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Wireless Body Sensor Network – Fundamental Concepts and Application

Abstract. *The rapid growth of wireless technologies and personal area networks enables the continuous healthcare monitoring of mobile patients using compact sensors that collect and evaluate body parameters. In this paper, the concept of the Wireless Body Area Network and WBAN applications was discussed.*

Streszczenie. *Dzięki dynamicznemu rozwojowi technologii bezprzewodowych rozwija się również koncepcja zdalnego monitorowania osób z wykorzystaniem sensorów. W przypadku zastosowania w medycynie - pozwalają one np. na pobieranie i ocenę parametrów życiowych pacjenta. W pracy przedstawiono koncepcję i wykorzystanie bezprzewodowych sieci WBAN. (**Sieci WBAN – koncepcja i zastosowanie**)*

Keywords: wireless body area network, sensors, applications.
Słowa kluczowe: sieć WBAN, sensory, zastosowanie.

Introduction

The wireless sensor networks are formed by small electronic devices called nodes, whose function is to obtain, convert, transmit and receive a specific signal, which is captured by specific sensors, chosen depending on the sensing environment. A wireless sensor network consists of devices such as are micro-controllers, sensors and transmitter/receiver which the integration of these form a network with many other nodes (sensors) [8].

Wireless Body Area Network

One of the most interesting areas for the implementation of the Wireless Sensor Network is in the medical field because there are different challenges which are associated with monitoring the human body. The concept of biomedical signals focuses on the acquisition of data common phenomena of the human body. The human body responds to its environment. In order to monitor all of these features the sensors on the body surface are strategically deployed on a patient, forming a cluster that is called Wireless Body Area Network (WBAN). A WBAN contains a number of portable, miniaturized, and autonomous sensor nodes that monitors the body function. It provides long term health monitoring of patients under natural physiological states without constraining their normal activities.

Wireless body communications are generally grouped into [5]: (1) off-body, device is located on a body and communicates with one (or more) devices located off-body; (2) on-body, a number of devices are located on the body and communicate with each-other; (3) in-body, the devices are implanted (some or all of them). Type of WBAN devices can be group into [1]: (1) (wireless) sensor node: respond to and gathers data on vital signal/physical stimuli, processes the data (if necessary) and reports this information wirelessly. The device components are: sensor hardware, power unit, processor, memory and transmitter or transceiver; (2) (wireless) actuator node: acts according to data received from the sensors or through interaction with the user. The device components are: actuator hardware, power unit, processor, receiver/transceiver, memory; (3) (wireless) personal device (also called a Body Control Unit): gather all the information acquired by sensors and actuators and inform the user. The device components are: processor, power unit, memory, transceiver.

The advances in Radio Frequency Integrated Circuit (RFIC) technology for wireless communication technologies are not be directly transferable to medical application, due to the different power, size and safety related radiation requirements of medical devices.

A WBAN uses transmission bands for transmission of data [10], e.g.: Wireless Medical Telemetry Services (WMTS), Industrial Scientific and Medical (ISM), Ultra-Wideband (UWB) and Medical Implant Communications Service (MICS). The first one (WMTS) is a licensed band used for medical telemetry system. The existing advanced wireless systems e.g. ZigBee (IEEE 802.15.4), WLANs operate at 2.4GHz ISM band and may suffer from the strong interference from each other, when they are located in the same environment [9].

Research on wireless healthcare/monitoring systems can be grouped into three categories: application specific sensor system design, collection and processing data, and communication [2].

Wireless Body Area Network Applications

Wireless Sensor Network are being investigated for use in a variety of applications, such as:

1. military (battle field surveillance, enemy/friendly forces monitoring and tracking, biological and chemical attack detection),
2. environmental applications (forest fire and flood detection, seismic activity, monitoring of drinking water and level of air pollution),
3. health applications (monitoring of human physiological data) – Fig. 1, home applications (intrusion detection, home automation),
4. commercial applications (inventory control, material fatigue, monitoring of product quality),
5. climate control in large buildings and habitat monitoring [10].

The application of WBAN in a medical environment may consist of wearable (on-body) and implantable (in-body) sensor nodes that sense biological information from the human body and transmit over a short distance wirelessly to a control device worn on the body or placed at an accessible location, e.g. (1) in-body applications: pacemaker, glucose sensor, endoscope capsule, (2) on-body medical applications: ECG, SpO_2, blood pressure, (3) on-body non-medical applications: forgotten things monitor, assessing soldier fatigue and battle readiness (report his activity to the commander, i.e. running, digging.

The modern healthcare system and sensors work in a medical environment (identify, monitor, communicate even small change in the monitoring parameters/patient body condition) make it possible to easily monitoring e.g. old aged people, mentally disordered person by the automatic health care monitoring system.

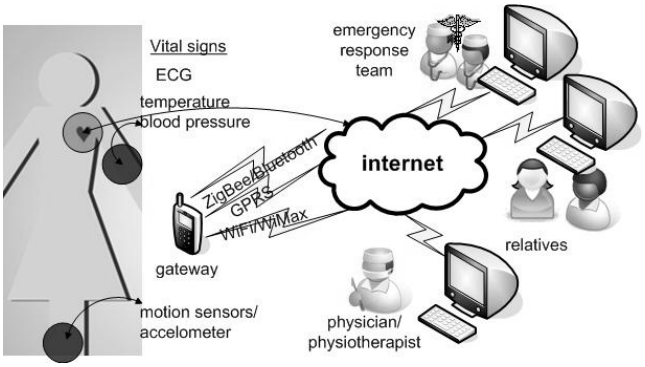

Fig.1. Conceptual diagram of WBAN for medical applications

Interferences

The interaction between devices emitting electromagnetic field is presented in literature. The medical equipment manufacturers generally comply with IEC Standard 60601-1-2. It is recommended 10 V/m immunity level against interference from RF emissions and this level of immunity is not guaranteed.

