

Agents to Help Context-Aware System in Home Care

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Abstract. Context-aware systems capture information from the attributes located within their surroundings and deal with different ways of interacting with the user in its environment. This paper proposes a multi-agent system that processes and reasons the data it receives in order to identify and maintain a permanent fix on the location of a patient at home, while reliably and securely managing the infrastructure of services in its environment. The proposed multi-agent system was used to develop a prototype for controlling dependent persons in their home. The results obtained are presented in this paper.

Keywords: Context-Aware Computing, Home Care, Multi-agent system.

1 Introduction

The search for software environments that can adapt better and better to the demands of users and their environments leads us to context-aware systems. These systems store and analyze all the relevant information that surrounds us and constitutes a user environment. One of the environments in which the aforementioned system can be most useful is Home Care. The sharp increase in the number of dependent persons and the advanced state of technological development create the need to generate new solutions for Home Care environments [15] [9] – advanced applications that can be installed in the homes of dependent persons in order to improve their quality of life. Home Care requires the use of sensors and intelligent devices to build a distributed [3] environment in which household functions are

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automated. In this respect, multi-agent systems [2] can facilitate the development of home care environments. Multi-agent systems have been studied recently as monitoring systems in the medical care [1] of sick patients and those suffering from Alzheimer's [8]. These systems can provide continuous support in the daily lives of these individuals [7], by predicting potentially dangerous situations, and handling physical and cognitive support for the person receiving assistance [4].

This article presents the Home Care Context-Aware Computing (HCCAC) multi-agent architecture, which is capable of supervising and monitoring persons in specific contexts. The objective of HCCAC is to facilitate the assistance of dependent users in their home. HCCAC integrates CBR-BDI [5] agents that are capable of learning beyond their initial knowledge, interacting autonomously with their environment and the system users, and adapting to the needs of the environment. Additionally, the HCCAC system can incorporate Case Based Planning (CBP) [16] mechanisms that provide the agents with a great deal of learning and adaptive abilities in a context-aware environment. The simple integration and interaction between intelligent agents, sensors and devices is what led us to propose the HCCAC architecture.

The remainder of the paper is structured as follows: section 2 describes the proposed system, the solutions offered by the Interpreter Agent, and a detailed description of the Interpreter Agent in HCCAC. Section 3 presents a case study in which the HCCAC was applied. Finally, section 5 presents the results and conclusions obtained from implementing a prototype Home Care scenario.

2 The Interpreter Agent in HCCAC

HCCAC [10] is a distributed system composed of intelligent agents that reason and interact with automatic control systems and autonomous components. The HCCAC architecture focuses primarily on tracking, control and notification. It is defined by the need to control distributed devices and to gather user information from Context-Aware environments [12] in a non-invasive and automatic way. In order to obtain and process context data and offer solutions to the user, the HCCAC system is based on a multi-agent architecture that is comprised of various types of intelligent agents [10]. The primary agent in HCCAC is the Interpreter Agent, which is integrated into the system. The purpose of this agent is to improve the quality of life for the user by providing efficient and relevant solutions in execution time. The most important characteristics of the system are: (i) the Interpreter Agent has reasoning capability; it can analyze and reason the context data gathered by the system and provide proactive solutions, (ii) the Interpreter Agent can easily adapt to the context within which it acts and (iii) gather sensor data and messages from other agents in order to provide efficient solutions. In order to meet the user's expectations, the Interpreter Agent is based on Case Based Reasoning (CBR).

Case Based Reasoning uses past experiences to solve problems [5]. The objective of CBR systems is to solve new problems by adapting solutions that have been used to solve similar problems in the past. The Interpreter Agent also utilizes the concept of Case Based Planning (CBP) to generate solution plans, using past

experiences and planning strategies. One example of how the Interpreter Agent works is its ability to apply the user's temperature preferences when the user's presence is detected within the environment. The system stores user preferences for the desired temperature. The system also stores the case base for the same user with past temperature preferences and similar temperature conditions, including external temperatures. The Interpreter Agent uses this information and similar case base plans to automatically adjust the control mechanism for the temperature when it detects the presence of the user. The system can thus maintain the desired temperature for each user within a specific context. The following section describes the design of the Interpreter Agent in greater detail.

2.1 Interpreter Agent Design

Agents that are designed and implemented by CBR systems can reason autonomously and adapt to changes in their environment [9]. These abilities satisfy two of the most important characteristics for the Interpreter Agent as mentioned in the previous point: (i) reasoning ability and (ii) facility in adapting to its surroundings. The other important characteristic is the ability to use sensors and other agents to gather information from its environment. Therefore, in order to design and implement the Interpreter Agent, it is necessary to consider the exchanges of information among the system agents. The FIPA¹ specification can be considered as a valid standard for the communication between agents. To design the Interpreter Agent, the Agent Unified Modeling Language (AUML²) methodology was used since it provides the mechanisms required to obtain a design that is detailed enough to simplify the implementation phase.

