ISBN 972886210-5

Marc Esteva / Adriana Giret / Alberto Fernández / Vicente Julian

IBERAMIA 2008 Workshop on Agreement Technologies

IBERAMIA'08

IBERAMIA 2008 Workshop on Agreement Technologies

Marc Esteva / Adriana Giret / Alberto Fernández / Vicente Julian

LISBOA /// October 14-17, 2008

WAT 2008

PROCEEDINGS

of

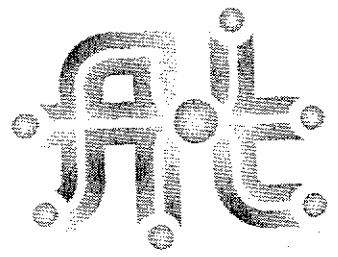
IBERAMIA 2008 Workshop on Agreement Technologies

(WAT 2008)

October 14th, 2008

Lisbon University Institute - ISCTE, Lisbon, Portugal

Marc Esteva, Adriana Giret, Alberto Fernández and Vicente Julian
(Eds.)



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Preface

Agreement is one of the crucial social concepts that helps human agents to cope with their social environment and is present in all human interactions. In fact, without agreement there is no cooperation and ultimately social systems cannot emerge. Agreement is necessary in our everyday life.

Until recently, the concept of agreement was a domain of study mainly for philosophers, sociologists and was only applicable to human societies. However, this situation has changed in the recent years, specially with the spectacular emergence of information society technologies. Computer science has moved from the paradigm of an isolated machine to the paradigm of a network of systems and of distributed computing. Likewise, artificial intelligence is quickly moving from the paradigm of an isolated and non-situated intelligence to the paradigm of situated, social and collective intelligence. Hence, the concept of agreement has become key for a robust understanding and an efficient implementation of artificial social systems.

In this context, Agreement Technologies is a new approach of Distributed Artificial Intelligence for constructing large-scale open distributed computer systems. This workshop on Agreement Technologies is specifically addressed for any work that aims at developing models, frameworks, methods and algorithms for constructing such systems. In other words, this workshop focuses on approaches and solutions for the needs of next generation computing systems where autonomy, interaction and mobility will be the key issues. Most importantly, it concentrates on techniques that enable software components to reach agreements on the mutual performance of services.

Agreement Technologies integrates many research efforts from different fields of Artificial Intelligence. Hence, this workshop is specifically tailored to research works related to this new approach. As Iberamia represents one of the leading Artificial Intelligence conferences for Ibero-american researchers in the field, it is a good forum to celebrate this workshop. Finally, the editors would like to thank all the people that bring about WAT and IBERAMIA 2008. First of all, thanks to the authors for ensuring the richness of the workshop and the members of the program committee for their professionalism and dedication. Furthermore, we owe particular gratitude to the IBERAMIA organizing committee.

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A Trust Model to Recommend Knowledge Objects in CoPs

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Abstract. In this article we study the various trust and reputation models found in literature and we present our own trust model which is used to facilitate knowledge exchange in organizations whose employees are organized into communities. In order to test the architecture a recommendation tool based on software agents, with which to recommend documents in Communities of Practice, is also described.

Keywords: Trust, Communities of Practice, Recommender tool.

1 Introduction

Communities of Practice (CoPs) have being defined as: "groups of people who share a concern, a set of problems, or a passion about a topic, and whose knowledge depend on their interacting on an ongoing basis" [1, 2]. These groups aim to develop knowledge practices and domains with a unique perspective, in which each community member has a distinctive identity and finds a unique place in the group [1]. According to [3], CoPs specify a knowledge domain of interest, in which ongoing processes of sense-making, knowledge sharing and discovery take place among interested and interconnected participants. Moreover, CoPs are an important centre of knowledge exchange in which feelings such as membership or trust play a significant role since both are the basis for a suitable sharing of knowledge. However, current CoPs are often "virtual" as their members may be geographically distributed. This implies a lack of face-to-face communication which affects certain aspects of interpersonal relationships. For instance, if people never experience face-to-face communication and only use groupware tools to communicate, then trust often decreases [4]. This lack of trust makes it more difficult for CoP members to decide which of their fellow-members are more trustworthy. This presents a problem, as in CoPs the main knowledge sources are the members themselves. We consider that it is highly important to be able to discover how trustworthy a knowledge source (i.e. another member) is. This knowledge will help members to decide whether or not a

