Ontology Composition using a Role Modeling Approach

Michael Pradel

TU Dresden
Lehrstuhl Softwaretechnologie

Supervisor: MSc. Jakob Henriksson
Professor: Dr. rer. nat. habil. Uwe Aßmann

Outline

Ontologies

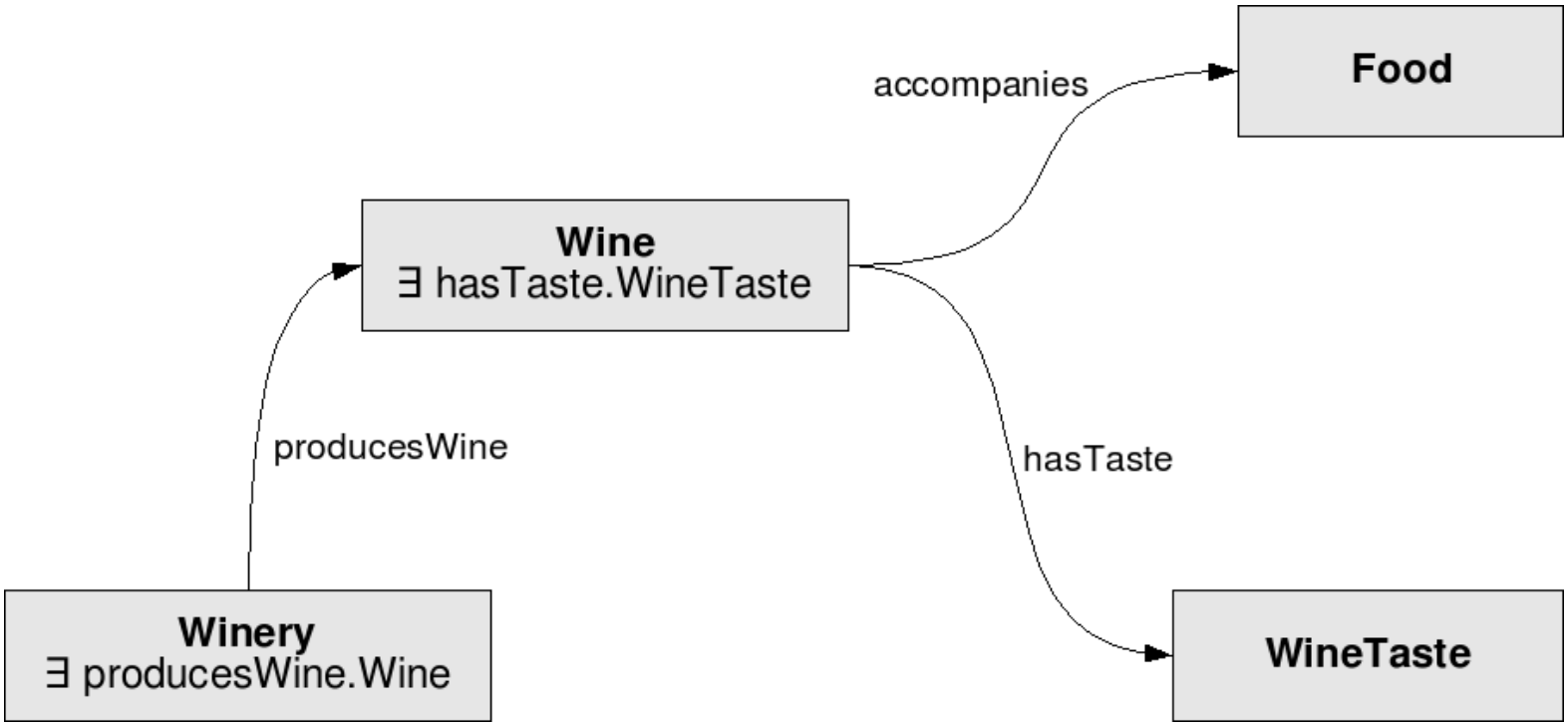
An ontology is an explicit specification of a conceptualization.

(Gruber)

- Set of axioms containing
  - Individuals
  - Classes built from class expressions
  - Properties
- Web Ontology Language OWL based on descriptions logics
- Applications
  - Semantic web
  - Domain modeling
  - Data integration
- Main advantage: Reasoning

Ontologies (2)

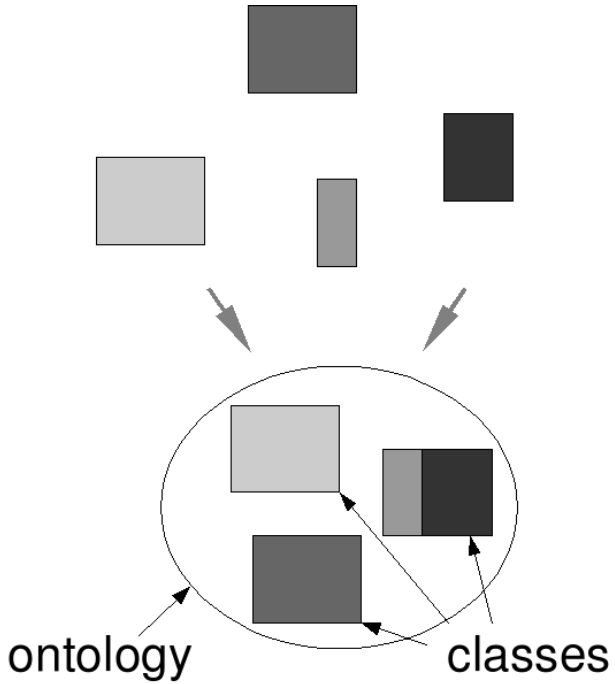
Wine Ontology:



