Semantic interoperability

Snježana Knezić and Martina Baučić

University of Split
Faculty of Civil Engineering, Architecture and Geodesy

Content

- Semantic interoperability - definition, challenges,
- Example: EPISECC project - a conceptual model

Presented by: Snježana Knezić

- Semantic interoperability - supporting technologies
- Technical solution - a prototype developed by the EPISECC project

Presented by: Martina Baučić

Semantics

- Meaning of data, information
- Use of data, information
- Relations between data, information
- Similarities between objects, data, information
- Understanding the context

Semantic models – saving knowledge

- Taxonomy
- Mind maps
- Semantic networks
- Ontology
- Artificial intelligence – models, neural networks, expert systems, etc.

Semantic interoperability in disaster and emergency response:

- extremely important during a response phase;
- identical interpretation of information exchanged between first responders;
- seamless evaluation of a common operational picture.

Application of semantic models in disaster and emergency response:

- the most used are ontologies because:
  - easy to create models;
  - supported with web technology;
  - easy to modify;
  - efficient for resource management;
  - easy to combine with spatial data (GIS).

A challenge:

- to support message exchange between first responders in a way that first responders:
  - use their own way of communication;
  - use their own terms for concepts;
  - speak their native language.

Causes of misunderstanding

- first responders use the same language but coming from different domains (humanitarian and firefighting) using the same terms for different concepts
- first responders belong to the same domain (medical service) but come from different countries, use different languages and translated terms may stand for different concepts

Various structures for saving knowledge by first responders – potential confusion:

- **Dictionaries&Glossaries**: ***lists the words of a language*** (typically in alphabetical order) and gives their meaning, gives the equivalent words in a different language.
- **Vocabularies**: ***a set of words or terms*** of a language (all words), or used by a particular person or group used. Words may be used for labelling, indexing or categorizing.
- **Controlled vocabularies**: a controlled vocabulary is ***a restricted list of words or terms*** used for labelling, indexing or categorizing, only terms from the list may be used for the subject area covered by the controlled vocabulary, adding terms to the list is under control.
- **Thesauri**: more ***structured controlled vocabulary***, provides information about each term and its relationships to other terms, It has terms that can be used as synonyms.
- **Terminologies**: ***a set of terms*** used with a particular technical application in a subject of study, theory, profession, etc. it establishes a common understanding so that consistent terms are used, provides terms' definitions.
- **Taxonomies**: related to the science of classifying things, has a hierarchy, but not necessarily other features of a standard thesaurus, a taxonomy is a pair (T ,≤), where T is ***a terminology*** and ≤ is a ***reflexive and transitive binary relation*** over T, called subsumption, built on hierarchical structure and/or facets.

Existing tools

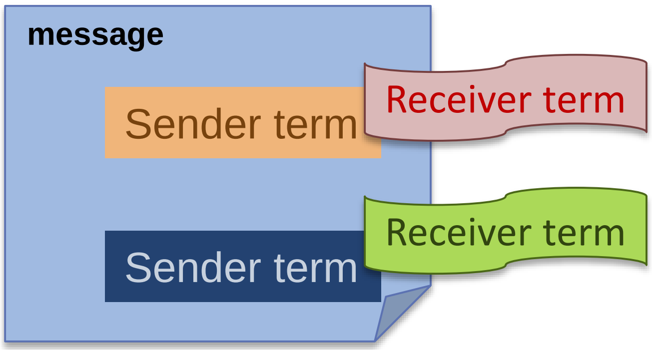
- automatic translation – still not reliable enough to be used in emergency and disaster management;
- standardisation, i.e. common terminologies – hard to implement because it uses one language and first responders should reach consensus on the common set of concepts and corresponding terms, which is extremely challenging process and, if ever created, such set will presumably cover only a part of used concepts;
- semantic networks applied in web technologies.

Example: EPISECC project approach

- to allow first responders to act according to their operational procedures, using their own ICT tools for communication and their own terminologies/vocabularies/taxonomies;
- syntactical interoperability: instead of having a common ICT solution for all, enabling first responders to use their own ICT tools by installing a dedicated adaptor to Common Information Space (CIS);
- semantic interoperability: Semantic Box Service creates portions of text called semantic annotations, which are attached to the messages exchanged during disaster response.
- the only effort first responders have to undertake, prior to joining CIS, is the implementation and installation of a specific adaptor for their ICT tools and to include their own terminologies/vocabularies/taxonomies into Semantic Box Service

