On Programming Organization-Aware Agents

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Background

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  - Can act and sense in their environment
  - They are:
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    - Reactive
    - Autonomous
    - Social
  - Beliefs, Desires and Intentions (BDI)

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- Multi-agent systems

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- Multi-agent systems
  - Multiple agents
  - The whole is greater than the sum of its parts

Motivation

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- How to respect (or deliberately ignore) organization?
  - Middleware
  - Reasoning capabilities $\Longrightarrow$ **Organization-aware agents**

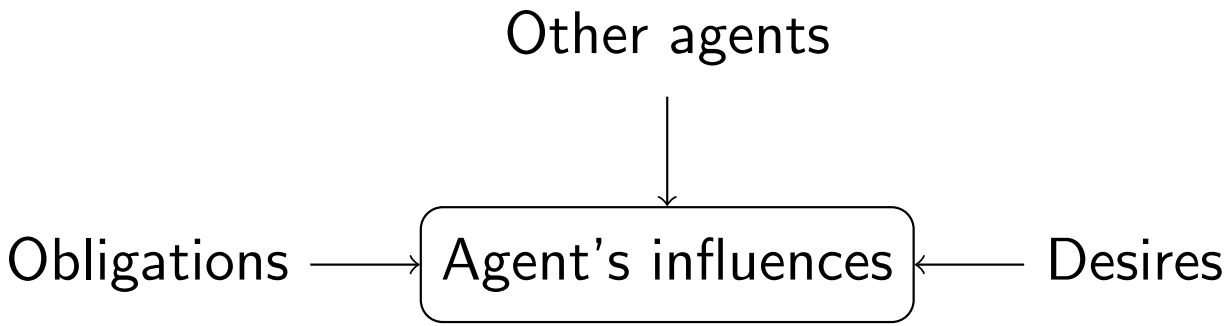
Aim & Approach

- Main goal: Organization-Aware Agents
- Theoretical
  - Organizational models: OperA – MOISE^+ – ISLANDER
  - Specification and verification: Logic of Agent Organizations
- Practical
  - Agent frameworks: *Jason* – GOAL – Jadex

Results

- Conflicts in decision making
  - *Deciding Between Conflicting Influences. Andreas Schmidt Jensen. In Engineering Multi-Agent Systems, volume 8245 of Lecture Notes in Computer Science. Springer, 2013 (to appear).*
- Formalizing organizational models
  - *Formalizing Theatrical Performances Using Multi-Agent Organizations. Andreas Schmidt Jensen, Johannes Spurkeland & Jørgen Villadsen. In Proceedings of the 12th Scandinavian AI Conference, 2013.*
- Organizational reasoning
  - *Dimensions of Organizational Coordination. Andreas Schmidt Jensen, Huib Aldewereld & Virginia Dignum. In Proceedings of the 25th Benelux Conference on Artificial Intelligence, p. 80-87, 2013.*
- Adding Organizational Reasoning to Agents
  - *AORTA: Adding Organizational Reasoning To Agents. Andreas Schmidt Jensen & Virginia Dignum. Submitted for the 13th International Conference on Autonomous Agents and Multiagent Systems.*

Conflicts in decision making



Conflicts in decision making

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Better: Consequences of being in different situations

- $\neg work \rightarrow fired$
- $work \rightarrow \neg fired$

Conflicts in decision making

- Conflicts arise in the agent deliberation process
- Rules of preference and expectation are specified
- Model generation
- Conflicts resolved using expected consequences
  - In some cases the agent violates its obligation.
  - In other cases it ignores its desire.

