INTERNET-BASED AGENTS:
Applications and Infrastructure

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Software agents are mitigating the complexity of modern information systems—technically by providing a locus for managing information subsets, and psychologically by providing an abstraction for human interaction with them.

Modern information systems, exemplified by the Internet and corporate intranets, are typically large and complex. The software applications and other components composing them are also complex. Software agents are becoming an essential part of these systems because they mitigate the complexity. They achieve this in two important ways—one technical and the other psychological.

Technically, each agent provides a locus of intelligence for managing a subset of the information in the system, either on its own initiative or under the direction of a user. Each intelligent agent can be readily replicated and then distributed as needed. This agent-based approach to information management is both scalable and cost-effective.

Psychologically, people need abstractions by which they can understand, manage, and use complex systems effectively. A natural and convenient abstraction appears to be one based on anthropomorphizing the information system components, that is, treating the components as animate. In this abstraction, software components are like human agents. The abstraction is effective, because people have a lot of experience in dealing with other people, and they can apply their experience to understanding and dealing with complex software.

Animate components are an example of a more general trend in software engineering to construct software that mimics real-world objects. If the mimicry is done well, the software will appear familiar and thus easy to use. The net result is a great interest in software agents.

This special issue of *IEEE Internet Computing* is devoted to software agents. Four peer-reviewed feature articles capture a slice of current research, practice, and commercialization of agents at two levels. At a higher level, a new class of applications is being developed based on the capabilities provided by software agent technology. As an example of this, the article by Andreoli, Pacull, and Pareschi (pp. 40-48) describes how agents can enable and simplify the implementation of the next generation of electronic commerce.

The article by Ohsuga et al. (pp. 50-57) similarly deals with Web-based interactions that support electronic commerce, but describes an alternative architecture and an implementation of agents that combines mobility and planning to satisfy their explicitly represented goals. The planning, a form of least-commitment planning, occurs at both a base level and a reflective level. It is interleaved with plan execution by the agents. The result is agents that decide on what appears to be their best course of action and, if they get stuck, become aware of it and either perform additional planning or move to a new environment where they might obtain the information they need to make progress toward their goals.

At a lower level, the new applications require the support of new infrastructure services. These services must provide for

- secure communications, ranging from simple exchanges of messages to structured conversations among agents,
- trusted transactions,
- persistent, robust, and reliable operation,
- ease of use and management.

The articles by Kotz et al. (pp. 58-67) and by Karjoth, Lange, and Oshima (pp. 68-77) focus on the infrastructure services enabled by the transmission and reception of executable code in the form of mobile agents. By making the mobile agents secure themselves, the services provided by the agents can be made secure as well.

Although software agents represent the outcome of a relatively young field of research, they are beginning to appear in products, and commercial tools are being marketed for their construction and application. This issue provides three perspectives on this productization and marketing. First, an interview with Pattie Maes discusses what she sees as the present and future possibilities for software agents. Her perspective is unique, as she is both a researcher and a commercializer of agent technology.

Next, Joseph Kiniry and Daniel Zimmerman report on three innovative and aggressive companies that are offering products based on Java mobile-agent technology. The authors put the software through its paces and compare the results. Their article also includes good lists of URLs for major commercial and research-based agent systems.

Third, Bruce Krulwich offers an in-depth look at the technology of his own company, AgentSoft. He describes four increasingly capable classes of agents needed to provide the next generation of Web services, and uses these classes to describe the market niche occupied by AgentSoft.

The day is approaching when the Web will be populated by agents carrying out the bidding of users. The research described here is helping to bring that day closer. We think you will enjoy this special issue. ■

Munindar P. Singh and **Michael N. Huhns** are members of the editorial board for *IEEE Internet Computing*. Links to their home pages are available at http://computer.org/internet/.

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