Protégé-OWL Tutorial

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[1] [2]

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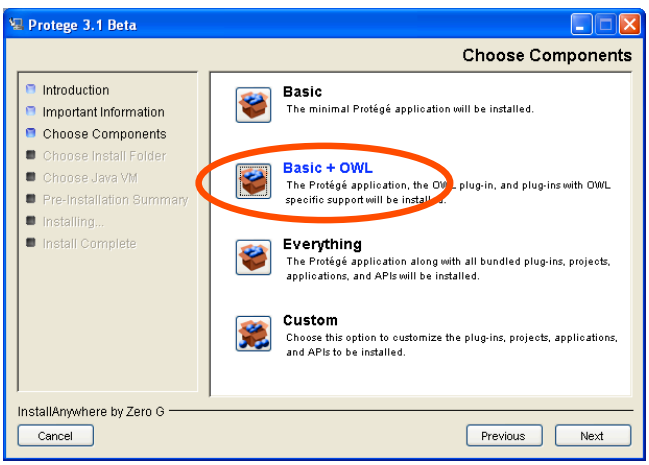
Installation

- Download the "Full" version of Protege
- Select "Basic + OWL" in the installation Wizard



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Overview

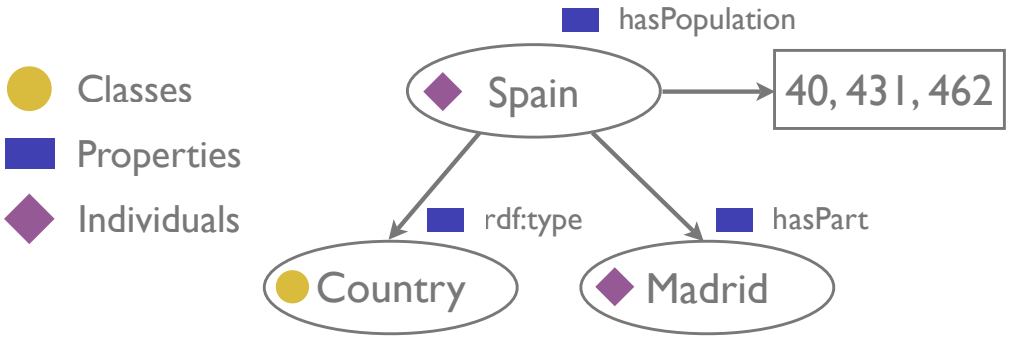
- Introduction
- RDF and OWL Lite
- OWL-DL
  - Classes and properties
  - Defined classes
  - Reasoning
- OWL-Full
- Other topics as time permits

The Semantic Web

- Platform for sharing domain models.
  - Designed by humans
  - "Understandable" for machines
- W3C standard languages
  - XML
  - RDF
  - OWL
  - ... SWRL (?)

RDF(S)

- Simple representation language for domain models / ontologies.
- Resources and links between them.
- Resource types:



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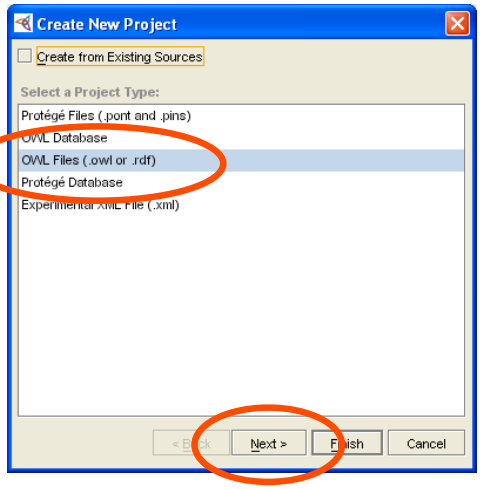
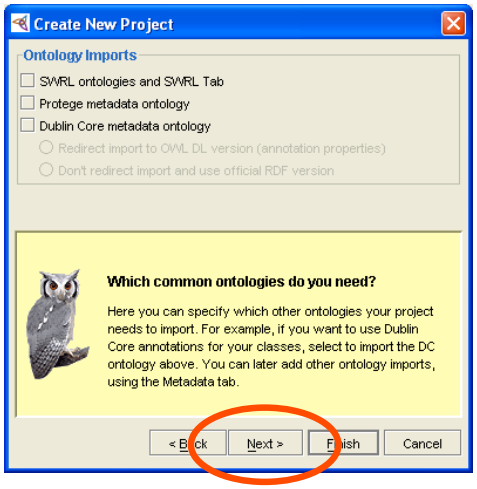
Creating a new RDF Project (1)





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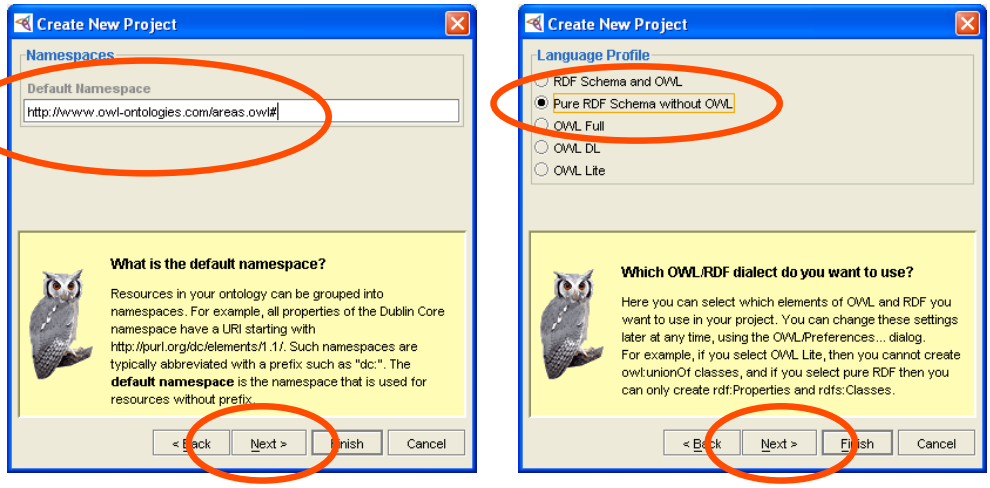
Creating a new RDF Project (2)



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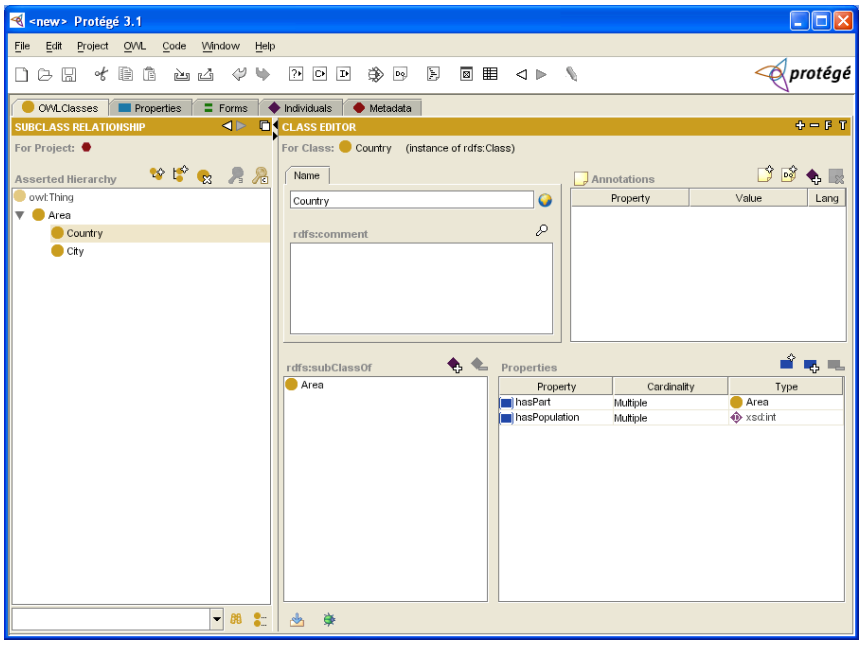
Protégé User Interface



