Data Management in an Intelligent Environment for Cognitive Disabled and Elderly People

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Abstract. Recently intelligent and personalized medical systems tend to be one of the most important branches of the health-care domain, playing a great role in improving the quality of life of people that want to feel safe and to be assisted not regarding the place they are. This paper presents an innovative way of data management based on a middleware platform providing services for fast and easy creation of applications dealing with the problems of taking care of patients in their homes. The work was carried out as a part of the MPOWER project, funded by the EU 6th Framework Programme, and carried out by a multinational development team. The project focuses on supporting activities of daily living and provides services for elderly and cognitive disabled, e.g. people with dementia. The MPOWER platform is designed to facilitate rapid development of a variety of applications and adopt them to specific users' needs. The paper introduces the whole platform, its functionality and principal goals along with the architectural background of data management, focusing on the different types of data that the system has to manage and analyze. The last section concludes the work done on the project.

1 Introduction

Nowadays taking care of elderly people using modern technologies is one of the general objectives of health-care domain research companies. This paper is based on one of those recent investigation projects – namely the MPOWER project. The project seeks to find solutions for cognitive disabled and elderly people to make their life more independent and to improve their life quality standard. Thus, MPOWER joins the most important health-care solutions for remote assistance, social-health care and surveillance**.** Moreover, MPOWER helps in managing the medical information and also possesses management solutions for networks of domotic (sensors) and medical devices which are considered as an important factor in making the life of the elderly independent. The MPOWER middleware is targeted to developers in order simplify and speed up the development process of applications for elderly and cognitive disabled persons.

With the open platform of MPOWER, developers are allowed to create and integrate new services as also they dispose a set of basic and complex ready made

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services in the platform, e.g., services for: information management including social and medical information, different communication channels with monitoring functionality, interoperability between different specific medical systems, security of information management, and at the end SMART HOUSE and sensor related services. The last ones together with the communication services create a mechanism which serves to monitor and control remotely the patient environment and allow reacting in a certain way in particular situations. Within the platform there is an integration component that supports different types of sensors. Components for processing the data captured from aforementioned sensors as well as mechanisms for data analysis is also developed. The MPOWER project deals with different types of data, defines the internal data-flow and finally provides services which make use of the analyzed information and manipulates with the provided data. All these services along with services to manage actuators and communication services such as video conferencing, mobile or email notifications form a mechanism that can make the life of the elderly safer and more independent. For example people with dementia can be given constant support not only in case of emergency situations but also in their activities of daily living.

2 Project Principal Objectives

The main objective of the MPOWER project is to create a platform of reusable, flexible, interoperable and innovative social and health-care related services. This platform makes possible rapid and easy development of novel smart-home sensor applications which help to take care and empower the everyday's live of elderly people in their daily activities. In this way cognitively disabled people will be more assisted and then they should feel more secure at their homes [3]. Within the project two proof of concept applications are being developed: one with the goal of demonstrating the feasibility of the platform with information sharing functionality and another that presents the usage of MPOWER platform with sensor's network and smart home technologies. Sensor networks together with the different communication and remote monitoring solutions may increase the level of patient's security and assistance by various mechanisms of control. In such way patients of different characteristics or the elderly can stay at constant surveillance by medical and care giving personnel.

The second objective of the project is applying new trends in software development process and architecture, in this case making use of Model-Driven Software Development for Service Oriented Architecture [2]. There has been worked out its proper toolchain for services creation based on UML models. These models are later transformed and some code is automatically generated.

3 Platform Functionality

This section gives an overview of the functionality provided by MPOWER. These functionalities, many of them implemented as web services make use of the data received from the MPOWER environment providing the data analysis and finally help

