Methods and Tools for Modular Ontology Modeling
Part II:Worked Example: Cooking Recipes

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Written version of this part

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A Tutorial on Modular Ontology Moeling with Ontology Design Patterns: The Cooking Recipes Ontology.

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22 pages

http://daselab.cs.wright.edu/pub2/mom-recipes-example.pdf

(it's also linked on the tutorial website)

Problem setting

Design an ontology which can be used as part of a "recipe discovery" website. The ontology shall be set up such that content from existing recipe websites can in principle be mapped to it (i.e., the ontology gets populated with data from the recipe websites). On the discovery website, detailed graph-queries (using the ontology) shall produce links to recipes from different recipe websites as results. The ontology should be extendable towards incorporation of additional external data, e.g., nutritional information about ingredients or detailed information about cooking equipment.

Collaborative modeling approach

- Collaborative modeling, group ideally has
  - More than one domain experts.
  - People familiar with the base data.
  - People understanding possible target use cases.
  - An ontology engineer familiar with the modeling approach.
  - Somebody who understands formal semantics of OWL.

- Domain experts are queried as to the main notions for the application domain.
  - E.g. for the recipes scenario, these would include
    - Recipe
    - Food
    - Time
    - Equipment
    - Classification of food (e.g., as a side)
    - Difficulty level
    - Nutritional information
    - Provenance

Collaborative modeling approach

- From available data and from application use cases, devise competency questions, i.e. questions which should be convertible into queries, which in turn should be answerable using the data.

Gluten-free low-calorie desserts.

How do I make a low-carb pot roast?

How do I make a Chili without beans?

Sweet breakfast under 100 calories.

Breakfast dishes which can be prepared quickly with 2 potatoes, an egg, and some our.

How do I prepare Chicken thighs in a slow cooker?

A simple recipe with pork shoulder and spring onions.

A side prepared using Brussels sprouts, bacon, and chestnuts.

GeoVoCamps modeling approach

- **Then prioritize which notions to model first. In the chess case, e.g.**

  recipe
  food
  equipment
  classification
  difficulty level
  time
  nutritional information
  provenance

GeoVoCamps modeling approach

- **Understand the nature of the things you are modeling.**

Recipe: Document? Sequence? Process? Plan? Description?
Food: A concrete piece of food? An abstract quantity of food?
Equipment: Do we want a complex model at this stage? No.

Classification: Do we want a complex model at this stage? No.

Difficulty level: Do we want a complex model at this stage? No.

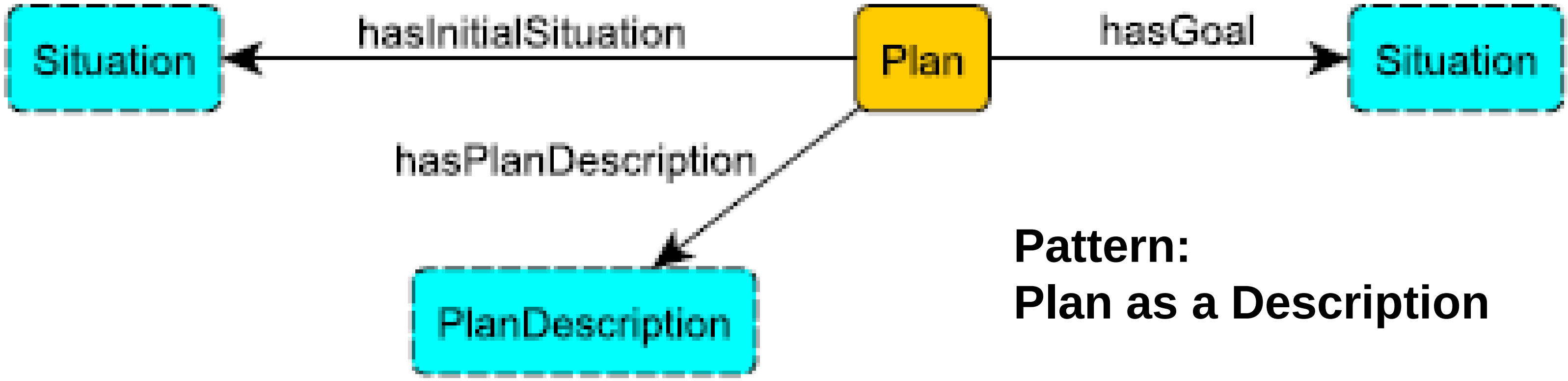
Time: Probably already incorporated in plan?

Nutritional information: model along some existing standard?

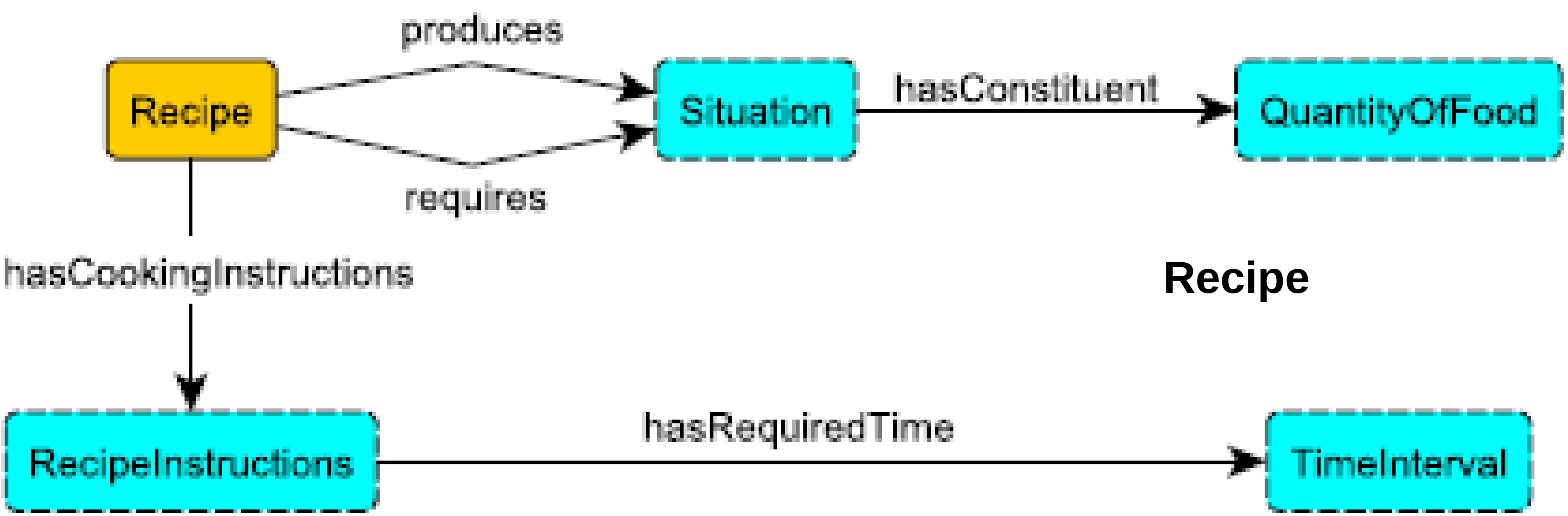
Provenance: just that!

