Modeling Role Interactions in a Social Organization for the Simulation of the Social Production and Management of Urban Ecosystems: the case of San Jerónimo Vegetable Garden of Seville, Spain

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Abstract. This paper presents some preliminary results obtained in the modeling of a multiagent system for the simulation of the social production and management of a urban ecosystem, in particular, the project of the San Jerónimo Vegetable Garden of city of Seville, Spain. We introduce a study regarding the interactions between agent roles in this particular social organization. For that, we use Activity Diagrams of UML , which provide a clear visualization of the communication between agent roles and allow the identification of communication protocols used by the agents. Furthermore, we show an initial proposal for the encapsulation of those protocols in CArtAgO artifacts, presenting a more modular approach for agent communication in multiagent systems.

1 Introduction

This work addresses, in an interdisciplinary approach, some preliminary results obtained in the modeling of a multiagent system for the simulation of the social production and management of a urban ecosystem – a joint effort for interrelating knowledge, seeking collective interpretations, adopting as case study the current tendency of (re)approaching the countryside to the city through urban vegetable gardens. The chosen organization is the project of social vegetable gardens conducted at the San Jerónimo Park (Seville/Spain), driven by the NGO "Ecologistas en Acción".

The general objective is to develop a MAS-based simulation tool for the analysis of the current reality of the project, allowing discussions on the adopted social management processes, and also for investigating how possible changes in actions, behaviors, and roles assumed by the agents in the organization, especially from the point of view of their participation in the decision making processes, may transform this reality, from the social, environmental and economical point of view, then contributing for the sustainability of the project.

In previous works [1, 2], we presented the first phase of the MAS organization modeling, developed using the organizational model MOISE+ [3, 4], identifying the organizational roles of the San Jerónimo vegetable garden and their routines, the social interactions, the regulative and constructive norms.

However, we noticed that, although the MOISE+ model allowed the visualization of the system organizational structure (and also its schemes), allowing to easily see, for example, the order in which the goals must be achieved, the interactions between the organizational roles cannot be either modeled or visualized. In the actual version of MOISE+ model, it is not provided any means to represent the interactions between organizational roles.

Then, in the present work, we use UML's activity diagrams in order to identify such role interactions and communication, overcoming the shortcomings found in the MOISE+ model. This study allows the analysis of how the different roles may interact and communicate in their routines in the organization. Having defined such interactions, we propose an approach to deal with agent communication in role interactions using CArtAgo artifacts [5].

The aim is to move away from the agents playing organizational roles the logics of the messages they exchange using a certain protocol, obtaining a more modular approach of agent communication. For that, we create CArtAgo "artifacts of speech acts" and "artifacts of protocols", which form a communication layer for the JaCaMo platform [6]. The use of communication artifacts provides a mediation of the multiagent communication, such that it is possible to abstract both implementation language and localization of the agents.

The paper is organized as follows. Section 2 discusses the social foundation that motivates this work in a general view. Section 3 presents briefly the roles and role routines in the social organization of San Jerónimo vegetable garden. In Section 4, we present the modeling of role interactions using Activity Diagrams. Sections 5 and 6 present the communication protocols and how we propose to encapsulate them in CArtAgO artifacts. Section 7 presents the conclusion and further works.

2 Foundation and Motivation

In order to tackle the different problems caused by the industrial society, it is necessary to use paradigms that are able to deal with the new social agents and new conflicts that emerge from the flexibility generated by the industrial civilization of the information era, including, obviously, themes encompassing the ecological and economical issues of this society [7]: a reformation in the scientific reasoning producing a "thinking about the context and the complex" [8], that is, unifying which was before compartmentalized, respecting the diversity and, at the same time, recognizing the unity, a thinking that does not isolate, but that considers the object of study for its relation with the social, economical, political, environmental surroundings, accepting the uncertainty of its actions.

When analyzing this complex thinking, considering a more ecological and systemic point of view, an alternative for diminishing the social, environmental and economical degradation of our present life emerges, related to the concept of sustainability. Al-

though many authors estimate that the success of this "new" terminology is due to its own conceptual ambiguity that accompanies it [9], it is possible to guide its application from a complex approach. There are many claims other than those suggested by the Brundtland Report[3], and, thus, one starts to consider that sustainability does not refer to the type of human interaction with the world that preserves the environment for not compromising the natural resources of future generations. The application of such concept under the complexity approach includes the reflections of the social and urban ecology, which consider, respectively, the holistic relation among the human beings and the environment – specially, how the human activity frequently causes great damages on the nature [10] – and the application of the scientific ecology, social and environmental simulation, artificial intelligence, multiagent systems (MAS), etc., in order to understand and to interpret the urban reality [11, 12].

