Using SOA for a Combined Telecare and Telehealth Platform for Monitoring of Elderly People

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Abstract. Remote monitoring is considered one key factor towards the improvement of elderly people's quality of life and the reduction of healthcare costs. This paper discusses the prevailing network and software architectural principles in this sector and presents the way that they are applied into the inCASA platform. We emphasize on how services could be offered in a standard and re-usable way on top of the underlying physical layers. The aim is to apply Service Oriented Architecture (SOA) in a healthcare-based Internet of Things (IoT) environment. This approach supports a combined telecare and telehealth solution for monitoring of frail elderly people.

Keywords: Remote healthcare monitoring, ageing independently, Service Oriented Architecture, Internet of Things, Web of Things, middleware, ubiquitous healthcare environment.

1 Introduction

Ageing population is one of today's major issues. There is a worldwide focus on improving elderly people quality of life while reducing health-care costs. Under these circumstances, Remote Healthcare Monitoring has gained a great interest for many years, with the perspective to offer health services remotely on top of health devices and biometric sensors. These services shall help elderly people to live in an independent way in their own home targeting and provide a significant decrease in their hospitalizations.

From a technical point of view, such environment consists of various devices, sensors, communication links and protocols. New services should be easily deployed to meet ever evolving needs of end users. There is thus a growing interest in applying Service Oriented Architecture (SOA) [1] to ease new services development and deployment in a healthcare-based Internet of Things (IoT[1]) environment.

[1] IoT refers to physical objects' virtual representation on the Internet or other network.

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There are several similar research and pilot deployment activities, namely MobiHealth [2], CAALYX [3], CommonWell [4] and RENEWING HEALTH [5]. The approach of the inCASA (Integrated Network for Completely Assisted Senior Citizen's Autonomy) project [6] differs from the previous ones, in the sense that it is based on a high level middleware which allows developers to build SOA-based applications on top of device and sensor networks without the need to get involved with low-level network and communication issues.

A key aspect of the inCASA solution is that it combines both a telecare and telehealth perspective, so that movements, activities and habits are monitored as well as vital health signs such as blood pressure, glucose levels, heart rate, weight etc. The service-oriented approach makes it possible to create a uniform way of integrating, accessing and consuming data from devices and sensors in both.

2 The inCASA Platform Architecture

inCASA aims to create citizen-centric technologies and a services network to help and protect frail elderly people, prolonging the time they can live well in their homes. As a key contribution of the platform, it is considered the profiling of user habits and the generation of alarms in case of divergence. This is instigated by the fact that elderly people tend to follow a quite habitual way of living (i.e. daily routines).

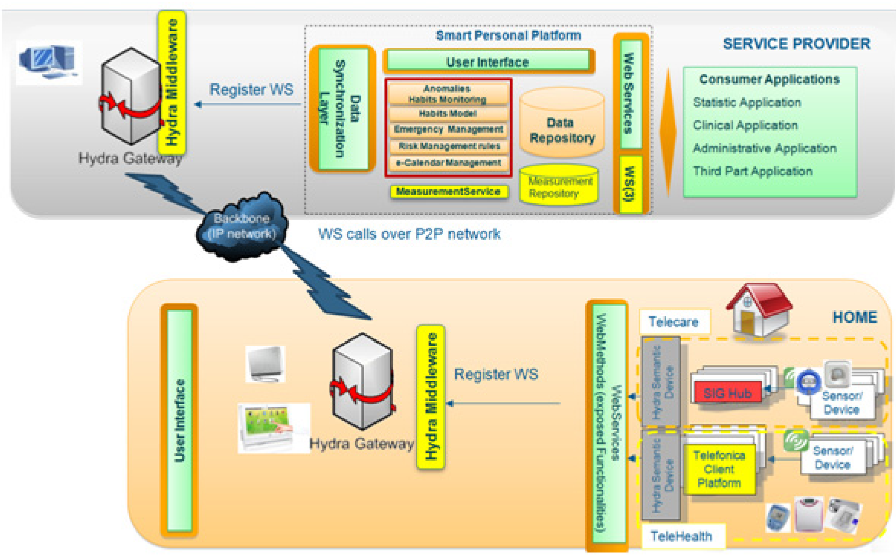

Fig. 1. The overall inCASA platform solution with two sets of middleware installations and physical locations with a Web Service defined structure of communication

The main functional user requirement is the existence of an interface provided to the professional end users where they can observe real-time measurements, extract historical data, get alerts, set and configure parameters per patient. In order to support this, a multi-component reference architecture has been developed (Fig. 1). The inCASA platform is divided into two entities that are communicating with each other through Web Service calls over a Peer-to-Peer (P2P) network provided by Hydra (more explained in the next section):

1. End User's entity where both clinical and environmental data are collected.
2. Service provider's infrastructure entity where data is collected, analyzed, stored and made available to Consumer Applications.

