

How to *Reuse* a Faceted Classification and Put It on the *Semantic* Web

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Shanghai - 9th ISWC - 8th November 2010

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Introduction (1)

- Modeling scenario
 - There are domain concepts that can be represented according to ***multiple classification criteria***
 - The ontology model requires to represent multiple classification criteria of the domain concept in question
 - A lack of guidelines in the context of the Semantic Web leaves ample room for ***ad-hoc practices***

Introduction (2)



colour
region
grape

wine



base
topping

pizza



gender
kinship

person



form
brand
scent

dish detergent

Faceted Classification Scheme (FCS)

- FCS: a set of mutually exclusive and jointly exhaustive categories, each made by isolating ***one perspective on the items*** (a facet), that combine to completely describe all the objects in question (Denton, 2003).
- Facet Analysis: the sorting of terms in a given field of knowledge into homogeneous, mutually exclusive facets, each derived from the parent universe by ***a single characteristic of division*** (Vickery, 1960).
- The Principles of Homogeneity and Mutual Exclusivity state respectively that facets must be homogeneous and mutually exclusive, the contents of any two facets cannot overlap, and that each facet must represent only ***one characteristic of division*** of the parent universe (Spiteri, 1998).

Dish Detergent FCS Example (1)

Dish Detergent (Denton, 2003)

Facets	Terms
Agent	dishwasher, person
Form	gel, gelpac, liquid, powder, tablet
Brand Name	Cascade, Electrasol, Ivory, No Name, Palmolive, President's Choice, Sunlight
Scent	green apple, green tea, lavender, lemon, mandarin, ocean breeze, orange blossom, orchard fresh, passion flower, ruby red grapefruit, ylang ylang
Effect on Agent	aroma therapy (subdivisions: invigorating, relaxing)
Special Property	antibacterial

Dish Detergent FCS Example (2)

- **President's Choice Antibacterial Hand Soap & Dishwashing Liquid**

- Agent: person
- Form: liquid
- Brand Name: President's Choice
- Scent: (none)
- Effect on Agent: (none)
- Special Property: antibacterial

- **Palmolive Aroma Therapy, Lavender and Ylang Ylang**

- Agent: person
- Form: liquid
- Brand Name: Palmolive
- Scent: lavender, ylang ylang
- Effect on Agent: aroma therapy
- Special Property: (none)

FCS Generic Structure

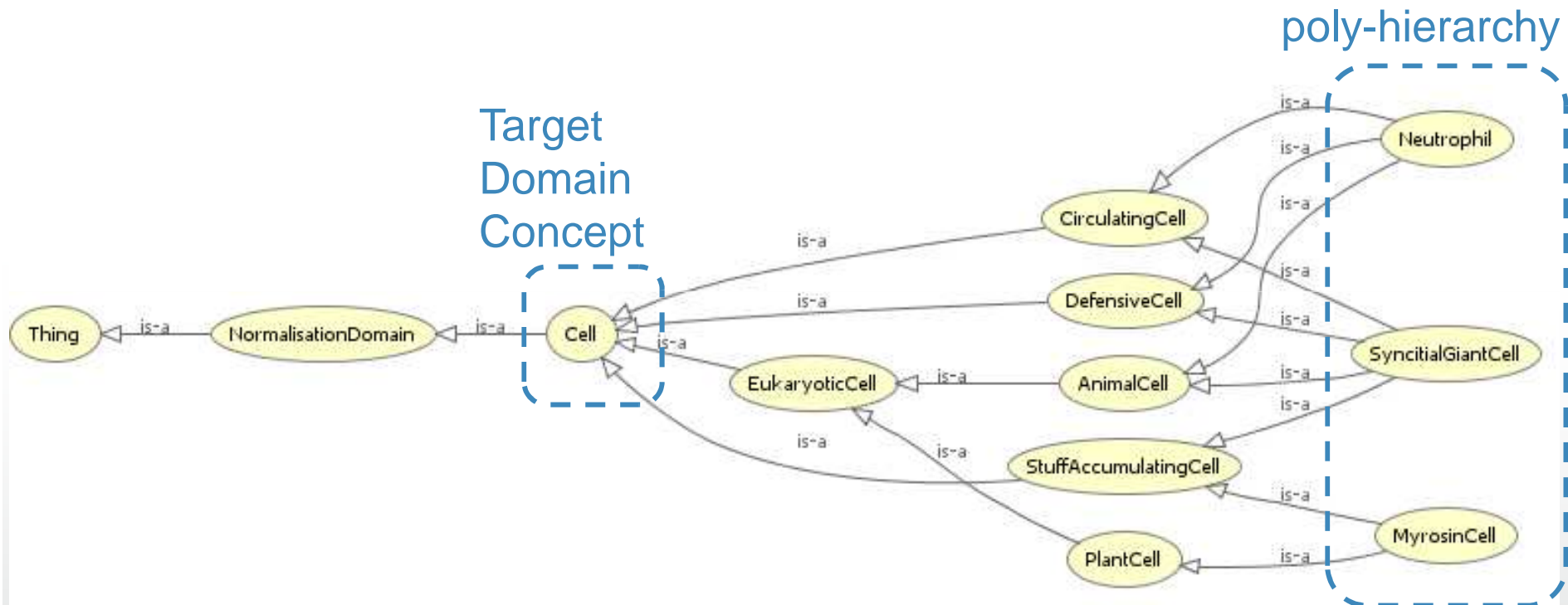
- **TDC**: Target Domain Concept
- **Facet_i**: *Facet₁, Facet₂, ..., rest of facets.*
- **F_iTerm_j**: Terms or foci organized by facets:
 - *Facet₁: F₁Term₁, F₁Term₂, ..., rest of terms in Facet₁.*
 - *Facet₂: F₂Term₁, F₂Term₂, ..., rest of terms in Facet₂.*
 - ... rest of terms by facet.
- **Item_x**: Set of items (from the TDC) to classify: *Item₁, Item₂, ..., rest of items.*

