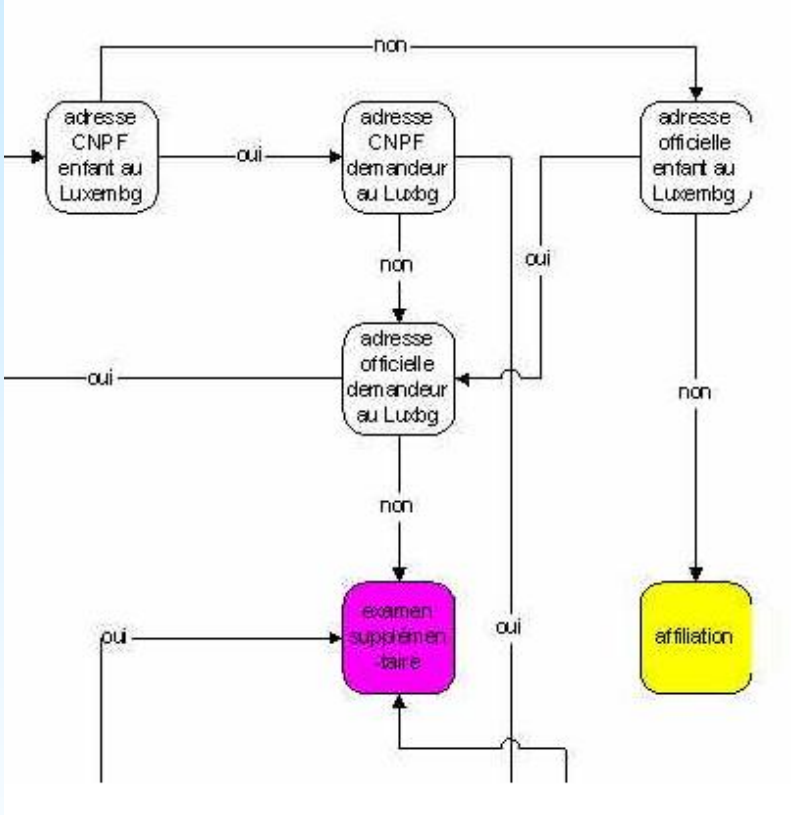

Flexible and Fine-Grain Decision Support Based on Data Interpretation

A Case Study with **Cadral** Decision Support System

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Context (1)

family benefits complexity

The National Family Benefits Fund

takes care of 100,000 families & 160,000 individuals

faces a constant augmentation in number & complexity of the beneficiaries

provides birth, household, education aids

applies European acts & legislation, bi-lateral agreements, national law

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Context (2)
Grand-Duchy of Luxembourg

open & active economy (agriculture, industry, services…)

40% foreigners (from Portugal, Italy, France, Eastern Europe…)

130,000 cross border workers (from France, Belgium, Germany)

450,000 inhabitants

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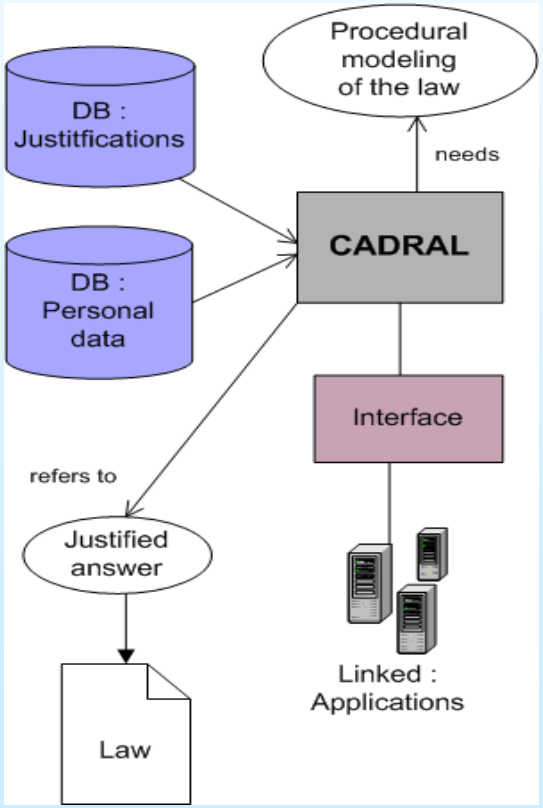
Cadral Overview (1)

