A Unified Framework for Pervasive Healthcare Medical Computing Based on SOA

K.M. Anandkumar and C. Jayakumar

Department of Computer Science and Engineering
Easwari Engineering College,
Anna University, Chennai
kmanandmss@gmail.com,
sowthaanand@yahoo.com,
cjayakumar2007@gmail.com,
cjayakumar2000@yahoo.com

Abstract. Increasing popularity of the pervasive computing paradigm on one hand and other technological developments like SOA (Service Oriented Architecture) on the other, have paved the way for development and deployment of unified pervasive services in the everyday habitat. The need for effective unified framework for healthcare information management is very high, with which each individual can monitor his/her health status and the ever increasing health care cost can be significantly reduced therefore. Moreover, advancements in information, communication (Mobile phones and Internet technologies can potentially be used) and sensor technology have made readily available many types of highly accurate yet affordable Health Care Devices with middleware integration features. The service providers, who build, operate and manage services, will want to maximize their revenues, and at the same time, the users will seek guarantees to support their applications. While there are a number of mechanisms proposed to build and operate SOA (Service Oriented Architecture) in pervasive computing arena, very little work has been done in terms providing unified framework. The work presented in this paper proposes a pervasive system infrastructure, i.e. a ubiquitous network mechanisms to (1) Integrate Healthcare devices with wireless communication capabilities so that various kinds of health information data can be pervasively captured, (2) Standard interfaces so that various components can interacts with each other in interoperable manners like IEEE 11073 standards and message format HL7 V 2.5 (Health Level 7 Version 2.5) middleware layer, (3) A Unified SOA (Service Oriented Architecture) - based architecture so that services can be easily implemented using well-defined reusable components.

1 Introduction

Telemedicine has become the most important research topic these days [1][2]. There have been several designs proposed on telemedicine that use devices with large form factor and restrict the patients to their residence area which is not really effective.

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The most recent health care systems use devices with minimum form factor. But these systems are designed such that the patient is not restricted to his/her residence area. However they restrict the patient to a particular area where a local care center is present. This paper mainly concentrates on the spatial aspects of the patients thus providing an effective system where the patients are allowed to move wherever they want.

Combining wearable technology with pervasive computing devices, such as sensor or actuators, is an approach with high potential for being an important part of IT solutions for applications in hospital and home environments [3]. With the growth of economy, interests in personal health grow as well. Also, as the information technology (IT) is advanced, the demand is ever increasing for healthcare services based on information and knowledge. Especially, recent advancements in sensor and communication technologies have opened the door to the pervasive society where not only traditional personal computers but also various portable devices such as mobile phones and personal digital assistants (PDAs) can be used to interact with humans to offer various services. Moreover, advancements in information, communication and sensor technology have made readily available many types of highly accurate yet affordable PHCDs (Personal Health Care Devices). Through these changes, it is possible to get health care service in all living areas as well as home and the paradigm is changing from disease treatment to prevention and health maintenance.

PHCD manufactures are very diverse and the fact that such vital signs have different structures and formats makes it a challenging task to send and receive the vital signs and is one of the primary obstacles in effective health care information sharing. Consequently, it is important to transform vital signs from each PHCD to standardized format to prevent increasing complexity. Although each PHCD manufacture provides the solution can manage vital sign from PHCD, it is need to manage the integrating information for better service. Also, in the pervasive health environment, we need to integrate based on international standard format because a user not only link one health care provider but also diverse healthcare providers and health care facilities. Different users may need different types of services. For instance, services and devices for diabetes patients (mostly needing constant monitoring of glucose levels in the blood using a glucose-meter) are different from those of people suffering from cardiovascular diseases (Sp02, blood pressure, ECG, etc.), obese (weight and body composition) or other kinds of health problems. To provide such personalized or customized services, the system must be designed such that each service can be easily built upon a set of well-defined, reusable, core services. [4]

The paper is organized as follows.(1) Requirements for the technology platform, (2) Integrate Personal Health Care Devices with wireless communication capabilities so that various kinds of health information data can be pervasively captured, (3) Standard interfaces so that various components can interacts with each other in interoperable manners like IEEE 11073 standards and message format HL7 V 2.5 (Health Level 7 Version 2.5) middleware layer, (4) A Unified SOA (Service Oriented Architecture) - based architecture so that services can be easily implemented using well-defined reusable components.

