



# Lab Modeling Exercise: Discussion

Protégé Short Course  
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# Scenario: Hosting Dinner

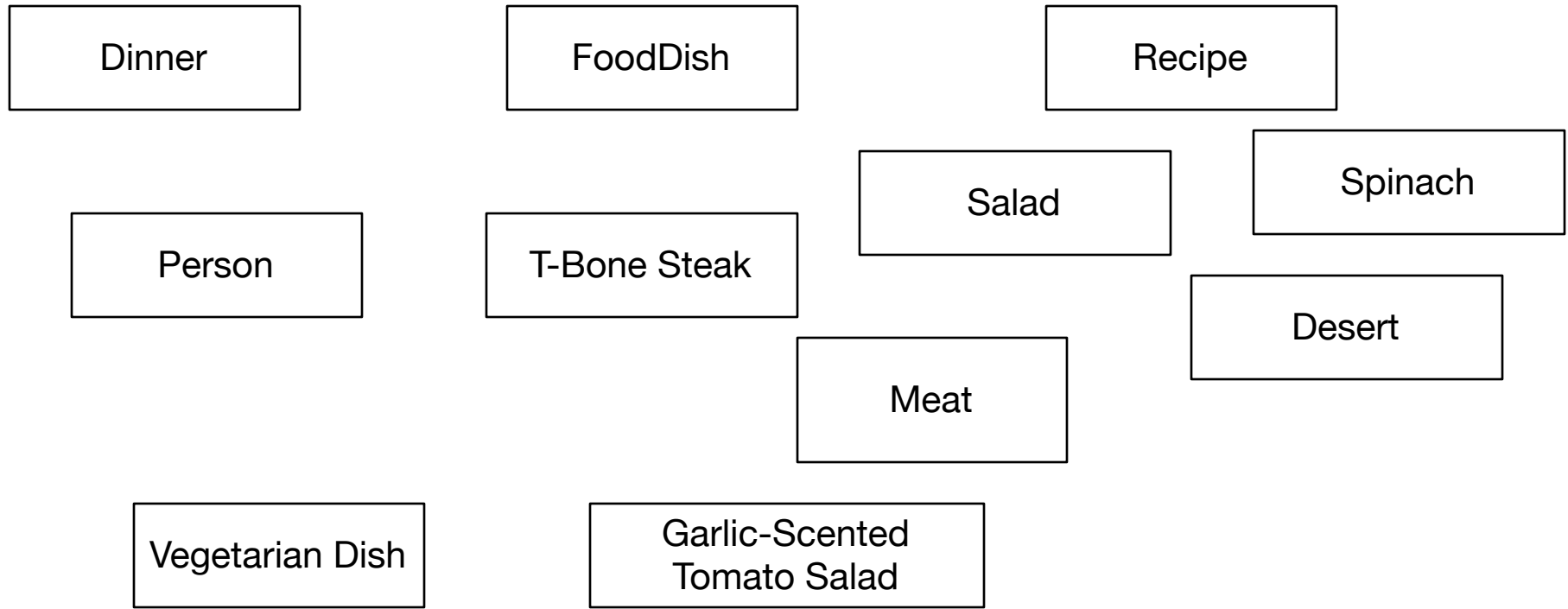
- Dinner party with guests Mary, Ashok, & Amara
  - Mary likes to have at least one main dish
  - Ashok eats only vegetarian food
- For Mary
  - At least one meat main dish
- For Ashok
  - A vegetarian soup or salad
  - At least one vegetarian main dish
  - A vegetarian dessert
- Dishes to be chosen from an Italian cookbook

# Competency Questions

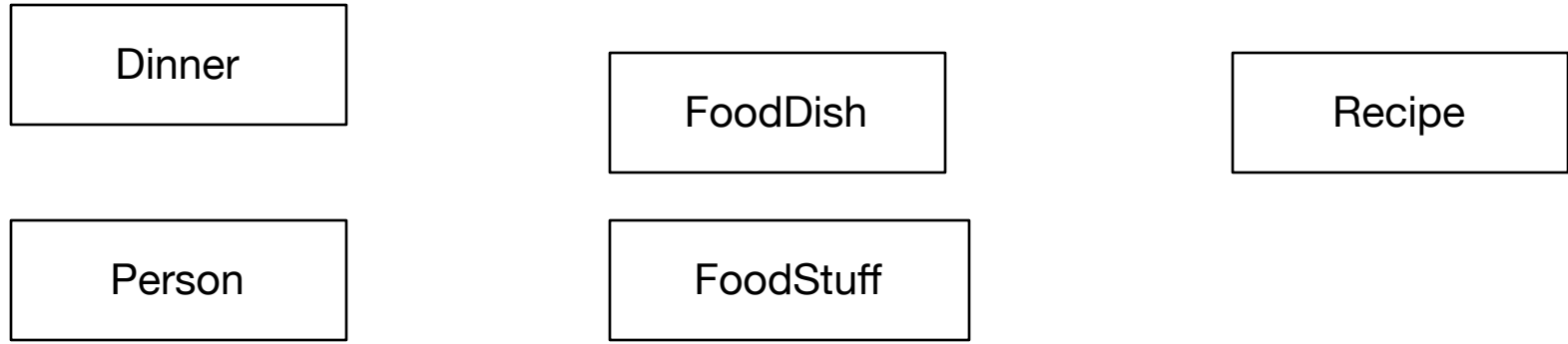
- What dishes have meat as an ingredient?
- What are “meat dishes” and “vegetarian dishes” in this ontology?
- What are some combinations of dishes
  - that are suitable for someone who eats only vegetarian food?
  - that will be appropriate for my party?
- Which recipe gives direction for a particular dish?
- Based on the recipes, what ingredients do you have to get for your dinner?