Recipe

A **plan**, a **description**.



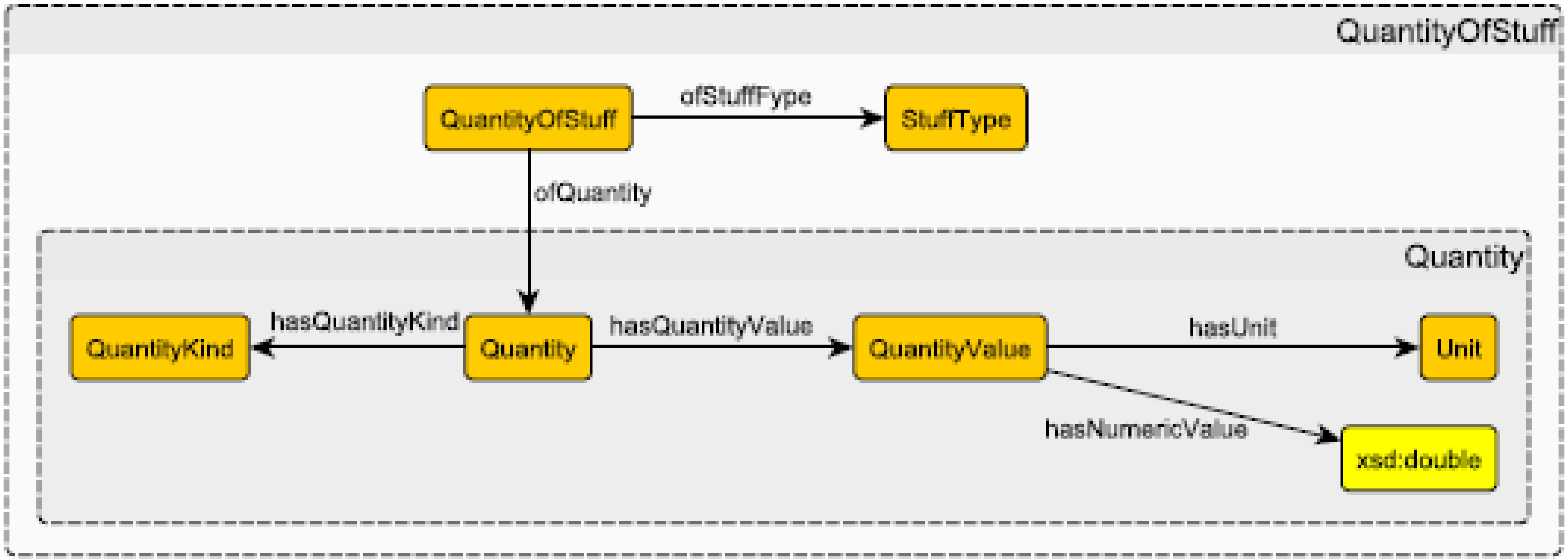
Pattern:
Plan as a Description



Recipe

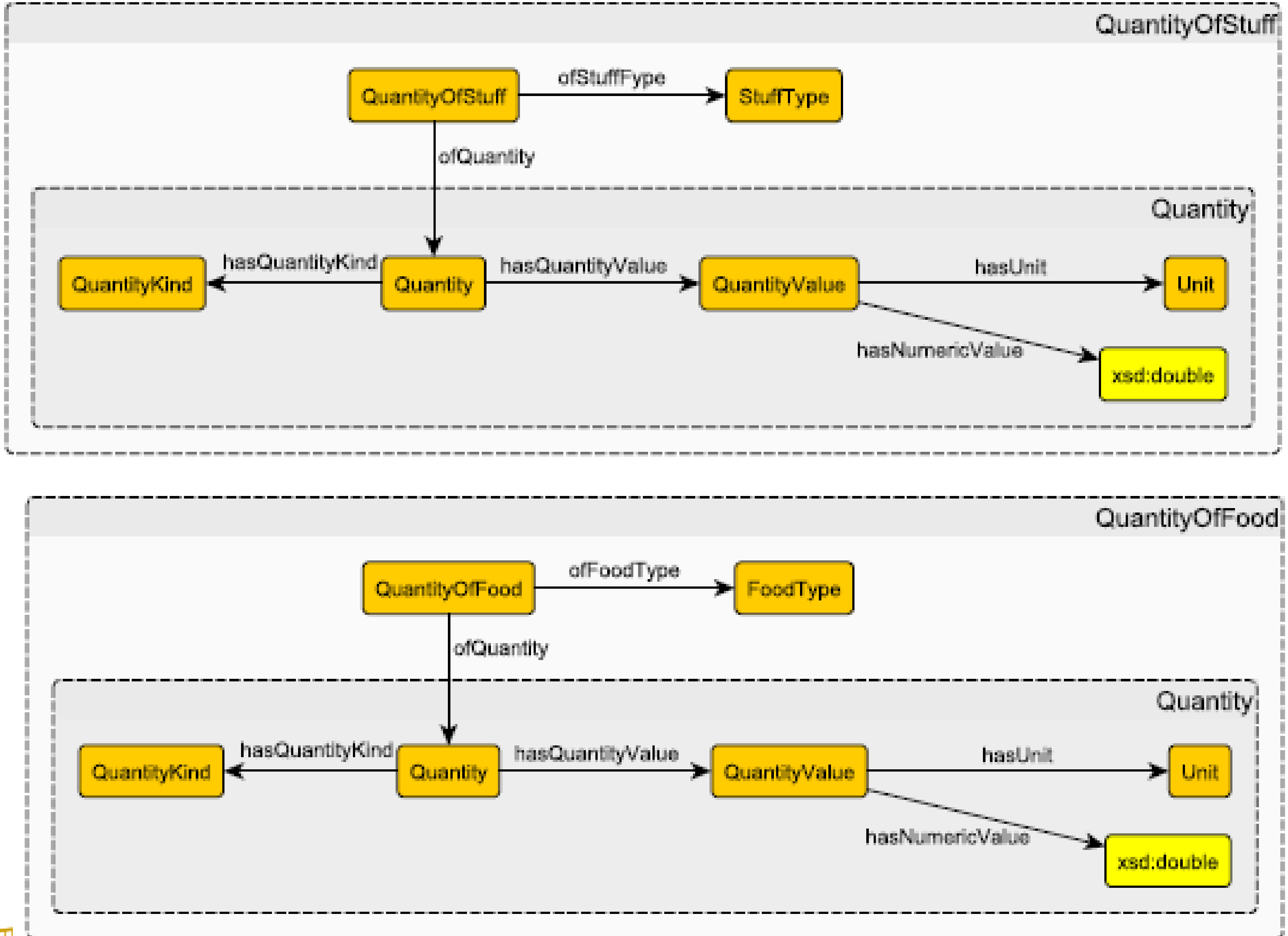
Food

An abstract quantity of food.



Pattern:
QuantityOfStuff (with Quantity sub-pattern)

(derived from QUDT)



QuantityOfStuff
QuantityOfStuff
ofStuffType
StuffType
ofQuantity
Quantity
QuantityKind
hasQuantityKind
Quantity
hasQuantityValue
QuantityValue
hasUnit
Unit
hasNumericValue
xsd:double