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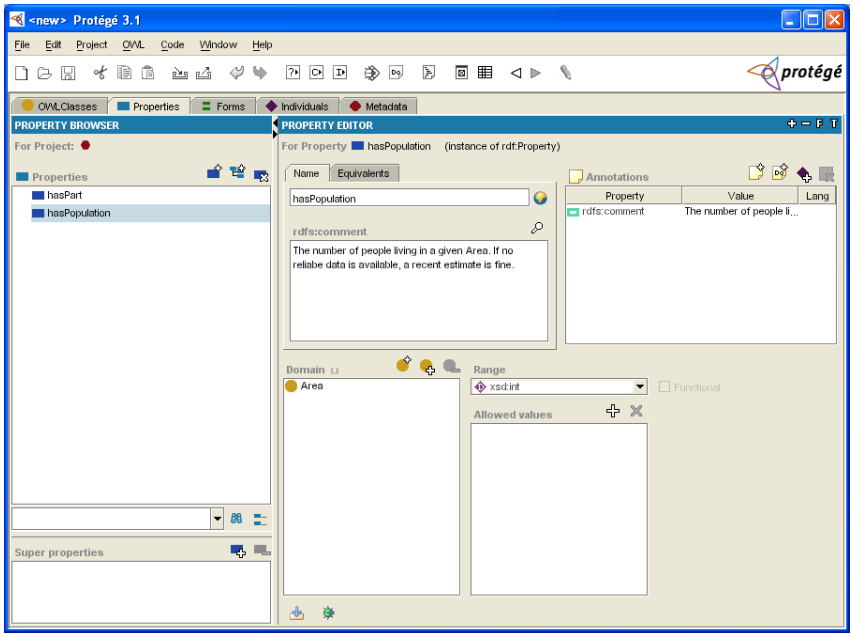
Properties Tab



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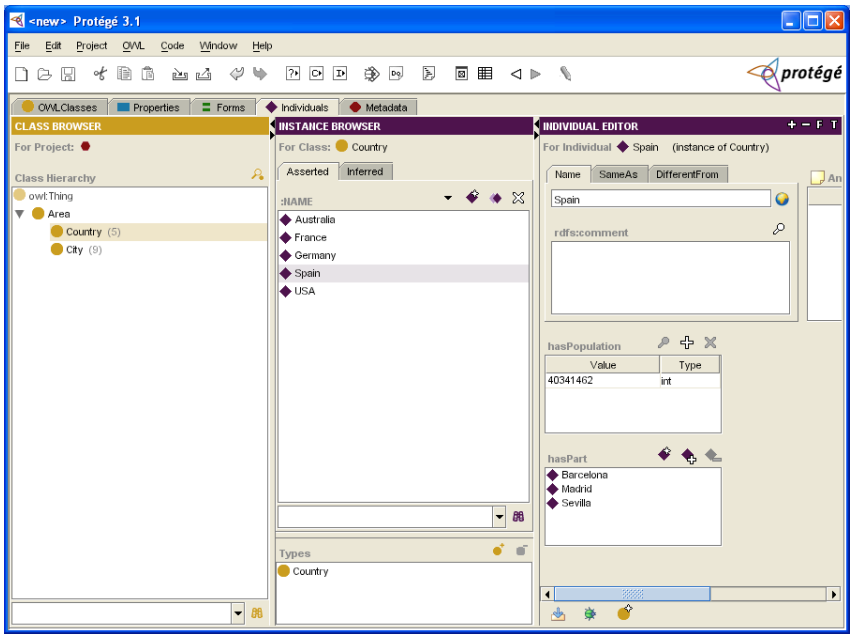
Individuals Tab



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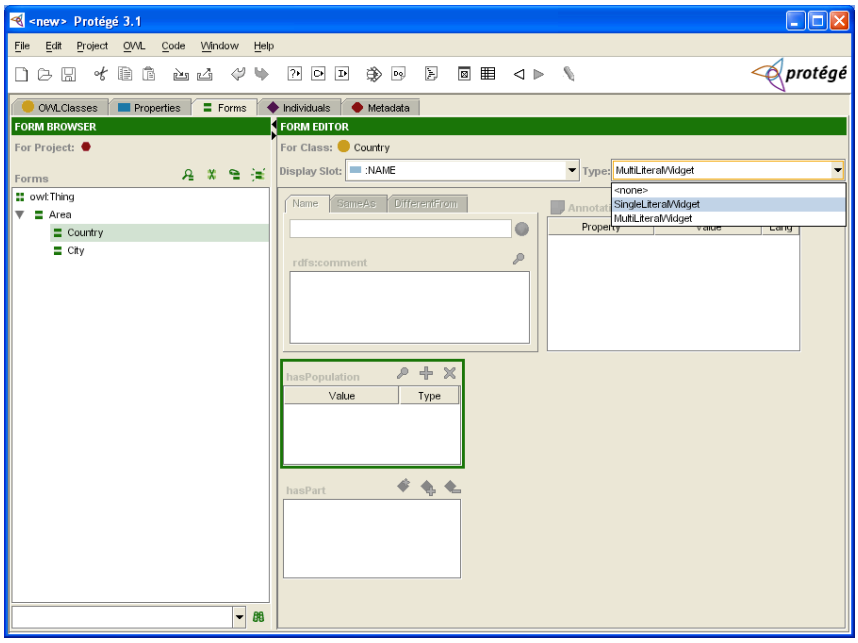
Forms Tab



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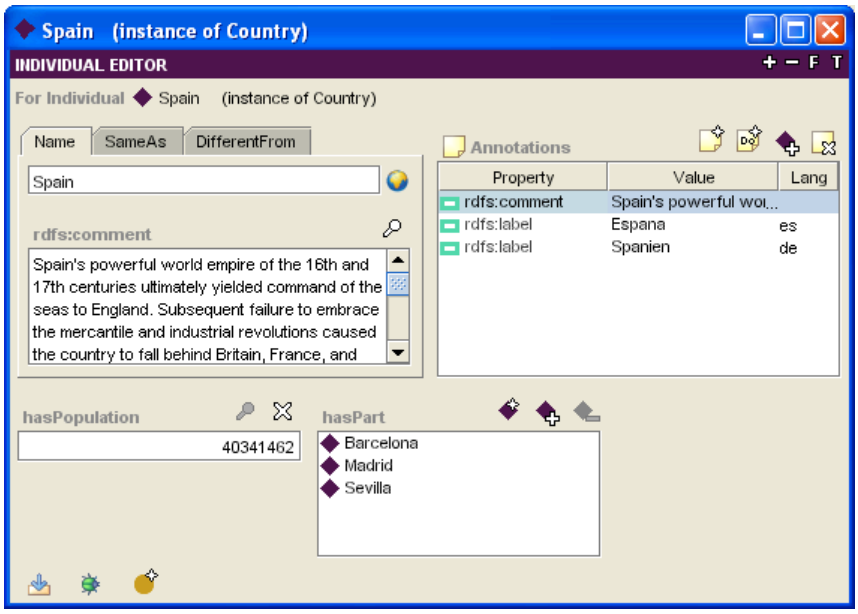
Optimising Forms



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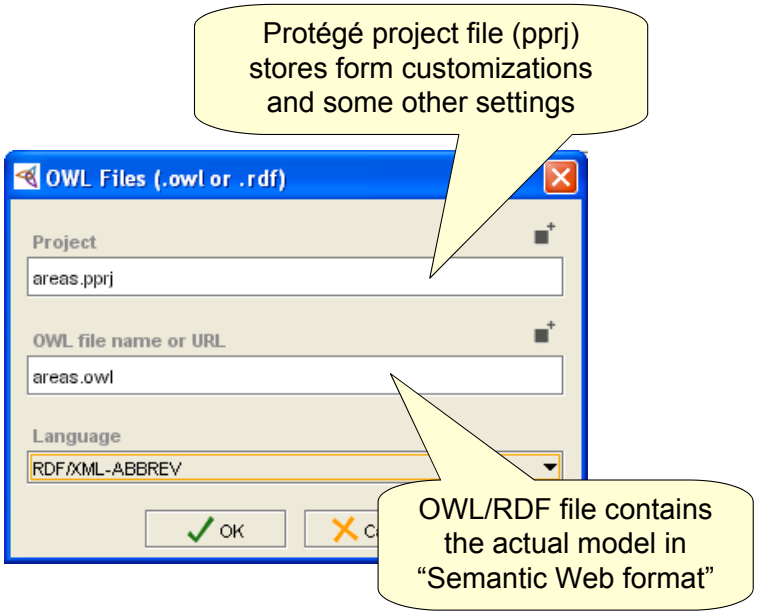
Saving Projects



