Probabilistic Ontology and Knowledge Fusion for Procurement Fraud Detection in Brazil

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Paper - Uncertainty Reasoning for the Semantic Web
URSW - ISWC

Agenda

- Introduction
- MEBN and PR-OWL
- Procurement Fraud Detection
- Conclusion

Introduction

Introduction

- Brazilian Office of the Comptroller General (CGU) primary mission
  - Prevent and detect irregularities (corruption)
    - Gather information from a variety of sources
    - Combine the information
    - Then evaluate whether further action is necessary
- Problem
  - Information explosion
    - Growing Acceleration Program (PAC)
      - 250 billion dollars - 1,000+ projects only in SP

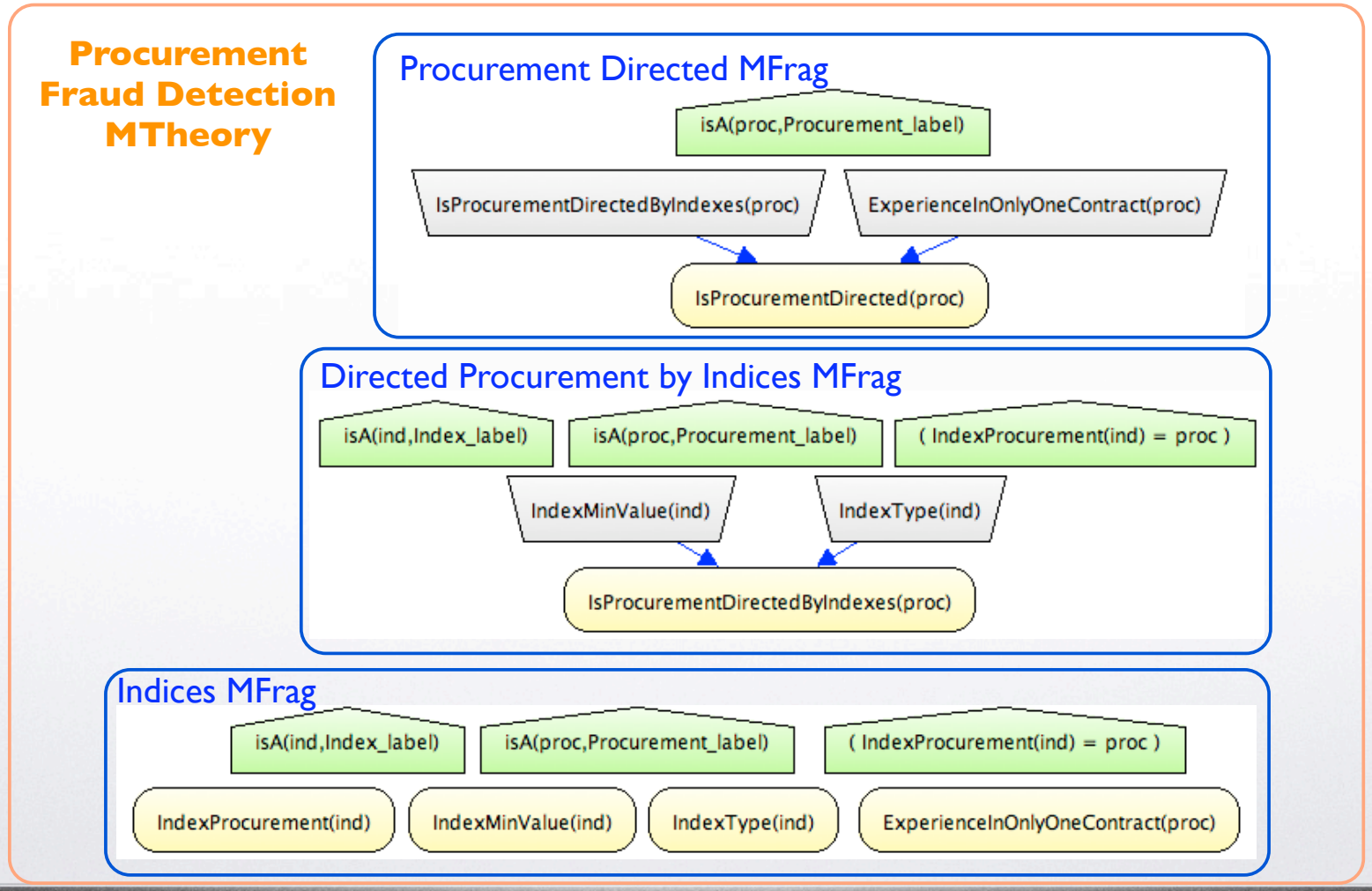
Introduction

- MEBN
  - Represent and reason with uncertainty about any propositions that can be expressed in first-order logic
- PR-OWL
  - Uses MEBN logic to provide a framework for building probabilistic ontologies
- Fraud Detection and Prevention Model
  - Uses MEBN and PR-OWL
  - Proof of concept