2 Requirements

The requirements for the technology platform were derived by investigating the current care practices and most recent research on both technology and clinical care models. The high level design requirements for the technology ewre, therefore, defined as [5]:

- Easy transferability to remote and rural sites, with minimal or no technology installation and set-up at patient's home, as a prerequisite.
- Use of cost efficient technologies ensuring possibilities for large scale roll out should be preferred.
- As the primary focus of the program is on exercise, and especially walking, the logging, monitoring and receiving feedback on walking and stepping activities should be as easy possible, preferably automatic.
- Others areas of health management should be supported (weight management, stress management, blood pressure and cholesterol monitoring, diet management).
- Sharing of information content and motivational material in electronic form should be cost-efficient and easy.
- Flawless communication between the mentor and the patient should be made easy.
- The technologies should support patient empowerment and augment their own possibilities to follow up on self progress and management of their health.

3 System Structure

The Architecture of an effective independent support system should include

- A Wireless Sensor Network (WSN), composed of infrastructural nodes equipped with several sensors and a wearable monitoring device, used for gathering data about the user and the environment.
- A reasoning component able of performing three main reasoning tasks: (i) continuous contextualization of physical, mental and social state of a person, (ii) prediction of possibly risky situations and (iii) identification of plausible cause for the worsening of a person's health.[15].

3.1 Personal Health Care Device

PHCD manufactures are very diverse and the fact that such vital signs have different structures and formats makes the challenging task to send and receive the vital signs and is one of the primary obstacles in effective health information sharing. To solve this problem, ISO/IEEE is developing 11073standards to make message from PHCDs to standardized format.

