Joan Cabestany
Ignacio Rojas
Gonzalo Joya (Eds.)

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Advances in Computational Intelligence

11th International Work-Conference
on Artificial Neural Networks, IWANN 2011
Torremolinos-Málaga, Spain, June 2011, Proceedings, Part II

2 Part II

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Advances in Computational Intelligence

11th International Work-Conference
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Proceedings, Part II

Springer

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Preface

We are proud to present the set of final accepted papers for the eleventh edition of the IWANN conference "International Work-Conference on Artificial Neural Networks" held in Torremolinos (Spain) during June 8–10, 2011.

IWANN is a biennial conference that seeks to provide a discussion forum for scientists, engineers, educators and students about the latest ideas and realizations in the foundations, theory, models and applications of hybrid systems inspired by nature (neural networks, fuzzy logic and evolutionary systems) as well as in emerging areas related to the above items. As in previous editions of IWANN, this year's event also aimed to create a friendly environment that could lead to the establishment of scientific collaborations and exchanges among attendees. Since the first edition in Granada (LNCS 540, 1991), the conference has evolved and matured. The list of topics in the successive Call for Papers has also evolved, resulting in the following list for the present edition:

1. **Mathematical and theoretical methods in computational intelligence**: Mathematics for neural networks; RBF structures; Self-organizing networks and methods; Support vector machines and kernel methods; Fuzzy logic; Evolutionary and genetic algorithms
2. **Neurocomputational formulations**: Single-neuron modelling; Perceptual modelling; System-level neural modelling; Spiking neurons; Models of biological learning
3. **Learning and adaptation**: Adaptive systems; Imitation learning; Reconfigurable systems; Supervised, non-supervised, reinforcement and statistical algorithms
4. **Emulation of cognitive functions**: Decision making; Multi-agent systems; Sensor mesh; Natural language; Pattern recognition; Perceptual and motor functions (visual, auditory, tactile, virtual reality, etc.); Robotics; Planning motor control
5. **Bio-inspired systems and neuro-engineering**: Embedded intelligent systems; Evolvable computing; Evolving hardware; Microelectronics for neural, fuzzy and bioinspired systems; Neural prostheses; Retinomorphic systems; Brain–computer interfaces (BCI) nanosystems; Nanocognitive systems
6. **Hybrid intelligent systems**: Soft computing; Neuro-fuzzy systems; Neuro-evolutionary systems; Neuro-swarm; Hybridization with novel computing paradigms: Qantum computing, DNA computing, membrane computing; Neural dynamic logic and other methods; etc.
7. **Applications**: Image and signal processing; Ambient intelligence; Biomimetic applications; System identification, process control, and manufacturing; Computational biology and bioinformatics; Internet modeling, communication and networking; Intelligent systems in education; Human–robot interaction. Multi-agent systems; Time series analysis and prediction; Data mining and knowledge discovery

At the end of the submission process, we had 202 papers on the above topics. After a careful peer-review and evaluation process (each submission was reviewed by at least 2, and on average 2.4, Program Committee members or additional reviewer), 154 papers were accepted for oral or poster presentation, according to the recommendations of reviewers and the authors' preferences.

It is important to note that for the sake of consistency and readability of the book, the presented papers are not organized as they were presented in the IWANN 2011 sessions, but classified under 21 chapters and with one chapter on the associated satellite workshop. The organization of the papers is in two volumes and arranged following the topics list included in the call for papers. The first volume (LNCS 6691), entitled *Advances in Computational Intelligence. Part I* is divided into ten main parts and includes the contributions on:

1. Mathematical and theoretical methods in computational intelligence
2. Learning and adaptation
3. Bio-inspired systems and neuro-engineering
4. Hybrid intelligent systems
5. Applications of computational intelligence
6. New applications of brain–computer interfaces
7. Optimization algorithms in graphic processing units
8. Computing languages with bio-inspired devices and multi-agent systems
9. Computational intelligence in multimedia processing
10. Biologically plausible spiking neural processing

