Graduate Program in Production Engineering and Systems

(PPGEPS)

Important Terms in an Ontology (1/6)

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Course Outlines

- Previously on the IOE
- The Representation of Semantics
  - What is “Pizza” ?
  - How Dictionary and Ontology Represent Semantic of a Pizza?
- Web Ontology Language (OWL)
- Important Terms in an Ontology (1/6)
  - Axioms
  - Concepts (Classes and Individuals)
  - Relationships (Class Assertion, Subclass, Disjoint/Equivalent Classes, and Individual Equality/Inequality Axioms)
- Protégé Practices

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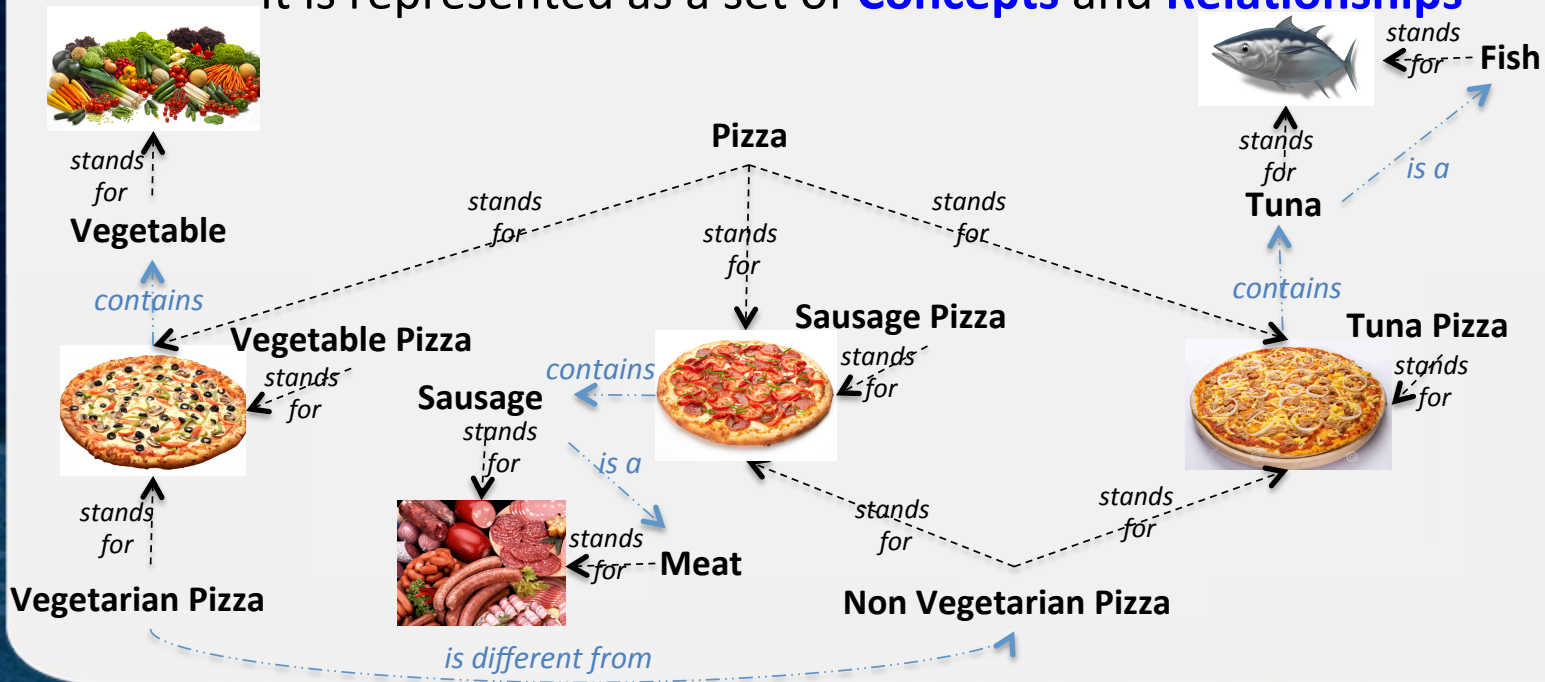
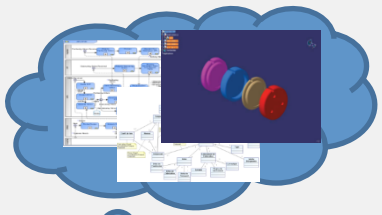
Previously on the IOE

- The Definition of an Ontology
  - An ontology is an explicit specification of a conceptualization
    - It is represented as a set of **Concepts** and **Relationships**



Previously on the IOE

- The Definition of an Ontology
  - An ontology is an explicit specification of a conceptualization
    - It is represented as a set of **Concepts** and **Relationships**
    - It can exist for an agent or a community of agents in a domain of interest



Engineering Domain

Production Engineers

"Model"

Fashion Domain

Fashion Designers

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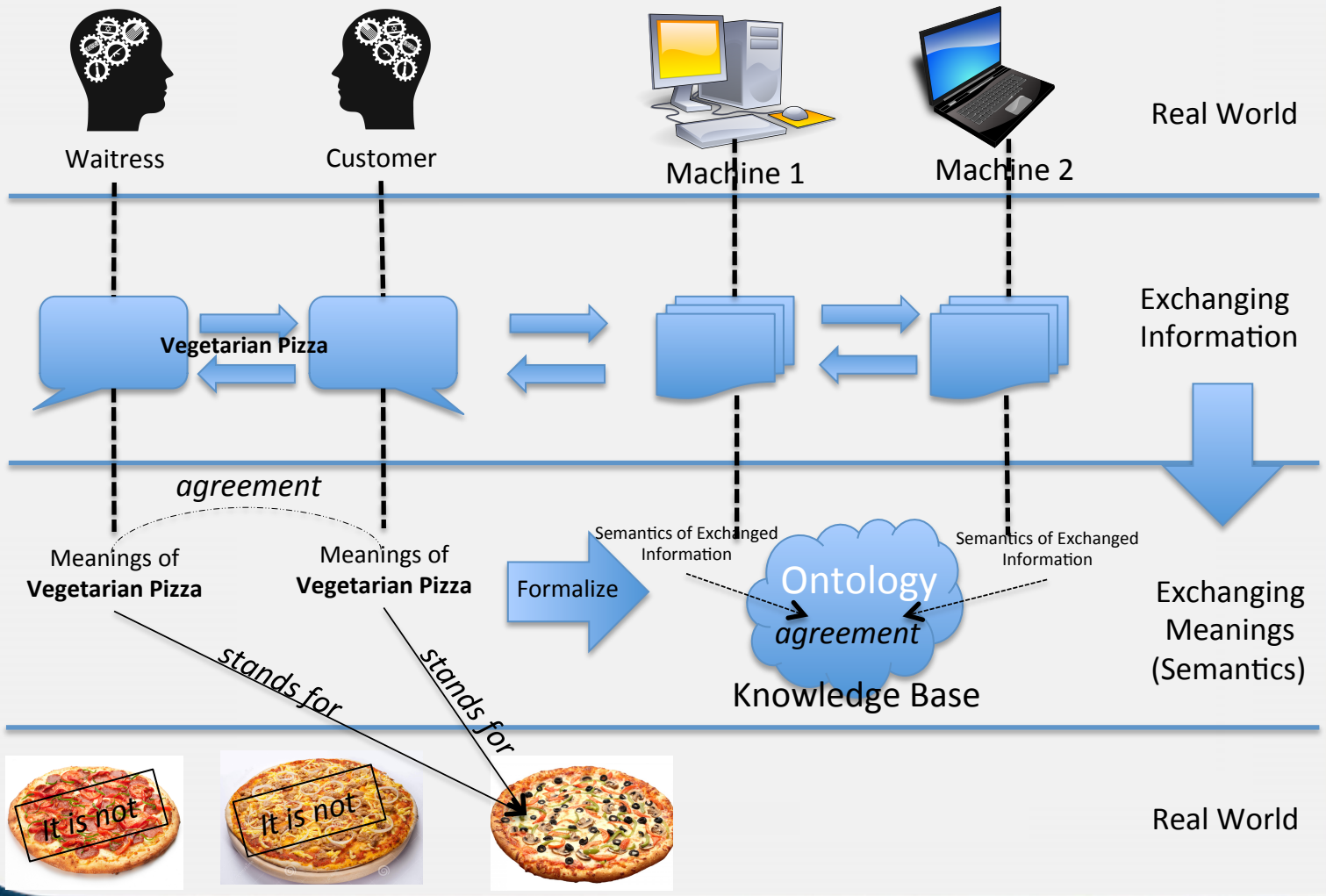
Previously on the IOE



Previously on the IOE

PLC Periods	PLC Phases	Ontology Application Examples
Pre-development	Requirement	E.g. For identifying the inconsistencies among requirements
	Definition	
Development	Design	E.g. Integration of multi-domain knowledge to assist product design
	Implementation	
Post-development	Production	E.g. For Supporting System Interoperability and Knowledge Sharing
	Maintenance	
	Retirement	

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Previously on the IOE

- Why Ontology?
  - Formally Represent Knowledge
  - Support the Reuse and Sharing of that Knowledge
  - Assist the Identification of Inconsistencies
  - Support the Interoperability
  - Discover New Knowledge

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The Representation of Semantics

- How Dictionary Represents the Semantics of “Pizza”?

Pizza: A dish of Italian origin, consisting of a flat round base of dough baked with a topping of tomatoes and cheese, typically with added meat, fish, or vegetables.

Cheese: A food made from the pressed curds of milk.

Curd: A soft, white substance formed when milk coagulates.

