

Network Design and Performance Analysis of Wearable Wireless Sensor Network

Lincong Zhang^{1, a*}, Wenbo Zhang^{1, b}

¹ School of Information Science and Engineering, Shenyang Ligong University, Shenyang, P. R. China

^alincongz@foxmail.com

^bzhangwenbo@yeah.net

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Abstract. Wearable devices have got rapidly development in recent years, and the information transmission of them becomes an international research focus. To meet the requirement of reliability, real time and high throughput, ZigBee protocol plays an important role with its own inherent advantages and reasonable design. We focus on the network design of wearable wireless sensor network (WSN) using ZigBee protocol to study the performances during information transmission. The simulation results provide feasible effective evidence and feasible solution for further development of wearable wireless sensor network.

Introduction

As the development of information science technology, wearable devices have gone into people's view and become the hot topic [1]. It means that the everyday wearable devices are designed intelligently by wearable technology, facilitating several sensors in them, to enable the functions such as motion tracking, data collection, information transmission and interaction, and so on. Throughout all wearable devices, we can find their same functions, which are supported by three-axis gyroscope, accelerometer, Distance sensor, ambient light sensor, etc.

Wearable devices can analyze and deal with the data real time dynamically, send the data to the user or monitoring system. On one hand, they can show the data to the user for timely response; on the other hand, they can send the data to the outside network, such as personal private network, wireless local network or central database, as is illustrated in Fig. 1. At first, wearable devices are used to detect each part of the human body health state, such as electrocardio, breath, blood pressure, blood oxygen, etc.[2-4]. As the demand to functions, the wearable devices now develop to the target that realizing all or part of functions do not depend on smartphone, for instance intelligent glasses. At present, the key technologies of wearable devices mainly include data-processing algorithms, human-interactive, sensor, highly integrated electronic components, highly production process, application development, low-power chips, and extensible operating system.

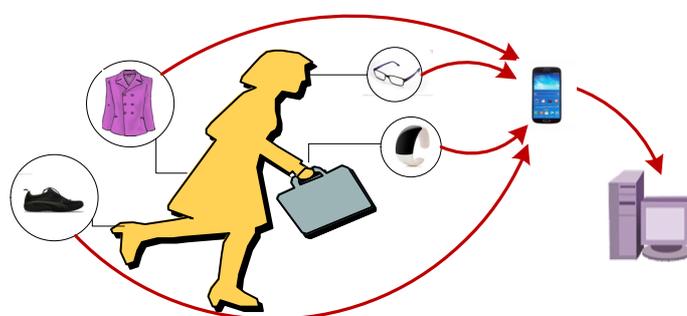


Fig. 1. The information transmission of wearable devices

The rest of the paper is organized as follows: we first describes the wearable WSN that studies in this paper. Next, we details the performances of wearable WSN from three aspects, i.e., different topologies, different channel sensing durations and a broken router. At last, we concludes the paper.

Wearable Wireless Sensor Network

To realize remote medical or mobile monitoring to objects by using wearable systems, wireless network technology is the inevitable choice, since transmitting the physiological signal detected by wearable system through the cable connection, limits the activities of monitoring objects and makes the characteristics of portability, low power consumption and low load of a wearable system meaningless. In certain circumstances, such as aerospace, medical and rescue and research, wireless network technology can maximize the function of wearable system. Table 1 shows the technical parameters of several major wireless transmission technologies. We can see that the technical advantages of Bluetooth and ZigBee in wearable system application, i.e., low power consumption, low cost, ideal transmission distance, etc.

	ZigBee	Bluetooth	WiFi
Power consumption	Low	Medium	High
Module cost	Low	High	Medium
Bandwidth	250	10M	54
Transmission distance	≤ 75	≤ 10	≤ 100
Security	Very high	High	Medium

This paper studies the wireless sensor network constructed by multiple sensors, the data collected by wearable devices is sent through wireless sensor nodes, and converges to source node, and reaches to monitor center at last, as is illustrated in Fig. 2. Furthermore, we adopt ZigBee protocol between the WSN nodes [5].

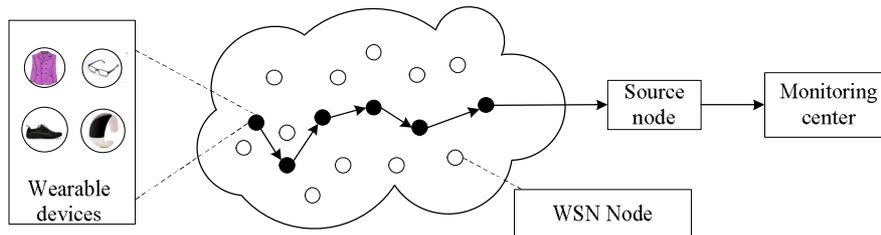


Fig. 2. Wearable Wireless Sensor Network

The characteristics of wearable WSN are as follows:

(1) Data transmission reliability. The wearable WSN is used to physiologic monitoring system, thus has to obtain accurate data, so that produces the effects of early prevention, diagnosis and treatment. In design, we need consider the factors about acquisition accuracy of sensors, link quality and reliability in routing protocol to avoid packet loss.

