AI INSTITUTE #AIISC
UNIVERSITY OF SOUTH CAROLINA

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CSCE 771: Computer Processing of Natural Language
Lecture 14 and 15: Representation & Reasoning, Project Review

PROF. BIPLAV SRIVASTAVA, AI INSTITUTE

4TH AND 6TH OCTOBER, 2022

Carolinian Creed: "I will practice personal and academic integrity."

Acknowledgement: Used materials by NLTK, Russel & Norving, Khemani

Organization of Lecture 14 and 15

- Opening Segment
  - Quiz 2
- Main Lecture
- Concluding Segment
  - About Next Lecture – Lecture 16

Main Section

- Knowledge representation
- Project Review

Quiz 2

- Reduce and eliminate carelessness
- Examples
  - No one, apart from one, prefixed file name with their names
  - Some did not even write their names on their answers
  - Some wrote HW instead of Quiz
- Statistics
  - 14 received on time
  - Late submissions
    - 4 Within 1 hr of deadline - will get 50% credit only
    - 1 very late – will get 25% credit only
  - 3 did not submit
    - 1 given relief based on unique situation and submitted. No penalty

Attendance Policy

- Excused absence
  - Intended for health-based exceptions; also possible for unique situations
  - To be informed by noon of the day of class
- Unexcused absence
  - Any other reason
  - Excused and supposed to be attending online via Blackboard, but did not attend
  - Noted in https://docs.google.com/spreadsheets/d/1xBOs4loR_iagqzj6Eo4vrhpY3Mm1e_smXXN3Q8Q5vlg/edit?usp=sharing in column E
- Penalty: More than two unexcused absences will lead to a 10% penalty on cumulative score.

Class Etiquette and Professionalism

1. Come on time

- Coming late by more than 5 mins will be considered unexcused absence
- Exception: Taken prior permission

2. Do quality work

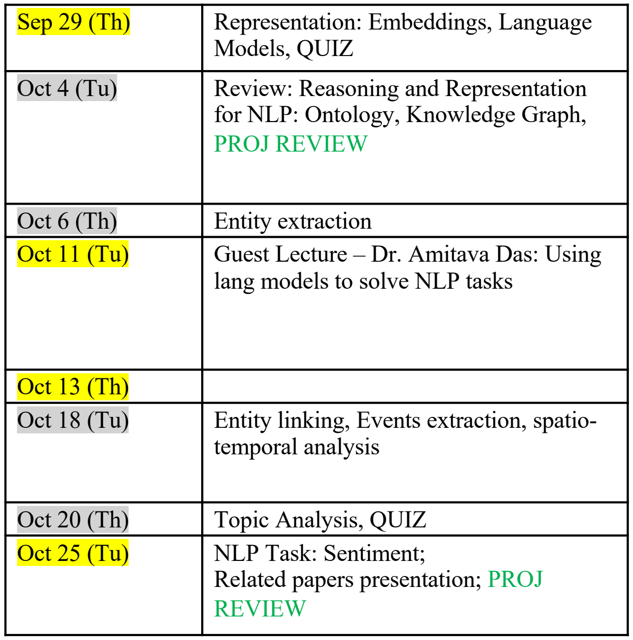
- Follow instructions for projects, quiz
- Do what you say; **running code says a thousand words**

3. Attend others project reviews

4. Honor code and plagiarism policy

- Go through: https://sc.edu/about/offices_and_divisions/student_conduct_and_academic_integrity/instructors/promoting_academic_integrity/index.php
- On **plagiarism**
  - Acknowledging / giving credits is essential when reusing material
  - Your work cannot be complete reuse by someone else; especially project
  - Will lead to being reported to corresponding office and a D or failed grade

Recent Classes



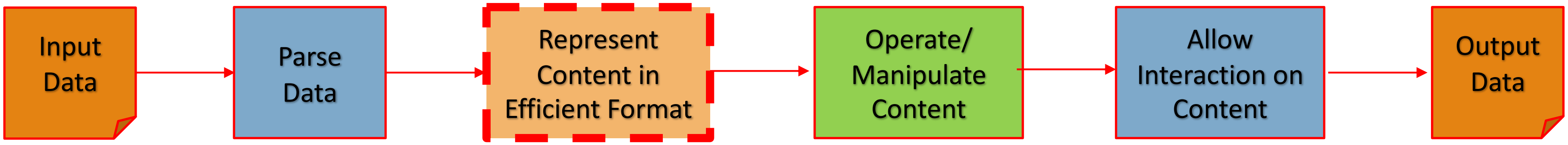
Sep 29 (Th)	Representation: Embeddings, Language Models, QUIZ
Oct 4 (Tu)	Review: Reasoning and Representation for NLP: Ontology, Knowledge Graph, PROJ REVIEW
Oct 6 (Th)	Entity extraction
Oct 11 (Tu)	Guest Lecture – Dr. Amitava Das: Using lang models to solve NLP tasks
Oct 13 (Th)	
Oct 18 (Tu)	Entity linking, Events extraction, spatio-temporal analysis
Oct 20 (Th)	Topic Analysis, QUIZ
Oct 25 (Tu)	NLP Task: Sentiment; Related papers presentation; PROJ REVIEW

