CARDEA:
Service platform for monitoring patients and medicines
based on SIP-OSGi and RFID technologies in hospital
environment

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Abstract. This paper describes the CARDEA platform. Main technologies are
described and how they are been used for this platform. CARDEA architecture
deployed in Hospital Gregorio Marañon is shown and the expected results of
the pilot.

Keywords: monitoring, hospital, medicines, patients, RFID, OSGi, ESB, SIP

1 Introduction

A hospital enclosure is usually a complex environment with a huge number of rooms
normally arranged in different and connected buildings. This situation means a lot of
obstacles for the transmission of the radio signals. Therefore, solid strategies and
redundant measures of position, and radio with good technical skills to cross materials
must be used in such environment.

A typical hospital service could be composed by scattered units physically and
logistically, that serve an important number of patients with a very high hospital
rotation and in where many resources of the hospital staff and assets (medicines,
material and equipment) are needed to be managed, which in many cases are residing
outside their own service.

The CARDEA Project, in order to allow the integration of new multimedia service
generation in a uniform way into the hospital environment, try to research the
definition and development of a service platform for hospital monitoring based on
different standards, which in turn allows third parties to deploy services on a standard,
safe and controlled way, without having to invest in proprietary solutions and difficult
integrations.
2 Technologies

As explained before, this project has been developed using four different technologies:

- The global element in this environment is the Framework. For this framework we have used the OSGi technology.
- The use of RFID tags allows the platform to capture information about medicaments such as quantity, name, composition, expiry date, etc.
- The information captured is processed on the platform and it will generate alarms and error messages that will be sent to mobile nodes. For this functionality we have used the SIP technology by integrating SIP elements into the OSGi Framework.
- CARDEA is context-aware. The situation of people considered as actors in the hospital together with assets like expensive medicines are considered as elements with a dynamical situation. A Semantic Web based ontology managed with Jena, a knowledge rules API integrating Pellet and a middleware for capturing, storing and delivering context information is integrated. This subsystem is called OCP (Open Context Platform).

For the correct understanding of how this system works it’s necessary to explain the main features of the technologies involved: OSGi, RFID, SIP and OCP

OSGi
The OSGi platform (Open Service Gateway initiative) was defined by the international association OSGi Alliance. Its main objective was to define open software specifications for designing compatible platforms that were able to provide multiple services. OSGi defines an extremely efficient infrastructure for designing service based applications inside a Java Virtual Machine (JVM) and provides a development environment running on Java and 100% compatible with J2ME.

The main part of the infrastructure is the Framework that implements a dynamic component-based model. With this model the mentioned environment is able to manage the applications installed in the framework in a dynamic way. The applications (named bundles) can be installed, started, stopped, uninstalled and updated remotely without needing to restart neither the device nor the framework.

The key element in the OSGi framework is the component or bundle. Every bundle can consume services provided by other bundles and can provide another services at the same time. This process can be explained below:

- A bundle can register and unregister services in the container in a dynamic way. For obtaining interaction this bundle must register a service interface and a class that implements this interface. Every change in the service (register, change, unregister) will produce some events that will be captured and processed by the framework.
- If another bundle wants to use the service registered by the previous bundle it will ask the platform for the service reference. When it obtains the service reference thought the OSGi platform, the service is ready to be used. The
consumer bundle will be able to call any method of the service which implementation was registered by the provider bundle.

The services will be available and registered if the bundles that implements them are installed in the platform.

**RFID**

RFID (Radio-frequency identification) is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID tags or transponders. The RFID technology is used to describe a communications system that transmits the information located in a RFID tag via Wireless. The technology requires some extent of cooperation of an RFID reader and an RFID tag.

An RFID tag contains the identity of an object that can be applied to a product, resource, person, etc. A RFID tag can be divided into two parts: integrated circuit for storing and processing information and for modulating and demodulating the radio-frequency signal, and antenna for receiving and transmitting the signal.

The main properties of the RFID technology for this project are: the RFID technology permits the system to store information about the products marked with RFID tags; RFID tags can be read from several meters away and beyond the line of sight of the reader; RFID tags have become very cheap nowadays with a unitary cost of a few cents of euro.

In this project we have used passive RFID tags which have no battery instead of active RFID tags which need to contain a battery to be located by the reader.

**SIP**

The SIP protocol (Session Initiation Protocol) is a application-level signaling protocol defined by the IETF (Internet Engineering Task Force) with the RFC 3261 4. The aim of the IETF is that the SIP protocol becomes the standard for the initiation, modification and finalization of interactive session which participate multimedia elements such as video, voice, instant messaging, online game, etc.

SIP supports device mobility, location independence and has robust security specifications. The main feature of SIP and the one that made us choose SIP in the project is that it can resolve addresses by the use of URI’s (Uniform Resource Identifiers) 4. With these addresses we can determine the physical address of the user in any time and also the IP address of the device that is used. Any user can establish a communication with another user only knowing the information about the URI identifier. Other features of SIP are: session negotiation, call management, modification of the features of a established session and possibility of updating the protocol with extensions.