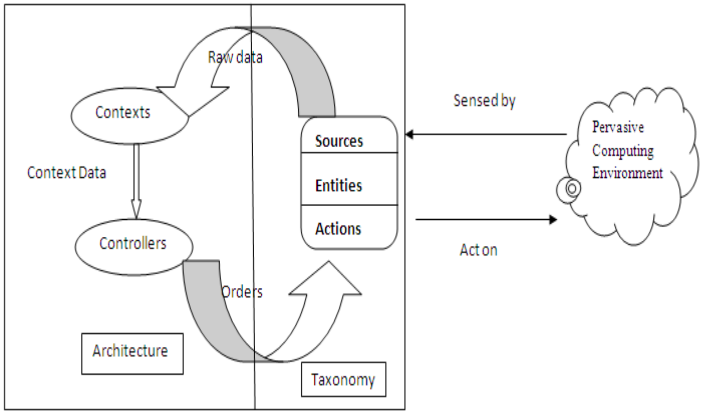

Fig. 1. Architecture of a pervasive computing system

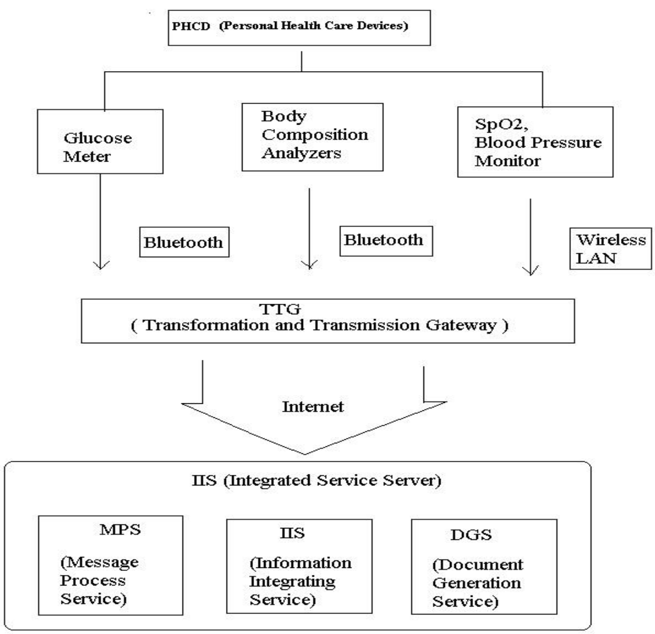

Fig. 2. System Structure of the entire system

ISO/IEEE 11073 Medical/ Health Device Communication Standards is a family of ISO, IEEE, and CEN joint standards addressing the interoperability of medical devices and they defines parts of a system, with which it is possible, to exchange and evaluate vital signs data between different medical devices, as well as remote control these devices. The primary goals of the standards are to "provide real-time plug-and-play interoperability for patient connected medical devices and facilitate the efficient exchange of vital signs and medical device data, acquired at the point-of-care, in all health care environments [19].

3.2 Transformation and Transmission Gateway (TTG)

This system is in charge of receiving vital signs from PHCDs and transforming to HL 7 V2.S messages, after that, sending to Integrated Service Server (ISS). It is possible to use one PHCD by various people, so we developed interface that can insert user 10 on TTG. ISS try to match user 10 that was registered before with user 10 from Gate Way Service (GWS). And then, ISS can store the vital signs with user 10. As such, TTG based on standards are critical for seamless data communications PHCDs and service server. Based on standards, the design offers independence of the types and vendors of PHDs.

3.3 Integrated Service Server (ISS)

Message Process Service (MPS) parse the message from TTG. If an addition PHCD can join, we can call the MPS and configure the service to get necessary information. Information Integrating Service (lIS) integrates the various vital signs associated with user ID and we can use the disperse information in the system as integrated information. And, we can view diverse vital signs from PHDs and retrieve them, using lIS. Furthermore lIS have alert service about abnormal vital sign. Document Generation Service (DGS) generate CDA (Clinical Document Architecture) document [IS] can provides interoperability to pervasive healthcare participants. Also we can see generated CDA documents and issue them. CDA is a document markup standard that specifies the structure and semantics of "clinical documents" for the purpose of clinical information sharing and exchange. In addition, ISS has User Management Service (UMS) for the management of users, including authentication and authorization, and Audit Trail Service (ATS) that manages various aspects of audit trails. One of the key factors that provide the personalized health information is to configure the core functions to service unit. And if the new PDH or new kind of users may join the system, it is possible to provide optimal service.

4 System Implementation

In this section, we describe the implementation module for monitoring the blood pressure and pulse rate monitoring system. The Bluetooth Hemadynamometer is responsible for measuring the blood pressure and pulse rate and transmitting them wirelessly to the patient's mobile phone [6]. This module is implemented in the patient's mobile phone in order to compare the readings and detect the abnormalities as a midlet and has been developed and tested for the S60 OS. Using this midlet application, the patient can ***scan*** the readings obtained from the device continuously without affecting the normal operations. The patient can ***setup*** normal values for both the blood pressure and the pulse rate to which the readings obtained will be compared. If an abnormality is found, **sendsms** is invoked.

