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INSPIRING INNOVATION SINCE 1816

Semantic Interoperability in 1,200s

Victor Charpenay

Mines Saint-Étienne, LIMOS

December 8th, 2021

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I am **Victor Charpenay**, associate professor Institut Mines-Télécom (IMT) and member of the LIMOS computer science research lab. I am based in **Saint-Étienne**.

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LIMOS

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My research topic is **semantics** for the **Web of Things**.

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System Compatibility

Interoperability

Semantic Interoperability

Summary

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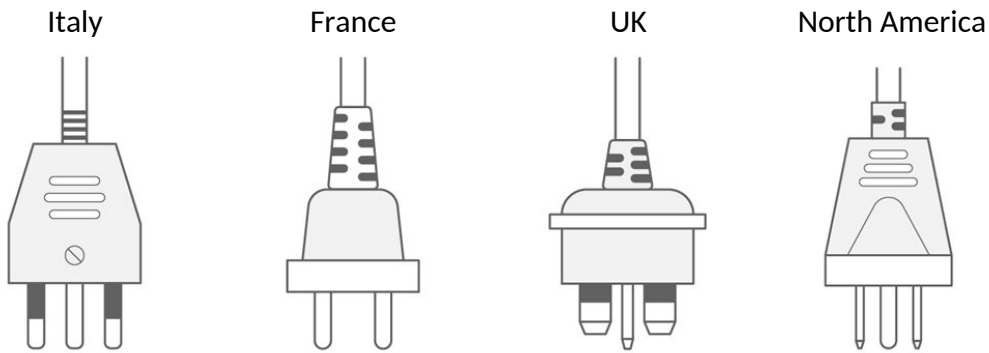
System Compatibility

1,080s

System Compatibility



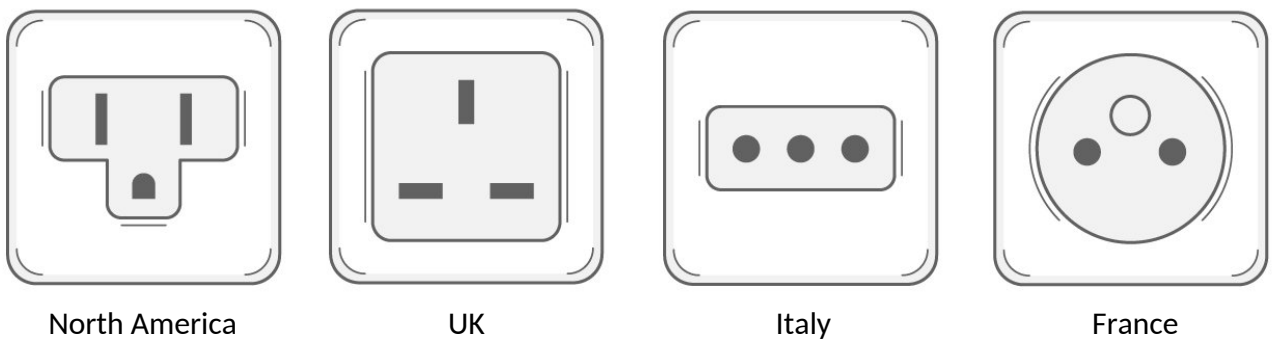


Figure: Power plug (in)compatibility across countries

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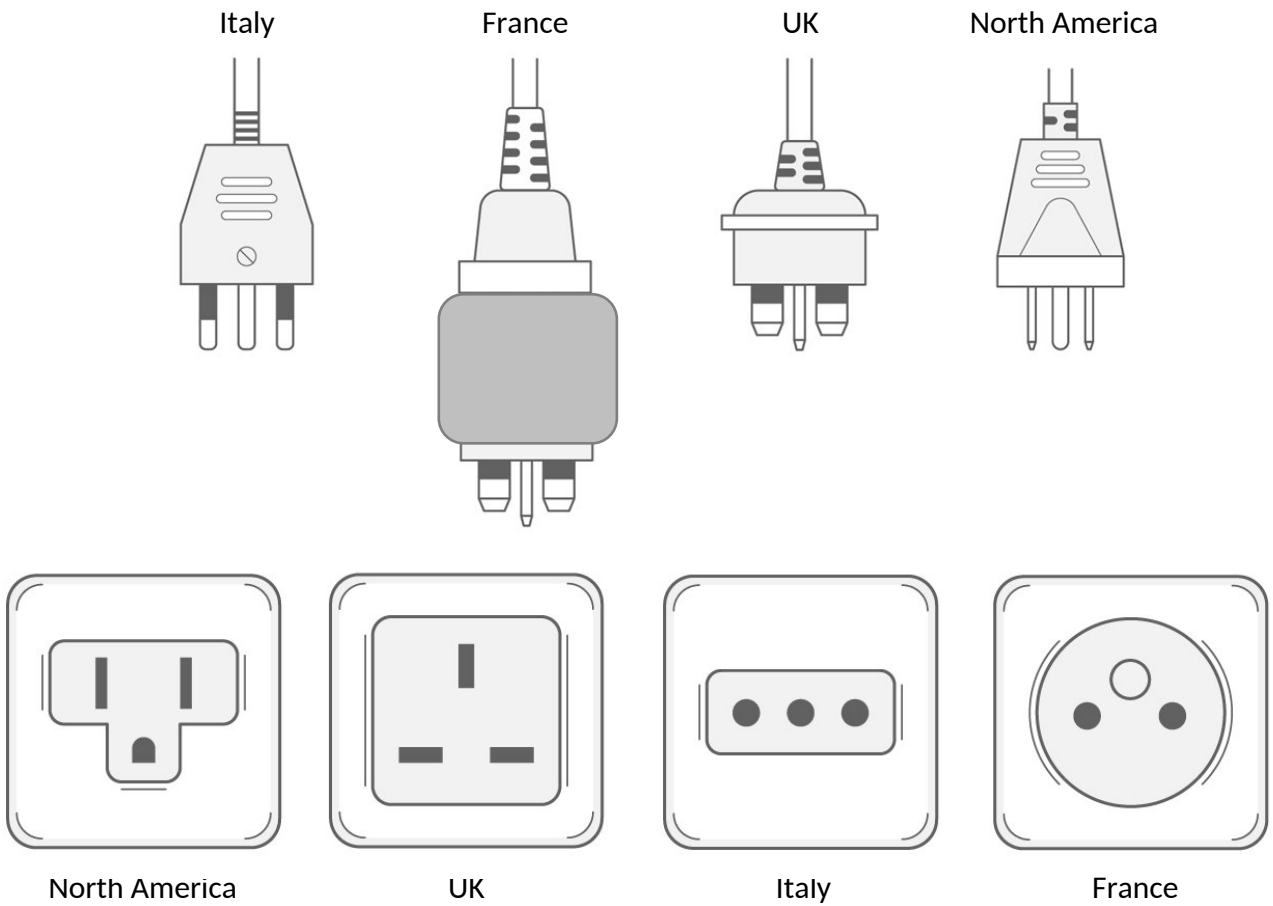
System Compatibility



