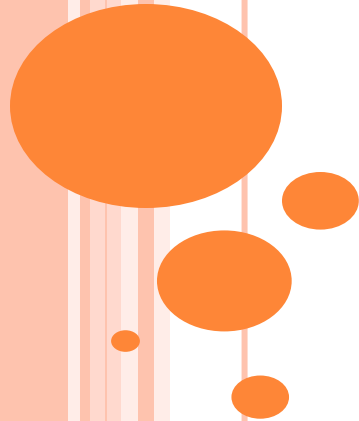


# KNOWLEDGE REPRESENTATION AND REASONING USING ONTOLOGY

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# 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

The screenshot displays an ontology editor interface with the following components:

- Navigation Tabs:** Active Ontology, Entities, Classes, Object Properties, Data Properties, Annotation Properties, Individuals, OWLViz, DL Query, OntoGraf, Ontology Differences, SPARQL Query.
- Class Hierarchy Panel:** Shows a tree structure starting with 'Thing' and including sub-classes like 'Climate', 'Disease', 'Pest', and 'Seed'. The 'Disease' class is expanded to show its sub-classes: 'Disease\_Causal\_Factors', 'Disease\_Observations', 'Disease\_Plant\_Parts', 'Disease\_Preventions', 'Disease\_Spots\_Size', 'Disease\_Symptoms', and 'Disease\_Types'.
- Annotations Panel:** Labeled 'Annotations' and 'Usage', it contains a section for 'Annotations' with a '+' icon.
- Description Panel:** Labeled 'Description', it lists various logical relationships with '+' icons: 'Equivalent To', 'Sub Class Of', 'Sub Class Of (Anonymous Ancestor)', 'Members', 'Target for Key', 'Disjoint With', and 'Disjoint Union Of'.



# ONTOLOGY COMPONENTS

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

The screenshot displays an ontology editor interface. On the left, a tree view shows a hierarchy of classes under 'Thing'. The 'Irrigation' class is expanded, showing its subclasses: 'Irrigation\_Intervals', 'Irrigation\_Methods', 'Irrigation\_Rates', and 'Irrigation\_Scheduling'. 'Irrigation\_Methods' is selected. On the right, the details panel for 'Irrigation\_Methods' is shown. It includes an 'Annotations' section with 'CN\_pl', 'Irrigation\_Methodses', 'CN\_sg', 'Irrigation\_Methods', and 'isDefinedBy [type: string]'. Below this is a 'Description: Irrigation\_Methods' section. The 'Equivalent To' section is empty. The 'Sub Class Of' section shows 'Irrigation' as a subclass. The 'Sub Class Of (Anonymous Ancestor)' section is empty. The 'Members' section lists several subclasses: 'Automatic\_Irrigation', 'Basin\_Irrigation', 'Border\_Irrigation', 'Capillary\_Irrigation', 'Flood\_Irrigation', 'Furrow\_Irrigation', 'Mist\_Irrigation', and 'Runoff\_Irrigation'.

**Class Hierarchy (Left Panel):**

- Thing
  - Climate
  - Climatic\_Requirements
  - Crop
  - Crop\_Management
  - Cropping\_Systems
  - Cultivation
  - Disease
  - Fertilizer
  - Harvesting
  - Irrigation
    - Irrigation\_Intervals
    - Irrigation\_Methods**
    - Irrigation\_Rates
    - Irrigation\_Scheduling
  - Pest
  - Pesticide
  - PostHarvestProcess
  - Seed
  - Soil
  - Sowing
  - Stage
  - Varieties
  - Weed

**Class Details (Right Panel):**

**Annotations:**

- CN\_pl
- Irrigation\_Methodses
- CN\_sg
- Irrigation\_Methods
- isDefinedBy [type: string]

**Description: Irrigation\_Methods**

**Equivalent To:**

- 

**Sub Class Of:**

- Irrigation**

**Sub Class Of (Anonymous Ancestor):**

- 

**Members:**

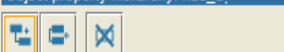
- Automatic\_Irrigation**
- Basin\_Irrigation**
- Border\_Irrigation**
- Capillary\_Irrigation**
- Flood\_Irrigation**
- Furrow\_Irrigation**
- Mist\_Irrigation**
- Runoff\_Irrigation**