Normalisation ODP

- Regarded as a best practice and also known as **Modularisation**, or **Untangling** (Rector, 2003).
- Motivation: An ontology where a class can have many superclasses (**poly-hierarchy**).
 - Subsumption becomes difficult to maintain and error-prone.
 - Subsumption is implicitly stated.
- Aim: to untangle the poly-hierarchy using **restrictions** to encode subsumption relationships.
 - Normalisation allows exactly **one unlabelled flavour of is-kind-of link corresponding** to the links declared in the primitive skeleton. All others are inferred by the reasoner.
 - Assertion of **multiple inheritance** relations among primitive concepts are not allowed.

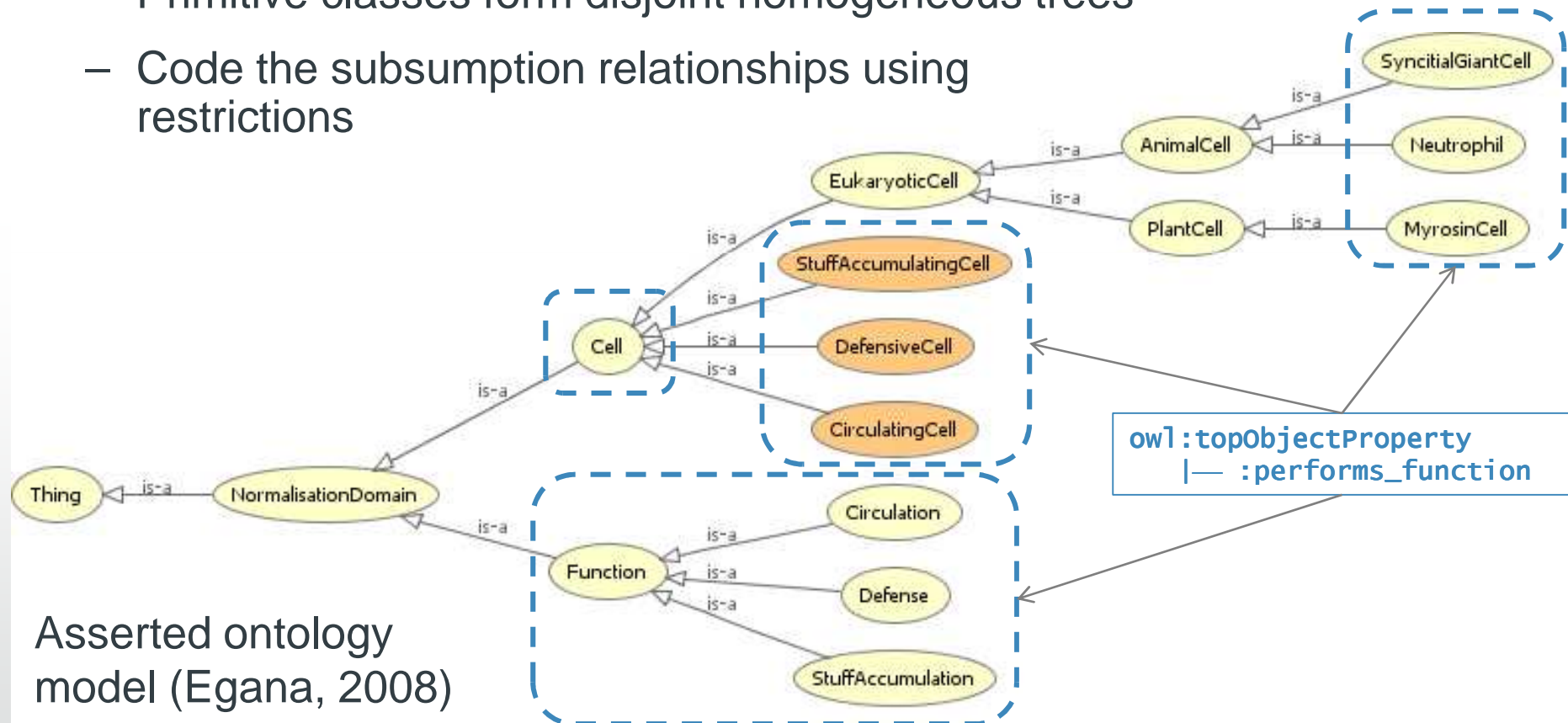
Normalisation ODP Example (1)

