Update: Agent Standardization Efforts

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By James Odell

Agent technology is currently one of the most active and vibrant areas of IT research and development. After many years, the word *agent* has become fashionable, because the state of the technology seems to match the prospect of several applications, including business process management, manufacturing, information retrieval, user assistants, and even entertainment.

A surge of recent activity in software agents has resulted in about 50 projects in Europe alone. [Sierra,2000] 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 "infohabitants." This article presents a selection of these standardization efforts.

Kinds of Agent Standardizaton

Agent technology is a field at different stages of development. While some areas are still in the infant stage, others are already approaching maturity, as demonstrated by the fact that some products that claim to (and sometimes do) use agent technologies have appeared. In most cases, agent-based applications require agents to interact with other agents. Since agents come from different sources, some form of standardization is needed to transform agent technologies into the products, applications, 21or services that are widely deployed. Standardization, however, means different things to different people:

- Formal standardization- Where organizations such as ANSI, ISO, and IEEE are formally designated as standards bodies. In principle, everybody agrees that this is the best solution. However, concerns have emerged because of the bureaucratic way some standardization projects are initiated and managed, particularly in such a new area as agents. Currently, no agent-related standards being developed by these organizations.
- Consortium standardization- A nonprofit association of organizations established for the purpose of standardizing some sector, such as the OMG, FIPA, and the ATM Forum. Standards here are based on the membership's consensus and, as such, they are *de jure* standards.

- Project-based standardization- Initatives formed and funded by some organization. Such projects have a plan with specific deliverables and timelines and generally involve many participating organizations. Examples of these would include the various DARPA and EUROSCOM projects.
- Industry standardization- This happens when one or more major players cooperate to produce some specification, such as MPEG or VHS. These may be successful because of the sheer weight of the players involved or may be antagonized by other players who fear that an advantage is gained by others because a particular technology is unfamiliar, owned by others, or based on business models not shared by others. This is one reason why otherwise valuable industrial initiatives in this domain have had mixed success. Currently, I do not know of any agent-related standards being developed in this way.

Consortium and project, then, are the way by which standards for agent technology are currently emerging and they are outlined below.

Standards Consortiums

Foundation for Intelligent Physical Agents (FIPA)

www.fipa.org

The Foundation for Intelligent Physical Agents (FIPA) is an international nonprofit organization formed in 1996. It is dedicated to developing and promoting standards for agent-based systems across multiple vendors' platforms. In particular, its emphasis on interoperability includes end-to-end interworking of agent systems in modern commercial and industrial settings. FIPA, then, is not just interested in theory, it is also concerned with the practical application of agent technology. FIPA has adopted and is working on specifications for agent:

- Application specifications including Nomadic Application Support Specification, Agent Software Integration, Personal Travel Assistance, Audio-Visual Entertainment and Broadcasting Specification, Network Management and Provisioning, and Personal Assistant Specification.
- Architecture specifications that specify which abstract entities are required to build agent services and an agent environment.
- Communication including an agent communication language, content languages, and interaction protocols.
- Management which addresses the control and management of agents within and across agent platforms.
- Message transport which specifies the transport and representation of messages across different network transport protocols, including wireline and wireless environments.

Currently, the membership exceeds 60 organizations (and growing) and is open to any individual or business entity without restriction. It has an ongoing work program, meeting around the globe on a quarterly basis, and has close working relationships with other standards-producing organizations, such as the Object Management Group (OMG), DARPA, and AgentLink.

The first publicly available FIPA implementation, *FIPA-OS*, came from Nortel Networks and was released as open source in October 1999. In the first three months, over 200 developers from around the world have downloaded the software. The FIPA-OS license provides a worldwide, royalty-free, nonexclusive license, subject to third party intellectual property rights. The third released "easy-install" Java 1.2 version of FIPA-OS is now available from www.nortelnetworks.com/fipa-os.

The *ZEUS* Agent Building Toolkit is BT Labs' award-winning integrated environment for the rapid development of collaborative agent applications. It makes good use of graphical programming, debugging, and visualization tools and sets a high standard for integrated GUI-based agent development environments. The ZEUS toolkit is entirely implemented in Java (JDK2) and will run on all major hardware platforms. It has been undergoing evaluation by researchers and engineers from 30 organizations around the world. ZEUS source code is available from www.labs.bt.com/projects/agents/zeus.

