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An Intelligent Latticed Model of Telemonitoring System

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Abstract. This paper is mainly aimed at the embedded telemonitoring system's utility which based on 3G. We have designed a latticed model, by segmenting the whole system in horizontal and vertical respectively. This model makes the software part and the hardware part plug in connectors, and then socket to the system. This idea makes the system more flexible, and finally, what we want to implement is plug and play. In this way, our system will have a great expandability. In addition, multi-view and intelligentized is also designed considering the requirement of patients and doctors. The system has two parts, one is monitoring terminal, the other is doctor workstation. They transmit data through 3G wireless network.

Keywords: 3G network, telemonitoring system, latticed model, expandability

1. Introduction

In recent years, along with the acceleration of the aging, the number of old people and chronic patients is increasing. Chronic disease ills for a long time and it is difficult to be cured. And if it has not been treated in-time, it will cause serious injury to patients' life and costs a lot of money. At present, health care is at a low level in our country for there are lots of patients while very few doctors are available. So the scale of hospitals is small relatively, and the medical facilities are in short supply. Besides, long-term medical treatment costs too much money. Also, it's time wasted and energy consumption. Especially to those busy white-collar and weak old people, it's a really difficult problem to overcome. Besides these problems, to healthy young people, even if they only want to take a health check, is generally one problem corresponding to one office. It will also take a long time to check more items.

Based on problems above, we consider that if we can design a kind of equipment, which patients can use independently, that is to say easy to operate, and it costs little but has many functions, and with it, patients can be monitored at home, at the same time the patients can be detected by doctors remotely. Having this equipment, we can solve the problems mentioned above.

2. Initial Design Of System Structure

Because the equipment we designed can be used at home, with the doctors' detection remotely, so it's a typical telemonitoring system. This system is composed by two parts, monitoring terminal and doctor workstation. The monitoring terminal has integrated many functional modules, and the doctor workstation is a PC.

Embedded ARM9 processor has been chosen the hardware platform of the system. Firstly, choose this platform can make our equipment small, cheap and customizable. Secondly, ARM9 has faster computing speed compared to ARM7. And compared with singlechip, ARM9 can run large-scale operating system such as Linux. To realize special functions by software but not hardware, can reduce the volume of the equipment, and also have a greater flexible and customizable.

Between the monitoring terminal and doctor workstation, we adopt 3G network connection method. It can make the equipment portable, and transmit life information to doctor workstation faster. The direct benefit is providing a possibility to reduce the morbidity even mortality.

2.1. Multi-view

Considering that patients may not have medical knowledge, so the interface we designed must be simple and clear, it's easy for patients to understand. So on the monitoring terminal, some easy and valuable values can be displayed, like blood pressure value, blood oxygen value, heart rate value, breathing rate value. And values of less value to patient like electrocardiogram and blood oxygen curve will be displayed on doctor workstation, together with blood pressure value, blood oxygen value, etc. Additionally, doctors can look over patients' monitoring record, manage patients' material, configure interface through the workstation software.

2.2. Intelligentized

Accompany with the birth of telemedicine and the manufacture of new medical equipments, medical issues which first shows as people and people interaction, has developed to a new form, a combination of people and machine interaction, and machine and machine interaction.

In this system, people and machine interaction reflected in two aspects. The first, monitoring terminal part. Considering patient may be has not basis of computer operation, so we adopt the way of keys for the interaction of patient and machine. Keys include turn on/off the machine, restore the data, start 3G and transmit data to doctor workstation/disconnect network. The second, doctor workstation part. Doctors can deliver control commands to monitoring terminals through the workstation interface, for example, start blood pressure measurement, switch ECG leads. Besides, they can also look over patients' monitoring record, manage patients' materials, configure interface.

2.3. Sockes

To expanding modules, hardware can be plug and play, and to software, our design can also make it plug and play. First of all, the system provides uniform software interfaces. Secondly, design an agent for each functional module, every agent chooses to implement system interfaces it needs. Inside these agents, they have completed specific data processing of their corresponding modules, and then interact to the control logical layer respectively. Thirdly, expanding modules only need to implement their device agents, and then they can interact with the control logical layer without affecting other modules.

If this happens, then software and hardware can both be plug and play. Our whole system is composed by software and hardware of plug-in form according to patients' requirements.

2.4. Reliability

System can connected automatically when the network is disconnected. When there is no 3G network, patients can use SD card to store data. And doctor can look over history data in SD card.

2.5. Expandable

When patients have more or different requirements to the measurement of physiological parameters, we need to add or delete some functional modules from the system. It demands strong expandable and flexible of the system. So, we have designed general hardware interfaces and uniform software interface for the system.

