

Data Interoperability and Semantics

< Part 3. Data schemas and semantics >

ICM – Toolbox Engineering and Interoperability of Software Systems – Course unit on Data Interoperability and Semantics
M1 Cyber Physical and Social Systems – Course unit on Data Interoperability and Semantics
Maxime Lefrançois <https://maxime-lefrancois.info>
Course unit URL: <https://ci.mines-stetienne.fr/cps2/course/data>

Data Interoperability and Semantics Outline

- < Part 3. Data schemas and semantics >
 - Part 3.1. Data schemas
 - Part 3.1.1. XML Schema
 - Part 3.1.2. JSON Schema
 - Part 3.2. Semantics
 - Part 3.2.1. Heterogeneities and data conflicts
 - Part 3.2.2. Controlled vocabularies and ontologies
 - Part 3.2.3. Resource Description Framework
 - Part 3.2.4. RDFa: Rich structured data markup for web documents
 - Part 3.2.5. JSON-LD: JSON for Linking Data

ICM – Computer Science Major – Course unit on Data Interoperability and Semantics
M1 Cyber Physical and Social Systems – Course unit on Data Interoperability and Semantics
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Data Interoperability and Semantics

< Part 3. Data schemas and semantics >

Part 3.1. Data schemas

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Data Interoperability and Semantics

< Part 3. Data schemas and semantics >

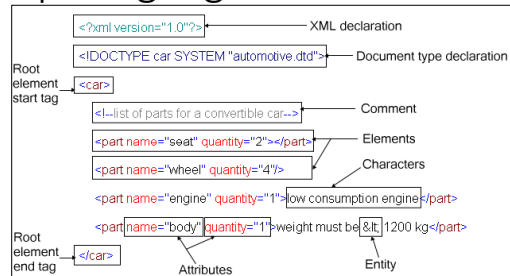
Part 3.1. Data schemas

Part 3.1.1. XML Schema

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Extensible Markup Language

XML (file format)	
Filename extension	.xml
Internet media type	application/xml text/xml [1]
Uniform Type Identifier (UTI)	public.xml
UTI conformation	public.text
Magic number	<?xml
Developed by	World Wide Web Consortium
Type of format	Markup language
Extended from	SGML
Extended to	Numerous languages, including XHTML · RSS · Atom · KML
Standard	1.0 (Fifth Edition) [2] (November 26, 2008, 12 years ago) 1.1 (Second Edition) [2] (August 16, 2006, 15 years ago)
Open format?	Yes



- v1.0 in 1998, still extensively used in many verticals
- numerous formats based on XML (418 registered on IANA) https://en.wikipedia.org/wiki/List_of_XML_markup_languages
application/atom+xml application/rdf+xml ...
- verbosity, complexity and redundancy

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Extensible Markup Language

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Open format?	Yes

Characters and escaping

- unicode implementations: `<?xml version="1.0" encoding="UTF-8"?>`
- escaping characters: `<`; `'` - `≈`; `'` - `❤`; `'` - etc.

Syntactical correctness

- well formed vs ill-formed*
- one root tag
- correct nesting
- tag names (approx) start with letter, then alphanumeric or `'`

Schemas and validation

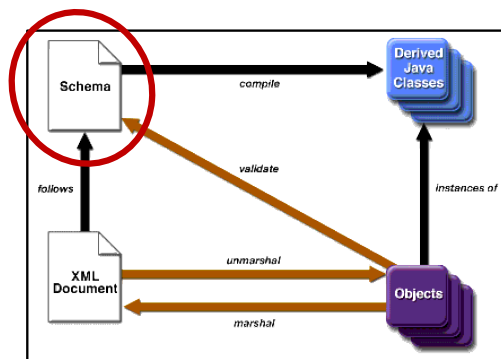
- valid vs invalid*
- DTD, or XML Schema

Namespaces

- `xmlns:ns1="http://example.org/ns1"`
`xmlns:ns2="http://example.org/ns2"`
- allows to use different schemas together: `<ns1:Tag> <ns2:Tag>`

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XML – OOP data binding



XML-OOP data binding

ex Java: <https://zetcode.com/java/jaxb/>

```
Employee.java
@XmlRootElement(name = "employee")
@XmlAccessorType(XmlAccessType.FIELD)
public class Employee implements Serializable {
    private Integer id;
    private String firstName;
    private String lastName;
}
```

```
employee.xml
<?xml version="1.0" encoding="utf-8" standalone="yes"?>
<employee>
  <firstName>Lokesh</firstName>
  <id>1</id>
  <lastName>Gupta</lastName>
</employee>
```

