MOBILE HEALTH MONITORING PLATFORM FOR AAL APPLICATIONS

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Abstract: Mobile devices able to monitor diverse health condition parameters are becoming widely available. Also, mobile devices with wireless communications with significant computing capability (e.g., tablets, smartphones) are becoming available every time everywhere. Placing such devices to operate together will allow to deploy the so called ambient assisted living technologies, which allows for individual health condition monitoring almost everywhere and any time required. This paper presents a solution able to monitor several physiological parameters using the mobile platforms running android. The implemented solution permits to integrate transparently services from remotely distributed devices.

1 INTRODUCTION

The use of information and communication technologies is nowadays widely accepted as a way to offer new solutions for healthcare. Those solutions will improve the quality of life of patients, reducing costs at the same time. However, before that happens, new solutions, including both hardware and software, must be available in order to acquire and store the required signals, to process and extract information from those signals, and to detect a set of features required to fire alarms and/or electronic assistance.

Despite the availability of several platforms for signal acquisition (Pantelopoulos and Bourbakis, 2010), a few technological issues must be solved before they can be used. The platforms must offer quality of service, be wearable, and operate for a comfortable period of time. The systems should allow to remotely monitor one or a set of subjects and to monitor their health and activity. Based on that, and on a set of information associated to that subject, it is possible to offer different levels of services. One will be self-remainders that are preset by the subject; the other will be reminders by some familiar or caregiver; and finally, a health service based on clinical data may also be offered, if good enough health engines are available to extract the "health condition".

Despite highly desirable, the success of such technologies depends on the users' (patients, caregivers, medical doctors) technology acceptability. One way to increase the acceptability is to design the solutions based on devices already widely familiar to users.

One solution already proposed is to use android based platforms. Such solutions were already used to record physiological signals and make them remotely available (Altini et al, 2010; Colunas et al, 2011). However, such solutions were not designed to support a significant number of signals, patients, and caregivers supplying and accessing to physiological signals.

We present the architecture of a complete system for a distributed monitoring system for ambient assistant living. We also describe the components of one of the subsystems, an application for a smartphone and the supporting hardware for vital-sign acquisition.

The paper is structure as follows: in the second section, we describe the complete architecture for our distributed system and its main subsystems. In the third section, we describe the hardware of our acquisition system. The fourth section, describes the Android application that implements the components of the mobile subsystem. Finally, we conclude.

2 e-UMIHEALTH SYSTEM

In Figure 1, we represent the application's scenario targeted by our system. In this scenario, we identify

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three key elements of our system: an e-UMIHealth domain controller (care centre), an e-HealthDroid device and a bio-signal device.

An e-UMIHealth domain controller is a caregiver centre. It is the entity in the network that manages the e-HealthDroid devices. A key aspect of the management is the definition of the users' profiles. These define categories of users that have different access to the data, such as medical doctors, nurses or other personnel. The e-HealthDroid device is a smartphone based on the Android OS that implements our software stack. Through its application-programing interface (API), it provides a bridge to its associated bio-signal device. In this sense it works as server for the sensors' data acquired by the bio-signal device. The bio-signal device is the sensing element that acquires the several biological signals. A bio-signal device is also called a secondary entity, since its sensors' data is only accessible through an e-HealthDroid device. An e-HealthDroid device may have no bio-signal device associated to it, but be used to inquire data on another e-HealthDroid device (server). The e-UMIHealth domain controller and the e-HealthDroid device are also called primary entities, since they interact directly among them.

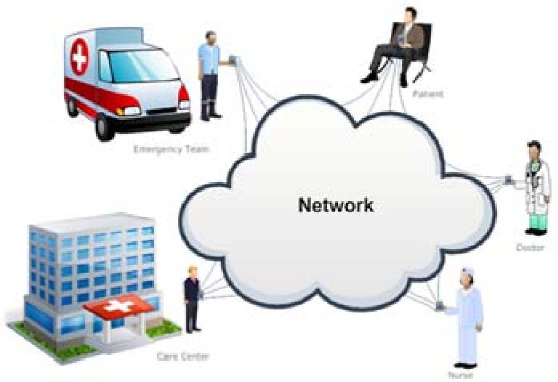

Figure 1: Business use case.

2.1 Architecture

In Figure 2, we present e-HealthDroid architecture. The e-HealthDroid subsystem has five components: service manager, event manager, subscription table, profile table and user table.

