Applying HoCCAC to Plan Task the COPD Patient: A Case Study

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Abstract. This paper presents a multiagent system that facilitates the performance of daily tasks for Chronic Obstructive Pulmonary Disease (COPD) patient within a context-aware environment. The paper analyzes the relevant aspects of context-aware computing and presents a prototype that can be applied to monitor COPD patient at their homes. The system includes computational elements that are integrated within a domestic environment with the goal of capturing context-related information and managing the events carried out by the patient. The services are support by the processing and reasoning out of the data received by the agents in order to offer proactive solutions to the user. The results obtained with this prototype are presented in this paper.

Keywords: Context-Aware, Multi-Agent Systems, Home Care.

1 Introduction

The preferred characteristics when designing software applications include autonomy, security, flexibility and adaptability. In order to achieve this objective, it is necessary to have mechanisms, methods and tools that can develop systems capable of adapting to changes within the environment. The search for flexible software applications that can continually improve their ability to adapt to the demands of the users and their surrounding leads us to context-aware systems that store and analyze all of the relevant information that surrounds and forms a part of the user environment. Context-aware systems provide mechanisms for developing

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P. Novais et al. (Eds.): Ambient Intelligence - Software and Applications, AISC 92, pp. 77–84.
springerlink.com

applications that understand their context and are capable of adapting to possible changes. A context-aware application uses the context of its surroundings to modify its performance and better satisfy the needs of the user within that environment. The current trend for displaying information to the system users, given the large number of small and portable devices, is the distribution of resources through a heterogeneous system of information networks. Web applications and services have been shown to be quite efficient [12] in processing information within this type of distributed system. Web applications are run in distributed environments and each part that makes up the program can be located in a different machine. Some of the web technologies that have had an important role over the last few years are multiagent systems and SOA (Service Oriented Architecture) architectures, which focus on the distribution of system service functionalities. This model provides a flexible distribution of resources and facilitates the inclusion of new functionalities within changing environments. In this respect, the multiagent systems have also already demonstrated their aptitude in dynamic changing environments [2] [6]. The advanced state of development for multiagent systems is making it necessary to develop new solutions for context-aware systems. It involves advanced systems that can be implemented within different contexts to improve the quality of life of its users. There have been recent studies on the use of multiagent systems [2] as monitoring systems in the medical care [1] patients who are sick or suffer from Alzheimer's [6]. These systems provide continual support in the daily lives of these individuals [5], predict potentially dangerous situations, and manage physical and cognitive support to the dependent person [3].

This paper presents the Home Care Context-Aware Computing [9] (HoCCAC) multi agent system that supervises and monitors dependent persons in their homes, providing the user with a certain degree of self-sufficiency. The proposed system focuses on incorporating mechanisms that facilitate the integration of web applications. The HoCCAC system provides wireless communication between its elements, and integrates intelligent agents with sensors and autonomous components that obtain context-aware information and are proactive in their interaction with the users. HoCCAC facilitates the automation of context devices and the ability to respond to the elements from a remote location. One of the most important characteristics of HoCCAC is the use of intelligent agents as one of the principal components.

The remainder of the paper is structured as follows: section 2 presents the agents in HoCCAC system. Section 3 describes a study case where the HoCCAC system is applied. Finally, section 4 presents the results and conclusions obtained after evaluating the study case.

2 Agents in HoCCAC

HoCCAC can be defined by the need to control various devices and gather user information in a non-intrusive and automatic way within Context-Aware environments [9]. HoCCAC makes it possible to automatically obtain information on

users, their actions and environment in a distributed manner. HCCAC primarily focuses on monitoring a person in their home and sending notifications on the state of the individual or possible incidents. Additionally, it combines the management of personal information with a model of daily activities that are developed by using the data provided by the sensors through the household network. The interpretation and reasoning of the base knowledge and the daily activity models developed by the system provide an added value to the system. HCCAC makes is possible to easily use and share context-aware applications within changing physical spaces. As seen in Figure 1, the system is composed of the following agents:

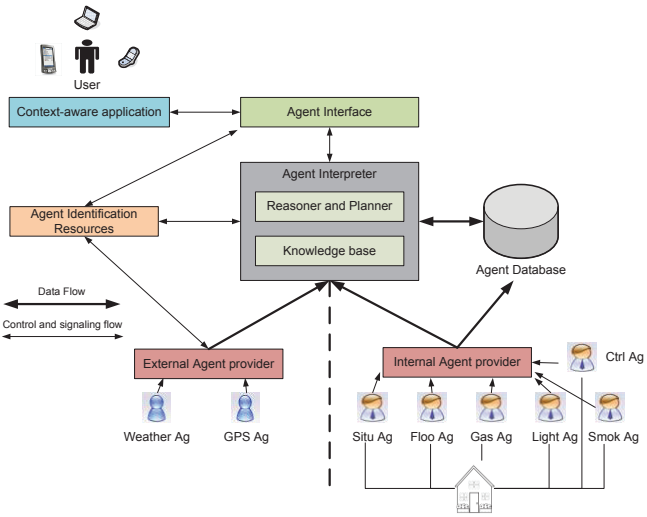

Fig. 1 Overview of the multi-agent system HoCCAC

- Provider agents capture and summarize the data obtained by both internal and external heterogeneous context sources so that the Interpreter and Database agents can process and reuse these data. The system is dynamic and is capable of incorporating an information Provider agent at any given moment by adding the corresponding sensor or capturing the necessary information from a server or external provider. The types of provider agents can connect to the system are: (i) agent situation, which continuously maintains the patient located at home, (ii) agent detector flood, (iii) gas detector agent, (iv) agent Smoke detector, (v) light sensor agent, (vi) agent thermostat, (vii) control agent, which establishes and controls the daily parameters desired by the patient, (viii) weather agent, which records the time abroad to act accordingly on the internal variables at home and (ix) GPS agent, which maintains the patient located outside the home. The system is dynamic and has the ability to incorporate information provider agent at any time by adding the appropriate sensor or capturing the necessary information from a server or external supplier.

- Database agents store the context data obtained by the Provider agents. The organization of this information is similar for different environments. This agent is in charge of managing and exploiting the stored data. Additionally it provides the necessary information to the interpreter agent and records and updates the action plans that are determined by the interpreter agent.
- Interpreter agent provides logical reasoning services to process the contextual information. The interpreter agent reasons out the actions that must be taken by creating a plan that determines the optimal course of action for reaching an objective. This agent provides the ability to reach high level and complex objectives and avoids errors that could result in inefficacies. It also allows for greater flexibility when dealing with new objectives. The interpreter agent, using information available in the system, the signals received by the agent interface and the knowledge base and beliefs regarding keeping context, reasoning about actions to take. In this way creates an argument that determines an optimal course of action or plans for the user to reach a goal. In this sense the agent interpreter uses the concept of CPM [11] to generate plans as solutions. The agent interpreter provides the ability to achieve complex high-level goals and avoid errors that could lead to inefficiencies. It also allows greater flexibility in the presentation of new targets.
- Resource Identification Agent (LcA) makes it possible for the provider agent and the interpreter agent to work directly with the applications and the users in order to avoid dangerous situations or particular incidents with the user. This agent is in charge of maintaining a record of the provider agents that are active in the system, in addition to allowing or denying the inclusion of new provider agents.
- Interface agent interacts with the Interpreter agent and the LcA agent without explicit user instructions. The interface agent reads the user inputs provided through the context-aware applications, and sends the agent behavior modification interpreter agent or LcA agent. The interface agent also sends notifications to users through context-aware applications. The agent interface for example, can receive many entries context-aware applications over a long period of time, before deciding to take a single action, or entry of a single context-aware application can launch a series of actions by the agent.

Context-aware applications in HoCCAC also check the information available from the context providers and are in constant listening mode to deal with possible events that the context providers transmit. The applications use different levels of context information and adapt their behavior according to the active context. They check the functionalities registered in the system and have a location for the entire context providers made available within the environment.

The agents described are independent of the platform on which they are installed. The external provider agents obtain context information through external resources such as, for example, a server that provides meteorological information about the weather in a specific place, or a location server that provides information on the location of a person who is not at home. The internal provider agents gather information directly from the sensors installed within the environment, such as RFID based location sensors installed in the home of a patient, or light sensors.

The functions of the interpreter agent include both processing information provided by the database agent, and reasoning out the information that has been processed.

3 Case Study: Applying HoCCAC to Plan Task the COPD Patient

A prototype has been developed to improve the patient quality of life at home using HoCCAC system. The system collects information from sensors and interacts with the patient through plans of tasks. The information collected by the sensors is primarily the user's location-aware in the environment. In addition the system also collects information about the temperature on the rooms of the patient's home and the state of the lights in areas for which the user travels. The prototype obtains information of the environment and plans tasks for COPD patients, trying to improve the living conditions of the patient.

The interpreter agent receives a set of key activities to be performed by a COPD patient at home. This list of activities is responsible for defining the medical staff monitors the patient's condition. The table 1 shows the list of core activities for a COPD patient. With the activities list defined and the medical personnel, the interpreter agent generates a plan following the CPM method. Prior activities list to each activity and the times list can be determined by the duration of the task execution plan and develop the work plan's network. Table 1 shows the activities list and their predecessors.

