European Commission

OPEN DATA SUPPORT

Training Module 1.2

Introduction to Linked Data

pwc

Presentation metadata

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Learning objectives

By the end of this training module you should have an understanding of:

- What is linked data;
- What is open data;
- What is the difference between linked and open data;
- How to publish linked data (5-star schema);
- The economic and social aspects of linked data.

Content

This module contains …

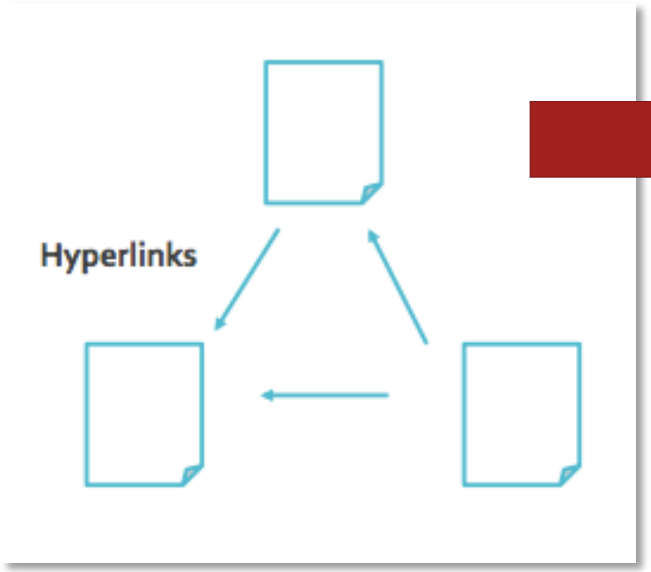
- An introduction to the linked data principles;
- An introduction to linked data technologies;
- An outline of the 5-star scheme for publishing linked data;
- An example of how tabular data can be published as linked data using Open Refine;
- The expected benefits of linked data for governments;
- An overview of linked data initiatives in Europe.

What is linked data?

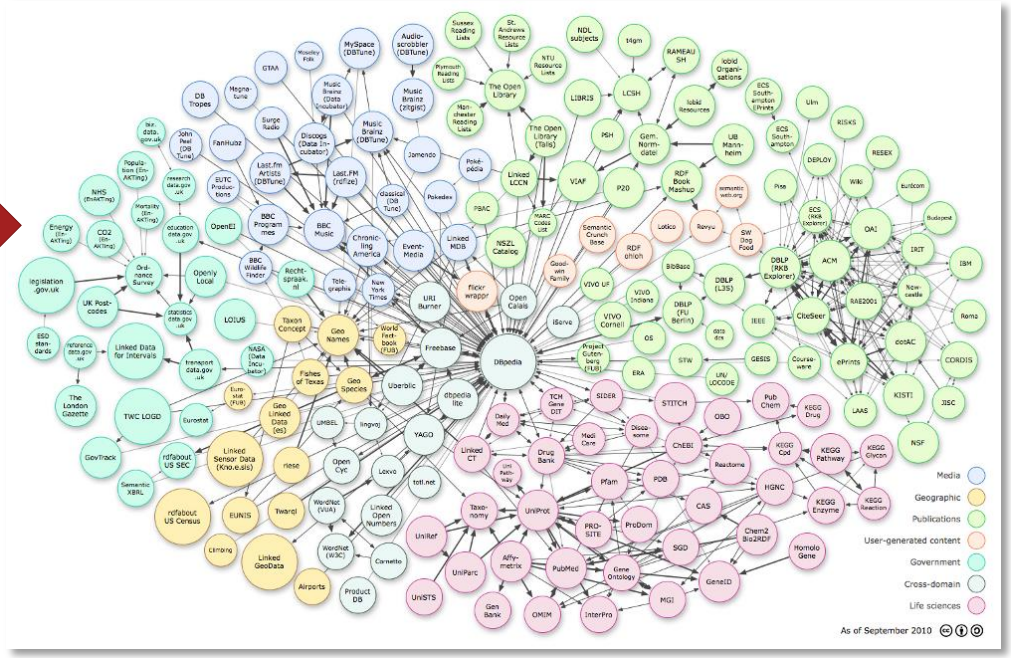
Evolution from a document-based Web to a Web of interlinked data.

The Web is evolving from a "Web of linked documents" into a "Web of linked data"... (1/2)

Web of documents...



Web of linked data...



The Web is evolving from a "Web of linked documents" into a "Web of linked data"... (2/2)

- The Web started as a collection of documents published online – accessible at Web location identified by a URL.
- These documents often contain data about real-world resources which is mainly human-readable and cannot be understood by machines.
- The Web of Data is about enabling the access to this data, by making it available in machine-readable formats and connecting it using Uniform Resource Identifiers (URIs), thus enabling people and machines to collect the data, and put it together to do all kinds of things with it (permitted by the licence).

Machine-readable data (or metadata) is data in a format that can be interpreted by a computer.

2 types of machine-readable data:

- human-readable data that is marked up so that it can also be understood by computers, e.g. microformats, RDFa;
- data formats intended principally for computers, e.g. RDF, XML and JSON.

See also:
http://www.ted.com/talks/tim_berners_lee_on_the_next_web.html
http://linkeddatabook.com/editions/1.0/

Defining linked data…

"Linked data is a set of design principles for sharing machine-readable data on the Web for use by public administrations, business and citizens."

EC ISA Case Study: How Linked Data is transforming eGovernment

The **four design principles** of Linked Data *(by Tim Berners Lee)*:

1. Use Uniform Resource Identifiers (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.

See also:
http://www.youtube.com/watch?v=4x_xzT5eF5Q
http://www.w3.org/DesignIssues/LinkedData.html
http://www.youtube.com/watch?v=uju4wT9uBIA

Linked (open) government data – value proposition

- **Flexible data integration:** LOGD facilitates data integration and enables the interconnection of previously disparate government datasets.
- **Increase in data quality:** The increased (re)use of LOGD triggers a growing demand to improve data quality. Through crowd-sourcing and self-service mechanisms, errors are progressively corrected.
- **New services:** The availability of LOGD gives rise to new services offered by the public and/or private sector.
- **Cost reduction:** The reuse of LOGD in e-Government applications leads to considerable cost reductions.

See also:
ISA Study on Business Models for LOGD
https://joinup.ec.europa.eu/community/semic/document/study-business-models-linked-open-government-data-bm4logd

The four principles in practice… (1)

1. Use Uniform Resource Identifiers (URIs) as names for things.
2. Use HTTP URIs so that people can look up those names.

E.g. for an organisation: ***UNICEF***

- http://publications.europa.eu/resource/authority/corporate-body/UNICEF

The four principles in practice... (2)

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.

```
<skos:Concept rdf:about="http://publications.europa.eu/resource/authority/corporate-body/UNICEF"
              at:deprecated="false">
  <skos:inScheme rdf:resource="http://publications.europa.eu/resource/authority/corporate-body"/>
  <skos:broader rdf:resource="http://publications.europa.eu/resource/authority/corporate-body/UNO"/>
  <at:authority-code>UNICEF</at:authority-code>
  <at:op-code>UNICEF</at:op-code>
  <atold:op-code>UNICEF</atold:op-code>
  <dc:identifier>UNICEF</dc:identifier>
  <at:start.use>1951-01-01</at:start.use>
  <skos:prefLabel xml:lang="bg">Уницеф – Детски фонд на ООН</skos:prefLabel>
  <skos:prefLabel xml:lang="cs">UNICEF – Dětský fond Organizace spojených národů</skos:prefLabel>
  <skos:prefLabel xml:lang="da">UNICEF – De Forenede Nationers Børnefond</skos:prefLabel>
  <skos:prefLabel xml:lang="de">Unicef – Kinderhilfswerk der Vereinten Nationen</skos:prefLabel>
  <skos:prefLabel xml:lang="el">Unicef – Ταμείο των Ηνωμένων Εθνών για τα Παιδιά</skos:prefLabel>
  <skos:prefLabel xml:lang="en">Unicef – United Nations Children's Fund</skos:prefLabel>
```

Linked data vs. open data

"Open data is data that can be freely used, reused and redistributed by anyone – subject only, at most, to the requirement to attribute and sharealike."
- OpenDefinition.org

Open data ≠ **Linked data**

Data can be published and be publicly available under an open licence without linking to other data sources.

