



# Interactive Configuration and Constraints

Knowledge, Filtering algorithms and Extensions

**Élise Vareilles**

[elise.vareilles@mines-albi.fr](mailto:elise.vareilles@mines-albi.fr)

Mines Albi

24<sup>th</sup> of November 2015





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### Definition : Interactive Configuration

{Components} + Dialogue with the user  $\rightsquigarrow$  solution(s) [Mittal et

Frayman1989],[Tiihonen1996], [Sabin1998], [Veron2001]

#### Composants

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## Definition : Interactive Configuration

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### Products

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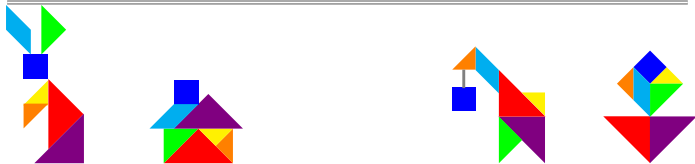


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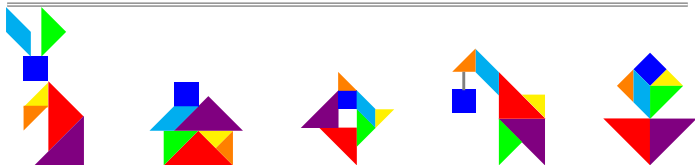


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### Products



Combinatorial Problem<sup>1</sup>

<sup>1</sup>7 pieces  $\Rightarrow$  6000 combinations

### Conception and Configuration

Extreme case of the routine design.... [Brown1989],[Sabin1998], [Stumptner1997]



Needs  
⇒ Creative

## Conception and Configuration

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Needs  
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+ Field  
⇒ Innovative



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Needs  
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+ Process  
⇒ Routine

## Conception and Configuration

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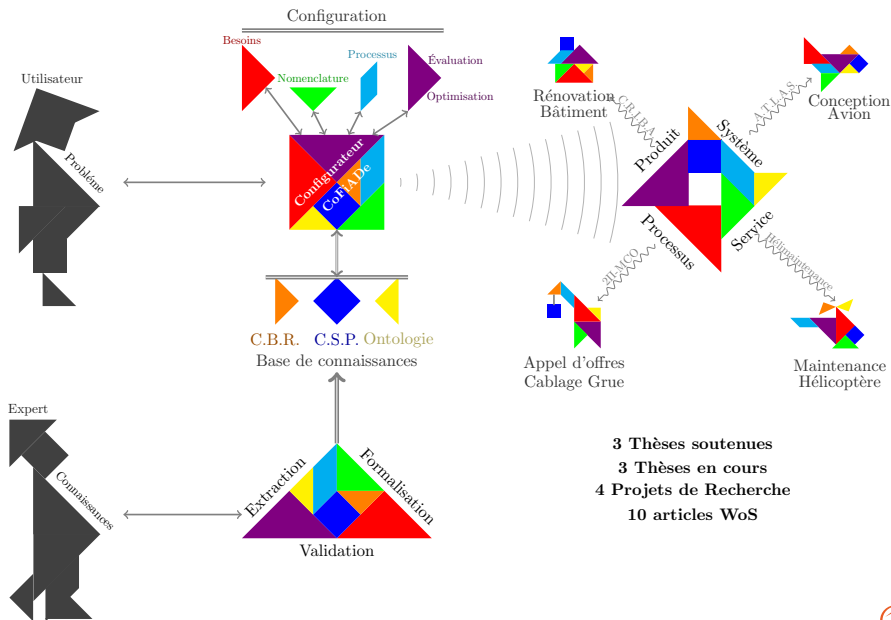


+ Process  
⇒ Routine



+ Exhaustiveness  
⇒ Configuration

# My Research Works

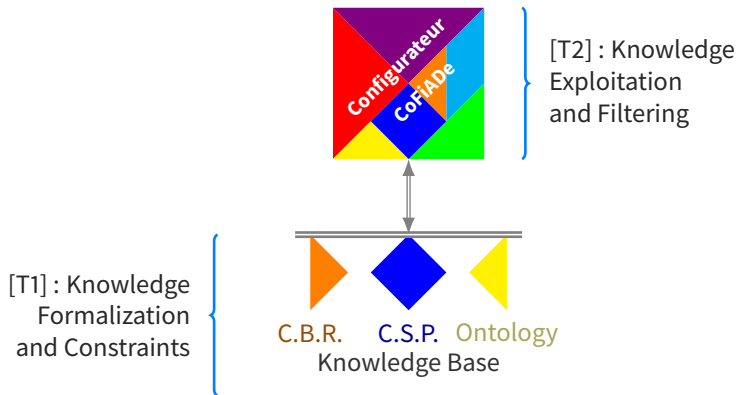


# Topics and Agenda

[T1] : Knowledge  
Formalization  
and Constraints

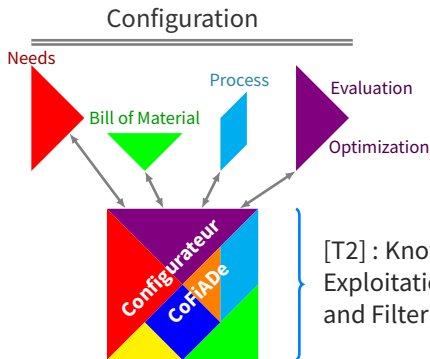


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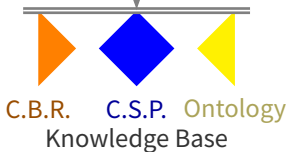


