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Mobile Caregivers in Continuous Care Networks: a Supporting Multimedia Platform

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Abstract: This paper describes a new mobile multi-channel multimedia platform, which aims at supporting mobile caregivers in continuous care networks dealing with the assistance of elderly people affected by chronic diseases. According to recent surveys, the number of individuals belonging to this group is continuously increasing as a consequence of the aging population trend. The overall objective of the platform is the creation of an extensible set of services allowing patients to stay at home in a familiar environment while being (mostly remotely) assisted 24x7. At the same time, such services support the cooperating activities of care providers working in mobility in different organizational domains and with different roles, towards the improvement of the patient's life quality.

Keywords: continuous care networks, collaboration, telemedicine, mobility

1. Introduction

The trend of aging population has attracted the attention of governments as well as business firms. As a fact, the older population is growing faster than the total population and projections indicate that, by 2025-2030, the population over 60 will be growing 3.5 times as rapidly as the total population (2.8 per cent compared to 0.8 per cent). In absolute terms, the number of older persons has tripled over the last 50 years and will increase further over the next 50 years by reaching 2 billions in 2050 [1]. Consequently, the group of people that need care and assistance services, in particular for declared chronic diseases, is continuously increasing.

Current practices, focused on care service provision supported by either patient relatives or elderly care centres, are not sustainable in the long term: on the one hand due to economical reasons (for both the social security budget and the families economic capabilities); on the other hand, the elderly care centre-based approach takes the elderly out of their usual environment and social network, thus increasing the probability of depression or social exclusion cases.

Therefore, the need to propose new care models for effective support of elderly people with chronic diseases is getting stronger and stronger, thus affecting health-care systems organization and effort coordination. Continuous care models promote home-based continuous care of chronic patients: effectiveness and efficiency of long-term condition care depend on the capability of both patients and relatives to manage their case (self-management) together with the collaboration of all care providers (integrated care). Patients, family members, health-care teams (e.g. clinicians, general practitioner, nurses,

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etc.) and social community members (e.g., social workers, volunteers) should be informed, motivated and prepared in order to collaborate effectively.

2. Objectives

The objective of this paper is to present the results achieved by the Hewlett-Packard Italy Innovation Center team during a project aimed to design and develop a mobile multi-channel multimedia platform supporting mobile caregivers in continuous care networks.

The overall objective was the creation of an extensible set of services allowing patients (typically elderly people) to stay at home in a familiar environment while being (mostly remotely) assisted 24x7. At the same time, such services support the cooperating activities of care providers working in mobility in different organizational domains and with different roles, towards the improvement of the patient's life quality.

3. Competitive Approaches and Methodology

There is a number of R&D projects and ICT solutions related to health-care and assistance to patients affected by chronic diseases. These can be grouped under two main application domains dealing with:

- Smart home, assistive technologies and environment for independent living
- Hospital-based context-aware health systems

In the former, most attempts analyzed specific aspects, such as health status monitoring, alarms and reminders based on scheduled activities (e.g. medicine taking, training activities, etc.), patient behavior and daily activities modeling [2] [3].

In the latter, examples applications of ICT tools in hospital environments provide relevant patient record information accordingly to contextual information (e.g. nurse position, patient, medicine tray), or leverage mobile devices in order to recognize through proper context elements the environment in which hospital workers perform their tasks. Users can also send messages and access hospital services according to these contextual elements [4] [5].

In all these solutions, guidelines and reference models for continuous and integrated care have not yet been extensively taken into account in the design of pervasive care solutions. Actually, this would require an integration of the aspects of home-based monitoring and assistance with cooperation support to professionals of different organizations (e.g. a hospital, care centres, etc.).

These aspects have been carefully taken into consideration during our platform design and development, considering and fulfilling requirements for both home-based patient assistance and care providers' support for collaboration, mobility and information sharing.

4. Solution and Technology Description

The proposed platform leverages different web-based, mobility and network communication technologies in order to enable:

- Real-time collaboration among the different actors involved in the care network, through a multi-channel access to shared patient-related data (an example model of EHR - Electronic Health Record - coming from a real scenario analysis in a nursing home has been implemented)
- Automatic monitoring of patient's health and environmental conditions
- Automatic generation and dispatching of personalized alarms towards the proper health operators, according to customizable management policies
- Notification of personalized reminders to the patient
- Management of requests for help or communication coming from the patient

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The solution scenario, as depicted in Figure 1, is spread over two main domains: the patient's home and the care centre. The former comprises the physical environment where the patient lives (usually with the relatives) and the biomedical and environmental equipment needed for monitoring his health conditions; the latter represents the organization responsible for providing care services (e.g. a health-care institution, a hospital, etc.) which hosts the main technology infrastructure of the system and its personnel (doctors, nurses, etc.).