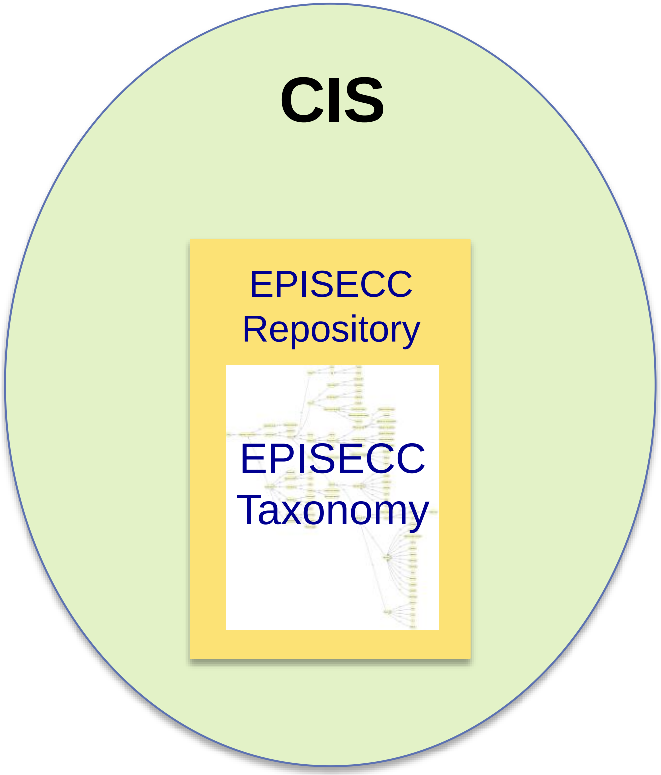
EPISECC Semantic Box Service

- Semantic Box Service creates portions of text called **semantic annotations**, which are attached to the messages exchanged during disaster response. When first responders receive messages, the semantic annotations **provide them explanations of key terms included in the message**.
- **The explanations are their own terms having best possible match with sender's terms**, no matter if the message is written in foreign or their own language.

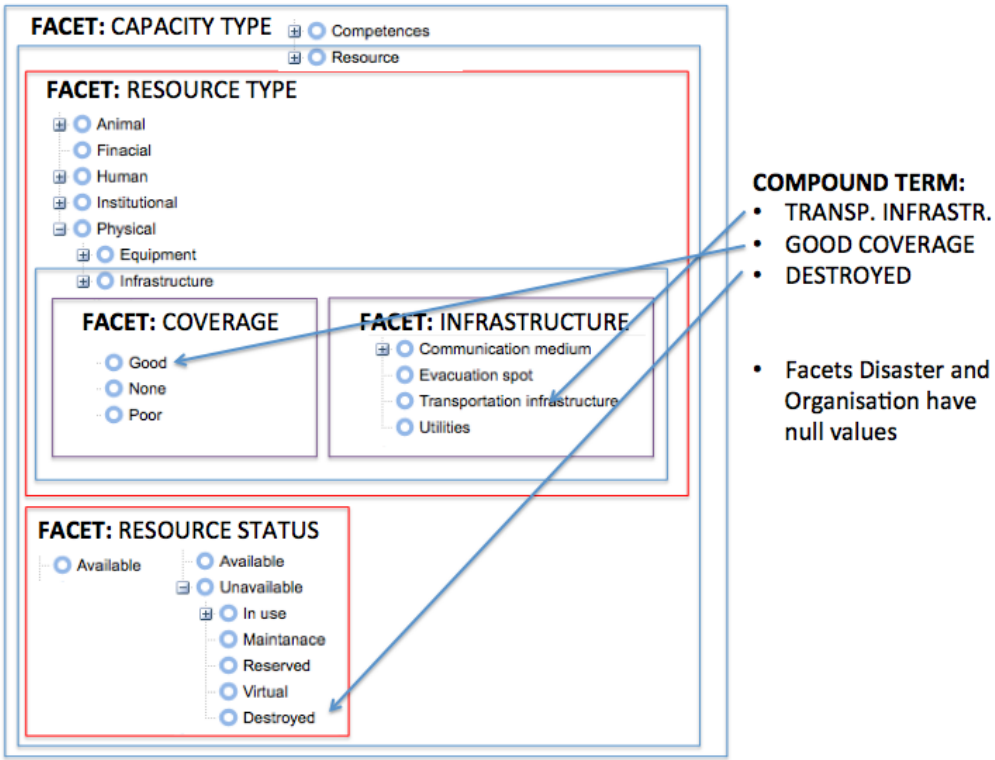


EPISECC Taxonomy

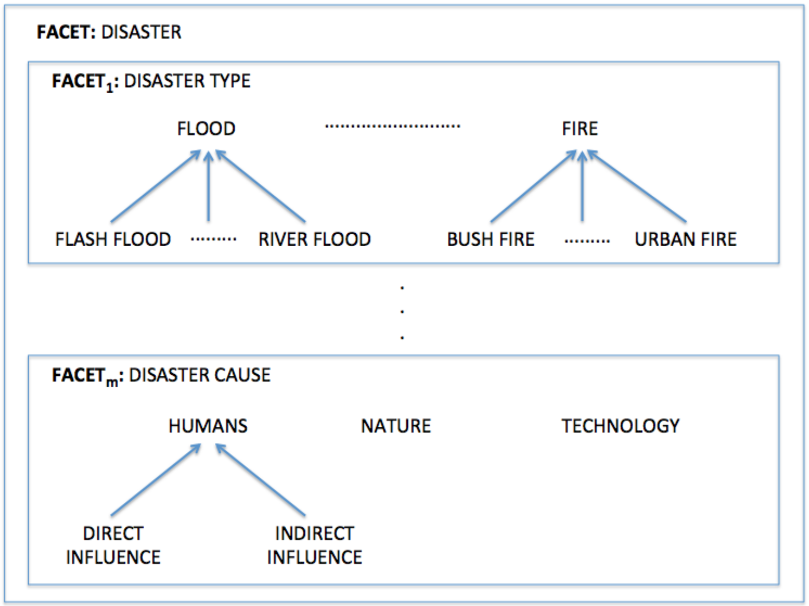
terms and concepts related to disaster response
(spatial, time-related, disaster-related, organisational, functional)



EPISECC Taxonomy is faceted taxonomy having concepts (315), facets (45), and many compound terms

