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Aggregation Patterns in Holonic Manufacturing Systems

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Pascal André, Olivier Cardin

LS2N lab, University of Nantes, France



Context



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Software development point of view on Holonic Manufacturing Systems

- Software Quality [[sohoma 2017](#)]
- Separate core concepts from case specific concepts [[sohoma 2018](#)]
- Communications & maintenance [[sohoma 2019-2020](#)]

We need

- Clear semantics of the HMS models
- Base implementations (frameworks)



More information ? Ask a question

Focus on **Aggregation**



Outline

- Introduction
- Problem statement
- Modelling issues
- HMS Aggregation patterns
- Design concerns
- Conclusion

Object of study =
Aggregation



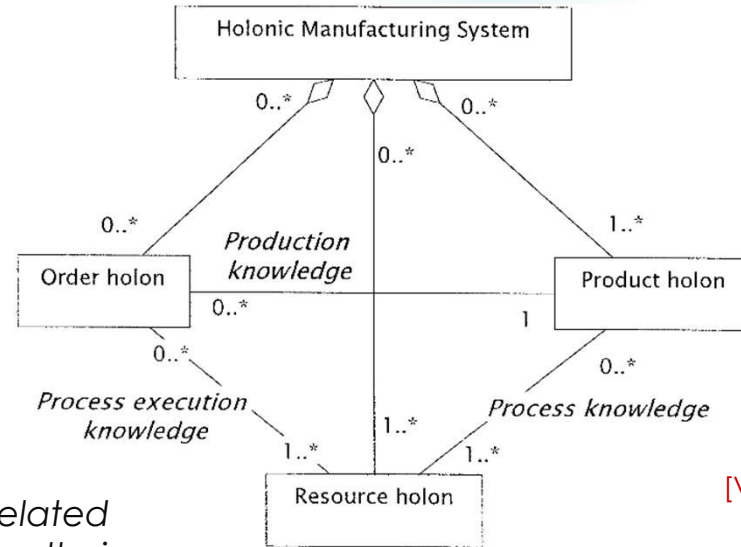
Focus

Aggregation (whole-part) is a key concept in HMS

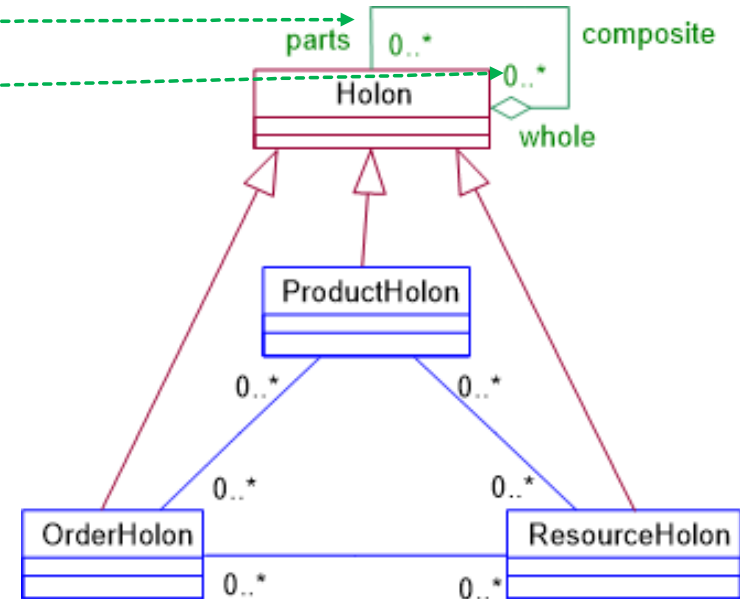
- **Prosa** [Van Brussel 1998]
 - “Aggregated holons are defined as a set of related holons that are clustered together and form on their turn a bigger holon with its own identity.”
 - “holons may belong to multiple aggregations,”
 - “Aggregated holons are no static sets of holons, but can dynamically change their contents”
- **ARTI** [Valckenaer 2018]
 - “PROSA aggregation remains a non-optional feature in ARTI.”



Different from Data Aggregation



[Van Brussel 1998]



Problem statement

a) Behind the shared idea of grouping holons, the models vary from one interpretation/model to another

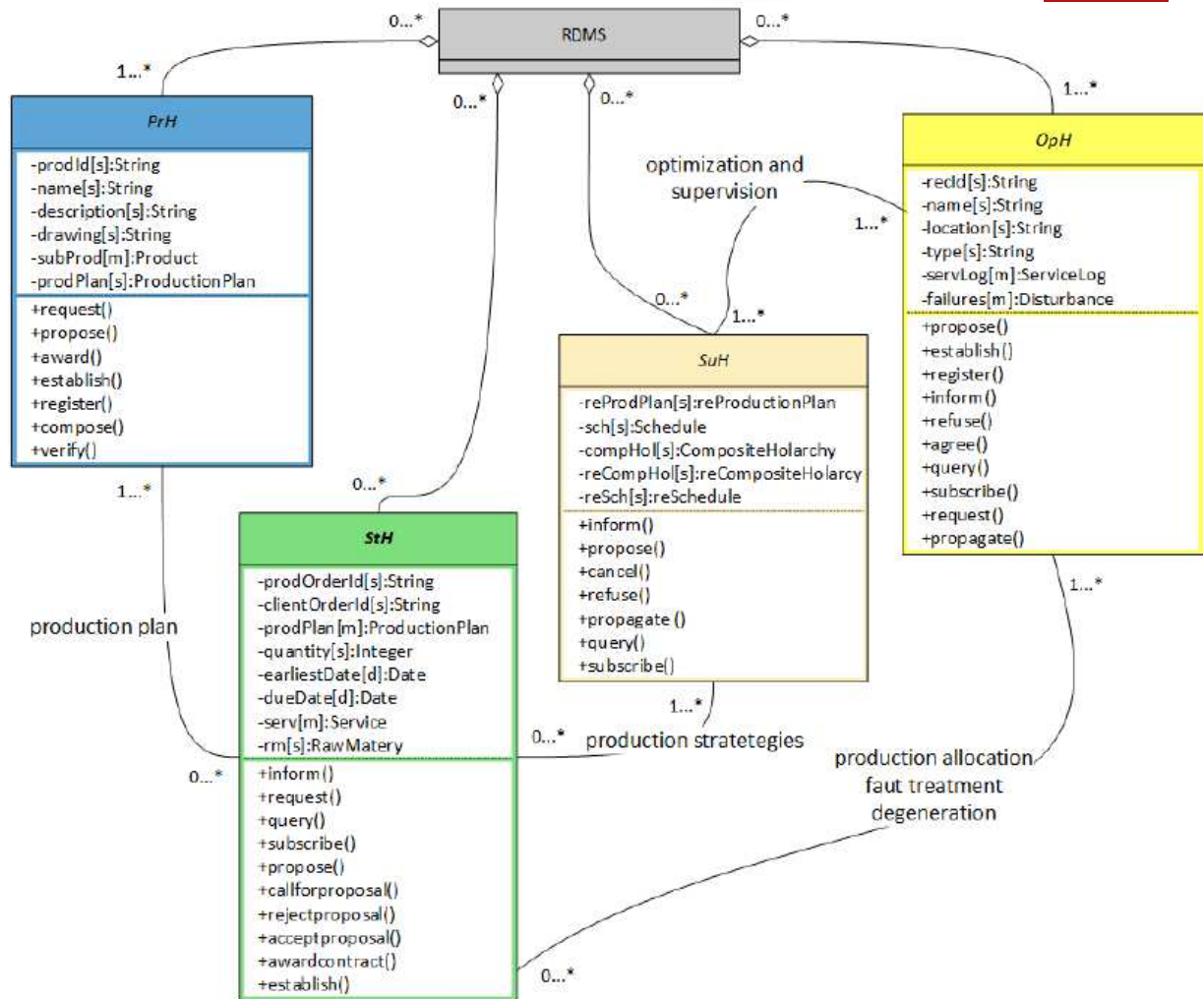
[Baïna et al. 2006]