The Problem

Building Ontologies from Components

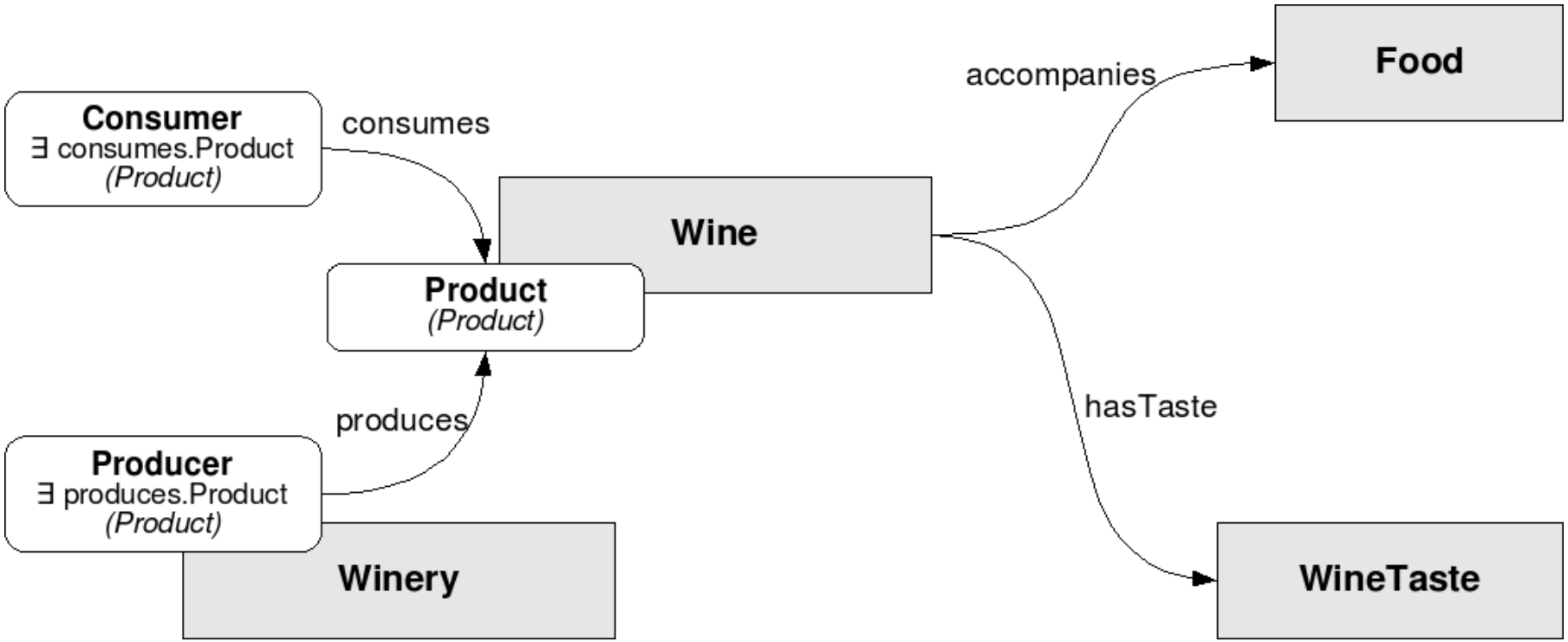
- Goal: Create new ontology from existing building blocks
- What is the reuse unit?
  - OWL *import* statement
    - ★ One ontology imports another
    - ★ No partial reuse
  - Approaches to modular description logics
- Problems with partial reuse
  - Classes depend on each other
  - No separation of concerns



A New Reuse Abstraction: Collaborations

- Natural types vs. role types
- Idea: Introduce roles into ontologies
  - Role as ontological primitives
  - Split class description into parts
  - Collaborations of individuals expressed by role models
- Benefits
  - Role models (= collaborations) as reuse abstraction
  - Different contexts in which classes appear are distinguished
  - Better modeling through distinction of natural types and role types

Wine Ontology with *Product* Role Model



What Do Roles Mean?

