AGENT-BASED COMPUTING

MICHAEL LUCK OUTLINES WHAT AGENT-BASED COMPUTING IS AND DESCRIBES SOME OF THE APPLICATIONS THAT USE THIS FORM OF COMPUTING IN SUCH AREAS AS DEFENCE, UTILITY AND TELECOMMUNICATIONS APPLICATIONS.

Agents can be defined to be autonomous, problem-solving computational entities capable of effective operation in dynamic and open environments. They are often deployed in environments in which they interact, and sometimes cooperate, with other agents (including both people and software) that have possibly conflicting aims. These environments are known as multi-agent systems. Since agents are autonomous entities capable of exercising choice over their actions and interactions, act to achieve individual objectives, they cannot, therefore, be directly invoked but can be assigned tasks by their owners. These notions find application in relation to three distinct views, considered below.

First, agents provide designers and developers with a way of structuring an application around autonomous, communicative components, and lead to the construction of software that follows from the particular design approach. They provide a new and often more appropriate paradigm for the development of complex systems, especially in open and dynamic environments.

Agent *technologies* are distinct and cover a range of specific *techniques* for dealing with interactions in these environments. They address issues such as balancing reaction and deliberation in individual agent architectures, learning from and about other agents in the environment, eliciting and acting upon user preferences, finding ways to negotiate and cooperate with other agents, and developing appropriate means of forming and managing coalitions. The adoption of agent-based approaches is increasingly influential in several domains. For example, multi-agent systems have already provided faster and more effective methods of resource allocation in complex environments, such as the management of utility networks, than previous centralised approaches.

Finally, *multi-agent systems* offer strong models for *representing* real-world environments with an appropriate degree of complexity and dynamism. For example, simulation of economies, societies and biological environments are typical application areas. The use of agent systems to simulate real-world domains may provide answers to complex physical or social problems that would be otherwise unobtainable, as in the modelling of the impact of climate change on biological populations, or modelling the impact of public policy options on social or economic behaviour. Agent-based simulation spans: social structures and institutions to develop plausible explanations of observed phenomena, to help in the design of organisational structures, and to inform policy or managerial decisions; physical systems, including intelligent buildings, traffic systems and biological populations; and software systems of all types, currently including eCommerce and information agency.

However, most new software technologies require supporting tools and methodologies. A fundamental obstacle to the take-up of

agent technology is the current lack of mature software development methodologies for agent-based systems. Clearly, basic principles of software and knowledge engineering need to be applied to the development and deployment of multi-agent systems, as with any software. This applies equally to issues of scalability, security, transaction management, and so on, for which there are already available solutions. A key challenge with agent-based computing is to augment these existing solutions to suit the differing demands of the new paradigm, while taking as much as possible from proven methods. For example, agent software development needs to draw on insights gained from the design of economic systems, social systems, and complex engineering control systems. In addition, existing middleware solutions need to be leveraged as much as possible, and this message has been understood: several companies have been working on platforms based on existing and standard middleware that is known and understood in the commercial domain.

Adoption of agent technologies has not yet entered the mainstream of commercial organisations, unlike, for example, object-oriented technologies. Indeed, the majority of commercial organisations adopting agent technologies might be classified as early adopters, since only a relatively small number of deployed commercial and industrial applications of agent technology are visible, and because considerable potential exists for other organisations to apply the technology.

To date, deployed applications of agent technologies have been concentrated in a small number of industrial sectors, and for particular, focused, applications. These have included: automated trading in online marketplaces, such as for financial products and commodities; simulation and training applications in defence domains; network management in utilities networks; user interface and local interaction management in telecommunication networks; schedule planning and optimisation in logistics and supply-chain management; control system management in industrial plants, such as steel works; and, simulation modelling to guide decision-makers in public policy domains, such as transport and medicine.

For example, Tankers International, which operates one of the largest oil tanker pools in the world, has applied agent technology to dynamically schedule the most profitable deployment of ships-to-cargo for its Very Large Crude Carrier fleet. An agent-based optimiser was developed by Magenta Technology for use in real-time planning of cargo assignment to vessels in the fleet. The system can dynamically adapt plans in response to unexpected changes, such as transportation cost fluctuations or changes to vessels, ports or cargo. Agent-based optimisation techniques not only provided improved responsiveness, but also reduced the human effort necessary to deal with the vast amounts of information required, thus reducing costly mistakes, and preserving the knowledge developed in the process of scheduling. In similar vein, after implementing recommendations derived from an agent-based simulation model of a corrugated box plant developed by Eurobios, SCA Packaging was able to make a 200% return-on-investment in the first month.

The European position on research and development in agent systems is healthy. There have been numerous active research groups in universities and research laboratories across Europe since the early days of the emergence of the field of agent-based computing as a distinct discipline, and the quality of work done is competitive at a global level. One reason for this is that since 1998, the European Commission has provided funding to support the community through coordination projects, providing a focus and coherence to the community that might not otherwise have been possible. The value of these AgentLink projects has not just been in academia; AgentLink counts around 40% of its nearly 200 institutional members from industry or research institutes.

In short, AgentLink is a European project aimed at promoting industrial and commercial deployment of agent technologies. As part of its activities, it has developed a roadmap for agent-based computing, which provides a more complete assessment of the current state of the art, considers the research issues, reviews existing deployments for business benefit, and outlines the likely future development of both the research field and the commercial environment. This roadmap is available from www.agentlink.org/roadmap

In application terms, we are already seeing the deployment of agent-like systems (in the areas of pervasive computing, the Semantic Web, P2P networks, and so on). In the longer term, we expect to see the industrial development of infrastructures for building highly scalable applications comprising pre-existing agents that must be organised or orchestrated. However, making the transition from research laboratory to deployed industrial applications is indeed a challenge, and it will be important to make scientifically sound business cases for implementations and descriptions that work as stimulators both for industry adoption and for further research.

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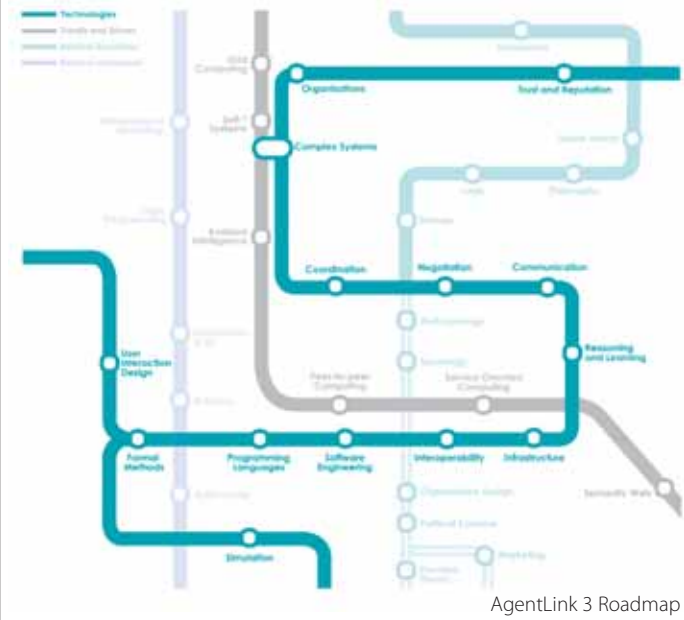

AgentLink 3 Roadmap