- Modeling problem (Egana, 2008)



Normalisation ODP Example (2)

- Implementation:
 - Identify the modules
 - Primitive classes form disjoint homogeneous trees
 - Code the subsumption relationships using restrictions



Normalisation ODP Example (3)

:DefensiveCell

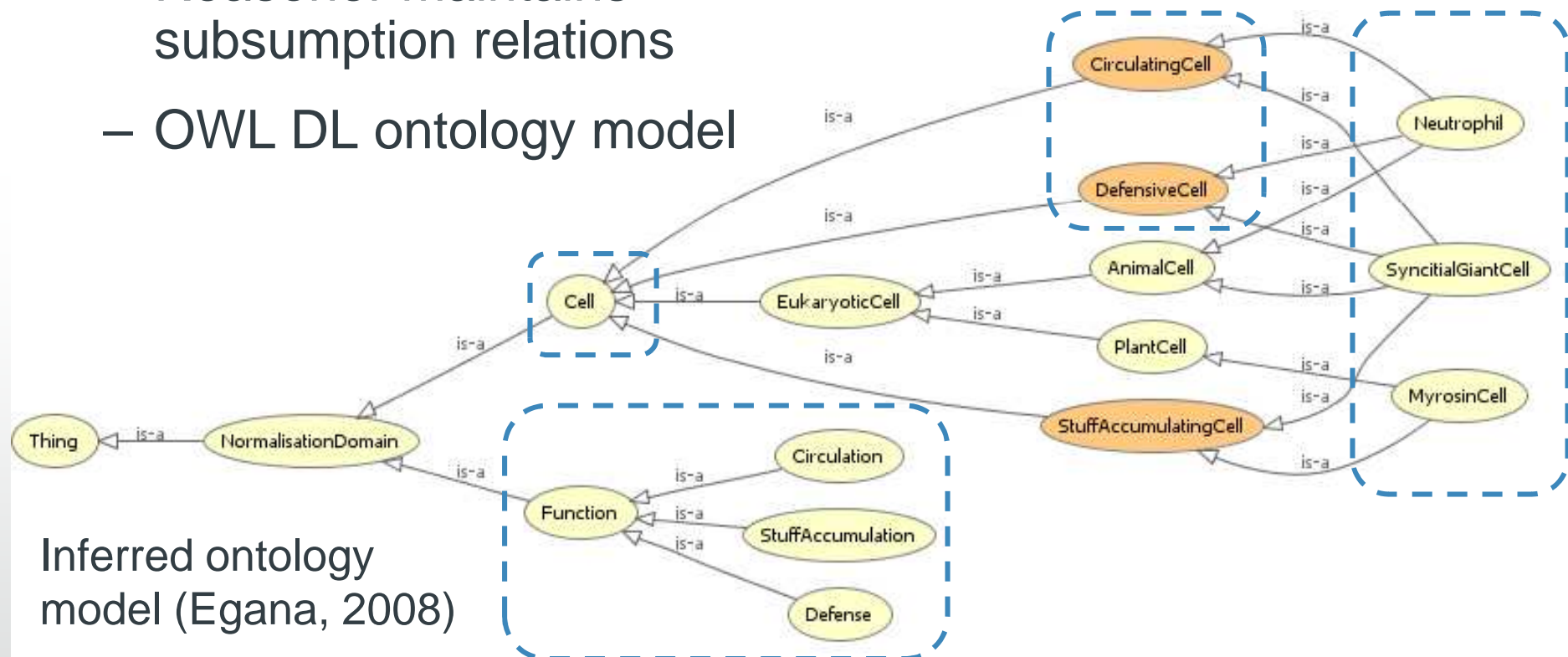
```
rdf:type owl:Class ;  
rdfs:subClassOf :cell;  
owl:equivalentClass [ rdf:type owl:Restriction ;  
                      owl:onProperty :performs_function;  
                      owl:someValuesFrom :Defence ] .
```

:Neutrophil

```
rdf:type owl:Class ;  
rdfs:subClassOf :AnimalCell,  
  [ rdf:type owl:Restriction ;  
    owl:onProperty :performs_function;  
    owl:someValuesFrom :Defence ] ,  
  [ rdf:type owl:Restriction ;  
    owl:onProperty :performs_function;  
    owl:someValuesFrom :Circulation ] .
```

Normalisation ODP Example (4)

