



..... MAKE WAY FOR

INTELLIGENT AGENTS

by Lawrence M. Fisher

Your next hire may not wear a suit or a skirt or come with an advanced degree from a prestigious school. Instead, get ready to shake hands with a bit of disembodied software code called an agent. And if you hire enough of the right ones, and treat them well, they could become a manager's dream: a quiet army of efficient workaholics who never ask for a day off or even a paycheck.

Sometimes called "intelligent" agents, these small, self-contained software programs are designed to be deployed across computer networks to perform a myriad of complex tasks, freeing the real workforce — the one that gets paid — to do other things or to shrink in size.

The agents carry a résumé that sports an impressive list of career objectives. In the outside world of

New software programs are now available that act as "smart filters" on the information superhighway. They can sort through mountains of data and find answers to specific questions. And they can learn. Their promise is to make the "horizontal" organization even flatter.



electronic online commerce, agents are capable of buying stocks, purchasing supplies and gathering intelligence about competitors. They aim to be no less industrious in-house, navigating the far corners of a company's database to ferret out information that could help in decision making at even the highest levels.

What makes them tick is ultra-sophisticated programming that gives them the flexibility that any kind of agent needs if it is to perform someone else's bidding: an ability to learn new jobs and new tricks by "watching" others do them ("self-learning" in agent argot) and the discrimination and fortitude to wade through mountains of megabytes to find just the right bit of information to win the day.

Because agents are so new, however, many of their career objectives

will remain unfulfilled for some time to come. That is because a number of technical issues need to be resolved. For agents to proliferate and operate smoothly, industry standards must be established for their programming languages, for example. [See sidebar.] Because agents must roam the electronic superhighway and knock on many strangers' doors, they won't be allowed in without a greater assurance of security than can be provided today. And the self-learning feature has yet to emerge from the lab.

Still, smart managers are already signing agents on. Even with one hand tied behind their backs, agents can do many useful things, and are busy performing them at a small but growing number of companies in fields as diverse as utilities, financial services and health care.

Security concerns and problems with industry standards are minimal when the agents are used by a company strictly on its own turf to handle standard employee requests for information about pension investments, say, or to answer consumer calls about products or services. And some companies are working out arrangements to send agents to important suppliers and major cus-

tomers to carve out a role in sales and procurement.

At some companies, enough tasks are being performed, in fact, to allow some real employees to do other, more valuable things. Even where the gain is not so clear, the time and money being spent on agents is seen by some managers as a necessary long-term investment. Waiting until agents are ubiquitous is hardly the way to gain a competitive advantage, these executives feel.

No company has done more to take agents out of the labs and into the corporate consciousness than General Magic, Inc., a spinoff of Apple Computer, Inc. in partnership with AT&T, Motorola, Philips Electronics and the Japanese consumer electronics giants Sony and Matsushita. But agent-based products and services are also being sold or developed by such giants as I.B.M., Sun Microsystems and Xerox and a passel of lesser-known companies, including Individual, Inc. and the Edify Corporation.

The current state of the art in agent technology is not unlike that of the personal computer in 1980 or client/server systems in 1990: immature, but screaming with potential.

Indeed, the proliferation of com-

Agents and Principals: The Looming Battle for Standards

Like many a supposedly new technology, agents have existed, at least conceptually, for decades. The term first appears in 1971, in a paper written by Thomas Standish, now a professor of computer science at the University of California at Irvine, and it was refined in the Rand Intelligent Terminal Architecture, developed by Robert Anderson at the Rand Corporation in 1973. John Vittal produced the first operational agent system in 1979 at Bolt Beranek & Newman, a diversified computer consulting company.

But it is only in the last few years, as agents have begun to enter the commercial arena, that an effort has been made to establish standards — the common language and protocols that make it possible for software and hardware made by different manufacturers to work together.

Standards are critically important because without them there would be no way for agents to move among multiple organizations with any assurance that they could carry out their duties. Recall the early personal computers, each with its own, mutually incompatible, operating system software.

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Standards give third-party software developers a platform on which to create applications, and can give the standard owner an enviable annuity. Think Microsoft.

Two standards are now emerging in the world of agents, and they are radically different in origin.

One is SafeTCL, a public domain language created at the University of California at Berkeley. For true early adopters of agents, SafeTCL can be downloaded from the Internet free of charge and has already been used to create an astonishing variety of applications.