RDF/OWL Files

```
<?xml version="1.0"?>
<rdf:RDF
    xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
    xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
    xmlns:owl="http://www.w3.org/2002/07/owl#"
    xmlns="http://www.owl-ontologies.com/areas.owl#"
  xml:base="http://www.owl-ontologies.com/areas.owl">
  <owl:Ontology rdf:about=""/>
  <rdfs:Class rdf:ID="Area"/>
  <rdfs:Class rdf:ID="Country">
    <rdfs:subClassOf rdf:resource="#Area"/>
  </rdfs:Class>
  <rdfs:Class rdf:ID="City">
    <rdfs:subClassOf rdf:resource="#Area"/>
  </rdfs:Class>
  <rdf:Property rdf:ID="hasPart">
    <rdfs:domain rdf:resource="#Area"/>
    <rdfs:range rdf:resource="#Area"/>
  </rdf:Property>
...
```

Namespace declarations

Short notation for full URI
http://www.owl-ontologies.com/areas.owl#Area

Using RDF Files on the Web

Classes and properties

http://www.owl-ontologies.com/areas.owl#Country

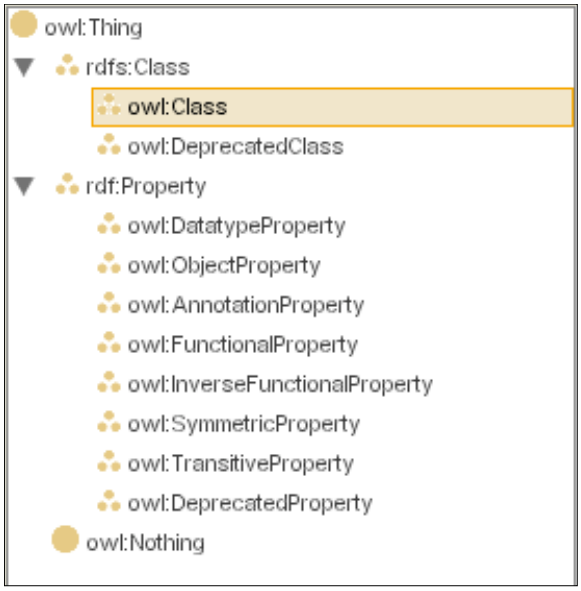
Individuals

http://www.cia.gov/cia/publications/factbook/maps/sp-map.gif

RDF(S) Limitations

- Simple mechanism to formalise domains.
- Limited expressivity.
- Cannot be used to express things such as:
  - "Each are has at most one value for hasPopulation"
  - "Each Country must have at least one City"
  - "Countries cannot have countries as parts"

From RDF to OWL



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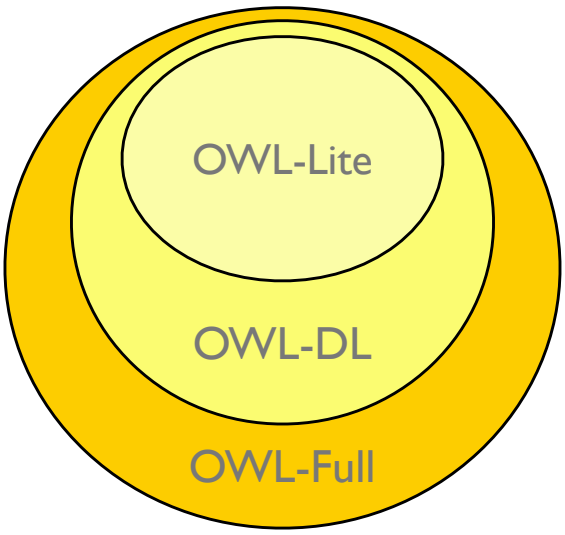
OWL Dialects



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Building an OWL-DL Ontology

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Why Pizzas?

- Fun
- Understood by a wide audience
- Not too controversial
- Simple - about the right numbers of classes and properties for a tutorial
- Comprehensive written version of the tutorial available

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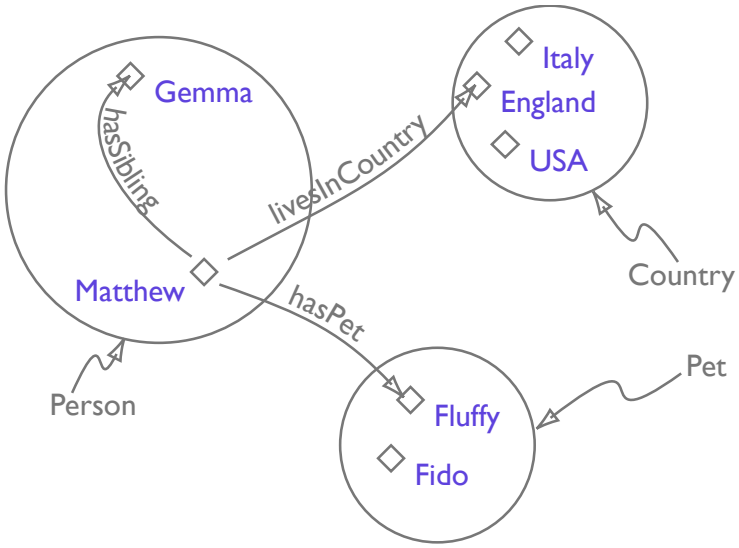
Components of an OWL Ontology



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OWL Class Descriptions

- OWL is an ontology language that is primarily designed to describe and define classes. Classes are therefore the basic building blocks of an ontology.
- Classes are interpreted as sets of individuals.
- OWL supports six main ways of describing classes of individuals. The simplest of these is a Named Class. The other types of class descriptions are anonymous classes.

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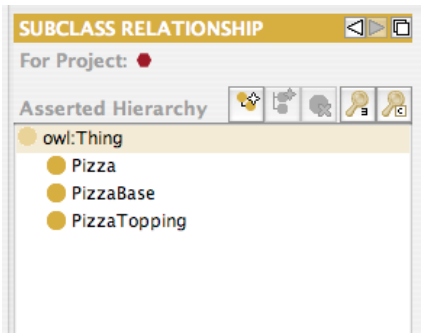
OWL Classes

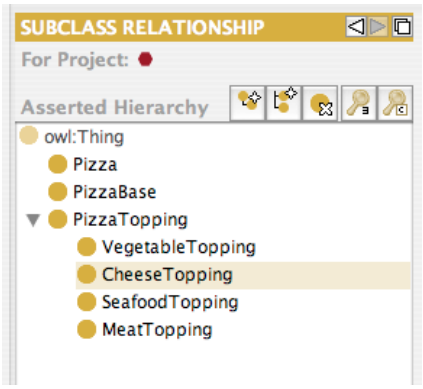
- Named classes - create a class and assign a name to it. Two 'built in' named classes: owl:Thing and owl:Nothing.
- Anonymous classes - built up from class descriptions
  - Intersection, Union and Complement classes
  - Restriction classes - existential, universal, cardinality, hasValue
  - Enumeration classes
- Combinations of Named classes and anonymous classes are used to build up complex class descriptions.

Creating Named Classes



- Select the classes tab use the 'Create subclass' and 'Create sibling class' buttons to create Pizza, PizzaBase and PizzaTopping.

Creating Subclasses



- Create some subclasses of PizzaTopping to represent high level categorisations of pizza toppings.
- Add additional classes to represent different kinds of pizza toppings.