Review of Lecture 13

- Word2Vec
- Glove
- Quiz 2

Main Lecture

Representation

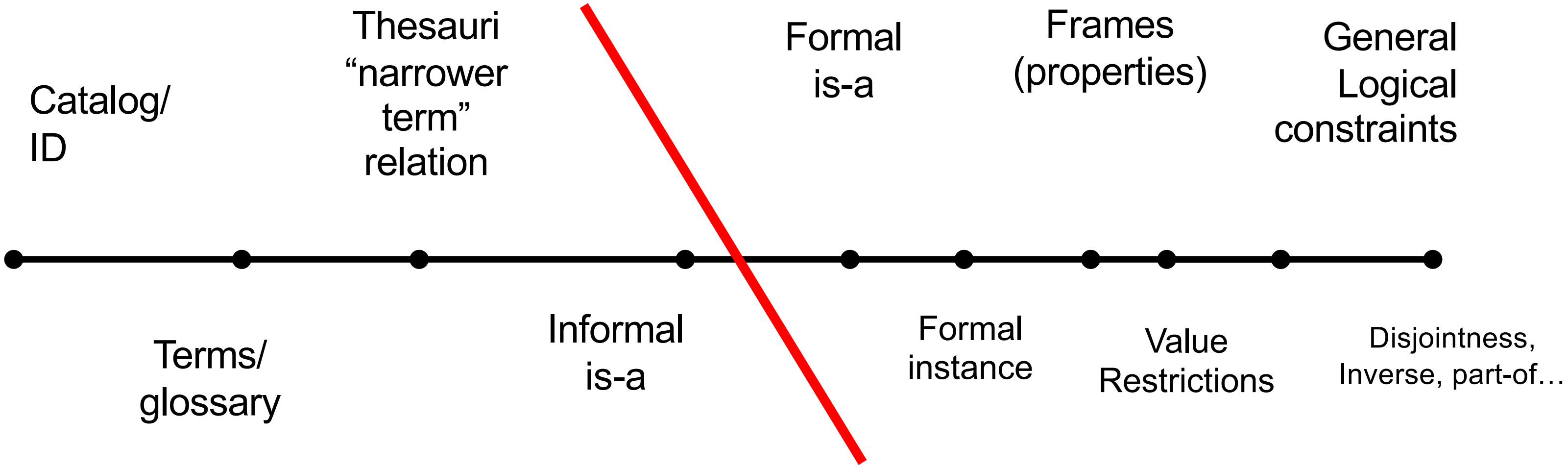

Input Data
Parse Data
Represent Content in Efficient Format
Operate/ Manipulate Content
Allow Interaction on Content
Output Data

Formalizing Knowledge in an Ontology

Sources:
Achille Fokoue, Anastasios Kementsietsidis Tutorial
SCRIBE presentation by Rosario Usceda Sosa, Biplav Srivastava, Bob Schloss

- https://github.com/rschloss/ismp ,
- https://researcher.watson.ibm.com/researcher/view_group.php?id=2505

What is an Ontology?

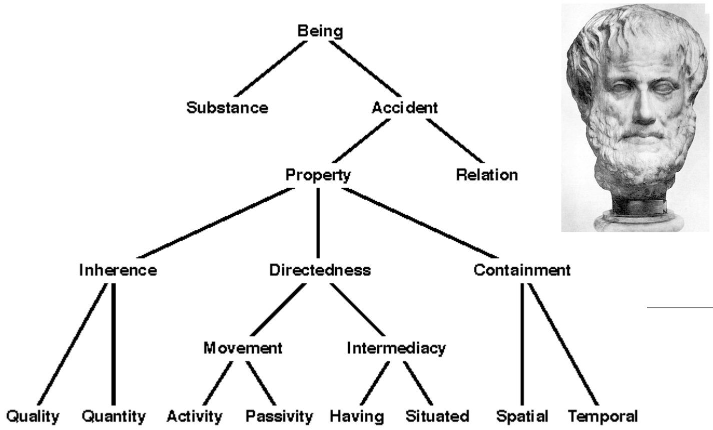


- Ontologies for information fusion, McGuinness, 2003
- Ontologies Come of Age – McGuinness, 2003, http://www.ksl.stanford.edu/people/dlm/papers/ontologies-come-of-age-mit-press-(with-citation).htm
- https://www.mkbergman.com/1842/conceptual-and-practical-distinctions-in-the-attributes-ontology/

