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SaaS-Platform for Mobile Health Applications

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Abstract—**Involving information and communication technology in health solutions has shown to raise satisfaction for both health care providers and patients. Several research works have been focusing on this issue, since it appears to be the suited solution for reaching an economically and socially viable solution to the increasing number of chronically ill patients which is currently stressing the healthcare systems. In today's context, Software as a Service (SaaS), a model in which software and its associated data are hosted centrally and are typically accessed by users using client interfaces, has become a common delivery model for several applications. However, security and privacy issues have to be given more attention in most of these implementation environments. This paper introduces an innovative SaaS-Platform suited for the implementation of mobile health solutions. The platform utilizes state-of-the art technologies in information and communication systems. It follows the principles of services oriented architecture and delivers services as a SaaS. The SaaS-Platform has a four-layer architecture model which includes the middle layer, the application layer, the communication layer and the user layer. At the application layer, solutions can be presented as web-interfaces, mobile-interfaces or client software. Basic tasks such as secure data communication, secure data storage, user management and easy-to-use interfaces are offered by the SaaS-Platform. The architecture and basic functions of the platform will be presented. The implementation of a number of telemedical and e-Health solutions on this Platform has been performed successfully.**

Keywords-SaaS; Platform; e-Health; Telemedicine; Telehealth; M-Diab; M-Skin; M-Stress; M-Fitness; fearless.

I. INTRODUCTION

The advancement in the healthcare solutions is strongly affected by the convergence between medicine and a series of technological progress in the information and communication technology, the increasing of requirements for the patient's quality of care and finally the raising cost pressure to both health system organizations and patients.

E-health solutions have been proved to be suitable candidate for the future of health care provision and it has become a very promising market for the industry. There is no wonder why big players such as Microsoft and Intel have been developing their eHealth platforms and related services in the last few years [1, 2]. Google health main focus was gathering medical information in one central place. The number of the interested users of the Google Health service was not increasing as quickly as Google expected; therefore the service is no longer available [3]. The reasons behind this failure could be among others the followings: the lack of information about the service at the consumer side, the privacy issue and the trust in the service, the lack of communication and interaction features with care provider, the lack of provider relationships and other data sources such as data from insurance companies.

A number of projects have been focusing on the conception of platforms for the hosting of e-health solutions in the last decades. In the year 1998, a telematics platform for patient oriented services was developed [4]. Three years later, a prototype for mobile telemedicine was conceived and presented in [5]; thereby the communication between the mobile phone and telemedical processor was enabled through the infrared (IrDA) interface which, however, does need a direct line of sight. In [6], a framework solution for information systems, which could be exploited for research projects in preventive medicine, is described.

The growing use of web-based user interfaces by applications continuously decreases the need for traditional client-server applications. This fact has motivated big players such as Oracle, IBM, SAP, Microsoft, Google, Amazon to react to the revolution of the SaaS technology [7]. They offer both SaaS services and Platform as a Service (PaaS) [8].

This paper extends the state-of-the art by adding more functionality to the SaaS-Platform suited for health solutions. The developed middleware covers not only common functions such as authentication, Authorization and user management, but also flexible interfaces to medical care software, easy connection of mobile applications (Android, Java, Windows Mobile and iPhone) and integration of the user hierarchical management adapted for the administration system of several hospitals, doctors and patients. Thus, patients are continuously monitored while not being disturbed in their mobility and every-day-activities.

II. SAAS-PLATFORM APPLICATION SCENARIOS

The SaaS-Platform connects users to different available services while providing basic functions such as enabling a secure communication, authentication, authorization control and secure data storage. Several types of telemedical and e-health solution can be easily hosted by the platform presented in this paper. In order to support the scalability, the application can be installed on multiple machines which are clustered. The use of HTTPS protocol guaranties a lightweight security that is the minimum requirement for interfacing with a number of medical software and the electronic health record (EHR).

