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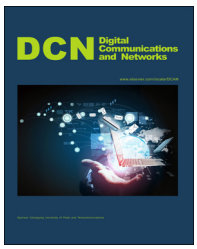

Use of wireless system in healthcare for developing countries

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Abstract
Healthcare is one of the major applications of wireless systems that possess crucial issues. Specifically developing countries require a low cost and reliable network with efficient protocols. The most challenging concern of Body Area Network (BAN) is heterogeneity, which requires fairness with reliability among all the network nodes. Solutions proposed for these networks either do not provide fair packet transmission or consume high energy and introduce delays. In this paper, we propose a cross layer protocol for healthcare applications meeting the requirements and challenges of the heterogeneous BAN. The protocol is also feasible for developing countries as it can be implemented over existing wireless infrastructure and provides high network reliability with energy efficiency through cooperation and adaptability. Results show that the proposed scheme improves reliability, throughput, Packet Delivery Ratio (PDR), and energy consumption for scalable and mobile networks over conventional BAN protocols.
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1. Introduction

The use of a WSN (Wireless Sensor Network) has facilitated every field of life in the last few decades; whether it is object tracking, military surveillance, industrial control, security or health monitoring. All these diverse applications have different requirements and there is no general solution to meet their demands and services. The use of a WSN in healthcare became an emerging trend in the developing world [1] which also gives rise to new issues and challenges. These problems of e-health services are more prominent in developing countries [2]. New generation networks and smart phones have increased the use of mobile health monitoring for elderly people and wireless aid in rural areas. According to reviews [3,4], e-health is growing with emerging

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technologies such as satellite, internet, mobile, cloud computing and also with advancement in 5th generation networks [5]. Studies [6,2] show that distant online aid and diagnosis can provide health services in interactive and modified ways, even in developing countries.

Moreover the successful deployment of wireless healthcare monitoring systems rely on reliability and robustness of the sensor network, which can be affected by interference [7]. Instantaneous and on-time delivery of the patient's data is essential for mobile treatment and medical services. Also the requirements of BAN vary with its application that should be achieved by managing the resources of the sensor network efficiently.

1.1. Body Area Network (BAN)

BAN is an emerging field of WSN, where different sensors are deployed inside and over the human body for health monitoring purpose. These networks require competitive protocol design to provide robust communication of health parameters for quick diagnosis and treatment. Medical wireless networks can be classified as hospital based applications and distant monitoring. Fig. 1 illustrates the use of Wireless Sensor Networks for different healthcare applications. Collecting data for several patients to a central data-base system makes it easier to monitor and locate an abnormality in large data sets. Also, sensor networks used for distant monitoring of elderly people gives them freedom to move freely while they are also being continuously monitored.

Wireless Sensor Network are broadly classified as homogeneous and heterogeneous, are based on network and data types. Homogeneous networks consist of nodes with the same functioning capabilities; hence such networks are used in sensing of similar kinds of data. However [8] complexity of wireless networks increases with heterogeneity as they demand different types of data to process.

Fig. 2 shows different types of homogeneous and heterogeneous networks being used. In BAN, heterogeneity arises with nodes implanted for measurements of different health parameters and has different power and computation levels to perform various tasks. Usually BANs are dense network because sensors mounted on the human body lie in same radio range. There is a possibility that several BANs operate in the same area. Therefore, interference issues and challenges of heterogeneous networks should be resolved for BANs. Some of the BANs applications, standards, challenges and their solutions are proposed [9,10]. Research in [9] concluded that BANs exhibit critical interference and energy issues which in turn affects network reliability. Therefore designing of BAN network and its protocol is more difficult as compared to a conventional WSN.

1.2. Challenges

Communication frequency and standards in BANs must provide interference free transmission without harming the human body. In the early days of BAN communication, techniques such as Bluetooth classic, Bluetooth low energy, ZigBee, sensium and ANT were used; however

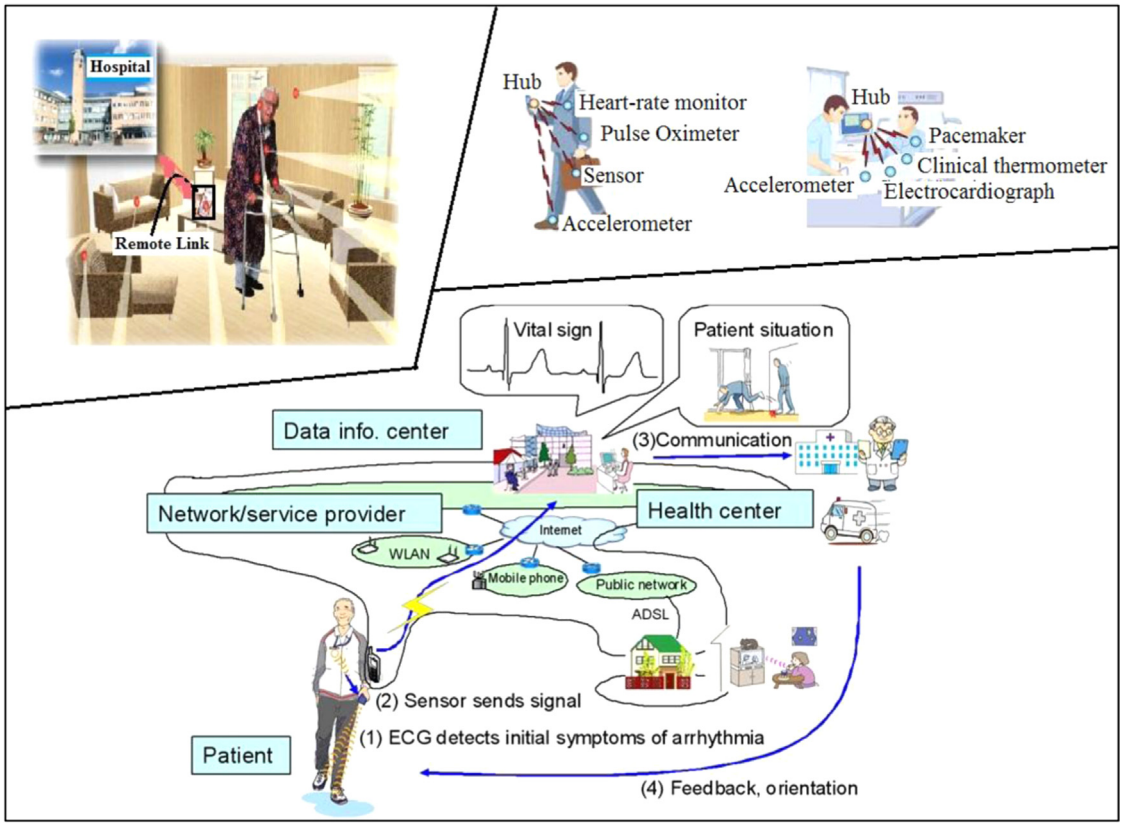

Fig. 1 Use of WSN for health monitoring.

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