2.1 The inCASA Platform Environment

Firstly, the inCASA platform environment is divided into environment monitoring devices and vital-sign monitoring devices where the first are collected by an Activity Hub [10] while the latter are collected by a Telehealth gateway. The common set of devices/sensors requirements includes accuracy, energy-saving, continuous up-time, configurability and wireless connectivity support. It is also important to prevent physical or logical unauthorized data access by data encapsulation in a standardized communication protocol.

Secondly, the platform environment is comprised by a service-oriented middleware for Internet of Things applications, Hydra, and service consuming subsystems like the Smart Personal Platform and for the inCASA project specially developed Consumer Applications.

2.2 The Hydra Middleware

The Hydra Middleware is the central building block for the Socio-Medical platform in inCASA solution supporting discovery and configuration of inter-connected devices. Hydra is the architectural component of the proposed solution that allows SOA application in a healthcare-based Internet of Things environment [7], [9].

Hydra allows different isolated home networks (for both patients and medical personnel) to be interconnected by implementing an architecture based on P2P technologies [11]. It discovers the different devices (medical sensors and actuators) and selects the most appropriate software components through a proxy that controls the specifics of the communication and data exchange with the device. It also offers the services of the device in a standard and easy-to-consume way, by the use of web services and UPnP (Universal Plug and Play) technologies. This allows for service discovery at the local network level where services are published in the overall Hydra network, that is a P2P network and transparent to the user of the application.

To summarise, it could be said that the Hydra middleware is an intelligent software layer placed between the operating system and applications and it contains a large number of software components (i.e. managers) that handle various processing tasks.

2.3 The Smart Personal Platform

The Smart Personal Platform (SPP) retrieves, stores and analyzes the end user's data received from the inCASA gateway (i.e. Hydra). The SPP has two main roles. Firstly, it collects the monitoring data and creates a habits model for the patient. Secondly, it is focused on the logical processing of incoming monitoring data including extended reasoning mechanisms responsible for comparing of collected data against stored user habits model, to detect deviations.

The SPP is a software application consisting of various modules, namely the Habits monitoring module responsible for the building of "User Habits" profile and the generation of alarms in case of divergence, the Emergency and Risk Management module which analyzes the incoming data to identify the possible actions needed or risks to be handled and the Socio-Medical Calendar module which allows the inCASA operators to arrange appointments and plan for future activities with the inCASA registered patients via the Consumer Applications interface.

2.4 The Consumer Applications

In inCASA, Consumer Applications (CAs) use Web Services exposed by the SPP. These are a set of high level views available to the personnel of the inCASA pilots and are responsible for the rendering of data and alerts for professional GUIs.

Since Consumer Applications are the back-end of the inCASA platform where the operators have access, they are also responsible for the integration of Telecare and Telehealth data into a unified view per patient. Moreover, Consumer Applications expose web services to be called by the SPP upon alarm generation, whose functionality includes on-screen alert and relevant update to the operators or/and to patient's relatives via SMS and e-mail.

3 Middleware as a Key Component towards SOA

Hydra's main role in inCASA is to allow software architecture specifications to be based on its middleware principles in order to ensure communication and interoperability between different modules.

Fig. 2 shows how the different middleware components are embedded in gateways and devices to create the SOA in which the services of each device appear as Web Services and UPnP services. Two Network Managers in two separate locations within same network are using P2P techniques to communicate. A Discovery Manager discovers any new device that appears on the other side by using SOAP tunnelling [11] mechanisms of the Network Manager on first side. It makes a query about the remote device or application. The Network Manager on second side receives the request and resolves it using an internal ID database which results in a local Web Service call to the device's generic Hydra Web Service. This call is then handled by the Application Service Manager that adds a semantic layer and complements the Application Device Manager with a service perspective mapped to the device

