

AgentSurvey: Assessing the state of the Art of Industrial Applications Using Agent Technology and AI

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Abstract

SAP initiated a survey project on agent technology in which the state of the art in the application of agents to industrial application domains is investigated. In this paper we describe our common effort and activities related to this project. The survey results consist of documents which describe relevant projects and products especially with respect to the technical details. These documents are grouped in a structure that reflects the currently existing business processes of industrial companies, i.e. there are categories for Supply Chain Management, Customer Relationship Management, Personal Digital Assistants, Knowledge Management and other relevant fields. The results will be displayed on a public website and will be made accessible to everybody. Every company or research group is invited to add templates to the website describing their work. We see this activity as a starting point for a common information repository, aimed at practitioners in industry as well as researchers willing to transfer knowledge into practice. Thus, we invite people to contribute relevant facts and ideas to the project web site (<http://www.dfki.de/AgentSurvey>).

1 Introduction

Companies are forced to increase their efficiency in many respects. Customers are analyzed and contacted based on previous interactions, supply chains turn into highly adaptive processes which automatically connect new suppliers or react to new upcoming events. Mobile devices enable everybody to communicate at every time and place.

Agent technology is an emerging field which is applicable to many of the currently existing business problems caused by this increasing rate of change. As autonomous intelligent pieces of software that increase automation, they will heavily influence the way in which business processes are carried out in future. There are already many agent-based products around that support today's business needs. These product companies are often startups growing out of academic research projects.

SAP has now started an open initiative for collecting and structuring the existing problems and solutions. In the first step the structure resembles the major business processes that are supported by IT. To these categories around 100 currently offered agent-based products or academic projects are described. This first step was realized as a joint project with academic support from Cognidata and DFKI.

In the next step the results will be made publicly available. Every company and every research group is invited to contribute to this project. Contributions to the survey are voluntary and can be made by requesting a template to fill in. Before being posted the contributions are reviewed and edited by the survey team. Currently, we would like to attract interested companies and researchers to contribute public information about their practical agent- or AI-related product or project. We would like to see the available collection as a starting point for a more comprehensive survey site about practical applications. The final goal will be the building of a landscape in which every practitioner can find out about approaches that already solved his problem and every researcher can recognize open questions.

Another goal of the survey is to generate ideas for projects and to locate project partners for future research projects with SAP. SAP intends to start a couple of AI/agent-based research projects soon after the survey ends.

In the following sections the state of the current project is described in more detail: Section 2 describes the specific application domains, we have selected for the survey. It also includes what other kind of information or related problems we found interesting and thus need to be considered. Section 3 gives an overview on how we started to structure information, what we found to be relevant features and key aspects, and how we put them in documentation. We also describe the procedures and activities we conducted, in order to make this a common

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agent activity and involve interested researchers as well as practitioners. Section 4 shortly lists the criteria, which we found necessary to select specific representatives for the categories or rather application areas. As we see this activity in its starting state still, we need to decide, how to use our resources and still produce an interesting repository of related information. In Section 5 we draw concluding remarks and again, ask people to join the activity.

2 Selected Application Domains

In order to present information to interested readers, we chose an application domain oriented approach. The domains have been selected with focus on requirements related to business processes occurring in many companies. Therefore, instead of selecting SAP business fields or internal groups as titles for the specific application domains, we decided to select more general, business independent categories to structure the information. We tried to avoid overlap. However, with respect to some application domains, this is never fully possible.

For each of these selected application domains, we shortly introduce the specific problems and then list interesting technologies and projects or products using these. In the text, you will not find detailed information about the mentioned projects. These have been compiled in questionnaire-like templates, which are available on the web, currently at the project website (<http://www.dfki.de/AgentSurvey>). We plan to publish this collection with AgentLink (<http://www.agentlink.org>), a European initiative which aims at promoting agent technology in industry.

2.1 Application Domains

The initially selected domains for this survey are given below. This categorization is not meant as an exclusive, final list. It will probably be subject to change, depending on results of the survey; we may identify different areas of special interest.

