Semantic Technology

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December 12, 2012

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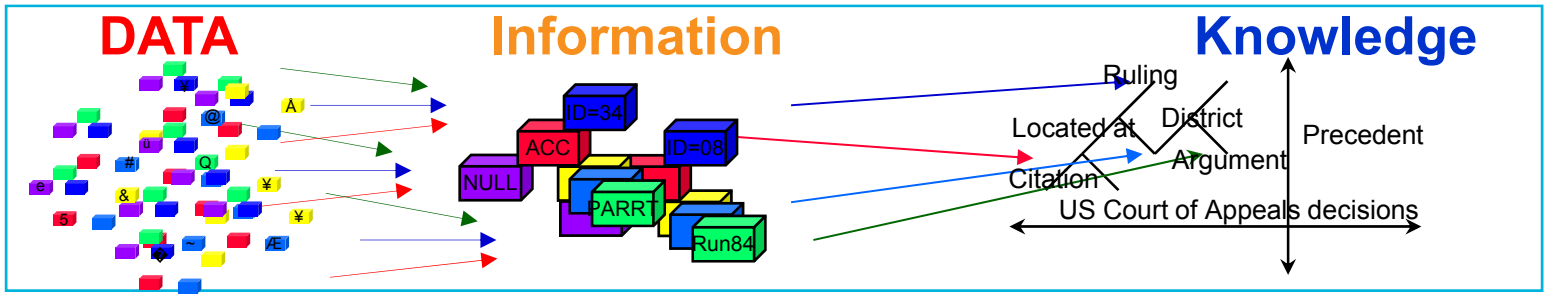
Towards Solving the Problem

- With the increasing complexity of our systems and our IT needs, we need to go to human level interaction
- We need to maximize the amount of Semantics we can utilize
- From data and information level, we need to go to human *semantic* level interaction



Noise → Human Meaning

- Semantic integration: Semantic technology is the key!

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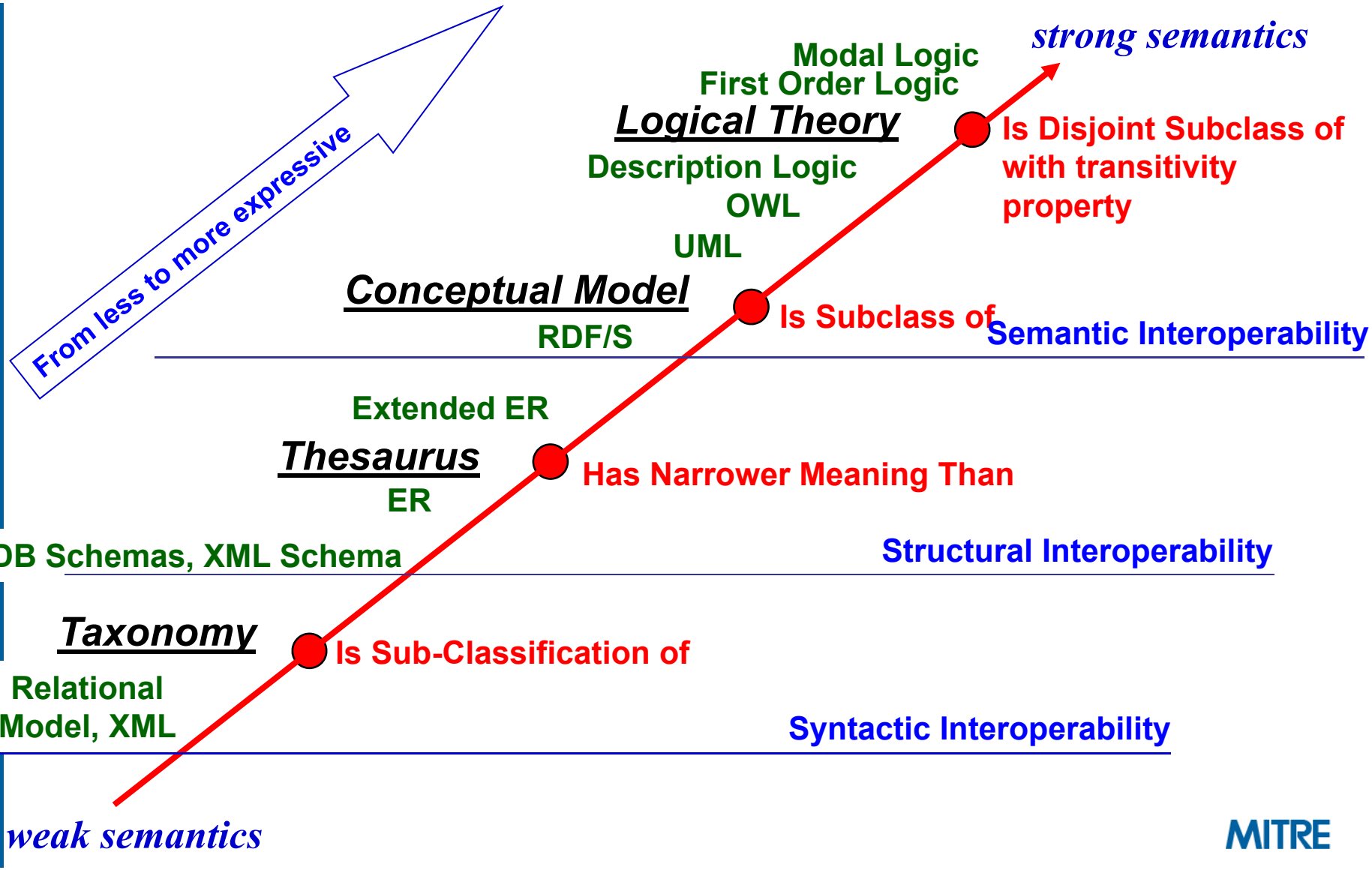
Premise & Promise

- **Semantic technologies can enrich search, discovery, navigation**
  - Applies to: data integration, social networking, intelligence analytics, situational awareness, etc.
  - Many emerging tools, existing and emerging semantic models, patterns, etc.
- **Application of semantic technologies to search, discovery, & navigation, by adding semantics to raw data, will provide:**
  - Finer grained search and navigation
  - Richer results in discovery, finding people and communities
  - Traversal of complex social and information relationships
  - Entity disambiguation and correlation; identity management
- **Humans have complex semantics, in both language, mental models**
  - We can't duplicate that fidelity, granularity, complexity, intent, context of usage
- **But semantic search can discover, develop, deploy, disseminate**
  - More complex patterns of relationships
  - Semantic engines can better use those patterns