Additional syntax:

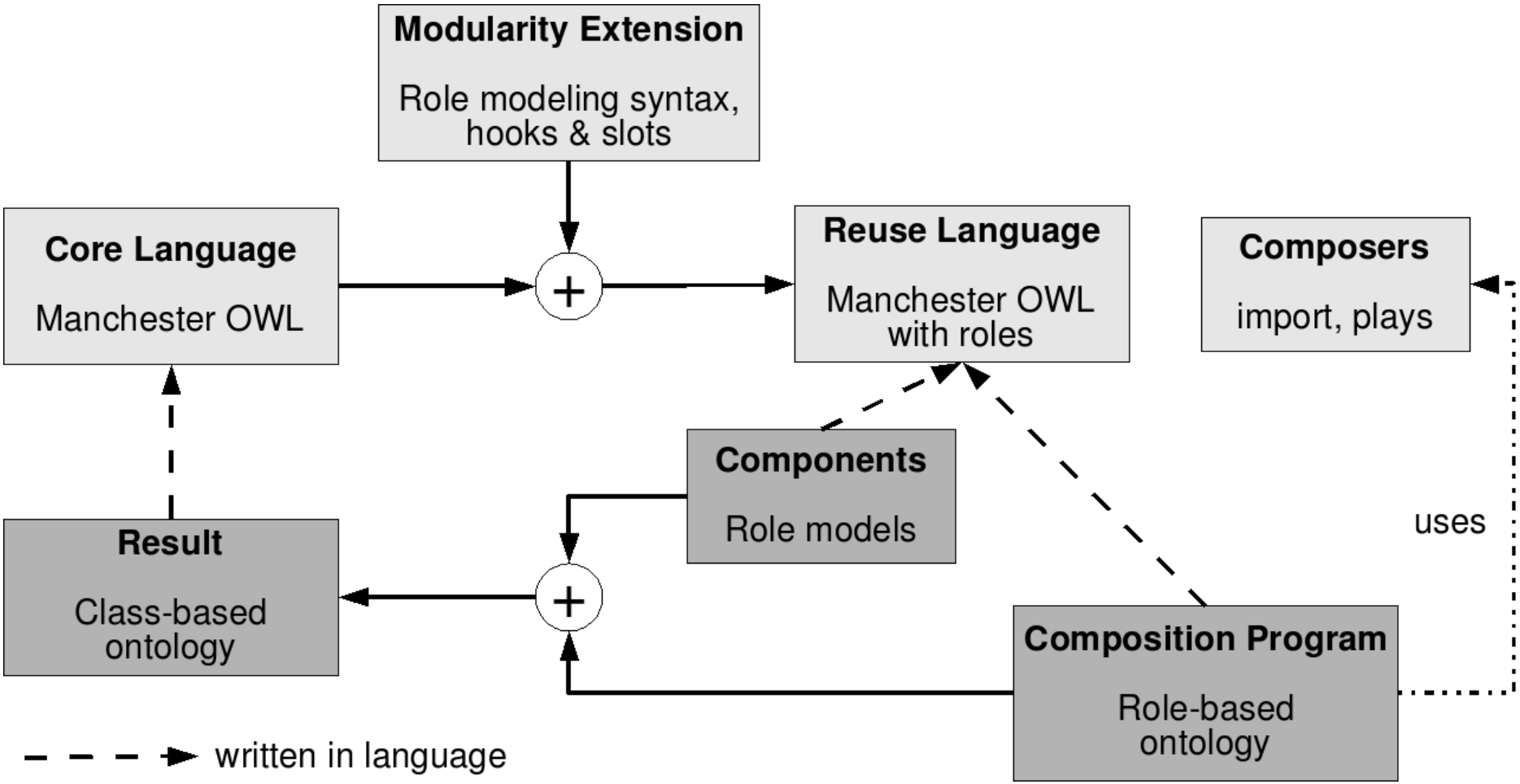
- Role types and role properties: R, p
- Role binding axiom: $R \rhd C$
- Role assertion axiom: $R(a)$

Meaning? Translational semantics!

- Algorithm (sketch):
  1. Role types and role properties $\rightsquigarrow$ Classes and properties
  2. For each role type R:
     If R bound to $C_1, \ldots, C_n$, then $R \sqsubseteq C_1 \sqcup \cdots \sqcup C_n \sqcup \bot$
  3. Role assertion $\rightsquigarrow$ Class assertion
- Note: Unbound roles lead to unsatisfiable classes

Implementation with Reuseware

Reuseware: Invasive composition for arbitrary languages



Composers

```
import http://ontology-rolemodels.org/product.rm

Class: Wine
    Plays: Product
Class: Winery
    Plays: Producer
Class: Food
    Plays: Product
```

Composers

```
Class: Product

Class: Producer
    EquivalentTo: produces some Product

Class: Consumer
    EquivalentTo: consumes some Product


Class: Wine
    Plays: Product
Class: Winery
    Plays: Producer
Class: Food
    Plays: Product
```

Composers

```
Class: Product
    SubClassOf: owl:Nothing or <<ProductSubClassHook>>
Class: Producer
    EquivalentTo: produces some Product
    SubClassOf: owl:Nothing or <<ProducerSubClassHook>>
Class: Consumer
    EquivalentTo: consumes some Product
    SubClassOf: owl:Nothing or <<ConsumerSubClassHook>>

Class: Wine
    Plays: Product
Class: Winery
    Plays: Producer
Class: Food
    Plays: Product
```