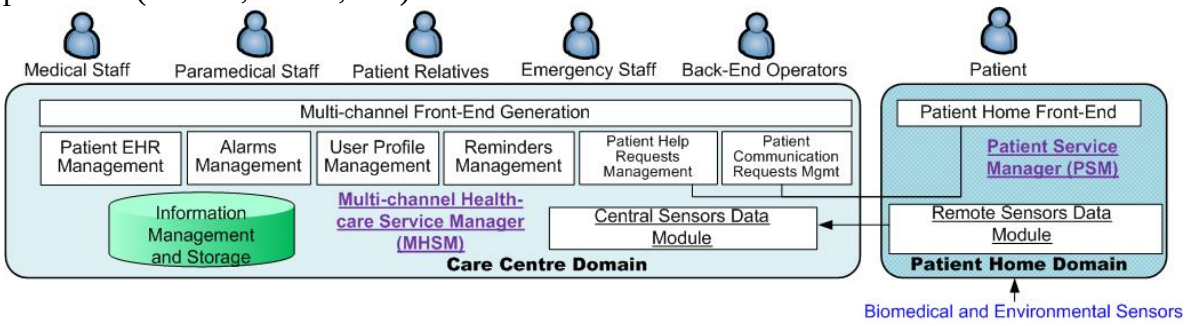

Figure 1: Overview of the Platform Architecture

The system consists of a main server-side component named Multi-channel Health-care Service Manager (MHSM), deployed in the care centre domain, and of a client-side component named Patient Service Manager (PSM), deployed in the patient's home domain. The MHSM implements a multi-channel front-end generation service, which allows providing customized user interfaces and dynamic contents, depending on the user's role and device. Internally, the MHSM is composed by a set of specialized modules for: the management of patients EHRs, alarms, reminders and system users' profile; the collection of data coming from remote PSMs; the management of patient's requests for help or communication. The PSM consists of a Patient Home Front-End module (PHFE), whose contents are dynamically provided by the MHSM through a web-service based communication, and of a Remote Sensors Data Manager module (RSDM), which collects measurements coming from (patient's related) biomedical and environmental sensors, performs a preliminary analysis, transmits them to the MHSM and, if needed, triggers alarms towards the MHSM.

After having analyzed the actual workflow in a real business scenario in Italy, we have modeled six categories of actors participating in the care network. Each of them interacts with the system through one or more devices, depending on their own role. In order to select the target devices and to design the more suitable (mainly in terms of usability) user interfaces, we have interviewed, through structured questionnaires, a meaningful and selected sample of actors involved in the system and we have analyzed their feedbacks. The actors, the selected devices and the system functionalities are depicted in Figure 2, and briefly described in the following.

The patient, at home, is equipped with a tablet PC running the PSM component of the system. After evaluating the patients' needs and their average skills in using electronic devices, we have selected a tablet PC as target device for this actor because it allows very intuitive interaction by simply touching the screen and, at the same time, it provides a large display on top of which it is possible to show big and intuitive icons. Accordingly, the PHFE component shows the patient a very simple Graphic User Interface (designed to maximize usability and easiness of access) composed by two large buttons and a text message area. Such GUI, which fits the whole screen area, enables him to receive multimedia reminder messages (e.g. for medicine assumptions) coming from the MHSM, and to perform help or communication requests by pressing one of the two big buttons placed on the touch screen of the device. The RSDM component of the PSM collects and

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transmits to the remote MHSM the performed measurements, according to scheduling policies defined by a doctor. In our current prototypal implementation (see Section 6) we have simulated the biomedical and environmental sensors, since our initial goal was mainly focused on the business case scenario evaluation and not on the integration of specific sensors. Nevertheless, the selection of real sensors should take into account specific requirements, such as measurement equipment that is not invasive for the patient and that does not require manual intervention to perform the measurements (e.g. medical wristlets, jackets, etc.). In the platform architecture, the RSDM component runs (as a daemon) on the patient's tablet pc, which is powerful enough to collect data coming from the sensors and to send them, after a preliminary reasoning (e.g. filtering in order to optimize the network traffic), to the MHSM. This distributed mechanism for collecting patients' data allows minimizing on the server-side node the processing load required to collect data related to a large patient population.