  Tomato, Parmesan, Mushroom, Pepperoni, Anchovy, Ham, Mozzarella, SpicyBeef

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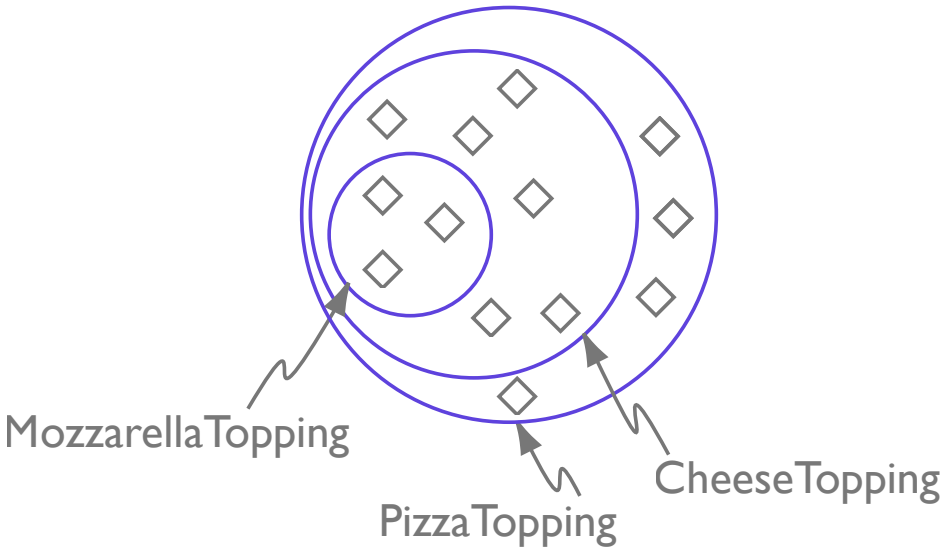
Meaning of Subclass



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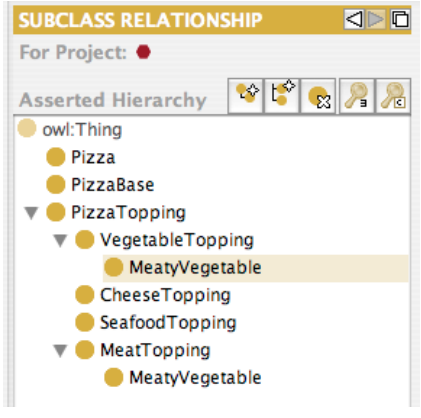
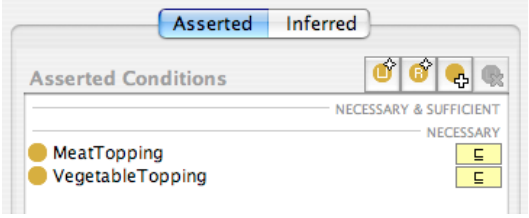
Create some classes to describe different pizzas

- Create a subclass of Pizza called 'NamedPizza'.
- Create 'MargheritaPizza', 'AmericanaPizza', 'SpicyBeefPizza' as subclasses of NamedPizza.

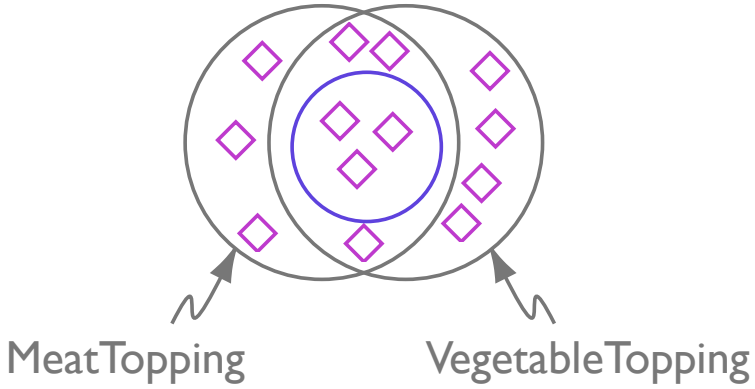
Multiple Inheritance

- OWL allows us to specify multiple named superclasses for any OWL class.
- Create a class called MeatyVegetable as a subclass of VegetableTopping.
- Use the Conditions Widget to add MeatTopping as an extra superclass to MeatyVegetable





What is a MeatyVegetable?



Does this make sense?

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Checking an Ontology

- We've just created a very strange class - intuitively, it should not be possible for individuals that are both a kind of MeatTopping and a kind of VegetableTopping to exist.
- We know that having individuals that are kinds of MeatyVegetables doesn't make sense from a modelling point of view, but can these individuals exist from a logical point of view?
- Ideally, we would like to automatically check our ontology to ensure that the logical meaning corresponds to the intended meaning. To do this, we can use a reasoner.

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Reasoning

- For an ontology that falls into the scope of OWL-DL, we can use a DL Reasoner to infer information that isn't explicitly represented in the ontology. Standard 'reasoning services' are:
  - Subsumption checking
  - Equivalence checking
  - Consistency checking
  - Instantiation checking

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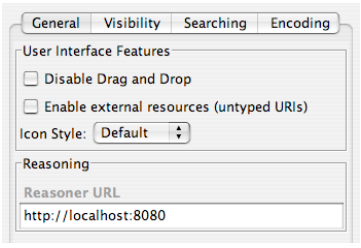
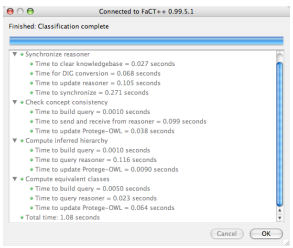
Using a reasoner to check class consistency

- Protege-OWL can be used with any DIG compliant reasoner.
- Communication with the reasoner takes place via HTTP.
- Ensure a reasoner is running and press the check consistency button to check the consistency of named classes in the ontology.



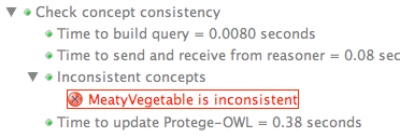


Disjoint Axioms

- Having used a reasoner to check the consistency of named classes in the ontology we notice that MeatyVegetable is consistent - in other words, it's possible for individuals that are both MeatTopping and CheeseTopping to exist!
- OWL classes 'overlap' unless they are explicitly stated to be disjoint with each other, or they are inferred to be disjoint with each other.
- We need to specify that if something is a MeatTopping it cannot be a VegetableTopping. To do this we use disjoint axioms.

Add disjoint axioms and reclassify the ontology

- Add a disjoint axiom to make VegetableTopping disjoint from MeatTopping.
- Reclassify the ontology.



Where else do we need disjoint axioms?

Properties

- OWL has two main types of properties: Object properties and Datatype properties.
- Object properties relate an individual to an individual.
- Datatype properties link an individual to a data value.
- A third type of property, Annotation properties, can be used to attach 'meta-data' to classes, properties and individuals.

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Property Hierarchies

- OWL supports the specification of a property hierarchy.
- We can specify that a property has a super-property. In fact, for any given property we can specify multiple super properties.
- In OWL-DL, object properties may only have object properties as super-properties, and datatype properties may only have datatype properties as super-properties.

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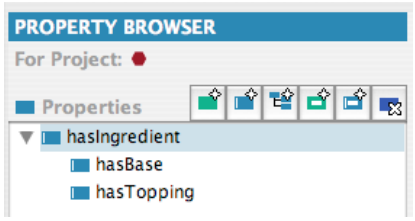
Create Properties to Describe Pizzas

- Create an object property called 'hasIngredient'.
- Create an object property called 'hasTopping' as a sub-property of hasIngredient.
- Create an object property called 'hasBase' as a sub-property of hasIngredient.



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Property Characteristics

- We can specify additional property characteristics by typing properties as:
  - Functional
  - InverseFunctional
  - Symmetic
  - Transitive
- Beware! Certain combinations of the above characteristics can cause the ontology to be OWL-Full.

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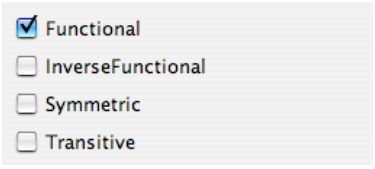
Augment the properties with characteristics

- A pizza only has one base - make the hasBase property functional.
- We want to capture the fact that the ingredients that make up the pizza toppings also make up the pizza - make the hasIngredient property transitive.



