Design of Health Supervision System Base on WBAN

Xinli Zhou

Abstract Traditional health care system in the family-oriented application of monitoring system has some disadvantage, which is relatively small, and function relatively single operability is more complex, real-time performance is poor, the price is relatively expensive. In recent years, with the progress of integrated circuit technology and wireless communication technology, wireless body area network (WBAN) systems have got fast development. The application system base on BAN technology also has received more and more people's attention. This paper presents a general framework BAN-based health care system, mainly introduces the design of the sensor from the perception layer and network protocol.

Keywords Wireless sensor · Wireless body area network (WBAN) · 802.15.6 · Health care and monitoring system

1 Introduction

Wireless body area network is the product of the rapid development and convergence of microelectronics technology and wireless communication technology. The principle of WBAN is, by various types of sensors perceiving from the body or body surface, collecting physiological signals and transmitting them to the local station, ultimately interact with information center and attain the monitoring and the purpose of medical treatment. Body area network [1] (wireless body area network, BAN or WBAN), also known as BSN (body sensor network), let the network extends to the human body, is an important part of internet of things.

The proposed BAN has been widespread concern on the medical community and the communications sector. IEEE has officially launched the standard of 2012 802.15.6 [2], the standard thought WBAN have a wide range of applications in

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health care, emergency care, specific population monitoring tracking, entertainment and other fields. Chinese scholars have carried out theoretical and applied the study. Berkeley of University of California focuses on studies of wearable BAN, scalability and resource optimization. Based on a variety of communication methods the Chinese University of Hong Kong has built a mixed BAN, and study on BAN and mobile tracking and energy-aware MAC for the relevant research. Korea information and Communications University BSN build new systems from the perspective of energy consumption and communication. In addition, studies in Canada, Germany, Ireland, Brazil, Belgium and Switzerland and other countries in terms of BSN adaptability and adjustability, middleware, signal processing algorithms, health and activity monitoring and network reliability has also made progress [3]. Base on the previous research results, this paper presents a general framework BAN-based health care system, mainly introduces the design of the sensor from the perception layer and network protocol.

2 Systematic Design

Our health care systems base on WBAN combined with sensor technology, wireless communication technology, embedded technology. It can be collected physiological information using wearable wireless sensor nodes without affecting the daily activities to record the trajectory change of the physiological signals in one day, then to analyze such information and data, as well as to determine the occurrence of unforeseen circumstances inform physical condition, and sends the results to a remote medical service center or guardian.

Structural health monitoring system of BAN is generally considered to have three layers [4]: BAN internal, between BAN and aggregation node and the information monitoring center (Fig. 1).

The first layer internal network is composed of a group of sensors monitoring of physiological characteristics, due to limited resources, their functions experienced a simplified design. In the medical field, sensor is capable of measuring and

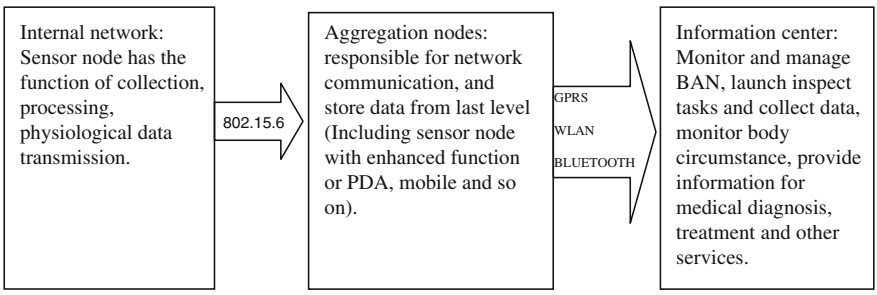

Fig. 1 Architecture of BAN network system

processing body's physiological signals or the environmental information, and transmitting the information to the outer control node. The sensor can also receive an external command to trigger action. In non-medical field, wearable devices (such as Headset, MP3 player and game controller) can include. In this paper, we analyze and design the various types of sensors used in the health monitoring system.

The second layer is a mobile personal server with fully functional design (mobile personal sever) or BSN Head or master nodes, and further includes a base station. It is responsible for the external communication and network, and stores the collected data from first layer. It manages each sensor node or device with low energy consumption, receives and analyzes sensing data and executes user program following provision. Here the base station can be mobile phone with relatively rich resources, PDA with accessable internet or other handheld devices.