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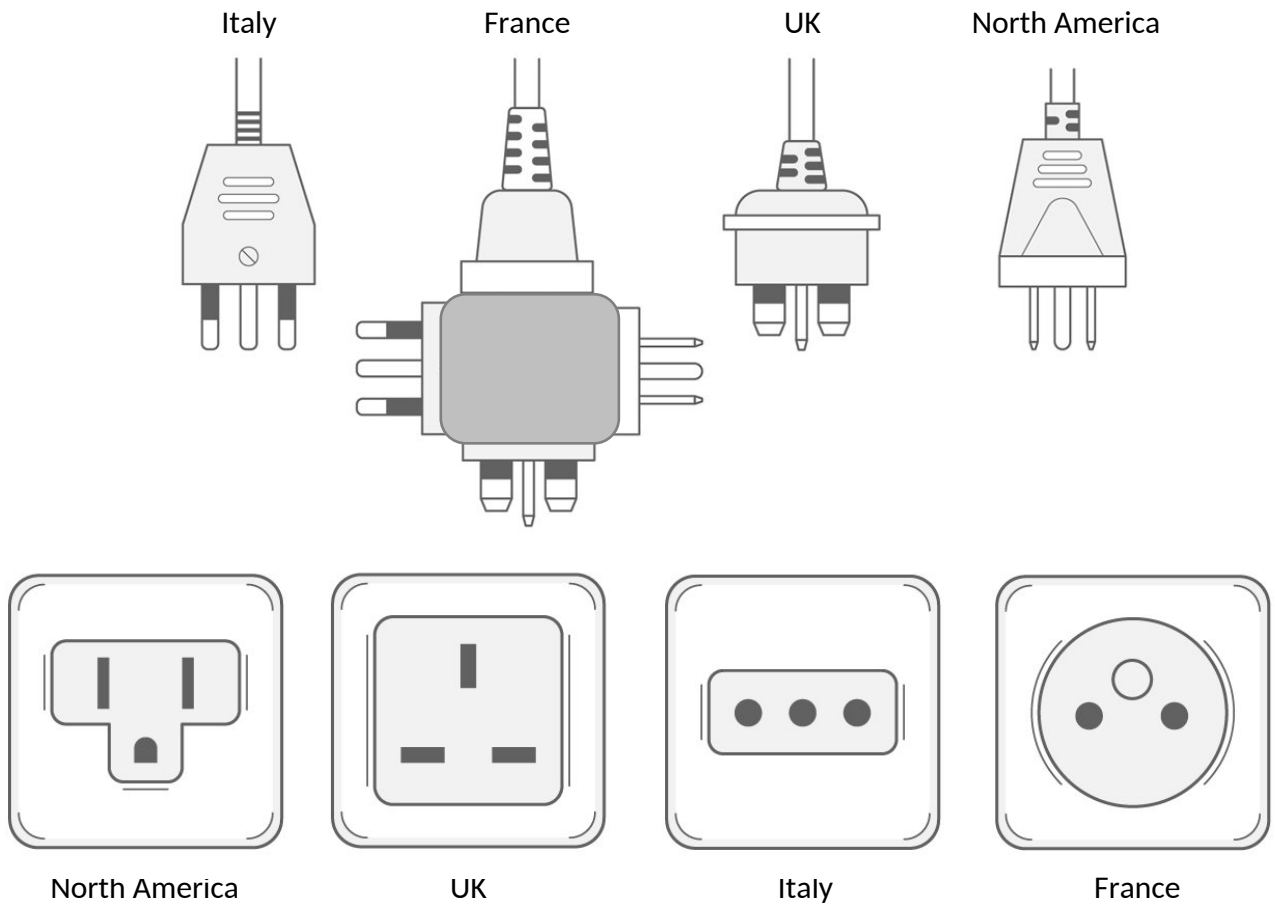

Figure: Power plug (in)compatibility across countries

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System Compatibility

The **combination** of compatible systems generally implies **new functionalities**.

