Translating Rules in Natural Language to RuleML

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August 27, 2012

RuleML 2012

Montpellier, France

Overview

- Problem statement and SOA.
  - From natural language expressions to formal, processable language.
- Tools:
  - Attempto Controlled English and C&C/Boxer.
  - Translation samples.
- Relation to:
  - SymposiumPlanner
  - Semantics of Business Vocabulary and Rules
- Problems and progress.

The Known Problem

- People use natural languages for communication, knowledge representation, and reasoning.
- Machines use formal languages, knowledge representation, and reasoning. RuleML is a particular example.
- How to bridge between natural and formal languages - the knowledge acquisition bottleneck?

Suggested Solutions

- Don't bother with natural language because:
  - context dependent, ambiguous, subjective, artifact, variable constructions and meanings, arbitrary meaning, complex, irony, sarcasm, unrestricted, when I was at school, I know language....
- Apply mathematical tools to analyse language:
  - Categorial grammar (Bar Hillel 1950s)
  - Phrase structure grammars (Chomsky 1950s)
  - Formal semantics (Montague 1960s)
  - Discourse analysis (Kamp/Heim 1980s)

State-of-Affairs - Academic

- Research, development, and success using statistical and machine learning approaches – Wide-scale parsers, Siri, Watson's Jeopardy, Google Translate, voice recognition.
- Developments in the formal maths approach:
  - van Bentham and ter Meulen (1997) *Handbook of Logic and Language*.
  - van Lambalgen and Hamm (2005) *The Proper Treatment of Events*.
- Developments in rule-based (or combo) computational approaches, where we parse an input sentence, output a semantic representation, draw inferences.
  - Blackburn and Bos (2005) *Representation and Inference for Natural Language*.
  - van Eijck and Unger (2010) *Computational Semantics with Functional Programming*.

State-of-Affairs - Industrial

- Industrial scale applications with *Oracle Policy Automation:*

  Scope legislation and regulation, express policies and knowledge base in a "just enough" controlled natural language, served as web-based business/policy system.

  - Creating Rules in Oracle Policy Automation
    - http://redstack.wordpress.com/2010/08/03/creating-rules-in-oracle-policy-automation/
  - UK DirectGov Benefits Calculator
    - http://www.direct.gov.uk/en/Diol1/DoItOnline/DoItOnlineByCategory/DG_172666
- This is one of the industrial competitors with respect to rules representation and reasoning using web-based natural language interfaces.
- Why no similar open-source, academic tool?

State-of-Affairs – Open NL Tools

- Attempto Controlled English.
- C&C/Boxer.

- Discuss each, give examples of parses and semantic interpretations, and show translations to RuleML.

- Discuss issues.

Attempto Controlled English (ACE)

- The Attempto Project
  - http://attempto.ifi.uzh.ch/site/
- Thanks to Tobias Kuhn, Kaarel , and Norbert Fuchs.
- A 'looks like English' formal language.
- Fixed (but large and extensible) lexicon and constrained grammar.
- Written as Prolog Definite Clause Grammar.
- Well-formed expressions are parsed and translated to Discourse Representation Structures (FOL).
- Deterministic (no ambiguity), assisted by construal rules.
- Translation to RuleML.
- Issues of deep semantic interpretation.
- Useful for building consistent knowledge bases; can be used in conjunction with an inference engine.