ADACOR [Leitão and Restivo 2006]
product/task/supervisor/operational

[Blanc et al. 2008]

[da Silva et al. 2014]
product/strategy/supervisor/operational

- Not comparable
- Not reusable
- Not interoperable





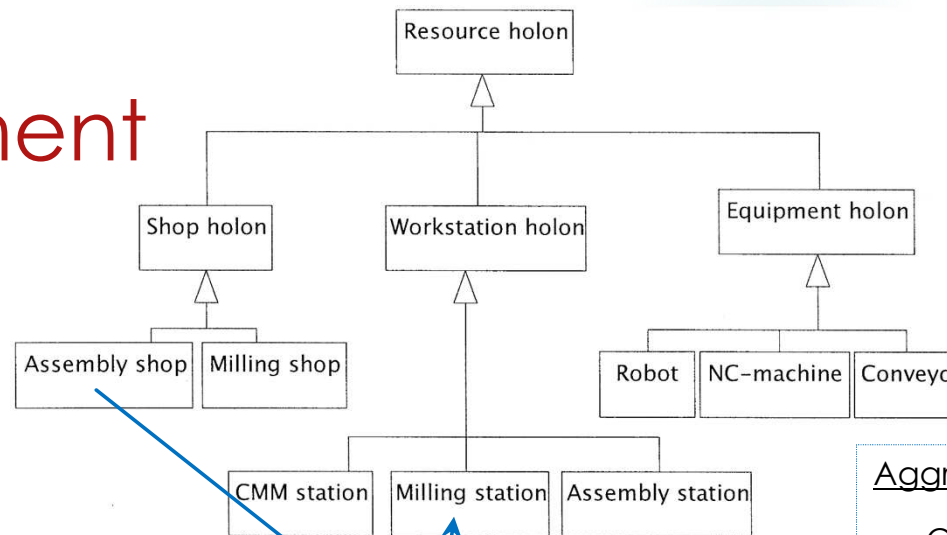
Problem statement

b) Misunderstandings / Interpretations

PROSA [Van Brussel 1998]

Aggregation

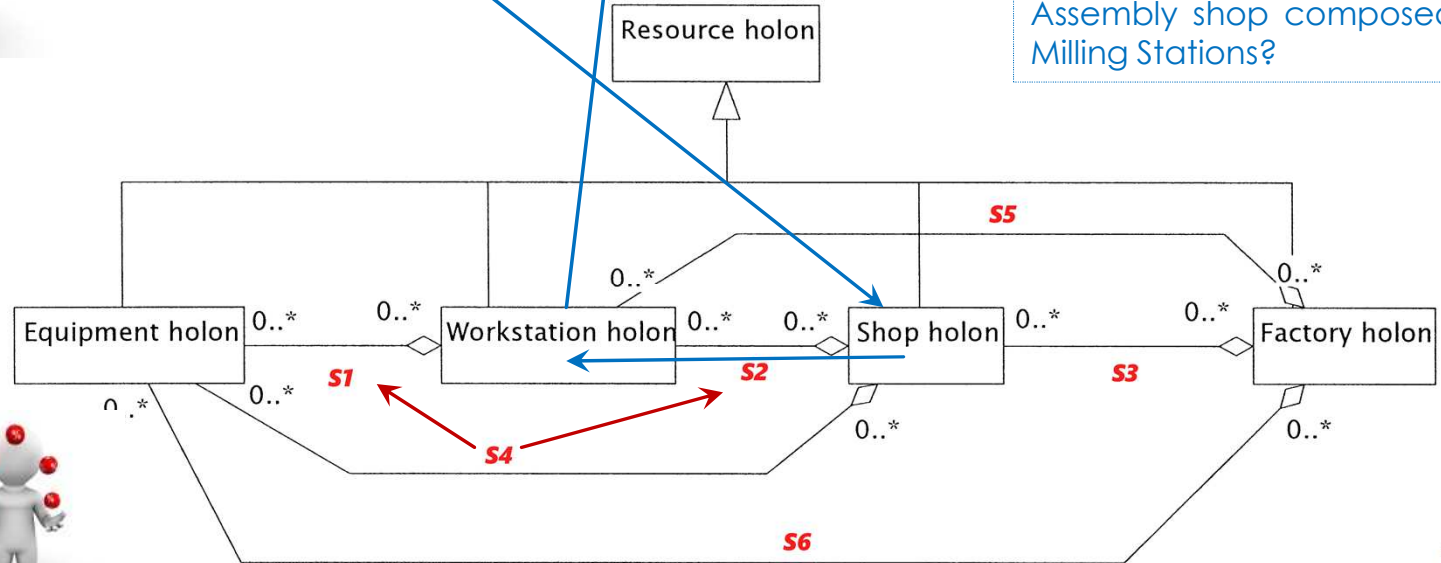
- Q1 Transitivity ?
 $S4 = S1 \circ S2$ or
 $S4 \cap (S1 \circ S2) = \emptyset$
- Q2 shareability ?
 $0..*$



Aggregation vs gen/spec

- Q3 homogeneity ?

Assembly shop composed of Milling Stations?



Free interpretations lead to software issues

- Lack of precision
- Lack of details
- Lack of semantics

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Modelling issues

1- Meaningless models

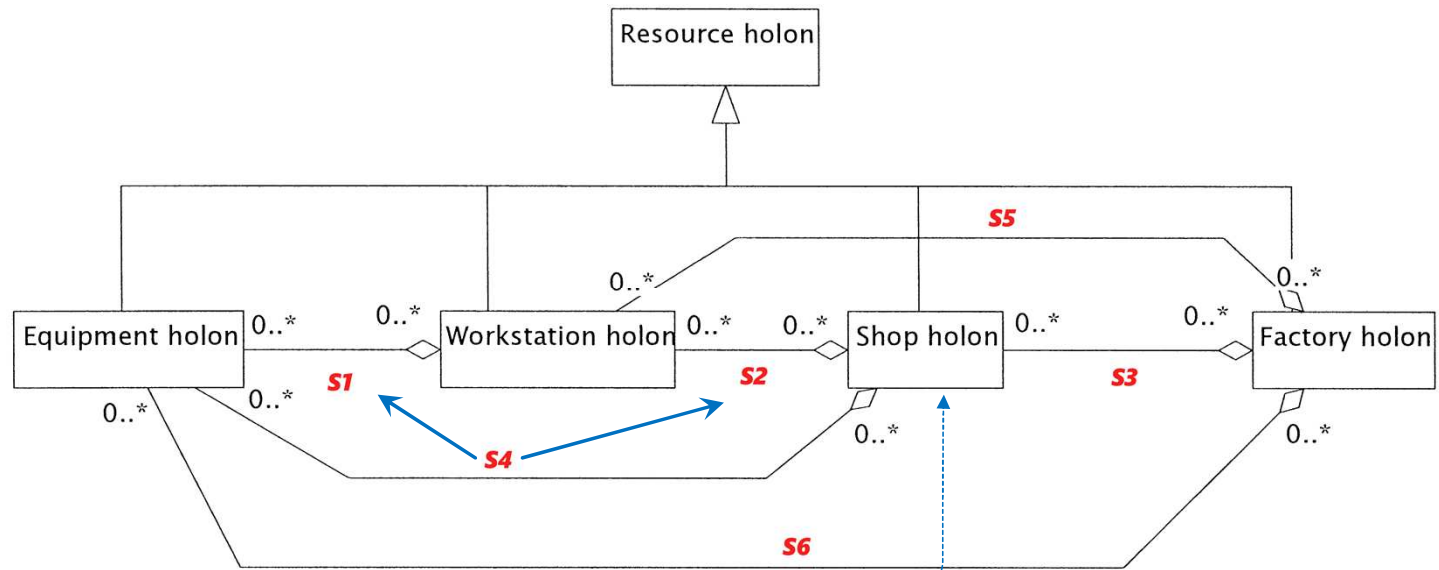
Formal assertions (OCL)

PROSA [Van Brussel 1998]

Aggregation

- Q1 Transitivity ?

