CONFERE
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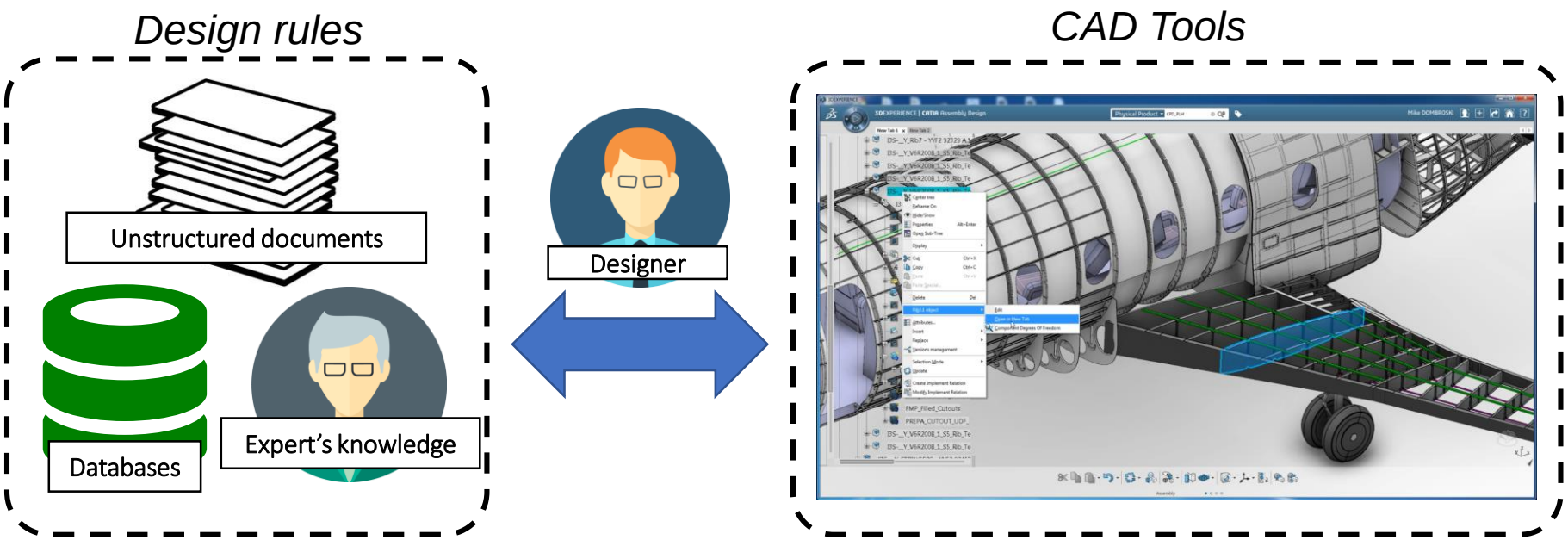
Simon DEBORD, Frédéric SEGONDS, Romain PINQUIE, Philippe VERON, Nicolas CROUE

Proposition of a Design Rules Framework

Summary



- Design rules are stored in **many different sources** (design handbooks, data bases, expert's head)
- **Many types** (sentences, formulas, tables…)
- **Many origins** (manufacturing, assembly, maintenance, safety, cost…)

Difficult for designers to find the right rule at the right time

State of the art: *design rules*

ARTS ET MÉTIERS ParisTech

Various sources

- Design handbooks
- Companies design manuals
- Databases
- Design expert's head

[Budynas et al. 2011], [J. Carvill 1994]

Different origins

- DfX : manufacturing, assembly, maintenance, costs, …
- Functional requirements

[Bralla 1996], [Tsai-C.Kuo 2001], [Huang 1996]

Design Rules

Different types

- Text (heuristics)
- Tables (Empirical)
- Standards or laws
- Equations, inequations (Laws of physics)
- Sketches
- …

[D.E. Calkins 2000],[Mani et al. 2017]