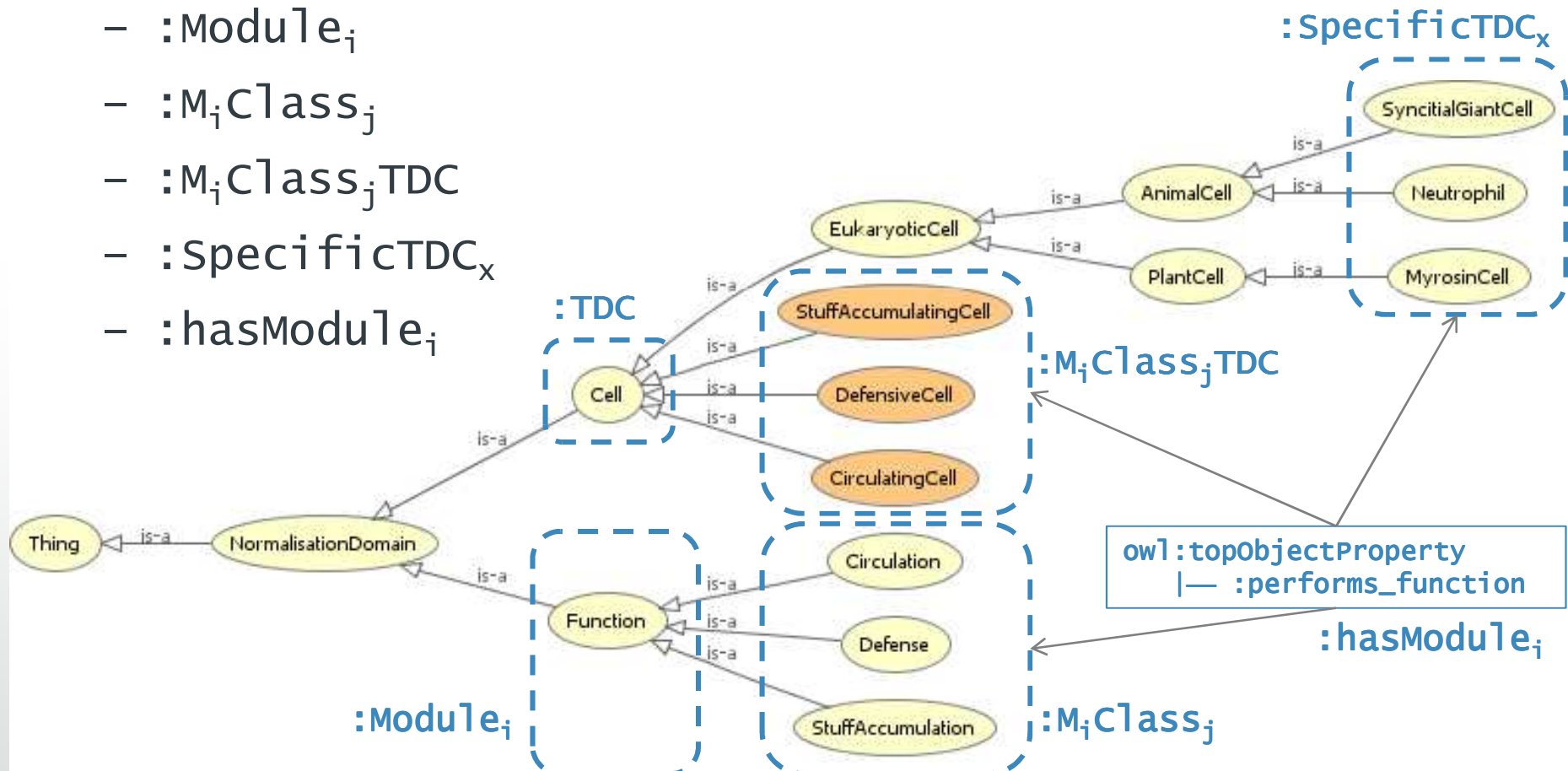
- Result:
 - The ontology gets untangled
 - Reasoner maintains subsumption relations
 - OWL DL ontology model



Normalisation ODP Generic Structure (1)

- Elements in the generic structure:

- :TDC
- :Module_i
- :M_iClass_j
- :M_iClass_jTDC
- :SpecificTDC_x
- :hasModule_i



Normalisation ODP Generic Structure (2)

- Elements in the generic structure:
 - :TDC
 - :Module_i
 - :M_iClass_j
 - :M_iClass_jTDC
 - :SpecificTDC_x
 - :hasModule_i

```
owl:Thing
  |— :Modulei
    |— :MiClassj
      |— :TDC
        |— (≡) :MiClassjTDC
          |— :SpecificTDCx
```

```
owl:topObjectProperty
  |— :hasModulei
```