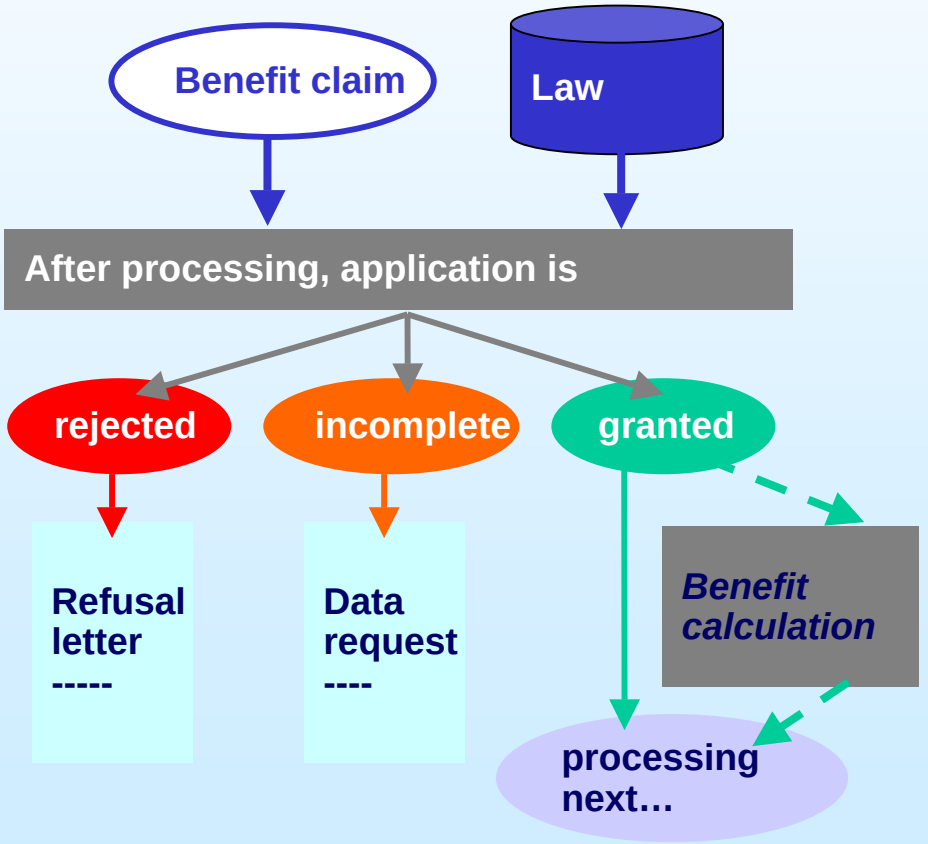
2 sides of a use-case

In Luxembourg, Cadral handles the acceptation / refusal of applications filled by the public for family benefits