Table 1 Activities list for COPD patients and its predecessors

Activity	Predecessors	Name	Time (min.)	Task
A	-	Oxygen cylinder	600	1
B	-	Wake up and exercise	10	6
C	-	Breakfast	10	10
D	A	Pill and spray at 8 hour	3	3
E	A, B, C, D	Doctor Visit	60	14
F	E	Walk	30	4
G	F	Lunch	20	9
H	G	Oxygen cylinder	300	2
I	G	Pill and spray at 14 hours	3	3
J	I	Lunch	40	10
K	J	Picnic	20	11
L	H, K	Walk	30	5
M	L	Pill and spray at 20 hours	3	3
N	M	Dinner	30	12

Once the interpreter agent has defined the work plan and the duration of the plan, it transfers this information to the rest of the agents in the HoCCAC system to execute the plan. The provider agents together with the interface agent are responsible for monitoring compliance with the plan of work. If at any time there was an interruption of the plan, for example, because the patient has a choke and has to do the activities specified for this case the system receives notice HoCCAC through the interface agent and immediately interpreter agent makes a redevelopment plan task. Another feature is given by the doctor visits, as are monthly. Depending on the type of interruption, the provider agent can also generate a notice, for example, in the case of failure of the oxygen tank.

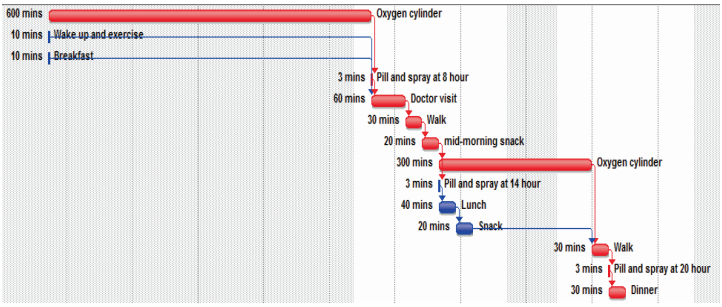

Fig. 2 Gantt chart associated with task plan

Figure 2 shows the Gantt chart with the proposed plan and the associated tasks. In addition Figure 2 also shows the activities that are critical and which not. In red are the critic task and blue are the task with slack. Figure 2 also shows the overlapping of tasks. For example, getting the oxygen cylinder up, exercise and breakfast and it also follows that a doctor's visit comes after the above activities, plus that of taking the medication at 8 am. During the entire sequence of operations performed by HoCCAC agents must take into account the transformation of information that occurs in the system. The information provider agents, together with the interpreter agent are responsible for carrying out this work. Furthermore, the patient at all times can interact with the context to set the parameters that govern the functioning of HoCCAC through context-aware applications.

4 Results and Conclusions

HoCCAC was used to develop a prototype used in the home of a dependent person. It incorporates JavaCard technology to identify and control access, with an added value of RFID technology. The integration of these technologies makes the system capable of automatically sensing stimuli in the environment in execution time. As such, it is possible to customize the system performance, adjusting it to the characteristics and needs of the context for any given situation.

Different studies related to context-aware systems, such as [4] [7] [12], focus exclusively on gathering positional data on the user. The authors of these papers gather the positional data on the users through GSP signals, mobile telephone towers, proximity detectors, cameras and magnetic card readers. Many of these signals work with a very wide positioning range, which makes it difficult to determine the exact position of the user. In contrast, the system presented in this paper determines the exact position of the user with a high level of accuracy. To do so, the system uses JavaCard and RFID microchip located on the users and in the sensors that detect these microchips in their context. Others studies, such as [10], in addition to locating the users in their context, try to improve the communication between patients and medical personnel in a hospital center by capturing context attributes such as weather, the state of the patient or role of the user. In addition to capturing information from various context attributes such as location, temperature and lighting, HoCCAC also incorporates the Interpreter agent reasoning process to provide services proactively to the user within a Home Care environment. At the same time offers the patient proactive work plans that seek to improve the patients' quality of life. The user can perform their daily tasks and receive support intelligent context without explicit interaction. Therefore, the user does not need to learn to use the system. This makes the degree of user satisfaction with the system which handles HoCCAC, increases. HoCCAC incorporates new information Provider agents in execution time. In this respect, HoCCAC proposes a model that goes one step further in context-aware system design and provides characteristics that make it easily adaptable to a home care environment.

Although there still remains much work to be done, the system prototype that we have developed improves home security for dependent persons by using supervision and alert devices. It also provides additional services that react automatically in emergency situations. As a result, HoCCAC creates a context-aware system that facilitates the development of intelligent distributed systems and renders services to dependent persons in their home by automating certain supervision tasks and improving quality of life for these individuals. The use of a multi-agent system, web services, RFID technology, JavaCard and mobile devices provides a high level of interaction between care-givers and patients. Additionally, the correct use of mobile devices facilitates social interactions and knowledge transfer. Our future work will focus on obtaining a model to define the context, improving the proposed prototype when tested with different types of patients.

Acknowledgements. This study has been supported by the Spanish Ministry of Science and Innovation project TRA2009_0096.

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