knowledge object is valuable depending on the knowledge source from which it originates. In addition, the information provided by the community members is stored in repositories and no previous quality control is take into account. Moreover, the information is frequently not updated or is not useful for the community. As a result of this, these repositories often do not contain valuable information or on other occasions the knowledge sources do not provide the necessary confidence for employees to reuse that information. In order to support the task of the CoP members, this work presents a trust model designed solely for CoPs in which various psychological aspects that a person uses, either consciously or unconsciously, to value whether another community member is trustworthy have been considered. A prototype has also been developed in which software agents attempt to assist individuals to share information and which helps CoPs work effectively together through a trustworthy network. We have chosen the agent paradigm because it constitutes a natural metaphor for systems with purposeful interacting agents, and this abstraction is close to the human way of thinking about their own activities [5]. This foundation has led to an increasing interest in social aspects such as motivation, leadership, culture or trust [6]. In addition, intelligent agents' specific characteristics turn them into promising candidates in the provision of a KMS solution [7]. Moreover, software agent technology can monitor and coordinate events, meetings and disseminate information [8], automate of complex processes [9], or build and maintain organizational memories [10].

This article proceeds as follows: in Section 2 we describe the related works focused on the concepts of trust and reputation. Next, in Section 3, we present the trust model proposed to be used in CoPs. In Section 4 we describe a prototype to test our model. Finally, Section 5 concludes the paper and gives directions for future work.

2 Related work

Trust and reputation mechanisms have been proposed for use in different domains such as e-commerce, peer-to-peer computing [11], recommender systems [12], etc. However, there is no universal agreement on the definition of trust and reputation. Since the main goal of our work is to rate the credibility of information sources and of knowledge in CoPs, it is first necessary to define these two important concepts.

Trust is a complex notion whose study is usually of a narrow scope. This has given rise to an evident lack of coherence among researchers in the definition of trust. For instance in [11], Wang and Vassileva define trust as a peer's belief in another peer's capabilities, honesty and reliability based on his/her own direct experiences.

Social scientists have collectively identified three types of trust, which are:

- *Interpersonal trust* which is the trust one agent directly has in another agent [13].
- *System trust* or *impersonal trust* refers to trust that is not based on any property or state of trustee but rather on the perceived properties or reliance on the system or institution within which that trust exists. For instance, inherited experiences of an organization.
- *Dispositional trust*, or *Basic trust*, describes the general trusting attitude of the truster. This is "a sense of basic trust, which is a pervasive attitude toward oneself and the world" [13].

Another important concept related to trust is reputation. Several definitions of reputation can be found in literature, such as that of Barber and Kim who define this concept as the amount of trust that an agent has in an information source, created through interactions with information sources [14], and Wang and Vassileva's work which defines reputation as a peer's belief in another peer's capabilities, honesty and reliability based on recommendations received from other peers.

In our work we intend to follow the definition given by Wang and Vassileva which considers that the difference between both concepts depends on who has previous experience, so if a person has direct experiences of, for instance, a knowledge source we can say that this person has a trust value in this knowledge.

This research can additionally be compared with other trust models. In models such as eBay [15] and Amazon [16], which were proposed to resolve specific situations in online commerce, the ratings are stored centrally and the reputation value is computed as the sum of those ratings over six months. Thus, reputation in these models is a global single value. However, these models are too simple (in terms of their trust values and the way in which they are aggregated) to be applied in open multi-agent systems. For instance, in [17] the authors present the Sporas model, a reputation mechanism for loosely connected online communities where, among other features, new users start with a minimum reputation value, the reputation value of a user never falls below the reputation of a new user and users with very high reputation values experience much smaller rating changes after each update. The problem in this approach is that when somebody has a high reputation value it is difficult to change this reputation or the system needs a high amount of interactions. A further approach of the Sporas authors is Histos which is a more personalized system than Sporas and is oriented towards highly connected online communities. In [18] the authors present another reputation model called REGRET in which the reputation values depend on time: the most recent rates are more important than previous rates. In [19] the authors present the AFRAS model, which is based on Sporas but uses fuzzy logic. The authors describe a complex computing reputation mechanism that handles reputation as a fuzzy set while decision making is inspired in a cognitive human-like manner. In [20] the authors propose a model which allows agents to decide which agents' opinions they trust more and to propose a protocol based on recommendations. The main problem with this approach is that every agent must keep rather complex data structures which represent a kind of global knowledge about the whole network. In [21] the authors present the TRSIM model which considers trust and reputation as emergent properties of direct interactions between agents, based on multiple interactions between two parties. In this model, trust is a belief an agent has with regard to the performance of other parties in order to solve a given task, according to its own knowledge.