Formalizing organizational models

- Formal model required for agent reasoning
  - Models such as OperA and MOISE^+
- We have shown correspondence with certain improvisational theatrical performances (my talk tomorrow)
- Multi-agent programming languages based on variants of Prolog (*Jason*, GOAL)

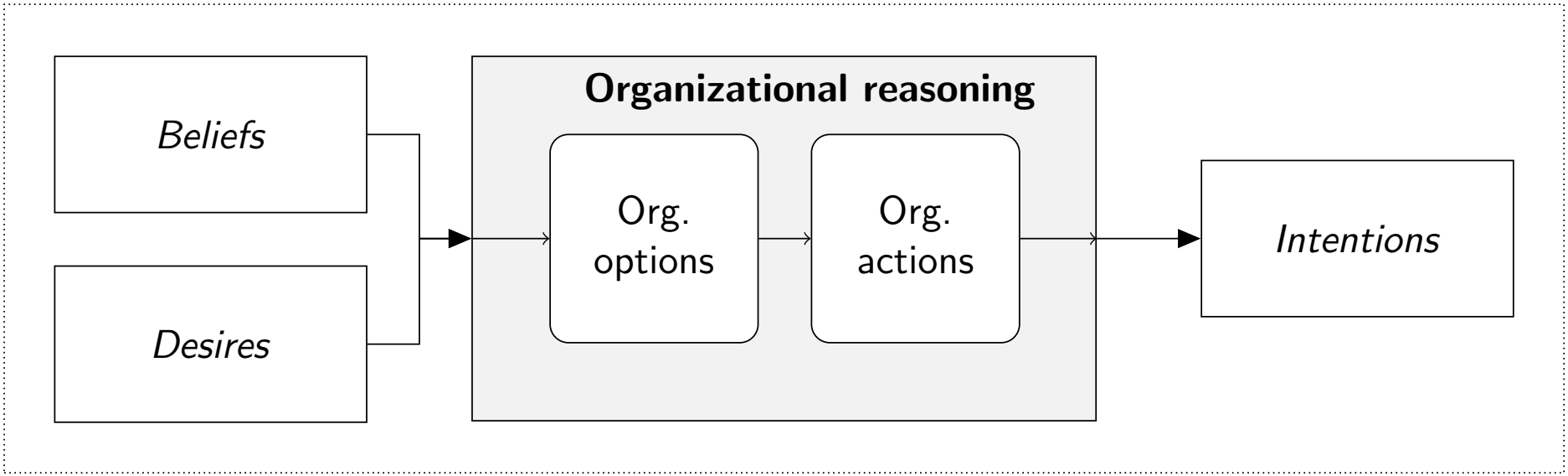
Formalizing organizational models

Predicate	**Description**
$role(r, O)$	Role r with objectives O.
$dependency(r_1, r_2, o, t)$	Dependency between roles r_1 and r_2 for objective o and dependency type t.
$scene(s, R, Res)$	Scene script s with roles R and results Res.
$rea(a, r, s)$	Agent a enacts role r in scene s.
...	

Formalizing organizational models

```
responsible(Obj, Scene, Role) :-
        scene(Scene, Roles, Objectives),
        member(Role, Roles), member(Obj, Objectives),
        role(Role, RoleObjectives), member(Obj, RoleObjectives).

delegate(Me, Objective, Scene, OtherAg, Type) :-
        rea(Me, MyRole, Scene), rea(OtherAg, OtherRole, Scene),
        dependency(MyRole, OtherRole, Objectives, Type),
        member(Objective, Objectives).
```

Organizational reasoning



Organizational reasoning in GOAL

Option consideration and organizational deliberation:

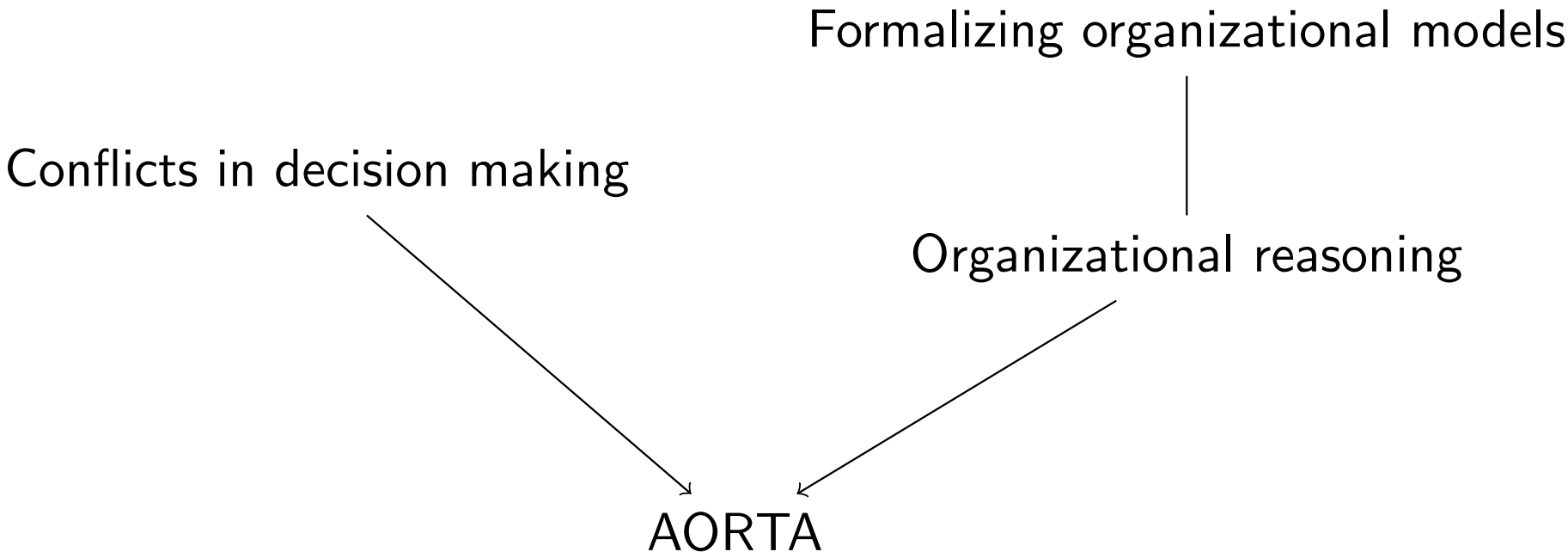
```
forall bel(rea(A,R,S), responsible(O,S,R), active(O))
do insert(option(A,O,S)).

if bel(option(_,injuredLocated,_)) then adopt(injuredLocated).
```

Delegation:

```
if a-goal(in(X)), bel(room_blocked(X), rea(Me,R,S),
                      delegate(Me,blockingFanRemoved,S,Other,_))
then send(Other, !do(blockingFanRemoved)).
```

Same objective:

```
forall a-goal(injuredLocated), bel(rea(A,R,S),
                      responsible(injuredLocated,S,R)) do {
    forall <injured found> do send(A, <location>).
    forall <room checked> do send(A, <room>).  }
```


Formalizing organizational models
Conflicts in decision making
Organizational reasoning
AORTA

AORTA: Adding Organizational Reasoning to Agents

- Organizational formulas
  - $\text{org}(\text{objective}(\mathit{injuredFound}, \mathit{medic})) \wedge \neg\text{bel}(\mathit{injuredFound})$
- Actions
  - $\text{consider}(\phi)$, $\text{enact}(\alpha, \rho)$, ...
- Reasoning rules
  - $\text{org}(\text{role}(r, Os) \wedge \forall o(o \in Os \rightarrow \text{bel}(\text{cap}(o))) \Rightarrow \text{consider}(\text{rea}(\alpha, r))$
- Transitions
  - $$\frac{\rho \Longrightarrow a_O \in OR \qquad \langle \Sigma, \kappa, \sigma, \gamma \rangle \models_{\mathscr{L}_R} \rho \qquad \mathscr{T}_O(a_O, \kappa, \sigma, \gamma) = \gamma'}{\langle \Sigma, \kappa, \sigma, \gamma \rangle \longrightarrow \langle \Sigma, \kappa, \sigma, \gamma' \rangle}$$

Ongoing & Future work

- AORTA
  - Prototype
  - Integration with existing tools (e.g. GOAL)
  - Verification
- Deciding between organizational and agent objectives
  - The multi-agent case
  - Allow for more expressive objectives and consequences
  - Integrate with AORTA
- Applications
  - Computer games (e.g. real-time strategy)
  - Theatrical improvisation

Thank you for your attention