INTELLIGENT AGENTS: ISSUES AND APPLICATION

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1 AGENTS — AN AI RENAISSANCE

Over the years artificial intelligence (AI) has received substantial attention for the potential benefits that it could bring to organizations. Unfortunately, AI was not always able to meet expectations. However, with the large amount of information available on the world wide web, there is renewed interest in technology that facilitates access, control and understanding of that information. One technology that is key to accomplishing that goal is intelligent agents. This interest in and use of AI in order to generate intelligent agents has led to a virtual renaissance in AI (e.g., O'Leary [1]).

This paper first analyzes agent characteristics, and then focuses on reviewing some of those activities that agents have been designed to accomplish. Then means through which agents can be used to create value are discussed. Next the impact of agents on organizations and processes is analyzed. Finally, there is a short discussion about some issues in privacy resulting from the generation of agents and related databases.

2 AGENT CHARACTERISTICS

Etzioni and Weld ([2], p. 44) define "software agent" as "... a computer program that behaves in a manner analogous to a human agent, such as a travel agent or an insurance agent." Although agents have a number of possible characteristics, not all are built into each agent. In any case, those characteristics include:

Autonomy. An agent controls many of their own actions. Typically, agents are goal oriented, collaborative, and flexible. Agents may ask for clarification or refuse to perform some activities. In some senses they are aware of their limitations.

Adaptability. Some agents have the ability to customize themselves in order to meet user needs. Some agents change in response to changes in environment. In many settings this adaptability is accomplished through the generation and use of "profiles" that characterize users. Agents may be learning agents. For example, recently, Autonomy released agent software that employs neural nets in order to facilitate search for patterns of information, rather than keyword search.

Knowledge-based. Agents typically have knowledge about processes, entities and communications. That knowledge can be stored in a number of different ways, including classic rule-based knowledge representation. Knowledge defines particular agent roles, including broker agents, supply and demand agents (e.g., Brown et al. [3]).

Communications Capabilities/Interface Capabilities. Since agents do not function in a vacuum, but may communicate with other agents, they have communication capabilities. Those capabilities may be limited to a particular set of protocols or to communicating with other agents whose role is to facilitate communication.

Homogeneous vs. Heterogeneous Initially, a set of agents may be identical to each other (homogeneous), and then evolve into a set of heterogeneous agents by adapting to users or the environment. Alternatively, the agents may be heterogeneous throughout their evolution.

Information Asymmetries Between Agents. Agents have different levels of knowledge of different information sets. For example, brokers of information have knowledge about the information that they sell (scope, quality, etc.), whereas buyers of the information have a differential set of insights about that same information.

3 WHAT ARE SOME ACTIVITIES THAT AGENTS DO WELL?

Agents have been used to accomplish many tasks, many on an ongoing basis. A number of these tasks are summarized in the references. In particular, agent have been built to facilitate knowledge navigation and search for information (e.g., O'Leary[4])

3.1 Assist Knowledge Navigation

Some intelligent agents have been developed to directly facilitate browsing by providing a tour guide of the Internet for the user. These systems function while the user is in the process of browsing. Two of the better known systems include *WebWatcher* and *Letizia.*

WebWatcher. (<http://www.cs.cmu.edu/afs/cs.cmu.edu/project/theo-6/web-agent/www/project-home.html>) provides the user with a browser that has a number of capabilities to facilitate browsing, including finding pages related to the current page, adding hyperlinks to the starting page in order to meet users search goals, and gives advice based on user preferences.

Letizia. (http://lcs.www.media.mit.edu/people/lieber/Lieberary/Letizia/Letizia-Intro.html) is an agent that assists a user's browsing on the WWW. While the user browses using, e.g., Netscape. the agent collects information about the user's behavior and tries to anticipate additional items of interest to the user. Using that data and various heuristics, the system make inferences about the user's interests and feeds that information back to the user.