(≡) denotes a defined class

FCS Generic Structure

- **TDC**: Target Domain Concept
- **Facet_i**: *Facet₁, Facet₂, ..., rest of facets.*
- **F_iTerm_j**: Terms or foci organized by facets:
 - *Facet₁: F₁Term₁, F₁Term₂, ..., rest of terms in Facet₁.*
 - *Facet₂: F₂Term₁, F₂Term₂, ..., rest of terms in Facet₂.*
 - ... rest of terms by facet.
- **Item_x**: Set of items (from the TDC) to classify: *Item₁, Item₂, ..., rest of items.*

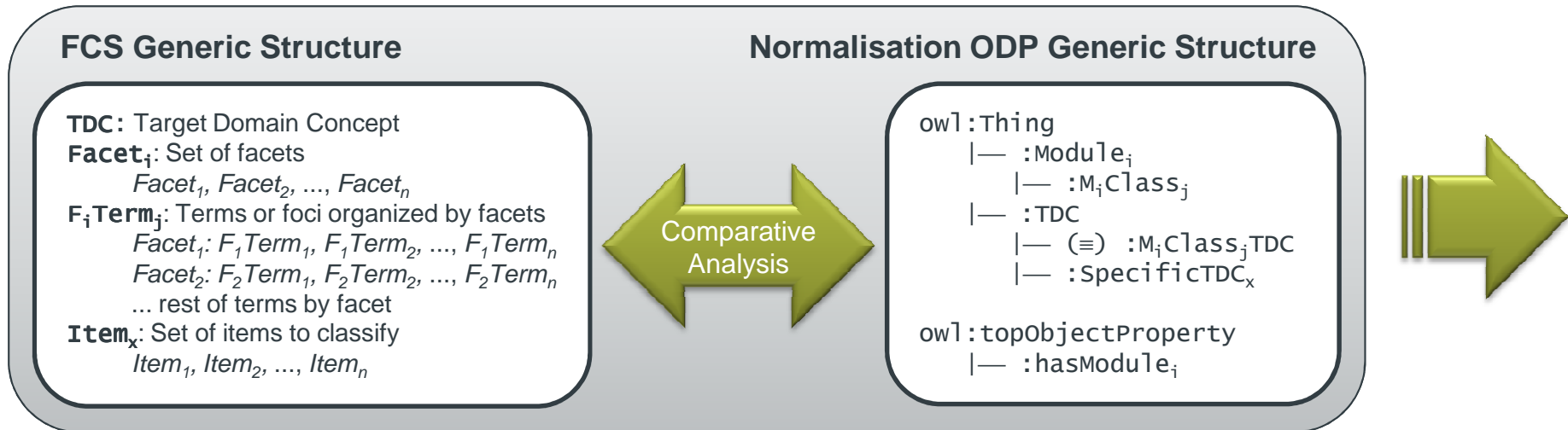
Alignment: FCS to Normalisation ODP (1)

- **facet** in FCSs and **module** (or *semantic axis*) in the Normalisation ODP
 - One perspective of the domain being modeled.
 - A single characteristic of division.
 - A single criterion of classification.
- **facets** in a FCS to be *homogeneous and mutually exclusive*.
- **modules** in the Normalisation ODP to be comprised of primitive classes arranged in a structure of *disjoint homogeneous class trees*.
- Both, a **facet term** and a **module subclass**, represents the same notion in their respective conceptual models. A subdivision, a refinement of the facet or module that they complement respectively.
- Both, an **item** in the FCS and a **class with multiple parents** in the Normalisation ODP, represent the same notion in their respective conceptual models. An element that is to be classified.

Alignment: FCS to Normalisation ODP (2)

Information Science	Ontology Modelling		
	FCS	Normalisation ODP	FCS in Norm. ODP
TDC	:TDC		owl:Class (primitive)
Facet _i	:Module _i	:Facet _i	owl:Class (primitive)
	:hasModule _i	:hasFacet _i	owl:ObjectProperty
F _i Term _j	:M _i Class _j	:F _i Term _j	owl:Class (primitive)
	:M _i Class _j TDC	:F _i Term _j TDC	owl:Class(defined) (≡)
Item _x	:SpecificTDC _x		owl:Class (primitive)

Alignment: FCS to Normalisation ODP (3)



Alignment Guidelines

Information Science	Ontology Modelling	
	Norm. ODP	FCS in Norm. ODP
TDC	:TDC	
Facet_i	:Module _i	:Facet _i
	:hasModule _i	:hasFacet _i
F_iTerm_j	:M _i Class _j	:F _i Term _j
	:M _i Class _j TDC	:F _i Term _j TDC
Item_x	:SpecificTDC _x	