To repair environmental damages it is necessary to solve social and economical issues, which imply mental and behavioral changes, increasing the participation and involvement of citizens in the defense of their surroundings. It is at this point that it is possible to make a connection between the urban ecology and the social production and management of the habitat [13–16]. To transpose the sustainability from the theory to practice means to conceive the human being and the territory where the majority of the species develops – the cities – as taking part of the nature, under the concept of "urban ecosystem" [17, 18]. A urban ecosystem is not a simple aleatory aggregation of spaces, but a total connected to networks inside networks with causes and effects; an habitat with a structure coherent with the cultural paradigms and specific necessities of a certain group and context; a process of constant increment of information; a physically closed territory, but open to energy and resource flows.

The concept of social production and management of urban ecosystems may be understood as the generation of new physical or relational situations, by constructing, transforming or eliminating physical objects and/or relational objects with the objective of ensuring, in the new produced situations, the fulfillment of their social and environmental functions [14, 19, 15]. This includes the citizen participation in the process of urban planning and transformation, articulating the different involved agents (government, institutions, technicians, citizens), forming a network structured and supported by mechanisms and tools that allow the equal distribution of power in the decision making, so that all agents can participate and dialogue actively in the whole process of a certain project, from its planning to its management. The social production and management of urban ecosystems contribute to the strengthening of community practices, to the increasing of responsibility for a collective project, to the exercise of democracy, to the development of more supportive actions, including both productive and economic issues, as well as environmental issues.

[3] Document entitled "Our Common Future" (1987), which defines Sustainable Development as the one that satisfies the actual necessities, without compromising the capacity of the future generations of supplementing their own necessities.

3 Identification of roles, norms and routines of roles

The Urban Vegetable Garden San Jerónimo (in Spanish: Huerta San Jerónimo - HSJ) is an initiative of the NGO Ecologists in Acción in order to promote social participation in organic farming practices through the use of urban vegetable gardens to recreation, and conducting activities related to environmental education. It occupies about 1.5 hectares of the San Jerónimo Park and it is divided into individual plots cultivated (around 42 units with sizes ranging from 75 to 150m^2) assigned to gardeners for a period of two years - - they must comply with the standards and rules set defined by the NGO. The main feature is this urban ecosystem is a nonprofit, social urban vegetable garden, that is, the production is dedicated to its own participants and it is economically supported by their collaboration and municipal funding as well.

To organize and establish the behaviors of the different roles and routines, as well as the frequency of these routines were used ellipses as Venn diagrams. The use of ellipses helps us to see the routines of each role, which facilitates the understanding of the agents' behavior, as well as the identification of interactions between them and the environment. As an example, Figure 1 shows the ellipses of the routines of the NGO's Secretariat, described as:

- **Daily routines:** to receive candidates documentation to participate in the project, called the Aspiring Vegetable Gardener, registering them; to receive transfer request to plot possession.

- **Monthly routines:** to receive monthly fees paid by the Vegetable Gardener to cover costs with water (drip), pest control material, use of common tools, etc., to inform the meetings; to register Auxiliar Vegetable Gardener (informed by Vegetable Gardener).

- **Biennial routine:** to receive a request from gardener to continue in the project.

- **Seasonal routine:** to sent the received documentation for the NGO Administration.

After that, we use the MOISE$^+$[3, 4] organizational model to model the organiztion. The modeling consists of the specification of three dimensions: the structural, where roles and inheritance links and groups are defined; the functional, which establishes a set of comprehensive plans and missions to achieve; and the deontic, which is the dimension responsible for defining what role or permission is required to accomplish each mission.

The representation of the organization of HSJ in the MOISE+ organizational model is shown in Figure 2. Observing the relationship between the roles, an example of inter-group communication is the one observed between the gardener (included in the group "plot") and the technician (included in the group "NGO"). More information about the MOISE+ modeling of HSJ can be seen in [2].