Data can be linked to URIs from other data sources, using open standards such as RDF without being publicly available under an open licence.

See also:
Cobden et al., A research agenda for Linked Closed Data
http://ceur-ws.org/Vol-782/CobdenEtAl_COLD2011.pdf

Linked data foundations

URIs for naming things, RDF for describing data and SPARQL for querying it.

Uniform Resource Identifier (URI)

"A Uniform Resource Identifier (URI) is a compact sequence of characters that identifies an abstract or physical resource."

– ISA's 10 Rules for Persistent URIs

A country, e.g. Belgium

- **http://publications.europa.eu/resource/authority/country/BEL**

An organisation, e.g. the Publications Office

- **http://publications.europa.eu/resource/authority/corporate-body/PUBL**

A dataset, e.g. Countries Named Authority List

- **http://publications.europa.eu/resource/authority/country/**

See also:
http://www.slideshare.net/OpenDataSupport/design-and-manage-persitent-uris

RDF & SPARQL

The **Resource Description Framework** (RDF) is a syntax for representing data and resources in the Web

RDF breaks every piece of information down in **triples**:

- Subject – a resource, which may be identified with a URI.
- Predicate – a URI-identified reused specification of the relationship.
- Object – a resource or literal to which the subject is related.

http://example.org/place/Brussels is the capital of "Belgium".

OR

http://example.org/place/Brussels is the capital of http://example.org/place/Belgium.

Subject Predicate Object

SPARQL is a standardised language for querying RDF data.

See also:
http://www.slideshare.net/OpenDataSupport/introduction-to-rdf-sparql

How to publish linked data?

Paving the way towards 5-star linked data

5 star-schema of Linked (Open) Data

★	Make your stuff available on the Web (whatever format) under an open license. optional
★★	Make it available as structured data (e.g., Excel instead of image scan of a table)
★★★	Use non-proprietary formats (e.g., CSV instead of Excel)
★★★★	Use URIs to denote things, so that people can point at your stuff
★★★★★	Link your data to other data to provide context

★ *Make your stuff available on the Web under an open licence*

The National Archives

Sustainable development targets for 2011-12

Our business plan for 2011–2015 sets out our strategic objectives for the next four years and our specific business priorities for 2011–12. Our aim of 'a more sustainable Kew' sets out actions which will deliver significant sustainability benefits.

1. **Reduce carbon emissions at Kew by 6% from 2010–11 levels, balancing record preservation and environmental conditions**

Period	Electricity (KWh)	Gas (KWh)	Carbon (tonnes)	Change on 2010–11 (%)
April	762,625	354,062	479	-8.6
May	757,291	348,324	475	-6.5
June	846,364	388,369	530	-13.0
July	908,864	338,278	555	-17.1
August	928,827	384,925	574	-6.1
September	868,526	463,960	556	-2.7
October	810,768	376,137	509	-11.0
November	697,957	439,482	459	-17.1
December	536,080	472,718	378	-24.9

Performance to the end of December 2011 is -11.6%, well ahead of target. Our long-term commitment, which we are on track to meet or exceed, is to redu[illegible] business-related travel by 25% from 2009–10 levels by April 201

Pros & cons of ★ open data

As a consumer…	As a publisher…
✓You can access the data.	✓It is simple to publish.
✓You can store it locally.	✓You do not have explain repeatedly to others that they can use your data.
✓You can enter the data into any other system.	
✓You can change the data.	
✓You can share the data with anyone.	

★★ *Make it available as structured data*

Table DA2301 (SST2.10): Security and fire safety - dwellings, 2010

all dwellings

	smoke alarm*	burglar alarm	door viewer	external lighting	secure windows and doors	**all dwellings in group (000s)**	*sample size (unweighted)*
				percentage of dwellings within group			
tenure							
owner occupied	-	36,9	51,9	63,3	77,3	**14.860**	*8.791*
private rented	-	20,0	48,5	53,2	66,0	**3.706**	*3.096*
local authority	-	11,9	67,4	60,9	76,7	**1.801**	*2.276*
housing association	-	11,9	75,3	68,0	78,7	**2.018**	*2.507*
all private	-	33,6	51,2	61,3	75,1	**18.567**	*11.887*
all social	-	11,9	71,6	64,7	77,8	**3.819**	*4.783*
dwelling age							
pre-1919	-	25,4	44,3	41,9	58,4	**4.865**	*3.249*
1919-44	-	33,1	51,1	54,9	72,3	**3.751**	*2.684*
1945-64	-	27,2	54,3	60,2	79,6	**4.397**	*3.609*
1965-80	-	26,0	56,6	67,8	81,8	**4.602**	*3.593*
1981-90	-	31,2	57,9	77,5	78,6	**1.880**	*1.429*
post 1990	-	42,6	72,2	87,5	90,3	**2.892**	*2.106*
dwelling type							
end terrace	-	28,6	51,9	51,3	75,3	**2.251**	
mid terrace	-	24,4	49,6	40,4	72,3	**4.105**	
small terraced house	-	22,1	49,5	42,1	71,7	**2.171**	
medium/large terraced house	-	27,8	51,0	45,4	74,3	**4.185**	

Pros & cons of ★ ★ open data

All the benefits of ★ open data; **plus**

As a consumer…	As a publisher…
✓You can directly process it with proprietary software to aggregate it, perform calculations, visualise it, etc.	✓It is still simple to publish.
✓You can export it into another (structured and/or non proprietary) format.	

★★★ *Use non-proprietary formats*

- Proprietary: Excel, Word, PDF…
- Non-proprietary: XML, CSV, RDF, JSON, ODF…

Road safety- Accidents 2006:

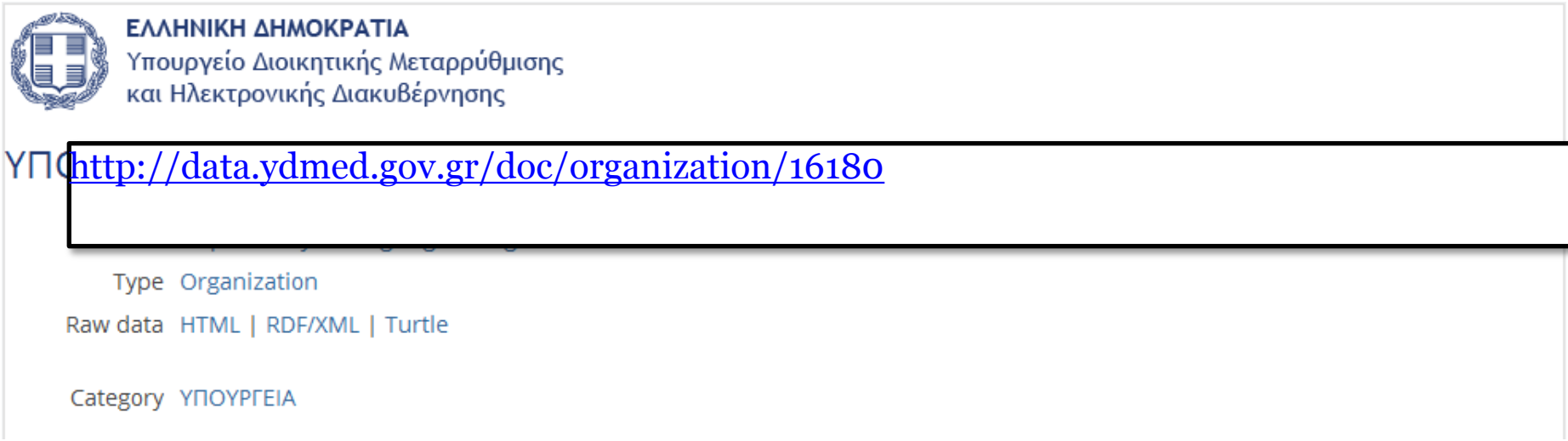
Pros & cons of ★ ★ ★ open data

All the benefits of ★ ★ open data; **plus**

As a consumer…	As a publisher…
✓You can manipulate the data in any way you like, without being confined by the capabilities of any particular software.	✓It is still simple to publish.
	- But, you may need converters or plug-ins to export the data from the proprietary format.

★★★★ *Use URIs to denote things*

For example, creating an URI for one of the units of the Greek Ministry of the Administrative Reform and e-Governance.



See also:
http://www.slideshare.net/OpenDataSupport/design-and-manage-persitent-uris

Pros & cons of ★ ★ ★ ★ open data

All the benefits of ★ ★ ★ open data; **plus**

As a consumer…	As a publisher…
✓You can link to it from any other place.	✓Other data publishers can now link into your data, promoting it to 5 star.
✓You can bookmark it.	✓You will be able to reuse vocabularies, data and metadata, and URI design patterns instead of creating them from scratch.
✓You can access information about a particular resource directly through its URI, without having to download the complete dataset.	
✓You may be able to reuse existing tools and libraries.	- But you typically need to invest some time in identifying the resources and assigning URIs.
✓You can combine the data with other data.	- You need to invest in a stable policy, management and infrastructure for persistent URIs.
- But understanding the technology requires effort and can have a steep learning curve.	

★★★★★ *Link your data to other data to provide context*

Pros & cons of ★ ★ ★ ★ ★ open data

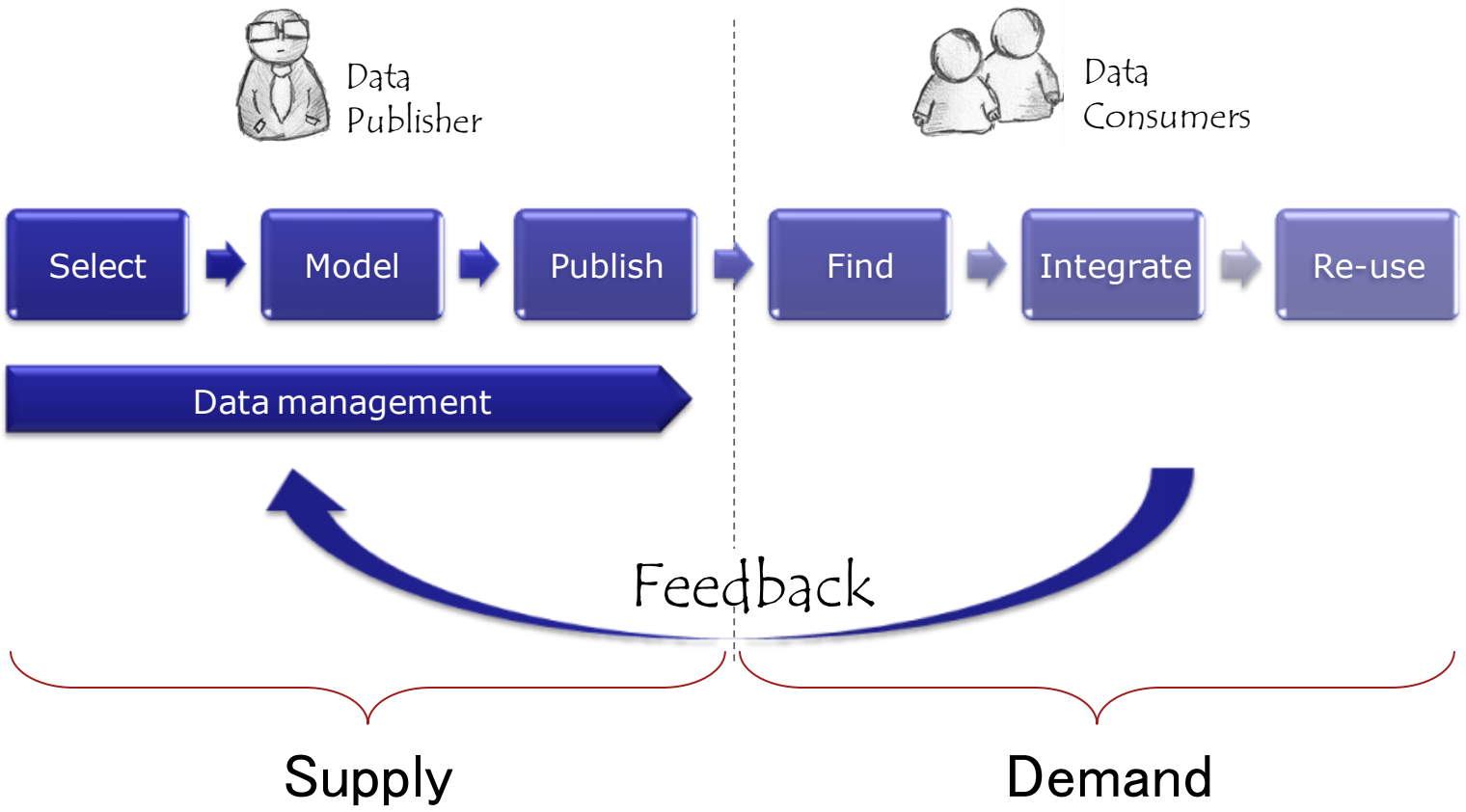
All the benefits of ★ ★ ★ ★ open data; **plus**

As a consumer…	As a publisher…
✓You can discover more (related) data while consuming the data.	✓You make your data discoverable.
✓You can directly learn about the data schema.	✓You increase the context, expressivity, quality and value of your data (and consequently you give visibility to your organisation).
✓You can combine data from different source, be innovative, gain new knowledge, be an entrepreneur…	- This requires an investment in time, money, technology and competencies/ skills.
- But, you now have to deal with broken data links. Not all publishers/data sources will be reliable.	

Prepare your data for publishing

The LOGD lifecycle

LOGD and metadata lifecycle
focusing on supply and demand



Selection of high-value data

Several dimensions can be considered in the selection process of Linked Open Government Data, both from the publisher's and the re-user's point of view:

- **Transparency:** Does the publication of the dataset increase transparency and openness of the government towards its citizens?
- **Legal requirements**: Is there a law that makes open publication mandatory or is there no specific obligation?
- **Relation to public task:** Is the data the direct result of the primary public task of government or is it a product of a non-essential activity?
- **Current status of open publication:** Is the data already openly available or does it still need to be opened up?
- **Type of value:** Is the data useful for social engagement or does it have commercial value?
- **Audience:** Is the data primarily intended for the public or is it primarily aimed at back-office integration?