Barber and Kim present a multi-agent belief revision algorithm based on belief networks [14]. In their model the agent is able to evaluate incoming information, to generate a consistent knowledge base, and to avoid fraudulent information from unreliable or deceptive information sources or agents. This work has a similar goal to ours. However, the means of attaining it are different. In Barber and Kim's case they

define reputation as a probability measure, since the information source is assigned a reputation value of between 0 and 1. Moreover, every time a source sends knowledge, that source should indicate the certainty factor that the source has of that knowledge. In our case, the focus is very different since it is the receiver who evaluates the relevance of a knowledge object rather than the provider as in Barber and Kim's proposal. Some of these trust and reputation models are summarized in the appendix of this work. Table 1 synthesizes the principal characteristics of the trust and reputation models previously described.

Table 1. Summary of the trust and reputation models

Model	Application domain	Centralized	Metric	Features
eBay	e-commerce	Yes	discrete, infinite	Simple values obtained through interactions
Amazon	e-commerce	Yes	[1,5]	Reputation is assigned to books and to reviewers
Sporas & Histos	e-commerce and online applications	Yes	[0,3000]	Reduces changes when reputation is very high. Most recent reputation values are the most important
Barber & Kim model	Social networks	No	[0,1]	Reputation is a probability measure. Try to avoid fraudulent information from unreliable or deceptive information sources
AFRAS	e-commerce	No	Fuzzy values	Based on BDI agents based on Sporas model but using fuzzy logic. Compares and combines fuzzy sets
FIRE	generic	No	[-1, 1]	Four main components: interaction trust, role-based trust, witness reputation, and certified reputation
Abdul-Rahman & Hailes	virtual communities	No	4 values	Use linguistic labels to represent an evaluation.
Wang & Vassileva model	P2P	No	0 & 1	Use Bayesian networks to present differentiated trust and combine different aspects of trust.
TRSIM	P2P	No	[0,1]	This model associates trust and reputation to the specification of the task that agents need to delegate by contracting
Regret	e-commerce	No	[-1, 1]	Divides reputation into three dimensions: Individual, Social and Ontological

3 Trust model

Our aim is to provide a trust model based on real world social properties of trust in CoPs. An interesting fact to bear in mind is that members of a community are frequently more likely to use knowledge built by their community team members than those created by members outside their group [22]. This occurs because people have a greater amount of trust in the information offered by a member of their community than in that supplied by a person who does not belong to that community. Of course, the fact of belonging to the same CoP already implies that these people have similar interests and perhaps the same level of knowledge about a topic. Consequently, the level of trust within a community is often higher than that which exists outside the community. As a result of this, as is claimed in [22], knowledge reuse tends to be restricted within groups. Therefore, people, in real life in general and in companies in particular, prefer to exchange knowledge with "trustworthy people" by which we mean people they trust. The aforementioned reasons have prompted us to consider that the implementation of a mechanism in charge of measuring and controlling the confidence level in a community in which the members share information is of great importance.

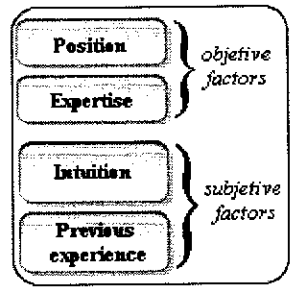

Fig. 1. Trust model factors: objective and subjective

Most previous trust models calculate trust by using the users' previous experience with other users but when there is no previous experience, for instance, when a new user arrives, these models cannot calculate a reliable trust value. We propose that trust should be calculated through the use of four factors which can be stressed according to the circumstances. These factors are (see Figure 1):

- **Position:** employees often consider information that comes from a boss as being more reliable than that which comes from another employee in the same (or a lower) position as him/her [23]. However, this is not a universal truth and depends on the situation. For instance in a collaborative learning setting collaboration is more likely to occur between people of a similar status than between a boss and his/her employee or between a teacher and pupils [24]. In an enterprise this position can be established in different ways by, for instance, using an organizational diagram or classifying the employees according to the knowledge that a person has.