In the purpose of describing some of the application scenarios of the SAAS-Platform in the medical sector, let us

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introduce some of the mobile health solutions either already implemented or under development on the platform as illustrated in Fig. 1:

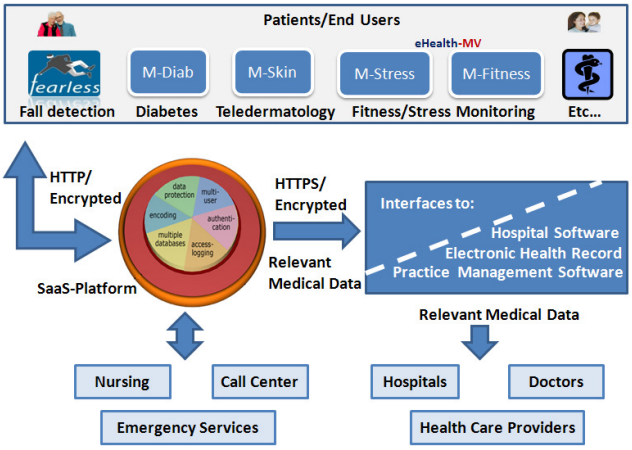

Figure 1. SaaS-Platform Application Scenarios

A. *FEARLESS/AAL*

Fear Elimination As Resolution for Loosing Elderly's Substantial Sorrows (FEARLESS) is a joint and ongoing project in cooperation with partners from four European countries (Austria, Italy, Spain and Germany) and consists in designing a system able to detect a wide range of risks (e.g. fall detection) with a single sensor unit, enhancing mobility and enabling elderly to take active part in the self-serve society by reducing their fears. It is a sub-project of the Ambient Assistant Living (AAL). The SaaS-Platform will fulfill the following tasks in this project:

- Enabling a secure communication and data exchange among partners.
- Connection of both web-based and mobile-based applications for the user interaction to the system
- Interaction with health care services such as nursing, call center and emergency center in case this is needed
- Ensure an interface for a secure transfer of relevant medical data to the Electronic Health Record (e.g. ELGA)
- Inclusion of an interface for electronic partners interaction to the system in order to ensure an effective dissemination of the product
- Access Control and Authentication of users

B. *Diabetes Management System (M-Diab)*

The Mobile Diabetes (M-Diab) system consists of mobile and web-based applications to allow diabetic patients manage their data and doctors analyze patients' data related to diabetes. The system is embedded on the SaaS-Platform which performs the following tasks:

- Connection of both web and mobile applications
- Allowing the user-hierarchical model (administration, hospital, doctor, patient) and control the access
- Enable the user management
- User interactions and visualization services
- Reporting of results in a PDF-Format
- Secure interface to Practice Management Software

C. *Mobil Teledermatology (M-Skin)*

The Mobile Skin (M-Skin) is an innovative mobile teledermatology for supporting both the therapy and the after care of patients suffering from skin diseases, "in press" [9]. This system is hosted on the SaaS-Platform which is in charge of the following tasks:

- Ensure a secure communication and data storage
- Connection of web and mobil applications with easy-to-use graphical interfaces

D. *eHealth-MV (eHealth-Mecklenburg Vorpommern)*

The eHealth-MV system was developed as the result of the cooperation between the University of Rostock (Institute for Preventive Medicine, Institute for Automation Technology) and the IT-Company Infokom GmbH, both from Germany. It is a mobile solution capable of estimating and monitoring both the stress and the fitness levels without a physical consultation of a medical specialist. The system consists of three main sub-components: a mobile real-time acquisition of physiological as well as subjective data, an expert model for stress and fitness estimations based on physiological signals collected from wireless vital sensors and the last sub-component is the SaaS-Platform on which the entire system is implemented , "in press" [10]. The mobile stress (M-Stress) and mobile fitness (M-Fitness) are the two applications developed in this project.

III. BASIC FUNCTIONS OF THE SAAS-PLATFORM

The basic functions of the SaaS-Platform include amongst others the following: user management, authentication, authorization control, secure data communication and storage, flexible interface to third-party application, visualization tools and connection of web and mobile applications.