Compatibility is achieved via **standardization**.

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Interoperability

960s

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Interoperability

Interoperability is an intangible form of **compatibility** between systems.

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Interoperability

Interoperability is the ability of two or more systems or components to **exchange information** and **to use the information** that has been exchanged[1].

[1] IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries, IEEE, 1990

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Interoperability

In theory, interoperability is realized via **standard interaction protocols**.

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Interoperability

In theory, interoperability is realized via **standard interaction protocols**.

In practice, interoperability is most commonly realized via **(Web) APIs**.

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Interoperability

A good example of (lack of) interoperability is the **portability** of **personal data** on the Web.

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Interoperability

A good example of (lack of) interoperability is the **portability** of **personal data** on the Web.

Web users should be able to **get access** to the data they produce on one platform and **give access** to that data to another platform.

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Interoperability

We can either **force Facebook** to make it **more difficult** for [shadowy influence brokers] **to access your data** without Facebook's explicit approval (...) or we can bar Facebook from using technical and legal countermeasurest to shut out new companies, co-ops, and projects that offer to **let you talk to your Facebook friends without using Facebook's tools**[2].

[2] Cory Doctorow, "*Competitive Compatibility: Let's Fix the Internet, Not the Tech Giants*," Communications of the ACM, October 2021

Interoperability

Microsoft Office

Google Docs

OnlyOffice

Google Drive

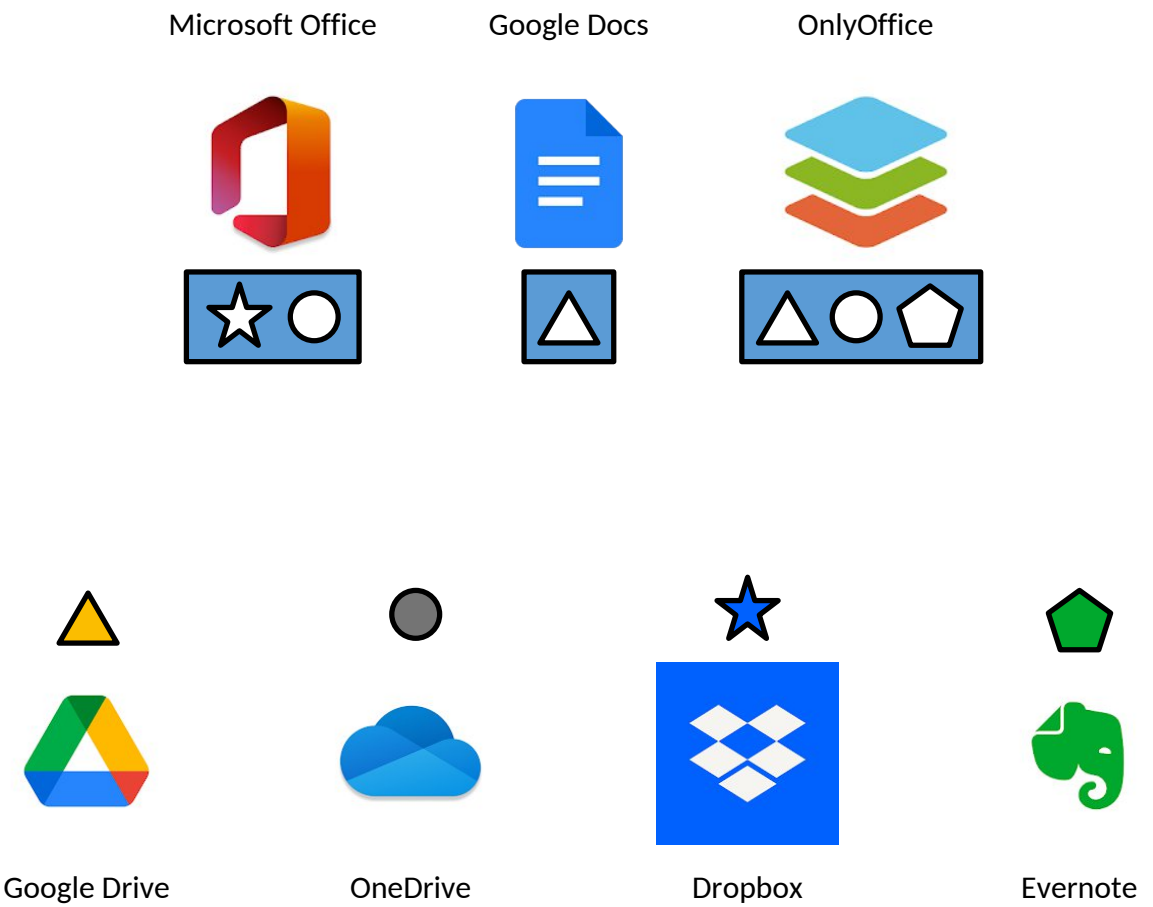
OneDrive

Dropbox

Evernote

Figure: (Lack of) interop. between text editors and document storage services

Interoperability



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Interoperability

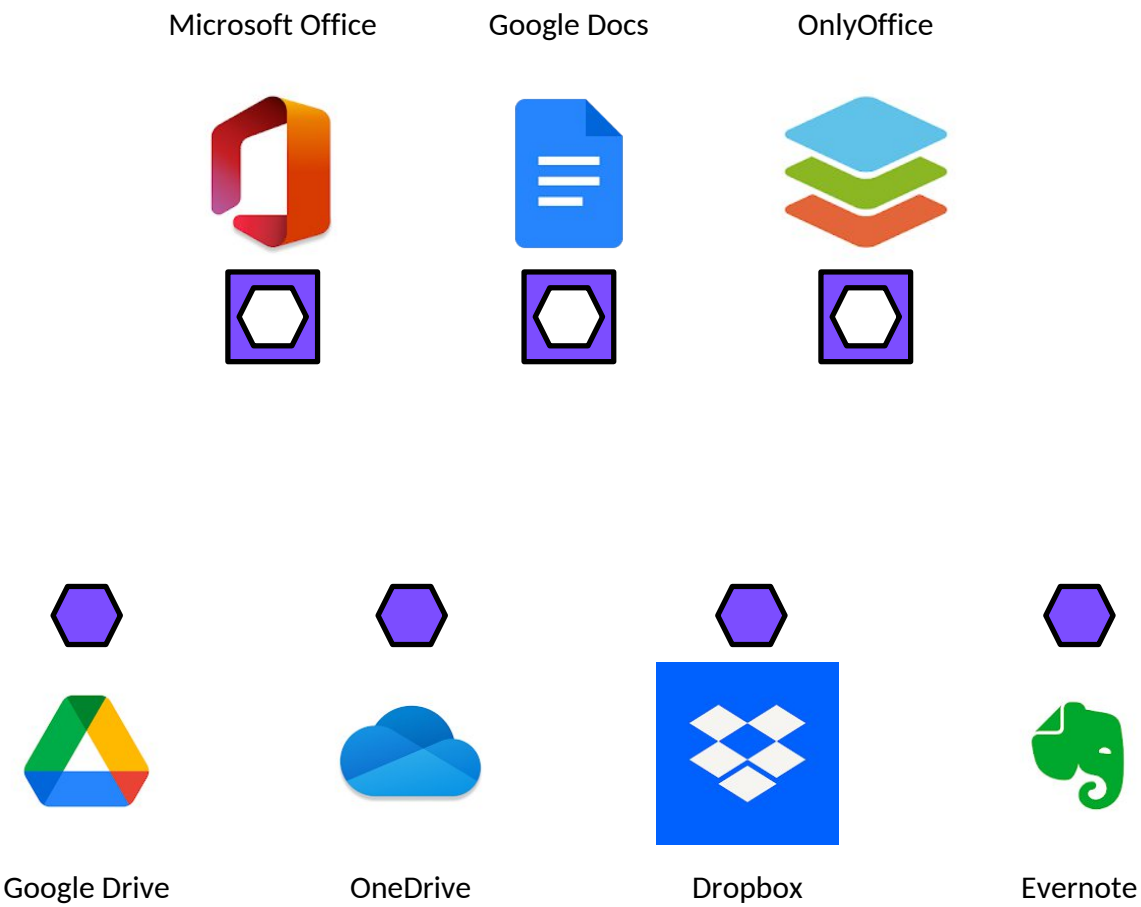

Figure: (Lack of) interop. between text editors and document storage services

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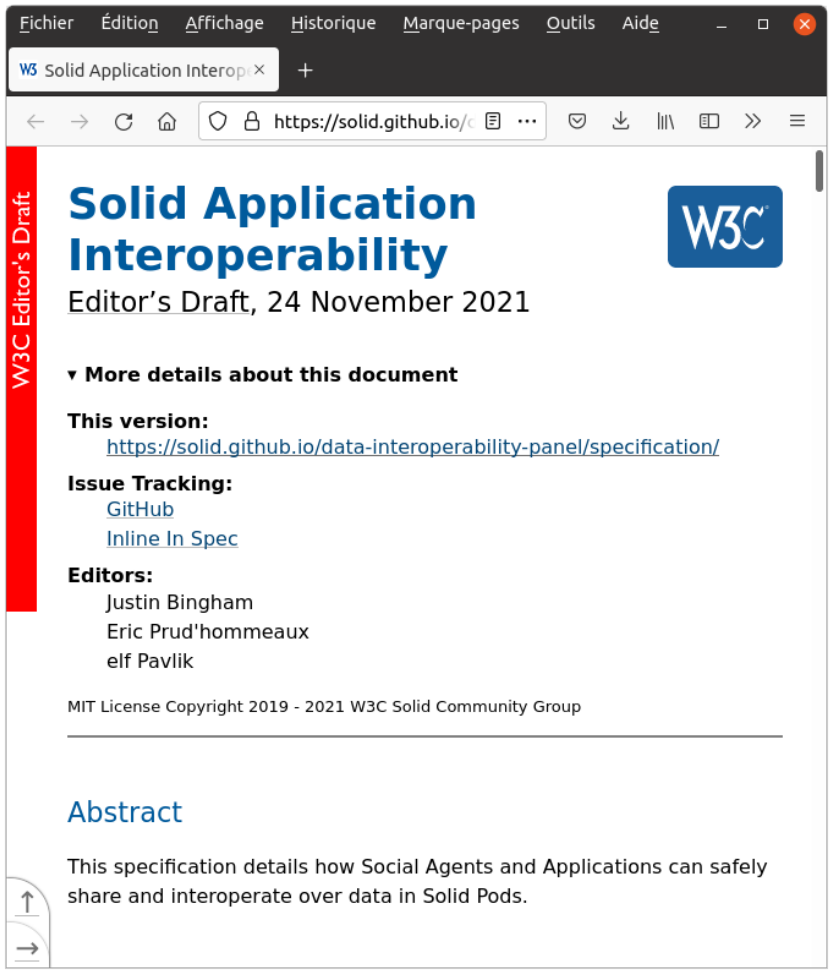
Interoperability

The **Solid project** (Social Linked Data) aims to provide Web-based standards to produce and consume personal data.