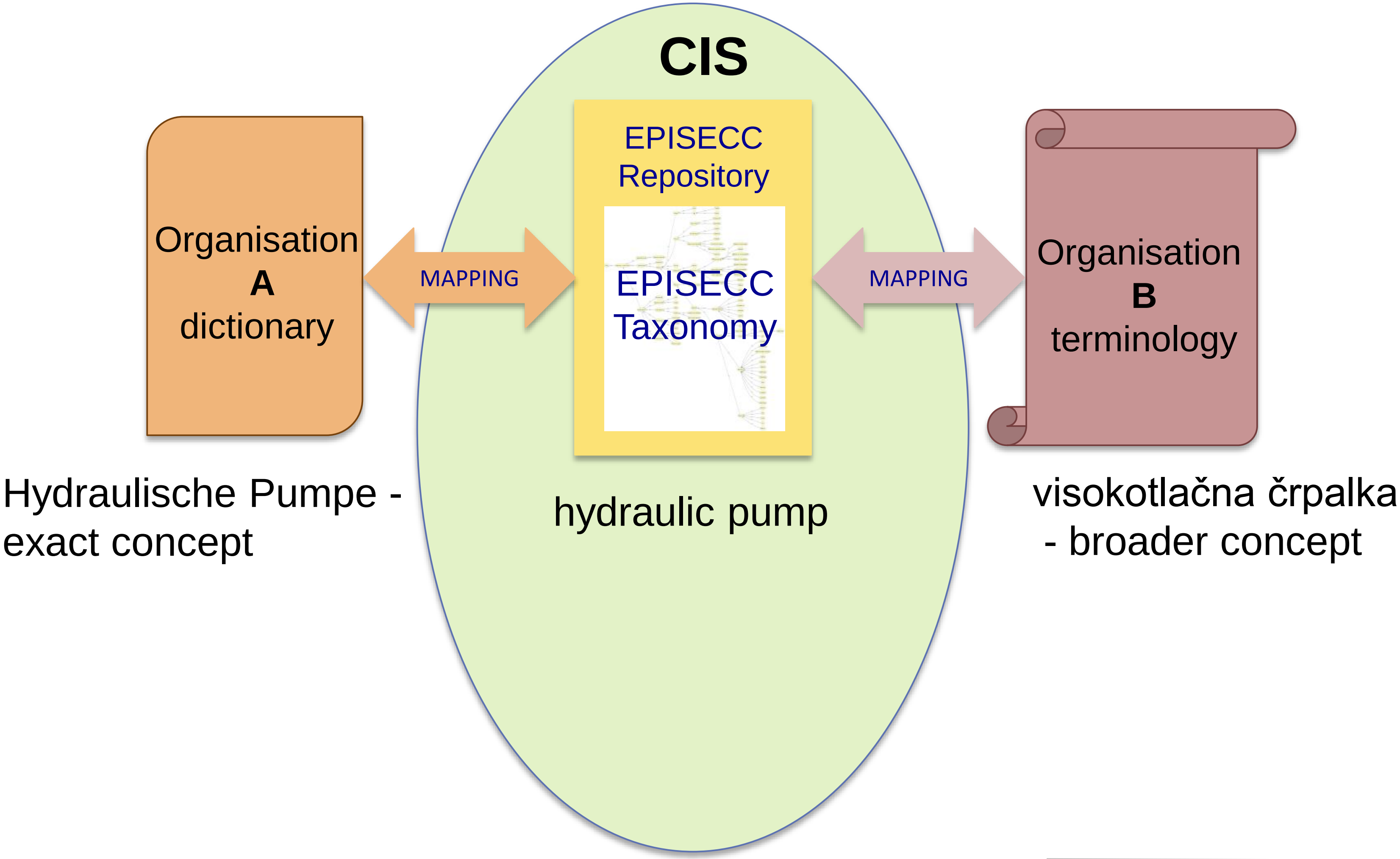


An example of a compound concepts: a dynamic aspect of the Taxonomy

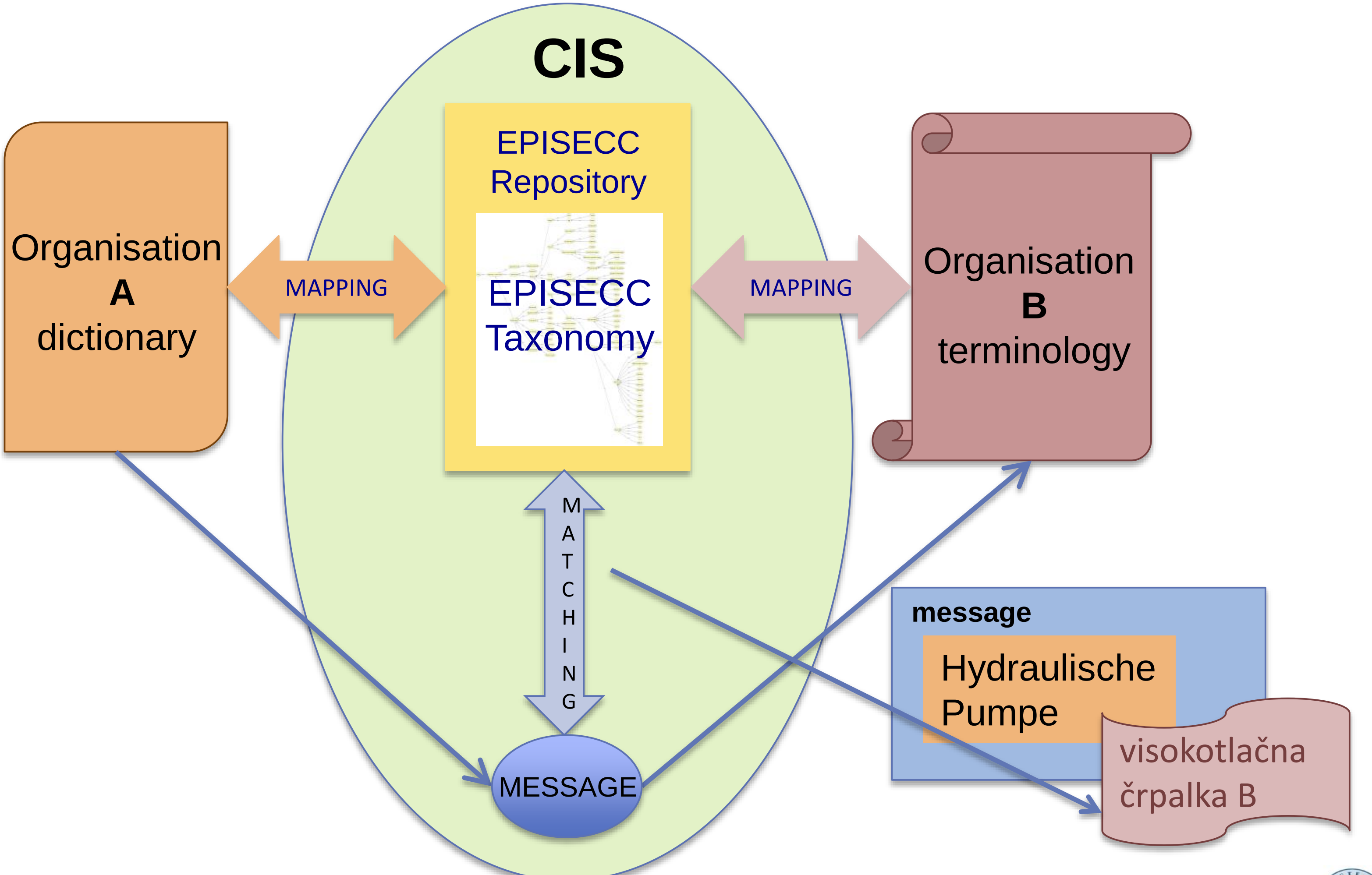


An example - a facet “disaster”, which is further described with more facets and hierarchical structures

EPISECC Semantic Box Service



EPISECC Semantic Box Service

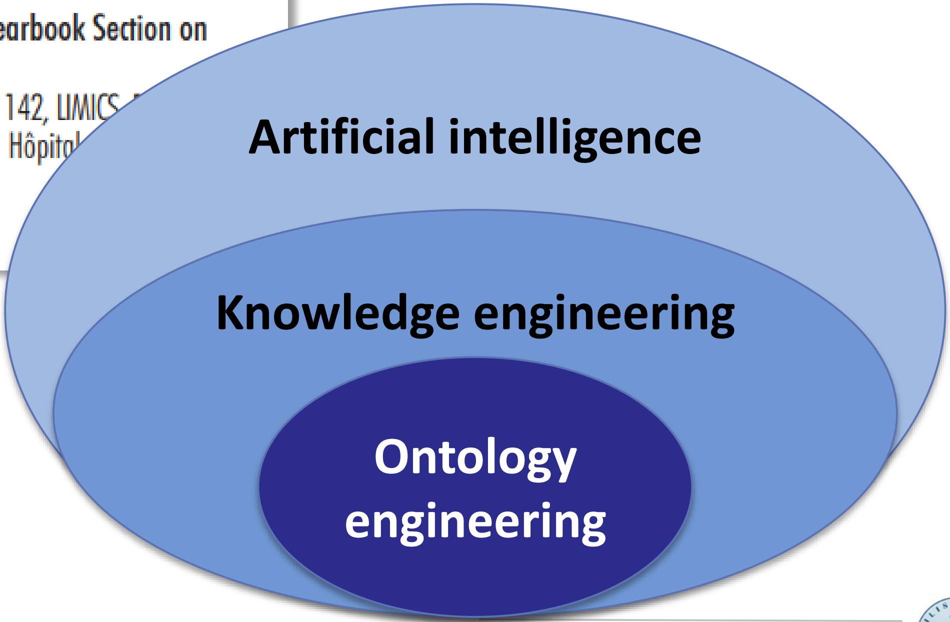


Semantic technologies

As Ontologies Reach Maturity, Artificial Intelligence Starts Being Fully Efficient: Findings from the Section on Knowledge Representation and Management for the Yearbook 2018

Ferdinand Dhombres[1,2], Jean Charlet[1,3], Section Editors for the IMIA Yearbook Section on Knowledge Representation and Management

[1] Sorbonne Université, Université Paris 13, Sorbonne Paris Cité, INSERM, UMR_S 1142, LIMICS, …
[2] Sorbonne Université Médecine, Service de Médecine Fœtale, AP-HP/HUEP, Hôpital … Trousseau, Paris, France
[3] AP-HP, DRCI, Paris, France



Semantic technologies

Technologies mostly used to support semantic interoperability

http://www.smarteim.com/

Semantic technologies - motivation

How to integrate, analyze and explain huge volume of heterogeneous data?

How to enable machines to understand the content?

How to enable software to process meaning of data, not only the data?

Data collecting:

Growth in number of sensors / Citizens as data providers / Increase in data volume, velocity ...