JADE from CSELT has just announced a public open-source distribution under the LGPL license. Jade runs on Java 1.2 and has been used on a number of European projects. Jade source code is available from http://sharon.cselt.it/projects/jade.

The Intelligent and Interactive System group at Imperial College, London, as part of its CASBAh (Common Agent Service Brokering Architecture) project, has announced an initiative called *FIPANET* to assist in locating and connecting to service providers in a FIPA agent society. FIPA-NET will consist of a publicly accessible Internet "yellow-page" service for agents which will act as a node for Federated Directory Facilitators. A number of other organizations have declared an intent to make some of their software available as open source, including a platform from Fujitsu and TIIERA from the U.S. Navy. If open source is not to your taste, then take a closer look at *Grasshopper* from IKV++ at www.ikv.de.

OMG Agent Special Interest Group (Agent SIG)

http://www.objs.com/agent/index.html

The Agent Special Interest Group is a subcommittee within the Object Management Group (OMG). Its primary mission is to work with OMG task forces:

- to identify and recommend new OMG specifications in the agent area.
- to recommend agent-related extensions to existing and emerging OMG specifications.
- to promote standard agent modeling techniques that increase the rigor and

consistency of specifications.

- to enable developers to understand better how to develop agent-based applications, including large-scale, distributed agent systems.

Since agents is a new area for most OMG participants, progress has been a little slow. On the other side, many agent-system developers may not think of collaborating with an object-oriented organization to work on agents' standards. Some work, however, is being done in the areas of agent-related extensions to UML (www.auml.org) and ontology. Although both are important areas, ontology is probably more significant. Ontology deals with establishing terms and their definitions. For XML, this is a major issue because each XML field needs an agreed term and definition for it to be shared among its users. While ontology is vital for agent communication, it is important for data communication in general.

One of the first products of this group was the *Agent Technology Green Paper* (http://www.jamesodell.com/ec2000-08-01.pdf).

Holonic Manufacturing Systems (HMS) Consortium

hms.ifw.uni-hannover.de

Change is a fact of life. Fundamental changes in government, business, technology, and society are currently transforming the world in ways that defy prediction. The rate and magnitude of these changes have created problems that are common to industrialized nations around the world. To thrive in the changing economic climate of the modern world, the industrialized nations must implement fundamental changes in their manufacturing base. Manufacturers around the globe must develop the means to operate efficiently on a global scale and to meet the needs of an ever more demanding consumer market.

Australia, Canada, the European Community (EC), European Free Trade Association (EFTA), Japan, and the U,S, have begun an international collaborative research program in manufacturing called the Intelligent Manufacturing Systems (IMS) program. This program has established a mechanism to carry out joint international research, development, and standardization for the next generation of manufacturing technologies. The IMS program currently consists of six major projects, one of which is the Holonic Manufacturing Systems.

Twenty-five years ago, the Hungarian author and philosopher Arthur Koestler proposed the word *holon* to describe a basic unit of organization in biological and social systems. Holon is a combination of the Greek word *holos*, meaning whole, and the suffix meaning particle or part. The Holonic Manufacturing Systems (HMS) consortium wants to translate the concepts that Koestler developed for social organizations and living organisms into a set of appropriate concepts for manufacturing industries. The consortium hopes to attain in manufacturing the benefits that holonic organization provides to living organisms and societies,that is, stability in the face of disturbances, adaptability and flexibility in the face of change, and efficient use of available resources.

The HMS concept combines the best features of hierarchical ("top down") and heterarchical ("bottom up," "cooperative") organizational structures as the situation dictates. This concept can preserve the stability of hierarchy while providing the dynamic flexibility of heterarchies. The HMS consortium continues to develop and standardize the means of incorporating holonic behavior into manufacturing systems with the intent of integrating holonic-based technology with the capabilities of human workers.