# Conceptualize the Domain:

## Mental Map of Terms in the Domain

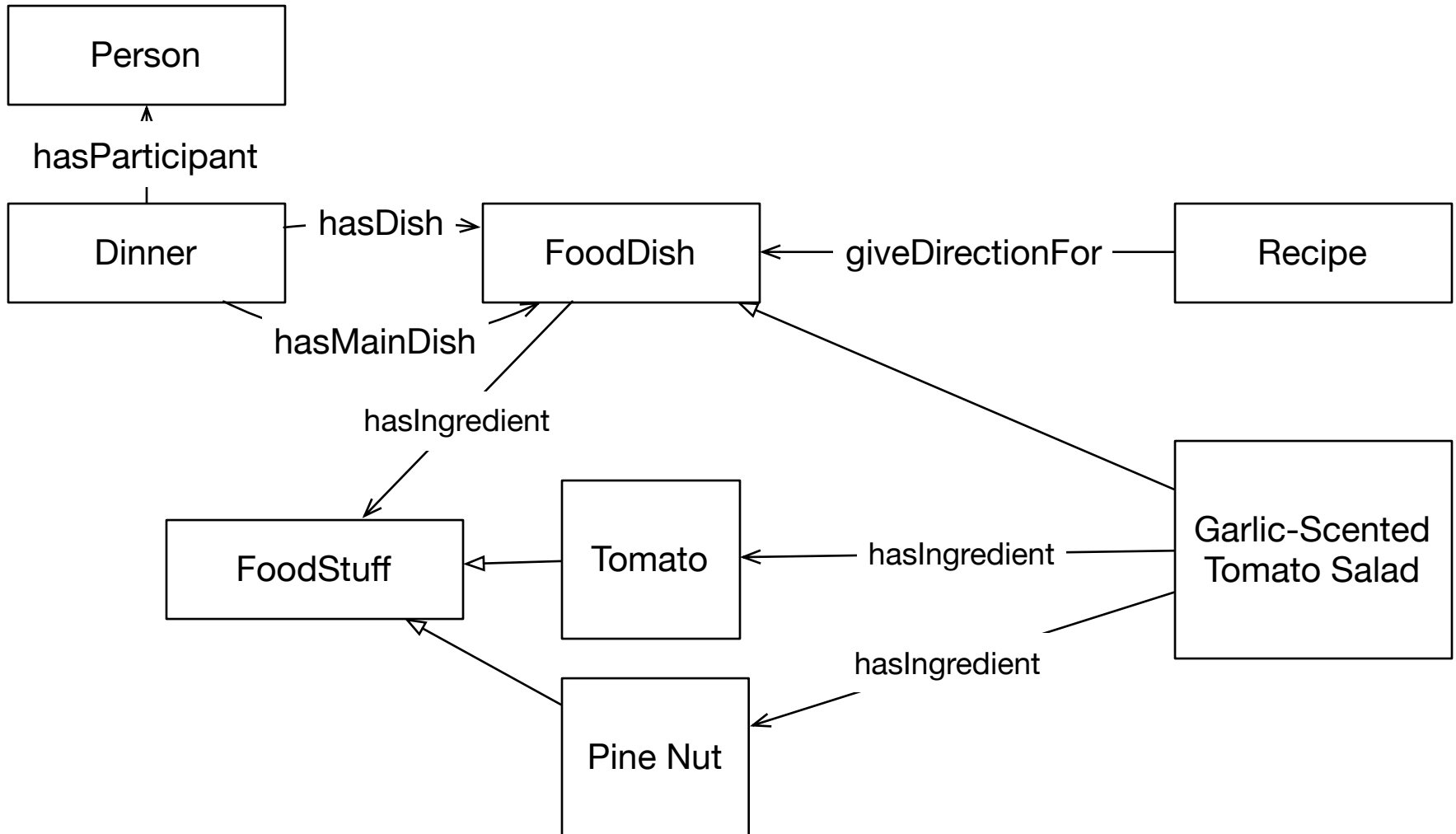


# High-Level Concepts in the Domain



- What are examples of subclasses and individuals?
- What relationships should be modeled between these concepts?

# One Possible Conceptualization



# Organize FoodStuff into a Hierarchy:

## Considerations

- Define superclass-subclass relationships that reflect is-a relationships
- Define vocabulary needed to answer competency questions
- Reuse existing definitions
- Siblings should be concepts that are similar in their levels of abstraction

# A Possible Hierarchy



As defined in dinner-finished.owl in course materials



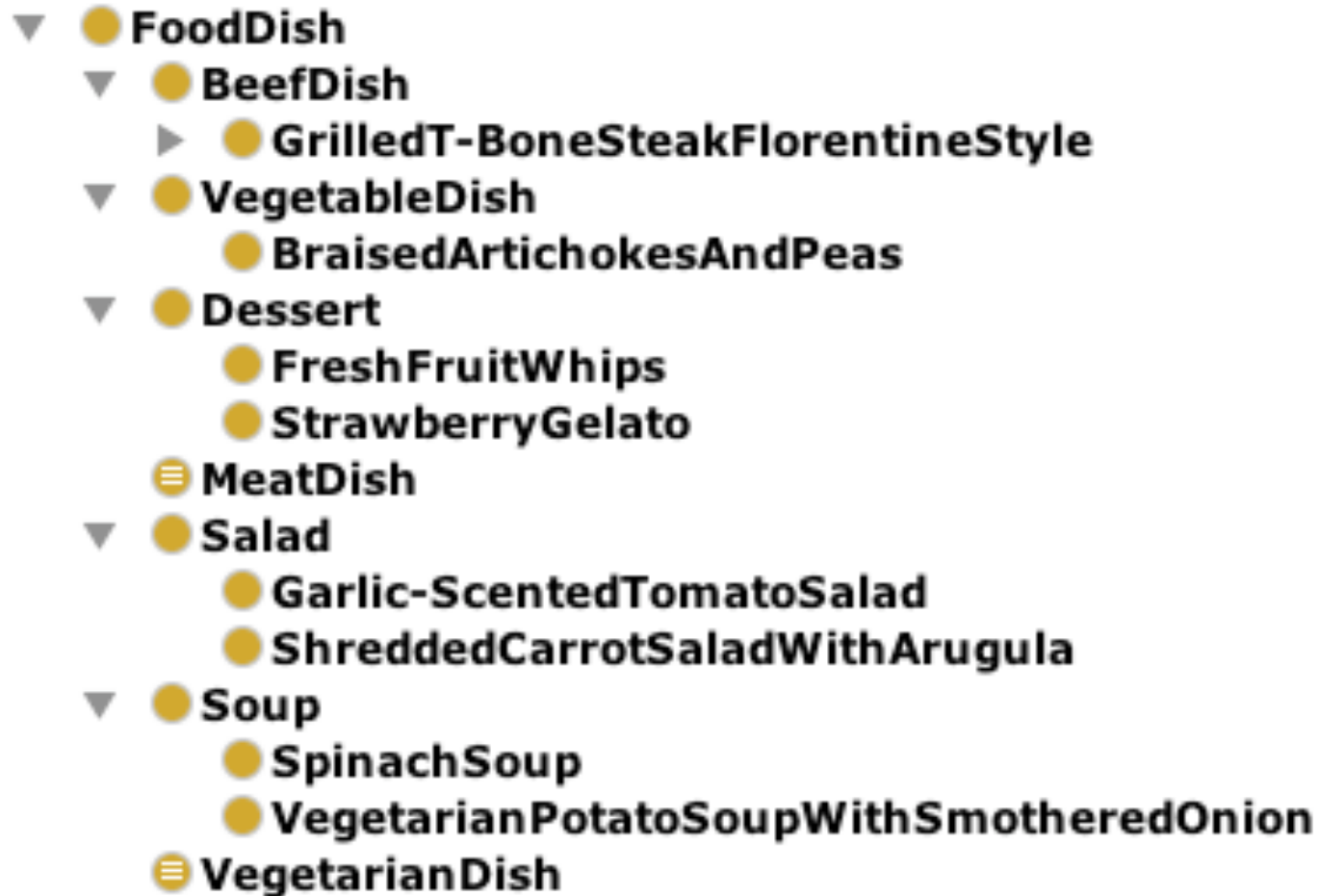
# Modeling “FoodDish” and “Dinner”