Java Architecture for XML Binding (JAXB) example

<https://howtodoinjava.com/jaxb/jaxb-annotations/>

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XML Schema

- Document Type Definition (DTD, 2008)

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
```

link to some .dtd document

```
[...]
<ELEMENT html (head, body)>
<ELEMENT p (#PCDATA | p | ul | dl | table | h1|h2|h3)*
[...]
<!ATTLIST img
  src CDATA #REQUIRED
  id ID #IMPLIED
  sort CDATA #FIXED "true"
  print (yes | no) "yes"
>
[...]
```

```
<?xml version="1.0" encoding="utf-8"?>
<!DOCTYPE html>
<!-- the XHTML document body starts here-->
<html xmlns="http://www.w3.org/1999/xhtml">
  ...
</html>
```

HTML5 : no more link to a DTD

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XML Schema

- Regular Language for XML Next Generation (RELAX NG, 2001) <https://relaxng.org/>

```
<element name="addressBook" xmlns="http://relaxng.org/ns/structure/1.0">
  <zeroOrMore>
    <element name="card">
      <element name="name">
        <text/>
      </element>
      <element name="email">
        <text/>
      </element>
    </zeroOrMore>
  </element>
```

RELAX NG document



```
<addressBook>
  <card>
    <name>John Smith</name>
    <email>js@example.com</email>
  </card>
  <card>
    <name>Fred Bloggs</name>
    <email>fb@example.net</email>
  </card>
</addressBook>
```

Valid XML document

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XML Schema

- XML Schema (W3C, 2003)
The only one you should use (if you need to)

```
<?xml version="1.0"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema">

  <xs:element name="note">
    <xs:complexType>
      <xs:sequence>
        <xs:element name="to" type="xs:string"/>
        <xs:element name="from" type="xs:string"/>
        <xs:element name="heading" type="xs:string"/>
        <xs:element name="body" type="xs:string"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>

</xs:schema>
```

XML Schema document



```
<?xml version="1.0"?>
<note
  xmlns="https://www.w3schools.com"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="https://www.w3schools.com/xml note.xsd">
  <to>Tove</to>
  <from>Jani</from>
  <heading>Reminder</heading>
  <body>Don't forget me this weekend!</body>
</note>
```

Valid XML document

https://www.w3schools.com/xml/schema_intro.asp 10

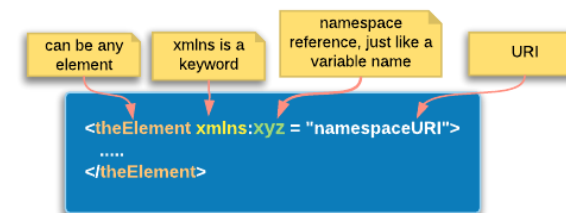
XML Schema

- Tutorials
 - https://www.tutorialspoint.com/xml/xml_schemas.htm
 - https://www.w3schools.com/xml/schema_intro.asp
 - ...
- What to do with XML Schemas
 - validate documents
 - generate forms
 - generate classes (any OOP language)
 - ...

https://www.w3schools.com/xml/schema_intro.asp 11

Multiple XML Schemas ?

- How to combine different XML schemas in a single file?
- Using XML namespaces



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```
<?xml version="1.0"?>
<!DOCTYPE html PUBLIC
  "-//W3C//DTD XHTML 1.1 plus MathML 2.0 plus SVG 1.1//EN"
  "http://www.w3.org/2002/04/xhtml-math-svg/xhtml-math-svg-flat.dtd">
```



reminder

JavaScript Object Notation

 JSON Schema Validator [newtonsoft.com](#)

An online, interactive JSON Schema validator. Supports JSON Schema Draft 3, Draft 4, Draft 6 and Draft 7. [View source code](#)

Select schema:

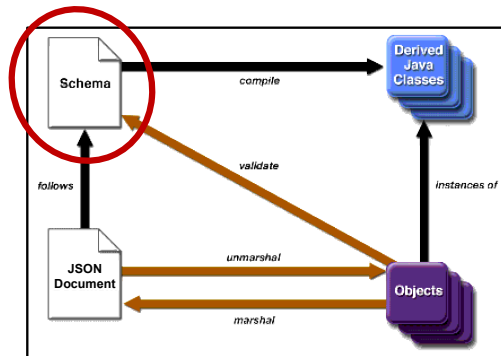
Input JSON:

```
1 {
2   "$schema": "http://json-schema.org/draft-07/schema#",
3   "definitions": {
4     "person": {
5       "type": "object",
6       "properties": {
7         "name": { "type": "string" },
8         "children": {
9           "type": "array",
10          "items": { "$ref": "#/definitions/person" },
11          "default": []
12        }
13      }
14    },
15    "type": "object",
16    "properties": {
17      "person": { "$ref": "#/definitions/person" }
18    }
19  }
```

```
1 {
2   "personsfad": {
3     "nameklk": "Elizabeth",
4     "childrensss": [
5       {
6         "names": "Charles",
7         "childrenss": [
8           {
9             "names": "William",
10            "children": [
11              { "namesss": "George" },
12              { "name": "Charlotte" }
13            ]
14          },
15          { "namesss": "Harry" }
16        ]
17      }
18    ]
19  }
```

