How Formal Logic Can Fail to be Useful for Modelling or Designing MAS

Bruce Edmonds (2002)

Paper presented by Beerend Lauwers

October 1, 2012

Outline

Introduction
- Motivation
- Some History

Problems with generalization
- Generalization of logics
- High-level theories

Problems with the type of logics
- What logics are suitable?
- The audience
- Arguments for formalism

How to go forward?

Bruce Edmond's motivation

- Formal systems are only a tool, not the content
- Choosing the wrong system introduces biases
- New formal systems should prove themselves!

Some History

- 1962: Whitehead and Russell prove that set theory can be formalised with first-order predicate logic
- Many different logics emerge, with two camps:
  - Philosophical approach
    - Concentration on axioms of the logic
    - Proof theory and formal semantic "more of an afterthought"
    - Intuitionistic logic, Free logic, Relevance logic, Modal logic
  - Pragmatic approach
    - Extensions of first-order predicate logic
    - Practically-oriented: Semantics checkable, easy to model, inference, do computation with?
    - SDML as an example
- First approach appears more popular and AI and MAS
- Logics are compared and discussed based only on a small set of properties
- Edmonds argues against this approach: not useful for understanding or building MAS!

Generalization of logics

- General theories appear to be preferred
- Three common ways to generalize (and their costs!):

1. Abstract away from details, only look at broad domain truths **(post-hoc abstraction)**
   - Loss of information by ignoring particular cases!
   - Information may be crucial to your research goal!
2. Determine structure beforehand, ignore contradicting cases **(a priori abstraction)**
   - Loss of relevance!
   - May exclude what you're researching!
3. Allow for adaptation to particular cases **(adaptive generality)**
   - Computationally expensive: may be unrealistic!

- Philosophical approach tends to generalize fruitlessly

Edmond's arguments against needless generalization

- Increased generality isn't a necessity
- Thinking up new logics is usually a better idea
- OTOH, choosing an incorrect specific formal system biases development of one's theory!
- **Conclusion:** Comparing systems by their level of expressivity is a weak justification
  - The generalized version also supports it
  - Easy to go wrong with it
- But of course, we still need these formal systems!

High-level theories

- Highly generalized logics aren't the way to go
  - Too general to be useful
  - Too complex to be insightful
- Any such proposed 'high-level' theories should be scrutinized
- Intermediate levels of abstraction work very well, too
- Established theories and methods are still up in the air
- Some papers seem to think otherwise, assuming their foundations to be established and proven

What logics *are* suited for MAS?

- In the past:
  - Non-temporal
    - Example: BDI logic's temporal element is implicit
    - Using a single state (timewise) is bound to lead to problems
  - Context-independent
    - Reasoning about norms, goals, etc. requires knowledge of contexts
  - Propositional
    - Most proposed logics do not support numbers
    - Gödel's incompleteness theorem is the culprit here
    - But we can never prove all of a MAS' properties anyway!
  - Lack of formal semantics
    - Philosophical approach emphasises 'meaning'
    - Surely formal semantics are important, then?
- Abstracting away from time, context and numbers to get a general theory?
  - Onus is upon the authors that it is valuable
- Better would be to use:
  - Temporal
  - Contextual
  - Predicate
- More complex, but MAS aren't simple systems!

The audience

- People first want to know if a work is worth learning: communication is paramount!
- Formal logic is claimed to aid communication
- It may be precise, but aiding in communication?
  - Logics require some knowledge to understand
- Most people are used to this kind of approach, aiding acceptance of papers
- Some of the papers were simply unproved ideas and intuitions
- Papers that do not show the usefulness of a formalism prevent the audience from evaluating it properly
- Using a formal system to model a realistic MAS will prove more valuable than intuition-based papers

Arguments for formalism

- Edmonds doesn't want to inhibit experimentation with new logics
- But the relevance of new formal systems has to be demonstrated
- Some papers don't solve particular problems but also refrain from formal theorems and proofs - unacceptable!
- Cheap computational power allows for quicker experimentation

How to go forward?

More pragmatic approach:

- Begin with less abstract models, chain models of different levels of abstraction together
- Sceptical view at unproved abstract theories
- Similarly for papers based on intuition and nothing else
- Papers suggesting formal systems for MAS should provide a demo MAS

A 'shortcut' to a powerful high-level theory (to bypass the empirical work required) may be nice, but is unrealistic and doesn't provide the necessary chain of abstractions to guide further search.