Mathematical Organization Theory Workshop

April 23 and 24, 1994

Boston, Massachusetts

Organized by

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MAGIC FINGERS -- OSCILLATIONS IN THE PRICES OF NYC HOTEL

by
William Starbuck
Joel Baum

ROOMS"HOW STRATEGIES ARE LEARNED

by
Erhard Bruderer

I propose that both individuals and organizations can learn strategies in complex or ill-defined situations more effectively, using the process of inductive versus deductive reasoning.

To support this proposition, a theory of strategy learning is developed, where a strategy consists of a set of moves which can be combined many ways to respond to business situations. Strategy learning is captured by three basic processes: variation, adaptation, and selection. My theory is implemented using a computer-simulated game among artificial agents, with each agent represented by a computer program (classifier system) capable of intelligent learning. This game can make more significant predictions for a reputation game than traditional game theory. Computer simulation results are then compared with results from corresponding economic experiments. They indicate that sophisticated strategies such as reputation building can be learned inductively.

Using computer simulation of the genetic algorithm, Part II explores different hierarchical levels of organizational evolution. In the case presented, selection at the population level of analysis influenced learning capabilities at the organizational level, while the learning capabilities influenced the selection process. Thus, it is crucial to understand how strategy learning at these different organizational levels interact with each other Part III (in collaboration with Alex Shevoroshkin) discusses the importance of long chains of strategy moves. A mathematical model demonstrates that specific strategic instances can be identified effectively with a "bottom-up" hierarchical search, which first looks for the smallest, stable parts of an action chain and then combines them into larger and larger sub-strategies until the final strategy is identified. This model can predict how humans learn specific strategic instances when provided with intermediate feedback. Empirical evidence from a pilot experiment indicates that humans use hierarchical search to discover action chains.

This work provides a theoretical foundation for the evolution of intelligent organizations. If individuals can learn sophisticated strategies inductively, then so can organizations. Organizations should be able to function like large, parallel-distributed information systems, capable of learning strategies more effectively and able to leverage their strategic decision-making capabilities through the contribution of many intelligent individuals.

HOW ALLIANCES ARE FORMED

Another major area of interest is alliance formation. A mathematical model explaining the emergence of domains in spin-glasses is used to predict the formation of business alliances. The model is applied to predicting UNIX standard alliances in 1988.

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9:45-10:00 Min-Cheol Kang - "T a different actor; drinks and food ordered are often delivered by a server instead of the person who took the order. The system is also involved in the first function: wait staff enter their orders on a computer system which calculates the bill and might also transmit them to the kitchen. Some restaurants already provide their wait staff with wireless terminals which transmit the order directly from the table to the kitchen. One could imagine providing such a terminal to the customer; the orders would be directly transmitted to the kitchen and delivered when they are ready, thus eliminating the waitress or waiter in the middle.

As well, the wait staff deliver the bill and collect payment. In some cases, this is a real financial relationship; in some bars, for example, the wait staff buy drinks from the bar when they are served and later collect payment from the customer. In others, the wait staff (or the customers themselves) take payments to a cashier and return the change. Such systems have the advantage that all the money in the wait staff's purses is their own, eliminating the need to cash out at the end of a shift. With an ordering system, however, cashing out is trivial, because the system can quickly report the total amount ordered, subtract credit card payments, etc.

It is also clear which problems a seat-allocation or order- entry system does not address. It does not appear to address processes in the kitchen; in both cases we were seated immediately but had to wait for our orders, presumably due to the time required to produce it.

While a restaurant may seem like a trivial example, using a system to manage producer/consumer dependencies is clearly a general opportunity. A similar analysis could be applied to any supply chain, e.g., in a factory. The coordination theory framework seems to usefully explain the variety of alternative mechanisms for managing these dependencies and to suggest the potential contribution of information technologies. In doing so it goes beyond simple flow charts of steps in a process, providing a much needed theoretical underpinning for the study and design of new organizational processes.

BELIEF SYSTEMS

by
Nalini Dyanad

Decision making is a central componenet of organizational behavior. The decision making process is affected by the organizational structure, knowledge, and beliefs of the group members. This paper focuses on the social impact (homogeneity and consensus) of structure, knowledge, and beliefs. Using the constructural framework alternative views of group influence on beliefs are examined.

Recent work by Carley examined the structural and cultural bases for group stability using the constructural perspective. According to this theory, groups form and endure because of differences in information possessed by individuals. Over time, members of groups interact and exchange information. Interaction between members of the group is determined by shared knowledge between group members. However, human behavior is often attributed to peoples' beliefs and attitudes. Further, humans are embedded in social networks or organizational structures which influence their opinion and hence their behavior. Theories and models of interpersonal influence are in general agreement that an individual's opinion is determined by knowledge and social pressure but propose varying mechanisms by which his or her opinion changes over time. In this talk, we consider the impact of three different models of interpersonal influence on group stability. We find that, in general, beliefs increase time to stability. Long term impact of group influence on cultural homogeneity and consensus depends on the influence model in operation and can be quite low in some cases.