Substance: …

“Pizza”

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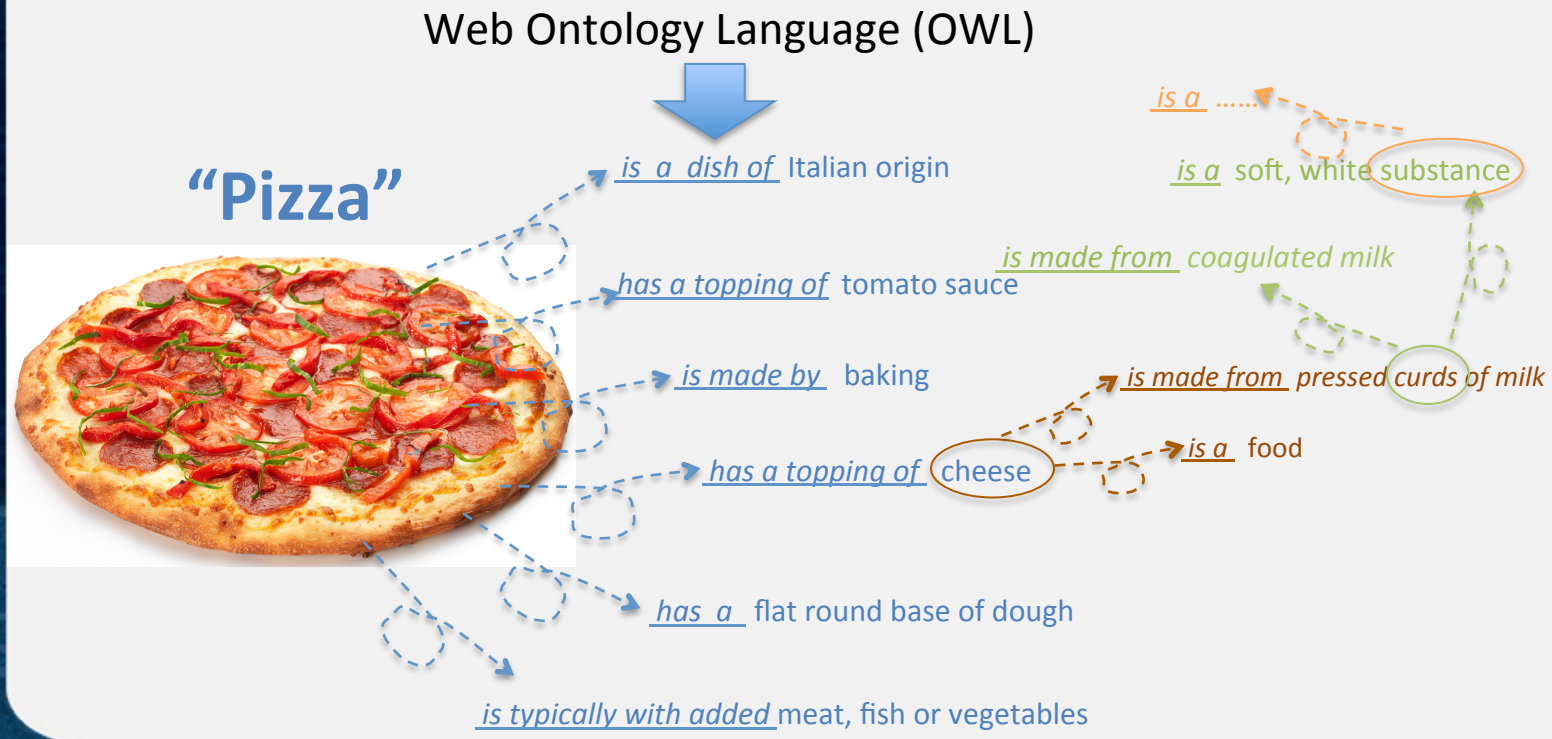
The Representation of Semantics

- How Ontology Represent the Semantics of "Pizza"?
  - Ontology represents the semantics of a Concept by formally specifying how this concept interacts with other concepts



Web Ontology Language (OWL)

- Web Ontology Language (OWL)
  - A Standardized Language for Constructing Ontologies.
  - It is developed and supported by World Wide Web Consortium (W3C).
  - It has the ability to be distributed across different systems
  - It is an open and extensible standard

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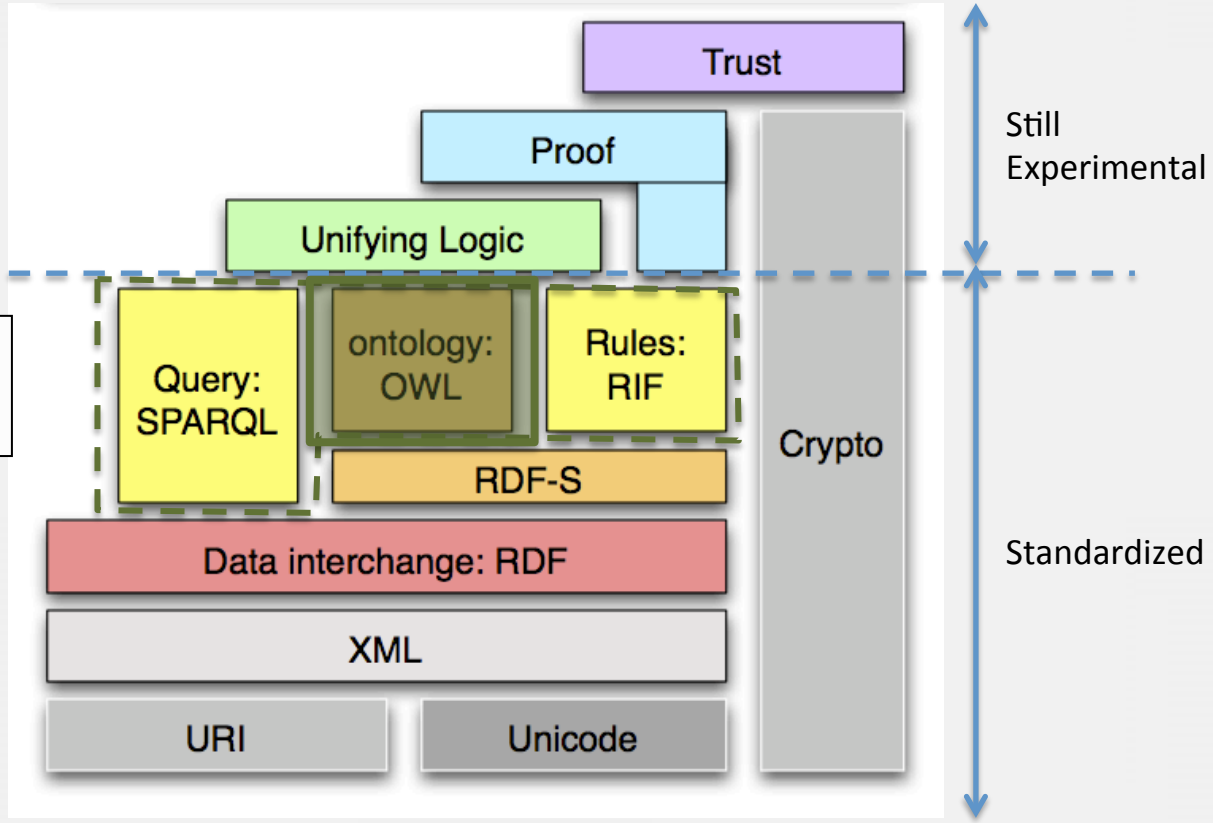
Web Ontology Language (OWL)



protégé

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Important Terms in an Ontology

- Several Important Terms
  - **Axioms**
  - **Concepts (Individuals and Classes)**
  - **Relationships (Class Assertions, Subclasses Disjoint/Equivalent Classes, Individual Equality/Inequality**
  - Properties, Property Assertions, Property Characteristics, and Property Descriptions)
  - Complex Class Expressions (Enumeration of Individuals, Propositional Connectives, Object Property Restrictions, Necessary and Sufficient Conditions, Data Property Restrictions)
  - Data Ranges (Data Types and Data Type Restrictions)
  - Reasoning Rules
  - Knowledge Base (T-box and A-box)
  - SPARQL Query

Part 1/6

Part 2/6

Part 3/6

Part 4/6

Part 5/6

Part 6/6

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Important Terms in an Ontology

- Axioms
  - An Axiom is a statement that says what is true in the domain.
    - Each axiom is considered as a piece of knowledge.
    - E.g. "Brazil *is a* Country" (in natural language expression)
  - An ontology is essentially a collection of Axioms (pieces of knowledge).
    - E.g. "Brazil *is a* country"
      "Curitiba *is a* city"
      "Curitiba *is located in* Brazil"
      "Brasilia *is a* city" (in natural language expression)
      "Brasilia *is a* capital"
      "Brasilia *is the capital of* Brazil"
      "Brasilia *is located in* Brazil"
      …

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Concepts in an Ontology

- Concepts
  - Concepts in an ontology are abstractions and representations of ideas, persons, processes, issues, locations, and etc.
    - A concept can be a number, a word, a combination of words, etc.
    - E.g. 55, Curitiba, Vegetarian Pizza
  - Taxonomy
    - The classification of concepts
    - The back bone of an ontology

