Context-aware and Home Care: Improving the quality of life for patients living at home

Juan A. Fraile[1], Javier Bajo[1] and Juan M. Corchado[2]

[1]Pontifical University of Salamanca, c/ Compañía 5, 37002 Salamanca, Spain
[2]Departamento de Informática y Automática, University of Salamanca,
Plaza de la Merced s/n, 37008 Salamanca, Spain
{jafraileni, jbajope}@upsa.es, corchado@usal.es

Abstract. This paper presents a multiagent system that facilitates the performance of daily tasks for people within a context-aware environment. The paper analyzes the important aspects of context-aware computing and presents a prototype that can be applied to monitor dependent individuals in their homes. The system includes computation 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 Computing, 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 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 information is usually obtained by sensors. 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 [15] in proc-

essing 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 [3] [9]. 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 [3] as monitoring systems in the medical care [2] patients who are sick or suffer from Alzheimer's [9]. These systems provide continual support in the daily lives of these individuals [8], predict potentially dangerous situations, and manage physical and cognitive support to the dependent person [4].

This paper presents the Home Care Context-Aware Computing (HCCAC) 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 HCCAC 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. HCCAC 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 HCCAC is the use of intelligent agents as one of the principal components in its system services-oriented approach. The system proposes a new and simple method of a distributed construction where the system functionalities are modeled as services that are activated by agents, which, essentially, control and coordinate the services.

The remainder of the paper is structured as follows: section 2 presents the problems of context-aware computing and introduces the need for developing new systems that can improve the living conditions of patients in their homes. Section 3 describes the proposed system and the interaction between agents and devices, focusing specifically on context-aware capabilities and the value-add provided by HCCAC. Finally, section 5 presents the results and conclusions obtained after evaluating the prototype in a Home Care scenario.

2 The context-aware computing.

The idea behind context-aware systems began when Want et al. [19] presented the Active Badge Location System, which is considered to be the first context-aware application. It is a system for locating individuals in their office, where each per-

and complex objectives and avoids errors that could result in inefficacies. It also allows for greater flexibility when dealing with new objectives.

- 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.

Fig. 1. Overview of the multi-agent system HCCAC.

Context-aware applications in HCCAC 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 all of the context providers made available within the environment. One way of developing context-aware applications is to specify actions that respond to changes in the context under specific conditions and rules.

The agents described function independently from 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.

within the parameters of the user's stored daily routine, such as if the user gets up prior to a specific hour on a non-work day, if the use spends more time than normal standing at a door without entering, or if the user remains motionless in the hallway for an extended period of time.

The main idea, which can be considered the core of the case study, is the system's ability to hide the available technological resources from the patient, ensuring that they remain concealed from the patient's daily life activities. In this way, users have only to be concerned with informing the system of their preferred living conditions and the system itself takes care of managing the resources and acting accordingly. It is necessary to apply or develop an appropriate analysis and design methodology, and to develop an organizational structure. The first step, however, is to analyze the extent of the system's performance as it is installed in the patient's home.

Fig. 2. Diagram of the different types of Interpreter Agents

The agent on which the HCCAC system is based is the Interpreter Agent. The diagram in Figure 2 shows the different types of Interpreter Agent, which involve a variety of roles or capacities: (i) RoleFind, assigns a role or finds a valid role for a user based on the identification of the user and the data assigned to him or her; (ii) DataFind, obtains information associated with a user; (iii) DataReasoning, detects any problem and the information associated with a user, evaluate the information and determines a solution to the problem; (iv) SolutionEvaluate, evaluates and transmites the result of a solution; (v) SolutionCheck, checks the solution and gives an assessment; and (vi) SolutionAssign, assings a solution to a user. The Interpreter agent can also initiate a series of services: (i) DirectAction, executions an action for a user; (ii) CommunicationAction, communicates an action that must be taken by a user; (iii) ServiceTask, initiates a task in the system; and (iv) GenerateEvent, generates an event after calculating or evaluating the data.

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 [11] [6] [13] [16], 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 [14], 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, HCCAC also incorporates the Interpreter agent reasoning process to provide services proactively to the user within a Home Care environment. HCCAC incorporates new information Provider agents in execution time. In this respect, HCCAC 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, HCCAC 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 multiagent 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 work was supported JCYL SA071A08 project.