The other standard is Telescript, which is aimed primarily at fostering electronic commerce. Telescript has been kept on a close leash by its creator, General Magic, Inc., restricting its impact so far. But the company has great ambitions for the standard down the line.

In that regard, Telescript's name is telling. Telescript aims to do for communications what Adobe Systems Inc.'s Postscript did for printing. Like Postscript, Telescript is proprietary: General Magic owns it and its source code is not published. Telescript and Postscript are both scripting languages, a programming language for creating so-called mobile software like an agent. For that reason, programmers tend to use the terms script and agent interchangeably.

puter networks and the explosion of information are turning agents from a technologist's toy into a business necessity. Users find themselves overwhelmed, both by the sheer volume of information and by the babel of multiple operating systems, programming languages and protocols under which the data are stored.

Agents can help. On the one hand, they can be dispatched to perform tasks that would be tedious for

in a mainframe running DB2 in New York and then putting them together to answer a query posed by touch-tone phone in San Francisco.

In these and other ways, agents can play the same role in reengineering information processes that robotics did in manufacturing. By automating repetitive tasks, agents can replace the legions of human data shufflers as surely as robots did assembly-line workers. Downsizing is, of course,

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humans, to wait for an event or a transaction to occur and then take appropriate action.

They can also act as smart filters in the flow of information, catching only those items of relevance to the user. They can be taught, for example, to speak the myriad tongues of disparate databases that may reside in a company's computers across the street and halfway around the globe — perhaps finding one bit of data in the Sybase file on the departmental server in Miami and another

one possible application, but many organizations will instead use agents to take over essential, but simple, single tasks, while directing complex, multi-task processes to humans.

It is no coincidence that client/server computer systems and business process reengineering have grown up together in the last few years. Client/server, which splits computing tasks across a network between large, powerful "server" machines and smaller, desktop "clients," does help make information

available to a broader base of workers in an organization. Making information access more horizontal empowers individuals to make decisions, a central tenet of most reengineering efforts.

Thus a leading client/server application like PeopleSoft, Inc.'s human resources package lets H.R. managers create their own reports for such tasks as benefits administration, wage reviews or applicant routing. The alternative had been to submit a request to the data processing staff and wait days

that eat up as much as 50 percent of the time of human resources professionals? Client/server doesn't answer that question.

Agents can. Client/server makes data retrieval interactive; agents make it automatic. The difference is analogous to putting computers on bank teller's desks, or putting an A.T.M. outside the door.

Agent-based software, like Edify's Electronic Workforce, can provide employees with self-service electronic access to their benefit information 24 hours a day, 7 days a week, via



or weeks for a report that might or might not be on target.

That's a powerful tool, but what about the routine information requests of rank-and-file employees

electronic mail or touch-tone telephone. Employees can apply for new positions within a company — and even upgrade their résumés for that purpose — without ever speaking to

Prior to Postscript, computers sent raw data to printers, which was fine for printing plain text, but did not allow for multiple fonts or any of the nice graphical touches we have all come to expect. Postscript, a page-description language, sends a document from the computer as a program that executes on another processor in the printer. It's more efficient and much more flexible.

Telescript applies the notion of remote programming to communications across wide-area computer networks. Today's e-mail simply sends data, packaged with the recipient's address, across a network. Telescript agents incorporate a message in a program, which can be instructed, for example, to send the data to the recipient's fax if the e-mail is not picked up by a given time, or to page the recipient.

Beyond smart e-mail, Telescript agents will be able to perform automated online transactions. A purchasing agent could wander the Internet with instructions to buy an item at a certain price; the agent could meet with merchant agents, make its offer and continue on its way until it found the goods at the right price.

"The agent can wander cyberspace and 'go' wherever it needs to go to carry out its assignment," explained James E. White, General Magic's vice president for Telescript technology.

For now, the only Telescript agents available are those created by General

Magic, and they operate only on AT&T's Personalink electronic mail service.

General Magic has said that it will publish the application programming interfaces, or A.P.I.'s, for Telescript, to allow others to design agents, but has set no date. Until the interfaces become known, Telescript will remain a tantalizing but isolated technology.

In contrast, TCL and its companion user interface, TK, have been available for the taking on the Internet since their creation about five years ago. SafeTCL is a secure variant developed by Nathaniel Borenstein at Bellcore.

Pronounced "tickle," TCL stands for tool command language, and it was developed by John Ousterhout as a reusable programming tool for creating the internal software in computer chips. Because he designed the language to be as flexible as possible, it turned out to be a powerful mechanism for creating agents that must interact with different programs and protocols across the Internet.