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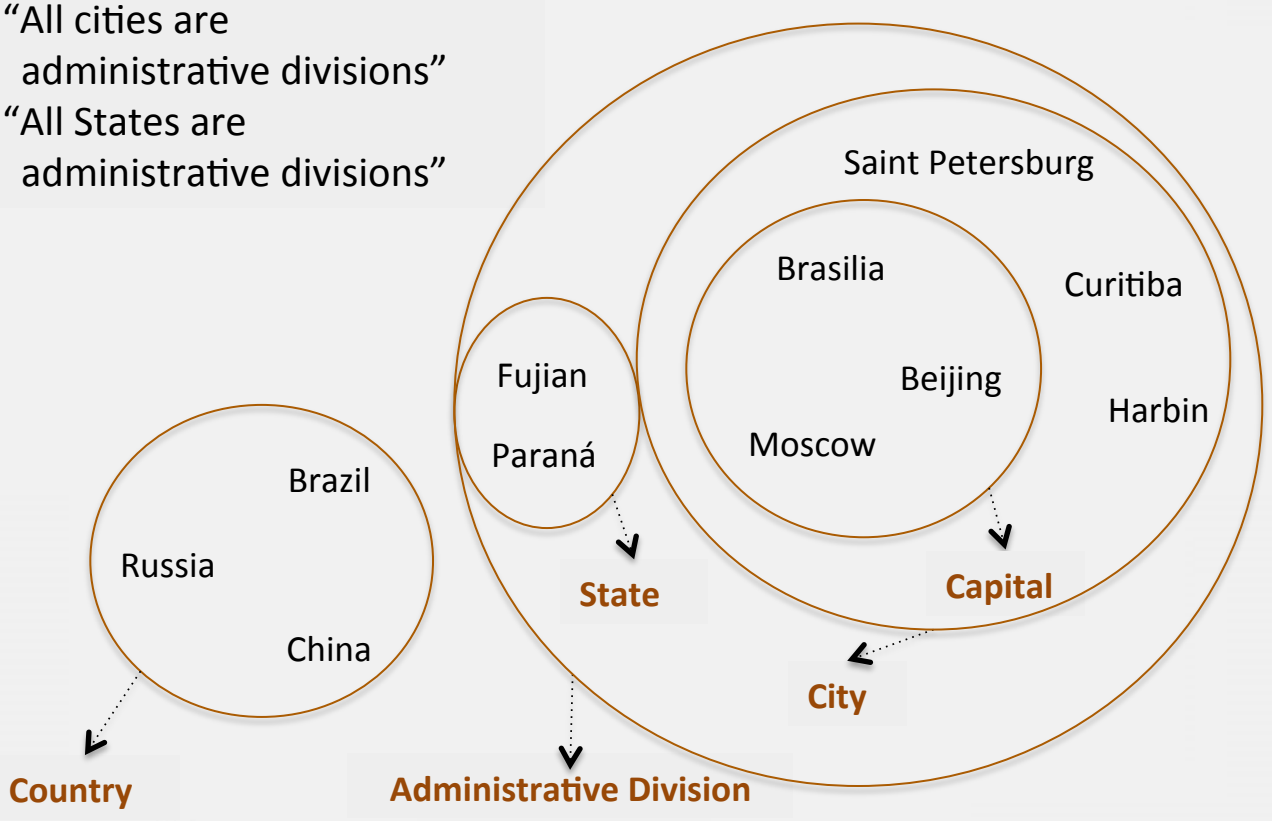
Concepts in an Ontology

- Taxonomy Example

Axiom 13: "All cities are administrative divisions"
Axiom 14: "All States are administrative divisions"



Concepts in an Ontology

- Individuals
  - Each individual simplifies and abstracts one actual object in a domain of interest.
  - The most specific concepts that **can not be** subdivided anymore in a domain of interest.

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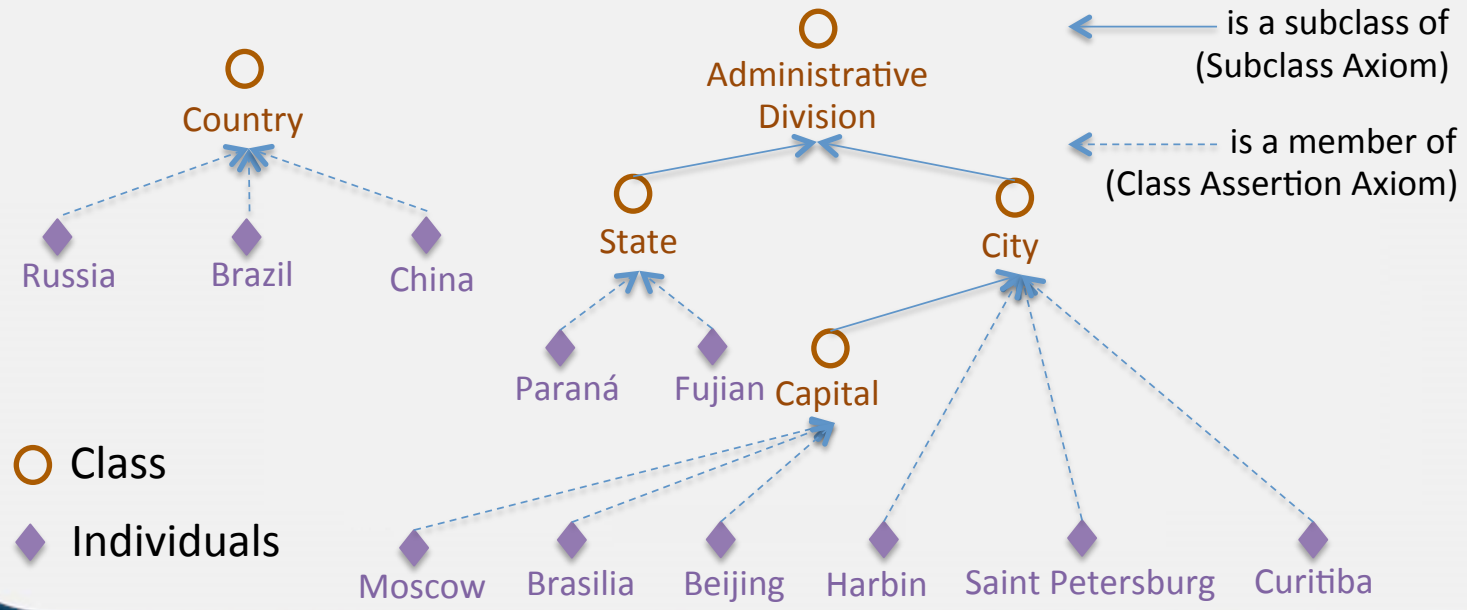
Concepts in an Ontology

- Classes
  - Each class simplifies and abstracts a set of actual objects that share some common properties in a domain of interest.
  - The concepts that **can be** subdivided into more specific concepts in a domain of interest.



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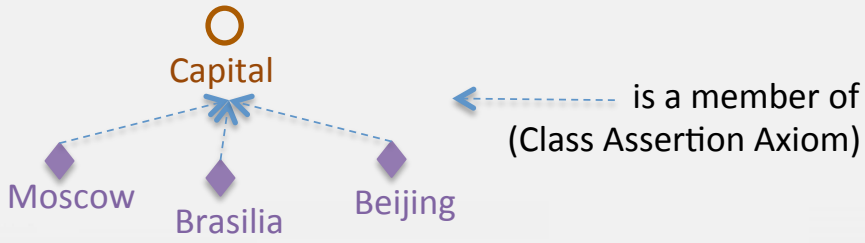
Relationships in an Ontology

- Class Assertion Axioms
  - Relationships between an individual and a class that it belongs to
  - The statement of an individual is a member of a class

    ⇒The individual *Brasilia* is a member of the Class *Capital*

    ⇒The individual *Beijing* is a member of the Class *Capital*

    ⇒The individual *Moscow* is a member of the Class *Capital*



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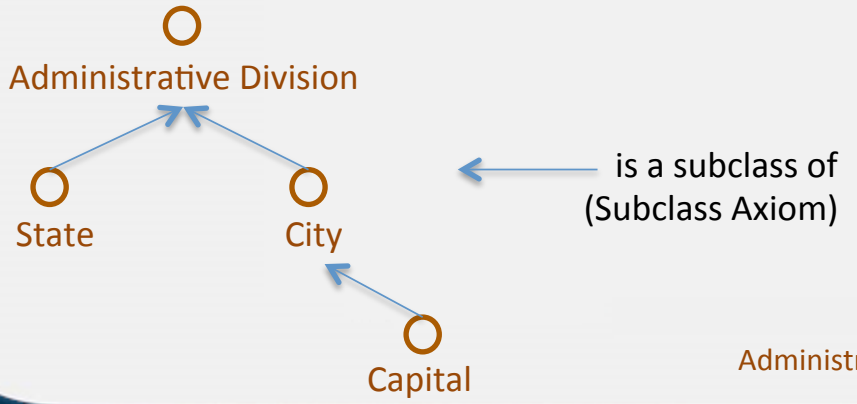
Relationships in an Ontology

- Subclass Axioms
  - Relationships between a class and its subclasses
  - A class contains *a set of objects* and its subclass contains a subset of those objects

⇒The Class *Capital* is a subclass of the Class *City*

⇒The Class *City* is a subclass of the Class *Administrative Division*

⇒The Class *State* is a subclass of the Class *Administrative Division*



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How to create the Taxonomy?