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Restrictions

- Restrictions describe a class of individuals that is determined by the type and possibly the number of relationships that they participate in.
- Restrictions can be grouped into three main categories:
  - Quantifier restrictions (Existential ∃, Universal ∀)
  - Cardinality restrictions (Min ≥, Equal =, Max ≤)
  - HasValue restrictions (∋)

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Existential Restrictions

- The most common type of restriction that we will use is an existential restriction, which has the symbol ∃ (backwards E)
- The existential restriction mean 'some values from', or 'at least one'.
- An existential restriction describes the class of individuals that have at least one relationship along a specified property to an individual that is a member of a specified class.

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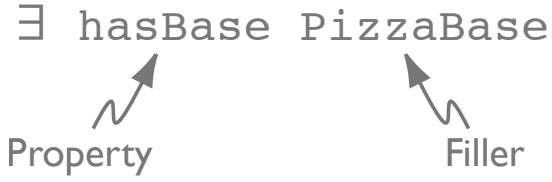
Create some existential restrictions

- We can specify that every pizza must have at least one base by creating an existential restriction along the hasBase property with a filler of PizzaBase.
- To do this in Protege-OWL we use the conditions widget.



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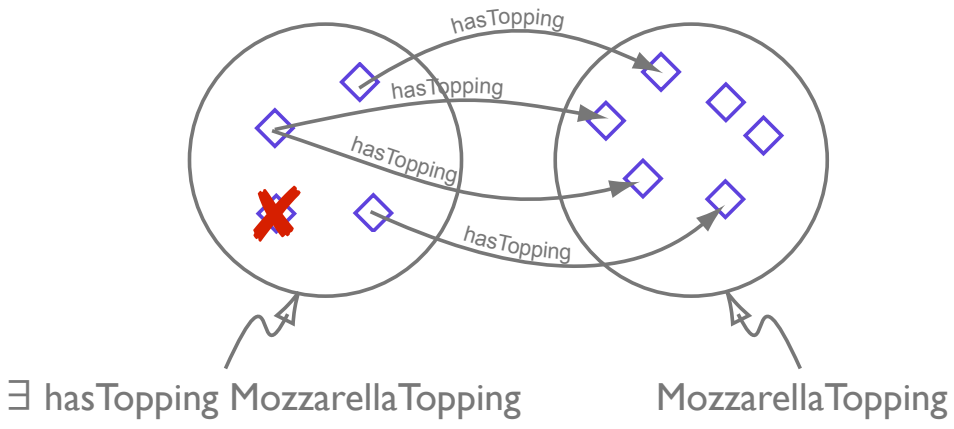
More Existential Restrictions

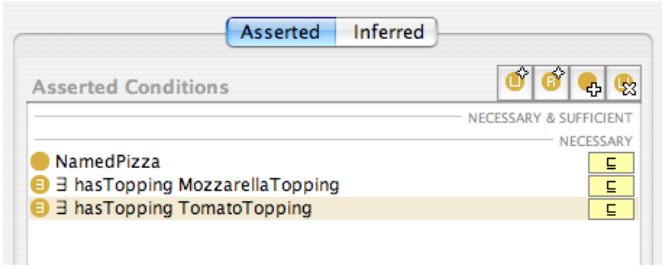
- Create restrictions to say that MargheritaPizzas have at least one mozzarella topping and at least one tomato topping.
- Create restrictions to describe the fact that AmericanaPizzas have toppings of mozzarella, tomato and pepperoni.
- Create restrictions to represent SpicyBeefPizzas having toppings of mozzarella, tomato and spicy beef.

Existential Restrictions



Necessary Conditions

- So far, all the conditions that we have used in class descriptions have been 'necessary' conditions.
- For a given class, necessary conditions are the conditions that an individual must fulfil if it is a member of that class.
- For example, recall our description of a MargheritaPizza...



If an individual is a member of MargheritaPizza, it is necessarily a NamedPizza, and it necessarily has at least one mozzarella topping, and it necessarily has at least one tomato topping.

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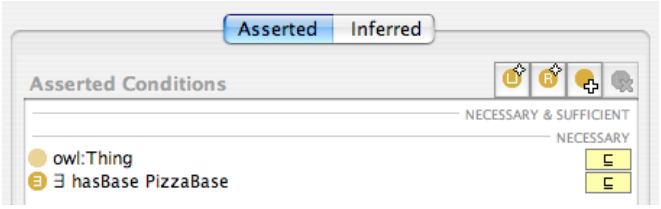
Necessary Conditions

- For a given class, the necessary conditions represent superclasses of that class.
- Recall our description of a pizza...



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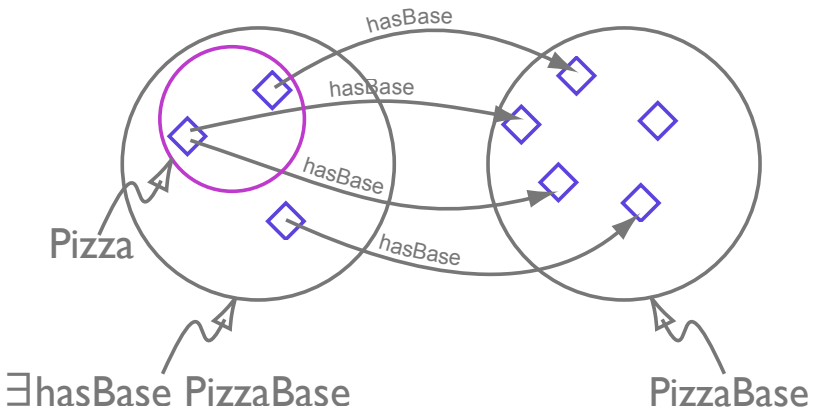
Necessary Conditions on Pizza



Necessary & Sufficient Conditions

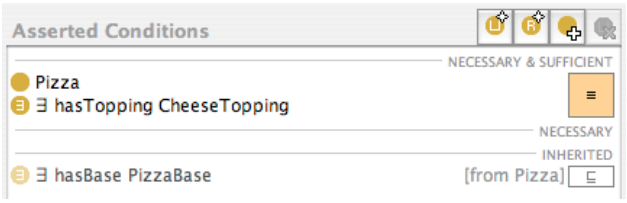
- With Necessary conditions, if we know that an individual is a member of a given class, we also know that it must fulfil the Necessary conditions on that class.
- What about going 'the other way round'? e.g. Given an individual that fulfils some conditions, what classes is it a member of?
- OWL also supports Necessary & Sufficient conditions, which allow us to determine that any individual that satisfies the conditions can be inferred to be a member of the class that the conditions are on.

Necessary & Sufficient Conditions

- Recall that ClassA is a subclass of ClassB if all individuals in ClassA are also in ClassB.
- Therefore, if all of the individuals in ClassB fulfil the necessary & sufficient conditions on ClassA, all of them must also be members of ClassA, and we can infer that ClassB is a subclass of ClassA.

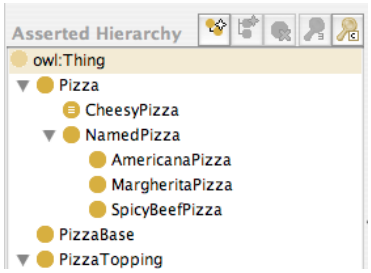
Necessary & Sufficient Conditions Example

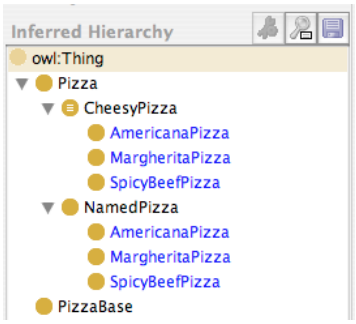
- Create a CheesyPizza class, which is a subclass of Pizza and also has at least one CheeseTopping.
- Create the conditions under the Necessary & Sufficient header in the conditions widget.