In combining constructural theory with models of interpersonal influence, this research makes some important contributions. Whereas previous models of group influence regarded social structure as fixed, constructural theory permits us to examine the impact of changing social structure on opinion formation and change. Social structure can be represented by the strength of ties between individuals. The constructural model allows us to theoretically account for changes in tie strength which is a key component in the process of opinion change.

TASK ENVIRONMENT CENTERED DESIGN OF ORGANIZATIONS

by
Keith Decker

The design of organizations or other coordination mechanisms cannot rely on the principled construction of agents alone, but must also rely on the structure and other characteristics of the task environment. The design of coordination mechanisms for groups of agents depends crucially on the agents' task environment. Such dependencies include both the structure of the environment (the particular kinds and patterns of interrelationships that occur between tasks) and the uncertainty in the environment. Task interrelationships include the relationships of tasks to the performance criteria by which we will evaluate a system, to the control decision structures of the agents which make up a system, and to the performance of other tasks. Less uncertainty in the environment means less uncertainty in the existence and extent of the task interdependencies, and less uncertainty in local scheduling---therefore the agents need less complex coordination behaviors (communication, negotiation, partial plans, etc) Representing and reasoning about the task environment must be part of any computational theory of coordination.

We have developed TAEMS (Task Analysis, Environment Modeling, and Simulation) as a framework with which to model complex, computationally intensive task environments at multiple levels of abstraction that is compatible with both formal computational agent-centered approaches and experimental approaches. The framework allows us to both mathematically analyze and quantitatively simulate the behavior of single or multi-agent systems with respect to interesting characteristics of the computational task environments of which they are part. We believe that it provides the correct level of abstraction for meaningfully evaluating centralized, parallel, and distributed control algorithms, negotiation strategies, and organizational designs. No previous characterization formally captures the range of features, processes, and especially interrelationships that occur in computationally intensive task environments.

My talk will briefly describe our modeling framework, TAEMS, for representing abstract task environments. I will also briefly describe a family of domain-independent, team-oriented coordination algorithms called Generalized Partial Global Planning (GPGP). Having a family of algorithms allows us to tailor the algorithm to the environment (or even a specific situation). GPGP is a modular approach that views coordination mechanisms as *modulating* the basic local control behavior of agents, not supplanting it. I will give an example of a simulation inspired by Burton and

Obel's work on organizational structure and technology decomposability. Finally, I will discuss how our approach can be extended to the analysis and simulation of more traditional (hierarchical) organization forms.

ORGANIZATIONAL KNOWLEDGE AND ANALYSIS/DESIGN DECISION MAKING IN ACTION

by
Les Gasser
Ingemar Hulthage
Ann Majchrzak

If we view organization design from an AI perspective, the process of design first involves making a series of modeling choices about 1) what conceptual and definitional elements are important in designing a particular sort of organization, and 2) what are the important relationships among these elements that designs must try to preserve or enhance. The effect of making these choices is to lay out a space of possible (partial) designs, which can be explored.

The next phases of a design process might be seen as a two-level process of A) exploration and refinement of designs within this space, and B) going back and redefining the space of design possibilities---modifying the sets of elements or relationships. The processes of design exploration and refinement involve several kinds of choices, and specific knowledge is needed to inform these choices. This talk will cover the specific choices supported and the particular types of knowledge used in ACTION to inform these choices. This knowledge is both concrete theory-driven knowledge, and heuristic design and design-process knowledge.

Specifically, the kinds of design knowledge and decisionmaking we will discuss include:

1) Knowledge about the order in which to settle (design) the different elements or relationships in an emerging organization design. This might be, for example, heuristic knowledge about which aspects of an organization to design, in which order. It's basically (in AI parlance) control knowledge applied to the design process - what action to take next.

2) Knowledge about how to make the specific design choices that arise--how to settle on values or configurations for one element, set of elements, or relationship in the organization. In the AI perspective, this is domain knowledge about how best to settle particular design decisions.

3) Knowledge about what makes high-quality organization designs.

4) Knowledge about how to link measures of organization quality (outcomes) to knowledge needed for heuristic choices on design process or organization configuration.

5) Knowledge about how to abstract an organization design space or organization design process to focus it at strategic levels, or to exploit metalevel coordination strategies in distributed design processes.

Two other phases of organization development with design implications come to mind as well: implementing organization designs, and revising existing organization designs (organizational change). The second of these involves other kinds of knowledge:

6) Knowledge of when and how to trigger organization change or redesign.

7) Knowledge of how to use and to feedback organizational performance information to focus the process and configuration choices in an organization redesign process.

