Cooperative Agent Model within ADELFE Framework:
An Application to a Timetabling Problem

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1. Introduction

ADELFE methodology is dedicated to applications characterized by openness and the need of the system adaptation to an environment. These applications are designed by using the AMAS theory [2]. Self-organization is founded on the capacity an agent possesses to be locally “cooperative”, i.e. it is able to recognize cooperation failures called “Non Cooperative Situations” (NCS, which could be related to exceptions in classical programs) and to treat them. It is based on the RUP process and follows its main phases: preliminary requirements, final requirements, analysis and design, and uses UML and AUML notations. The methodology is provided with OpenTool, released by TNI-Valiosys (www.tni-valiosys.com), which already supports the UML notation and that was extended to support also the AUML one.

2. Cooperative Agent Model

Cooperative agents are equipped with several modules representing a partition of their “physical”, “cognitive” or “social” capabilities (see figure 1). Each module represents a specific resource for the agent during its “perceive-decide-act” life cycle. During the perception phase of the agents’ life cycle, the Perception Modules updates the values of the sensors. These data could directly imply changes in the Skills and Representations Modules. Once the knowledge updated, the decision phase must result on an action choice. During this phase, the Aptitudes Module computes from knowledge and proposes action(s) or not. In the same manner, the Cooperation Module detects if the agent is in a NCS or not. In the former case, the Cooperation Module proposes actions that subsume the proposed action by the Aptitudes Module. In the latter case, the only actions proposed by the Aptitudes Module is chosen. Once an action chosen, during the action phase, the agent acts by activating effectors or changing its knowledge.

AMAS theory identifies several types of NCS, resulting from the analysis of the cooperation definition: an agent is cooperative if: all perceived signals are understood without ambiguity ($c_1$) and the received information is useful for the agent’s reasoning ($c_2$) and reasoning leads to useful actions toward other agents ($c_3$). Therefore, a NCS occurs when $\neg c_1 \lor \neg c_2 \lor \neg c_3$ is true. We identify seven NCS subtypes that express these conditions: incomprehension, ambiguity, incompetence, unproductiveness, concurrency, conflict and uselessness.

3. ADELFE Stereotypes

ADELFE provides an extension of the UML notations. Nine stereotypes have been defined to express how an agent is formed and/or how its behavior may be expressed: $(\{\text{cooperative agent}\})$, $(\{\text{characteristic}\})$, $(\{\text{perception}\})$, $(\{\text{action}\})$, $(\{\text{skill}\})$, $(\{\text{aptitude}\})$, $(\{\text{representation}\})$, $(\{\text{interaction}\})$ and $(\{\text{cooperation}\})$ [4]. In order to modify the semantics of classes and features depending on
the specificities of cooperative agents these stereotypes
have been included in OpenTool, the graphical develop-
ment tool linked with ADELFE.

Agents’ interactions and languages are specified by us-
ing AUML interaction protocol model [3]. To fit with
AMAS specificities, the model has been extended and in-
cluded in OpenTool functionalities [4]. These extensions
are illustrated with the ETTO application, in the next sec-
tion.

4. A Sample Application: ETTO

The sample application ETTO (Emergent TimeTabling
Organization) is a course timetabling problem in which
timeslots and locations must be assigned to teachers and stu-
dent groups in order to let them meet during lectures. For
more details, see [1, 5].

During the analysis, designers identify agents depend-
ing on characteristics such as autonomy, local goal to reach,
ability to negotiate, possibility to be faced with cooperation
failures and to treat NCS. This results in a preliminary class
diagram using the stereotype ⟨⟨cooperative agent⟩⟩ to tag
classes linked with agents. Teachers are verifying, as well
as students groups, these characteristics and can be consid-
ered as agents : RepresentativeAgent (RA). In the ETTO ap-
plication, teachers and student groups have to evolve during
duration and ADELFE proposes to recursively decompose
RA into lower levels agents. A RA is then composed of new
agents called BookingAgent (BA). Their goal is to find con-
venient timeslots in the timetable for a course given by the
teacher, considering his constraints. Attributes and methods
designed in order to equip agents with the different mod-
ules have to be tagged using the previously defined stereo-
types.

Six main Non Cooperative Situations (NCS) have been
identified for a BA: partnership incompetence, booking in-
competence, message unproductiveness, partnership con-
flict, booking conflict and booking uselessness.

Resolution by cooperation and information exchanges
can be modeled with protocol diagrams using the AUML
notation added to OpenTool. The figure 2 shows a sample
protocol for Booking conflict between two BAs with two dif-
terent roles, an exploring one (EBA) and an occupying one
(OBA). The EBA verifies if the room fits with its constraints.
In terms of the result of this decision process (attached to the
XOR node) the EBA will either request information to the
occupying OBA or try to negotiate. In the former case, as the
room does not fit, the EBA will move to another cell. In the
latter case, the EBA informs the OBA about its constraints.
In terms of the results of its decision (manageConstraints
method attached to the second XOR node), the OBA either
accepts to free the room or not. If the OBA frees the room,
it is a NCS (booking conflict, marked in figure 2) that can be
solved by leaving the room, else it informs the EBA which
is now in a NCS.

5. Conclusions

ADELFE is a special-purpose methodology which is
dedicated to the design of systems needing adapt. It
has been applied in different applications [5, 2] which en-
able us to give some conclusions. A methodology associ-
ated with an agent model facilitates the design phase for
a designer not well-experienced in agent technology. The
modules proposed are guides for developers. The stereo-
types definitions help designers to define an agent behavior
in the system. All the rules associated with stereotypes are
enabling to check how the code of the agents is produced.
The implementation of AUML in OpenTool has enabled to
transform automatically sequence diagrams into state dia-
agrams in order to test the agent behavior. Finally, a proto-
type of timetabling has been developed and is operational.

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