Data processing:

Modelling / Analysis / Explanations

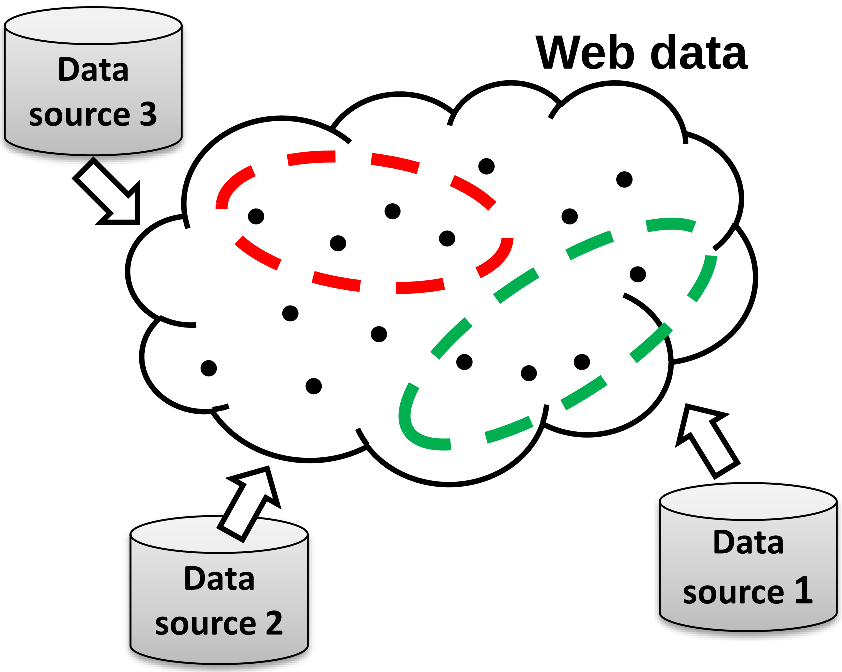
Dissemination:

Information / Knowledge

Semantic technologies

How Semantic web works?

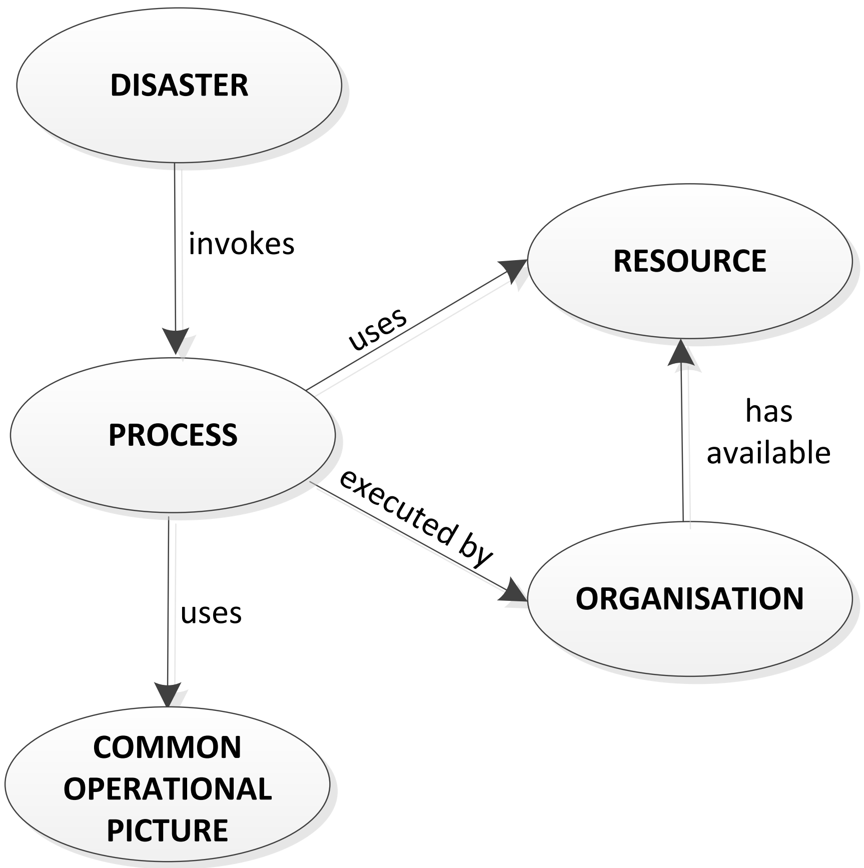
- From data to schema (<u>bottom to top</u>)
- By use of semantic descriptions we can classify, filter, infer data...



Semantic technologies

Ontology in computer science

- describes meanings and relationships separately from data, files or application code,
- most typical kind of ontology has a taxonomy and a set of inference rules,
- OWL (Ontology Web Language) – standard for ontology scheme creation, software can read it.



Semantic technologies

Ontology schema

- the ontology's elements – **semantics are formalised in OWL in RDF/XML syntax**