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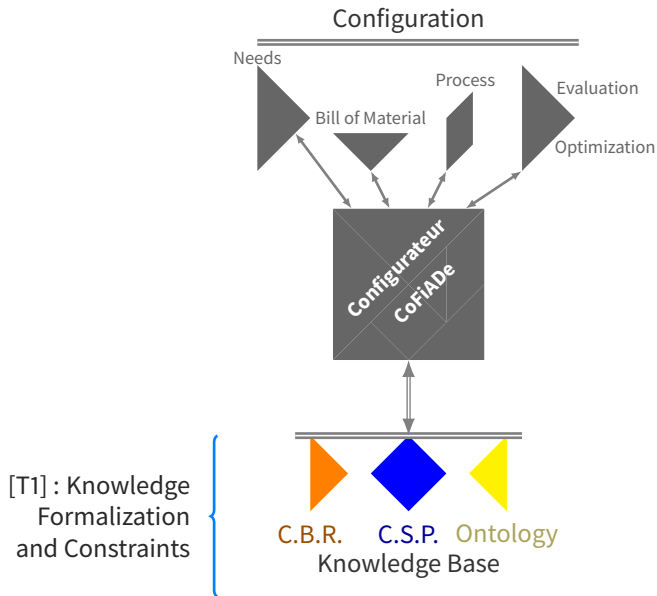
T[3] : Extensions  
of configuration



[T1] : Knowledge  
Formalization  
and Constraints



# [T1] - Knowledge and Constraints



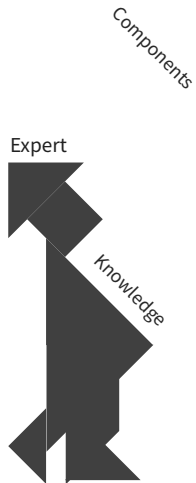


### Configuration and Generic Model

Capitalized Knowledge.... [Sabin1996], [Sabin1998], [Felfernig2015]

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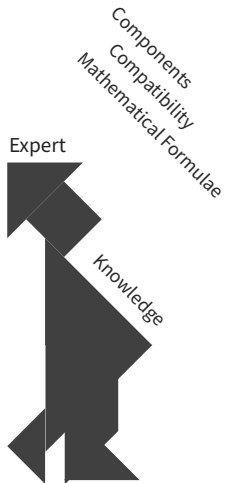
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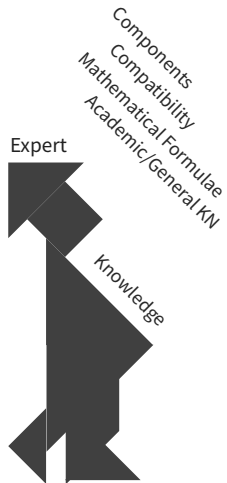
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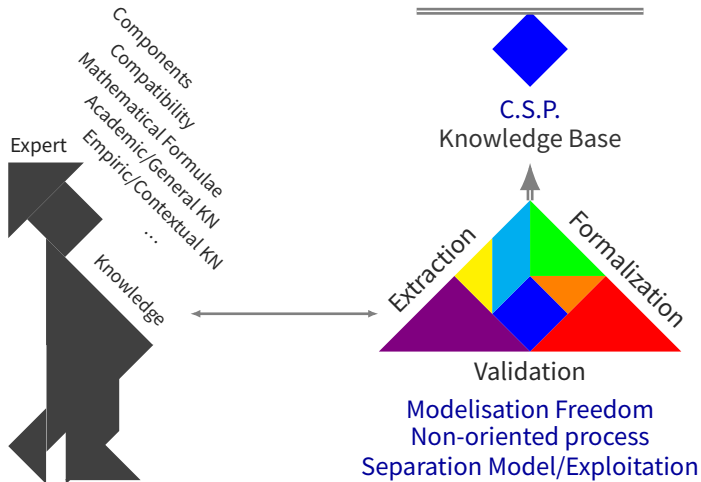
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# [T1] - Knowledge and Constraints

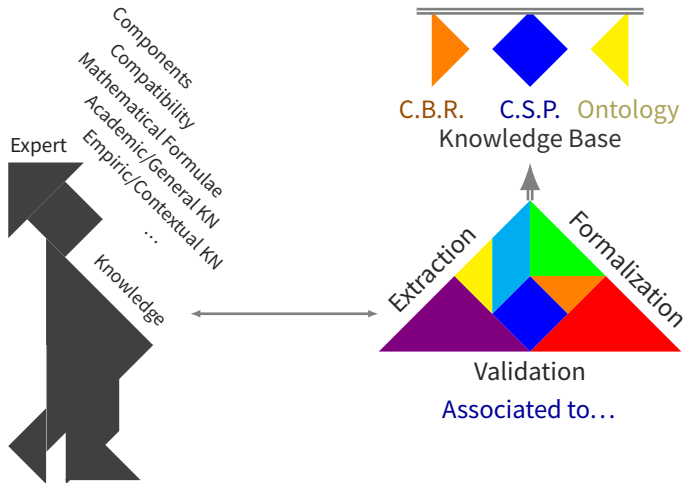
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Capitalized Knowledge.... [Sabin1996], [Sabin1998], [Felfernig2015]



## Configuration and Generic Model

Capitalized Knowledge.... [Sabin1996], [Sabin1998], [Felfernig2015]





### Definition : Constraint Satisfaction Problem

Triplet  $(\mathbb{V}, \mathbb{D}, \mathbb{C})$  [Montanari1974]

### Solution

$$\forall_{i=1}^k v_i \in \mathbb{V}, |D_{v_i}| = 1 \wedge \exists_{j=1}^m c_j \in \mathbb{C}, c_j = \perp$$

### Configuration and Constraints

Association of several types of CSP



C.S.P.  
Knowledge Base

### Configuration and Constraints

Association of several types of CSP



## Configuration and Constraints

Association of several types of CSP



Th. Vareilles



Th. Djefel

IJPR 2013



Th. Codet



Th. Barco

CP 2015



Collaboration Pays Bas

Collaboration Danemark

## Constraints and Empirical Knowledge

Abacus Formalization



C.S.P.  
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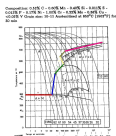


## Constraints and Empirical Knowledge

### Abacus Formalization



C.S.P.  
Knowledge Base



Continuous Cooling Flow Diagram



Th. Vareilles

JIM 2008, EAAI 2009

## Contraintes and Ontology

Knowledge Structure



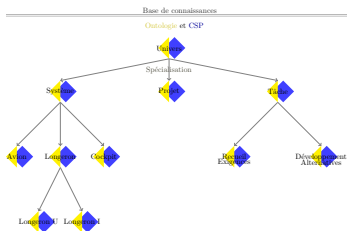


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### Knowledge Structure



C.S.P. Ontology  
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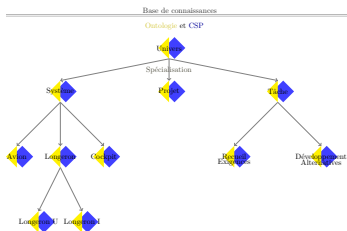


## Contraintes and Ontology

### Knowledge Structure



C.S.P. Ontology  
Knowledge Base



A.T.L.A.S.



