This booklet has been produced as part of AgentLink’s roadmapping activity. Electronic copies of the roadmap, which assesses the current state and likely future developments in agent-based computing, are available from www.agentlink.org/roadmap.

For paper copies, or for further information on agent-based computing and its application and deployment, contact:

Professor Michael Luck
School of Electronics and Computer Science
University of Southampton
Southampton SO17 1BJ
United Kingdom
e-mail: mml@ecs.soton.ac.uk

Published by the University of Southampton on behalf of AgentLink III. © 2005 AgentLink.

The success of the Internet has changed the way we think about computing. No longer is computing just about numerical calculation, or information processing, it is now about interaction and co-ordination between distinct entities.

Agent systems provide us with the means to design and implement interactive computing, whether between machines, or people, or both.

Professor Michael Luck
AgentLink Roadmap Co-ordinator
School of Electronics and Computer Science
University of Southampton
50 facts about Agent-Based Computing
Agent / n. 1a An agent is a computer system that is capable of flexible autonomous action in dynamic, unpredictable, typically multi-agent domains.

Intelligent agents are helping astronomers detect some of the most dramatic events in the universe, such as massive supernova explosions. Created by the ‘eScience Telescopes for Astronomical Research’ (eSTAR) project, agents have been deployed on the United Kingdom Infrared Telescope (UKIRT) in Hawaii.
Multi-agent systems offer strong models for representing complex and dynamic real-world environments. For example, simulation of economies, societies, and biological environments are typical application areas.
Calico Jack has developed solutions tackling several key issues in primary health care. Among new services being offered as a result are the ability to co-ordinate repeat prescriptions using SMS (reducing load on the practice administrator, and simplifying the process for the patient), and to book appointments and handle reminders through a combination of SMS and email (with the aim of reducing the expense of wasteful missed appointments and smoothing the booking process for patients).

Agents provide software designers and developers with a way of structuring applications around autonomous, communicative components. They offer a new and often more appropriate route to the development of complex computational systems, especially in open and dynamic environments.
Working with Rolls Royce, Lost Wax has developed Aerogility, a multi-agent system to help business managers better understand the complexities of the aerospace aftermarket.

(www.aerogility.com)

Agent technologies span a range of specific techniques and algorithms for dealing with interactions in dynamic, open environments. These 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.
Autonomous market trading agents outperform human commodity traders by 7%
An agent-based system developed by Acklin in The Netherlands for international vehicle insurance claims reduced human workload at one participating company by 3 people, and reduced the total time of identification of client and claim from an average of 6 months to under 2 minutes!

There are over 100 agent-related software products currently registered on the AgentLink website.

www.agentlink.org
Whitestein Technologies of Switzerland has developed an agent-based application designed to provide automatic optimisation for large-scale transport companies, taking into account the many constraints on their vehicle fleet, cargo, and drivers. Although the agent solution accounts for only 20% of the entire system, agent technology plays a central role in the optimisation.

Negotiations are performed automatically by agents, with each agent representing one vehicle, using an auction-like protocol, so that the vehicle that can provide the cheapest delivery wins the auction, reducing the overall cost of cargo delivery and, in most cases, the combined distance travelled for all vehicles.
Agent technology was used to model individual combatants in Peter Jackson's trilogy The Lord of the Rings.
There are many different types of *co-ordination and co-operation mechanisms*, ranging from emergent co-operation (which can arise without any explicit communication between agents), co-ordination protocols (which structure interactions to reach decisions) and co-ordination media (or distributed data stores that enable asynchronous communication of goals, objectives or other useful data), to distributed planning (which takes into account possible and likely actions of agents in the domain).

www.agentlink.org is the premier agent web portal, containing case studies, technical reports, event listings, project listings, and numerous other resources.
Many applications involving multiple individuals or organisations must take into account the relationships between participants. Individual agents may also need to be aware of these relationships in order to make appropriate decisions. Some aspects of agent-based computing seek to capture human notions such as trust, reputation, dependence, obligations, permissions, norms, institutions, and other social structures in electronic form.

