

## Wireless Body Sensor Network in Health Maintenance Systems

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**crossref** <http://dx.doi.org/10.5755/j01.eee.115.9.762>

### Introduction

Health Maintenance Systems are focused on wireless monitoring of base life functions in home use. These systems were introduced in early 1990's. The first patent in this area was registered in U.S.A by Alyfuku Kiyoshi a Hiruta Yoshiki [1]. From that time many research teams are involved in this problematic. The field of application was changed many times from the first idea. These days the first field of implementation of Health Maintenance Systems is remote care of elderly people.

Currently, there is worldwide problem of aging population. In the European Union was seventies percent of the population older than 65 years in 2001 during last census. According to the mean estimate of 2035 there will be approximately 33% of the population older than 65 years in the EU. As a result, the proportion of people aged 16-65 to persons older than 65 years will be changed in 2040 to 2:1. Similar demographic changes are taking place in most European countries, USA, China and Japan. Overall, this trend suggests that by 2050 approximately 20% of the world's population aged at least 60 years.

One way to avoid institutionalization of the elderly (or at least postpone it for as long as possible) and reduce the cost of health care is through new technologies. The goal is not cure the disease but also to ensure the recovery and prevention of diseases in all stages of life. The use of telemetry technology applied in the remote areas of home care can be especially elderly persons in better health and independence.

From this reason it is very important to design new system of health maintenance. There are designed many health maintenance systems but each of that has another basis of solution as describes [2].

Independently of the development of Health Maintenance Systems there are developed new standards in Body sensor networks. It is therefore very convenient implement news from body sensor networks in the Health Maintenance Systems. Before the design of new health maintenance systems it is important to define which category of health maintenance systems we like to design.

The second step in health maintenance system design is to choose suitable body sensor network standard for communication.

### Health Maintenance systems categories

The Health Maintenance systems are separated to the four basic categories which are different by the type of utilization the first.

The first direction is the orientation of the health maintenance systems to the problems of home automation and also to increase comfort and safe housing. Solutions are making the most of networks, regulation and control systems for temperature control, lighting, humidity and so on. This creates communications networks of home appliances or heating systems. These applications serve to increase user comfort apartment but also to enhance its safety. They are also as an extension able to control the activity of various electrical appliances to ensure greater safety for the user's dwelling. In terms of health care workers are not monitored by the application of major importance, however, prevent accidents in the apartment and increase comfort. However, the system can provide valuable information about the activities of the monitored person.

The second focus is on remote systems, home care, which is actively involved in monitoring the monitored person. These systems have long collected information on current health status of the monitored person. The basic way of collecting this information is the measurement of biological signals on body surface area. Based on the measured data is then monitored by the current health status of persons assessed in the event of a health problem is monitored person is given first aid and urgent medical or nursing care. A special focus of this sub-systems are remote home care monitoring the current position of the person in the apartment to determine physical, daily activities and habits of those monitored in environmental monitoring. The values can also be used to the diagnosis of falls of the monitored persons. Such application systems, remote home care is designed for people living alone,

otherwise there are no significance. These systems are most important in the sense of care for monitoring of persons of terms of personal health.

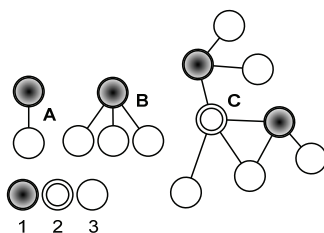
The third area is remote home care systems, which reduce the difficulties caused by health or disability. These systems are in foreign language literature called assistive technologies. This includes technologies for the disabled, for people with visual disabilities and people affected by hearing loss and deafness. This area usually combines knowledge of more areas of technologies, not only electrical but also there is a civil and mechanical engineering fields of applications. Examples include barrier-free apartments, wheelchair different types of uses (e.g. sports), hearing aids, aids for the blind and aids for people with reduced mobility, such as special joysticks, computer mice and the like.

The last group of health maintenance systems is remote home care systems involved in therapeutic systems. These include systems for home therapy, in conjunction with measuring technique that checks the status of rehabilitation. Furthermore, this system of local coaches to improve cognitive function, improving the condition. This group will also include means to control the use of drugs and devices for automatic dosing of drugs and hormones.

### Sensor network design

BSN is in most cases implemented wireless technology with a small range. In this area using two very basic technology and Bluetooth and ZigBee is typical.

