



Agent Research and Development in Europe

*Carles Sierra • Spanish AI Research Institute
Michael Wooldridge • University of Liverpool
Norman Sadeh • European Commission*

Since the mid-1980s, the European Community has funded research and development in information and communication technologies through a succession of research programs. Best known among these are ACTS/RACE (Advanced Communications Technologies and Services/R&D in Advanced Communication for Europe), Telematics, and Esprit, as well as their common successor, the Information Society Technologies program, launched in late 1998 with a budget of 3.6 billion Euros (about US\$3.2 billion) over four years. These programs combine long-term research activities with more applied efforts, joining European industry and academia in consortia that typically must include partners from at least two participating countries among the 15 member states of the European Union. These states include Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Portugal, Spain, Sweden, the Netherlands, and the United Kingdom, and there is a growing number of associate countries as well.

Advanced IT areas funded by these R&D programs include agent

technologies. One of the first European agent R&D projects was Archon (Architecture for Cooperating Heterogeneous Online Systems), launched in 1989 to develop multiagent control applications. Deployed in Iberdrola, Spain, Archon manages power distribution in part of Spain's electricity distribution network.

A surge of recent activity in software agents has resulted in about 50 projects. Application areas include electronic commerce (CASBA and AIMedia), mobile agents (the Climate cluster of 12 projects), learning assistant agents (NIMIS), wearable assistant agents (Comris), geographical information systems (Agent), and manufacturing management (Mascada and Terpsichore). These activities include a combination of stand-alone projects and more coordinated initiatives such as the Climate cluster in mobile agents and the recently launched Universal Information Ecosystems initiative, an interdisciplinary research program aimed at exploring new technologies and solutions to take full advantage of an infrastructure with a trillion or more "inhabitants."

AgentLink: Coordinating European Agent R&D

The various agent projects are further coordinated through initiatives such as the AgentLink "network of excellence" for agent-based computing. The European Commission funds several networks of excellence, infrastructures designed to enhance communication and cooperation among entities working in specific, strategically important areas. A network's members are typically university departments or R&D companies, and researchers can self-organize along themes and activities of common interest. The objective is to create synergy among researchers and projects and to promote international standardization efforts and value-adding activities such as seminars, workshops, conferences, competitions, newsletters, and new educational curriculum guidelines. Complementary activities, such as the E-Clip project in the e-commerce area, explore legal issues and provide a bridge between R&D and policy issues.

The European Commission began funding AgentLink in May 1998. This network's four main goals are to

- gain competitive advantage for European industry by raising awareness of agent technology and European agent research activities, promoting technology transfer from research to industry, focusing research activities on industrially relevant issues, and encouraging European industrial consortia to pursue promising new areas of development;
- encourage excellence in European agent systems research by bringing together researchers, promoting cross-fertilization of research skills, and accentuating areas of European strength;
- promote the excellence and relevance of teaching and training in agent-based systems across Europe by organizing summer schools devoted to agent-related issues and by disseminating curricula, courses, and teaching materials; and finally,
- provide a pan-European infrastructure for communicating the results

of the AgentLink network and debating relevant issues.

In mid-2000, AgentLink was funded for three additional years. Although full membership is open only to researchers satisfying the rules for participation in European projects, associate member status is free to international centers performing significant agent R&D work.

Exemplar Projects

Three current projects funded by the European Commission suggest the breadth of agent-related issues being investigated under the banner of European funding.

Intelligent agents in NIMIS. Incorporating a large interactive display in a framework called the computer-integrated classroom, the Networked Interactive Media in Schools (NIMIS) project aims to support young pupils in developing reading skills, notions of "narrativity," and the ability to take a second- or third-person perspective across a range of situations.

To achieve these goals, NIMIS is developing applications and materials to encourage reading and writing by enabling young learners to create, revise, and publish their own stories with integrated multimedia features. NIMIS uses agents in three ways: as software components; as synthetic personae to help, mediate, advise,

and motivate children; and as synthetic characters in a story-creation environment.

The main reason for using agents as components is their reusability and their potential for sharing knowledge. Agents thus serve as a development booster by helping application design-

**pull quote here. pull quote here.
pull quote here. pull quote here.
pull quote here. pull quote here.**

ers and programmers reuse components developed by others. Each application functions as a social agent that cooperates with other agents (applications) using the NIMIS software environment.

NIMIS is one of 13 projects launched by the Esprit program in the context of the Intelligent Information Interfaces (i3) initiative on the Experimental School Environment. ESE explores novel scenarios and IT environments for early learning (typically children ages 4 to 8), encouraging development of creativity, self-expression, sharing, teamwork, and learning skills.

Competitive agents in CASBA. The Common Agent Service Brokering Architecture (CASBA) project is intended to improve existing e-commerce services and develop new ser-

vices to create a flexible electronic marketplace. The basic idea combines electronic auctions with automated negotiation techniques to provide a framework for future e-commerce scenarios. CASBA is developing two main prototypes:

- the CASBAmarket—a tool with which Internet service providers set up and administer electronic markets, and
- the CASBAagent—a tool for creating specialized agents that will access and trade in these markets.

