

# **Sociability as a decision model for artificial agents**

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## **Abstract**

In this paper we propose the design of a multi-agent system which has the concept of sociability like the main feature in the behavior of artificial agents. We expose the concept of social-inspired computing and the design of an artificial agent like a finite-state machine as a way to modeling a set of behaviors and solve problems in interconnected systems

## **Keywords**

Artificial agent, multi-agent systems, ad hoc networks, sociability

## **1. Introduction**

In this paper we describe the proposal for a multi-agent system which has the sociability like the main feature among its components. The need of include the concept of sociability in artificial systems is a consequence in the increase of the number of interconnected systems and their ability to communicate and work together as a distributed system. This new features make the traditional control schemes not enough robust to work in dynamical environments (Gershenson & Fernández, 2012). First we make a description of the main features of an interconnected system and mention some of the new challenges that appear when we work with these kind of systems. Second, we explain the concept of social-inspired computing as a way to modeling these new challenges and work with systems with a high amount of components (Shoham & Tennenholtz, 1995) (Insa-Cabrera, Benacloch-Ayuso, & Hernández-Orallo, 2012).

Additionally, we expose how it is possible to include the concept of sociability in the logical design of a artificial agent. To achieve this, we use the finite-state machine as way to model different kind of behaviors in the system and to allow change de decision model of an agent according to the context (Chaczko, Chiu, & Kale, 2010) (Leitão, Barbosa, & Trentesaux, 2012).

As a future work we expose a layer model for a distributed system that has as a base a ad hoc network. In the upper layer can find a multi-agent system which the features mentioned above.

The paper is organized as follows: in section 2 the interconnected networks are described. In section 3 and section 4 we expose the concept of social-inspired computing and the the logical design of an artificial agent based on sociability. Finally, in section 5 and 6 discussion and future work are drawn.

## **2. Interconnected networks**

The communication networks has had a great development in the last years. Since the first communication systems, with the purpose to make phone calls, until nowadays where we have networks with a convergence of services.

The communication systems evolved from serve for phone calls to a data transmission with a great amount of service working at the same time. The increase in the amount of devices and the possibility to communicate among them had as consequence an exponential increased in the size of communication networks (Nitti, Girau, & Atzori, 2014).

As result of the growth of fixed systems, the needs of users started to change; the mobility appear as a desirable condition of communication systems. Therefore, there was a change in the routing algorithms and in the way the systems manages the packets and communications. The possibility to communicate terminals through wireless

channels increase the flexibility of the networks but as consequence generate new challenges specially in dynamical systems (Fitzek & Katz, 2013).

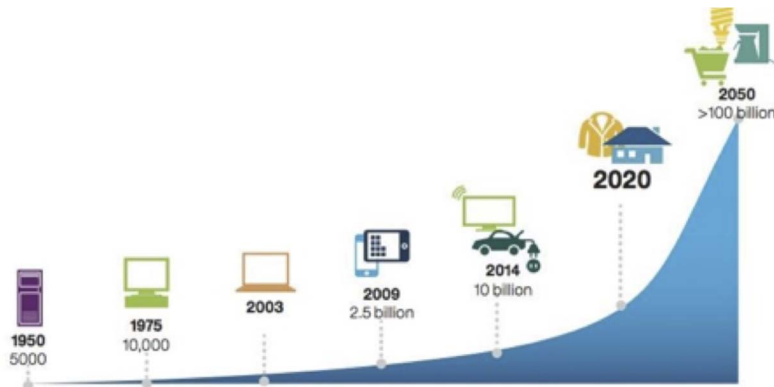


Figure 1. Increasing in the amount of wireless devices (Brody & Pureswaran, 2014)

A trend that has occurred since the 1950s is the growth in the number of devices, which are smaller and with better features of performance. Mobility is also part of this evolution, so the devices have improved their communication interfaces. On the other hand, it is an increased in the heterogeneity of the devices, where not only computers have the possibility to connect to the networks, but also in all kinds of elements that are related in the daily life of the users (Brody & Pureswaran, 2014) (Ortiz, Hussein, Park, Han, & Crespi, 2014).

The systems that were designed to handle information in fixed networks now receive information from mobile networks. These mobile networks were originally used to make only phone calls, but over time they were also used to transmit data, where several communications services like text messages, voice and videos (Helen & Arivazhagan, 2014). The following figure shows the evolution of the infrastructure of the communications network systems.