Browsers that assist browsing provide increased access to different parts of the web. However, these tour guide browsers will not necessarily be free from bias. For example, we can imagine an agent that assists the browsing by guiding us to "sponsored" activity that directly or indirectly relates to the user's profiled interests. In addition, tour guide browsers could influence privacy. Theoretically, the agent could capture records of browsing activity and periodically report back to some server regarding that activity. Knowledge discovery could then be used to investigate the large databases of individual or groups of users' behavior for trends.

Agents also search for information. For example, a number of intelligent systems have been developed to find information or products on the WWW. Typically, these agents depend on the user providing information either directly or indirectly through their choices, so that the system can learn about their interests. Three of the better known such systems include:

Firefly (http://www.agents-inc.com/agents/AgentsInc.html>) helps the user find music that they are likely to enjoy. Firefly uses information gathered from others "similar" to the user to suggest new music to the user.

Webdoggie (z<http://webhound.www.media.mit.edu /projects/webhound/>) attempts to mitigate the impact of information overload. Either on-demand or periodically, the system will recommend WWW documents, based on user-expressed preference (e.g., interesting, boring, etc.).

Bargain Finder (http://bf.cstar.ac.com/bf/>http://bf.cstar.ac.com/bf/) is designed to help the user find the "lowest" price for a CD.

3.2 "Frequently Asked Questions"

"Frequently Asked Questions" (FAQs) files are compendiums of the semi-structured wisdom of newsgroups on topics that of frequent interest. FAQs are found at home pages of "centers" of knowledge about particular issues, and thus are dispersed around the world.

FAQFinder (http://www.cs.uchicago.edu/~martin/faq_finder.html and http://cs-www.uchicago.edu/~burke/faqfinder.html) is an automated question-answering system that uses files of FAQs. The system will take a query from a user and try to find the FAQ file that will most likely provide an answer. Then the system searches within that file for similar questions, and provides the answers given provided by the FAQ source. FAQFinder is a meta FAQ.

3.3 Improving Productivity

Internet technology has been used for improving the productivity. "Globenet" (<http://www.watson.ibm.com:8080/main-cgi-bin/search_paper.pl/entry_ids3D7838; <http://www.watson.ibm.com:8080/main-cgi-bin/search_paper.pl/entry_ids3D7863), developed by IBM (presented at the workshop by Grosof and Foulger), does knowledge-based retrieval and handling of heterogeneous databases. Rule-based agents provide control on information retrieval. Reasoning is performed on both structured and unstructured aspects of qualitative databases, in particular, network newsgroup filtering. Globenet is currently deployed in a customer service support application within IBM, assisting the staff with customer questions and problems.Early tests with Globenet suggest that productivity can be improved by over 30

3.4 General Purpose Intelligent Agent Assisted Search

Intelligent agents can be used to assist search of the Internet and the Intranet. In general, agents developed for search on the Internet can also be used to search Intranets. In contrast to intelligent search engines or intelligent browsers, intelligent agents perform in the background while the user is performing other tasks.

Agents, whether for the Internet or for an Intranet, should have certain technical capabilities. First, they need pattern matching capabilities to perform the activities requested of them. As a result, they should be able to handle relatively complex logical comparisons. In addition, agents should have hierarchical and time intelligence. In particular, agents should be able to "inherit" rules from other structurally related agents. Further, the agent should be able to discriminate between "the current month" as time changes in a rule like:

"For the current month which of the products have sales above budget?"

Further, agents should be able to function for individual users and for the organization as a whole. Since agents are for individuals, they must have the ability to be personalized. As a result, agents must be easy to build. In order to be easy to build, problem and opportunity detection rules, must be easy to use. Further, it suggests that the agent have the ability interface with data in an intelligent manner. If data requested is not directly available, but is derivable, then ideally, the agent should be able to generate that derivable data.

In addition, when an agent comes back with an "alert" that information should be placed in context. Agents need to provide the executive with information as to (1) why the alert was generated, (2) where the executive can go for further information, without having to generate a complicated query and (3) possibly, some recommended action for the problem or opportunity.

In a classic executive information system, executives are provided a single corporate view of the competition. With intelligent agents available to individual executives, this notion of corporate knowledge of the competition disappears. Individual executives can begin to do their own competitor analysis. King and O'Leary [5] explore this point in more detail.