In the following subsections, we describe the main components and their interaction.

2.2 Service Manager

The service manager manages all incoming service requests. These requests are session based; therefore, the manager requires that the requesting entities must authenticate themselves before issuing any further request besides the authentication service. After opening a session, several services may be issued till the session is closed. Upon receiving an authentication service request, the service manager contacts its e-UMIHealth domain controller to validate the credentials of the user and its profile. This information is recorded in the user table and it is active while the session is open.

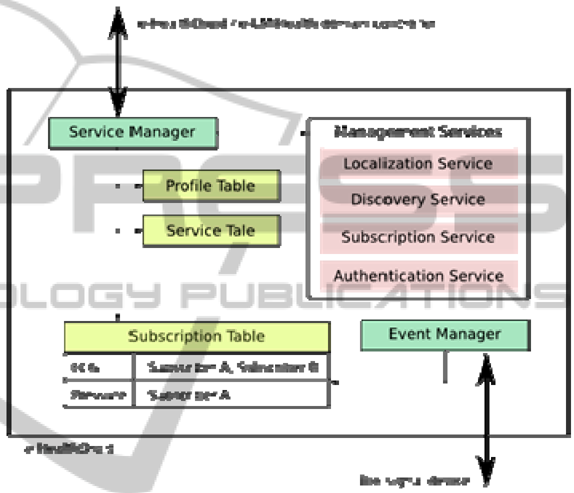

Figure 2: e-HealthDroid architecture.

Table 1: Description of services.

Service	Description
Authentication	The authentication service is used by a primary entity to authenticate an user in order to request further services. All services are subject to authentication and are subject to the level of access defined for the user's profile.
Subscription	This service permits that a primary entity may subscribe to one or the several sensors' data. This subscription can be issued for a single value (pressure at the moment) or a stream or chunk of data (ECG signal).
Discovery	Any primary entity may get a list of all kinds of sensors present in the bio-signal device.
Localization	Using the localization service, we can find the position of the e-HealthDroid device. This service uses the capabilities provided by the Android OS.

When a primary entity requests a subscription service, the service manager updates its subscription table, taking into account the user's profiler. This information is used by the event manager. In Table 1, we list all the services provided by the service manager.

2.3 Event Manager

The event manager is responsible for routing the sensors' data (events) according to the information contained in the subscription table. The routing is based on the publisher/subscriber model (Buschmann, 1996). The data may be requested as different types of events: a single sample event, a chunk of samples event or a stream of samples event. Upon finishing serving a single sample or a chunk of samples, the event manager clears the respective entry in the subscription table. An entry in the subscription table may also be cleared by the service manager if the associated session is closed.

3 ACQUISITION SYSTEM

In addition to the developed software, and for test purposes, it is also required to implement an acquisition system able to be worn by users. One solution is to develop regular clothes with the acquisition devices directly embedded. The other is to develop small enough devices to be hidden in regular clothes, with the ability the record the required signals. Figure 3 shows the available device used for signals recording (*bio-signal device*).

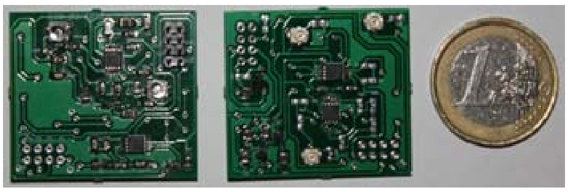

Figure 3: Physiological acquisition device.

This in-house device allows recording one lead ECG, oximetry, and temperature. This device has then possibility to be directly connected to an e-HealthDroid device (android platform) through USB or using a wireless link. Either case, the recorded signals may become available through the e-HealthDroid device.

4 THE APPLICATION

Figure 4 presents the various screens for the Android application that implements the API of the e-HealthDroid sub-system. This application enables the user to connect to his bio-signal device or other servers (e-HealthDroid devices), choose events from the ones permitted by each server and see the received data in the form of a dynamic graph or a numerical value. The e-HealthDroid device can itself be a publisher for the user's events (associated bio-signals device) and so permissions should be defined in the profiles.