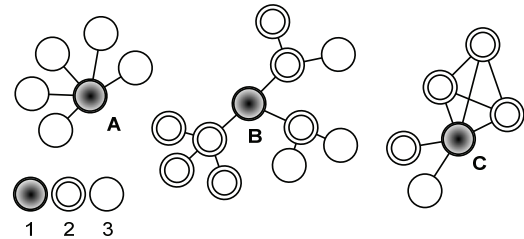
Bluetooth is a standard often used by wireless communication, with seemingly simple communication protocol. Another benefit of this technology is the production of various devices using Bluetooth technology as one of the main communication technologies in the BSN, which has been implemented so easily connectable device. Its major drawback is the large consumption and unnecessarily wide communication channel for applications in the health maintenance systems. It is also a limited number of establishments operating in one network. This limitation is due to the architecture of the Bluetooth network Fig.1 [3].



**Fig. 1.** Bluetooth Network Topology: A - piconet (point-to-point) B - piconet (point-to-multipoint), C - scatternet (more master units), 1 = master 2 = master / slave, 3 = slave

The first health maintenance system implemented in our laboratory was built on Bluetooth. However, this proved to be very inefficient, especially in of network architecture and the consumption of terminal equipment. It was also very difficult to add a network device with its own dedicated communication protocol.

ZigBee is a simple wireless communication standard that allows for mutual communication of many subtle devices to tens of meters, which is perfectly adequate for the health maintenance systems. Due to low demands on hardware and low consumables it is applied in the areas of building management, and consumer electronics industries, such as battery-powered non wired sensors. Therefore, it is advantageous to use this technology to measure biological signals. Good is the structure of ZigBee networks, the simplicity of adding additional equipment and self-organizing network Fig.2. [3]



**Fig. 2.** Bluetooth Network Topology Figure 2. ZigBee network topology, a) star, b) tree c) mesh, where 1 = Coordinator (FDD), 2 = router (FDD) and 3 = end device (RFD)

In the first stage, the use of ZigBee technology has been used to implement communication ZigBee OEM modules with the programmed transfer parameters and transmission protocols lowest layers of the ZigBee protocol. They are now replaced by the ZigBee solutions at the lowest level System-on-Chip (SoC) components. At one point the exchange networks were made up to three different solutions, the ZigBee hardware.

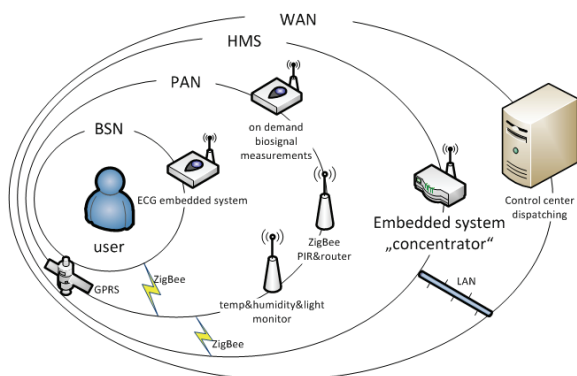
### Health Maintenance system design

Our laboratory has designed own health maintenance system (HMS) Fig.3., which is innovative in the connectivity array of sensors, used in communications technology strategy and overall approach for implementing the system in all categories of health maintenance systems. Its purpose is to link the provision of comfort and security for lone elderly who live in their homes. The basic concept reflected possibility of elderly activity, so it is not only designed for the monitoring of people in the apartment but also outside it. Using body sensor standards we reached the high efficiency of the monitoring system and its reliability.

The basis of the whole system is embedded microprocessor system, which provides collection, preparation and transmission of measured data and evaluated crisis. Sensors used to measure variables interact with embedded microprocessor system wirelessly using ZigBee, with regard to user comfort. Communication between the flat embedded microprocessor system and the surveillance center is secured using a LAN mostly. While in areas outside the apartment, the data transfer is secured solely through wireless (GPRS).

The correct choice of sensor systems in HMS was very important. Since the monitored person is constantly monitored, the sensor must be used to monitor persons harmless in terms of physical and even psychological. For these reasons, these systems use non-standard types of

sensors of biological parameters, represented by textile electrodes, the development and testing was carried out in recent years in the Biomedical Engineering laboratory.



**Fig. 3.** Health Maintenance System design

The other non-biological sensor values must satisfy the conditions resulting from the principles of medical ethics to bother monitoring person psychological pressure. Therefore, the sensor were be minimized not to evoke feeling inadequate monitoring.

The most biosignals are scanned, pulse curve, electrocardiogram, blood pressure, blood oxygen saturation, weight, temperature or blood glucose. The final choose of measured signal depends on medical staff, which cad decide professionally on the patients diagnosis, what is necessary to monitor.

Important information about cardiac electrical activity, temperature, blood oxygen saturation may be with regard to the methodology for measuring the scanned continuously. Since it is a continuous measurement, we try to minimize the number of such measured signals. The electrical activity of the hearth is only one continuously measured parameter now. From efficient processing of the electrocardiogram we can process not only not only of stroke but also for example respiratory curve. The measurement is provided by ECG monitor, which was developed in our laboratory. This monitor consists of electronics for analog preprocessing of ECG and ZigBee module for data transmission.