- Determine Your Goal!
  - What is the domain that your ontology will cover?
  - What are the main functions that the ontology should provide?
    - a number of detailed competency questions should be created for each function.
  - Who will develop, use and maintain the ontology?
- Consider Reusing Existing Resources.
- Enumerate and Classify the Concepts related to the Goal

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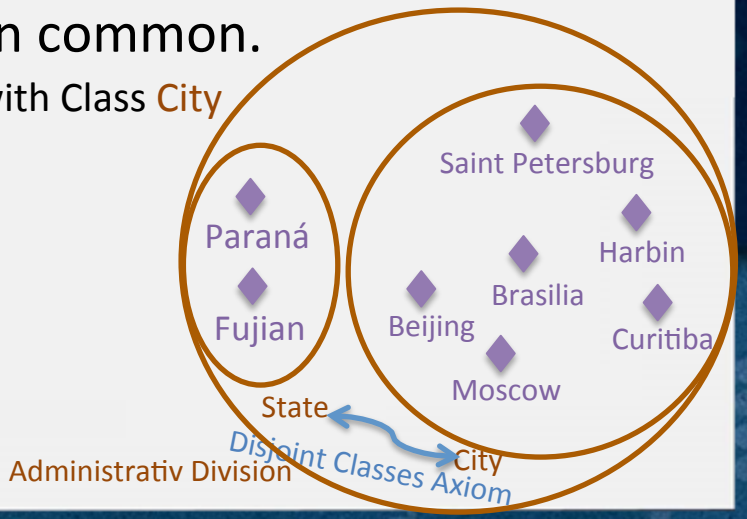
Relationships in an Ontology

- Disjoint Classes Axioms
  - OWL is based on Open World Assumption.
    - Open World Assumption (OWA): Missing Information treated as unknown
    - Close World Assumption (CWA): Missing Information treated as false
  - To emphasize two or more classes are disjoint
    - They have no element in common.
      - E.g. Class State is disjoint with Class City

Axiom 13: "All cities are administrative divisions"
Axiom 14: "All States are administrative divisions"
Axiom 15: "Cities are different from States"

Question: Is a city different from a state?
Answers: - No (CWA) - Yes (CWA)
- Don't know(OWA) - Yes (OWA)



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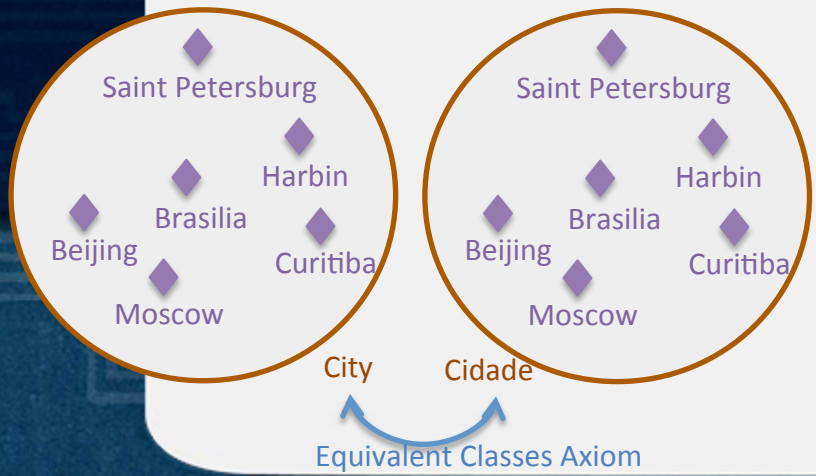
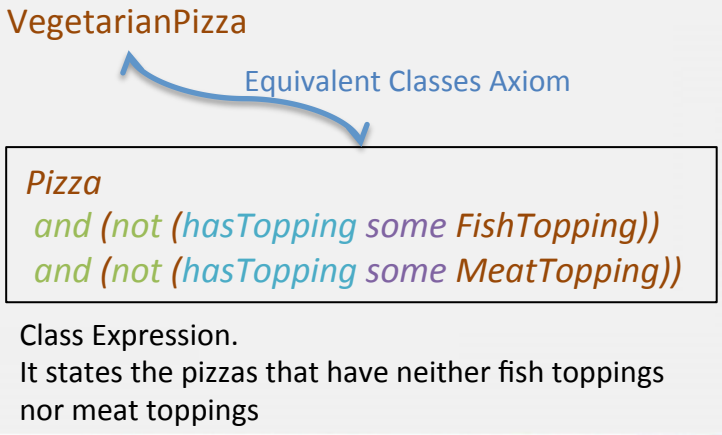
Relationships in an Ontology

- Equivalent Classes Axioms
  - To emphasize two or more classes are equal to each other
    - One can be used as a synonym for another.
      - E.g. Class Cidade is equal to Class City

        Class VegetarianPizza is equal to a Class Expression





Class Expression.
It states the pizzas that have neither fish toppings nor meat toppings

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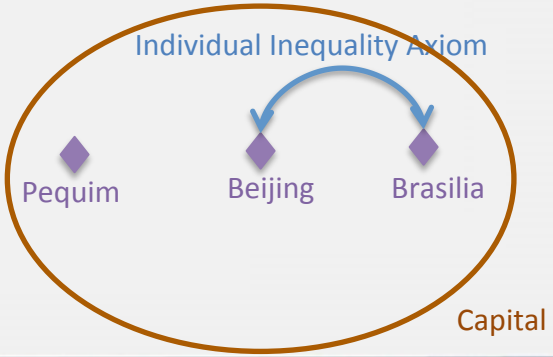
Relationships in an Ontology

- Individual Inequality Axioms
  - OWL is based on No Unique Name Assumption.
    - Unique Name Assumption(UNA): Each actual object is represented by a single and unique individual.
    - No Unique Name Assumption (NUNA): Each actual object may be represented by one or more individuals.
  - To emphasize two or more individuals are different from each other
    - They are not representing an instance with different names.
      - E.g. Individual Beijing is different from Individual Brasilia

Axiom 4: "Brasilia is a capital"
Axiom 5: "Beijing is a capital"
Axiom 16: "Pequim is a capital"
Axiom 17: "Beijing is different from Brasilia"
Question: How many capitals?
Answers: - 3 (UNA)
- at least 1 (NUNA) - at least 2 (NUNA)



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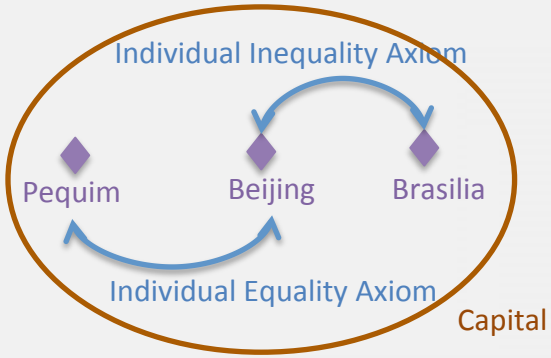
Relationships in an Ontology

- Individual Equality Axioms
  - To emphasize two or more individuals are equal to each other
    - One can be used as a synonym for another.
      - E.g. Individual Beijing is equal to Individual Pequim

Axiom 4: "Brasilia is a capital"
Axiom 5: "Beijing is a capital"
Axiom 15: "Pequim is a capital"
Axiom 16: "Beijing is different from Brasilia"
Axiom 17: "Beijing is equal to Pequim"

Question: How many capitals?
Answers:- 3 (UNA)
- at least 2 (NUNA) - at least 2 (NUNA)



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Reasoners (1/2)

- Consistency Checking Among Classes
  - Based on the descriptions (conditions) of a class to check whether or not it is possible for this class to have any members.
    - If a class cannot possibly have any members, then it is deemed to be inconsistent.

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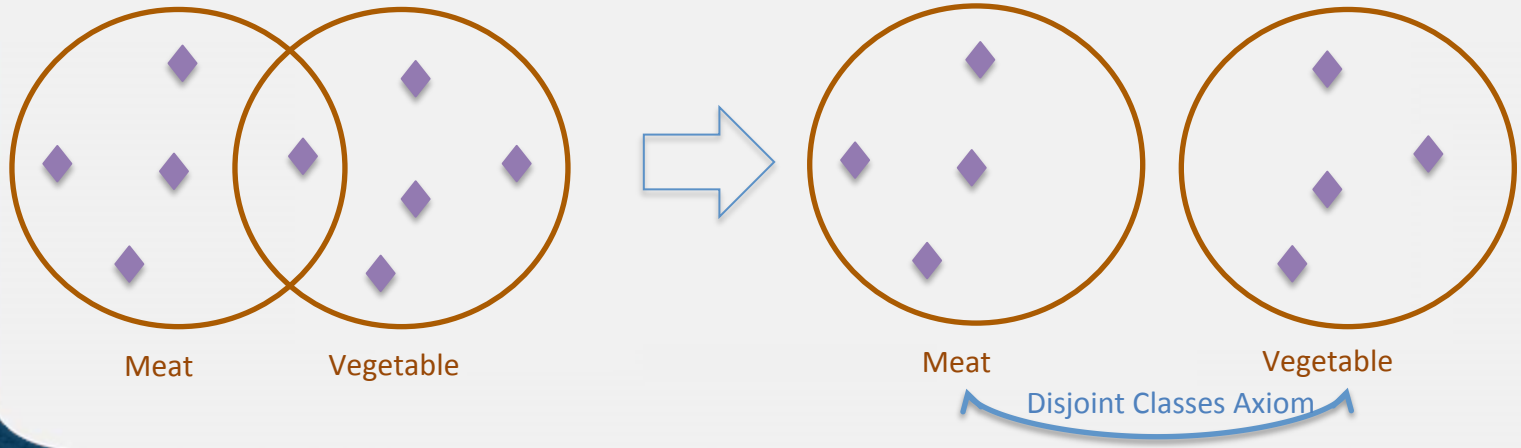
A Simple Consistency Checking Example

- OWL -> Open World Assumption
  - OWL assumes the classes are overlapping
    - For example, the class Meat and the class Vegetable
      - It means an individual can be both Meat and Vegetable at the same time
      - The disjoint classes axiom is used to state this is not the case



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An Inconsistency Example (Among Classes)

- Existing Knowledge

  (1) The class Meat is disjoint with the class Vegetable

  (2) MeatVegetable is a sub class of the class Meat

  (3) MeatVegetable is a sub class of the class Vegetable

- Inference
  - Base on (1), the class Meat and the class Vegetable have no elements in common.
  - Base on (2), all members of MeatVegetable are members of Meat.
  - Base on (3), all members of MeatVegetable are members of Vegetable.

  => MeatVegetable can never contain any members.

Inconsistency

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Reasoners (2/2)

- Consistency Checking Among Individuals and Classes
  - Based on the descriptions (conditions) of a individual and classes that it belongs to check whether or not it can be a member of those classes.
    - If an individual can not be a member of classes that it is asserted to, then it is deemed to be inconsistent.

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An Inconsistency Example (Among Individuals and Classes)

- Existing Knowledge
  - (1) The class Meat is disjoint with the class Vegetable
  - (2) foodsample is a member of the class Meat
  - (3) foodsample is a member of the class Vegetable
- Inference
  - Base on (1), the class Meat and the class Vegetable have no elements in common.