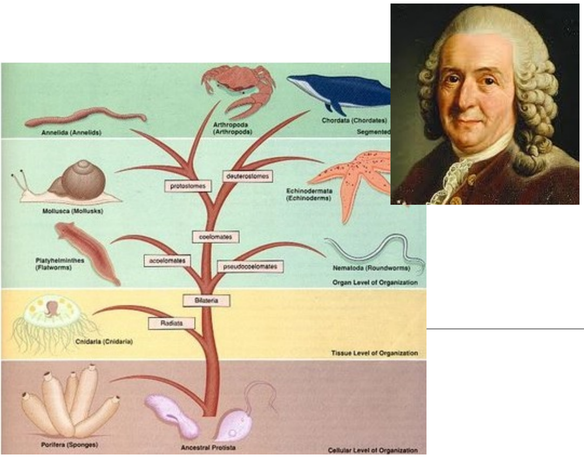
What is an ontology?

In Computer Science, “An ontology is a formal explicit description of concepts in a domain of discourse (**classes** (sometimes called concepts)), **properties** of each concept describing various features and **attributes** of the concept (slots (sometimes called roles or properties)), and **restrictions** on slots (facets (sometimes called role restrictions)). An ontology together with a set of individual instances of classes constitutes a knowledge base. In reality, there is a fine line where the ontology ends and the knowledge base begins.” [Noy, 2000]

Not to be confused with ontologies (and/or taxonomies) in Philosophy or Life Sciences



Being
Substance
Accident
Property
Relation
Inherence
Directedness
Containment
Movement
Intermediacy
Quality
Quantity
Activity
Passivity
Having
Situated
Spatial
Temporal



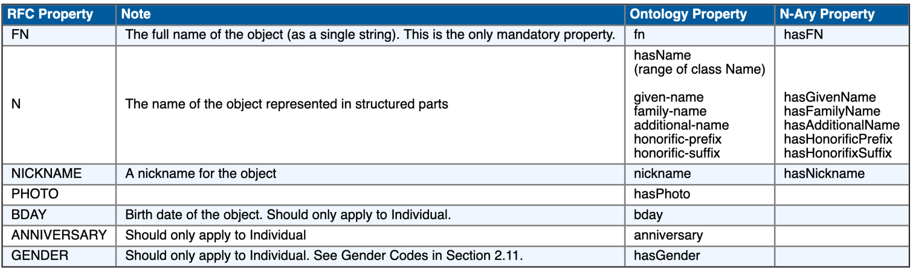
Ontology = Class + Relations + Constraints

Knowledge Base = Ontology + instances + (Standard) Inference and rules

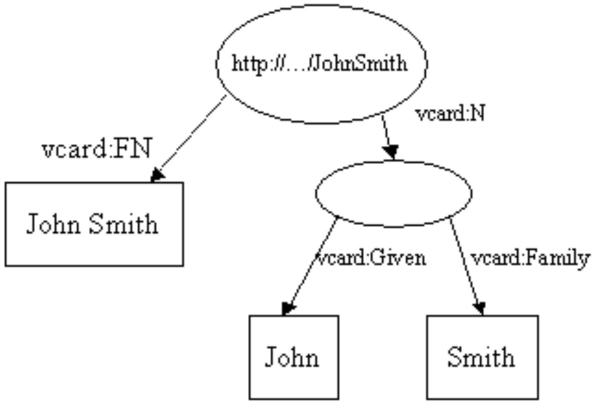
Slide courtesy: Rosario Usceda-Sosa

RDF / Turtle Example

vcard: https://www.w3.org/TR/vcard-rdf/



RFC Property	Note	Ontology Property	N-Ary Property
FN	The full name of the object (as a single string). This is the only mandatory property.	fn	hasFN
N	The name of the object represented in structured parts	hasName (range of class Name) given-name family-name additional-name honorific-prefix honorific-suffix	hasGivenName hasFamilyName hasAdditionalName hasHonorificPrefix hasHonorifixSuffix
NICKNAME	A nickname for the object	nickname	hasNickname
PHOTO		hasPhoto	
BDAY	Birth date of the object. Should only apply to Individual.	bday	
ANNIVERSARY	Should only apply to Individual	anniversary	
GENDER	Should only apply to Individual. See Gender Codes in Section 2.11.	hasGender	



```
---- Turtle ----
<http://somewhere/JohnSmith>
     <http://www.w3.org/2001/vcard-rdf/3.0#FN>
            "John Smith" ;
     <http://www.w3.org/2001/vcard-rdf/3.0#N>
            [ <http://www.w3.org/2001/vcard-
      rdf/3.0#Family>
                      "Smith" ;
             <http://www.w3.org/2001/vcard-
      rdf/3.0#Given>
                      "John"
            ] .
```

```
<rdf:RDF
   xmlns:rdf="http://www.w3.org/1999/02/22-rdf-
 syntax-ns#"
   xmlns:vcard="http://www.w3.org/2001/vcard-
 rdf/3.0#" >
  <rdf:Description rdf:nodeID="A0">
   <vcard:Given>John</vcard:Given>
   <vcard:Family>Smith</vcard:Family>
  </rdf:Description>
  <rdf:Description
 rdf:about="http://somewhere/JohnSmith">
   <vcard:FN>John Smith</vcard:FN>
   <vcard:N rdf:nodeID="A0"/>
  </rdf:Description>
</rdf:RDF>
```

