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ORIGINAL RESEARCH ARTICLE

Research status and progress of intelligent wearable system for first aid based on body area network

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ABSTRACT

With the rise of electronic health services, wireless body area network (WBAN) technology has attracted great international attention. The body area network can obtain human vital sign parameters in its natural state, and support applications in areas such as clinical diagnosis and treatment, emergency rescue and treatment, and health information services. This article introduces the concept of body area network and the electronic medical architecture of body area network, summarizes the advantages of body area network: In low data rate scenarios, the system power consumption of body area network is much lower than that of other wireless communication standards, providing more choices for special frequency bands for medical equipment (500 MHz to 5 GHZ), thereby reducing the interference problem between different communications; proposing bottlenecks and hot spots of body area network: Ultra-low power consumption requirements of sensor nodes and hardware resource constraints with limited computing power, and data security protection problems in body area network sensor nodes; the application of body area network in emergency scenarios was analyzed, and the hot spots of body area network research in the field of emergency were summarized and predicted: The development of ultra-low-power chips, wearable wireless nodes, intelligent medical terminals, health and monitoring instruments and other devices and equipment.

Keywords: body area network; first aid; wearable system; scene application

1. Research status of emergency intelligent wearable system in body area network

1.1. Background

The diversification and facilitation of healthcare services is increasingly rely on the support of information technology[1]. The medical field is one of the application fields with the widest coverage, the greatest support of information technology, the widest industrial driving area, and the most obvious service demonstration effect[2,3]. With the rise of electronic health services, WBAN technology has attracted great international attention. As the system and application of the integration of biotechnology, sensor network, and Internet, it will lead to the mutual penetration and coordinated development of information technology and other new

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technologies, the BAN has aroused strong interest in academia and industry around the world since its inception[4]. As shown in **Figure 1**, the BAN can obtain human vital sign parameters in its natural state, and support applications such as clinical diagnosis and treatment, emergency rescue and treatment, and health information services[5], which belongs to the intersection of biomedicine and information science, is a local area network with a communication distance of no more than 3 m through multiple wearable sensor nodes[6,7].