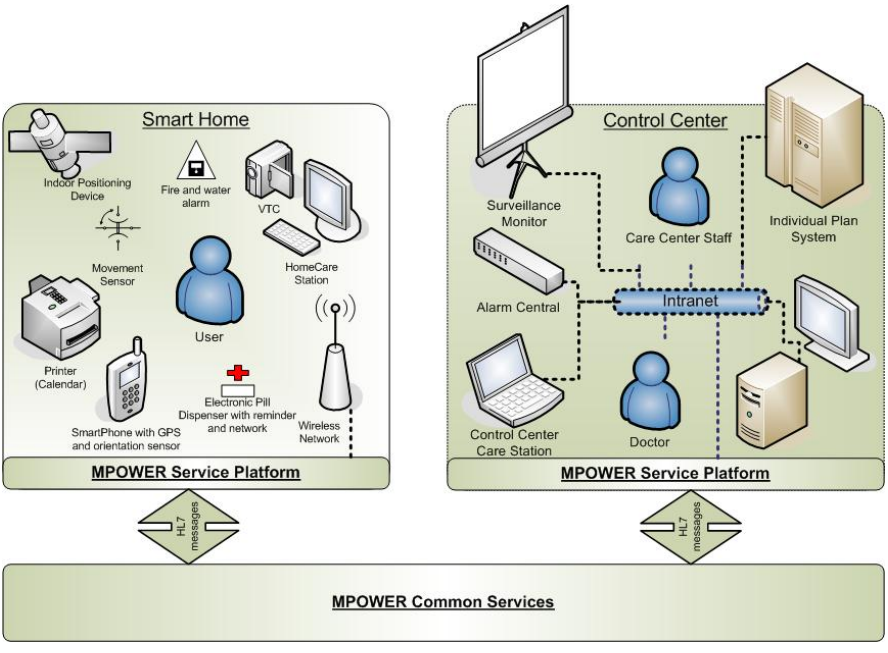

Fig. 1. MPOWER platform elements

the medical personnel or caregivers to take care of the subject of care and have them under constant attention providing constant assistance.

Moreover MPOWER-based systems consist of two parts: one intended for the subject of care (patients), and one designed for the healthcare personnel and caregivers. Figure 1 presents an example of a MPOWER application as care center and smart house environments. These two parts communicate with each other through different middleware services or directly passing medical information. Some services use HL7 format others not depending on the message origin. HL7 messages play an important role when exchanging information with legacy systems or other health systems. In the smart house environment a very important factor is the data capturing and its manipulation. Different types of devices or sensors send the data and MPOWER has to be able to read and interpret the data. For this purpose MPOWER provides special components that facilitate the data manipulation process describing the proper data flow.

For example, patients' movements can be controlled through a tracking system which sends information about the current patient position to a control point. Two services have been implemented to provide this functionality, monitoring indoor and outdoor location of the elderly. Patients can be easily localized in the case of different situations. GPS and WiFi technologies let caregivers and even family members be aware of this fact and help them is such case.

Another feature of the platform provided for the elderly is giving the possibility of sending alarm information in situations when the patient feels insecure or needs urgent medical assistance. This functionality is covered by a notification mechanism

designed as another basic and crucial platform service. In this situation caregivers can communicate with the MPOWER application user through different communication channels depending on its current location. For this purpose audio and audio-video conferencing as well as surveillance cameras services are provided to have the full control and contact with the patient at any time.

Medical and social information is also managed by the MPOWER services. Medical information can be exchanged with other medical systems using HL7v3 messages standards. Subjects of care and care centers can communicate also through messaging services which play the role of reminders, passing different medial data or just simple notification messages.

MPOWER services can be used separately or in cooperation with other services. The platform has been designed in such a way that use of services can be orchestrated through designing business processes and running them on an integration platform such as Enterprise Service Bus (ESB) where processes and data flows can be defined through implementing appropriate BPEL for each situation treatment.

4 Data Management Mechanisms

Cases where MPOWER solutions are applied often involves analysis and management of data collected from different sources. This data is provided to the middleware services by a specially prepared component called Frame Sensor Adaptor (FSA) which unifies the way of data capturing for either medical devices or different kind of sensors and Smart Home standards (in the case of MPOWER proof of concept domotic sensors were used) or any other kind of incoming data.

Data received through the FSA is passed (through Enterprise Service Bus - ESB) to another component called ContextManager where the data is analyzed. This analysis is based on rules defined in the platform environment. Rules matching can detect the emergency situations and react in a particular manner e.g. an alarm notification can be sent to a mobile phone or to another platform service.

Figure 2 presents a data flow diagram from the data capturing stage to the final notifications sending. As showed on the diagram the central element of the data management mechanism is the Enterprise Service Bus (ESB) which gathers all collected data and passes it to the appropriate targets. The main element which analyzes the data is the ContextManager component which performs expected data analysis.

4.1 Frame Sensor Adapter (FSA)

The MPOWER platform is prepared to receive information from any known medical device, network of sensors or incoming source. Ambient Assisted Living is one of the most important factors when providing a remote assistance and monitoring of the elderly. There has been created a component called FSA [4] thanks to which any sensor/actuator or device can be integrated with the MPOWER environment. That is the most important feature of the component. FSA serves to receive data from those devices and send them to a predefined target in a specific format. FSA receives heterogeneous information from many kind of devices and transforms it to a