Ontology Spectrum: The Range of Semantic Models



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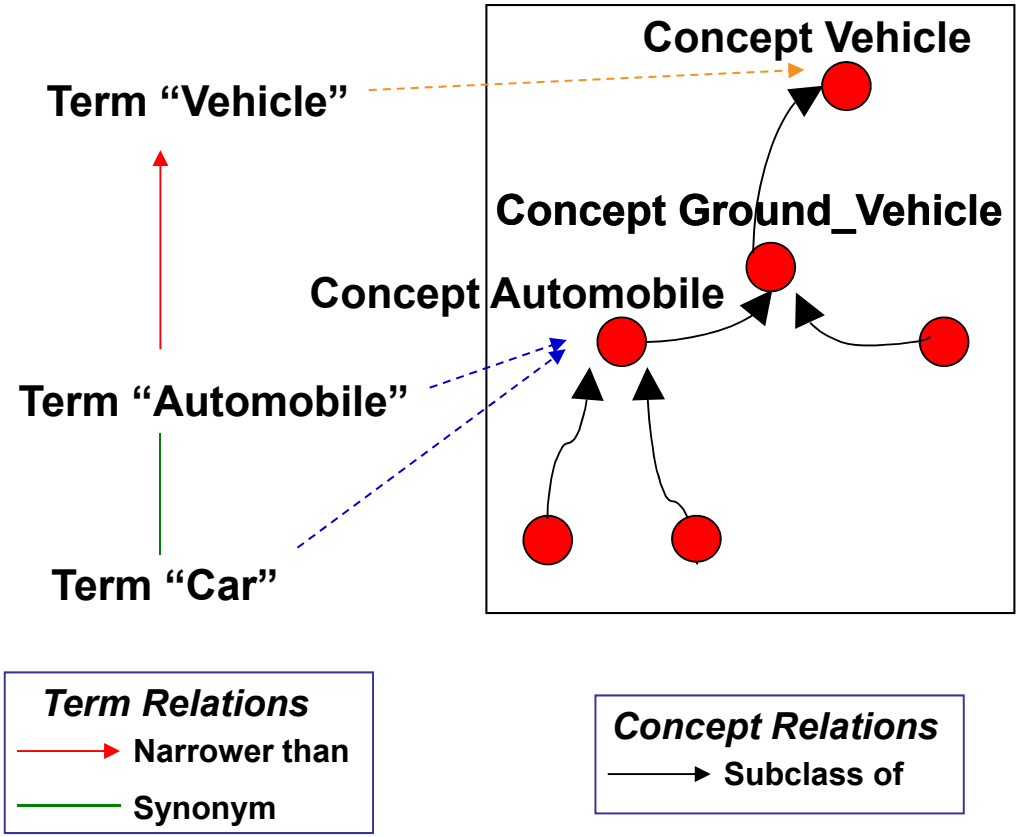
Ontology & Ontologies

- **An ontology defines the terms used to describe and represent an area of knowledge (subject matter)**
  - An ontology also is the model (set of concepts) for the meaning of those terms
  - An ontology thus defines the vocabulary and the meaning of that vocabulary
- **Ontologies are used by people, databases, and applications that need to share domain information**
  - Domain: a specific subject area or area of knowledge, like medicine, tool manufacturing, real estate, automobile repair, financial management, etc.
- **Ontologies include computer-usable definitions of basic concepts in the domain and the relationships among them**
  - They encode domain knowledge (modular)
  - Knowledge that spans domains (composable)
  - Make knowledge available (reusable)

Term vs. Concept

- **Term (terminology):**
  - Natural language words or phrases that act as indices to the underlying meaning, i.e., the concept (or composition of concepts)
  - The syntax (e.g., string) that stands in for or is used to indicate the semantics (meaning)
- **Concept (ontology):**
  - A unit of semantics (meaning), the node (entity) or link (relation) in the mental or knowledge representation model



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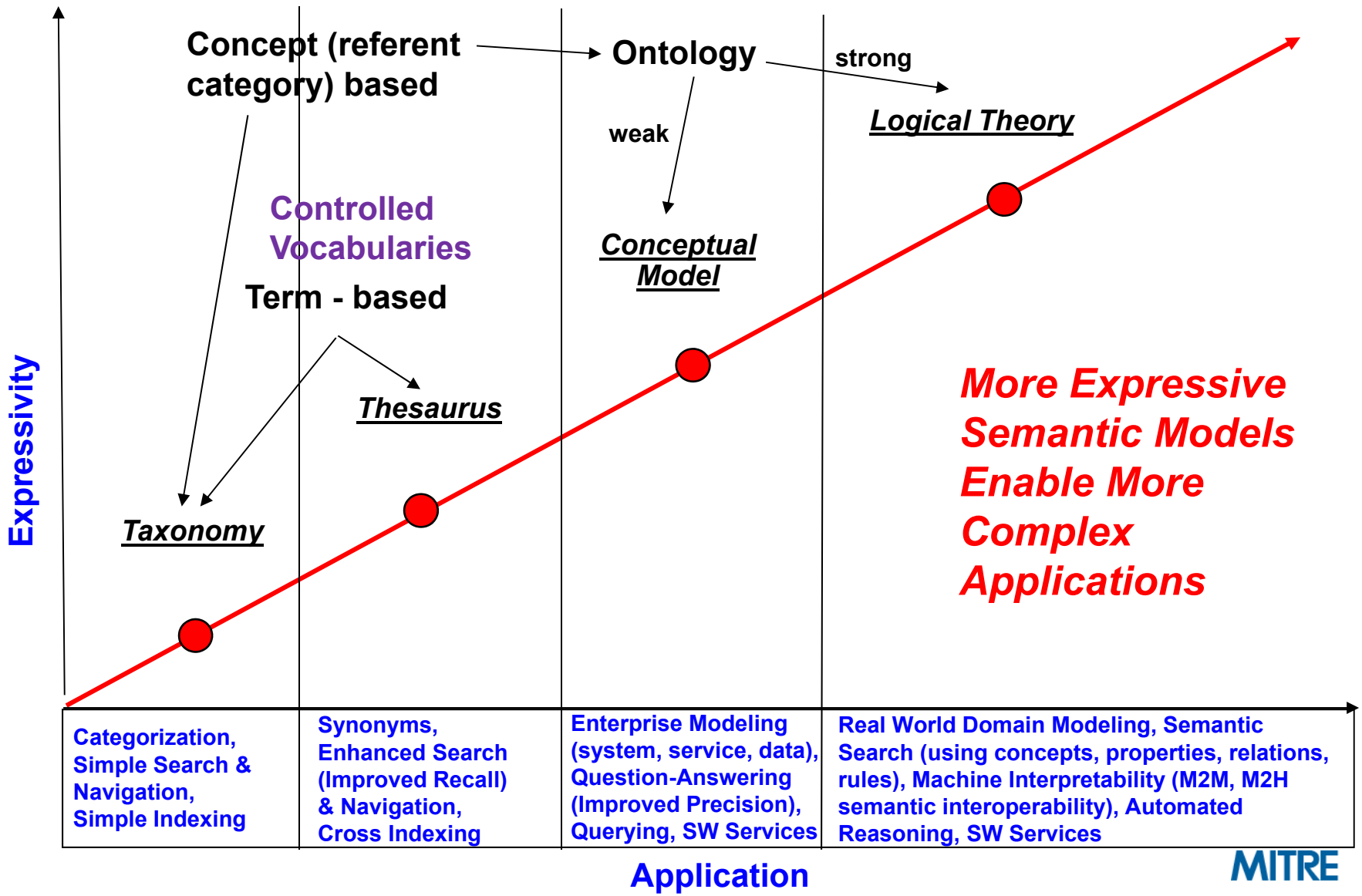
Ontology Spectrum: Application



