Knowledge Representation and Reasoning Using Ontology

Prepared by
Chetan Moradiya
Research Engineer @ ezDI

Outline

1. Motivaton
2. Today's Web and Limitations
3. Semantic Web and Components
4. Ontology
5. Ontology Development Methodology and Tools
6. OWL
7. Ontology Reasoning
8. SPARQL
9. DBMS vs Ontology

Motivation

- Inability to use the abundant information resources on the web
  - The web has tremendous collection of useful information however getting information from the web is difficult.
  - Search engines are restricted to simple keyword based techniques. Interpretation of information contained in web documents is left to the human user.

- Difficulty in information Integration
  - The integration of data from various sources is a challenging task because of synonyms and homonyms.

- Problem in knowledge management
  - "People as well as machines can't share knowledge if they do not speak a common language" [T. Davenport]

Today's Web

- In current web, most of the web pages are designed to be read by people not machines because machines cannot understand it without human intervention
- Today's web content is suitable for human consumption
- Keyword based search engines
- Web search results are not even in structural information

Limitation of Today's Web

- Conventional Information Retrieval (IR) technology is based on the occurrence of words in documents. Therefore it's difficult to get a relevant result
- Precision and Recall value is low
- Web results could create confusion as one word having several meanings and several words having same meaning.
- Web searches are not readily accessible by any software tool so Human involvement is necessary

Summarizing the Problem: Computers don't understand Meaning

- "My mouse is broken. I need a new one…"

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.“ - Tim Berners-Lee [1]

- It is structure of meaningful content of web pages that enables the machine to understand the content of web pages and respond to human requests based on their meaning.

Semantic Web Vision

- “The idea of having data on the Web defined and linked in a way that it can be used by machines not just for display purposes ,but for automation, integration and reuse of data across various applications.”

Semantic Web Basic Components

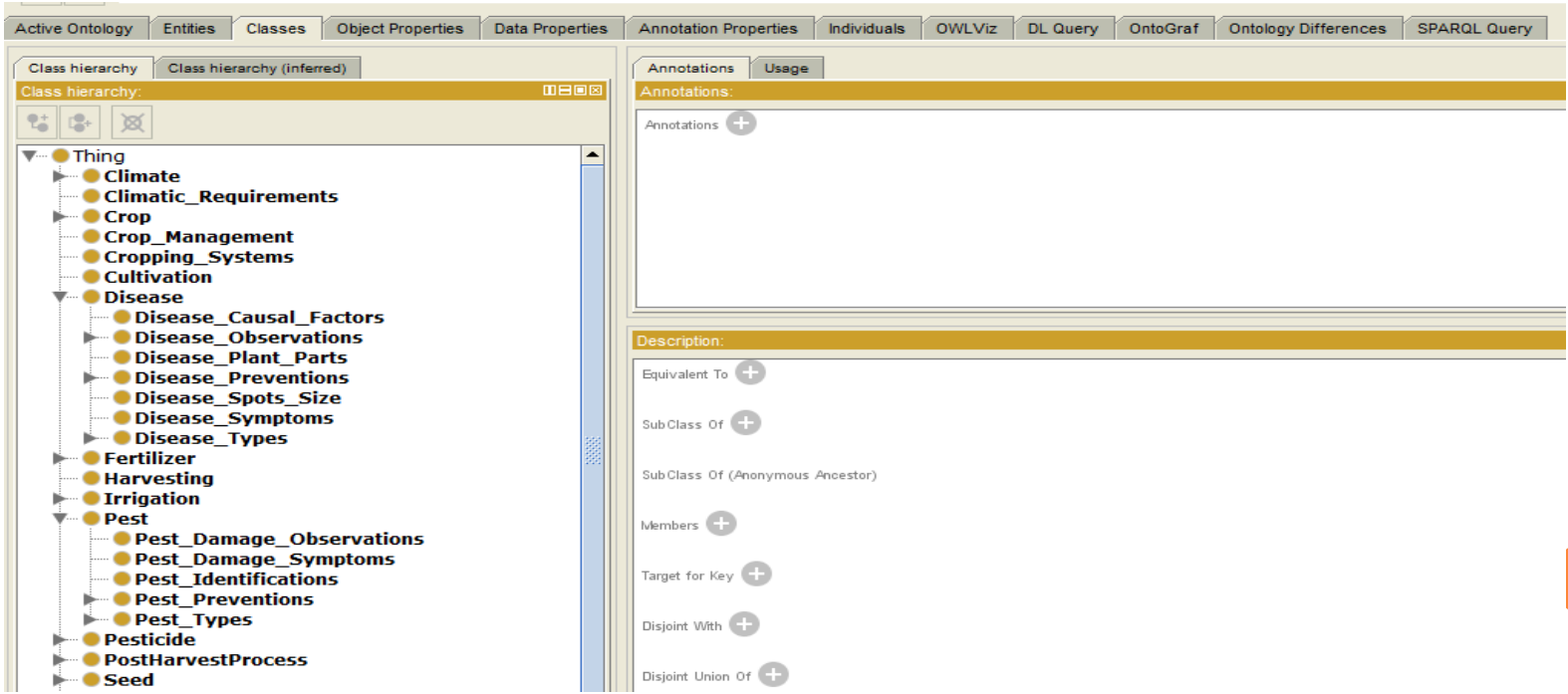
- XML [3] and RDF [4]
- Ontology
- Software Agents