CASBA agents lack the authority to actually transact on a user's behalf. Rather, they negotiate and agree in principle, then return to their owner for the authority to complete the transaction.

CASBA is developing and using the following technologies:

- electronic payment tools and procedures,
- Web and e-mail servers with secure protocols,
- intelligent agent support environments,
- database support, and
- administration tools, including control, directories, and access statistics.

Multiagent manufacturing control in Mascada. The Holonic Manufacturing System (HMS) consortium is using the holon concept in the Mascada project to develop a technology for manufacturing industries. A *holon* is an autonomous, cooperative building block of a manufacturing system for transforming, transporting, and storing and/or validating information and physical objects. The project's goal is to attain manufacturing stability in the face of disturbances, adaptability and flexibility in the face of change, and efficient use of available resources.

The HMS consortium has adopted a reference architecture built around three basic holon types, each responsible for one aspect of manufacturing control: *order* holons for logistical

European Agent R&D URLs

European R&D funding

- ACTS • <http://www.uk.infowin.org/ACTS/>
- Esprit • <http://www.cordis.lu/esprit/home.html>
- Information Society Technologies • <http://www.cordis.lu/ist/>
- Telematics • <http://www2.echo.lu/telematics/>
- Universal Information Ecosystems • <http://www.cordis.lu/ist/fetuie.htm>

Agents-related projects

- AgentLink • <http://www.AgentLink.org/>
- CASBA • <http://casbah.ee.ic.ac.uk/~cbs/casbah.htm>
- i3 and ESE • <http://www.i3net.org/>
- Mascada • <http://www.mech.kuleuven.ac.be/pma/project/mascada/>

aspects, *product* holons for technological planning, and *resource* holons for resource capabilities. Object-oriented concepts such as aggregation and specialization serve to structure basic holons. *Staff* holons can also be added to assist basic holons by providing expert knowledge. These staff holons allow developers to use centralized algorithms and incorporate legacy systems. Interaction between numerous low-level holons results in complex system behavior, which is difficult to understand, control, and predict. Structuring, by aggregating holons into a hierarchy, manages this complexity.

Distinguishing Features

European Community programs have been supporting agents-related projects for 15 years, initially on a relatively small scale but more recently, as the technology has matured, through broader collaborative initiatives. One distinguishing feature of European programs is their emphasis on coordination and the support of value-adding activities that exceed the scope of specific projects. Another is the holistic approach, which ensures that technology isn't developed in a vacuum and that research is generally anchored in practical application contexts. ■

Carles Sierra is a senior researcher with AI Research Institute, CSIC, 08193 Bellaterra, Barcelona, Spain; sierra@iia.csic.es.

Michael Wooldridge is a professor with the Department of Computer Science, University of Liverpool, Liverpool L69 7ZF, UK; M.J.Wooldridge@csc.liv.ac.uk.

Norman Sadeh is a program manager with the Information Society Directorate General, European Commission, Avenue des Nerviens 105, B-1040 Brussels, Belgium; Norman.Sadeh@cec.eu.int.

IEEE Internet Computing

Editorial: *IEEE Internet Computing* targets the technical and scientific Internet user communities as well as designers and developers of Internet-based applications and enabling technologies. Instructions to authors are online at <http://computer.org/internet/edguide>. Articles are peer-reviewed for technical merit and copyedited for clarity, style, and space. Unless otherwise stated, bylined articles and departments, as well as product and service descriptions, reflect the author's or firm's opinion; inclusion in this publication does not necessarily constitute endorsement by the IEEE or the IEEE Computer Society.

Copyright and reprint permission: Copyright ©2000 by the Institute of Electrical and Electronic Engineers. All rights reserved. Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limits of US copyright law for private use of patrons those articles that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through the Copyright Clearance Center, 222 Rosewood Dr., Danvers, MA 01970. For copying, reprint, or republication permission, write to Copyright and Permissions Dept., IEEE Service Center, 445 Hoes Ln., Piscataway, NJ 08855-1331.

Circulation: *IEEE Internet Computing* (ISSN 1089-7801) is published bimonthly by the IEEE Computer Society. IEEE headquarters: 3 Park Avenue, 17th Floor, New York, NY 10016-5997. IEEE Computer Society headquarters: 1730 Massachusetts Ave., Washington, DC 20036-1903. IEEE Computer Society Publications Office: 10662 Los Vaqueros Circle, PO Box 3014, Los Alamitos, CA 90720; (714) 821-8380; fax (714) 821-4010. Annual subscription: \$34 in addition to any IEEE Computer Society dues, \$48 in addition to any IEEE dues; \$58 for members of other technical organizations. Nonmember subscription rates are available on request. Back issues: \$10 for members, \$20 for nonmembers. This magazine is also available on microfiche.

Postmaster: Send undelivered copies and address changes to IEEE Internet Computing, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08855. Periodicals postage paid at New York, NY, and at additional mailing offices. Canadian GST #125634188. Canada Post International Publications Mail Product (Canadian Distribution) Sales Agreement #1008870. Printed in USA.

Filler ad here.