

# Chapter 18

## Evaluating the IEEE 802.15.6 2.4GHz WBAN Proposal on Medical Multi-Parameter Monitoring under WiFi/ Bluetooth Interference

**Yufei Wang**

*The Hong Kong Polytechnic University, Hong Kong*

**Qixin Wang**

*The Hong Kong Polytechnic University, Hong Kong*

### ABSTRACT

*Wireless body area networks (WBAN) play a key role in the future of e-Health. In response, IEEE sets up working group 802.15.6 to standardize WBAN schemes. Of all existing standard proposals, the 2.4GHz proposal is the most mature and ready for mass production. However, as e-Health WBAN applications are often mission/life critical, people are concerned with the reliability (particularly, coexistence reliability) of this proposal. This study evaluates the 2.4GHz proposal under WiFi/Bluetooth interference in the context of medical multi-parameter monitoring. The authors conclude that WiFi poses a major threat to such application scenario, while Bluetooth does not.*

### 1. INTRODUCTION

Healthcare has become a major concern for many countries across the globe. For example, the United States' healthcare expenditure surpassed US\$2.3 trillion in 2008, which is 16.2% of the nation's GDP (National Health Care Expenditures Data,

2010); and China is facing the severe challenge of aging, as a consequence of long-lasting one-child policy (Kaneda, 2006).

To curb the healthcare crisis, medical devices and systems must be upgraded to expand capabilities, increase efficiency, improve safety, and enhance convenience. One enabling technology to these goals is *wireless body area networks* (WBAN).

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A key application of WBAN is *multi-parameter monitoring* (i.e., monitoring multiple vital signs). For instance, during operation or intensive care, a patient must be attached with multiple electrodes to simultaneously monitor various vital signs: *electrocardiography* (ECG), *electroencephalography* (EEG), temperature,  $CO_2$  level, oxygen level, blood pressure, etc.. In many cases, the patient must be plugged with these electrodes for hours, days, or even longer durations (e.g.,  $24 \times 7$  monitoring in *intensive care unit* (ICU)).

Goldman (2009) investigated the drawbacks of using wired electrodes instead of wireless electrodes in multi-parameter monitoring settings. According to his investigation, the wires of electrodes can literally tie a patient to the bed. Even worse, a small movement of the patient may stretch the wires, causing electrodes to fall off. This can be at least annoying to the patient and care givers, and sometimes can even cause lethal ramifications. In contrast, replacing wired electrodes with WBAN wireless electrodes will not only make the patient more comfortable, but also reduce the probability that electrodes fall off. This idea, which we call *WBAN multi-parameter monitoring*, is illustrated by Figure 1.

Same as wired monitoring, in Figure 1, the patient is attached with various types of electrodes, e.g., twelve ECG electrodes, one oxygen level electrode, one blood pressure electrode, one respiration electrode, etc. But unlike the wired case,

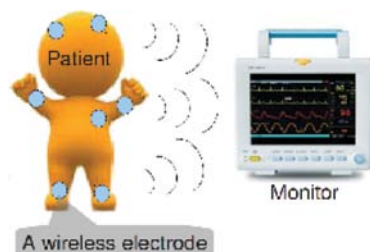
all electrodes connect to the monitor through wireless. The monitor and all electrodes form a WBAN. The monitor plays the role of *base station*, while the electrodes play the role of *clients*. We call the wireless links from the base station to clients the *downlinks*, while the wireless links from clients to base station the *uplinks*.

Researchers and engineers have spent a lot of efforts to build WBANs. CodeBlue is a famous wireless sensor network solution for healthcare (Georgios, 2007). MobiHealth and UbiMon also contribute to regulate a ubiquitous wireless monitoring environment for wearable sensors (Halteren, 2004; Imperial College, 2011). Recently, IEEE 802.15.6 Task Group begins to define guidelines for wireless body area networks, focusing on low power, small size and light weight (Reichman, 2009).

A number of RF bands and wireless technologies can be the candidates for WBAN. The traditional *wireless medical telemetry service* (WMTS) bands include at least three exclusive bands: 608-614, 1395-1400, 1429-1432MHz (Baker, 2008). Exclusive medical bands like WMTS can effectively reduce interference threats, but such bands imply additional costs (e.g. for license) and are inadequate for today's many sophisticated applications. As a result, the free 2.4GHz *industrial scientific and medical* (ISM) band begins to attract the industry. Reichert (2009) studied how to deploy Bluetooth medical devices and customized Bluetooth standards/protocols (such as the *Bluetooth medical device profile*). Baker (2008) gave a solution on how to build IEEE 802.11 compatible networks for life-critical applications. *Bluetooth low energy* (BTLE) and Zigbee can also be good candidates for WBAN (Patel, 2010). The variety and the complex interdependencies of available candidate technologies forced the establishment of IEEE 802.15 Task Group 6 in November 2007, to standardize WBAN *physical layer* (PHY) and *multiple access layer* (MAC).

Currently, more than twenty manufacturers and organizations are participating the IEEE 802.15.6

Figure 1. Multi-parameter monitoring through WBAN



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