Modelling your data & metadata is about …

- Making your data available in a **structured**, **comprehensible** and **machine-readabl**e way.
- **Reusing** what already exists in terms of vocabularies and reference data.
- Reaching the right quality level by **cleansing** your data.
- Providing **licensing information** so that data consumers know what the conditions of reuse are.
- Providing a rich description (**metadata**).
- Using **semantic technologies** (RDF, HTTP URIs…) for describing your data.

Cleansing your data & metadata

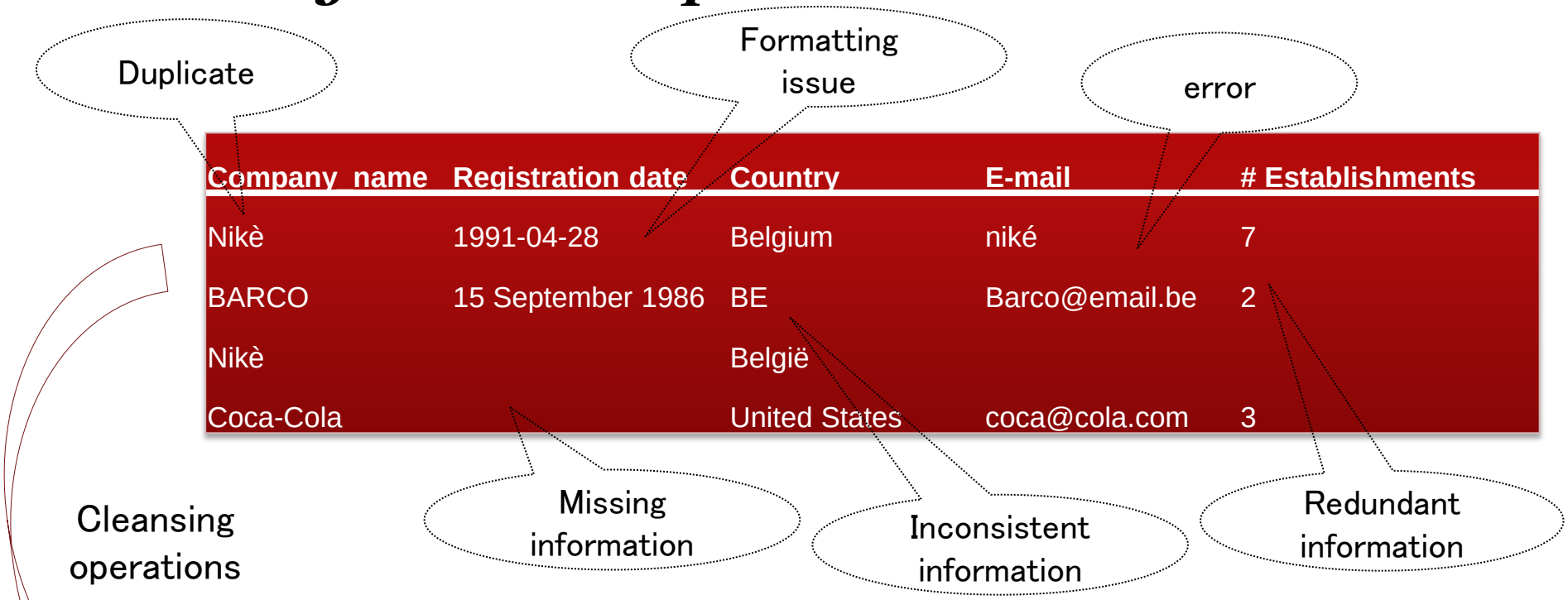
To ensure data and metadata can be published with an appropriate level of quality and minimum errors.

This means:

- Fixing errors.
- Transforming/homogenising formats.
- Aligning inconsistencies in data and metadata.
- Removing duplicate/redundant information.
- Adding lacking information.
- Making sure the information is up-to-date.

See also:
http://www.slideshare.net/OpenDataSupport/introduction-to-rdf-sparql
Cleanse your data with Open Refine (Google Refine) - https://code.google.com/p/google-refine/

Cleansing data - example



Company_name	Registration date	Country	E-mail	# Establishments
Nikè	1991-04-28	Belgium	niké	7
BARCO	15 September 1986	BE	Barco@email.be	2
Nikè		België		
Coca-Cola		United States	coca@cola.com	3

Company_name	Registration date	Country	E-mail
Nikè	1991-04-28	BE	niké@sport.org
BARCO	1986-09-05	BE	Barco@email.be
Coca-Cola	1964-03-26	US	coca@cola.com

Publishing linked data is about …

Breaking down the walls of the silos in order to create more value.

- Making your data and metadata publically and easily accessible on the Web.
- Linking your data and metadata to other data (or metadata) in order to:
  - Attach meaning and content to it.
  - Give context to it.
  - Enrich it.
  - Allow people to discover more.

Collecting feedback from the reusers of your data

Ask feedback to the (potential) users of data:

- Which data do they need.
- How did they use the data.
- What did they think about the quality.
- Make sure that requests and fixes reach you – crowdsource data quality!

data.overheid.nl

data.gov.uk

Example

Using Open Refine for RDF to publish tabular data as Linked Data.

What is Open Refine RDF extension

Open Refine RDF extension, allows you to easily import data in different formats such as :

- CSV;
- Excel(.xls and .xlsx);
- JSON;
- XML; and
- RDF/XML.

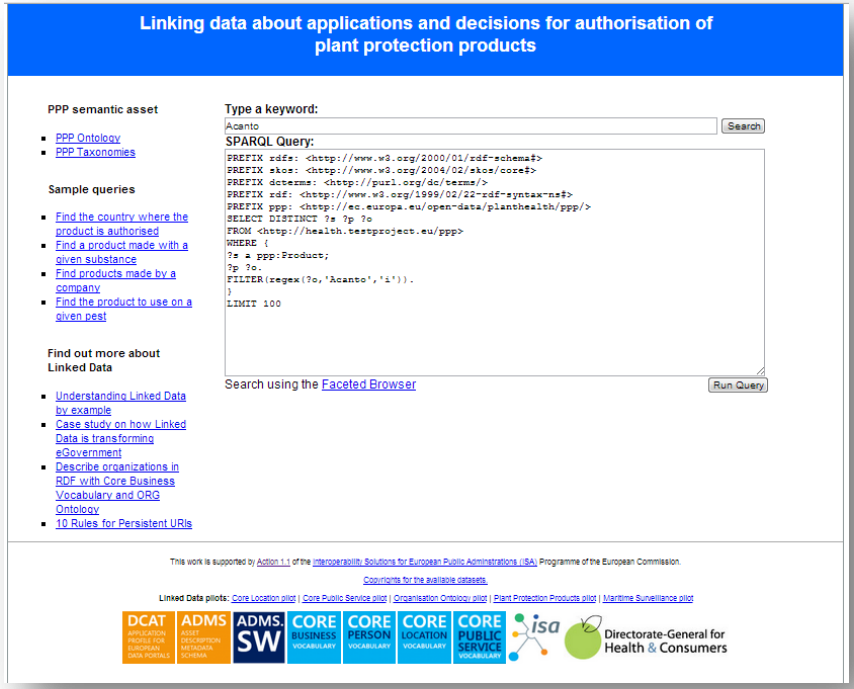
And then determine the intended structure of an RDF dataset, by drawing a template graph.

