Abstract

Agent-based systems are one of the most important and exciting research areas which have arisen within the Information Technologies in the last decade. However, if competitive advantages for the Spanish industry have to be achieved through increasing the use of agent-based technologies, it will be necessary to invest a great deal of effort in solving some major flaws which currently affect such technologies. In particular, two of the weaknesses of current multi-agent systems platforms are their low performance and their poor scalability, even with a relatively small number of agents and interactions among them. Both problems are related to the software technologies which have traditionally been used for building such platforms. In general, these technologies have favored portability and interoperability aspects rather than efficiency. The main objective of this project is to try to solve both weaknesses. In order to achieve this, we plan to develop an agent platform, conforming to the FIPA standard, integrated in the Linux operating system. The services offered by Linux will be directly used and extended for supporting multi-agent systems technology.

Keywords: Multi-agent systems, multi-agent platforms.

1. Project objectives

This project presents two joint motivations. On the one hand, we intend to help the consolidation of multi-agent systems technology in the industry, by means of solving two of the main weaknesses currently detected in such technology: low performance and poor scalability of multi-agent platforms. On the other hand, having our own open-source, FIPA-compliant multi-agent platform is a key research interest in our research group. The availability of such platform will allow us to develop great-scale agent-based applications, as well as to evaluate the applicability of agent technologies to new realms.

This project has two main goals:

a) The development of a software architecture which can integrate a multi-agent platform with the operating system. We consider that this will imply a major improvement in terms of performance, having that the intermediate layers of software (or middleware) by which the majority of current platforms are implemented could be removed.

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b) Initiate a new research line that may support agent technologies from the operating system level, while also employing the agent technology in the design and implementation of the operating system itself. From this viewpoint, the application of agent technologies to operating systems would benefit their extension to cope with the specialized services that will be required by future applications, as well as improving their flexibility and scalability.

In order to achieve the two main goals explained above, the following particular objectives are proposed:

1. To analyze the run-time behavior of real, and widely used, multi-agent platforms, in such a way that it is possible to identify quantitatively (and objectively) the platform services that produce the greatest degree of overhead to the system (either in processor time or in amount of system resources used), as well as in which conditions (number of running agents, number and type of agent interactions, etc.) such high overhead takes place.
2. To study and design the required resources to support the execution of agents and their life cycle. These resources will need to support the creation, execution, suspension, destruction and naming of agents.
3. To study and design the services of agent discovering and location. These services will allow for the availability of yellow and white pages services according to the FIPA specification.
4. To design the high-level interfaces which are required to support some different communication mechanisms, in such a way that these mechanisms can be transparent to the user and allow the agents to communicate inside the platform, and across platforms.
5. To study possible security mechanisms to be incorporated to the proposal. Such mechanisms can be seen at three different levels: agent level, platform level and access control.
6. To integrate the multi-agent platform in the Linux operating system, by using its services when possible, or by designing new ones.
7. To validate and evaluate the previous objectives by means of developing some applications appropriate for the different aspects of the platform.
8. To study the viability of agent technologies in the design of operating systems, taking into account the state-of-the-art multi-agent systems and operating systems. This objective includes a preliminary, high-level design of an operating system architecture based on agents; the architecture will integrate the services which are required in order to be compatible with other FIPA-compliant platforms.

In the Fig.1, we present the timetable for the different project tasks.

2. Level of achievement

In this section the activities and achievements of the project in their first 18 months are described. The current state of the project development is according to its proposed schedule, with a high degree of satisfaction in the achievements obtained so far. Some of the project tasks are even including some objectives which were not considered initially, as a result of the feedback that we are getting from our participation in other recent projects with different research groups. The following list includes the main achievements of the project so far, as well as the extensions that have been designed in order to cope with the new objectives mentioned above.
T01 Analytical evaluation of existing platforms.

- A tracing infrastructure has been developed. The infrastructure combines different tools available in Linux and Java in order to obtain statistics of the parameters related to the processor, memory and network usage [33, 13].
- A battery of experiments devoted to characterize the performance of the message and directory services of a platform has been developed [11, 29].
- The platforms Spade [10], AgentScape 0.7.5, Madkit 4.0 and Jade 3.3 have been exhaustively analyzed, by means of some experiments over a network of 140 computers connected by Fast Ethernet in the DSIC department laboratories. A report with the results and conclusions of the platform execution with the test cases has been issued [37]. Part of this report has been published in the most prestigious international conference in the field of multi-agent systems, the AAMAS, in its 2006 edition [9].

