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Introduction

Electronic commerce may be defined as the buying and selling of products and services, including information, through the use of the computer networks that make up the Information Superhighway (Kalakota, 1996). Projections show that this technology will transform many of the traditional aspects of commerce. The two products that have arguably been the most effective catalysts in promoting this change have been the computer and communications technology. For the past few decades these two domains have been converging so that a logical division no longer exists between them. This convergence of technologies along with advances in distributed artificial intelligence (DAI) research is in the process of facilitating the creation of a future that promises even more dramatic change. General Magic, Inc., with its Telescript-based electronic commerce (EC) technology, is attempting to provide a foundation for this future. This paper is an endeavor to understand this proposed foundation in the light of traditional organization science research.

One of the many definitions that could be used to examine an organization has been proposed by Richard Scott (Scott, 1992) as an open systems viewpoint:

Organizations are systems of interdependent activities linking shifting coalitions of participants; the systems are embedded in -- dependent on continuing exchanges with and constituted by -- the environments in which they operate.

Traditional organizational research, using this definition as a foundation, has focused on examining the characteristics of an organization, its environments, and the interactions that enable it to be effective, to be efficient, and to survive. An implicit assumption in such research is that the subject organization(s) utilize primarily human actors. The tools and resources that the organization utilizes are usually physical, and concepts such as efficiency are normally measured using the transformation of physical objects as an indicator. Until the recent developments in information systems and telecommunications technology this assumption has been valid. However, if the assumption of human actors is left out of the traditional definition of an organization, then any system of interacting actors with a common purpose and overriding authority could qualify as an organization, even though most of the actors and their tools are software programs operating primarily in a virtual universe. One of the purposes of this research is to expand the domain of organizational research to include the nascent realm of electronic commerce.

An additional goal of this research is to examine the viability of using an agent-based organization as a proxy for future research involving normal human-oriented organizations. Much of the difficulty found in organization research results from the confounding effect of human actors in the subject organizations. Humans do not always respond in a rational manner and have many interacting influences that make operationalization of theoretical constructs very difficult. In an effort to resolve some of these empirical problems and to facilitate research focused more precisely on the desired organizational constructs, this study will focus on an organization in which most of the actors, including line workers through mid-level managers, are software agents (SA). Since the terminal benefactors of all commerce are currently human actors and since it is necessary for most organizations to interact with the physical world, this domain encompasses both the virtual and physical universes. Most of the utilization of nonphysical actors called software agents in the EC domain currently consists of individual or groups of SA created as tools to facilitate physical transactions. A potential exception is an organization composed of a complete system of SA operating with the authority and goals of individuals or traditional organizations. Even though this type of organization has a link to the physical universe through human authorities and through other interactions such as shipping, its primary existence is in the nonphysical portion of the EC domain. Such an organization would therefore be an excellent representation of the proposed non-human organization.

DAI researchers are gradually producing some interesting modular tools for use in solving complex problems (Ubois, 1996). As these modular software agent-based tools become more effective, they will be combined to create systems of SA that are used in a wide variety of real world environments. A system is created using modular agents that are able to "communicate" with each other. It can be recreated to "fit" its task environment anytime such realignment becomes necessary. Specific problems can be solved in the most efficient and effective manner using existing tools. Traditionally developers of software applications of this complexity have had a variety of methodologies available to assist them. Tools such as computer-aided system engineering programs and design techniques such as object-oriented development greatly reduce the effort required to create and modify data flow diagrams, entity relationship diagrams, and other data models. Some also provide error and consistency checking functions, a design repository to facilitate code reuse, and automated code generation tools. Such methodologies are based on information systems research focused on creating an effective application or at most a system of applications to be used as tools by human actors. The implicit assumption is to create a relatively static application. The dynamic creation of an entire organizational system of software actors from modular components requires tools that are based on research of a completely different nature. Coordination techniques and authority relationships between interacting, and possibly competing, software agents that operate in non-traditional computing environments need to be understood much more fully to allow the creation of agent organization developmental paradigms. It is our belief that the integration of organization science research, specifically the line of research usually understood as contingency theory, and DAI research will provide an excellent foundation for such developmental techniques.