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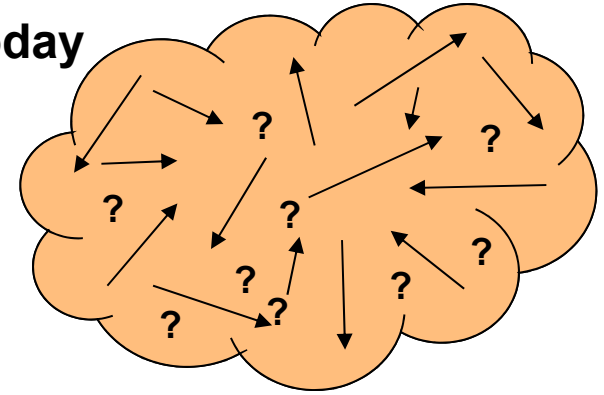
The Semantic Web

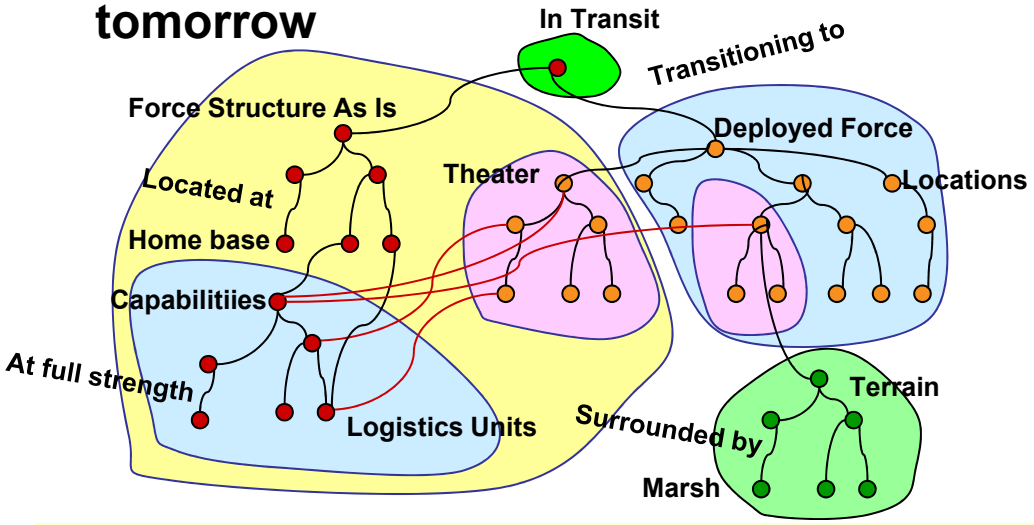
- Current Web is a collection of links and resources
  - Is syntactic & structural only
  - Excludes semantic interoperability at high levels.
  - Google of today is string based (keyword) & has no notion of the semantics (meaning) of your query
- Semantic Web extends the Current Web so information is given well-defined meaning
  - Enables semantic interoperability at high levels
  - Google Knowledge Graph is more semantic
  - Able to evaluate knowledge in context

Web today



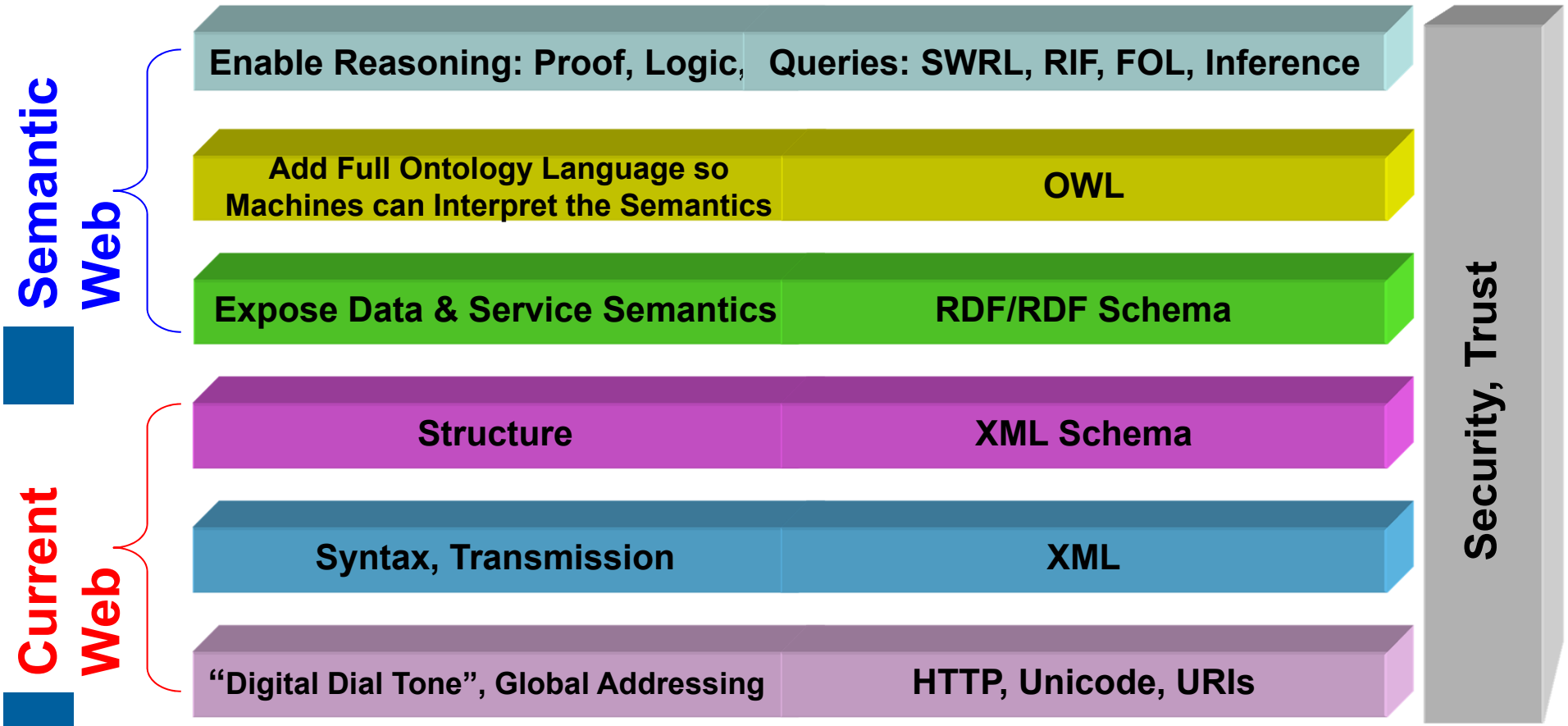
Humans have to do the understanding

Semantic Web tomorrow



Machines partially interpret what humans mean

Semantic Web: Another View



- Anyone, anywhere can add to an evolving, decentralized "global database"
- Explicit semantics enable looser coupling, flexible composition of services and data