Manufacturing, transport, telecommunications, and healthcare are seen as the most significant domains for agent technology (AgentLink Delphi Survey).
In 1999, a software agent was given primary command of a spacecraft for the first time, as part of the Remote Agent eXperiment (RAX). The Remote Agent operated NASA’s Deep Space 1 spacecraft during two experiments that started on Monday, May 17, 1999. For two days Remote Agent ran on Deep Space 1, more than 60,000,000 miles (96,500,000 kilometres) from Earth.
Air Liquide America turned to agent technology to reduce production and distribution costs. Developed by NuTech Solutions, their system used a multi-agent ant system optimisation approach to discover efficient product distribution routes from the plant to the customer. As a result, Air Liquide managed to adapt production schedules to changing conditions and deliver products cost-effectively, where and when the customer demands, and in a manner that is responsive to unexpected events.

By 2009, revenues from agent technology are expected to outstrip development costs (AgentLink Delphi Survey).
Agent Oriented Software has developed a system for the UK Ministry of Defence to model changes in human behaviour in military environments due to moderating influences, such as heat, tiredness, consumption of stimulants like caffeine, as well as battlefield experience and cultural factors. The objective was to offer a simulation environment for studying how people alter their decision making and interactions with other military personnel in these situations.

Over 1000 agent-related publications are listed at www.agentlink.org
The first major international agent conference, the International Conference on Multi-Agent Systems, took place in San Francisco in 1995. Since then, numerous events have been spawned, with the International Joint Conference on Autonomous Agents and Multi-Agent Systems now attracting 800 delegates from around the world.
The 2005 AgentLink agent technology roadmap is available from www.agentlink.org/roadmap.

Over 5000 hard copies of AgentLink’s roadmaps have been distributed to industry, government and academia, with over 50,000 electronic copies distributed globally.

IBM is building agent technology to support its autonomic computing systems, which have the intelligence to reconfigure themselves in response to changing conditions.
DaimlerChrysler implemented an agent-based system on one factory floor to allow individual workpieces to be directed dynamically around the production area. The intention was to implement flexible manufacturing to meet rapidly changing operations targets, and the result was a 20% increase in productivity on average. The resulting prototype system was in day-to-day operation for five years up to the end of the life-cycle of the targeted product.

In the first quarter of 2002, CombineNet in the US helped its clients save over $100 million through the use of combinatorial auction technology.
Goal-driven agents in a multi-agent system typically have conflicting goals; in other words, not all agents may be able to satisfy their respective goals simultaneously. This can occur, for example, with contested resources or with multiple demands on an agent's time and attention. In such circumstances, agents need to enter into negotiation with each other to resolve conflicts.
AT&T prepared its bidding strategy in a Federal Communications Commission auction in part based on its work in the first Trading Agents Competition in 2000. The Trading Agents Competition is an annual event that aims to shed light on research issues in automating trading strategies.

**The Semantic Web** is based on the idea that the data on the Web can be defined and linked in such a way that it can be used for the automatic processing and integration of data by intelligent agents.
AgentLink III has OVER 200 full member organisations across Europe.

Since 1998, AgentLink has published 19 issues of AgentLink News, a magazine devoted to current developments in research, development and commercial deployment of agent-based computing. Newsletters are available from www.agentlink.org/newsletter.
RoboCup is an international initiative that aims to foster agent research by providing a standard problem – soccer – where a wide range of technologies can be examined and integrated. In order for a robot team to actually perform a soccer game, various technologies must be incorporated including: design principles of autonomous agents, multi-agent collaboration, strategy acquisition, real-time reasoning, robotics, and sensor-fusion.
The eighth annual European Agent Systems Summer School will be held in Annecy, France, following previous schools in Saarbrucken, Prague, Barcelona, Bologna, Liverpool, and Utrecht.

Each summer school has attracted over 100 participants, ranging from PhD students to academics and industrialists.
iRobot has sold over 1.5 million autonomous Roomba vacuuming robots.
In February 2001, Trade Extensions, Accenture, and Volvo performed a combinatorial auction for the procurement of wooden packaging material. Due to the competitive nature of combinatorial bids, a feature of Trade Extensions’ auction technology, significant cost savings were made: during the auction, the total cost decreased from 180 million to 172.9 million Swedish Kronors, a saving of 7.1 million; and the number of suppliers was reduced from 15 to 6.
Automated agent traders account for over 50% of portfolio trades by value most weeks on the New York Stock Exchange and, in some weeks, as much as 70% of portfolio trades.