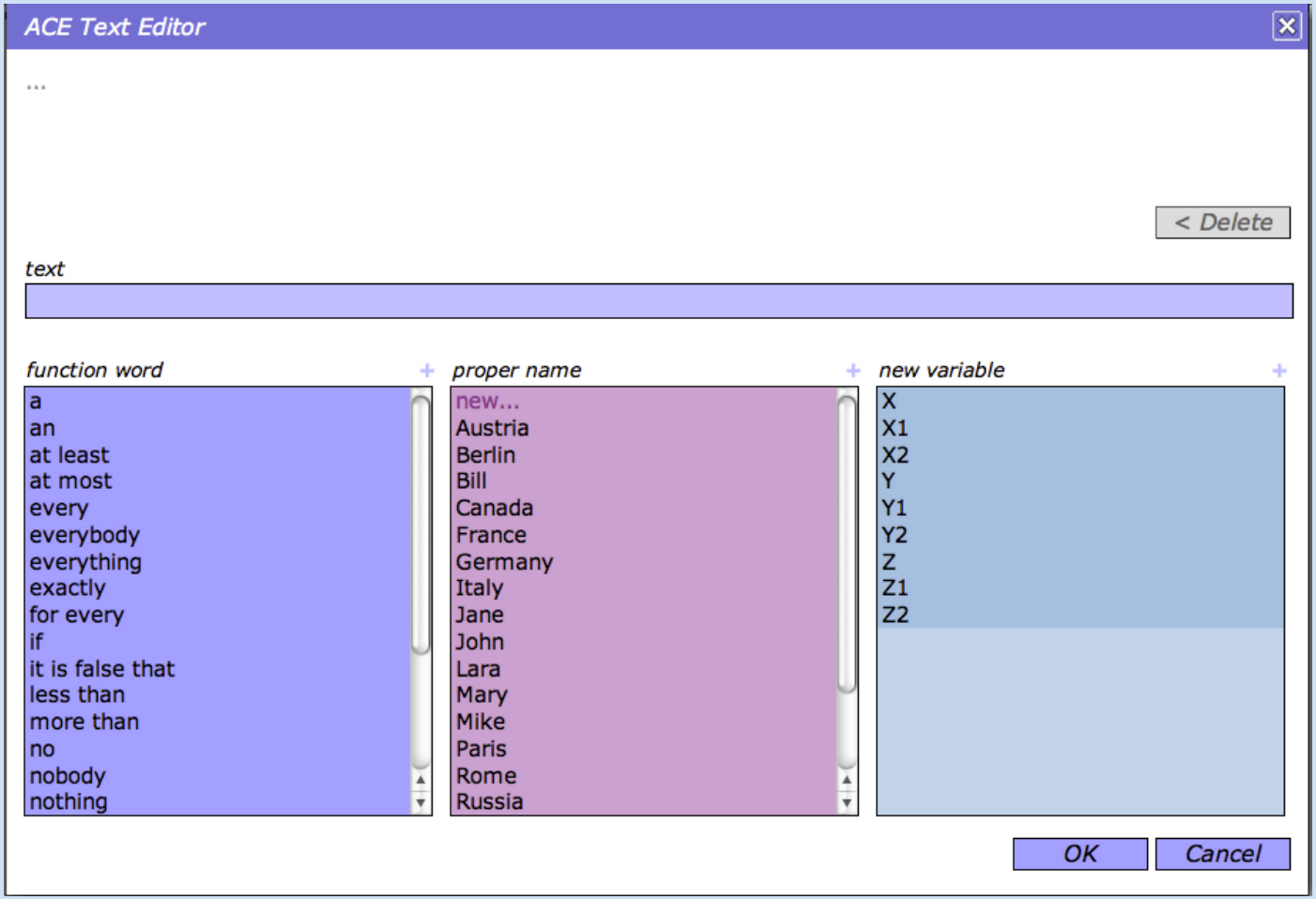
ACE Tools

- APE, the ACE parser. Input a sentence that is well formed in ACE, the output is a parse and semantic interpretation. Fails if it cannot parse.
- ACE Editor, which has a look ahead editor that guides the user to input grammatically well-formed sentences (allows semantically ill-formed expressions).
- ACE View, a Protege plugin NL interface to create, view, edit, and query OWL ontologies and SWRL rulesets.
- RACE, an ACE reasoner to check consistency of statements, prove theorems, and answer queries.

