Using Environmental Patterns to Evaluate Agent Teams Performance

(Extended Abstract)

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ABSTRACT

The design of a rational organization composed by a team of agents is a challenging problem in domains such as collective robotics, war games and military missions. In these domains, a team is designed to confront an opponent team with technical and numerical equivalence, and aiming to conquer areas where there are scarce resources distributed in locations within a territory whose topology is unknown. In these scenarios, it is hard for the agents to do the right thing. In addition to being competitive, the task environments are unknown, partially observable and dynamic. The challenge is how to design a rational team whose members are not ideal rational agents. This work argues that one approach is to implement a suitable organizational specification that fits the task environment, according to some previously defined environmental patterns that include both domain-specific and topological characteristics. In this work, we present an experimental evaluation of these patterns' influence on the performance of teams of agents evolving on the Agents on Mars environment, a well-known agent programming testbed. The results of the evaluation show that organizational specifications that exploit this information perform better than others that don't.

Keywords

Organisations and Institutions; Team Formation; Engineering Multi-Agent Systems; Profiling and Benchmarking of Agent-Based Systems

1. INTRODUCTION

In competitive domains, a challenge that arises is how to design a rational team of agents, each of those not ideally rational. We argue that one way to face this challenge is to implement a suitable Organizational Specification (**OS**) that fits the task environment in each domain. Moreover, we focus on the influence of *environmental patterns* (**EP**) in the performance of a team of agents designed to confront a technical and numerical equivalent opponent, and aiming to conquer areas where there are scarce resources of high economic value (*clusters*), that are distributed in locations within a territory whose topology is unknown. The notion of environmental pattern is defined based on some *clusters'* spatial attributes, whose values are perceived by the teams when they explore the environment.

The agents' team performance evaluation is domain-dependent. In our case, it is based on the testbed provided by the Multi-agent Programming Contest (**MAPC**), more precisely in the *Agents on Mars* (**AoM**) scenario [1]. The results of our evaluation show that **OS**s that exploit this information perform better than others that don't. For example, the number of clusters leads, in some cases, to situations where it may be better for the whole team to occupy a single cluster, while in other cases it may be better to divide the team into smaller squads to try to gain control over multiple clusters in the environment.

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2. EVALUATION SCENARIO

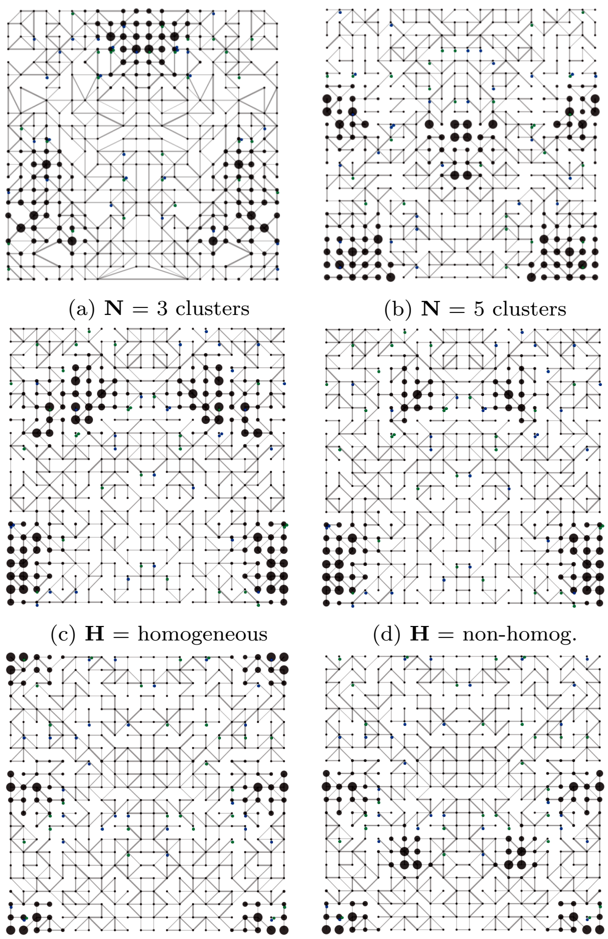
In the **AoM** scenario, the environment is represented by a weighted graph, where the vertices denote water wells and possible locations for the agents, and the edges indicate the possibility of crossing from one vertex to another.

