A Multidimensional Environment Implementation for Enhancing Agent Interaction

(Extended Abstract)

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ABSTRACT

The environment, as a space shared between agents, is a key component of multiagent systems (MAS). Depending on systems, this space may integrate physical, communication or social dimensions. Each of them has its own process and rules to support agents' interaction. For instance, in the physical dimension, the rules may be based on the agents' location. The agents' interaction is then contextualized, and the environment allows a multiagent control since it performs the interactions according to the state and rules of the MAS. The dimensions of the environment are generally connected either in an application-dependent ad-hoc way outside of the agents or within each agent. In order to ensure a multiagent control, the relations between dimensions must be explicit outside of the agents. Using these relations between the environment dimensions, the interaction becomes also multidimensional. In this paper, we propose to formalize rules and mechanisms to make this connection outside of the agents and in a generic way.

Categories and Subject Descriptors

Computing methodologies [**Distributed Artificial Intelligence**]: Multiagent systems—*Environment, Interaction, Programming language*

Keywords

Agent-based simulation::Complex systems; Agent-based simulation::Simulation techniques, tools and environments

1. INTRODUCTION

The environment, as a space shared between agents, is a key component of multiagent systems. Depending on systems, this space may integrate physical, communication or social dimensions where agents interact.

This multidimensional point of view on the environment opens new perspectives in the design of contextualized interactions. Interaction between agents is not only the result of the action of an agent in one dimension of the environment but also the potential propagation of the interaction through the other dimensions. The issue is to be able to take into account, in a unified model, the interaction in one of the dimensions of the environment, and the relation between all these dimensions.

In this extended abstract, a model and its implementation for combining the social and physical dimensions of the environment in order to contextualize the interaction between agents are proposed.

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2. DIMENSIONS OF THE ENVIRONMENT

Heterogeneous implementations of the environment in MAS have been proposed. Several real or simulated systems are based on a "physical environment," where agents and objects have an explicit location, and proceed actions that are located too. In these systems, interaction results from these actions. The *physical dimension* of the environment contains objects, including the agent bodies, and a description of its topology.

Other types of systems are based on a "social environment," where agents have a social knowledge about the others, and they interact following different modalities: direct, indirect, or awareness. The *social dimension* may take different forms: blackboard, sugar space, organizational group, etc.

It is commonly admitted that the environment is dynamic, and changes in ways beyond the agents' control. We advocate that for dynamic environments in multiagent simulation, dynamism should be modeled explicitly as part of the simulated environment. Each dimension of the environment has its own set of dynamic processes, since they are specialized to the related dimension.

One major issue is to ensure the management of all potential dimensions and their relations in a normalized way. This extended abstract focuses on the articulation between the physical and social dimensions in order to support contextualized interactions. The following types of relations are considered in our works:

- r_a: the interaction in one dimension is constrained by the second dimension;
- r_b: the same interaction has different forms in the two dimensions;
- r_c: an interaction in a dimension generates an interaction in the other dimension.