Agent-based virtual organisations are one of the key driving visions of Grid Computing.
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, Ocean i-Scheduler, 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.
AgentLink has 38 companies among its member organisations.
Agent technologies are mission critical to the Grid, to pervasive computing, to ambient intelligence, and to service-oriented architectures.
Agent technology developed by Agentis Software was used to manage the complex processes and changing business requirements involved in the challenging task of relocating residents during the $1.6 billion project to refurbish or rebuild housing for 25,000 people by the Chicago Housing Authority.

After implementing recommendations derived from an agent-based model of a corrugated box plant developed by Eurobios, SCA Packaging was able to make a 200% return on investment in the first month.
AgentLink’s 2005 agent technology roadmap is the result of contributions and discussions with over 100 researchers, developers and business people.

www.agentlink.org/roadmap
FIPA, the standards organisation for agents and multi-agent systems, was officially accepted by the IEEE as its eleventh standards committee on 8th June 2005.

AgentLink III is a project funded by the European Commission as part of its Information Society Technologies programme in 2004 and 2005. It follows on from earlier projects, AgentLink (1998-2000) and AgentLink II (2000-2003), also funded by the European Commission.

www.agentlink.org
Traditional object-oriented computer systems involve static relationships between software entities sharing the same beliefs, preferences and goals, in a system with a single thread of control.

Agent systems typically involve dynamic relationships between autonomous software entities with different beliefs, preferences or goals, where there is no single thread of control.
Since 2004, more than 20,000 electronic copies of the AgentLink News magazine have been distributed. www.agentlink.org/newsletter

eBay’s application program interface allows users to define their own automated bidding agents.
NASA's agents are designed to achieve the goals and intentions of the designers, not merely to respond to predefined events, so that they can react to unimagined events and still ensure that the spacecraft does not waste fuel while keeping to its mission.

NASA satellites use autonomous agents to balance multiple demands, such as staying on course, keeping experiments running, and dealing with the unexpected, thereby avoiding waste.
The success of the Internet has changed the way we think about computing. No longer is computing just about numerical calculation, or information processing, it is now about interaction and co-ordination between distinct entities. Agent systems provide us with the means to design and implement interactive computing, whether between machines, or people, or both.
Whitestein Technologies AG
Switzerland
Contact: Monique Calisti
mca@whitestein.com

University of Bologna
Italy
Contact: Andrea Omicini
andrea.omicini@unibo.it

University of Liverpool
United Kingdom
Contact: Peter McBurney
p.j.mcburney@csc.liv.ac.uk

University of Southampton
United Kingdom
Contact: Terry Payne
trp@ecs.soton.ac.uk
The success of the Internet has changed the way we think about computing. No longer is computing just about numerical calculation, or information processing, it is now about interaction and co-ordination between distinct entities.

Agent systems provide us with the means to design and implement interactive computing, whether between machines, or people, or both.

Professor Michael Luck  
AgentLink Roadmap Co-ordinator  
School of Electronics and Computer Science  
University of Southampton

Czech Technical University  
Czech Republic  
Contact: Michal Pechouček  
pechuoc@labe.felk.cvut.cz

British Telecom  
United Kingdom  
Contact: Simon Thompson  
simon.2.thompson@bt.com

Universitat Politècnica de Catalunya  
Spain  
Contact: Steven Willmott  
estev@lsi.upc.edu

The facts in this booklet are reported in good faith but may contain omissions or errors. Neither the partners, nor the European Commission accept any responsibility for loss or damage arising from the use of information in this booklet.

Designed & produced by Telephone 023 8070 6100.
This booklet has been produced as part of AgentLink’s roadmapping activity. Electronic copies of the roadmap, which assesses the current state and likely future developments in agent-based computing, are available from www.agentlink.org/roadmap

For paper copies, or for further information on agent-based computing and its application and deployment, contact:

Professor Michael Luck
School of Electronics and Computer Science
University of Southampton
Southampton SO17 1BJ
United Kingdom
email: mml@ecs.soton.ac.uk

Published by the University of Southampton on behalf of AgentLink III. ©2005 AgentLink. AgentLink III is a Co-ordination Action funded by the European Commission in Semantic-Based Knowledge Systems (Project Reference: IST-7FP-002306CA).