- **Manufacturing**, including Holonic Manufacturing, Agile Manufacturing, Planning and Scheduling & Control. Manufacturing has been an interesting application domain for AI for more than twenty years. Also, it is still a major business field for SAP, with close ties to Supply Chain Management and Enterprise Resource Planning (ERP).
- **Intelligent User Interfaces and Usability**, including Human Collaboration, and E-Learning. Interface design is a key factor for many software products. Support of AI technique for Intelligent Design or Intelligent User Interfaces is becoming more and more interesting, as the suggestions for usability ripen from research theories to best-practice rules for companies.
- **Personal Digital Assistants (PDA)**, with the growing availability of handheld devices and their growing computational power, personalized agents residing on these, as well as synchronizing by means of stationary PCs offer great potentials for application of agents and adaptive guidance of users, important applications and properties are e.g. Field Service Management, Matchmaking, and Mobility.
- **Knowledge Management and Human Capital Management (HCM)**, including Sourcing, Matchmaking, and Team Finding. Sourcing, e.g. finding and evaluating suppliers, has become so important that SAP recently created a new application called Supplier Relationship Management (SRM), which is closely tied to SCM and Markets.
- **Customer Relationship Management (CRM)**, covers the way customers are connected and the analysis of customer preferences. Agents and AI are applied in many respects, e.g. recommendations, shopping agents, and price agents. Workforce Management and Field Service Management are also part of CRM. Here constraint problem solving and optimization play a role.
- **Supply Chain Management (SCM)**, uses agents in many forms: in simulation agents take the function of suppliers or resources, they are used as intermediates coordinating tasks, or for wrapping legacy applications.
- **Markets**, including Market Mechanisms, E-Commerce, Auctions, Information Discovery, and Web Mining. Here agents often are representatives of either customers or sellers and reflect their specific behaviors, as well as individual preferences, by means of individual profiling
- **Product Life Cycle Management (PLM)** encompasses a wide range of functions, such as product configuration & change management, project management, quality management and environment health and safety. A core basis function of PLM is to manage the changing product, process and production-resource data that is needed across the entire product lifecycle from design, to sales & production, to service and, finally, to product retirement. PLM tracks this data over time, remembering each variant and each change, e.g., the product/process as-engineered, as-sold, as-planned, as-built and as-maintained. This rich PLM data

is effectively a knowledge base that can benefit from the use of KM techniques. Moreover, it is the basis for processes in the domains of SCM, Markets and CRM, such as production planning, sales and service. PLM data on product variants is the basis for AI-driven Internet Product Configuration (IPC), which is used in Internet sales to easily customize products. So far, the agent-based projects we have found concentrate on the design phase of the product lifecycle.

- **Business Rules** have become very popular to judge by the number of companies offering products (e.g., Corticon, Nisus, IBM, ILOG, YASU Technologies) and the forums devoted to the topic, e.g., <http://www.brcommunity.com/>. Business rules cut across application domains. The company ILOG e.g., claims that they have applied business rules to SCM, CRM, Finance/Insurance, and Telecommunications.

2.2 Platforms and Agent Related Standards

Besides these application domains, when we talk about agents in practical environments, we need to look at *agent platforms*. They enable the building of agent systems and support the powerful communication and coordination required in agent-based systems, in a much easier way, than doing things from scratch. Another highly important issue is that of *standards*. During the last 5 years agents have started to reside no longer in the closed world of the agent builders PC, but they have started to emerge into the internet, in open systems etc. where the need for standards becomes obvious, in order to support flexibility and services. Therefore, we also collect information about these two subjects.

- **Platforms;** a basic building block for an agent system is an agent platform. It should offer agent software related services, such as communication and cooperation methods in terms of protocols, support agent specific interfaces and access to shared ontologies.
- **Standards;** with the rapid growth of the internet and greater availability of networked devices, software systems must be able to smoothly interact with each other. A key factor for interactions between unknown communication partners are standards, about protocols, behaviors, architectures etc. Therefore, the survey lists the main agent and AI related standards, why they are useful and how, and which are the major standards available and to come within the next years.

2.3 Other aspects of Interest

2.3.1 Major Problems

Besides the major goal of assessing the state of the art with respect to agent technology in practical applications, we are driven by practical problems we encounter in the daily life of business processes. One of these major problems is that of Information Integration. A good example for this problem is the highly heterogeneous IT landscape most companies have. Even if a company has only one type of ERP system, the same object may be represented using different keys and/or different database schemas. This is a large, complex sea of data, that needs to be transformed into inter-related information before it can be used to make business decisions. And that is, where *semantics and ontologies* could come into play. Generally, it is hard for users to create semantics before applying a business software system, so support for this, must come from within the system itself and be automated to the fullest extent possible.

2.3.2 Interesting Companies

During our work we sometimes encountered a project or a product, where we thought it was interesting and necessary to also provide for information on the manufacturer of the product. Thus, we decided to include what we call innovative companies or companies strongly engaged in pushing new technology.

3 Information Compilation

Our goal was to find a broad sample of projects and products in industrial applications. For this, we needed some kind of selection criteria, to decide, which work and approaches to include. We currently chose a very pragmatic approach, where we decided to have at least 10 project or product descriptions per domain, so that we would finally at least have around 90 information sheets about application domain related projects and agent building platforms.

However, we found ourselves faced with a tough problem: which uniform document structure would enable us to allow interested readers to get an idea about the basic features of the approach, the product or the platform and at the same time offer enough flexibility to enhance and refine the information once we included them into our work.