Figure 2. Infrastructure evolution in data networks (Brody & Pureswaran, 2014)

The scenario that was described in the above Figure 2 can be seen as a trend for the near future. New applications can be developed with an open access infrastructure and distributed networks. These new applications will be focused on the concept of Internet of things. The internet of things (IoT) intend that any element that has a communication interface is capable of transmitting information and work together with other devices in a network.

Fixed systems	Mobile systems (Cloud)	Interconnected systems (Mobil Cloud)
Centralized architecture	Cloud computing	Distributed systems
Restricted access	Open access	Open access
Access to mobile and fixed networks	Mobility	Mobility
Homogeneous technologies	Online services	Sharing services
	Access to mobile networks	Sharing resources
	Heterogeneous technologies	Access to mobile networks

In the previous table a description of the relevant characteristics of the evolution of the infrastructure is made. There are common elements between cloud systems and interconnected systems, this is the access technology that is wireless and the way in which services are used. One of the challenges found in interconnected systems is where the devices have the ability to share resources and services among them.

When the structure of interconnected networks is reviewed, it is possible to note that they have the characteristics of a complex system. The main features are mentioned below:

- A big amount of interconnected components
- The interaction among components given new information to the systems
- Different layers and levels of abstraction
- There are common behaviors among layers

Thus, interconnected networks can be seen as a complex systems it involves several components such as mobile devices, computers, tablets, sensors or any devices with an interface of wireless communication. Obviously the interactions that are generated among these devices are dynamic and are changing in function of time and mobility. This features generate different scales or levels, since some devices with greater resources can generate hierarchical architectures and can be act as controllers in the network operation. In this way the devices with greater resources interact among them and with the other devices in the group. An example: are the clusters that form in cellular networks.

The challenges presented with this kind of systems are oriented to try to control performance. Since it has a complex characteristics, it is difficult to predict how the system will behave. This situation makes task such as resource assignment, node management, service provision and control of QoS, make necessary to think of non-traditional strategies to achieve these objectives in interconnected networks (Sumathi & Srinivas, 2012).

### **3. Social-inspired computing**

In order to understand this concept, an analogy must be made with the way that bio-inspired algorithms. Bio-inspiration, is a set of techniques that study and analyze the behavior of biological systems, to generate algorithms that solve computational problems (Gershenson, 2013) (Leitão et al., 2012).

In the literature is possible to find a examples of bio-inspired algorithms to solve computational problems:

- To perform routing on data networks. The concept of colony of ants is used (Balseiro, Loiseau, & Ramonet, 2011).
- For multi-objective optimization. Genetic concepts are used to find the best solution (Rao & Patel, 2013).
- To carry out searches of information, the concept of intelligence of swarm, fish, bees, birds is used (Kennedy, 2011).
- For learning processes, artificial neural networks for classification problems or recognition of patterns (Huang, Wang, & Lan, 2011) (CireşAn, Meier, Masci, & Schmidhuber, 2012).

The Figure 3 shows a three-coordinate axis where you find three branches representing a classification for bio-inspiration. Phylogeny is the part of biology that makes a representation of evolution. Ontogeny is the representation of the development of organisms. Epigenesis is the part that explains how individuals develop. These representations are some bio-inspired techniques that are used in computation, such as genetic algorithms, cellular automata and neural networks (Chaczko et al., 2010).

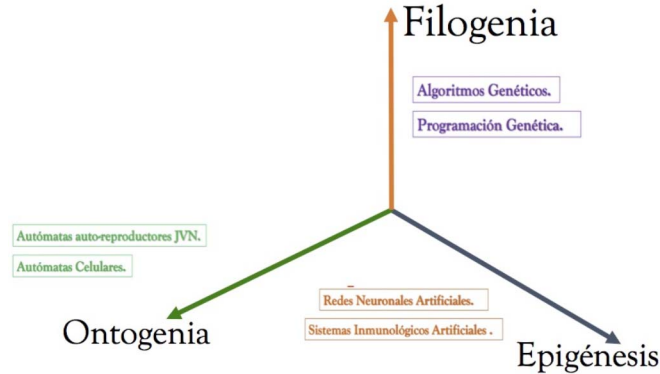


Figure 3. Bio-inspired techniques

The proposal of this research, following the analogy presented for bio-inspired systems, is to analyze and interpret the social systems that are given in the human communities. To achieve this, it is necessary get a model that allows to represent social concepts in a computational way.