The third layer is the data center contains various information such as electronic medical records which provide medical server maintains a registered user, some responding services for the user, medical and nursing staff.

3 Physical Channel Design

In the physical channel, we need to consider the wireless connection, antenna and power three parts.

3.1 Wireless Connection

In the earlier researchers realize the BAN with 802.15.4ZigBee, Wi-Fi or low power Bluetooth or other short-distance wireless communication technology. While considered the existence of large power consumption, easy interference and work in the ISM band of IEEE 802.11 and IEEE 802.15.4, so the NB in PHY layer are defined in the IEEE 802.15.6, ultra wideband (UWB) and human body communication (HBC) three physical layers. When working in different frequency range to meet the needs of different scenarios. Narrow band in the physical layer is mainly responsible for the activation/deactivation of wireless transceiver. In current channel NB can estimate the idle channel (CCA) and data sending and receiving. Narrow band (NB) signal is conformity with the energy level of MICS, and the interference is very low to other equipments. UWB physical layer has two working modes: the default mode and QoS mode. Human body communication (HBC) physical layer work in 4 MHz bandwidth, center frequency in two bands of 16 and 27 MHz, these two bands are available in American, Japan and South Korea, the working frequency in Europe is 27 MHz.

In this paper, the ultra wideband (UWB) the design of health monitoring system was selected. It's default mode is suitable for medical use, QOS model is more suitable for medical applications in high priority.

3.2 Antenna Connection

Considering the practical application of BSN, the antenna design is an important problem. The antenna is a decisive factor in the BSN health care system with reliability and high efficiency of wireless communication link, or mini implant biosensor in the body to ensure long-term monitoring. For the design of the antenna, the main consideration should be given to the following three factors: little reverse radiation, compact structure, little interaction between the bodies. As Verbiest et al. designed a printed monopole antenna of miniature, low cost, has good energy saving effect in the human body surface, but the frequency and the bandwidth of the antenna and the emission efficiency is vulnerable to human disturbance.

Therefore, this design uses the Kang et al. proposed a folding of the ultra wideband (UWB) antenna. It uses the edge structure to achieve from 3 1 to 12 GHz ultra wide band, slightly the adjacency effect only on the human body, and the specific absorption rate (SAR) is much smaller than a single omni-directional antennas, also it can get the better energy-saving effect [5]. Of cause, the UWB antenna can use the existing ISM band (2.4 GHZ) and frequency of national medical and/or regulatory authorities approved medical implant communication system (middle-income countries) and wireless medical telemetry system (WMTS), and ultra wideband (UWB) frequency.

3.3 Power and Protection

Lithium ion battery can not meet the capacity and volume of the application requirements in BAN. Some scholars suggested by devices of super-capacitors and carbon-nanotube-based, Latre et al. [6] pointed out, can also be converted human body temperature or vibration to electrical energy. For instance, using thermoelectric generator (TEG) to convert the temperature difference between the body and the surrounding environment to electrical energy supply the node power. The latest technology is the study of a new type of biological catalysts of fuel energy [7], by the decomposition of glucose to the human body sensor supply the node power. In this paper, the design of the model is the use of Hewitt through a mesh fabric which is composed of tiny tubes, convert the temperature into energy [8].

4 Design of MAC Layer

Media access control (MAC) is the core content of any communication protocol, which influences the quality of service (QoS). The purpose of MAC is to reduce collisions and achieve the maximum possible throughput of the signal with

minimum delay, thereby increasing the reliability and performance of network communication and maximize energy efficiency.

In the IEEE 802.15.6 standard, the access method in the super-frame period can be divided into three categories: (1) random access mechanism using CSMA/CA or Slotted-Aloha to obtain the channel resources; (2) access to resources by unscheduled Polling/Post improvisation and non scheduled access (access connection free competition); (3) by a predetermined then one or more of the super frame distribution (called the 1-cycle or m-cycle distribution) to get scheduled access for slot (access connection free competition).