U.S. Projects

In addition to the recognized standards consortia such as the OMG and FIPA, other organizations are establishing joint projects that could lead to *de facto* standards. The primary initiatives in the United States aimed at standardizing agents and agent-based systems are centered in DARPA and Sun Microsystems. While many other American organizations are working in this area (e.g., IBM, AgentSoft, ObjectSpace, and Microsoft), DARPA, and Sun are encouraging a group effort that could accelerate standards for agents.

DARPA (Defense Advanced Research Projects Agency) has several research programs that address aspects of agent technology. The two major programs include: the Control of Agent-Based System (CoABS) and the DARPA Agent Markup Language (DAML) projects. Sun created the Java Community Process (JCP) where the specification for a Java Agent Services (JAS) API is being developed by several companies.

Control of Agent-Based System (CoABS)

coabs.globalinfotek.com/

The CoABS Grid is a framework for federating heterogeneous agent systems. It is designed to meet the challenges of the military environment, as well as address the heterogeneity among the participating agent research communities. Although the CoABS Grid is being developed with a military application in mind, it is a general-purpose agent framework with potential use by a wide variety of applications.

In the complex realm of modern military operations, commanders must deal with increasingly diverse missions, including operations other than war, and situations in a dynamic, uncertain environment. Many of these missions require the participation of integrated forces from multiple services and multiple coalition partners. To support these joint and coalition military operations, a number of information technology (IT) applications and data sources from the various allied units come together, potentially for the first time, and need to be made interoperable in days or hours.

These applications need to be highly tailored to the battlespace and mission at hand and yet flexible enough to support rapid, (ideally) automatic reconfiguration to adapt to changes in the battlespace situation, coalition membership, currently accessible IT

systems and data sources, available computing power and communications bandwidth, and commanders' objectives and guidance. Users need to participate in these dynamic teams of components. Applications will coexist with one another, sharing computing, communication, and data resources on the Internet, WWW, or other environments. Many applications will need to run continuously with a high degree of reliability and security.

This vision is not yet a reality. Currently military operations supported by large staffs using a variety of legacy information technology systems and applications, many of which are either standalone or "hardwired" to other systems in static configurations. This results in fixed, inflexible information flows. A mechanism is needed to enable the dynamic, run-time integration of agent, object, and legacy software components into applications. A key enabler of this vision is the CoABS Grid, a major research and development effort of the DARPA Control of Agent Based Systems (CoABS) Program.

The Grid leverages emergent agent technology and standards from the CoABS community and industry (e.g., FIPA). Not every component needs to be an agent. Thus, the Grid also leverages other technologies supporting component interconnectivity and interoperability among objects and other components (e.g., OMG's CORBA, Sun's Jini).

DARPA Agent Markup Language (DAML)

www.daml.org

DAML (DARPA Agent Markup Language) is a markup language for the U.S. Defense Advanced Research Project Agency (DARPA) that is based on the Extensible Markup Language (XML). DAML is designed to have a greater capacity than XML for describing objects and the relationships between objects, expressing semantics, and creating a higher level of interoperability among Web sites. As the central research and development agency for the U.S. Department of Defense, DARPA was instrumental in the creation of the Internet and many of its technologies. DARPA is developing DAML as a technology with intelligence built into the language through the behaviors of agents. This will help agents to dynamically identify and comprehend sources of information and to interact with other agents in an autonomous fashion.

DAML is being designed as an XML-based semantic language that ties the information on a page to machine-readable semantics (ontology). DAML designers have begun working with the World Wide Web Consortium to make sure that DAML fits with the W3C's plans for a semantic Web.

DAML agents can be embedded in code and maintain awareness of their environment while behaving autonomously and learning from their experiences. DAML uses a number of different types of agents (such as information agents, event-monitoring agents, and secure agents) for different purposes. DAML's semantic knowledge and autonomous behavior is expected to make it capable of

processing huge volumes of data in a way similar to human beings. DAML is a type of query language with a specialized ability to find and process relevant information, for example, finding related information on separate Web sites and processing it into a comprehensive report.