#### 4. Artificial agent design

One way of modeling the the concepts showing above arise from the need to have a community or society to applied and test the social inspiration techniques (Minkov & Hofstede, 2012). The form in which distributed systems and Ad-hoc networks are formed have the required organization to apply these concepts. By themselves, devices could not form a society, but they can be programmed with software elements to help them to achieve these features. One of these software elements are artificial agents.

An artificial agent can be defined as a five-tuple as it is showed below (Leitão et al., 2012) (Vanhée, Ferber, & Dignum, 2013):

$$A = (\Sigma_e, \Sigma_s, \xi, \delta, \psi)$$

where:

$\Sigma_e$  Input alphabet

$\Sigma_s$  output alphabet

$\xi$  States of A

$\delta: \xi \times \Sigma_e \rightarrow \xi$  Next state function

$\psi: \delta \times \Sigma_e \rightarrow \Sigma_s$  Output function.

Starting from the agent definition show above, a multi-agent system is proposed as a set of agents with the ability to communicate, cooperate and negotiate among them. All those feature have the aim to help in the control process in a ad hoc network. Taking into account the definition of agent, it is easy to see that the configuration of this element can be easily modified. By updating their states, they can be programmed to perform management functions on the nodes or communication among agents to improve the network performance.

The proposal of model an artificial agent as a finite-state machine, has the purpose to give flexibility and allow modeling each component of the agent as a separate element. Figure 4 shows that the agent beliefs are modeled with the value of  $\delta$  definition.

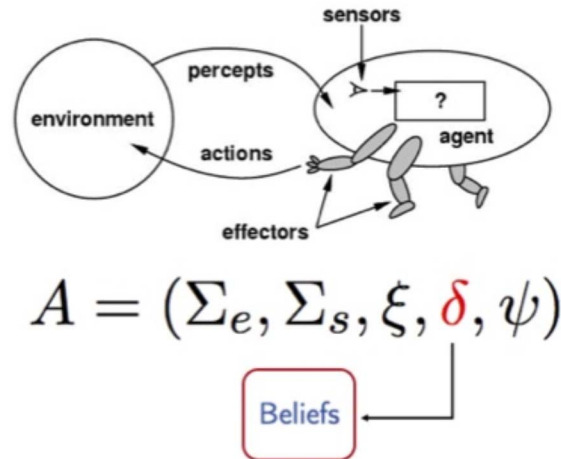


Figure 4. Artificial agent as finite-state machine

Beliefs, is the component that allows the agents to behave in a certain way. therefore it is necessary become those beliefs into a knowledge base, which is being updated each time that the agent gets new information, as consequence learning-based agent can be achieved.

1.  $\beta = \{\delta, B\}$
2.  $\delta = \{p_1, p_2, \dots, p_n\}$
3.  $\beta = \Sigma_e \times \rho(\delta)$
4.  $A = (\Sigma_e, \Sigma_s, \xi, \beta, \psi)$

In step 1 the knowledge base is created as a pair between the next state function  $\delta$  and  $B$  the beliefs. Then in step two, the set of perception is defined. Finally, in step 3 the representation of the change of beliefs of the agent, according to the experience is described. Figure 5 shows the model of this process of an artificial agent.

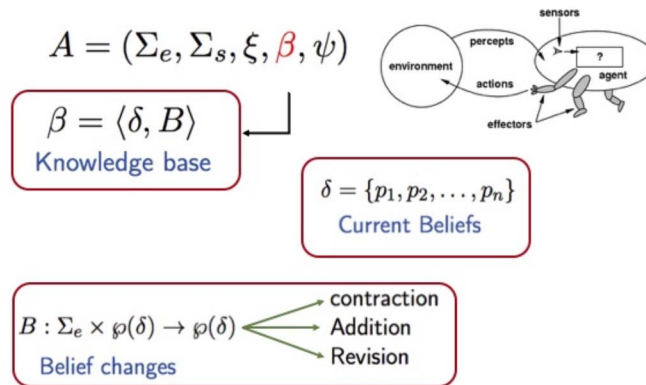


Figure 5. Agent beliefs

With the new agent model:

$$A = (\Sigma_e, \Sigma_s, \xi, \beta, \psi)$$

The possibility of an agent to change its beliefs by itself, become the exchange of information among agents in an important part in the behave of the multi-agent system. It must be taken into account that sociability is the result of interactions between agents, or elements of an organization. In the case of this proposal, artificial agent.