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JSON – OOP data binding



JSON-OOP data binding



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JSON Schema Specification (latest)

<https://json-schema.org/draft/2020-12/json-schema-validation.html>

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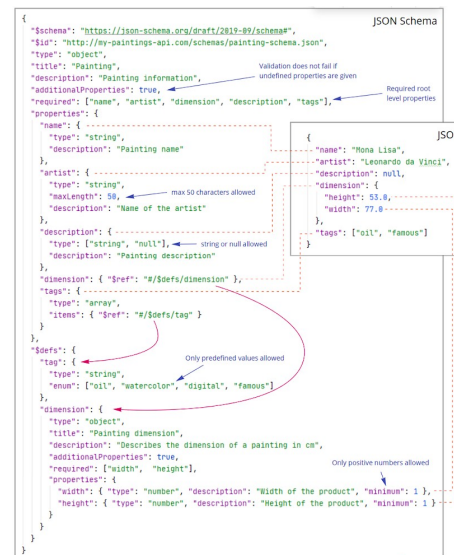
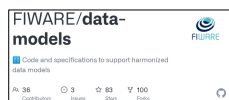
1. Introduction	7. Vocabularies for Semantic Content With "format"
2. Conventions and Terminology	7.1. Foreword
3. Overview	7.2. Implementation Requirements
4. Interoperability Considerations	7.2.1. Format-Annotation Vocabulary
4.1. Validation of String Instances	7.2.2. Format Assertion Vocabulary
4.2. Validation of Numeric Instances	7.2.3. Custom format attributes
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6.3. Validation Keywords for Strings	8.4. contentType
6.3.1. maxLength	8.5. contentSchema
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6.4.1. maxItems	9.2. "default"
6.4.2. minItems	9.3. "deprecated"
6.4.3. uniqueItems	9.4. "readOnly" and "writeOnly"
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6.4.5. minContains	10. Security Considerations
6.5. Validation Keywords for Objects	11. References
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6.5.4. dependentRequired	Appendix B. Acknowledgments
	Appendix C. Changelog
	Authors' Addresses

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JSON Schema

Examples:

- <https://json-schema.org/learn/miscellaneous-examples.html>
- <https://www.fiware.org/developers/data-models/>
- <https://oneiota.org/>



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Part 3.2. Semantics

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Data Interoperability and Semantics

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Part 3.2. Semantics

Part 3.2.1. Heterogeneities and data conflicts

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DEMO: Compare JSON documents

<https://samples.openweathermap.org/data/2.5/weather?id=2172797&appid=b6907d289e10d714a6e88b30761fae22>

and

<https://www.prevision-meteo.ch/services/json/lausanne>

and

<https://github.com/smart-data-models/dataModel.Weather/blob/master/WeatherForecast/examples/example-normalized.json>

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DEMO: Compare JSON documents

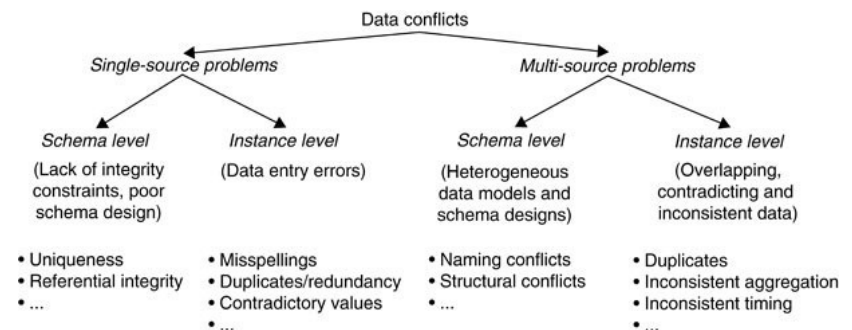
Different modeling choices were made, which make these two services completely non-interoperable:

- the lat/long coordinates: string vs number
- the UNIX timestamps vs dates and times
- the choice of keys and the semantics (meaning) of the values
- the units of temperature, pressure, wind speed, ...
- the semantics of wind direction
- the value for "icon": "03n" - (if we follow our nose on the website, we may figure out it refers to <http://openweathermap.org/img/w/03n.png>)
- the country codes ISO 3166-1 ALPHA-2 and ISO 3166-1 ALPHA-3 (example of Australia and Austria)