Conception  
Avion

Th. Abeille

AIEDAM 2014

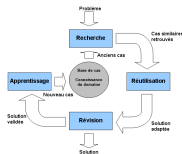
### Constraints and Contextual Knowledge

Use of relevant knowledge in a specific and changing context.



## Constraints and Contextual Knowledge

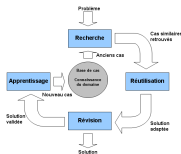
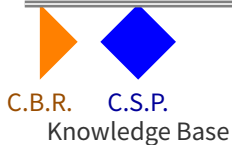
Use of relevant knowledge in a specific and changing context.



$cc(LV_R, sim_g^{cc}, ms, LV_C, LV_p, FP)$

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Hélimaintenance

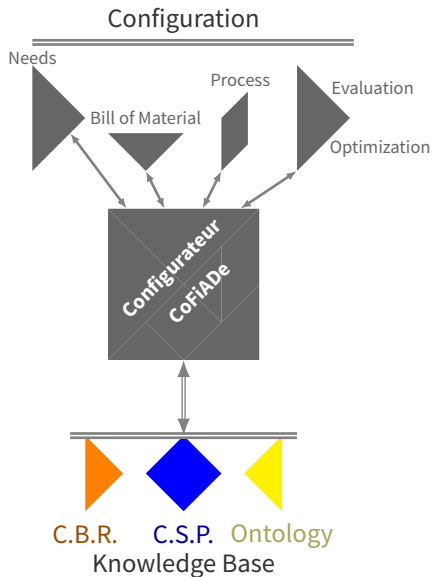


Maintenance  
Hélicoptère

Th. Codet

EAAI 2012

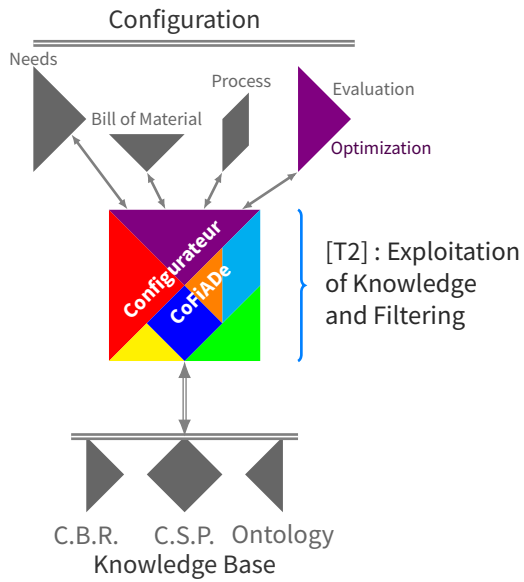
# [T1] - Knowledge and Constraints: Synthesis