SafeTCL is most commonly used with TK, a cryptically named chameleon-like user interface that adjusts to its environment. A TCL script bundled with TK actually sends two or more possible interfaces: one is a simple text-based screen, readable on any terminal; the other uses the power of agents to query the recipient computer at the time of sending and then build a graphic-user interface to suit.

a human resource professional. And Edify's agents work with applications like PeopleSoft and all the major relational databases, so the existing software infrastructure is not made obsolete.

The Hewlett-Packard Company used Edify agents to automate the quarterly wage-review process for 11,000 field employees under 1,600 managers in its Atlanta-based U.S.

Now Hewlett-Packard uses agents, via phone, fax and electronic mail, to spearhead a paperless review process. The agents provide interactive e-mail forms with current H.R. information, and route them to the appropriate managers, who can approve or amend them via laptop computer or touch-tone phone wherever they may be. Field managers also enter proposed wage increases



field operations. Under the old four-week process, no less than three weeks were spent generating paper forms, obtaining performance information and approvals by several levels of managers in far-flung locations and transferring all the newly gathered information into a central database. Delays, errors and runaway Federal Express bills plagued the process.

on electronic forms, which are then approved by secondary-level managers. The agents collect the new information, enter it in the H.R. database and make the necessary salary changes. The data collection process takes just one week, leaving three weeks to perform a more thorough review of the merits of each case.

It is worth noting that this appli-

cation did not involve the Internet, electronic commerce, self-learning or many of the other much-ballyhooed facets of agents, but it did lower Hewlett-Packard's costs and improve the wage-review process. Edify's mission is to make the information within an organization useful to the different populations to whom it is relevant: employees, customers, suppliers.

"Our whole notion is self-service applications to let these people serve their own information needs," says Jeffrey M. Crowe, Edify's president.

DHL Worldwide Express now uses Edify agents to handle customer calls regarding the status of package deliveries. A call to DHL's 800 number

human agent of the nature of the call before it is transferred.

"If you think about trying to code this up in a conventional program it would be a nightmare," says Alan Boehme, DHL's director of customer access. With Edify's agent technology, "we had a prototype that was giving us satisfactory results in three and a half weeks," at a cost, including hardware, of under \$200,000, he says. Edify's agents free DHL's human staff to sell more services, and to better handle incoming orders.

Clearly, agents deployed in such sensitive applications must be robust and error-free. They must also be easy to train, says Mr. Crowe. "To the extent that you deploy lots and lots

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AGENTS CAN PERFORM SYSTEMS ADMINISTRATION TASKS, FREEING UP TECHNOLOGY STAFF FOR HIGHER VALUE WORK

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connects a customer to an Edify software agent that responds with a verbal delivery of the information, a faxed confirmation or a transfer to a human agent if more information is needed. The Edify agent informs the

of resources training these agents, you disrupt the cost benefits," he says. The Edify software training tool requires no actual programming, but some knowledge of programming is needed. "It is wholly unrealistic to

"The world is going to be heterogeneous; I don't want to have to know whether you're on Windows or Macintosh," said Mr. Borenstein, who is now chief scientist at First Virtual Holdings, a company that provides secure transactions on the Internet.

Few people know how to evaluate free software, despite the availability of many cutting-edge programs on the Internet, so SafeTCL and TK might both have remained programmers' curios were it not for the interest of Sun Microsystems Inc. Mr. Ousterhout recently left U.C. Berkeley to join Sun; now he is creating commercial versions of SafeTCL and TK for Windows, Macintosh and Unix computers, which should reach the market by the end of the year. Meanwhile, the core software code will remain free.

There are multiple ways to establish a standard, of course. Sun is banking on transferring the grass roots support for SafeTCL and TK into a commercial venture, much the way it did with the Unix operating system. General Magic is counting on the blessings of powerful early adopters – its corporate partners plus France Telecom and NTT – much the way I.B.M. anointed MS-DOS.

Meanwhile, waiting in the wings, conspicuously silent about agents, is Microsoft, with the power to declare its own standard.

A PLAYER'S LIST

What follows is a list of some of the key companies now researching, designing or marketing software programs known as agents. The programs, which are deployed across computer networks to perform complicated tasks, are based on what are called scripting languages. Some agents are capable of teaching themselves aspects of the work they perform.

