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Enhancing the Services Integration Mechanism in the HoCa Multi-agent Architecture

J.A. Fraile, Jesús A. Román, and Belén Pérez-Lancho

Abstract. This work presents improvements in the communication protocol and service coordination mechanism of the HoCa architecture, a multi-agent based architecture designed to facilitate the development of pervasive systems that proposes a new model where multi-agent systems and service oriented architectures are integrated to facilitate compatible services. A coordinator agent proposes a new planning model, where the complex processes are modeled as external services. The agent acts as coordinators of Web services that implement the four stages of the case-based planning cycle. One of the main aims of the pervasive systems is to be able to adapt themselves in execution time to the changes in the number of resources available, the mobility of the users, variability in the needs of the users and failures of the system. Multiagent systems are suitable to resolve these issues due to their capabilities such as autonomy, reactivity, pro-activity, mobility, etc.

Keywords: Multi-Agent Systems, Services Oriented Architectures, Distributed Computing.

1 Introduction

The importance acquired by the dependency people sector has dramatically increased the need for new home care solutions [7]. Besides, the commitments that have been acquired to meet the needs of this sector, suggest that it is necessary to modernize the current systems. Multiagent systems [11], and intelligent devices-based architectures have been recently explored as supervisor systems for health care scenarios [1] [17] for elderly people and for Alzheimer patients [7]. These systems allow providing constant care in the daily life of dependent patients [4], predicting potentially dangerous situations and facilitating a cognitive and physical support for the dependent patient [2]. Taken into account these solutions, it is possible to think that multi-agent systems facilitate the design and

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development of pervasive environments [9] and improve the services currently available, incorporating new functionalities. Multi-agent systems add a high level of abstraction regarding to the traditional distributed computing solutions.

While the challenge of bringing smart environments to multi-agent scales is somewhat overwhelming, multi-agent settings also raise a number of opportunities for unique research [8]. The HoCa multi-Agent architecture [12] uses a series of components to offer a solution that includes all levels of service for various systems. It accomplishes this by incorporating intelligent agents, identification and localization technology, wireless networks and mobile devices. Additionally, it provides access mechanisms to multi-agent system services, through mobile devices, such as mobiles phones or PDA. The architecture integrates two types of agents, each of which behaves differently for specific tasks. The first group of agents is made up of deliberative BDI agents, which are in charge of the management and coordination of all system applications and services. The second group of agents is made up of reactive agents responsible for handling information and offer services in real time. The communications between agents within the platforms follows the FIPA ACL (Agent Communication Language) standard. The protocol for communication between agents and services is based on the SOAP standard.

The main objective of this paper is to improve the HoCa hybrid Multi-Agent architecture [12], for the control and supervision of pervasive environments [10]. The improvements focus on the communication protocol and the coordination mechanism for the services. In this way, the architecture provides innovative mechanisms to integrate multi-agent systems with service oriented architectures and intelligent interfaces to obtain context-aware information. The architecture incorporates technologies for automatic identification, location, alarms management and movement tracking. These technologies facilitate the monitoring and management of dependent patients at their home in a ubiquitous way. One of the main contributions of this paper is the use of coordinator deliberative BDI agents [7], specialized in the distribution of complex tasks.

The next section reviews the problem that motivates the majority of this research. Section three describes the communication protocol proposed for the HoCa architecture [12]. Section four presents new mechanism for the coordinator agent. Finally the conclusions and some preliminary results are presented.

2 Problem Description and Background

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 [18] 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 [4] [10]. 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 [4] as monitoring systems in the medical care [2] patients who are sick or suffer from Alzheimer's [10]. These systems provide continual support in the daily lives of these individuals [11], predict potentially dangerous situations, and manage physical and cognitive support to the dependent person [4].

