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An Efficient Method for Monitoring, Management and Treatment of Diabetes

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Abstract: **SMARTDIAB is a platform designed to support the monitoring, management, and treatment of patients with diabetes. Here we are creating a platform that mainly consists of two units Patient Unit (PU) and Patient Management Unit (PMU). The PU consists of patient personal details and glucose level. These values are stored in the central data base that can be accessed by both the Patient and the Physician. The PMU consists of a diabetes data management system (DDMS) that provides risk assessment for long-term diabetes complications. The aim is to facilitate the patient information in a distributed manner; the details include all the medical records and daily intake of food and glucose level and visit entry. Effective information sharing through web services and mobile services is the aim of the proposed system SMARTDIAB.**

Keywords: **diabetes management, home care, information and communication technologies**

I. INTRODUCTION

To a large extent computer based monitoring and intensive care unit systems have become cheap enough to be deployed on a large scale in many intensive diabetic care units around the world. The bedside has become an important point of displaying data. Bedside monitors have capabilities of intelligent monitoring, intelligent alarming, plug and play modules, TCP/IP and Ethernet networking and many other features provide easy, integrated monitoring in any facility. The systems often provide database and analysis functions that previously only was available on large systems. Most bedside monitors sold today can incorporate data from clinical laboratories, bedside laboratories devices.

In order to improve the monitoring and glycaemic control of patients with diabetes mellitus both academic and diabetes technology industry research is focused on the design and development of personal details as well as patient medical report. It is likely that the doctors and nurses would want to be mobile. When they visit a patient they could have a tablet PC with all the current charts and data for that particular patient ready. The architecture for supporting this could be designed in different ways, but the main parts that have to be realized would be:

- An infrastructure for the monitoring devices to push their data into, for example a server with a database.
- An infrastructure for the mobile devices to get the data.
- It could also be realized in such way that the monitoring device stores all the data and applications needing data connected directly to the monitoring device.

Diabetes mellitus, previously known as insulin dependent diabetes mellitus, is a chronic metabolic disease characterized by absence of insulin secretion due to destruction of pancreatic beta-cells. Inadequate treatment leads to short-term (hypoglycaemia and hyperglycaemia) and long-term (e.g., neuropathies, nephropathy, retinopathy, heart disease, and stroke) complications,whereas intensive glycaemic control has been shown to reduce the risk to develop such complications [1]. In Diabetes, intensive glycaemic control is achieved by means of: 1) insulin therapy either through administration of multiple daily injections (MDI), known also as intensive conventional therapy, or through continuous subcutaneous insulin infusion (CSII) via insulin-pumps; and 2) regular self-monitoring of glucose levels by using either conventional finger-stick glucose meters (three to four times daily), or continuous glucose monitors (CGMs) that provide high frequency (e.g., every 5 min) measurements of glucose levels. In order to improve the monitoring and glycaemic control of patients with diabetes mellitus both academic and diabetes technology industry research is focused on the design and development of personal sensors for CGM multisensor device SMARTDIAB: A COMMUNICATION AND INFORMATION TECHNOLOGY APPROACH for physical activity monitoring, novel instruments for delivery of insulin , computational algorithms for insulin treatment optimization[13] , data mining and visualization tools for better management of diabetes data, and intelligent decision support systems (DSS) to be used for patients health status assessment and prediction of diabetes-related complications.

Furthermore, advances in Information and Communication Technology have accelerated the design and implementation of telemedicine platforms, [11] for various diagnosis and treatment applications. Several telemedicine platforms have been proposed for diabetes

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monitoring and management [10]. Systems using Internet and Public Switched Telephone Network (PSTN), allows a diabetes patient to send glucose measurements to a hospital, where a physician with a set of tools for data visualization, analysis, and decision support can analyze them and advise the patient on appropriate treatment adjustmen. In the IDEATel project,Web-based computing and telecommunication networks have been established in both urban and rural economically disadvantaged areas within New York State. The project has involved 1500 diabetes patients. Another EU funded research project, entitled multiaccess services for managing diabetes mellitus (M2DM), has proposed a high-performance Web and a computer telephony integration server that can be accessed using different communication links, such as standard telephone lines, mobile phones, and Internet. Users (physicians and all types of diabetes patients) can access information using customized applications, general applications and terminals. Core of the platform is the multiaccess organizer, which is responsible for the coordination of a series of software agents.