(2) Data real time. It includes three aspects, i.e., 1) the real time of data acquisition, which includes sensitivity of sensors and scope of data collection, etc.; 2) the real time of data transmission, mainly focuses on routing protocol, i.e., how to build routing and choose transmission path, etc.; 3) the timeliness of data process.

(3) Large load. Generally, there are more than four biomedical sensors in a human body. Compared with environmental monitoring sensor network, bandwidth demand of physiological data is much higher. Moreover, wearable WSN collects the data real time dynamically and so produces large amounts of data, which requires high network load to store all kinds of physiological data.

(4) Frequent changing topology. In wearable WSN, due to the movement, external environment changes, and the demand of health care of human body, the network topology always changes as the node's movement, death and join. As a result, wearable WSN has strong dynamic property, so routing protocol must adapt to the frequent changes of topology.

Performances and analysis

In this section, we first study the performances and features of wearable WSN by three different topologies. As ZigBee protocol is used, we name the wearable WSN nodes as ZigBee nodes. The topologies of middle transmission network part of wearable WSN are constructed as star, tree and mesh, respectively. The same number of ZigBee nodes, ZigBee routers are includes in each topology.

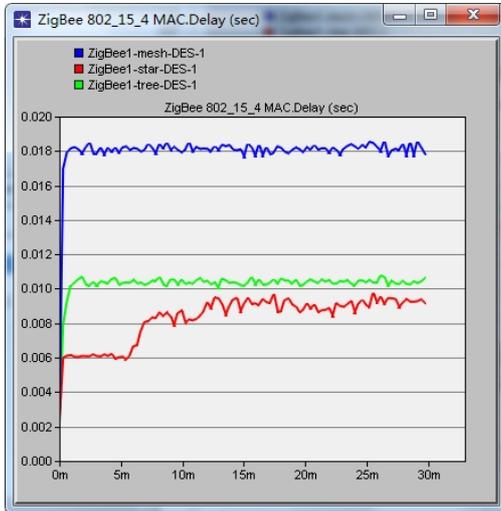


Fig.3. The delay of different topologies.

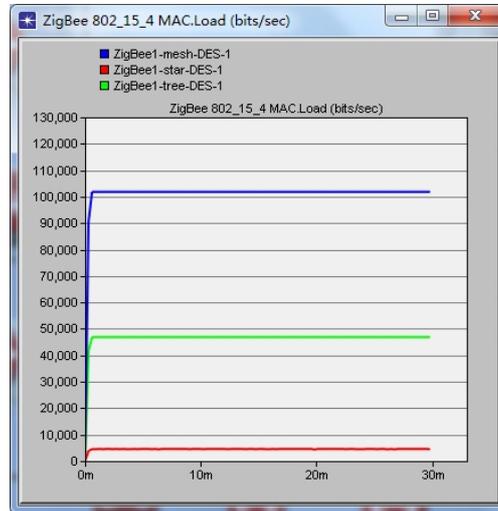


Fig.4. The load of different topologies.

As is shown in Fig.3, the delay of star topology is the least, and the mesh topology is the most. The nodes in star topology connect directly with the central coordinator, and the number of hops is the least. The average hops in tree topology is more than star topology since the coordinator does not locate in the center of the network. And the average hops in mesh topology is the largest due to the multiple hops. The comparison of load of wearable WSN is similar to the delay, as is shown in Fig.4. This is because that more hops lead to larger forwarding delay.