COMPANY	LOCATION	PRODUCT	STATUS
General Magic, Inc.	Sunnyvale, Calif.	Telescript, a scripting language for creating communications applications and services.	Available now over AT&T's Personalink online service. Currently supports electronic mail services using Sony's Magic Link or Motorola's Envoy portable computing devices. Versions for Windows and Macintosh software, and for electronic shopping services, will be available late this year.
Sun Microsystems, Inc	Mountain View, Calif.	SafeTCL, a broadly applicable scripting language for creating agents; TK, a flexible user interface for agent-based programs.	SafeTCL and TK available at no charge over the Internet; commercial programming tools and packaged user interfaces for Macintosh, Windows and Unix available late 1995.
I.B.M.	Armonk, N.Y.	Intelligent Communications, an agent-based electronic messaging service incorporating voice recognition and self-learning.	Under development, delivery date not scheduled.
Edify Corporation	Santa Clara, Calif.	Electronic Workforce, trainable agents for self-service information retrieval applications, including customer support, human resources and workflow automation.	Available now, in use by more than 200 corporations.
Hewlett-Packard Company	Palo Alto, Calif.	Distributed Smalltalk, a programming environment incorporating self-learning agent technology.	Available now.
Xerox Palo Alto Research Center	Palo Alto, Calif.	Researching agent technology in connection with so-called ubiquitous computing, which employs small mobile devices.	Under development.
Interval Research	Palo Alto, Calif.	Like everything connected with this think tank, financed by Microsoft co-founder Paul Allen, agent-related projects are shrouded in secrecy. Company employs Yoav Shoham, associate professor of computer science at Stanford University, who coined the term "agent-oriented programming."	Who knows?
Oracle Corporation	Redwood Shores, Calif.	Mobile Agents, specialized agents for performing remote queries involving relational databases and using personal digital assistants.	Available now.
GTE	Stamford, Conn.	Developing agent-based solutions for interactive television, unstructured database queries and broadband network searches. Employs John Vittal, creator of the first operational agent system, R2D2, in 1979.	Under development.
Microsoft	Redmond, Wash.	Developing agents in connection with its operating system software for interactive television and "smart" set-top boxes.	Under development.
Individual, Inc.	Burlington, Mass.	First! service, agent-based customized information services for business professionals. Company has exclusive license for the Smart agent technology developed by Cornell University.	Available now.
First Virtual Holdings Inc.	Sunnyvale, Calif.	Offers secure Internet transaction services. Employs Nathaniel Borenstein, creator of Atomic Mail, an early agent-based active e-mail system, and SafeTCL, the secure variant of TCL now being commercialized by Sun.	Available now.

expect an end-user to give instructions to an agent,” Mr. Crowe adds.

Edify’s model assumes that agents will be managed by information technology professionals, but

associate professor of computer science at Stanford University and a member of the research staff at Interval Research in Palo Alto, Calif.

But the unavoidable downside

program that can be sent across networks to execute on a remote computer. A virus is an autonomous program that enters your network with the intent of disrupting it in some way. An agent-based system is not necessarily any more susceptible to external viruses than any other network, but it must also be safeguarded against rogue agents.

AN AGENT-BASED SYSTEM MUST ALSO BE SAFEGUARDED AGAINST ROGUE AGENTS

there is an unexpected payoff here as well. Because many companies buy twice as many agents as they need, to provide some redundancy on critical applications, these otherwise idle agents can perform systems administration tasks, again freeing up the technology staff for higher-value work.

As long as agents remain stationed in one computer, as do Edify’s, or even within one company on multiple computers, they pose relatively little security risk. But with the growing reliance on wide-area networks and the Internet, most companies will want to deploy free-ranging agents that can go wherever the information is, or wherever the transaction must occur.

“In wide-area networks and distributed computing, things have to interoperate and coexist; it’s in that setting that agent-oriented programming is a win,” says Yoav Shoham,

to opening up an enterprise’s network to incoming agents is that the security risk increases. To be sure, networks are vulnerable today, and there is seemingly no firewall so strong that it can resist the attack of the most determined hacker. But the power of agents increases the potential for mischief.

“YOU NEED TO BE ABLE TO RECEIVE AN AGENT FROM YOUR WORST ENEMY WITHOUT FEAR OF THE CONSEQUENCES.”