Due to the following character of health care monitoring system:

1. Energy is more limited, because the BAN sensor is implanted or placed on the surface, so the energy capacity is limited, replacement cost is large than ordinary sensor network, so the energy efficiency problem is more prominent.
2. The BAN channel environment changes constantly. Many sensors to monitor in the human body will change because of the movement of the body and the surrounding environment. The BAN sensor is on the movable, increases the complexity of the network, can not use the fixed network architecture to consider.
3. The physiological data of BAN sensor for the detection is of regular, stable data stream. For example, in the medical care application, the above MAC protocol were not considered the most physiological information of the human body (such as blood pressure, body temperature) changed little during the day, and most of them are in the normal range, the normal physiological information is not necessary for real-time processing, there should be a selection method.
4. For medical care in the BAN, the transmission delay of abnormal data is fatal consequences, so send emergency data should be a priority. This is a common WSN are considered. For the emergency data of some sudden illness of human body may be the priority must be considered.
5. The BAN node is strategically placed in the body or body surface, no redundant nodes handle communication failure. And the sensor network is to balance the general service quality through the redundant nodes.
6. To sum up, it is very important with the design of MAC layer priority to urgent data real time communication. In this paper, the French scholar LETI proposed hybrid medium access control protocol of priority MAC (PMAC) [9] base on IEEE 802.15.6, here data channel separates from the control channel, give priority to important traffic (traffic emergency).

5 Network Topology

The network architecture of BSN is an important part of the previous system architecture. It is the logic organization of communications equipment in the system (such as sensor nodes). In general, network architecture includes the star topology,

ring topology, mesh topology and bus topology. The choice of network architecture influences by system characteristics, and can be influence on lot of performance of system, such as energy consumption, traffic load capacity, node failure robustness and MAC protocol etc. The destination of the BAN network architecture choice is to better ensure that the wireless communication with low energy consumption and high reliability of data transmission, and the choice of architecture needs to consider the following factors: energy consumption, transmission delay, inter-user interference, node failures and mobility. In normal circumstances, the star topology network structure corresponds to one hop wireless communication mode, while the mesh topology corresponds to the multi hop wireless communication.

The structure of the IEEE 802.15.6 is mainly star network topology, but also there will be a net or mixed topology structure, such as the need for multi-hop communication mode when the nodes far away from the body or body block. So it is in large scale BAN network. In this paper, the choice of network architecture is not a single. From a practical perspective, the scale of general BAN networks and the complex degree is mainly base on the architecture of choice. Application of BAN with less node and simple function will first choice the star topology structure of hop wireless communication. General speaking, for the more nodes or large scale BAN network, to select the mesh topology and hybrid topology is suitable.

The design of this paper is BAN network with mesh or mixed topology structure. In the network there has a lot of work to do. On the one hand, the connection probability model in multi hop BSN network need to propose, without the use of circular coverage model considering the problem of wireless communication link. In addition, in the multi-hop communication architecture there will have multiple communication links between two entities, so the mesh topology structure can improve the reliability of the system. On the other hand, multi-hop communication network or mixed topology corresponds also to wearable sensors and peripheral sensor combination, then by using the method of distributed reasoning or strategy to realize intelligent identification and monitoring, multi- hop wireless communication another role is to construct the control system based on BSN network.

6 Choice of Sensor

The sensor technology is an important foundation to build a health monitoring system. All kinds of sensor miniaturization, intelligent, high precision, low power is necessary to support BAN. Low power to the sensor inside the body is essential for implantation of performance. The sensor must be collecting physiological signals, such as wireless ECG and pulse blood oxygen node and nodes of wireless temperature sensor can measure a variety of important physiological signals such as blood pressure, body temperature, blood oxygen, ECG, EEG, emg, etc.

According to the location of the body, sensor nodes in the monitoring system can divide into 3 categories: 1. sensor nodes implanted in the body, including implanted biological sensors and inhaled sensors (such as a camera pills); 2. sensor nodes