OWL 2 (1)

- **OWL 2 is a W3C Recommendation (27 Oct 2009)***
- **Compatible with OWL 1 (04 Feb 2004)**
- **New features**
  - Increased datatype coverage: Designed to take advantage of the new datatypes and clearer explanations available in XSD 1.1 (a recommendation 05 Apr 2012)
  - Syntactic Sugar for more easily saying things in OWL:
  - New constructs that increase expressivity
  - Simple meta-modeling capabilities
  - Extended annotation capabilities
  - Profiles

* http://www.w3.org/TR/owl2-new-features//

OWL 2 (2)

- **Syntactic Sugar for more easily saying things in OWL:**
  - DisjointUnion:
    - DisjointUnion(:CarDoor :FrontDoor :RearDoor :TrunkDoor) : A :CarDoor is exclusively either a :FrontDoor, a :RearDoor or a:TrunkDoor and not more than one of them.
  - DisjointClasses
    - DisjointClasses(:LeftLung :RightLung) : Nothing can be both a :LeftLung and a :RightLung.
  - NegativeObject(Data)PropertyAssertion
    - NegativeObjectPropertyAssertion(:livesIn :ThisPatient :IleDeFrance) :ThisPatient does not live in the :IleDeFrance region.
  - Self-restriction on Properties: “local reflexivity”
    - SubClassOf(:AutoRegulatingProcess ObjectHasSelf(:regulate)): Auto-regulating processes regulate themselves.
  - Property Qualified Cardinality Restrictions: counted cardinality restrictions (Min, Max, Exact)
    - ObjectMaxCardinality(3 :boundTo :Hydrogen): Class of objects bound to at most three different :Hydrogen
  - Many others

OWL 2 (3)

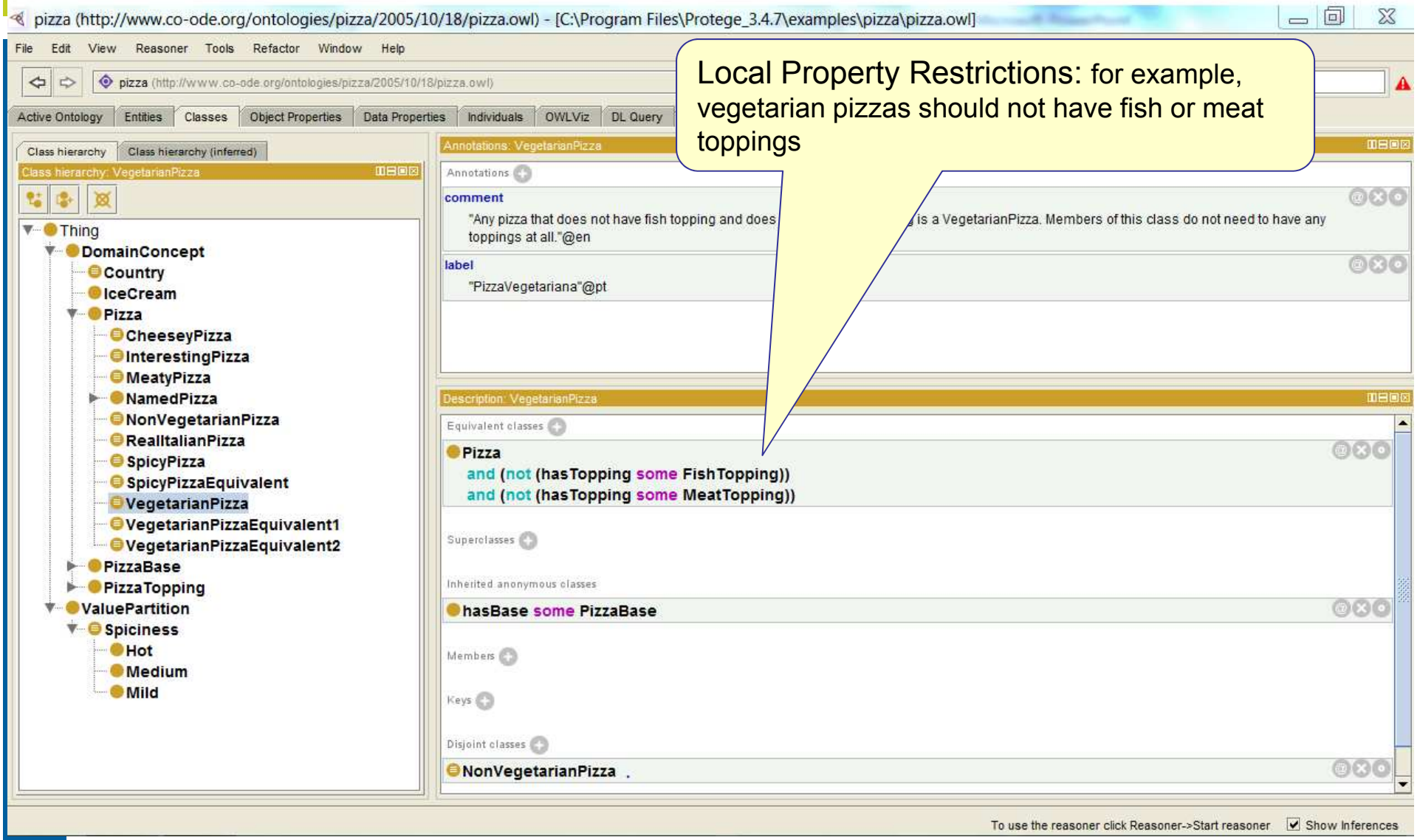
- **Simple meta-modeling capabilities:**
  - Punning: allows different uses of the same term and an individual
  - OWL 2 DL still imposes certain restrictions: it requires that a name cannot be used for both a class and a datatype and that a name can only be used for one kind of property; semantically names are distinct for reasoners
- **Annotations:**
  - AnnotationAssertion: for annotation of ontology entities
  - Annotation: for annotations of axioms and ontologies
  - Etc.
- **New constructs that increase expressivity**
  - Declarations: a declaration signals that an entity is part of the vocabulary of an ontology. A declaration also associates an entity category (class, datatype, object property, data property, annotation property, or individual) with the declared entity
  - Declaration(NamedIndividual(*:Peter*)): *Peter* is declared to be an individual

OWL 2 (4)