The principal screen (Figure 4a) is the one where the user fills the user and password's login and writes the name of a server to which is intended to connect. The login is necessary so that the server can obtain the client's category (by contacting the Care Center Database) and tell the client what events can be then subscribed. The Figure 4b) shows the Subscribing screen, where the user selects one of the servers to which is already connected and is presented with the events that has permission to subscribe. In the exampled case, the user selected the Festa-HP device, for which has permission to subscribe the ECG, the Heart Rate, the SPO2, the Temperature and the Server's Profile. In this case, the user is going to subscribe the ECG event. After this subscription the user is conducted to the graphical screen (Figure 4c), the most important screen, for the visualization of the ECG signal in real time, sent by the server's device.

Every screen has at least two options: the configuration and the application exit. The configuration option leads to the permissions area (Figure 4d and Figure 4e) where the user can define the permissions for each category of clients (profiles) who are allowed to subscribe each event. This can be done by first selecting the event and then choosing its desired corresponding permissions from the categories defined as Everyone (in case the event could be subscribed for every person connected), Doctor, Nurse, Other Medical Staff (such as an auxiliary or a medical student) and Care Center.

Other options are the Subscribing, which lead to the subscribing screen to add more events to the subscribed ones, and the unsubscribing screen, where the user is conducted to a similar screen to the previous one, but where the events presented are the ones already subscribed and where the user selects the ones to stop subscription. The last option is Start Menu, where the user goes back to the principal screen, with a new connection opportunity.

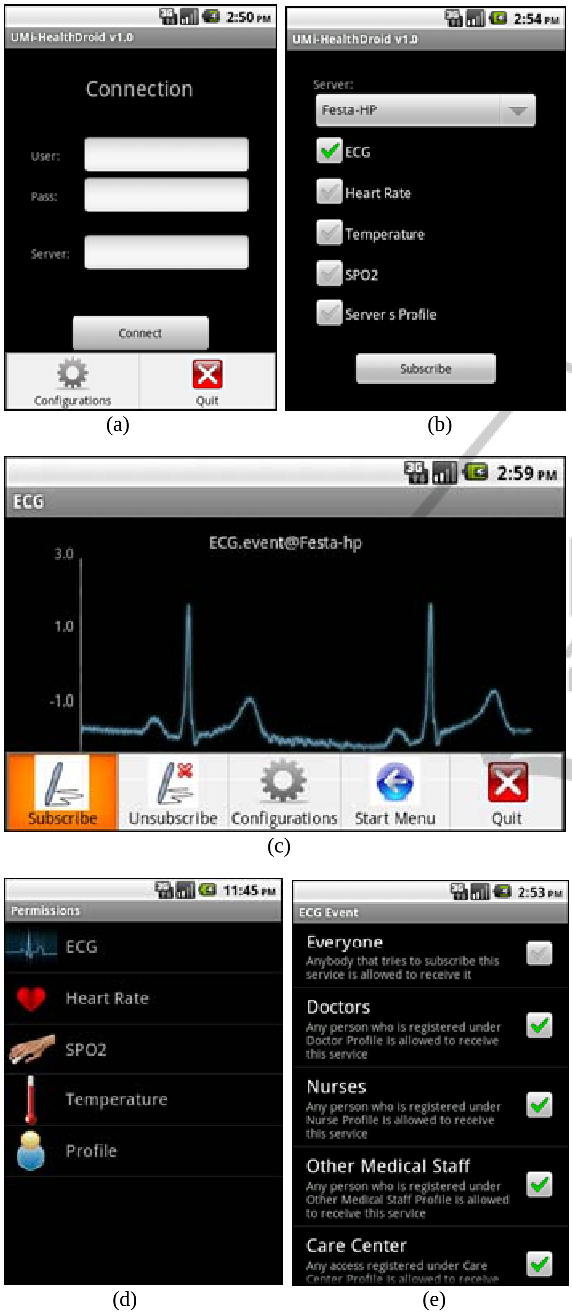

Figure 4: UMi-HealthDroid application screens: (a) Start screen – connection to servers (with Android Menu button pressed), (b) Subscribing screen, (c) Graphical screen in landscape, (d) Permissions screen (to selected event), (e) Permissions screen (to define permissions for the selected event) for each profile.

5 CONCLUSIONS

In this paper, we presented a distributed system for vital-sign acquisition. It permits that health professionals may monitor remotely and transparently critical information, as well to locate the patient using the capabilities provided by current smartphones based on Android OS. Another important aspect is the use of permission profiles that allows customising the access through a central authentication that ensures privacy of information.

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