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Multiagent Hybrid Architecture for Collaborative Exchanges between Communicating Vehicles in an Urban Context

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Abstract

Nowadays, we are more and more surrounded by powerful and intelligent communicating objects. Many of these objects, as smartphones, watches, detectors and soon cars, are moving in increasingly interconnected environments, have abilities to communicate with each other and to exchange information. A collaborative approach allows these entities to exchange information and objectives and to implement rules in a structured manner in order to optimize the execution of their own mission and, therefore, the operation of the system in general. For example, collaborative behaviours and informations exchanges could improve the movement of vehicles in an urban center and avoid traffic jams. Our contribution puts a stress on a definition of collaboration in the context of mobile communicating entities. For the sake of agent-based modeling, we also list challenges raised like technical architecture and data organisation. Then we propose an hybrid architecture for collaborative exchanges with an example based on communicating vehicles in an urban context and implemented on the GAMA platform.

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Keywords: Multiagent Systems ; Hybrid Architecture ; Collaboration ; Communicating Vehicles

1. Introduction

Smart objects (computers, smart phones, etc) are now occupying a wide part in our life and are fully interconnected. They intend to carry on services for an individual user or for the community. In the case of communicating vehicles, interaction between vehicules is currently mainly done through an external infrastructure (cloud). In such infrastructure, a vehicle is considered as client that sends data to the infrastructure and receives specific information extracted by the infrastructure from gathered data. This interaction scheme does not however match all vehicle needs and vehicle-to-vehicle interactions are needed to improve security and services to drivers for instance. This interaction scheme does not give a response to novel vehicle requirement, especially in the domains of security and driver assis-

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tance. What does it happen if the infrastructure is down or unavailable (in a tunel for instance)? Vehicle-to-vehicle interactions could give a response to that.

According to some studies [1,2,3], there is no real autonomy if the vehicle can not fully cooperate or collaborate with any other entities. These same studies attempt to describe how these intelligent and autonomous vehicles will change our lives through three main goals: guarantee the road safety, improve the quality of life, permit the accessibility for all. So collaboration is the key of the success of such applications.

In the multiagent systems literature, several works tackle the collaboration domain [4,5,6]. Due to the variety of mobile smart objects, a large variety of collaboration scheme exists but exchanges between connected objects are often specific to the application domain. We can note a lack of domain-expert oriented methods providing concepts and tools to qualify and study the collaboration in a complex system. Thus, we tackle the problematic of collaboration and promote methods, concepts and tools to qualify exchanges between mobile entities (vehicles, drones, etc) evolving in a complex environment (city, forest). Introducing and describing collaboration between mobile entities should enhance their journey and their efficiency. For that, we take advantage of agent based systems for which the versatility allows to describe real systems by interactions between autonomous entities. In this paper, we present an hybrid agent architecture that can be used to model collaborative exchanges between mobile entities and its assessment as a autonomous vehicle model in a multi-agent system.

In section 2 of this article, we first propose a definition of the concept of collaboration and, according to this definition, we present technical challenges to implement a collaborative behaviour. In the third section we propose a collaborative agent architecture, the data organisation and the world representation. Then, in section 3, we propose a new hybrid agent architecture with its main communication components, in an urban context. At last, a first implementation is presented using GAMA platform in section 4.

2. Collaboration and Multiagent System

In this section, a general analysis on collaboration is given as a preambule of a short overview about communication between agents. It permits to refine our point of view on collaboration and outline linked issues in the domain of multi-agent system.

In the domain of Multi-Agent Systems, cooperation and collaboration concepts highlight interactions between agents and cognition: it needs some coordination actions and conflict resolution algorithms to achieve tasks [7]. Nevertheless there are differences between collaboration which is "*a form of interaction who is interested in how to distribute the work among several agents, whether it is centralized or distributed technics*" and cooperation that "*remains the prerogative of beings capable of having an explicit project therefore cognitive agents.*" [8] Collaboration is thus considered as cooperation refined by the development of a mutual understanding associated with a shared point of view of the task being solved by several interacting individuals [9,10]. In the context of mobile objects like communicating vehicles, collaboration intends to achieve an individual mobility objective while performing a collective local task, by exchanging information between two or more mobiles. It is an intentional and cognitive process: it also results from the wishes of each mobile which collaborates with an effort of sharing selected information and a common vision of the goal to be reached.

Several architectures have been proposed to permit communication between agents or collaborative processes such as, for example: (i) the Belief-Desire-Intention (BDI) architecture of Rao and Georgeff [11], (ii) Touring Machines of Ferguson [12], (iii) InteRRaP model of Müller [13], etc.

All these previous models propose a multi-layer architecture with a layer for the world representation, a layer for basic behaviours, another one for planned behaviours and a final one generally dedicated for communication and/or collaborative process. Communications between agents are often limited to this dedicated layer (the higher one, the more "cognitive" layer which initiate communication if needed). This approach implies that agent do everything it can before asking help to another agent, somewhere in the simulation environment. But in cases where agents represent quick mobile objects, this consideration could be useless because the processing time would be too long. For example, if a vehicle detects an accident in front of it, it must inform immediatly vehicles all around to avoid another one.

So, for *modeling collaborative exchanges between mobile entities*, an hybrid agent architecture is required to answer quickly to environmental stimuli (reactive part). This architecture must also include some storage capacity to record experiments and an management of objectives and priorities (deliberative or cognitive part). It must be