- **Profiles:**
  - OWL 1 defined two major dialects, OWL DL and OWL Full, and one syntactic subset (OWL Lite)
  - Needs:
    - Some large-scale applications (e.g., in the life sciences) are mainly concerned with language scalability and reasoning performance problems and are willing to trade off some expressiveness in return for computational guarantees, particularly w.r.t. classification
    - Other applications involve databases and so need to access such data directly via relational queries (e.g., SQL)
    - Other applications are concerned with interoperability of the ontology language with rules and existing rule engines
  - Therefore, 3 profiles (sublanguages, i.e., syntactic subsets of OWL 2) are defined: OWL 2 EL, OWL 2 QL, and OWL 2 RL*
- **And more!**

*http://www.w3.org/TR/owl2-profiles/

Protégé 4.1: OWL Pizza Ontology: Local Property Restrictions



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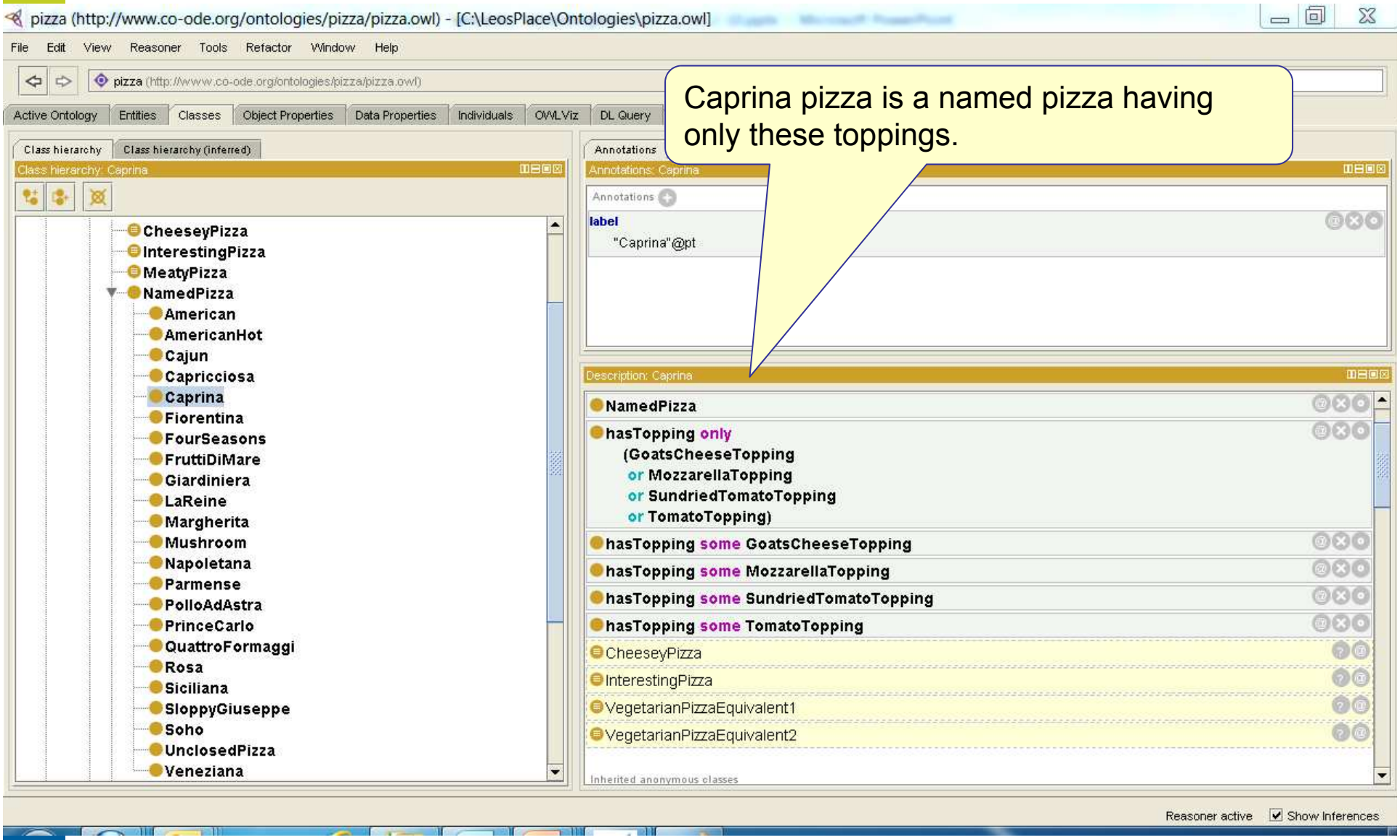
Protégé 4.1: OWL Pizza Ontology: Caprina Pizza



