Task Assignment with Dynamic Token Generation

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Summary. The problem of assigning tasks to a group of agents acting in a dynamic environment is a fundamental issue for a MAS and is relevant to several real world applications. Several techniques have been studied to address this problem, however when the system needs to scale up with size, communication quickly becomes an important issue to address; moreover, in several applications tasks to be assigned are dynamically evolving and perceived by agents during mission execution. In this paper we present a distributed task assignment approach that ensure very low communication overhead and is able to manage dynamic task creation. The basic idea of our approach is to use tokens to represent tasks to be executed, each team member creates, executes and propagates tokens based on its current knowledge of the situation. We test and evaluate our approach by means of experiments using the RoboCup Rescue simulator.

36.1 Introduction

The problem of assigning tasks to a group of agents or robots acting in a dynamic environment is a fundamental issue for Multi Agent Systems (MAS) and Multi Robot Systems (MRS) and is relevant to several real world applications. Many techniques have been studied to address this problem in different scenarios, providing solutions that in different ways approximate the optimal solution of the Generalized Assignment Problem (GAP), which consists in assigning a predefined set of tasks (or roles) to a set of agents maximizing an overall utility function that takes into account the capabilities of all the agents in the team.

While GAP requires the definition of a static set of tasks, that must thus be known in advance, in many application domains, tasks to be accomplished are not known a priori, but are discovered dynamically during the execution of the mission. Furthermore, when the system needs to scale up with size, communication quickly becomes an important issue to address.

The problem of dynamic task assignment has been studied and experimented by many researchers both in MRS (e.g. [3, 16, 10]) and in MAS (e.g. [6, 4, 7, 13]) communities. Several different aspects of the problem have been investigated and several approaches proposed. However, the growing complexity of missions in which
robots and agents are involved pushes toward the development of novel solutions for task assignment, which are able to address the more challenging issues posed by the applications. For example, auction based approaches to task assignment, have been proved to fail in the RoboCup Rescue domain, due to high communication requirements [8].

In this paper we present a distributed task assignment approach that is able to dynamically discover new tasks to be accomplished according to the situation perceived by the agents during the execution of their activities, and to ensure very low communication overhead. We focus on task assignment for teams operating in environments that need to meet (soft) real time constraints in their mission execution, where agents involved have similar functionalities but possibly varied capabilities. The reference scenario we are interested in has the following characteristics: i) the domain and the number of agents involved pose strict constraints on communications; ii) agents may perform one or more tasks, but within resource limits; iii) too many agents fulfilling the same task lead to conflicts that needs to be avoided; iv) tasks are discovered during mission execution.

The basic idea of our approach is derived from previous work based on token passing [12]. Tokens are used to represent tasks that must be executed by the agents, and each team member creates, executes and propagates these tokens based on its knowledge of the environment. The basic approach is based on the assumption that one token is associated to every task to be executed and that the token is maintained by the agent that is performing such a task, or passed to another agent if the agent that has the token is not in the condition of performing it.

In the case of dynamic discovery of the tasks to be performed and thus of dynamic token generation, the token passing approach must be appropriately extended in order to limit the number of tokens associated to the same task. Indeed, in our reference scenario optimal performance is obtained when there is a limited number of agents cooperating to execute the same task; when too many agents operate on a single task the overall performance decreases, since they ignore other tasks that evolve in a dynamic environment. The algorithm presented in this paper allows every agent to generate tokens dynamically whenever a task to be accomplished is perceived, while limiting the number of tokens associated to the same task and minimizing the bandwidth (i.e. communication messages among agents) required.

We test and evaluate our approach by means of experiments on a simulated scenario, that models a team of fire-fighters engaged in fighting fires in a city. To this end, we use the RoboCup Rescue simulator, that models the evolution of fires in the buildings of a city, city traffic, fire-fighters actions of extinguishing fires and communication among them. In this scenario, the location of the fires are not known a priori and the fire-fighter agents find them during their activities; in addition fires may unpredictably spread over adjacent buildings if not extinguished in time. Moreover, communication constraints are very strict, since messages are both limited and costly (in terms of simulation time steps).

The results that are reported in this paper show that the proposed extension of the token passing approach provides good performance in this scenario, while maintaining a very low communication bandwidth and thus significantly increasing the scala-