Finally, practical computational support for design and analysis of realistic-scale human organizations requires specialized user interface concepts to support gathering and understanding these types of knowledge. For example, a key problem is representing, navigating, and developing a focus in huge bodies of knowledge with relatively low-bandwidth interaction tools. Another issue is the user interface design process--a long term, collaborative effort that integrates the experiences of using ACTION with the needs of communicating theory, conclusions, and explanations. Time permitting, we will raise several of these issues and ACTION's approaches to them.

SIMULATING LEARNING AND CHANGE PROCESSES IN ORGANIZATIONS: DO INDIVIDUALS MATTER?

by
Mary Ann Glynn
and
Steve Mezias

Recent years have witnessed a flourishing of computer simulation research in the literature on organizations. These simulation studies have made important contributions to the development of theories on organizational learning and change, (e.g., Levinthal & March, 1981; Lant & Mezias, 1992), entrepreneurship in established organizations (e.g., Lant & Mezias, 1990), innovation (e.g., Mezias & Glynn, 1993), technological change (e.g., Mezias & Glynn, 1994), and policy formulation (Whicker & Sigelman, 1990).

The focus of the simulations has been to explicate the consequences of different types of an organization's learning routines and rule-governed behaviors over time. Given this focus, the organizational unit is generally is modeled as a homogenous entity or unitary actor, bereft of the internal dynamics that underlie learning processes (Glynn, Lant, & Milliken, 1994). In the few simulations that explicitly include individual decision makers, individual behaviors typically are highly structured, constrained (Lant, 1994), or simplified without the cognitive limitations known to affect humans" (Carley, 1992: 39). In spite of some important attempts at modeling mutual learning processes in organizations (e.g., Carley, 1992; Lounama & March, 1987; March, 1991), there is little understanding of the interplay between individual and organizational characteristics in affecting both learning processes and outcomes. Levinthal and March (1981: 208) cogently described the limitations characterizing the typical computer simulation: "it ignores the problems produced by conflict of interest within a learning organization; it does not introduce any significant elements of cognition into a basically behavioral learning process; it assumes a very simple goal structure and a very simple conception of search." The need for addressing the level of analysis question lies in the fact that organizational learning is "neither strictly micro nor macro in character" (Rousseau, 1985:2).

In this paper, we explore how computer simulations can incorporate a multi-level approach to modeling learning and change processes in organizations. The literature (e.g., DiMaggio, 1991; Rousseau, 1985) suggests three possibilities for developing such a model of causality between the micro-level (individual) and macro-level (organizational) of analysis: 1) an aggregation of micro level effects, 2) cross-level effects, which can downward (macro to micro) or upward (micro to macro) in orientation, or 3) system interaction effects, which can be embedded as structured patterns of behavior. This last category -- that of system interaction effects -- is the focus of most simulation studies, with their explicit examination of those institutionalized learning routines that affect organizational outcomes. In this paper, we turn our attention to the first two categories and examine how computer simulations might capture aggregation or cross-level effects between the micro and macro levels. To accomplish this, we draw on related literatures to examine how individual differences may cumulatively or interactively affect organizational processes and suggest some possible simulation strategies. In trying to model the effects of both individual difference variables and organizational variables, our objective is to answer the question: Do individuals matter?

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of individuals comprising a group can be inconsistent with its average properties.

"TEAM-SOAR": A COMPUTATIONAL MODEL OF GROUP DECISION MAKING

by
Min-Cheol Kang

The proposed model, called "Team-Soar", models a naval command and control team consisting of four members who have different expertise and located apart from each other. The mission of the team is to identify aircraft and make decisions based on the identification. Members of the team cooperate interactively to make the decisions.

Groups are collections of individuals whose behavior can be understood by considering the properties of both the group and individual members. Broadly speaking, determinants of group performance belong to the following three categories; group- level, task and task environment, and individual-level. Past group performance research focused on examining the category 1 parameters (such as group structure, size, and coordination scheme) and category 2 parameters (such as task complexity, uncertainty, and stressful condition) with group performance. There exists relatively little research concerning the impact of category 3 parameters (such as agent style, cognitive ability, and level of training or skill) on group performance because of the need to address the issue of human cognition. But cognition is an important factor in determining the behavior of the individual and the group. Therefore modeling human cognition is necessary in studying group performance, especially in studying of group decision making.

Cognition can be viewed as computation using symbols. Accepting this view means that one can construct computational models of cognition. "Team-Soar" explores the relationships of all three categories' parameters on the team performance by constructing a set of cognitive-oriented computational models of team members and interlinking these models through team structure. "Team-Soar" explores group decision making as a macro- level phenomenon by using a set of micro-level cognitive models of group members.