QuantityOfFood
QuantityOfFood
ofFoodType
FoodType
ofQuantity
Quantity
QuantityKind
hasQuantityKind
Quantity
hasQuantityValue
QuantityValue
hasUnit
Unit
hasNumericValue
xsd:double

Equipment

No complex model desired at this stage. We just want to use strings, i.e., use our stub meta-pattern.

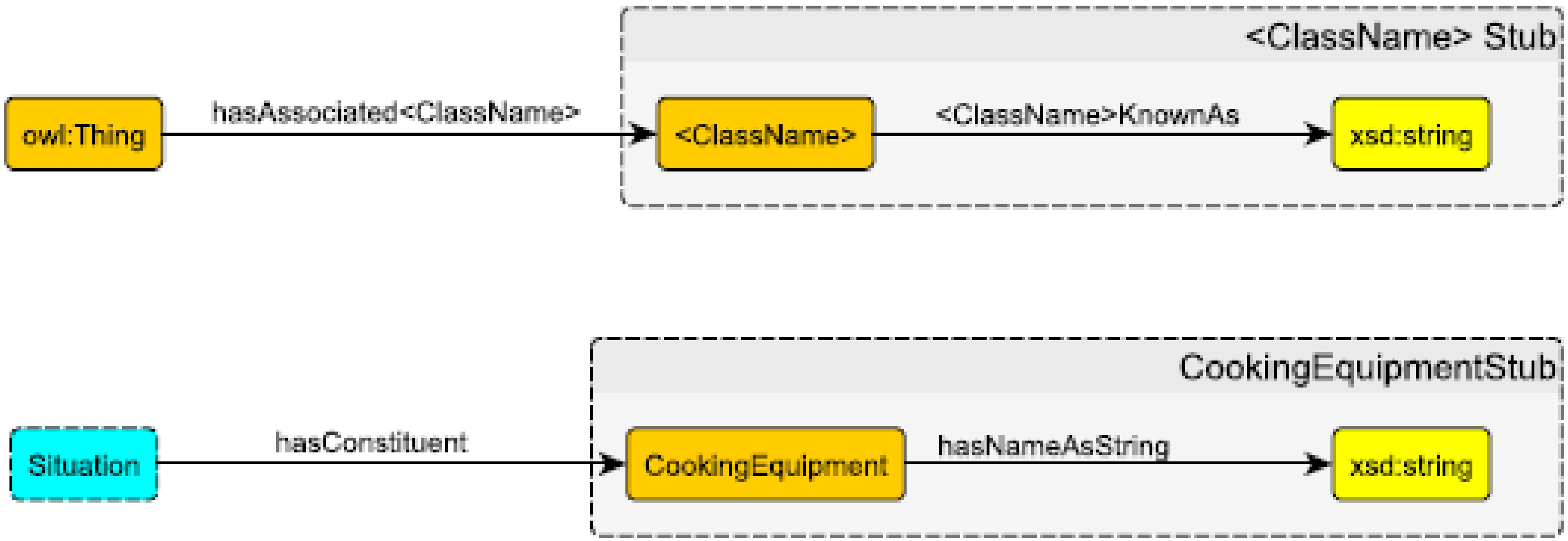
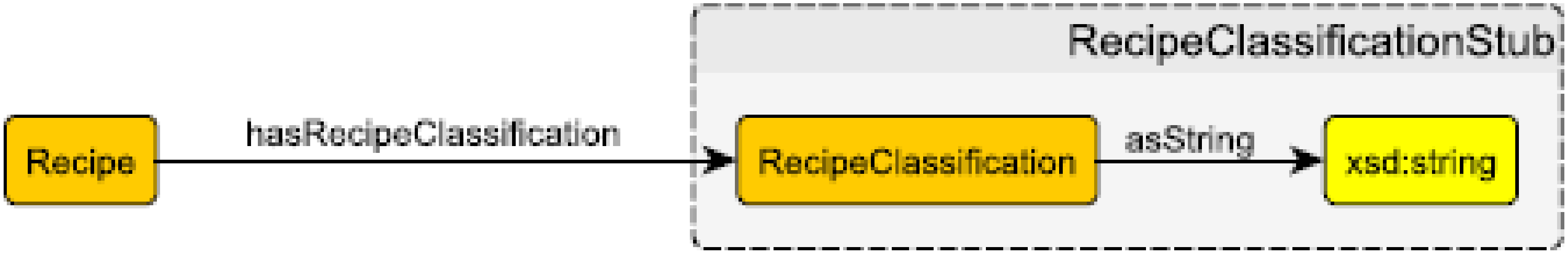


Figure 2.10: Top, the Stub (meta)pattern. Bottom, its instantiation for equipment.

