TELKOMNIKA, Vol.13, No.1, March 2015, pp. 314~320
ISSN: 1693-6930, accredited A by DIKTI, Decree No: 58/DIKTI/Kep/2013
DOI: 10.12928/TELKOMNIKA.v13i1.1265

Family Health Monitoring System Based on the Four Sessions Internet of Things

Yang Jingjing[1], Hao Shangfu[1], Zhang Xiao*[1], Guo Benzhen[1], Liu Yu[1], Dong Beibei[1], Liu Yun[2]
[1] School of Information Science and Engineering, Hebei North University
Zhangjiakou 075000, Hebei, China
[2] China System Technology Lab, IBM, Shanghai 201203, China
*Corresponding author, e-mail: r78z@foxmail.com

Abstract

The accelerating pace of modern life results in the lack of effective care of people's health status. Nowadays, resorting to the technology of the Internet of Things, we can provide home health monitoring services to minimize the impact of the disease brought to people. In this article, we proposed the realization method for the architecture of the four sections of the Internet of Things oriented to home health monitoring service, furthermore, the secondary the smoothness index method is applied to the monitoring of human health index, data from body temperature detection experiments verified the feasibility of the four sessions system, which laid firm foundations for the requirement of real-time and accuracy of the Internet of Things based home health monitoring system with a common reference significance and value in use.

Keywords: *four sessions, internet of things, family health monitoring, prediction*

1. Introduction

In recent years, with the continuous improvement of living standards,for various reasons, such as excessive intake of high-calorie food, irregular diet, environmental pollution, aging of the population which have become increasingly prominent, sudden cardiovascular disease and a variety of chronic disease incidence has increased annually[1]-[3]. This way,Physiological indicators of day-to-day check can help people keep abreast of their own health and can also prevent and treat some of the disease in advance.

Generally, there are two ways for people to obtain their own physiological indicators: hospital examination and detection instruments. The hospital check can provide you a comprehensive and reliable result, and the doctor can give a clear explanation of the indicators, but the hospital examination always takes a long time with complex procedure, expensive fees and other defects. Own instruments detect, for example, to buy their own electronic sphygmomanometer blood pressure testing, the method is simple but the test results can not get professional doctors' explanation so that the single test results do not have statistical properties and can not give warning in time when physical condition shows red light [4].

Applying the Internet of Things to home health monitoring, human physiological parameters collected by the sensor terminal can be sent to the background server for further process by the computer or doctor and then the tester can get feedback after a detailed explanation of the test results and health advice. The method avoids the drawbacks of the hospital and own equipment detection and can keep people being aware of their own health and provide important help for prevention and treatment of sudden and chronic diseases.

2. The Internet of Things of Four Sessions

Proposal of the concept of the Internet of Things can be traced back to 1999, with a relatively narrow comprehension at that time which is confined to the face that objects links with Internet through radio frequency identification. After ten years of development, it is now possible to be understood as network with certain automated data collection the ability, agreed communication protocols which can connect real and virtual goods and network connections so that it can information exchange information and achieve a network of intelligent identification, interaction, management and other functions [5],[6]. Nowadays, there is a very wide range of

Received October 21, 2014; Revised December 20, 2014; Accepted January 5, 2015

Internet of Things applications, including smart home, telemedicine, industrial automation, etc. [7],[8].

The design process of the system of the Internet of Things is always more complex than the general engineering because in addition to its hardware and software design, it is also involved with the multi-system structure, security, low power consumption [9] .The traditional design methods of the Internet of Things usually have a three-stage common property [10],[11], that is, three-tier structure: the perception layer, network layer, application layer. Perception layer is usually with lower hardware configuration and poor data processing capability, so, direct data communication interaction with the application layer through the network layer is unstable or even cause a crash of the whole system. In addition, the perception layer is often including more equipment, if there is no unified management, the design work of the application layer is too complex. With this situation, this paper proposes a four sessions Internet of Things structure, that perception layer, coordination layer, network layer, application layer. Data of the perception layer is managed by the coordination layer, no longer directly communicate with the application layer, the application layer just communicate with the coordination layer through the network layer which is no longer interested in the details of the perception layer.

