A Comprehensive Survey of MAC Protocols for Wireless Body Area Networks

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***Abstract*—In this paper, we present a comprehensive study of Medium Access Control (MAC) protocols developed for Wireless Body Area Networks (WBANs). In WBANs, small battery-operated on-body or implanted biomedical sensor nodes are used to monitor physiological signs such as temperature, blood pressure, ElectroCardioGram (ECG), ElectroEncephaloGraphy (EEG) etc. We discuss design requirements for WBANs with major sources of energy dissipation. Then, we further investigate the existing designed protocols for WBANs with focus on their strengths and weaknesses. Paper ends up with concluding remarks and open research issues for future work.**

***Index Terms*—Biomedical, Node, Energy, Consumption, Wireless, Personal, Body, Area, Sensor, Networks**

I. Introduction

Number of small and smart devices increases due to advancement in wireless and storage technologies. These small devices are capable of long time health monitoring with in hospital or outside. Wireless Body Area Networks (WBANs) enable us to use portable, small and lightweight sensor nodes for long time health monitoring. Using sensing capabilities, these small energy constrained devices measure human body parameters and communicate with some external monitoring station for diagnose or prescription from a physician. Data streaming from human body to monitoring station using wireless communication channel is an energy consuming process. Low power signal processing and energy efficient communication mechanisms prolong lifespan of these small devices. For Low-Rate Wireless Personal Area Networks (LR-WPANs), IEEE 802.15.4 defines specification for Physical Layer and Data Link Layer [1].

In WBANs, sensor nodes of small size with low power and limited computational capabilities are attached or implanted to human body for measurement of physiological signs. These physiological signs include; respiratory patterns, heartbeat, temperature, posture, breathing rate, ElectroCardioGram (ECG), ElectroEncephaloGraphy (EEG) and many more. Transmission data rates for these physiological parameters vary from 1Kbps to 1Mbps. Sensor nodes collect information from human body and communicate with a central device called Coordinator.

Energy efficiency is the most important requirement of a good MAC protocol for WBANs. To improve energy efficiency of WBANs, a versatile MAC protocol should have the capabilities to reduce power dissipation due to collision of packets, overhearing of nodes, idle listening to receive probable data packets and control packet overhead of communication. Similarly Quality of Service (QoS) is an important goal to achieve in WBANs. This includes latency, jitter, guaranteed communication and security.

For fair access of shared medium, MAC protocols for Wireless Sensor Networks (WSNs) and other short range wireless technologies use Time Division Multiple Access (TDMA) or Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). Due to complex hardware and high computational power requirements, Frequency Division Multiple Access (FDMA) and Code Division Multiple Access (CDMA) are not suitable approaches for medium access in sensor networks [5]. CSMA/CA approach out performs in dynamic networks. It is presumed that WBANs are not dynamic. TDMA approach is well suited for WBANs. However, TDMA-based MAC protocols require extra energy consumption for synchronization. Comparison of CSMA/CA and TDMA is given in Table I.

TABLE I
Comparison of CSMA/CA and TDMA

Feature	CSMA/CA	TDMA
Power Consumption	High	Low
Bandwidth utilization	Low	Maximum
Traffic level support	Low	High
Mobility(Dynamic)	Good	Poor
Synchronization	N/A	Necessary

We organize our work in this paper as follows. In subsequent section, we discuss design requirements for WBANs, however, section III presents major sources of energy dissipation. In section IV, we present existing MAC protocols with their pros and cons. Section V provides a brief discussion with a number of open research issues for design of efficient and reliable MAC protocols for WBANs. Finally, section VI concludes the research work carried out in this paper.

II. Design Requirements for WBANs

In WBANs, sensor nodes collect critical and non-critical information from different parts of patient body and communicate with coordinator. Latency and transmission reliability are