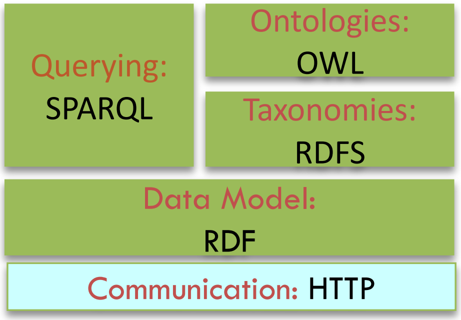
OWL extends RDF…

RDF-schema
- Class, subclass
- Property, subproperty

+ Restrictions
- Range, domain
- Local, global
- Existential
- Cardinality

+ Combinators
- Union, Intersection
- Complement
- Symmetric, transitive

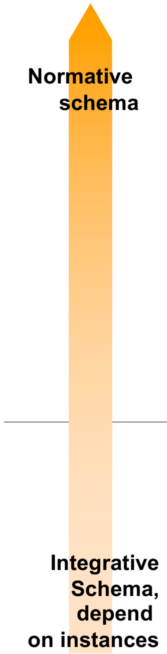
+ Mapping
- Equivalence
- Inverse



Source: Achille Fokoue, Anastasios Kementsietsidis Tutorial

Not all ontologies are created equal

In practice, ontologies are used, together with inferencing engines and rules, for a variety of purposes. If we think of them as schemas, there are different ways

