Manage users and spaces security constraints on a multi-agent system in a Adaptive Environment System

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Abstract. Nowadays manage user preferences and local actuators specifications is a actual problem on an IoT adaptive systems. This paper proposes a multi agent system to achieve a Smart Environment System, that manage interaction between persons and physical spaces, where spaces smartly adapt to user preferences in a transparent way. With this work we also propose a set of security customization's to secure actuators and users present on managed spaces, that has been developed using a multi agent system architecture with different features to achieve a solution to support all proposed objectives.

Keywords: adaptive-system, AmI, multi-agent, IoT, actuators, preferences, constraints

1 Introduction

The Artificial Intelligence field continues with an exponential growth rate, especially in the different sectors applicability. Currently, multi-agent systems have been used to solve diverse situations, like in Ambient Intelligence.

Ambient Intelligence (AmI), is an ubiquitous, electronic and intelligent environment, recognized by the interconnection of different technologies/systems, in order to carry out the different daily tasks in a transparent and autonomous way for the user [3].

Thus, multi-agent systems are made up of autonomous agents present in the environment and who have the ability to make decisions derived from the interpreted stimuli as well as the connection with other agents, to achieve common goals [15].

This work aims to propose an autonomous Smart Home model controlled by cognitive agents and to manage physical devices, since agents allow communication with different controllers (Arduino, Raspberry).

The main expected contribution of this work is the possibility of applying MAS (Multi-agent system) to ubiquitous prototypes using the *Jason* framework and *ARGO* architecture applied to intelligent environments.

2 Materials and Methods

Figure 1 [9][10][11][12][13], shows the scenario of an environment where it intends to develop this work. Explaining this figure, it can be seen the user who through its different devices (smartphone, wearable, and other compatible) communicates with the system, and for that can be used different technologies, like Near Field Communication (NFC) [14], Bluetooth Low Energy (BLE) [1] and Wi-Fi Direct [2]. Next, the system performs communication with the Cloud, to validate the information. And then the system will perform the management of the different components in the environment (climatization systems, security systems, other smart systems).

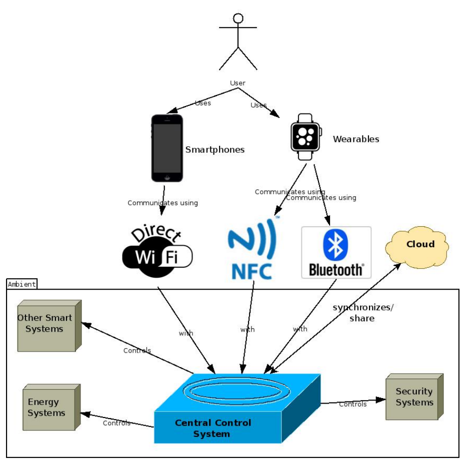

Fig. 1: Problem Statement

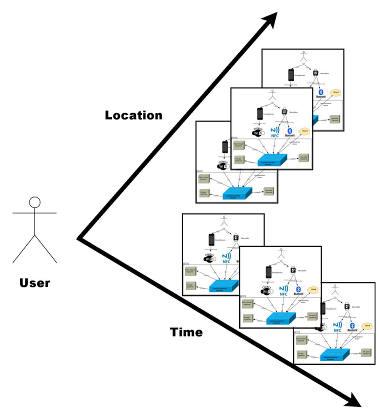

Fig. 2: Contextualization of Time/Environment Dimensions

To optimize the predictions of the solution proposed, an architecture for a multi-agent system was defined. The roles that each agent should represent, as well as the negotiation process to be taken, and the different scenarios in which this negotiation should take place and the way it should be processed were specified.

Firstly, the entire physical structure must be prepared, where the local devices (Raspberry) equipped with the network technologies previously identified, so that they can detect the users present in the space.

For this purpose, a Raspberry is used per division, in this case three on the ground floor (living room/kitchen, office, bedroom) and three on the first floor (one per room).

Regarding the actuators, these divisions have a hydraulic radiant floor heating system heated by a heat pump, and a home automation system that controls the luminosity intensity in the different rooms.

This work proposes an autonomous Smart Home model, controlled through cognitive agents, which get the final information to be applied by the actuators.

For do that, a house with six divisions was prototyped with different comfort features, namely temperature, luminosity, audio and video.

This work resulted in the complete specification of an architecture that supports the solution found, to solve the presented problem. It will now be implemented, tested and validated using real case studies, so as to gather statistical information to assess its effectiveness and performance in the context of application.

In the final stage of this project, all sensor information transmission to the local system are demonstrated . Different sensors of presence, temperature, luminosity, humidity, etc. were inserted in this system. Some of these sensors include all these features, as is the case with some sensors that use ZigBee[4][8] as communication technology as shown in Figure 4. In this way, all the information collected by these sensors is passed through ZigBee to a receiver that is connected to a Raspberry representing the local system, as shown in Figure 3. Then all the information is stored on a database, and then can be used by the different agents present in the system.

It is well known that actually the problem of security, is of relevant importance, particularly with regard to intelligent environments, and all that can interact with user security. Also in this sector, which deals with configuration parameters for the welfare of the user, with regard to different valences. It should be noted the importance, to maintain the safety of these systems, since it is known that temperature and humidity values can impact into question the well-being and even the health of users. Thus, it is necessary to define all actuators, with regard to these security issues, especially with regard to maximum and minimum values.

