A Family Healthcare Monitoring System with 'Healthcare cloud'

Junping Dong, Haijun Gao, Huilian Sun

School of Information Science and Technology, Wannan University of Science and Technology, Anhui, China

ABSTRACT

The new generation of family healthcare monitoring system not only requires low cost, low power consumption and low volume, but also requires rapid adaptation to the development of national medical information based on cloud computing. In view of this, it is an urgent need to design a 'healthcare cloud' family healthcare monitoring system. First of all, this paper analyzes the process of family healthcare monitoring system connecting 'healthcare cloud' on the basis of hierarchical structure of 'healthcare cloud'. Secondly, four key technologies of the system are solved, including the design of family healthcare monitoring network based on physiological parameter sensor, the data exchange mechanism based on HL7 RIM, the gray model and the health risk assessment model of the Markov model, based on BPEL4WS Health service personalized assembly. Finally, the validity of the prototype system is verified by the case data of Jimei District in Xiamen City, which lays the foundation for the service of 'healthcare cloud'.

KEYWORDS: HL7 RIM-based Data Conversion Framework, HRA (Health Risk Appraisal), Healthcare Cloud

At present, China is facing population aging, low fertility, chronic diseases and other social health issues. Large and medium-sized hospitals provide mainly diagnosis and treatment of the disease, and therefore the daily community health care services, health advice and emergency medical assistance have become a burden to the hospitals. Medical information is regarded as an important solution to significantly reduce medical costs, alleviate the situation of medical resources shortage and improve the standards of medical care. At present, medical information exists in two trends:

(1) The rapid development of medical information service platform based on cloud computing. The United States in the wisdom of the medical field of the total investment has more than 44 billion US dollars. IBM's 'digital hospital integration platform' [1]; the United States HHS Department of electronic health records system, Microsoft Health Vault, etc. in the United States began to widely used and achieved great economic and social benefits. January 2013 Japan Fujitsu launched the 'elderly person care cloud computing', is expected to create 6 billion yen in 2015 market [2]. Nanjing 2012 based on the H3C cloud storage to build a new generation of community public health service system, to achieve the residents’ health records, community health service station desktop virtualization, the use of SaaS way delivery and other new medical information applications. Chinese Academy of Sciences to implement the 'sea cloud project' and the introduction of low-cost health services [3]. 2013 City, 'Healthcare cloud' using cloud computing technology to integrate public health records and appointment system, has access to the Third Hospital, Xian Yue Hospital 38 hospitals and 63 community health center.

(2) low-cost family healthcare care has become the most important technology to alleviate the shortage of medical resources. US Honeywell Laboratory Development I. L.S.A system, based on multi-sensor interconnection, to achieve the perception model, timing response, real-time response and other functions, monitoring cardiovascular and cerebrovascular diseases [4]. 'Sukoyaka Family 21' telemedicine detection and emergency ambulance, the use of Internet of things terminal SUKYOYAKA NETi compression zone measurement of blood pressure and electrode measurement of ECG, through the touch screen LCD display input weight and other values [5,6]. France to build EMUTEM platform using wearable equipment to test the pulse of chronic diseases, heart rate and blood pressure and blood glucose and other physiological data and infrared sensors to detect the sitting position and movement state [7]. Chinese Academy of Sciences developed a body-based network of wireless ECG monitoring system, real-time receiving ECG signal and timely warning feedback [8]. This kind of family healthcare monitoring system uses the Internet of things technology, including the attachment of the human body's fingertips blood oxygen sensor, watch blood glucose sensor, watch type sleep quality measuring device, sleep physiological checker, long-term monitoring and recording of various physiological data, Assess the physical condition and early warning of physiological lesions.
New generations of family healthcare monitoring system not only have ‘low cost, low power consumption and low volume’ and other characteristics, but also require rapid adaptation of cloud computing based on the development of national medical information. To this end, Xiamen Institute of Technology and Xiamen excellent medical information services Co., Ltd. jointly developed a 'health cloud' family healthcare monitoring system to support the family healthcare monitoring system and the 'healthcare cloud' between the data exchange, to achieve health risk assessment and personalized care program customization, health records for the cloud management, health consulting, health and other services into the family healthcare care to lay the foundation for health care.

