Norms for Typing MAS Multi-Agent Systems

(Article begins on next page)

Normative Multi-Agent Systems: NorMAS 2013

Norms for Typing MAS

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Overview

B2B, cross-business, open environment systems

- Software infrastructures: more and more global, pervasive and autonomic
- Computing is becoming ubiquitous, with embedded and distributed devices interacting with each other
- MAS have been recognized to be a promising paradigm for this kind of scenarios

Typing Systems

> **HOWEVER**
>
> The more the complexity of programming these systems will increase, the more the need for effective tools for reasoning on properties of programs is noticed

> **Types**
>
> provide abstractions to perform sophisticated forms of program analysis and verifications that help programmers to face the complexity of their job
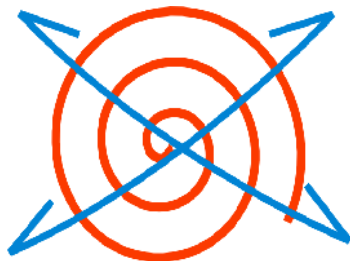
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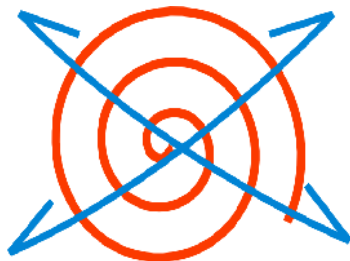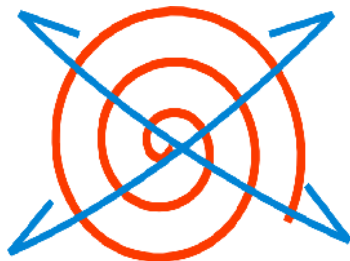- Enable compile time/runtime error checking
- Conceptual and abstraction tools for modeling
- Documentation
- Conformance and compliance
- Reasoning about programs and components
- Type checking as a simple form of (a priori/runtime) verification

Typing Systems for MAS

- Here we focus on two more recent proposals:

Global Session Types in Jason

- By D. Ancona, S. Drossopoulou, and V. Mascardi [Ancona et al., 2012, Ancona et al., 2013]
- Behavioral types for multiparty interactions
- Monitoring agent that verifies (dinamically) the conformance of interacting agents w.r.t. a global session type

simpAL

- By A. Ricci and A. Santi [Ricci and Santi, 2012a, Ricci and Santi, 2012b]
- An agent-oriented programming language with types checking inspired by main stream OO languages
- Static type checking for error detection

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Global Session Types in Jason

- Inspired by Scribble, in [Ancona et al., 2012, Ancona et al., 2013] protocols are the key aspect
- Protocols are expressed by means of global session types
- Jason is extended in order to automatically generate an agent monitor for dynamic conformance (compliance) verification
- Cyclic Prolog terms

Global Session Types in Jason

- Global session types are "*procedural*" types (process abstraction), so they do not:
  - ▶ respect autonomy of agents
  - ▶ clearly espress what is expected from a role and what is possible for a role

- Who is the agent monitor? Who trusts it? Should all messages/actions be notified to it? How to guarantee this fact?

- Lack of a *normative* characterization of coordination [Castelfranchi, 1997, Singh, 1999], so that the publicly acceptance of the regulation allows reasoning about agents' behavior [Conte et al., 1998]

simpAL

- Inspired by main stream OO languages, in
  [Ricci and Santi, 2012a, Ricci and Santi, 2012b] static type checking
  for error detection is the key aspect
- Builds on the experience of JaCaMo
- role, usage-interface, org-model: interfaces
- agent-script, artifact, org: implementations