- Are dishes such as “Braised Artichokes and Peas” classes or individuals?
- Class
  - Collection of individuals
  - Can be specialized
- The dinner I am hosting this Saturday versus the collection of possible dinners someone might give

# Modeling Subclasses of “FoodDish”

- Subclasses based on source material
  - Salad, Soup, Beef Dish etc.
- Subclasses based on competency questions
  - Meat Dish
  - Vegetarian Dish
- Defined classes based on
  - Consensus on subject matter (e.g., source material)
  - Classification requirement

# One Possible “FoodDish” Hierarchy



MainDish as a class?

# What (Sub)Properties Are Needed?

- Familiar properties
  - Food dish *hasIngredient* some FoodStuff
  - Food dish *contains* some FoodStuff
- New object properties
  - Dinner *hasDish* some FoodDish
  - Dinner *hasMainDish* some FoodDish
  - Dinner *hasParticipant* some Person

# Modeling “Dinner” and “FoodDish”

## Description: Dinner

Equivalent To +

SubClass Of +

- hasDish **some** FoodDish
- hasParticipant **some** Person

## Description: FoodDish

Equivalent To +

SubClass Of +

- hasIngredient **some** FoodStuff

## Description: SpinachSoup


Equivalent To +


SubClass Of +

- hasIngredient **some** Butter
- hasIngredient **some** MeatBroth
- hasIngredient **some** Milk
- hasIngredient **some** Nutmeg
- hasIngredient **some** Onion
- hasIngredient **some** ParmigianoReggianoCheese
- hasIngredient **some** Salt
- hasIngredient **some** Spinach
- Soup

# Defining and Querying for “MeatDish”

**Description: MeatDish**

Equivalent To 

-  **FoodDish**  
and (contain **some** Meat)




**DL query:**

Query (class expression)

MeatDish

**Query results**

Subclasses (3)

-  **GrilledT-BoneSteakFlorentineStyle**
-  owl:Nothing
-  **SpinachSoup**

# Why is Spinach Soup a “MeatDish”

**Description: MeatDish**

Equivalent To +

- **FoodDish**  
and (contain some Meat)

**Description: MeatBroth**

Equivalent To +

SubClass Of +

- hasIngredient some Meat
- **SoupStock**

**Description: SpinachSoup**

Equivalent To +

SubClass Of +

- hasIngredient some Butter and hasIngredient some Milk and hasIngredient some Nutmeg and hasIngredient some Onion and hasIngredient some ParmigianoReggianoCheese and hasIngredient some Salt and hasIngredient some Spinach
- **hasIngredient some MeatBroth**
- **Soup**

☰ MeatDish

# Defining Vegetarian Dish

- A vegetarian dish does not *contain* Meat

Description: VegetarianDish

Equivalent To 

 **FoodDish**

**and (not (contain some Meat))**



# Is This Dish Vegetarian?

Description: BraisedArtichokesAndPeas


Equivalent To +


SubClass Of +

- hasIngredient some Artichoke
- hasIngredient some BlackPepper
- hasIngredient some ExtraVirginOliveOil
- hasIngredient some Garlic
- hasIngredient some Lemon
- hasIngredient some Onion
- hasIngredient some Parsley
- hasIngredient some Pea
- hasIngredient some Salt
- VegetableDish

# Open-World Assumption

**Description:** BraisedArtichokesAndPeas

Equivalent To 

SubClass Of 

- hasIngredient **some** Artichoke
- hasIngredient **some** BlackPepper
- hasIngredient **some** ExtraVirginOliveOil
- hasIngredient **some** Garlic
- hasIngredient **some** Lemon
- hasIngredient **some** Onion
- hasIngredient **some** Parsley
- hasIngredient **some** Pea
- hasIngredient **some** Salt
- VegetableDish

The dish may contain additional (unmentioned) ingredients!

# Add Closure Axiom

Description: BraisedArtichokesAndPeas

Equivalent To +

SubClass Of +

- hasIngredient some Artichoke
- hasIngredient some BlackPepper
- hasIngredient some ExtraVirginOliveOil
- hasIngredient some Garlic
- hasIngredient some Lemon
- hasIngredient some Onion
- hasIngredient some Parsley
- hasIngredient some Pea
- hasIngredient some Salt
- not (contains some Meat)
- VegetableDish

# Alternative Approach

Description: BraisedArtichokesAndPeas

SubClass Of +

contains only (Artichoke or BlackPepper or ExtraVirginOliveOil or Garlic or Lemon or Onion or Parsley or Pea or Salt)

hasIngredient some Artichoke

hasIngredient some BlackPepper

hasIngredient some ExtraVirginOliveOil

hasIngredient some Garlic

hasIngredient some Lemon

hasIngredient some Onion

hasIngredient some Parsley

hasIngredient some Pea

hasIngredient some Salt

VegetableDish

Description: Meat

SubClass Of +

FoodStuff

General class axioms +

SubClass Of (Anonymous Ancestor)

Instances +

Target for Key +

Disjoint With +

Condiment, SoupStock, PlantFood, CrushedIce, DairyProduct, AlcoholicDrink, VegetableOil

# Find Combination of Dishes Suitable for My Dinner

- For Mary
  - At least one meat main dish
- For Ashok
  - A vegetarian soup or salad
  - At least one vegetarian main dish
  - A vegetarian dessert
- What is one minimal list of dishes that would be suitable for both?

