ontologies, annotation services and user interfaces	ISOCO	Uniliv	---	---	---
	D5.2: Multilinguality and ontologies	ISOCO	Uniliv	---	---	---
WP6: User interface and visualisation services	D5.3: Multilinguality and annotation services	ISOCO	Uniliv	---	---	---
	D5.4: Multilingual user interface	ISOCO	Uniliv	---	---	---
	D6.1: State of the art on visualisation technologies feasible for the Semantic Web	ISOCO	Uniliv	---	---	---
WP7: Definition and integration	D6.2: Ontology visualisation core services	ISOCO	Uniliv	---	---	---
	D6.3: Semantic Web context visualisation services	ISOCO	Uniliv	---	---	---
	D6.4: Semantic Index and Routing Monitor service	ISOCO	Uniliv	---	---	---
WP8: Test case 1. Fund finder for	D7.1: System specification	ISOCO	Uniliv	---	---	---
	D7.2: Cooperation protocol definition	ISOCO	Uniliv	---	---	---
	D7.3: Application development guidelines	ISOCO	Uniliv	---	---	---
	D7.4: Integration test plan	ISOCO	Uniliv	---	---	---
	D8.1: Test case system specification	ISOCO	Uniliv	---	---	---
	D8.2: Test case system implementation	ISOCO	Uniliv	---	---	---

Workpackage

has associated

Deliverable

is generated by

has Q.A. partner

Organization

Semantic markup based on many different ontologies

The screenshot shows the KMI website with several examples of semantic markup (RDF/OWL) highlighted by red circles. The examples include:

- Enrico Motta's profile:**

```
<foaf:Person rdf:about="http://identifiers.kmi.open.ac.uk/people/enrico-motta">
<foaf:name>Enrico Motta</foaf:name>
<foaf:firstName>Enrico</foaf:firstName>
<foaf:surname>Motta</foaf:surname>
<foaf:phone rdf:resource="tel:+44(0)1963-653068"
<foaf:homepage rdf:resource="http://kmi.open.ac.uk/people/motta"
<foaf:workplaceHomepage rdf:resource="http://kmi.open.ac.uk/"/>
<foaf:depiction rdf:resource="http://kmi.open.ac.uk/img/members/enrico.jpg"/>
<foaf:topic_interest>Knowledge Technologies</foaf:topic_interest>
<foaf:topic_interest>Semantic Web</foaf:topic_interest>
<foaf:topic_interest>Ontologies</foaf:topic_interest>
<foaf:topic_interest>Problem Solving Methods</foaf:topic_interest>
<foaf:topic_interest>Knowledge Modelling</foaf:topic_interest>
<foaf:topic_interest>Knowledge Management</foaf:topic_interest>
```
- Cristian Barlaideanu's profile:**

```
[info] [email] [RDF/XML]
```
- Robbie Bays' profile:**

```
[info] [email] [RDF/XML]
```
- Asunción Gómez Pérez's profile:**

```
<rdf:Description rdf:about="Asunción_Gómez_Pérez">
<rdf:type rdf:resource="Full_Professor"/>
<NS0:Name>Asunción de María</NS0:Name>
<NS0>Last_Name>Gómez</NS0>Last_Name1>
<NS0>Last_Name2>Pérez</NS0:last_Name2>
<NS0:DisplayName>Asunción de María Gómez Pérez</NS0:DisplayName>
<NS0:Academic_Degree>Ph.D.</NS0:Academic_Degree>
<NS0:Telephone>+34 913367439</NS0:Telephone>
<NS0:Fax>+34 913524819</NS0:Fax>
<NS0:Address>Campus de Montegancedo</NS0:Address>
<NS0:City>Boadilla del Monte</NS0:City>
<NS0:Country>Spain</NS0:Country>
<NS0:Date_of_Birth>03/09/1967</NS0:Date_of_Birth>
```

The page also shows the Ontology Engineering Group logo and navigation menus for Home, News, Projects, Technologies, Publications, and People.



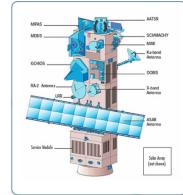
Processing satellite information

- Geographically distributed organizations
- Organizations send plans to the Envisat
- Envisat has Instruments on board that take “pictures”
- Envisat sends back information to the Earth

USE CASE DIMENSION:

- 1 planning file (DMOP) is generated per planning day
 - Parameters for instrument operation (taking pictures)
 - Parameters for the satellite general configuration.
 - MacroCommands (MCMDS): translation from planning
- For each DMOP file:
 - Hundreds of planning activities per instrument and instrument mode