- ⊗ CSP
- Empirical KN
- Contextual KN
- Ontology

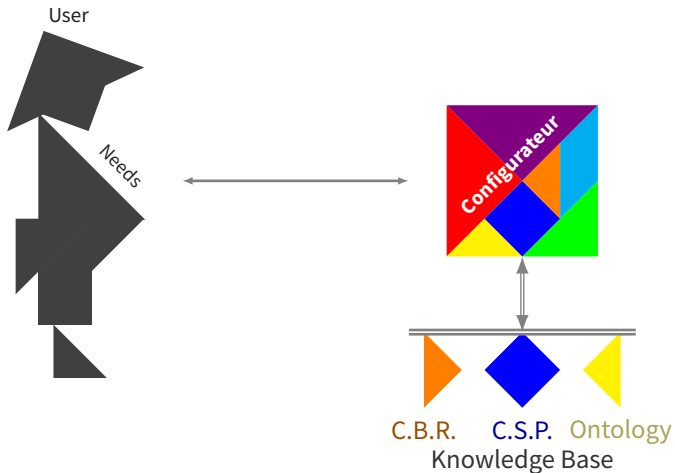


# [T2] – Exploitation and Filtering



### Design and Development of Filtering Algorithms

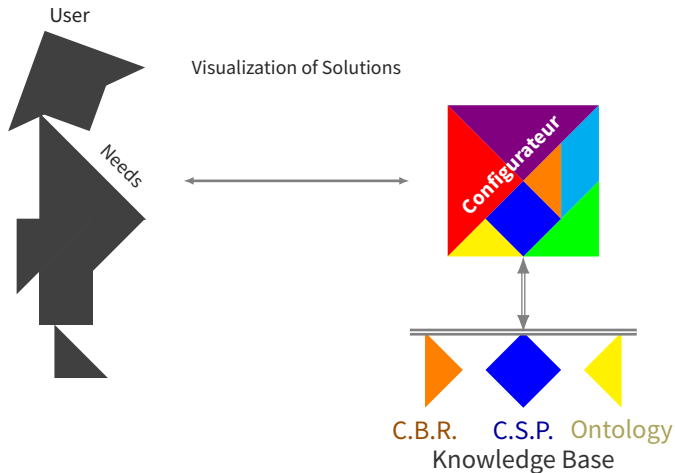
Interactions and Users' Needs





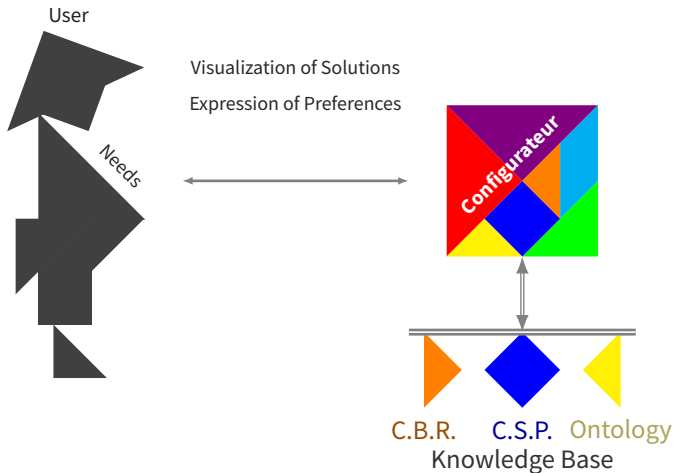
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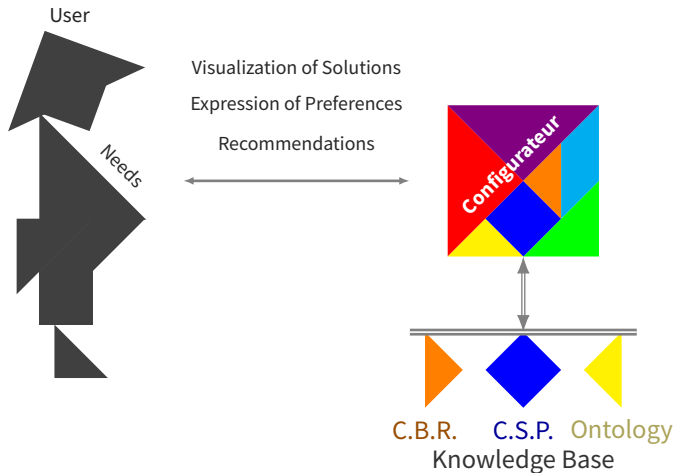
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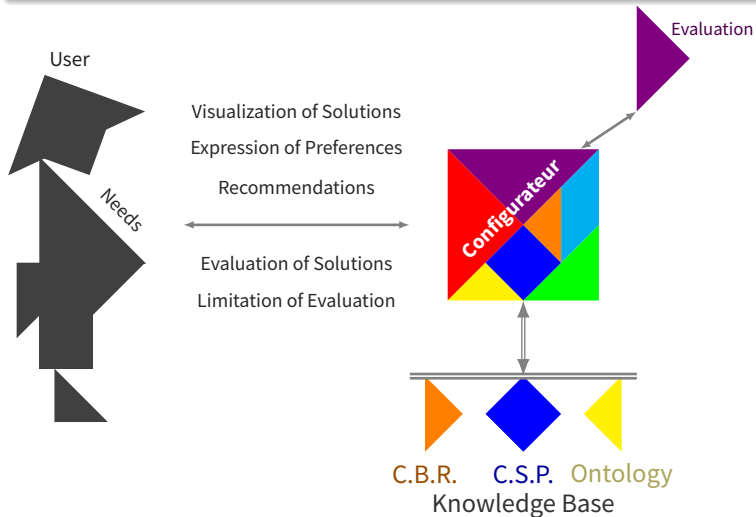
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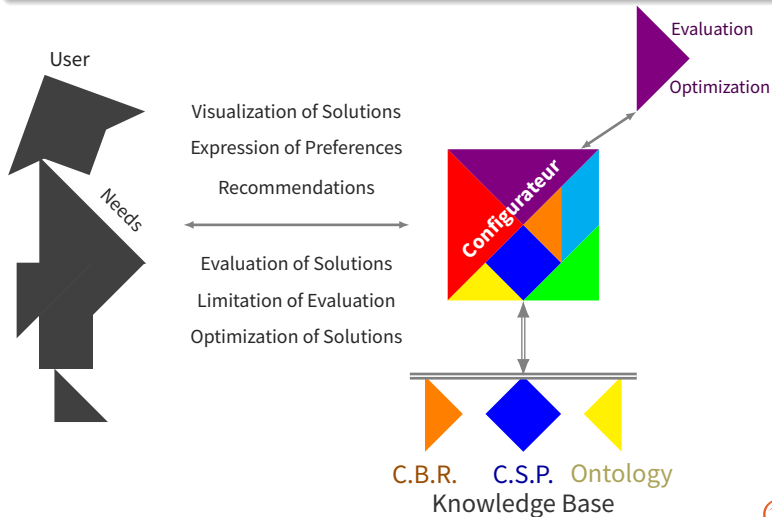
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### Design and Development of Filtering Algorithms

#### Interactions and Users' Needs



## [T2] – Exploitation and Filtering

### Filtering Methods

Prune research space  $\rightsquigarrow$  convergence

- Arc consistency for discrete or mixed CSP
- $2B$ -consistency or *Box*-consistency for continuous or temporal Caps

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Find one or more solutions.

- Exhaustive Exploration : Generate & test, Backtrack ...
- Partial Exploration : Look ahead, Forward checking ...



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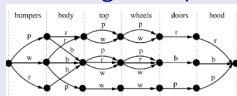
### Solving Methods

Find one or more solutions.

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### Compilation Maps

Compilation of CSP into Knowledge Compilation Maps.