Ontology

- "An ontology is a formal, explicit specification of a shared conceptualization" (Tom Gruber)
- A data model which represents the information in terms of knowledge in the semantic web.
- Describes concepts and relationship between objects in the domain.
- Includes basic components:
  - Classes
  - Properties
  - Individuals

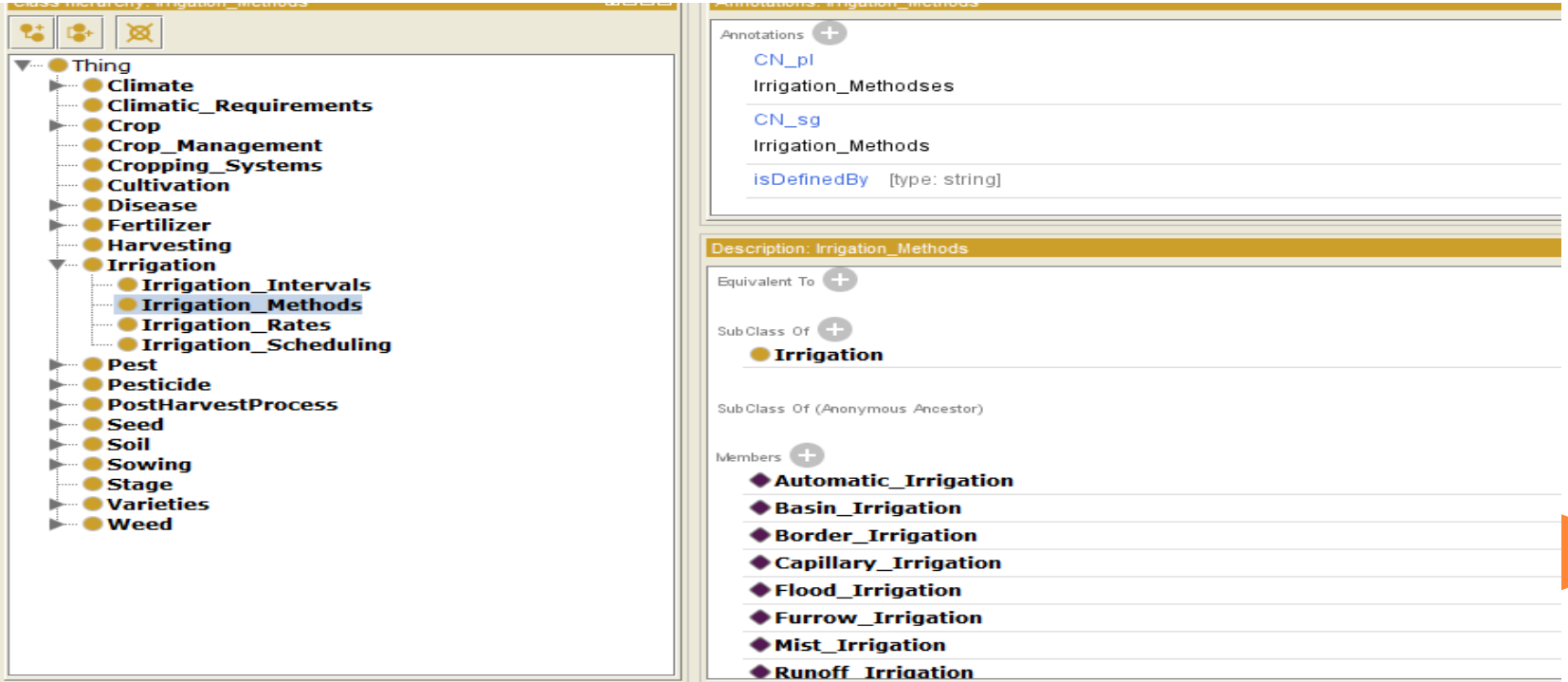
Ontology Components

- Classes
  - Concepts in ontology
  - Two Types of concepts: General and Specific