MEBN and PR-OWL

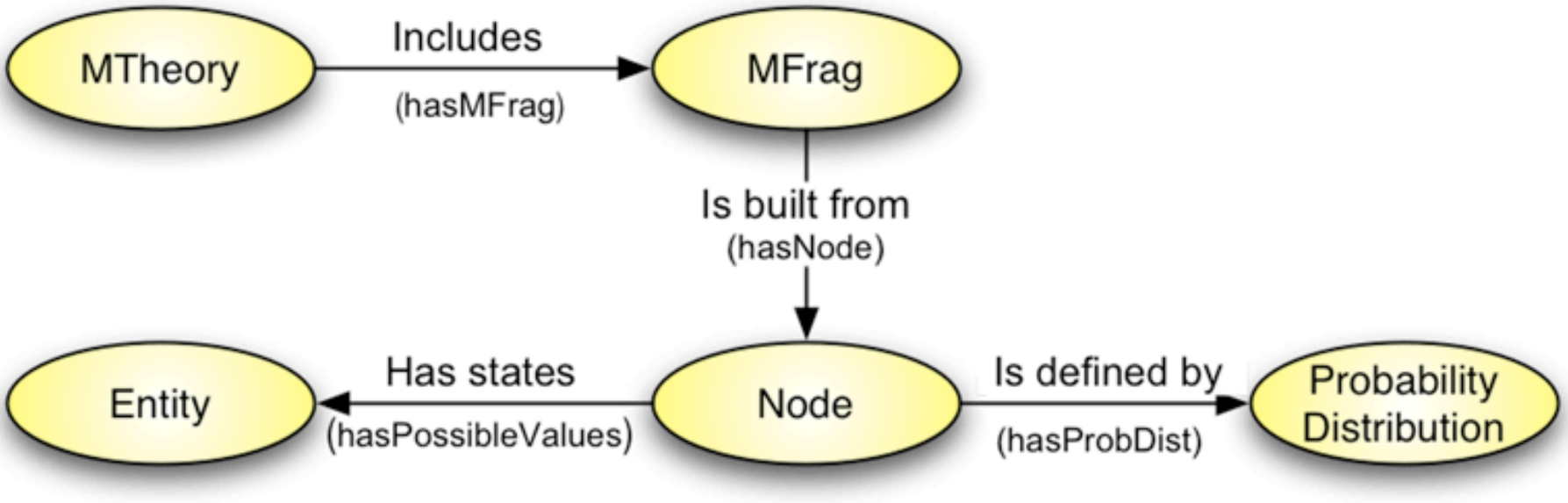
MEBN

- BN + FOL

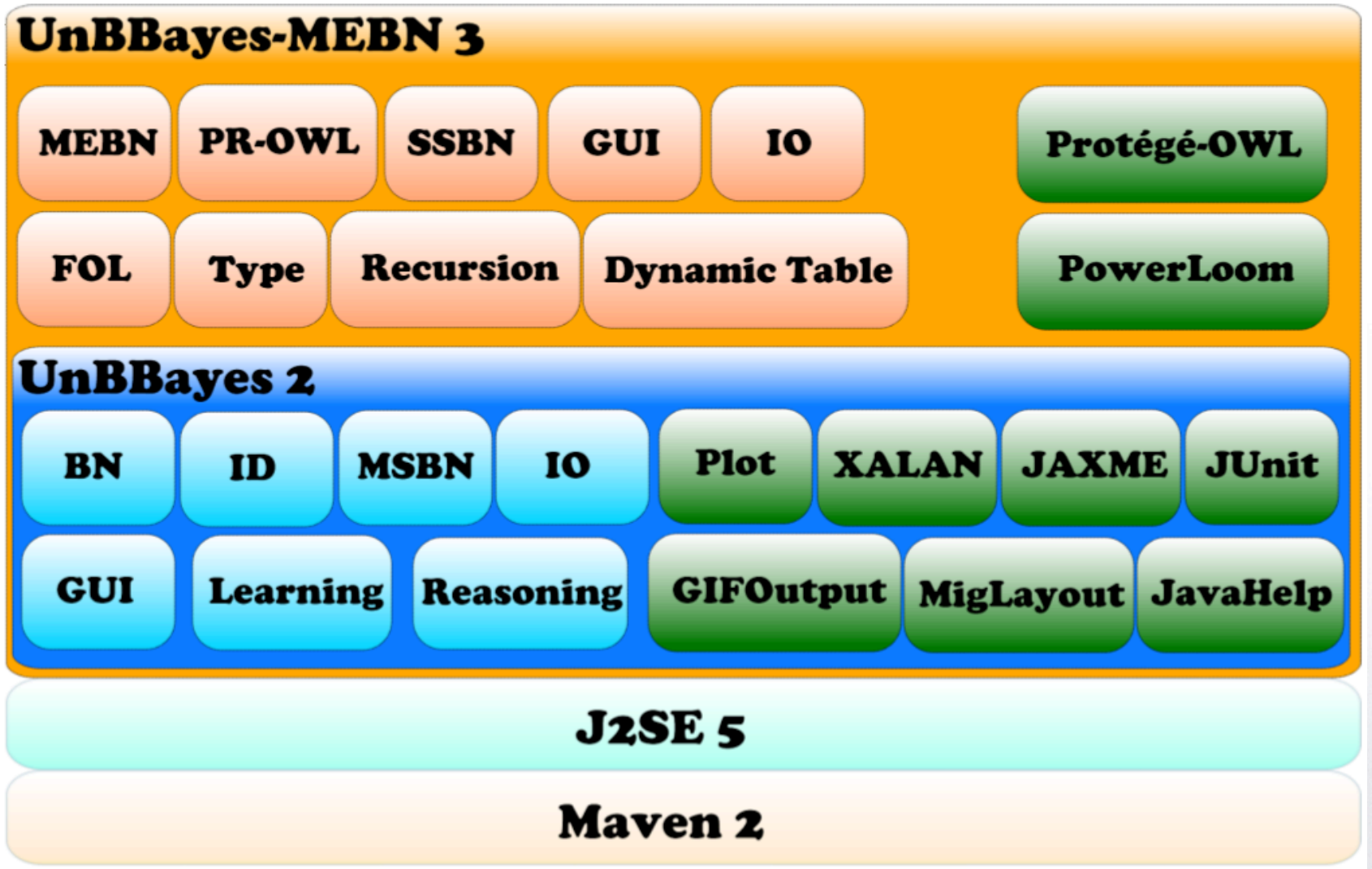

Procurement Fraud Detection MTheory
Procurement Directed MFrag
isA(proc,Procurement_label)
IsProcurementDirectedByIndexes(proc)
ExperienceInOnlyOneContract(proc)
IsProcurementDirected(proc)
Directed Procurement by Indices MFrag
isA(ind,Index_label)
isA(proc,Procurement_label)
(IndexProcurement(ind) = proc)
IndexMinValue(ind)
IndexType(ind)
IsProcurementDirectedByIndexes(proc)
Indices MFrag
isA(ind,Index_label)
isA(proc,Procurement_label)
(IndexProcurement(ind) = proc)
IndexProcurement(ind)
IndexMinValue(ind)
IndexType(ind)
ExperienceInOnlyOneContract(proc)

PR-OWL

- MEBN + OWL



UnBBayes


UnBBayes-MEBN 3
MEBN
PR-OWL
SSBN
GUI
IO
Protégé-OWL
FOL
Type
Recursion
Dynamic Table
PowerLoom
UnBBayes 2
BN
ID
MSBN
IO
Plot
XALAN
JAXME
JUnit
GUI
Learning
Reasoning
GIFOutput
MigLayout
JavaHelp
J2SE 5
Maven 2