FCS in Normalisation ODP Generic Structure

```
owl:Thing
  |— :Faceti
  |— :FiTermj
  |— :TDC
  |— (≡) :FiTermjTDC
  |— :SpecificTDCx

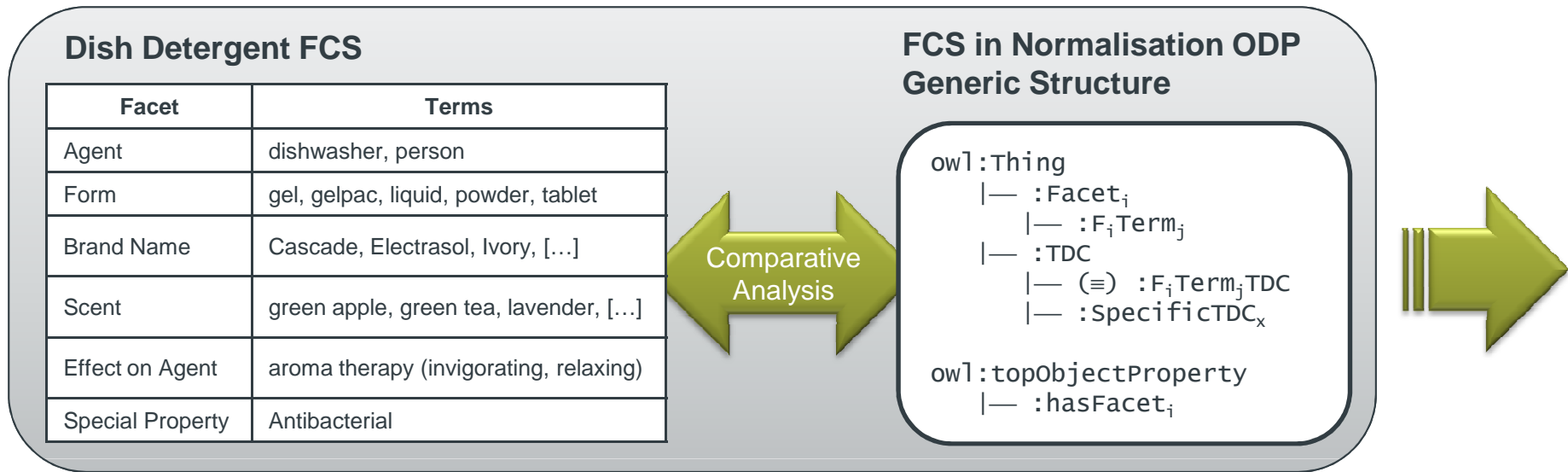
owl:topObjectProperty
  |— :hasFaceti
```

Dish Detergent FCS Example (1)

Dish Detergent (Denton, 2003)

Facets	Terms
Agent	dishwasher, person
Form	gel, gelpac, liquid, powder, tablet
Brand Name	Cascade, Electrasol, Ivory, No Name, Palmolive, President's Choice, Sunlight
Scent	green apple, green tea, lavender, lemon, mandarin, ocean breeze, orange blossom, orchard fresh, passion flower, ruby red grapefruit, ylang ylang
Effect on Agent	aroma therapy (subdivisions: invigorating, relaxing)
Special Property	antibacterial

Dish Detergent FCS Normalisation Example (1)