This paper is outlined as follows: Section 1 introduces the hierarchical architecture of the 'healthcare cloud' and analyzes the work of the family healthcare monitoring system linking the 'healthcare cloud'. Section 2 analyzes four key technologies, namely, home health monitoring network design, HL7 RIM-based data exchange mechanism design, health risk assessment model and health service personalized assembly. Section 3 uses the case data of Jimei District, Xiamen to verify the validity of the prototype system, including the assessment of the health risk assessment effect (predicting the relative risk and absolute risk) and the success rate of the health service portfolio. Section 4 summarizes the full text and looks forward to the next step.

1. System structures

1.1. Healthcare cloud' hierarchical structure

'Health cloud' construction of the main goal is to achieve centralized and unified regional medical information sharing and improve the utilization of medical resources, that is, virtual medical hardware and software resources to achieve the allocation of hardware and software resources, medical data security and green use. Typical hierarchical architecture includes: infrastructure (hospital, disease control center, community health service center, etc.); data integration exchange shared cloud services (integrated hospital information system HIS, electronic medical records EMR, medical image archiving and communication System data management system LIS, etc.); cloud infrastructure (based on virtualization, network security, operational monitoring and maintenance technology to achieve infrastructure services that IaaS integration); cloud data center (health records database EMR, electronic medical records Database EHR, public health database, platform-as-a-service PaaS capabilities), cloud services (services provided by Software-as-a-Service SaaS, including Health File Cloud Management, Remote Video Clinic, Health Consultation, Message Services, Sports Services and Healthy Meals) Object (citizen, doctor, third party).

1.2. Connect the 'healthcare cloud' family healthcare monitoring system

Family healthcare monitoring systems linked to 'healthcare clouds' include family healthcare monitoring networks, family healthcare monitoring systems and 'healthcare clouds'.

The family healthcare monitoring network is essentially an Internet of things (IoT), composed of a series of intelligent physiological parameter sensor nodes, including blood oxygen sensor, watch blood glucose sensor and accelerator, continuous monitoring of physiological signals and record human health signals, including ECG, Blood oxygen saturation SPO2, pulse and other parameters. Nodes have independent data storage, computing, power management and wireless communications and other functions. Integration of advanced network protocols (such as Bluetooth, WIFI or Zigbee), to achieve real-time health monitoring data uploaded to the family healthcare management system.

(2) based on the HL7 RIM data exchange mechanism to achieve with the 'healthcare cloud' data exchange, upload the various physiological monitoring data to achieve personal (1) based on the family healthcare monitoring system dynamics, real-time access to physiological measurement data; (3) in the 'healthcare cloud' data center support, based on the health risk assessment model to achieve individual health assessment and the development of personalized health interventions; (4) get 'health cloud' background special doctors, functional medicine Teams and nutritionists to provide medical, prevention, health care and other services. In order to ensure the versatility, flexibility and scalability of the family healthcare care system, the family healthcare monitoring system supports on-demand dynamic, loose coupling, orderly assembly of health services, and health services, as a result of the 'healthcare cloud' providing cloud services in the form of SaaS Personalized assembly, to overcome the traditional family healthcare monitoring system unified and fixed service process model.
2. Key Technologies

2.1. Family healthcare monitoring network design

The Family Healthcare Monitoring Network is a hardware facility that enables human physiology to be connected for a long time. Paradiso R. et al developed the wireless ECG detection system using GPRS protocol, there is power consumption (average current 100mA / 12V or so), electromagnetic radiation is too high and larger (due to high-power solar panels or large capacity Battery) and other defects [9]; Tianjin University development based on ZigBee technology for the elderly family healthcare monitoring system, using CC2430 chip, operating current 25-27mA, each chip about 2 US dollars, the maximum data transfer rate of 250Kbps [10].

The system family healthcare monitoring network a series of intelligent physiological parameters of sensor nodes, need to consider the energy consumption, cost, volume and data transfer rate and other factors. ECG acquisition, for example, based on Neurosky BMD 101 control chip (shown in Figure 3), from uV to mV within the biological signal detection of high-performance analog front-end real-time reception and cycle to read ECG data, Amplification, filtering, calculation and other processing output ECG digital signal and sent through the serial interface. The BMD101 features a system configuration, analog and digital signal processing, control of both internal and external communications and power management, with 16-bit ADC with high accuracy resolution, 3.3V power supply, 3 * 3mm, and price $ 3. Physiological monitoring of digital signals sent by Bluetooth to the home health monitoring system, the maximum data transfer rate of 720Kbps. Table 1 statistics ECG modules in different working conditions of the power consumption.