Procurement Fraud Detection

Procurement Fraud Detection

- A major source of corruption is the procurement process
  - Laws attempt to ensure a competitive and fair process
  - Perpetrators find ways to turn the process to their advantage while appearing to be legitimate
- Specialist from CGU (Mário Spinelli)
  - Structured the different kinds of procurement frauds found in the past years

Procurement Fraud Detection

- Types of fraud
  - Characterized by criteria
    - Principle of competition is violated when we have
      - Owners who work as a front (usually someone with little or no education)
      - Use of accounting indices that are not common
- Ultimate goal
  - Structure the specialist knowledge in a way that an automated system can reason with the evidence in a manner similar to the specialist
    - Support current specialists
    - Train new ones

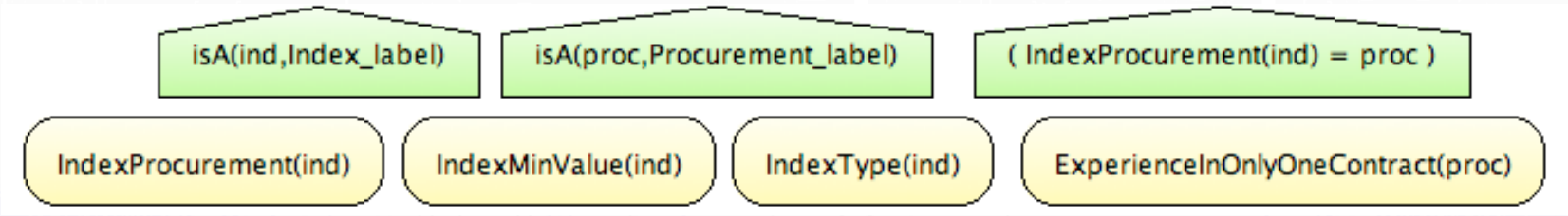
Procurement Fraud Detection

- Realistic goal (this paper)
  - Proof of concept
    - Selected just a few criteria
  - Why Semantic Web?
  - Propose an overall architecture for collecting data, reasoning with uncertainty (model designed), and reporting alerts
  - Ask specialists to analyze results (subjective)
    - No massive data used
  - Show that new criteria can be easily incorporated

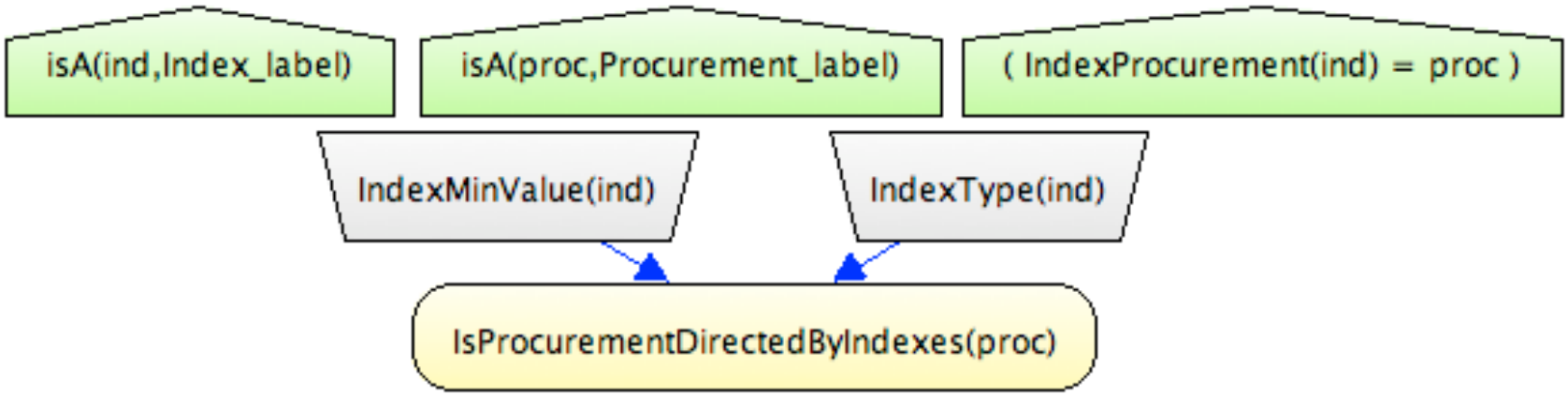
Why Semantic Web?