"Team-Soar" is a group of AI agents called Soar. Soar models human cognitive capabilities of knowledge-based problem solving, learning, and interacting with external environments. Soar is used for modeling individual members. "Team-Soar" also incorporates current Distributed AI (DAI) technologies. Multi- agent problem-solving is a basic characteristic of groups. DAI is concerned with problem-solving situations in which several agents cooperate to achieve a common goal. Thus DAI can provide useful ideas and techniques for modeling group decision making. Here, such ideas and techniques are embedded into "Team-Soar" model.

Future research will compare the results of "Team-Soar" with simulations using human experimentation in the same problem domain. The model will then be used to produce research propositions for other problem domains.

ORGANIZATIONAL VISCOSITY AND THE DIFFUSION OF CONTROVERSIAL INNOVATIONS

by
David Krackhardt
Joel Podolny

This paper proposes a model for diffusion of innovations in organizations. The model draws heavily from Boorman and Levitt's Genetics of Altruism model, wherein they describe a mathematical solution to the problem of how a genetic predisposition to altruistic behavior might be able to propogate through a species, even though each altruistic conspecific has lower survival probability than its selfish counterparts.

In this model, proposed innovations are categorized as being sovereign, inferior, or controversial. Sovereign innovations are inherently and obviously superior to the status quo and recognized as such by anyone who is presented with the option to adopt it. Thus, the diffusion of sovereign innovations is simply a matter of the flow of information about the existence of the option to adopt the innovation. Inferior innovations are those innovations inherently and obviously inferior to the status quo. As such, inferior innovations are never adopted by anyone presented with an alternative. Controversial innovations are innovations that are not obviously inferior or sovereign, but can be viewed as either good or bad by different potential adopters. Thus, the decision to adopt becomes a complicated one of convincing the potential adopters that the innovation is a good one (superior to the status quo). This model focuses solely on the controversial innovations and the structural conditions under which the innovation will spread throughout the organization.

The model describes a minimal process by which conversion takes place. Each member of the organization is either disposed to favor the innovation (such people are called "B-people"), or to not favor it ("non-B-people"). Following the work of Asch, it is assumed in this model that if individuals encounter at least one person who agrees with their predisposed position (either favoring or not favoring the innovation), then they will retain their position. If, however, they encounter no one who agrees with them, then they will convert to the other position with a given probability.

We further assume that, as a starting point, the organization contains a small number of planted believers in the innovation ("B-people"). If we assume they have equal access to everyone else in the organization (a random mixing, or low viscosity case), we can show that it is almost certain that the innovation will die at equilibrium (everyone will become "non-B-people"). On the other hand, if structure is imposed on the mixing of people, so that people are only permitted to interact with others in certain groups, then the dynamics become nonlinear and counterintuitive. We can show that, under certain conditions, the minority B-people can virtually take over the organization, converting everyone to B-people. Under other conditions, the long run equilibrium contains stable pockets of B-people in a sea of non-B-people. These results parallel those of Boorman and Levitt and can be used to explain odd findings in the research on diffusion.

AN ANALYSIS OF THE EFFECT OF TRAINING UNDER TIME PRESSURE

by
Zhiang Lin
Kathleen Carley

Organizations spend much resources on training their members. One expectation is that training should help organizational performance. In fact, training has been shown to help organizational performance and prevents degradation of performance under stress (Perrow, 1984; Shrivastava, 1987; Roberts, 1989). However, the merit of different types of training under different levels of time pressure has not been fully explored. In this paper, we examine the impact of three types of training on organizational performance when three different levels of time pressure exist. Our results show that under high level of time pressure, when time is often short or insufficient, organizations without training, thus virtually guessing, organizations with operational training, thus following standard operating procedure, and organizations with experiential training, thus using historical experience, all exhibit low performance at about 33%. Under medium level of time pressure, when time constraint is tight, operationally trained organizations and experientially trained organizations all clearly outperform untrained organizations. In addition, organizations with operational training also exhibit higher performance than organizations with experiential training. However, under low level of time pressure, when time does not matter much, experientially trained organizations outperform operationally trained organizations, and both types of organization further outperform untrained organizations. Our results show that operationally trained organizations, which follow strict procedures, are more susceptible to time pressure than experientially trained organizations, which follow prior experience and are supposed to be more discretionary. This suggests that the advantage of experiential decision making procedure, which is more sophisticated though time consuming, only exists when there are enough time resources.

ALX.3, A MULTI-AGENT ACTION LOGIC, BASED ON BOUNDED RATIONALITY: FORMAL SYNTAX, FORMAL SEMANTICS, COMPLETENESS, AND ITS APPLICATION TO J.D. THOMPSON'S ORGANIZATIONS IN ACTION

by
Michael Masuch
Zhisheng Huang

We propose an action logic combining H.A. Simon's notion of *bounded rationality*, G. H. v. Wright's approach to *preferences*, S. Kripke's *possible world semantics*, Stalnaker's notion of *minimal change*, and more recent ideas from update semantics. Based on a first-order description language, ALX.3 (the x's action logic; third version) is sound and complete. The talk will present the formal syntax and semantics of ALX.3, give a glimps at the derivation of its tractability (completeness) and present an application of ALX.3 to J.D. Thompson's *Organization in Action*.