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Data conflicts

*Data conflicts are **deviations between data intended to capture the same state of a real-world entity**. Data with conflicts are often called "dirty" data and can mislead analysis performed on it.*



Do HH. (2009) Data Conflicts. In: LIU L., OZSU M.T. (eds) Encyclopedia of Database Systems. Springer, Boston, MA. https://doi.org/10.1007/978-0-387-39940-9_97

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Data Interoperability and Semantics

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Part 3.2. Semantics

Part 3.2.2. Controlled vocabularies, thesauri, taxonomies

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Controlled vocabularies

... an established list of standardized terminology for use in indexing and retrieval of information

— OECD

... an organized arrangement of words and phrases used to index content and/or retrieve content through browsing or searching

— Getty institute

... an standardized – yet dynamic – set of terms and phrases authorized for use in an indexing system to describe a subject area or information domain

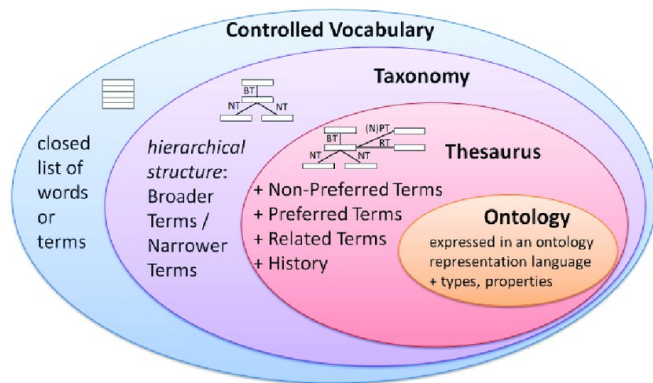
— SCIP

vocabulary for which the entries, i.e. **definition/term** pairs, are controlled by a **Source Authority** based on a **rulebase** and **process** for addition/deletion of entries

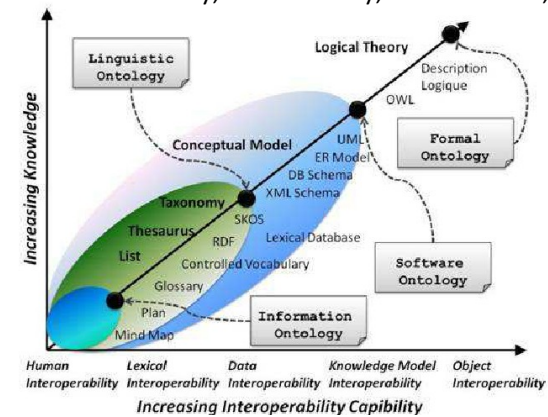
— ISO/IEC 15944-5:2008(en)
Information technology — Business Operational View

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Controlled vocabulary, taxonomy, thesaurus, ontology



Controlled vocabulary, taxonomy, thesaurus, ontology



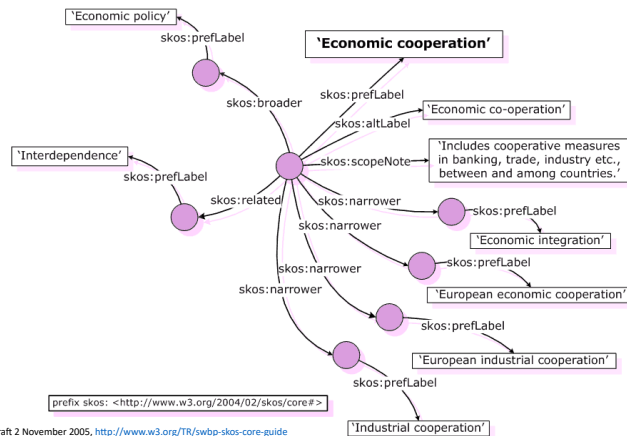
Kopácsi, Sándor & Hudak, Rastislav & Ganguly, Raman. (2017). Implementation of a Classification Server to Support Metadata Organization for Long Term Preservation Systems. Mitteilungen der Vereinigung Österreichischer Bibliothekarinnen und Bibliothekare. 70. 225. 10.31263/voebm.v70i2.1897.

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Roussey, Catherine & Pinet, François & Kang, Myoung-Ah & Corcho, Oscar & Falquet, Gilles & Métrol, Claudine & Teller, Jacques & Tweed, Christopher. (2011). Ontologies for interoperability. 10.1007/978-0-85729-724-2_3.