Composers

```
Class: Product
    SubClassOf: owl:Nothing or Wine or <<ProductSubClassHook>>
Class: Producer
    EquivalentTo: produces some Product
    SubClassOf: owl:Nothing or <<ProducerSubClassHook>>
Class: Consumer
    EquivalentTo: consumes some Product
    SubClassOf: owl:Nothing or <<ConsumerSubClassHook>>

Class: Wine

Class: Winery
    Plays: Producer
Class: Food
    Plays: Product
```

Composers

```
Class: Product
    SubClassOf: owl:Nothing or Wine or <<ProductSubClassHook>>
Class: Producer
    EquivalentTo: produces some Product
    SubClassOf: owl:Nothing or Winery or <<ProducerSubClassHook>>
Class: Consumer
    EquivalentTo: consumes some Product
    SubClassOf: owl:Nothing or <<ConsumerSubClassHook>>

Class: Wine

Class: Winery

Class: Food
    Plays: Product
```

Composers

```
Class: Product
    SubClassOf: owl:Nothing or Wine or Food <<ProductSubClassHook>>
Class: Producer
    EquivalentTo: produces some Product
    SubClassOf: owl:Nothing or Winery or <<ProducerSubClassHook>>
Class: Consumer
    EquivalentTo: consumes some Product
    SubClassOf: owl:Nothing or <<ConsumerSubClassHook>>

Class: Wine

Class: Winery

Class: Food
```

Composers

```
Class: Product
    SubClassOf: owl:Nothing or Wine or Food
Class: Producer
    EquivalentTo: produces some Product
    SubClassOf: owl:Nothing or Winery
Class: Consumer
    EquivalentTo: consumes some Product
    SubClassOf: owl:Nothing

Class: Wine

Class: Winery

Class: Food
```

Composers

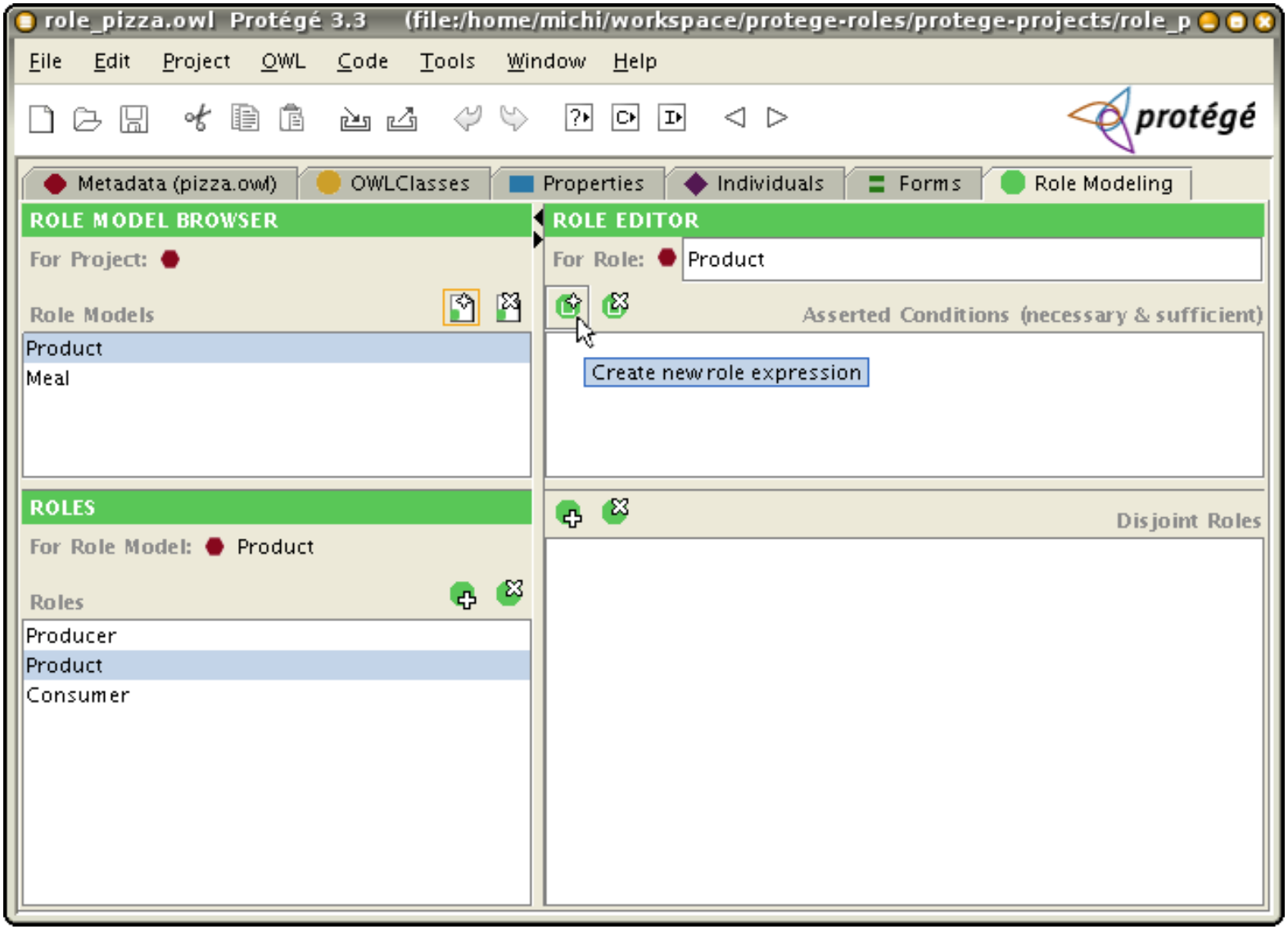
```
Class: Product
    SubClassOf: Wine or Food
Class: Producer
    EquivalentTo: produces some Product
    SubClassOf: Winery
Class: Consumer
    EquivalentTo: consumes some Product
    SubClassOf: owl:Nothing

Class: Wine

Class: Winery

Class: Food
```