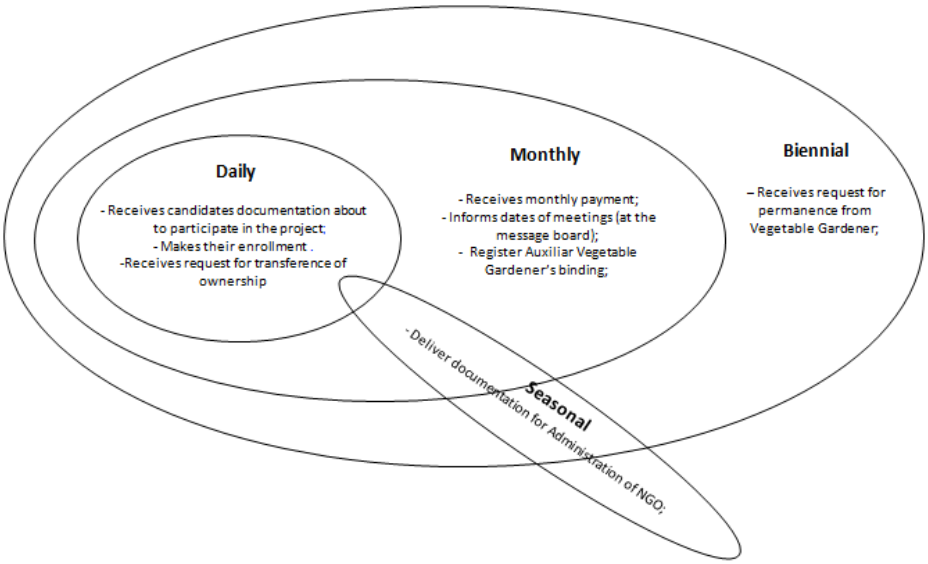

Fig. 1. Ellipses of the routines of the NGO Secretariat.

4 Activity Diagrams

An Activity Diagram is a diagram defined by the Unified Modeling Language (UML), representing the flows driven by processes. It is essentially a flow chart that shows the flow of control from one activity to another. Usually this involves the modeling of sequential steps in a computational process.

The diagrams allow a clear visualization of the interactions between instances of classes. In our work, we use these diagrams to visualize the interactions between roles of the HSJ organization.

Sociability is an inherent characteristic to any agent, which is its capability of communicating with other agents, for example, as a means of mutual cooperation. The activity diagrams allow the visualization of communication between agents and, therefore, identification of protocols used by them.

Figure 3 is an activity diagram showing interactions between the the roles of Auxiliar Vegetable Gardener, Vegetable Gardener and Technician. In the following we explain it briefly.

Initially, the agent that assumes the Auxiliar Vegetable Gardener role arrives at the NGO's building, and it listens to a lecture. This lecture is given by another agent, playing the Technician role, and teaches some rules on how to harvest adequately. This activity is executed as soon as the Technician agent perceives that everyone has arrived at the hall. The interaction between each role is accomplished through oral communication, in which the latter agent talks to everyone.

Following this interaction, another one is performed between the Auxiliar Vegetable Gardener and the Vegetable Gardener agents. The former one requests authorization to

