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Planning of work schedules through the use of a hierarchical multi-agent system

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ABSTRACT

We propose a methodology to simulate every small task of a site-work with a multi-agent system. These agents handle resources as a way to perform transformations on their world. The system will simulate the construction of a building through the definition of the atomic elements of the system and the automatic recombination of these elements. This allows us to foresee parallel and sequential tasks and handle the creation of a graph, in the form of a Petri net, that facilitates the task of accurately planning the schedule of the site-work.

1. Introduction

Construction success highly depends on the capacity of the project manager to handle multiple teams with a wide variety of tasks and with different needs. These teams must be correctly orchestrated during the realization of their labor since the total cost of the construction depends on the total amount of time the building takes to be constructed. Therefore, parallelization of tasks is highly desirable, although this is not always achievable. Different tasks cannot be executed before a certain amount of resources has already been created or before the team in charge of executing the task is free to start its implementation.

It is therefore mandatory to create a timed organizational structure of the planned work. The instruments more commonly used to handle this need are *Gantt diagrams* and *Critical Path graphs*. Although good planning is usually achieved through the experience gathered by the project manager, a number of elements are always left out. Imperfections are therefore left in the schedule of the work site and these sometimes lead to undesired time delays. We present in this paper a computational system that, through the use of agents, simulates the resources created or exchanged by every agent in the construction site and that self-organizes these agents to define a possible sequential frame in which every task is to be executed. More specifically, our goal is to provide a system that automatically constructs a graph, in the form of a Petri net [1], representing the sequence of jobs to be undertaken during a construction process. Actually, one of the main advantages of Petri nets is that there exist several formal methods for analyzing them.

Our methodology uses a system of agents that recreates the construction process in a simulated manner. Because of the modularity of this approach, once an agent is designed, it can take part in any new project that handles similar needs. Therefore, the system is scalable and further increments in complexity of the project do not need to increase computation times. The methodology also allows parallelization of the tasks, which helps to model up to a high level of detail any construction process. Furthermore, since every agent represents a real world agent of the construction process, it is easy to translate the characteristics of the system to the construction site.

We use two types of agents: *atomic* and *complex*. *Atomic* agents are a metaphor of work force. These agents are in charge of the actual transformation of resources. A complex agent is similar to the leader of a team. These agents are used to gather atomic agents (and/or other complex agents) to reunite and conglomerate their individual properties, and arrange the order in which they will start working.

Agents simulate the procedure of the construction of a building by exchanging resources. This is done through destroying and creating new types of resources. In that sense, when using our methodology one has to think a little bit different from the real world. For example, an agent painting a wall, *destroys* a non-painted wall and *creates* a painted one.

Agents can be reincorporated from other projects that we have dealt with before, that is, we do not need to reconstruct every agent each time that we want to plan a new construction site. What we need to do is either to incorporate new complex agents through the use of petitions or to define the new needs of our project in terms of resources. The system will reconfigure itself to be able to handle the demands.

Agents are introduced into a *cell* structure. This structure maintains close those agents that are related in terms of the kind of

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