

SOFTWARE

S T R A T E G I E S

Fetch!

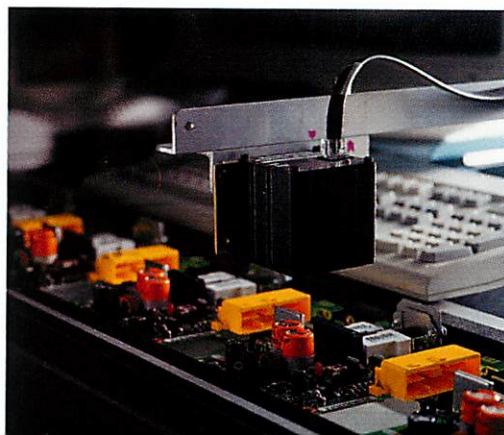
Why Software Agents
Will Be Manufacturing's
New Best Friend

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FETCH!

WHY SOFTWARE AGENTS WILL BE MANUFACTURING'S NEW BEST FRIEND

BY MARTY WEIL, CONTRIBUTING EDITOR

There's a new generation of intelligent software agents on the horizon that, like the dog who fetches your morning paper, are poised to make your life even easier. Imagine a Dalmatian that will not only let himself out and get the paper, but will trim and prioritize the articles you'd find interesting—all before you've gotten out of bed.

This may seem remarkable, but consumer agents that prowl the World Wide Web—for the best deal on Dog Chow or for other tidbits of information—are already the new techno-darlings of the media. Meanwhile, in the hot kitchen of manufacturing, intelligent industrial agents are springing to life to work on more mundane, yet important tasks.

For the uninitiated, intelligent industrial agents, like their better known Internet brethren, are not spies—they're more like airline ticket agents or insurance agents that act on your behalf. They're a variety of programming that is "capable of flexible, autonomous action on behalf of the user," says Michael Wooldridge, a professor in the Dept. of Computing, Manchester Metropolitan University in Manchester, U.K.

Like a benevolent concierge, intelligent agents act as a proxy for a user executing high-level computing tasks. "The technical view of an agent is anything that carries out computation across a network, but

technical definitions lose sight of the 'agent' metaphor," says Bruce Krulwich, research scientist, Center for Strategic Technology Research, Anderson Consulting, Northbrook, Ill.

Although not everyone agrees on the definition of an intelligent software agent, it's clear that all software agents are programs, but not all programs are agents.

What makes intelligent agents different from everything that has come before?

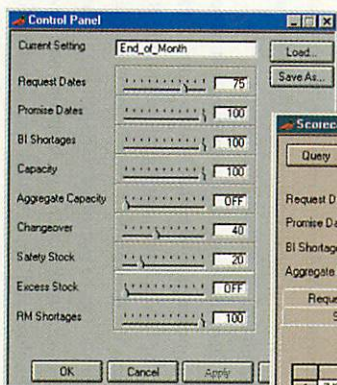
"Agents are the first computer paradigm that is user-centric," explains Peter Janca, manager, Software Technology Center for IBM's Intelligent Agent Program in Raleigh, N.C. "Every other software requires that the user learns the environment. Agents represent the first case where software adapts to the user. Agents either learn or can be instructed to respond to the user."

The user-centric focus is what makes agents so intriguing and powerful. According to a recent study, "Intelligent Agents: Technology and Applications," published by Giga Information Group of Norwell, Mass., agents will be the most important computing paradigm in the next 10 years. Early adopters report agent benefits including complexity reduction, time/cost savings, and increased business productivity. By the year 2000, every significant application will be agent-enabled to some degree.

AGENTS OF CHANGE

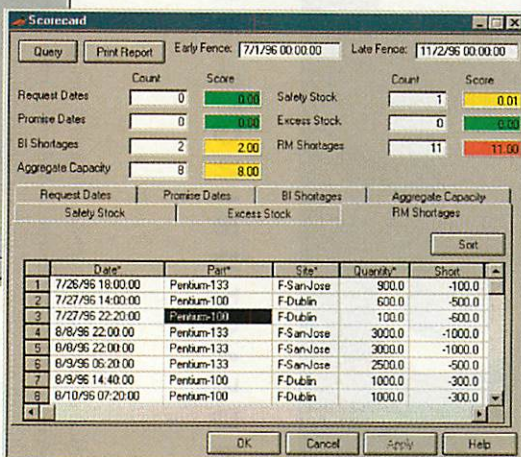
According to Janca, there are at least 50 vendors currently supplying agent-enabled software and/or services. These are spread across virtually every application in use today.