4 CREATING VALUE USING AGENTS

There are a number of ways that we can create value using agents. First, agents create value by doing things people can't do or can't do effectively. For example, it is physically impossible for a person to visit as many world wide web sites as an agent can do. There are somewhere over a 100 million web pages, resulting in information overload. In addition, many settings, such as virtual organizations, require responses in a real time.

Since agents are assigned to do tasks (e.g., search) that a person might ordinarily do, they create value by freeing up person hours. Further, since computer-based agents perform tasks that people might perform, they can lower costs.

Finally, agents create value because they can meet decision making needs. In the case of "Bargain-Finder" the agent finds the most inexpensive source for a CD, something the user has direct interest in. Agents find useful information in a world of information overload.

5 IMPACT ON ORGANIZATIONS AND PROCESSES

5.1 Virtual Organizations

Intelligent agents play a critical role in the generation and development of virtual organizations. Goldman et al. ([6], p. 7) define a virtual company as one "...where complementary resources existing in a number of cooperating companies are left in place, but are integrated to support a particular product effort for as long as it is viable to do so. ...." Resources are selectively allocated to the virtual company if they are underutilized or if they can be profitably utilized there more than in the 91home' company."

Agents provide the ability to respond quickly so that companies can create value by making use of unused or underused company resources. O'Leary, Kuokka and Plant [7] provide an extensive analysis of some of the issues underlying the integration of agents and virtual organizations.

5.2 Economic Impact

Agents also can have a substantial economic impact on organizations and industries, and influence strategy. Arthur Andersen's experiment with the BargainFinder agent originally began with eight firms. After eight months, of those eight firms, only one store was actively cooperating, one store quit operating, three refused queries and remained neutral. In addition, an additional seven stores have asked to participate in the experiment. Of those seven, currently one is participating actively.

It is easy to guess which of the original eight firms was the low cost provider and which were not. In addition, it is also easy to guess the strategy of the seven firms that want to be included in the experiment. Since there is a non trivial cost of setting up a store front, each of the active participants must anticipate substantial revenues from the sales of CDs. However, in order to generate any substantial revenues in a BargainFinder environment, the stores must be low cost providers.

In addition, it is also clear that the three that refuse queries apparently found that cost exceeded benefit. These apparently were not the lost cost providers. Instead, these stores apparently feel that they are able to exploit alternative market niches resulting from limiting information flow.

Systems such as BargainFinder generally force prices down in an industry. An analogy in the travel agent market occurred when firms such as American and United Airlines made all airfares available in a single database.

BargainFinder forces a change in industry structure, moving the industry towards one where sales are concentrated in a smaller number of firms, those with the lower prices and a large selection of titles. BargainFinder ultimately turns some market segments of near commodity markets into highly price competitive industries, since it facilitates information about price.

The case of BargainFinder also shows that information gathered by agents can create value. Consumers benefit from the availability of real time search. But how do the developers benefit? BargainFinder was a prototype, built to try and understand some emerging issues in electronic commerce. So an interesting question is how can value be created for the developer of such an agent. Although a usage price might be charged, it is unlikely and also subject to potential price competition. Using the world wide web a user can generally perform a search on CD prices without a large cost. As a result, knowledge discovery probably is the source of value to the developers of such agents. Databases can be generated that capture profiles of agent users. Those profiles could be strengthened if the search data would then be combined with the actual purchase databases at the stores. Then manifestation of search behavior could be linked to buying behavior. Unfortunately, there may be privacy issues that need to be addressed before such databases are integrated for knowledge discovery.

Agents developed for search and communication of similar information on other commodity or near commodity markets are likely to generate similar sets of results.