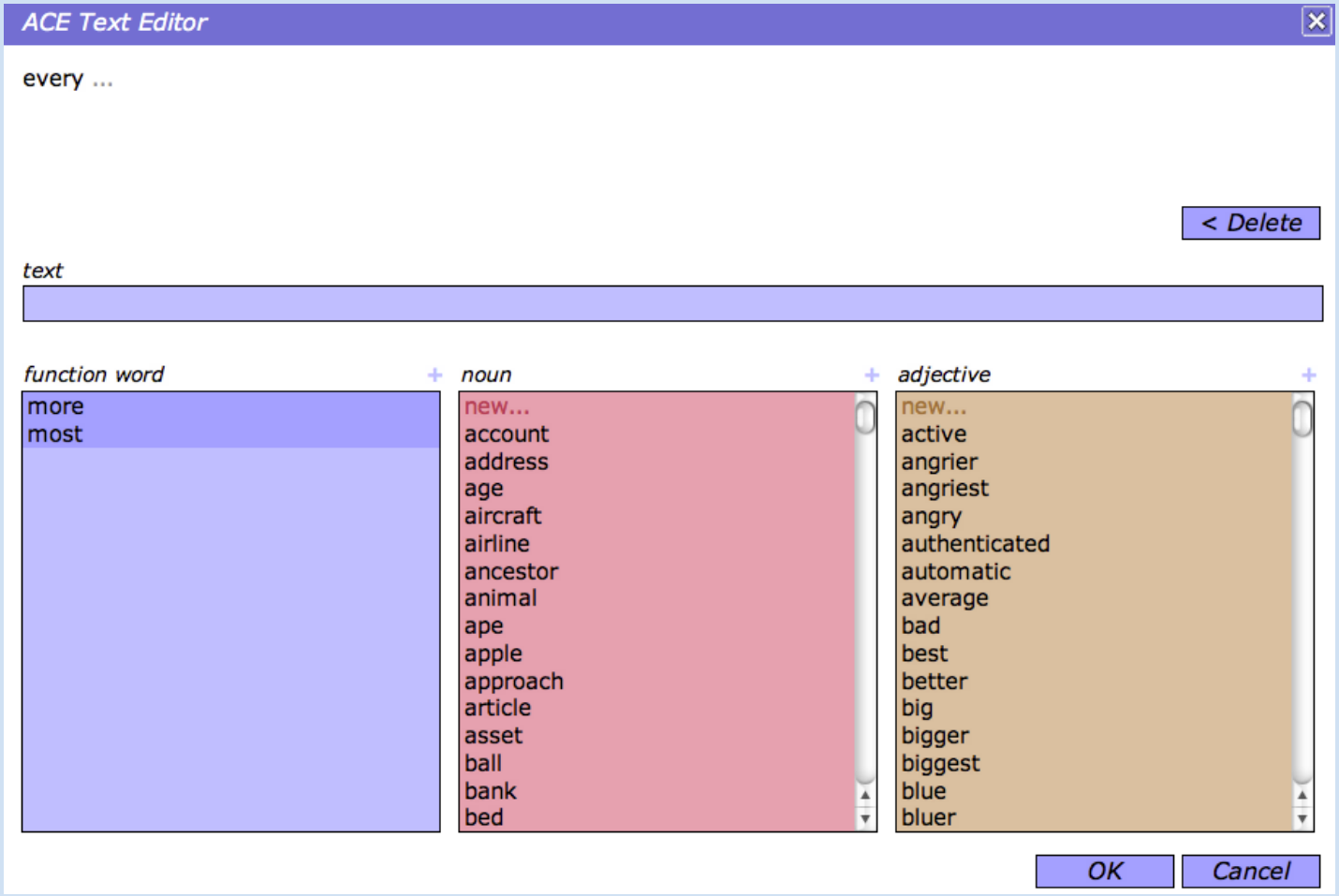
ACE Constructions

- negation on nouns or verbs, conjunction, dis- junction, conditionals, quantifiers, adjectives, relative clauses, discourse anaphora, modals ("necessity", "permission"), possessives, prepositional phrases, verbs with three arguments, verbs with subordinate clauses ("know"), negation-as-failure ("It is not provable...") and so on.
- DRS for interclausal and intersentential constructions to bind variables:
  - If a customer is rich, then the customer gets a discount.
  - If a customer is rich, then she gets a discount.
  - A customer is rich. She gets a discount.
- DRS for rhetorical relations: presupposition, explanation, justification, ...