This paper refers to the design and development of a pilot platform named SMARTDIAB, which is based on the combined use of information and communication technologies for the intelligent monitoring, management and followup of individuals with T1DM [11]. The platform integrates mobile infrastructure, Internet technology, novel, and commercially available continuous glucose measurement devices and insulin pumps, advancedmodeling techniques, control methods, and tools for the intelligent processing of diabetes patients information. The platform allows 1) intensive monitoring of glucose levels; 2) diabetes treatment optimization; 3) continuous medical care; and 4) improvement of quality of life of individuals with T1DM.

The rest of the paper is organized as follows,The specifications and overall architecture of the SMARTDIAB platform.Design and implementation issues of the basic platform's units, the patient unit (PU) and the patient management unit (PMU), are presented. Functional issues emphasizing on security aspects and service usage scenarios. The strategy toward SMARTDIAB evaluation is described.while future research directions and conclusions are presented.

II. SMARTDIAB CONCEPT AND ARCHITECTURE

The SMARTDIAB platform consists of two units: 1) the PU; and 2) the PMU. In the PU, patient's related information, e.g., glucose levels, insulin intake, diet, and physical activity is acquired and transmitted, through telecommunication networks, using cellular phones or PC/laptops to the PMU. The PMU can be accessed from both medical personnel and patients, with appropriate security access rights. In the PMU, advanced tools for the intelligent processing of the patient's data are provided to the physician, who is able to monitor the health evolution of the subject patient and make recommendation about his/her treatment .

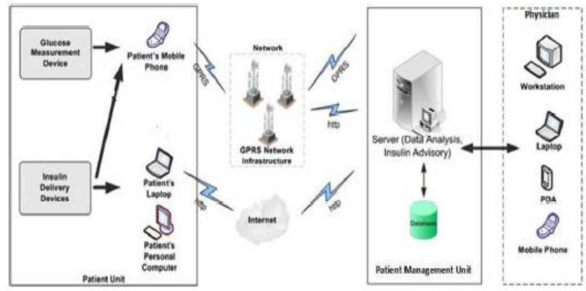

Fig.1. General architecture of SMARTDIAB

Furthermore, advanced computational tools permit the estimation of optimum insulin infusion rate in case the individual is under insulin pump treatment. Moreover, the T1DM individual can have a clear picture of his/her health status and how his/her habits influence the glucose profile. The major specifications of the PU are summarized in the following: 1) accurate, portable, lightweight devices for glucose measurement and insulin delivery; 2) visualization abilities; 3) wired and wireless communication capabilities; and 4) user-friendly interfaces. The specifications of the PMU comprise: 1) connectivity to the Internet and GPRS; 2) user-friendly interfaces; 3) ability to retrieve and manage patient information and data; and 4) advanced tools for data analysis, processing, modeling, decision support, and visualization.

III. EXPERIMENTAL SETUP

The experimental setup includes the following units namely Patient Management, Patient unit Management, Diabetic Management system, Policy analysis.

A. Patient Management:

The patient module contains all details about patients such as name, age, gender, date of birth, blood group and address. Rather than this the system maintains sugar level, glucose levels, insulin intake, diet and physical activity is acquired and transmitted, through telecommunication networks, using cellular phones or mail to the Patient Management Unit.

- personal data, such as height, weight, etc.;
- his/her personal logbook, consisting of important data, such as daily glucose level measurement, insulin intake, meal intake, and time of the action;
- medical record, such as medical exams, illness, etc.;
- Lifestyle and daily habits, such as exercise, etc.

B. Patient Unit management

This module can be accessed by the Patient Unit through the internet or using devices, such as mobile. The

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Patient Management Unit consists of a diabetes data management system, a decision support system that provides risk assessment for long-term diabetes complications, and an insulin infusion advisory system, which reside on a Web server. Here the decision support has been developed with some flexibility, which can be used by patient as well as personnel with appropriate security access rights.

C. Diabetic Management system

This module maintains all the details about the patients and as well as the status in the web server. So that the data can be viewed by anyone with security access. This helps to know physicians to evaluate a patient's clinical state through the web application. For secured data processing the system implements secured TCP/IP connection by using 3 DES algorithms, which encrypts all sensitive data before transmission. The overall diabetic information management shared through mobile or PC with consistence security. The central DB is designed on the basis of the Health Level. Standard enabling communication with the hospital information system,
where the patient management unit will be deployed. In the DB, information related to patient's data, records regarding laboratory examination results, Meta analysis results, and comments about the patient health state are stored.

