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Self-Organized e-Health Application using IEEE 11703: An Experimental Approach

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Abstract

Nowadays, increasing interest in the health care enables active research about the standard for transmitting/receiving data of health devices. Body Area Networks play a vital role of supporting various e-Health applications. Standardization and testing / certification are continuing through the IEEE 11073 PHD, Health Level Seven and the Continua Health Alliance. In this paper, we introduce an e-Health Application using the IEEE 11073 PHD standards for exchanging remote health information as well as the Bluetooth Health Device Profile (HDP) for health device profile of the Bluetooth technology. In addition, we conduct experiments about exchanging health information between a health device and a smart device, which are conforming to the IEEE 11073 PHD and Bluetooth HDP. While using the Bluetooth HDP, our experiments show communication between two devices i.e. health and smart device. During transmitting/receiving operations, the IEEE 11073 PHD standard protocol is used. It is expected to implement a variety of remote medical services through health devices supporting these standards in future.

Keywords: e-Health, Bluetooth, Android, Body Area Network

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1. Introduction:

Body Area Networks (BANs) also known as Body Sensor Networks (BSNs) consist of wearable computing devices equipped with small sensors. Those sensors have limited computing, storage and communication capabilities [1]. These devices are mounted on human body to collect vital data like blood pressure, heartbeat rate, and diabetes level and so on. The information gets transmitted to a system/pc, which processes the data and then transmits it to the server in a timely manner and authorized personnel are alerted in case of emergency [2-3].

On behalf of human, a software or hardware agent is required to collect, calculate and process data into relative form when the information is received from sensor/equipment attached with human body. These agents are also named as Personal Health Device (PHD). The benefit of such devices is to avoid continuous direct supervision or control of patients monitoring and it also provides a significant degree of flexibility and intelligence. PHDs always require some managing architecture, artificial intelligence, distributed algorithms and processing to perform efficiently. This manager can be a PC, tablet, handy devices and a Cell Phone, which can be connected wired or wireless. While transmitting critical data, reliable and secure communication is a prerequisite.

IEEE 11703 standardization enables the most efficient and reliable communications between a PHD and a wireless managing device such as laptop, tablet and so on. This standard addresses a need for an openly defined, independent standard for controlling information exchange to and from personal health devices and compute managers (e.g., cell phones, personal computers, personal health appliances). Interoperability is the key to growing the potential market for these devices and enabling people to be better-informed participants in the management of their health.

Android is a well-known growing operating system for mobiles and tablets. Since it is open source and enables custom applications for users along with easy deployment. We pursue to use android OS features to provide doctors with the facility of accessing patients' data anywhere and anytime.

In this paper, we use android features to implement IEEE 11703 stack and utilize the simple and easily available Bluetooth 2.0 technology [4]. We propose an e-Health Application for critical monitoring of patients. During our application development, a normative communication between a PHD and an android phone is defined in a manner that enables plug and play interoperability. For instance, we develop this application for 3G/4G enabled android device where patient data is transferred to a managing device (Cell Phone) via Bluetooth and then it can be forwarded to a core Data Base through LTE or WLAN. Fig.1 provides the overview of our application.

The rest of paper is structured as follows. In Section 2, we discuss the compatibility of android platform for our e-Health application. Section 3 provides a detailed overview of our proposed application. Section 4 provides our experimental scenario we tested with our application. Finally, some concluding remarks are given in Section 5.