In the second volume (LNCS 6692), with the same title as the previous volume, we have included the contributions dealing with topics of IWANN and also the contributions to the associated satellite workshop (ISCIF 2011). These contributions are grouped into 11 chapters with one chapter on the satellite workshop:

1. Video and image processing
2. Hybrid artificial neural networks: models, algorithms and data
3. Advances in machine learning for bioinformatics and computational biomedicine
4. Biometric systems for human–machine interaction
5. Data mining in biomedicine
6. Bio-inspired combinatorial optimization
7. Applying evolutionary computation and nature-inspired algorithms to formal methods
8. Recent advances on fuzzy logic and soft computing applications
9. New advances in theory and applications of ICA-based algorithms
10. Biological and bio-inspired dynamical systems
11. Interactive and cognitive environments
12. International Workshop of Intelligent Systems for Context-Based Information Fusion (ISCIF 2011)

During the present edition, the following associated satellite workshops were organized:

1. **4th International Conference on Computational Intelligence in Security for Information Systems (CISIS 2011)**. CISIS aims to offer a meeting opportunity for academic and industry-related researchers belonging to the various vast communities of computational intelligence, information security, and data mining. The corresponding selected papers are published in an independent volume (LNCS 6694).
2. **International Workshop of Intelligent Systems for Context-Based Information Fusion (ISCIF 2011)**. This workshop provides an international forum to present and discuss the latest scientific developments and their effective applications, to assess the impact of the approach, and to facilitate technology transfer. The selected papers are published as a separate chapter in the second volume (LNCS 6692).
3. **Third International Workshop on Ambient-Assisted Living (IWAAL)**. IWAAL promotes the collaboration among researchers in this area, concentrating efforts on the quality of life, safety and health problems of elderly people at home. IWAAL papers are published in LNCS volume 6693.

The 11th edition of IWANN was organized by the Universidad de Malaga, Universidad de Granada and Universitat Politecnica de Catalunya, together with the Spanish Chapter of the IEEE Computational Intelligence Society. We wish to thank to the Spanish Ministerio de Ciencia e Innovacion and the University of Malaga for their support and grants.

We would also like to express our gratitude to the members of the different committees for their support, collaboration and good work. We specially thank the organizers of the associated satellite workshops and special session organizers. Finally, we want to thank Springer, and especially Alfred Hofmann, Anna Kramer and Erika Siebert-Cole, for their continuous support and cooperation.

June 2011

Joan Cabestany
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Francisco Herrera	Head of Research Group SCI2S (Soft Computing and Intelligent Information Systems), Department of Computer Science and Artificial Intelligence, University of Granada, Spain
Tom Heskes	Head of Machine Learning Group, Intelligent Systems Institute for Computing and Information Sciences (iCIS) Faculty of Science Radboud University Nijmegen, The Netherlands

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New Applications of Brain–Computer Interfaces

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Ricardo Ron	University of Malaga

Optimization Algorithms in Graphic Processing Units

Antonio Mora	University of Granada
Maribel García-Arenas	University of Granada
Pedro Castillo	University of Granada

Computing Languages with Bio-inspired Devices

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A. Ortega De La Puente	Autonomous University of Madrid

Computational Intelligence in Multimedia

Adriana Dapena	University of A Coruña
Julio Bregáins	University of A Coruña
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Biologically Plausible Spiking Neural Processing

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Richard R. Carrillo	University of Almeria

Video and Image Processing

Enrique Domínguez	University of Malaga
José García	University of Alicante

Hybrid Artificial Neural Networks: Models, Algorithms and Data

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Advances in Machine Learning for Bioinformatics and Computational Biomedicine

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Biometric Systems for Human–Machine Interaction

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Data Mining in Biomedicine

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Multiagent-Based Middleware for the Agents' Behavior Simulation

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Abstract. Nowadays, simulation is used for several purposes ranging from work flow to system's procedures representation. The main goal of this work is the design and development of a middleware to communicate the current technology in charge of the development of the multiagent systems (MAS) and the technology in charge of the simulation, visualization and analysis of the behavior of the agents. It is a key element when considering that MAS are autonomous, adaptive and complex systems and provides advances abilities for visualization. The adaptation of technology in charge of the development of MAS to support the notion of time is the most important and complex feature of our proposal The proposed middleware infrastructure makes it possible to visualize the emergent agent behaviour and the entity agent.