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SKOS Simple Knowledge Organization System



SKOS Core Guide, W3C Working Draft 2 November 2005, <http://www.w3.org/TR/swbp-skos-core-guide>

Examples of thesauri, taxonomies, ...

UNESCO Thesaurus

The UNESCO Thesaurus is a **controlled and structured list of terms used in subject analysis and retrieval of documents and publications** in the fields of education, culture, natural sciences, social and human sciences, communication and information.

<https://skos.um.es/unescothes>
UNESCO Thesaurus - SKOS

GEMET General Multilingual Environmental Thesaurus
<https://www.elonet.europa.eu/gemet/en/webservices/>

nasa/dictionaries

A collection of NASA "dictionaries", including thesauri, taxonomies and ontologies.

<https://github.com/nasa/dictionaries>

Project Haystack
Using Standard Markup for...

Site

Equipment

Point

<https://project-haystack.org/>

List at <https://www.w3.org/2001/sw/wiki/SKOS/Datasets>

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Data Interoperability and Semantics

< Part 3. Data schemas and semantics >

Part 3.2. Semantics

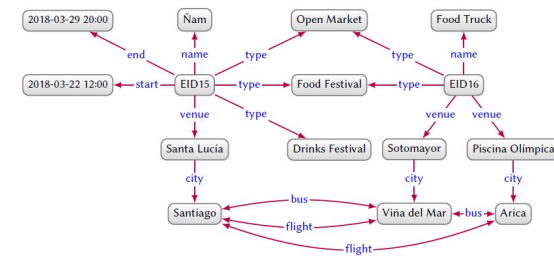
Part 3.2.3. Resource Description Framework

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RDF- Resource Description Framework

RDF

Resource Description Framework	
Abbreviation	RDF
Status	Published, W3C Recommendation
Year started	1996; 25 years ago
First published	February 28, 1996; 25 years ago
Latest version	1.1 (Recommendation) February 25, 2014; 7 years ago
Organization	World Wide Web Consortium (W3C)
Committee	RDF Working Group
Editors	Richard Cyganiak, David Wood, Markus Lanthaler
Base standards	URI
Related standards	RDFS, OWL, RIF, RDFa
Domain	Semantic Web
Website	www.w3.org/TR/rdf11-concepts/



An RDF Graph

Vertices:

Resources: Things. Uniquely identified by URIs

Literals: Unicode string + Datatype identified by URI. *out-degree=0*

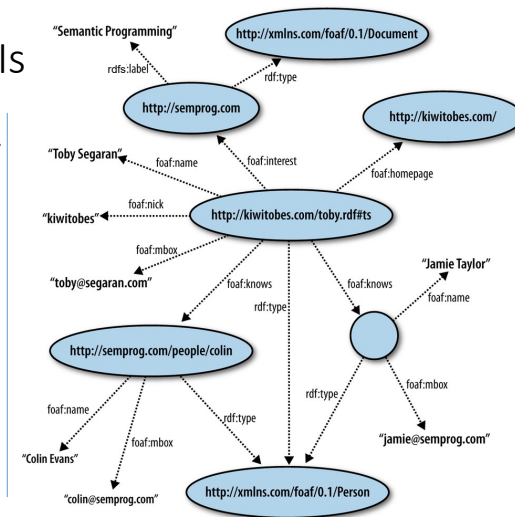
Edges:

Relationships: connections between vertices. Uniquely identified by URIs

W3C Semantic Web

CURIE = Compact URIs

```
@prefix rdf:
  <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@prefix rdfs:
  <http://www.w3.org/2000/01/rdf-schema#>.
@prefix foaf:
  <http://xmlns.com/foaf/0.1/>.
@prefix schema:
  <http://schema.org/>.
...
```



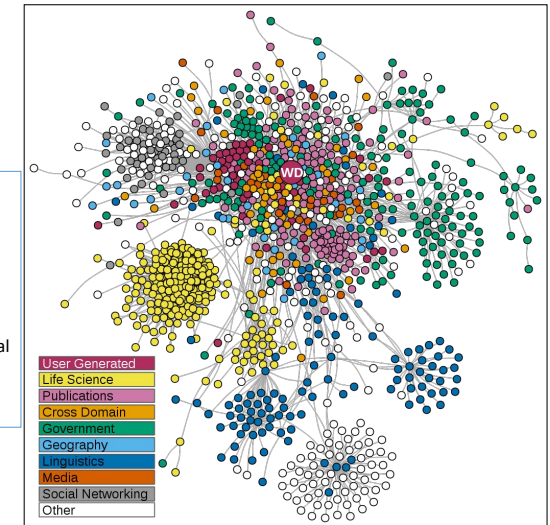
The Linked Data

It's possible to use URIs defined in an external graph

- to use a reference identification system
- to augment a graph
anyone can say anything about anything