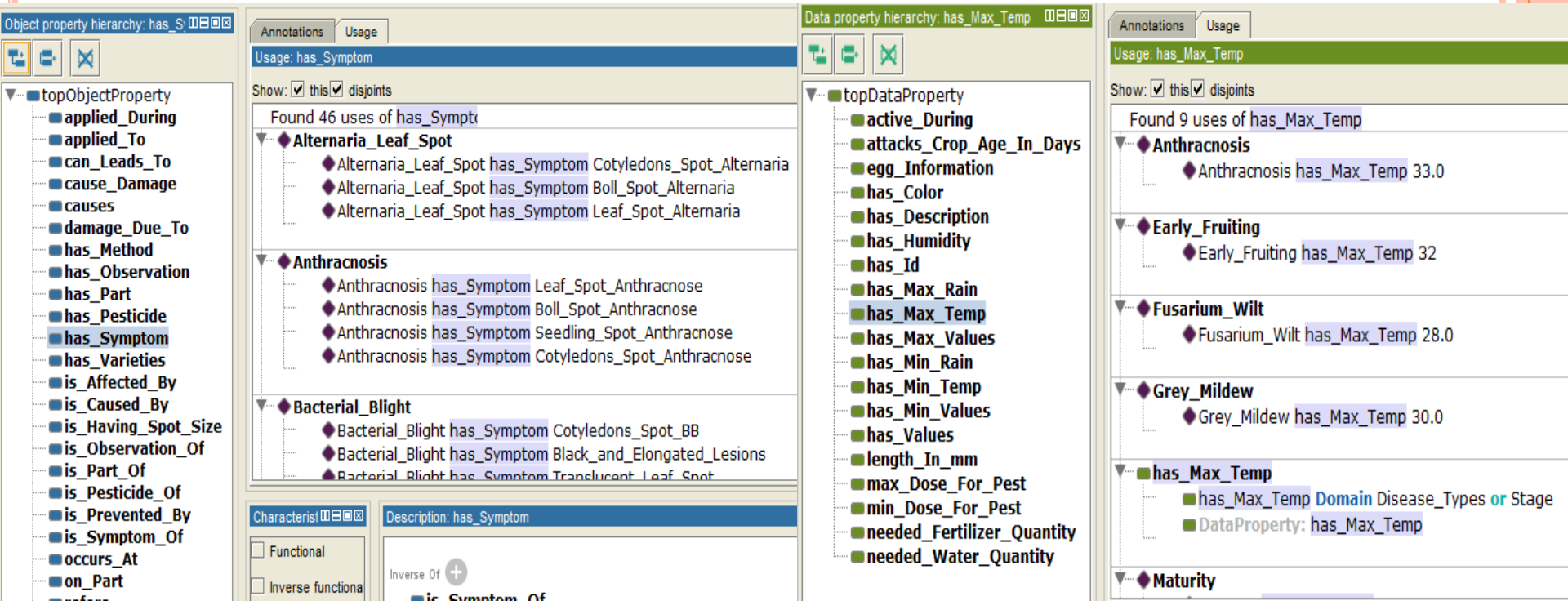
Ontology Components

- Individuals
  - Instances or objects of the classes
  - Object cab be concrete or abstract



Ontology Components

- Properties
  - Relationships between concepts.
  - Object Properties and Data Properties

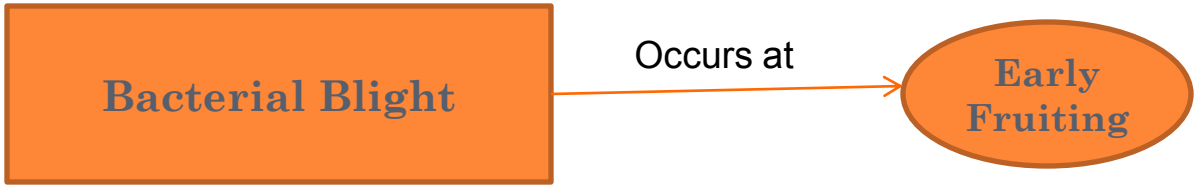


Triples

- A representation of ontological components

  Subject verb Object

- Example: Bacterial Blight occurs at Early Fruiting stage.