# General Definition of a Dinner Suitable for My Party:

A vegetarian soup or salad

At least one vegetarian main dish

A vegetarian dessert

At least one meat main dish

SubClass Of (Anonymous Ancestor)

● hasDish **some** FoodDish

---

● Dinner **and** (hasDish **some**  
(Dessert **and** VegetarianDish)) **and** (hasDish **some**  
((Salad **and** VegetarianDish) **or** (Soup **and** VegetarianDish))) **and**  
(hasMainDish **some** VegetarianDish)

---

● Dinner **and** (hasMainDish **some** MeatDish)

---

# A Dinner Suitable for My Party: Specific Choices

A vegetarian soup or salad

At least one vegetarian main dish

A vegetarian dessert

At least one meat main dish

Description: DinnerWithParticularDishesForVegetarianAndMeatEater\_2

Equivalent To +

SubClass Of +

- Dinner
- hasDish some StrawberryGelato
- hasMainDish some Garlic-ScentedTomatoSalad
- hasMainDish some GrilledT-BoneSteakFlorentineStyle
- ☰ DinnerSuitableForVegetarianAndMeatEater

Is this what you expect?

# Modeling “Recipe”

From the book *Essentials of Classic Italian Cooking* by Marcella Hazan

## **Garlic-Scented Tomato Salad**

For 4 or 6 servings

4 to 5 garlic cloves

Salt

Pine nuts

Choice quality red wine vinegar

2 pounds fresh, ripe, firm, round or plum  
tomatoes

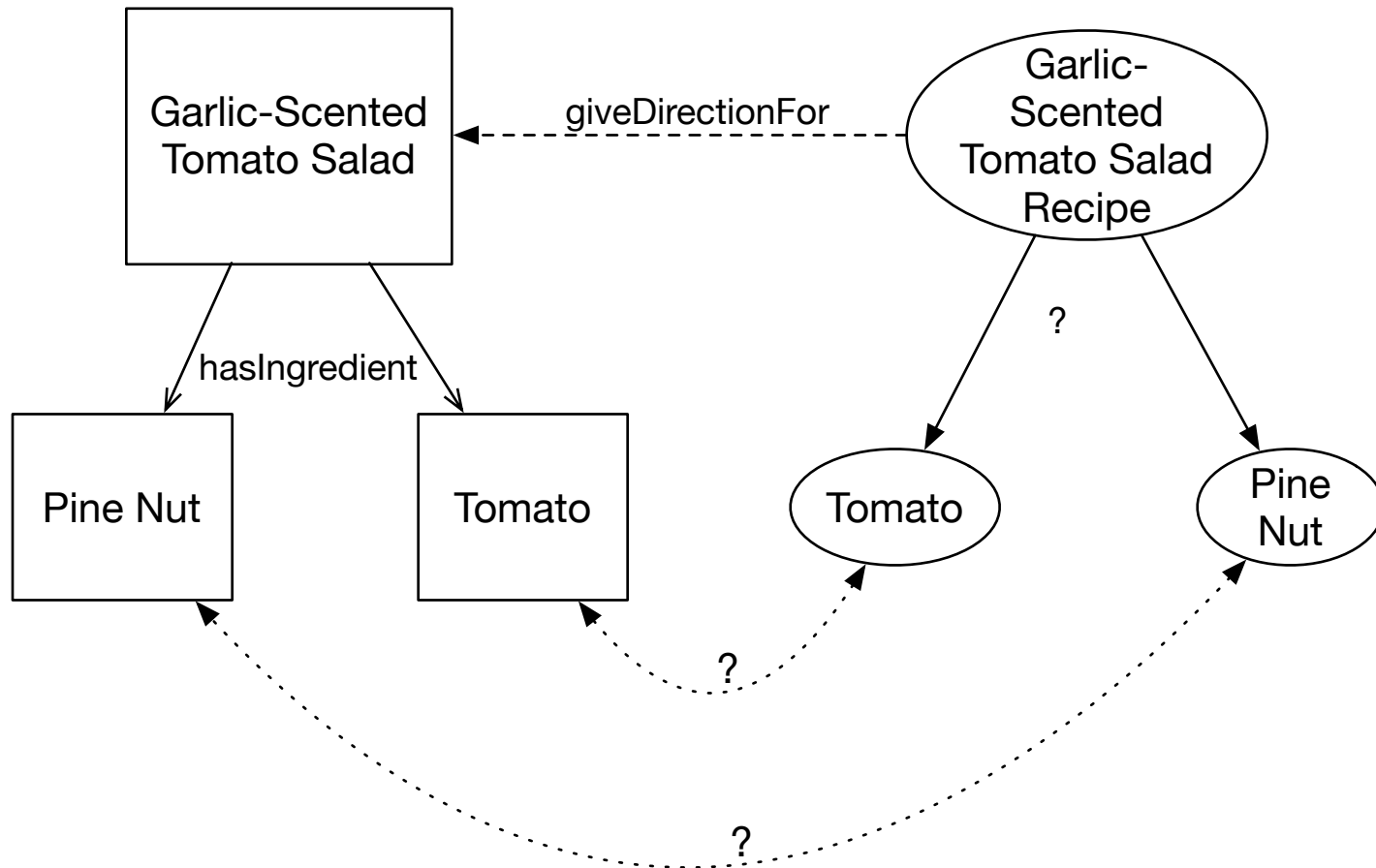
1 dozen fresh basil leaves

Extra virgin olive oil

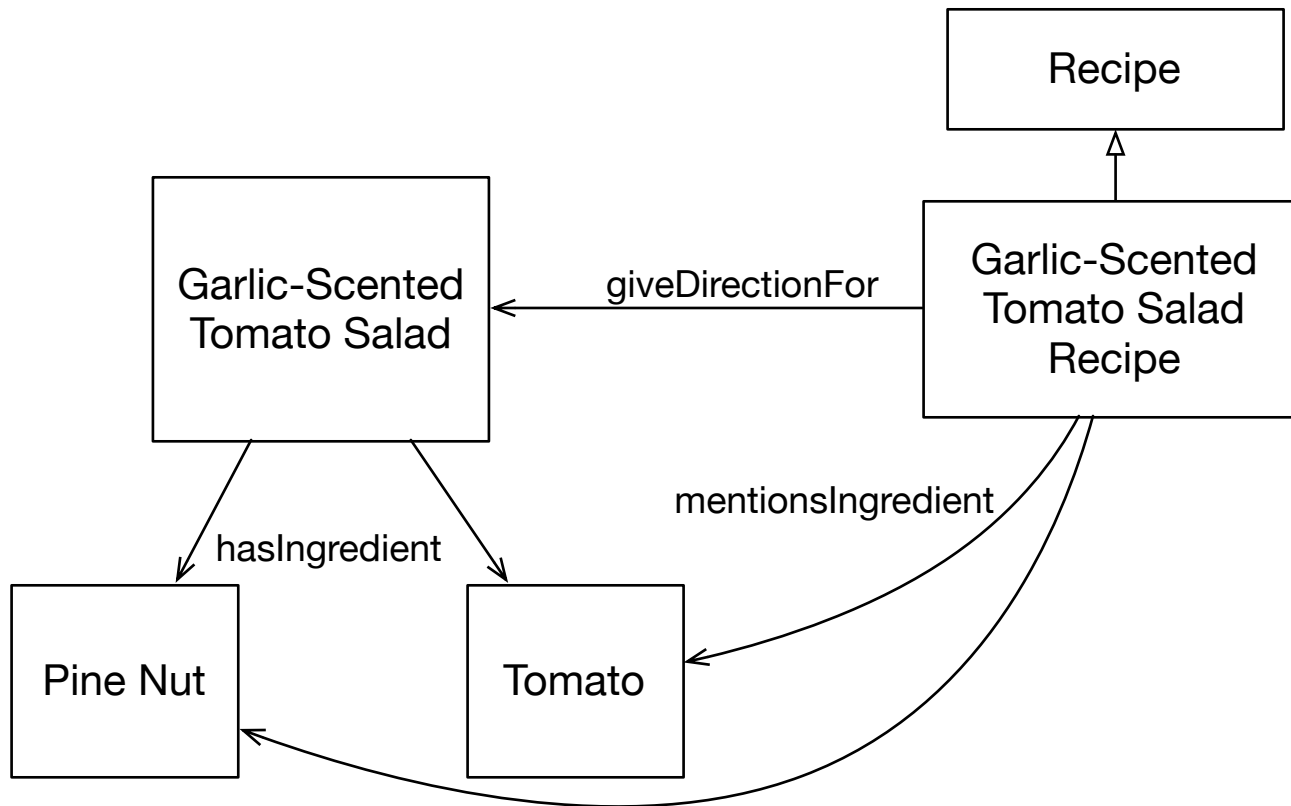
What are classes and what are individuals?



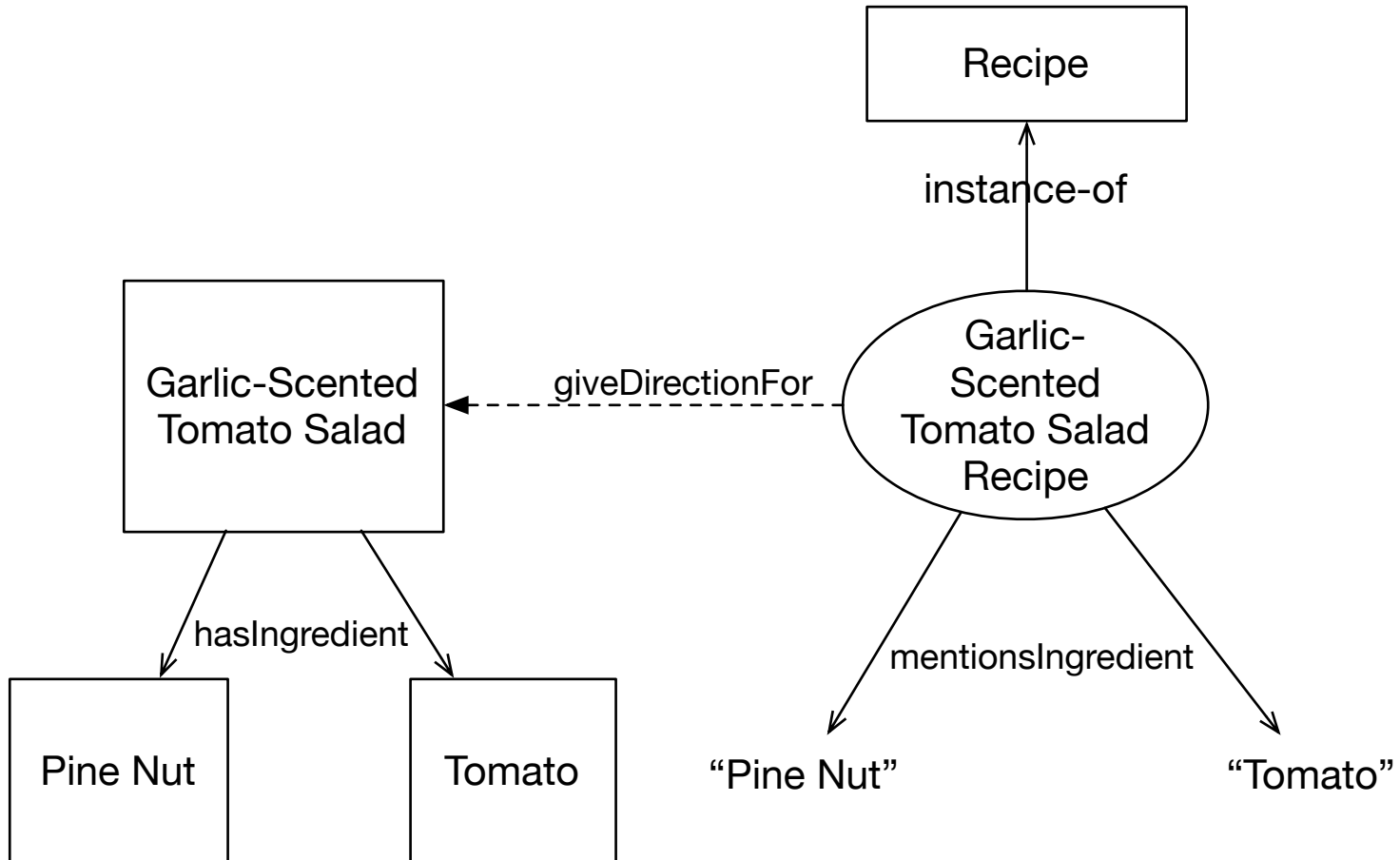
# What are the Relationships Between Terms in a Recipe and Ingredients in a Dish?