Integration side



Workflow processing side



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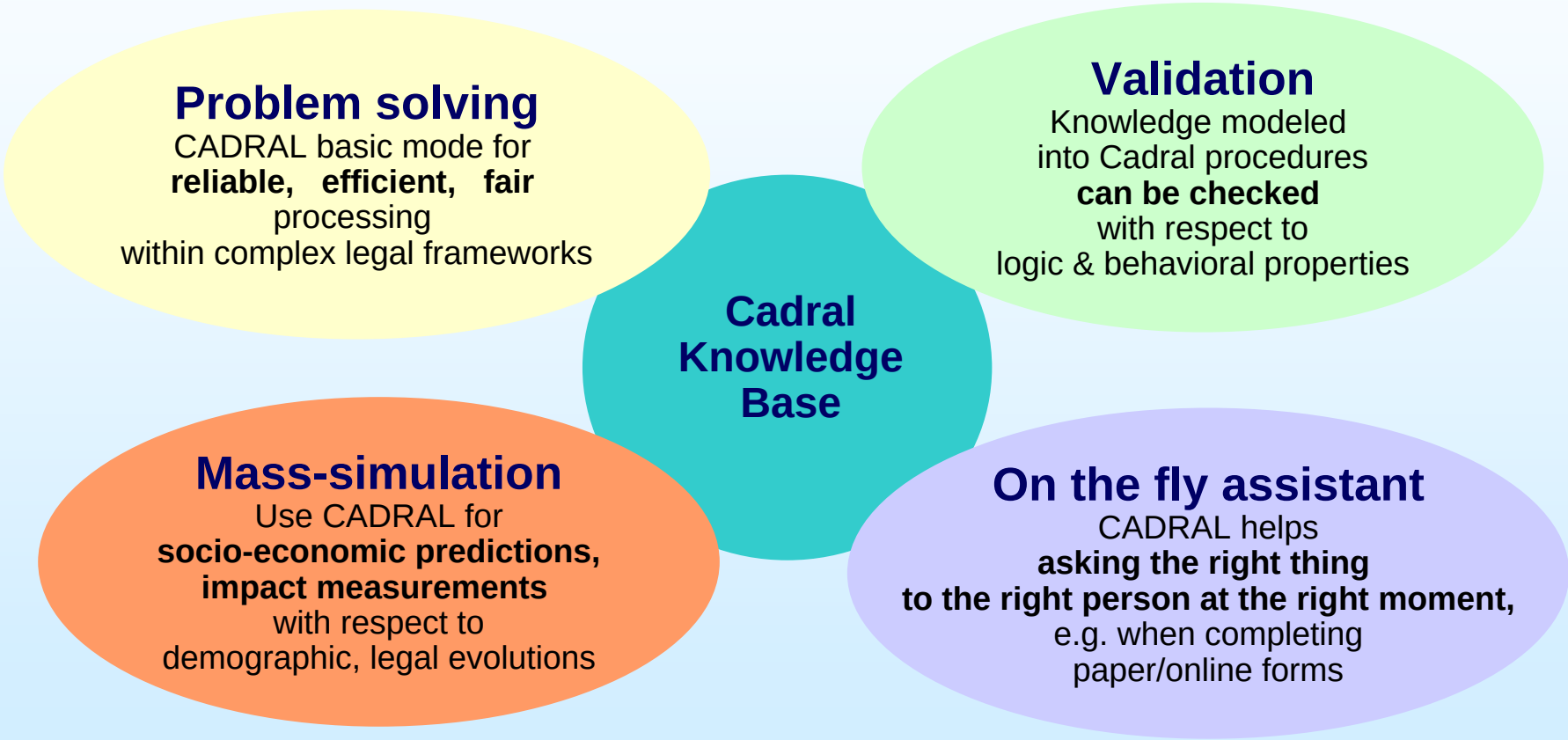
Cadral Overview (2)

utilization modes



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Cadral Architecture (1)

Developed with operational (integrated into the Luxembourg's Family Benefit Fund infrastructure) and academic (PhD hosting) partnerships,

Cadral is a decision support framework tailored to fits operational requirements, through:

- business oriented procedural knowledge model

- flexible reasoning kernel

- data interpretation to refine computed results

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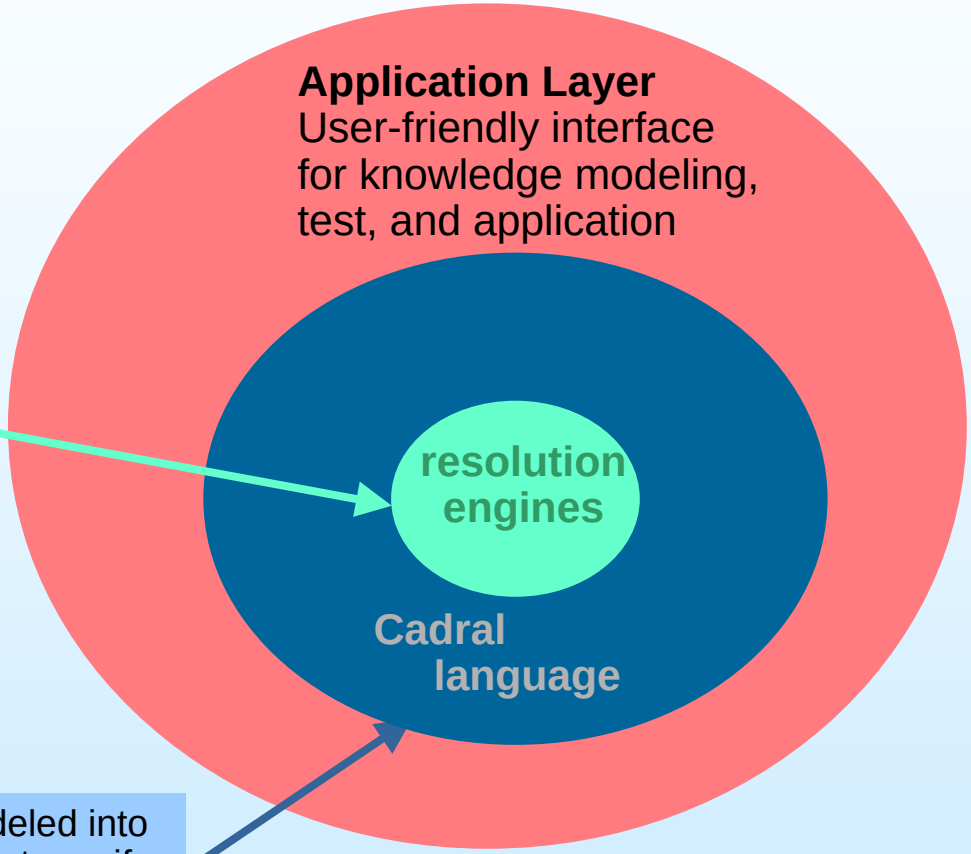
Cadral Architecture (2)

a business expert system

Cadral adapt its artificial brain to concrete and business cases.



The resolution kernel is made of technologies (Soar, Prolog, CSPs…) selected according to the characteristics of the problems to solve.

Business procedures are modeled into Cadral Proprietary Formalism to verify them (e.g. wrt. logical properties), and to guarantees a safe behavior of the resolution kernel

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Procedural Model (1)
reasoning schemes

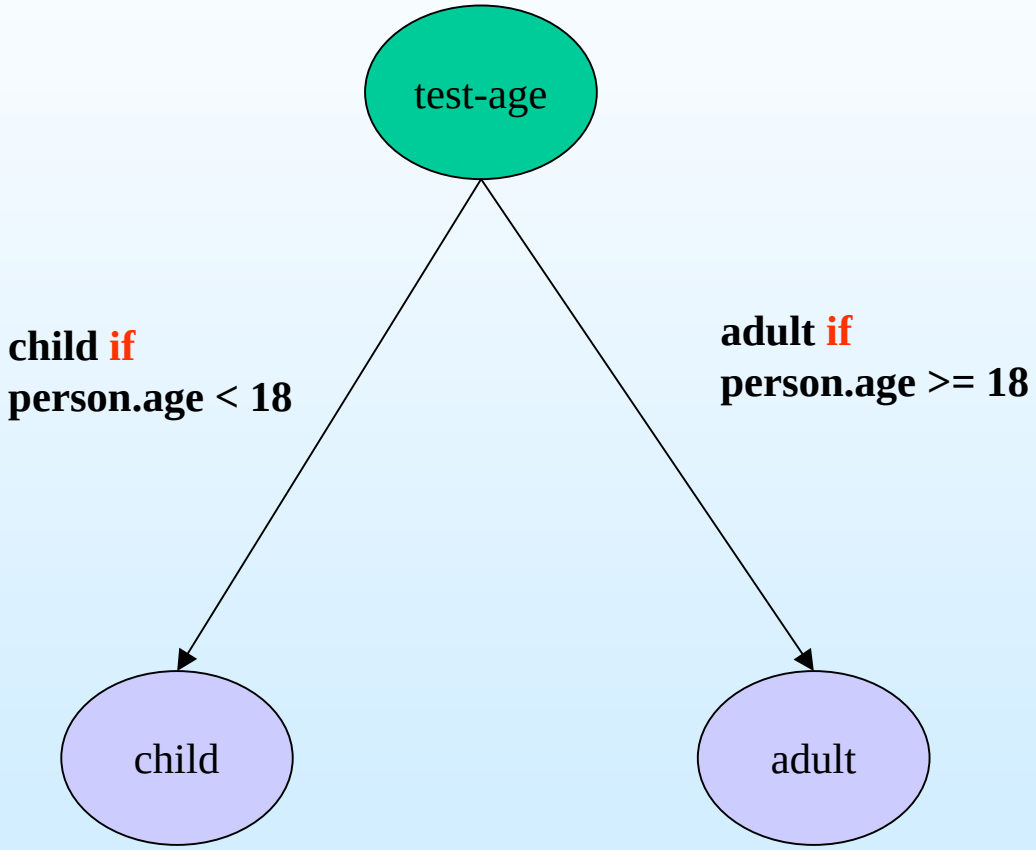
	Backward Reasoning	Forward Reasoning
Setting	Specialized	Intuitive (if…then… rules)
Behavior	Logic	Complex (erratic)
Results	Efficient find of 1 solution	Exhaustive search