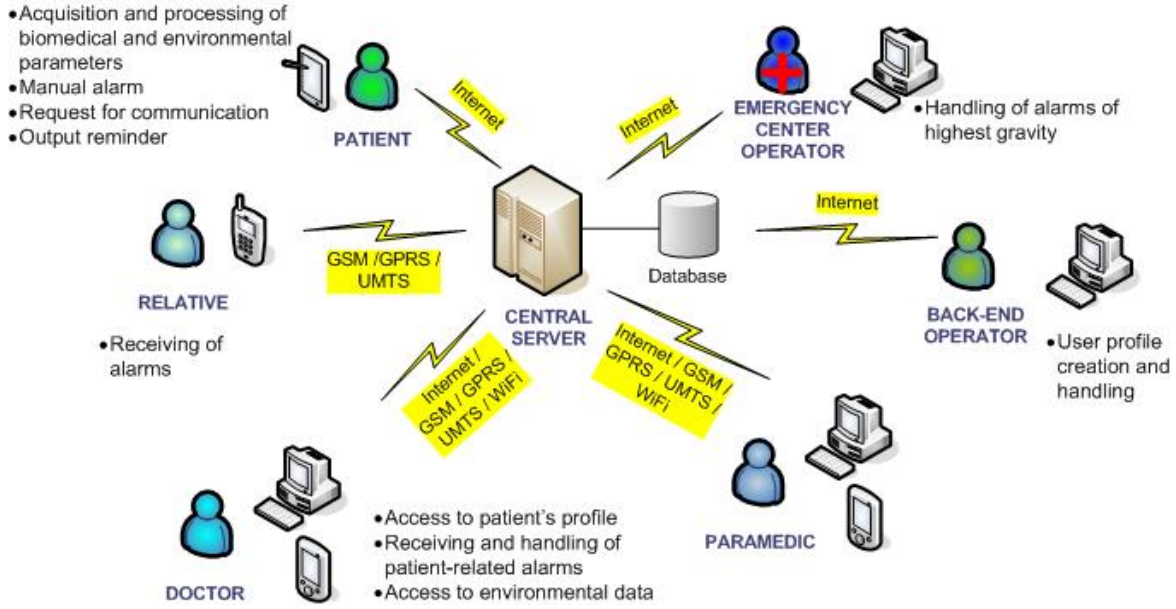

Figure 2: Solution Scenario: Actors, Devices and Main Functionalities

Medical and Paramedical staffs interact with the system either through a PC/laptop (when they are working in their care centre office) or a PDA with phone capabilities (when they are working in mobility, out of office). According to their role, they can configure for each patient a custom, threshold-based alarm policy for each kind of biomedical or environmental monitored parameter. In our prototypal implementation, we have actually simulated four different kinds of biomedical parameters: "blood pressure", "body temperature", "heart rate frequency" and "SpO2" (percentage of oxygen saturation in blood). Just to give an example of how the thresholds mechanism works, a doctor can define for a specific patient that a value of 38ºC for the "body temperature" parameter must trigger an alarm of level "HIGH". When an alarm is triggered, the MHSM alarm handling module contacts the Medical and Paramedical staff through SMS and/or email communication channels, according to proper dispatching policies that depend on both the alarm gravity levels (currently four levels have been implemented) and on the activity protocol defined by the health-care system organization. By accessing the system, the medical and paramedical staff is able to analyze the recent history of patient's related parameters and to decide the best intervention strategy. This kind of threshold-based alarm handling system is indeed independent of the pathology; it has been designed to be open to future customizations for specific pathologies, according to the specific requirements coming from the customers' health-care system organizations.

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When the system triggers an alarm, it also contacts (through SMS) the patient's *relatives*, who may provide an initial assistance to the patient. In case of highest gravity alarms (e.g. biomedical parameters at a very critical level), the platform alarms management module contacts immediately an "always available (24x7)" emergency staff, which handles the alarm by applying a proper intervention policy for emergencies.

Finally, back-end operators are responsible to manage the personal data of all the actors involved in the care network.

The MHSM and PSM components and their internal modules communicate each other by means of web services. Such Service Oriented Architecture based communication infrastructure allows to easily extending the platform, e.g. by wrapping data from external systems through web service calls. This mechanism enables the interoperability and the integration of the platform with external existing entities, e.g. the IT back-end infrastructures of health-care centers for accessing existing patient records and test results collected by other medical systems.