  =>Base on (1) and (2), foodsample can not be a member of Vegetable.

  =>Base on (1) and (3), foodsample can not be a member of Meat.

Inconsistency

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Protégé Practices

- The Pizza Ontology
  - Pizzas were selected as a domain because:
    - They are internationally known
    - They are highly compositional
    - They are often used as the basic materials for ontology trainings
    - They can be produced by an industry
  - Although arguments might break out over representation
    - Different Viewpoints.
      - E.g. Tomato – Vegetable or Fruit?

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Protégé Practices

- The "Active Ontology" Tab
  - The Specification of a New Ontology
- The "Classes" Tab
  - Classes
  - Subclass, Disjoint/Equivalent Classes Axioms
- The "Individuals by class" Tab
  - Individuals
  - Class Assertion, Individual Equality/Inequality Axioms
- An Inconsistency Checking Practice

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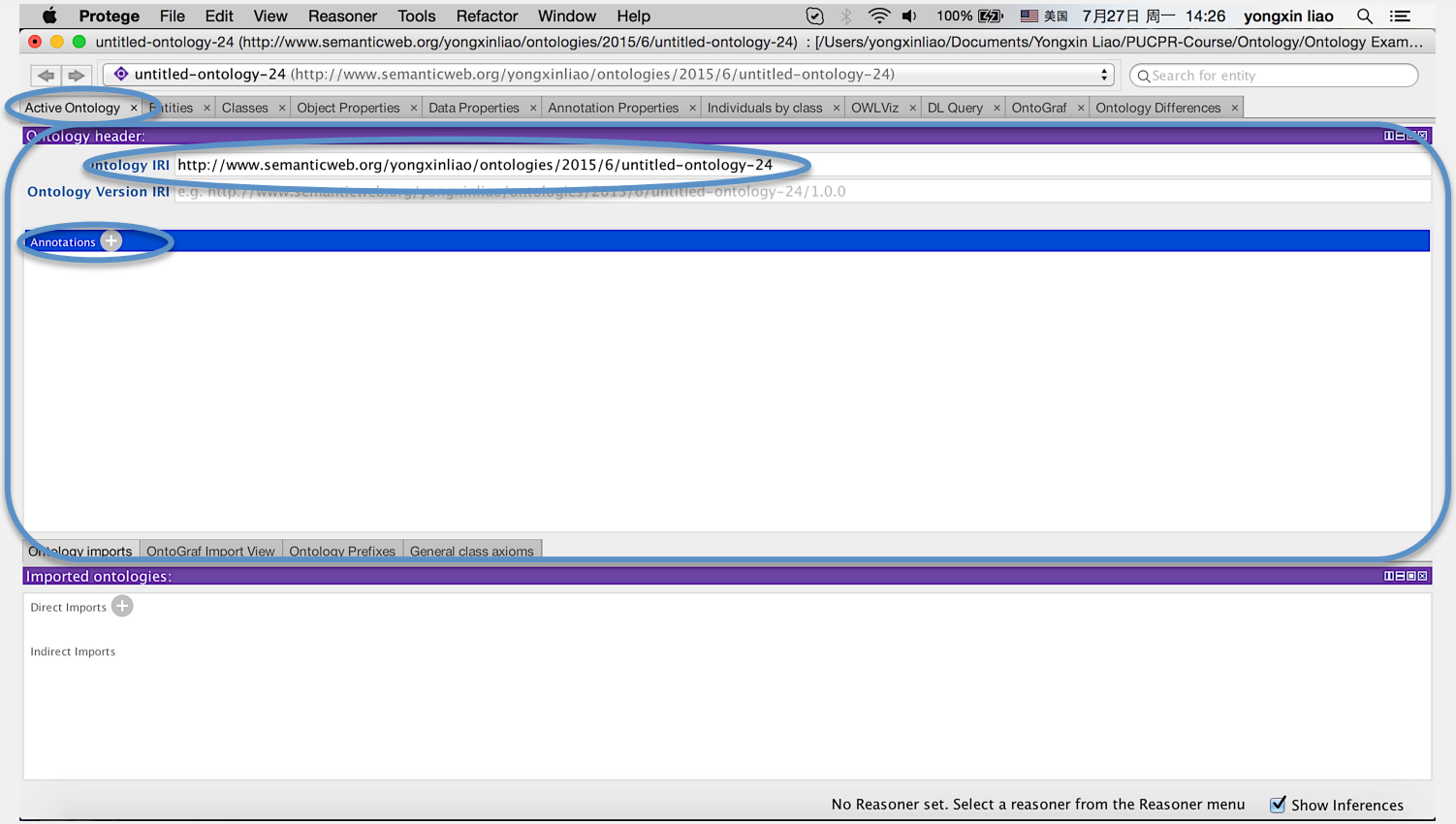
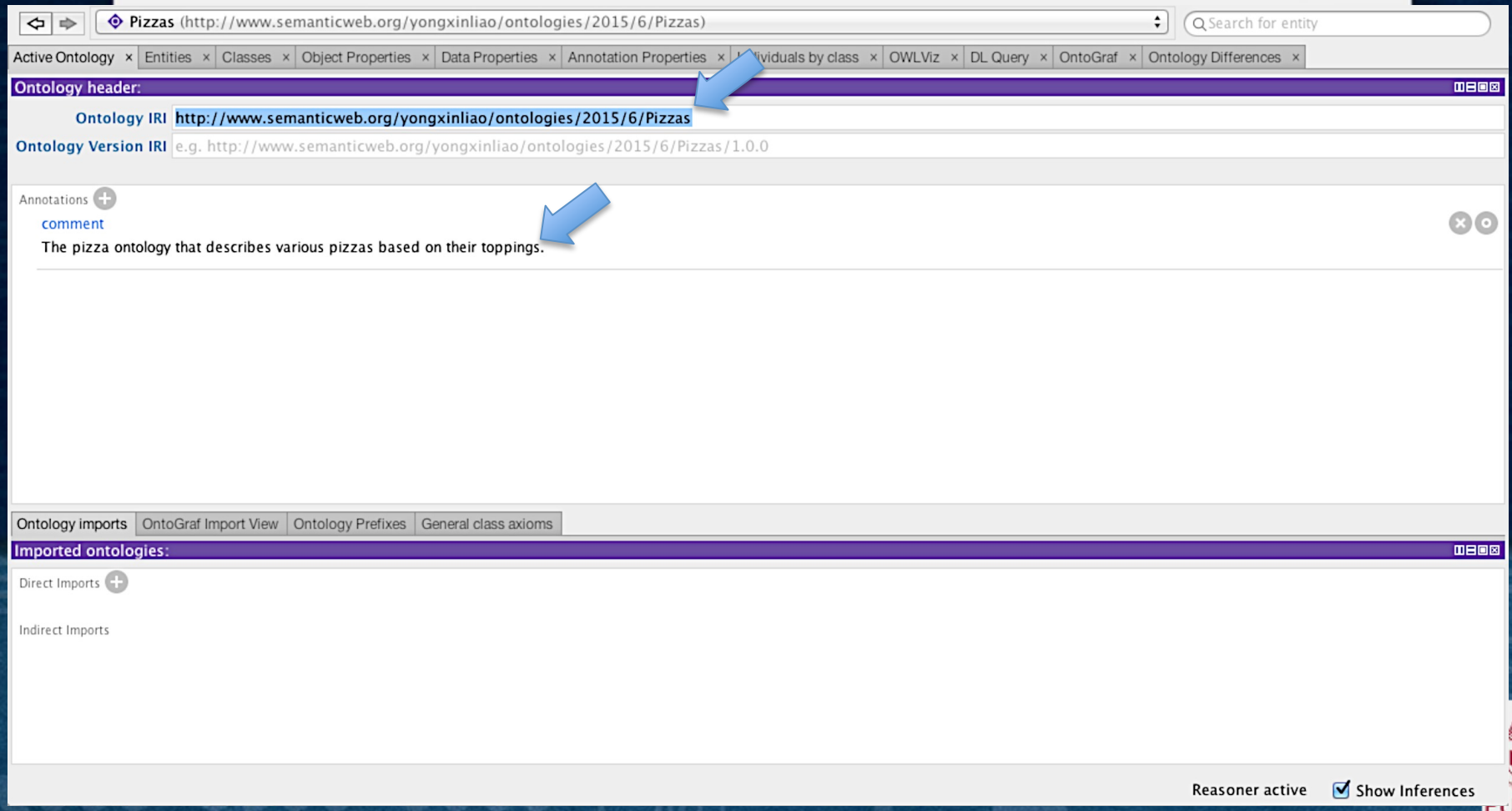
Protégé Practices