Procedural Model (2)

rule & illustration

```
RULE child
PRE test-age
IN  age < 18
THEN
POST child
END

RULE adult
PRE test-age
IN  age >= 18
THEN
POST adult
END
```



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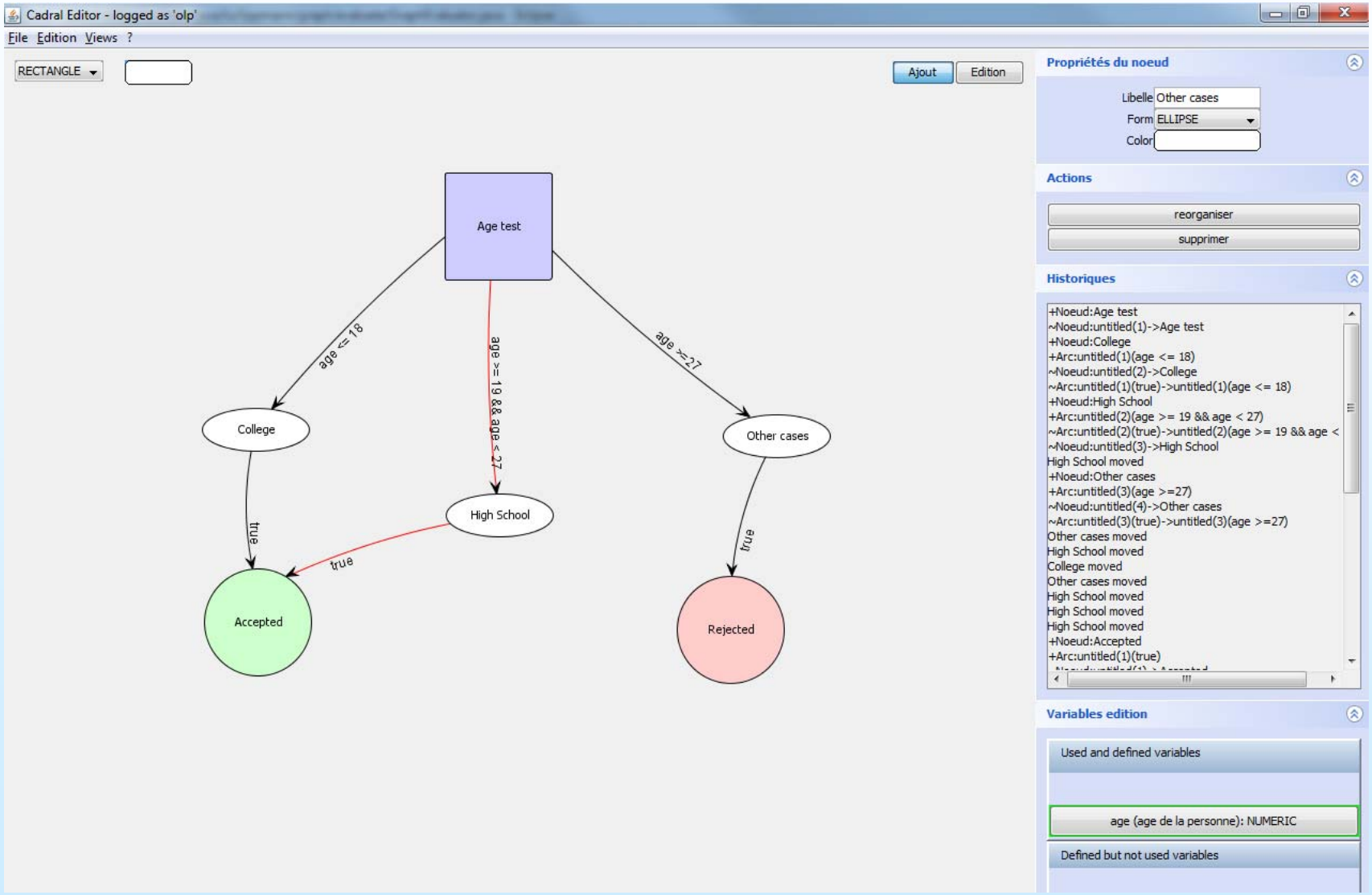
Procedural Model (3)
Hierarchical Graph Editor