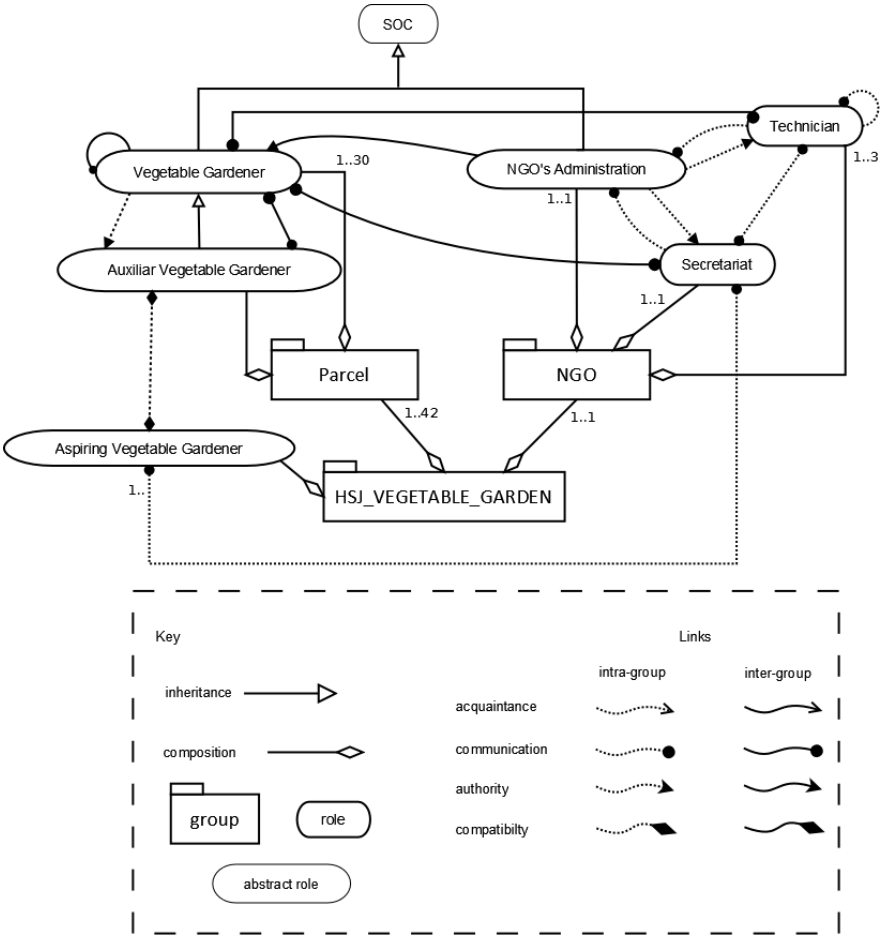

Fig. 2. Structural Specification of HSJ with MOISE$^+$ model.

use a cabinet, using oral communication. Finally, the latter answers the request giving the other agent permission to use the requested cabinet, giving it the key to access that object.

Many other interactions follow these, as Figure 3 presents. Our goal in this section is to briefly show how activity diagrams can be used to study interactions in multi-agent systems.

5 Communication protocols

A communication protocol can be understood as a sequence of messages exchanged between agents, following some standard. This standard concerns the types of the mes-