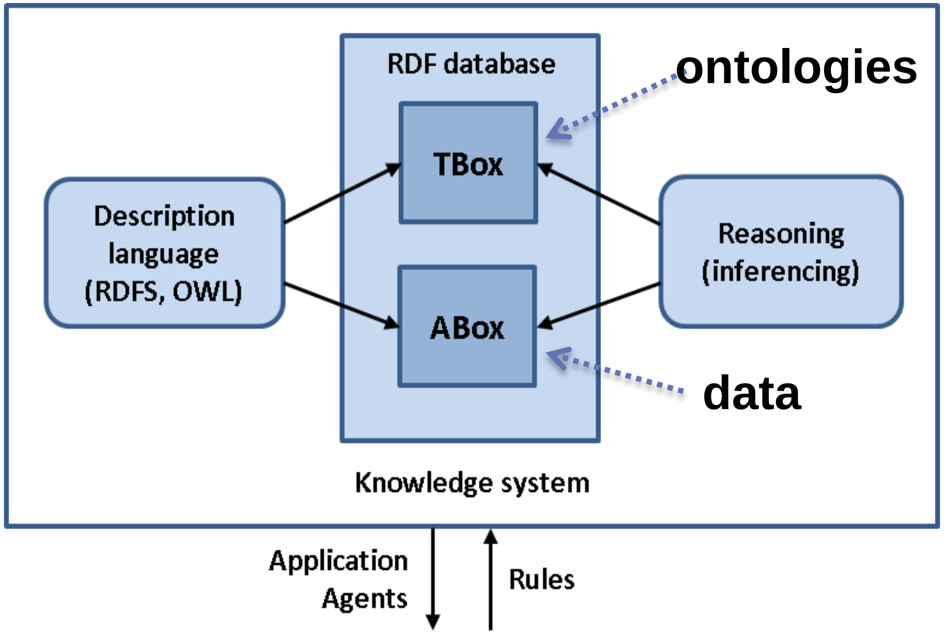
```
<owl:Class rdf:about="http://webprotege.stanford.edu/epi00242">
    <rdfs:label>Organisation</rdfs:label>
    <rdfs:comment>An organisation is a unit established to meet goals related to disaster management. It is structured along its management, which defines the relationships between responsibilities, tasks and its structure.</rdfs:comment>
</owl:Class>
```

```
<owl:ObjectProperty rdf:about="http://www.episecc.eu/sem_rep#epi00089">
    <rdfs:label xml:lang="en">invokes</rdfs:label>
    <owl:inverseOf rdf:resource="http://www.episecc.eu/sem_rep#epi00090"/>
</owl:ObjectProperty>
```

```
<owl:Class rdf:about="http://webprotege.stanford.edu/epi00093">
    <rdfs:label>Process</rdfs:label>
    <rdfs:subClassOf rdf:resource="http://www.episecc.eu/sem_rep#epi00057"/>
    <rdfs:comment>Process is a set of actions aiming for a certain result, executed by an organisation during a response to a critical event.</rdfs:comment>
</owl:Class>
```

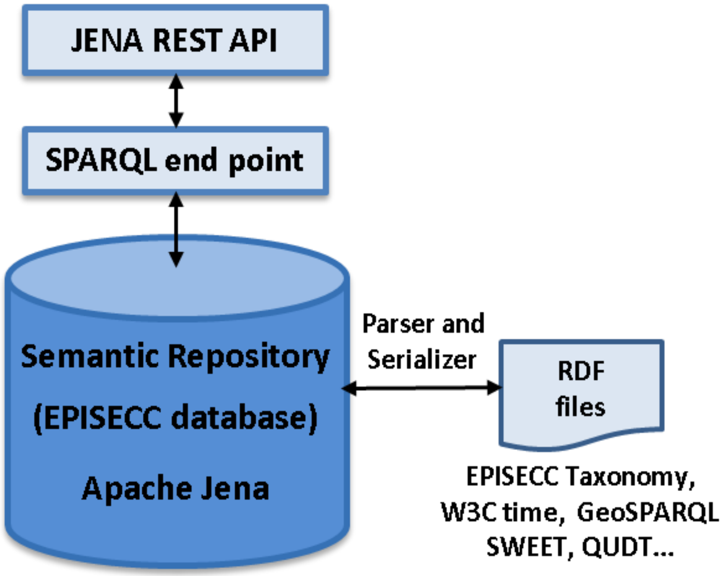
Semantic technologies

Architecture of Knowledge base



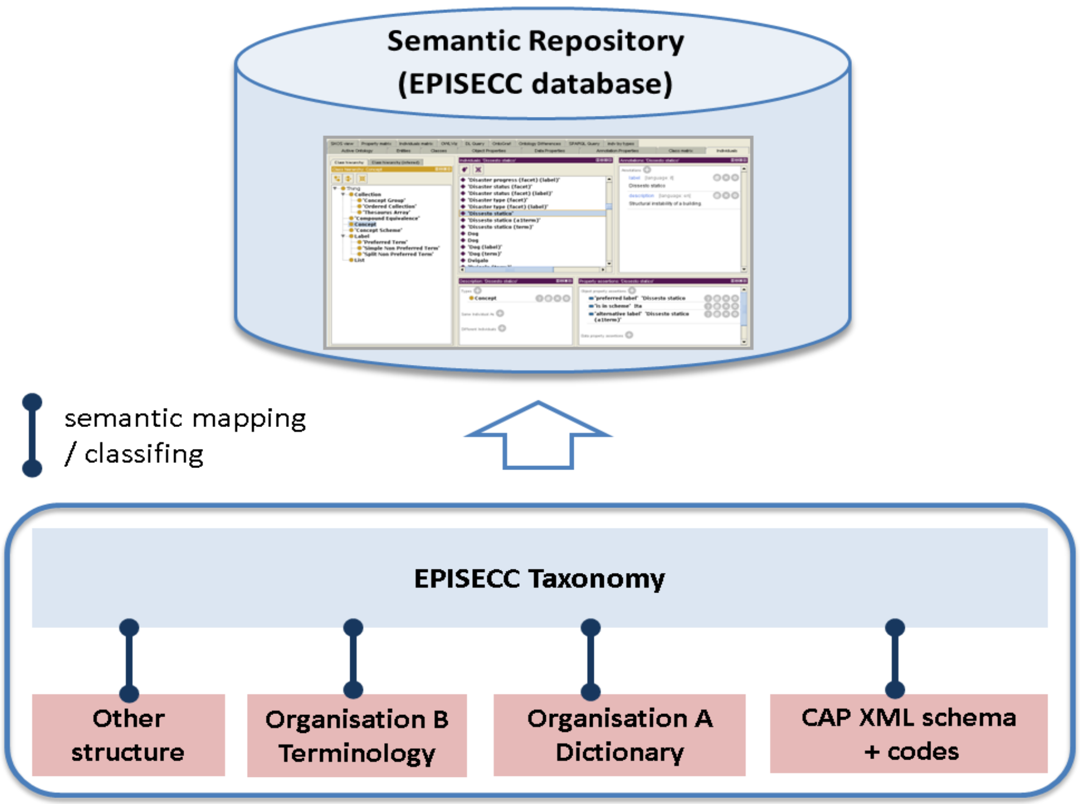
Modified from F. Baader and W. Nutt, “Basic description logics”, “The description logic handbook: theory, implementation, and applications”