Thousands of Product files are generated



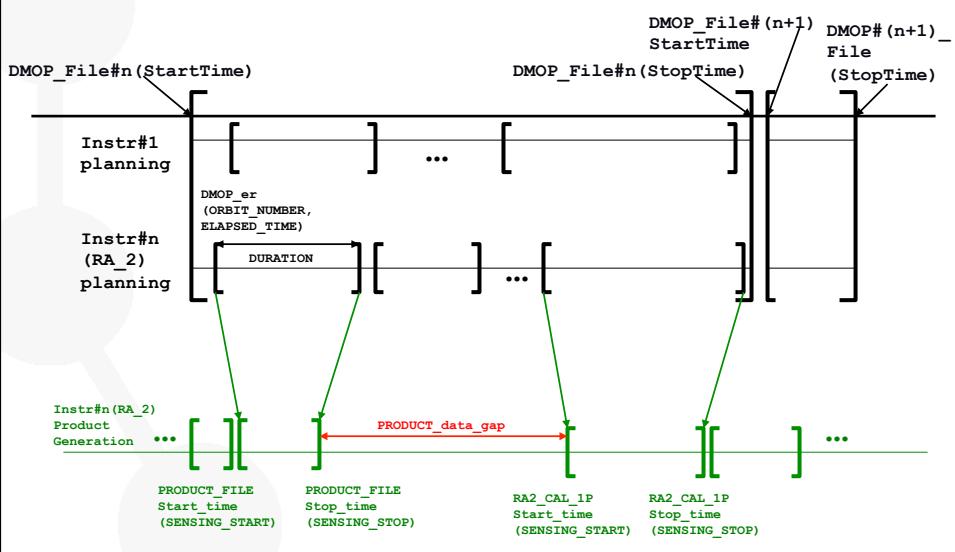
Analysis needs to be carried out on the existence, contents and correlation of these files



Thousands of Product files are generated



Comparison between planning and product generation



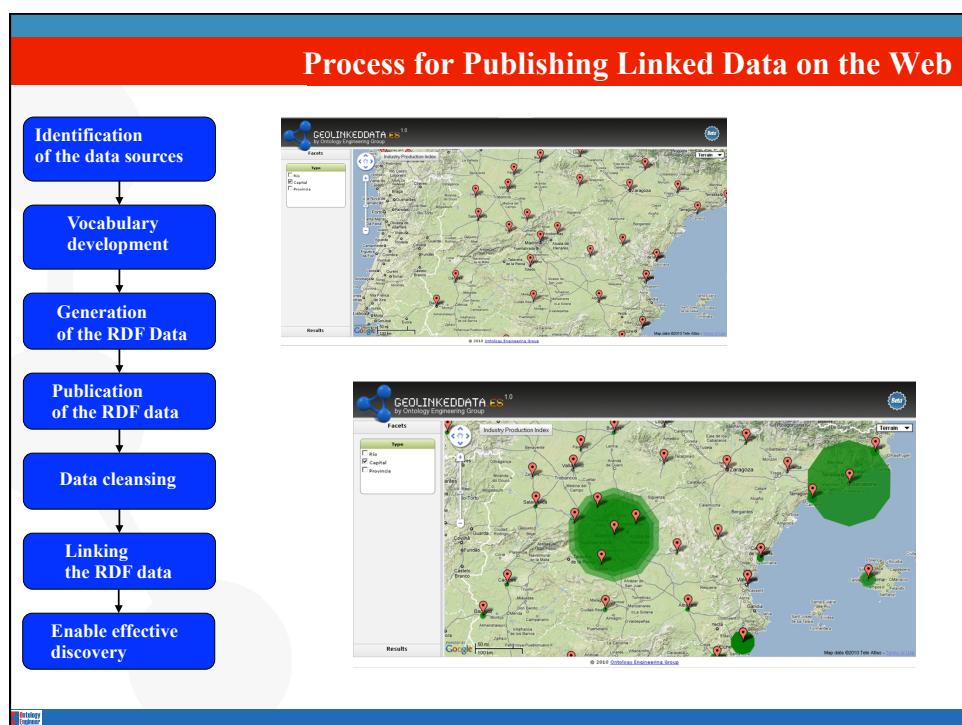
GeoLinkedData

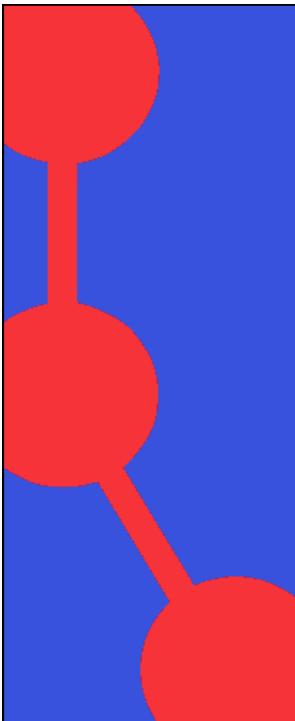
- It is an open initiative whose aim is to enrich the Web of Data with Spanish geospatial data.
- This initiative has started off by publishing diverse information sources, such as National Geographic Institute of Spain (IGN-E) and National Statistics Institute (INE)

GeoLinked Data



- <http://geo.linkeddata.es>





The Web of (Linked) Data

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