Cardiovascular Fitness and Activity Monitoring using Biomedical Sensor Network

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Abstract—This paper presents a prototype model for cardiovascular activity and fitness monitoring system based on personal health device standards. These standards are a group of protocols addressing the interoperability of personal health devices. This standard defines a common core of communication functionality for personal telehealth glucose meters. It denotes basic requirements for developing a biomedical sensor network having resource limited sensor nodes to get and retrieve the various physiological parameters while using short range wireless technologies. Earlier the set of protocols for telehealth environment at application layer and rest of the communication infrastructure is covered by the medical grade Bluetooth network. Here, the design addresses the development issues required to report any severe cardiovascular deficiency without compromising mobility and convenience of the victim.

Keywords—Biomedical sensor network; cardiovascular; Physiological monitoring.

I. INTRODUCTION

The idea of Biomedical Sensor Network (BSN) is derived from a thought of mixing these technologies for assessment of physiological parameters and offering the medical assistance to the person in need [1]. BSN consists of 5 to 10 invasive or noninvasive sensor nodes acquiring physiological signals from the subject body and transmitting it to the network coordinator through wireless media. All the sensor nodes in the network share the same medium with different traffic characteristics and different Quality of Service (QoS) requirements [2]. BSN is a new class of wireless networks which offers opportunities to new services for monitoring health, fitness and wellness of persons. It offers prompt feedback for an efficient and reliable patient monitoring, disease management and promotes own care [3]. Special design characteristics of sensor and their human centric application make such networks different from conventional wireless networks [4]. These characteristics pose different challenges for system architecture and protocol design. Monitoring physiological activity has become increasingly important to prevent institutionalization of chronic diseases management. This system can help in monitoring and managing cardiovascular diseases in cost effective manner [5]. The demographic ageing, modern era, unhealthy diet, use of tobacco, physical slothfulness, mentally disturb, socio-economic and cultural changes are major underlying determinants for cardiovascular diseases.

The cardiovascular disease management contributes to 45 percent of total medical care cost in India. More than 20 million people are at possible risk for cardiac diseases [6]. The early detection of cardiovascular risk factors can help in saving a valuable life reflecting its socio-economic impact in many ways.

II. ARCHITECTURE

The technology of sensor, ubiquitous computing, and intelligent information processing is widely used in Body Sensor Networks (BSNs), which are a branch of wireless sensor networks (WSNs). BSNs are playing an increasingly important role in the fields of medical science, social welfare and sports, and are changing the way humans use computers. The general architecture of a BSN is shown in Figure 1. Sensor nodes which are inserted in the body collect physical data and perform preceding processing. The data are collected by a sink node and then transmitted to a base station in order to share over the Internet, which is the base for many applications, including medical care systems, patients and immediate services, detection services by doctors and medical experts [7].

It is necessary to have some understanding of the subject on which the measurements are carried out to obtain valid physiological information from a living human body. [8]
Human body is set of many systems collectively working to perform physiological activities such as electrical, mechanical, thermal, hydraulic, well ventilated, chemical etc, each of which co-ordinate with external environment as well as other internal systems of the body.

Concentrated operations of these systems and their sub-systems make a man able to support life, learn to perform, acquire personality and behavioral traits and even developed him. Measurement of parameters reflecting operations of these systems using sensors can help in faster and quicker healing or rehabilitation for a patient [9].

The proposed BSN traffic model, as shown in Figure 3. Simulated with the help of OMNeT++ discreet event simulation environment using Chipcon CC-2420 radio transceiver that operates in accordance with IEEE 802.15.4/ZigBee communication standard and analyzes traffic and performance issues. This model represents a basic BSN architecture when different sensor nodes share the same medium with different packet rates and packet sizes. Result metrics of intra BSN communication model includes throughput, packet delay and energy consumption [10]. This proposed architecture is supported by five physiological sensors acquiring Electrocardiogram (ECG), Blood Pressure (BP), SO2, Temperature and Accelerators and Gyroscopes for Body Movement. This many-parametric and multidimensional time series information is transmitted by each individual sensor node to the BSN coordinator. All detection decisions are taken at this stage with the help of advance.[11]

III. PROTOCOL OVERVIEW
IEEE 11073-10441 defines a lightweight uses layer protocol for Personal Health Devices in the domain of cardiovascular
activity and fitness monitoring [12]. This standard establishes a normative definition of the communication between personal cardiovascular fitness and activity monitoring devices and managers (e.g. cell phones, personal computers, personal health uses, set top boxes) in a manner that enables plug-and-play interoperability. Here the ability to exchange and use information (usually in a large heterogeneous network made up of several local area networks) is a key issue to growing the potential market for these devices and enabling people to be better informed participant in the management of their health. The basic framework of this standard is based on IEEE 11073-20601, IEEE 11073-10201 and IEEE 11073-20101 protocols [13]. Communication between the BSN node (agent) and the BSN co-ordinator (manager) is defined by the application protocol in IEEE Std. 11073-20601. The medical module encoding rules (MDER) used within this standard are fully described in the standard. It is based on an object oriented systems management paradigm. The overall system model is integrated into three principal components: the domain information model (DIM), the service model, and the communication model.[14]

IV. DOMAIN INFORMATION MODEL

Domain information model (DIM), as shown in Figure 4, is a hierarchical model that represents a BSN node as a set of articles. These objects represent the elements that control behavior of the Physical process sensing mechanism and report the status of the BSN nodes to the BSN coordinator as and when required.[15]

![Figure 4 Domain Information Model](image)

Some of the important physical parameters covered under IEEE 11073-10441 are heartbeat, breathing rate, altitude, latitude, longitude, ferocity of activity, stride length, session duration etc.[16] These attributes are represented in five different formats given as medical device system (MDS), numeric, real time sampled arrays (RTSA), scanner and persistent metric stores (PMStores) DIM is described with the help of Abstract Syntax Notation (ASN) and the data formats described in DIM can also be used by other platforms for feature extraction at latter stages.[17]

V. SERVICE MODEL

Service model defines conceptual mechanism for data development. This model maps messages exchanged between sensor nodes and BSN coordinator. Protocol messages are defined as ASN.1 notation.[18] Message formats defined with in IEEE 11073-20601 can coexist with messages defined in other standard application profiles defined in the ISO/IEEE 11073 series of standards [19].

VI. CONCLUSION

BSNs, arranging sensors in, on and around the human body, realizes the detection of human action and physiological information, which has been widely used in the fields of health care, social welfare, sports, entertainment, etc. The ubiquitous network is coming with the method of taking human body as a part of the communication network. Therefore, BSN has broad application prospects and market potential. Designers should place emphasis especially on avoiding the danger of damage to human tissue caused by the heat generated by sensors implanted in the human body. When designing data processing algorithms and communication protocols, the same problem of power consumption should be solved, as well as the network robustness problem resulting from moving nodes.

REFERENCE

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