World without ontology = Ambiguity Example

- Ambiguity for computer

Rice?

- International Rice Research Institute
- Rice Research Program
- Rice Carrier Service Center
- Rice University

Cook?

- chef
- information about how to cook something,
- simply a place, person, business or some other entity with "cook" in its name.

Methodology for Ontology Development

1. Determine the domain and scope of the ontology
2. Consider reusing existing ontology
3. Enumerate important terms in ontology
4. Define the class and class hierarchy
5. Define the properties of classes
6. Define the values of the properties
7. Create Instances

Why Ontology ? [9]

- To share common understanding of the structure of information among people or software agents
- To enable reuse of domain knowledge
- To make domain assumptions explicit
- To separate domain knowledge from the operational knowledge
- To analyze domain knowledge

Ontology Development Tools [10]

- Protégé
- OntoEdit
- OilEd
- Neon
- Swoop

OWL

- Web Ontology Language
- Ontology is presented in OWL[5].
- Provides three sub languages: [7]
  - OWL Full
  - OWL DL
  - OWL Lite

Ontology Reasoning

- Reasoning process deduce inference from ontology
- Extracts implicitly facts from ontology given explicitly stated facts.
- Reasoning process can be done with help of reasoning tools.
- Reasoning Tools [8]
  - Pellet
  - Racer
  - KAON
  - Fact/Fact++
  - Jena
  - Ontolbroker

Reasoning Examples

- P is father of Q and Q is father of R then R is grandchild of P.
- Q is daughter then Q is female.
- A and B are equivalent $\Leftrightarrow A \subseteq B$ and $B \supseteq A$
- C and D are disjoint $\Leftrightarrow C \cap D \subseteq \emptyset$

SPARQL

- SPARQL[2] is used to access ontology data.
- It is a RDF query language and used to query on RDF data.
- SPARQL take the description of what the application wants, in the form of a query, and returns that information, in the form of a set of bindings or an RDF graph.[6]
- Syntax:

```
SELECT ?subject ?object
        WHERE {?subject rdfs:subClassOf ?object}
```

Database schema vs Ontology [11]

Database Schema	Ontology
• Focus on data • No Taxonomy • Querying, views • Simple and smaller	• Focus on meaning • Taxonomy is backbone • Infer new information • Larger and complex

References

[1] Tim Berners-Lee, James Hendler and OraLassila, "The Semantic Web," Scientific American, pp. 02, May 17, 2001.

[2] "SPARQL: SPARQL Protocol and Query Language for RDF," http://www.w3.org/TR/rdf-sparql-query/, June, 2014.

[3] "XML: Extensible Markup Language," http://www.w3.org/XML/, June, 2014.

[4] "RDF: Resource Description Framework," http://www.w3.org/RDF/, June, 2014.

[5] "OWL: Web Ontology Language," http://www.w3.org/2001/sw/wiki/OWL, June, 2014.

[6] http://jena.apache.org/tutorials/sparql.html.Copyright©2011-2013 TheApacheSoftwareFoundation,LicensedundertheApacheLicense,Version2.0.

[7] Matthew Horridge, Alan Rector, Robert Stevens, Chris Wroe, and HolgerKnublauch, ,Practical Guide To Building OWL Ontologies Using The Protg-OWL Plugin and CO-ODE Tools Edition 1.0,' The University Of Manchester and Stanford University, pp. 11, http://protege.stanford.edu, June 2014.

[8] Wolfgang Gassler, and Eva Zangerle, "Using Databases for Ontology Processing, Storage and Reasoning in Common and Mobile Environments," University Innsbruck, Institute of Computer Science Databases and Information Systems, pp. 09, 2006.

References

[9] Natalya F. Noy and Deborah L. McGuinness, ‚Ontology Development 101: A Guide to Creating Your First Ontology,‘ Stanford University, Stanford, CA, 94305, protege.stanford.edu, June 2014.

[10] Eliza Sachs, Jennifer Vendetti at stanford dot edu. Getting Started with Protg-Frames, June 6,2006. Page no. 4. The Protégé Project- http://protege.stanford.edu.

[11] Michael Uschold, Senior Ontology Consultant, Semantic Arts. https://www.slideshare.net/UscholdM/ontologies-and-db-schema-whats-the-difference

THANK YOU