~~$S4 = S1 \circ S2$~~ or
 $S4 \cap (S1 \circ S2) = \emptyset$



```

context Shop_holon
inv non_transitive: — A shop consists of ...
self.workstation_holon.equipment_holon -> excludesAll(self.equipment_holon)
    
```


Modelling issues

2- Type/Instance confusion

Shareability

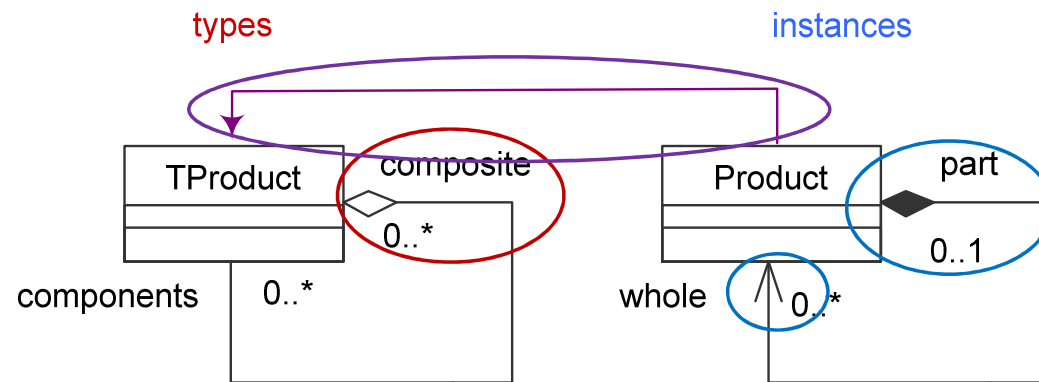
PROSA [Van Brussel 1998]

Aggregation

- Q2 shareability
- 0..*



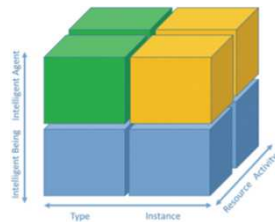
Instanciation – aggregation or metaclass



Types : YES – many 0..*

Instances : NO – one 0..1

Key axis in ARTI



More information ? Ask a question

Modelling issues

Instanciación - focus

Metaclass

- Class features

Attributes (shared by instances)
e.g. *number of doors*

Operations
e.g. *new*

- Instances features

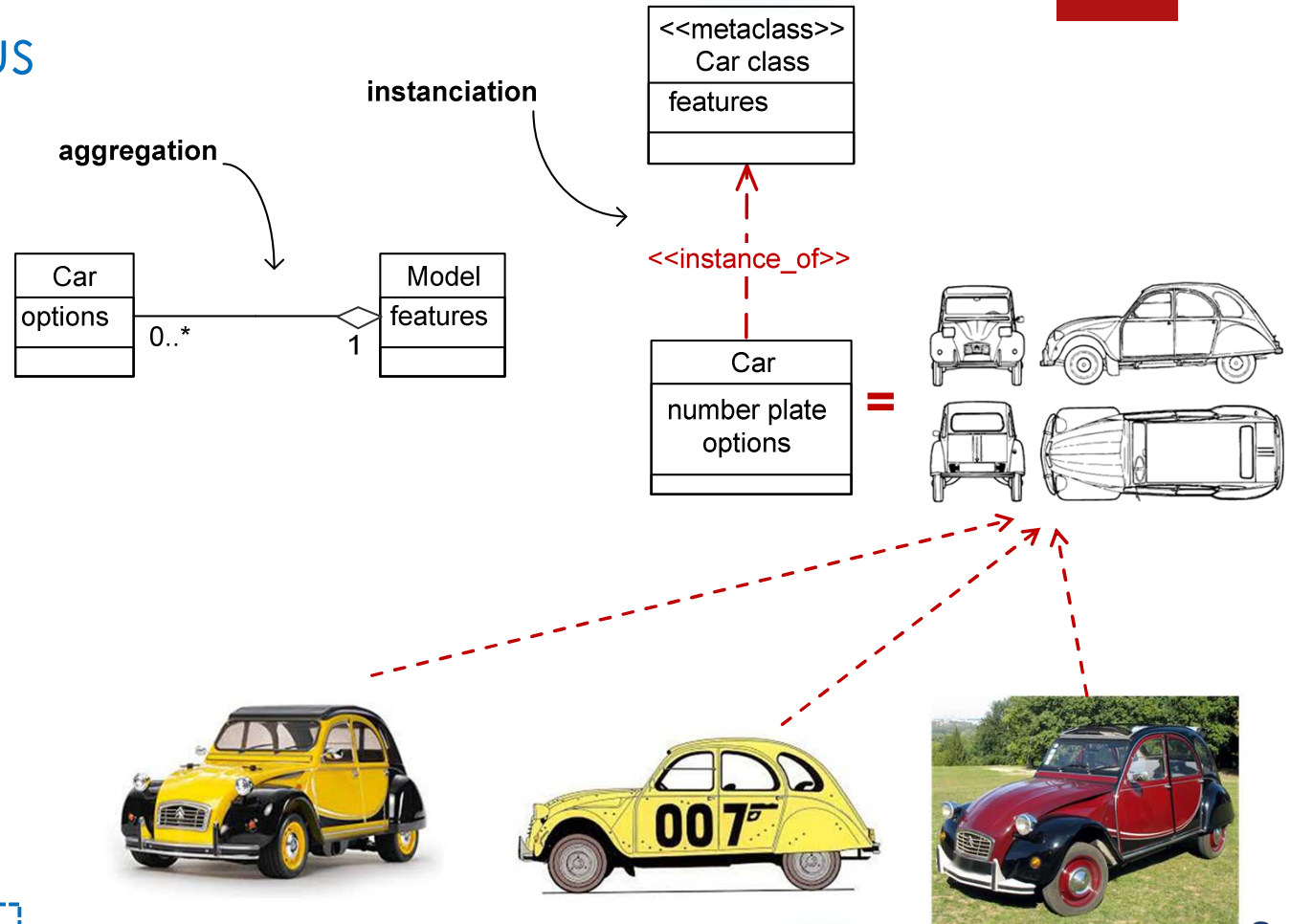
Attributes
eg *registration number*

Operations
eg *drive*

- A metaclass instance is a class
- A class instance is an object

Concise models

Instanciación vs aggregation



Modelling issues

3- Recursion failures

Avoid infinite loops

Aggregation properties

- Not reflexive
- Asymmetric
- Transitive

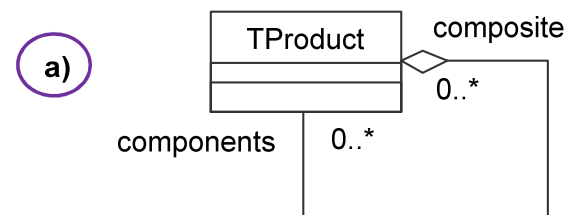
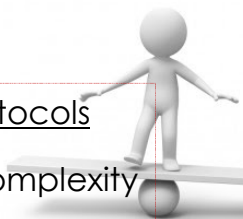