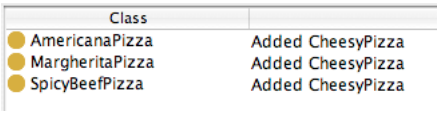


Necessary & Sufficient Conditions Example

- Classify the ontology...





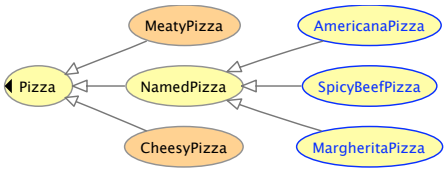


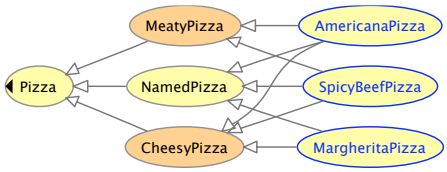
Terminology

- Classes with only Necessary conditions are also known as Primitive classes.
- Classes with at least one set of Necessary & Sufficient conditions are known as Defined classes.
- Classes with only Necessary conditions are said to have a Description. Classes with at least one set of Necessary & Sufficient conditions are said to have a Definition.
- A distinction can be made between asserted and inferred information.

Add another defined class

- Create another defined class called MeatyPizza to specify that any pizza with at least one meat topping must be a MeatyPizza and then reclassify the ontology.





Multiple Parents

- Take a look at our asserted class hierarchy. Notice that each class only has one primitive parent - the class hierarchy is a tree.
- Notice that the inferred class hierarchy is a lattice - classes have multiple parents.
- We let the reasoner take care of maintaining a multi-parent hierarchy - the asserted hierarchy is maintained as a tree.

Vegetarian Pizzas

- We want to define what it means to be a VegetarianPizza, so that we can use the reasoner determine which of our pizzas are vegetarian pizzas.
- How should we define a VegetarianPizza?

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Vegetarian Pizzas

- We will define a VegetarianPizza to be any pizza that only has vegetarian toppings.
- To do this we need to decide what a vegetarian topping is...

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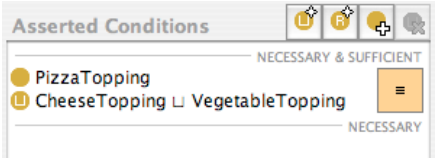
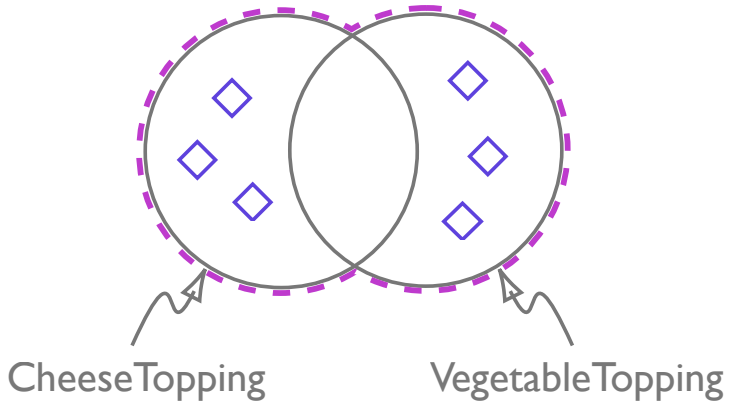
Vegetarian Toppings

- A VegetarianTopping is any pizza topping that is either a CheeseTopping or VegetableTopping.
- We can use a Union Class to specify this.
- Create VegetarianTopping as a subclass of PizzaTopping, and add a necessary & sufficient condition to specify that VegetarianToppings are either CheeseTopping or VegetableTopping.



Union Classes



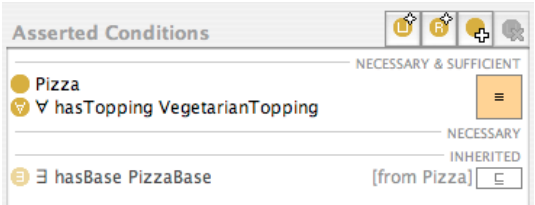
`CheeseTopping ⊔ VegetableTopping`

Universal Restrictions

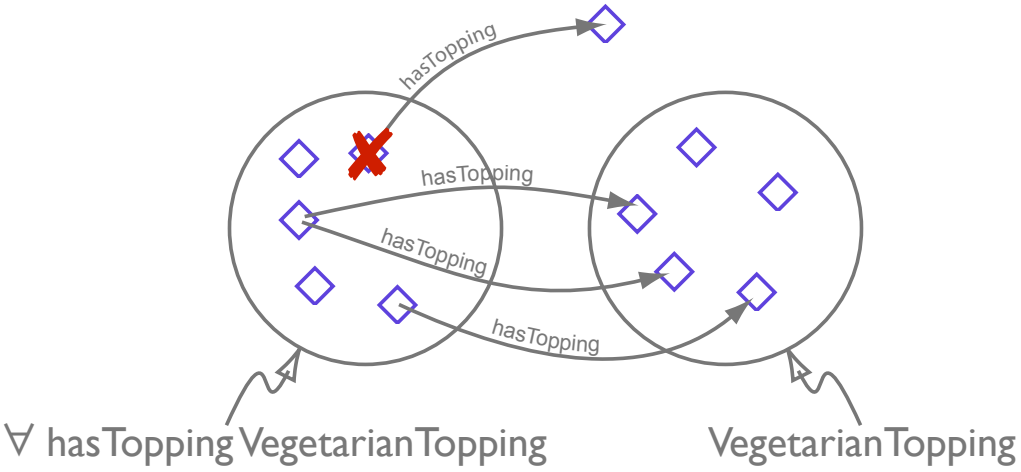
- We want to be able to say that VegetarianPizzas only have toppings that are VegetarianToppings.
- In order to do this we can use a Universal Restriction.
- Universal restrictions are written using the symbol ∀ (upside down A).
- Universal restrictions mean 'all values from', or 'only'.
- A universal restriction describes the class of individuals that for a given property, only have relationships to individuals from a specified class.

Define VegetarianPizza

- Create a subclass of Pizza called VegetarianPizza. Add a universal restriction to specify that a VegetarianPizza only has toppings that are VegetarianToppings. Make VegetarianPizza a defined class.



Universal Restrictions

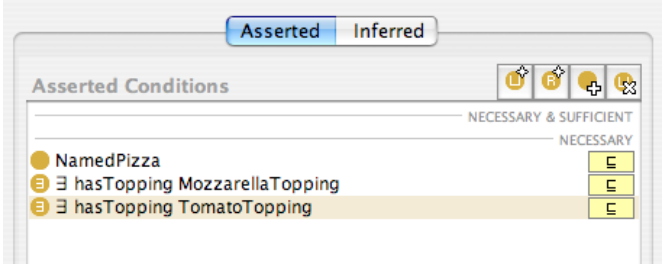


Subclasses of VegetarianPizza

- Use the reasoner to classify the ontology.... what are the subclasses of VegetarianPizza?
- Is our definition of VegetarianPizza correct?

The Open World Assumption

- None of the pizzas have been classified as subclasses of VegetarianPizza.
- Let's revisit the description of MargheritaPizza...



The Open World Assumption

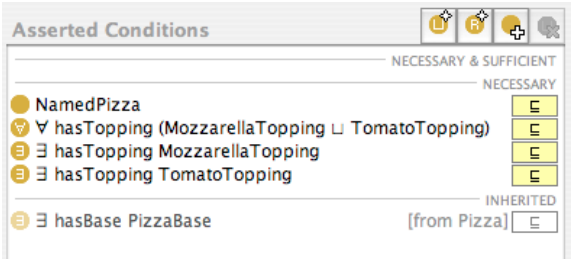
- Just because something hasn't been stated doesn't mean that it isn't true. Contrast this with a database.
- For example we haven't stated that a Margherita pizza has some pepperoni topping, but because of the open world assumption, it could have some.
- In Open World Reasoning, something isn't assumed to be false unless it is explicitly stated to be false.