D. Policy analysis.

This policy module defined to maintain the data's in a secured manner. For privacy and security this module has been proposed. This module establishing security policies, guidelines, and procedures is a critical step towardsecuring an infrastructure and its information. Policies set the overall tone and define how security is perceived. In
the current information and communication technologies platform, appropriate security policies have been designedand applied in such a way that they will protect confidential, proprietary and sensitive information fromunauthorized disclosure, modification, theft or destruction.

IV.FUNCTIONAL ISSUES

Treatment based on Patient's Profile: The fig 2 shows the process of the treatment of a T1DM patient and how the physician can be supported by SMARTDIAB in order to decide the necessary treatment alterations. More specifically, the T1DM patient uses the system's front-end interface to enter particular information concerning:

- personal data, such as height, weight, etc.;
- his/her personal logbook, consisting of important data, such as daily glucose level measurement, insulin intake, meal intake, and time of the action;
- medical record, such as medical exams, illness, etc.;
- lifestyle and daily habits, such as exercise, etc.

All the aforementioned information is stored in the central DB and is online available to the physician. Based on this information, the physician can use the platform to recommend alterations in patient's treatment, such as changes in the predefined glucose or insulin limits that can be tolerated by the patient, changes in insulin bolus dosage, in the nutrition program, or the exercise or even the pharmaceutical treatment, if considered necessary. These changes are stored in the central DB and are available online on patient's front-end application.

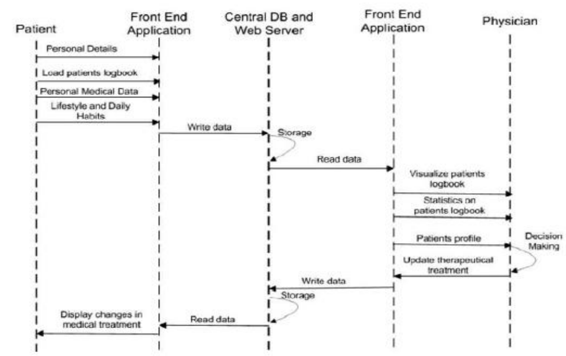

Fig.2. Treatment based on Patient's Profile

V. SECURITY FRAMEWORK

The used security framework is based on a component design approach [15], [16], which is comprised of the following four main components.

1) Platform Component:

Role-based access control (RBAC) was used to grant permissions to certain functionalities of the system for the three main categories of the users. RBAC was implemented using the object-oriented paradigm by authenticating the user to a role object in the DB. Thereafter, the role object loaded is passed as a parameter to the tasks that compose the overall functionality of the system and permission to invoke the task is granted to the initiating user according to her role.

Furthermore, several different GUI views have been implemented and the final front-end is constructed after role assignment achieving an extra layer of transparency for the separate roles. Three basic role groups were defined in the system.

The *patient role* that allows the patient to remotely access information concerning his/her current treatment status as well as any information stored in the DDMS.

- The *healthcare professional role* that gives access to the patient information in the DDMS. Each healthcare professional is tightly coupled with certain patients and can only view and alter their clinical information. An auditing mechanism ensures recording of every change made. This poses a strong security mechanism for intentional or nonintentional malalteration of information. Furthermore, the healthcare professional is provided with a smart interface to interact with the IIAS. He has the ability to enable reporting for all or part of the decision made by the system.

- The *administrator role* that allows knowledge administrators to import new knowledge entities in the system. New medications and diseases can be imported to the system for future use by healthcare professionals. Furthermore, new users and their roles can be defined. User authentication is achieved at a DB scope through the usual username–password scheme. Hashing algorithms are implemented for secure transmission of user data. User-oriented data
- views provide further security by restricting access to specific medical data only to relevant users. On hardware level, a high level of redundancy is achieved using technologies, such as redundant array of inexpensive disk (RAID) with hard disk (HD) mirror imaging. Online transaction processing (OLTP) and online analytical processing (OLAP) algorithms that are implemented in the proposed system reside on different server machines to avoid interference between usual transactions on the patient object and decision support algorithms.