OCL invariants

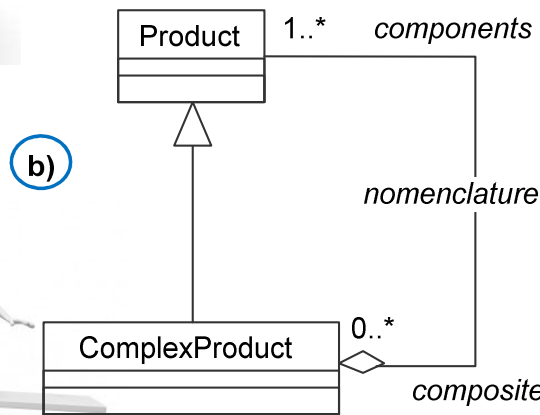
Protocols

Aggregation protocols

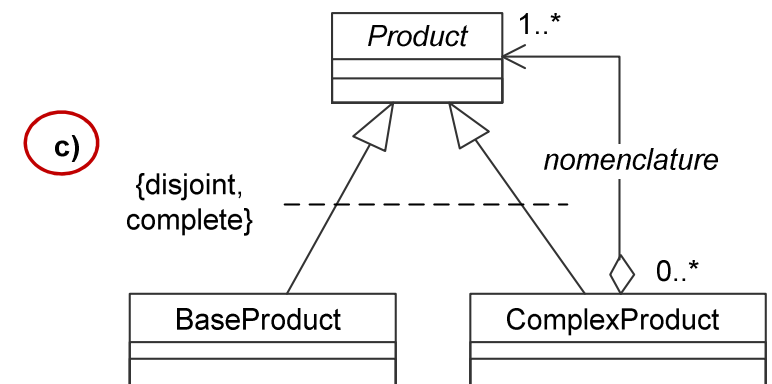
- Reduce complexity (testing)
- Modularity, Reusability
- Documentation



Concise but complex



Separate composite



Separate atomic- composite - abstract

Modelling issues

4- Specialisation errors

Inheritance side-effects

Aggregation inheritance

- Polymorphism
- Heterogeneity
- Exceptions

Precision

Restrictions

- Homogeneity
- Inheritance Schema

OCL invariants



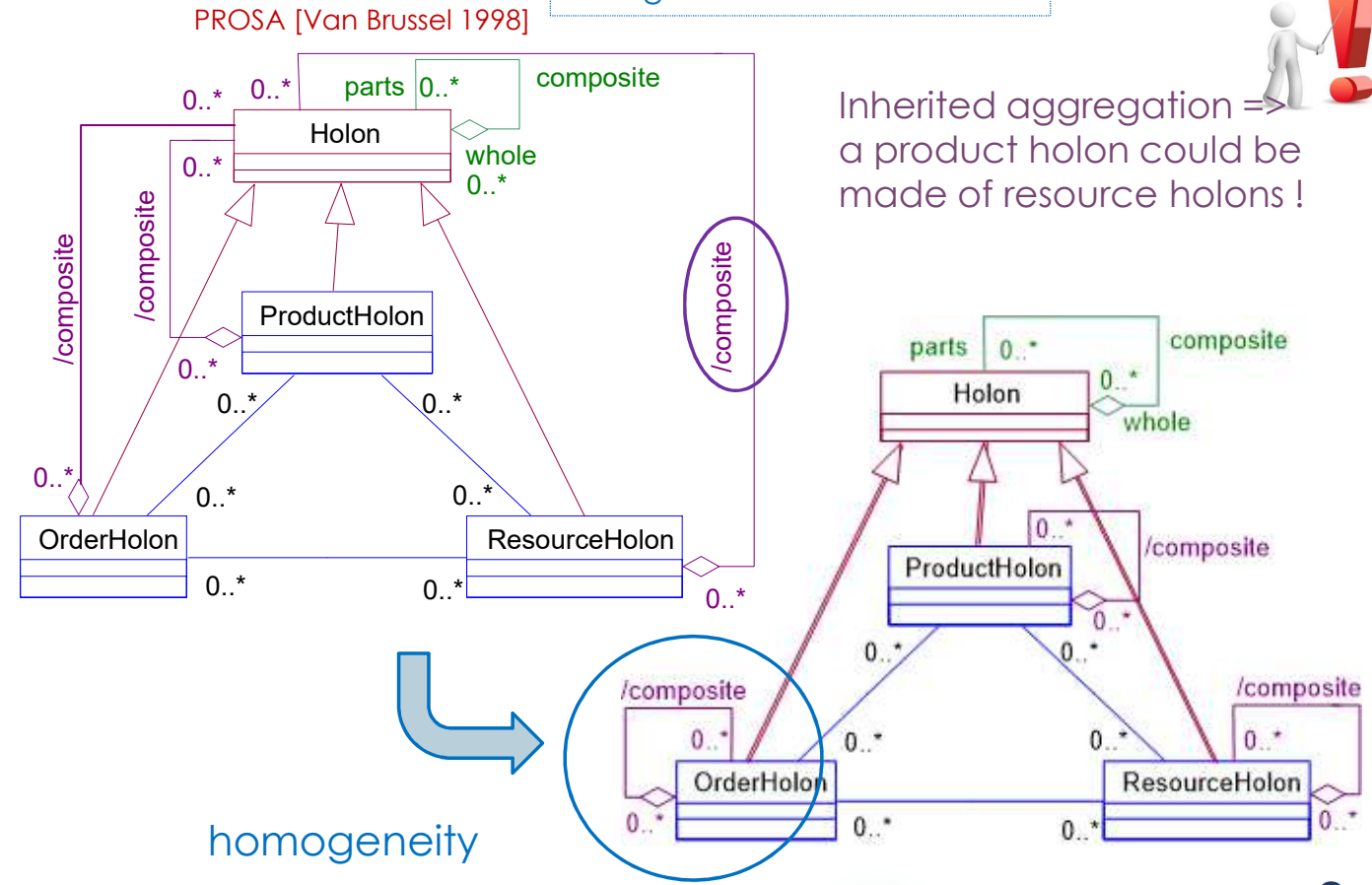
Aggregation vs gen/spec

- Q3 homogeneity ?

Assembly shop composed of Milling Stations?



Inherited aggregation => a product holon could be made of resource holons !



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HMS Aggregation patterns

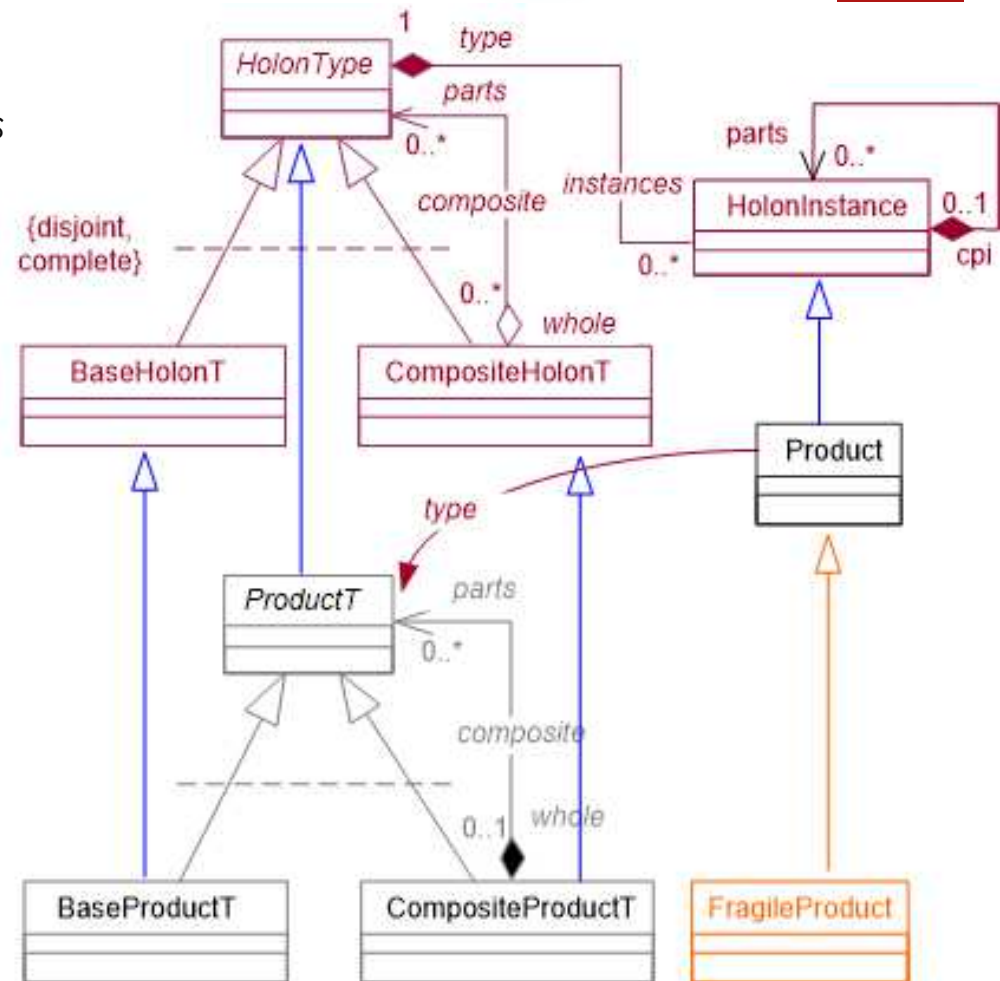
A non-trivial structure that implies several classes with aggregation and specialisation relations