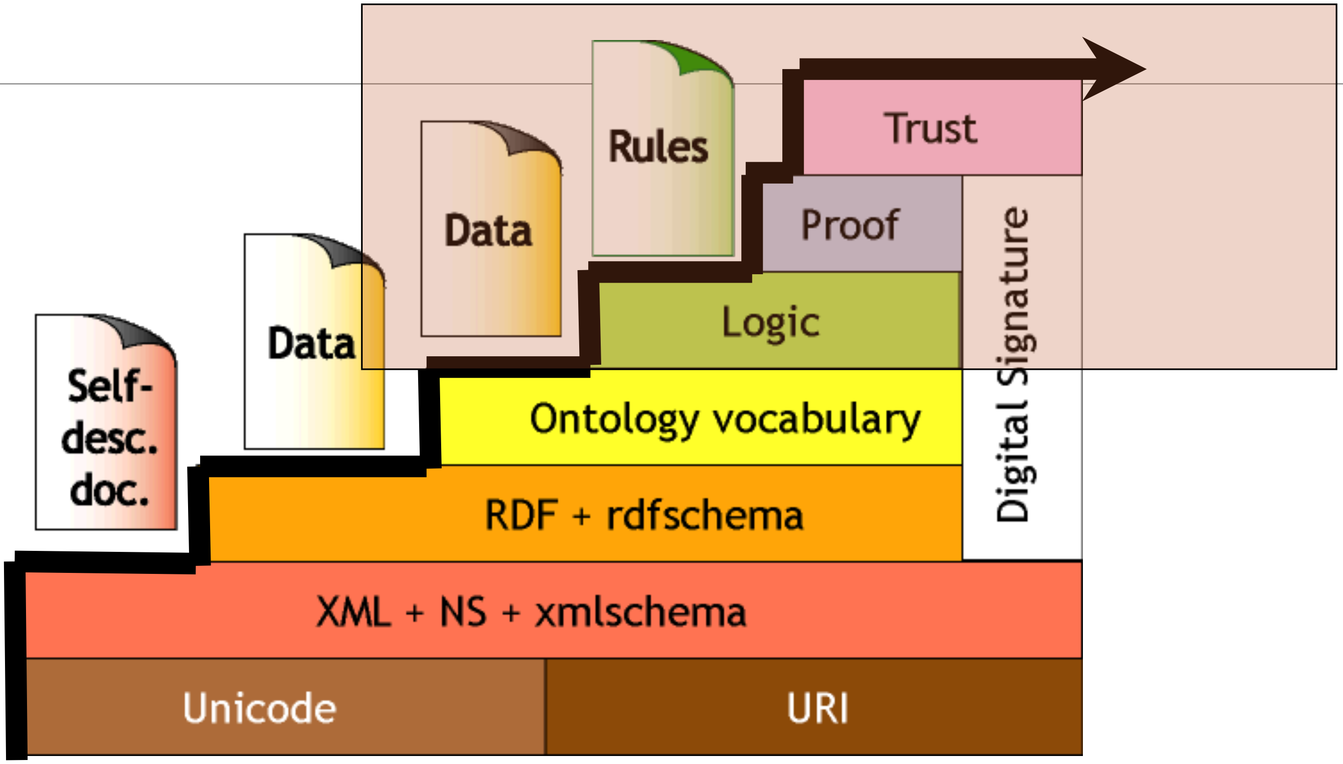


	Purpose	Instances	Inferencing	Examples
As a deductive system	Deductive System (axioms + deductive rules)	Part of the knowledge base	Defined by rules.	Expert systems, Planning, Optimization.
As a data blueprint	Constrain a domain	Must conform to the normative schema determined by the ontology	Subsumption, class inferencing	Biomedical and life sciences (FMA, Radlex)
As a data classifier	Classify open data	Unknown formats	Subsumption, class inferencing	Tag ontologies (MOAT, Echarte, SCOT, NAO, etc.)
As a data integrator	Integrating pre-defined model to existing data sources	Instances are mapped, no constraint enforcement.	Subsumption, class, entity inferencing	**SCRIBE**
As data mapping vocabulary	Mapping to/from existing data sources	Mined instances determine the ontology/schema.	Subsumption, class inferencing	D2RQ (a tool)

SCRIBE belongs to the **fourth** category: It has no constraints and was designed to support the programming of tools that allow domain experts to deal with entities natural to them (even if the recorded data is actually distributed).