T02 Design and implementation of the Magentix software architecture

- An agent model has been developed. The model contains the basic components, the behavior model for the task management and the communication model [39]. The platform gives support to this communication model.
- The Magentix platform version 0.2 has been developed, and it is currently stable. This version includes [28]:
  - The agent management service (FIPA's AMS). The service has been distributed among the different hosts in the platform.
  - A yellow pages service (FIPA's Directory Facilitator), with a proprietary interface.
  - A basic intra-platform communication API.
Basic tools to run the platform, add hosts to an existent platform, build agents with the dynamic link library that provides the communication API, and run agents.

- The Magentix version 0.3 is currently under development. In this version, the replication and fault-tolerance mechanisms of the AMS are being improved, new interfaces based on message systems are being introduced, and a more sophisticated API to manage conversations among agents is being incorporated.
- The MIT Kerberos security suite, along with some typical Linux tools, has been used in order to provide authentication, integrity and confidentiality in the communications among agents that run in the Magentix platform.

T03 Evaluation and validation of the Magentix platform

The validation and evaluation of the results obtained so far is being performed by means of different case studies. These case studies have been developed in other platforms, and will be developed in Magentix. As a result, it will be possible to compare different characteristics of the platforms, both qualitatively (the functionality provided) and empirically (in terms of performance). The main results of this validation and evaluation task are the following:

- The real problem initially proposed has been analyzed [7] with the TISSAT company, which is the EPO (Ente Promotor Observador, Supervising Industrial Partner) interested in the project. The first version of the application is available on top of the 0.2 version of the Magentix platform.
- In addition, a framework based on a multi-agent system for classification evaluation [22] has been developed as a new case study.
- Finally, the following multi-agent system have been designed in order to be implemented in the new version of the Magentix platform, in order to evaluate its new functionalities:
  - Design of a multi-agent system for the scheduling of a group of mail robots that operate in an office environment [14, 15].
  - Design and development of a simulation tool for manufacturing systems, based on multi-agent systems [2, 5, 16, 18, 20, 21, 30].
  - Design of a programming tool for flexible and dynamic production, based on multi-agent systems [3, 8, 17].

Realization of new activities not considered in the initial project

- Development of a model for agent organizations:
  - Proposal of a development method based on agent organizations; the method incorporates a new model and taxonomy of agent organizations, which will be incorporated to the Magentix platform [1, 32].
  - The integration of the agent organization concept inside the Magentix platform has been studied; the current communication model is being extended in order to give support to communication acts among agent units.

- Extension of the capabilities of Magentix agents:
  - Some reasoning models that can be incorporated to Magentix agents are being developed. In particular, there is a proposal of a case-based reasoning model that has already been evaluated in the ARTIS agent architecture [6].
  - There are some preliminary results of which requirements have to be satisfied in a case-based argumentation system; we believe that it will be possible to incorporate these results to the argumentation of agents inside the Magentix platform.
• Evaluation of new functionalities of the platform:
  – As a result of collaborations with other research groups, a new abstract architecture for
    open multi-agent systems has been proposed. By means of this architecture, the
    functionalities initially proposed for the Magentix platform can be extended; in particular,
    the functionalities related to the interaction with Web services and to the incorporation of
    agents that offer services and agents with service search and service composition
    capabilities [26].

3. Result indicators

This section summarizes the results obtained in the first 18 months of the project lifetime. The
results of the project are here described in terms of trainees, publications, technology transfer,
collaborations with other research groups, and other dissemination activities.

3.1. Staff in training.

Eight PhD students are involved in the Project, in different stages: 4 of them have already got his
research qualification (DEA) at UPV within the project framework.