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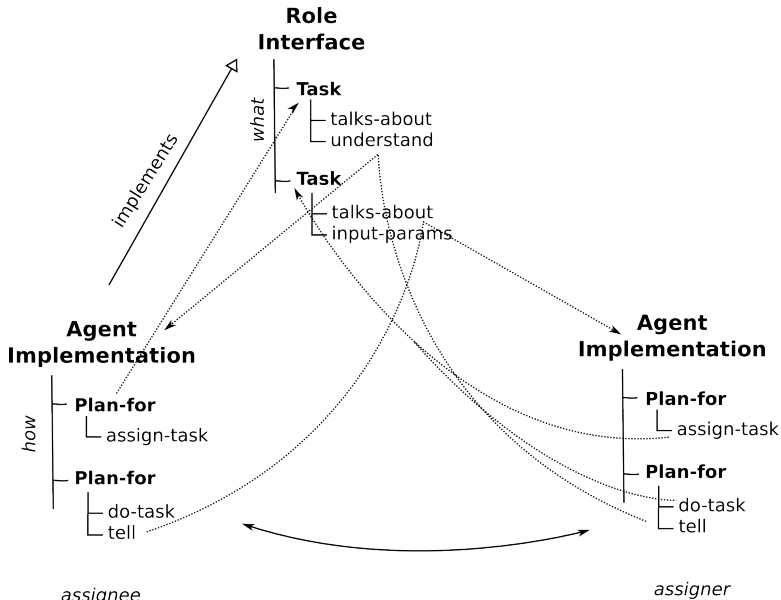
- Static vs dynamic type systems: is compile time checking the key point? Sometimes this is not good also for OO languages (eg. downcasting)
- Types or ontological reasoning?
- Are roles mere agent interfaces?
- What is the semantics of types? Is type checking only a syntactic matching?

Commitment

$$C(x, y, r, p)$$

represents the engagement from x to y, to bring about the consequent condition p when the antecedent condition r holds.

- Commitments have a normative nature: agents are liable for the violation of the commitments they have taken
- Commitment protocols allow for flexible behaviours: x is free to choose its actions
- The agent's compliance can be verified by *observing* the interaction

Commitment-based protocols

A commitment-based protocol is a **set of actions** whose meaning in terms of effects on the social state is agreed upon by all the interacting agents.
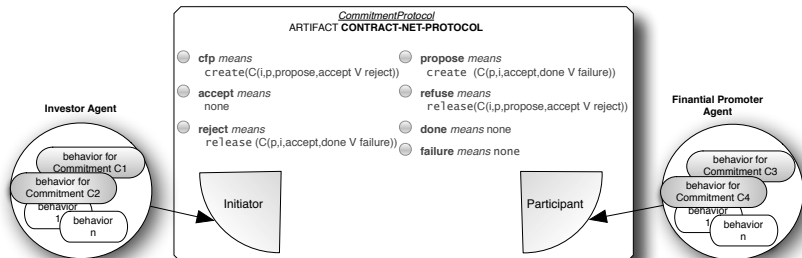
Actions definition

action **means** effects **if** *condition*

The *means* construct captures which *physical* events count as which *social* events

- **means:** introduces the social effects
- **if:** condition for the action to have the intended meaning

Commitment-based protocols

- An agent/initiator should be able to *accept* or *refuse* a proposal
- An agent/participant should be able to complete the assigned task (*done*) or to communicate its *failure*

Commitment-based protocols
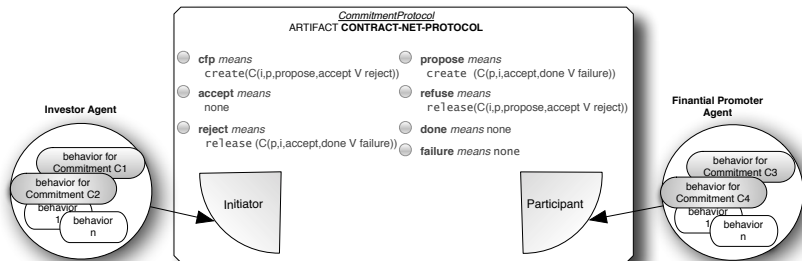
Organizational Roles
[Baldoni et al., 2007, Boella and van der Torre, 2007]

- *Foundation*, *definitional dependence*, and *institutional empowerment*
- *Requirements* (ability to satisfy own commitments) and *powers* (action with a institutional meaning)
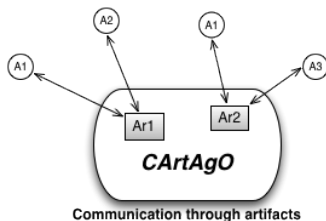
Mercurio [Baldoni et al., 2011]