One can specify vertex co-reference with some special edges: owl:sameAs from W3C OWL vocabulary

`chile:Santiago` **owl:sameAs** `geo:SantiagoDeChile`

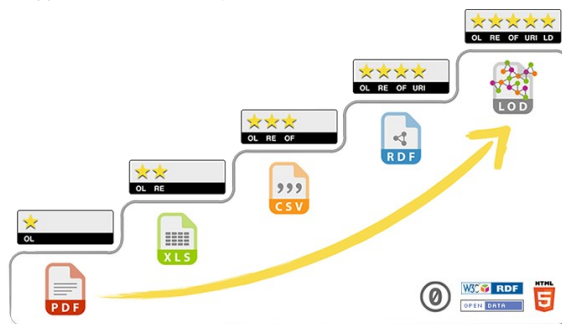


Linked Open Data cloud visualisation: each node is a RDF dataset. Links indicate the existence of external identification links. Source: wikipedia

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5 ★ OPEN DATA

[Tim Berners-Lee](#), the inventor of the Web and Linked Data initiator, suggested a [5-star deployment scheme](#) for Open Data.



<https://5stardata.info/en/>

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Examples of RDF vocabularies & ontologies

schema.org

Documentation

Here is some of the documentation available on this site:

- **Getting Started:** A simple introduction to microdata and using schema.org for marking up your site.
- **Schemas:** The actual schemas, arranged in a hierarchy, with a page for each item in the schema.
- **The full type hierarchy:** The full type hierarchy, in a single file.
- **Frequently asked questions**
- **Data model:** a brief note on the data model used, etc.
- **Extension Mechanism:** The extension mechanism that can be used to extend the schemas
- **Schema.org Discussion Group:** Forum for finding answers to questions, etc.
- **Feedback form:** Please give us feedback, report bugs, etc.

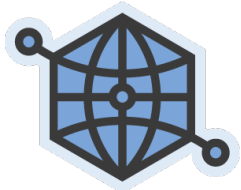
Over 10 million sites use Schema.org to markup their web pages and email messages. Many applications from Google, Microsoft, Pinterest, Yandex and others already use these vocabularies to power rich, extensible experiences.

Founded by Google, Microsoft, Yahoo and Yandex, 2011

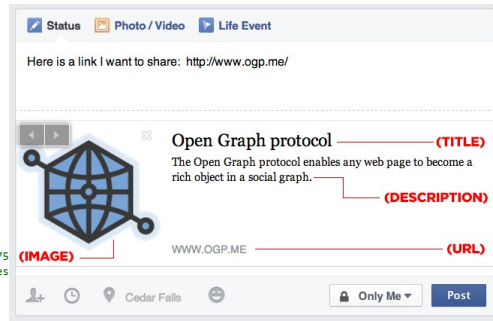
Test with <https://validator.schema.org/> or <https://developers.google.com/search/docs/advanced/structured-data>

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Examples of RDF vocabularies & ontologies



```
<html prefix="og: https://ogp.me/ns#">
<head>
<title>The Rock (1996)</title>
<meta property="og:title" content="The Rock" />
<meta property="og:type" content="video.movie" />
<meta property="og:url" content="https://www.imdb.com/title/tt0117500/" />
<meta property="og:image" content="https://ia.media-imdb.com/images/rock.jpg" />
...
</head>
...
</html>
```



Open Graph Protocol <https://ogp.me/> (Facebook, 2010), test with <https://developers.facebook.com/tools/debug/>

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Data Interoperability and Semantics

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Part 3.2. Semantics

Part 3.2.4. RDFa: Rich structured data markup for web documents

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RDFa Resource Description Framework in Attributes

See RDFa 1.1 Primer - Rich Structured Data Markup for Web Documents
- <https://www.w3.org/TR/rdfa-primer/>

```
<html prefix="og: https://ogp.me/ns#">
<head>
<title>The Rock (1996)</title>
<meta property="og:title" content="The Rock" />
<meta property="og:type" content="video.movie" />
<meta property="og:url" content="https://www.imdb.com/title/tt0117500/" />
<meta property="og:image" content="https://ia.media-imdb.com/images/rock.jpg" />
...
</head>
...
</html>
```

```
<div type="foaf:Person" xmlns:foaf="http://xmlns.com/foaf/0.1/">
  <p property="foaf:name">
    Alice Birpemschwick
  </p>
  <p>
    Email: <a rel="foaf:mbox"
    href="mailto:alice@example.com">alice@example.com</a>
  </p>
  <p>
    Phone: <a rel="foaf:phone" href="tel:
    +1-617-555-7332">+1 617.555.7332</a>
  </p>
</div>
```