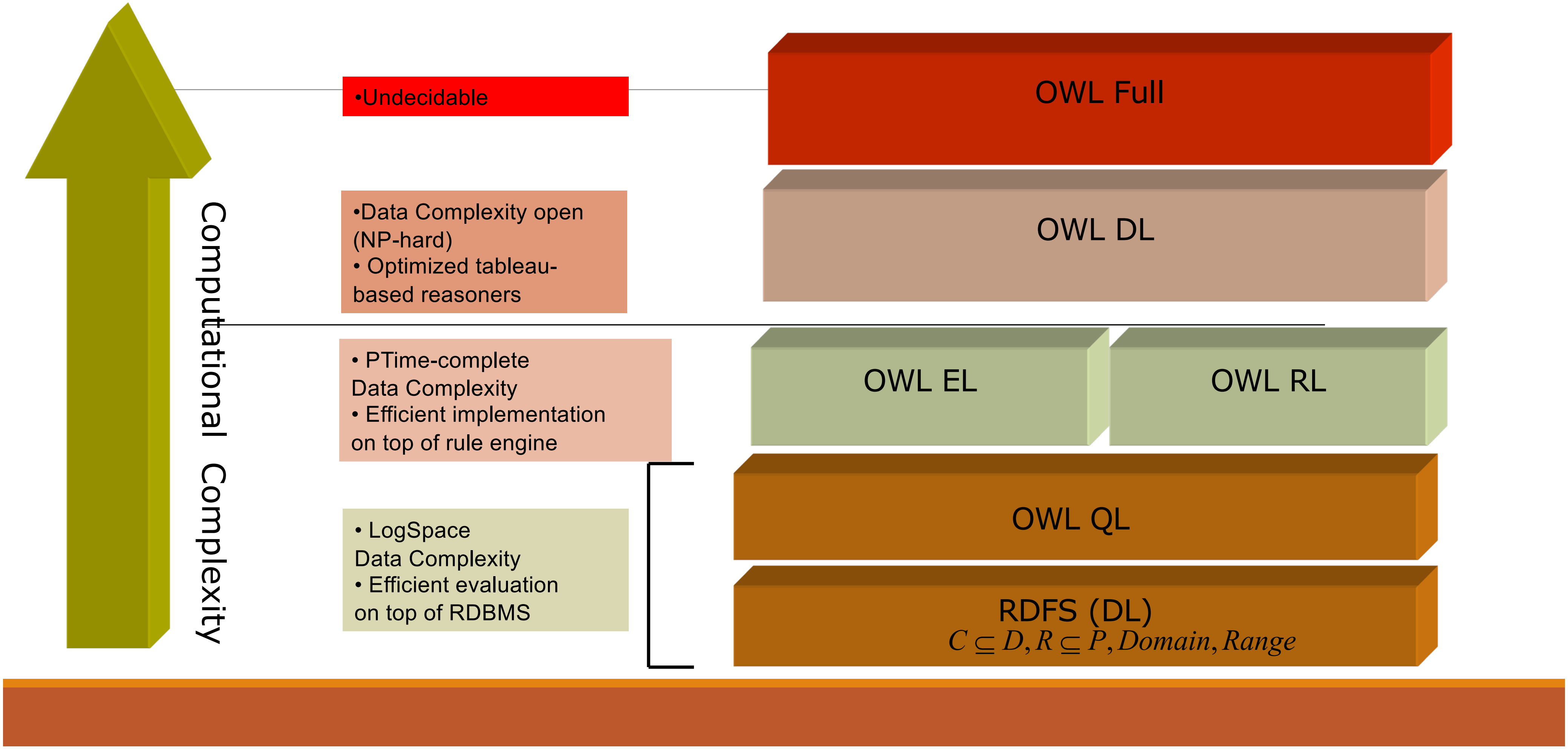
https://github.com/rschloss/ismp

Moving to the futureof the web



Semantic Web LayerCake (Berners-Lee, 99;Swartz-Hendler, 2001)

Challenge of Reasoning on Ontologies



Computational Complexity

•Undecidable

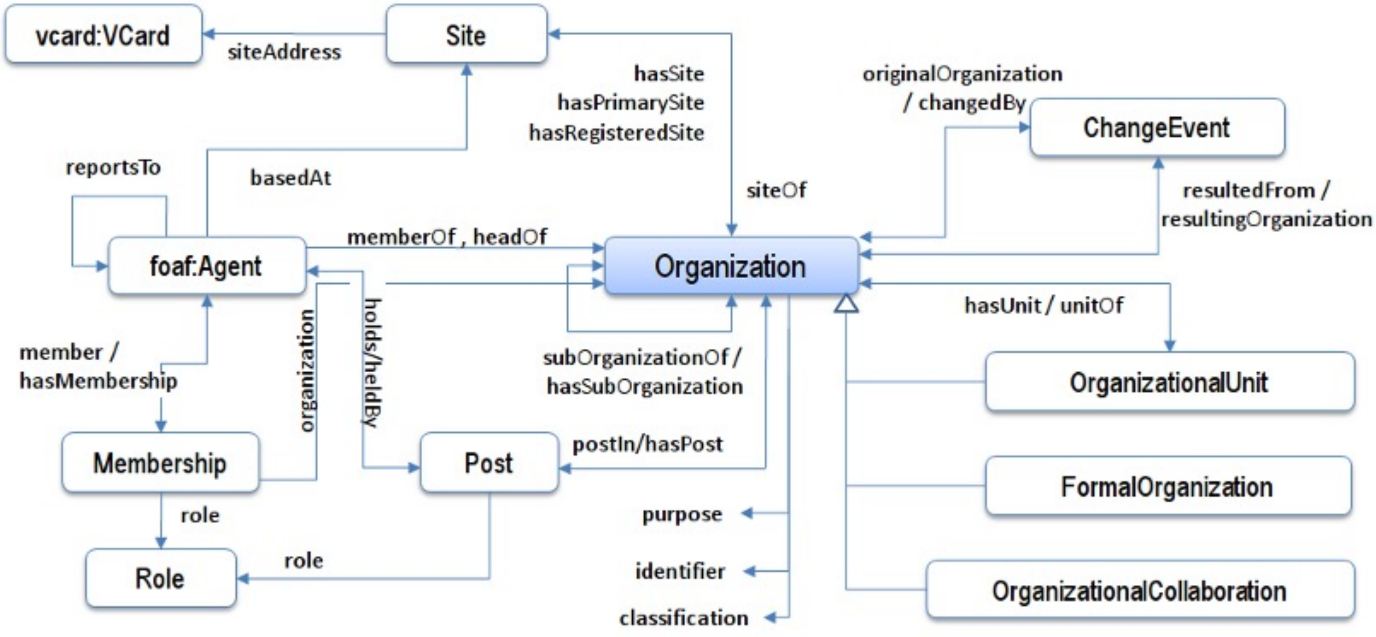
•Data Complexity open (NP-hard)
• Optimized tableau-based reasoners

• PTime-complete Data Complexity
• Efficient implementation on top of rule engine