A. *User Management*

This function allows the SaaS-Povider to register/ update/ delete user information, to control end user information and to manage end users by grouping them. The user hierarchy is not only suitable for hospital administration cases, but can also be adapted according to the wish and need of the customers. Fig. 2 shows a sample of SaaS model for a medical case. For the illustrated scenario, the SaaS-Platform provides different services (e.g. Diabetes Management, fitness/stress management, etc…) to health institutions (e.g. hospitals, GP practices, rehabilitation centers etc..). The health institution acquires an administration tool and can easily register doctors and patients who will benefit from the offered service. Depending on the offered services, different scenarios are possible.

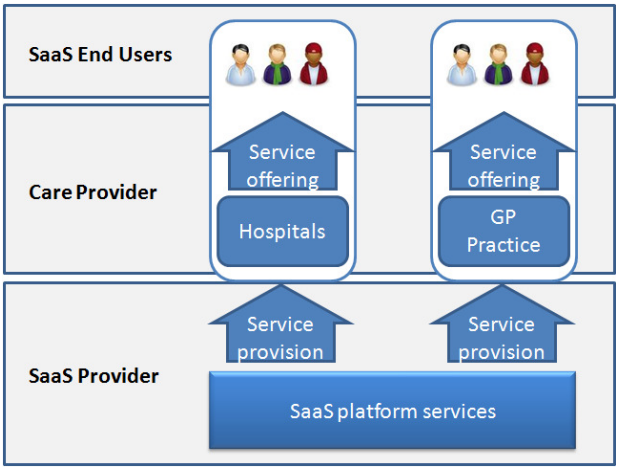

Figure 2. Sample of a SaaS Model for a Medical Case

B. *Authentication*

This function includes the mechanism that allows end users to authenticate themselves by entering the ID and password or by scanning the QR-Code containing their identification key as shown on the Infokom-Diabetes Application 'M-Diab', Fig. 3.

Figure 3. QR-Code Authentication method for 'M-Diab'

C. *Authorization Control*

This function sets the authorization to SaaS applications, services and some areas of the data according to the user category and privacy constraints.

D. *Secure Data Communication and Storage*

During the conception phase of the platform, special consideration has been paid on the security and the privacy issues. Therefore, session models, robust data encryption methods, authentication, authorization control and methods ensuring confidentiality have been designed and implemented. Moreover, medical data and personal data are encoded and stored separately. Data are transferred and stored anonymously with only an identification number. The symmetric encryption method AES (Advanced Encryption Standard) is the method used in encoding data. The encryption engine is built up in a modular way to enable flexibility.

E. *Flexible Interface to third- party Application*

The SaaS-Platform is conceived in a way that it is able to support different types of Interfaces, including those based on XML and SOAP Standards. This alleviates the communication to third-party medical care providers and services that are using XML-based standards such as HL7/CDA (Health Level 7/ Clinic Document Architecture) and many others. Interfaces to most of the practice management software of the general practitioners, such as Doctor to Doctor (D2D) and KV-SafeNet are supported also by this SaaS-Platform.

F. *Connection of Mobile Applications*

Mobile Applications of different operating systems (OS) such as Android, Windows Mobile, iOS, Java, can interact easily with the SaaS-Platform. Encrypted data are transmitted anonymously through the internet channel using HTTP/HTTPS protocols. Fig. 4 presents a screen shot of the diabetes management 'M-Diab'. This graphical representation of blood glucose on the Android Galaxy Tablet shows how the mobile applications are developed with a user-friendly and self-explained graphical interface. Moreover, interaction features of the OS are explored and supported in our developed mobile applications.