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Procedural Model (4)

knowledge management

```
RULE child
PRE test-age
IN  age < 18
THEN
POST child
END

RULE adult
PRE test-age
IN  age >= 18
THEN
POST adult
END
```

Lex & Yacc compilation

```
sp { propose*enfant-mineur
(state <s> ^io.input-link <il> -^enfant-mineur)
(<s>  ^test-age oui)
(<il> ^enfant.age < 18)
-->
(<s> ^operator <o> + = )
(<o> ^name enfant-mineur)
}

sp { propose*enfant-majeur
(state <s> ^io.input-link <il> -^enfant-majeur)
(<s>  ^test-age oui)
(<il> ^enfant.age >= 18)
-->
(<s> ^operator <o> + = )
(<o> ^name enfant-majeur)
}
```

```
sp { apply*enfant-mineur
(state <s> ^operator.name enfant-mineur)
-->
(<s> ^majeur-non oui)
}

sp { apply*enfant-majeur
(state <s> ^operator.name enfant-majeur)
-->
(<s> ^majeur-oui oui)
}
```

Cadral uses the Soar architecture for Knowledge-based systems

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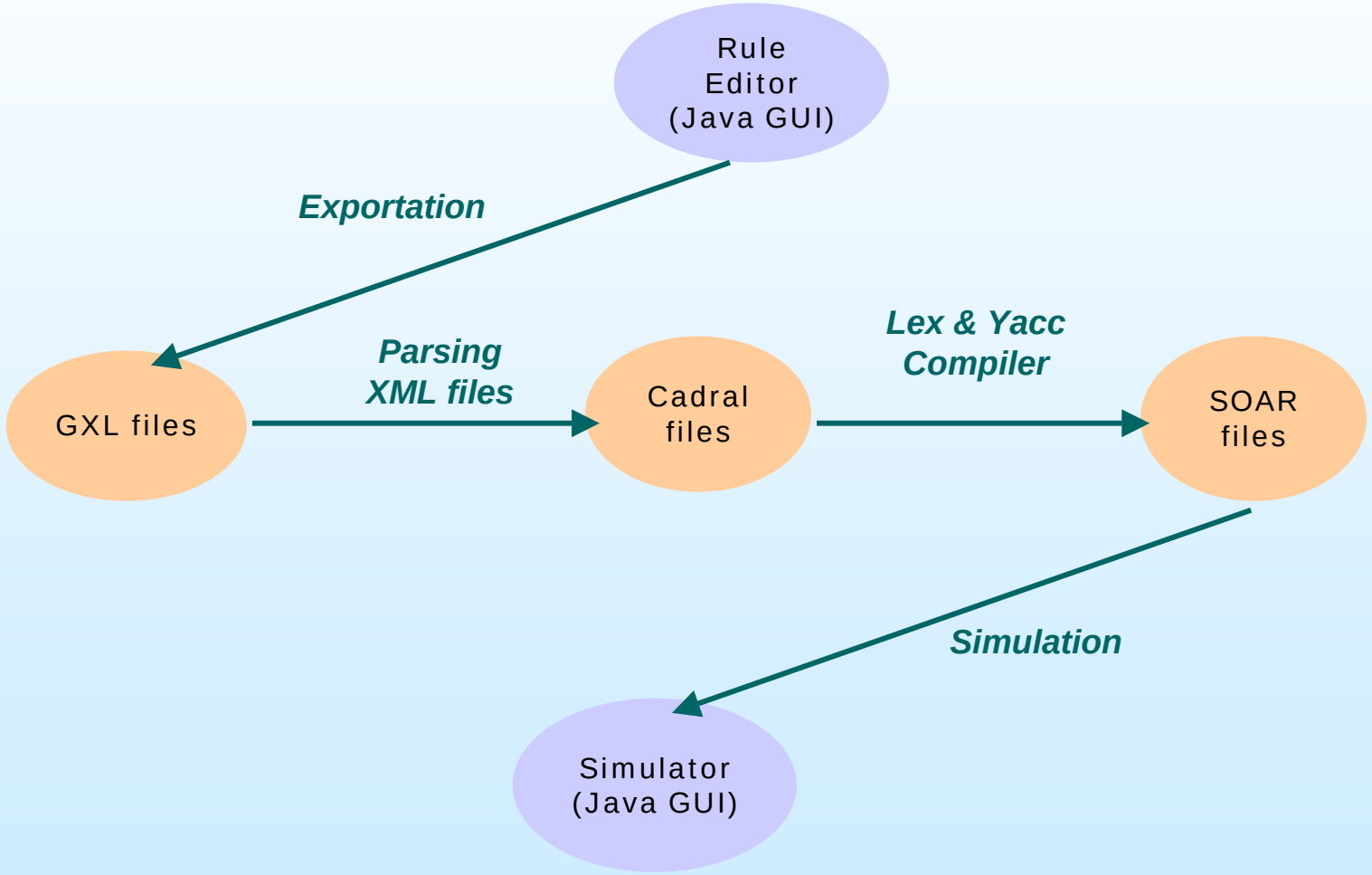
Procedural Model (5)