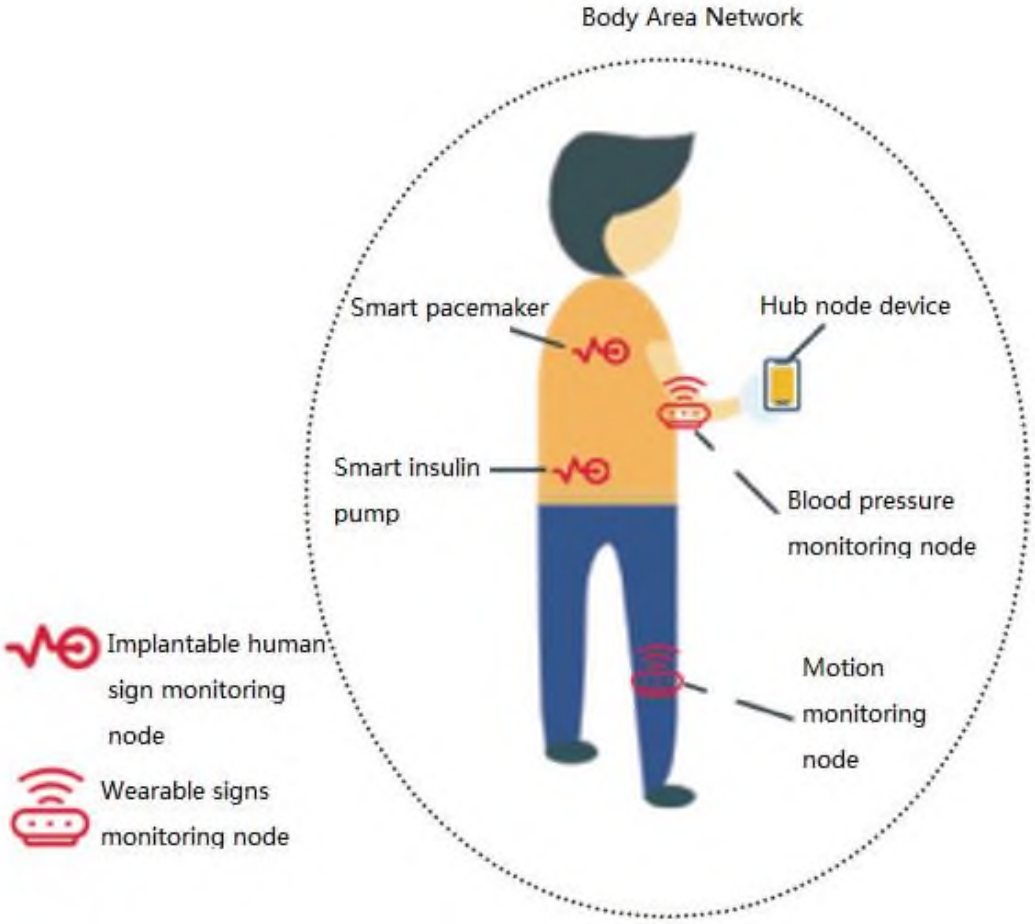

Figure 1. Body area network.

1.2. Electronic health architecture of BAN

The sensor nodes collect vital sign parameters such as blood pressure, heart rate, body temperature, respiration, oxygen saturation, ECG, and the coordinator sends data collected from the sensor node to hospital through the communication network and switching center[8,9], as shown in **Figure 2**, depicting a body area network-based electronic medical architecture diagram. After processing, it can be forwarded to individuals, communities and families, can provide a variety of services such as the mobile clinical, remote diagnosis, health education, health consultation and evaluation, which is extremely effective in alleviating the outstanding contradictions of the current medical shortcomings and low utilization rate[10], rationally allocating medical resources, and significantly improving the level of people's medical and health services, and also the treatment during emergency[11].

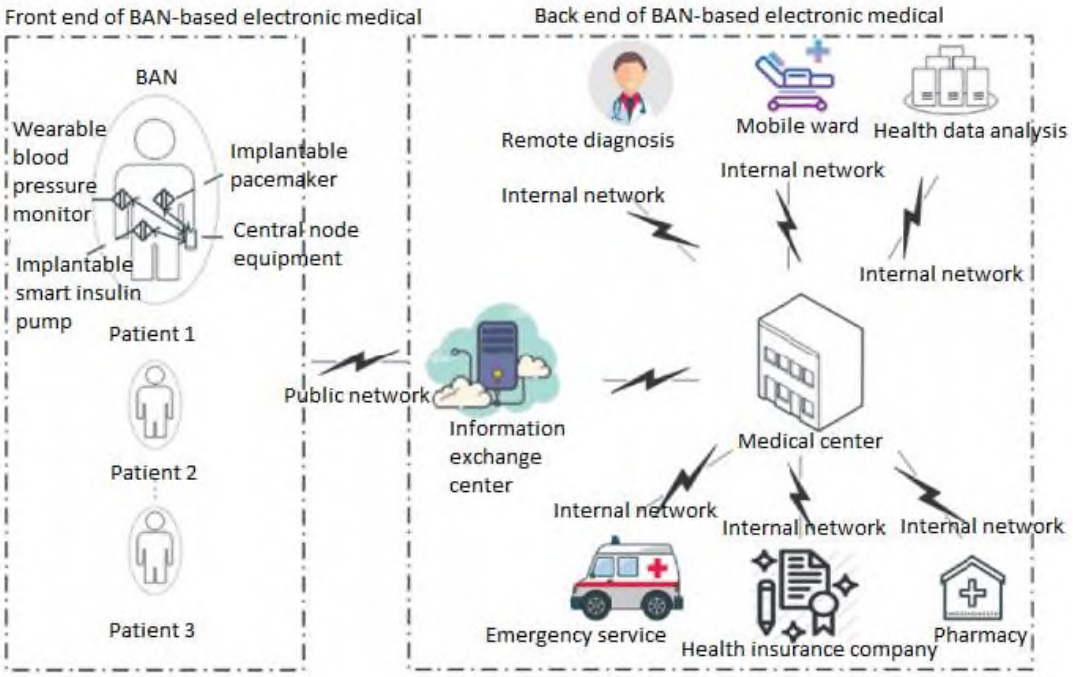

Figure 2. BAN-based electronic medical architecture diagram.