COMPLEX MODEL VARIATIONS: THE AFFECTS OF SELECTED PARAMETER CHANGES TO SIMULATION OUTCOMES

by
Steven Patrick

Computer simulation is one method of understanding and testing complex social theories. Mathematical modeling of linear verbal theories produces dynamic interactive models of social processes that are analyzable over time. Simulation have discovered and analyzed unexpected outcomes and interactions in complex systems (Patrick 1995) and attempts have been made to create empirically driven simulations through linkage to empirical data (Patrick 1993).

This paper will discuss the relationship between simulation outcomes and changes in selected equation parameters. Complex models, while highly robust, are sensitive to changes in equations parameters. A complex theory of organizational control developed by Collins (1988) is presented. Collins' theory holds that the same processes should predict control in all organizations with only parameter adjustments.

Simulations are presented showing differences in the model for coercive, material, and normative organizations. The model differentiates between organizational types based on changes to three parameters. The affects of coercive, material and normative controls on compliance. The results show that a single model can produce different outcomes based on changes to key variables.

Simulation models are sensitive to parameters changes without losing robust outcomes much in the same way natural systems are. With advances in empirical linkage, simulation can be seen as a powerful predictive tool for social science.

MODELING LEARNING AND ADAPTABILITY IN ORGANIZATIONAL BEHAVIOR THROUGH THE USE OF ARTIFICIAL ADAPTIVE SYSTEMS

by

David L. Paul
Keri E. Pearlson
Andrew B. Whinston
University of Texas

A framework for the simulation and modeling of organizational behavior utilizing a specific artificial intelligence approach is under development. This approach to simulating organizational behavior differs from previous efforts in that it utilizes an artificial intelligence technique, called an artificial adaptive system (AAS) (based upon various works by John Holland), that enables the model to include the concepts of learning and adaptability in the organization, and it attempts to develop a method to model aggregate organizational behavior as a function of the actions and interactions of the individual agents of which the organization is composed. In general, management theory tends to view adaptability in a macro context, while this work develops a micro view. Within the AAS, a learning mechanism can enable an organization to determine which of the organization's agents, functions, and/or processes are critical to its survival in different environments. The organization can then make those changes, thus increasing the likelihood that it can adapt to the various and changing environments in which it operates. This research framework is applied to a financial trading organization. The financial trading adaptive system (FTAS) is an example of how the learning mechanism in an AAS can be used to coordinate and allocate resources to critical departments or functions within an organization.

In this work, an organization is considered an artifact: an artificial, man-made entity. An organization represents the link between an inner environment composed of employees, managers, tasks, and departments, and an outer environment which includes the business environment in which the organization operates. The model or simulation of an organization is referred to as the AAS.

There are three major advantages to viewing an organization as an artifact{1}. First it is possible to predict the behavior of the organization by having knowledge of the organization's goals and of the outer environment in which it operates. Second there are numerous versions of the inner environment of the organization that are capable of achieving similar or identical goals in similar or identical environments. One does not need to know the exact operations and order of the inner workings of an organization in order to make reasonable predictions of its behavior. As a result, an AAS has properties that make it a good candidate for simulation via simplified models. Third, since systems can be described as nearly decomposable, in the short run, behavior of the components of the system are approximately independent of each other, and in the long run, the behavior of any one component depends only on the aggregate behavior of the others. An AAS can be considered a method for determining the near-optimizing, or satisficing, level of organizational performance in the noisy, uncertain, and ambiguous business environment.

We take the view of an organization made up of independent agents, each performing a separate sub-portion of a task. The agents' outputs are linked together by a decision mechanism in order to produce a system-wide output. An agent can in effect be considered to be an input-transformation-output cycle. Organizations have multiple levels of agents, including a division, department, function, or individual employee. Note that each agent itself can be considered an AAS. Decision mechanisms in an organization are made to define the relationship between agents. Organizations must have the ability to learn and to adapt to their environment to continue to operate. Learning is accomplished through the organization determining which of its agents' results is of most value to the organization, and adjusting to increase the likelihood of increasing the performance next time, through a feedback loop. These goals, or fitness functions, are based on a set of indicators most important to the organization, such as financial, productivity, or quality benchmarks.

An AAS is a means to experiment at a low cost with an organization and to explore how to best utilize the feedback from performance. By developing a simulation of an organization as an AAS, one can test various conditions, fitness functions, agent relationships, and decision criteria to see what the effects will be on the overall organization over time. Multiple time periods can be simulated in a matter of seconds, producing predictions about organizational performance at some future date.