• LogSpace Data Complexity
• Efficient evaluation on top of RDBMS

$C \subseteq D, R \subseteq P, Domain, Range$

Larger Example: Organization Ontology



Ontology description: http://www.w3.org/TR/vocab-org/

Ontology: http://www.w3.org/ns/org.ttl

Larger Ontology

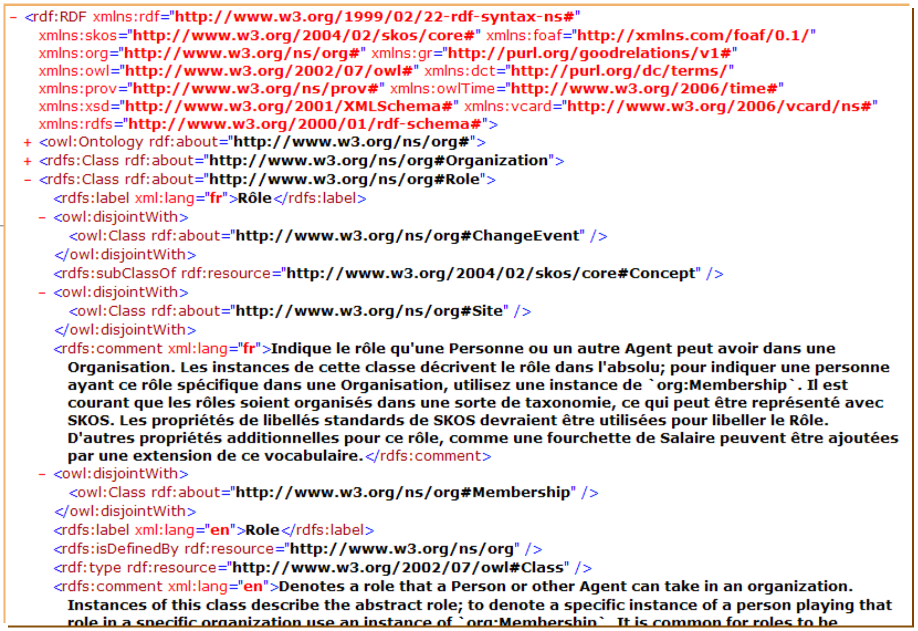
```
@prefix rdf:        <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs:       <http://www.w3.org/2000/01/rdf-schema#> .
@prefix owl:        <http://www.w3.org/2002/07/owl#> .
@prefix xsd:        <http://www.w3.org/2001/XMLSchema#> .
@prefix skos:       <http://www.w3.org/2004/02/skos/core#> .
@prefix foaf:       <http://xmlns.com/foaf/0.1/> .
…
@prefix :           <http://www.w3.org/ns/org#> .

# -- Meta data -----------------------------------------------------------

<http://www.w3.org/ns/org#>
    a owl:Ontology;
    owl:versionInfo "0.7";
    rdfs:label "Core organization ontology"@en;
    rdfs:comment "Vocabulary for describing organizational structures,
specializable to a broad variety of types of organization."@en;
    dct:created "2010-05-28"^^xsd:date;
    dct:modified "2010-06-09"^^xsd:date;
    dct:modified "2010-10-08"^^xsd:date;
…
    rdfs:seeAlso <http://www.w3.org/TR/vocab-org/> ;
    .

# -- Organizational structure -------------------------------------------------
----------

org:Organization a owl:Class, rdfs:Class;
    rdfs:subClassOf  foaf:Agent;
    owl:equivalentClass foaf:Organization;
    rdfs:label "Organization"@en;
    rdfs:label "Organisation"@fr;
    owl:hasKey (org:identifier) ;
    rdfs:comment """Represents a collection of people organized together into a
community or other social, commercial or political structure. … Alternative
names: _Collective_ _Body_ _Org_ _Group_"""@en;
    rdfs:comment """Représente un groupe de personnes organisées en communauté
où tout autre forme de structure sociale, commerciale ou politique. … code
provenant d'une liste de code."""@fr;
    rdfs:isDefinedBy <http://www.w3.org/ns/org> ;
    .
```



```
- <rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:skos="http://www.w3.org/2004/02/skos/core#" xmlns:foaf="http://xmlns.com/foaf/0.1/"
    xmlns:org="http://www.w3.org/ns/org#" xmlns:gr="http://purl.org/goodrelations/v1#"
    xmlns:owl="http://www.w3.org/2002/07/owl#" xmlns:dct="http://purl.org/dc/terms/"
    xmlns:prov="http://www.w3.org/ns/prov#" xmlns:owlTime="http://www.w3.org/2006/time#"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema#" xmlns:vcard="http://www.w3.org/2006/vcard/ns#"
    xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#">
  + <owl:Ontology rdf:about="http://www.w3.org/ns/org#">
  + <rdfs:Class rdf:about="http://www.w3.org/ns/org#Organization">
  - <rdfs:Class rdf:about="http://www.w3.org/ns/org#Role">
      <rdfs:label xml:lang="fr">Rôle</rdfs:label>
    - <owl:disjointWith>
        <owl:Class rdf:about="http://www.w3.org/ns/org#ChangeEvent" />
      </owl:disjointWith>
      <rdfs:subClassOf rdf:resource="http://www.w3.org/2004/02/skos/core#Concept" />
    - <owl:disjointWith>
        <owl:Class rdf:about="http://www.w3.org/ns/org#Site" />
      </owl:disjointWith>
      <rdfs:comment xml:lang="fr">Indique le rôle qu'une Personne ou un autre Agent peut avoir dans une
        Organisation. Les instances de cette classe décrivent le rôle dans l'absolu; pour indiquer une personne
        ayant ce rôle spécifique dans une Organisation, utilisez une instance de `org:Membership`. Il est
        courant que les rôles soient organisés dans une sorte de taxonomie, ce qui peut être représenté avec
        SKOS. Les propriétés de libellés standards de SKOS devraient être utilisées pour libeller le Rôle.
        D'autres propriétés additionnelles pour ce rôle, comme une fourchette de Salaire peuvent être ajoutées
        par une extension de ce vocabulaire.</rdfs:comment>
    - <owl:disjointWith>
        <owl:Class rdf:about="http://www.w3.org/ns/org#Membership" />
      </owl:disjointWith>
      <rdfs:label xml:lang="en">Role</rdfs:label>
      <rdfs:isDefinedBy rdf:resource="http://www.w3.org/ns/org" />
      <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#Class" />
      <rdfs:comment xml:lang="en">Denotes a role that a Person or other Agent can take in an organization.
        Instances of this class describe the abstract role; to denote a specific instance of a person playing that
        role in a specific organization use an instance of `org:Membership`. It is common for roles to be
```

