Programming Open Systems with Agents, Environments and Organizations

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Outline

1. Introduction

2. Embodied Organisations: Abstract Model

3. Embodied Organisation Implantation in Moise Framework and CArtAgO Platform

4. Conclusion
Current Issues in MAS Programming

- Seamless integration of multiple entities and mechanisms
- Interaction, Openness
Current Approaches in MAS Programming

Introduction
Embodied Organisations:
Abstract Model
Embodied Organisation Implantation in Moise Framework and CArtAgO Platform
Conclusion
Current Approaches in MAS Programming

Embodied Organizations: Abstract Model

Current Approaches in MAS Programming: AGENT(S)

AGT(S) [Bordini et al., 2007], Jadex [Pokahr et al., 2005], 2APL [Dastani, 2008], etc.

ORGANIZATION

AGR/MADKIT [Ferber et al., 2003], 2OPL [Baldoni et al., 2008], Electronic Institutions [Esteva et al., 2004], S-MOISE + [Hübner et al., 2005], OPERA [Dignum, 2003], etc.

ENVIRONMENT

CArtAgO [Ricci et al., 2010], GOLEM [Bromuri and Stathis, 2007], MASQ, AGRE [Stratulat et al., 2009, Báez-Barranco et al., 2006], Normative Objects [Okuyama et al., 2009], Situated Electronic Institutions [Campos et al., 2008], Brahms [Sierhuis, 2001] etc.
A-E-O Integrations
The Idea: **Embodied Organisations**

Human Organisations Analogy

- instrumentation of the environment with specific Infrastructures that are explicitly conceived for easing humans’ activities/tasks in organisations [Kirsh, 1995].

Hospital Scenario Example:

- A visitor entering the hospital has not a complete knowledge of the organisation behind
- Visitors (as users) ignore the mechanisms and the structures at the basis of the organisation
- Nonetheless, visitors find those things which they are interested in, means to achieve their goals finally
Expected Outcomes

Integration and Synergy between E and O

- enabling agents to profitably interact with both organisation and other environmental entities;
- enabling organisation to control agents and regiment environmental resources;
- allowing environmental changes to affect both organisation dynamics and agents activities;

→ At the application level, possibility:

- To reconcile agents and their work environments with institutional dimensions (i.e. organisations);
- To exploit a strong notion of agency, i.e., mental attitudes (purposes, knowledge), events, perception
- To cope with Interoperability and Openness
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Constitutive Rules [Searle, 1964]

- Typical of human societies (*Social Reality* [Searle, 1997])
- The reification of a state in a particular context may constitute the realization of a particular institutional/organizational fact
Embodied Organization Rules

• Used to automate particular dynamics between E-O:
Embodied Organization Rules

- Used to automate particular dynamics between E-O:
  - “Entering an ambulatory room \textit{count-as} adopting the role patient”
  - “Finalizing the payment operation on the billing machine \textit{count-as} achieving the goal pay”
  - “A sold out in the visit schedule \textit{enact} the suspension of the booking service”
Embodied Organisation

Meta-Model

Constitutive Rule (Emb-Org-Rule)

Count-as Rule

Enact Rule

Embodied Organisation

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Embodied Organisation Rules

Event-Condition-Action (ECA) rules: “when ev in the context c apply oeExp”

- $+ ev : c \rightarrow oeExp^*$
- $ev$ are organisational event (org-ev) or environment event (env-ev)
- $c$ refers to observable states of the Organisation or of the Environment
- $oeExp$ refers to organisation embodiment expressions
Embodied Organisation Rules

Event-Condition-Action (ECA) rules: “when ev in the context c apply oeExp”

- $\text{ev : c } \rightarrow \text{oeExp}^*$
- $\text{ev}$ are organisational event (org-ev) or environment event (env-ev)
- $\text{c}$ refers to observable states of the Organisation or of the Environment
- $\text{oeExp}$ refers to organisation embodiment expressions

Organisation Embodiment Expressions include workspace operators:

1. $\text{applyOp(target}_{id}, \text{op}_{name} [, \text{Params}])$
2. $\text{applyLop(target}_{id}, \text{op}_{name} [, \text{Params}])$
3. $\text{disable(target}_{id} [, \text{ag}_{id}] \{, \text{op}_{name}\})$
4. $\text{enable(target}_{id} [, \text{ag}_{id}] \{, \text{op}_{name}\})$
5. $\text{make(target}_{id}, \text{target}_{n} [, \text{Params}])$
6. $\text{dispose(target}_{id})$
7. $\text{exclude(\text{ag}_{id})}$
8. $\text{include(\text{ag}_{id})}$

where $\text{target}_{id}$ is the management component id, $\text{op}_{name}$ is an organisation operation (org-op) or environment operation (env-op)
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A Concrete Embodied Organisation

EMI based on CArtAgO Platform [Piunti et al., 2008, Ricci et al., 2009].
- env-op: operations provided by the “physical” artifacts
- env-ev: change of observable properties, results of operations, ...

OMI based on ORA4MAS [Hübner et al., 2009]:
- org-op: adopt-role, commit-mission, achieve-goal, ...
- org-ev: any change of the organisation state
Hospital Scenario

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Hospital Workspace

ORGANIZATION MANAGEMENT INFRASTRUCTURE

Scheme artifacts

player_agents

schemes

group_specification

○ adoptRole

○ leaveRole

○ addScheme

○ removeScheme

commitMission

leaveMission

setGoalAchieved

committed_agents

goals_states

scheme_specification

obligations_state
Hospital Scenario
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Hospital Scenario
Count-as Rule Example

An event occurring in the system may “count-as” an institutional event and **automatically update** the organisation

```
+join_req(Ag) : true
   -> make("visitorGroupBoard",
          "OMI.GroupBoard",
          ["moise/hospital.xml","visitGroup"]);
      make("visitorSchBoard",
          "OMI.SchemeBoard",
          ["moise/hospital.xml","visitorSch"]);
      apply("visitorGroupBoard",
             adoptRole(Ag, "patient"));
      include(Ag).

+op_completed("visitorGroupBoard",_,
              adoptRole(Ag, "patient"):true
   -> apply("visitorSchBoard",
            commitMission(Ag, "mPat")).

+ws_leaved(Ag) : true
   -> apply("visitorGroupBoard",
            leaveRole(Ag, "patient")).

+op_completed("BillingMachine",Ag, pay) : true
   -> apply("visitorSchBoard",
            setGoalAchieved(Ag, pay_visit)).

+op_completed("Terminal",Ag, sendFee) : true
   -> apply("monitorSchBoard",
            setGoalAchieved(Ag, send_fee)).
```
Organisation may produce a control by enacting changes upon the environment (i.e., to promote equilibrium, avoid undesirable states).

+signal("visitorGroupBoard", role_cardinality, visitor) : true

+signal("monitorSchBoard", goal_non_compliance, obligation(Ag, ngoa(monitorSch,mRew,send_bill), achieved(monitorSch,send_bill,Ag), TTF) : true
-> exclude(Ag).
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Conclusions

An unifying approach to MAS programming

- Embodied Organisation;
- No need for agents to bring about organisational notions;
- Environment infrastructures succeed to mediate between agents and organisations;
- Global dynamics shaped on workspace events and transparently handled by the system.

Limitations and Aspects we do not address (yet):

- Complex interaction patterns may result in many relationship to be specified between E-O.
- Direct communication between agents (Agent-Agent interaction) through message passing (i.e. ACL) is not currently under the control of the organisation.
Perspectives

Ongoing and Future Work:

- To generalize the mechanism of *Workspace Laws* and *Embodied Organisation Rules* defining a wide set of inter-system functional relations (i.e. access control, security);
- To provide a general framework for integrated MAS development

Applications in future ICT:

- Any scenario integrating artificial agents, devices, humans in the same application
- Future Internet, Cloud Computing
- Sociotechnical systems, pervasive computing
- Virtualization, Electronic Marketplaces, etc.
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