<table>
<thead>
<tr>
<th>Working state</th>
<th>Total power consumption</th>
<th>Microcontrollers</th>
<th>Bluetooth module</th>
<th>Analog signal processing module &amp; Digital signal processing module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standby</td>
<td>63.1μA</td>
<td>Low power consumption</td>
<td>shut down</td>
<td>shut down</td>
</tr>
<tr>
<td>Bluetooth search</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>normal work</td>
<td>31.4mA</td>
<td>jobs</td>
<td>Open</td>
<td>shut down</td>
</tr>
<tr>
<td></td>
<td>14.6mA</td>
<td>jobs</td>
<td>Open</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. The working status and total power consumption of each module

The upper-level application sends the data through link management and I / O to the link control unit, carries on the carrier modulation, then carries on the data encapsulation, sends the data temporarily in the buffer, passes through the 2.4GHz radio frequency transmitting and receiving terminal (agreement HCI) ; The home health monitoring system receiver to reverse demodulation, get the source data and then through the link management and I / O transfer to the upper implementation of the module for data processing.

2.2. Data exchange mechanism design based on HL7 RIM

As the monitoring data model is not unified, 'healthcare cloud' commonly used SaaS way. Only a unified standard can be used to solve the barrier-free transmission and can be interpreted by both parties without any ambiguity, in order to achieve the family healthcare monitoring system and 'healthcare cloud' data exchange.

HL7 (Health Level 7) [11] is an international standard developed by Health Level Seven Inc., a standard development agency authorized by the US National Standards Institute (ANSI), for medical and health institutions and medical instruments and equipment data transmission , In which the internal structure of health records using HL7 to develop CDA (Clinical Document Architecture) standards. HL7 RIM data model can clearly express the timing, level and logic, the purpose is to solve the different developers to develop and develop information standards inconsistency, for the standard development and development of a maximum reference model.

Figure 4 shows the HL7 RIM-based data conversion framework, including HL7 dictionary, HL7 XML model generator and HL7 RIM model. Physiological monitoring data is encapsulated in the form of data elements, each data element or complex attribute is compounded into composite data, or a list of data elements, that is, each of the composite data type attributes. Multiple order elements of multiple data elements form a message segment, and multiple ordered message segments form a specific message. HL7 RIM Use the HL7 dictionary any element, data type, and vocabulary
are derived from the RIM specification requirements to ensure consistency. The HL7 XML Schema Generator converts the physiological monitoring data into an XML unified data format that conforms to the HL7 standard.

Based on the HL7 RIM data exchange mechanism, data exchange between the home health monitoring system and the health cloud host can be achieved to support personal health records management and health risk assessment. The data exchange process is as follows:

(1) Transmission process: the receiver to the family healthcare monitoring system, for example, based on physiological monitoring data to build HL7 RIM logical structure of the object map, using XML to build a data format in line with HL7 message, through simple object transfer protocol (SOAP) news.

(2) The receiving process: the receiver to listen to the target network is their own message, according to HL7 protocol standard extraction XML domain directory, further analysis of the message document object, restore HL7 RIM format object map, HL7 CDA standard to the cloud host.

In conclusion, the data is converted into XML SOAP message format according to the grammar standard of HL7, and then encapsulated and transmitted according to the underlying network transport protocol. The receiving system responds at the application layer and the corresponding control, and then analyzes according to the HL7 standard syntax, the message is finally converted to the application data format.

2.3. Health risk assessment model

Health Risk Appraisal (HRA) is used to describe and estimate the likelihood that an individual will cause a particular disease in the future or cause death due to a particular disease. Through the collection of individual health information, including family healthcare monitoring to obtain the physiological information and family history, eating habits and lifestyle. Combined with the health records and electronic medical records provided by the Healthcare cloud, quantified the assessment with the digital model to help individuals fully understand the health status and the risk of disease and provide support for the development of personalized health interventions.

American Framingham Hazard Assessment Model FRS is a classical health risk assessment model that predicts the risk of cardiovascular disease in the next 10 years. Due to differences in the cultural background and living habits of different countries, regions, people, the accuracy of the actual screening of different populations is different. In view of the limitations of Framingham model, the factors such as age, body weight, blood pressure, blood lipid, blood glucose and body mass index BMI [12,13] were selected, and the ‘relative risk’ prediction and ‘absolute risk’ were predicted. 'Relative risk' refers to the possibility of suffering from certain chronic diseases compared with the same age group, the same sex population; 'absolute risk' refers to the individual in the next few years suffering from certain chronic diseases the possibility of [14].