2) Network Component:

This research resulted in the implementation of a system with increased extranet traffic consisting of critical data. IPSec on the network layer, secure socket layer (SSL) on the transport layer are used to ensure secured communication between the remote servers. SSL over GPRS ensures secure transmission from the mobile phone. Hypertext Transfer Protocol Secure (HTTPS) is the protocol relied on to deliver secure transmission via the DDMS component. The central DB is protected using a router with specific access lists as well as an application layer firewall–intrusion detection system (IDS) that continuously monitors network traffic.

3) Physical Component–Securing Access:

The physical security component's main role is to prevent unauthorized users to physically contact the SMARTDIAB's devices. Furthermore, this subcomponent has to deal with the possibility of a natural disaster or possible lack of energy resources. Critical systems of the proposed project will operate in controlled environments, safe from intrusion.

4) Policy Component–Designing Guidelines:

Establishing security policies, guidelines, and procedures is a critical step toward securing an infrastructure and its information. Policies set the overall tone and define how security is perceived. In the current information and communication technologies (ICT) platform, appropriate security policies have been designed and applied in such a way that they will protect confidential, proprietary, and sensitive information from unauthorized disclosure, modification, theft, or destruction.

VI. SIMULATION RESULTS

The design are done with the help of dot net. The patient details along with their continuous glucose measurements are designed by using dot net and patient registration , patient lifestyle and patient reports are given below.

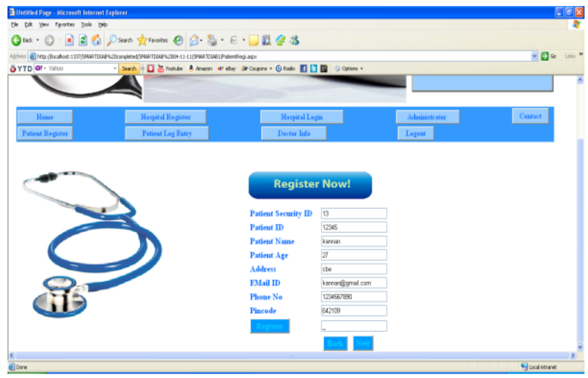

Fig.3.Patient Registration

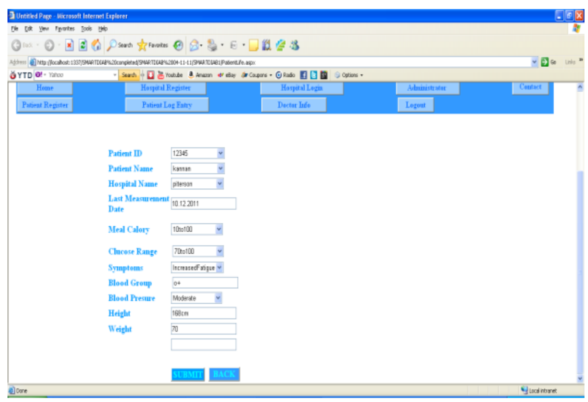

Fig.4. Patient Lifestyle

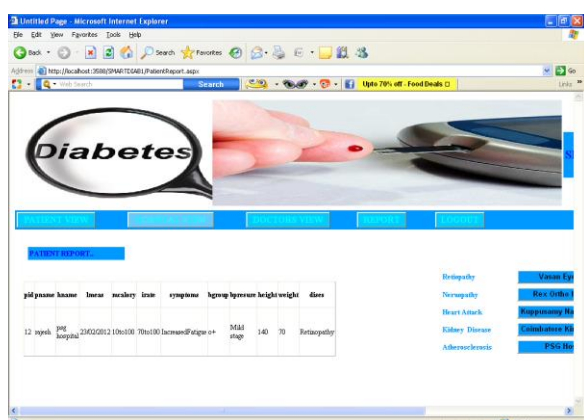

Fig.5. Patient Report

VII. CONCLUSION

In this paper, SMARTDIAB platform has been designed by using Information and Communication Technology for the monitoring, management and treatment of diabetes. The platform permits the continuous monitoring and the continuous provision of healthcare to diabetes patients using telemedicine, through the Internet. User-friendly Web and mobile phone interfaces along with advanced data processing functionalities allow for the optimization of diabetes mellitus treatment Additionally, a central DB, containing patients related data , clinical and laboratory exams, along with appropriate tools for data storage, management, mining and visualization allow healthcare professionals to assess the health status of their patients and update/modify the applied treatment.

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