The Belief Desire Intention (BDI) [11] model is a solid foundation for modeling and applying the internal behavior of the agents. The BDI model allows us to perceive the agent as an entity that is searching for an objective and that behaves rationally. The CBR system and BDI agents can be connected if cases are implemented as beliefs, intentions and desires that lead to the resolution of a problem. For a smooth transition between the design phase and the implementation phase, the CBR-BDI paradigm must be supported in the implementation phase.

The (JADE) JavaAgent Development Framework [19] is a good option for developing agent-based applications. Jadex (JADE eXtension) [17] is the implementation of a hybrid agent (reactive and deliberative) architecture for representing the state of JADE agents that follow the BDI model. Jadex is designed to be easily integrated into JADE by simply adding a packet. The primary objective is to facilitate the use of reasoning concepts during the implementation.

As seen from the outside, the Interpreter Agent is a black box that receives and sends messages. The following section will attempt to explain the functioning of the Interpreter Agent in greater detail by using the figure below. The Interpreter Agent, as previously described, will be implemented as a Jadex agent. To do so, some variations in the Jadex architecture are introduced, as shown in figure 1.

¹ www.fipa.org

² www.auml.org

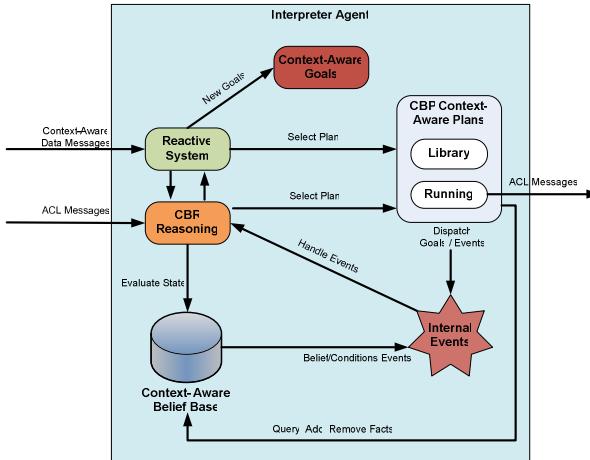


Fig. 1 Overview of the Interpreter Agent Architecture

Figure 1 provides a summary of the architecture for the Interpreter Agent. All messages received by the Interpreter Agent, as well as internal events and new goals, are the first steps towards the internal reactions and the deliberative and reasoning mechanisms processed by the Interpreter Agent. The most significant new feature of the Interpreter Agent's design, as seen in figure 1, is the integration of a CBR reasoning engine and a reactive system that gathers data from the sensors and control systems. This makes the design unique in its conception and reasoning capabilities. Based on the results from the CBR reasoning engine, the Interpreter Agent sends plans through the CBP Context-Aware Plans. These plans can be executed immediately as events, or new plans can be generated and stored in the context-aware library to be executed at a future time. The execution of plans can modify the base of context-aware beliefs, send messages to other agents, create new context-aware goals or produce internal events. These action plans can respond to sensors installed in the system and facilitate the user's daily tasks, making the time spent by the user in the context-aware environment much more comfortable. The plans are used by different types of HCCAC system agents that manage the active devices. The functionality implemented in Java classes can also be incorporated in other similar systems. The next section presents a low level AUML design for the Interpreter Agent, followed by the implementation of Jadex.

As shown in figure 2, the AUML design produces a diagram of capabilities and services for the Interpreter Agent, the most important agent within the HCCAC architecture. The agent has five capabilities and four services, as described in figure 2. The capabilities are: (i) P-Solution, (ii) C-Sensor, (iii) S-Plans, (iv) St-Data and (v) E-Result. The services are: (i) Provide Information (ii) Describe Plan, (iii) Provide Plan Result and (iv) Component Task Assignment.

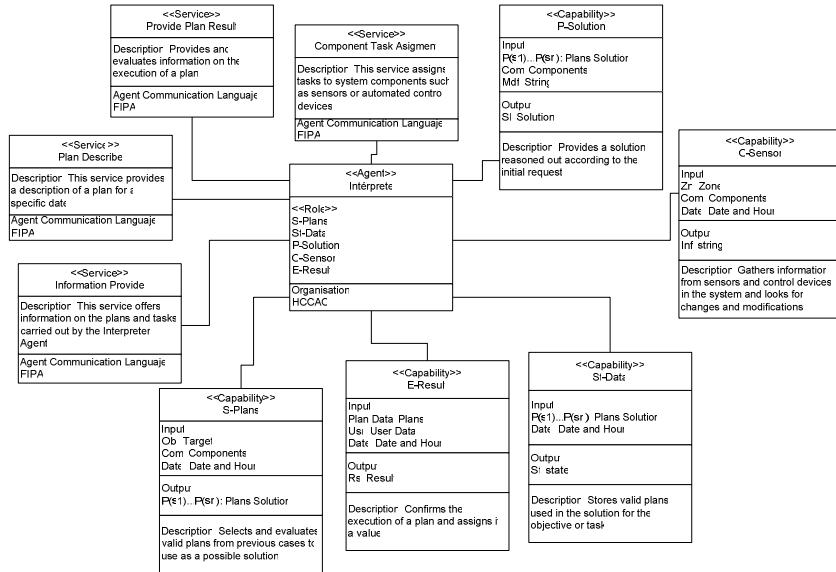


Fig. 2 Diagram of the different capabilities and services for the Interpreter Agent