  Different positions inevitably influence the way in which knowledge is acquired, diffused and eventually transformed within the local area. Because of this, as will later be explained, this factor will be calculated in our research by taking into account a weight that can strengthen this factor to a greater or to a lesser degree.
- **Expertise:** This term can be briefly defined as the skill or knowledge that a person who knows a great deal about a specific thing has. This is an important factor since

people often trust experts more than novice employees. In addition, "individual" level knowledge is embedded in the skills and competencies of the researchers, experts, and professionals working in the organization [25]. The level of expertise that a person has in a company or in a CoP could be calculated from his/her CV or by considering the amount of time that a person has been working on a topic. This is data that most companies are presumed to have.

- **Previous experience:** Experience and knowledge form the basis of trust in future familiar situations [26]. Consequently, members of CoPs have greater trust in those knowledge sources from which they have previously obtained more "valuable information". Therefore, previous experience increases or decreases trust, and this factor may be very useful in detecting trustworthy knowledge sources in CoPs. In this case this factor is subjective since it depends on a person's opinion.
- **Intuition:** This is a very important factor since when people do not have any previous experience they often use their "intuition" to decide whether or not they are going to trust something. Other authors have called this issue "indirect reputation or prior-derived reputation" [27]. In human societies, each of us probably has different prior beliefs about the trustworthiness of strangers we meet. Sexual or racial discrimination might be a consequence of such prior belief [27]. We have attempted to model intuition according to the similarity between personal profiles: the greater the similarity between one person and another, the greater the level of trust in that person as a result of intuition.

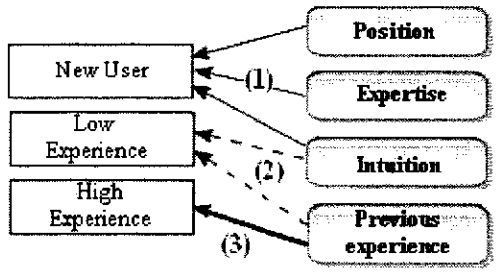

Fig. 2. Using the trust model

As we observed in Figure 1, we use four factors to obtain a trust value, but how do we use these factors? We have classified these four factors into two groups: objective factors (position and expertise) and subjective factors (intuition and previous experience). The former is given by the company or community and the latter depends on the agent itself and the agent's experience over time. There are three different ways of using these factors, which depend upon the agent's situation (see Figure 2):

1. If the agent has no previous experience, for instance because it is a new user in the community, then the agent uses position, expertise and intuition to obtain an initial trust value and this value is used to discover which other agents it can trust.
2. When the agent has previous experience obtained through interactions with other agents but this previous experience is low (low number of interactions), the agent calculates the trust value by considering the intuition value and the experience value. For instance, if an agent A has a high experience value for agent B but agent A has a low intuition value for agent B (the profiles are not very similar), then agent A reduces the value obtained through experience. In this case the agent does not use position and expertise factors (objective factors) because the agent has its own experience and this experience is adjusted with its intuition which is subjective and more personalized.
3. When the agent has sufficient previous experience to consider that the trust value it has obtained is reliable, then the agent only considers this value.

This model permits us to calculate the trust level by considering the following formula:

$$T_{sj} = w_c * E_j + w_p * P_j + w_i * I_{sj} + (\sum_{j=1}^{n} QC_{sj})/n \qquad (1)$$

where T_{sj} is the value of trust of Agent j in the eyes of another Agent s, E_j is the value of expertise which is calculated according to the degree of experience that the person upon whose behalf the agent acts has in a domain.

P_j is the value assigned to a person's position.

I_{sj} denotes the intuition value that Agent s has in Agent j which is calculated by comparing each of the user's profiles.

Previous experience should also be calculated. When an Agent s consults information from another Agent j to obtain information, then Agent s should evaluate how useful that information was. This value is called QC_{sj} (Quality of j's Contribution in the opinion of s). To attain the average value of an agent's contributions, we calculate the sum of all the values assigned to these contributions and we divide it between their total. In the expression n represents the total number of evaluated contributions.