Large diversity of Knowledge to use

Association of  $\otimes$  filtering methods



Large diversity of Knowledge to use

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Arc Consistency  
2B Consistency  
Quad Tree

Large diversity of Knowledge to use

Association of  $\otimes$  filtering methods

Multi-intervals  
Piecewise Constraints  
Constraints Activation



Arc Consistency  
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Quad Tree

Large diversity of Knowledge to use

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Th. Vareilles



Th. Djefel



Th. Codet

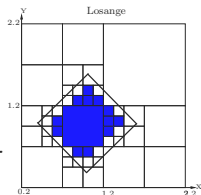
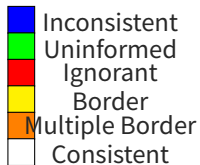
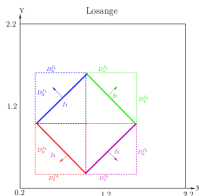


Th. Barco



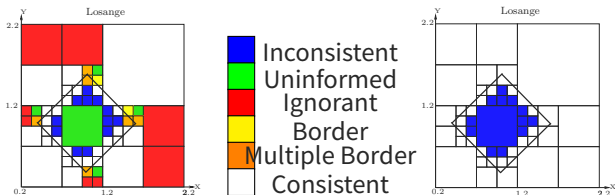
### Filtering and Piecewise Constraints

Extension of Quad Trees [Haroud1996]



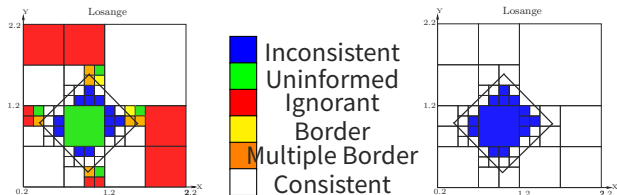
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## Filtering and Piecewise Constraints

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Th. Vareilles

JIM 2008, EAAI 2009





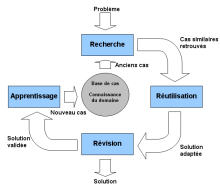






### Filtering and Contextual Constraints

Similarity, occurrence frequency and filtering



Contexte triangle **orange**



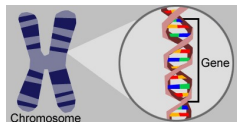






### Filtering and Optimization

#### Evolutionary Algorithm and CSP

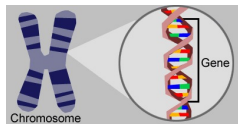


SPEA2



## Filtering and Optimization

### Evolutionary Algorithm and CSP

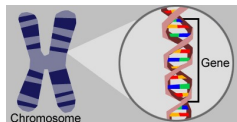


SPEA2



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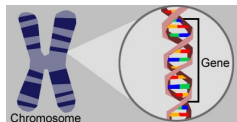


SPEA2



## Filtering and Optimization

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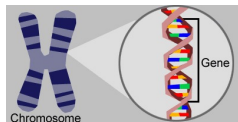


SPEA2

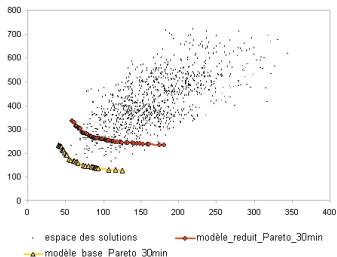


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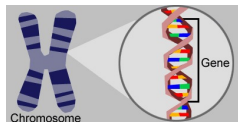


SPEA2



## Filtering and Optimization

### Evolutionary Algorithm and CSP



SPEA2



A.T.L.A.S.

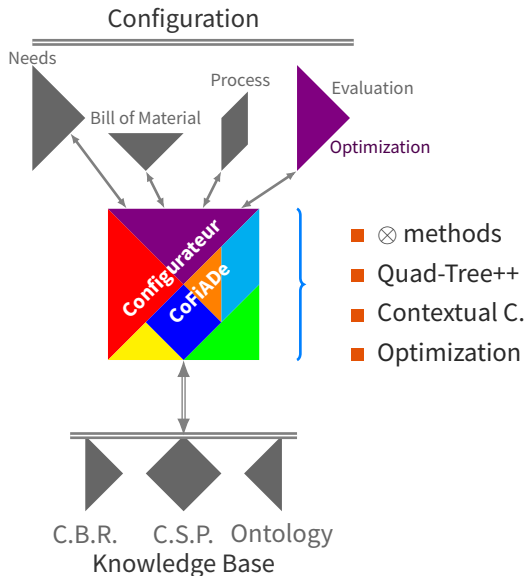


Conception  
Avion

Th. Djefel

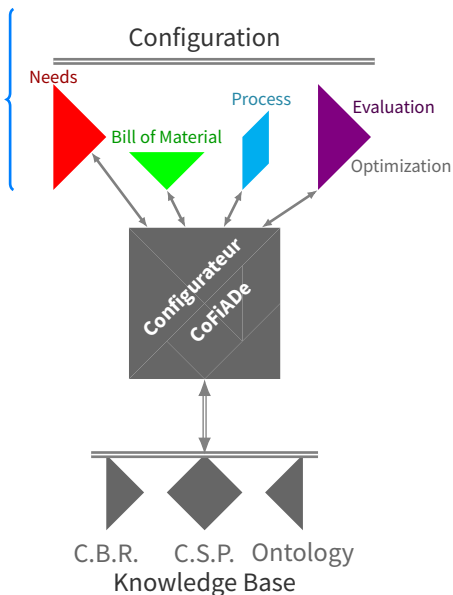
IJPR 2013, CII 2014

## [T2] – Exploitation and Filtering: Synthesis



# [T3] – Configuration and Extensions

T[3] : Configuration  
Extensions





### Solutions Evaluation

From selling Price to others criteria:

- Response Time<sup>[Nikolaidou2002]</sup>,
- Thermal Performance,
- Carbon Footprint, ...

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From selling Price to others criteria:

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### From Products Configuration to...

- Processes Configuration (concurrent) <sup>[Zhang2012], [Campagna2013]</sup>
- documentation<sup>[Rabiser2014]</sup>,
- Engineering to Order (ETO).

Evaluation mono  $\rightsquigarrow$  Multi-criteria

Several evaluations criteria.

Configuration

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### Evaluation mono $\rightsquigarrow$ Multi-criteria

Several evaluations criteria.

#### Configuration

Evaluation



Thermal Def.

Th. Vareilles

IJCIM 2007



Cost/Time

Th. Djefel

IJPR 2013



Time

Th. Codet

EAAI 2012



Cost/Ener. Perf.