Product Holons

- Product Holons
- Resource Holons
 - Equipment Pools
 - Organisational units
 - Transportation
- Order Holon Pattern

Non exhaustive list

+ Spécialisation

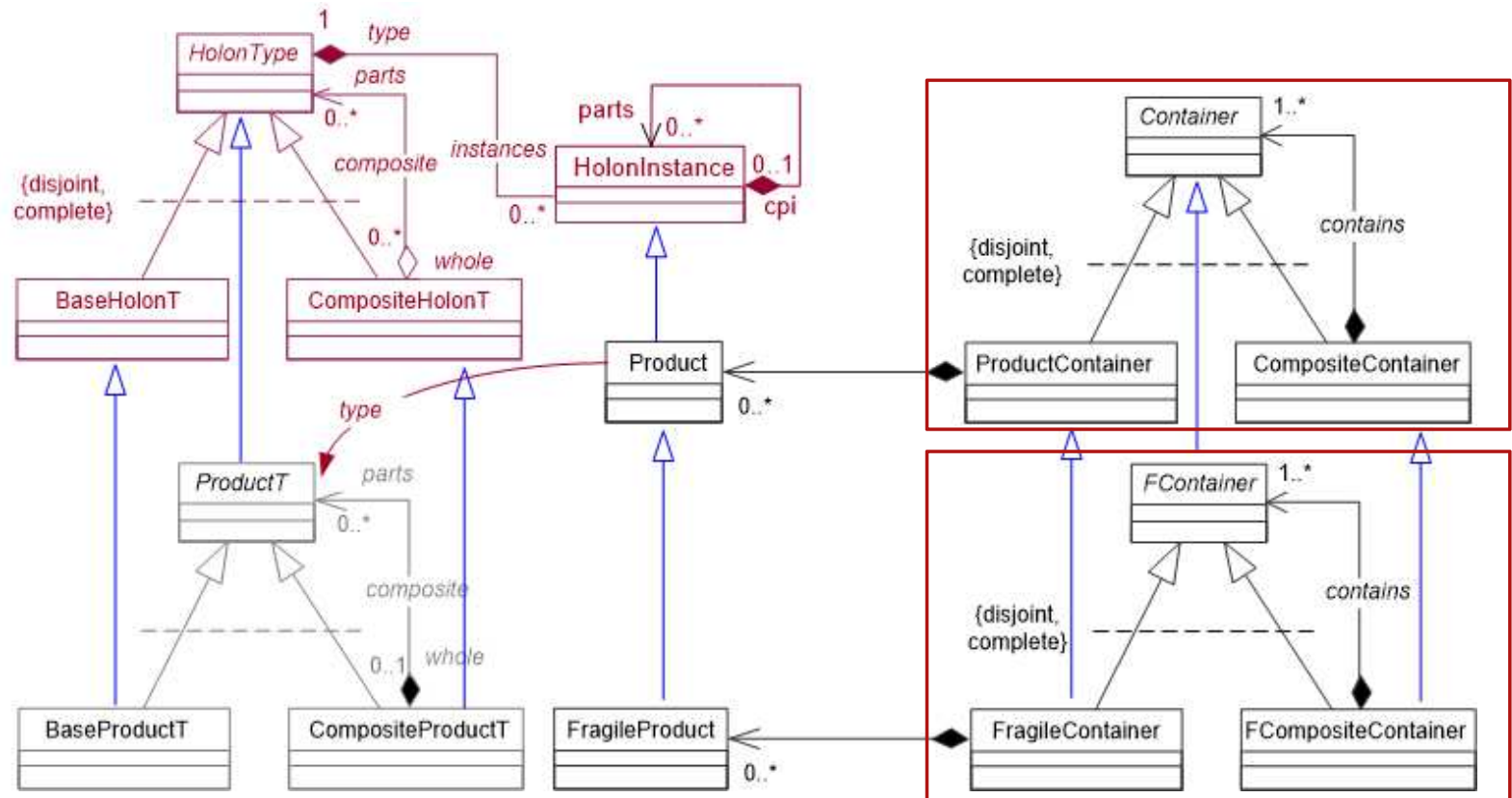


HMS Aggregation patterns

Pattern combination

- Product Holons
- Storage Holons

Schema specialisation (again)



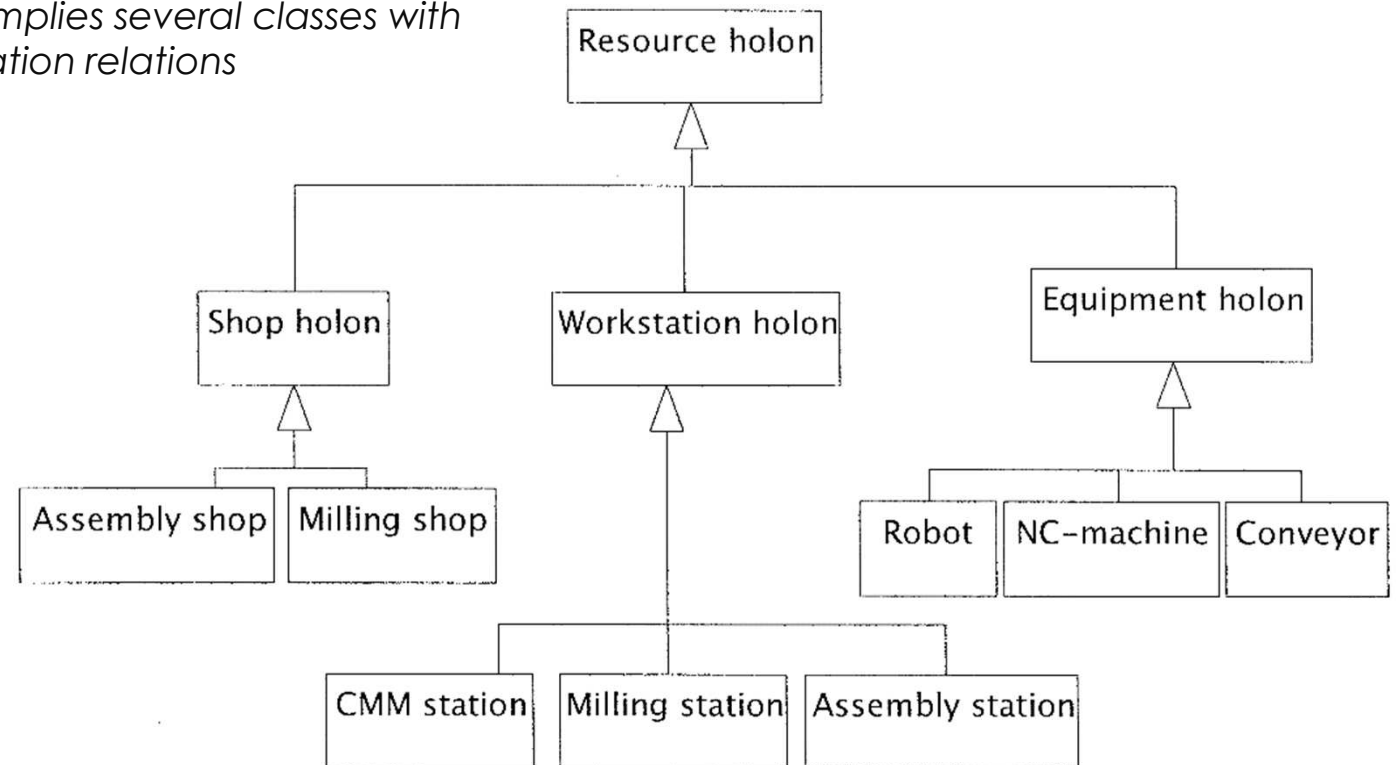
HMS Aggregation patterns

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A non-trivial structure that implies several classes with aggregation and specialisation relations