A multiagent system consists of intelligent entities that are called agents. An agent is a physical or abstract entity that can collect information through sensors, is able to assess such perceptions and make decisions through mechanisms of simple or complex reasoning, communicate with other agents to obtain information and act on the environment in that it operates through executing [18]. Multiagent systems can easily adapt their behavior to the changing context. These systems can use the latest technology in computer whenever necessary and to minimize network traffic, especially in wireless networks. A Multiagent system provides users with various wireless services that enhance the capabilities of mobile devices connected. These systems adapt in a transparent way the user interface to a specific platform, monitoring the movements of the user and communicate this information to agents on the platform. There are also a number of agents who are in charge of streamlining operations at the network and interact with other agents.

Multiagent systems are easily adaptable to pervasive environments [18]. The main function of a pervasive multiagent pervasive is to provide a framework for implementation of the agents who are part of it. Pervasive multiagent system consists of at least one channel of communication and a set of services that facilitate the interconnection between the agents that comprise it [17]. These services provided by the system are invisible to the user. This paper presents a communication protocol to integrate Web Services with multiagent systems and an intelligent agent for coordinating services in the HoCa architecture [12].

3 Communication Protocol to Integrate Web Services and Multiagent Systems

Communication protocol allows applications, services and sensors to be connected directly to the platform agents. The protocol presented in this work is open and independent of programming languages. It is based on the SOAP (Simple Object Access Protocol) standard and allows messages to be exchanged between applications and services as shown in Figure 1.

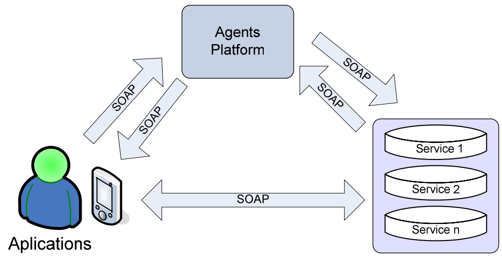

Fig. 1 Communication using SOAP messages in HoCa

SOAP is a standard protocol that defines how two objects in different processes can communicate through XML data exchange. For example, here are displayed as a HoCa user since the supervisor application, which can run on a PDA asks the agent CoAp (see Figure 4) the patient location in his home. The application requests the patient location with a SOAP message (see Alg. 1) and the CoAp agent when has the patient location gets to communicate with the application back in another SOAP message (see Alg. 2) the information requested.

```
  <soap:Envelope
xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/">
      <soap:Body>
        <getHCPatientLoc xmlns="http://hoca.example.com/lc">
          <patientId>6267581</patientId>
        </ getHCPatientLoc>
      </soap:Body>
  </soap:Envelope>
```

Alg. 1 Request for patient location

In the algorithm 1 is seen as the application asks for the patient location through his identifier in the system. Both in the algorithm 1 as in the algorithm 2 are seen as the SOAP message structure consists of a header or envelope and content or message body.

```
  <soap:Envelope
xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/">
      <soap:Body>
        <getHCPatientLocDetailsResponse
xmlns="http://hoca.example.com/lc">
          <getHCPatientLocDetailsResult>
            <patientName>Juan Nieto</patientName>
            <patientId>6267581</patientId>
            <description>Juan is in the dining room near the
TV</description>
            <location>835,264,176</location>
            <inHome>true</inHome>
          </getHCPatientLocDetailsResult>
        </getHCPatientLocDetailsResponse>
      </soap:Body>
   </soap:Envelope>
```

Alg. 2 Reply with the patient location

The algorithm 2 shows as the agent CoAp responds with more patient data such as name, house area description where he is and the patient location.

However, interaction with environmental sensors requires Real-time Transport Protocol (RTP)[14] which provides transport functions that are adapted for applications that need to transmit real-time data such as audio, video or simulation data, over multicast or uncast network services. The RTCP protocol is added to RTP, allowing a scalable form of data supervision. Both RTP and RTCP are designed to work independently from the transport and lower network services. They are in charge of transporting data with real-time characteristics, and of supervising the quality of service, managing the information for all the entities taking part in the current session.