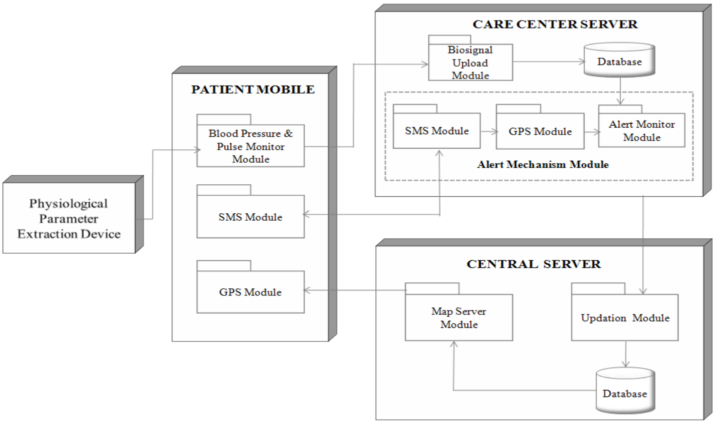

Fig. 3. The Overall Architecture Deployment diagram

4.1 Blood Pressure and Pulse Rate Monitor Module

Fig. 4. Bluetooth Hemadynamometer

4.2 Data Retrieval Module

This module is mainly designed to track the patient's position and obtain the nearest local care center's phone number. An application is developed in the patient's mobile phone such that when abnormality arises, this module is automatically invoked [7]. Every local care center carries along with it a tag showing its phone number. It is this phone number that the application (midlet) extracts invisible to the patient and automatically sends an SMS to. On not receiving any acknowledgement from that phone number the midlet application chooses the next closest care center and sends a SMS to its phone number.

Once the patient's physiological data are sent from the extraction device to his/her mobile phone, the application in his mobile phone receives this data and checks for abnormality. If abnormality is found then the SMS is sent from the patient's mobile phone to the default local care center's mobile phone consisting of the patient's physiological data as well as his/her coordinates. If his coordinates indicate that his location is out of the range of his default local care center then the application in his mobile scans the map invisible to the user for the nearest local care center. Since the local care centers are all tagged with their names and phone number, the application extracts this number and sends a SMS to this number. The local care center's mobile which receives this SMS which identifies his location using the coordinates automatically such that further assistance could be administered to the patient on the phone or directly in person. The centralized server which hosts the map server is in touch with all the local care centers so that any change in the phone numbers of any of these centers could be incorporated in the tags immediately.

4.3 Health Care Center Server Software Module

The server at the care center will be receiving the readings of the patient continuously. When the server fails to receive the data for a certain period of time, the alert monitor mode is setup. (i.e.) ***alert ()*** function is invoked automatically. Similarly, when an alert message is received from the patient's mobile, the alert mode is setup. Simultaneously, the details about the patient ID be retrieved and displayed on monitor.

5 System Performance Evaluation

Since an intelligent mobile healthcare system described in this paper automatically transmits information to the right persons at the right time in order to achieve the function of intelligent healthcare, evaluation of the time needed to transmit necessary information and accuracy must be performed.

There can be two cases when time is taken as the criterion for evaluation. First is the best case. In this case, let us assume that the patient receives acknowledgment from the first care center itself [4]. The time taken for the message transmission will be very fast since the system uses the GSM technology. The next case is the worst case. Here, the patient does not receive any acknowledgement from the first care center. So, an alert has to be sent again to the default care center. In this case, though the time taken is more than the best case, it is considerably less because it uses the default number to send the SMS.

Where accuracy is concerned, since the system uses the GPS technology, the location of the patient is traced accurately. Moreover since there are alternate solutions proposed when the system fails in an emergency situation, this system is more accurate and effective.

6 Conclusion

In this paper, we present our experience with the design and implementation of an integrated pervasive personal health management system. The system can reduce complexity of service server because of standardized message transformation. And for interoperability, we adopted CDA document. Also, SOA-based service architecture so that customized services can be easily implemented using well-defined reusable components. We expect this system will offer high interoperability and personalized health information. In near future, we plan to expand this system to accommodate more PHCDs. We also plan to conduct thorough test and verifications for the effectiveness of the system in real life setting. Usually the patients go for self healthcare or go to the hospital only after feeling uncomfortable for a prolonged period of time. This often greatly increases the possibility of accidents. In addition to this, most healthcare devices being used presently are of large form factor and have coverage of limited area, which would reduce the desire of usage and the quality of everyday life of the patient. The concept of mobile care service is, thus, to overcome restrictions of this kind in order to reduce the form factor of healthcare devices and to prevent interference with patients' daily life and still be able to provide a long-term monitoring services. In our proposed system, if an emergency occurs, healthcare providers can assist instantly, providing further services of rescue and medical treatment, if necessary. We thus propose to use a commercial mobile phone as the processing core for symptom recognition, location identification and alert message generation in collaboration with physiological devices with wireless transmission capability and back end healthcare center as a platform for message processing and data storage to construct an intelligent health care system.

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