EPISECC Semantic Repository architecture



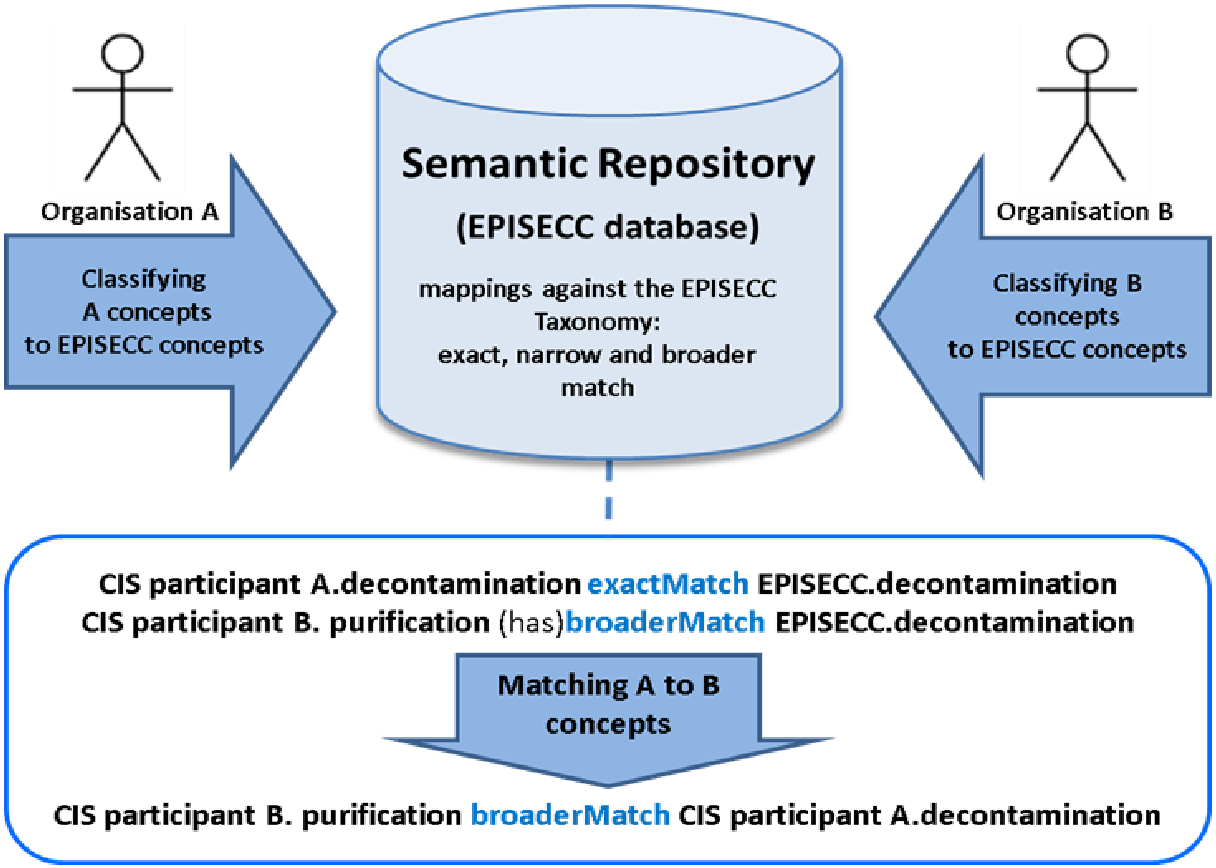
EPISECC Semantic Repository

- A permanent store of concepts, their semantic descriptions and relations.
- Resource Description Framework **RDF data model**
- **Simple Knowledge Organization System-thes (SKOS-thes ontology schema)** described by OWL
- It enables processes of Semantic Mapping and Matching.