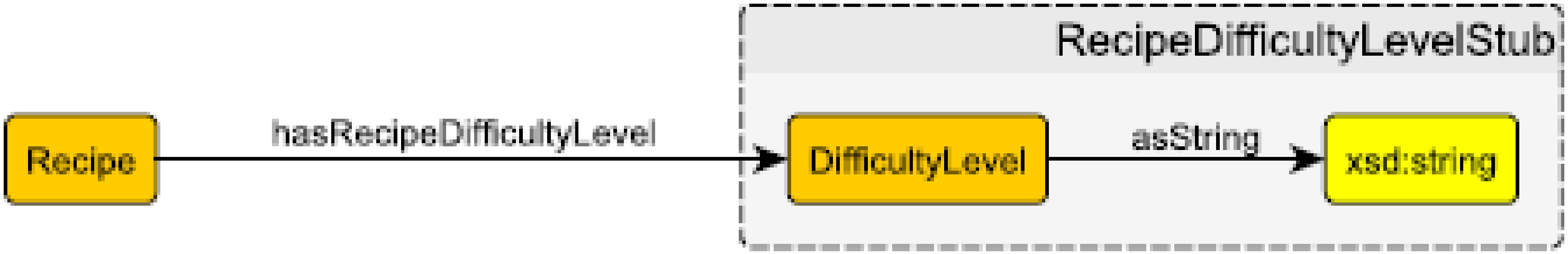
Classification (e.g., entrée)

No complex model desired at this stage. We just want to use strings, i.e., use our stub meta-pattern.



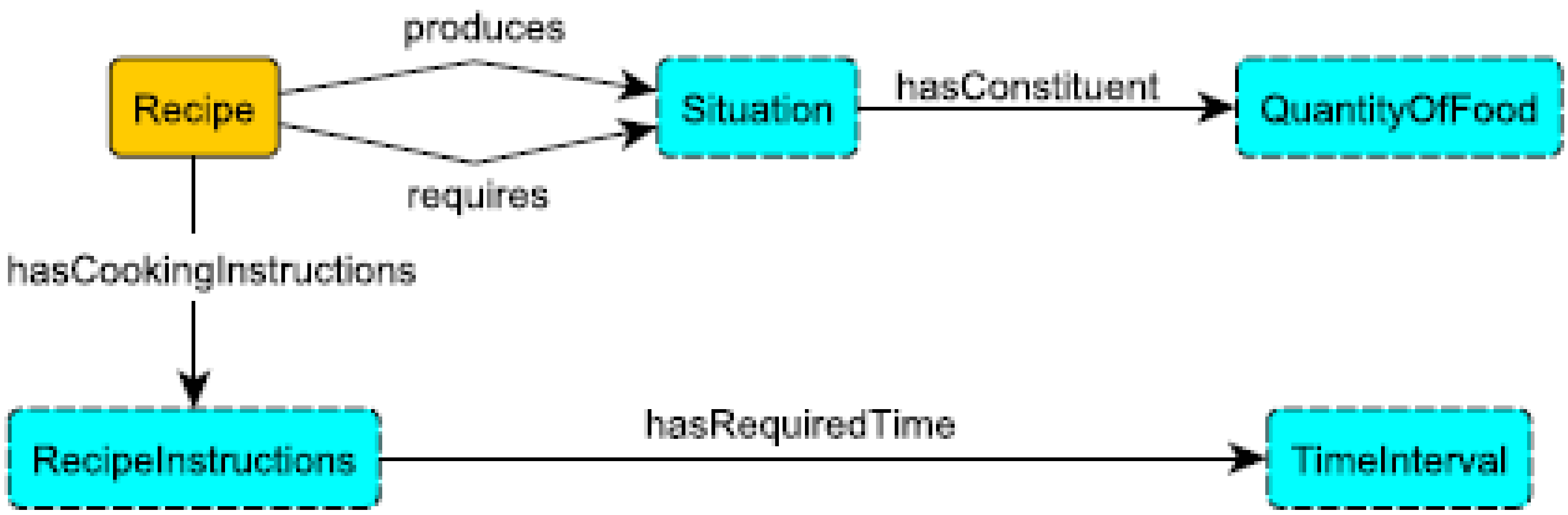
Difficulty level

No complex model desired at this stage. We just want to use strings, i.e., use our stub meta-pattern.



Time

Already incorporated in plan!



Nutritional information

Model along some existing standard.

Let’s use the U.S. FDA Nutritional Facts label standard.

Nutrition Facts

Serving Size 2/3 cup (55g)
Servings Per Container About 8

Amount Per Serving

Calories 230 | Calories from Fat 40

	% Daily Value*
Total Fat 8g	**12%**
Saturated Fat 1g	**5%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 160mg	**7%**
Total Carbohydrate 37g	**12%**
Dietary Fiber 4g	**16%**
Sugars 1g	
Protein 3g	

Vitamin A	10%
Vitamin C	8%
Calcium	20%
Iron	45%

* Percent Daily Values are based on a 2,000 calorie diet. Your daily value may be higher or lower depending on your calorie needs.

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Nutritional information

Model along some existing standard.