Th. Barco

CP 2015

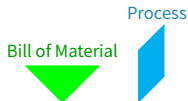
### From Products to Processes

Upstream: Bidding & Downstream: Assembly process, Development Projects

Configuration

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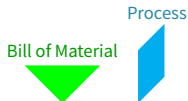
## From Products to Processes

Upstream: Bidding & Downstream: Assembly process, Development Projects

Configuration

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2II-MCO  
  
Appel d'offres  
Cablage Grue

BOM  
Doc. Bidding

A.T.L.A.S.  
  
Conception  
Avion

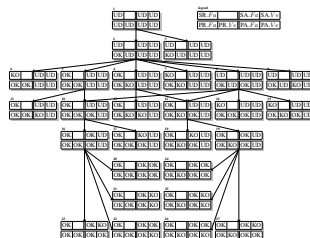
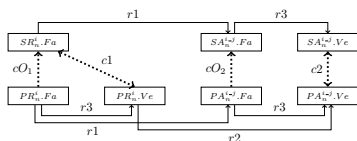
Th. Abeille  
BOM  
ETO

C.R.I.B.A.  
  
Rénovation  
Bâtiment

Th. Barco  
BOM  
Assembly

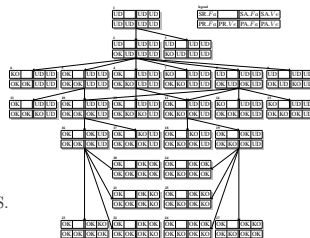
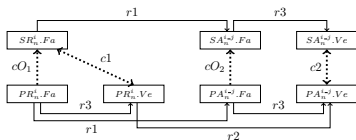
## From Configuration To ETO

### Synchronization of processes



## From Configuration To ETO

### Synchronization of processes



A.T.L.A.S.



Conception  
Avion

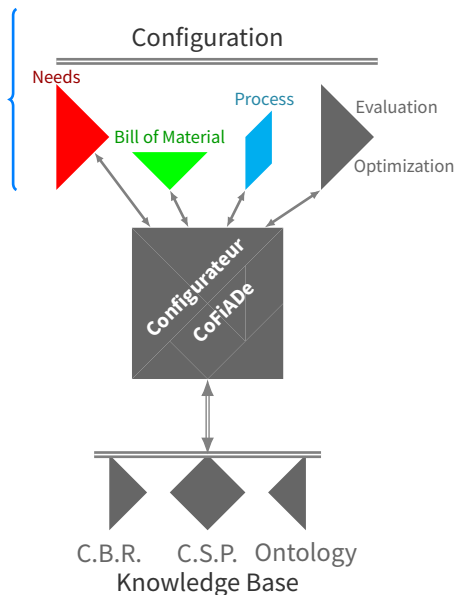
Th. Abeille

ICAE 2015



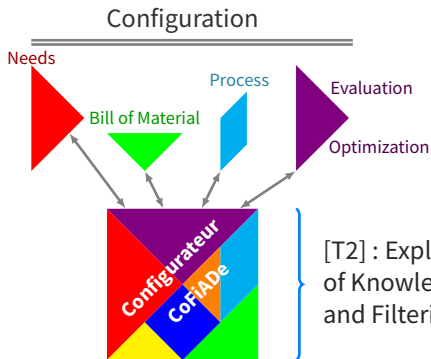
## [T3] – Configuration and Extensions: Synthesis

- Multi-criteria Evaluation
- Processes
- Synchronization



# Conclusion and Perspectives

T[3] : Extensions  
of configuration



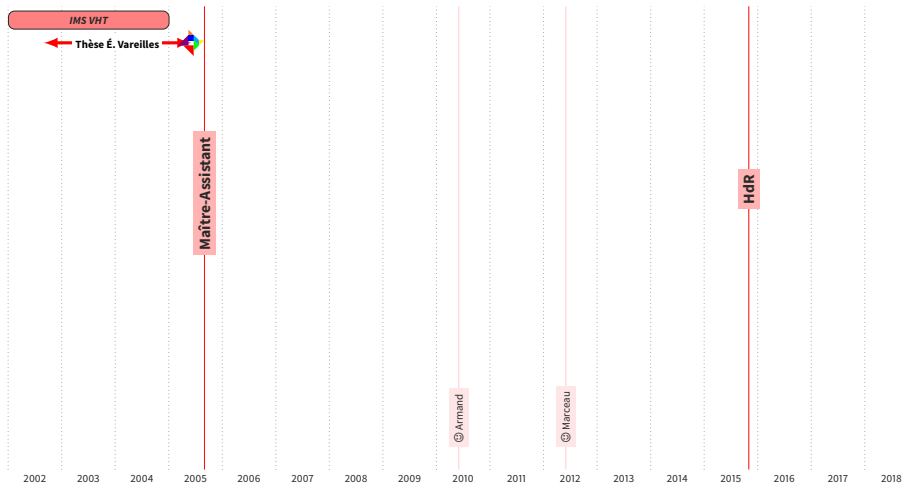
[T2] : Exploitation  
of Knowledge  
and Filtering

[T1] : Knowledge  
Formalization  
and Constraints

C.B.R. C.S.P. Ontology  
Knowledge Base

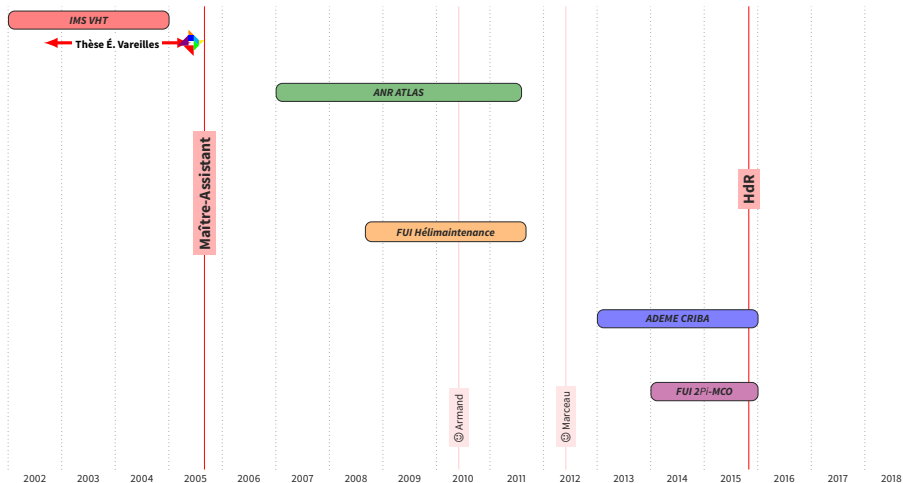
# Conclusion and Perspectives

4 projects (subv. 660KE), 3 PhD Students (110%) + 3 in progress (120%),  
10 WoS, 3 software mock-ups