- The “Active Ontology” Tab



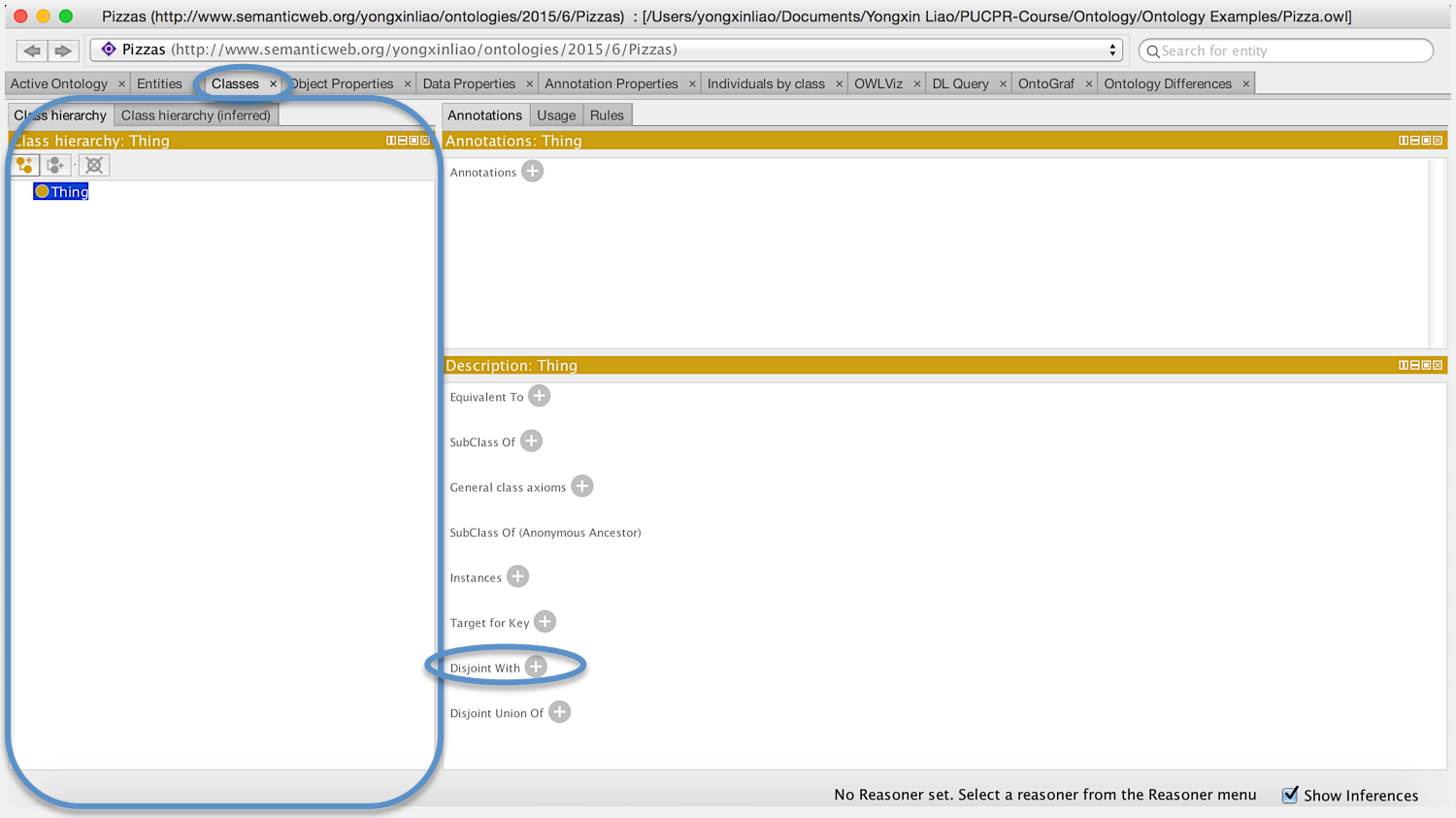
Protégé Practices

- The Specification of a New Ontology



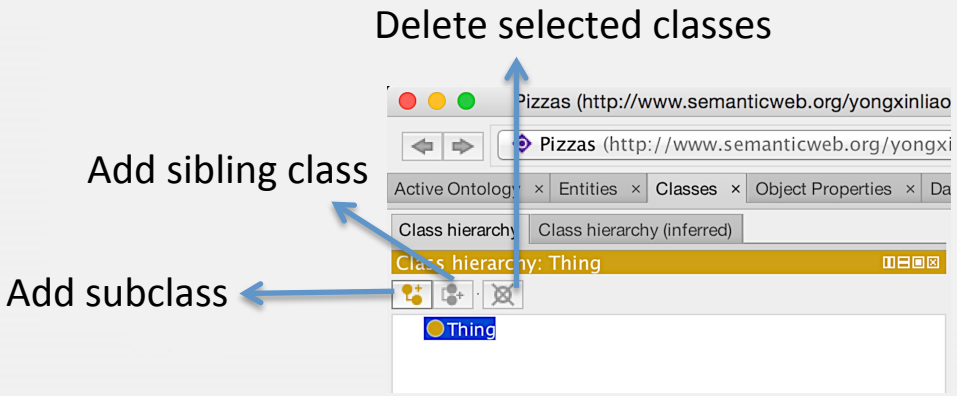
Protégé Practices

- The “Classes” Tab



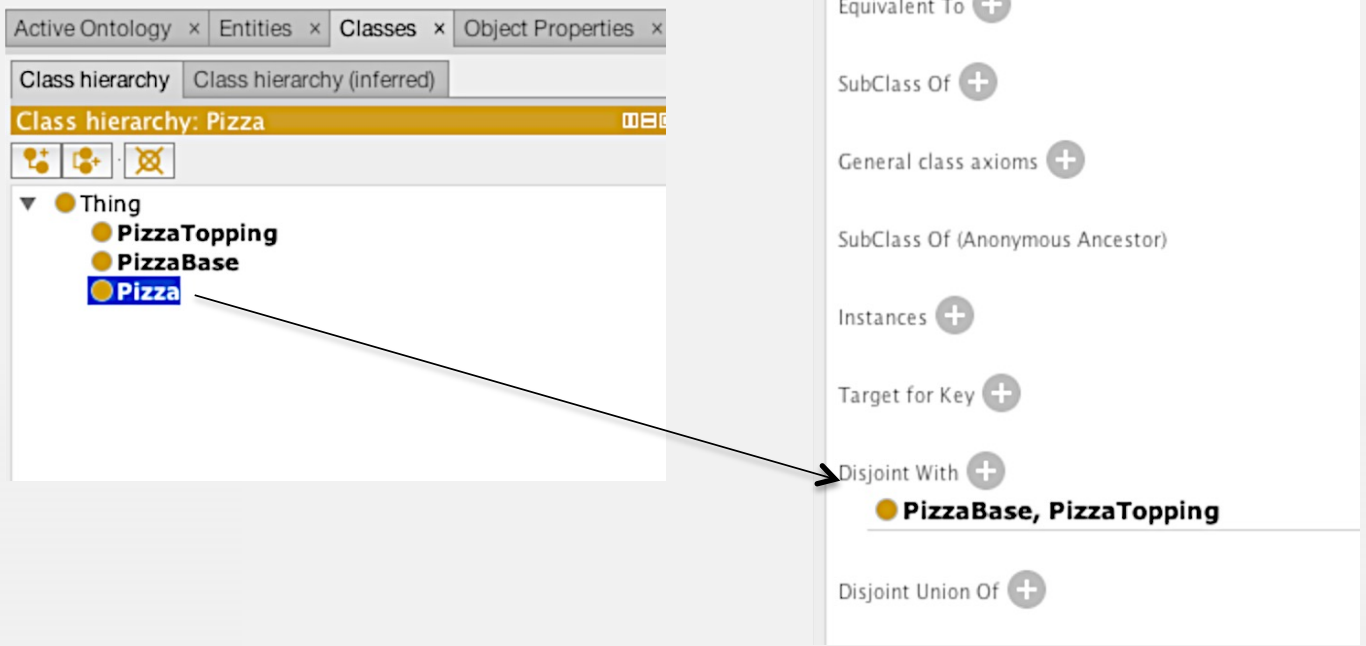
Protégé Practices

- The Class Thing
  - It is a pre-defined class as the most general class in an ontology.
  - It is a root class (superclass) of all classes
  - It represents the set containing all individuals



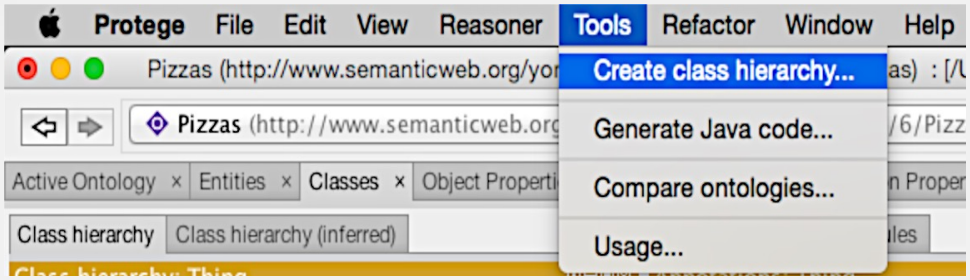
Protégé Practices

- Classes and Subclass Axioms
- Disjoint Classes Axioms

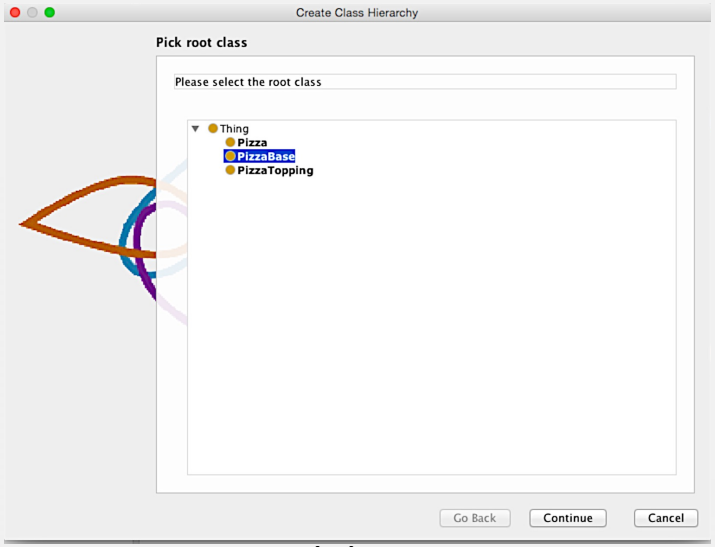


Protégé Practices

- Class Hierarchy Tool



(1)



