Producer Behavior in a Virtual Food Court

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Abstract

Economic entities exhibit many of the characteristics associated with agents. First, each economic entity is (generally) viewed as a rational decision-maker attempting to maximize its own welfare. An economic entity can thus be thought of as a rational computational agent accomplishing a goal. Second, each economic entity/agent is concerned with and in control of its own welfare, and is thus an autonomous agent. Third, each agent is viewed as intelligent because it engages in purposeful activity expected to achieve goals or objectives. We use these three observations and the DECAF agent toolkit [2] to model individual consumer and individual business behaviors explicitly, giving us a collection of economic agents which we expect to behave as received economic theory instructs us. Our agents have limited rationality (unlike traditional economic agents), can engage in certain specific well-defined behaviors, and have explicit representations of how to compute their own self interest. We then let the individual agents communicate and bargain with each other, where each agent only makes those transactions, choosen from among those available to be made with other autonomous agents, that maximize its own individual best interests, as best it can. The aggregate behavior of such agents should provide the same results as received economic and organizational theories (as far as such theories rely primarily on economic behavior). Our modeling approach provides us with the ability to prohibit certain selected behaviors, and thus to identify those key individual behaviors which are essential to the production of a particular economic/organizational behavior.

This paper describes initial work on economic modeling, including the modeling of voluntary organizational contracts, of a set of business entities set in the market context of the food court at an upscale suburban mall, the Virtual Food Court (VFC). VFC models diners, workers, and entrepreneurs. These economic entities are simple versions of the participants in transactions that take place within a simplified shopping mall food court. Although caricatures, the entities exhibit behaviors, chosen from a repetoire of self-interested behaviors, sufficient to allow VFC to contain a labor market, markets for food service equipment, and markets for food products. For example, accepting a contract to perform labor and forming an organization are reciprocal events. Because both of these are voluntary actions, we believe it necessary to model and explain both sides of the transaction simultaneously. This is what we do in VFC, planning to extend our results to model organizational structures more complicated than a simple employment contract while still basing the analysis on the need for there to

be reciprocally voluntary contracts. We expect that such models will be expanded to include aspects of governance [3] and non-economic social forces [1] as we explore the long term control and stability of such structures.

DECAF (Distributed, Environment-Centered Agent Framework) is a toolkit which allows a well-defined software engineering approach to building multi-agent systems. The toolkit provides a stable platform to design, rapidly develop, and execute intelligent agents to achieve solutions in complex software systems. DECAF provides the necessary architectural services of a large-grained intelligent agent: communication, planning, scheduling, execution monitoring, coordination, and eventually learning and self-diagnosis. This is, essentially, the internal "operating system" of a software agent, to which application programmers have strictly limited access. (DECAF extends the task structure frameworks of TAEMS and RETSINA.)

VFC exhibits its behaviors in a model of bounded rationality. Information is only available through reporting mechanisms or communications with other entities. Not all information is available to all decision makers, and limits are be placed on the amount of information that can be analyzed and the amount of time available to analyze it. The presence of limits is a reasonable reflection of actual decision making, which is often bounded by time. DECAF provides a convenient mechanism for modeling economic activity as the actions of a set of agents. DECAF is the toolkit which allows the development of the agents and the exchanging of information among them. In particular, DECAF's model of software agency includes as primary features the need to support reasoning under deadlines, reasoning about alternatives, and reasoning about tradeoffs between multiple activities.

Management of an arbitrarily large number of interacting agents, organizing them into workable units while still recognizing and respecting their individual autonomy, is a significant problem. Since multi-agent system toolkits such as DECAF do not limit the number of agents, since the various agents can reside on different machines, and since the computational location of an agent is of no concern for modeling purposes, simple computational scalability does not loom as a significant problem. However, when these agents must interact in complex, changing ways, the scalable control and coordination of such systems becomes a pressing issue. One principal interest is, then, how to organize and at least partially control large dynamic multi-agent systems.

DECAF lets us create an artificial world with all the essential characteristics of the economic market place. With this tool, we can study and explain the "management" of numerous autonomous agents to simulate the economic activities which characterize the agent-selected activities that result from the mutually independent desires of each agent to maximize its own well being. To fully achieve such an explanation, we must further explain how autonomous agents communicate and interact with one another within constraints imposed by physical reality, to achieve organizations. We put quotes around the word "management" because, as Mintzberg would have it, there is mutual adjustment between agents. The only decisions are those of individuals, and thus organization is an observable result of the communication and actions of individual autonomous agents. Explaining how organizations come about out of large numbers of autonomous individuals, in a changing environment, with changing technologies and changing demands, is our principal long term goal.

As with the general economy, activity in VFC is consumer (Diner) driven. Each Diner has the goal of maximizing its own satisfaction from food purchases. Diners'

preferences for food are known to the Diner and are revealed through requests for items and selections from among the available foods. Entrepreneurs act as vendors and attempt to maximize their incomes (the difference between sales revenue and total labor and preparation costs). Information on labor and food purchases is available through "governmental" bureaus that record and publish some (but not all) information related to labor use and to food consumption. As a result of the interaction of diners, workers, and entrepreneurs, restaurants are formed (organized) to serve the needs of the diners. The restraunts, in turn, serve the income desires of the entrepreneurs. Alternative forms of ownership and organization are expected to evolve in later versions of the VFC. Notions of market purchases and contracts are used in VFC. Market purchases are simple exchanges of money for food products or for one act of labor where each exchange is independent of (not monetarily related to) any other such exchange. A contract is any other arrangement for the exchange of money for either a product or labor, but none are currently implemented. Key to the identification of a contract is the idea that the transactions contracted for cover more than one instance or exchange. A purchase activity in which multiple products are purchased is treated as a set of market purchases unless it is part of a broader agreement.

Our purpose in a typical study with VFC is to explain, step-by-step, one specific and particular economic phenomenon, say the equilibriation of a purely competitive market. We believe it is not sufficient to show simply that such phenomena can happen, but rather that is necessary to detail the conditions under which the studied phenomenon happens as a result of voluntary action. With competitive markets, we would show the conditions that must exist so entrepreneurs, operating in their own best interests, act in ways consistent with competitive markets. Models which require agents to act in other than their own best interests should not be demonstrable using the VFC.

Transaction cost economics, for example, places a great deal of weight on the behavioral and engineering assumptions upon which it is built. The behavioral emphasis has to do with cost minimization and self interest. The engineering assumptions have to do with the particular production functions (in VFC, these are the technologies and the parameters which differentiate them). In total, though, transaction cost economics deals with only simple cost minimization, and the contracts that occur are those needed to secure resources needed to continue to produce.

In this paper, we show how our producers accumulate the resources necessary to engage in the productive activities that support restaurant behavior. Additionally, we illustrate how consumers gravitate to a smaller number of restaurants when restaurants are relatively more resource constrained, and to a larger number of restaurants when relatively more ample resources support the restaurants.

References

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