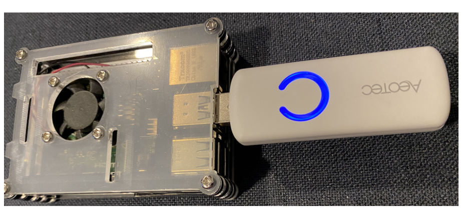

Fig. 3: Local System Raspberry and ZigBee receiver

Fig. 4: ZigBee Sensor

All these values are configured on local systems, and then used by agents in the decision-making process. These values have a high priority, and will function as restrictions, since in addition to being concerned the safety of actuating equipment, but mainly concerned the safety of users present in space.

Table 1 identifies the defined preference constraints, these constraints are necessary for a correct balance of spaces, whether private or public. A maximum value is defined for each preference, as well as the increment/decrement value that can be performed. Obviously this table will be customized according to each location, and in the case of public places, we may have different restrictions, resulting from the specific environment of each space. This is the only way to guarantee the safety of the spaces and equipment present in the space. These validations will be guaranteed in the logical layer,depending of each negotiation agent results, before the result is sent to the actuators.

Table 1: Preferences constraints

Preference/Constrain	**Minimum Value**	**Maximum Value**	**Range**	**Units**
Lighting	0	90	+- 10	%
Temperature	15	28	+- 2	ºC/ºF
Luminance	0	40	+- 2	Lux (lx)
Brightness	0	100	+- 2	Watts/cm2
Relative Humidity	20	80	+- 10	%
Sound	0	30	+- 2	dBm

3 Results

This section presents the technologies used in this project for the development of the entire multi-agent system applied to AmI.

At figure 5 is represented the different architecture layers, the agent that represents the local system receives its information, namely the security information (maximum values of temperature, gases, and others). Also for each user present at the local, there will be an agent who represents him, he will receive information about the user preferences from the central system, that will be used for the negotiation process.

The negotiation process will then be made up of the local system agent and each of the users agents present at the local. The negotiation result of will then be passed on to the different actuators present in the local.

In the course of this project, the environments the focuses will be mainly on domestic/family, professional environments (workplaces) and public spaces, where a large number of people are usually present.

One of the rules used for conflict resolution was the hierarchy of preferences. Starting with family contexts, it was taken into account to maximize the preference value of adult elements (parents) over the children, in a ratio of 1 to 0.75.

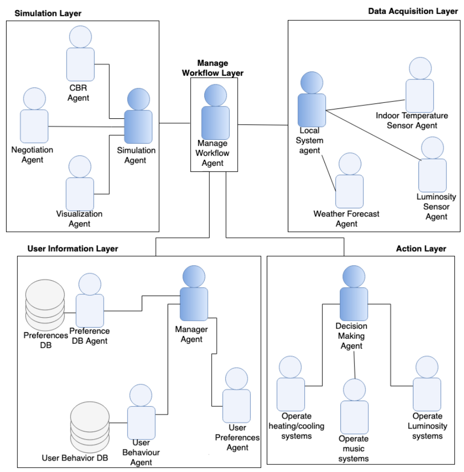

Fig. 5: Architecture of the multi-agent system [12][6][5][7]

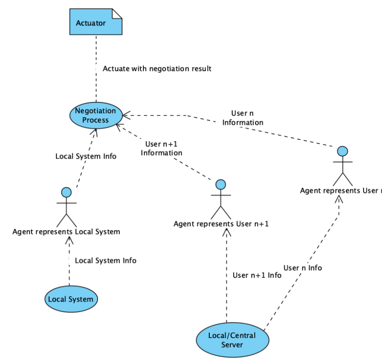

Fig. 6: AmI System - Use Case diagram

Another hierarchy is the preference value of the space if it exists, in this case a proportion of 1.5 will be used. These cases may exist in spaces where there is some conditioning, such as kitchens/wc, or other spaces that have some type of conditioning.

The proportions described and used for the rules are detailed in Table 2.

In the professional context, the proportion values are also defined in a hierarchical way, and in this context the professional hierarchy of space will be used, as well as the space preference value if it exists. The proportions described are detailed in Table 3.

Regarding public/social spaces, the predominant value will obviously be the space value with a proportion of 2, and each user will have a proportion of 0.15, as in these spaces it is natural that there is little variation in the values, derived by the high movement of people. The proportions described are detailed in Table 4. The formula used to achieve the optimum preference value to the different spaces is the following:

$$prefValue = \frac{\sum_{user=1}^{n} userPref \times userHierProportion + (spacePref \times spaceProportion)}{\sum_{user=1}^{n} userHierProportion + spaceProportion}$$

4 Discussion and Conclusions

With this work, the specification of constraints for all specifications of proposed preferences for this work was achieved. In this way the safety of users and actuators present in space is achieved.

Type	Proportion
Adult	1
Child	0,75
Visitor	1
Space	1,5

Table 2: Type of users and proportions - Home space

Type	Proportion
Hierarchy_1	(100-1)
Hierarchy_2	(100-2)
Hierarchy_n	(100-n)
Space	150

Table 3: Type of users and proportions - Work space

Type	Proportion
User_1	0,15
User_2	0,15
User_n	0,15
Space	2

Table 4: Type of users and proportions - Public/Social space

Also the total development of an architecture and respective cognitive model for a Smart Home was achieved, using an MAS with BDI (Belief-Desire-Intention) agents, developed using Jason and ARGO.

The main objective of this work was to verify the potential that this type of architecture has for the development of ubiquitous MAS using low cost hardware, such as Raspberry.

The agent system modeling is fully developed. At this stage the agent layer is developed and implemented, and is now in a testing phase in the testing environment developed for this project.

For future work, the results of the testing phase, will be analyzed and evaluated and with that results improve this project and support other works in this field.

Figure 1 and 2 exemplifies in a global way the architecture of the system where this work has been carried out.

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