This work in progress develops a conceptual model for an organization as an AAS. We explore potential issues in the formulation and development of an organizational AAS by taking a micro or emergent view of the organization and adaptability. We present a new way of simulating an organization by using a modeling technique that includes learning and adaptability. And finally, because financial markets are complex environments, of the availability of large amounts of data facilitates testing, and there is an objective, explicit fitness function based on performance, we identify uses of an AAS in the financial trading environment, which we call an FTAS, a financial trading adaptive system.

FOOTNOTES————————————————————

{1} These concepts are based upon work by Herbert Simon in his book The Sciences of the Artificial, MIT Press, 1969.

DESIGNING INCENTIVE SYSTEMS UNDER CONDITIONS OF BOUNDED RATIONALITY.

by
David Rose

Conventional principal-agent models assume players are completely rational: they know their own and other players' utilities and probabilities of all states of nature. In reality, players are boundedly rational, and must make decisions without such knowledge. We examine behavioral models of incentive systems using computer simulation techniques.

THE TRAINING IMPACT DECISION SYSTEM (TIDES): A DECISION-AIDING SYSTEM FOR PERSONNEL UTILIZATION AND TRAINING IN U. S. AIR FORCE OCCUPATIONAL SPECIALTIES

by
Dr. Frederick H. Rueter
Dr. Bruce Perrin
Dr. Jimmie Mitchell
Winston Bennett
Captain Gary Grimes

The Training Impact Decision System (TIDES) is a computer-based decision support system that has been developed to assist U.S.. Air force managers who are responsible for establishing and implementing policy relating to manpower, personnel, and training (MPT). It accomplishes this objective by evaluating the impacts on training and staffing that will likely result, within an Air Force occupational specialty, from various organizational policy options in which managers have expressed interest.

The TIDES models the flow of enlisted personnel through jobs in a specialty, estimates the quantities of formal and on-the-job training (OJT) required for the personnel to achieve proficiency on their jobs, estimates the amounts of labor and non-labor resources and associated costs required to support those training quantities, and evaluates the capacities of representative operational and training units to provide those volumes of training with available quantities of resources. Within the TIDES, the probable consequences of organizational policy options are evaluated by suitably adjusting the values of system parameters to represent changes in such organizational characteristics as: the contents of jobs and training states (e.g.., courses, individual OJT programs), the organizational relationships among jobs and training states, and the volumes of personnel flowing through and between individual jobs and training states.

The system has recently been applied to provide real-time analytic support for organizational planning by air force operational and training managers in Utilization and Training Workshops for two occupational specialties.

AFTER THE REVOLUTION, WAIT A WHILE
EVIDENCE FOR DYNAMIC ORGANIZATIONAL DECISION RULES IN REVOLUTIONARY CHANGE THEORIES

by
M. Anjali Sastry

A formal model demonstrates that existing theories of revolutionary or punctuated organizational change fail to explain how it is decided that the reorganization is over. In addition, these theories neglect to show how the rules governing the organization's searching and decision-making might change in the aftermath of an organizational reorientation. The need for such rule changes is demonstrated by a simple computer simulation based on published theories. Alternative strategies for managing the organization in the period immediately following a reorganization are found to influence two competing determinants of organizational performance: the organization's ability to manage change and its ability to build competence through processes that increase convergence. The computer results show that revolutionary organizational changes ultimately result in the failure of the organization, unless the processes that led to the reorientation-- scanning the environment, and comparing measured to desired performance--are suspended after the change is undertaken. In order for the organization to continue to function well, these activities must be reinstated after some period has elapsed. This waiting period is compared with clock resetting, the honeymoon period, and other effects described elsewhere in the literature. Finally, implications for research and practice are listed.

IMPROVE BUSINESS PROCESSES THROUGH ORGANIZATIONAL LEARNING

by
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Andrew B. Whinston
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Maintaining competitiveness is a great challenge for any organization: it often requires continuous adaptation of business processes to accommodate changes in the environment. The goal of this research is to introduce a representation scheme that allows an organization to build a model describing how it will respond to its environment, and to propose an alternative organizational learning process to assist in modifying and updating the model.

There are two research questions driving this work.

1. How does an organization construct its model of how to respond to the environment?
2. Once the model is constructed, how is it modified and updated to reflect the changing environment?

Shell Oil Company{1} has developed a system dynamic simulation model based on the mental model of senior managers. The model produces new insights into the power and stability of OPEC, the dynamics of oil prices, and the investment opportunities of non-OPEC producers. Thus, it enables the organization to recognize business problems and prepare to deal with them. This research seeks to develop a general representation scheme which would allow other organizations to develop a model such as that at Shell.