We came up with a multi-featured idea for this, which includes the following activities:

- We agreed on our goals, which were to show the relevance of agent technology to SAP developers and business developers. So, example products/projects in the report should be relevant for this target audience and give them ideas about how they might use agents. We also wanted to concentrate especially on producing a report of use to SCM, since they are currently most interested in the topic.
- For each product or project we created a document about 2-6 pages long, which gives a short problem description and a solution sketch.
- We created a website, to host the collected information as generated html (from the above mentioned documents), in order to allow interested readers to access the information and use this as a reference service or reference web address.
- We continuously are searching the web and other resources for the relevant information.
- We are contacting researchers and practitioners, and aim at motivating them to join our efforts and support it, by either filling out a questionnaire like document or proofreading the information collected so far.

The results we have achieved will be eventually summarized in a report, which serves as internal deliverable, reference about agent and AI related information, and possibly as a guide through the survey website.

3.1 Information Presentation

For the presentation of information about a selected project or product, we designed questionnaire-like documents. Each of them starts with a *table*, which holds *relevant facts* about the maturity of the system, the area of the solution, which company or participants are involved, for research projects the time frames and funding, for products the date from when they were available.

Then each document describes either a *business need* or a *research problem*, and the *solution* or *product features*. Finally, contact information is provided. If personal experience with the respective system or project is available, this can be noted in a comments section or provided as further information.

The tables at the top of each document provide a structured overview to the system, project or product. We shortly describe the tables in the next paragraphs.

3.1.1 Product Information

Table 1: Header table for the Product Information (example Neugents , Computer Associates)

Maturity	Production, but no longer available, has been integrated into CA Clever Path
Solution Area	SCM, PLM, CRM
Industry	Utilities, Enterprise Portals, Insurance, Any that needs detection and prediction of “system failures”.
Company	Computer Associates (CA) http://www.cai.com/
Dates	No longer available, see CA Clever Path
Keywords	Artificial Intelligence, agents, e-commerce, neural networks, data mining

Maturity is a phrase (based on Weiss) that aims at best indicating the maturity of the respective product, for example:

- **Pilot:** the system has been demonstrated in a commercial environment
- **Production:** the system is used in regular commercial practice
- **Product:** the system is sold and supported as a commercial product
- **Shareware:** the system is available as shareware without guaranteed support

Solution Area can be chosen of one of these items appropriately (derived from SAP solutions):

- Enterprise Portals
- CRM (Customer Relationship Management)
- SCM (Supply Chain Management)
- Exchanges (e-commerce)

- E-Procurement
- BI (Business Intelligence, e.g., Business Warehouse, Data Mining)
- PLM (Product Lifecycle Management)
- HR (Human Resources)
- Financials
- Mobile Business

Industry to which the solution is applicable (derived from the list of SAP Industries)

Table 2: Applicable Industry

Aerospace & Defense	Healthcare	Oil & Gas
Automotive	High Tech	Pharmaceuticals
Banking	Higher Education & Research	Public Sector
Chemicals	Insurance	Retail
Consumer Products	Media	Service Providers
Engineering & Construction	Mill Products	Telecommunications
Financial Service Provider	Mining	Utilities

3.1.2 Project Information

Table 3: Header table for the Project Information (example InfoBeans)

Maturity	Prototype, Research Project
Solution Area	Intelligent Interfaces
Industry	All, horizontal approach
Participants	DFKI GmbH
Time Frame	1997-2000
Sponsor	Bundesministerium für Bildung und Forschung
Funding	unknown
Keywords	information agents, personalization, programming by demonstration, wrapper generation,

In the same manner as the product information, we defined the project information, the respective slots in the table have a slightly different meaning.

Maturity should be one of the following categories (Weiss 99).

- **Modeled:** the system exists as an architecture or a theoretical model
- **Emulated:** the system has been demonstrated against a simulation of its intended domain environment
- **Prototype:** the system has been demonstrated on real domain hardware, but in a controlled laboratory environment
- **Pilot:** the system has been demonstrated in a commercial environment
- **Production:** the system is used in regular commercial practice
- **Product:** the system is sold and supported as a commercial product (Actually, this one shouldn't be used, since there is a separate template for products.)

Problem/Solution Area is the same as in the product document, i.e. derived from SAP solutions. The same applies for the *Industry* slot.

3.1.3 Company Information

We found it necessary to include company profiles, as some companies are very specialized in their business domain. Besides a product or project participation, it might be interesting, to contact such a company for business purposes or, to find out which strategic alliances or partnerships they are engaged in.

Therefore such an information sheet starts off with a table as well, however, the structure of the body of the document is different, describing the main technologies used or the major area of expertise, and possibly listing strategic partners or partnerships.