See also:
LOD 2 Webinar – Open Refine
http://www.youtube.com/watch?v=4Ve93C238gI

Case study: Linking data about plant protection products

We will show how a dataset of the Greek Ministry of Rural Development and Food was described using an ontology developed by DG Health and Consumers and was then published as Linked Data.

The dataset was in CSV format.

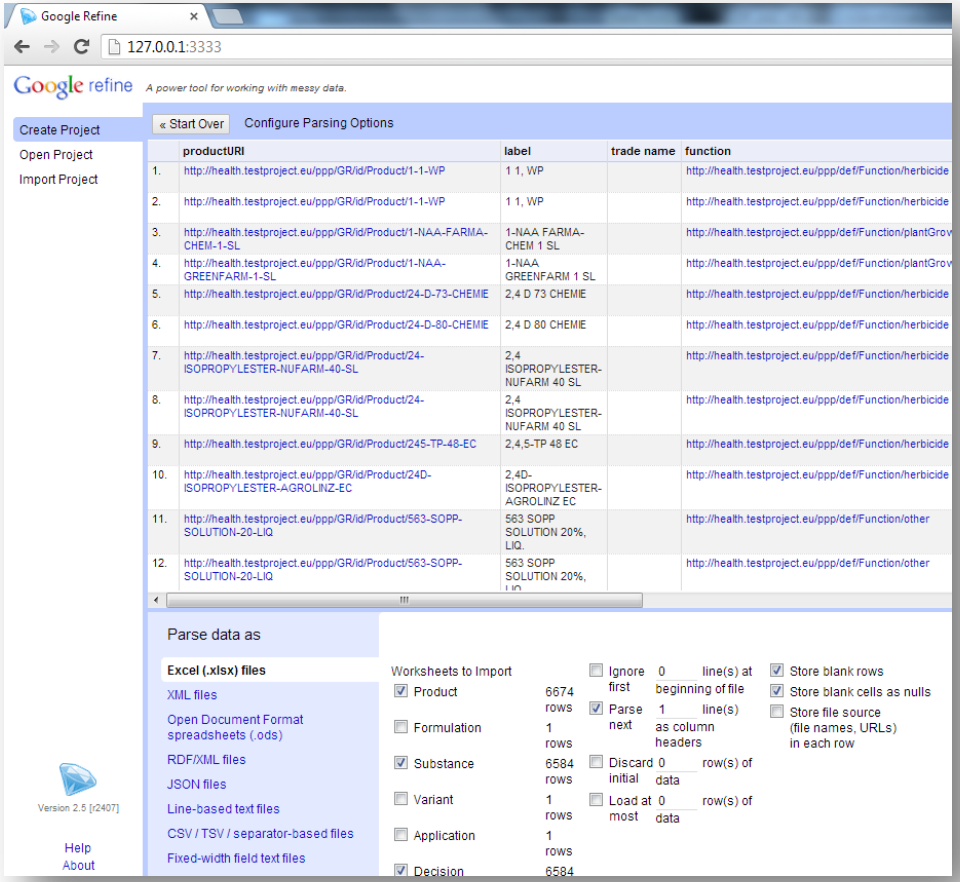


http://health.testproject.eu/PPP/

See also:
http://joinup.ec.europa.eu/asset/core_business/document/linking-data-about-applications-and-decisions-authorisation-ppp

Creating the project in Open Refine

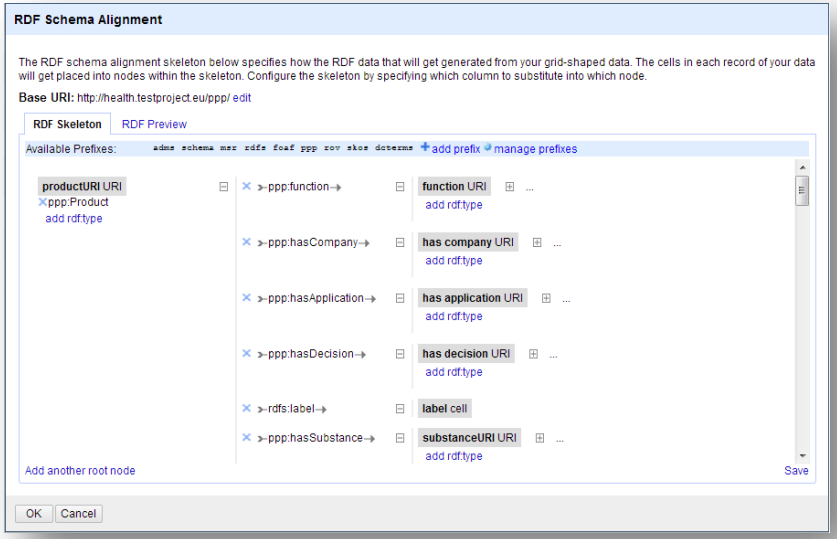
- Make sure that Open Refine and the RDF extension are installed on your machine.
- Launch Open Refine.
- Upload the spreadsheet and selected the sheets that you want.
- Confirm the creation of the project.



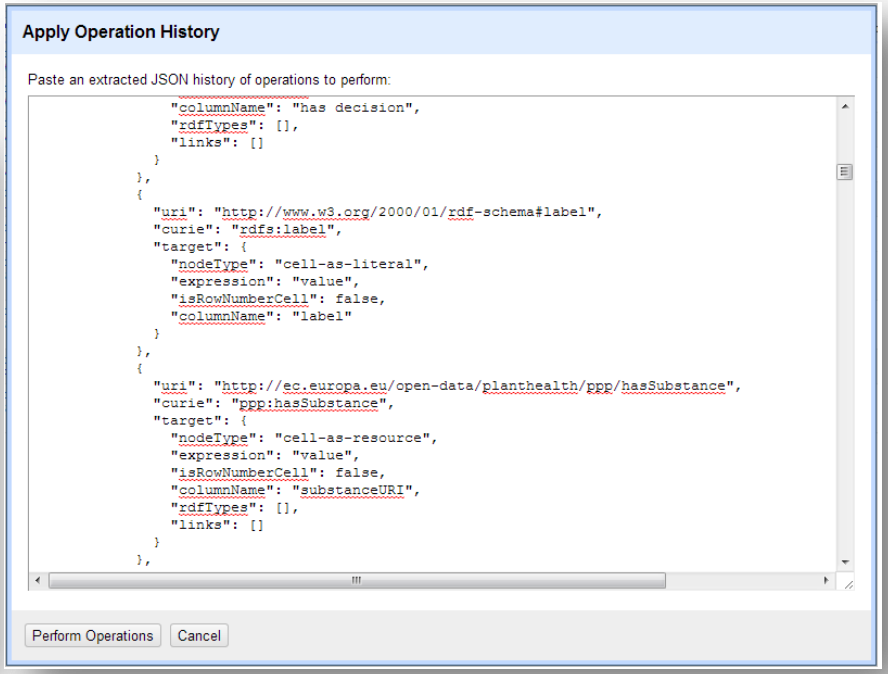
Mapping the raw data to the ontology

You can map the data to the ontology using a simple graphical interface to create or edit an existing RDF skeleton.

You can set the base URI for the data.