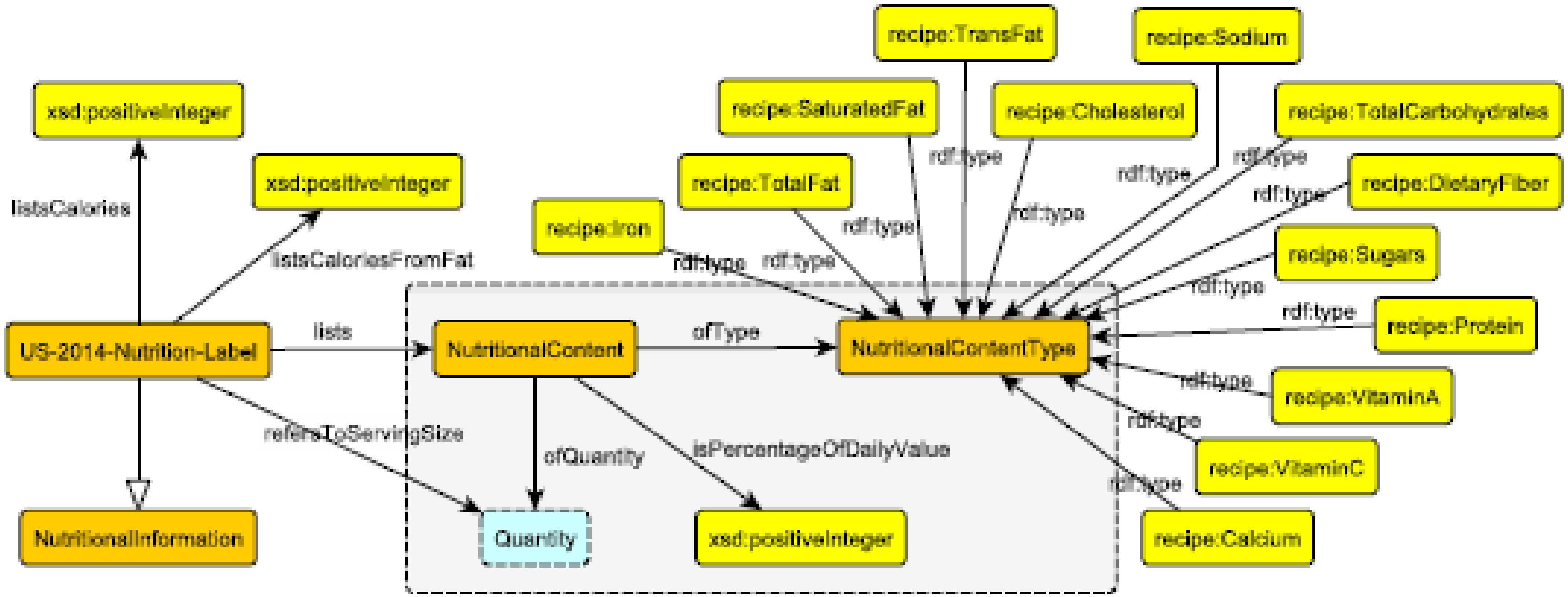
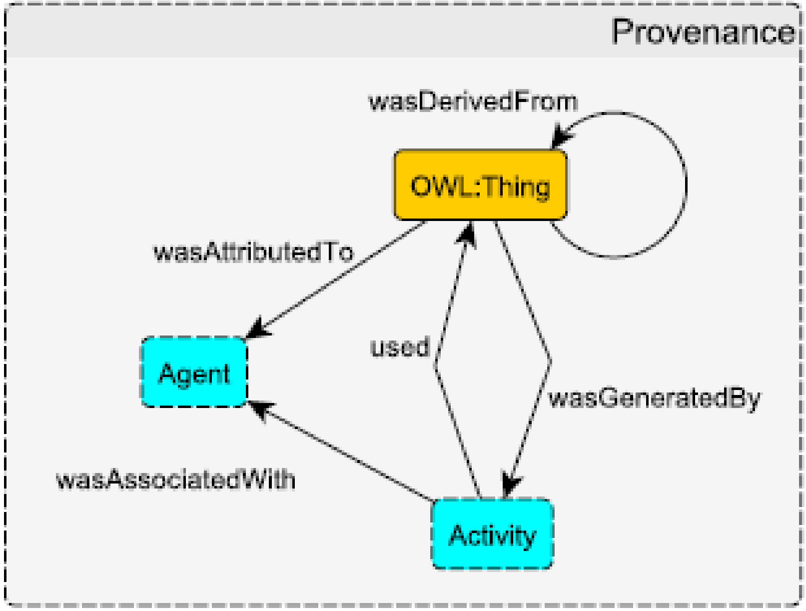


Figure 2.13: Nutritional Information module. The box indicates a modified instance of the QuantityOfStuff pattern.