1.3. The application scope and characteristics of BAN

BAN technology can help achieve in the intelligent medical work for people, the digitization of medical information, real-time diagnosis and treatment process, scientific medical process, and humanized service communication[12,13], which can meet the needs of medical health and emergency rescue information, intelligent management and monitoring of public health safety, etc., and at the same time achieve the interaction between individuals and medical personnel, medical institutions, and medical equipment, and achieve the management of personal health by oneself, which enable the early treatment of diseases and the maintenance of emergency rescue information, and promote the informatization and intelligence of management in the medical field[14,15]. BAN can also be widely used in entertainment, sports, environmental intelligence, military and public safety, etc.[16], which is a key area that strongly related to the development of national economy and people's livelihood, and the market demand, which its social and economic benefits are immeasurable[17].

1.4. Advantages of BAN

As shown in **Figure 3**, compared with the standards of other wireless communication, the advantages of the BAN are mainly reflected in the following three aspects. (1) In the scenario of low data rate, the system power consumption of the BAN is much lower, and the battery life is much higher than the standards of other wireless communication. (2) The information transmission of WiFi, Bluetooth, and Zigbee are all concentrated in the 2.4 GHz frequency band, which is easy to interfere with each other and brings additional power consumption overhead[18,19]. While BAN offer more options for medical device-specific frequency bands (500 MHz to 5 GHZ)[20], thereby reducing interference between different communications. At the same time, the BAN system can choose the best channel for communication between the narrowband channel, the ultra-wideband channel and the human body communication channel according to the requirements of different application scenarios[21]. (3) Due to the BAN is aimed at the transmission of human body signs information in medical scenarios, its information sensitivity and privacy are

high. Improper information leakage will lead to serious security problems, and even directly affect the safety of users' lives. Therefore, the security protection measures of BAN are also higher and more unique by comparing to other wireless communication standards.

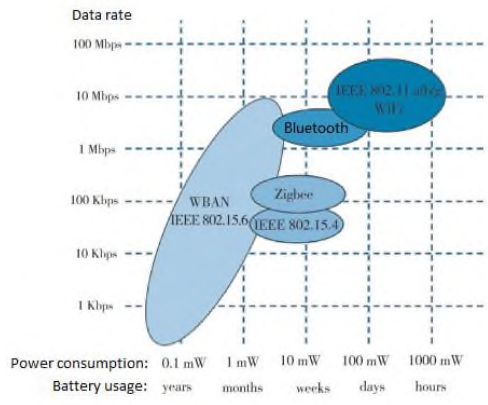

Figure 3. Power consumption and battery usage contrast between BAN and other wireless communication standards under different data rates.

1.5. Bottlenecks and hotspots of the BAN

Compared with other wireless communication networks, the main bottlenecks hindering the large-scale promotion and implementation of body area networks are concentrated in the following aspects. (1) The ultra-low power consumption requirements of the sensor node and the hardware resource constraints of limited computing power[22]. As a basic component of the electronic medical system, the BAN system node is responsible for monitoring and tracking the patient's body parameters for 24 h at anytime and anywhere, the long-term efficient, stable physiological information collection, and data exchange are the basic requirements for achieving its function[23,24]. However, due to the implantable and wearable characteristics of BAN sensor node, it is bound to use a limited power supply and low-power hardware with low computing power[25], and each power supply replacement or charging will have a greater impact on the continuous extraction and tracking of physical parameters[26]. Especially for implantable sensor nodes, each battery replacement will cause great inconvenience and pain to the user. Therefore, under the condition of limited power supply and hardware resources, how to design a long-term, efficient and stable communication design method for ultra-low power consumption BAN sensor nodes has become a hot issue in the field of BAN research[27,28]. (2) Data security protection problems in the sensor node of BAN. The BAN contains a large number of extremely private data information such as various vital signs data, medical diagnosis information, user medical records, etc. Illegal access, modification or information leakage will not only cause greater security risks, but also cause serious threat to the user's life safety, resulting in irreversible social impact[29,30], so the information security requirements of the BAN are higher than other wireless communication networks. (3) The sensor node of BAN and its limited power supply and hardware resource limitations make it difficult for the traditional high-intensity data security scheme to achieve the protection for each data in this scenario[31–33]. Therefore, how to design a safe and reliable encryption algorithm under the constraints of limited hardware computing power, power consumption and area, and establish a reliable environment for data transmission in the BAN, preventing illegal tampering of medical data, and ensure the legitimacy of nodes has become a key scientific problem that needs to be solved urgently in the field of BAN[34,35]. (4) Due to the limitations of low-power communication and data security in the BAN, although the BAN has a good development prospect in the medical field, however, it has always been a major defect in the current clinical application field[36,37].