(1) Relative risk prediction

According to the method of [14], Logistic model was used to calculate the risk score of a chronic disease, and a risk factor evaluation model was obtained to evaluate the effect of different exposure levels on the occurrence of different diseases.

Definition 1 is the relative risk of exposure to a level factor, and the percentage of individuals exposed to a certain level of factors is the proportion of the population.

Definition 2 Risk = Baseline incidence × Relative risk. For a number of risk factors, the combined risk of relative risk (relative risk), = (-1) + (-1) + ... + (- 1) + × × ... ×, which is the combined risk; greater than or equal to 1 of the risk; less than 1 of the risk [15].

(2) Absolute risk prediction

Currently used predictive models include regression models, ARIMA models [16], Markov models and gray models. The ARIMA model requires that the non-equilibrium data be transformed into a zero-mean equilibrium stochastic sequence for short-term prediction; Markov emphasizes the state transition probabilistic prediction of internal changes [17]; the gray model GM (1,1) is the most widely used model in the gray model, and it is not necessary to specify the data index relation, which is suitable for small sample and uncertain system forecast [18]. Because of hypertension, diabetes is a chronic disease with long-term chemotaxis, easy to show some changes in the trend of non-equilibrium characteristics, so the use of gray model and Markov model combined forecast model. The gray model only considers the effect of the integrated gray amount on a certain disease, and the Markov applied to the state transition behavior of the stochastic process can compensate for the gray prediction of the random fluctuation of the large time series prediction bad.

The main steps include:

gray model GM (1,1)
Raw data sequence, enhanced regularity accumulation processing, obtained, the establishment of GM (1,1), get
\[
\frac{dx^{(1)}}{dt} + ax^{(1)} = \mu \quad (1)
\]
Which can be solved by the least squares method, solving the equation:
\[
x^{(1)}(t) = [x^{(0)}(t) - \frac{\mu}{a}]e^{-at} + \frac{\mu}{a} \quad (2)
\]
The model predictions of the cumulative generation are obtained, indicating that:
\[
x^{(0)}(t) = [\hat{x}^{(0)}(t) - \frac{\mu}{a}]e^{-2at} + \frac{\mu}{a}, \quad T = 1, 2, ..., n \quad (3)
\]
GM (1,1) model of residual sequence
\[
e^{(0)}(t) = [x^{(0)}(t) - \hat{x}^{(0)}(t)] \quad (4)
\]
After a similar solution, get
\[
x^{(0)}(t+1) = (1 - e^{\alpha})[x^{(0)}(t) - \frac{\mu}{\alpha}]e^{\alpha} + sgn(t + 1)(1 - e^{\alpha})[e^{(0)}(t) - \frac{\mu}{\alpha}]e^{\alpha}\quad (5)
\]
Where the sgn (t) value is determined by the sign of the original residual.

Markov model transfer probability matrix

The Markov model is concerned with the probability of state and state transition. Suppose that the predicted object has n kinds of states, and the probability of transition from a certain state to the n states is. To blood pressure, for example, covers the ideal blood pressure, normal blood pressure, critical hypertension, high blood pressure, high blood pressure. According to the Markov model to solve the probability of residual transfer, determine the residual sgn (t) value.

The gray model and the Markov model are used to obtain the predicted value, and the absolute risk is obtained by multiplying the combined risk relative to the total morbidity. Relative risk and absolute risk measure the quantitative relationship between risk factors and chronic morbidity and its regularity, and provide reference and basis for the development of personalized health interventions.

2.4. Personalized service of health services

Family healthcare monitoring system flexibility, maintainability and customization are important factors that affect health care performance. For the needs of home users, health service processes need to be customized. Personal health monitoring and 'healthcare cloud' service needs, including regular (blood pressure, ECG and acceleration) monitoring, information reminders, healthy meals, and sports services, based on the patient's actual situation. In view of this, based on different health monitoring needs, a scalable and flexible method is used to achieve the dynamic reorganization of health services to meet the needs of different persons.