• Javier Palanca Cámara has a FPI-MEC grant associated to the project from Sept. 2006.
  (Ref. No. BES-2006-13320). He defended his DEA qualification in Apr. 2007 with the
  work entitled Organizaciones de agentes basadas en Mensajería Instantánea.
• Nancy Ruiz Vega has a CONACYT grant from the Mexican government (Ref. No.
  N178874), and she is working in the project from its beginning. PhD: Herramienta de
  Simulación asistida por Agentes para Sistemas de Fabricación. Expected to be defended in 2008.
• Lluis Mulet Mengual got a FPU-MEC grant AP2005-3731, and he is working in the
  project from its beginning. DEA expected to be defended in Sept. 2007 with the work
  Arquitecturas de Sistemas Multiagente.
• José Miguel Such Aparicio got a FPI grant from the Generalitat Valenciana BFPI06/096,
  and he is working in the project since its beginning. DEA expected to be defended in Sept.
  2007 with the work Interoperabilidad en Sistemas Multiagente.
• Juan M. Alberola Oltra got a grant from the UPV University, and he is working in the
  project since its beginning. DEA expected to be defended in Sept. 2007 with the work
  Entornos de desarrollo de sistemas multiagente.
• Luis Búrdalo Rapa got a grant from the UPV University, and he occasionally worked in
  the project until April 2007.
• Soledad Valero Cubas was hired in Apr. 2006 as the technician position associated with
  the project. She is currently working in her Ph.D., which is related to the project.
• Carlos García Montoro has been recently hired. DEA expected to be defended in Sept.
  2007 with the work Lenguajes de desarrollo de agentes.

Courses

The Ph.D. students mentioned above have enrolled the following National and International
advanced courses on agents:
In relation to the training activities of the research group, some members of the research team are teaching master courses in the RFIA Ph.D. program and the IARFID Master. These doctoral programs have renewed their Quality Mention of ANECA in 2007.

Finally, the course “Sociedades de Agentes” (Agent Societies) has been taught by members of the research team in the Escuela de Primavera de Agentes 2007 mentioned above.

### 3.2. Publications

The following table summarizes the publications related to the project, which are listed in the References section.

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<th>Category</th>
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<td>Others</td>
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<td>[28,29,30,31,32,33] are acceptance pending.</td>
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### 3.3. Technology Transfers

Currently, the research team is collaborating with the TISSAT Company in a technology transfer project entitled Integral management of hotel reservation services. In this project, the GTI-IA research group is providing a technology transfer of its main results in the area of agent and multi-agent systems in order to develop a reservation management system and, in particular, the Magentix platform is being used to implement this application.

In addition, all the software developments related to the project will be made available in the following web page: http://www.dsic.upv.es/users/ia/sma/tools/Magentix/index.html

### 3.4. Other diffusion activities

#### Participation in networks

- Our research group GTI-IA is full member of IEEE FIPA Standards Committee.
- We also regularly participate (as members) in the Spanish Excellence Network of Agents, Agentcities.es. (Ref. No. TIN2005-25869-E of the Spanish Ministry of Education and Science).

#### Organization of international and national events

The research team has organized the following events over the last year:

- 9th European Agent Systems Summer School (EASSS'07), August 27th-31st, 2007, organized by Agentlink.
• 1st International Workshop on New Trends in Real-Time Artificial Intelligence NTeRTAIn 2006. ECAI 2006. Members of the research team were also in the editorial board and program committee members.
• INADIS Workshop (Workshop on Industrial Applications of Distributed Intelligent Systems), Ribeirao Preto, Brasil. 27th October 2006, including the committee chair.
• Spring School of Agents 2007 (Escuela de Primavera de Agentes 2007).

3.5. Relations with national and international teams
We are regularly collaborating with several research groups with common research interests related to the topics of the project. In fact, these collaborations normally imply actual projects and shared publications [4, 26].

Some members of the research team have started their participation, over this last year, in the R&D project funded by the Spanish Ministry of Education and Science called “THOMAS: Métodos, Técnicas y Herramientas para Sistemas Multiagente Abiertos” (THOMAS: Methods, Techniques and Tools for Open Multi-Agent Systems). This is a coordinated project with the Rey Juan Carlos University (Dr. Sascha Ossowski) and the University of Salamanca (Dr. J.M. Corchado). The Magentix platform is intended to be extended with the inclusion of new services as a result of this collaboration.

As another result of our research collaborations, the Spanish Government has recently granted a Consolider–Ingenio 2010 project (Ref. No. CSD2007-00022) called Agreement Technologies, which is led by Dr. Carles Sierra (IIIA-CSIC). This project aims at developing models, frameworks, methods and algorithms for constructing large-scale, open, distributed systems. This project proposes a new paradigm for next generation distributed systems. The new paradigm will be structured around the concept of agreement among computational entities. The project will also build algorithms, software platforms and three demonstrators on electronic procurement, mobile health and water conflict resolution. The tools generated by the project will be enhanced versions of some existing tools developed by the three participant research groups (IIIA-CSIC, GTI-UPV and URJC). One of these tools is the Magentix platform.

Finally, Professor Patrick Doherty from the Department of Computer and Information Science at the Linköping University is going to make a research stay at UPV on Sept. 2007.

4. References