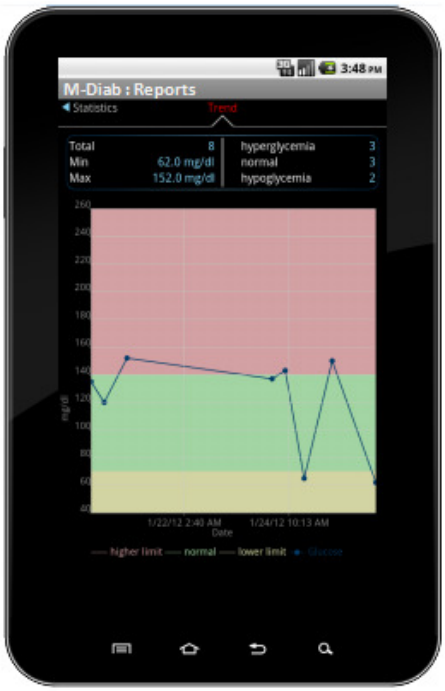

Figure 4. Mobile Application, Glucose Graph (M-Diab)

G. *Connection of Web-based Portals*

The web-based portals are generally structured as follow: System administrator Portal, Hospital Portal, Doctor Portal and Patient Portal. The system administrator has the right to register several hospitals to the system using the administration portal. Thereafter, he creates an administrator account for every registered hospital. The administrator of each hospital is given then the right to register patients and medical personal belonging to that hospital through the hospital portal. This portal allows also the assignment between patients and doctors for a defined period. This gives registered doctors the right to access data of patients who have been assigned to them. Patients are able to access their own data through the patient portal.

IV. SAAS-PLATFORM ARCHITECTURE

The SaaS-Platform is conceived as client-server architecture. It has a four-layer architecture model with the user layer, communication layer, application layer and the middle layer as illustrated in Fig. 5. The system is modular conceived in order to enable an easy extension for new functionalities. Every module represents different functional blocks that embed individual code libraries, special methods or even a complete application such as portals. Clients such as mobile applications, windows applications and online web-browsers communicate via the communication layer with the server modules which execute respective functionalities.

Features of this platform include amongst others the followings: high performance through the multiprocessor / multicore technology, implementation for 32-bit and 64-bit architectures, optimal load sharing through clustering capability, universal and transparent data storage, integrated user hierarchical model, visual presentation of data for online web-based portals, flexible Interfaces to third-party applications, connection of mobile devices with android, Windows Mobile, iPhone and java-based applications.

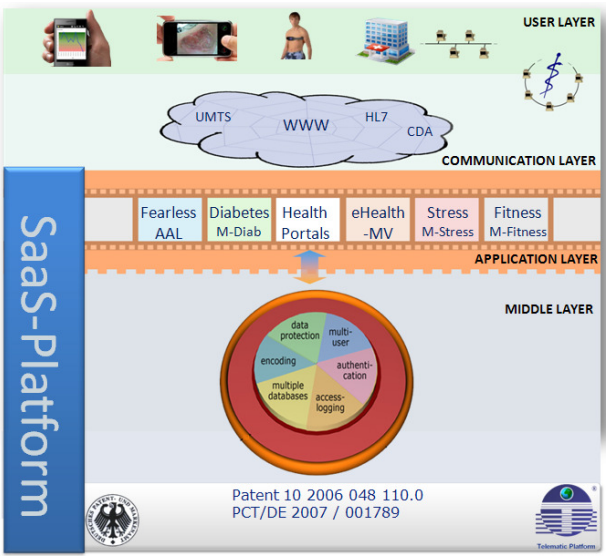

Figure 5. Architecture of the SaaS-Platform

V. CONCLUSION

This paper has presented the SaaS-Platform suited for the implementation of different mobile health applications. The basic functions and features of the Platform have been summarized. These multiple functions extend the state-of-the art in developing SaaS-Platform suited for medical applications. Special attention has been paid on issues dealing with the privacy and the data security. The proposed secure solution should reduce end users' fear. Therefore, limitations which slow down the acceptance of SaaS and prohibit it from being used in some cases could be reduced.

The developed Platform has been successfully applied for the implementation of several mobile health applications. Four of these implemented solutions were briefly presented in this work.

The proposed middleware will constitute a revolutionary utility for the provision of healthcare services via telematic support as well as for the creation of information exchange systems between the patients and the healthcare providers.

Future developments are directed in extending the communication interfaces, in order to cover as much standards as possible.

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