State of the art: *design rules*

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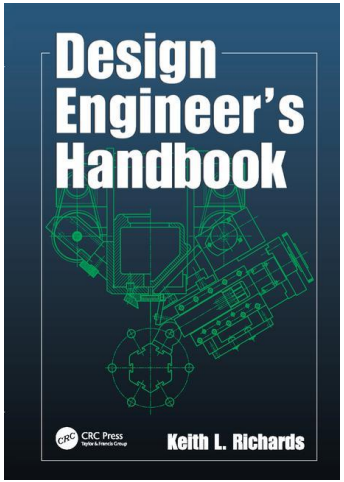

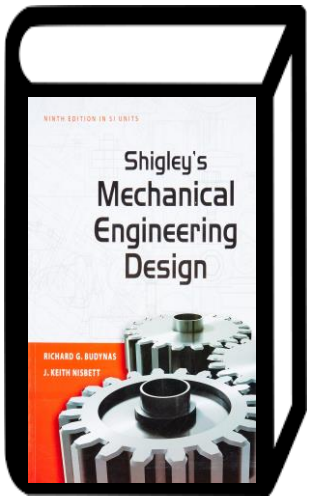

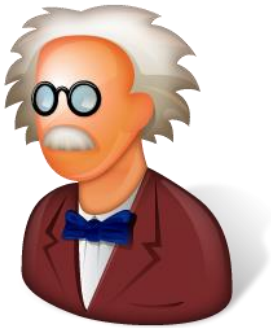

TECHNIQUES DE L'INGÉNIEUR

State of the art: *design rules*

Different origins

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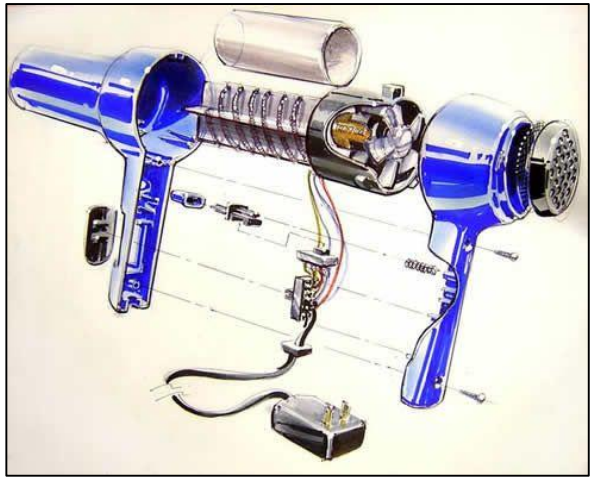
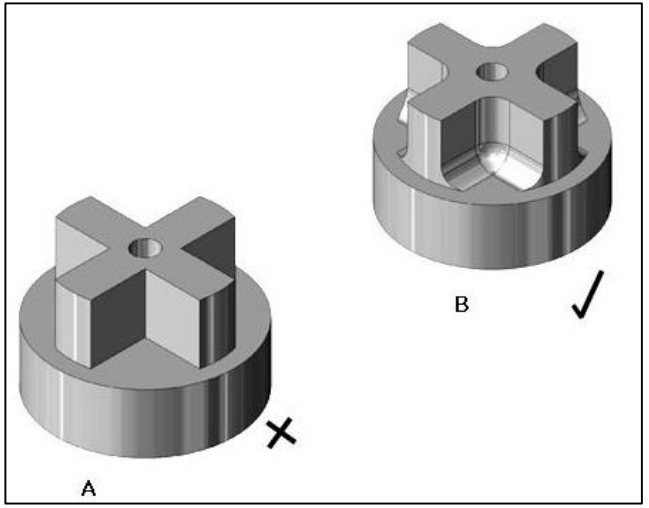


State of the art: *design rules*

"The junction must be designed to minimize weight."

$$f_x = \frac{qL^4}{24EI}\left(\frac{6x^2}{L^2} - \frac{4x^3}{L^3} + \frac{x^4}{L^4}\right)$$