http://www.w3.org/ns/org

http://www.w3.org/ns/org.ttl

What makes a good ontology for data integration?

Human Usability

Communicable. Naming, natural language support, etc.

Concise. A simple way to describe the key entities of the model and yet able to infer many facts

Consistent. Naming conventions and modeling patterns

Authoritative to domain experts

Documented, not just descriptions, but also provenance

Managed and maintained by people throughout the model lifecycle.

Reusable in similar domains, for similar instances.

System Usability

Scalable so large amounts of data can be parsed, stored and retrieved.

Efficient query and inferencing

Programmable solutions, both in open and closed data paradigms.

Open infrastructure and tools

- ***Formal*** *representation of* ***knowledge*** *in a particular domain*
- *Formally defines key* ***concepts*** *and* ***relations*** *in the domain*
- *Specifies relationships between those key concepts and relations*
- *Supports* ***automated reasoning*** *about entities in the domain*

A *good* ontology is a *useful* ontology, an ontology that *both* humans and systems can process.

Slide courtesy: Rosario Usceda-Sosa

Using Ontology

- Visually via tools like Protégé - https://protege.stanford.edu/
- Programmatically with APIs like
  - Jena (Java) - https://jena.apache.org/documentation/ontology/
  - OwlReady2 (Python) - https://bitbucket.org/jibalamy/owlready2/src/master/
  - Rdflib (Python) - https://github.com/RDFLib/OWL-RL
- A compendium of resources - https://github.com/totogo/awesome-knowledge-graph

Code Illustration - 1

Using RDF

On Github:
https://github.com/biplav-s/course-nl/blob/master/l11-ontology/Exploring%20ontologies.ipynb

Code Illustration - 2

Using ConceptNet

- FAQ: https://github.com/commonsense/conceptnet5/wiki/FAQ

On Github:
https://github.com/biplav-s/course-nl/blob/master/l11-ontology/Explore%20Conceptnet.ipynb

Project Review

Project Update Presentations

- W1 - Sep 26
- W2 – Oct 3
  - **Review presentation for class: 3 min each – Oct 4, 2022**
- W3 – Oct 10
- W4 – Oct 17
- W5 – Oct 24
  - **Review presentation for class: 3 min each – Oct 27, 2022**
- W6 – Oct 31
- W7 – Nov 7
- W8 – Nov 14
- W9 – Nov 21

Milestones

- Penalty: **not** ready by Sep 15, 2022 **[-20%]**
- Project report **not** ready by Nov 10, 2022 **[-20%]**
- Project presentations **not** ready by Nov 15, 2022 **[-10%]**

Format for Review Presentation Slide (2 mins)

- Project Name
- Problem
- Approach
- Status (based on your project plan)
- Comment:
  - Challenges faced
  - Need help

Test Case – *how will your program be run*

- Input
- Output
- Assumptions

Lecture 14 and 15: Concluding Comments

- We looked at ontology and knowledge graphs
- Connected it with reasoning capabilities provided
- Reviewed project status

Concluding Segment

About Next Lecture – Lecture 16

Lecture 16 Outline

- Invited Talk by Dr. Amitava Das
  - Representational Learning - Transformers