

Cultivating the Agent Economy

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Abstract

Advances in electronic commerce and agent technology are pushing the world rapidly toward ever-increasing e-business automation. The logical development of this movement is agent-based electronic commerce, in which software agents act as autonomous (or semi-autonomous) businesses in their own right, buying and selling information goods and services online.

We review some of the foreseeable developments and challenges in the growth of agent-based electronic commerce.

1 Enabling agent-based e-businesses

For several years now, the Information Economies Project at IBM Research has been projecting a future in which billions of software agents buy, sell, produce, and consume information goods and service online, forming an important—or even dominant—sector of the global economy.[3] In that time, intellectual and technological advances both in software agents and in electronic commerce have brought such a world significantly closer. These two fields, which have thus far developed independently, are now poised to converge on a common vision of agent-based electronic commerce.

Incentives. The information agents that have thus far appeared in e-commerce contexts have not themselves been economic. For example, a typical shopbot neither charges for providing its service, nor tailors its actions based on considerations of trade. These agents suffer from the problem of incentive: why would a firm choose to create and offer such a service? This problem becomes especially acute when the users of the service are themselves software agents, in which case selling banner ads (e.g.) ceases to be a viable revenue source. The natural answer is for agents to receive value in return for giving it—i.e., for agents to charge for their services.

Interoperability. Within the agents community, standards of interoperability at the messaging level are solidifying.[2] And despite formidable challenges, interoperability at the knowledge level (ontology, conversation protocol, etc.) has seen much progress. But agent-based e-businesses cannot survive unless they can integrate into the larger world of e-commerce, with all its complexities and idiosyncracies. One of the most active areas of e-commerce is business-to-business integration, and technologies and standards for programmatic, Web-based business interaction are already appearing (e.g., UDDI[5]). Thus far these have been tailored to fit existing business models, and it is not at all clear how the needs of agent-based e-businesses will mesh with them.

Composability It is not possible to compose an economy of agent-based e-businesses by defining roles and assigning agents to them, as is usually done in multi-agent system design. Each firm unilaterally chooses, and sometimes invents, its own role. Sometimes a firm's very survival depends on its ability to redefine its role as it sees fit. Thus we cannot cultivate agent-based trade by deciding what niches the agents should fill; we can only do it by providing means whereby an agent-based firm can define its own niche.

Perhaps the key to this problem lies in the close kinship of composition of services across agent boundaries with composition of functions within an agent. By finding ways to assemble agents out of off-the-shelf reusable business functions, for example, we may reduce the technological problem of how to agent-based services are composed to the economic problem of whether a firm should perform a function in-house or outsource it. Providing this sort of functionality may be the most significant software engineering challenge in agent-based e-commerce.

2 Automating economic behavior

Beyond enabling agents to provide Web-based services, however, agent-based trade requires automation of specifically economic modes of behavior.

Automated pricing Price information is perhaps the most universal and easily quantifiable attribute of a product, so it is not surprising that it has been the target of the first bots. Similarly, auctions are attractive because auctioneer bots are easily automated, as are the mechanics of bidding. Auctions may well continue their renaissance, though it doesn't seem likely that posted pricing will disappear any more than will other forms of price-setting. If anything, automation will lead to an ever-greater variety of price-setting mechanisms. Combinatorial auctions, nonlinear price schedules or complex service plans that would bewilder human clients are much more easily handled by agents. (Automating the *competitive* strategies behind price-setting is another matter entirely; see [4].)

Differentiation Beyond price information, we are faced with the hard issue of specifying complex attributes such that bots can recognize, process, and exploit them. In vertically differentiated goods, for which the alternatives have a universally agreed-upon value-ordering (e.g., more bandwidth is always better), the situation is at least comprehensible. But what about other, less orderly attributes?

Similar to this is the issue of differentiation among companies. Firms today compete on identity at least as much as on price. One consequence of this is the high level of attention firms pay toward brand value and reputation.

Far from disappearing in an agent economy, branding and product differentiation may take on an even more important role. One consequence of shopbots is that it becomes significantly more difficult for a firm to profit by providing undifferentiated commodity services. The technological question, therefore, is how to enable agents to generate and to process reputation and brand identity information.

3 Emergent markets

Agent-human hybrids The differences between agents and humans are economically crucial. Clearly agents are faster at carrying out well-specified tasks and capable of employing sophisticated mathematical reasoning far beyond the typical human's ability. But of course people are vastly more able to learn from past behavior, to invent new approaches to problems, and employ what is usually called common sense.

Given these considerations, it is likely that a new type of agent-human hybrid firm will take over the marketplace. Such a thing would combine the strengths of each of its parts. The human, for example, could concentrate on setting long-term policy or strategy, while the agent carried out the day-to-day operations of the business. Taken to its extreme, this results in a world of which one might claim, "Everyone is a CEO, and all the employees are digital".

Bot-centric services It is clear that the advent of business bots will permit the creation of fundamentally new business models and fundamentally new services tailored to bots as customers. Clear examples of these are "middle agents"[1] such as bot-centric brokers, directory services and match-makers, as well as reputation services, ontology translation services, and the like.

What other bot-centric services can be foreseen? One possible approach to answering this is to look at parts of business function that are automatable, but not easily so. In such cases, someone with specialized knowledge or a clever idea can provide the function as an online service better than clients could do for themselves. Here again, technology to permit easy assembly of an agent-based e-business is key.

Collective dynamics As agent-based services come online, we can expect to see new forms of collective behavior. This is true even in the early stages, when bots are primarily existing in a human-dominated economy, because of the radical separation of timescales between bots and humans. But as agent-provided services become more common, and agent-agent interactions and bot-centric services become commonplace, we can also expect new forms of collective behavior to show up in the marketplace. This may be the agent-based economy's greatest danger; but it may also hold its greatest promise.

We have already investigated collective dynamical effects in a number of contexts.[4] Many of our results have uncovered sensitivities in market dynamics to the particular mix of participant strategies. This emphasizes the need of holding *robustness* as a primary design criterion at least as important as putatively optimal behavior.

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