- Product Holons
- **Resource Holons**
 - Equipment Pools
 - Organisations
 - Transportation
- Order Holon Pattern

Non exhaustive list

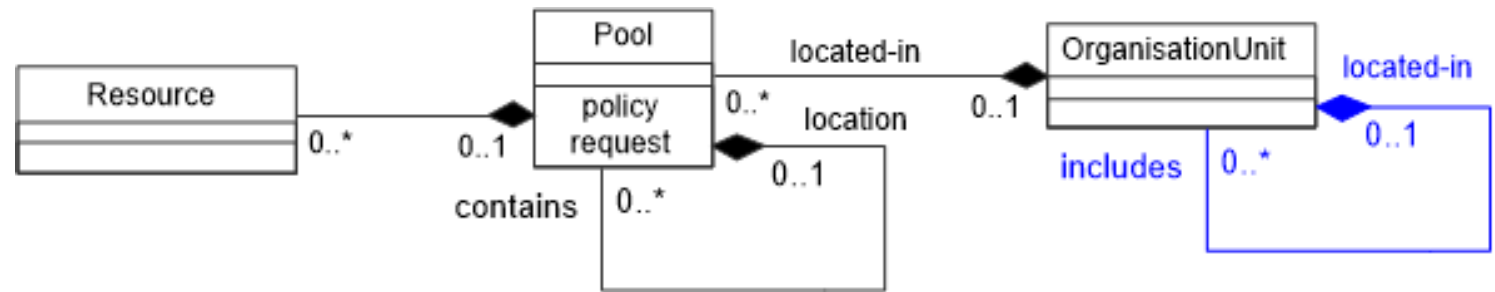


[Van Brussel 1998]

HMS Aggregation patterns

A non-trivial structure that implies several classes with aggregation and specialisation relations

- Product Holons
- Resource Holons
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 - Organisations
 - Transportation
- Order Holon Pattern



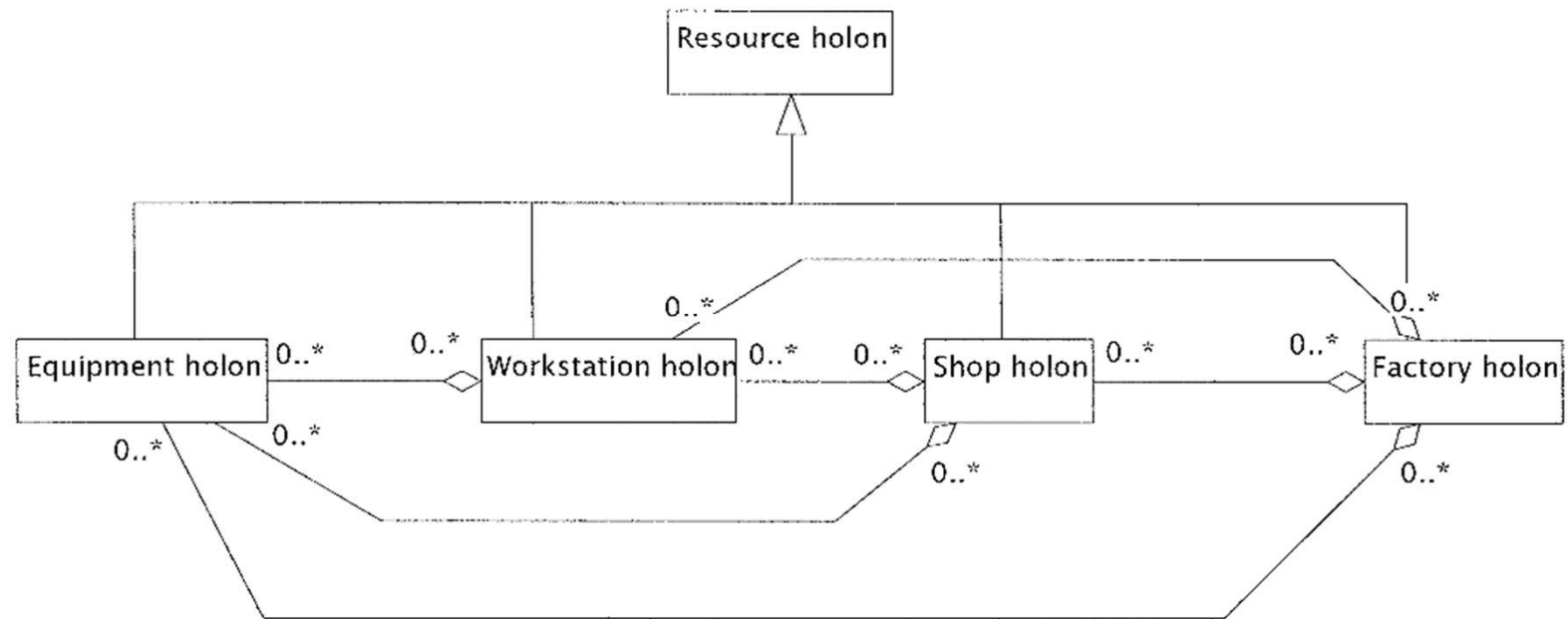
Non exhaustive list

HMS Aggregation patterns

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Non exhaustive list

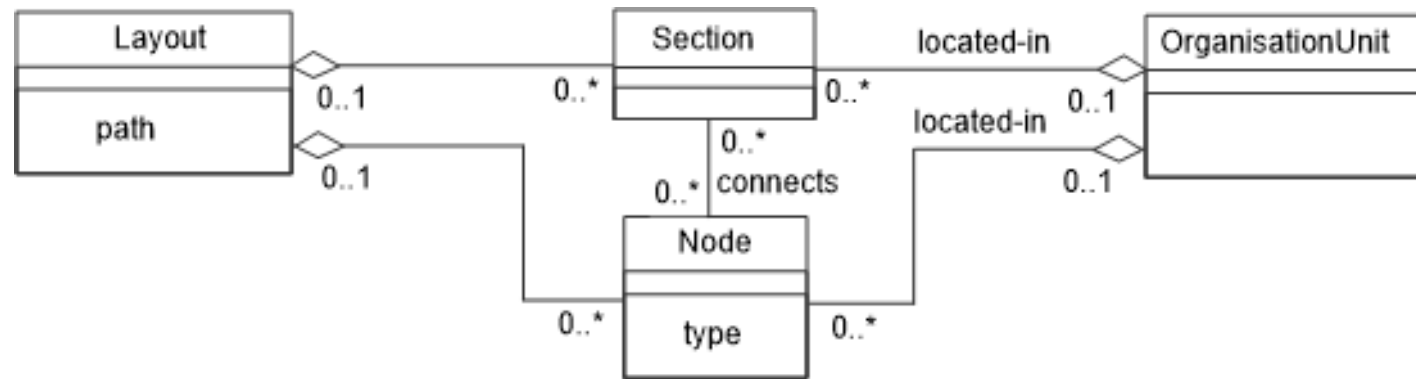


[Van Brussel 1998]