The representation scheme for this work is based on similar scheme in the machine learning field. It is composed of a set of specifications that predict future observations from previous experience. The scope of the model is based on the actions and perceptions of the organization, which allow the organization to predict the consequence of actions and direct subsequent actions toward organizational goals. If the model is denoted as M, an action is denoted as a , a set of predictions of these actions is denoted P, and a set of observations is denoted C, the following represents a high level notation for this model: M: (C,a) --> P

To construct a model, the organization must express its decision making rules following this scheme. The initial model can then be corrected, updated or modified, which is the second research question. Building on research in machine learning{2}, the work at hand seeks to describe an alternative organizational learning process to assist in updating and modification (see Figure 1 below).

As Figure 1 indicates, this process can be described as a cycle which is initiated by the model's construction. The organization then selects a series of actions which enable it to reach it's goal of generating maximum expected value. The outcomes of the action planning step are both the action taken by the organization and the prediction of the results of the action. The action is observed and measured and compared to the prediction in the evaluation step. If the prediction is within acceptable limits of the measurements made of the action, the model is satisfactory and no revisions will be made. However, the learning process takes place when there is a significant difference between prediction and results of the action. At this point, the model is revised and a new set of actions and predictions are made, completing the cycle. The revised model now contains updated knowledge about the environment, which is used in the next turn of the cycle.

The organizational learning process can be summarized by the following procedure:

1. Let M be the current model.
2. Let c be the current observation
3. Let t be the current model state
4. Select a sequence of action b
5. For each action a Œb, do:
6. xMake a prediction P based on M: (C, a)-->P, where C matches c
7. Execute a in the environment
8. Observe the actual consequence o from the environment
9. If the prediction is correct (i.e. P matches o)
10 Then record the experience (c, a, o) as an example of (C, a)
11. else (this is a mismatch) do:
12. identify the differences D between c and the examples of (C, a) --> P,
13. revise M using D so that c is distinguished from C and (c, a) has a prediction that matches o)
14. record (c, a, o) as an example of the proper entry of M.

As the model is continuously refined over each cycle, the organization develops a more accurate picture of its environment and produces more accurate predictions of the consequences of its actions.

The learning process will help organizations make better business decisions by incorporating the feedback into the business model. The contribution of this work is the application of the machine learning scheme to modeling of decision mechanisms. This structured language facilitates the translation of managerial knowledge into a computer simulation whose decisions can be studied and compared with their human counterparts.

FOOTNOTES——————————————

{1} See Morcroft, J.D.W. and van der Heijden, K.A.J.M. "Modelling the Oil Producers-Capturing Oil Industry Knowledge in a Behavioral Simulation Model." European Journal of Operations Research, Vol. 59, 1992, pg. 102-122.

{2} For example, Shen, W.M. "Autonomus Learning from the Environment." Computer Science Press, W.H. Freeman and Company, 1994.

TEAMWORK

by
Mei Ye

Increasingly, in modern society, work is done collaboratively within groups or teams. This is true especially in engineering or technical settings. Even though there has been extensive research on group behavior, we know little about how work relationships among team members affect performance in the domain of software development. In this paper we study how the `works with' and `dependency' relationships among individuals in software engineering teams evolve overtime and are related to project success. We examine teams of students involved in semester long projects during which they design, build and implement an information system.

The network of works with and dependency relations among groups is the group structure. These structures can be compared and contrasted across groups. In our study, we ask the following questions: Does a common structure emerge across all groups? Does this common structure vary over time? Are the common structures for junior's and senior's, or for successful and failed groups, similar or distinct?

Banks and Carley (1992) proposed a procedure for locating the common structure for estimating whether a random number of networks have a common structure and whether two common structures are significantly different. They proposed a metric for distributed networks. The metric that is indexed by two parameters : the location parameter and dispersion parameter. By using this measure, one can develop maximum likelihood estimates, hypothesis tests in the context of independent and identically distributed networks. We apply this metric to team project data gathered in three different time periods (beginning, middle, end of the project) in each semester for three years including junior and senior students. We test the hypothesis of common central networks between juniors and seniors, and between successful and failed groups.

The results we found are: 1) There are common structures for all juniors and seniors, but junior's and senior's common structures are different; 2) There are common structures for all successful groups, but the common structures between successful junior and successful senior are different; 3) There are common structures for all failed groups, but the common structures between failed junior and failed senior are different; 4) Successful groups tend to have more ties than failed groups based average group tie; 5) Juniors tend to have more ties than those of seniors; 6) The common structures for seniors fit better than those of juniors; 7) The common structures for successful groups fit better than those of failed groups. 8) These software project groups are all manager centered groups in terms of ties; 9) In senior groups students tend to depend on and work with the same other persons; 10) Juniors have a common structure only in dependency relations; 11) Successful groups have stable work with common structures, but failed groups do not have a common structures for work with relations.