2.6. Security

Only doctors have permission to modify and see about patients' information and monitoring records. Doctors can encrypt for patients' private information.

2.7. Manageable

The system is easy to be installed and maintained. We set data storage management and log management through event management mechanism.

3. Latticed Model Of The Teleminitoring System

Figure.1 is the latticed model we have designed for the telemonitoring system.

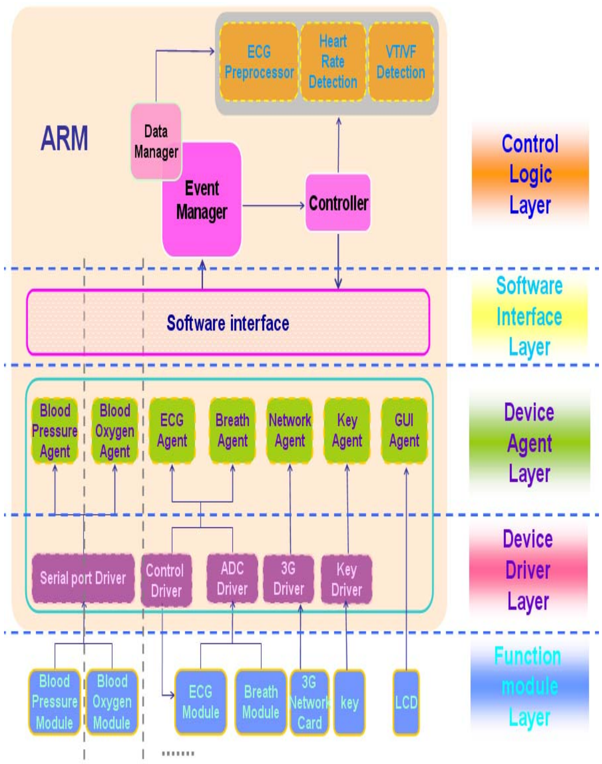

Fig. 1:Latticed model of telemonitoring system

3.1. Latticed model overview

As figure.1 has shown, segment the system structure.

At first, segment horizontally. Extracted the parts which have familiar functions as a independent layer. The whole system has five layers.

- Functional module layer: Composed by sensor device modules, 3G network card, keys, LCD. This layer is the system's hardware layer.
- Device driver layer: This layer is a interface between the system's hardware and software. To modules which need to collect data from serial port, need a serial port scan and shunt driver. To modules which need AD conversion, need an ADC driver. To modules which need to be controlled, such as ECG module, need a control driver. 3G module, needs 3G driver, key module needs key driver. The characteristic of this interface layer is that when many modules connect to an interface at the same time, the interface can be in common use, and make some changes to the driver of this interface, then the system has been expanded. And to single modules, we need to design device drivers for them separately.
- Device agent layer: Including sensor device module agent, network agent, key agent, GUI agent. The characteristic of this layer is that each module has an agent, device agent is in charge of processing data and events of this module specially.
- Software interface layer: This layer will connect device agent layer and control logical layer. It provides uniform software interface, it's easy to be called. Data which has been processed by device agent layer will be transmitted to control logical layer through uniform software interface layer. Control commands from control logical layer will be transmitted to device agent for responding through software interfaces.
- Control logical layer: Functions of this layer are as follows, data management, including data storage and display, send control commands, including start the blood pressure measurement and switch ECG leads, preprocessing ECG signals, detection of heart rate, detection of VT/VF, warning when data beyond the threshold, and event management function, for example, key event, connect/disconnect 3G network, save, turn off, error event, etc.

Secondly, segment vertically. Take "function module----hardware interface----device agent----software interface" as a structure, and then segment the system to many structures. Each structure connects the system's control logical layer as a plug in connector, and all plug in connectors have familiar structure and function.

Over all, segment the system horizontally, it has uniform interface and clear structure. And vertically, the system has a good expandable and a good reusability of the code. The whole system has presented a latticed structure, and this structure has all advantages of both horizontal segmentation and vertical segmentation.