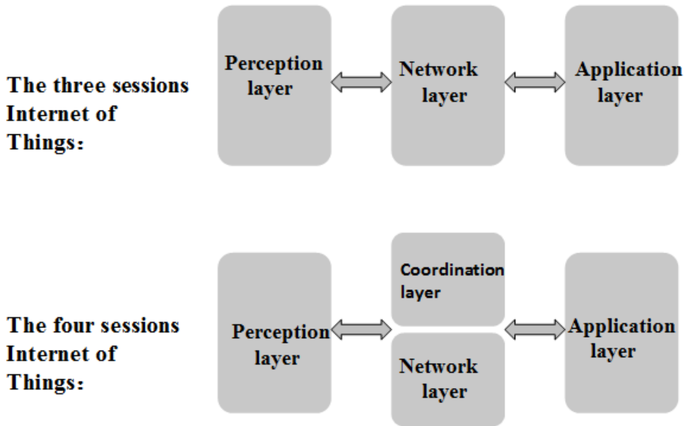

Figure 1. Comparison of The three and four sessions Internet of Things

(1) The perception layer

The perception layer is the skin and facial features of the Internet of Things with the ability of object recognition and information collection. Perception layer comprising a webcam, GPS, and various other sensor nodes which mainly recognize object and collect information, is the last layer of the entire IOT network. The perception layer devices is mainly constituted by the sensor and micro-controller, the sensor can transform the measured data into an electric signal, while the microcontroller recognize and further process the electric signal which is performed to draw the digital quantity to be measured which means that the measure adopted ZigBee or WiFi sent to coordination layer. Furthermore, the sensing layer devices directly receive the control signaling packets issued directly from coordination layer.

(2) The coordination layer

The coordination layer is the nerve center of the brain, information transmission and processing center of the four sessions of Internet of Things structure. The coordination layer receives the raw data uploaded from the perception layer through a variety of ways (ZigBee or WiFi) and the raw data can be pre-processed and re-packed into a unified data format to facilitate the application layer processing. In addition, the coordination layer monitors the perception layer device real-time, in the case of out of the application-layer control, the coordination layer can control the perception layer device automatically.

(3) The network layer

The network layer is the nerve of the Internet of Things and the carrier of information transfer. Between perception layer and the coordination layer, the network layer communication implementation is based on WiFi or ZigBee. Between the application layer and the coordination layer, the network layer is mainly realized in the form of WiFi or 3G.

(4) The application layer

The application layer can combine "social division of labor" and industry demand d to achieve a wide range of intelligence. In conjunction with the Family Health, two front-end programs should be needed: the client terminal and terminal application layer. Client terminal can intuitively show physical health parameters to the people, when some parameters exceeded, the client terminal can receive a corresponding alert. The service terminal combined with a doctor or relevant information of a knowledge base can feedback advice to the client terminal.

3. System Design

3.1. Hardware design

According to the definition of the four sessions Internet of Things, the home health monitoring system hardware block diagram is shown in Figure 2.

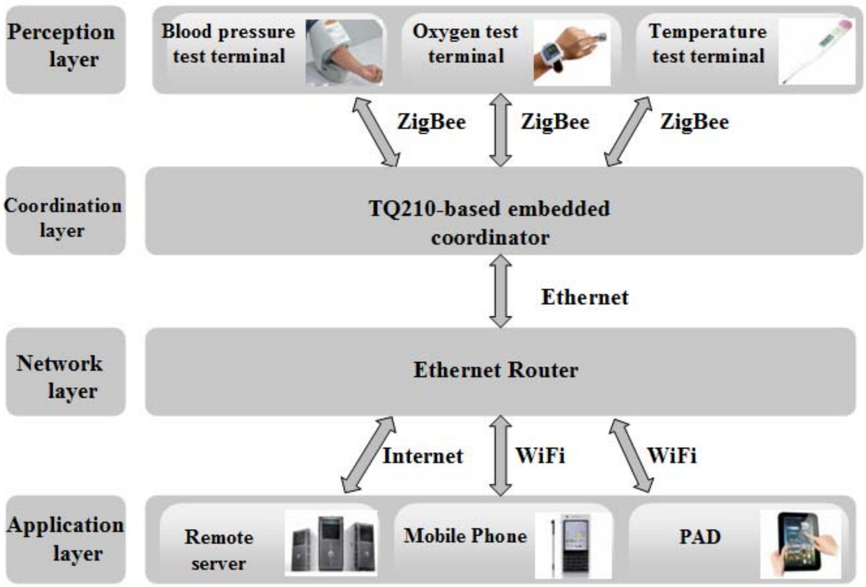

Figure 2. Family health monitoring system design

(1) The perception layer

Containing the temperature detection terminal, the blood pressure monitor terminal and the blood oxygen detection terminal. Each terminal gathers the value of human physiological parameters and then sends the value to the coordination layer devices. The device of this layer has a lower requirement of hardware configuration and the main the controller selection is a low-power microcontroller.