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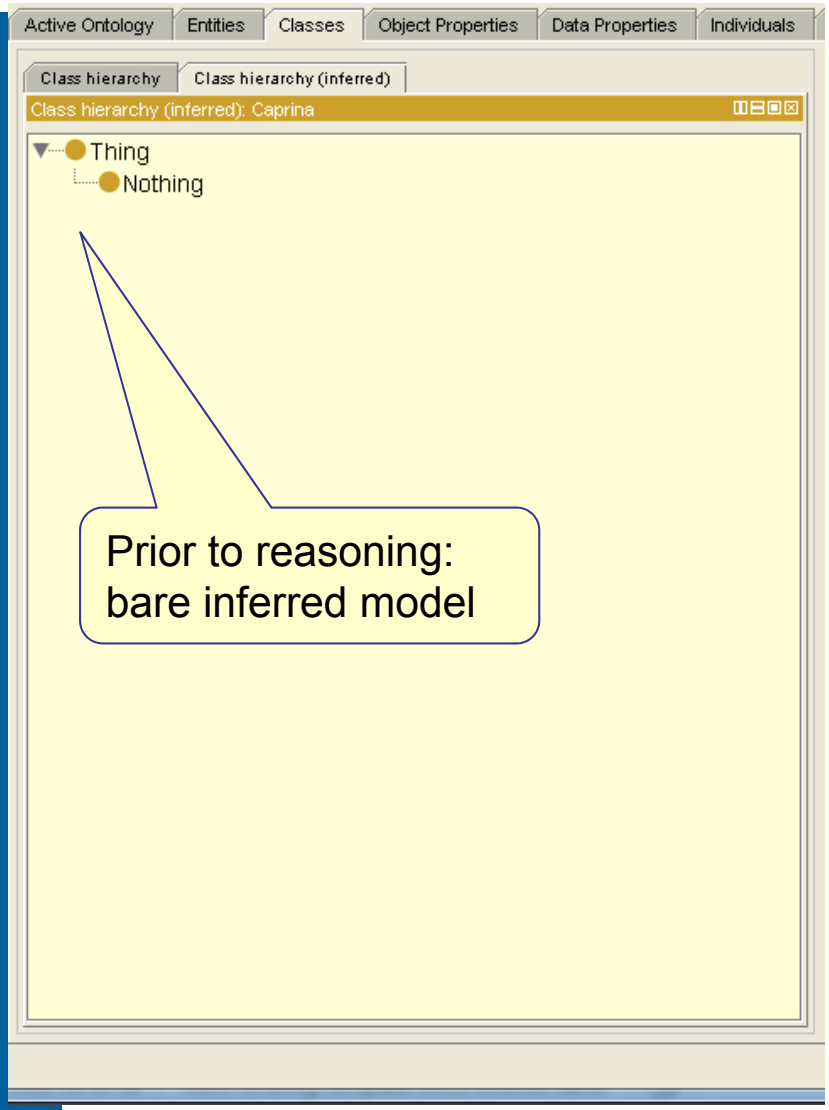
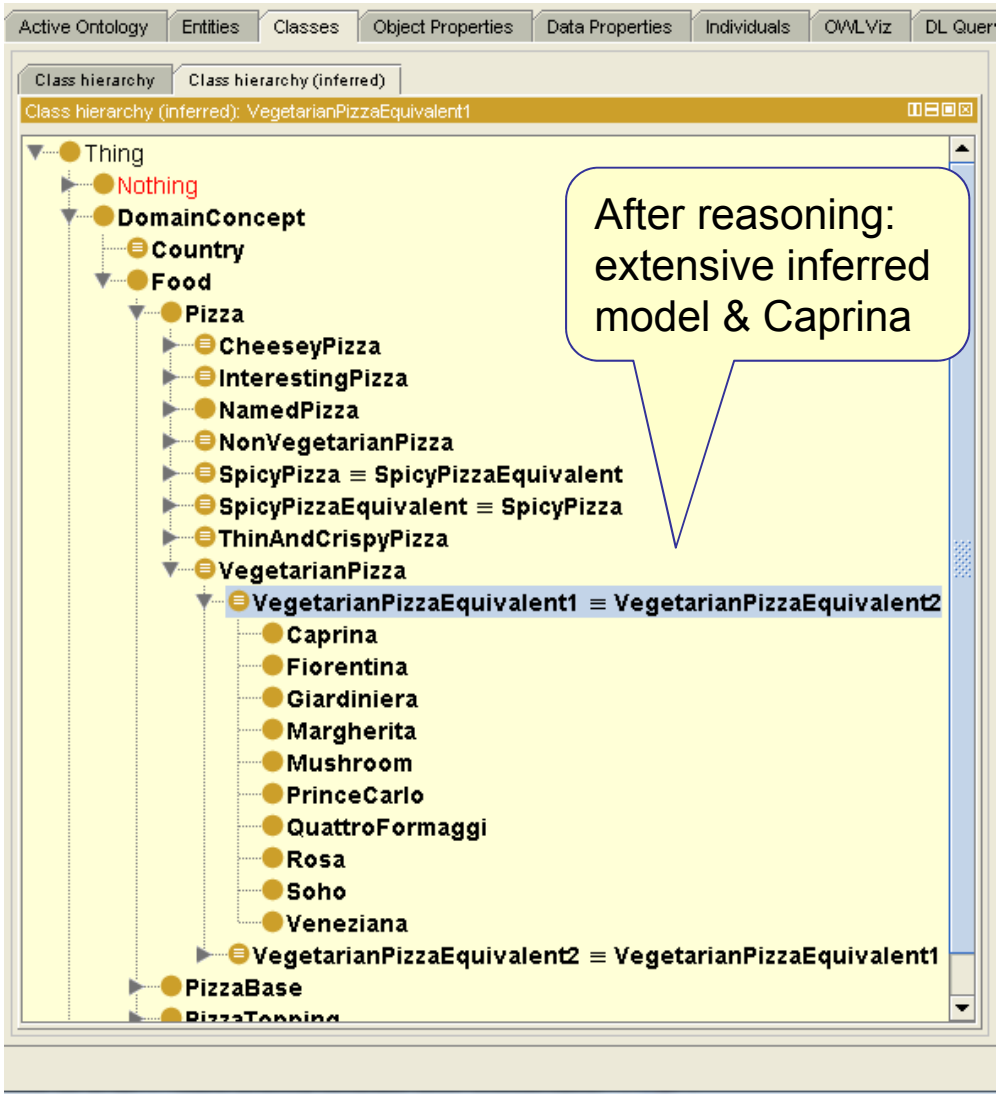
Protégé 4.1: OWL Pizza Ontology: Inferred Model Prior to HermiT 1.3.4 Reasoning, & After