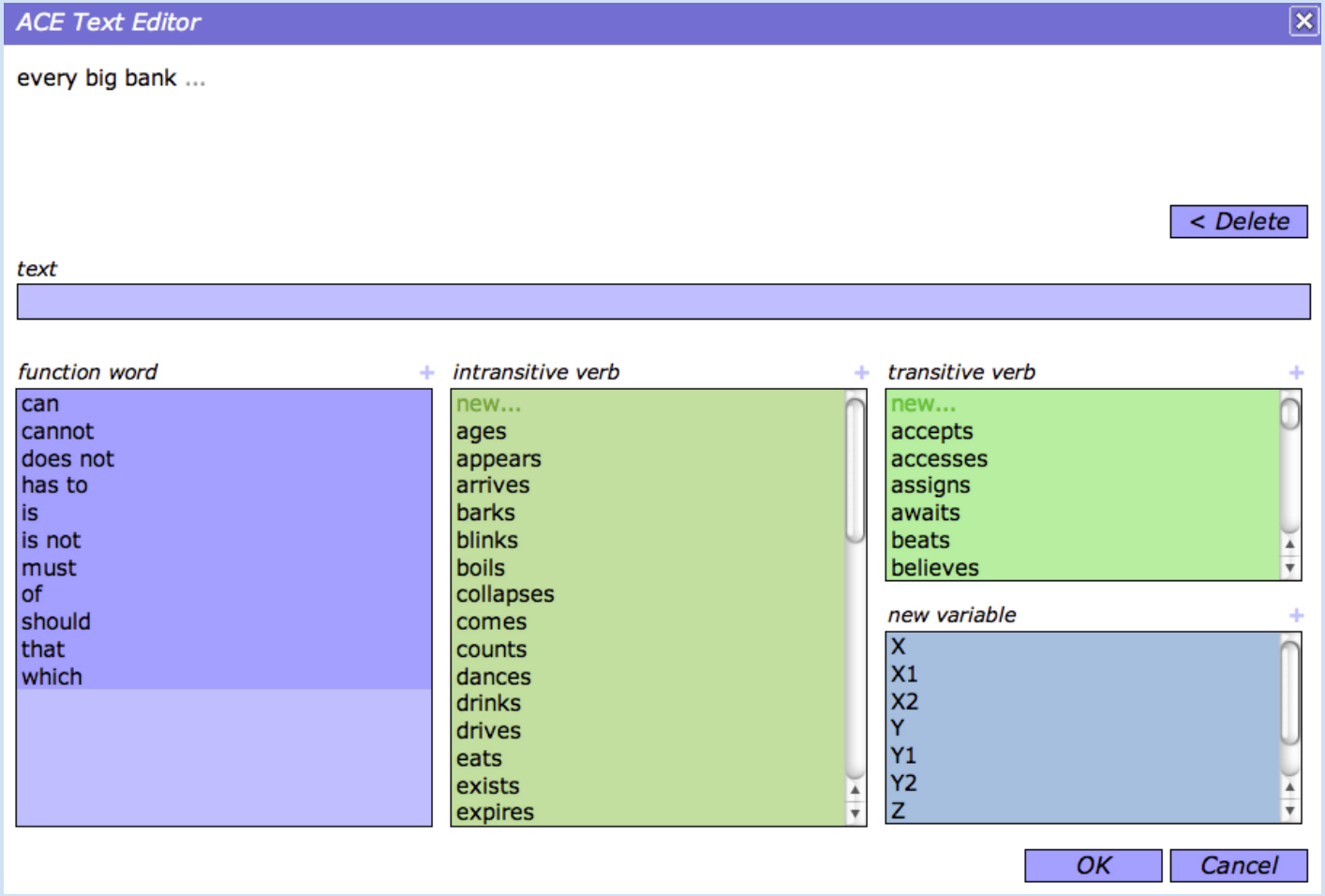
ACE Editor Example



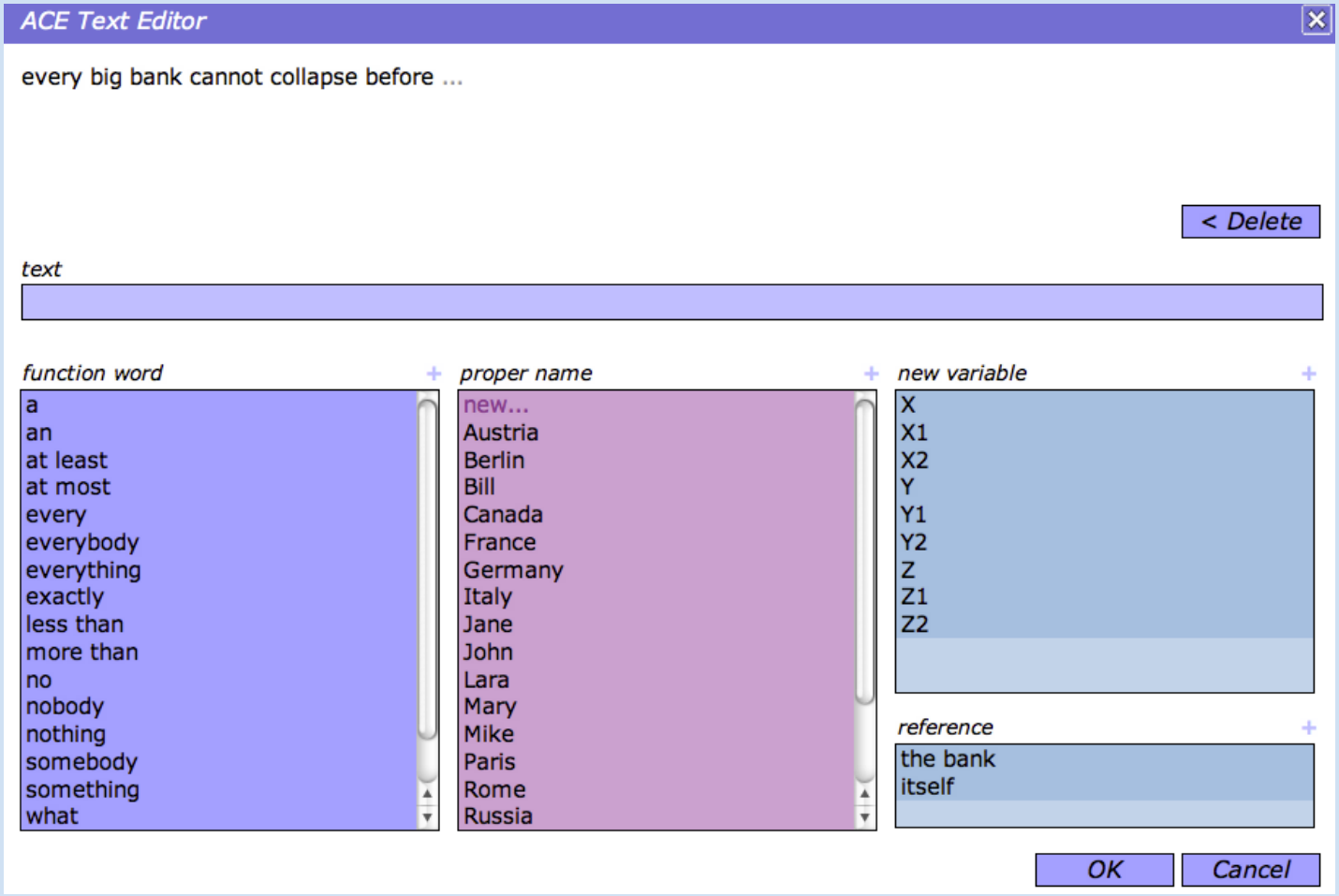
ACE Editor Example



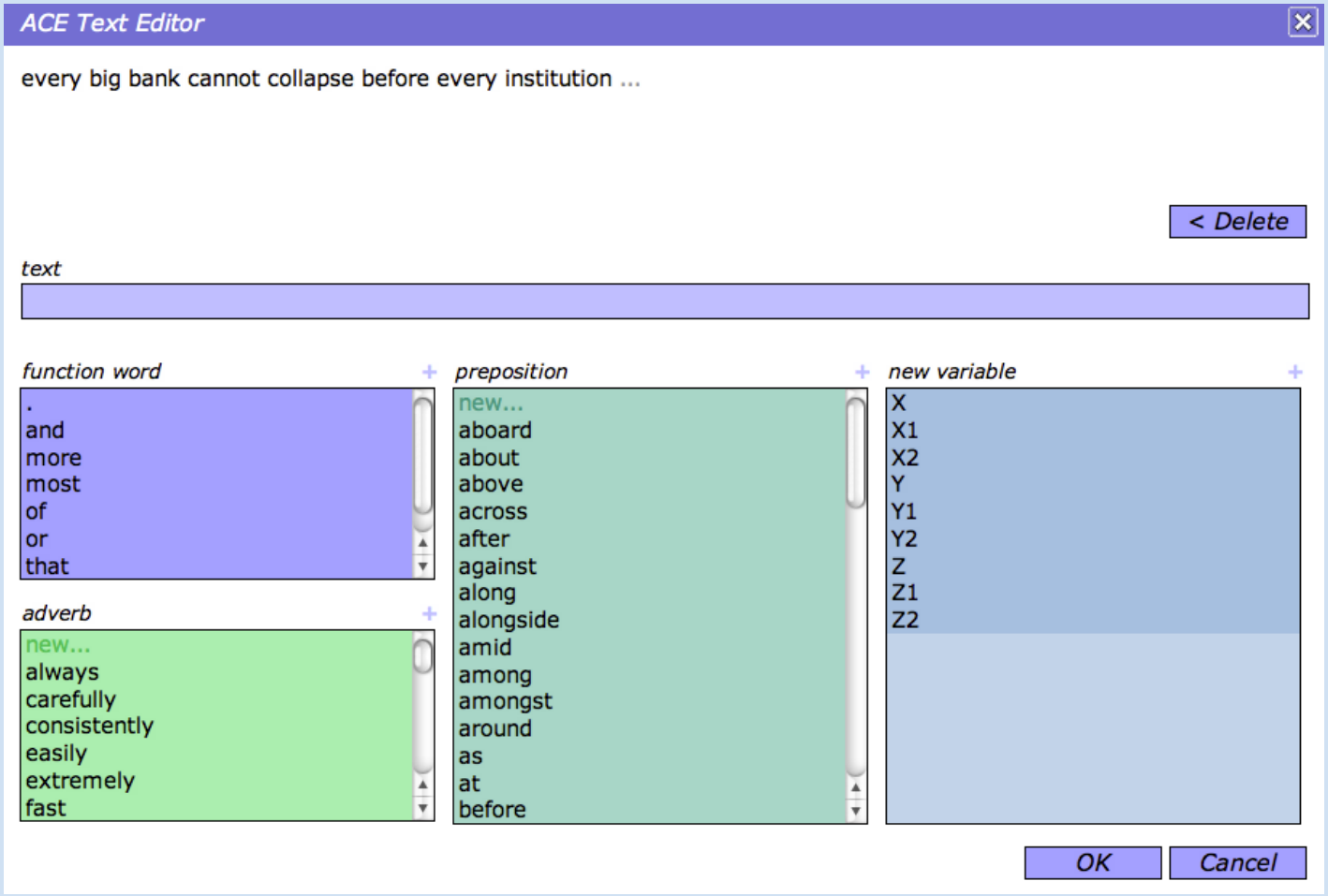
ACE Editor Example



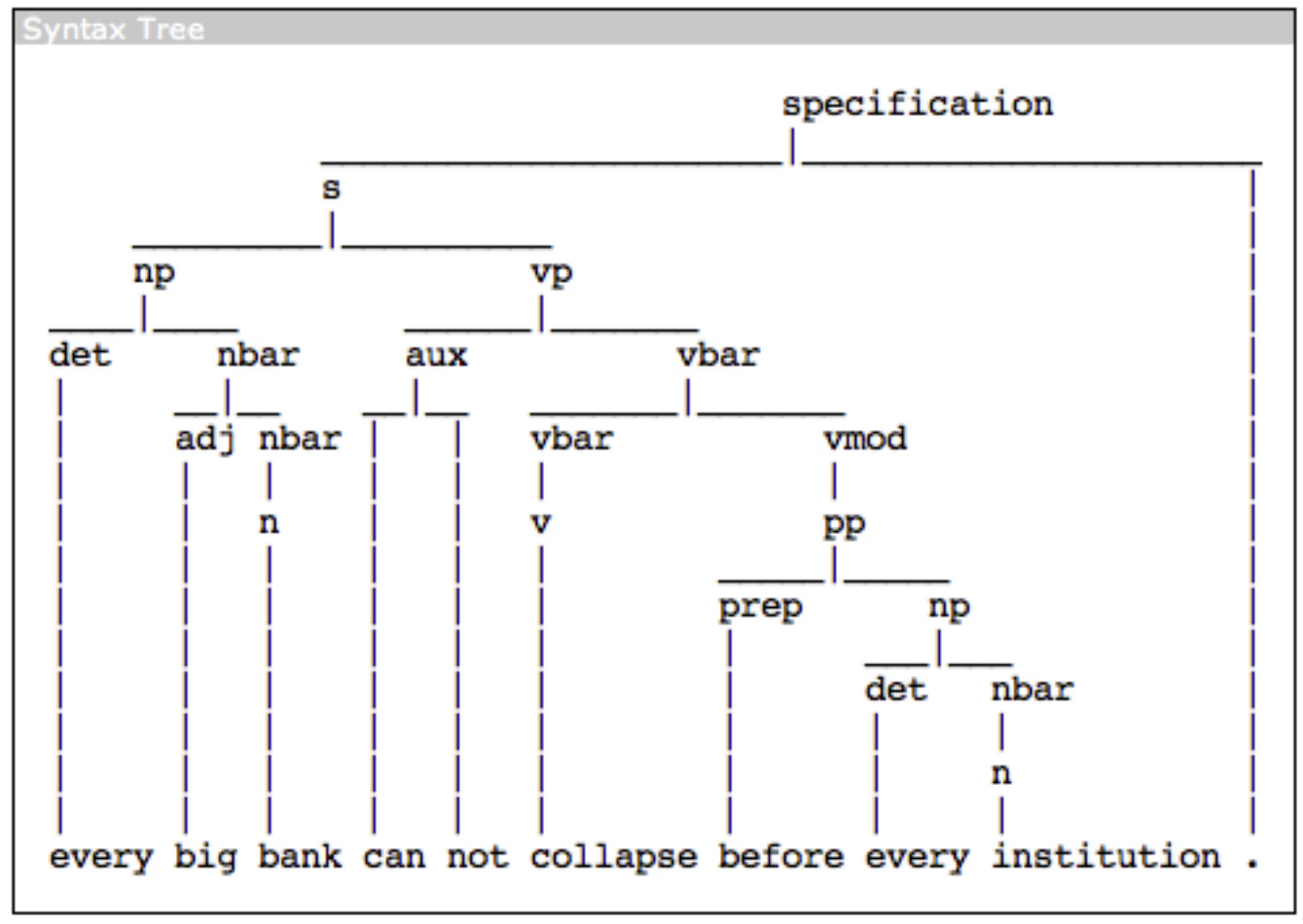
ACE Editor Example



ACE Editor Example



ACE Syntax Tree



ACE DRS

Pretty-Printed DRS

```
[]
    [A]
    object(A,bank,countable,na,eq,1)-1/3
    property(A,big,pos)-1/2
    =>
    []
        NOT
        []
            CAN
            []
                [B]
                object(B,institution,countable,na,eq,1)-1/9
                =>
                [C]
                predicate(C,collapse,A)-1/6
                modifier_pp(C,before,B)-1/7
```

