Issues in Developing Simulations for Designing and Evaluating Agile Processes in Organizations

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Introduction

Simulation is widely acknowledged as a potentially important tool in developing and evaluating organizational redesigns. However, as businesses move to more "agile" forms of product development and support, existing simulation tools, including object-oriented simulations, need to be re-examined in light of the inherently fluid and dynamic forms of organizational structure and coordination that these new ways of doing business will demand.

We are developing a prototype of a simulation development tool to aid administrators in the process of redesigning organizational structures. Our hypothesis for the simulation design tool is that by structuring the tool around a model construction library of coordination mechanisms, based on the work of Malone and his colleagues at MIT, designers will be able to compose models more rapidly for their existing and proposed organizational coordination designs. This library should help them to think about alternative designs better, based on the desired functionality, and it should lead them to useful comparative analyses.

We are now investigating how these coordination structures must be made available, in some sense, not only to the human model designer, but also to the simulation itself if work groups are to be in any interesting senses "self organizing". We are also investigating how to simulate policy directives that could be made to alter the communications and action pathways within an organization as simulation proceeds.

A Modeling and Simulation Tool for Agile Manufacturing

Concepts like "Just-In-Time" and "Agile" manufacturing are being touted as methodolgies which will the productivity of American industry. But visualizing the processes that these methods suggest will require tools that help organizational designers to prototype and evaluate implementations of these notions for their organizations. The process of designing new organizational structures that fulfill the basic missions of the organization and are at once efficient, reliable and versatile requires the designer to visualize the performance of a highly interdependent set of agents in likely future circumstances. He or she

must be able to detect potential pitfalls, communications bottlenecks, and the critical capabilities that might fail in those circumstances. The organization design task bears many similarities to other design tasks, such as hardware design, where communications channels are used to coordinate processes. However, this new brand of organizational structure also requires that parts of the organizations, in essence, continually redesign themselves, at least to the extent that the multi-talented workforce may be expected to respond to frequent calls for dymanic job-team formation to handle small, batch jobs with what once might have been called "customized" specifications.

These shifts in emphasis within businesses highlight the fact that with human organizations, the problem of evaluating potential designs is more difficult because these organizations are composed of inherently adaptive agents, agents that implement policies by adapting their own procedures, and will often seek out information to accomplish their tasks outside of proscribed lines of communications.

BBN, working with the Center for Coordination Science at MIT, is designing a prototype of a system to help organization leaders' to define and evaluate new organizational structures before they are put into effect. We hope to be able to produce a tool that allows these designers to produce simulations of their organizations that are much in the spirit of the Virtual Design Team simulator of (Levitt et al. 1993). The system will be constructed around a modeling vocabulary of organizational structures and a simulation tool for autonomous agents that can respond to communications of a variety of types, from arbitrary agents the organizational structures modeled. Agents are being designed to follow operating policies in a flexible, goal-driven fashion for a variety of situations.

The existing modeling and simulation system we are building on, called SIM-AGENT, is descended from an earlier system, SPROKET (Abrett et al.1989), which was developed at BBN over a period of years, and applied in a number of government and industrial projects (Abrett, Burstein & Deutsch,1989; Abrett et al, 1990; Abrett, 1991, Downes-Martin et al, 1992.). It models agents as acting on internal goals, plans and procedures using a number of representational constructs from planning systems like PRS (Georgeff and Lansky, 1986) and SIPE (Wilkins, 1988), and the representational models of (Schank and Abelson, 1976; Wilensky, 1982). It provides the capability to simulate a large number of agents each pursuing their own goals asynchronously.

On top of this basic simulation framework, we are constructing a library of templates for common coordination strategies that users will be able to compose to represent their organizations. This library is built around a representational theory of organizational coordination structures based on work at MIT's Center for Coordination Science to develop a 'handbook of oordination structures'. Malone and his colleagues there have using AI representational techniques for the construction of organizational models which capture aspects of the organization's actual behavior, as discovered from extensive case studies (e.g.,Malone, 1987; 1988; Crowston, 1991; Malone & Crowston, 1991).

Simulating Agents that Coordinate Dynamically using Policies

The goal-driven model of agent behavior allows us to simulate business processes in which agents can dynamically to take on multiple roles, or switch to jobs that they had not previously held, and communicate with new sets of agents. This provides the framework on which we expect to build models in which agents can be directed to do things like form new worker teams: asking other agents to perform new roles, and report to new managers.

In addition, we are developing a framework for representing and simulating agents' incorporation of new *policies* that modify the details of those agents' standard procedures for existing tasks. We take policies to be things that modify multiple aspects of their existing goals and procedures. For example, we take as a goal for our system that agents should be able to receive and act on communications from other simulated agents containing the following kinds of directives (we list some examples):

1. Use EMAIL to report on weekly progress on task X.
2. Notify your manager if output falls below 500 units per week.
3. Send all purchase orders directly to accounting (rather than through your manager).
4. Use 'Rapid Limo Service' for all travel to and from the airport.

Some policy directives can be implemented as new goals or procedures that can be communicated to the agents who will execute them. These include things like new condition/action rules (e.g., 2). Other policies require modifications to existing procedures of those agents. Many of the latter are can be viewed as describing preference rules to be used in the selection of a procedure to achieve specific subgoals (e.g., 1, 3, 4). As we begin to build procedures for dynamically composing job teams, we expect a new range of policy considerations to emerge, as it is by using such policies as guidelines, rather than by directly implementing organizational communications and coordination procedures, that such teams will form.

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References

Abrett, G. (1991) Planning by Autonomous Agents with Many Concurrent Goals in and Elaborate Simulated World. *Proceedings of the IEEE Conference on Planning in High Autonomy Systems*, Cocoa Beach, FL.

Abrett, G., Burstein, M. and Deutsch, S. (1989) *TARL: An Environment for Building Goal-Directed Knowledge-based Simulations.* BBN Report 7062.

Abrett G., Deutsch S. & Downes-Martin (1990) Two AI Languages for Simulation. *Transactions of the Society for Computer Simulation*, Vol. 7, No 3, 229-250.

Crowston, K. G. (1991). *Towards a coordination cookbook: Recipes for multi-agent action.* Ph.D. thesis, Sloan School of Management, Massachusetts Institute of Technology, Cambridge, MA.

Georgeff, M. & Lansky A. (1986) Proceedural Knowledge. *IEEE Special*

Issue on Knowledge Representaion, Vol. 74, 1383-1398.

Levitt, R.E., Cohen, G.P., Kunz, J.C., Nass, C.I., Christiansen, T, and Jin, Y. (1993) *The Virtual Design Team: Simulating how organization structure and information processing tools affect team performance.* CIFE TR#83. Stanford University.

Malone T. (1987) Modeling Coordination in Organizations and Markets. *Management Science,* Vol. 33 No, 10.

Malone, T. W. (1988) *What is coordination theory?* Massachusetts Institute of Technology, Sloan School of Management Working Paper #2051-88.

Malone, T. W., & Crowston, K. (1991) *Toward an interdisciplinary theory of coordination.* Center for Coordination Science Technical Report No. 120, Massachusetts Institute of Technology, Cambridge, MA.

Schank, R. & Abelson R. (1977). *Scripts, Plans, Goals and Understanding.* Hillsdale, New Jersey. Lawrence Erlbaum Associates.

-- 21st Century Manufacturing Enterprise Strategy. Iacocca Institute (1991) Lehigh University

Wilensky, R. (1982). *Planning and Understanding.* Reading, MA: Addison-Wesley.

Wilkins, D. (1988) *Practical Planning.* San Mateo CA:Morgan Kaufman.