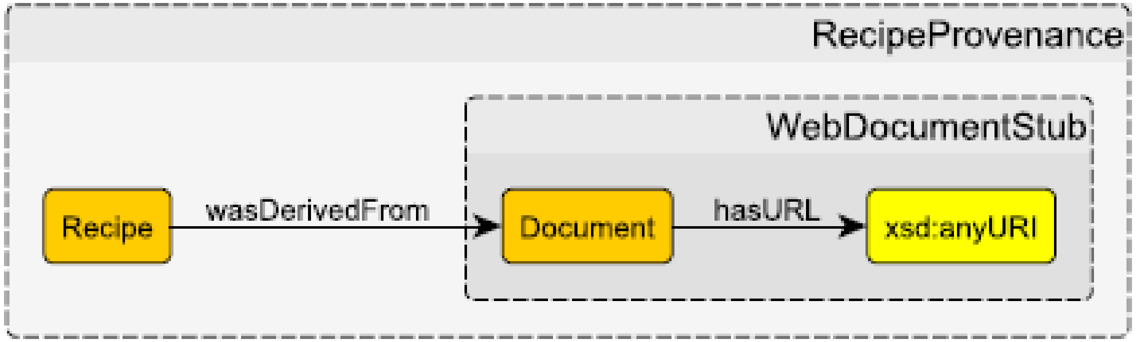
Provenance

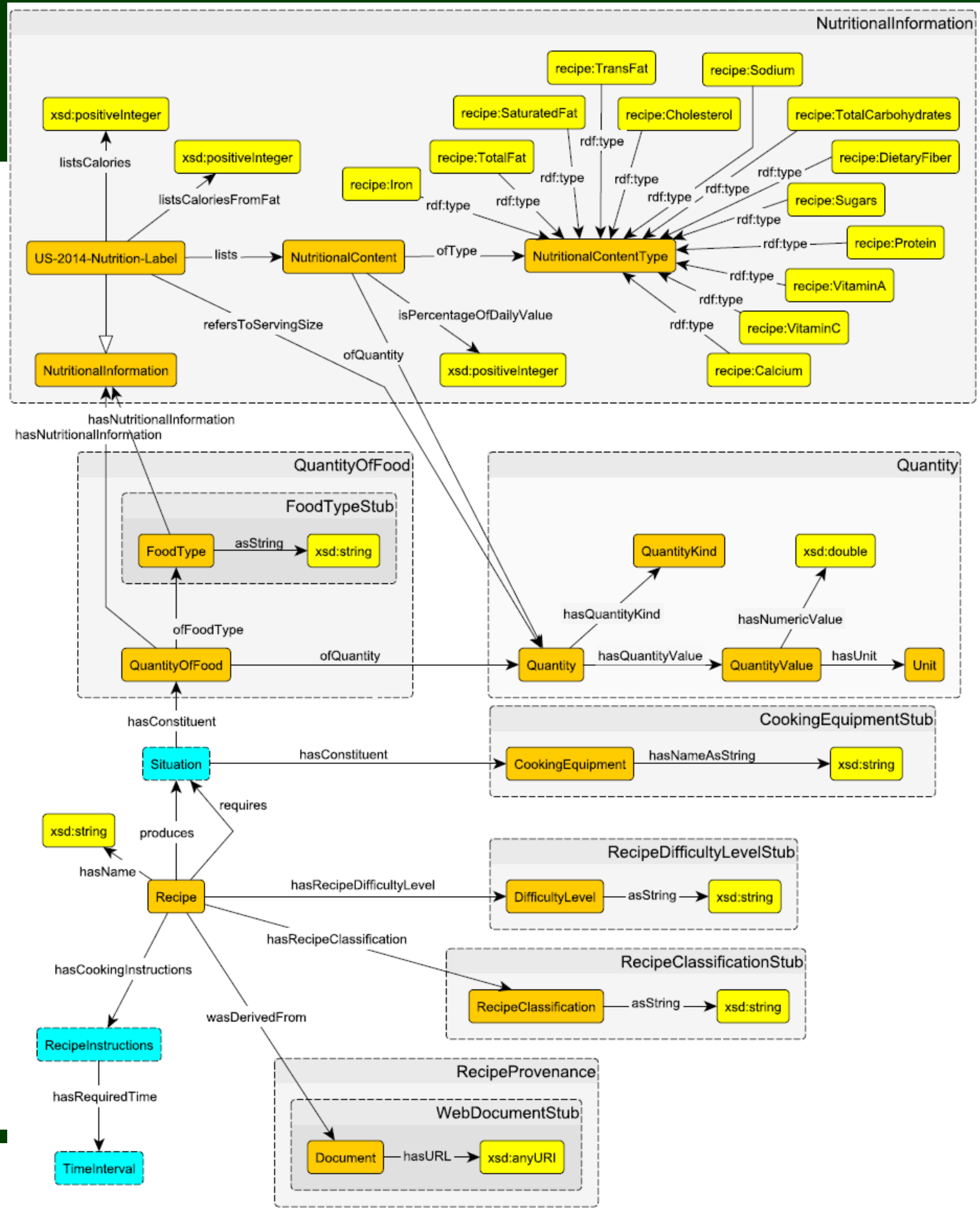
Use an ontology design pattern based on PROV-O.

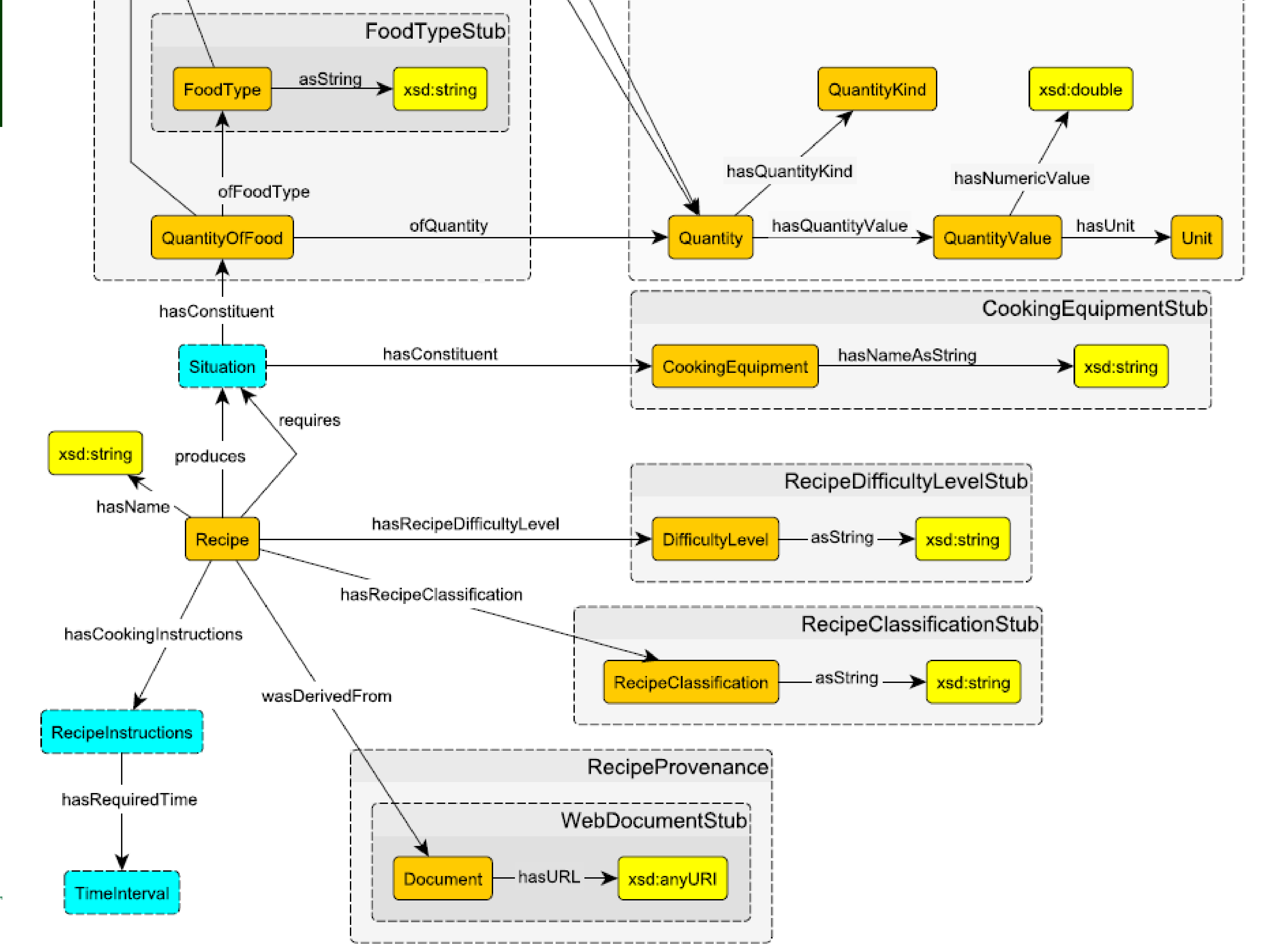
PROV-O derived Provenance pattern:

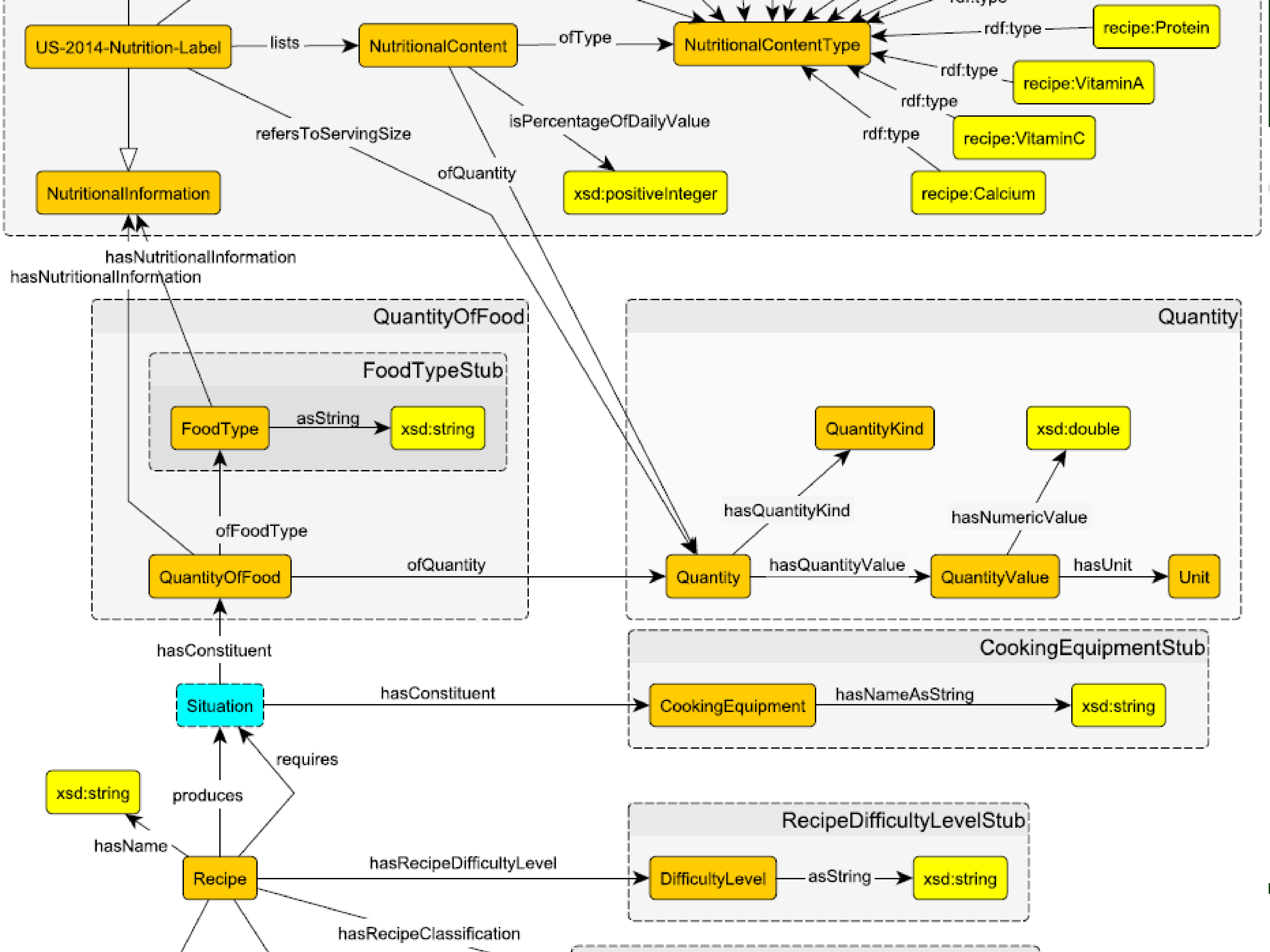


We'll use only this:




NutritionalInformation
recipe:TransFat
recipe:Sodium
recipe:SaturatedFat
recipe:Cholesterol
recipe:TotalCarbohydrates
recipe:TotalFat
recipe:DietaryFiber
recipe:Iron
recipe:Sugars
recipe:Protein
recipe:VitaminA
recipe:VitaminC
recipe:Calcium
rdf:type
xsd:positiveInteger
listsCalories
listsCaloriesFromFat
US-2014-Nutrition-Label
lists
NutritionalContent
ofType
NutritionalContentType
refersToServingSize
isPercentageOfDailyValue
ofQuantity
NutritionalInformation
hasNutritionalInformation
QuantityOfFood
FoodTypeStub
FoodType
asString
xsd:string
ofFoodType
Quantity
QuantityKind
xsd:double
hasQuantityKind
hasNumericValue
hasQuantityValue
QuantityValue
hasUnit
Unit
hasConstituent
Situation
CookingEquipmentStub
CookingEquipment
hasNameAsString
requires
produces
hasName
Recipe
hasRecipeDifficultyLevel
RecipeDifficultyLevelStub
DifficultyLevel
hasRecipeClassification
RecipeClassificationStub
RecipeClassification
hasCookingInstructions
wasDerivedFrom
RecipeInstructions
hasRequiredTime
TimeInterval
RecipeProvenance
WebDocumentStub
Document
hasURL
xsd:anyURI


FoodTypeStub
FoodType
asString
xsd:string
ofFoodType
QuantityOfFood
ofQuantity
Quantity
hasQuantityKind
QuantityKind
hasQuantityValue
QuantityValue
hasNumericValue
xsd:double
hasUnit
Unit
hasConstituent
Situation
hasConstituent
CookingEquipmentStub
CookingEquipment
hasNameAsString
xsd:string
requires
produces
xsd:string
hasName
Recipe
hasRecipeDifficultyLevel
RecipeDifficultyLevelStub
DifficultyLevel
asString
xsd:string
hasRecipeClassification
RecipeClassificationStub
RecipeClassification
asString
xsd:string
hasCookingInstructions
RecipeInstructions
wasDerivedFrom
hasRequiredTime
TimeInterval
RecipeProvenance
WebDocumentStub
Document
hasURL
xsd:anyURI



US-2014-Nutrition-Label
lists
NutritionalContent
ofType
NutritionalContentType
rdf:type
recipe:Protein
recipe:VitaminA
recipe:VitaminC
recipe:Calcium
refersToServingSize
isPercentageOfDailyValue
ofQuantity
xsd:positiveInteger
NutritionalInformation
hasNutritionalInformation
hasNutritionalInformation
QuantityOfFood
FoodTypeStub
FoodType
asString
xsd:string
ofFoodType
QuantityOfFood
ofQuantity
Quantity
QuantityKind
xsd:double
hasQuantityKind
hasNumericValue
Quantity
hasQuantityValue
QuantityValue
hasUnit
Unit
hasConstituent
CookingEquipmentStub
Situation
hasConstituent
CookingEquipment
hasNameAsString
xsd:string
requires
xsd:string
produces
RecipeDifficultyLevelStub
hasName
Recipe
hasRecipeDifficultyLevel
DifficultyLevel
asString
xsd:string
hasRecipeClassification

Adequacy check

- Triplify sample data using the ontology.
  Does it work?