Keywords: Multiagent systems, Simulation, JADE, Repast.

1 Introduction

Agents and multiagent systems (MAS) are adequate for developing applications in dynamic and flexible environments. Autonomy, learning and reasoning are especially important aspects for an agent. These capabilities can be modelled in different ways and with different tools [11]. The contribution from agent based computing to the field of computer simulation mediated by ABS (Agent Based Simulation) is a new paradigm for the simulation of complex systems that require a high level of interaction between the entities of the system. Possible benefits of agent based computing for computer simulation include methods for evaluation of multi agent systems or for training future users of the system [3]. The properties of ABS makes it especially suitable for simulating this kind of systems. The idea is to model the behaviour of the human users in terms of software agents.

Mainly there are two ways for visualizing multiagent systems simulation: the agents interaction protocol and the agent entity. In the former, it is visualized a sequence of messages between agents and the constraints on the content of those messages. On the other hand, the latter method visualizes the entity agent and its iteration with the environment. Most software programs, such as JADE platform [1][8] or Zeus toolkit [2], provide graphical tools that allow the visualization of the messages exchanged between agents. The toolkits MASON [5], Repast (Recursive Porous Agent Simulation Toolkit) [6][9] and Swarm [10] provide the visualization of the entity agent and its interaction with the environment. Repast seeks to support the development of

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extremely flexible models of living social agents, but is not limited to modelling living social entities alone. Repast is differentiated from other systems since it has multiple pure implementations in several languages and built-in adaptive features such as genetic algorithms and regression [7].

The most well-known agent platforms (like JADE [8]) offer basic functionalities for the agents, such as AMS (Agent Management System) and DF (Directory. Facilitator) services; but designers must implement nearly all organizational features by themselves, like simulation constraints imposed by the MAS topology. In order to model open and adaptive simulated systems, it becomes necessary to have an infrastructure than can use agent technology in the development of simulation environments. The presented middleware makes use of JADE [8] and Repast [9], and combines them so that it is possible to use their capabilities to build highly complex and dynamic systems.

The main contribution of this paper is the reformulation of the FIPA protocol used in JADE [8], the most widely used platform for based software agents middleware, achieving several advantages: (i) development of a new middleware that provides independence between the model and visualization components; (ii) improvement on the visualization component that makes it possible to use the concept of "time", essential for simulation and analysis of the behavior of agents; (iii) improvements to the user capabilities to which several tools were added, such as message visualization, analysis behavioral, statistics, etc.

The article is structured as follows: Section 1 makes a review of agent-modeling toolkits and presents the challenges for simulated multiagent systems. Sections 2 introduces a description of the middleware specifically adapted to the simulation of multiagent systems within dynamic environments. Finally, some results and conclusions are given in Sections 3.

2 Middleware for Behavior Simulation

MISIA (*Middleware Infrastructure to Simulate Intelligent Agents)* is a middleware infrastructure that allows to model JADE multiagent systems with the possibility of being represented in Repast. The main concept introduced in this environment is the notion of time in JADE, which means it is possible to render in real time the events into Repast. One of the main differences between JADE and Repast is that in JADE, there not exists the concept of time as such, and the agents interact each other based on changes or events that occur in the execution environment. However, Repast has a time unit: the tick, which is what sets the pace and allows simulations. Agents in the JADE context are implemented based on FIPA standards. This allows to create multi-agent systems in open environments, which is not possible within Repast. These differences are what MISIA solved, integrating these two environments and achieving a working environment for creation and simulation of multiagent systems more powerful and versatile.

