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An Agent-Based Global Economy

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Any people are buying music CDs over the Web, but with multiple retail sites offering the same CDs, how do you decide which retailer to buy from? Typically, you visit a few sites and choose the one with the lowest price. Shopbots—shopping agents that automatically search the Internet to obtain information about prices and other attributes of goods and services—are ideal helpers for such a task. The better ones can visit hundreds of sites, giving price-conscious consumers a powerful tool that could work to the detriment of some retailers.

However, retailers also use shopbots (they call them pricebots) to check each other's prices. This is precisely how Books.com used to operate: it would charge one cent less than the cheapest price offered by Amazon, Barnes & Noble, and Borders. With this strategy, a clever retailer such as Barnes.com might garner sufficient sales to capture a disproportionate share of the market.

Visions of the Future

But what happens if all shoppers use shopbots and all retailers use pricebots? This is the subject of current research by Jeff Kephart and his colleagues at IBM, who build simulated worlds of shoppers and retailers and then unleash teams of agents into those worlds. Depending on the conditions they impose, price wars erupt, chaos ensues, and some retailers go out of business. In many ways, these simulations preview the future of electronic commerce.

The Internet is moving toward an open, friction-free marketplace in which software agents will manage the buying and selling of goods. In the near term, agents' major roles will occur in the general economy of goods and services, where they will dynamically link teams of buyers and sellers, producers and consumers, in efficiently managed transactions. Agents will contribute to this economy by reducing communication and interaction costs—the "friction"—associated with doing business.

In the new information economy, agents will purchase ideas, computational results, search results, and raw information from other agents and refine this information through aggregation, filtering, knowledge discovery, data mining, classification, translation, and other processes into information products. They will then sell the resultant products to other agents—both computational and human.

Earlier Agents on the Web columns reported on how agents are managing Web-based auctions such as eBay and how teams of agents are using collaborative filtering to recommend books at Amazon and Barnes & Noble. Some years hence the Internet will likely support numerous agents that may not be associated with a particular website. These independent, economically motivated software agents will find and process information and disseminate it to humans and, increasingly, to other agents.

Using the Internet for an agent-based information economy seems beneficial. After all, economic processes already manage the conflicting needs of billions of human agents. Adam Smith referred to just such processes when he explained in The Wealth of Nations (1776), "every individual necessarily labors to render the annual revenue of the society as great as he can... He intends only his own security; and by directing that industry in such a manner as its produce may be of the greatest value, he intends only his own gain, and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention." Perhaps a similar process will operate in an agent-based economy.

Simulating Agent-Based Economies

University of Michigan professor Michael Wellman has turned Smith's idea into a computational mechanism, albeit on a limited scale, in his development of market-based programming. He set up a system of producing and consuming agents, each intent on maximizing its own profit. By running the system until it reaches equilibrium, he can solve optimization problems.

At first glance, it seems that this mechanism can be applied to agent-based information economies. However, information economies involve human as well as software agents, and by comparison, software agents are immeasurably less sophisticated, less flexible, less able to learn, and notoriously lacking in common sense. Given these differences, it's entirely possible that agent-based economies will behave in unexpected ways.

This is exactly what Kephart and his colleagues found. They first assume a mixture of buyers, some searching for the lowest price and the rest buying from the first seller who meets the
price they have in mind. Their pricebots operate according to one of three different pricing strategies:

- **game-theoretic**, based on a mixed-strategy Nash equilibrium;
- **myopically optimal**, by which prices are set according to the known mix of buyers and other sellers’ current prices; and
- **derivative**, whereby each seller sets prices according to its own profit trend—increasing its prices as long as profits are rising and decreasing prices as long as profits are falling.

The first two strategies require perfect knowledge of buyer statistics and the number of sellers, whereas the third requires only local knowledge.

When all pricebots follow the same strategy, the derivative strategy yields the highest profits for all. However, with a mixture of pricebots following different strategies, those following the myopically optimal strategy fare best. Interestingly, if pricebots are allowed to change their strategies, they will end up with the myopically optimal strategy, which leads not only to repeated price wars but also to lower profits for all.

**The Future of Brand Names**

One potential outcome of a mass market of interacting pricebots and shopbots is the loss of brand-name identity. In our present economy, sellers rely heavily on brand-name influence, and buyers learn to depend on known brands. First-generation bots focus only on price and are oblivious to brand names: to them, a mom-and-pop garage operation is indistinguishable from a major manufacturer, and there is no such thing as monopolistic competition. Agents, however, might be able to dynamically form large coalitions and chains of producers and consumers, then find matches to make such bartering feasible.

Agents will continue to evolve from assistants into decision-makers, and their autonomy and responsibility will increase. Ultimately, transactions among economic software agents will constitute an essential and perhaps even dominant portion of the world economy.

**REFERENCES**


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