**OCP**

OCP is a middleware which allows services and applications in a service oriented architecture to be context-aware. Context-aware computing is a recently emerged paradigm which allows to adapt to changes in the environment. Adaptation is done by
services and applications by using up to date information about the state of end-users (i.e. patients and hospitalary personnel in the case of CARDEA).

In OCP environments, there are two main roles for software entities engaged in them. The first one is the context producer. A context producer is a dynamic entity, usually a software entity related to a concrete person, which changes as the user changes her state. For example, a CARDEA client running on a hand held device will change its current location within the hospital when the corresponding nurse carrying the device changes her location also. The second role is the context consumer. Usually, a consumer of context information is a service or application that consumes such information to adapt its behaviour. For example, a different interface for the CARDEA application is displayed depending on the device that the user is working with (e.g. PDA, laptop, etc.).

Users, devices, physical environment, all these information is represented in an ontology domain. This representation is based on OWL and hosted and managed by Jena. Among the main advantages of such representation we have a common and shared representation of the domain for all the CARDEA elements, managed by OCP.

4 Global Architecture of CARDEA

The diagram of Fig. 2 describes the architecture by levels and identifies the subsystems involved and the relationship between them.

![Fig 1: Global Architecture](image)

The global element in the infrastructure is the OSGi node. It deploys the basic elements of CARDEA that are, the Contextual Information Management System (OCP), the service that allows the interaction multi-device (SIP) and the services of hospitals and laboratories thought the Mule module. We can see different layers; the bottom layer supports the operative system, with a Java virtual machine installed. Running on the virtual machine we can see the OSGi framework, which is 100%
Java. The rest of the items placed on the upper layer are the corresponding OSGi bundles which register services in the platform that can be used by other applications. One example of the services built based on this architecture is the “OCP - Contextual Information Management System”, formed by the following components:

- **Jena 4**: Open Source Semantic Web Framework for Java. It provides a mechanism to manage ontology in OWL format, extract the data and store it in the database and obtain results thought its inference engine.
- **OCP Service**: Main part of the OCP System. It creates context objects with the information provided by other agents and manages them. It communicates with Jena in order to make it persistent.
- **RFID**: Acts as a RFID server. This service receives the information that was read by the RFID readers and transmits it to the OCP service so that it can be transform into context information.
- **SIP**: The SIP service is used to establish communication between the OSGi framework and some external elements (mobile phones, PDAs, etc.). The SIP service is provided by a bundle installed in the platform, so every bundle can use it in order to send messages or make SIP calls.
- **ESB**: This element is a middleware based on synchronous and asynchronous messaging that provides secure interoperability between applications using XML. This middleware allows business applications to communicate each other. This service make logical decisions using the information provided by the OCP service and use the SIP bundle for accessing to external entities.

This system provides some functional facilities:

1) When a medicine tagged with RFID crosses the system of RFID readers, the information of the tag is transmitted to the RFID service in the OSGi platform.
2) This information contains the type of the medicine, the expiry date, the current time and the identification of the tag. When calling to the OCP service these attributes that define a medicine are transformed into a context object called “Medicine” and managed by the OCP Service.
3) The OCP Service stores this object into a database thought the Jena service, so the database contains all the object references generated in the OCP bundle.
4) The ESB service is subscribed to the context notifications generated by new Events in the OCP bundle. This subscription allows the ESB service to be notified when a new medicine object arrives. The ESB service can determine the stock of a certain medicament and act in consequence.

5 **Validation at Gregorio Maraño Hospital**

The CARDEA platform is being tested in a real scenario by means of a pilot deployed in Gregorio Maraño hospital. This scenario has the following elements:

- **CARDEA platform**: The CARDEA platform was installed in a server located at Gregorio Maraño facilities.
• RFID tags. These tags are stuck on the medicine unit. (Fig 2-b)
• RFID sensors (Fig 2-a). Two groups of RFID sensors are installed in Gregorio Marañón Hospital facilities.
• RFID PDA reader (Fig 2-b). This reader registers the tags stuck on medicine units and inserts them into CARDEA platform. Besides the registration, the reader allows to get/modify the information registered and check the localization of the medicine units readers.
• Console of activity. This console allows viewing the activity registered by CARDEA platform. Basically, it receives all the notifications sent by CARDEA ESB module.
• SIP agent on device emulator. A SIP agent was installed in a mobile device emulator. This agent receives alarm notifications from CARDEA SIP module of different alarms:

Currently the pharmacy service of Gregorio Marañón Hospital is validating CARDEA and the results will be collected at the end of March.

Fig. 1. a) Pharmacy service corridor. Two RFID sensors are shown, which registers the out of medicine units. b) Medicine units with RFID tag and the RFID PDA reader.

Acknowledgments. Many people have been involved in the success of CARDEA platform: Alfredo Pedromingo, Eneko Taberna, Pablo Piñeiro (Ariadna Servicios Informáticos); Francisco López (Murcia University), Augusto Morales (Universidad Politécnica de Madrid), Carlos Ángel Iglesias (E-Práctica), Dra Ana Herranz and Dra Arantxa (Pharmacy service in Gregorio Marañón Hospital)

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