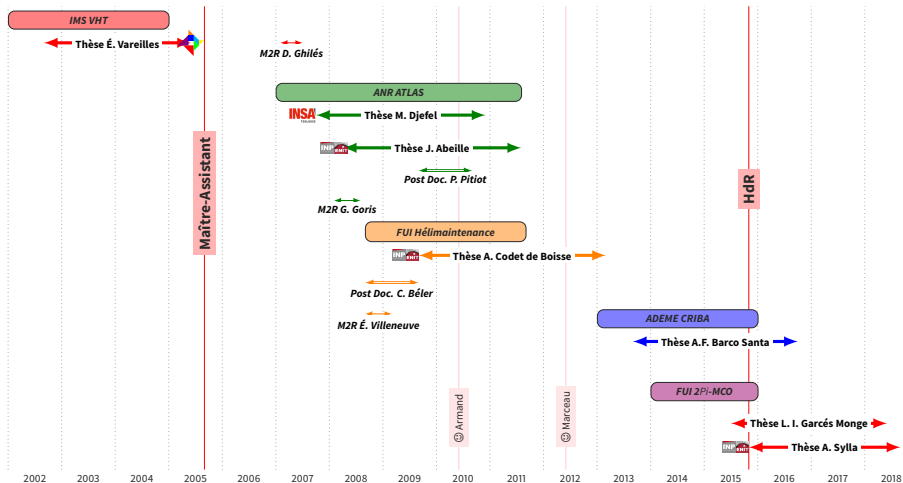
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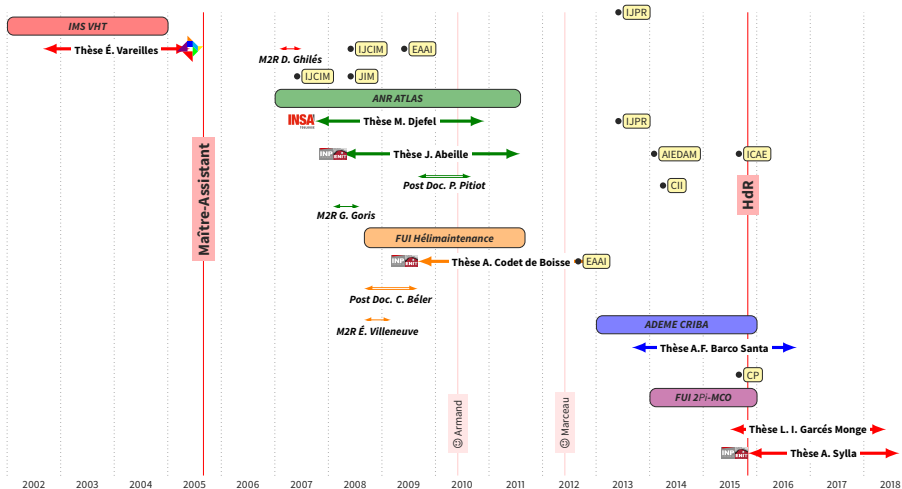
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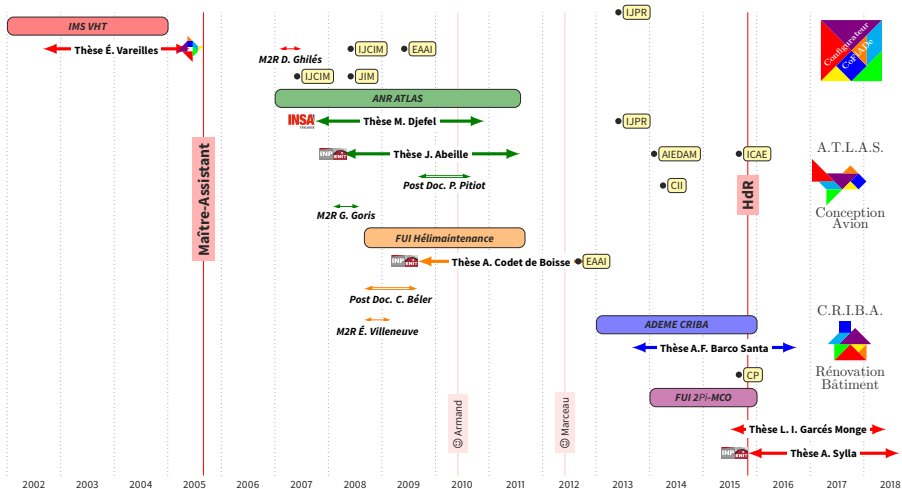
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10 WoS, 3 software mock-ups

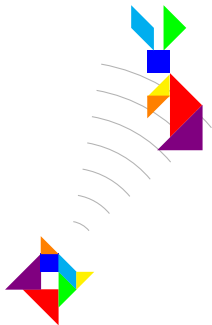


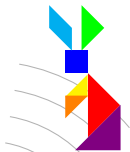
# Conclusion and Perspectives





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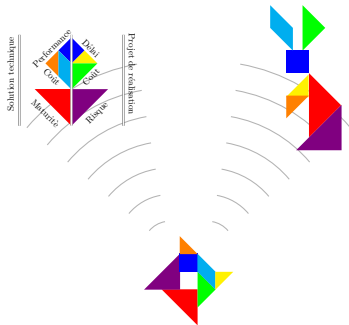