For its part, IBM, along with business application developers J.D. Edwards, QAD Inc., Berclair, and others, have joined forces in CIIMPLEX, the Consortium for Integrated Manufacturing Planning and EXecution partially sponsored by the U.S. Dept. of Commerce. The consortium proposes to develop the basic algorithms and technologies for linking agile planning systems with the wealth of real-



Agents in the Enterprise:

Planners define and/or simulate scheduling constraints using Red Pepper's Control Panel (above). A Score Card (right) highlights any violations of those constraints.



time factory-floor information provided by manufacturing execution systems (MES). There are two main objectives: develop a self-configuring, plug-and-play MES framework based upon intelligent software agents, and develop the basic enabling technologies for CIIMPLEX applications. This will require developing the largely experimental technology of intelligent software agents into something robust and reliable enough for the demands of a real-time manufacturing control system.

CIIMPLEX will require similarly robust and reliable algorithms and software to assimilate a wide variety of inputs on the current state of the factory for resource needs and deadlines. It will also develop a plan to optimize the use of existing resources. The consortium's framework and applications will be designed with the needs of small and mid-sized manufacturers in mind, by providing a solution that is both affordable and low-maintenance. The successful adoption of CIIMPLEX, say consortium members, could increase manufacturing efficiency by 30%, reduce work in process by 30%, and, if fully implemented, would save the manufacturing industry billions of dollars.

In many ways, the industrial agent vision of Sandia National Laboratories, Livermore, Calif., parallels the work of the IBM consortium: "Software and information technology is increasingly important to manufacturing competitiveness," says Sandia's Carmen Pancerella. "Manufacturers have a demand for improved quality, lower process costs, and shorter development cycles. Additionally, more businesses will be connected to the Internet—doing business across the Internet as a normal business operation. It will be necessary to build an infrastructure to support this new model of

manufacturing. Software will be necessary to build plug-and-play manufacturing components, which assure a flexible information infrastructure. An agent-based architecture will allow the system to easily respond to changes in the environment. New agents will be added, while other agents are deleted without the entire system failing."

Pancerella, whose own interest lies in agent architectures as a method for integrating intelligent systems across domain boundaries and geographic boundaries for unifying engineering applications (e.g., design and manufacturing), also sees agents as mechanisms for providing feedback loops among the different cycles in product realization. "Agent-based approaches can be used to integrate a manufacturing facility—we're doing this in our agile manufacturing cell at Sandia. We have machining agents, a cell manager agent, and we're able to intelligently dispatch jobs, where the machining agents actively participate in the process.

"The business model is changing daily," Pancerella continues. "Today, companies have more information available online; they have a need for designers to have feedback from manufacturing facilities early in the design phase; they face heterogeneous information infrastructure (i.e., databases, legacy codes, CAD tools, etc.); and, they require team collaboration and concurrent engineering. The need for intelligent software components is evident now."

AGENTS AT WORK

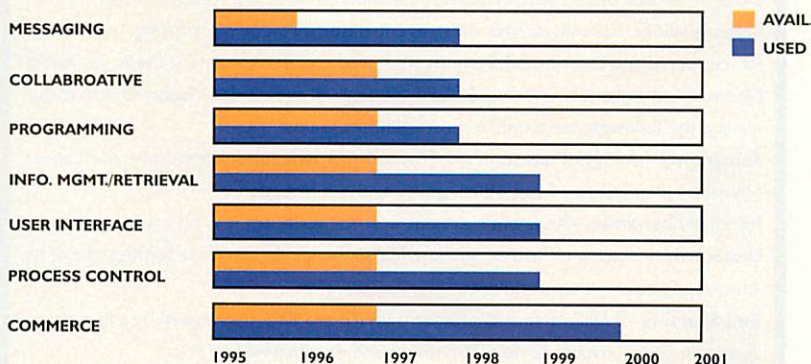
In the private sector, Red Pepper Software, San Mateo, Calif., already has introduced a new class of real-time planning and scheduling software based on intelligent agent technology. The company's ResponseAgent products complement existing transactional systems (i.e., manufacturing and distribution planning and shop floor control), and enable real-time responsiveness to customer demands. The new Production ResponseAgents work as "intelligent assistants"



Anchor Glass Container Co.'s real-time sales order system makes use of agent technology to provide material and capacity availability as well as associated transportation for orders across all of its 13 production facilities.

for manufacturing planners and schedulers, generating optimized plans, monitor-

FIGURE 1: AGENTS WILL FIND THEIR WAY INTO APPLICATIONS ENTERPRISEWIDE



A recent study calls agents the most important computing paradigm in the next 10 years. By the year 2000, every significant application will be agent-enabled to some degree.