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RDFa Resource Description Framework in Attributes

See RDFa 1.1 Primer - Rich Structured Data Markup for Web Documents
- <https://www.w3.org/TR/rdfa-primer/>

The Goal →



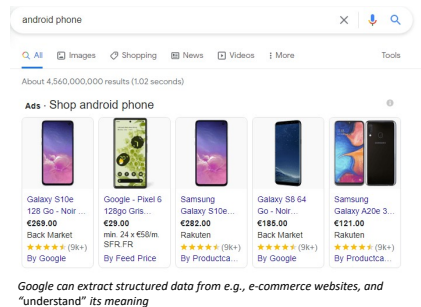
Figure 1: On the left, what browsers see. On the right, what humans see. Can we bridge the gap so that browsers see more of what we see?

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RDFa Resource Description Framework in Attributes

See RDFa 1.1 Primer - Rich Structured Data Markup for Web Documents
- <https://www.w3.org/TR/rdfa-primer/>

The Result



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Data Interoperability and Semantics

< Part 3. Data schemas and semantics >

Part 3.2. Semantics

Part 3.2.5. JSON-LD: JSON for Linking Data

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M1 Cyber Physical and Social Systems – Course unit on Data Interoperability and Semantics
Maxime Lefrançois <https://maxime-lefrancois.info>
Course unit URL: <https://ci.mines-stetienne.fr/cps2/course/data>

JavaScript Object Notation for Linked Data

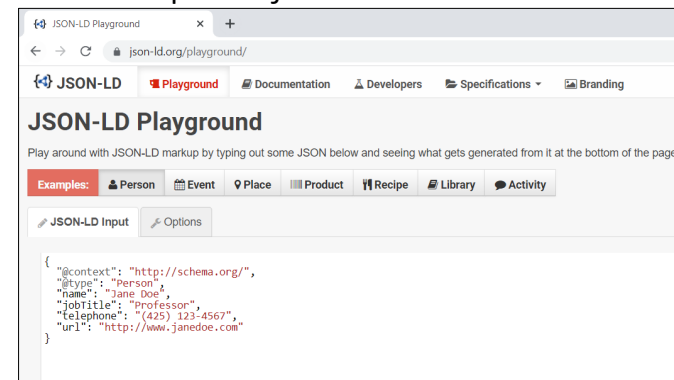
See JSON-LD 1.1 - A JSON-based Serialization for Linked Data -
<https://www.w3.org/TR/json-ld11/>

JSON-LD	
Filename extension	.jsonld
Internet media type	application/ld+json
Type of format	Semantic Web
Container for	Linked Data
Extended from	JSON
Standard	JSON-LD 1.1 API / JSON-LD 1.1 API
Open format?	Yes



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JavaScript Object Notation for Linked Data



<https://json-ld.org/playground/>

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JavaScript Object Notation for Linked Data

JSON-LD Playground

Play around with JSON-LD markup by typing out some JSON below and seeing what gets generated from it at the bottom of the page.

Examples: Person Event Place Product Recipe Library Activity

JSON-LD Input Options

```
{
  "@context": "https://www.w3.org/ns/activitystreams",
  "@type": "Create",
  "actor": {
    "@type": "Person",
    "id": "acct:sally@example.org",
    "name": "Sally"
  },
  "object": {
    "@type": "Note",
    "content": "This is a simple note"
  },
  "published": "2015-01-25T12:34:56Z"
}
```

<https://json-ld.org/playground/>

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JSON-LD and schema.org

Schema.org

Product

A Schema.org Type

Thing > Product

Any offered product or service. For example: a pair of shoes; a concert ticket; the rental of a car; a haircut; or an episode of a TV show streamed online. [more...]

Property	Expected Type	Description
additionalProperty	PropertyValue	A property-value pair representing an additional characteristics of the entity, e.g. a product feature or another characteristic for which there is no matching property in schema.org. Note: Publishers should be aware that applications designed to use specific schema.org properties (e.g. https://schema.org/width, https://schema.org/color, https://schema.org/gtin13, ...) will typically expect such data to be provided using those properties, rather than using the generic property/value mechanism.
aggregateRating	AggregateRating	The overall rating, based on a collection of reviews or ratings, of the item.
audience	Audience	An intended audience, i.e. a group for whom something was created. Supersedes serviceAudience.
award	Text	An award won by or for this item. Supersedes awards.
brand	Brand or Organization	The brand(s) associated with a product or service, or the brand(s) maintained by an organization or business person.
category	PhysicalActivityCategory or Text or Thing or URL	A category for the item. Greater signs or slashes can be used to informally indicate a category hierarchy.