Java Agent Services (Sun JSR 000087)

www.java-agent.org

The Java Agent Services (JAS) project wants to define an industry standard specification and API for the development of network agent and service architectures. Java is, of course, the most pervasive technology in use today for creating FIPA agent systems. However, to date there is no standard Java API for creating them—an omission that must be rectified if agents are to penetrate the world of business applications. The JAS initiative intends to address this by developing specifications that define specialized objects and service interfaces to support the deployment and operation of agents. It is based upon the Abstract Architecture developed by FIPA. The specification defines Java classes to support an ACL (agent communication language) and SL (content language), as well as FIPA agent names and descriptions. It also specifies Java interfaces for agent registration, discovery, and communication services. The service interfaces can be implemented in terms of a number of different technologies, including both existing Java standards and proprietary systems. This implies that the base messaging service employed will be JMS, but with API extensions to allow for other transport mechanisms such as HTTP, SMTP, and SOAP. Similarly, the base for directory services will be JNDI due to its inherent LDAP extensions.

In September 2000, a proposal was proposed to the Java Community Process (JCP) outlining the Java Agent Services (JAS) API. The JCP program identifies three primary commitments that the proposing parties must make when undertaking a project; a specification document describing the API and underlying technology, a reference implementation and a compatibility test suite. Development of the first two of these is underway.

Implementations built using the JAS API are likely to find a strong foundation in the B2B application space, enabling activities such as eCommerce, business process management,nd trading partner integration. This may imply that the JAS will find itself in the same space as other technologies such as the UDDI initiative and Hewlett-Packard's E-Speak, albeit from a more abstract perspective. As such, the JAS will focus on creating an API flexible enough to be adapted to diverse applications by combining the knowledge and experience of the expert group membership and other contributing parties.

European Projects

AgentLink

www.agentlink.org

AgentLink is Europe's ESPRIT-funded Network of Excellence for agent-based computing. It is a coordinating organization for research and development activities in the area of agent-based computer systems aimed at raising the profile, quality, and industrial relevance of agent systems in Europe. AgentLink divides its activities into four main areas:

- Industrial action- facilitating technology transfer through a program of industrial meetings, workshops, standardization updates, and working group
- Research coordination- promoting excellence in European agent research through support for workshops, special interest groups, and dissemination of research results
- Teaching and training- establishing agent related skills throughout Europe by support for summer schools and courses
- Infrastructure and management- providing an infrastructure through which AgentLink can do its work, including a WWW site, regular newsletter, email list, and an awareness program.

AgentLink expects to establish a database of developed agent systems, technologies, and products, with the goal of showing interested industrialists what types of problems agent technology has been applied to, and what resources and products are available to tackle different types of industrial problems. The database will also summarize the special areas of expertise available within AgentLink. The database will be made freely available via the AgentLink site.

More importantly, AgentLink will facilitate the transfer of agent technology, skills, standards and best-practice from academia to industry. Initiatives currently developing such standards include:

- Agent-Mediated Electronic Commerce
- Methodologies and Software Engineering for Agent Systems
- Information Agents
- Agent-Based Social Simulation
- Multi-agent Coordination and Control
- Mobile Agents in Telecommunications and the Internet

The lack of appropriate standards for communication, cooperation, and negotiation is one of the main obstacles in the way of wider deployment of agent systems technology. AgentLink aims to promote the development, dissemination, and adoption of such standards within the European region—and by doing so, leveraging competitive advantage for European industry. AgentLink provides

regular reports on the state of these standardization initiatives on its website and publications.

Methodology for Engineering Systems of Software AGEnts (MESSAGE)

www.eurescom.de/~public-webspace/P900-series/P907/index.htm

EURESCOM, the European Institute for Research and Strategic Studies in Telecommunications, is the leading institute for collaborative R&D in telecommunications. This virtual company uses the resources of its shareholders to perform high-impact research projects.

MESSAGE is the name of one EURESCOM project developing a software methodology for software agents. The aim of MESSAGE is to define an agent-based methodology that encompasses requirements for analysis and design and which is appropriate for use in mainstream software engineering departments. The current approach is to use an object-oriented approach to analysis and design such as UML as a baseline. This will be extended with special purpose notations for modeling agent-related concepts that cannot be modeled easily with UML.

The first phase of this project is just coming to a close. The methodology as it has been developed so far can be obtained from their website.