It is necessary to synchronize JADE to work simultaneously to Repast. This is achieved by keeping the JADE agents informed about the tick of the simulation they are involved. Moreover, agents are informed when a tick is elapsed. To obtain versatile simulations, it is necessary that all events occurring in JADE are rendered

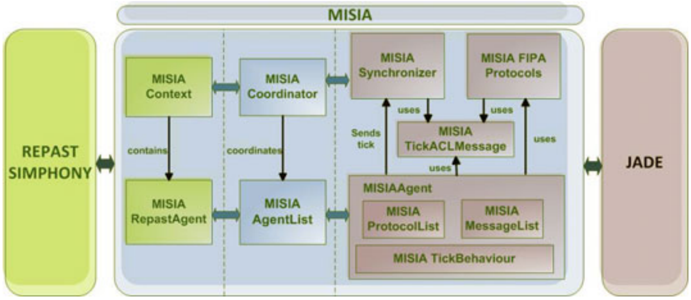

Fig. 1. Functional structure of MISIA

instantly on Repast. The minimum unit of time is the tick, thus, the idea is that every JADE agent can perform functions in a tick (must be simple actions, such as sending a message, receiving or re-establishment of their state) and once finished, they can be updated in Repast. This must occur during the course of all ticks, which are getting updated in real time all events.

The bottom layer of the framework is which connects JADE, and is divided into four functional blocks: (i) *MISIAAgent***,** is the extension of JADE agent. Performs the same functions, but adapting them to the presence of ticks. It consists of a number of features to manage the time in JADE. (ii) *MISIATickACLMessage***.** JADE messages are used for communication between agents. MISIAAgent agents communicate between them with MISIATickACLMessage messages. MISIATickACLMessage is the extension of JADE ACL message that incorporates the concept of time. It includes aspects such as the tick where to send the message, and the delay that the message has when achieves its destination. In JADE, the messages exchanged between agents are sent and arrive instantly, but in real life, that is not the case. It aims to simulate and view the evaluation of the system as time passes, and to achieve this, it is necessary that messages are not instant, but must have a shipping time and a different reception time. (iii) *MISIAFIPAProtocols***.** JADE implements FIPA standards, which, among other things, specify multiple communication protocols. These define a series of patterns that respond to different types of communication that two or more agents can perform. The objective is to adapt FIPA protocols defined in JADE with Repast ticks. (iv) *MISIASynchronizer* is a JADE agent that acts of notificator. It is responsible for notifying the MISIAAgent when a tick goes by. Is the system clock synchronization. When a tick goes by, MISIASynchronizer is notified in order to notify MISIAAgents. It is made through MISIATickACLMessage messages with a special performative.

The top layer is the contact with Repast. Contains two functional blocks, which are: (i) *MISIARepastAgent*. Each MISIAAgent existing in the system will be represented by a MISIARepastAgent in the context of Repast. This means that for every agent that we want to have on the system actually have to create two: a MISIAAgent agent running on JADE, and its respective MISIARepastAgent released on Repast. It can be seen as follows: a logical agent, and two physical agents. MISIARepastAgents have an important role: they cannot updated their status until their respective MISIAAgents does not end with all the work they need to perform during that tick. This is a very important aspect, since it is the characteristic of the framework as a system in real time. (ii) *MISIAContext* has two important goals. One is to establish the synchronism in the execution. When a tick goes by, lets know MISIASynchronizer agent that it is necessary to notify MISIAAgent agents that following tick happened. The other goal is to incorporate new agents MISIARepastAgent that entry in the context of the Repast simulation. For each new MISIAAgent that appears in the system, MISIAContext will create their respective MISIARepastAgent and will added it to the simulation environment.

Finally, the intermediate layer is divided into two functional blocks, and its goal is to join adjacent layers. These modules are: (i) *MISIAAgentList*, as its name implies, stores all agents in the system at a given time. It plays an important role because it enables communication between a MISIAAgent and their respective MISIARepast-Agent, and vice versa. The diagram shows two-way information flows ranging from MISIARepastAgent to MISIAAgentList and MISIAAgentList to MISIAAgent. These flows are representing that communication, that union between the two physical agents, to confine a logical agent. (ii) *MISIACoordinator* coordinates communication between the two adjacent layers. It is necessary the presence of a coordinator to maintain synchronism between both layers. Thanks to MISIACoordinator, MISIAContext can notify the occurrence of a tick to MISIASynchronizer, and MISIASynchronizer can assure that its purpose is served to MISIAContext, reporting that all MISIAAgent received tick. This kind of communication is necessary to maintain full synchronization between the two platforms.

