P2-9

Personal Gateway Design for Portable Medical Devices Used in Body Area Networks

Chua-Chin Wang, *Senior Member, IEEE,* Cheng-Yen Yang, and Chi-Chun Huang, *Student Member, IEEE*

***Abstract* – This paper presents a low power Personal Gateway (PG) device to wirelessly reply biomedical data between sensors and a databank server. Physiological signals acquitted by the sensors including ECG signals, and bladder pressure data, are converted and packed following IEEE 802.15.4 protocol [1], which are designed for LR-WPAN (low-rate wireless personal area network). Most important of all, CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance) is fully implemented in the proposed device to ensure the security and privacy of patients' personal biomedical information.**

Key word: LR-WPAN, CSMA/CA, physiological signals, ECG, Personal Gateway

I. INTRODUCTION

Thanks to rapid development of semiconductor technology and wireless communication, miniaturization of sensors for the physiological signal acquisition from different recording sites over a human body becomes feasible. A network consisting of various physiological sensors such as electrocardiographs (ECG), body motion sensors, electromyographs (EMG) or pressure transducers has been realized, namely Body Area Network (BAN), as shown in Fig. 1 [2]. Some of the sensors are very critical, e.g., bladder pressure reader, as shown in Fig. 2. Many hemiplegic or disabled patients are suffering from urocystitis and other bladder diseases, which might cause death by complication and infection therewith [3]. Therefore, periodic evaluation of patients' conditions to discover urodynamic problems and help these uro-ataxic to urinate normally has been recognized as one of the most important daily healthcare tasks.

A central control node, called Personal Gateway (PG), is then needed to coordinate the sensors in the BAN to avoid any data collision and ensure the security therewith. Besides, the physiological signals might be lost or jammed during the wireless transmission due to RF (radio frequency) interference and power inefficiency. Therefore, we propose to employ IEEE 802.15.4 protocol to carry out the data coordination of the PG. The difference between IEEE 802.15.4 and well-known ZigBee is that the former defines the lower MAC layer and physical layer, while the later defines the network layer and the application layer. Notably, CSMA/CA is fully implemented in our design to provide the collision-free security of the sensed physiological data. Therefore, monitoring patients' condition over a long period of time over the BAN will be feasible in home healthcare applications.

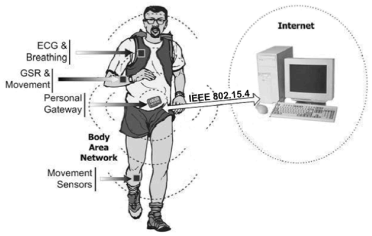

Fig. 1. Body Area Network.

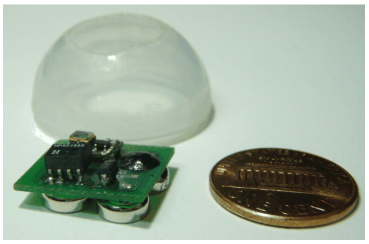

Fig. 2. Bladder pressure reader device.

II. PERSONAL GATEWAY DESIGN

The positioning of PG in the BAN is disclosed in Fig. 3. PG coordinates various sensors to orchestra them to transmit data packets in pre-defined time slots. It then communicates with the servers using IEEE 802.15.4 protocol. Notably, we adopt the non-beacon mode in our implementation since the beacon mode is very power-consuming due to the required periodical broadcast. PG possesses an RF transceiver, and SPI wired connectors for different sensors. Fig. 4 reveals the internal function blocks of the PG, which will be described briefly in the following text.

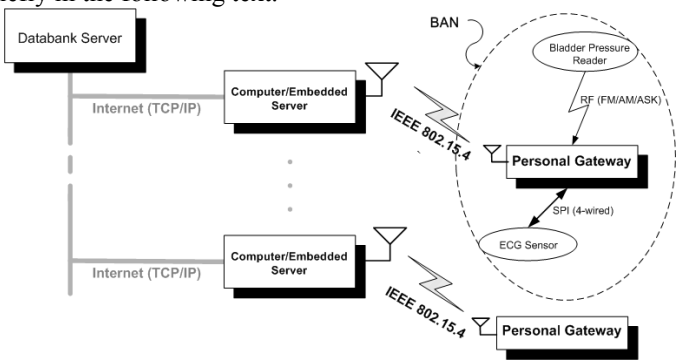

Fig. 3. Positioning of PG in a BAN.

* This research was partially supported by National Science Council under grant NSC96-2923-E-110-002-MY2, and National Health Research Institutes under grant NHRI-EX98-9732EI, Taiwan.

[1] C.-C. Wang. C.-Y. Yang, and C.-C. Huang are with Department of Electrical Engineering, National Sun Yat-Sen University, 80424, Taiwan. (email: ccwang@ee.nsysu.edu.tw)

978-1-4244-4316-1/10/$25.00 ©2010 IEEE

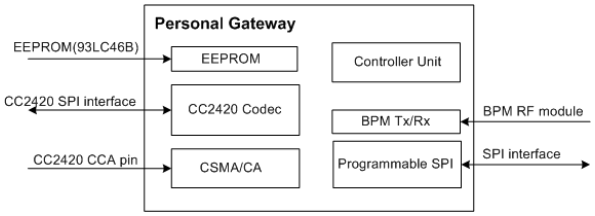

Fig. 4. Function Blocks of PG .