effective compilation



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Implementation (1)

Cadral core API

Generic Java API used to define concepts

- engines: for learning, data interpretation, resolution
- datasets: working memory data with operational contexts
- data encoders/decoders: depends on engines and datasets

Cadral Core integrates proven reasoning technologies

- Soar: general cognitive architecture library
  http://sitemaker.umich.edu/soar
- Encog: neural network library
  http://www.heatonresearch.com/encog
- Weka: machine learning library
  http://www.cs.waikato.ac.nz/~ml/weka/

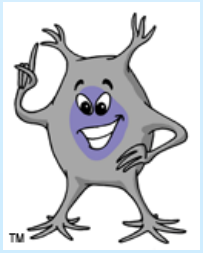
Implementation (2)

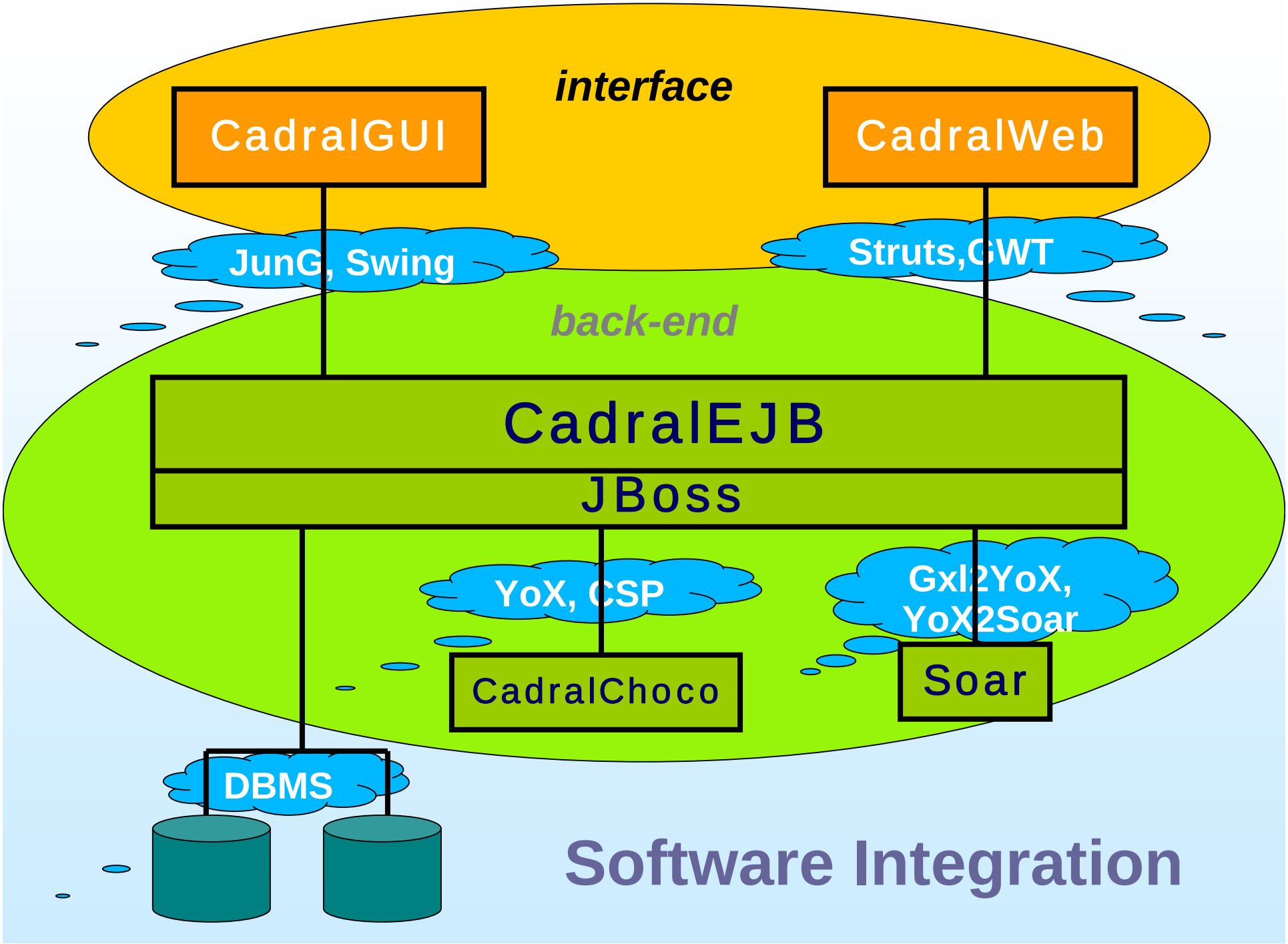
engines' integration

```
Engine
{
    DataMap run(DataMap input)
}
```

```
LearningEngine extends Engine
{
void learn(DataMap inputs, DataMap expectedOutput);
}
```

```
RuleBasedEngine extends Engine
{
void addRule(Rule r);
}
```




interface
CadralGUI
CadralWeb
JunG, Swing
Struts,GWT
back-end
CadralEJB
JBoss
YoX, CSP
Gxl2YoX,
YoX2Soar
CadralChoco
Soar
DBMS
Software Integration

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Experiments (1)

Business pre-processing

Goal: Cadral Core for automatic recognition of Benefit Claims' complexity

- Selection of a classification engine (J48 in Weka: decision tree with pruning)
- Building a pertinent dataset
  - Choice of pertinent criteria (children age, family situation…)
  - Extract & encode data from CNPF database
  - Tag problematic claims with the help of operational/maintenance team
- Train the classification engine on the dataset
- Result: classification of the claims according to their complexity before their processing

Limits & perspectives

- Available: a binary, rigid classification
- Needs: clustering for automatic determination of profiles according to specificities of datasets

Interesting points

- Business knowledge essential for initialisation with right criteria and datasets
- Business knowledge essential to interpret results: decision support helps the business but does not replace it

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Experiments (2)

monitoring software engineering

Sonar: open platform to manage code quality

- http://www.sonarsource.org/

Goal: using Cadral Core to discover quality similarities between CRP-GL projects and major open source projects

- Data extraction and learning from demo Sonar instance -> X clusters http://nemo.sonarsource.org/
- Data extraction from CRP-GL Sonar instance and trying to link projects to clusters
- Use weka clustering (in progress)

Interesting points

- Metrics selection (ex: is ‘number of line code’ useful/pertinent?)
- Clusters discovery (are clusters significant?)