2.1 Redefinition of FIPA Protocols

JADE has a number of implemented FIPA protocols, which help the programmer. With these protocols, it abstracts the developer from having to prepare messages to be sent, sending, or to of manage the reception them, among other things. In this framework has been re-implemented FIPA protocols defined in JADE to support the notion of time.

In the FIPA protocols implemented in Jade [4], it is possible to observe the presence of two roles: *Initiator* and *Responder* o *Participant.* Jade provides a predefined class for each role and each type of FIPA interaction protocol, or rather, for a certain group of FIPA protocols. In the *jade.proto* package are all the classes that, in the form of behaviors , facilitate the implementation of the FIPA communication protocols. Each pair of classes is indicated to implement a series of protocols. MISIA aims to adapt all these classes to their environment, so that an end user can use them as in Jade, without worrying about the presence of time. For example, with the first pair adapted (*AchieveRE-Initiator* and *AchieveREResponder*), it is possible to implement *FIPA-Request, FIPA-Query, FIPA-Recruiting, FIPA-Request-When* y *FIPA-Brokering* protocols.

To implement any of these protocols in MISIA, it is necessary to use *AchieveRE-Initiator* (Jade class) and *MisiaAchieveREResponder*, the adapted class of the *Responder* role. *MisiaAchieveREResponder* intends to replace *AchieveREResponder* (Jade class). It's provides two handling methods, such as Jade: *manejarPeticionRequest,* to send the first message in response, and *manejarResultadoPeticionRequest,* to send a second message to the agent with the Initiator role. In addition, it implements the exceptions, to try to provide the same Jade interface (*MisiaNotUnderstoodException, MisiaRefuseException* y *MisiaFailureException).* The exceptions are important because Jade uses them to send messages of rejection or no understanding of a task (i.e. if *Responder* role sends a message of acceptation for a task, the execution flow does not diverge in exception).

Table 1. *jade.proto* package

Behaviors	**FIPA protocols**
AchieveREInitiator **AchieveREResponder** **SimpleAchieveREInitiator** **SimpleAchieveREResponder** **IteratedAchieveREInitiator** **SSIteratedAchieveREResponder**	FIPA-Request FIPA-Query FIPA-Recruiting FIPA-Request-When FIPA-Brokering
ContractNetInitiator **ContractNetResponder** **SSContractNetResponder**	FIPA-Contract-Net
SubscriptionInitiator **SubscriptionResponder**	FIPA-Subscribe FIPA-Request-Whenever
ProposeInitiator **ProposeResponder**	FIPA-Propose

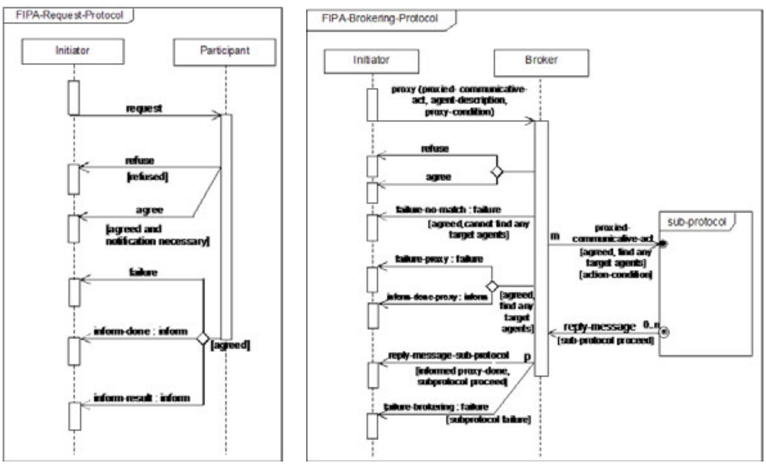

Fig. 2. FIPA-Request Protocol, FIPA-Brokering Interaction Protocol

The messages of *refuse, failure* and *notUnderstood* (Fig. 2) will diverge in exceptions, that also be adapted to the notion of time to send these messages in the desired tick. Thus, the equivalence between Jade classes (and methods) and MISIA is as shown in the table below.