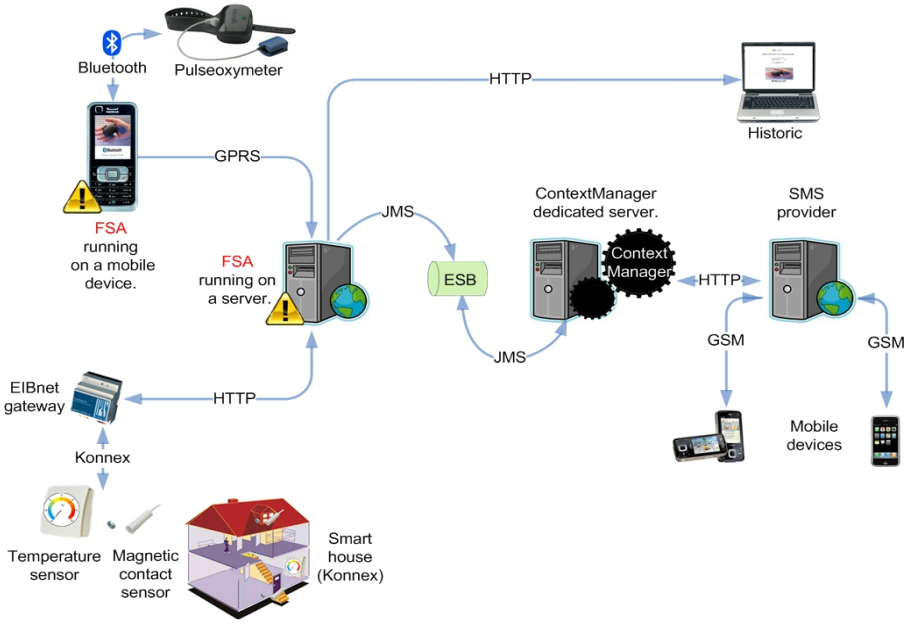

Fig. 2. MPOWER environment data flow

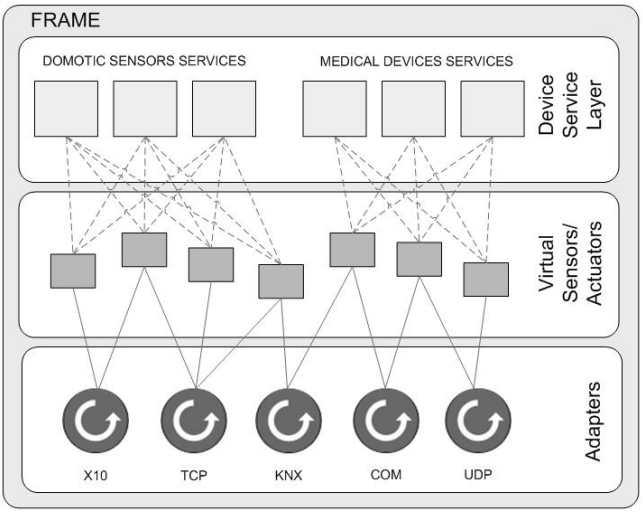

Fig. 3. Frame Sensor Adapter architecture

standardized messages using IEEE 11073 specification. This message is later sent to the aforementioned integration environment ESB. Any component or service which is designed to make use of this data has to subscribe to this bus in order to capture the data in the time of its inserting to the messaging bus.

FSA architecture defines a framework to access sensors and actuators through several communication channels with the same interface in terms of information instead of raw data and whatever the information comes from. The goal of the FSA model is to hide complexity and details inherent to the sensor communication to the remaining system. The FSA model can be divided into three layers: Adapters, Virtual Sensors/Actuators and Device Services. In terms of SOA, the first two aforementioned layers belong to resource layer, whereas the last one - Device Services belongs to the service layer.

Adapters face communication protocols and can communicate with the physical layer (devices, sensors). For instance, serial port adapter knows which virtual sensor it is associated with, so when a message from real sensor comes, the protocol specific adapter figures out related the virtual sensor. Then the message is passed to that virtual sensor which knows which message format to be used for communication with a physical sensor and which represent a device/sensor in the system.

Furthermore, there exists another layer which makes the captured data accessible for any external component. This layer consists of web services which talk to the proper virtual sensor asking for specific information.

4.2 Context Management

The component called ContextManager allows taking certain actions suitable for the given context where context is defined as a particular state of environment where the platform is running. It is an important piece of software which compares the received data produced by domotic sensors or medical devices with predefined by the user situations to be recognized and treated. These situations (contexts) are described by a series of rules and the execution of the comparison is done by a rules engine [6]. This mechanism responds differently when a particular rule matches the given at the moment context. Its main objective is to launch specific alarm types related to different kind of those situations. Afterwards other components or services are able to receive the alarm notifications and react properly. Figure 4 presents the MPOWER architecture emphasizing the FSA, ContextManager and ESB roles. The arrows represent the data flow within the MPOWER environment.

4.3 Enterprise Service Bus - ESB

The ESB plays a crucial and very strategic role in controlling the MPOWER data flow. It gathers all the information from the physical level and distributes it to the proper target. Moreover by the means of different kind of binding components and service engines ESB can manage with a variety of protocols and messages formats as SOAP or JMS.

MPOWER is designed to use business processes definitions in Business Process Execution Language (BPEL). For example there exists a process especially prepared to control the data flow during the notification process execution which runs on the BPEL integrated engine. The notification process serves to send the alarm notification messages to the subscribed applications and control its treatment progress. The chosen ESB environment for the project was Open-ESB [5].