At the beginning of the simulation, the map is unknown to the agents. Each team consists of 28 players that can be of 5 different types: explorers, sentinels, saboteurs, inspectors and repairers. These types define the characteristics of each agent such as life level, maximum energy, and strength. The roles also limit the possible actions that the agent can perform in the environment. For instance, explorers can discover water wells and help to explore the map, while sentinels have long distance sensors and thus can observe larger areas, saboteurs can attack and disable enemies, inspectors can spy opponents, and repairers can repair damaged agents.

We associated the notion of **EP**s in the context of **AoM** to capture the diversity of environments, i.e., how many "valuable areas" (subgraph with high value) appear in the map. In our work, these "valuable areas" are called *clusters*. From the agents' point of view, we define the environmental pattern $\mathbf{EP} = (\mathbf{N}, \mathbf{H}, \mathbf{D})$ associated with an environment by three attributes related to its clusters: the number (**N**) of clusters, their homogeneity (**H**) and their dispersion (**D**). Figure 1 shows environments with different cluster patterns.

3. DESIGNING THE ORGANIZATION

In order to design a solution for our problem, we need to solve two related problems: the design of individual cooperative heterogeneous agents and the design of an **OS** for a rational team of these agents. The notion of **OS** in this work is based on Moise organizational modeling language [3], where an organizational specification **OS = (SS, FS, DS)** is decomposed in three dimensions. The Structural Specification (**SS**) defines the roles and the groups. The Functional Specification (**FS**) defines as the overall objectives are broken down into goals and missions. The Deontic Specification (**DS**) relates these two dimensions, identifying subsets of missions and goals in **FS** that are permitted and/or required for each role in **SS**.



(a) **N** = 3 clusters (b) **N** = 5 clusters

(c) **H** = homogeneous (d) **H** = non-homog.

(e) **D** = dispersed (f) **D** = non-dispersed

Figure 1: Environments with different patterns.

4. EXPERIMENTAL EVALUATION

The goal of our experiments was to evaluate the impact of the **EP**s over teams' performance, and measuring the performance of two adversary teams composed by the same BDI agents, but with two different **OS**s.

Considering teams' **OS**s, we have fixed the attribute values associated with the **FS** and **DS**, and have just modified the number of squads and the cardinality of each squad in the **SS**. Hence, the experiments consisted of seven different teams that competed each against other for 10 times, using 14 environments with different **EP**s. Each team is composed of a different number of groups called *squads* which are in charge of occupying the best possible clusters they can find in the map [2].

We used the *Wilcoxon T* test as a hypothesis test to define for each match if the 10 simulations were sufficient or not to conclude that a team was better than other in a determined environment.

Regarding **N**, the team must have a number of squads equal or closer to the number of clusters on the map. If the number of squads is smaller than the number of clusters, the team will not cover all good areas, which can then be easily occupied by the opponent.

For **H**, the experiments showed that occupying the clusters with highest values is critical in non-homogeneous environments since the winner ends up by being the team that occupies the bigger clusters. This favours teams with small number of squads, since they can occupy the best clusters, while an opponent with a larger number of squads ends up by spreading its agents in smaller clusters.

Finally, regarding **D**, the results showed that less dispersed clusters help teams with a larger number of squads to form larger areas than they could if the clusters (and the agents) were dispersed.

5. CONCLUSIONS AND FURTHER WORK

Although our results are preliminary ones, we believe that they provide at least two contributions that can be exploited in the design of agents' teams when the task environment is hard, but can be described in terms of **EP**s.

The first contribution is related to the knowledge the designer can learn about these task environments, to assess whether a team will be able to selectively search for solutions. The second one is related to the proper notion of **EP** realized in this work. Considering it as a complementary representation of the state of the environment, and the consistent knowledge that can be provided by a more intensive evaluation of the impact of **EP**s over teams' performance, we believe that two possibilities are generated for the designer (that may be a team agent): (1) to predict the behavior of a team if he knows its goals, its **OS**, and the current **EP**s; (2) to define a team behaviour by designing a suitable **OS** if he knows the current **EP** and team's goal. These are hypotheses that we hope to prove in the near future.

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