Table 2. Relation AchieveREResponder (Jade) - MisiaAchieveREResponder (MISIA)

Jade	**MISIA**
`AchieveREResponder` **(class)**	`MisiaAchieveREResponder` (class)
`protected ACLMessage handleRequest(ACLMessage request)` **(AchieveREResponder method)**	`protected MisiaTickACLMessage manejarPeticionRequest (ACLMessage requestMessage)` (MisiaAchieveREResponder method)
`protected ACLMessage prepareResultNotification(ACLMessage request, ACLMessage response)` **(AchieveREResponder method)**	`protected MisiaTickACLMessage manejarResultadoPeticionRequest (ACLMessage requestMessage, ACLMessage responseMessage)` (MisiaAchieveREResponder method)
`NotUnderstoodException` **(class)**	`MisiaNotUnderstoodException` (class)
`RefuseException` **(class)**	`MisiaRefuseException` (class)
`FailureException` **(class)**	`MisiaFailureException` (class)

The communication protocols JADE defines two roles, which starts the conversation (Initiator role) and which is evolved in the conversation (Responder role). The Initiator agent role will begin by the conversation by sending a message to the recipient. Therefore, it follows the logic developed with the message queue. When a MISIAAgent agent wishes to follow a communication protocol in a given tick, just add the protocol of communication to the agent in the tick established. Therefore, one of the functions of MISIAAgent agent after receiving a tick is to add communication protocols. The rest of communication for sending and receiving messages is re-implementing, recording different behaviors that make the different functions of the protocols. The novelty is that these new behaviors support MISIA modules redefined for JADE, such as support MISIA-TickACLMessage messages or the ability to respond to a message in a certain tick, without being immediately.

An example reimplemented is the FIPA-Request protocol, which is like follows: the agent with Initiator role sends a request to agent with Responder role. Responder replies, accepting or rejecting the request, and immediately returns to answer the agent with Initiator role informing the result (if the request was made correctly, or there was a problem). With the new definition by MISIA of this protocol, it is possible to send messages during the tick chosen. In this case, MISIA only redefines the role Responder. The Initiator is not necessary because it only sends a message to the beginning.

In the case of the Responder role, must send two messages, as discussed above. So, MISIA provides to programmers two handles, like JADE; one to send the first message, and another to send the second one, abstracting from all the system logic that is to managing ticks.

Below is a fragment of code in Java where it shown how a behavior is reimplemented to manage the arrival of the request by the agent with Initiator role. In this example, *handleMISIARequest* is the procedure that the final developer overwrites to provide the message he want to send in response.

```
registerPrepareResponse(new OneShotBehaviour(){
   public void action() {
          //Get DataStore to obtain the request message
      DataStore ds = getDataStore();
      ACLMessage requestMessage = (ACLMessage) ds.get(REQUEST_KEY);
      TickACLMessage agreeMessage = null;
      try {   agreeMessage = handleMISIARequest(requestMessage);
       } catch (Exception e) {}
    //If the message isn't null, send
    if (agreeMessage != null)     jadeAgent.MISIASend(agreeMessage);    }
```

3 Experimental Results and Conclusions

It has been developed a case study using this middleware to create a multiagent system aimed at facilitating the employment of people with disabilities, so it is possible to simulate the behavior of the agents in the work environment and observe the agents actions graphically in Repast. This is a simple example that defines four jobs, which are occupied by four people with certain disabilities. Every job is composed of a series of tasks. Agents representing the workers have to do them, and according to their capabilities, carry out the assignment with varying degrees of success. Performing various simulations, and seeing the evolution in time, the results can be assessed to