ACE DRS XML

```
<DRS domain="">
  <Implication>
    <DRS domain="A">
      <object
          ref="A"
          noun="bank"
          struct="countable"
          unit="na"
          numrel="eq"
          num="1"
          sentid="1"
          tokid="3"/>
      <property ref="A" adj="big" degree="pos" sentid="1" tokid="2"/>
    </DRS>
    <DRS domain="">
      <Negation>
        <DRS domain="">
          <Possibility>
            <DRS domain="">
              <Implication>
                <DRS domain="B">
                  <object
                      ref="B"
                      noun="institution"
                      struct="countable"
                      unit="na"
                      numrel="eq"
                      num="1"
                      sentid="1"
                      tokid="9"/>
                </DRS>
                <DRS domain="C">
                  <predicate ref="C" verb="collapse" subj="A" sentid="1" tokid="6"/>
                  <modifier_pp ref="C" prep="before" obj="B" sentid="1" tokid="7"/>
                </DRS>
              </Implication>
            </DRS>
          </Possibility>
        </DRS>
      </Negation>
    </DRS>
  </Implication>
</DRS>
```

ACE FOL

```
forall (A,=> (& (object(B,A,bank,countable,na,eq,1)-1/3, property(B,A,big,pos)-1/2),
-(exists (C,&(accessibility_relation(B,C)-accessibility_relation/0,
forall(D,=> (object (C,D,institution,countable,na,eq,1)-1/9,
exists (E, & (predicate(C,E,collapse,A)-1/6,modifier_pp(C,E,before,D)-1/7)))))))))
```

ACE RuleML

```
<RuleML>
  <Assert>
    <Forall>
      <Var>_G431</Var>
      <Implies>
        <Atom>
          <Rel>object</Rel>
          <Var>_G431</Var>
          <Ind>customer</Ind>
          <Ind>countable</Ind>
          <Ind>na</Ind>
          <Ind>eq</Ind>
          <Data>1</Data>
        </Atom>
        <Exists>
          <Var>_G1557</Var>
          <Var>_G1280</Var>
          <And>
            <Atom>
              <Rel>property</Rel>
              <Var>_G1557</Var>
              <Ind>important</Ind>
              <Ind>pos</Ind>
            </Atom>
            <Atom>
              <Rel>predicate</Rel>
              <Var>_G1280</Var>
              <Ind>be</Ind>
              <Var>_G431</Var>
              <Var>_G1557</Var>
            </Atom>
          </And>
        </Exists>
      </Implies>
    </Forall>
  </Assert>
</RuleML>
```

ACE Query

Axioms: Every man is a human. Every woman is a human. Mary is a woman. John is a man. Jill is a woman.

Query: Who is a woman and is a human?

Parameters:

ACE Answers

- Subset 3
  - 2: Every woman is a human.
  - 3: Mary is a woman.
  - Substitution: who = Mary
- Subset 4
  - 2: Every woman is a human.
  - 5: Jill is a woman.
  - Substitution: who = (at least 1) human
- Subset 5
  - 2: Every woman is a human.
  - 5: Jill is a woman.
  - Substitution: who = (at least 1) woman
- Subset 6
  - 2: Every woman is a human.
  - 5: Jill is a woman.
  - Substitution: who = Jill