Table 1 Sensor nodes in the health care system

Type	Sensor	Function	Location
Medical area: EEG, brain electrical activity for monitoring; ECG, used to monitor cardiac activity; electromyography, used to monitor muscle activity; respiratory monitoring, monitoring of respiratory system. Also has some simple monitoring such as body temperature, heart rate, blood oxygen, blood pressure, glucose etc.	Saturation of blood oxygen sensor	The concentration of oxygen in the blood, is an important parameter of respiration and circulation	Internal
	Ring type heart rate sensor	Describing the voltage charts during the heartbeat caused by heart or heart	Surface, internal
	Glucose sensor	Subcutaneous implantation of nano measurement of blood glucose	Internal
	Blood sensor	No compression with blood pressure measurement	Surface
	EEG scanner	Monitoring the human brain electrical signal	surface
	Sensor of lung function	Velocity and mass flow rate measurement of human breath, and calculated the forced expiratory vital capacity and pulmonary function of human body	Internal
Geographical location, environment: information: To monitor the patient's daily activities, to help find the disabled access to environmental information, or the lost people	Temperature and humidity sensor	Real time monitoring object information and advice given by the temperature and humidity information	Surface
	GPS + Pressure sensor	Absolute pressure measurement of gas, used for localization of GPS, that the altitude and weather conditions	Surface
	Vision sensor	Use of laser scanner, or digital camera to obtain the image information of CCD	Surface
	Auditory sensor	Bionics sensor	Surface
	Acceleration sensor	Recognition of human posture and motion	Surface

worn on the body, such as a glucose sensor, pressure sensor, non invasive blood oxygen saturation sensor and temperature sensor; 3. environment nodes around the body and near the body the distance which is (relatively) short used for recognition of human activities or behaviors.

Combined with the existing medical information and sensor development status, this paper designed the sensor nodes in the health care system as follows (Table 1).

According to the technical challenges faced in the design of node in the above, we can consider the aspects of electronic and electrical characteristics of node and the function optimization design, also can consider to increase the battery life to

deal with. Another strategy is to design a transmitter with low voltage low power repeater, high integration and high performance to deal with the above challenges of sensor nodes with low energy consumption. In addition, facing the implantable node energy consumption we hope to reduce the energy consumption to 100 W. The radio interface is still a challenge, the design of a good radio interface and its optimization strategy is also able to promote the performance of the sensor node operation and low energy consumption.

7 Security Design

Health monitoring system is mainly used in human peripheral, the human physiological information and other important data transmit in the network, so it is a very private system, only the authorized user can query and monitoring the network; on the other hand, the WBAN is composed of the main data of the accident notification chain, so it need protected, can not failure otherwise, even failure, once the emergency situation, will cause unimaginable consequences for users. In general, protocol, software should be considered its security at the beginning of design, especially in fields of the protection of confidentiality of data transmission and reliability of the network. There are three security levels defined in IEEE 802.15.6 standard, each level has different security properties, protection level and frame format.

The first level is one-time authentication of both sides of communication. It will inevitably to be a fraud, forgery, interception of information security incident follow-up; third levels encrypted for each data frame to ensure the communication security of sensor networks, but this does not meet the purpose of energy saving. Therefore, this paper will design the safety level of health care system in second levels, namely, a certification need to be done at the beginning of each session, so a choice of tradeoff on safety and energy saving was in consideration (Fig. 2).

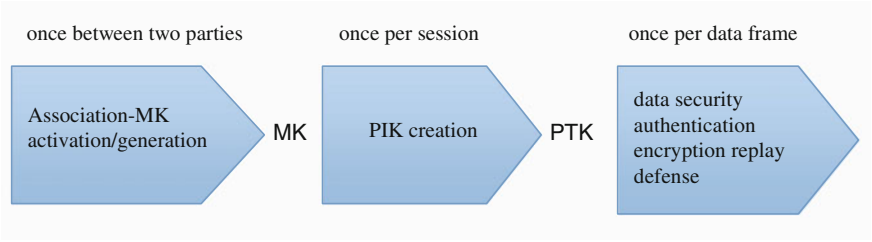

Fig. 2 Three security levels in IEEE 802.15.6 standard

8 Conclusion

In a word, the WBAN will develop towards intelligent, while the sensor nodes develop towards minimized, mobile, implantable and wearable, interactive. We hope to be able to combine various communication technology and network technology, meanwhile, construct the adjustable precision, large-scale, comprehensive health monitoring platform based on BAN. In addition to the measurement of blood pressure, pulse, ECG, EEG, blood, body temperature, blood glucose concentration, action, the surrounding environment information, our system can perform image recognition and intelligent information processing to provide clinical professional degree.

BAN will be more and more involved in data fusion, MAC protocol, energy, parallel and distributed algorithm in the field of technology development. In short, as a new technology, BAN has wide application space in the next year. It is generally considered BAN is worth to research more deeply and widely.

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