A Survey of Power Efficient Technologies for Wireless Body Area Networks

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Abstract—**Wireless Body Area Networks (WBANs) of intelligent sensors emerged as the most promising architecture for ambulatory health monitoring. Integrated in an m-Health system they provide means for unobotrusive ubiquitous monitoring. However, proper design of wireless communication system is application dependent and critically influences system performance and user acceptance. In this paper we present a survey of existing and emerging wireless communication technologies and critical parameters for the system design.**

Keywords—**Wireless Body Area Network, WBAN, Ambulatory Monitoring, Power Efficient Communication, Low Power Systems.**

I. Introduction

Wireless Body Area Networks (WBAN) have great potential for continuous monitoring in ambulatory settings, early detection of abnormal conditions, and supervised rehabilitation. The advances in WBAN technologies are driven by the developments in wireless communications, pervasive, and wearable computing. They share the same ultimate design goals: minimization of weight and size of sensors that are critical for user's acceptance, portability, unobtrusiveness, ubiquitous connectivity, reliability, and seamless system integration.

A typical Wireless Body Area Network (WBAN) consists of a number of inexpensive, lightweight, and miniature sensor platforms, each featuring one or more physiological sensors, such as motion sensors, electrocardiograms (ECG), SpO2, breathing sensors, blood pressure, electromyograms (EMG), electro-encephalograms (EEG), and blood glucose sensors. The sensors could be located on the body as tiny intelligent patches, integrated into clothing, or implanted below the skin or embedded deeply in tissues.

Power efficient communication in a WBAN system requires a careful design that takes into consideration application requirements, such as average application data bandwidth, maximum required data bandwidth and latency, need for alerts, etc. Application requirements are then matched with the characteristics of the particular wireless technologies.

We present a survey of existing and emerging wireless technologies for WBAN systems and describe system design space and critical design parameters.

II. Power Efficient Wireless Technologies

Critical parameters in the design of a power efficient WBAN system are described as follows:

- ***Average communication bandwidth*** influences the active communication time of wireless controllers and therefore the duty cycle of the system
- ***Maximum required communication bandwidth*** is parameter critical for bursts of urgent messages, and affects the maximum latency for data transmissions
- ***Maximum power supply current*** determines the type, size, and weight of the battery. Maximum current is usually required during transmission
- ***Active power*** determines the type, size and weight of the battery, as well as the battery life.
- ***Standby power*** determines the maximum battery life, as a function of the system duty cycle
- ***Startup time*** represents the overhead and determines the efficiency of individual transmissions
- ***Communication setup*** is a protocol-related timing parameter that represents time necessary to (re)establish a connection between nodes or a node and a gateway
- ***Standards based communication technology*** influences the system interoperability and application development time
- ***Protocol stack size and processing requirements*** determine characteristics of the wireless sensor platform

The most widely used currently commercially available WBAN technologies include Bluetooth and ZigBee. Bluetooth is a mature technology, already integrated in many cell phones and Personal Digital Assistant (PDA) devices. Wibree is a low power version of Bluetooth that is well suited to personal monitoring applications. ZigBee is an emerging wireless standard for low data rate, very low-power applications, with potential applications in home automation, industrial control, and personal health care. Other emerging wireless technologies, such as Ultra Wide Band (UWB) and Wireless USB, target high bandwidth applications. On the other side of the design spectrum, MEMS resonators offer extremely low power consumption. A typical example of the new generation of ASICs designed specifically for WBAN with hardware implementation of the protocol stack is Sensium from Toumaz.