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Semantic Interoperability

660s

Semantic Interoperability

The European Telecommunication Standard Institute (ETSI) identified several levels of interoperability[3].

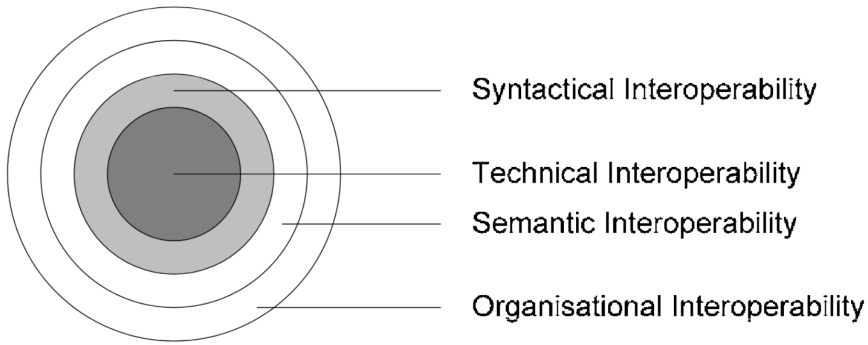

Figure: Different levels of interoperability (source: ETSI)

[3]Hans van der Veer and Anthony Wiles, Achieving Technical Interoperability - The ETSI Approach, ETSI White Paper, April 2008

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Semantic Interoperability

Assuming syntactic interoperability by exchanging documents in the OpenDocument Format (ODF), text editors may still not be able to **interpret** the content of these documents.

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Semantic Interoperability

Assuming syntactic interoperability by exchanging documents in the OpenDocument Format (ODF), text editors may still not be able to **interpret** the content of these documents.

In that case, **semantic interoperability** is still not guaranteed.

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Semantic Interoperability

For instance, an **address** may be the author's personal address (administrative form), a professional contact point (academic publications) or a recipient's address (letter).

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Semantic Interoperability

For instance, an **address** may be the author's personal address (administrative form), a professional contact point (academic publications) or a recipient's address (letter).

If documents include **numeric data** (e.g. spreadsheets), contextual information is likely to be stored in other, unreferenced documents.

