

# Autonomously Reorganizing Information Systems

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With our increasing reliance on information, we have put ourselves at risk. The risk is that our information infrastructure could be attacked and disabled, leading to failures in both public and private information systems (IS). Companies could suffer economic loss while government, and DoD, agencies could be unable to respond effectively to emergencies. When coupled with a physical attack, the problems could be disastrous. What we need are survivable IS that can respond to failures and attacks by adapting to the available infrastructure by continuing to provide the best available information, whatever the source.

The problem with current IS lies in the fact that they are designed to work within a rigid infrastructure and with a limited set of information sources. Even when the data required to produce the requested information is available, IS are often constrained by their own rigid information source and infrastructure requirements. To overcome this problem, we need to develop IS that can adapt to dynamic information environments. Specifically, we are tackling the problem by developing theories, techniques, and tools to allow systems to adapt to the changing environment via autonomous system *reorganization*.

Our proposed solution is based on the concept of a cooperative team of agents, which consists of agents playing the roles of information producers, sources and processors. *Information producer agents* represent the actual sources of raw data and information in the system. *Information source agents* know how to generate a particular type of information from raw data as well as how to interface with information producers to obtain that data. *Information processor agents* understand how to fuse particular types of information and raw data to create new, higher-level information that is of interest to users. Because there are generally many ways to produce information, there are typically multiple source and processor agents capable of producing the same type of information within a given team. The key to providing an adaptable, yet efficient IS, is being able to choose the appropriate information producer/source/processor at the appropriate time for the right task. This choice can be equated to selecting the correct multiagent organization for a particular task. If an information source is lost during the process, the team must be able to immediately reorganize (by choosing new producers, sources, or processors) and continue to generate the requisite information.

We have embarked on a multi-agent approach to providing this reorganization capability. First, we have developed a formal model of team organization. This model is based on the IS information production goals and valid organizational structures, and embodies the knowledge upon which all organizational reasoning and decision-making takes place. Our proposed organization model contains a structural model, a state model and a transition function. The *structural model* includes the goals that the team is attempting to achieve, the roles that must be played to achieve those goals, the capabilities required to play those roles, the possible relationships that may exist between roles, the rules that constrain the organization, and the static relations between roles and the goals, capabilities, and relationships. The *state model* defines an instance of a team's organization and includes the agents and the relationships between the agents and the various structural model components. The *organization transition function* defines how the organization may transition from one organizational state to another over the lifetime of the organization. We are also investigating appropriate reasoning techniques to determine (1) when reorganization is necessary and (2) how to go about performing the reorganization, as well as integrating the organizational model and reasoning techniques into existing multiagent development methodologies.

To show the efficacy of our organizational approach, we have developed an IS simulation using the Battle of Khafji scenario from the 1991 Gulf War. To answer queries, we developed an organization-based IS, which produces information requested by battlefield commanders from the best available information sources. Our initial results show that our IS is able to quickly organize to satisfy information requests and monitor itself and reorganize in the event of the loss of a team member agent or information source.