MULTI-AGENT INTEGRATED FRAMEWORK FOR ANALYZING SUPPLY CHAIN DYNAMICS

by
Jayashankar. M. Swaminathan *

In a global economy, manufacturers are striving to shorten product development time, improve quality, and, reduce cost and leadtime for production. Manufacturer's interaction with the suppliers plays an important role in meeting the above objectives. Hence, it has become extremely important for managers to understand the dynamics of their supply chain. Flagrant inefficiencies in current supply chain design and management practice, as characterized by high levels of inventory, poor customer service (e.g. low order fill rates, long delivery times, etc.), waste due to sub-standard quality, high transportation costs, unavailability of accurate internal and/or external information(e.g. inaccurate delivery information, inaccurate demand information) etc. attest to the inadequacies and limitations of traditional techniques and tools.

To better understand the advantages and limitations of emerging manufacturing philosophies (like JIT manufacturing, EDI implementation, long term supplier relationships) and develop decision support techniques that help to operationalize these philosophies, account for opportunities provided by new technological advances and address the limitations of current supply chain management techniques, we have initiated work towards the development of a multi-agent integrated framework for the study of supply chain dynamics. In our framework, agents represent the entities (nodes) that comprise the supply-chain network being modeled.

Agent descriptions provide a basic structure for specifying both static and dynamic characteristics of various supply chain entities, and agents are specialized according to their intended roles in the supply chain network. Agents may have conflicting objectives (like the manufacturing agent might want JIT shipments, however, the supplier agent may not be willing to incur whole cost for implementing JIT) or may co-operate for mutual benefit.

The framework supports specification and experimental investigation of a wide range of supply chain configurations and coordination/management policies under different market circumstances. One goal is to analyze comparative performance of well-known inventory policies across scenarios that vary with respect to such features as external product demands, supply-chain network topology, quality of information exchanged, and level of modeling detail. We also plan to analyze the evolution of supply chain over time under different simulated conditions. Our initial study indicates that sharing of supplier information improves the performance of the supply chain under consideration and provides very interesting insight on the evolution of agent behaviour in the supply chain.

* This work is being done with Prof. Stephen Smith and Prof. Norman Sadeh at The Robotics Institute, Carnegie Mellon University.

CONSTRAINT SATISFACTION WITH LEARNING FOR MACHINE SCHEDULING

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In today's increasingly competitive and global manufacturing environment, profitability of an enterprise depends heavily on the efficient utilization of both time and resources. Scheduling is a fundamental task in the pursuit of that profitability and have received considerable attention in both industrial and academic settings. The emergence of artificial intelligence methods has provided an additional property in the arsenal of techniques to be brought to bear on scheduling --- the capability to learn. The embryonic in its accomplishments, the promise of imparting a scheduling system the capability to learn is enormous; however, much work must be done to understand the subtleties of learning in the context of scheduling. In this talk, we describe a system called CONSOAR, which casts production scheduling tasks in a constraint satisfaction framework. This framework is implement in a system called Soar, which is a general architecture of intelligence having the capacity to learn.

CONSOAR demonstrates how Soar can be used to solve the parallel machine scheduling problem and learn how to reduce scheduling effort during the process by exploiting computational regularities in the task. The particular scheduling problem we consider involves both sequencing and resource allocation decisions. We conducted a series of experiments to explicitly test where and how learning contributed to the effort reduction. The results show that accumulation of knowledge could lead to both within-problem and across-problem transfer of learning. It was also found that both problem-specific knowledge and general search control knowledge was learned.

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ANNOUNCEMENT: CALL FOR PAPERS

Journal of Mathematical Sociology
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The Journal of Mathematical Sociology invites submissions for a special issue to be titled "Computational Organization Theory." Papers should be concerned with organizational issues of traditional interest to sociologist. Papers should employ either mathematical, logic, or simulation models of organizations, models of organizations as collections of intelligent agents, or models of individuals' actions within organizations.

Relevant issues include but are not limited to:

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Each paper should include the following:

• A clear statement of the organizational issue that is being addressed. This introduction should be grounded in the sociological and organizational literature.

• A discussion of the key building blocks in the model. What was important about including just these components. This discussion will be considered one of the critical aspects of the paper. Issues of robustness and sensitivity should be addressed.

• A brief discussion of why formal modeling techniques are needed for this particular problem (not general comments). This should include a discussion of the benefits of using these formal modeling techniques to work on this particular problem (again, not general comments about the benefits of formal modeling). Why was formal modeling needed to generate the observed result. Provide a look into the future work, based on the current effort(s).

• A discussion of earlier formal models in this area (mathematical, logical, or simulation). If alternate current models exist they should also be mentioned. This discussion should be brief, but should motivate the model(s) to follow. Prior literature can also be located in the context of the current modeling issues.

• A clear statement of the organizational finding(s) generated. How does this advance our understanding of organizations.

Submit four copies of your paper, in JMS style, before February 1, 1995, to the special-issue editor: Kathleen M. Carley

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