5. Developments

The proposed solution is a distributed platform made by various functional components, as described before, and it has been developed leveraging different and heterogeneous software and hardware technologies.

The MHSM has been developed as a mobile web application written in Java language, and leveraging the J2EE JSP/Servlet technology framework [6] in order to dynamically generate HTML pages tailored to different device clients characteristics (e.g. display size, memory and processing capabilities). In the current available implementation, we target specific mobile devices, the Hewlett-Packard iPAQ Pocket PCs and general laptop/desktop PCs. To properly manage user interface generation, business and navigation logic, and content generation, the Model View Controller design paradigm [7] has been adopted. The deployment and execution environment is Tomcat 5.x application server, as Servlet/JSP container. The platform uses the Web Services technology standards (SOAP, WSDL) [8] to interact with external components, e.g. the PSM. The underlying DBMS is MySQL [9].

The PSM Patient Home Front-End module has been developed as a standalone application written in Java language, and leverages the J2SE Swing technology framework [10] in order to generate the graphical user interface.

The PSM Remote Sensors Data Manager module has been developed as a standalone application written in Java language, and leverages the J2SE low level communication APIs (plus, when appropriate, specific sensors interface APIs provided by the related manufactures) in order to collect measurements coming from biomedical and environmental sensors. The PSM also leverages the Web Services technology standards to interact with external components, e.g. the MHSM.

In the current PSM available implementation we target specific mobile devices, the Hewlett-Packard tablet PCs. The deployment and execution environment is a standard J2SE 1.5.x virtual machine.

6. Results

The platform has been developed by the Hewlett-Packard Italy Innovation Center team, and is now part of the company Consulting & Integration services official portfolio. It has been designed to be extended and customized for specific deployment contexts.

At the time of writing, the platform architecture design has been fully specified. Moreover, a software implementation has been realized, deployed and evaluated into a real target environment, a nursing home, with simulated patients and biomedical and environmental sensors (as said before, the trial focused on the business case usage scenario,

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not on the integration of specific sensors). The testing aimed at evaluating real health operators' collaboration and acceptance of the implemented features. During the trial, practitioners (some dozens) have been equipped with Hewlett-Packard mobile devices (iPAQ PDAs and tablet PCs) and PCs and have been asked to perform day-by-day operations through the system (as depicted in Figure 3).

Figure 3: Some Pictures of the Trial Session

At the end of trial sessions, the testers' opinions about the system features have been collected through structured interviews and questionnaires. In particular, we were interested in evaluating the usability of the platform and the effectiveness of the functionalities provided in a real target scenario. Regarding the former, our main concern was related to the adoption of PDAs as usual working devices, since in Italy they still don't have a so large diffusion and people are normally not used to such kind of technologies. Regarding the latter, we wanted to investigate how long did it take for the health-care operators to gain confidence with such new technologies and instruments to fulfill the usual daily working procedures, and if they perceived actual added value from the platform.

After the interviews, a structured analysis of the responses has been performed, providing initial but significant feedbacks about the potential system capabilities. In the following, we describe some of the results coming from such analysis.

During the trial sessions we noticed that after some initial difficulties, mainly due to the pen tip-based interaction with the PDA screen, the users took confidence with the device in a very short time. Figure 4 shows how they answered the two basic questions "Have you ever used a PDA before?" and "After this trial, did you learn to use a PDA?". The pie-chart shows that most of the users had never used a PDA before, and that the majority of them actually felt to have gained confidence with it after the trial sessions.

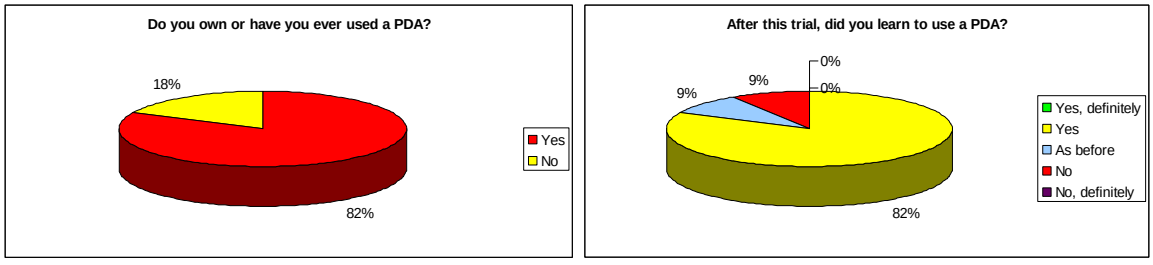

Figure 4: Results of Survey on Device Usability

Regarding the system functionalities and their effectiveness, we have submitted a set of questions related to each single feature, as well as on the overall impression over the whole platform. The feedback provided by the users were promising and, based on them, we can conclude that globally the core functions implemented were considered important and effective. Figure 5 depicts how the users answered to two generic questions related to the effectiveness of the system. The pie-charts show that the health-care center operators