Content of the repository

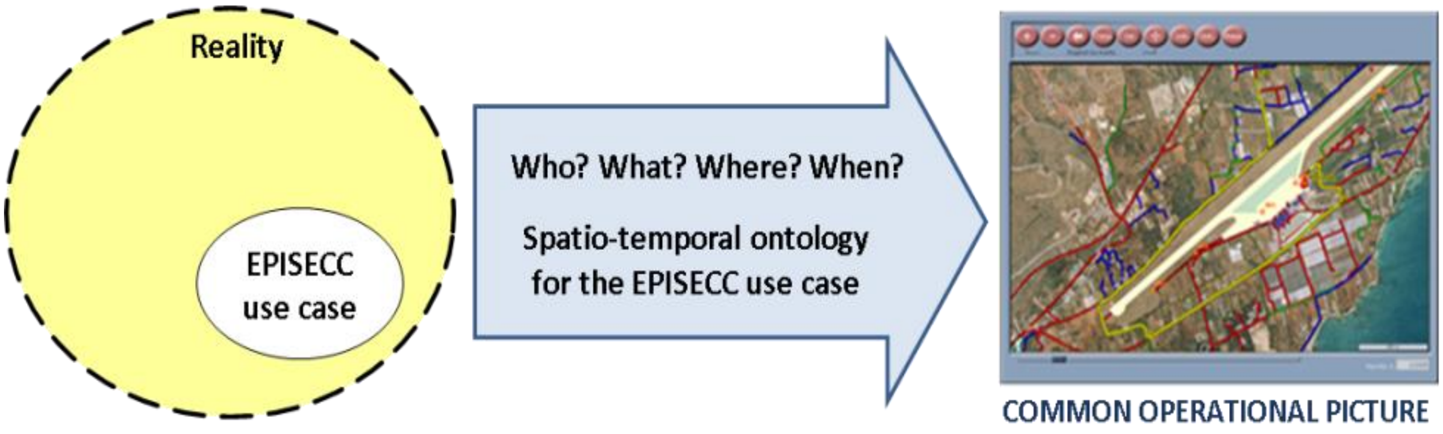
Semantic Matching
Creation of semantic annotations



DIRECTED GRAPH QUERIES
+
REASONING

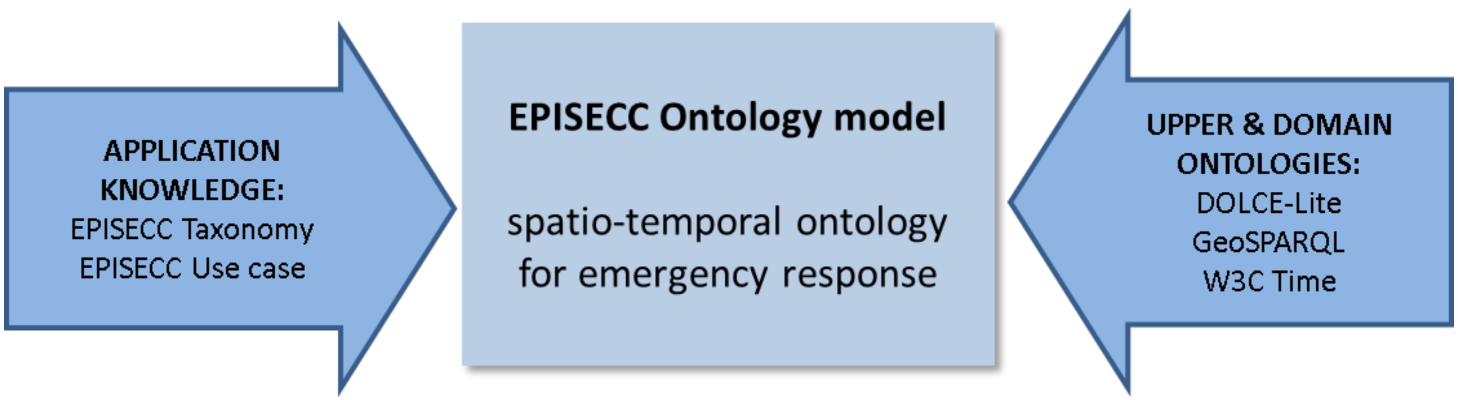
Ontology model for the EPISECC use case

- to enable ad-hoc users, like citizens, to participate in the common operational picture together with first responders;
- enriches the EPISECC Taxonomy towards semantics for the spatial and temporal concepts;
- describes the EPISECC use case showing the situation in affected area and locations of resources.



Ontology model for the EPISECC use case

- a conceptual model - nine directed graphs are developed;
- upper and domain ontologies are referenced what enables dynamic merging of data;
- the Ontology schema is defined by Ontology Web Language (OWL), created with Protégé Desktop;
- it is not implemented as a part of CIS.



Ontology model for the EPISECC use case

Why ontology model?

- the intention is that spatio-temporal data coming from different end users **could be classified automatically and merged into one operational picture;**
- the added value of introducing the ontology model is that **solution becomes open to ad-hoc participants and creates entirely shared situational awareness** during disaster response.

Semantic interoperability modelling - expectations

- To eliminate terminological inconsistency
- To eliminate reasoning inconsistency
- To enhance mutual comprehension of the situation
- To clarify common operating picture

Future

- Is the ontology the only modelling technique that can effectively cope with EM complexity, being implementable at the same time?
- Do we see a novelty at the horizon?

Future: Web 4.0, Industry 4.0

Web 4.0

- The Internet of Things
- Artificial Intelligence, self-learning systems, electronic agents
- RFID tags (radio frequency identification)
- The Internet of People - new symbiotic relationships between man and machine
- Virtual Reality

Industry 4.0

- Cyber-physical systems
- The Internet of things
- Cloud computing
- Cognitive computing

Society 4.0

- Information society

Society 5.0

- A human-centered society

Future: Disaster management 4.0 ?

All about communication ?

- mediated computer/machine communication
- machine - machine communication (IoT)
- human – human, human – machine ....

The key requirement in disaster management is:

trustworthiness of data - the future technological challenge