References

1. Abowd, G. D., Atkeson, C. G., Hong, J., Long, S., Kooper, R., and Pinkerton, M. (1997). Cyberguide: A mobile context-aware tour guide. Wirless Networks, 3(5).
2. Angulo, C., & Tellez, R. (2004). Distributed Intelligence for smart home appliances. Tendencias de la minería de datos en España. Red Española de Minería de Datos. Barcelona, España.

3. Ardissono, L., Petrone, G. and Segnan, M. 2004. A conversational approach to the interaction with Web Services. Computational Intelligence, Blackwell Publishing. Vol. 20. pp. 693-709.
4. Bahadori, S., Cesta, A., Grisetti, G., Iocchi, L., Leone1, R., Nardi, D., Oddi, A., Pecora, F. & Rasconi, R. (2003). RoboCare: Pervasive Intelligence for the Domestic Care of the Elderly. In AI*IA Magazine Special Issue, January, 2003.
5. Brown, P. J. (1996). The stick-e document: A framework for creating context-aware applications. In Proceedings of the Electronic Publishing, Palo Alto, pages 259–272.
6. Burrell, J. and Gay, G. (2002). E-graffiti: evaluating real-world use of a context-aware system. Interacting with Computers – Special Issue on Universal Usability, 14(4):301–312.
7. Cheverst, K., Davies, N., Mitchell, K., Friday, A., and Efstratiou, C. (2000). Developing a context-aware electronic tourist guide: some issues and experiences. In Proceedings of the SIGCHI conference on Human Factors in Computing Systems, pages 17–24, New York, NY, USA. ACM Press.
8. Corchado, J.M. , Bajo, J. , de Paz, Y. & Tapia, D. (2008). Intelligent Environment for Monitoring Alzheimer Patients, Agent Technology for Health Care. Decision Support Systems. ISSN 0167-9236.Vol 34 (2) pp. 382-396.
9. Corchado, J.M., Bajo, J. & Abraham, A. (2008). GERAmI: Improving the delivery of health care. IEEE Intelligent Systems. Special Issue on Ambient Intelligence - Mar/Apr 08.
10. Dey, A. K. (1998). Context-aware computing: The CyberDesk project. In Proceedings of the AAAI, Spring Symposium on Intelligent Environments, Menlo Park, CA.
11. Espinoza, F., Persson, P., Sandin, A., Nyström, H., Cacciatore, E., and Bylund, M. (2001). GeoNotes: Social and navigational aspects of location-based information systems. In Proceedings of the 3rd International Conference on Ubiquitous Computing, Atlanta, Georgia, USA, pages 2–17.
12. Hull, R., Neaves, P., and Bedford-Roberts, J. (1997). Towards situated computing. In Proceedings of the International Symposium on Wearable Computers.
13. Kerer, C., Dustdar, S., Jazayeri, M., Gomes, D., Szego, A., and Caja, J. A. B. (2004). Presence-aware infrastructure using web services and RFID technologies. In Proceedings of the 2nd European Workshop on Object Orientation and Web Services, Oslo, Norway.
14. Muñoz, M. A., Gonzalez, V. M., Rodriguez, M., and Favela, J. (2003). Supporting context-aware collaboration in a hospital: an ethnographic informed design. In Proceedings of Workshop on Artificial Intelligence, Information Access, and Mobile Computing 9th International Workshop on Groupware, CRIWG 2003, pp. 330–334.
15. Oren, E., Haller, A., Mesnage, C., Hauswirth, M., Heitmann, B., Decker, S.: A Flexible Integration Framework for Semantic Web 2.0 Applications. IEEE Software, vol. 24, no. 5, pp. 64-71, (2007)
16. Priyantha, N. B., Chakraborty, A., and Balakrishnan, H. (2000). The cricket location-support system. In Proceedings of the 6th Annual International Conference on Mobile Computing and Networking, pages 32–43. ACM Press.
17. Ryan, N., Pascoe, J., and Morse, D. (1997). Enhanced reality fieldwork: The context-aware archaeological assistent. Computer Applications in Archaeology.
18. Schilit, B. and Theimer, M. (1994). Disseminating active map information to mobile hosts. IEEE Network, 8(5):22–32.
20. Want, R., Hopper, A., Falcao, V., and Gibbons, J. (1992). The Active Badge Location System. ACM Transactions on Information Systems, 10(1):91–102.
21. ZhiqunChen (Sun Microsystems). Java Card Technology for Smart Cards. Addison Wesley Longman. ISBN 0201703297.