Implications of Translation

- Multiple uses of one role type translated into the same class
  $\longrightarrow$ An individual of class *Product* can be a wine, a food, or both
  $\longrightarrow$ Get all products of the ontology
- Open role types are a subclass of *owl:Nothing*
  $\longrightarrow$ Individuals of *Consumer* make ontology inconsistent
  $\longrightarrow$ Individuals need a natural type

Demo...

Integration into Protégé

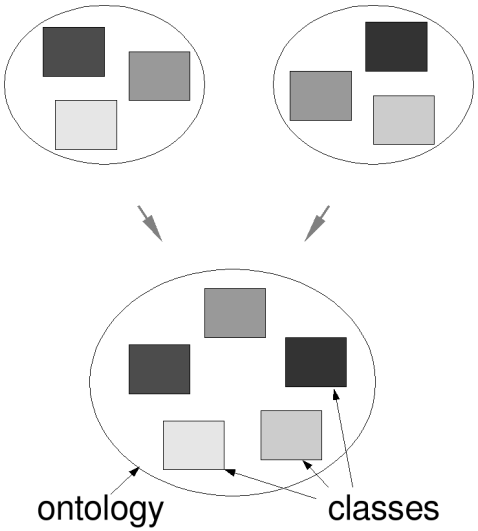


Composition of Multiple Ontologies

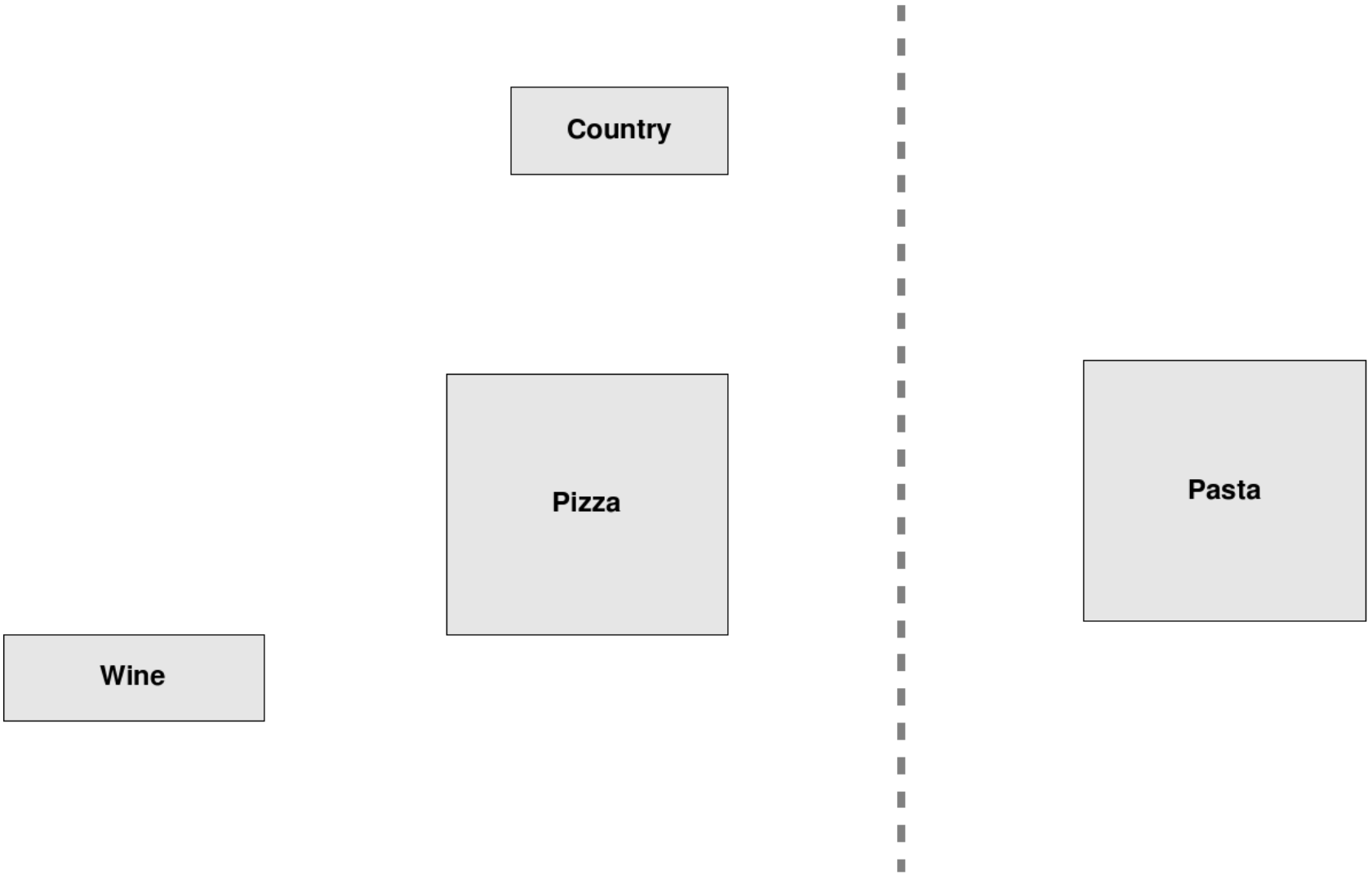
Outlook: Other uses of roles in ontologies