2. Research progress of BAN intelligent wearable system for first aid

On the basis of solving the low-power and high-reliability communication mechanism and data security problems of the BAN, the wireless signs monitoring system of BAN is developed for emergency scenarios, such as disasters, traffic accidents, public health events, family sudden cerebrovascular accidents and other scenarios, and completes the

multi-parameter sign data collection, monitoring and rumination of emergency patients, improves the efficiency of emergency treatment and the speed of diagnosis, and speed up the process of medical informatization. As a bottleneck in the field of BAN research, the breakthrough of its core technology can effectively support the development of a new generation of information technology strategic industries such as information networks (services), wireless communications, semiconductors, etc., thereby driving the development of manufacturing and information service industries such as basic components, communication terminals, and system equipment, and the level of informatization and health care services in the medical industry will be improved. Applications: Smart terminal detection and analysis of physiological data, injury assessment, completion of electronic medical records, transmission of information to the medical cloud information platform through 5G, and the medical cloud information platform transmits hospitals and ambulances inspections, testing analysis and early warning physiological data, injury assessment, and completion of electronic medical records through 5G. It had been reported[38] that advances in BAN wearable systems that improve the current emergency department visit process by monitoring patients after emergency triage, thereby reducing the risk of adverse events. The study proposes a dynamic mathematical decision-making model to determine patient priorities, forming a feedback loop in the emergency department. Coupling of wearables (collecting data) and decision theory (synthesizing organizational information) can help reduce uncertainty in emergency department triage systems. The emergency wearable point-of-care-testing (POCT)[39] can significantly reduce the turnaround time of laboratory test results. POCT devices can test samples on patients directly, including bilirubin meters, pulse oximeters, breathalyzers (for alcohol and cannabinoid testing), transcutaneous blood gas analysis, postoperative glucose, and tumor markers. The use of these devices is very important in critical care medicine and emergency departments. Wearable POCT devices have great promise to meet the needs of current and emerging clinical disciplines.

3. Research hotspots and prospects of BAN emergency intelligent wearable systems

China's research in the field of BAN has just started, and there is a big gap compared with developed countries. At present, there is no theoretical and applied research on BAN in the field of emergency, and it is urgent to carry out relevant research to narrow the gap with the international advanced technology and lay the core technical foundation for the industrialization of the BAN system[40,41]. Information and security technology is a key issue that must be solved to establish a theoretical system and application system of BAN[42]. The cutting-edge research work the author intends to carry out has important academic significance for the exploration of network security technology of BAN and the realization of application-specific integrated circuits; it has high practical application value in reducing the power consumption of wireless nodes, stable and reliable communication, etc., and its successful implementation can promote the development of ultra-low-power chips, wearable wireless nodes, intelligent medical terminals, health and monitoring instruments and other devices and equipment, that can help to form an electronic medical implementation solution that benefits people's livelihood and emergency rescue. It has made direct contributions to the orderly promotion of the deployment and application of remote electronic medical services, and the improvement of the informatization level of medical industry and the level of emergency rescue medical services. The author did extending and deepening on the basis of the original team's work, and the team has a good research foundation in the design of BAN system security solutions, hardware design and emergency rescue application verification[43].

Conflict of interest

The authors declare no conflict of interest.

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