Graphical interface to edit an RDF skeleton

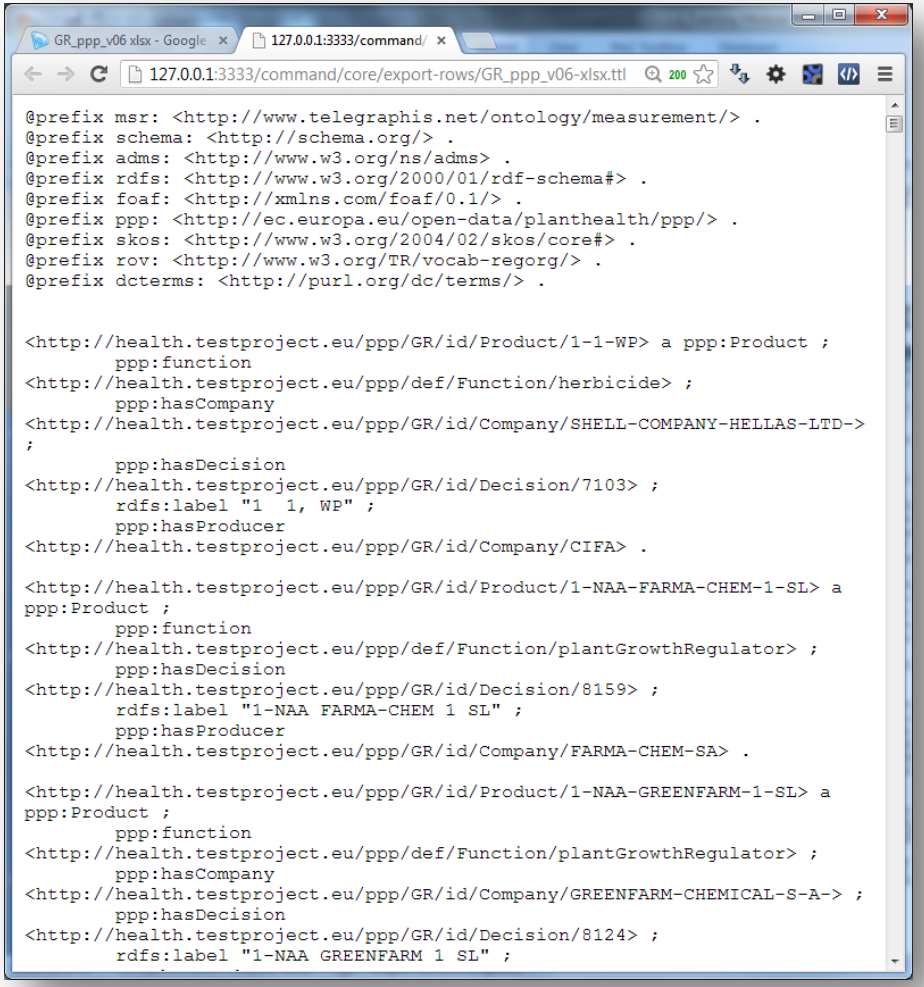


Graphical interface to copy/paste an existing RDF skeleton

Exporting the data in RDF – Linked Data

You can now export your data in:

- RDF/XML; or
- Turtle



Export of the data in Turtle

LOGD enablers & roadblocks

From the study on Business Models for LOGD of the ISA Programme of the European Commission.

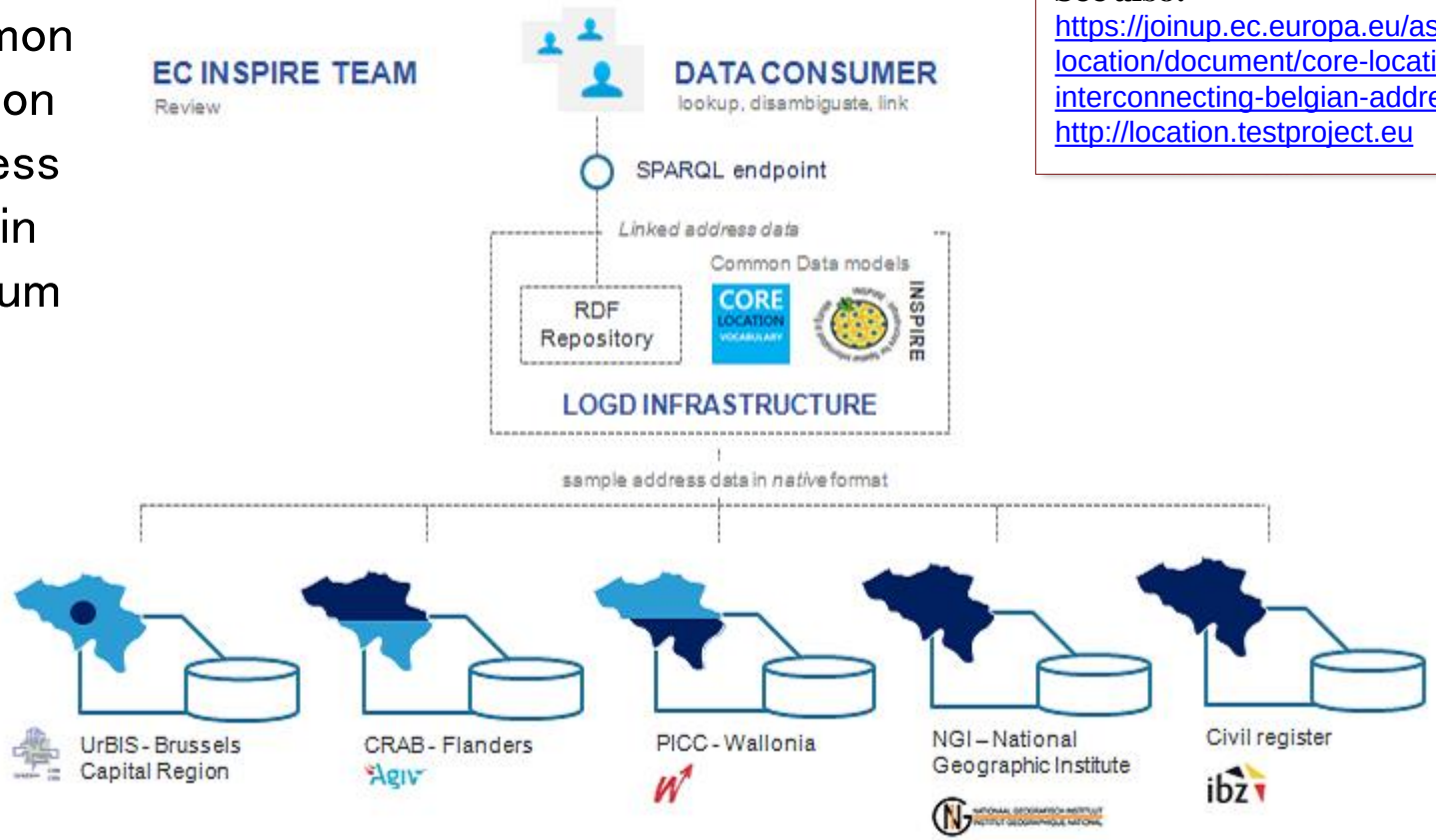
LOGD enablers

- Efficiency gains in data integration – the network effect.
- Forward-looking strategies.
- Increased linking and integrated services.
- Ease of model updates.
- Ease of navigation.
- Open licensing and free access.
- Enthusiasm from ‘champions’.
- Emerging best practice guidance.