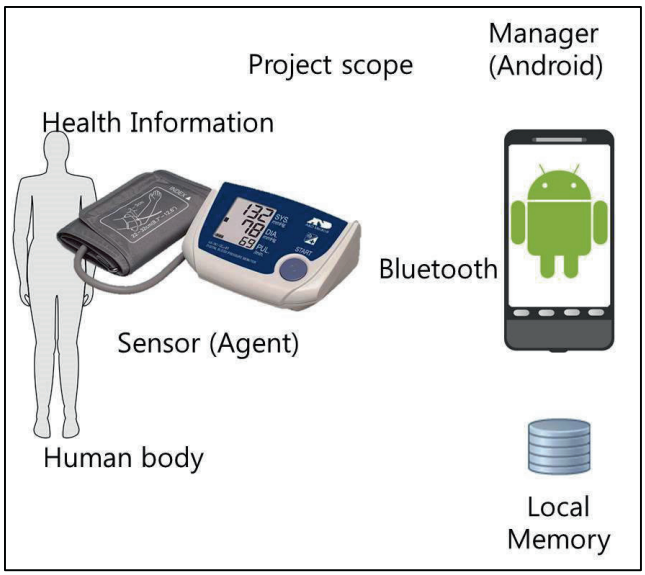

Fig.1 Application Overview

1.1. Motivation:

Healthcare through IT technology is progressively needed in today's world. Doctors need to continuously monitor patients admitted in hospitals. The condition of patients, who have been operated on, needs to be continuously monitored [5]. Highly specialized doctors may not be available in the hospital throughout the day. However, they sometimes need to monitor patients for a long time. Patients admitted in the Intensive Care Unit (ICU) of a hospital need to be monitored continuously due to their critical condition. Even, round-the-clock monitoring is required in some cases. The patient per doctor ratio is relatively high in developing countries as well as developed countries. Doctors have consultations at two or three hospitals and clinics. They need to monitor many patients at different places. A technology, which would allow doctors to view, the vital signs of a patient remotely will therefore be of good use to the doctor. Such a system was sought to be designed in this paper. The system would have to display the data of the patients under the doctor or nursing staff remotely. It would also have to organize data from different patients and provide quick access to any details so that the doctor can quickly recognize the patient (and his /her condition) and appropriately respond. Unlike other applications, our proposed solution also satisfies the basic network security issues such as to provide authentication and confidentiality to the critical data of a specific patient while transmitting it to the multiple available managing devices. The application was developed using the Android platform due to its open source characteristics apart from its rich user interface features.

2. Android Compatibility:

Wide presence in most of today's smart phones makes Android the most suitable platform for developing our e-Health application. An Android enabled device can run the application without any relation to the hardware. Additionally, its flexibility gives the user a range of devices to choose (such as mobile phones, tablets, etc.). The Android software easily integrates with the existing applications in the devices. Many healthcare applications are being developed on Android due to its ability to interact with hardware at a high level [6-7]. Another major advantage of Android is its quick and simple installation process for applications. A user must go to the Android Market (which is a preinstalled app on the Android device) and simply load the software by clicking on it. Any required information can be supplied at the time of installation. This eliminates the need for a technician to install software and immensely speed up the implementation of a patient monitoring system.

2.1 Communication Model:

IEEE 11073 deals with top three layers of the fundamental OSI model for networking i.e. Presentation, Session and Application layer. The presentation layer is enabled by Medical Data Encoder Rule (MDER), which is also known as a common denominator rule. MDER is optimized in order to facilitate low end devices such as medical sensors. The IEEE 11703 is determined to support the session layer even when physical and transport layers are disconnected due to power cut and so on. The application layer is used when useful data finally flows from agent to manager.

3. Our Proposed e-Health Application:

In this paper, we mainly focus on providing an IEEE 11703-enabled application for monitoring critical data of a patient. We achieve this goal by developing an android application which receives medical device information and also configures data into an usable format by following the rules defined in Domain Information Model (DIM) of IEEE 11703 stack.