The Healthcare cloud provides health services in SaaS, and uses the SOAP transport bus based on the HL7 RIM data exchange mechanism. Therefore, the family healthcare care service program uses the network service business process implementation language BPEL4WS description. The SOAP control engine receives the SOAP request message from the remote network through the unified request interface and identifies the priority of the request message with the SOAP message queue mechanism. The SOAP control engine parses the BPEL4WS (Business Process Execution Language for Web Services) file, invokes the health service sequence in sequence and ensures that the entire assembly completes successfully.

Different families monitor the different needs of patients (such as diabetes, high blood pressure, etc.), only need to dynamically modify the family healthcare monitoring program corresponding BPEL4WS file, so as to ensure the family healthcare monitoring system flexibility and applicability.

3. Experiment

Based on WinCE 6.0 embedded operating system environment, the use of Visual Studio 2010 C # R \u0026 D home health monitoring system, the main technical indicators: support Bluetooth transmission; support and 'healthcare cloud' data exchange; support personalized health care; support personal health File management; health data analysis results. Figure 7 shows the normal state of the system monitoring interface and abnormal state ECG monitoring data interface:
Details are as follows:

(1) Cooperated with Xiamen Heart Center, combined with the data of 'Healthcare cloud' electronic archives and electronic medical records in Xiamen City, the selection targets of 55-65 years (male) and comparison cases were included in Jimei District, Xiamen. Smoking, exercise, heart rate, BMI, blood pressure, stroke history, blood lipids, using Logistic model, were exposed to different risk factors of the baseline incidence and risk scores (as shown in Table 1). According to health records and family healthcare monitoring system to obtain a 61-year-old health data: primary school culture, no smoking, do not like exercise, abdominal obesity, blood pressure 240/209, heart rate 92, stroke history. The relative risk of personal illness \((1.658 + 2.873 + 2.885 + 6.543 + 1.778 + 5.325 - 6) + 0.952 \times 0.926 = 15.666\). The total incidence of diabetes in Jimei District of Xiamen City is close to 5% and the absolute risk is \(15.666 \times 5\% = 78.78\%\). The combination of Markov model and gray prediction can predict the absolute risk in 5 years.

(2) Diabetes and high blood pressure and other patients and health promoters, according to the doctor’s recommendations to develop personalized health management program, measure ECG, blood oxygen saturation SPO2, pulse, body temperature, and to the health of the cloud to upload physiological monitoring data.

(3) The use of 'health service portfolio success rate' to measure the family healthcare monitoring system and the 'healthcare cloud' connection effect. The 'Health Service Portfolio Success Rate' is defined as the ratio of the number of successes to the total number of times the health service is successfully based on the sequence specified by BPEL4WS, i.e. *100%, which indicates the number of successful assurances, indicating the number of failed asserts. The success rate of the health service portfolio was 89% calculated from 1000 test data, indicating that the family healthcare monitoring system was able to effectively link the 'healthcare cloud'. Xiamen City, 'Healthcare cloud' is still in the construction process, the above indicators are still within reasonable limits.

It should be noted that different countries, regions, diabetes risk assessment model there is a big difference. For the baseline incidence and risk score measurement models, such as Germany and Oman, respectively, using Cox regression model and Logistic regression model; the introduction of different risk factors, such as Germany stressed that as much as possible variable risk factors, Oman stressed the body mass index (BMI), Family history of diabetes, hypertension [19]. After establishing the model and calculating the risk score, the high risk individuals / populations are generally screened by comparing the overall risk score with the size of the judgment point. The risk assessment model established in this paper and the risk score of Table 1 are simple, fast and cheap for the risk assessment of diabetes, but only to the population of Xiamen, not the whole population of Fujian Province.

4. Conclusion

A new generation of family healthcare monitoring system requires low cost, low power consumption and low volume at the same time, need to adapt to the cloud based on the development of national medical information. This paper designs and implements a family healthcare monitoring system that connects the 'healthcare cloud', uses the intelligent physiological parameter sensor attached to the human body to monitor and record the physiological data of the human body, realize the health risk assessment and personalize the family healthcare monitoring program to ensure the family healthcare monitoring The flexibility and effectiveness of the health cloud for the 'health cloud' to provide health records cloud management, health counseling, health meals and other services into the home health care to lay the foundation.
The future work includes: localized health risk assessment model to improve the relative risk and absolute risk prediction accuracy; to solve the family healthcare monitoring object privacy protection issue; improve the family healthcare system, expand the demonstration application and promotion.

References