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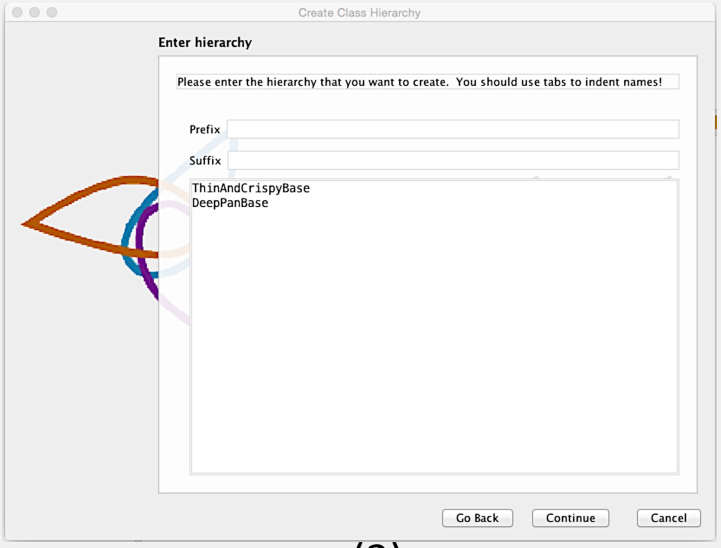

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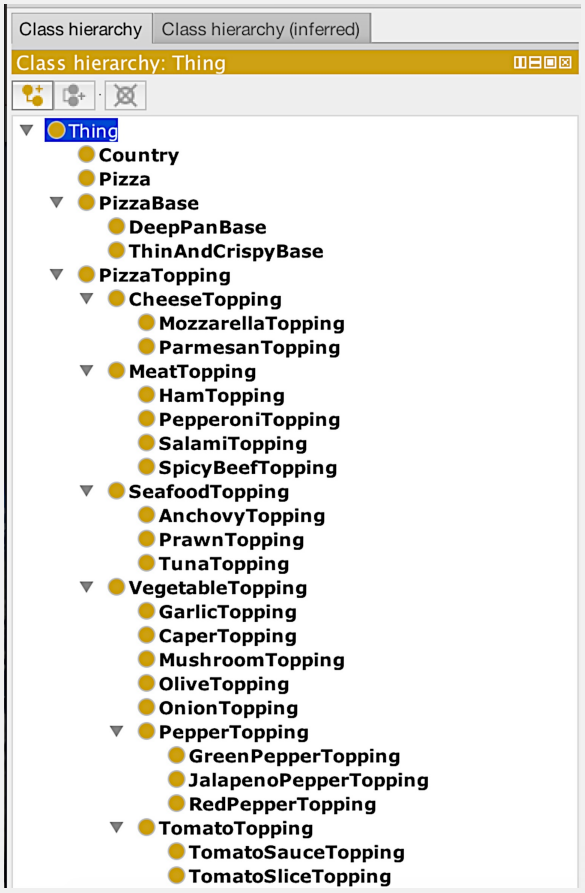
Protégé Practices

- Subclasses of PizzaBase and PizzaTopping



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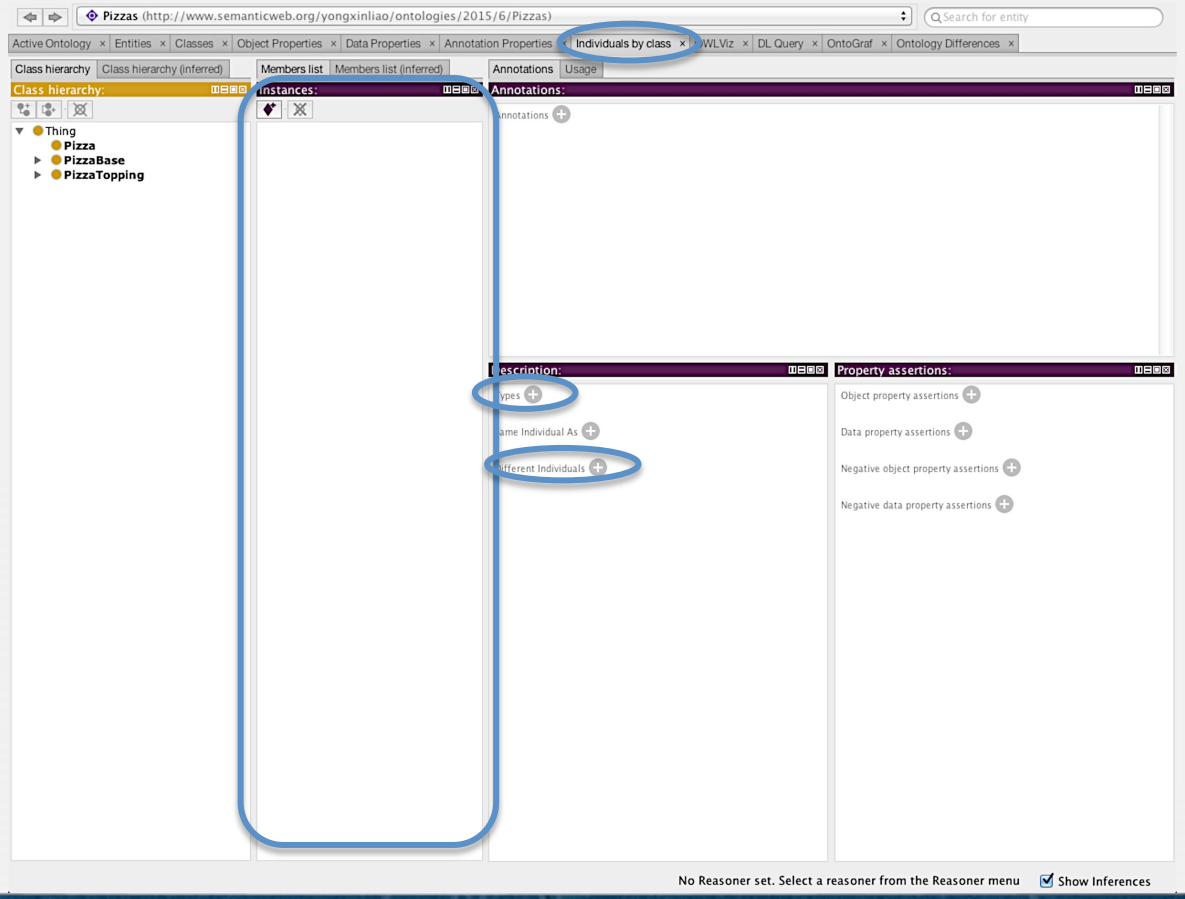
Protégé Practices

- The “Individuals by class” Tab



Protégé Practices

- Individuals and Class Assertions

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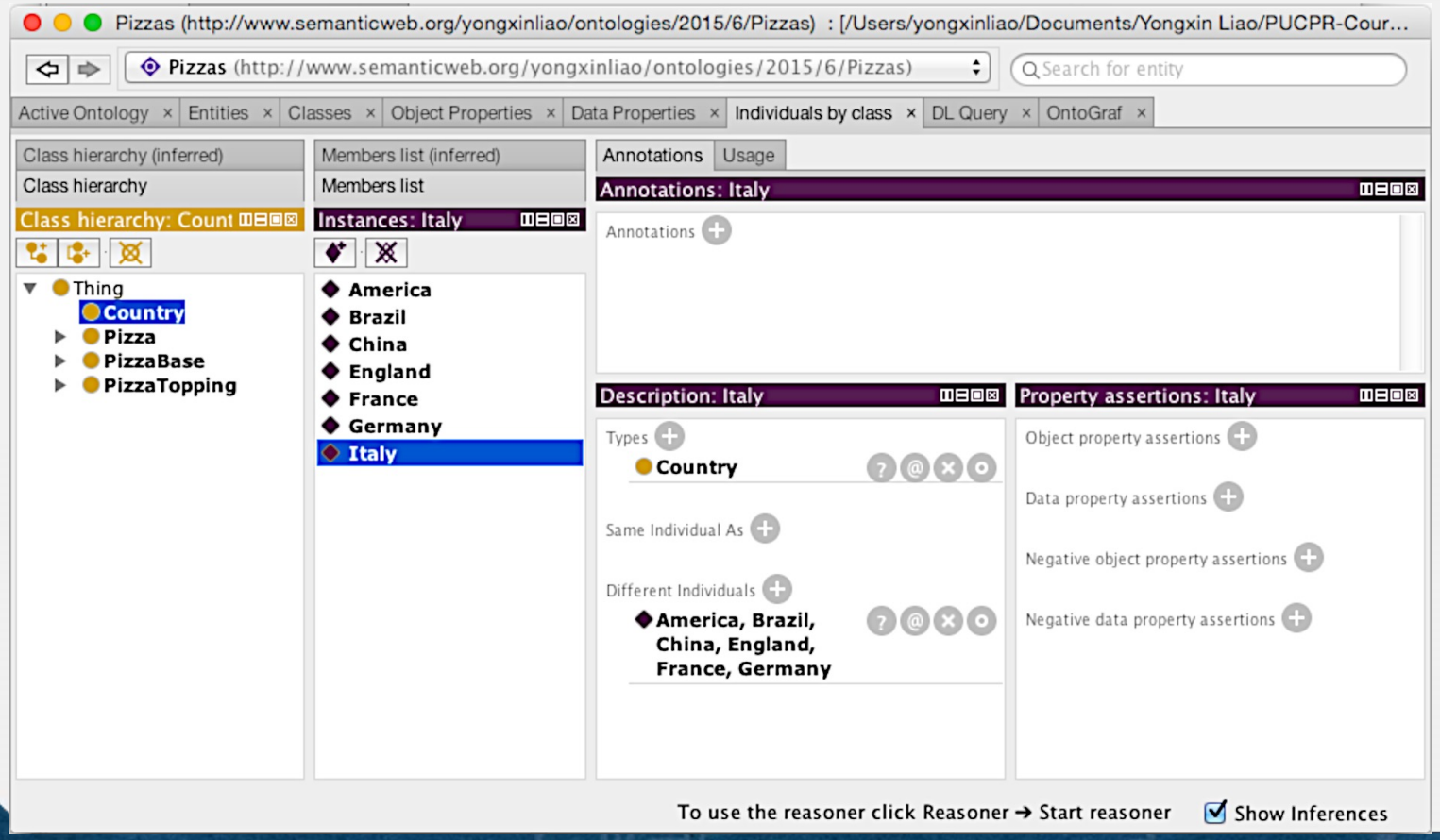
Protégé Practices