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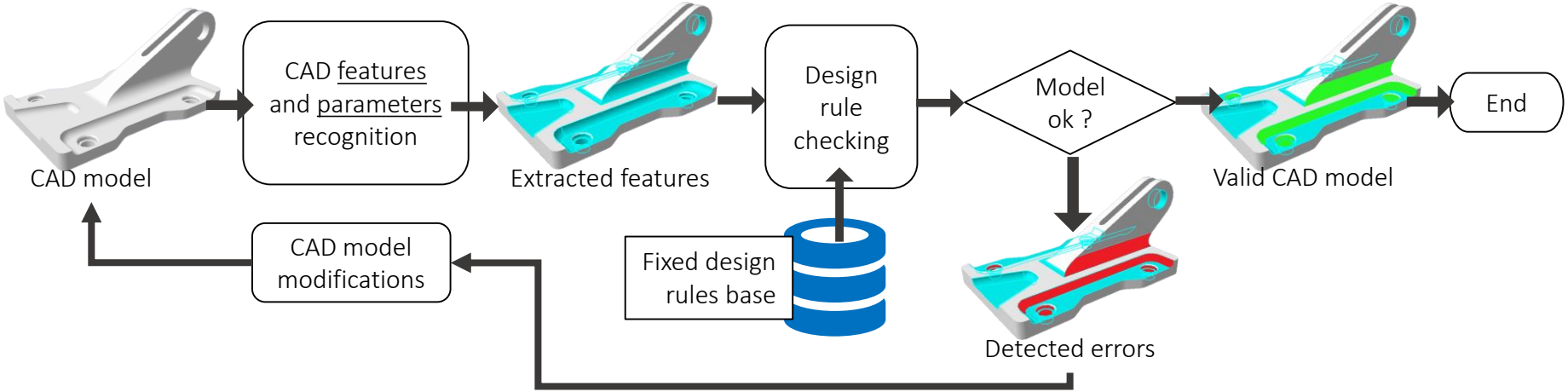
State of the art: *checking design rules*



[Radhakrishnan et al. 1996], [Huang et al. 2015], [Hariya et al. 2010], [Rangarajan et al. 2013], [Bojan et al. 2008]

Fixed design rules database
Verification of geometric and topological rules **only**
Verification of a whole set of design rules ***a posteriori***

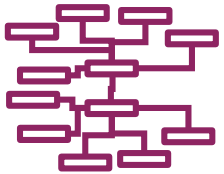
→ *No rules addition or maintenance*
→ *No relevant design rules **recommendation** while designing*
→ *No **automation** of design routines*
→ *No **user learning** of design rules*

State of the art: *engineering ontologies*

Ontologie : definition

An ontology is a formal representation of the knowledge (concepts and relationships) of a given domain of interest. Composed of classes, properties and individuals.

In engineering, ontologies are mainly used for:



1. Knowledge representation, search and retrieval (e.g. product modeling)
2. Semantic interoperability (e.g. between software)

3. Intelligent product configuration

Ontologies are increasingly used in the engineering domain, except for design context reasoning and suggestion of design rules suggestion.

[Liu and Jim 2011], [Bock et al. 2010], [Catalano et al., 2009], [Li and Yoo, 2011], [Dartigues et al. 2007], [Pinquié, 2016], [Yang et al. 2008]

Design Rules Framework

A user-centered description

Knowledge Engineer

Design rules →
Modifications →

← Design rules & informations

Design rules framework

Capture, retrieve, maintain, suggest & verify design rules

← New design context definition
← CAD design actions

→ Design rules set suggestion
→ Design rules & informations

Design engineer

Knowledge engineer
Design rules capture: rule authoring and assignation of known concepts
Design rules retrieval: query with keyword (i.e. concepts)
Design rules maintenance: variant creation, modification/suppression of design rules

Design engineer
Design rules suggestion: suggestion of design rules set adjusted to user design context
Design rules verification: • dynamic design rules suggestion while designing • **(**Design rules verification**)**