- **EEPROM :** Storage of firmware and configuration settings. A 1-Kb serial EERPOM is used in our device.
- **CC2420 Codec :** CC2420 is a PHY Tx/Rx compliant with IEEE 802.15.4. It has an SPI interface and 4 GPIOs.
- **BPM Tx/Rx :** It is an RF Tx/Rx to receive bladder pressure reader's packets.
- **CSMA/CA :** Since the non-beacon mode is used in our PG, the CSMA/CA in our design is basically "unslotted" CSMA/CA. Two parameters must be included in the algorithm : NB (Number of backoff) and BE (Backoff exponential). The former indicates the times of being delayed, while the later is used to generate a random number. Both of them have individual upper limits. If RTS (requests times) exceeds macMaxBE (the upper limit of BE), the fail signal is issued (CASMACA_fail=1). Fig. 5 is the "unslotted" CASMA/CA algorithm.
- **Controller Unit :** Fig. 6 shows the mastermind of the entire PG, the Controller Unit. The control sequence is relatively straightforward mainly because of CSMA/CA block.

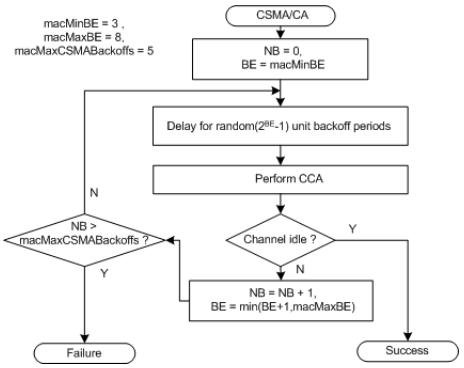

Fig. 5. CSMA/CA Algorithm.

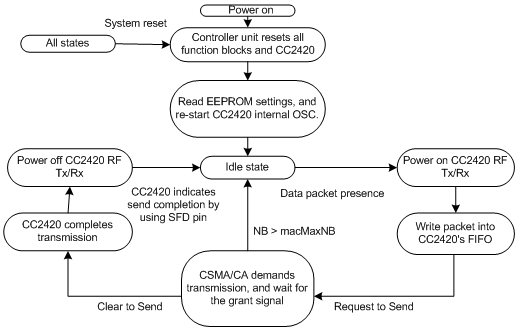

Fig. 6. Controller Unit.

Fig. 7 is the packet frame of the proposed PG which is fully accommodated in the IEEE 802.15.4 packet frame. The physiological data are encapsulated in the payload field.

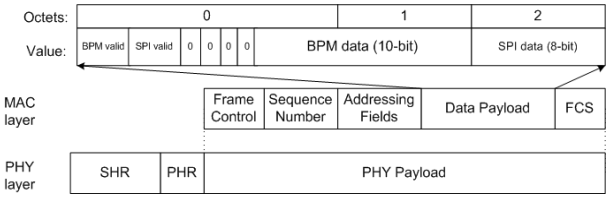

Fig. 7. PG Packer Frame.

III. Implementation and Simulation Result

The proposed PG design is carried out on silicon by a typical 0.18 um single-poly six-metal CMOS technology. Fig. 8 shows the post-layout simulation results of the entire PG operation flow. Fig. 9 is the readout of the bladder pressure reader.

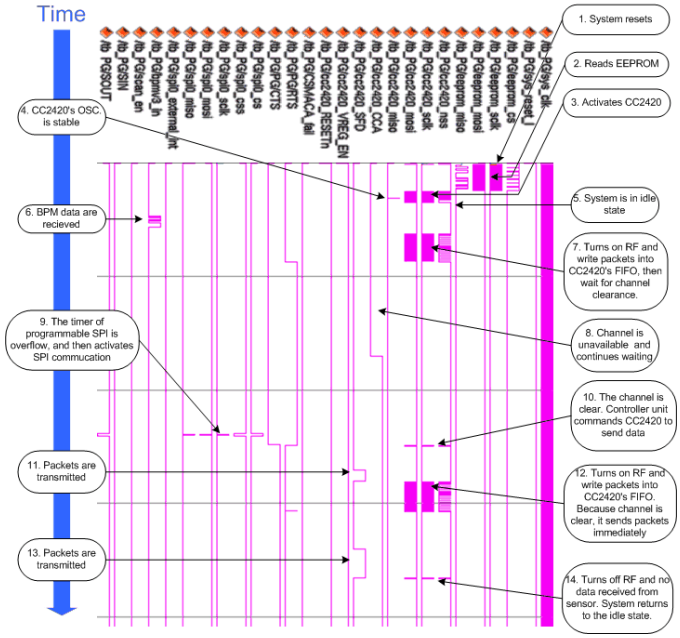

Fig. 8. Post-layout simulation of the proposed PG.

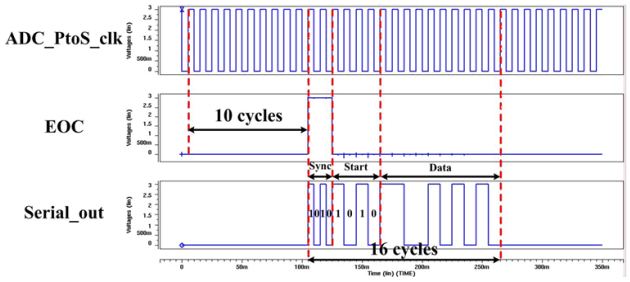

Fig. 9. Readout of the sensed bladder pressure data.

References

[1] IEEE Standard 802.15.4-2006.

[2] C.-C. Wang and C.-C. Huang, "A system prototype for portable wireless medical devices," in Proc. of 2008 IEEE Inter. Conf. on Consumer Electronics (ICCE'2008), paper P2-27, CD-ROM , Jan. 2008.

[3] C.-C. Wang, C.-C. Huang, J.-S. Liou, Y.-J. Ciou, I.-Y. Huang, C.-P. Li, Y.-C. Lee, and W.-J. Wu, ``A mini-invasive long-term bladder urine pressure measurement ASIC and system," IEEE Trans. on Biomedical Circuits and Systems, vol. 2, no. 1, pp. 44-49, Mar. 2008.