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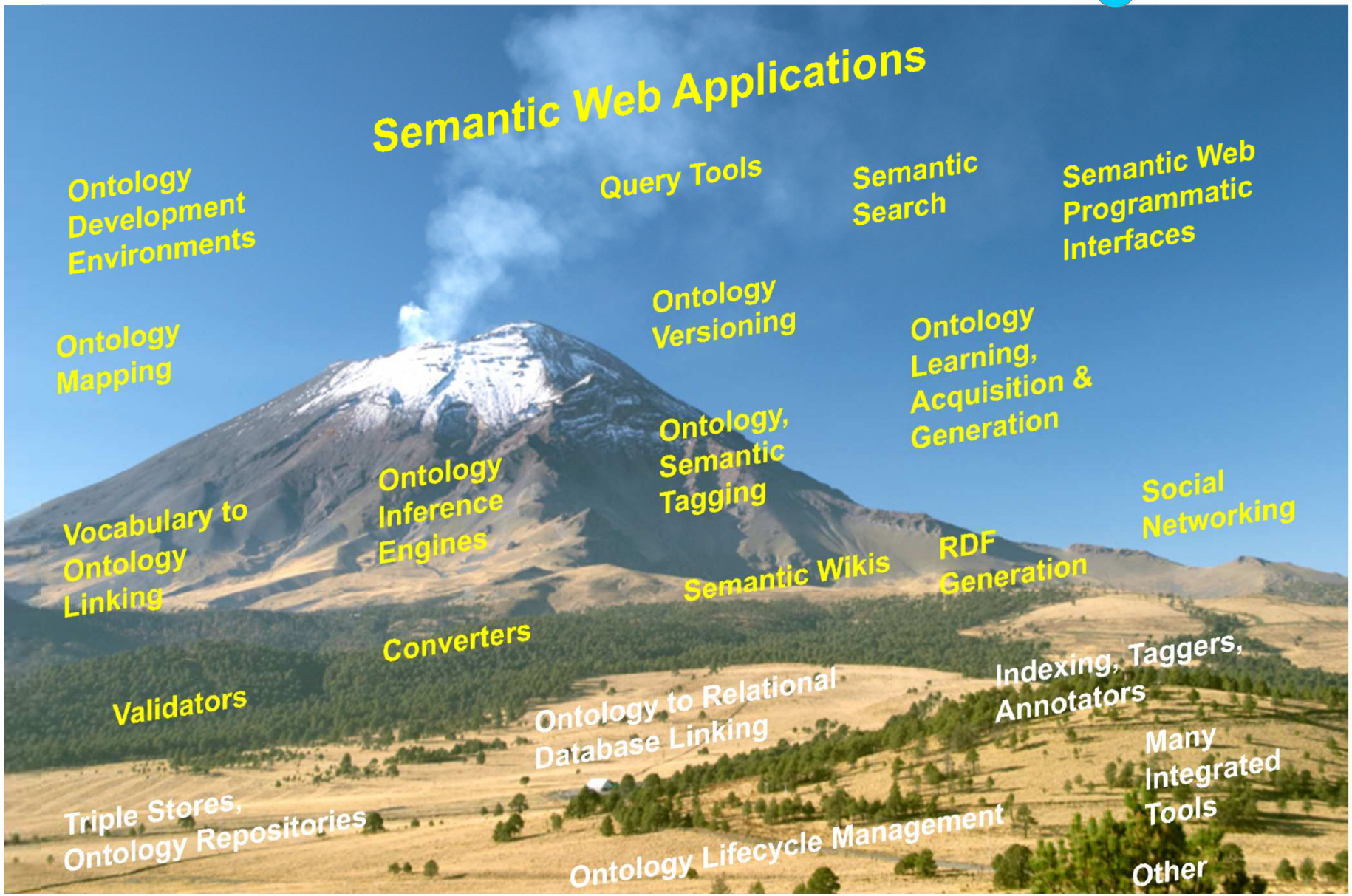
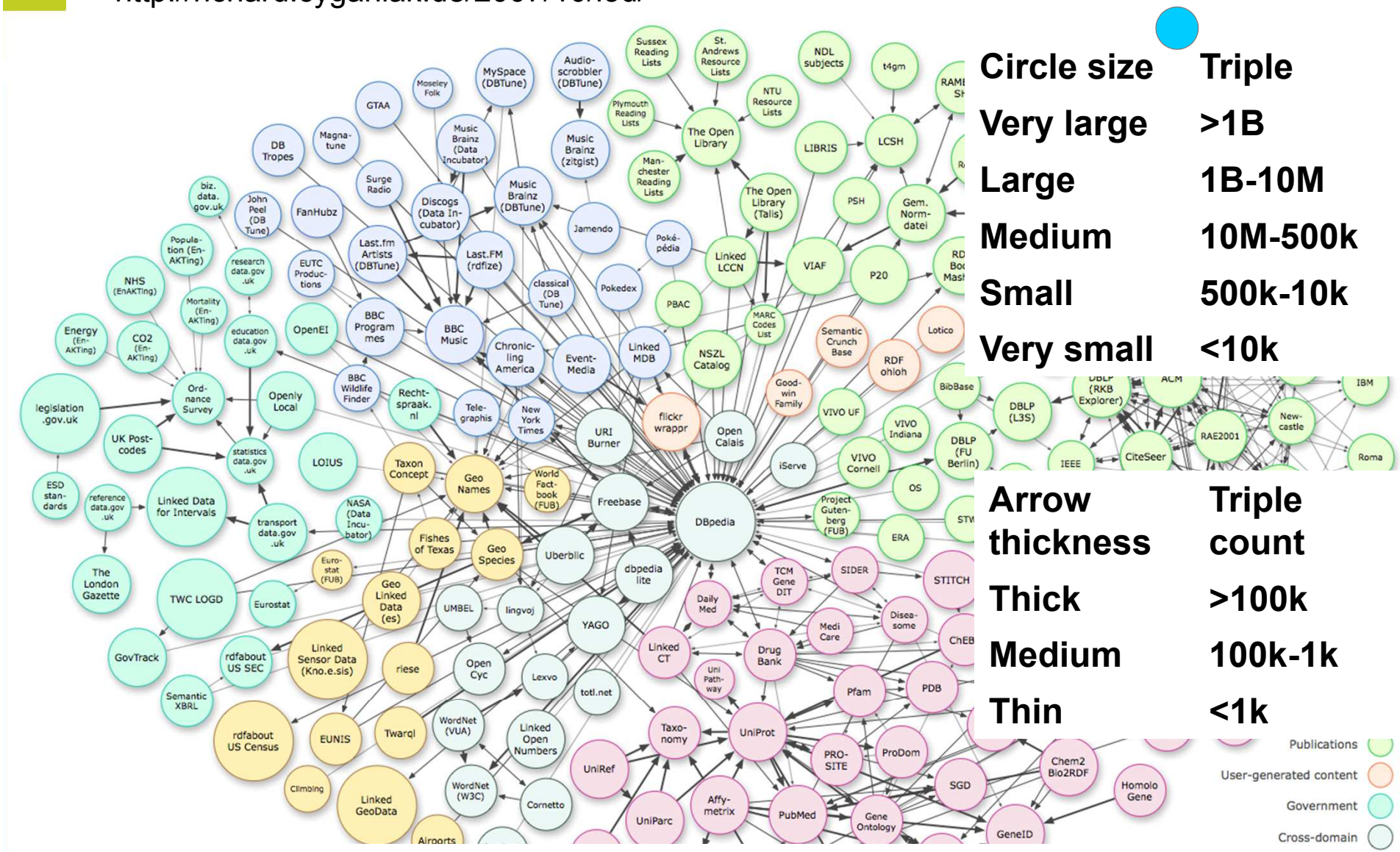
Semantic Web Tool Landscape