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```
time,hmdt,lumi,temp,location
1636954288932759918,,,19.9,emse/fayol/e4/S431H
1636954288981725847,54.7,,,emse/fayol/e4/S431H
...
```

Figure: Sensor measurements (CSV) with unresolved ref. to room S431H

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Semantic Interoperability

Semantic interoperability is the ability of two or more systems or components to **share a common interpretation** of the information that has bee exchanged.

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Semantic Interoperability

If two systems agree on how to interpret data, they must use the **same concepts** to describe that data.

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Semantic Interoperability

If two systems agree on how to interpret data, they must use the **same concepts** to describe that data.

The two systems have the same ***ontology***.

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Semantic Interoperability

An **ontology** is a formal description of **concepts and relationships** that can **exist for a community** of human and/or machine agents[4].

[4] Steffen Staab and Rudi Studer, Handbook on Ontologies, Springer, 2010

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Semantic Interoperability

Ontologies are typically expressed as logical **axioms** over a well-defined **vocabulary**.

[5] Aidan Hogan *et al.*, Knowledge Graphs, Morgan & Claypool, 2021

Semantic Interoperability

Ontologies are typically expressed as logical **axioms** over a well-defined **vocabulary**.

They allow for **ontology-based data access** and **ontology alignment**, so that data from several sources is integrated into a single Knowledge Graph[5].

[5] Aidan Hogan *et al.*, Knowledge Graphs, Morgan & Claypool, 2021

Semantic Interoperability

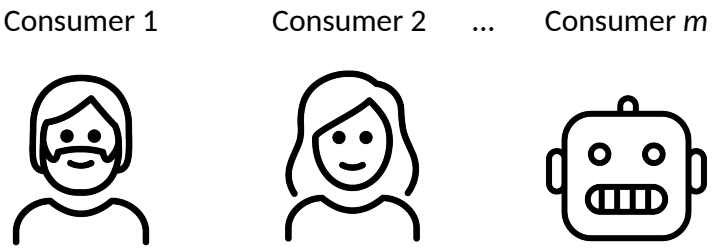
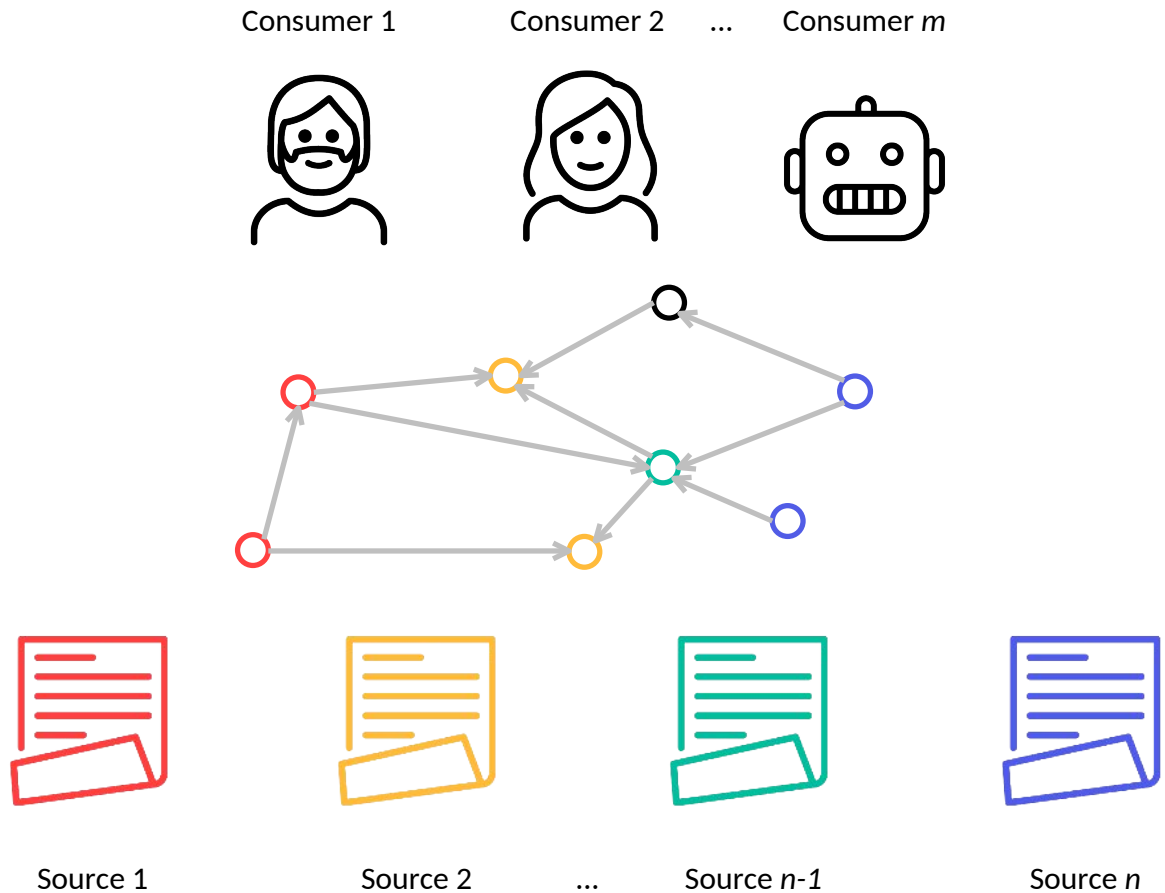


Figure: Semantic interoperability via ontologies

Semantic Interoperability



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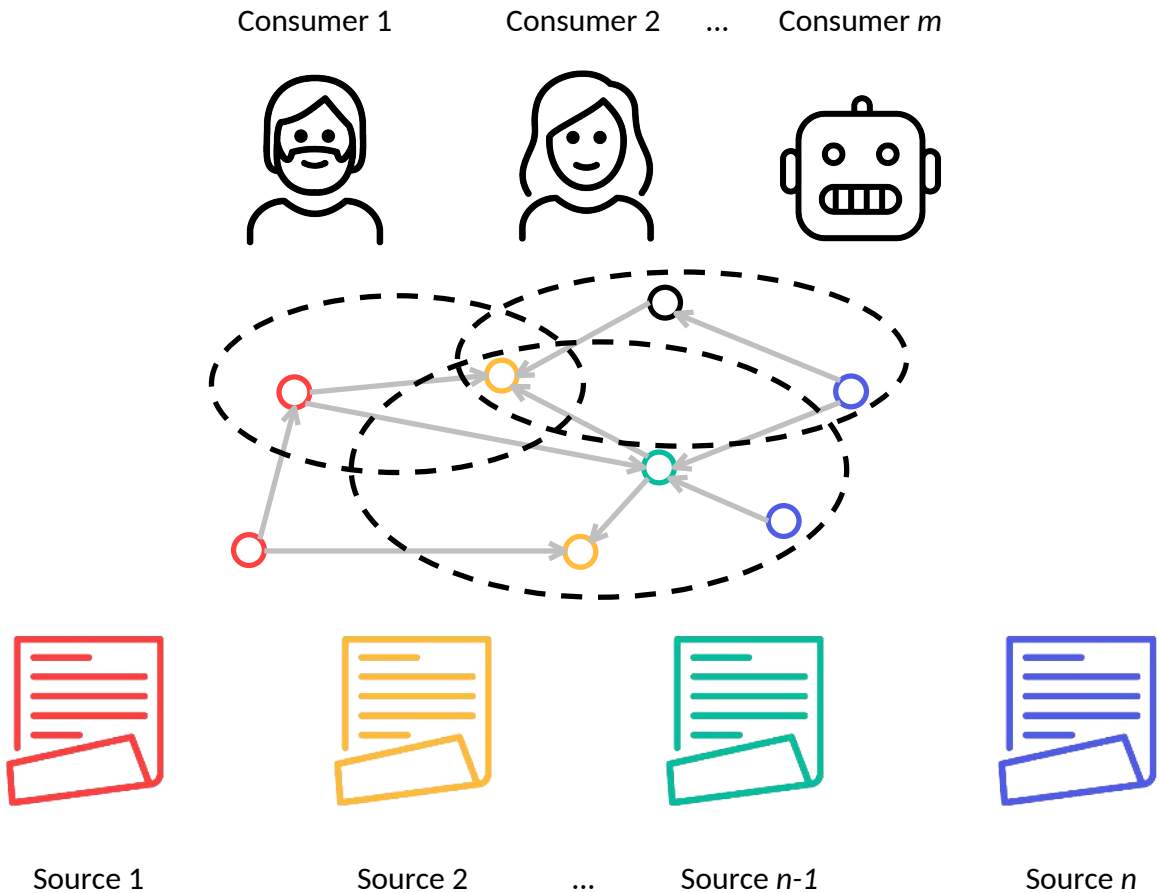

Figure: Semantic interoperability via ontologies

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Semantic Interoperability

How to "formally describe" concepts and relationships?

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Semantic Interoperability