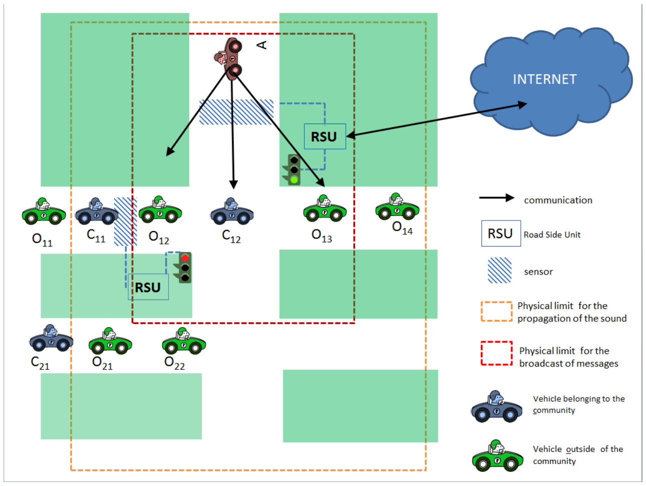

Figure 1: Traffic Simulation

3. IMPLEMENTATION WITH SARL

The SARL agent-oriented programming language[1] is used for implementing the physical and social dimensions of the environment. Each dimension of the environment has a collection of rules that regulates the interaction within the related dimension. These two dimensions are combined within an unique SARL entity: the environment. This entity contains an additional collection of rules that support the relations between the dimensions. Each rule is composed by an activation condition of the rule, and the definition of the actions to execute when the rule is triggered. The activation condition describes expected states for the environment's dimensions. The actions are transformations of the dimensions' states. The arbitration heuristic between the rules that are activated at the same time consists in triggering the first matching rule, and moving this rule at the end of the list for giving a chance to another rule to be triggered.

In order to illustrate our proposal, a multiagent traffic simulation, where vehicles are modeled as agents, is implemented (Figure 1). Every vehicle agent communicates with the others and the infrastructure following a cooperative model (V2X communication). Our example focuses on the following scenario: a vehicle is interacting in the simulation by requesting the priority at junctions. The interactions are supported by communication and the use of a siren. A subset of vehicles (noted C_x) belongs to a community, where the messages are shared.

In our example, four rules are needed to consider the relations between the dimensions of the environment. The first rule restricts the set of receivers of every priority request message to the vehicles that are close to the source of the priority request in the physical dimension (r_a). Two rules describe an interaction that is shared between the two dimensions (r_b). The first (resp., second) rule permits to emit automatically the `PriorityRequestMessage` message (resp., `Siren` action) in the social (resp., physical) dimension when the agent have sent the `Siren` action (resp., `PriorityRequestMessage` message) in the physical (resp., social) dimension. Consequently, when an event (message or action) was sent in a specific dimension, it is automatically sent in the other dimension without change of its content. The last rule describes an interaction in the social dimension that generates an interaction in the physical dimension (r_c), as illustrated by the SARL statement:

[1] `http://www.sarl.io`

```
[ m : Message | m instanceof PriorityRequestMessage]
=>
[ env,e,o | physicSpace.doAction(
   new PriorityRequestAction(e.source),
   Scopes.addresses(roads.nearRSU(e.source))
]
```

The activation condition of this rule is the perception of a message PriorityRequestMessage (social dimension), and the activation part is a modification of the traffic light plan by the Road Side Unit (RSU) in the physical dimension. In our scenario, the agent A uses its siren and interacts with the agents that are close enough in the physical dimension to perceive this event. This interaction is regulated thanks to a rule, which is specific to the physical dimension. Thanks to the rule r_b, a message is emitted in the social dimension. This message is received by the agents belonging to the community, like C_{12} or C_{21}, thanks to a rule related to the social dimension. This message is also received by O_{12}, O_{13} thanks to the first rule (r_a), because they are close enough to perceive this event even if they do not belong to the community. Finally, this message implies new interaction in the physical environment. Indeed, the RSU will change the traffic light plan to give priority to A, thanks to the last rule (r_c).

4. RELATED WORKS

According to our knowledge, the model proposed in this extended abstract is the first attempt to link the various dimensions of the environment without the agent as an intermediary. However, many studies have been done on the modeling of the environment in one of its various dimensions.

Our inspirations for the physical environment are the models for the simulation of crowds and traffic into virtual environments [1]. The Artifact, CArtAgO and Smart Object models are also an inspiration. They propose similar interaction models between agents and objects in the environment, and the definition of the latter.

In the social environment models, the environment is a shared space in which agents drop off or withdraw filters that describes the context of their interactions, in order to manage their multipart communications [3]. These filters are managed by the environment. The physical environment is not separated from the social environment, and filters always involve an agent. Therefore, it is possible to treat the first of the three types of relations between the environment's dimensions, but not the other two types explicitly.

Several organizational approaches consider the environment [2]. In the context of this extended abstract, the key element is the introduction of the concept of space as an abstraction for organizational groups and spatial areas. However, these models do not explicitly propose to consider the physical and social dimensions jointly, as well as their direct interactions.

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