# ONTOLOGY COMPONENTS

## ➤ Properties

- Relationships between concepts.
- Object Properties and Data Properties

Object property hierarchy: has\_Symptom



- topObjectProperty
  - applied\_During
  - applied\_To
  - can\_Leads\_To
  - cause\_Damage
  - causes
  - damage\_Due\_To
  - has\_Method
  - has\_Observation
  - has\_Part
  - has\_Pesticide
  - has\_Symptom
  - has\_Varieties
  - is\_Affected\_By
  - is\_Caused\_By
  - is\_Having\_Spot\_Size
  - is\_Observation\_Of
  - is\_Part\_Of
  - is\_Pesticide\_Of
  - is\_Prevented\_By
  - is\_Symptom\_Of
  - occurs\_At
  - on\_Part

Annotations Usage

Usage: has\_Symptom

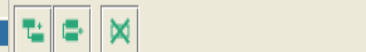
Show:  this  disjoints

- Found 46 uses of has\_Symptom
- Alternaria\_Leaf\_Spot
    - Alternaria\_Leaf\_Spot has\_Symptom Cotyledons\_Spot\_Alternaria
    - Alternaria\_Leaf\_Spot has\_Symptom Boll\_Spot\_Alternaria
    - Alternaria\_Leaf\_Spot has\_Symptom Leaf\_Spot\_Alternaria
  - Anthracnose
    - Anthracnose has\_Symptom Leaf\_Spot\_Anthracnose
    - Anthracnose has\_Symptom Boll\_Spot\_Anthracnose
    - Anthracnose has\_Symptom Seedling\_Spot\_Anthracnose
    - Anthracnose has\_Symptom Cotyledons\_Spot\_Anthracnose
  - Bacterial\_Blight
    - Bacterial\_Blight has\_Symptom Cotyledons\_Spot\_BB
    - Bacterial\_Blight has\_Symptom Black\_and\_Elongated\_Lesions
    - Bacterial\_Blight has\_Symptom Translucent\_Leaf\_Spot

Characteristics Description: has\_Symptom

- Functional
- Inverse functional
- Inverse Of +
- is\_Symptom\_Of

Data property hierarchy: has\_Max\_Temp



- topDataProperty
  - active\_During
  - attacks\_Crop\_Age\_In\_Days
  - egg\_Information
  - has\_Color
  - has\_Description
  - has\_Humidity
  - has\_Id
  - has\_Max\_Rain
  - has\_Max\_Temp
  - has\_Max\_Values
  - has\_Min\_Rain
  - has\_Min\_Temp
  - has\_Min\_Values
  - has\_Values
  - length\_In\_mm
  - max\_Dose\_For\_Pest
  - min\_Dose\_For\_Pest
  - needed\_Fertilizer\_Quantity
  - needed\_Water\_Quantity

Annotations Usage

Usage: has\_Max\_Temp

Show:  this  disjoints

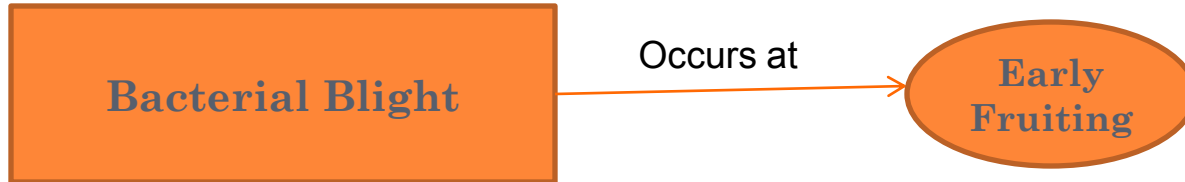
- Found 9 uses of has\_Max\_Temp
- Anthracnose
    - Anthracnose has\_Max\_Temp 33.0
  - Early\_Fruiting
    - Early\_Fruiting has\_Max\_Temp 32
  - Fusarium\_Wilt
    - Fusarium\_Wilt has\_Max\_Temp 28.0
  - Grey\_Mildew
    - Grey\_Mildew has\_Max\_Temp 30.0
  - has\_Max\_Temp
    - has\_Max\_Temp Domain Disease\_Types or Stage
    - DataProperty: has\_Max\_Temp
  - Maturity

# 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
<ul style="list-style-type: none"><li>• Focus on data</li><li>• No Taxonomy</li><li>• Querying, views</li><li>• Simple and smaller</li></ul>	<ul style="list-style-type: none"><li>• Focus on meaning</li><li>• Taxonomy is backbone</li><li>• Infer new information</li><li>• Larger and complex</li></ul>



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THANK YOU