General Magic, Inc. of Mountain View California has created a network-based system capable of creating such an organization. The General Magic Agent Organization (GMO) is based on typical marketplace concepts such as (1) places, (2) agents, (3) transactions, (4) travel between places, and (5) communication. A transaction is generally the same in the EC domain as it is in the physical universe, with the exception that the material involved may be non-physical items such as information or a process such as scheduling a meeting. A GMO place provides the infrastructure necessary to complete a transaction. All of the facilities necessary to tie the GMO to the physical universe exit in places. Agents are GMO employees that exist to carry out the mission statement created by their ultimate human authority. Some of these employees are mobile and "travel" the network to carry out their assigned tasks. Others are non-mobile and act as virtual world shopkeepers by maintaining a presence in the GMO places. All interaction and communication in a GMO is through these two types of agent-employees. The process of network travel is conceptually similar to its physical world analog. A GMO employee simply requests to move from one place to another in the EC domain. The infrastructure built into places facilitates this transfer in the same way the infrastructures of the physical world facilitate human employee travel. Finally, communication is the process wherein GMO agents impart their desires to one another. Information is transferred either between intra-organizational agents in an effort to impart task assignments or results or in a boundary-spanning role between inter-organizational agents. Just as GMO employee travel is conceptually similar to physical world travel, agent communication is similar, if much more limited, to physical communication. It may consist of either "face-to-face" meetings or remote communication of messages.

The remaining sections of this abstract will briefly examine the concept of GMOs as focal points for research in organizational science. A prototypical GMO will be used rather than examining any one agent system. The format of the discussion will generally follow Scott's (Scott, 1992) adaptation of Leavitt's Diamond as a guide to the elements that are required in any organization. The paper will discuss the following two elements necessary for an organization as they relate to the GMO. First, the task environment within which the GMO must interact will be examined. Second, the participants, the workforce that makes up any GMO in terms of its management, staff, and line workers, will be discussed. Along with the discussion of the structure of the GMO, the organizational science concepts necessary to support the model presented in this paper will be presented. After the examination of the GMO environments the remaining sections of the paper will discuss the methodology and the simulation that will be used to operationalize and test the concepts in the above propositions. Variations of this simulation along with a survey of current agent systems will provide the basis for testing the validity of the propositions presented herein.

Task Environment

Just as no individual exists in a vacuum, no organization operates without constraints from external influences (Scott, 1992). If an object such as an organization is to have the intended effect upon its environment, any facets of the object's structure that provide inherent limitations must be recognized. In the 1960's Marshall McLuhan argued that television could provide a better means of establishing a global village than could the printed word. That "the medium is the message" (McLuhan, 1969) is easily as relevant a discussion of organizational fit as it was in an examination of divergent communications media. The medium in which a GMO operates, its domain, can be defined to be constituted of those elements which impinge upon its efforts (Dess, 1984). A detailed examination of the constituents and technology of the domain of EC are many and diverse and well beyond the scope of this paper. However, in order to support our contention that organizations, such as a GMO, that operate within this domain provide fruitful bases of research and to define the nature of the domain of EC, it is necessary briefly to examine its nature as a task environment.

An organization's task environment can be effectively represented as composed of three dimensions (Dess, 1984; Pfeffer, 1978). These dimensions are based upon the makeup of the entities which inhabit the domain, upon the rate and predictability with which they change, and the extent to which the environment is capable of supporting growth and providing organizations with "slack" (Galbraith, 1973). The first dimension is typically conceived of as complexity, the second as the dynamism, and the third as munificence. The first two dimensions, complexity and dynamism, are those which were chosen by (Thompson Chapter 3, 1967) from (Dill, 1958) in his examination of environmental constraints and are examined in this section of the paper in more detail within the specific context of the EC task domain.

The General Magic Organization

In order to investigate the organization structure-task environment relationship, an organization or a set of organizations operating in the correct domain must be studied. For the purposes of this paper the organization chosen is one made up primarily of electronic entities. General Magic, Inc. has created one of the first systems of software agents designed specifically to operate in the domain of EC. Even though the GMO's employees are electronic entities called software agents, in many ways they can be viewed as any agent is viewed in a normal organization. In this broader perspective an agent-employee can be hired (a software agent program is written and activated), fired (the agent process is terminated), dispatched on an outside job (the "go" or the "send" instructions in Telescript), and delegated a task along with the autonomy to complete it (instantiated with goals and functionality) (White, 1994). As with a more "normal" organization, there also must be processes for system coordination, information processing and control (Bond, 1988). This broader perspective allows us to use theories and research from the organizational sciences to examine the GMO from a new perspective. To establish a basic knowledge of the GMO, this section the paper examines, in a very non-technical manner, its nature in terms of its management and its staff and line employees. Relevant organizational control processes and further propositions are then discussed.

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