3 Applying HCCAC in Context-Aware Environments

The case study presented in this paper uses the HCCAC system to develop a prototype for improving a patient's quality of life at home. The system gathers information from the sensors that use automatic control systems to capture data and interact with the environment. The sensors installed in the environment primarily pick up location-aware information on the user. The system also gathers information related to the temperature inside the patient's home, smoke detectors, flooding and lighting conditions in the areas most frequented by the user.

Figure 3 illustrates how the information provider agents are directly connected to the devices capturing the information. The application in this case is comprised of six modules: (i) to control the patient's location (ii) to control the lighting conditions in the home (iii) to control temperature (iv) to control gas escapes (v) to control flooding and (vi) to control smoke detection. The Identification Resources Agent is responsible for identifying and either accepting or rejecting the data submitted by the information providers. Its task is to oversee the information provider agents that are incorporated into the system. All of the data are stored in the system and interpreted by the Interpreter Agent, which is also responsible for processing the stored information, obtaining, for example, the desired temperature and lighting, and then using the context-aware application to apply the data to the automated control devices. With the help of the automated control devices, the Interpreter Agent can also control the detection of flooding, smoke, and gas escapes in the patient's surroundings.

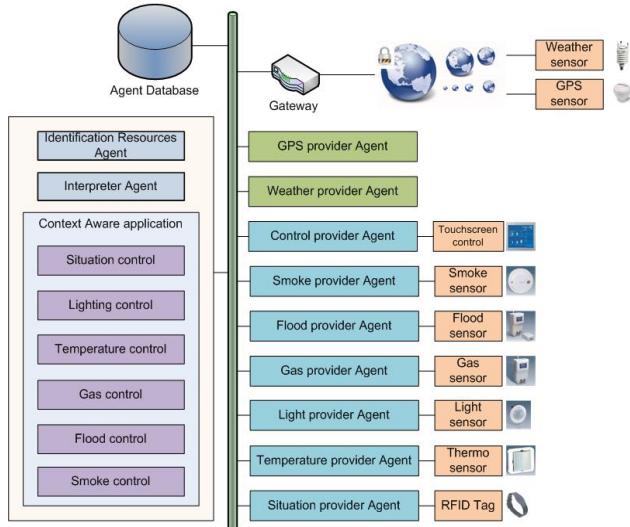


Fig. 3 Home Care context-aware application

Throughout the sequence of operations carried out by the HCCAC agents, it is important to consider the transfer of information that takes place in the system. Low level data are gathered from the patient's environment and then stored in the information system as high level data. As a result the data can be interpreted more quickly and used more easily. The information provider agents and the Interpreter Agent are responsible for carrying out this task together. The case study presented in this paper explains how the agents defined in the system interact with the sensors installed in the environment, and how they influence the automated control devices and the patient.

Additionally, the patients can interact with their surroundings at any given time, establishing the parameters that control the function of each application. Just as provider agents gather context information, they can also receive orders to execute events from devices or automated control device systems. In this way, for example, the administrator can determine which patients can be monitored by the system and can also allow or deny patients access to certain areas in the home.

4 Results and Conclusions

HCCAC acts like a global system in context-aware systems. It not only captures information from its surroundings and responds to users' requests, but it also collaborates with the information system to constantly evaluate the attributes of the user's context and provide proactive solutions. The solutions provided by HCCAC are supported by a vast knowledge base that the system continually stores and processes. HCCAC is a novel system compared to other context-aware types of works [6] [13] [14] [18]. Other studies have focused on gathering data from the user's

position. Others, such as [16], in addition to locating users within the context, try to improve the communication in a hospital center between patients and medical personnel by capturing such context attributes as weather, the patient's state or the user's role. However, the new services offered by HCCAC allow a closer and more natural and indirect interaction. The user can perform daily tasks and receive support from an intelligent context without needing direct interaction. As a result, the user does not actually need to learn to use the system since the HCCAC system itself manages the environment, and user satisfaction is notably increased.

Although there is still much work to be done, the system prototype developed in this study improves security in the homes of dependent persons through the use of control and alert devices. It also provides additional services that automatically react to emergency situations. As a result, HCCAC creates a context-aware environment that facilitates the development of distributed intelligent systems and provides services to dependent persons at home. This makes it possible to automate certain monitoring tasks and improve the quality of life for those individuals. Furthermore, the proper use of mobile devices facilitates social interactions and knowledge transfer. Our future work will focus on obtaining a model that can define contexts and improving the proposed prototype and testing it on patients with different needs and characteristics.

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