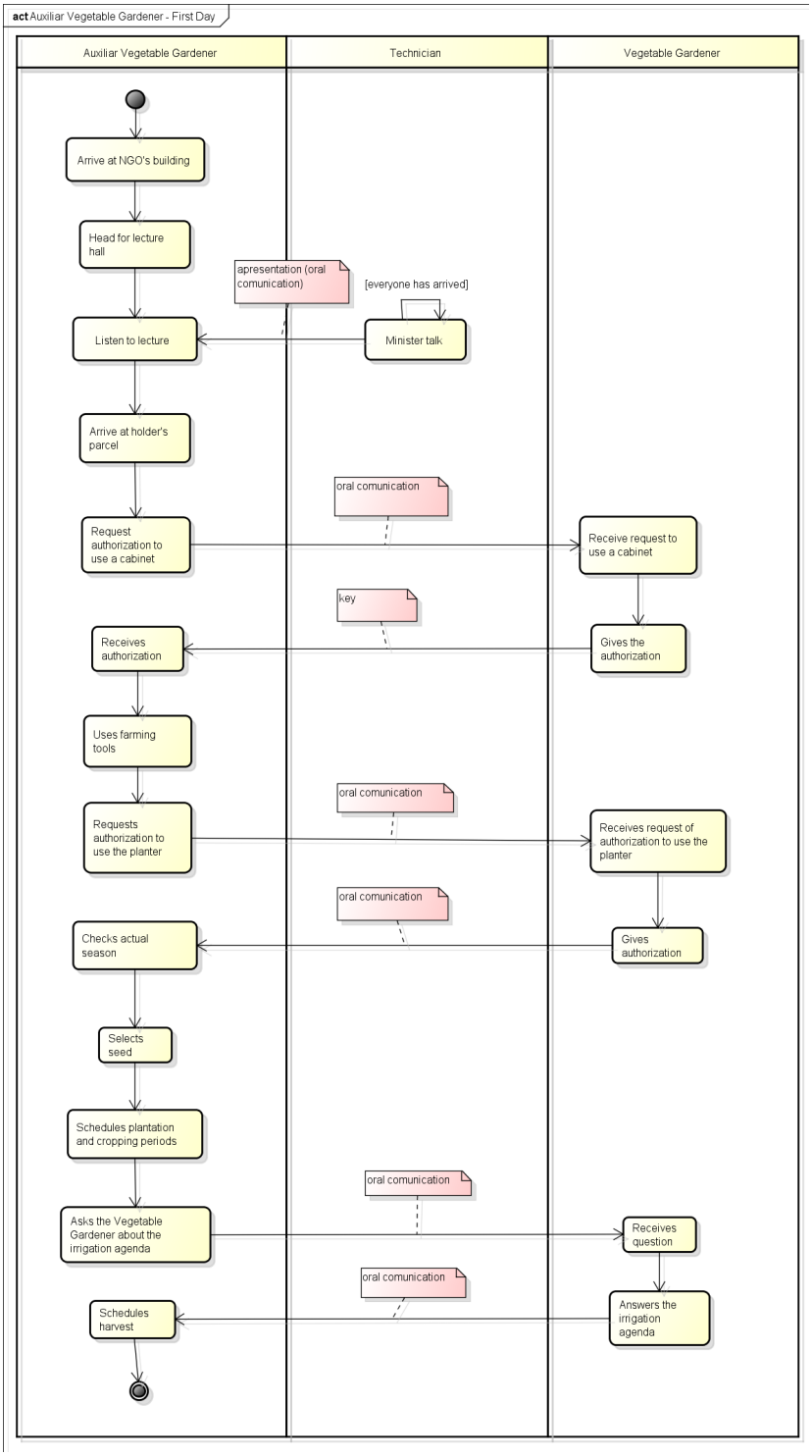

Fig. 3. Activity Diagram - Auxiliar Vegetable Gardener - First Day

sages accepted by the protocol and when they can be used, as well. Every protocol must have a state where the communication ends and this state must be reachable.

Through communication, a group of agents can increase its chances of achieving an objective, because they can cooperate to reach it. This communication happens through a protocol, defined for that group of agent roles.

The Figure 4 presents a communication protocol used for getting seeds, called Seeds protocol. It is used between agents playing the roles Vegetable Gardener and Secretariat.

The first agent initially wants to achieve the goal of getting some seeds. To do that, it initiates a communication with the second agent, eventually achieving its desired objective. In this way, we can link the accomplishment of the goal "getting some seeds" with the execution of the Seeds protocol.

On the Seeds protocol there are only three different types of messages:

- request ("Secretariat", "Seeds"): indicates a request for seeds, aimed at the agent playing the Secretariat role;
- inform("Vegetable Gardener", "Take Seeds"): indicates a notification aimed at the agent playing the Vegetable Gardener role, telling that it can take its desired seeds;
- inform("Vegetable Gardener", "There are no Seeds"): informs the agent playing the Vegetable Gardener role that currently there are no seeds to get.

Since the existing communication protocols in a multiagent system are linked to agent roles (agent types) and not to individual agents, they must be outside the population. In the Seeds protocol the communication protocol is connected to the Vegetable Gardener and Secretariat roles (not to the agents that execute it). An approach regarding this issue can be found in [20].

6 Encapsulating communication protocols in artifacts

Usually, when using the multi-agent oriented programming paradigm, it is considered a conceptual division which separates the system into four dimensions. Each one handles a different aspect of the system: organizations, agent populations, environments and interactions [6]. A promising tool used for this end is the JaCaMo platform.

JaCaMo is constituted by three programs/models: Jason (an AgentSpeak interpreter and responsible by programming the agent population), CArtAgO (responsible by programming the environment) and MOISE+ (responsible by the organization specification).

The CArtAgO framework provides a set of abstractions over the environment called artifacts. An artifact encapsulates functionalities and services that can be used by agents during runtime. It is possible to create distributed workspaces (sets of artifacts), also [6].

Until now, the JaCaMo platform treats the interactions' dimension making use of ad hoc, direct communication between agents using speech act facilities provided by Jason or using existing mediated communication support based on artifacts provided by CArtAgO [6].

We propose another way to treat interactions, encapsulating in artifacts the logics of each protocol. In other words, each protocol would be mapped into an artifact.