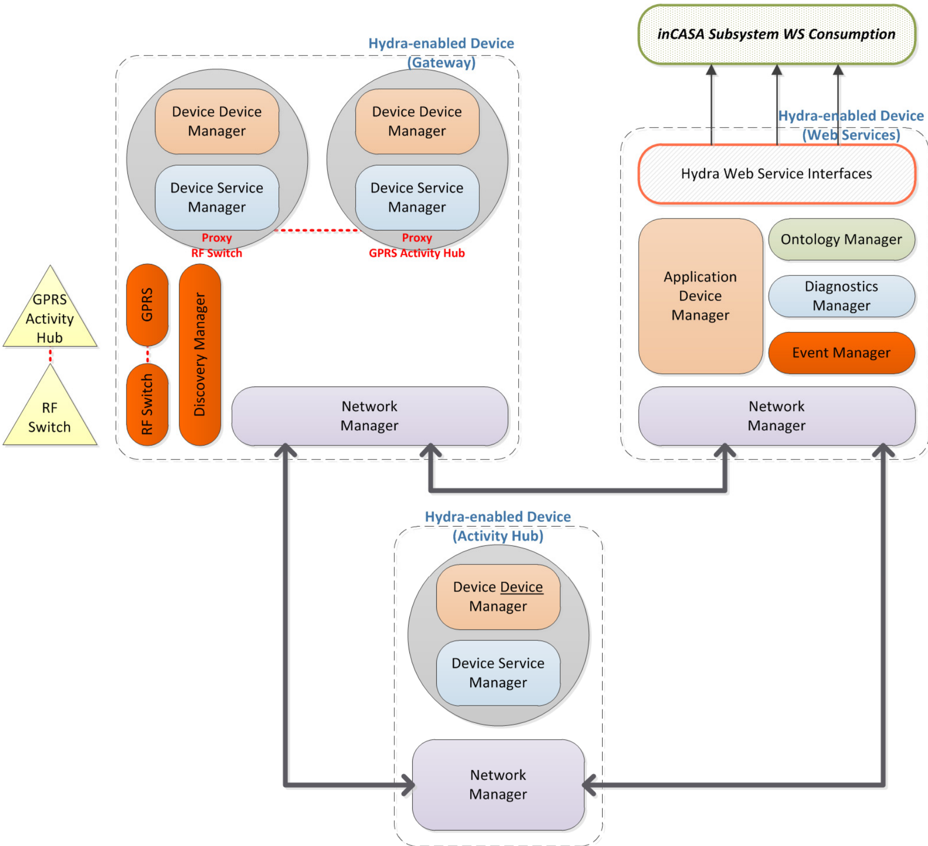

Fig. 2. The Hydra Middleware architecture and its main components for representing a physical device as a web service

functionalities. This underlying communication in Hydra is based on SOA and transparent as resource for model-driven development of inCASA applications [7].

4 inCASA SOA Solution

inCASA's various types of medical devices and sensors are managed by extended device ontology where the semantic representations of devices and their service descriptions are used to generate Web Service interfaces. These allow inCASA programmers to access and use devices using standard web technology.

The inCASA middleware uses SOAP tunnelling to make web services calls between physical devices in two different networks enabling control and access of a device in patient's home from a service provider network. Using the SOA and MDA

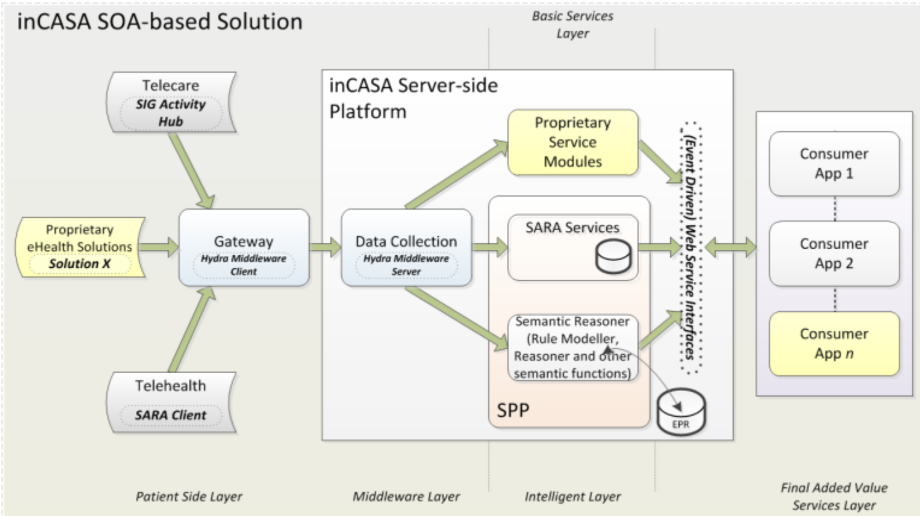

Fig. 3. The inCASA SOA solution with all involved technologies present

approaches in Hydra, inCASA has gained features that allow developers to create any possible ubiquitous services and systems that interconnect devices, people, terminals, buildings, etc. This is realised by providing interoperability at a semantic level by extending semantic web services to the device level. The middleware client that runs on the home gateway uses web services to publish embedded interfaces and services to the inCASA network. In this way inCASA uniformly supports different standards where for instance any Continua/IEEE11073 [8] device can connect to the gateway as well as other types of non-Continua devices.

5 Conclusion

This paper shows how a middleware based approach allows inCASA to implement SOA support to a wide range of applications for ageing independently by remote monitoring. The approach achieves interoperability at service level and not by data exchange mechanisms alone while meeting the requirements for connecting and using a wide range of different devices even though following different types of standards.

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