Table 4: Header for a company table (example ArtificialLife)

Company URL	http://www.artificial-life.com/
Solution Area	eCommerce, eLearning, Biotech
Revenues	\$ 2,785,000 in 2001, \$12,465,000 in 2000
Founded	1994
Keywords	software bots, natural-language processing

3.2 Website

We have created a website for the project, which is currently located at <http://www.dfki.de/AgentSurvey>. This address will persist during the next two years. We plan to hand over the website and the published results to AgentLink as a general information repository for agents and AI in industrial practice.

3.3 Networking, asking people for support

We met with SAP product groups to find out about their interests in agents. In hindsight, we should have asked some of them for definitions of agents. The world appears to divide into two groups: those who ask you what an agent is, and those who know, but whose definition does not match yours. We also attended several related conferences and events, where agent researchers and practitioners from industry would meet, so that we could contact many of the relevant people working with agent technology or AI in more or less practical contexts.

- *UKMAS (Oxford December 2001)*: British national workshop on multiagent systems. In this informal, but high quality workshop we gave a presentation of the ideas connected with the survey and asked people for contributions.
- *AgentLink (London January 2002)*: This was a meeting to involve industrial practitioners in agent technology, here we mainly had small individual meetings and talked as a panel member about the initiative of the survey.
- *FIPA (Lausanne February 2002)*: Agentcities: At the FIPA meeting, we talked to several people involved in the Agentcities activities and also gave a talk where we invited people to join our efforts.
- *BASeWEB (this paper)*: we hope to trigger interested researchers and practitioners into involvement. We feel, the Semantic Web and the business procedures modeled in many practical applications offer a vast amount of common interests and challenging problems, as well as promising solutions ideas
- *Silicon Valley World Internet Center (ongoing events since November 2001)*: These events were think tank session, symposium, and ongoing regular working group meetings to which SAP contributed information, presentations, with the focus using agent technology and AI for information integration (see also <http://www.worldinternetcenter.com/Publications/proceedings.html>)

3.4 Documentation of the Results

The major results of our efforts will be recorded in the *project report* which is based on the projects and products. Here we will try to answer relevant questions, which we decided upon during several meetings and discussions. We list some of these questions is given here, and as far as we have them, some of the sketchy answers.

Where are agents being used to advantage and related to this, what might be the major uses? We are also interested in the pros and cons of agent-based programming as well as how mature the field is, and which major methods exist for analysis, development, testing and specific languages.

Another important aspects is what are the agent based platforms and what are the major services that they offer. From a practical point of view, we would like to uncover, what it is that makes a piece of software an agent in a practical application or context.

Based on these results, SAP will be looking for interesting cooperation partners or strategic partnerships in this area, to finally enhance products and innovate the market.

4 Information Selection

For each of the categories in the project, we selected representative projects and products. Among the major selection criteria for this were:

- *Novelty*: the approach should not be too old, as we need to collect new information for interested readers; too old in the agent community usually implies, that it should have been published within the last 5-6 years. However, we also found older interesting candidates.
- *Representative*: Some of the projects or products were selected as major representatives, as they illustrate the main challenges or offer highly pragmatic solutions, we found appropriate.
- *Personal Experience*: As we have a vast amount of personal experience and expertise in the field of agents and their applications in prototypes, we recalled on our experiences and selected especially agent building tools and platforms along these lines.
- *Popularity*: Some approaches are just highly popular, therefore, we decided to include them.
- *Availability*: Much of the information in the survey has been gathered from website or published documents.

This is not an exhaustive list of the selection criteria, just, a short list, to illustrate, how our decision making was influenced during the information compilation.

5 Conclusion

In the last 6 months SAP, Cognidata and DFKI have prepared a survey of current products and projects using agent technology. So far, we have collected information about approximately 100 instances. The information is organized in form of templates which have a uniformly defined structure. The templates again are ordered with respect to the business process or application domain of the described approach.

The survey will be published on a public website. The focus of this effort is different from other well-known communities, such as the Knowledge Sharing Effort (Finin et al. 1993; Finin, et al. 1994) or FIPA, in that we look for ongoing, practical activities and how the use of agent and information management is realized within such systems.

As we are still at the beginning, the number of published approaches is rather limited right now. During our research we found so many different aspects worth mentioning that we are still in the process of establishing a first comprehensible picture. The bandwidth is impressive, some examples of agents represent customers and sellers others resource agents and monitoring agents. Agents have been applied in a vast variety of business processes and practical contexts.

We consider this project as the start of an open initiative. It shall help interested people to find research and products concerned with a specific agent-oriented topic. Currently, the mentioned project partners are conducting the project activities and attempt to find the most interesting approaches. As we publish the information as a structured collection on the web, we highly encourage every company or research group to add a description of their work to the website. The acceptance of the community will decide about success or failure of this initiative.

Acknowledgements

We would like to thank our students at the University of Siegen and the Saarland University and the University of Karlsruhe for their support in compiling and researching information about projects. We would also like to thank the many people who took the time to answer questions and review templates.

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