ACE Inference

INPUT

```
Every woman is a human.  Mary is a woman.  Jill is a woman.
```

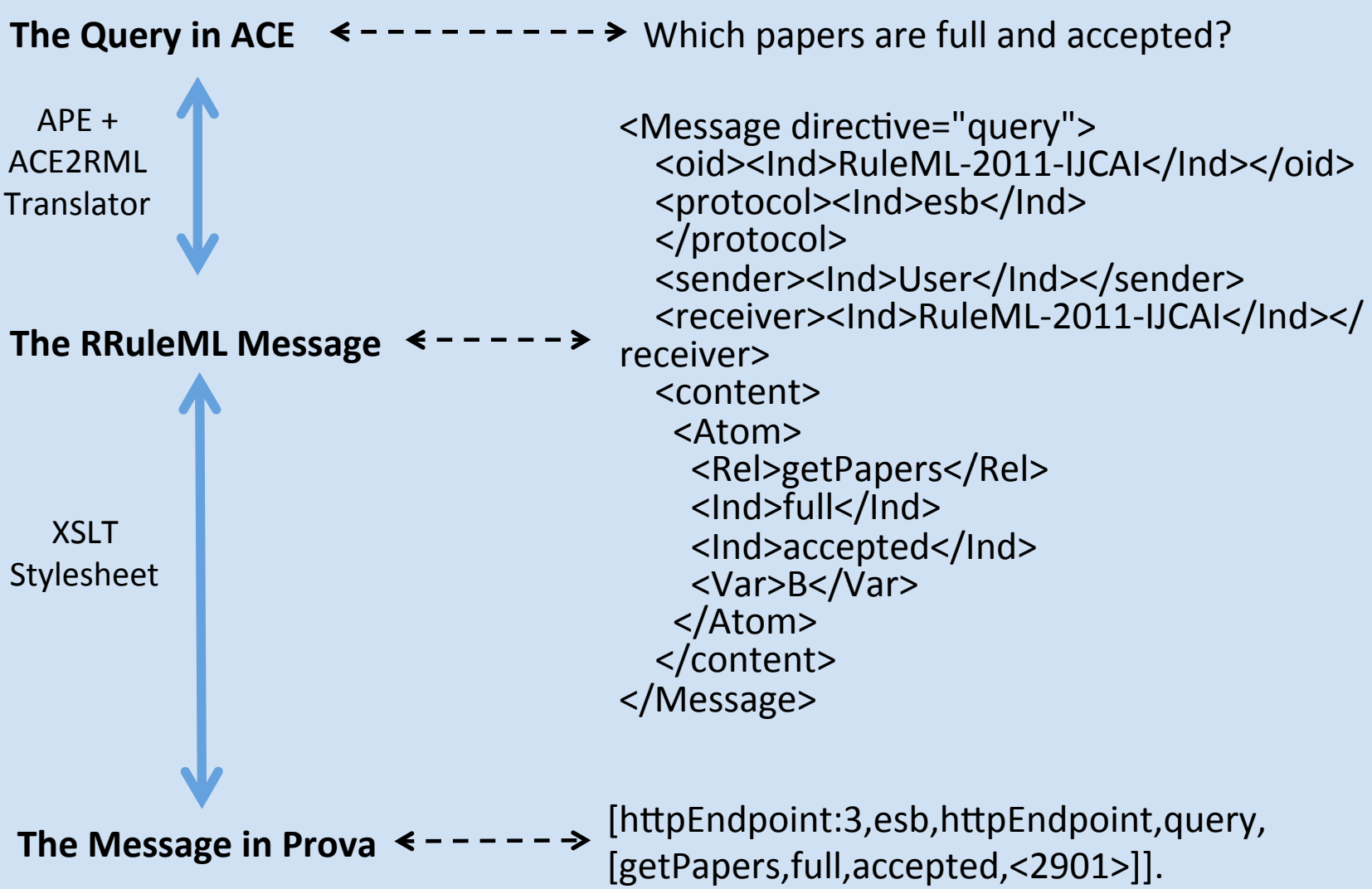
ANSWER TEXT 1

```
Mary is a woman.
Jill is a woman.
Mary is a human.
Jill is a human.
```

Applications

- SymposiumPlanner Q&A.
  - http://ruleml.org/SymposiumPlanner/
- Building OWL ontologies and SWRL rules in Protege.
  - http://protege.stanford.edu/

SymposiumPlanner



Question and DB Input

- Which papers are full and accepted?

DB that can be queried:

- "RuleML for Farming" is a paper.
- "RuleML for Farming" is full.
- "RuleML for Farming" is accepted.
- "RuleML for Beer Brewing" is a paper.
- "RuleML for Beer Brewing" is full.
- "RuleML for Beer Brewing" is accepted.
- "RuleML for Biomolecular Processes" is a paper.
- "RuleML for Biomolecular Processes" is accepted.
- "RuleML for Chemical Manufacture" is a paper.

ACE Problems

- Input well-formed sentence that is meaningful to the user, but the semantic interpretation is not quite what one wants.
- Wyner, van Engers, and Bahreini (2010) From Policy-making Statements to First-order Logic
  - http://wyner.info/research/Papers/WynerVanEngersBahreini2010.pdf
- Input well-formed 'junk', since there is not enough semantic control between words – entered in ACE Editor.
  - A more bad and most authenticated address cannot boil extremely alongside no declaration that ages amongst Austria.
- Declarative or interrogative sentences are third person and simple present tense.
- No thematic roles, no tenses, no aspects,....
- Moral is that if you are well-behaved and pay close attention, it will help you.

Other Examples

- Extracted sentences from Hirtle's thesis, RuleML Primers, RuleML slides.
- Not everything is well-formed and/or unproblematic in ACE.
  - Peter Miller's spending has been min 5000 euro in the previous year.
  - Peter Miller spent at least 5000 eruos in the previous year.

  Gerund, where a verb appears in a nominal form.
  - The discount for a customer buying a product is 5 percent if the customer is premium and the product is regular.
  - If a customer is premium and a product is regular, then the discount for the customer buying the product is 5 percent.

  Not parseable for lexical issues and punctuation. Clause order issues.
- And other issues....

Other Examples

- Sentences tested using a local installation of ACE.
  - If a customer is a student then she receives a discount of five percent or the customer receives 200 dollars.
  - It is necessary that a customer is satisfied.
  - Mary knows that a customer should be satisfied.
  - Mary sends the check to Bill.
  - Mary sends the check to Bill on Tuesday.

C&C/Boxer

- C&C/Boxer
  - http://svn.ask.it.usyd.edu.au/trac/candc/
- GMB Webdemo
  - https://urd.let.rug.nl/basile/gsb/webdemo/demo.php
- Groningen Meaning Bank
  - http://gmb.let.rug.nl/
- Thanks to Valerio Basile and Johan Bos.

C&C/Boxer

- Lexically given grammar (how words combine).
- Uses a statistical model to output the most likely parse.
- Successful wide-coverage (of the Penn Treebank corpus). Parses and semantically represents more than ACE.
- Translates to DRS (FOL).
- Nutcracker inference tool (textual entailment th).
- Translation to RuleML.
- Issues of interpretation increased.