Another Biosignal collected in the HMS are measured only in those moments of time. The main reason for limiting these measurements, the methodology of measurement, where these values cannot be collected continuously with regard to the limitations of sensors systems for HMS.

They are blood pressure, weight and blood glucose. These measurements are provided by standard measuring devices, which have communication interface suitable for next data transmission. These devices are connected with ZigBee module, where origin data protocol is changed to data protocol of our HMS. Which of these measurements will be implemented in the remote home care physician identifies a particular person with respect to the history and current health status. These measurements are performed on demand. Measurement patient initializes itself (on the scales, measure the pressure monitor, automatic blood

pressure).

Essential components of a remote home care system is unique positioning as defined by vertical and horizontal movement of species and detection of falls. For this purpose we use accelerometers built into the device continuously measuring ECG. This part of embedded system for ECG measurement includes accelerometer and microprocessor for data preprocessing. The information about position is only transmitted to central database.

Movement of people running around the apartment equipped by HMS is a valuable source of information about the current position of the reference person in the apartment.

Other physical values are sensed in our HMS. The first it is temperature, humidity and lighting of the apartment.

The whole system is built on the ZigBee technology with its own communication protocol. Using appropriate wireless modules, we have achieved open system approach for implementing new sensors and devices.

### Testing

The designed system was the first partially tested on a pilot racing cars on hydrogen-powered race in the Shell Eco - Marathon in France 2006. Designed sensors were mounted to the race car, and we had test physical conditions of race pilot. Design and development of the system was implemented in close cooperation with doctors and professional health workers. Based on this partial test changes were made mainly in wireless sensor network. ZigBee technology has been successfully implemented. We tested the co-operation of ZigBee modules from different manufacturers. We used in our ZigBee network two types of ZigBee modules form different manufacturers. One of the modules was based on freescale silicon and other one was based on Texas Instrument silicon. The ZigBee stack was used. The cooperation of the modules was the same as in the case we used modules form one manufacturer.

The health maintenance system has been installed to the testing flat of Health Maintenance Systems which we have built in cooperation of Ostrava University. The first there were tested movement monitoring systems in vivo. The one person lived there one month during monitoring. The measured data are processed now into circadian rhythms. Other devices were tested in the laboratory conditions.

### Conclusions

The Health Maintenance Systems will certainly be part of systems of care for the elderly. The design of these systems must provide for the basic requirements of confidentiality and system reliability. Important criterions for selection of components are also the price of individual components and their durability. Our proposed system is trying to meet these requirements. We are constantly striving to improve the various components such as User Interface Design.

## Acknowledgements

The work and the contribution were supported by the project: Ministry of Education of the Czech Republic under Project 1M0567 "Centre of applied electronics", student grant agency SV 4501141 "Biomedical engineering systems VII" and TACR TA01010632 "SCADA system for control and measurement of process in real time". Also supported by project MSM6198910027 Consuming Computer Simulation and Optimization.

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Received 2011 03 23

Accepted after revision 2011 05 23

**M. Cerny, M. Penhaker. Wireless Body Sensor Network in Health Maintenance Systems // Electronics and Electrical Engineering. – Kaunas: Technologija, 2011. – No. 9(115). – P. 113–116.**

Health Maintenance systems are a special monitoring systems of the basic life functions. The goal of the work was to design and realize the wireless body sensor networks for on line vital function monitoring. The system is based on wireless sensors, information technologies and embedded computer systems. The man uses modified places where the monitoring systems that watch movement, position and chosen life functions are installed. In this case all the information about person's basic life functions and geographical location transmitted by wireless technology. All the measuring devices communicate with embedded microprocessor system wireless by Bluetooth or ZigBee technology. Ill. 3, bibl. 9 (in English; abstracts in English and Lithuanian).

**M. Cerny, M. Penhaker. Sveikatos priežiūros sistemoje naudojamų bevielio ryšio kūno jutiklių tinklas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2011. – Nr. 9(115). – P. 113–116.**

Sveikatos priežiūros sistema skirta bendrųjų gyvybinių funkcijų specialiajai stebėsenai. Bevielio ryšio kūno jutiklių tinklas yra sudarytas iš bevielio ryšio jutiklių, informacinių technologijų ir įterptinės kompiuterinės sistemos. Tokia sistema yra gana mobili ir geba sekti žmogaus būseną nepriklausomai nuo jo buvimo vietos. Informacija perduodama taikant bevielio ryšio technologiją. Visi jutikliai susieti su įterptine sistema taikant „Bluetooth“ ar „ZigBee“ technologiją. Il. 3, bibl. 9 (anglų kalba; santraukos anglų ir lietuvių k.).