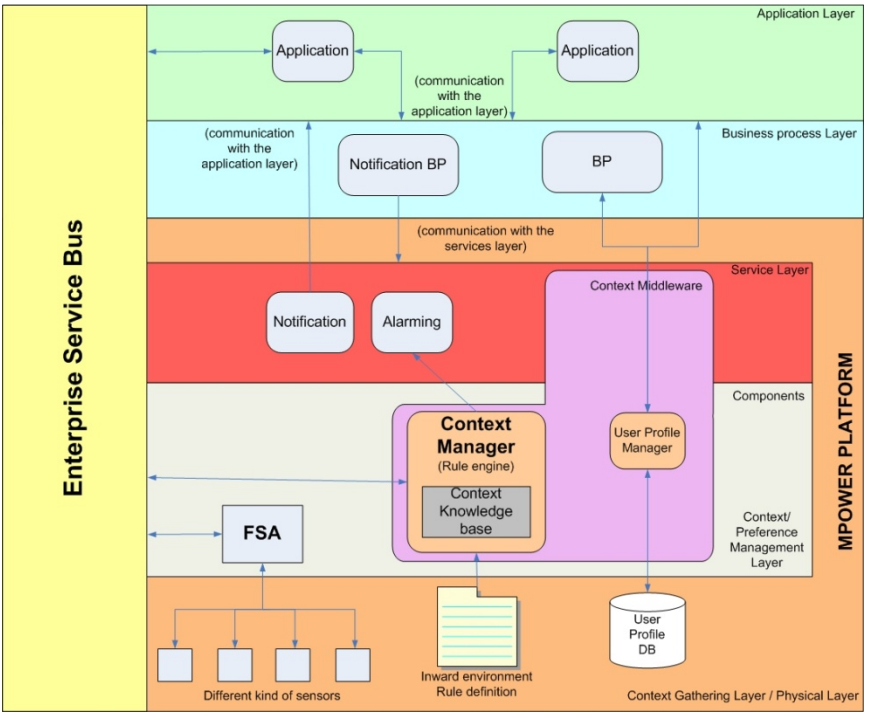

Fig. 4. Context Manager within the MPOWER architecture

5 Conclusions

Many people need medical assistance, but it is very hard for them to accept the new conditions of living in residences, clinics or other medical centers. Therefore new trends are to assure the constant medical support, patients surveillance and assistance, in the place of their living. In case of the MPOWER project the target group of end users is elderly and cognitive disabled. The elderly can stay at their houses sending necessary medical data to their medical centers and being constantly monitored or attended to raise their independence and to improve their quality of life.

The MPOWER project now reaches its final stage of development. Within the project has been created a platform for the development of interoperable applications that use innovative end-user services. Key application-level and integrated complex services have been implemented. In order to validate the MPOWER middleware platform two Proof-of-concept applications were designed for end-users of different needs and characteristics. The main achievement is providing two applications: first that help in medical information sharing and the second one which is SMART HOUSE technologies based. Both applications are currently being tested in order to get the feedback from the elderly on how the applications improve their daily life applying new trends in health-care outside their medical centers.

The real platform usage evaluation will be based on that aforementioned feedback. It is expected that MPOWER information, interoperability, security, communication, sensor and SMART HOUSE integration middleware makes the development of health-care applications and integrating new health-care related services fast and easy. Experience gained when developing the platform should be a considerable step towards the sought improvement of life of the elderly and cognitive disabled. It can also indicate new trends of home-care in conjunction with the intelligent environments of sensor technologies.

References

[1] MPOWER project official web site, http://www.mpower-project.eu

[2] Walderhaug, S., Mikalsen, M., Benc, I., Loniewski, G., Stav, E.: Factors affecting developers' use of MDSD in the Healthcare Domain: Evaluation from the MPOWER Project. In: Proceedings in ECMDA related workshop, Berlin (June 2008)

[3] Mikalsen, M., Walderhaug, S.: eMPOWERing the elderly and cognitively disabled. IEEE Pervasive Computing 6(1) (January-March 2007), http://www.sintef.no/project/MPOWER/b1wip.pdf

[4] Poza Lujan, J.L., Posadas, J.L., Simo, J.E., Perez, P., Simarro, R.: Modelo de arquitectura de comunicaciones Frame-Sensor-Adapter (FSA)., XXV Jornadas de Automatica, Ciudad Real (September 2004), http://www.ceaifac.es/actividades/jornadas/XXV/documentos/119-osanaupspo.pdf

[5] Official web site of Sun Enterprise Service Bus implementation: Open-ESB, https://open-esb.dev.java.net/

[6] Official web site of JBoss Rules Engine implementation: DROOLS, http://www.jboss.org/drools/