How to "formally describe" concepts and relationships?

The World Wide Web Consortium (W3C) answers the question from a technical perspective with the **Semantic Web** technology stack.

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Semantic Interoperability

The Resource Description Framework (**RDF**) provides a common framework for expressing [**information about resources**] so it can be exchanged between applications without loss of meaning.

[6] Frank Manola, Eric Miller and Brian McBride, RDF 1.1 Primer, W3C, June 2014.

Semantic Interoperability

The Resource Description Framework (**RDF**) provides a common framework for expressing [**information about resources**] so it can be exchanged between applications without loss of meaning.

Resources can be anything, including documents, people, physical objects, and abstract concepts[6].

[6] Frank Manola, Eric Miller and Brian McBride, RDF 1.1 Primer, W3C, June 2014.

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Semantic Interoperability

RDF triples can state e.g. the type of an online document and how its parts (such as an address) relate to other resources.

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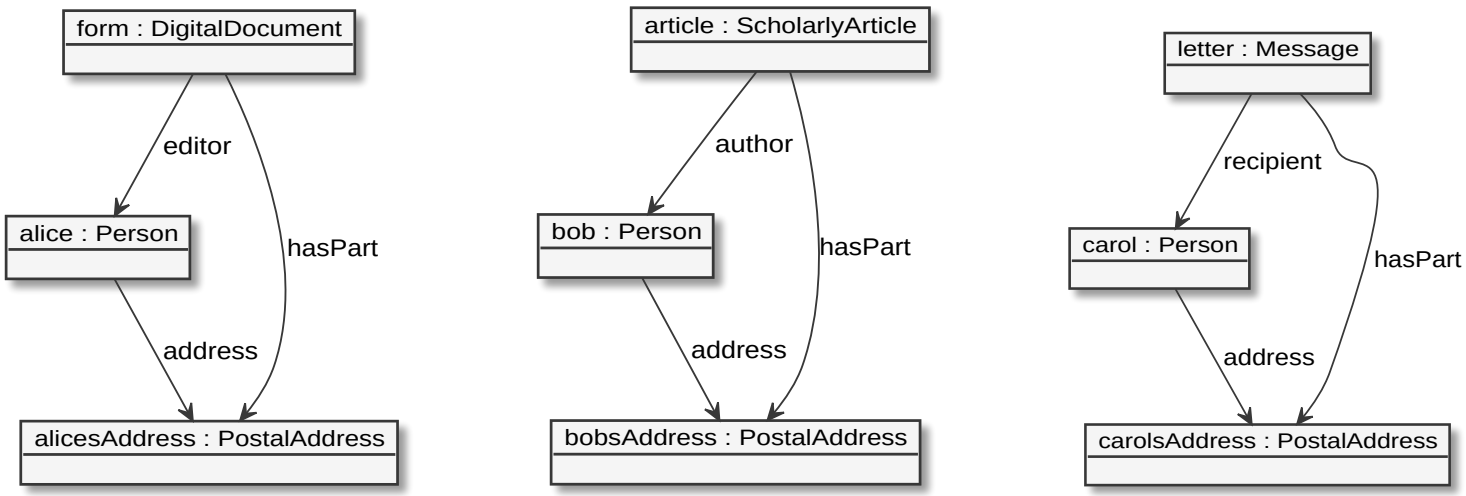

Figure: RDF triples describing various documents with schema.org

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Semantic Interoperability

RDF triples can also describe datasets (such as a CSV history of sensor measurements).

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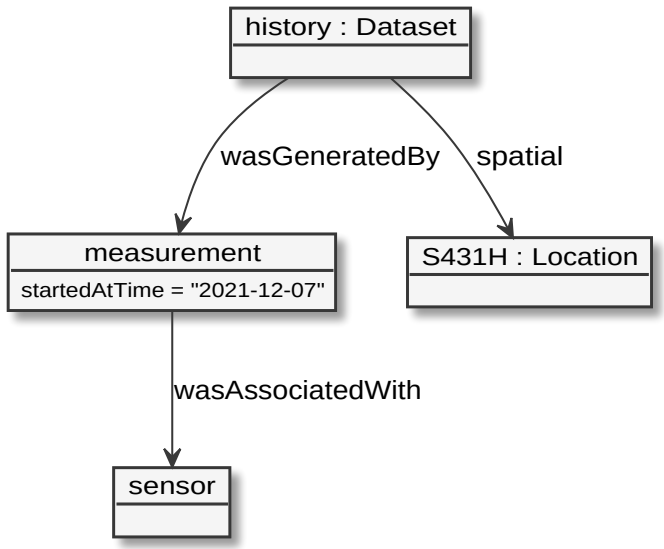

Figure: RDF triples describing a CSV history with DCAT

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Semantic Interoperability

Basics

resource `rdf:type` concept .

Intermediate

concept `rdf:type rdfs:Class` .
concept `rdfs:subClassOf` otherConcept .
property `rdf:type rdfs:Property` .
property `rdfs:domain` concept .

Advanced

concept `rdf:type owl:Class` .
concept `owl:unionOf` (concept1 concept2 ...) .
property `rdf:type owl:ObjectProperty` .
property `rdf:type owl:SymmetricProperty` .

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Semantic Interoperability

The Simple Knowledge Organization System (**SKOS**) standardizes how to define **taxonomies** (i.e. hierarchies of concepts).