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Product - Schema.org Type

Examples

Example 1

No Markup Microdata RDFa JSON-LD Structure

Example encoded as JSON-LD in a HTML script tag.

```
<script type="application/ld+json">
{
  "@context": "https://schema.org",
  "@type": "Product",
  "aggregateRating": {
    "@type": "AggregateRating",
    "ratingValue": "3.5",
    "reviewCount": "11"
  },
  "description": "0.7 cubic feet countertop microwave. Has six preset cooking categories and co",
  "name": "Kenmore White 17\" Microwave",
  "image": "kenmore-microwave-17in.jpg",
  "offers": {
    "@type": "Offer",
    "availability": "https://schema.org/InStock",
    "price": "55.00",
    "priceCurrency": "USD"
  },
  "review": [
    {
      "@type": "Review",
      "author": "Ellie",
      "datePublished": "2011-04-01",
      "reviewBody": "The lamp burned out and now I have to replace it.",
      "name": "Not a happy camper"
```

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JSON-LD and Google

Understand How Structured Data Works

Google Search Central

Documentation

Search

English

with translation-related Google Search features

Using structured data

Understand how structured data works

Try the structured data code lab

Explore the search gallery

Structured data general guidelines

Generate structured data with JavaScript

Feature guides

Enriched search results

Flexible Sampling general guidance

Enable Top Places List

Opt out of display in local search results and other

Google uses structured data that it finds on the web to understand the content of the page, as well as to gather information about the web and the world in general. For example, here is a JSON-LD structured data snippet that might appear on a recipe page, describing the title of the recipe, the author of the recipe, and other details:

```
<html>
<head>
<title>Party Coffee Cake</title>
<script type="application/ld+json">
{
  "@context": "https://schema.org/",
  "@type": "Recipe",
  "name": "Party Coffee Cake",
  "author": {
    "@type": "Person",
    "name": "Mary Stone"
  }
}
```

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JSON-LD and Bing

The screenshot shows the Bing Webmaster Tools interface. On the left is a sidebar with navigation links. The top header includes the Bing logo and user profile information. The main content area features a 'Validateur de balisage' (Markup Validator) section with a text input field for a URL and a 'VALIDER' button. Below this, a JSON-LD code snippet is displayed, showing a schema for 'Internet-Formation' and a person named 'Maxime Lefrançois'.

Mes sites

- Tableau de bord
- Configurer mon site
- Statistiques
- Suggérer des URL
- Ignorer les paramètres d'URL
- Contrôle de l'analyse
- Liens profonds
- Bloquer des URL
- Déja vu des liens
- Catégorie géographique
- Vérifier la possession du site
- Pages connectées
- Utilisateurs
- Rapports et données
- Traffic sur vos pages
- Adaptation à l'utilisation sur appareil mobile de la page
- Explorateur d'indexation
- Recherche par mots clés
- Rapports SEO
- Liens entrants
- Information sur l'analyse

Site [www.internet-formation.fr](#)

Validateur de balisage

Saisissez un lien URL et notre outil vous informera sur tout le balisage structuré trouvé sur la page. Ce balisage sera ensuite probablement utilisé pour afficher des extraits enrichis de vos URL dans Bing.

Ressources

- [HTML Microdata](#)
- [JSON-LD](#)
- [Microformats](#)
- [Schema.org](#)
- [JSON-LD](#)

JSON-LD

```
{
  "@context": "http://schema.org",
  "@type": "Organization",
  "name": "Internet-Formation : centre de formation et agence web",
  "url": "https://www.internet-formation.fr/",
  "logo": "https://www.internet-formation.fr/img/logo-if.png",
  "contactPoint": [
    {
      "telephone": "+33(0)3 24 29 91",
      "address": [
        "1 rue de la République"
      ]
    }
  ],
  "contact": "http://schema.org",
  "@type": "WebSite",
  "name": "Internet-Formation : centre de formation et agence web",
  "alternateName": "Internet-Formation",
  "url": "https://www.internet-formation.fr/",
  "contact": "http://schema.org",
  "@type": "Person",
  "name": "Maxime Lefrançois",
  "jobTitle": "Consultant web et webmaster",
  "affiliation": "Internet-Formation",
  "sameAs": [
    "http://www.linkedin.com/company/internet-formation"
  ]
}
```

Data Interoperability and Semantics

</ Part 3. Data schemas and semantics >

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Course unit URL: <https://ci.mines-st-etienne.fr/cps2/course/data>