Tim Finin, professor of computer science and electrical engineering at the University of Maryland in Baltimore (UMBC) agrees. "One of the problems is that agents cannot currently communicate across platforms," he says. "In fact, it is the primary thing that needs to be done if we are to make good on this system-building paradigm of having artificial agents."

Janca agrees. "Future applications development will require even more rapid development and ease of tailoring to each other. IBM's agent strategy includes structure, reference, implementation of each part of the Agent Design Model, open interconnection to other agent-enabled applications, and rapid inclusion of parts produced from both within and outside IBM," he says.

IBM's vision for agents follows its vision for objects: "Open standards must exist which allow the free replacement or extension of components across the computer industry," says Janca.

Researchers and scientists, like Tim Finin, have been working feverishly to create these new open agent communications languages. According to Eric Brethenoux, analyst at Gartner Group RAS Services in Stamford, Conn., the two main initiatives for building standard knowledge representation frameworks are the Knowledge Sharing Effort (KSE) and EuroKnowledge.

KSE, a consortium of 18 universities and industry research centers, addresses standard knowledge representation schemes, mapping between various schemes, as well as work on standard application ontology. At the Palo Alto Collaborative Testbed (PACT) in California, they're testing early applications of the KSE's work. PACT corporate participants such as Hewlett-Packard, Lockheed, and EITech are investigating the concurrent engineering domain and the reuse of knowledge at all stages of a product.

Meanwhile, a group of commercial and academic organizations has launched EuroKnowledge, an effort at establishing practical, well-defined knowledge representation standards aimed at openness. The mission of EuroKnowledge is to keep an open mind while putting in place an all-encompassing mechanism to coordinate results, and to

elaborate, evaluate, maintain, and promote standards within the end-user and developer communities.

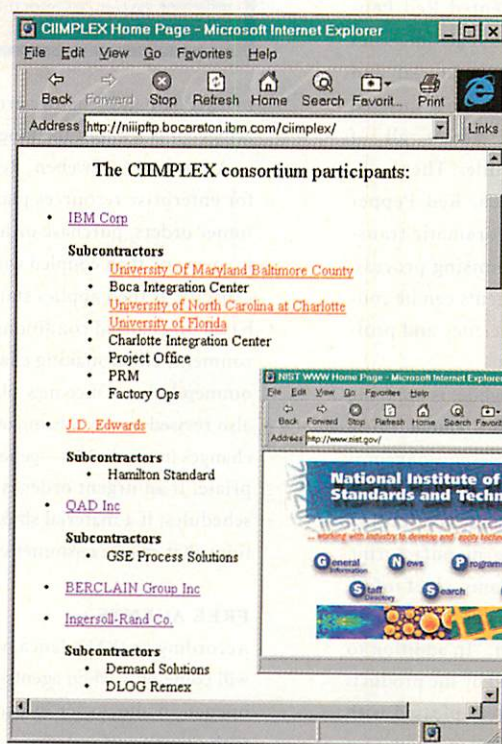
The bottom line, according to Brethenoux, is that the domains that KSE and EuroKnowledge support are all linked to different aspects of agent activities. Reusable knowledge bases, for example, look at common semantics across different industries for agents to retrieve and exchange knowledge regardless of their domain or competence. The Gartner Group strongly recommends organizations developing agent-based systems for large applications to include the results of these efforts in their project specifications.

With the vast potential of intelligent software agents, there are bound to be numerous vendors that heed the Gartner Group's advice—for in the end, the real intelligent agent is the vendor who sells the most software.