Closure

- For all our pizzas we need to say something along the lines of "these kinds of pizzas have these toppings and only these toppings".
- For example, a MargheritaPizza has some mozzarella topping and has some tomato topping and only has mozzarella topping or tomato topping.
- In other words, for any given pizza, we want to 'close off' the possible toppings.

Closure Axioms

- To close off the possible toppings that a MargheritaPizza can have, we need to use a universal restriction to say that a MargheritaPizza can only have toppings that are MozzarellaTopping or TomatoTopping.

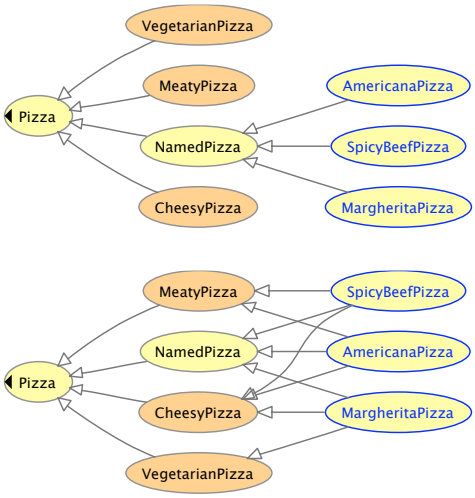


The universal restriction is known as a closure axiom

Add more closure axioms

- Modify the descriptions of the other pizzas by adding closure axioms along the hasTopping property.
- The general pattern for a closure axiom is to create a universal restriction along the property being closed, that has a filler which is the union of the fillers of the existential restrictions for that property.
- After adding the closure axioms, classify the ontology.

The asserted and inferred hierarchies

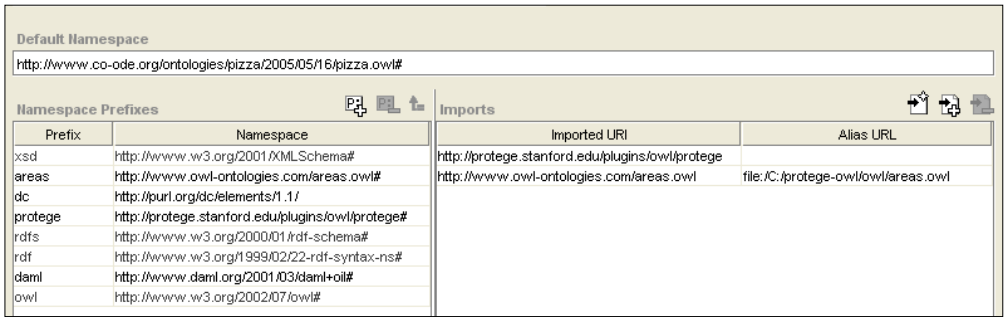


Summary

- Classes are the building blocks of an OWL ontology - OWL has two main types of class description: Named classes and anonymous classes.
- OWL distinguishes between necessary, and necessary & sufficient conditions.
- OWL-DL is underpinned by a description logic. For ontologies that fall into the scope of OWL-DL we can use a reasoner to automatically check the consistency of classes, and take what we have explicitly stated in the ontology and use it to infer new information.
- OWL makes the Open World Assumption and uses Open World Reasoning.

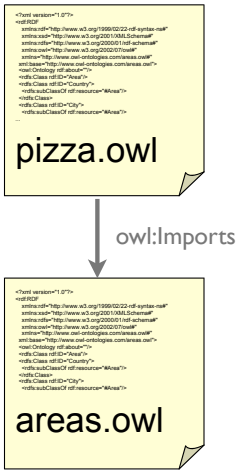
Namespace and Prefixes

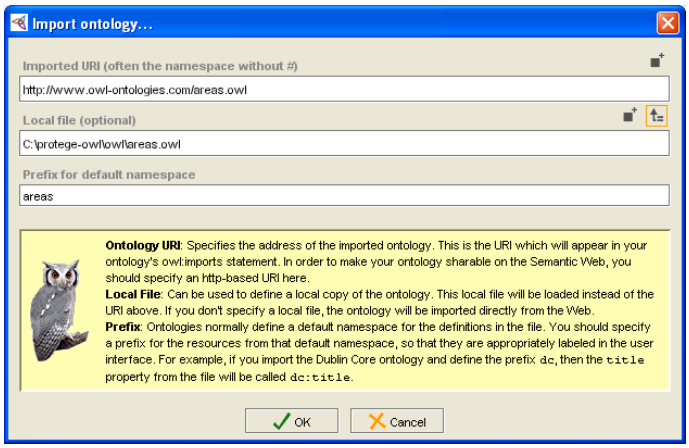
- Each ontology should have a unique default namespace.
- Imported concepts are prefixed.



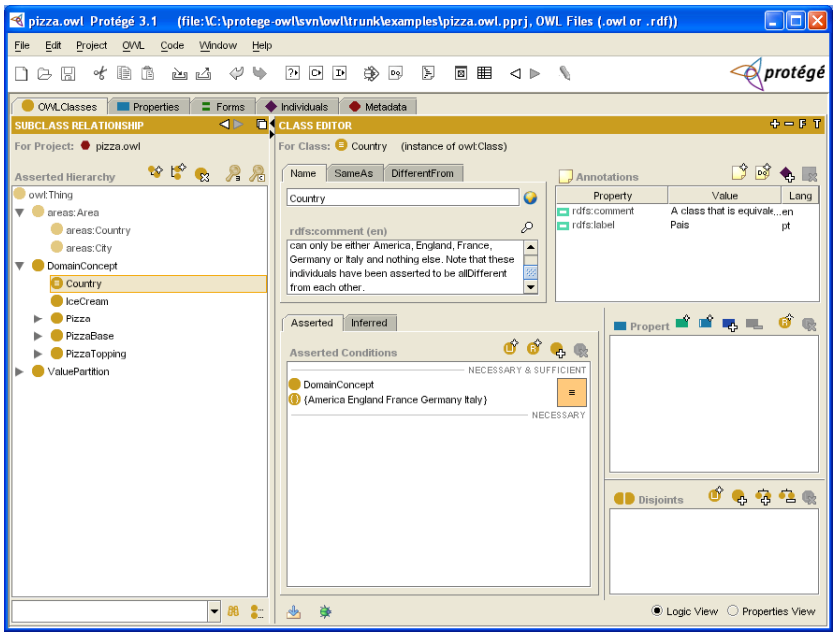
Ontology Imports (1)

- Allows ontology A to access all the resources from ontology B.

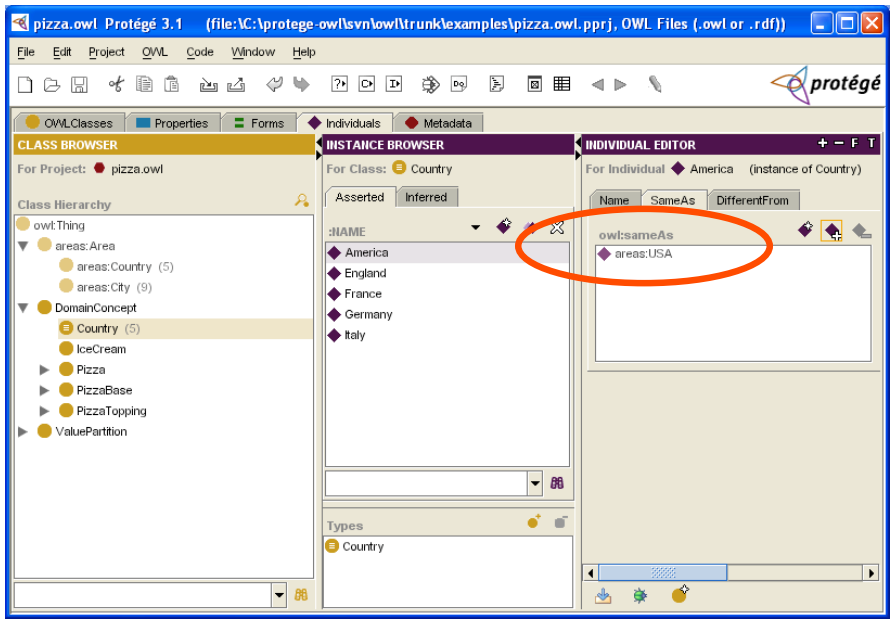




Ontology Imports (2)