Finally, w_c, w_p and w_i are weights with which the trust value can be adjusted according to the degree of knowledge that one agent has about another.

In order to test our model we have developed a prototype system into which CoP members can introduce documents and where these documents can also be consulted by other people. This prototype will be described in the following section.

4 A recommendation tool based on software agents to support CoPs

In order to evaluate the feasibility of the trust model, we have developed a recommendation tool to support CoPs. The goal of this tool is to allow software agents to help users to discover the information that may be useful to them, thus decreasing the overload of information that employees often have and strengthening the use of knowledge bases in organizations. In addition, we attempt to avoid the situation of employees storing valueless information in a knowledge base.

The following sub-sections describe different situations or scenarios in order to show how the agents work in this tool. These situations will represent some general community rules and will show the main interactions between agents in a community.

4.1 Proposing new documents

It is assumed that any person is able to propose documents in those communities of which he/she is a member.

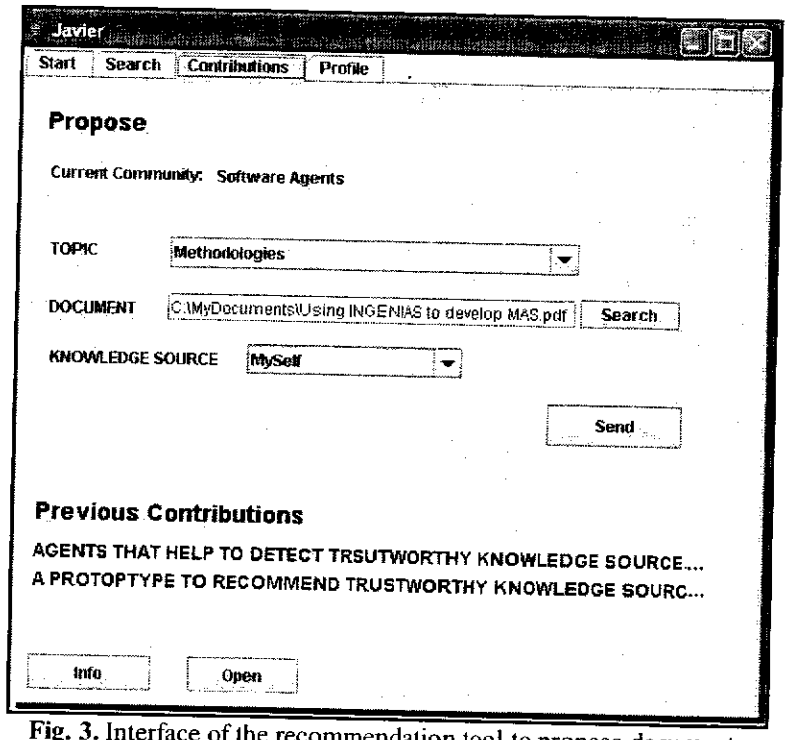

Fig. 3. Interface of the recommendation tool to propose documents

To propose a document one person must use the "Contribution Menu" and will have to configure the followings options (see Figure 3):

- Topic: In each community there may be different topics or areas and the user will choose the one in which s/he intends to propose the document.
- Document: The proposed document.
- Knowledge Source: Where the knowledge came from. It could have come from a partner, from the person him/herself, from a web page, etc.

Once the user has chosen the options, the User Agent (which represents a person in the community) takes the values and sends them to the Manager Agent that is in charge of adding the new document to the community document list and modifying the frequency of contribution of this agent in this community. The Manager Agent is also in charge of managing and controlling the community.

4.2 Using community documents and updating trust values

People can search for documents in every community in which they are registered. When a person searches for a document relating to a topic his/her User Agent will contact other user agents which have documents relating to the topic, and the user agent will then calculate the trust value for each agent. This means that these agents are considered to be knowledge sources and the user agent needs to calculate which "knowledge source" is more trustworthy. Once these values have been calculated, the user agent only shows his/her user the documents which have come from the most trustworthy agents. If the contributors are unknown then the information is listed, and taking their expertise and positions are taken into account. The User Agent can thus detect how worthy a document is, therefore saving employees' time, since they do not need to review all the documents related to a topic but only those which are considered to be most relevant by the members of the community or by the person him/herself according to previous experience of the document or its authors.