Linked Data: Sept. 2010: 13 billion triples

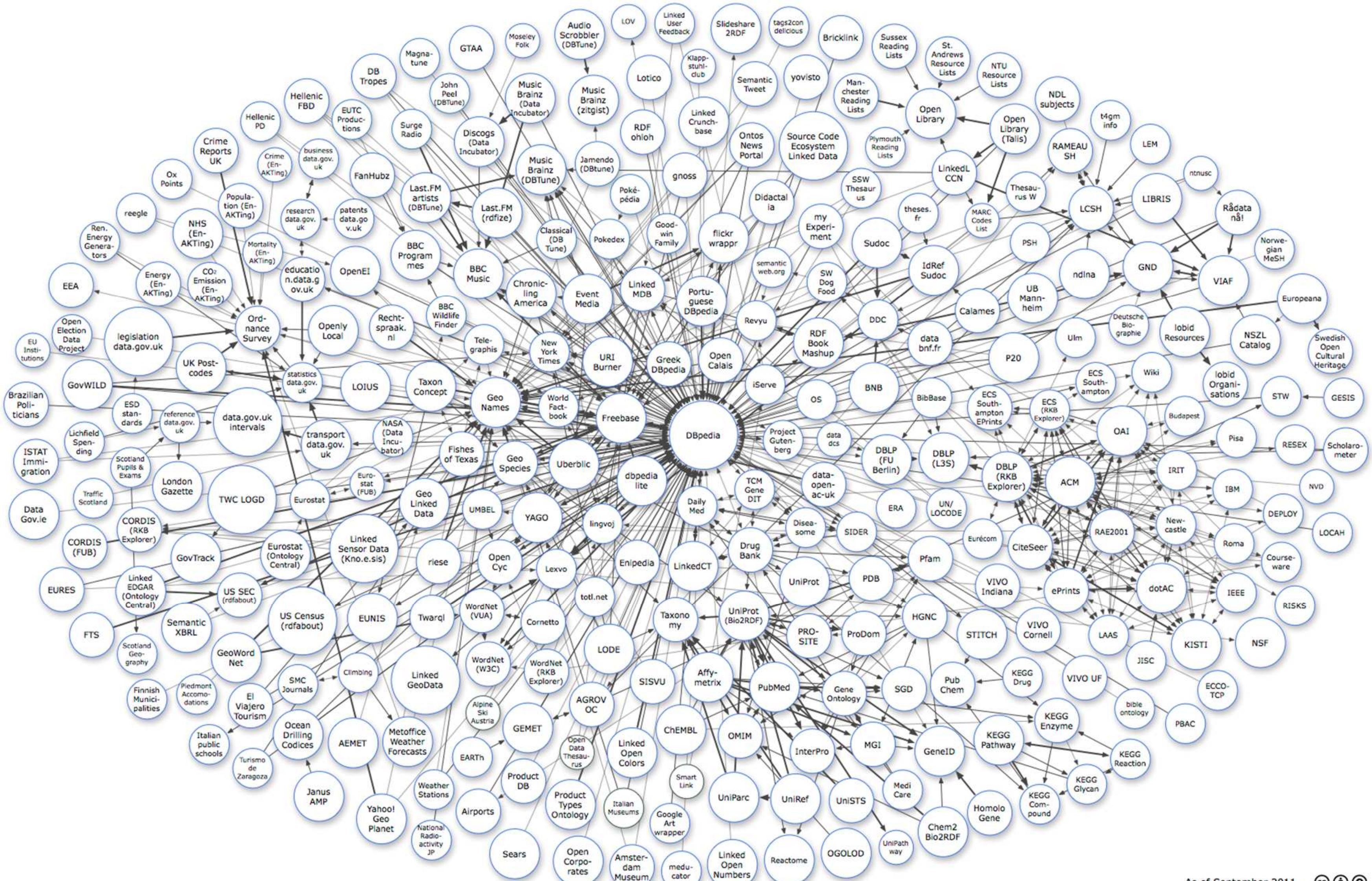
http://richard.cyganiak.de/2007/10/lod/



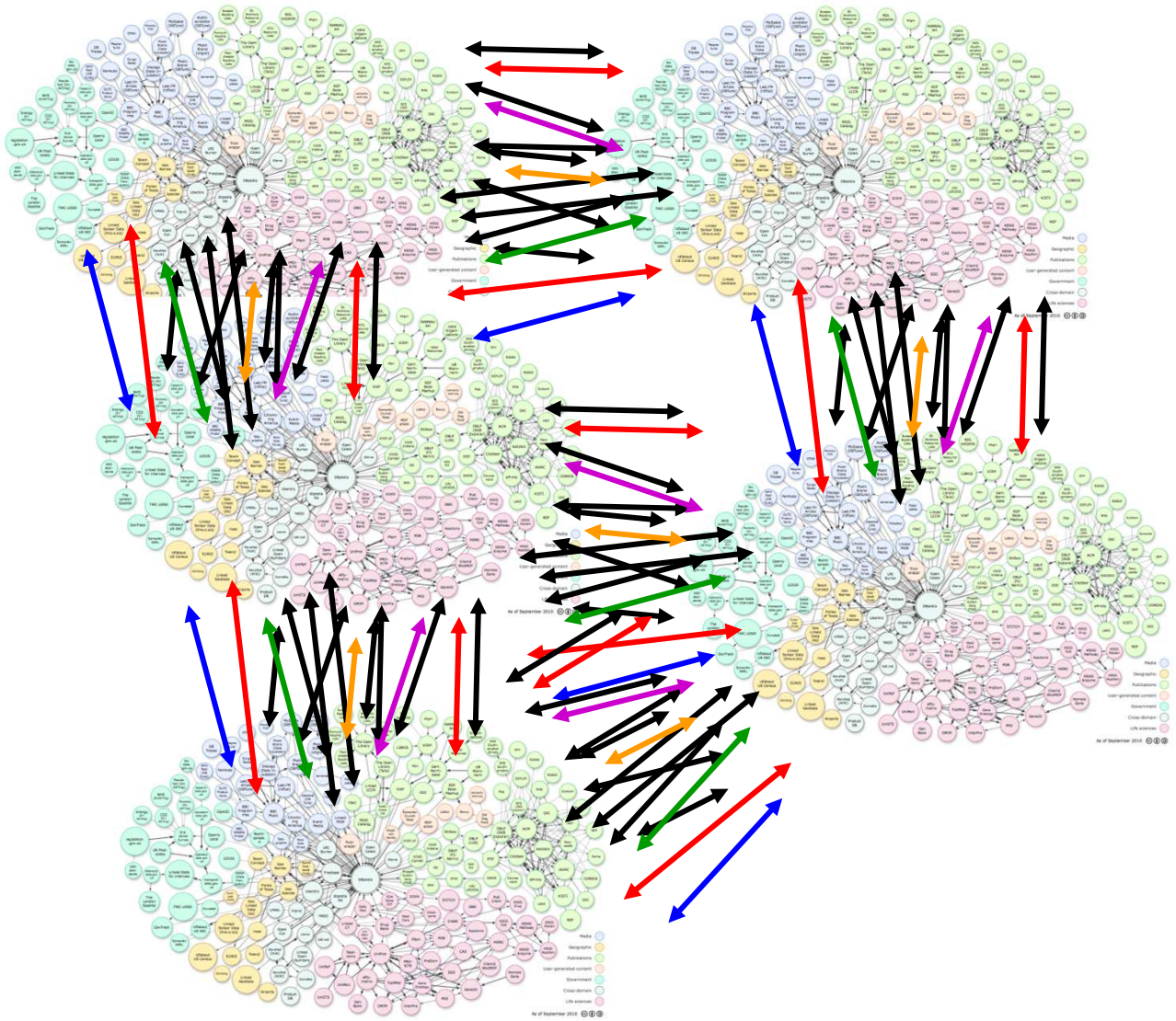
In May, 2009, 4.7 billion RDF triples, interlinked by around 142 million RDF links, reported by W3C's Linking Open Data Project. In Sept, 2010, 13 billion triples.

Linked Data: Sept. 2011: 31.5 billion triples

http://wifo5-03.informatik.uni-mannheim.de/lodcloud/state/



Tomorrow: Ontologies for Big (Complex) Systems & Big Data: Millions of Semantic Interactions



And more: RIF, SPARQL

More is coming: Common Logic

Thanks!

Questions?