Dish Detergent FCS Normalised Ontology

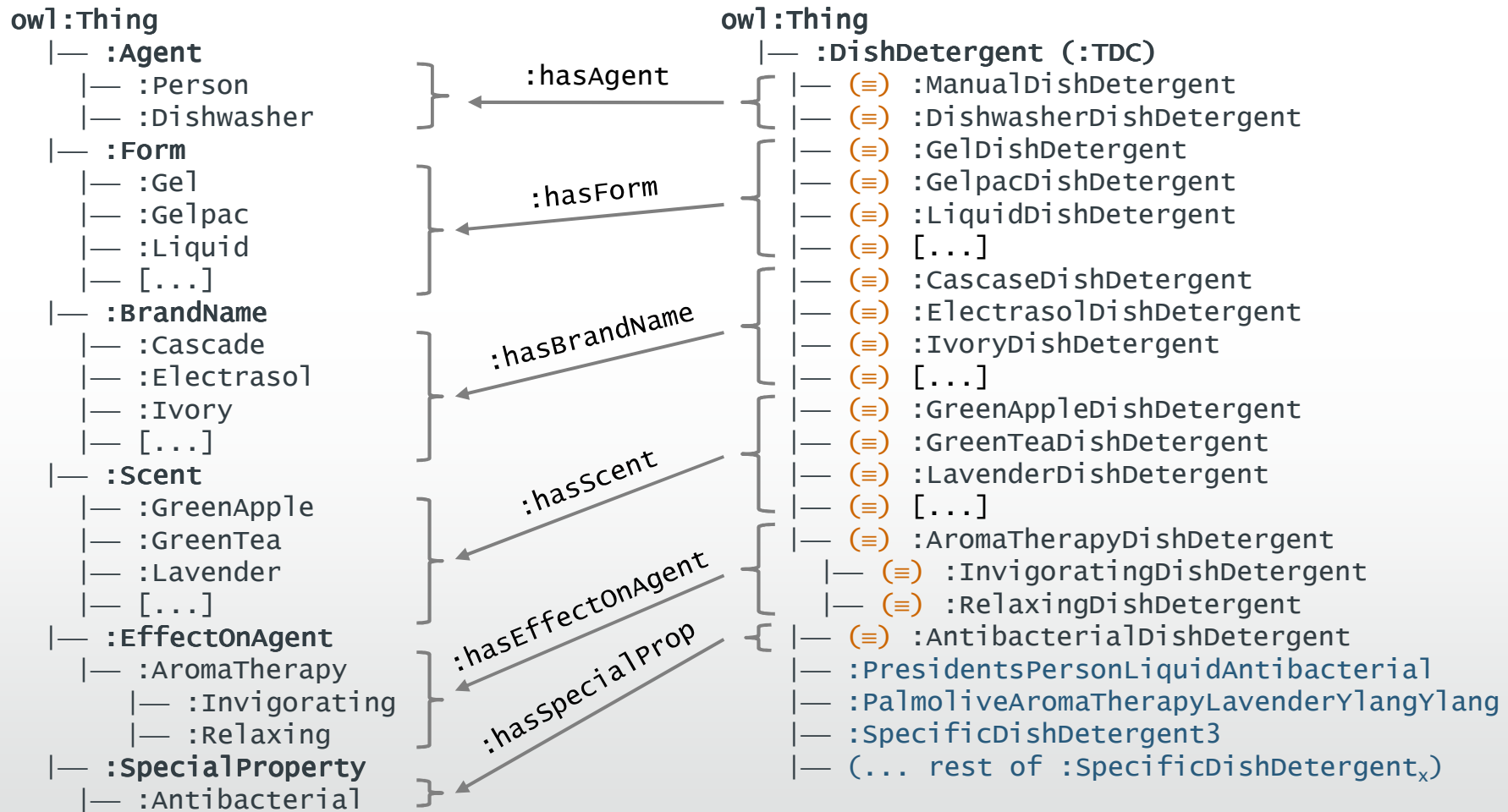


```
owl:Thing
  |— :Agent
  |   |— :Person
  |   |— :Dishwasher
  |— :Form
  |   |— :Gel
  |   |— :Gelpac
  |— [...]
  |— :BrandName
  |   |— :Cascade
  |   |— :Electrasol
  |— [...]
  |— :Scent
  |   |— :GreenApple
  |   |— :GreenTea
  |— [...]
  |— :EffectOnAgent
  |   |— :AromaTherapy
  |       |— :Invigorating
  |       |— :Relaxing
  |— :SpecialProperty
  |   |— :Antibacterial
```

```
owl:Thing
  |— :DishDetergent (:TDC)
  |   |— (≡) :ManualDishDetergent
  |   |— (≡) :DishwasherDishDetergent
  |   |— (≡) :GelDishDetergent
  |   |— (≡) :GelpacDishDetergent
  |   |— (≡) [...]
  |   |— (≡) :CascadeDishDetergent
  |   |— (≡) :ElectrasolDishDetergent
  |   |— (≡) [...]
  |   |— (≡) :GreenAppleDishDetergent
  |   |— (≡) :GreenTeaDishDetergent
  |   |— (≡) [...]
  |   |— (≡) :AromaTherapyDishDetergent
  |       |— (≡) :InvigoratingDishDetergent
  |       |— (≡) :RelaxingDishDetergent
  |— (≡) :AntibacterialDishDetergent
  |— :PresidentsPersonLiquidAntibacterial
  |— :PalmoliveAromaTherapyLavenderYlangYlang
  |— :SpecificDishDetergent3
  |— (... rest of :SpecificDishDetergentx)
```

Dish Detergent FCS Normalisation Example (2)

- FCS Normalised Ontology



Dish Detergent FCS Example (2)

- **President's Choice Antibacterial Hand Soap & Dishwashing Liquid**

- Agent: person
- Form: liquid
- Brand Name: President's Choice
- Scent: (none)
- Effect on Agent: (none)
- Special Property: antibacterial

- **Palmolive Aroma Therapy, Lavender and Ylang Ylang**

- Agent: person
- Form: liquid
- Brand Name: Palmolive
- Scent: lavender, ylang ylang
- Effect on Agent: aroma therapy
- Special Property: (none)

Dish Detergent FCS Normalisation Example (3)

:PresidentsPersonLiquidAntibacterial

```
rdf:type owl:Class ;
```

```
rdfs:subClassOf :DishDetergent ,
```

```
  [ rdf:type owl:Restriction ;
```

```
    owl:onProperty :hasAgent;
```

```
    owl:someValuesFrom :Person ] ,
```

```
  [ rdf:type owl:Restriction ;
```

```
    owl:onProperty :hasForm;
```

```
    owl:someValuesFrom :Liquid ] ,
```

```
  [ rdf:type owl:Restriction ;
```

```
    owl:onProperty :hasBrandName;
```

```
    owl:someValuesFrom :PresidentsChoice ] ,
```

