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Using Self-Diagnosis to Adapt Organizational Structures *

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Abstract

The specific organization used by a multi-agent system is crucial for its effectiveness and efficiency. In dynamic environments, or when the objectives of the system shift, the organization must therefore be able to change as well. In this abstract we propose using a general diagnosis engine to drive this process of adaptation, using the TÆMS modeling language as the primary representation of organizational information. A complete version of this paper is at [1].

As the sizes of multi-agent systems grow in the number of their participants, the organization of those agents will be increasingly important. In such an environment, an organization is used to limit the range of control decisions agents must make, which is a necessary component of scalable systems. Are agents arranged in clusters, a hierarchy, a graph, or some other type of organization? Are the agents’ activities or behaviors driven solely by local concerns, or do external peers or managers have direct influence as well? Is communication between agents active, via messaging of some sort, or passive, using observations or engineered assumptions? These and other characteristics define the organizational structure of a multi-agent system - the rules which define the roles agents play and the manners in which they interact with other agents in the system.

Clearly the characteristics described above will have an impact on the efficiency and responsiveness of both large and small multi-agent systems. It should also be intuitively clear that the effectiveness of the organization is dependent on the agents, environment, and goals involved in the system. The problem then, is how to derive and maintain such a structure given a particular situation. The term Organizational Self-Design (OSD) has been used previously to describe the general technique of employing the members of a multi-agent system to generate or adapt their own organizational structures at runtime. Earlier work in this area tended to focus on adapting specific qualities of the organization, such as task allocation or load balancing. Organizational structure generation has also been proposed as arising from local, global, and hybrid perspectives. In this abstract we outline a more general approach, using diagnosis, to detect deficiencies in the organizational model and assist in the creation of solutions to those deficiencies; the eventual goal being to create a reusable organizational adaptation engine. We will show how a general diagnosis engine, coupled with a powerful representation of that organization, can be used to effect change in a wide range of characteristics.

In the architecture we propose, critical components within the agent, such as those responsible for problem solving, negotiation and scheduling, obtain the vast majority of their information from an organizational design layer. This layer abstracts and filters elements of the operating environment in a manner consistent with the agent’s role in the organization. The abstraction is composed of one or more information sources, such as TÆMS structures, capable of encoding the various aspects of the organization. To permit adaptation, the organizational design layer is maintained by a diagnostic subsystem, which attempts to repair faults and inefficiencies by adjusting elements of the organizational structure. This diagnostics process can itself be driven by a number of sources, including observations of the environment, conditions monitored within the agent, and discourse with other agents. The direct effects of these diagnoses will typically (but not necessarily) take place within a relatively small group of agents, so one can think of this technique as a search for the correct organization through local adaptation.

The range of information that comprises an organizational structure can be quite broad. It is our opinion that there is no single, comprehensive set of characteristics that

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might make up the definition of an organizational structure. Instead, the set is dependent more on what alternatives are possible within a particular multi-agent system and which of those alternatives can have an impact on the system’s behavior and effectiveness. To address this, we use TÆMS models as our organizational representation, which are flexible enough to model a wide range of characteristics.

Figure 1 shows the architecture of the diagnostics subsystem we currently employ. It uses a blackboard-based design, separating the process into three distinct layers: symptoms, diagnoses, and reactions. This type of system offers several advantages. It promotes a clear chain of reasoning, since the diagnoses supporting a given reaction can easily be identified, as can the symptoms that support a particular diagnosis. The layers also clearly define the separation of responsibilities, which enables arbitrary components or even remote agents to asynchronously use and add to elements on the blackboard.

The lowest level of the blackboard contains symptoms, elements that contain observations about such things as the environment, agent activities and commitments. This level is maintained by both observers, which passively collect data, and modelers, which use learning techniques to make predictive models. The diagnosis level contains descriptions of possible faults or inefficiencies derived from the data on the symptom level. These diagnosis are produced with the use of a causal model, which will be described below. At the highest level, a set of potential reactions to the diagnoses are generated, which may be selected from by the inducer to effect change in the organizational design layer. A feedback loop is maintained by the effect monitor, which determines if changes made were successful and effective.

Diagnosis is a well-researched field, with many different methods and techniques already available to the system designer. Our goal was to use a technique that offered great flexibility in the information it could use and the diagnoses it could generate, without sacrificing subject scope or domain independence. It is not clear from the outset, howev-

![Figure 1. High-level architecture of the diagnostics subsystem.](image-url)

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**References**