Architecture

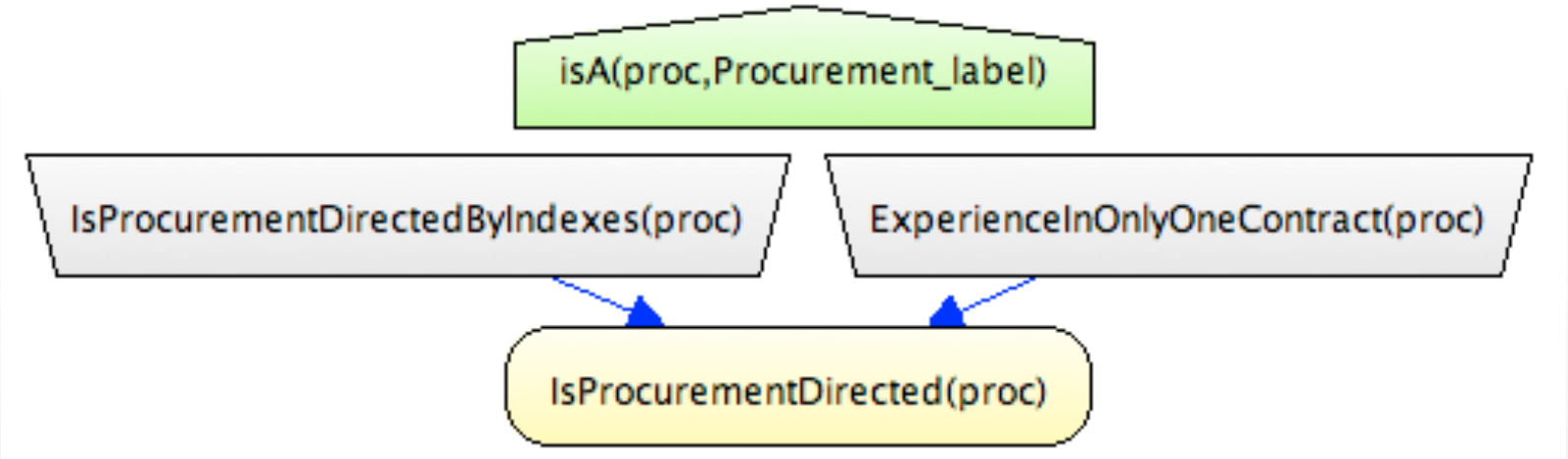
Used Criteria



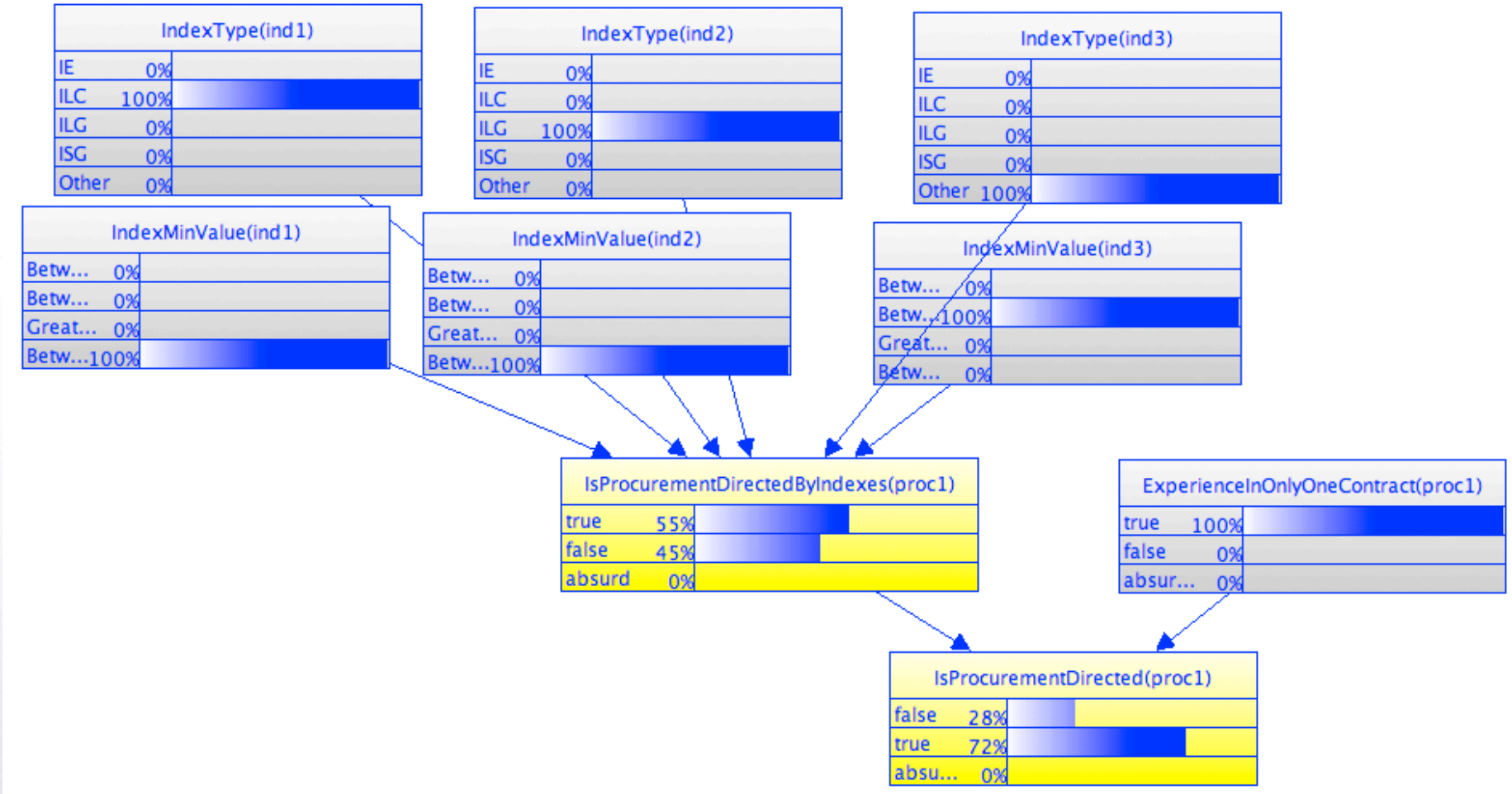
Used Criteria



Used Criteria



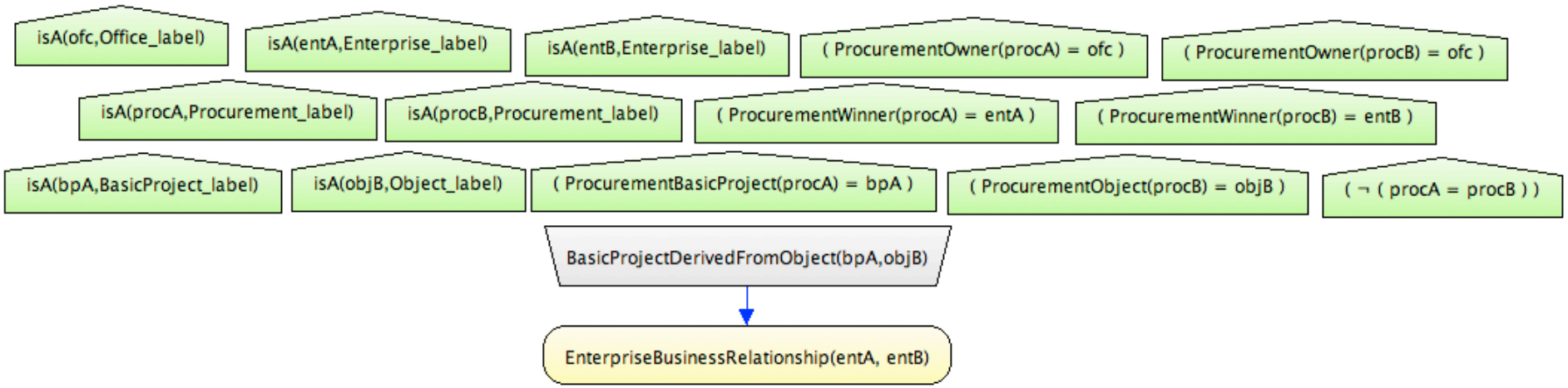
Results


IndexType(ind1)
IE 0%
ILC 100%
ILG 0%
ISG 0%
Other 0%
IndexType(ind2)
IE 0%
ILC 0%
ILG 100%
ISG 0%
Other 0%
IndexType(ind3)
IE 0%
ILC 0%
ILG 0%
ISG 0%
Other 100%
IndexMinValue(ind1)
Betw... 0%
Betw... 0%
Great... 0%
Betw...100%
IndexMinValue(ind2)
Betw... 0%
Betw... 0%
Great... 0%
Betw...100%
IndexMinValue(ind3)
Betw... 0%
Betw...100%
Great... 0%
Betw... 0%
IsProcurementDirectedByIndexes(proc1)
true 55%
false 45%
absurd 0%
ExperienceInOnlyOneContract(proc1)