3.1 Components:

In In this subsection, we discuss software and hardware components we used during our implementation. There are two devices named as Agents and Managers [8-9]. Agents produce data with sensors while the managers are data collectors. Communication can be initiated by either the agent health device or by the manger hand-held device according to the IEEE 11703 protocol. A manager device is capable of communicating with multiple agent health care devices enabling the authorized personals to monitor multiple patient data. However, an agent healthcare device is designed to communicating only with a single manager device at once. An agent device is a resource scarce

device having limited memory and communication capabilities while the Android based hand-held manager device is much more powerful in computing capabilities. Therefore, processing intensive tasks of the IEEE 11703 protocol stack are assigned to perform on the manager device. In IEEE 11703, an agent and a manager with connection established among them are said to be associated. The detailed software overview is summarized in Fig.2.

3.2 Data Flow:

For the data communication between an agent and a manager device, the protocol specific information is encoded using the Abstract Syntax Notation (ASN.1) based on MDER rules. The information is organized in a structured format based on object oriented concepts which are easier to be processed and interpreted at the both agent and manager devices. According to the protocol rules, both agent and manager devices go through different states in a state machine implemented at the heart of both application ends. The set of states of a manager device implemented according to the IEEE 11703 protocol are as follows.

- Disconnected
- Connected
  - Associating
  - Associated
    - Waiting for configuration.
    - Checking configuration.
    - Operating.
  - Disassociating.
  - Unassociated

Every sensor attached to the body has different configuration and every android device may contain various settings. In order to uniform communication, we need association request and configuration information before starting communication between the agent and manager. Medical Device System configuration is one of building blocks to start exchanging health care data unit. Communication overview is provided in Fig.3.

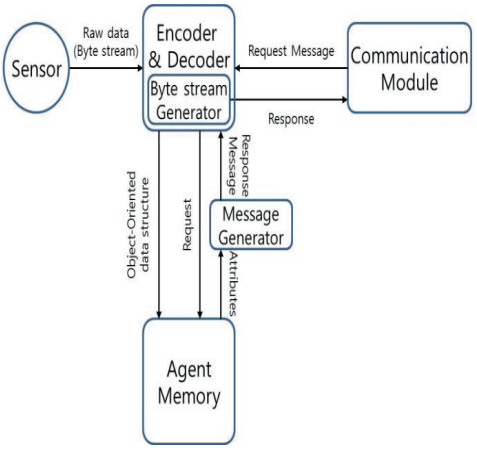

Fig.2 Software Overview

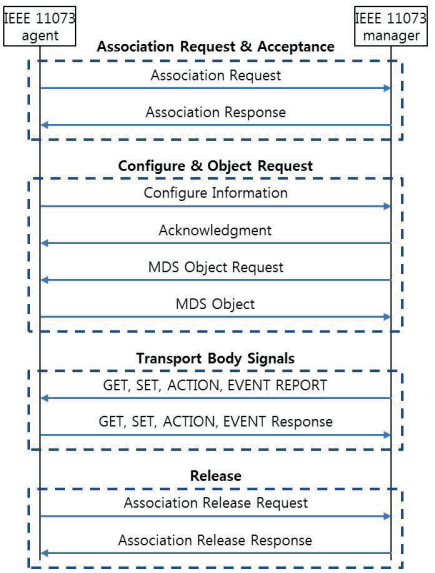

Fig.3 Communication Overview

3.3 Implementation:

Our application consists of three core modules: a module for sending and receiving data, a module for displaying

usable data after encoding/decoding and a module to generate alarm if threshold values are being compromised.

- Data Exchange Module:
  Domain Information Model (DIM) defines an ideal structure of data inside the agent device which is copied at a manager as well. Object oriented approach has been carried out while implementing IEEE 11703, where classes are defined with some mandatory attributes and others optional. Each agent must contain one MDS class which contains attributes such as System ID, Manufacturer information, specialization and so on.

- Display Module:
  For instance, our application uses a conventional simple GUI for the testing purpose [Fig.4]. There are four sections to be displayed throughout implementation. The blue section is responsible for displaying Bluetooth pairing state. The red colour is showing association status. The green section displays MAC address of a particular device. Future work includes multiple devices where this section will require to be updated. Finally, the brown colour shows the main critical data. In our experiments, we used a blood pressure and heart beat rate monitor.