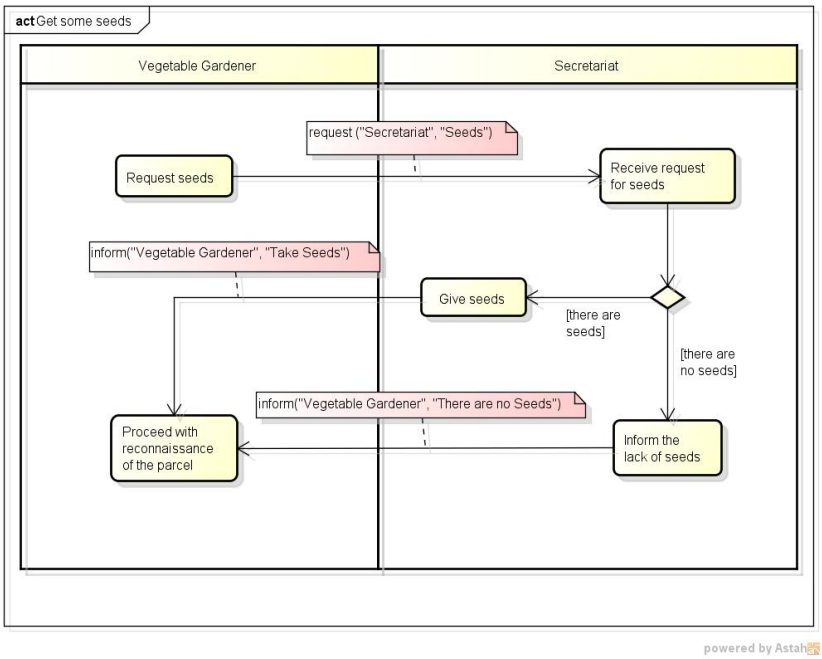

Fig. 4. Activity Diagram: Get Some Seeds

Figure 5 presents a simple outline of our initial approach, showing an artifact that encapsulates the Seeds protocol. Two operations are present: request and inform. These operations will be used by agents to execute the protocol, thus avoiding the usage of direct communication to send messages.

Each operation makes the artifact send a corresponding signal, which allows the identification of what message has been sent. Through the request operation, the receiver agent perceives a newRequest signal, by which is possible to know a request has been made and also who made it. The inform operation sends a newInformation signal, which is used by the receiver agent to know who sent the message and what has been informed.

To allow a formal specification of protocols, we base ourselves on the approach suggested in [20]. Our proposed protocol artifacts will be used together with the protocols' definition found on the organizational specification, which keeps them linked to agent roles and not to individual agents.

7 Conclusion and Further Works

This paper constitutes the second phase of the developing of a MAS-based simulation tool for the analysis of the social production and management of urban ecosystems, in particular, the case of the project San Jerónimo Vegetable Garden of Seville, Spain.

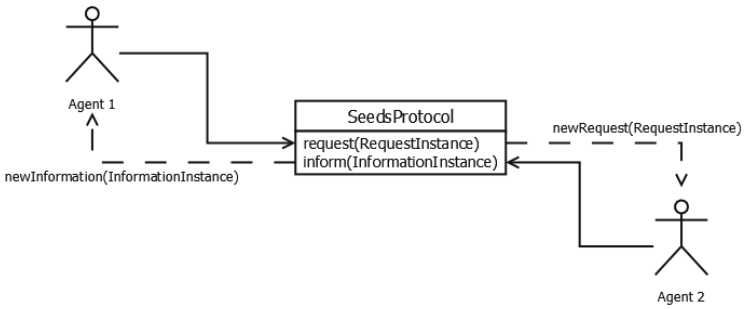

Fig. 5. Diagram - Simple Outline - Protocol Artifacts

Many technologies can be used to model a computational system. In our work, we have already used Venn Diagrams, MOISE+ Organizational Model and UML's Activity Diagrams. With that, we can analyze the different roles, routines and interactions in social organization of San Jerónimo Vegetable Garden.

Based in this information, we have proposed an approach to encapsulate communication protocols within CArtAgO artifacts. That way we can keep the artifacts (and therefore the interactions) related to roles, and not to individual agents. In this way, the implementation of the protocols is treated in a independent/modular form in relation to the application.

As further works, we intend to define all the protocols and artifacts needed by our case study, as well as to implement them in a multiagent system.

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