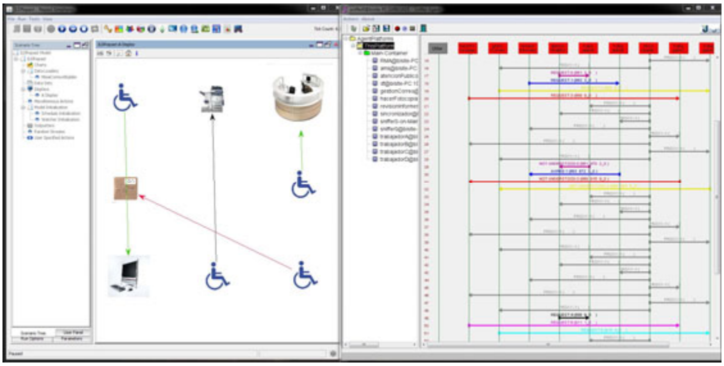

Fig. 3. Case Study MISIA

determine what would be the most suitable job for each employee. Below is an example of the execution of this case study. There are two ways for visualizing multiagent systems simulation: the agents interaction protocol and the agent entity.

MISIA provides the capabilities visualize the sequence of messages between agents and the entity agent and its iteration with the environment. The union of these two platforms involves having a highly efficient environment for the creation of multiagent systems, getting the benefits of JADE to create the systems, as is the use of FIPA standards; and also the visual representation and extraction of simulation data to different applications provided by Repast.

Simulation is a helpful tool for understanding complex problems. Therefore, the simulation of multiagent systems in several levels of details and the emergent behavior s fundamental for analyzing the systems processes. In this study, a list of basic concepts and advances is presented for the development of simulated multiagent systems. MISIA allows simulation, visualization and analysis of the behavior of agents. With the MAS behavior simulator it is possible to visualize the emergent phenomenon that arises from the agents' interactions.

The proposed visualization system also suggests further developments. One of them is make the agent representation more realistic. A 3D agent visualization in more levels of details showing the interaction them would make the system complete and realistic. Another future work is to improve interactivity with the user. The goal is to improve the interactivity by means of allowing the interaction of the specialists with the live execution besides the basic functionalities such as play, pause, stop and increase/decrease the speed, by means of putting some substances in the position and observing the emergent behavior. It would allow the self-organization optimization and the proposal of new hypotheses. Even more: generation of reports about the information visualized during the simulation process in several levels of detail, which could increase the comprehension about the process. MISIA is the ideal framework for this purpose.

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References

[1] Bellifemine, F., Caire, G., Poggi, A., Rimassa, G.: Jade a white paper. EXP in search of innovation 3(3), 6–19 (2003)
[2] Collis, J.C., Ndumu, D.T., Nwana, H.S., Lee, L.C.: The zeus agent building tool-kit. BT Technol. Journal 16(3) (1998)
[3] Davidsson, P.: Multi Agent Based Simulation: Beyond social simulation. In: Moss, S., Davidsson, P. (eds.) MABS 2000. LNCS (LNAI), vol. 1979, Springer, Heidelberg (2001)
[4] Foundation for Inteligent Physical Agents."FIPA Agent Management Specification". Disponible en, http://www.fipa.org/specs/fipa00001/SC00001L.html
[5] Luke, S., Cioffi-Revilla, C., Panait, L., Mason, S.K.: A new multiagent simulation toolkit. In: Proceedings of the 2004 SwarmFest Workshop (2004)
[6] North, M.J., Howe, T.R., Collier, N.T., Vos, J.R.: The repast symphony runtime system. In: Proceedings of the Agent Conference on Generative Social Processes, Models, and Mechanisms (2005)
[7] North, M.J., Collier Nicholson, T., Vos Jerry, R.: Experiences Creating Three Implementations of the Repast Agent Modeling Toolkit. ACM Transactions on Modeling and Computer Simulation 16(1), 1–25 (2006)
[8] JADE, Java Agent Development Platform, http://JADE.tilab.com
[9] Repast, http://repast.sourceforge.net/repast_3/index.html
[10] Swarm, http://www.swarm.org
[11] Wooldridge, M., Jennings, N.R.: Agent Theories, Architectures, and Languages: a Survey. In: Wooldridge, M., Jennings, N.R. (eds.) Intelligent Agents, pp. 1–22. Springer, Heidelberg (1995)