- Goal: Relate and combine independently developed ontologies
- Alignment & Merging
- What if classes semantically overlap?

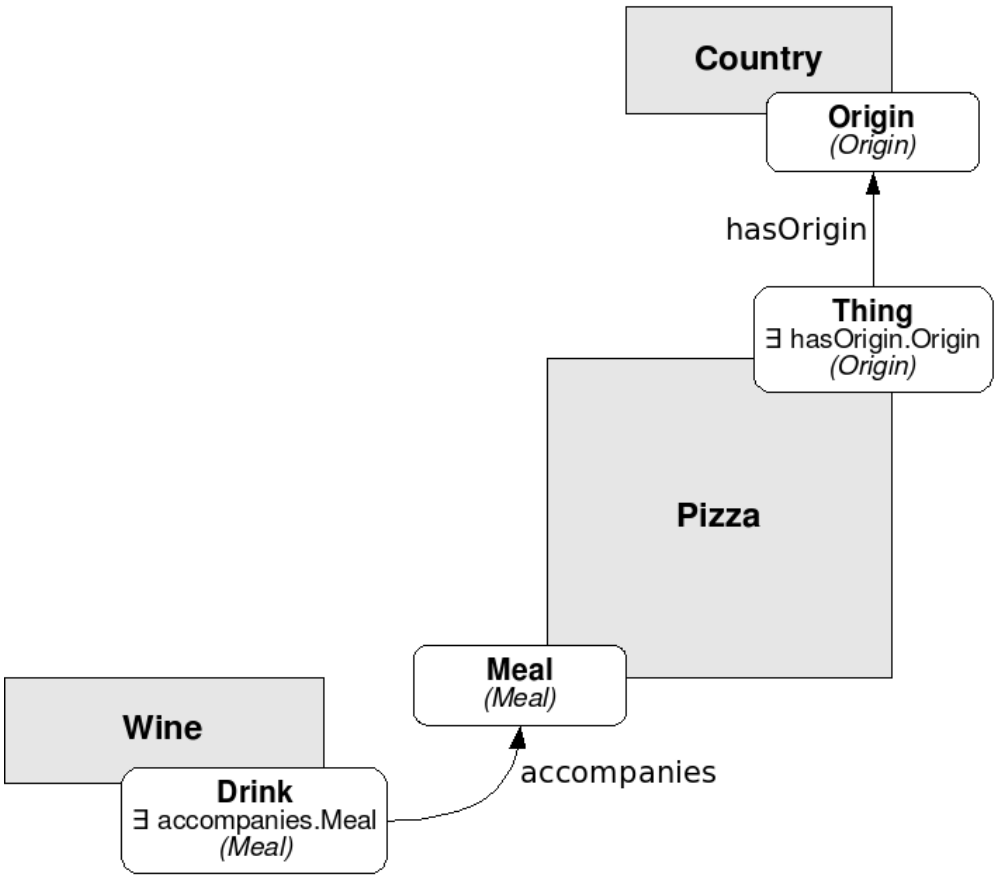
- Idea: Compose role types
  $\rightarrow$ Only one concern: More precise matching
- Process:
  1. Align role models
  2. Compose classes based on role type alignment