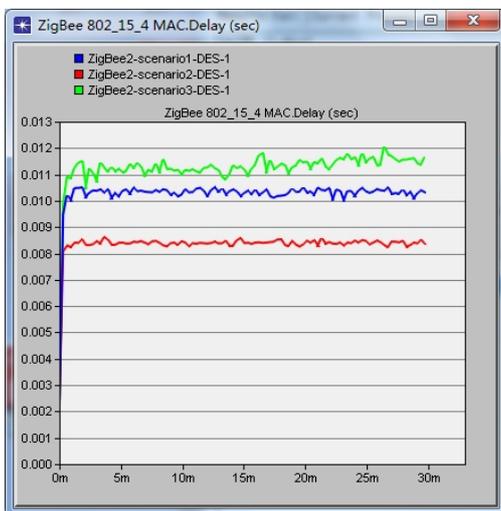


Fig.5. The delay under different channel sensing durations. (Left)

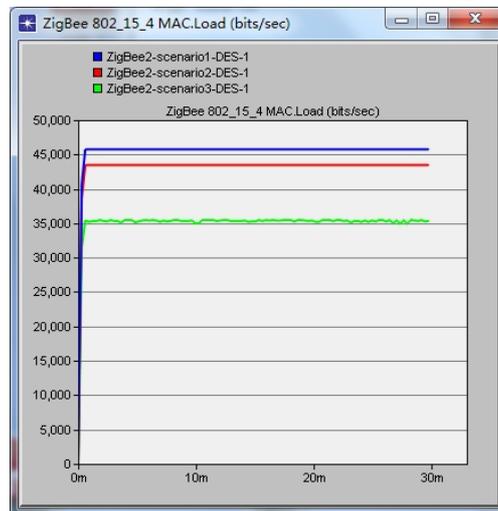


Fig.6. The load under different channel sensing durations. (Right)

Next, we studies the performances of wearable WSN under different channel sensing durations. We set channel sensing duration of scenario 1, 2, 3 as 0.1, 0.15, 0.25, respectively. As is shown in Fig.5, the network delay are 9.5ms, 8.5ms, 10.5ms according to channel sensing duration 0.1, 0.15, 0.25. Therefore, we can find that the channel sensing duration has effect on the network delay. And when the channel sensing duration is around 0.15, the network delay is the least. As is shown in Fig.6, we can obtain that the communication duration is longer with larger channel sensing duration, so that the number of packets get into the network is smaller, so the load is smaller, vice versa.

At last, we study the performance of wearable WSN with a broken router. The router in the center of the network is broken. Then the network delay and load are shown in Fig.7 and Fig.8. We can see that the delay become longer when the router is broken, this is because that the route need to be rebuilt, and so the transmission durations from source nodes to destination nodes become longer. Instead, the packet processed by the network reduces, so the network load becomes smaller.

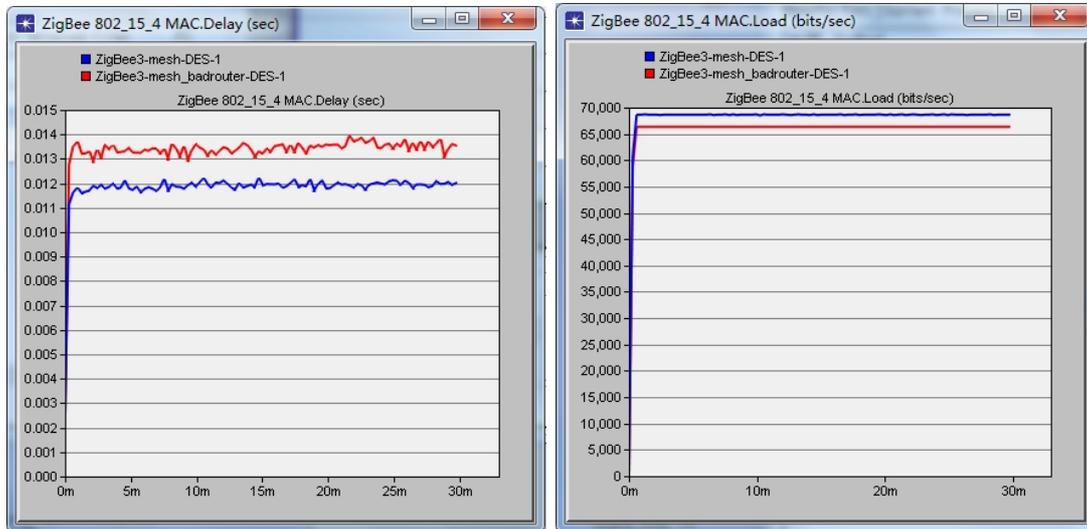


Fig.7. The delay before and after the router fails. (Left)
 Fig.8. The load before and after the router fails. (Right)

Conclusion

This paper introduced the hot topic-wearable devices, constructed a wearable WSN, and analyzed the characteristics of the proposed network. At first, we compared the performances of wearable WSN by star topology, tree topology and mesh topology. Next, we set different channel sensing durations to study the network delay and load. Then, we assumed that there was a broken router in the network and study the performances of wearable WSN. Wearable WSN is a new proposed network which will be applied in large scale on industrial production and human social life, and we will study it in further work.

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