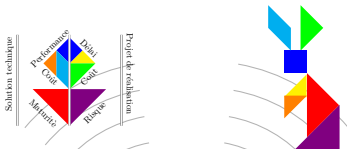


## Optimization & Configuration

- Validation our approach SPEA2  $\oplus$  CSP
- Configuration of tests
- Methodology to tune SPEA2  $\oplus$  CSP
- Thèse L.I. Garcés Monge (2015-20xx)
- Collaboration P. Pitiot

# Conclusion and Perspectives

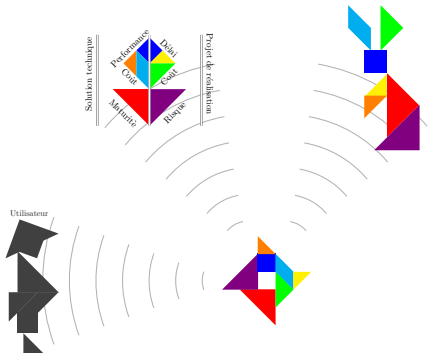


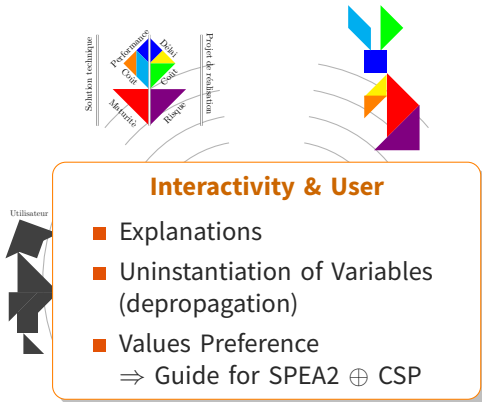


## Configuration, Maturity & Risks

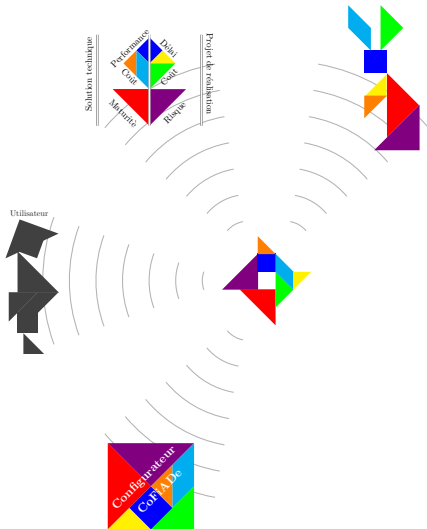
- Configuration (Technical Solution/Project)
- Evaluation (Maturity/Risks)
- Thèse A. Sylla (2015-20xx)
- Collaborations ENI Tarbes et *UniSA* Adélaïde Australie
- Common Project in ORKID team

# Conclusion and Perspectives





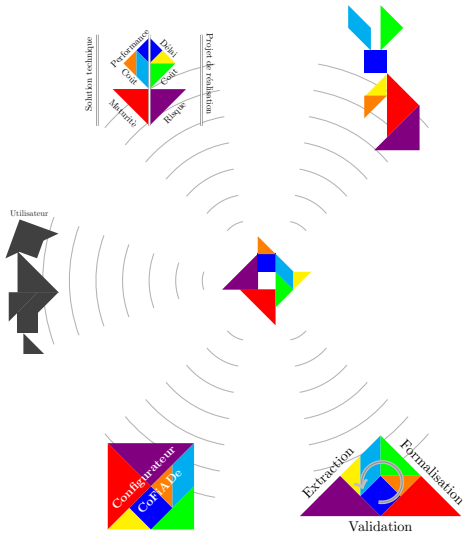
# Conclusion and Perspectives

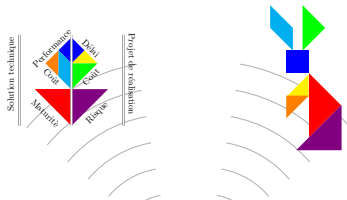






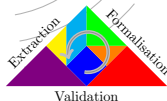
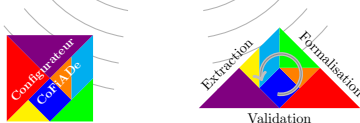
# Conclusion and Perspectives



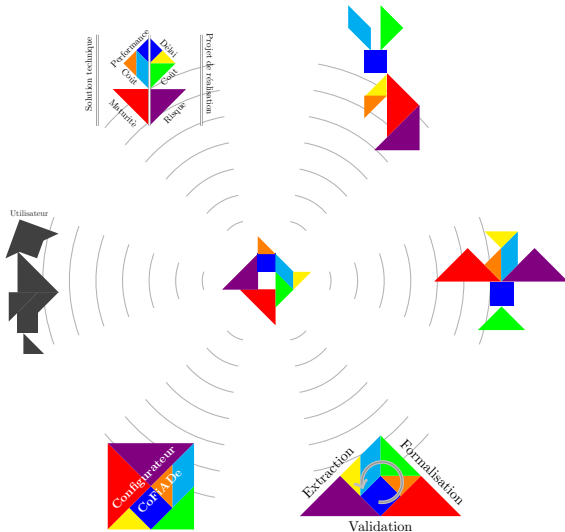


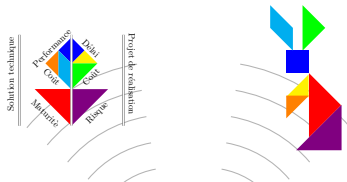
## Knowledge Life Cycle

- Inconsistencies Identification
- Reverse-engineering of field knowledge



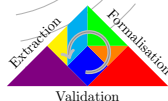
# Conclusion and Perspectives





## Collaborative Configuration

- Collaborative Configuration
- Common Project in IO & ORKID teams





# Interactive Configuration and Constraints

Knowledge, Filtering algorithms and Extensions

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Mines Albi

24<sup>th</sup> of November 2015