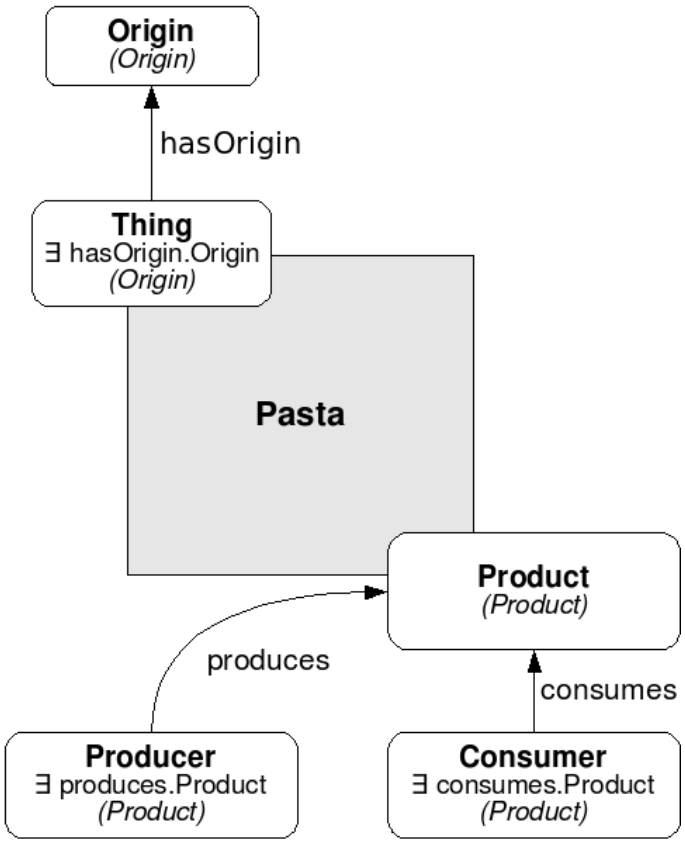


Example: Pizza and Pasta Ontologies

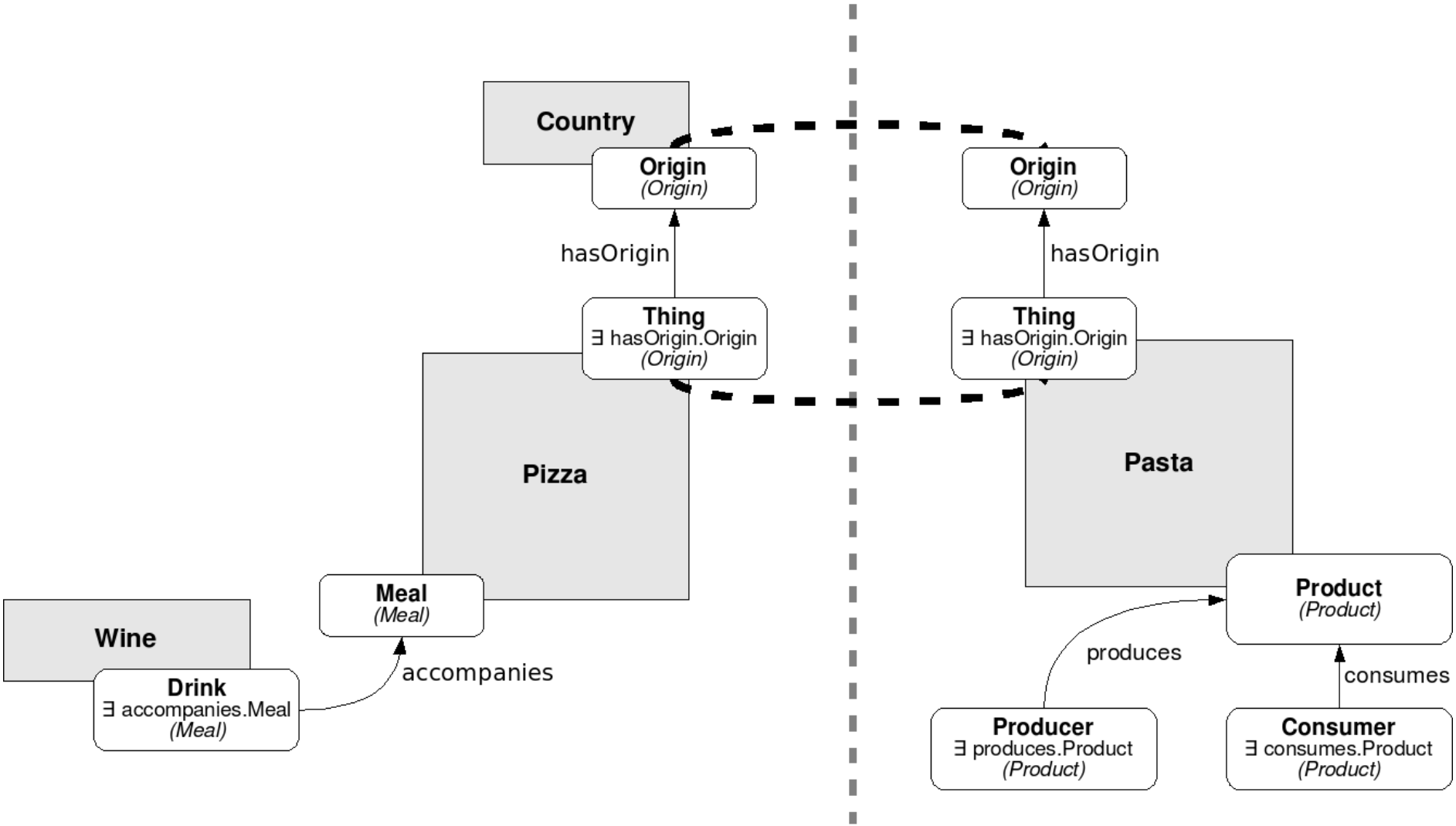


Example: Pizza and Pasta Ontologies

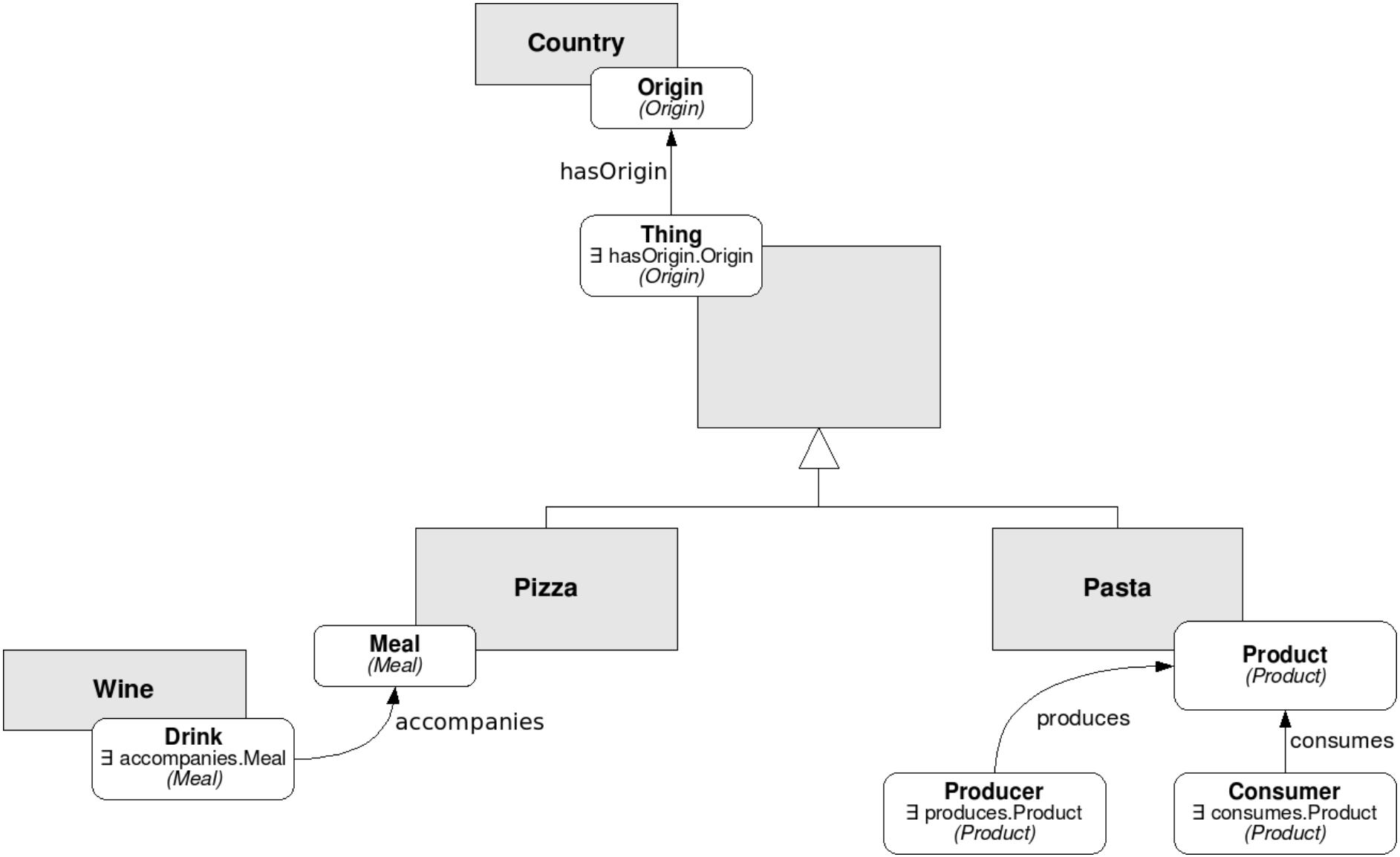




Example: Pizza and Pasta Ontologies



Example: Pizza and Pasta Ontologies



Conclusion

- Ontologies need roles as first class concept
  - → Role models = Ontological components
  - → Reusable, intuitive unit of abstraction
  - → Separation of concerns
  - → More natural modeling
- Translational semantics
  - → Compatible with existing tools
  - → Reuseware-based implementation
- Open questions
  - Different semantics (must-play?)
  - Multiple uses of one role model

See also:

A Good Role Model for Ontologies: Collaborations
M. Pradel, J. Henriksson, U. Aßmann

Workshop on Semantic-Based Software Development at OOPSLA'07

Thanks!