(2) The coordination layer

The coordination layer device is primarily responsible for data pre-processing and management of the perception layer device, thus requiring the coordination layer possessing certain data processing capabilities and strong communication interface. In this scenario, the coordination layer device master chip is a Cortex A8 processor clocked at up to 1GHz, with comprehensive peripheral communication interface.

(3) The network layer

This layer uses high-performance routers and ZigBee module of coordinator as hardware load.

(4) The application layer

Including service terminal and client terminal. Service terminal should be placed in community hospitals with professional medical knowledge and expertise, or professional medical knowledge. The client terminal contains mobile phone, tablet, etc., which should be user-friendly interacting with customers and users can visually observe indicators of their own body.

3.2. Software design

(1) According to the definition of the four sessions Internet of Things the, the family health monitoring system software design is divided into five parts:

The hardware abstraction layer (HAL) [12]: it hides the details of hardware interface of specific platform and provides a virtual hardware platform for the operating system which makes it hardware-independent, portable on multiple platforms. These devices are considered as other parts of the operating system and the can use the form of machine-independent services (function calls and macros). With hardware abstraction layer services and indirect hardware addressing, when ported to new hardware, the drivers and core only need to do a few changes.

The Cross compiler layer [13]: In the way of compiler, computer software written in advanced computer language code is transformed in binary code which computer can recognize and execute. However, during the development of embedded systems, the target platform running the program typically have limited storage space and computing power, however, the general compiler tool chain requires a lot of storage space and need a strong CPU power. By cross-compiler tool, we can compile the program on the host platform with strong CPU and enough storage space making it executable for other platforms.

The service end of the coordination layer: the server of this layer mainly plays the role of the distribution, coordination of data. The operating system commonly used in the ARM processor including Linux, Wince, Android, etc. On the basis of this operating system, development of services to the sensing layer and application layer service to coordinate the sending and receiving of all device data, is the core part of the the entire software system.

The application layer server: receiving data from the coordinator server end and analyzing the specific meaning of the data combined with the knowledge base or the recommendations of the professionals, then processed data is returned to the client application layer.

The application layer client: the client is intuitively presented to the user, so it should have a good user interface and user experience. Currently, popular clients include IOS-based client and Android-based client.

(2) The communication principle of the whole system:

Coordination layer and application layer must establish communication socket and coordination layer should first enter the listening state, and then the application layer socket issues connection request by the network layer, and network layer distributes the request to the coordination layer to create a socket to communicate, if there is a connection request sent from other customers, then create a socket. Therefore, the design process of the program should be: coordinated layer first start, and then start the application layer to make it establish a connection with the coordination layer at some point. Coordination and application layers start with a socket and coordination layer bundles the socket together with a local network address, and then the socket is ready to receive a passive state, it also provides request queue length. After this, the coordination layer can receive application layer connection. The application layer requests sensor data transmission, and the coordination layer sends the sensor data via the network layer to the application layer in the form of a socket. However, to write a port program, the signal flow method must be considered and data structure should be defined, the programmer must also understand data transmission of the sensor side, so multi-threaded technology must be used.

3.3 The prediction algorithm of the application layer

Exponential smoothing method [14],[15] is a common method of production forecasts. The simple average method can completely use all the time series data; The moving average rule does not consider the longer-term data, and give the recent data larger weight in the weighted moving average method; The index smoothing rule is compatible with the whole term average and the moving average which do not give up the past data and only gives a waning impact, namely, as the data wanes away, it can present weights which gradually converge to zero.