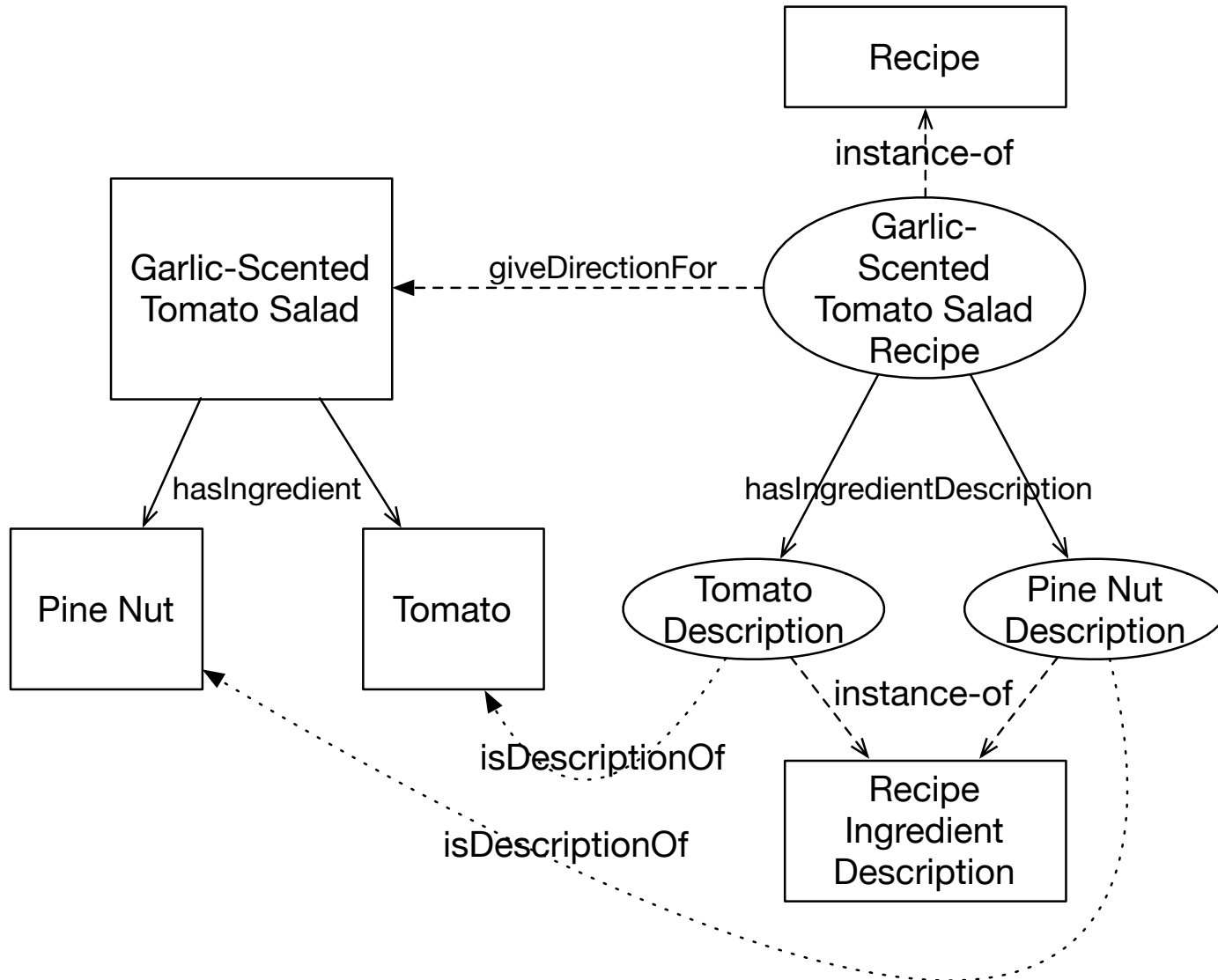
# “Recipe” Modeling Choice 1



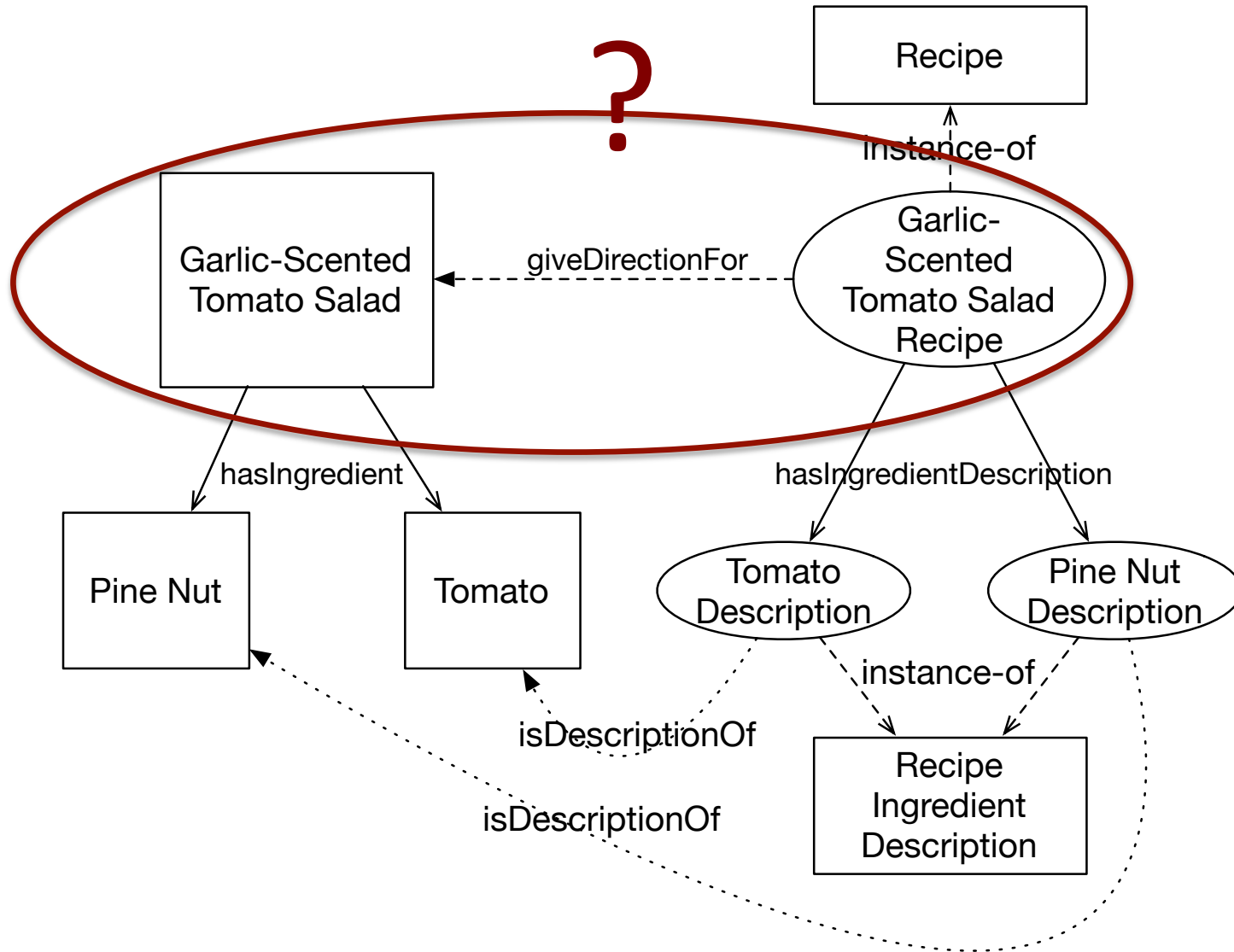
# “Recipe” Modeling Choice 2



# “Recipe” Modeling Choice 3



# Implementing “Recipe”



# Garlic-Scented Tomato Salad Recipe

Description: Garlic-ScentedTomatoSaladRe

Types +

- givesDirectionFor some Garlic-ScentedTomatoSalad
- Recipe

Same Individual As +

Different Individuals +

Property assertions: Garlic-ScentedTomatoSaladR

Object property assertions +

- hasIngredientDescription RedWineVinegarDescription
- hasIngredientDescription BasilLeafDescription
- hasIngredientDescription GarlicDescription
- hasIngredientDescription ExtraVirginOilDescription
- hasIngredientDescription TomatoDescription
- hasIngredientDescription SaltDescription
- hasIngredientDescription PineNutDescription

# Query for Recipe that Gives Direction for a Garlic-Scented Tomato Salad

DL query:

Query (class expression)

Recipe **and** givesDirectionFor **some** Garlic-ScentedTomatoSalad

Query results

Instances (1)

◆ **Garlic-ScentedTomatoSaladRecipe**

# Query for Ingredients Descriptions of a Recipe

## Use SPARQL

Property assertions: Garlic-ScentedTomatoSaladRecipe

Object property assertions +

- hasIngredientDescription  
RedWineVinegarDescription
- hasIngredientDescription  
BasilLeafDescription
- hasIngredientDescription  
GarlicDescription
- hasIngredientDescription  
ExtraVirginOilDescription
- hasIngredientDescription  
TomatoDescription
- hasIngredientDescription  
SaltDescription
- hasIngredientDescription  
PineNutDescription

SPARQL query:

```
PREFIX : <http://www.protege.stanford.edu/dinner/>  
SELECT ?object  
WHERE { :Garlic-ScentedTomatoSaladRecipe :hasIngredientDescription ?object }
```

object  
SaltDescription  
ExtraVirginOilDescription  
RedWineVinegarDescription  
BasilLeafDescription  
PineNutDescription  
GarlicDescription  
TomatoDescription