A representation of the interactions can be given in the multi-agent system as it shown in the Figure 6, where a part of the communication is the exchange of information related with the set  $\delta$ . The exchange of information is an important part of the concept of sociability. The language and the communication is the basis of a society.

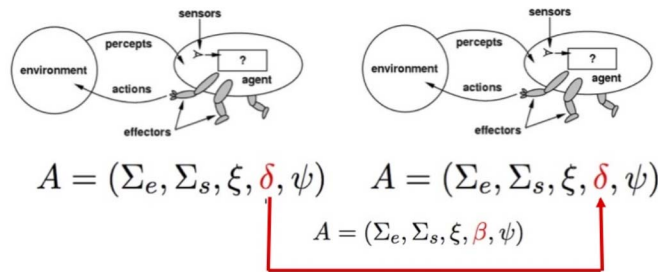


Figure 6. Interaction among agents

## 5. Future work

This section has the purpose to give a roadmap, which takes into account the main aspects of the proposed research. The agent model allows the configuration of the multi-agent system to be easy. But to make the multi-agent system work, an environment must be designed. The environment will provide the operating conditions for the multi-agent system. On the other hand, the implementation of a prototype in embedded systems is important, since this type of artifacts provide the conditions for exploring the sociability concept in real devices.

For the implementation process, the design of a system with different layers is proposed. This system is based on an Ad-hoc network, which provides flexibility to offer different kind of services. Inside this layer, there is virtualization, which allows to control the computational resources of the Ad-hoc network and provides support the multi-agent system. On the multi-agent system layer, the configuration of applications and the management of the network is done. In Figure 7, the layered model is described. It is necessary to note that this model has two transversal elements, one is a programming language created as a tool that helps the construction of the system and on the other hand, a knowledge dynamics, which feeds the multi-agent system. Finally, this whole system is framed by a social model.

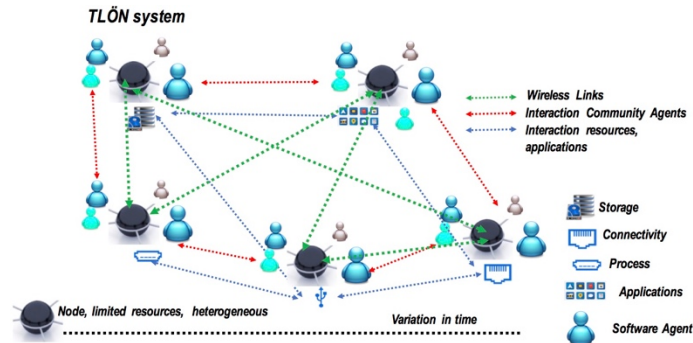


Figure 7. System model

A summary of future work is shown below:

- To verify in an implementation that the interactions between the agents are the base of sociability.
- To implement the knowledge base of an artificial agent through logic programming
- To implement the system-layer model to allocate the multi-agent system
- Choose a specific scenario to test the sociability concept

## 7. Conclusions

In the presentation of this document a research proposal is made for the design of a multi-agent system based on the concept of sociability. The proposal shows the design of the agents as a finite-state machine as a way to give flexibility and adaptive mechanisms to a set of agents. To achieve this the concept of a knowledge base is used.

However, the interesting thing about this proposal is that in definition of the interactions among agents and the exchange of information among knowledge bases works as the base base of sociability. As a proposal, a future work section is planned where the implementation of a layer model has the necessary conditions for the construction of the multi-agent system. All these concepts working together will be the base of social-inspired computing.

Additionally it is assumed that the basis of this research are the needs of the interconnected systems. These conditions provide the framework for the development of the *IoT* and in response to solve problems related with these new technological approach. It is necessary start to think in new ways if we want to develop these technologies.

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## **Biography**

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