The secondary exponential smoothing method [15] is also known as Brown exponential smoothing. Quadratic exponential smoothing value St(2) is denoted, which is an exponential smoothing value of St (1), i.e.:

$$St^{(2)} = \alpha \cdot St^{(1)} + (1-\alpha)St_{-1}^{(2)} \tag{1}$$

The secondary exponential smoothing method is mainly used for prediction of the varying parameters linear trend time series. The expression of varying parameters of a linear trend forecasting model is as the following equation:

$$\hat{y}_{t+T} = a_t + b_t T \tag{2}$$

The difference between the prediction model of the formula (2) with a general linear trend model is that at and bt are the parameter variables which change with the change of the time variable t, i.e. the slope and intercept of a straight line in each period may differ; T is forecast periods from period t.

$$\begin{cases} a_t = 2St^{(1)} - St^{(2)} \\ b_t = \dfrac{\alpha}{1-\alpha}(St^{(1)} - St^{(2)}) \end{cases} \tag{3}$$

According equation (3), the value of each parameter variables can be calculated, when the values used by equation (2), it has indefinitely ability to forecast. In the case of once prediction,

$$\hat{y}_{t+1} = a_t + b_t = 2St^{(1)} - St^{(2)} + \frac{\alpha}{1-\alpha}(St^{(1)} - St^{(2)}) = \frac{2-\alpha}{1-\alpha}St^{(1)} - \frac{1}{1-\alpha}St^{(2)} \tag{4}$$

When monitoring the online operation of the system, the first 15 historical data is be used as a sample to predict the next data based on the sample data with secondary exponential smoothing method. After comparison of real-time accessed data and forecast data the system can determine whether there is abnormal signs. If 10 consecutive points exceed the threshold range of the forecast data, it is considered as normal state, otherwise, it gives alarm. Specific steps are as follows:

First step, access the historical data and calculate the value of exponential smoothing;

Second step, calculate the quadratic exponential smoothing value of St(1) of the first step according to the formula (1);

Third step, calculate the parameters of the value of the variable at and bt;

Fourth step, calculate the trend predict values according to (4) and (2);

Fifth step, the system obtains a new value and compares it with the predicted value and the new value is used as the new sample data, return to the first step to continue to run.

4. Exeprimental Results and Analysis

In accordance with this article, the coordination layer device processor of the four sections Internet of Things model is equipped with ARM Cortex A8, running frequency 1G Hz, 1GB of memory, outer expansion ZigBee, WiFi communication module. The network layer is a local area network setup with wireless router. The PC works as the server side of the application layer while the android phone works as a client of the application layer. A temperature collection terminal developed with ZigBee wireless transmission function is used as a sensing layer. The experimental results shown in Table1,Figure 3 and Figure 4.

Table 1. Comparing the two kinds of Internet of Things results

List	Run Time	Packet Loss Rate	The system breakdown times
the Four Sessions Internet of Things	1000hour	0.0002%	3
the Three Sessions Internet of Things	1000hour	0.0032%	19