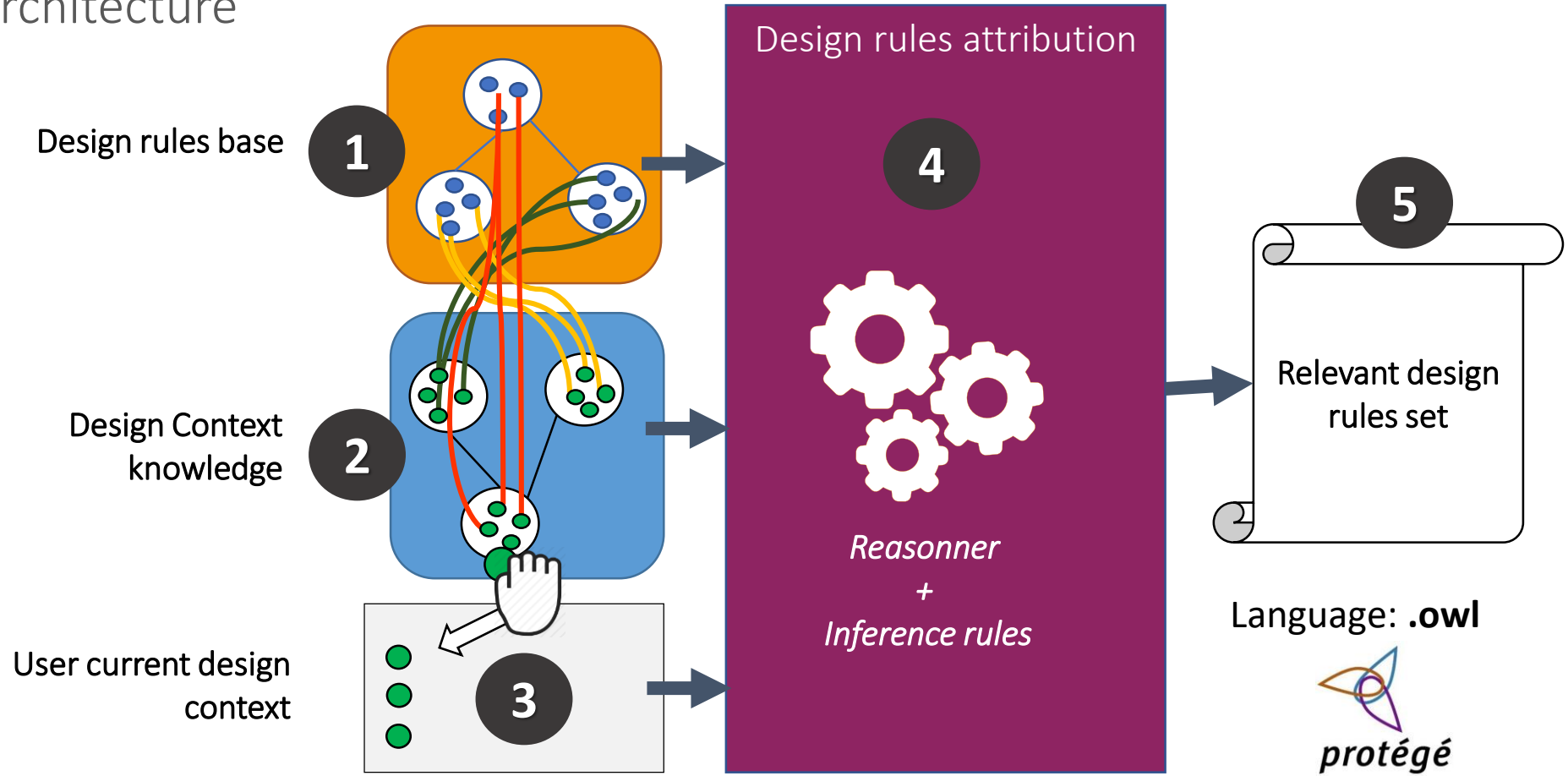
A taxonomy of design rules

Attributes:

- **The DfX origin:** the life cycle phase from which the design rule is required;
- **Topics:** designer's domain of expertise ;
- **The application domain:** tool-based modelling activity or engineering activity
- **Objective:** function to fulfill;
- **Authority:** degree of applicability of a design rule;
- **Granularity**: to distinguish design rules that constrain the design of parts from the ones that constrain the design of assemblies;

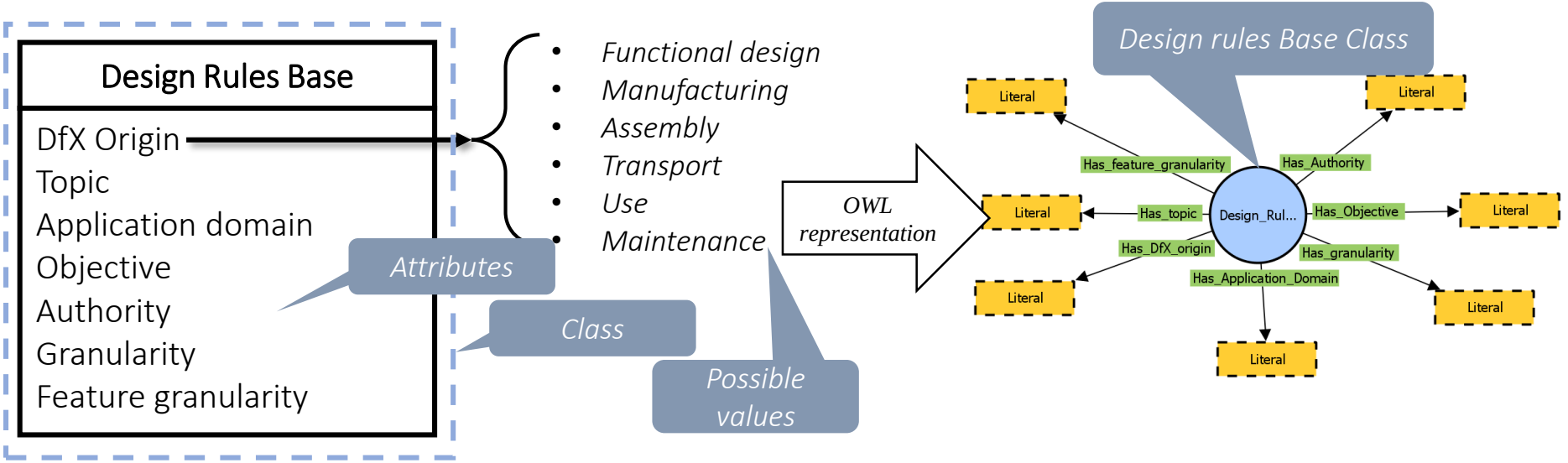
Design Rules Framework

Architecture



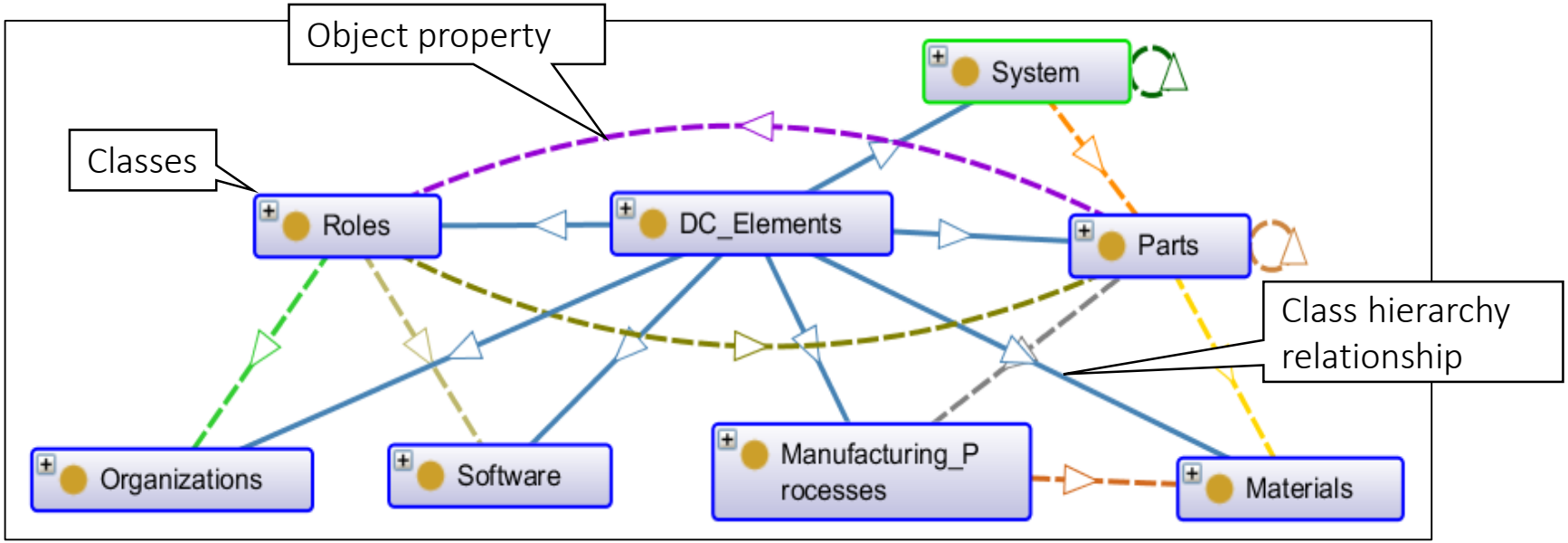
Design Rules Framework

Design rule base



Design Rules Framework

Design context representation



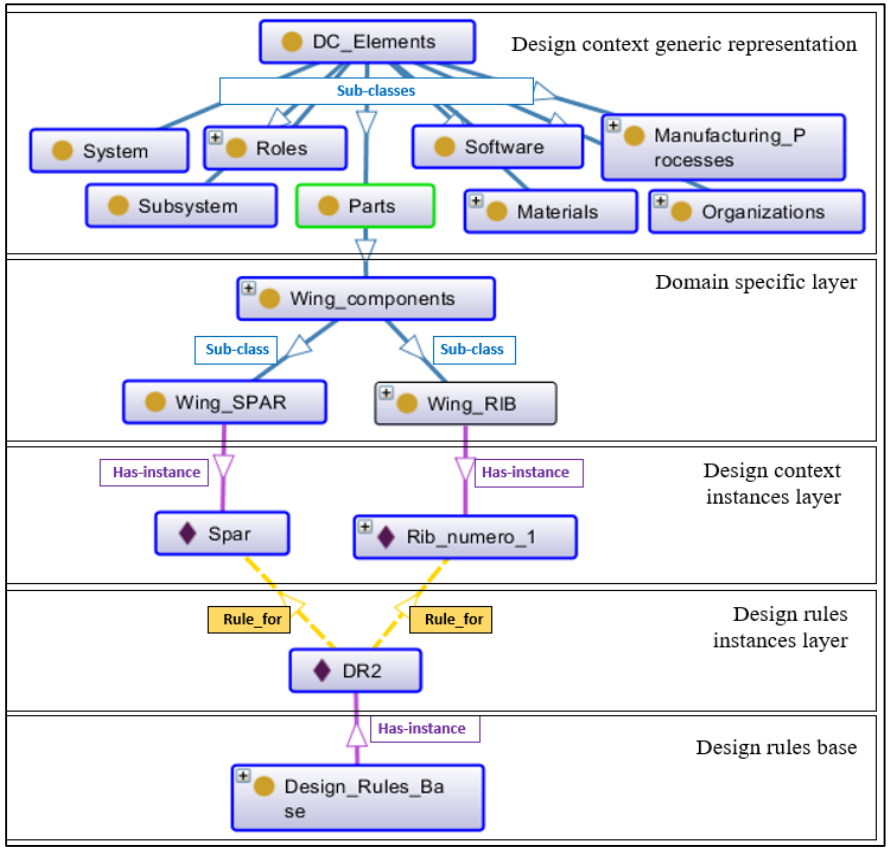
Meta-ontology ⇔ skeleton for any design context representation