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involved in the trial considered the platform as an useful work instrument, that would provide added value if adopted in real health-care center environments.

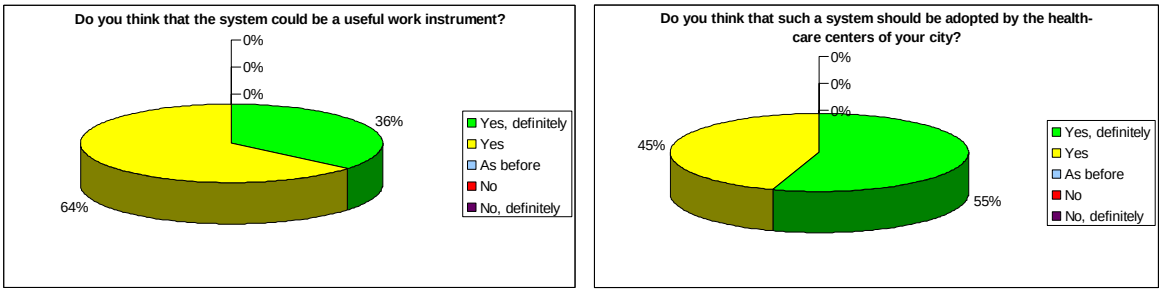

Figure 5: results of Survey on System Effectiveness

7. Business Benefits

The business impacts and benefits introduced by the platform can be analyzed and summarized from the different involved stakeholders points of view:

- The patients (and consequently their relatives), that will benefit from new innovative way of "living their chronic diseases", remaining within their usual environment and social network, thus decreasing the probability of depression or social exclusion cases and towards a better life quality. This will also benefit the impacts of such diseases on the families economic capabilities
- The mobile caregivers, who will get a enhanced support to provide a more effective assistance to the patients
- The health and social institutions which offer the value-added services, based on continuous care models, to the patients through the deployment of the customized platform in their own target coverage area: the availability of such kind of innovative services is a chance to optimize the budget spending and save money (e.g. optimizing the occupancy of hospital bed-places that instead of being occupied by people with chronic diseases can be used for other kinds of patients), and to improve the effectiveness and efficiency of long-term condition care
- The system integrators and/or service providers involved in the platform customization
- The manufacturers of biomedical and environmental sensors, mobile devices and (general) hardware, leveraged by the platform deployments

8. Conclusions

This paper presented a new mobile multi-channel multimedia platform, which aims at supporting mobile caregivers in continuous care networks dealing with the assistance of elderly people affected by chronic diseases.

The platform has been designed as a framework ready to be customized in specific deployment environments and according to particular customer's requirements. The gathered feedbacks got from an initial deployment have then been structured and analyzed in order to define a reference for further work and enhancements, targeting potential commercializations. Generally, they are very promising, showing the good platform potential for providing innovative services able to support an effective implementation of continuous care networks.

In the future work, functional aspects can be improved analizing requirements coming from specific customers' use cases, e.g. by further interacting with health-care organizations, for detecting which are the most suitable categories of patients and diseases that fit the remote assistance model we propose. Accordingly, the biomedical parameters to

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monitor and the protocols to follow in case of an emergency are strictly related to the patient's disease and also depend on the organizational policies of the care centers.

Particular attention will be given to the improvement of the usability of the platform itself according to the analyzed feedbacks, both for the customization phase (to reduce the development time of a specific customization) and for the final experience lived by the end-user (patients, medical staffs, etc.).

Additionally, scaling trials can still be planned to further consolidate the platform. At any rate, Hewlett-Packard Italy considers it ready to support full market deployment, that's expected to happen in the very next timeframe. Consequently, the platform is now part of the official Hewlett-Packard Italy Public Sector portfolio and then the reference for pre-sales activities, e.g. in the health-care business domain.

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