6 A CONCERN FOR PRIVACY: SHARING INFORMATION BETWEEN AGENTS

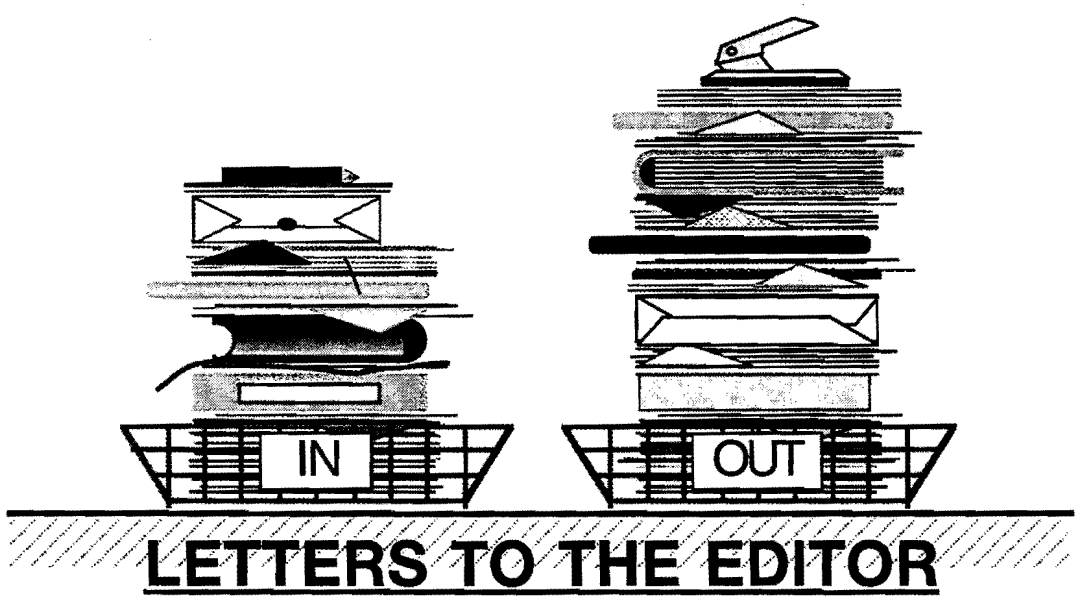
Different agent groups sharing information about their user base or other types of data is a potential threat to privacy. As O'Leary (1996, p. 11) noted "Perhaps some of the most future developments (greatest threats to privacy or greatest value creation opportunities, depending on your perspective) will come when multiple sites pool their data to generate knowledge about users. Most agents have knowledge

bases and most agents have the ability to discover and/or capture knowledge about a particular entity. One of the major findings of knowledge discovery is that much knowledge is discovered when previously disparate databases are juxapositioned and used in the analysis.

As a result, it is probably not surprising that there has been a movement to have different agent-based systems to share information about their users. For example, (Andrews [8]) a recent headline in Web Week read "Firefly proposes Clearinghouse for Sharing Information on Users." In that article, Firefly Network, an agent based service that, at one level, suggests products and services that consumers may want, suggested forming a consortium to establish a process for sharing information. In so doing, different agent-based services can get a better and extended notion of customer profiles. Unfortunately, initial or extended use of profiles can result in invasion of privacy.

7 REFERENCES

1. O'Leary, D., "The Internet, Intranets and the AI Renaissance," Computer, January 1997, pp. 71-78.
2. Etzioni, O. and Weld, D., "Intelligent Agents on the Internet: Fact, Fiction and Forecast," IEEE Expert, August 1995, pp. 44-49.
3. Brown, C., Gasser, L. O'Leary, D., and Sangster, A., "AI on the WWW: Supply and Demand Agents," IEEE Expert, August 1995, pp. 50-55.
4. O'Leary, D., "AI and Navigation on the Internet and Intranet," IEEE Expert, April 1996, pp. 8-11.
5. King, D., and O'Leary, D., "Intelligent Executive Information Systems," IEEE Expert, December 1996, pp. 30-35.
6. Goldman, S., Nagel, R., and K. Preiss, Agile Competitors and Virtual Organizations, Van Nostrand Reinhold, 1995.
7. O'Leary, D., Kuokka, D. and Plant, R., "Artificial Intelligence and the Virtual Organization," Communications of the ACM, January 1997, pp. 52-59.
8. Andrews, W., "Firefly Proposes Clearing house for Sharing Information on Users," Web Week, March 3, 1997, p. 21.



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