true 100%
false 0%
absur... 0%
IsProcurementDirected(proc1)
false 28%
true 72%
absu... 0%

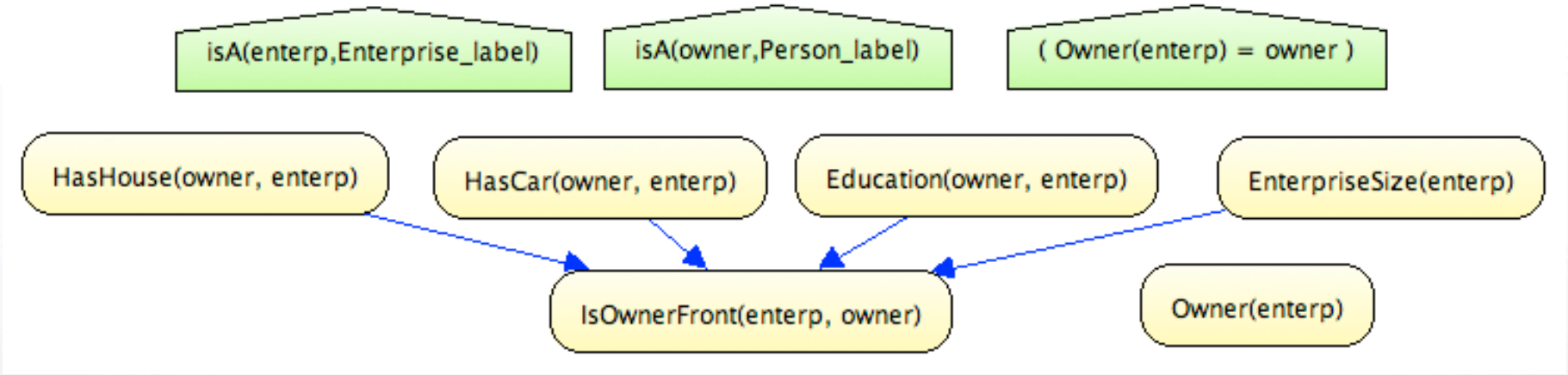
Results

- Non suspect procurement:
  - 0.01% that the procurement was directed to a specific company by using accounting indices;
  - 0.10% that the procurement was directed to a specific company.
- Suspect procurement:
  - 55.00% that the procurement was directed to a specific company by using accounting indices;
  - 29.77%, when the information about demanding experience in only one contract was omitted, and 72.00%, when it was given, that the procurement was directed to a specific company.

Adding new Criteria



Adding new Criteria



Conclusion

Conclusion

- Correct conclusion for both suspicious and non-suspicious cases
  - Results are encouraging
    - Suggesting that a fuller development of our proof of concept is promising
    - Needs more testing, especially with real data for validating the conclusions
- Advantages
  - Impartiality in the judgment
  - Scalability
  - Joint analysis of large volumes of indicators

Conclusion

- Future work
  - Choose/add new criteria
  - Collect more data for validation of the model
  - Will probably required fusion of data from different agencies
    - Good for assessing the usefulness of ontologies and the SW

Obrigado!