Design Rules Framework

Design rules base – design context relationship

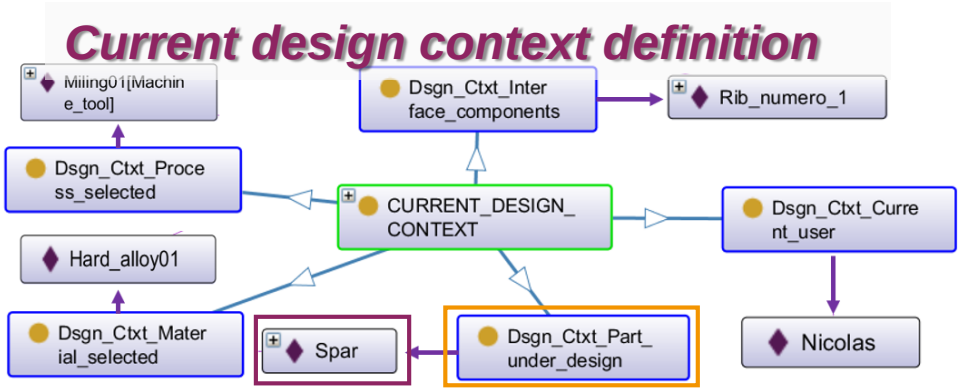
Design context Kowledge

Design Rules Base



Design Rules Framework

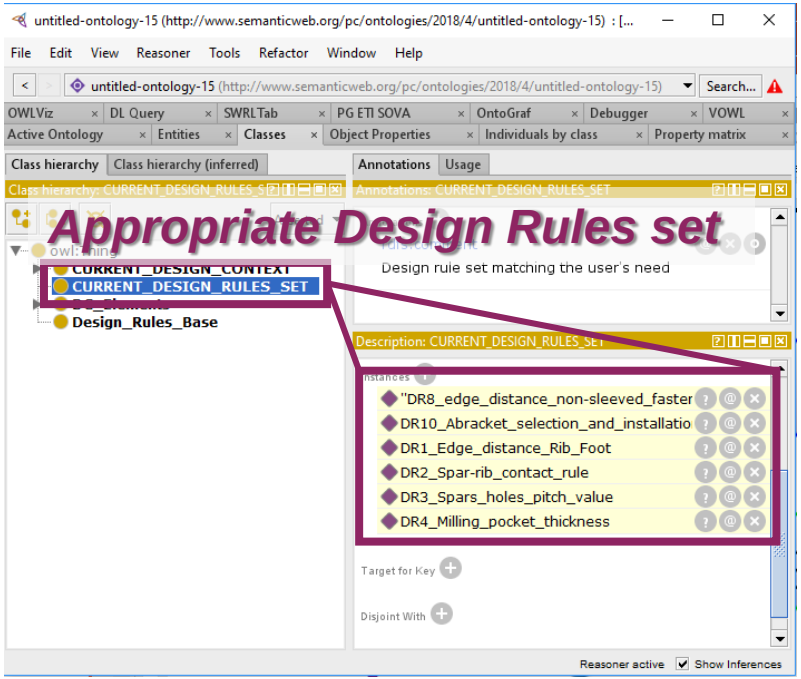
Appropriate design rules set generation



SWRL rules

```
CURRENT_DESIGN_CONTEXT(?z)∧ Rule_for(?r,?z)∧
Design_Rules_Base(?r)→ CURRENT_DESIGN_RULES_SET(?r)
```

Reasoner: **PELLET**



Conclusion

- Proposition of a Design Rules Framework that aims to ease capture, retrieval and suggestion of design rules.
- Modelisation of a design context knowledge thanks to .owl ontology language
- Propostion of design rules attributes to facilitate retrieval.

FUTURE WORK

- Assessment of the solution on a large set of design rules
- Formalization of design rules to verify CAD models automatically

Merci de votre attention.

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