- Individuals and Class Assertion Axioms
- Individual Inequality Axioms



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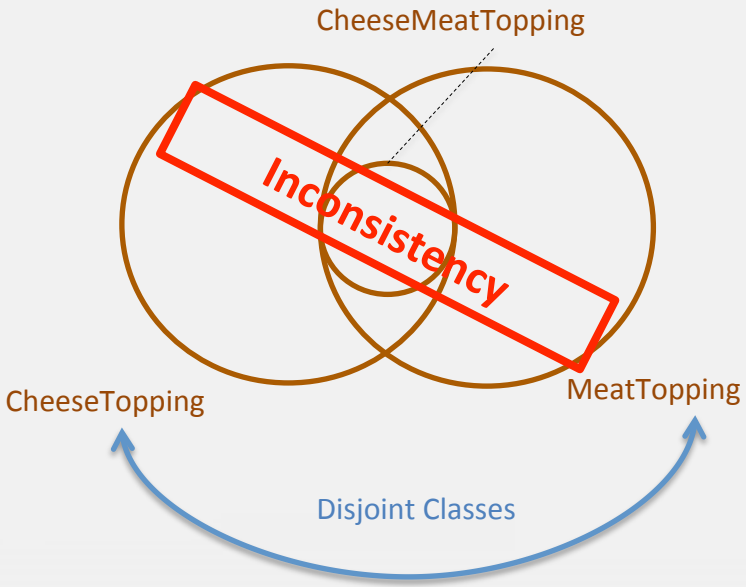
An Inconsistency Checking Practice

- Existing Knowledge

  (1) CheeseMeatTopping is a sub class of CheeseTopping

  (2) CheeseMeatTopping is a sub class of MeatTopping

  (3) The class CheeseToppingis disjoint with the class MeatTopping



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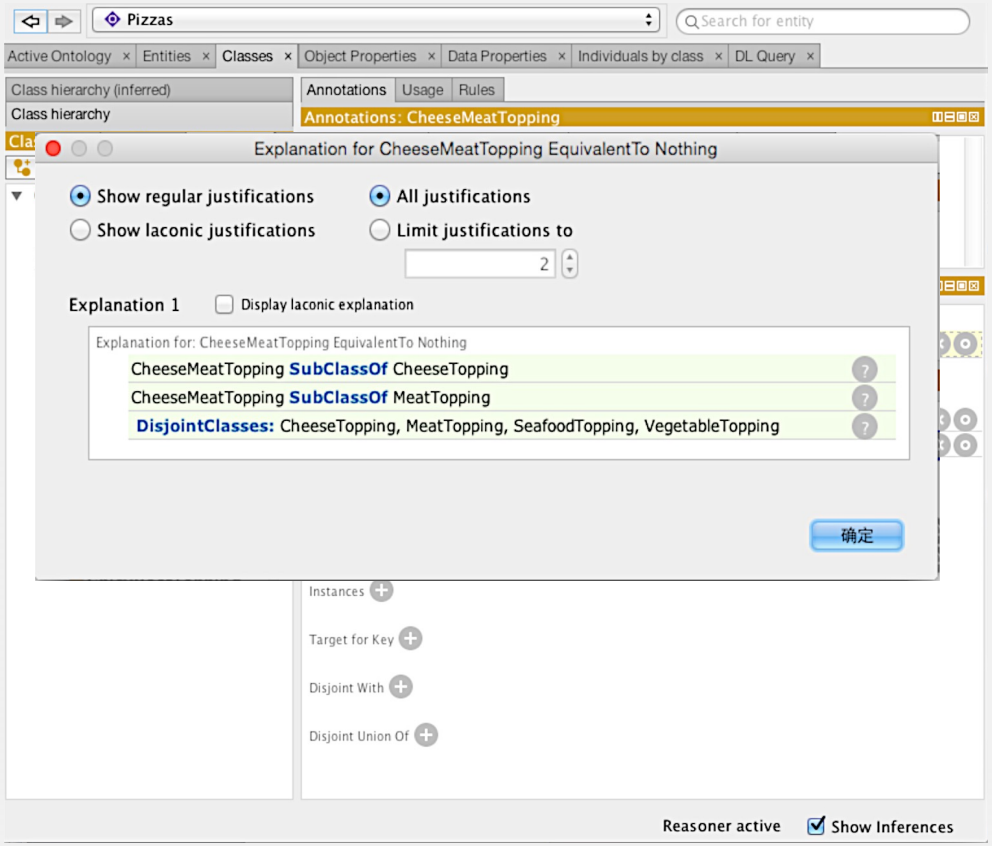
An Inconsistency Checking Practice

- Inference Result



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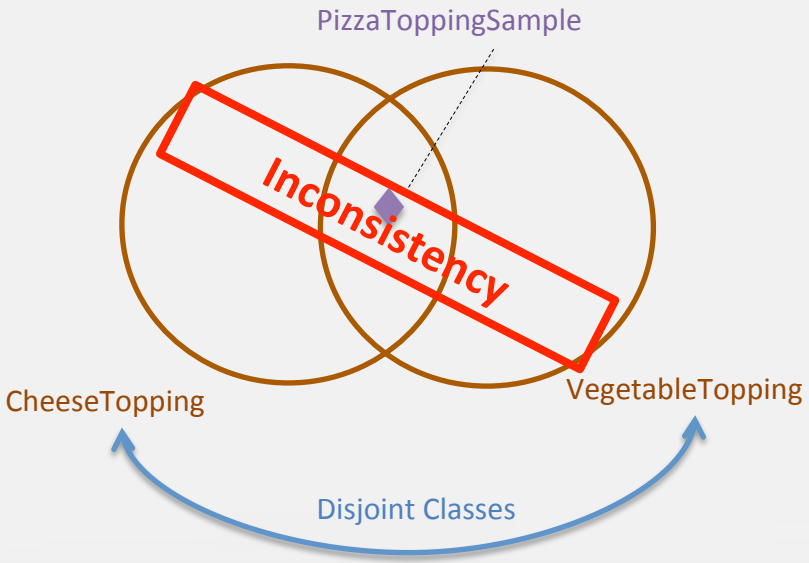
An Inconsistency Checking Practice

- Existing Knowledge

  (1) PizzaToppingSample is a member of CheeseTopping

  (2) PizzaToppingSample is a member of VegetableTopping

  (3) The class CheeseTopping is disjoint with the class VegetableTopping



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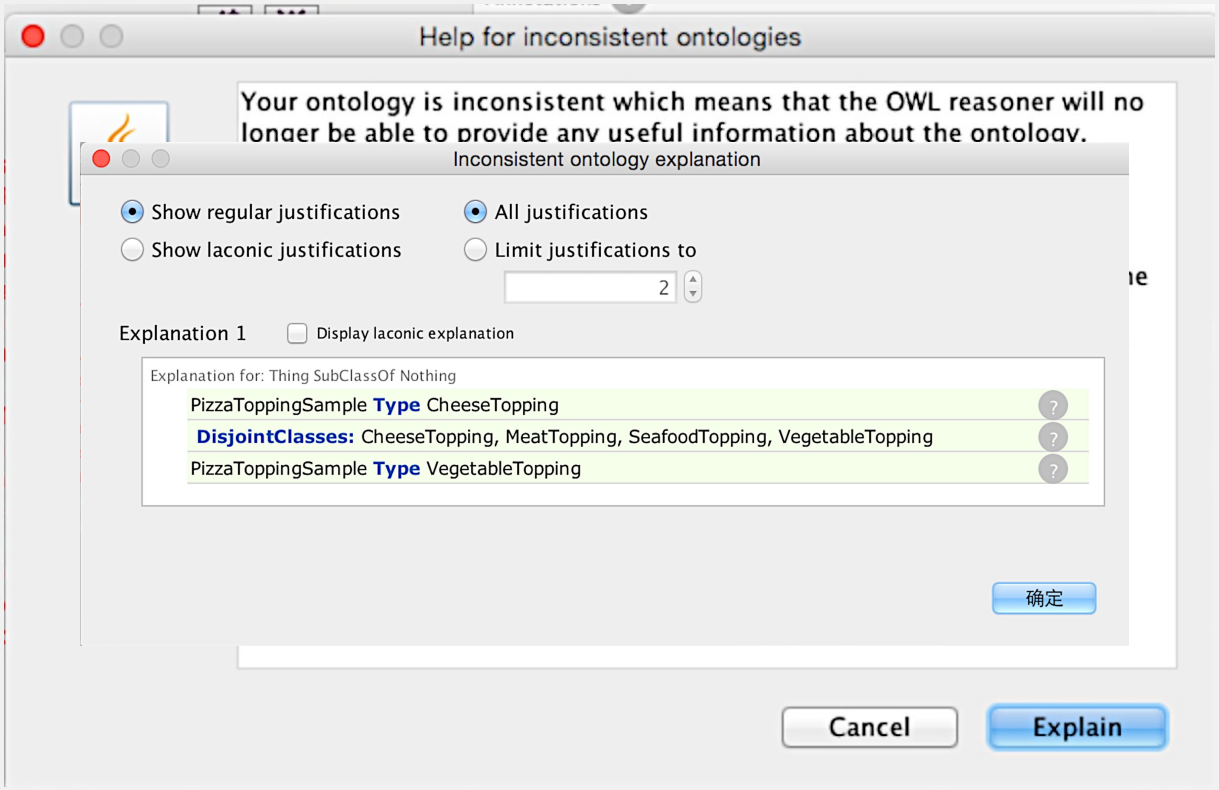
An Inconsistency Checking Practice

- Inference Result



Thank you
for your attention!

Any Questions?

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