Communications Management Process Integration Using Software Agents

http://www.eurescom.de/~public-webspace/P800-series/P815/web/index.htm

The traditional centralization of management decision making and control does not scale up to the demands of today's multiservice markets. New architectures are being developed (e.g., TINA) to introduce distributed and decentralized management solutions. However, these tend to focus on the issues related to the integration of management systems, mostly ignoring the integration of business processes.

In response, another EUROSCOM initiative was established to address this problem—the Communications Management Process Integration Using Software Agents project. This recently completed project investigated the application of agent technology to the management of processes and systems across communications management domains. Its objectives include:

- Evaluating the application of agent technology to process management through rapid prototyping and experimentation.
- Defining a framework for the introduction of agent technology for process and systems integration.
- Validating and contributing to emerging agent standards (e.g., FIPA), wherever possible

- Producing recommendations on the maturity and suitability of agent technology to communications process management.

Mobile agents and their applicability to service and network management

www.eurescom.de/Public/Projects/p700-series/P712/P712.htm

Software agents are not confined to a particular network or computing node but can migrate and replicate themselves in the network. They do this with the aim of finding specific services and applications, thereby checking constraints and observing physical and computing interfaces. Such flexible concepts are very useful for many management procedures, such as for service provisioning that takes user, terminal and network capabilities into account, and for quality monitoring, or fault management.

A significant research body already exists. However, what is largely unproved is the applicability of this technology to the telecommunications industry. The main objective of this recently completed EUROSCOM project was to assess the maturity and implications of "Intelligent and Mobile Agents" concepts and technology and their applicability to service and network management.

The project showed that agent technology is becoming mature and can be used in service and network management as well as in other application areas. Its deliverables describe the potential advantages of using software agents together with the current software technology. The description in the deliverable is detailed enough for engineers to take advantage of this brand new technology, for strategists to recommend the investment in this technology, and for marketers to propose new services using agents.

Agents in NIMIS

collide.informatik.uni-duisburg.de/Projects/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 potential for sharing knowledge. Agents thus boost development by helping application designers

and programmers reuse components. 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 Environments. 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

www.casba-market.org

The Competitive Agents for Secure Business Applications project (CASBA) is intended to improve existing e-commerce services and develop new services 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 CASBA-market—a tool with which Internet service providers set up and administer electronic markets, and
- the CASBA-agent—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 and 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,
- agent support environments,
- database support, and
- administration tools, including control, directories, and access statistics.

AgentCities

www.agentcities.org

AgentCities is a new initiative designed to help realize the commercial and research potential of FIPA agent applications. It aims to build a publicly accessible, continually available, network of FIPA platforms. Each platform will support services modeled for a single real world city or place. Services deployed in the test bed will initially center on information and transaction services for real world objects such as bars, restaurants, hotels, travel infrastructure, theatres, etc. Virtual cities that

do not have a direct physical analogue will also be permitted. Agent-based applications will be able to access these services worldwide using federated directory services and FIPA communication services. The set of services deployed in the network can then be used as building blocks to construct new agent services. Complex compound services such as planning a weekend away (organizing flights and opera tickets, selecting restaurants, locating and booking a hotel, and proposing an art exhibition to visit) would then be a real possibility for the first time.

The AgentCities test bed will:

• Act as a resource for agent application developers allowing their agents to interact with service agents developed by others, worldwide.

• Test applications in a realistic, distributed, open environment.

• Provide examples of service models, ontologies, and usage of FIPA standards.

• Deploy a publicly visible and accessible FIPA technology.

• Create an implementation experiment generating feedback on FIPA standards.

• Develop a benchmark environment for compliance testing.

The test bed will be built by contributing organizations each hosting its own "city" which is a publicly available FIPA agent platform and accompanying agent services for a selected city or place. Several organizations have signed up to contribute to AgentCities, including EPFL, Fujitsu Labs USA, Imperial College, UK, Motorola, and Nortel Networks. The core effort of AgentCities is devoted to interoperability at the service level, in particular, the development of ontologies, service descriptions, and the practical usage of FIPA protocols, ACL, and content languages. AgentCities is funded by European Commission's Information Society Technologies Research Programme (IST). For more information, check the web site.

Sierra, Carles *et al*, "Agent Research and Development in Europe," *IEEE Internet Computing*, 3(5), September/October, 2000, pp. 81–83.

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