The communications between agents within the platforms follows the FIPA ACL (Agent Communication Language) standard. This way, the applications can use the platform to communicate directly with the agents. The agent's messages structure are key-value row. These rows are written in an agent's communications language as FIPA ACL. The messages include the names of the sender and the receiver and may contain other messages recursively. Moreover defining protocols for high-level interaction between the agents, called talks and it is possible to define new primitives from a core of primitive by composition.

4 Agents with Advanced Services Coordination Abilities

Services represent the activities that the multi-agent architecture offers. Services are components of the architecture. The services are invoked on the applications through the agent's platform. They are the bulk of functionalities of the pervasive system at processing, delivery and acquire information level. Services are designed to be invoked locally or remotely. Services can be organized as local services, web services, or even as individual stand alone services. Services can make use of other services to provide the functionalities that users require. There is a flexible and scalable directory of services, so they can be invoked, modified, added, or eliminated dynamically and on demand. It is absolutely necessary that all services follow the communication protocol to interact with the rest of the architecture components.

The coordinator agent is the core of the system, since provides the ability for self-organization. The agents in the organization layer have the capacity to learn from the analysis carried out in previous procedures. They adopt the model of reasoning CBP, a specialization of case-based reasoning (CBR) [16]. CBP is the idea of planning as remembering [13]. In CBP, the solution proposed to solve a given problem is a plan, so this solution is generated taking into account the plans applied to solve similar problems in the past [16]. The problems and their corresponding plans are stored in a plans memory. A plan P is a tuple $<S,B,O,L>$, S is the set of plan actions, O is an ordering relation on S allowing to establish an order between the plan actions, B is a set that allows describing the bindings and forbidden bindings on the variables appearing in P, L is a set of casual links.

The CBP-BDI agents stem from the BDI model [5] and establish a correspondence between the elements from the BDI model and the CBP systems.

The BDI model adjusts to the system requirements since it is able to define a series of goals to achieve based on the information that has been registered with regards to the world. Fusing the CBP agents together with the BDI model and generating CBP-BDI agents makes it possible to formalize the available information, the definition of the goals and actions that are available for resolving the problem, and the procedure for resolving new problems by adopting the CBP reasoning cycle.

Based on this representation, the CBP-BDI coordinator agents combine the initial state of a case, the final state of a case with the goals of the agent, and the intentions with the actions that can be carried out in order to create plans that make it possible to reach the final state. The actions that need to be carried out are services, making a plan an ordered sequence of services. It is necessary to facilitate the inclusion of new services and the discovery of new plans based on existing plans. Services correspond to the actions that can be carried out and that determine the changes in the initial problem data. Each of the services is represented as a node in a graph. The presence of an arch that connects to a specific node implies the execution of a service associated with the end node. The plan described by a graph can be defined by a sequence (i.e.: $S_7\ o\ S_5\ o\ S_3\ o\ S_1)(\ e_0)$. e_0 represents the original state that corresponds to Init, which represents the initial problem description e_0. Final represents the final state of the problem e^*.

CBP-BDI agents use the information contained in the cases in order to perform different types of analyses. As previously explained, an analysis assumes the construction of the graph that will determine the sequence of services to be performed.

5 Results and Conclusions

The architecture presented in this paper was used to develop a prototype 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 [15] [20], focus exclusively on gathering positional data on the user. 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.

The architecture, 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, the architecture provide services proactively to the user within 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, we have create 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.

Adopting a multi-agent software architecture for smart environments opens up a number of new research directions. One challenge for multi-agent smart environment software architectures is to define lightweight, simple, and scalable methods for communicating between the agents [8]. HoCa [12] provides an integral Ambient Intelligence-based solution for Home Care. The architecture facilitates the development of distributed environments using RFID, JavaCard and mobile devices, providing a high level of interaction with the users and patients, which is an essential factor in building pervasive environments. Moreover, the incorporation of CBR-BDI agents facilitates automatic decision making, as well as great capacities for learning and adaptation. However, the system needs to be tuned and evaluated in different real environments. That is our next challenge.

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