- Alert Module:
  For monitoring critical health conditions of patients, our application also includes an alert module. In the local database, threshold values for different patients are set based on their age and various other conditions. Whenever an abnormal data reading is received from an agent device to the manger, which exceeds the thresholds, the alert module can detect this critical condition. After detection, our alert module generates alarms by sending SMS[1] and also can show pop up text on android screen.

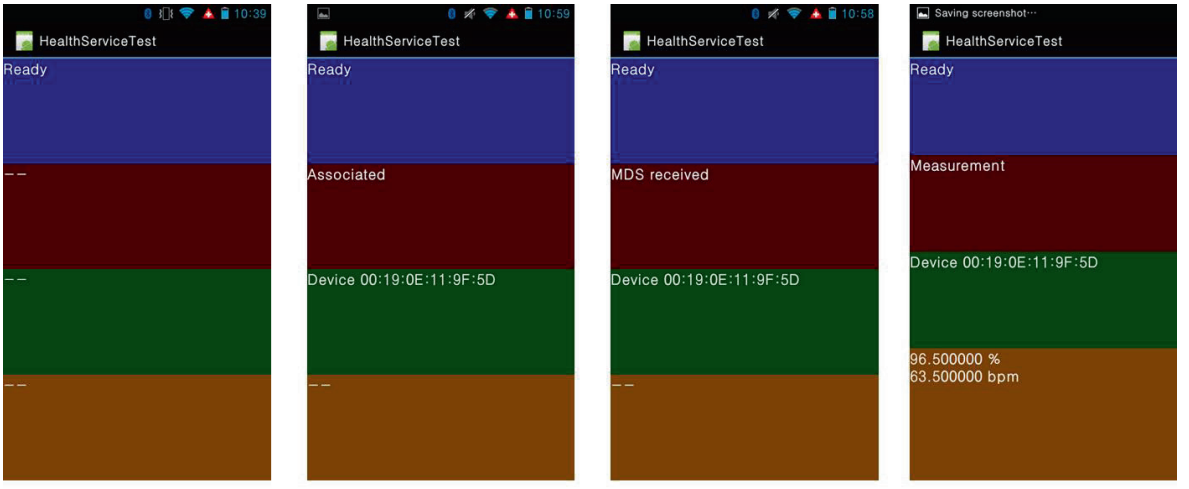

Fig.4. Implementation Results

4. Scenario:

In this section we discuss scenario of the experiments where we deploy agent and manager. Fig.5 shows Blood Pressure Monitor embodied with agent and android 4.0.4 Operation System in Motorola X series used. First we wind blood pressure monitor on human hand and then make sure that the power is applied. Then we run our App on smart device. After main screen appears blood pressure monitor is selected on smart device screen. At first association process is completed and then data gets exchanged using Data Exchange Protocol in stack of IEEE 11703 stack. Our application supports self-organizing while updating blood pressure measurements automatically. Since Bluetooth has limited transmission range, connection link goes down if user steps out that range. Once

[1] *If GSM technology is enabled in an android device.*

required data is collected, unwind the cuff on arm. Turn the power of blood pressure monitor off. Push the Exit button on smart device and then make sure that the App does not running on screen. Experimental results are demonstrated in Fig.4.

Fig.5. Experimental Scenario

5. Conclusion:

In this paper we discuss implementation of IEEE11703 Health Device stack protocol using android. We found that android compatibility enables us to make a self-organized application for e-Heath monitoring. For instance, we use blood pressure monitor embodied with agent, which is capable of sending data wirelessly over Bluetooth channel. Experimental results show that while using Bluetooth channel we have a limited range for collection of critical data. We have used android platform to collect that data on manager with simple GUI this time. Future work includes exchanging data over Wi-Fi and store in on server rather than on local memory. In case of multiple managers we need intelligent prioritizing e-Health application.

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