HMS Aggregation patterns

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- Product Holons
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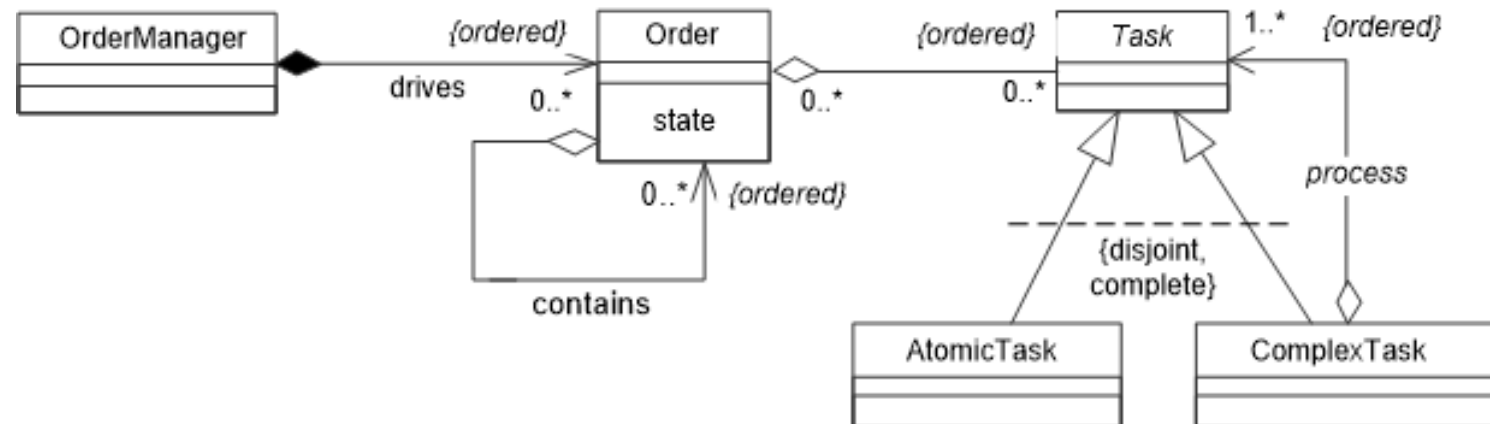
Non exhaustive list

HMS Aggregation patterns

A non-trivial structure that implies several classes with aggregation and specialisation relations

- Product Holons
- Resource Holons
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- **Order Holon Pattern**

Non exhaustive list



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Design concerns

Software design patterns

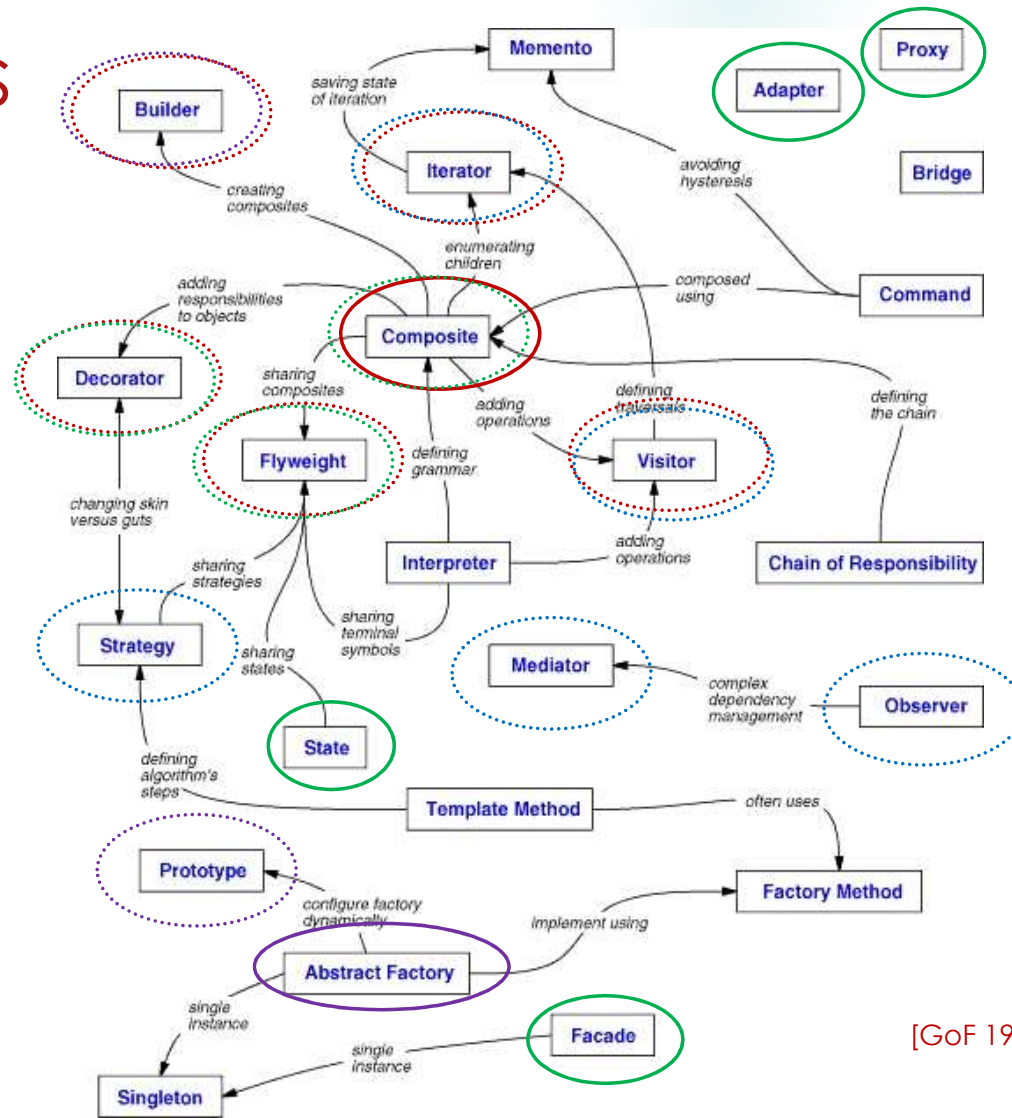
Composite

Others

- Creation
- Structure
- Behaviour



Just an architectural sketch



[GoF 1995]

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Conclusion and perspectives

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Aggregation is a key concept in HMS

- Many modelling issues may reduce the model quality
- We identified basic patterns for HMS.
- We tracked design concerns.