C&C/Boxer Example

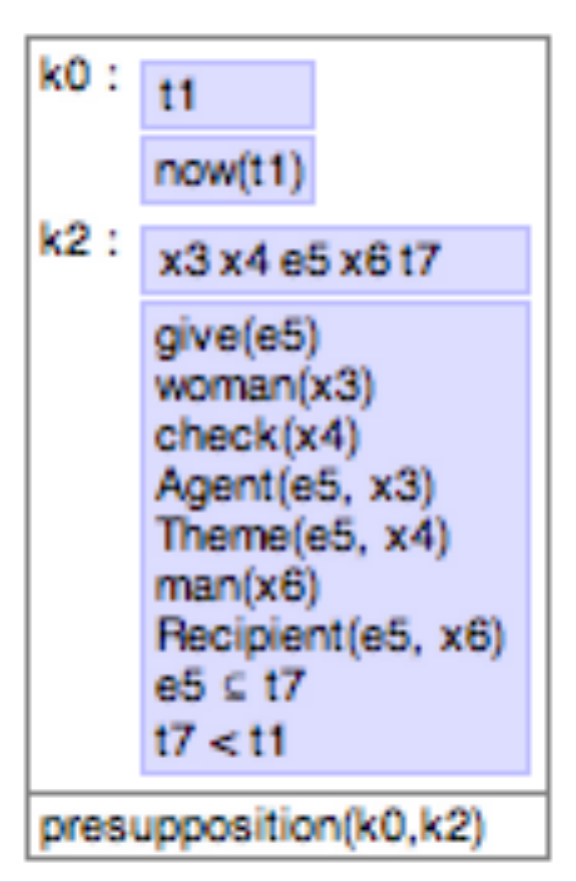
- David Cameron is a British citizen.
- The woman gave a check to a man

- https://urd.let.rug.nl/basile/gsb/webdemo/demo.php

- Examples with or without thematic roles or tense. No thematic roles in RuleML – 'flat' predicate argument structure.

C&C/Boxer Example

- The woman should have given a check to the man



∃ A : ∃ B : ∃ C : ∃ D : (n1woman(A) ∧ (n1check(B) ∧ (v1give(C) ∧ (r1agent(C,A) ∧ (r1patient(C,B) ∧ (n1man(D) ∧ r1to(C,D)))))))

RuleML version removes temporal and event arguments as well as temporal relations. Event argument remains as bound variable. Leaves thematic roles.

Other Examples Tested

- Reaction RuleML
  - A customer gets a discount of 7.5 percent to be deducted from each purchase of a product, starting on July 1st, 2012 and ending on December 31st, 2012, if the customer is premium and the product is luxury.
- RuleML Inc Discount
  - RuleML Inc discount contract: According to this contract, which is applicable in all member states of the European Union, a RuleML Inc customer gets a discount of 7.5 percent to be deducted from each purchase of a RuleML Inc product starting on July 1st, 2012 and ending on December 31st, 2012 if the customer is premium and the product is luxury.
- Citizen
  - A British overseas territories citizen who falls to be treated as a national of the United Kingdom for the purposes of the Community Treaties shall be entitled to be registered as a British citizen if an application is made for his registration as such a citizen.
- Vehicle
  - Vehicles are not permitted in this park.

Modals

- Alethic (necessity, ...), Epistemic (know, ...), Temporal, Deontic (must, may, ...).
- Subclasses of modal operators and propositional attitudes with different inference properties. Why are these not relations rather than sentential operators?
  - Factive – know, saw, heard,...
  - Non-factive – believe, remember (?),...
  - Contrafactive – wish, imagine, ...
  - Epistemic-root interpretation – may, must, can,....
  - Scope issues with de re/de dicto.

Issue

- Representational correspondence and/or redundancy.
- Example, NL semantics uses event arguments to tie together the representation of terms with respect to a predicate, not flat, labelled arguments (compare to OrdLab graphs).
- Different typing of expressions (data, individual, relation).
- How to handle Production, Trigger, and ECA rules? Some lexical, some structural?

Using SBVR in C&C/Boxer

- Semantics of Business Vocabulary and Rules.
  - http://www.omg.org/spec/SBVR/1.0/

Comments on Interpretation

- Issues about statutory and judicial interpretation.
- Interpretive guidelines to resolve vagueness, ambiguity, contexts of use.
- There is literature and practice guidelines (e.g. UK and USA) about how legislation *ought* to be written to avoid problematic interpretation:
  - Solan (2010) *The Language of Statues: Laws and Their Interpretation*
  - Stephen Hofler (2012) *Legislative Drafting Guidelines.*

Comments on Interpretation

- ACE and C&C/Boxer parse text (deterministically or statistically).
- Given a parse, we get a translation to a semantic representation.
- The tools are neutral about about vagueness and interpretation. Some may make lexical semantic interpretations.
- They do contribute to issues bearing on a formal semantic representation, e.g. quantifier or negation scope, binding, subordination. There are some instances where someone is 'hung upon a comma', but Solan argues this is relatively rare.
- Interpretation as refinement or embedding.
- Perhaps have multi-parsing tools to maintain ambiguity.
  - Quelo: a NL-based Intelligent Query Interface

Future work

- Close evaluation of parses, semantic translations, and conversion to RuleML.
- Compare and contrast outputs.
- Extension and application of ACE and GMB. For example, extract the vocabulary and structures from SBVR or see what is/is not available in ACE or GMB.
- Corpus development.
- Gold standards for ACE or GMB.
- Applications
  - Ontologies
  - Knowledge bases
  - Business and policy rule systems

Acknowledgements

- Thanks to RuleML organisers for the invitation.
- Thanks for support to FP7-ICT-2009-4 Programme, IMPACT Project, Grant Agreement Number 247228.
- Thanks to colleagues who developed ACE and C&C/Boxer.

Thanks for your attention!

- Questions?
- Contacts: Adam Wyner adam@wyner.info
- Join Adrian Paschke and I for further discussion of Natural Language Interfaces to RuleML over dinner in a downtown Montpellier restaurant at 20:30. Location TBA.