See also:
ISA Study on Business Models for LOGD
https://joinup.ec.europa.eu/community/semic/document/study-business-models-linked-open-government-data-bm4logd

Linked data can help you publish structured data and integrate data from different sources

Building a common view on address data in Belgium



See also:
https://joinup.ec.europa.eu/asset/core_location/document/core-location-pilot-interconnecting-belgian-address-data
http://location.testproject.eu

LOGD roadblocks

- Necessary investments.
- Lack of necessary competencies.
- Perceived lack of tools.
- Lack of service level guarantees.
- Missing, restrictive, or incompatible licences.
- Surfeit of standard vocabularies.
- The inertia of the status quo – change is accomplished slowly.

See also:
ISA Study on Business Models for LOGD
https://joinup.ec.europa.eu/community/semic/document/study-business-models-linked-open-government-data-bm4logd

Linked data initiatives in Europe

Some examples on supra-national, national, regional and private initiatives in the area of linked (open) data across Europe.

Member State initiatives – some examples

DE – Bibliotheksverbund Bayern

Linked data from 180 academic libraries in Bavaria, Berlin and Brandenburg.

IT – Agenzia per l'Italia digitiale

Three datasets published as linked data: the Index of Public Administration, the SPC contracts for web services and conduction systems and the Classifications for the data in Public Administration.

NL – Building and address register

The Dutch Address and Buildings base register published as linked data.

UK – Ordnance Survey

Three OS Open Data products published as linked data: the 1:50 000 Scale Gazetteer, Code-Point Open and the administrative geography taken from Boundary Line.

UK – Companies House

Publishing basic company details as linked data using a simple URI for each company in their database.

See also:
ISA Study on Business Models for LOGD
https://joinup.ec.europa.eu/community/semic/document/study-business-models-linked-open-government-data-bm4logd

Linked Government Data & Metadata initiatives funded by the European Commission

European Environment Agency

LOD2
Creating Knowledge out of Interlinked Data

CORE PERSON VOCABULARY
CORE LOCATION VOCABULARY
DCAT APPLICATION PROFILE FOR EUROPEAN DATA PORTALS
ADMS.SW
CORE PUBLIC SERVICE VOCABULARY
CORE BUSINESS VOCABULARY
ADMS ASSET DESCRIPTION METADATA SCHEMA
SEMIC SEMANTIC INTEROPERABILITY COMMUNITY

LATC

europeana
think culture

OPEN DATA SUPPORT

European Union Open Data Portal

EUCLID
EdUcational Curriculum for the usage of LInked Data

publicdata.eu
Europe's Public Data

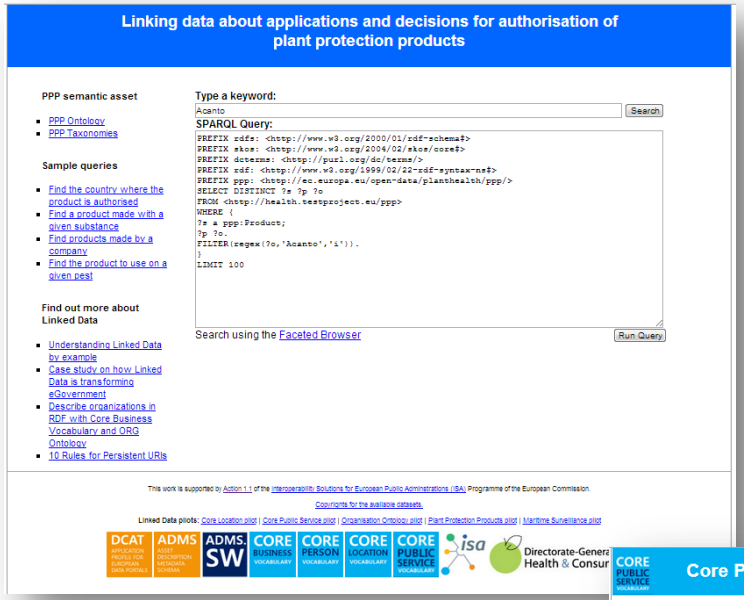
MDR Metadata Registry

INSPIRE · Infrastructure for Spatial Information in Europe

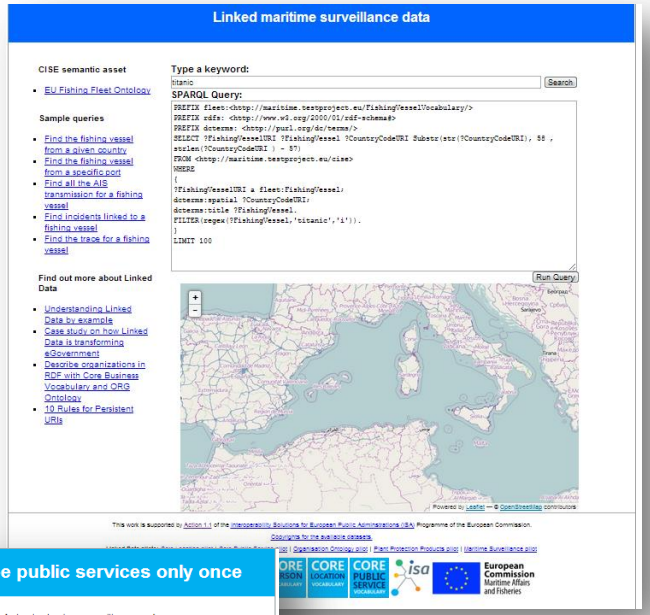
DIRECTIVES

DIRECTIVE 2013/37/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 26 June 2013
amending Directive 2003/98/EC on the re-use of public sector information

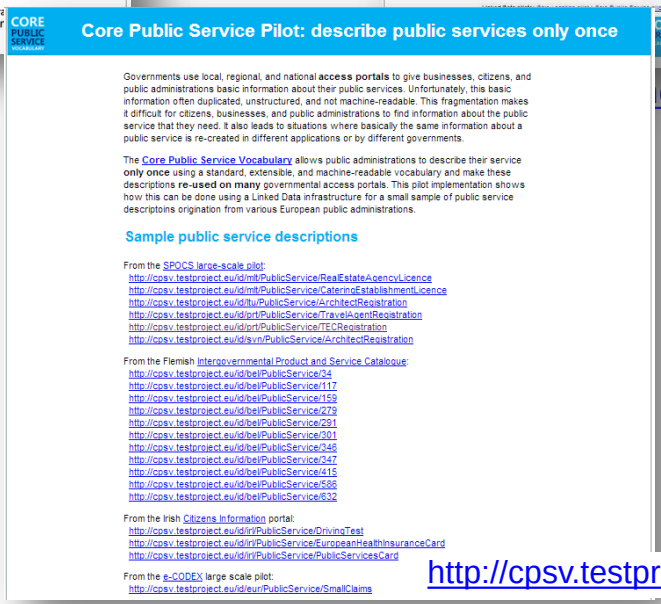
The Linked Government Data Pilots of ISA