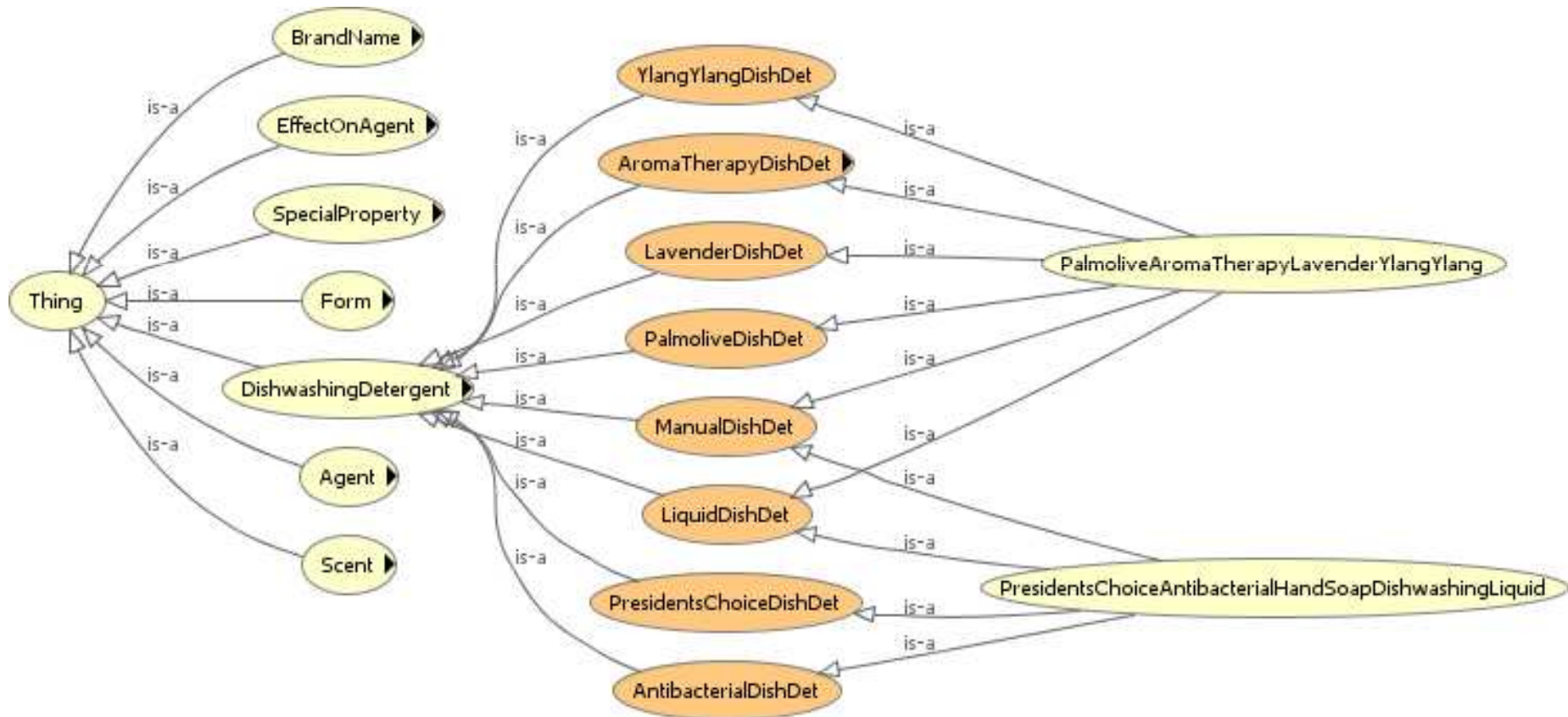
```
  [ rdf:type owl:Restriction ;
```

```
    owl:onProperty :hasSpecialProperty;
```

```
    owl:someValuesFrom :Antibacterial ] ,
```


Dish Detergent FCS Normalisation Example (4)

- FCS Normalised Ontology



Conclusions

- Initial set of *basic design guidelines* to develop an ontology model within *OWL DL* that supports the representation of *multiple classification criteria* of a specific domain concept.
- A series of *mappings* between the elements of a generic FCS and the Normalization ODP have been identified that allow us to convert a given FCS into an *OWL DL* ontology model following a consistent and systematic approach.
- The guidelines presented in this first effort consider *explicitly* the conceptualization of existing classification criteria in the context of ontology modeling for the Semantic Web and provide a *partial solution* to the problem scenario described.
- An existing *FCS example* in the domain of “Dishwashing Detergent” is used to illustrate the main steps of our conversion procedure

Future Work

- FCS and Normalization ODP: bidirectional alignment?
- Multiple FCSs in the same ontology model
- Universal Faceted Classifications
- Revisiting the Normalization ODP using OWL 2 meta-modelling (punning)
- *:M_iClass_j* and *:SpecificTDC_x* - owl:Class or owl:NamedIndividual