— NATHANIEL BORENSTEIN
AGENT DEVELOPER

The reason is that agents and viruses are basically similar, differing primarily only in intent. An agent, according to the classic definition, is an autonomous, mobile computer

Both Telescript and SafeTCL, two programming languages battling it out in the standards race, deal with security through the use of an interpreter. Early languages sent “compiled” scripts — programs in the native language of the receiving computer — which could cause all manner of mayhem. An interpreter is an intermediary program that translates the script (a term that is interchangeable with agent in the language of programmers) on the fly and that is simply incapable of executing any dangerous commands. The tradeoff is a slight loss of performance for a

great gain in security.

“We as software developers need to provide an environment in which it is safe to run scripts,” says John Ousterhout, who is working with Sun Microsystems Inc. to develop a com-

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AN AGENT THAT DOES NOT REFLECT THE WISHES OF ITS MASTER IS WORSE THAN USELESS

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mercial version of SafeTCL. Or as Nathaniel Borenstein, another agent pioneer puts it, a little more ominously: “You need to be able to receive an agent from your worst enemy without fear of the consequences.”

Clearly agents will require a great degree of collaboration between a company’s information science staff and the providers of agent-based programming tools. Information managers will also have to work more closely with all the entities a company intends to do elec-

tronic commerce with — customers, suppliers, distributors — to see that common protocols are adopted and common rules are accepted. Agents must not overstay their welcome; agents must not use more

than their share of computing resources, and so forth. Fortunately, the ability to readily reject unmanner-



ly agents is another benefit of the interpreter programs.

But information science managers will also have to work more closely with department heads in the world of agents than they have in traditional computing. Because agents are autonomous once released and because they work on behalf of users and not on behalf of information managers, more effort must go into creating them. An agent that does not accurately reflect the needs and wishes of its master is worse than useless.

Building agents that bring back not only bare-bones facts but also a context in which to weigh them requires a close understanding of the business. It is the difference between one agent returning with the fact that a company’s widget sales are down in Podunk and another reporting not only that fact but also news of the arrival of two key competitors in town.

“What I really need to know as a manager is not so much did the data change, but did the underlying relationships change,” says Doug Neal, a partner in the New York office of Booz-Allen & Hamilton. “We know how to build the search engines and the database; what we’re working on now is building the business model.”

One answer may be the development of self-learning agents that end users can instruct in an interactive “watch what I do” mode. For now, self-learning agents are denizens of

the laboratory, but commercial versions could appear within the next year or two. At the Massachusetts Institute of Technology's Media Lab, for example, an e-mail agent "watches" a user's behavior by recording keystrokes, and then makes certain assumptions regarding the handling of new messages.

At the State University of New York at Binghamton, an agent named Mr. Wizard attempts to replace the kind of organizational memory preserved in pre-technological times by word of mouth. Employing "active" electronic mail forms, which are agents, users can seek expert advice in normal written English, and Mr. Wizard will supply the answers,

stood by relational databases has bedeviled programmers for years, a more likely reason is that some tasks really are better done interactively than automatically. Agents do not actually possess the "intelligence" needed for complex analyses, only some encoded knowledge.

On the other hand, some jobs will be given to agents for purely economic considerations. As long as network bandwidth is not free, and wireless connection is truly precious, it will be more economical to send an agent in one brief burst that can then perform a series of tasks without the two computers being linked. Task accomplished, the linkage can be reinstated, again briefly.

calls into an Oracle database, a task that would be far beyond the capabilities of this small device using conventional programming techniques.

But it will probably always be a judgment call whether a task is better accomplished with traditional client/server calls, or with the complex "query, search, wait for something else and then get back to me" sort of instructions necessary for an agent.

You want the agent to do a lot more for you than you had to do to instruct the agent, says Steve Schramm, General Magic's vice president, engineering.

In the world of distributed computing, the network *is* the computer, as the Sun Microsystems slogan put it, a bit prematurely, about 10 years ago. And if applications are to run on the network, as opposed to simply shunting data across it the way most do today, then those applications must be autonomous and mobile. That means they will be agents.

The prospects held out for agents by their creators are vast, but the reality will probably be greater. No one knows what a world of ubiquitous agents will be like. Smart companies are not waiting for an answer: they are too busy figuring out how to put agents to work in their world today. 

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either from its database or by e-mail from human experts.

It may be that some tasks will never be performed by agents. Notably, none of today's decision-support tools employ agents. And while that may be because the technical hurdle of translating plain English questions into the structured queries under-

The tiny portable computing and communications devices known as personal digital assistants, or P.D.A.'s, lend themselves to agent-based software because of their limited resources. The Oracle Corporation has developed a program called Mobile Agents that allows Apple Computer's Newton to make remote