- Check if competency questions can be answered.

- Add axioms as appropriate (the graph is only for intuition, the OWL axioms are the actual ontology).

- (there are more post-hoc details to be taken care of, but let's leave it at that)

Axiomatization

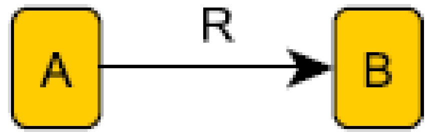
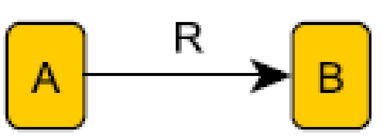


Figure 2.17: Generic node-edge-node schema diagram for explaining systematic axiomatization

1. $A \sqcap B \sqsubseteq \bot$
2. $\exists R.\top \sqsubseteq A$
3. $\exists R.B \sqsubseteq A$
4. $\top \sqsubseteq \forall R.B$
5. $A \sqsubseteq \forall R.B$
6. $A \sqsubseteq R.B$
7. $B \sqsubseteq R^{-}.A$
8. $\top \sqsubseteq\ \leq 1 R.\top$
9. $\top \sqsubseteq\ \leq 1 R.B$
10. $A \sqsubseteq\ \leq 1 R.\top$
11. $A \sqsubseteq\ \leq 1 R.B$
12. $\top \sqsubseteq\ \leq 1 R^{-}.\top$
13. $\top \sqsubseteq\ \leq 1 R^{-}.A$
14. $B \sqsubseteq\ \leq 1 R^{-}.\top$
15. $B \sqsubseteq\ \leq 1 R^{-}.A$

Figure 2.18: Most common axioms which could be produced from a single edge R between nodes A and B in a schema diagram: description logic notation.

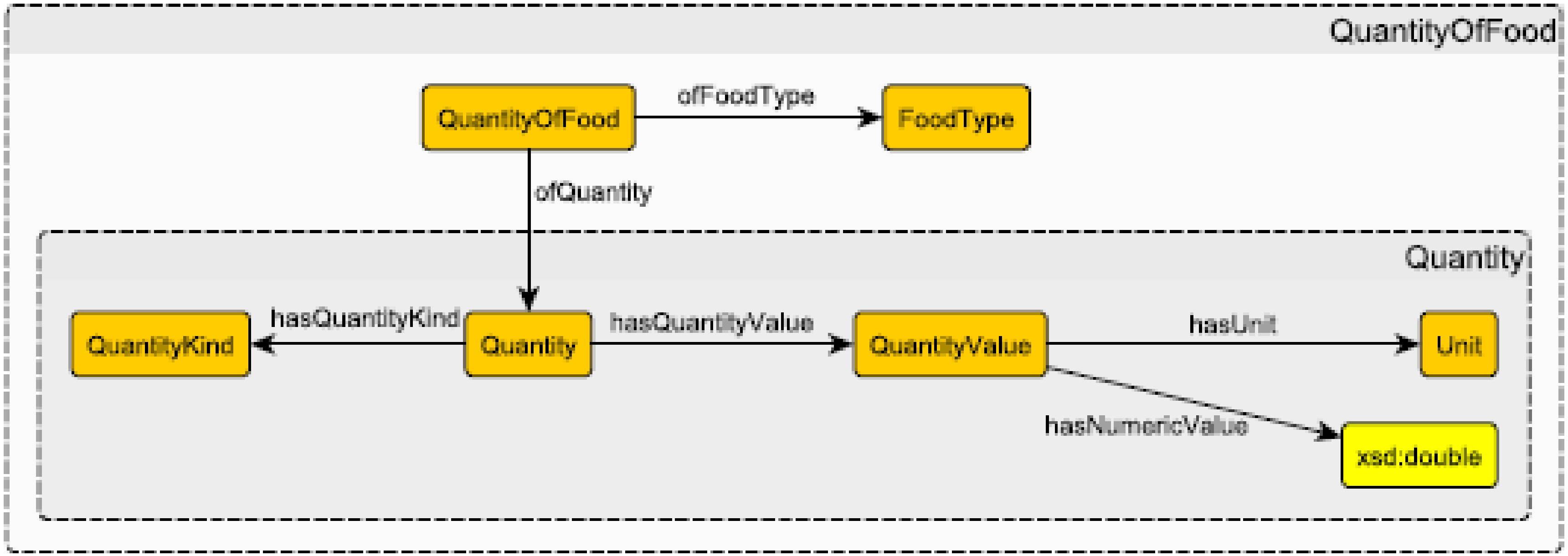
Axiomatization



1. A DisjointWith B (disjointness)
2. R some `owl:Thing` SubClassOf A (domain)
3. R some B SubClassOf A (scoped domain)
4. `owl:Thing` SubClassOf R only B (range)
5. A SubClassOf R only B (scoped range)
6. A SubClassOf R some B (existential)
7. B SubClassOf inverse R some A (inverse existential)
8. `owl:Thing` SubClassOf R max 1 `owl:Thing` (functionality)
9. `owl:Thing` SubClassOf R max 1 B (qualified functionality)
10. A SubClassOf R max 1 `owl:Thing` (scoped functionality)
11. A SubClassOf R max 1 B (qualified scoped functionality)
12. `owl:Thing` SubClassOf inverse R max 1 `owl:Thing` (inverse functionality)
13. `owl:Thing` SubClassOf inverse R max 1 A (inverse qualified functionality)
14. B SubClassOf inverse R max 1 `owl:Thing` (inverse scoped functionality)
15. B SubClassOf inverse R max 1 A (inverse qualified scoped functionality)

Figure 2.19: Most common axioms which could be produced from a single edge R between nodes A and B in a schema diagram: Manchester syntax.

Example Axiomatization



ofFoodType, ofQuantity: scoped range, existential

hasQuantityKind, hasQuantityValue: scoped domain, scoped range, existential, inverse existential, scoped qualified functionality

hasUnit: scoped range, existential, scoped qualified functionality

hasNumericValue: scoped range, existential, functionality

Mutually disjoint: QuantityOfFood, FoodType, QuantityKind, Quantity, QuantityValue, Unit

Thanks!

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