- Integrating JADE with support for indirect communication
- According to Keil and Goldin, indirect communication fosters the collaboration and the coordination inside open systems
- PrThe adoption of programmable communication channels allows the specification of a normative facet that applies to the agents that are involved in the interaction
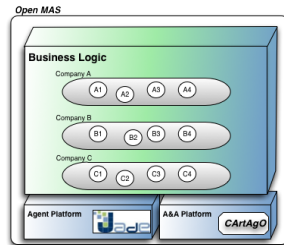
Mercurio [Baldoni et al., 2011]

- Artifact abstraction [Weyns et al., 2007, Omicini et al., 2008]: first-class entity, i.e. non-agent dynamic and programmable resource, that an agent can use, perceive, observe
- Artifacts can provide mediated, indirect communication to agents
- Designers can leverage artifacts to explicitly model interaction protocols, defining a social agreement accepted by agents using them

Communication through artifacts

Mercurio [Baldoni et al., 2011]

- Artifacts, as programmable indirect communication channels, can reify and implement normative characterization and social expectation

- Such an artifact entails mutual, social dependencies between agents using it

- We model social dependencies as commitments
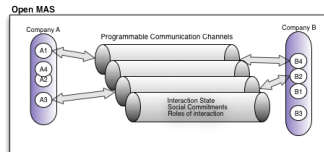
2COMM [Baldoni et al., 2013]

- 2COMM: reifying commitment protocols in JADE by means of CArtAgO framework [Ricci et al., 2009]

2COMM [Baldoni et al., 2013]
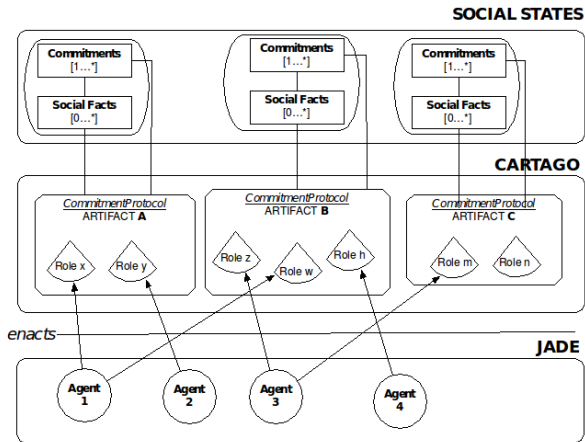
- An agent can use a communication artifact enacting a role
- A role represents the interface between the artifact and the agent using it
- When acting as a certain role, an agent's actions impact on the interaction state

Type checking via commitments
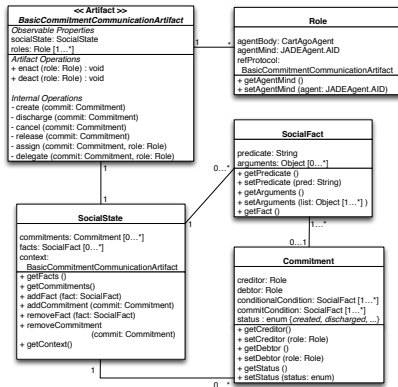
Type checking with commitments
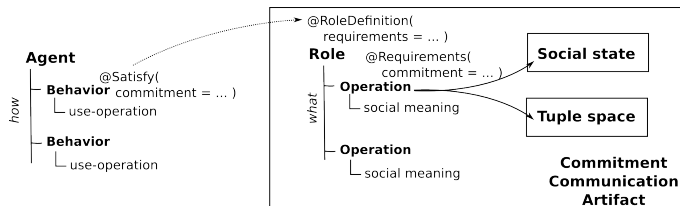
- Type checking by means of Java Annotations
- Dynamic type checking: behaviors must comply to requirements (java reflection is used)
- Type system as a logic "theory" of commitments
- Commitment to regulation [Marengo et al., 2011]: regulating how

Conclusion

- Dynamic vs static type checking
- Conformance as logic entailment
- Compliance: programmable communication channel with monitoring functionalities
- A normative value thanks to commitment-based approach
- Flexibility and openess typical of MAS
- Modularity and compositionality typical of design and development methodologies
- Enable a business level architecture as fostered in [Chopra and Singh, 2009]

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