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The RDF Schema (**RDFS**) standardizes how to define **basic vocabularies** (i.e. class names and property names) for Knowledge Graphs.

Semantic Interoperability

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The RDF Schema (**RDFS**) standardizes how to define **basic vocabularies** (i.e. class names and property names) for Knowledge Graphs.

The Web Ontology Language (**OWL**) standardizes how to define **expressive ontologies** (i.e. axioms) for any kind of logical theory.

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Semantic Interoperability

Semantic interoperability is obtained when the resource descriptions of various data sources are **specializations** of a **common generic ontology**.

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Semantic Interoperability

The International Data Space Association (IDSA) has created an ontology, based on DCAT, to ensure semantic interoperability across **data spaces**[7].

[7] Sebastian Bader *et al.*, The International Data Spaces Information Model – An Ontology for Sovereign Exchange of Digital Content, ISWC, 2020

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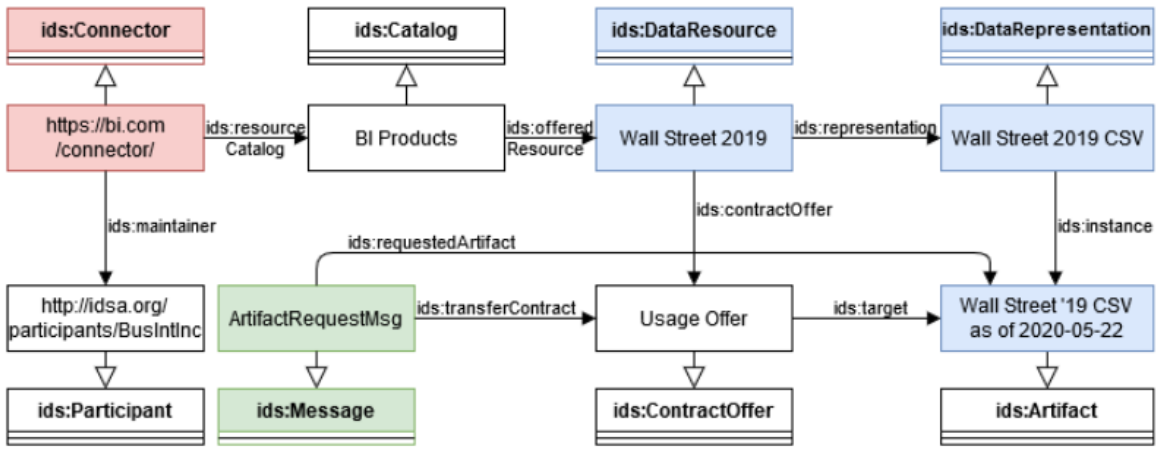

Figure: IDS core classes and example instances

[7] Sebastian Bader *et al.*, The International Data Spaces Information Model – An Ontology for Sovereign Exchange of Digital Content, ISWC, 2020

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Summary

60s

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Summary

Semantic interoperability is essential in **data-intensive** applications.

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Summary

Semantic interoperability is essential in **data-intensive** applications.

Semantic Web standards play an important role in guaranteeing **minimal interoperability**.

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Summary

Semantic interoperability is essential in **data-intensive** applications.

Semantic Web standards play an important role in guaranteeing **minimal interoperability**.

Several degrees of interoperability can be achieved '**as-you-go**' via incremental **ontology engineering**.

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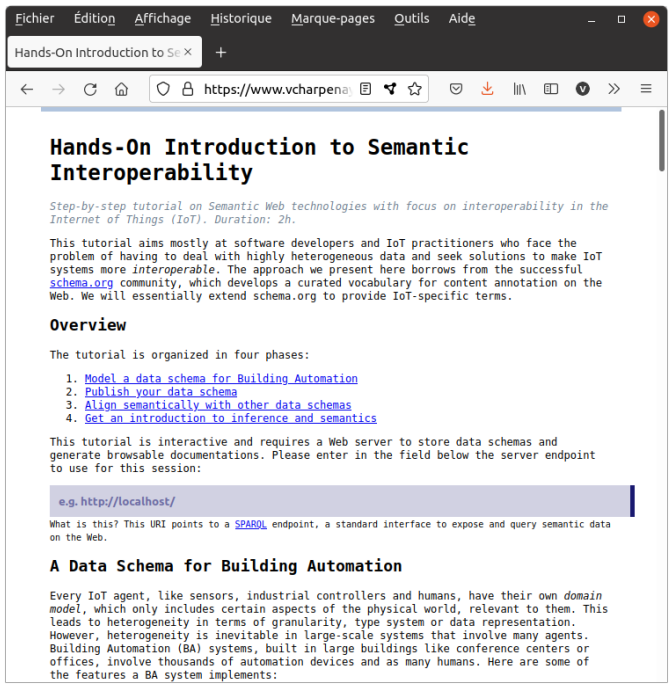
Summary

https://www.vcharpenay.link/talks/iot-semantics.html



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Summary

Thank you. Qestions?