Witters and colleagues [11] studied on the EMI effect to wireless healthcare devices. They discussed risk for wireless technology in healthcare with examples – effect of emission from RFID on implantable cardiac pacemaker and defibrillators. Authors summarized "…*there is clear need to develop unbiased, consensus information and tools that will set the pathways and tools needed to meet the risks and challenges for widespread incorporation of wireless technology in healthcare*.".

The interaction between insulin pump [7,3] and RFID tags used for identify blood samples is an example of electromagnetic interference. The insulin pomp exposed to an RFID signal (915 MHz) is disrupted and inject although there is no need. For diabetes patients it is not recommended (excess) dose.

Houliston [6] and colleagues investigated if using RFID technology interfere with common drug infusion device. Authors published conclusion "*...electronic medical devices may fail in the presence of high-power RFID readers, especially if the device is tagged*…".

Summary

Due to the development of wireless technologies, an uncontrolled electromagnetic influence on medical devices used for telemetry can be found in the public and home environment. The signal monitoring does not focus only on the medical area also find that developments in the search (for example): (1) monitoring the environment, soil or water observation, (2) the maintenance of certain physical conditions (temperature, pressure, etc.), (3) detection of fires, earthquakes or floods, (4) civil or military assistance. As a conclusion, applications of Wireless Body Sensor Network was reported.

The other problem associated with the use of wireless technologies (e.g. RFID) is the potential impact of electromagnetic radiation to human bodies. Italian scientists [4] formulated opinion that "…*RFID technology does not correspond to a parallel increase in studies on its possible impact on health in terms of electromagnetic field exposure*…". They estimated by computational techniques, the EMF generated by passive RFID systems for mother-newborn identity confirmation. The scientists concluded "*The need to reduce the exposure time as much as possible indicates the importance of specific training on the practical applications of the RFID (DATALOGIC J-series, Bologna, Italy) device...*". Chen ah Pompili [2] noted that "...no research has focused on prioritizing the transmission of healthcare data over the wireless network under the electromagnetic interference (EMI) environment by *jointly* considering the patient condition *and* the data content, i.e., the type of measurement (temperature, *O*2 saturation, blood pressure and pulse, heart rate variability, etc.), which is critical in emergency services.".

REFERENCES

[1] I.F. Akyildiz, W. Su, Y. Sankarasunramaniam, E. Cayirci, A survey on sensor network, IEEE Communications Magazine, Vol. 40, No 4, 2002, pp. 102-114

[2] B. Chen and D. Pompili, Transmission of Patient Vital Signs using Wireless Body Area Networks, *Mobile Networks and Applications (Springer)*, Vol. 16, No. 6, 2011, pp. 663-682

[3] B. Christe, *Evaluation of Current Literature to Determine the Potential Effects of Radio Frequency Identfication on Technology Used in Diabetes Care*, Journal of Diabetes Science and Technology, No 3(2), 2009, pp. 331-335

[4] S. Fiocchi, M. Parazzini, A. Paglilonga, P. Ravazzani, *Computational exposure assessment of electromagnetic fields generated by an RFID system for mother-newborn identity reconfirmation*, Bioelectromagnetics, Vol. 32 (5), 2011, pp. 408-416

[5] P.S. Hall, Y. Hao, Introduction to Body-Centric Wireless Communications, *Antennas and Propagation for Body-Centric Wireless Network*, P.S. Hall, Y. Hao (editors), Artech Hosue: Boston, USA, 2012 (second edition)

[6] B. Houliston, D. Parry, C.S. Webster, A.F. Merry, *Interference with the operation of medical devices resulting from the use of radio frequency identification technology*, The New Zealand Medical Journal, No 122(1297), 2009, pp. 9-16

[7] N. Lasorte, I.B. Akunne, H.H. Refai, I*n vitro protocol to study the electromagnetic interaction of RFIDs and infusions pumps*, Asia-Pacific Symposium on Electromagnetic Compatibility, Beijing, China, 12-16 April 2010, Conference Publications, pp. 1084-1087

[8] C.A. Lozano, C.E. Tellez and O.J. Rodriguez (2011). *Biosignal Monitoring Using Wireless Sensor Networks, Biomedical Engineering, Trends in Electronics, Communications and Software*, Anthony N. Laskovski (Ed.), ISBN: 978-953-307-475-7, InTech, Available from: http://www.intechopen.com/books/biomedical-engineering-trends-in-electronics-communications-and-software/biosignal-monitoring-using-wireless-sensor-networks, accessed: May 2012

[9] S.Y. Shin, H.S. Park, W.H. Kwon, *Mutual interference analysis of IEEE 802.15.4 and IEEE 802.11b*, Computer Networks, Vol. 51, 2007, pp. 3338-3353

[10] S. Ullah, P. Khan, N. Ullah, S. Saleem, H. Higgins, K.S. Kwak, *A Review of Wireless Body Area Networks for Medical Applications*, International Journal of Communications, Network and System Sciences, Vol. 2, No. 8, pp 797-803, 2009

[11] D. Witters, S. Seidman, H. Bassen, *EMC and Wireless Healthcare*, Asia-Pacific Symposium on Electromagnetic Compatibility, Beijing, China, 12-16 April 2010, Conference Publications, pp. 5-8

[12] T. Yilmaz, R. Foster, Y.Hao, Detecting Vital Signs with Wearable Sensors, *Sensors* 2010, 10, 10837-10862; doi:10.3390/s101210837

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