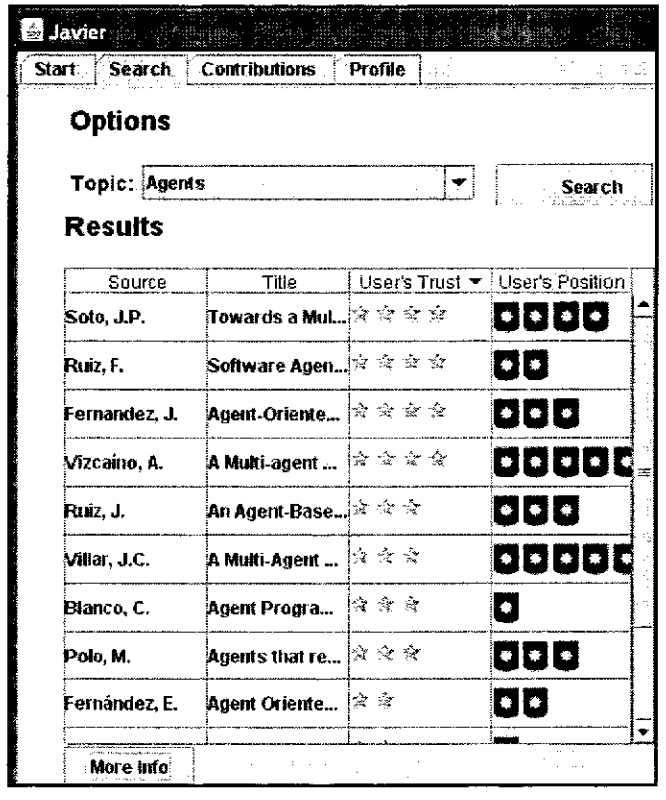

Fig. 4. Showing and sorting results

Figure 4 shows the results of a search sorted by trust values, that is, the first documents on the list come from the most trustworthy knowledge sources (in this case the most trustworthy agents with the highest trust values). There are other

possibilities, depending on user preferences. For instance, as Figure 4 shows, the results of the request (sorted by trust) show a large amount of results, and the first item on the list has four stars in the trust level and four shields in the position level.

Once the person has chosen a document, his/her User Agent adds this document to its own document list (list of consulted documents), and if the author of the document is not known by the person because it is the first time that s/he has worked with him/her, then the User Agent adds this information to their history. This step is highly important, since when the person evaluates the document consulted, his/her User Agent will then be able to assign a QC (explained in previous section) for this document.

5 Conclusions and future work

In this work we propose a trust model to support knowledge exchange in communities. We have also designed a prototype to support CoPs in which knowledge source are rated by using the trust model proposed, which is to be used solely in CoPs. In this prototype CoP members can introduce documents and the software agents must decide how trustworthy those documents are for the user that they represent.

One important contribution of this prototype is that it detects experts in a community, since those knowledge sources with high trust values are supposed to be people who contribute with valuable knowledge. The trust model used also helps to detect fraud when users contribute with non-valuable knowledge. Another important feature of our trust model, and that which makes it different from previous models, is that even when a user is new to the community and other agents do not have any previous experience of working with him/her, the trust model allows agents to obtain a preliminary trust value by considering other factors such as the new agent's position, and level of expertise, along with the intuition that each agent has with regard to the new member. We thus attempt to model human features, since when a person has to evaluate something and s/he has no previous experience that person uses other aspects such as his/her intuition in order to decide whether or not to trust in it.

This proposal implies several advantages for organizations, for instance:

- It permits them to identify their employees' expertise and to measure the quality of their contributions.
- The trust model used in the architecture helps to detect fraud when users contribute with non-valuable knowledge.

As future work, we are performing different tests with the prototype and the trust model in order to verify how they might be improved according to different domains.

Acknowledgments. This work is partially supported by the MELISA project (PAC08-0142-3315), Junta de Comunidades de Castilla-La Mancha, Consejería de Educación y Ciencia, in Spain, partially supported by MECENAS (PBI06-0024) and ESFINGE project (TIN2006-15175-C05-05) Ministerio de Educación y Ciencia (Dirección General de Investigación)/Fondos Europeos de Desarrollo Regional (FEDER) in Spain and CONACYT (México) under grant of the scholarship 206147 provided to the first author.

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