SS

Technology and manufacturing firms have joined forces to develop software agents under the banner of CIIMPLEX, the Consortium for Integrated Intelligent Manufacturing PLanning and EXecution. CIIMPLEX is one of four projects dedicated to real-time manufacturing planning, tracking and control systems research receiving a combined \$31 million in funds from the U.S. Dept. of Commerce's National Institute of Standards and

Technology, under its Advanced Technology Program. Funding continues, despite Congressional wrangling over budget cuts. For more information, consult your local Web browser.



critical manufacturing variables, alerting users to problems as they arise, and recommending optimized solutions in real time. One company, 3Com Corp., has used ResponseAgent to improve flexibility and meet increased demand for its networking products. "The ResponseAgent enables us to be real-time responsive to the requirements of our customers without incurring large overhead costs," says Randy Heffner, vice president of manufacturing, 3Com Network Adapter Div. "We view the Production ResponseAgent as the next wave in manufacturing planning and scheduling technology, and we are very pleased with the results it is generating."

"AGENTS ARE THE FIRST COMPUTER PARADIGM THAT IS USER-CENTRIC."

PETER JANCA, MANAGER OF IBM'S
INTELLIGENT AGENT PROGRAM

Anchor Glass Container Co., Jacksonville, Fla., the company implemented Red Pepper's Sales ResponseAgent, a real-time sales order system that provides material and capacity availability, as well as the associated transportation for orders across all of Anchor's 13 production facilities. The result, according to Monte Zweben, Red Pepper president/CEO, has been a dramatic transformation in the order promising process, wherein customer commitments can be confidently met and overall efficiency and profitability are improved.

Sun Microsystems, meanwhile, is applying the system as it integrates its manufacturing into one global entity. "The ResponseAgent is playing a key role in our efforts to integrate all of our manufacturing and distribution facilities into one cohesive manufacturing enterprise," says Leon Williams, chief information officer, Sun Microsystems Computer Corp., Mountain View, Calif. "In addition to the baseline benefits provided by the products themselves, we have been very pleased with the speed of the system implementation. Our

WHAT DOES IT TAKE TO BE INTELLIGENT?

Despite the lack of a universally accepted definition, there are some orthogonal properties/qualities that cut across most agent-based projects, according to Carmen Pancerella of the Distributed Systems Research and Development Dept. at Sandia National Laboratories, Livermore, Calif. Though all agents don't subscribe to every quality, the following are found in most agent programs:

Autonomy—An agent has some control over its own actions and state; each agent operates independently from other agents, without direction.

Flexible/Dynamic—An agent's actions are not scripted; it is able to dynamically choose which actions to invoke, and in what sequence, in response to the state of its internal and external environments.

Self-Starting—Unlike standard programs which are directly invoked by the user, an agent can sense changes to its environment and decide when to act.

Temporal Continuity (always present)—Agents are continuously running processes.

Communicative—An agent is able to engage in complex communication with other agents, including humans, in order to obtain information or enlist their help in accomplishing its goals; agents exchange messages in a formally defined unambiguous agent communication language; agents interact with other agents on a peer-to-peer level (not a strictly client/server level). These agents are used to integrate software systems and facilitate the integration across knowledge domains, networked computers, and even among organizations.

Adaptive/Reactive—An agent automatically adapts to changes in its environment; an agent perceives its environment and reacts to changes in it.

Goal-Oriented/Proactive—An agent accepts high-level requests indicating what the problem outcome is, and the agent is responsible for deciding how and where to satisfy the request; an agent takes initiative to exhibit a goal-directed behavior.

Encapsulation—An agent serves as a container for some knowledge representing some domain.

Mobile—An agent is able to transport itself from one machine to another and across different system architectures and platforms.

market demands that we are real-time responsive, and the ResponseAgent is helping us achieve this without the long implementation cycle associated with many applications."

According to Zweben, ResponseAgents integrate with transactional systems (such as for enterprise resources planning) to capture basic data such as bills of materials, customer orders, purchase orders, forecasts, and other information. This data is assembled in memory, then coupled with a detailed model of a supply chain, including materials and capacity. It then applies state-of-the-art optimization technology to generate new plans based on changed conditions. Users can consider recommended plans in a 'what-if' environment, either making changes to the software's suggestions or accepting the new recommendation. Once new plans are approved, other agents and transactional systems are also revised and synchronized. The software continuously monitors and alerts the user to changes in conditions—generating ongoing planning and scheduling alternatives as appropriate. If an urgent order is received for rush delivery, the agent will adjust production schedules; if a material shipment fails to arrive, the agent alerts users and presents solutions that ensure customer commitments are met.

FREE AGENTS

According to IBM's Janca, while agent technology holds much promise, mainstream use will come only when agents can be added to existing applications, when agent systems are opened to allow user integration flexibility, and when agents systems can interconnect with other agent systems.