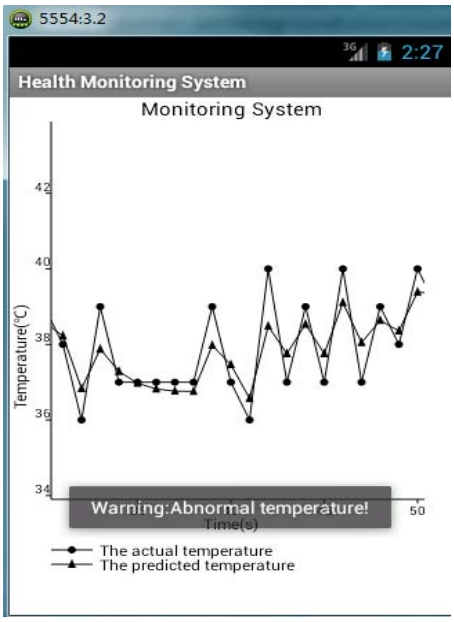

Figure 3. Alarm appeared when temperature fluctuates with human intervention

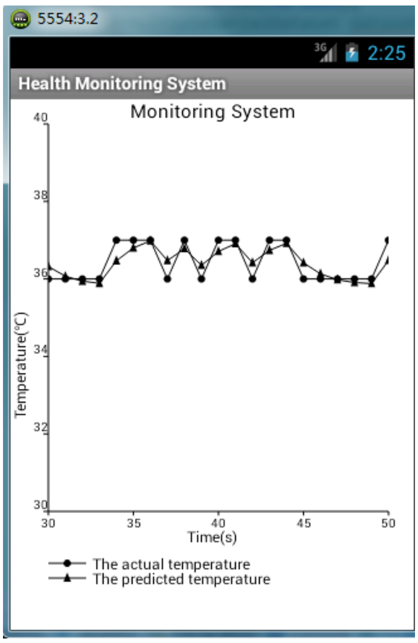

Figure 4.Test results with normal body temperature

Table 1 indicates the superiority of the four sessions of the internet of things.The experimental verification Figure 3 and Figure 4 shows two experimental situations. One situation is when the temperature sensor is exerted in human intervention resulting in analog temperature anomalies and there exists great difference between the predicted results with the experimental data, the application layer client will alarm. The other is the monitoring of the normal body temperature, when the predicted and the actual temperature sensor measurement result is basically consistent with the application layer, in this case, the client does not alarm. The experimental results verified the fact that the four sessions Internet of Things structure proposed in this paper has ideal data transmission stability, clear structure and a strong feasibility.

5. Conclusion

In this paper, the structure of the four sessions Internet of Things is proposed at first, then on the basis of this structure, the hardware and software of the home health monitoring system is designed and the second exponential smoothing is applied at the application layer for real-time forecasting and monitoring the health status of the human body. Finally, with the human body temperature detection application, the experimental results verified the system described in this article. This study laid firm foundations for meeting the requirements of real-time property and accuracy of the home health monitoring system based on the Internet of Things with a common reference and use value.

Acknowledgements

This work was supported by Hebei North University (No. Q2014002, No.ZD201301, No.ZD201302, No.ZD201303, No.Q2014005, No.Q2014008) and the Education Department of Hebei Province (No.QN2014182).

References

[1] Brook RD, Franklin B, Cascio W, et al. Air pollution and cardiovascular disease A statement for healthcare professionals from the expert panel on population and prevention science of the American Heart Association. *Circulation*. 2004; 109(21): 2655-2671.

[2] Menotti A, Kromhout D, Blackburn H, et al. Food intake patterns and 25-year mortality from coronary heart disease: cross-cultural correlations in the Seven Countries Study. *European journal of epidemiology*. 1999; 15(6): 507-515.

[3] Bhatnagar A. Environmental cardiology studying mechanistic links between pollution and heart disease. *Circulation research*. 2006; 99(7): 692-705.

[4] McGregor C, Eklund J M. Next generation remote critical care through service-oriented architectures: challenges and opportunities. *Service Oriented Computing and Applications*. 2010; 4(1): 33-43.

[5] L. Tzorj, A. Iera, G. Morabito. The Internet of Things: A survey. *Computer Networks*. 2010; 54: 2787-2805.

[6] Lu Yan, Yan Zhang, Lawrence T. Yang, et al. The Internet of Things; From RFID to the Next-Generation Pervasive Networked Systems. Auerbach Publications(book). 2008.

[7] John Dill, Rae Earnshaw. Expanding the Frontiers of Visual Analytics and Visualization. Springer London. 2012: 397-415.

[8] C. Amardeo, Identities in the Future Internet of Things. *Wireless Personal Communications*. 2009; 49(3): 353-363.

[9] B Jia, YJ Yang, CS Cui, L Li. Intelligent Supervision and Tracing System for Food Quality Under the Internet of Things. *Journal of Computational Information Systems*. 2012; 8(17): 7113-7120.

[10] Liu Y,Chu XL, Wang L. Design for the Internet of Things Based on Three-Stage Methods. *Computer Systems & Applications.* 2011; 20(7): 5-10.

[11] K Gama, L Touseau, D Donsez. Combining heterogeneous service technologies for building an Internet of Things middleware. *Computer Communications*. 2012; 35(4): 405–417.

[12] Modem Hardware Abstraction Layer Application Program Interface(Version:2.11.1). Joint Tactical Radio System Standard . 2007.

[13] Miller G, Hall K, Willis W, et al. *The Evolution of Powertrain Microcontrollers and It's Impact on Development Processes and Tools*. SAE Conference Proceedings. 1998: 423-436.

[14] Zhang L, Xing X. Study on the optimization estimation method of smoothing coefficients. *Journal of Xi'an Institute of Technology*.1998; 18(3): 217.