# Class Expression for Ingredient Descriptions of a Recipe?

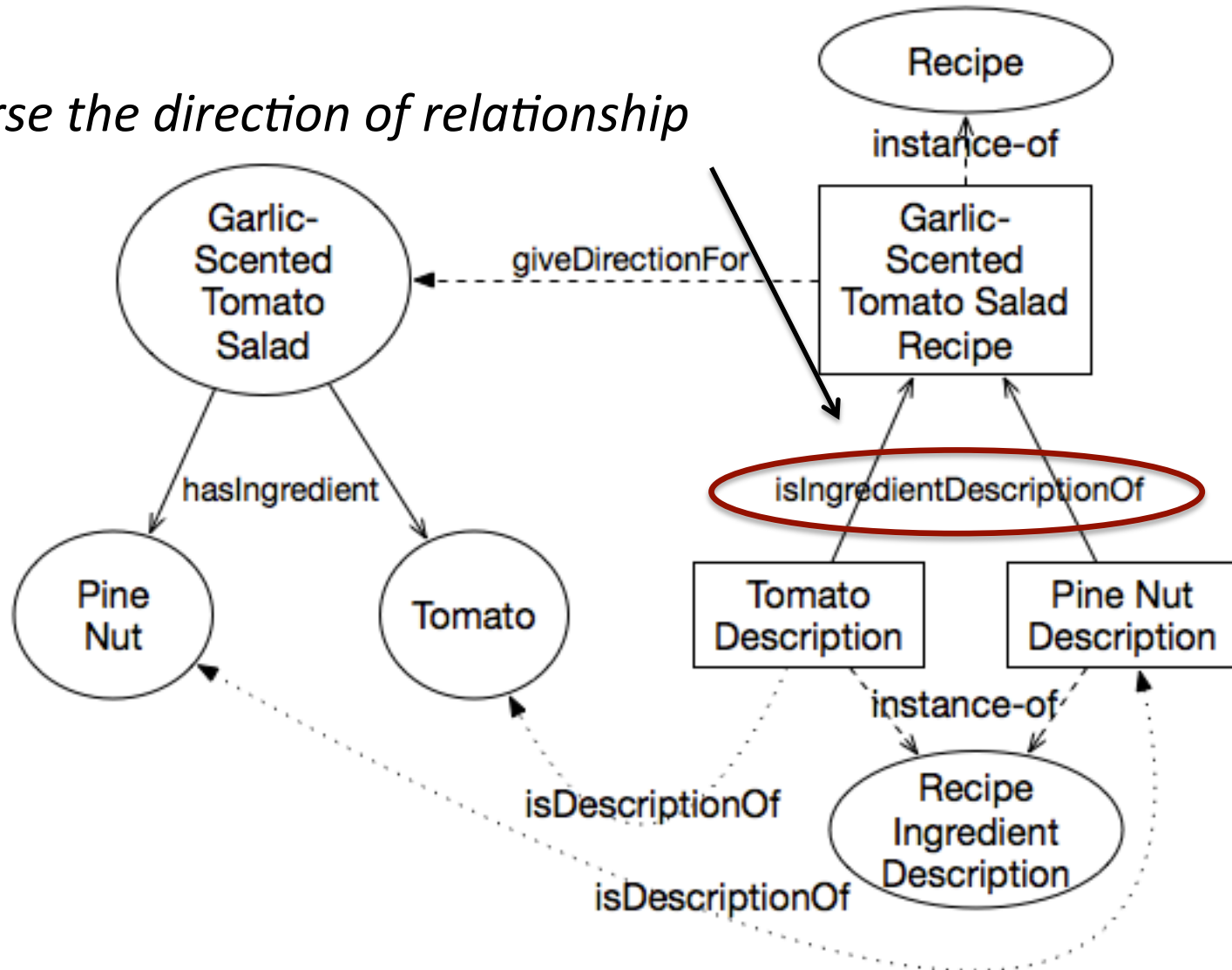
Property assertions: Garlic-ScentedTomatoSaladRecipe		
Object property assertions +		
<input checked="" type="checkbox"/> hasIngredientDescription	?	@
RedWineVinegarDescription		x
<input checked="" type="checkbox"/> hasIngredientDescription	?	@
BasilLeafDescription		x
<input checked="" type="checkbox"/> hasIngredientDescription	?	@
GarlicDescription		x
<input checked="" type="checkbox"/> hasIngredientDescription	?	@
ExtraVirginOilDescription		x
<input checked="" type="checkbox"/> hasIngredientDescription	?	@
TomatoDescription		x
<input checked="" type="checkbox"/> hasIngredientDescription	?	@
SaltDescription		x
<input checked="" type="checkbox"/> hasIngredientDescription	?	@
PineNutDescription		x

- Find the set of **ingredient descriptions** that *are mentioned in the Garlic-Scented Tomato Salad recipe*

RecipeIngredientDescription and (?? ?? GarlicScentedTomatoSaladRecipe)

# Ingredients Mentioned in a Recipe

*Reverse the direction of relationship*



# Query Ingredients Mentioned in a Recipe

DL query:

Query (class expression)

RecipeIngredientDescription and isIngredientDescriptionOf value Garlic-ScentedTomatoSaladRecipe

Execute

Add to ontology

Query results

Instances (7)

◆ ExtraVirginOilDescription	?
◆ BasilLeafDescription	?
◆ PineNutDescription	?
◆ GarlicDescription	?
◆ RedWineVinegarDescription	?
◆ TomatoDescription	?
◆ SaltDescription	?

☐ Direct superclasses

☐ Superclasses

☐ Equivalent classes

☐ Direct subclasses

☒ Subclasses

☒ Instances

# Query Ingredients Mentioned in a Recipe (Use Inverse Property)

DL query:

Query (class expression)

RecipeIngredientDescription and (inverse hasIngredientDescription value Garlic-ScentedTomatoSaladRecipe)

Execute

Add to ontology

### Query results

Instances (7)

### ◆ Extra Virgin Oil Description

7

### ◆ BasilLeafDescription

7

### ◆ PineNutDescription

7

### ◆ GarlicDescription

### ◆ TomatoDescription

7

### ◆ SaltDescription

7

### ◆ RedWineVinegarDescription

7

☒

# What Ingredients Do You Have to Get?

DL query:

Query (class expression)

RecipeIngredientDescription and isIngredientDescriptionOf some {  
Garlic-ScentedTomatoSaladRecipe, GrilledT-BoneSteakFlorentineStyleRecipe, StrawberryGelatoRecipe}

Execute

Add to ontology

Query results

Instances (12)

◆ ExtraVirginOilDescription	?
◆ BasilLeafDescription	?
◆ T-BoneBeefSteakDescription	?
◆ StrawberryDescription	?
◆ PineNutDescription	?
◆ SugarDescription	?
◆ GarlicDescription	?
◆ BlackPepperCornDescription	?
◆ WhippingCreamDescription	?
◆ RedWineVinegarDescription	?
◆ TomatoDescription	?
◆ SaltDescription	?

☐ Direct superclasses

☐ Superclasses

☐ Equivalent classes

☐ Direct subclasses

☐ Subclasses

☒ Instances

# Can you write a DL query to get the ingredients of the dishes?

Description: GrilledT-BoneSteakFlorentineStyle

Equivalent To +

SubClass Of +

- BeefDish
- hasIngredient some BlackPepperCorn
- hasIngredient some ExtraVirginOliveOil
- hasIngredient some Salt
- hasIngredient some T-BoneBeefSteak
- ☰ MeatDish

DL query:

Query (class expression)

???

Execute

Add to ontology

Query results

Superclasses (1)

● Thing

Subclasses (65)

● AlcoholicDrink  
● Apple  
● Artichoke  
● Arugula  
● Banana

# Querying for Ingredients of Dishes

- DL query is a class expression for which ingredients need to be subclasses/superclasses/individuals
- Each dish uses **some**, not all, individuals of ingredient class
- Easier to query for ingredient descriptions of recipes: construct a class whose individuals are the desired ingredient descriptions

DL query:

Query (class expression)

???

Execute Add to ontology

Query results

Superclasses (1)

- Thing

Subclasses (65)

- AlcoholicDrink
- Apple
- Artichoke
- Arugula
- Banana

# Modeling Exercise

- Conceptualization of domain
  - Food stuff, food dish, dinner and their properties
- Modeling decisions
  - Recipe and its relationship to food dish
- OWL language
  - Classes, properties, individuals, restrictions
- Queries
  - SPARQL, DL query