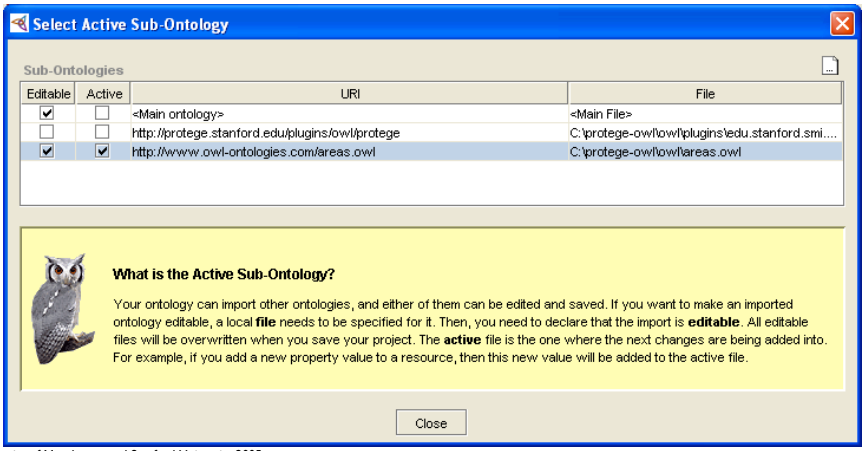


Ontology Imports (3)



Multi-File Projects

- One ontology is "active".
- Changes will only be applied to the active ontology.



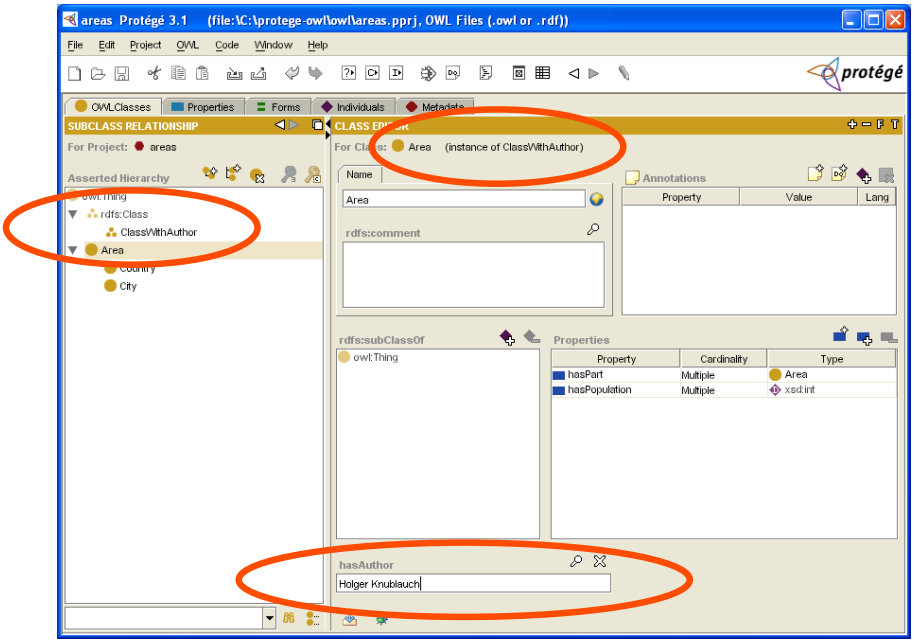
Import Redirection

- To be sharable on the web, ontologies should import other ontologies via http: addresses.
- However, at development time ontologies are local files (file://...address).
  - Ont-Policy file defines a mapping between
    - Logical address: http://...
    - Physical address: http://...

Namespace Pitfalls

- One file can define resources from multiple namespaces.
- The physical location of a file does not have to match with the default namespace.
- Different files can access the same namespace using different prefixes.
- Good practice: Keep it simple!

OWL-Full: Metaclasses



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Using Metaclasses

- Make rdfs:Class (or owl:Class) visible.
- Create Metaclass (subclass of rdfs:Class).
- Add properties to metaclass.
- Change type of classes:
  - Right click on class.
  - Go to Metaclasses/Change metaclass...
  - Select new type.

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Classes as Values (1)

- All classes are instances of a metaclass.
- Properties can take classes as values (rdfs:range = rdfs:Class).
- For example, a city may be famous for a kind of pizza.

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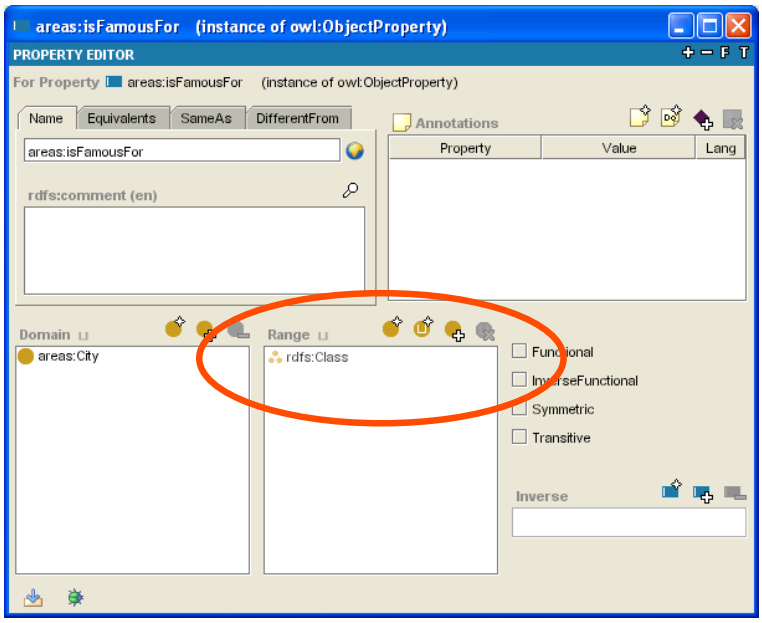
Classes as Values (2)



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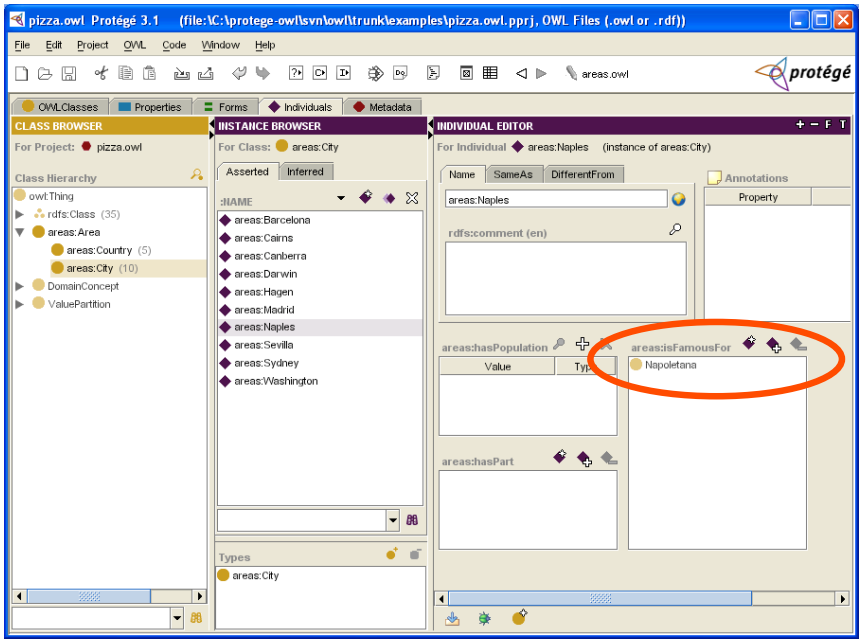
Classes as Values (3)



Links

- Protege-OWL web site:

  http://protege.stanford.edu/plugins/owl

- CO-ODE web site:

  http://www.co-ode.org