Next requirements

1. Common HMS reference model
2. Customisable HMS framework
3. Instantiation to different contexts and case studies

Ambitious open
project



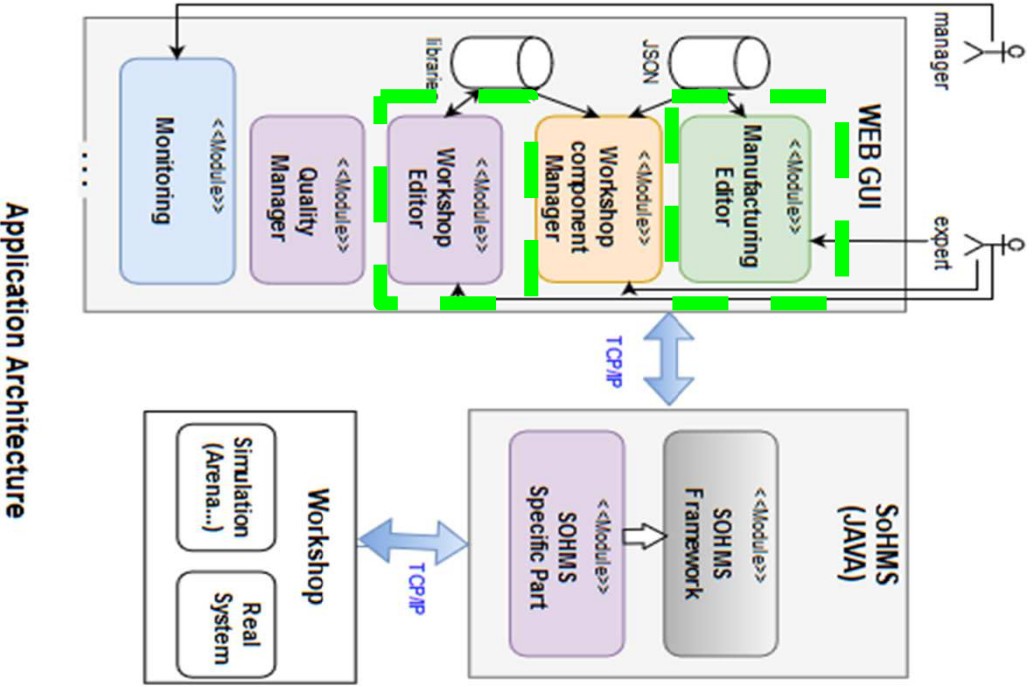


Aggregation Patterns in Holonic Manufacturing Systems

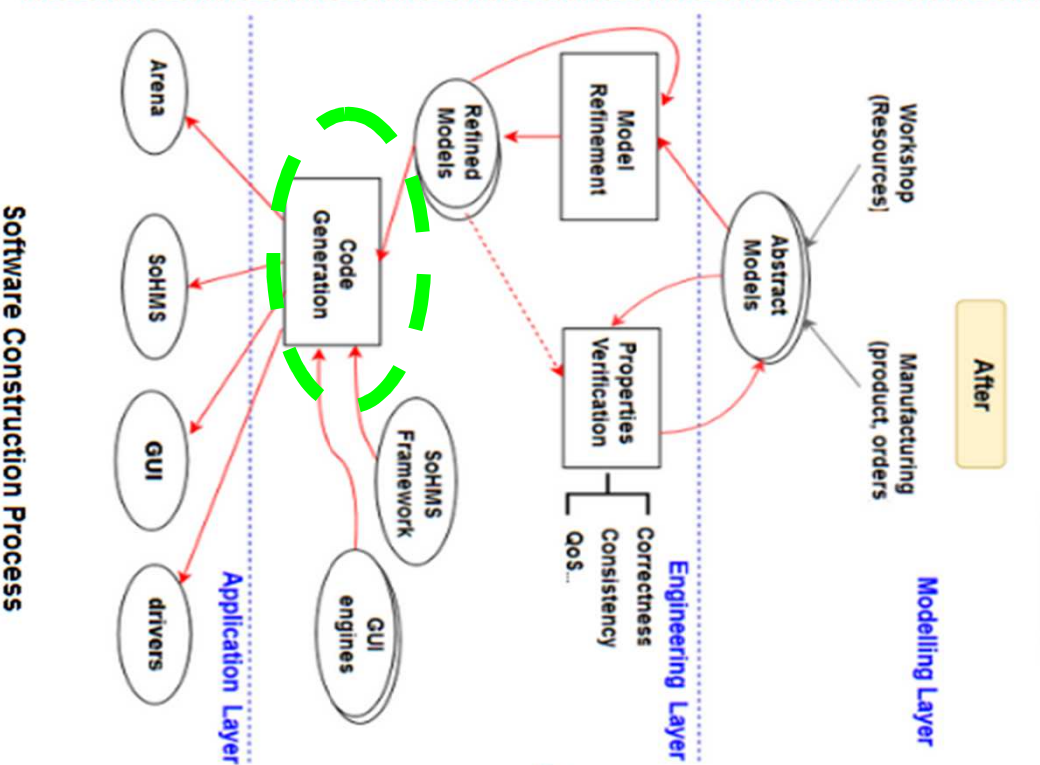
any questions?



HMS Software factory



Application Architecture



Software Construction Process

SOHOMA'18



Introduction

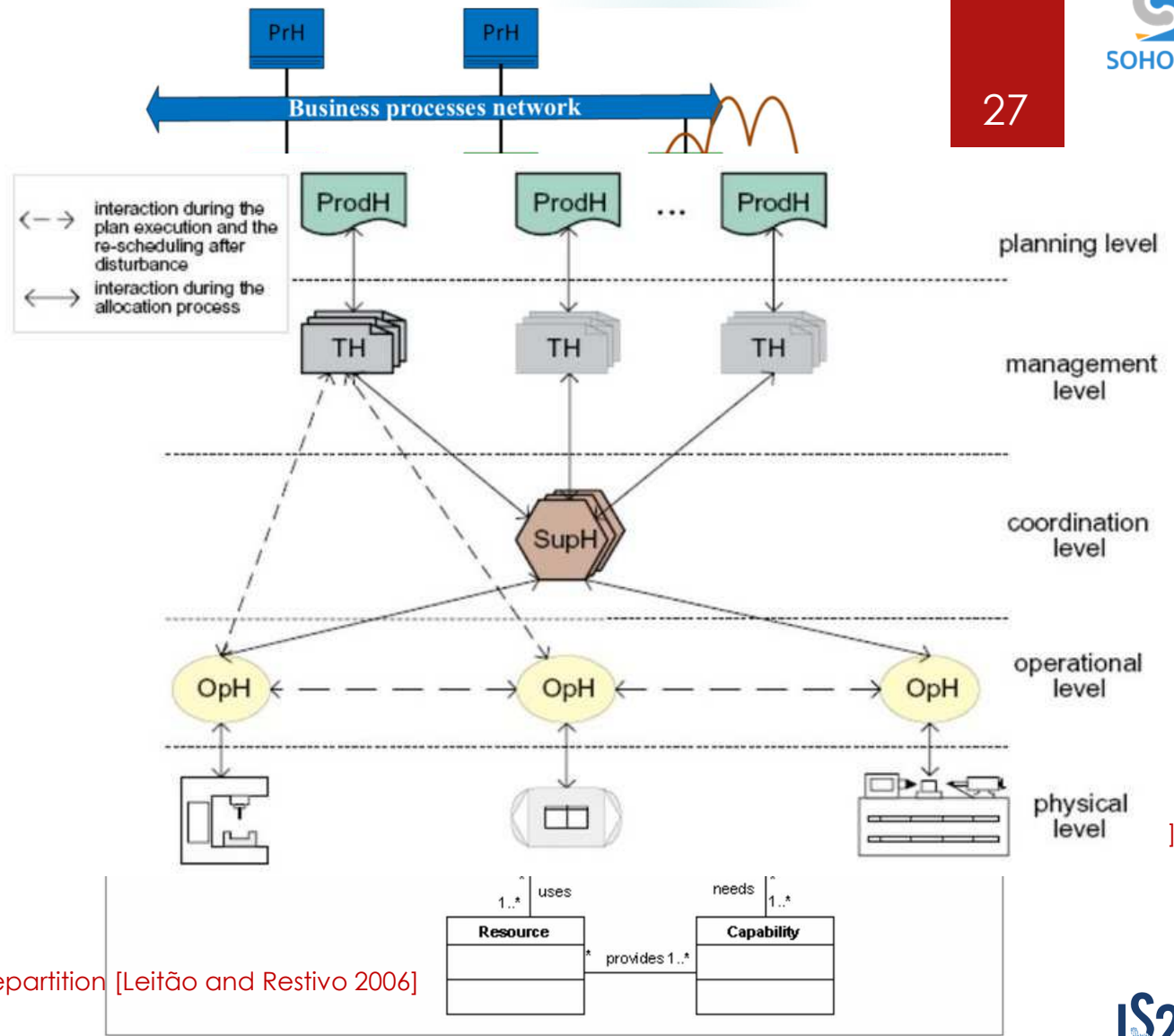
Problems

1. Behind the shared idea of grouping holons, the models vary from one interpretation/model to another

[Blanc et al. 2008]

- Non comparable
- Non reusable to other case studies and other manufacturing systems

ADACOR holons repartition [Leitão and Restivo 2006]



[da Silva et al. 2014]