http://health.testproject.eu/PPP/

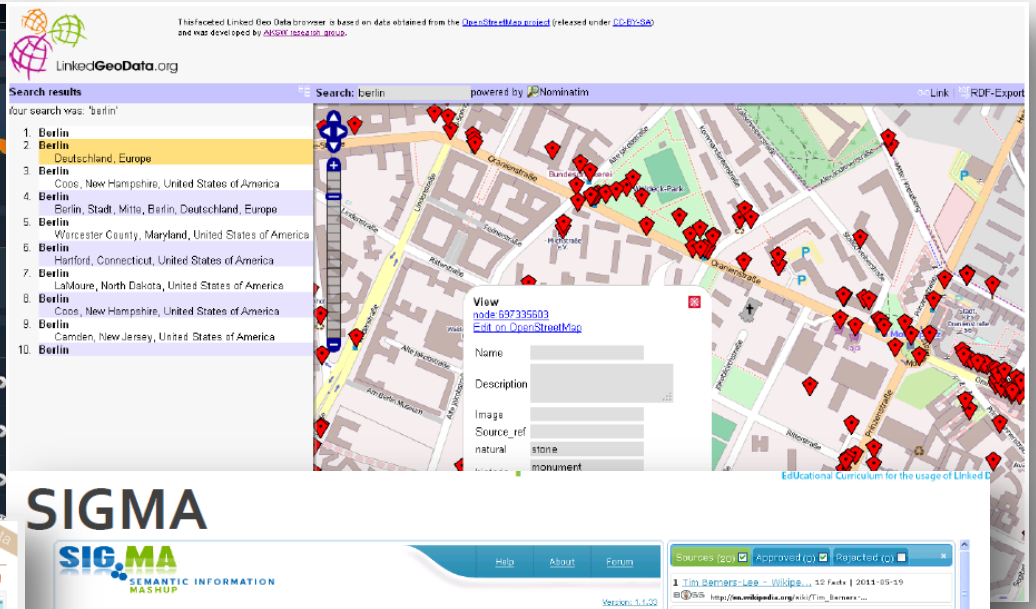


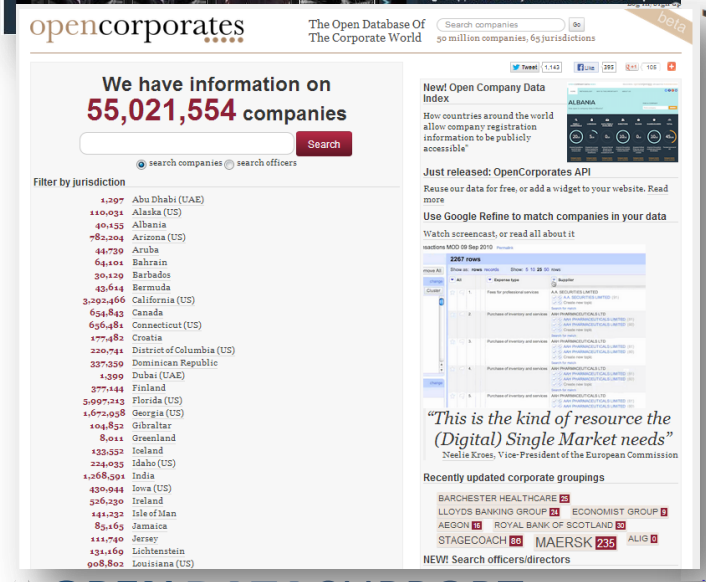
e.testproject.eu/CISE/



http://cpsv.testproject.eu/CPSV/

Non-governmental applications





Conclusions

- Linked data is a set of design principles for sharing machine-readable data on the Web.
- Linked data and open data are not the same.
- URIs, RDF and SPARQL form the foundational layer for Linked data.
- Linked data offers a number of advantages for:
  - Data integration with small impact on legacy systems;
  - Enables for semantic interoperability;
  - Enables creativity and innovation through context and knowledge-creation.

Group questions

http://www.visualpharm.com

Is there supply and demand for (Linked) Open Government Data in your country?

http://www.visualpharm.com

What are, in your opinion, the expected benefits and pitfalls of Linked Data?

http://www.visualpharm.com

Are there any Linked (Open) Data initiatives in your country? If so, how many stars would you give them?

Take also the online test here!

Thank you!

...and now YOUR questions?

References

Slide 6:

- EUCLID. Course 1: Introduction and Application Scenarios. http://www.euclid-project.eu/modules/course1
- Linking Open Data cloud diagram, by Richard Cyganiak and Anja Jentzsch. http://lod-cloud.net/

Slides 8:, 13, 36, 38:

- ISA Programme. Case study on how Linked Data is transforming eGovernment. https://joinup.ec.europa.eu/community/semic/document/case-study-how-linked-data-transforming-egovernment
- Tim Berners-Lee. Linked Data. http://www.w3.org/DesignIssues/LinkedData.html

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- ISA Programme Study on Business Models for LOGD https://joinup.ec.europa.eu/community/semic/document/study-business-models-linked-open-government-data-bm4logd

Slide 12:

- The Open Knowledge Foundation. Open Data – An Introduction. http://okfn.org/opendata/

Slides 18-28:

- 5 ★ Open Data. http://5stardata.info/

Slide 19:

- UK National Archives, Sustainable development targets 2011-12.

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- Data.gov.uk. Housing stock. http://data.gov.uk/dataset/uk-housing-stock

Slide 23:

- Data.gov.uk. Road Safety Data. http://data.gov.uk/dataset/road-accidents-safety-data

Slide 25 & 27:

- ISA Organization Ontology pilot - Linking public sector's organisational data, https://joinup.ec.europa.eu/asset/core_business/document/organization-ontology-pilot-linking-public-sectors-organisational-data

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- ISA Programme. Core Location Pilot - Interconnecting Belgian Address Data. https://joinup.ec.europa.eu/asset/core_location/document/core-location-pilot-interconnecting-belgian-address-data

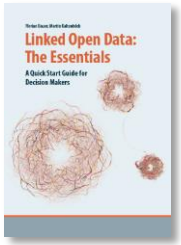
Slides 30-34:

- Open Refine: https://github.com/OpenRefine
- RDF Extension: http://refine.deri.ie/
- ISA Programme, Linking data about applications and decisions for authorisation of PPP, http://joinup.ec.europa.eu/asset/core_business/document/linking-data-about-applications-and-decisions-authorisation-ppp

Slide 40

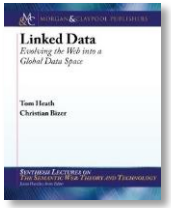
- Bibliotheksverbund Bayern, http://lod.b3kat.de/doc
- Agenzia per l'Italia Digitale, http://spcdata.digitpa.gov.it/data.html
- NL – Building and address register, http://lod.Geodan.nl
- UK Ordnance Survey, http://data.ordnancesurvey.co.uk/
- UK Companies House, http://companieshouse.gov.uk/

Further reading



Linked Open Data: The Essentials. Florian Bauer, Martin Kaltenböck.

http://www.semantic-web.at/LOD-TheEssentials.pdf



Linked Data: Evolving the Web into a Global Data Space. Tom Heath and Christian Bizer.

http://linkeddatabook.com/editions/1.0/

Linked Open Government Data. Li Ding Qualcomm, Vassilios Peristeras and Michael Hausenblas.

http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6237454

EUCLID - Course 1: Introduction and Application Scenarios

http://www.euclid-project.eu/modules/course1

Related projects and initiatives

LOD2 FP7 project, http://lod2.eu/

The Open Knowledge Foundation, http://okfn.org/

W3C Semantic Web, http://www.w3.org/standards/semanticweb/

EUCLID, http://projecteuclid.org/

ISA Programme, http://ec.europa.eu/isa/

W3C LOGD WG, http://www.w3.org/2011/gld/wiki/Main_Page

LOD Around The Clock FP7 project, http://latc-project.eu/

Data.gov.uk, http://data.gov.uk/linked-data

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Open Data Support
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