3.2. Detailed design of software interfaces

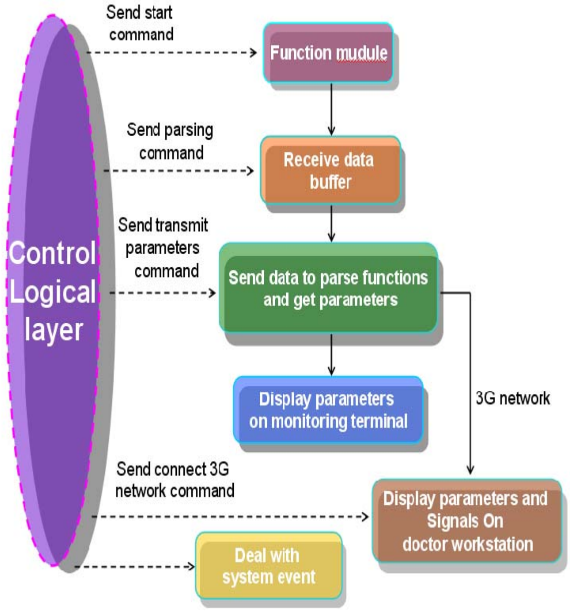

Fig. 2:ystem's data flow

Software interfaces are the connection part of control logical layer and device agent layer. Control logical layer send control commands to device agent layer, and respond to the events of device agents. Next, we will explanation the principle of software interface design with data flow in the system.

- Control logical layer send command to device agent, here needs a control interface I_ctrl_t.
- The device agent puts data collected from function module to data buffer. At this time the control logical layer send parsing command to device agent layer, achieving an I_parse_t interface.
- Device agent responds to the parsing command, and extracts data from data buffer and put the data to their device agent for special data parsing. After that, send signals and parameters getting from parsing to parameter buffer. Parameters refer to blood pressure value, blood oxygen value, heart rate value, breath rate. Signal data refers to the signal data of electrocardiogram, blood oxygen curve, breath curve.
- The control logical layer sends transmitting parameter command, achieving an I_param_feeder_t interface. Device agent extracts parameters and sends them to the monitor for display.
- If control logical layer send transmitting parameter and transmitting signal command at the same time, we also need an I_signal_feeder_t interface. Then device agent extracts signals and parameters from parameter buffer, and sends them to doctor workstation through 3Gnetwork. And finally, display all the parameters and curves on the workstation interface.
- Control logical layer also need to achieve an I_event_t interface, used to process some events happened at device agent layer. For example, error massage processing, key massage processing, etc.

For device agent layer, every device agent needs to achieve a device interface I_dev_t, inside which including the description of device ID, used to identify device. Every device agent can choose to achieve other interfaces mentioned above according to its function module's characteristic. For example, blood pressure module needs a start command for starting, so it needs an I_ctrl_t interface. After receiving blood pressure data, we should parse the data, so we need a parsing interface I_parse_t. We only need to display the blood pressure values on the interfaces of monitoring terminal and doctor workstation, so we need a parameter interface I_param_feeder_t for parameter transmitting. But to signal interface I_signal_feeder_t, is an optional implementation. If we want to full monitor the operation status of the device, it's needed. And with it, the information of device operation will be delivered to system in real time. Additionally, we need to achieve an event interface I_event_t, used to process error events. It's the same with other devices, choose the software interfaces it needs according to its characteristic.

3.3. Application advantages of latticed model

Imagine, sensor devices developing towards diversification in the future. The existing sensor devices can't content patients' needs, or the doctor can reference more physiological parameter information to diagnose the illness, to improve the reliable and accuracy of the diagnosis. So, with the innovation of sensor devices or other function modules, what will happen to our system?

First of all, we need to add this function module to the device module layer of the system. General function modules use serial port or system bus interface as their signal output port, and in the future, sensor devices will develop towards uniform interface, easy to expand, easy to use. And our system adopts many forms of hardware interfaces, including serial port, system bus interface, USB interface, common and convenient.

Secondly, according to the characteristic and the data processing requirements of the additional module, add device drivers. If this module uses serial port or system bus interface, we only need to add data processing requirement information of the module to the existing serial port driver or ADC driver. If the additional module needs to receive control command, we only need to add its information to the existing control driver. If the additional module use interface of other form, we need to add a corresponding device driver, and don't need to change other part of the system.

Thirdly, design a device agent for the additional function module. Inside the device agent, according to the characteristic of the additional module, has designed a special parsing function. Through the parsing function, we can get the signals and parameters, and then put them into parameter buffer.

After that, on the basis of the functional characteristic of the additional function module, add software interfaces it needs. First of all, we need to achieve a device interface and a parsing interface. After that, if it needs to receive control commands from the system, it also needs control interface. If it needs to transmit parameters, it needs to achieve parameter interface. And if it needs to transmit signal or send event processing massage to the system, it needs to achieve a signal interface or an event interface.

Finally, we need to add event, control commands, signal and parameter information corresponding to the additional module in the event manager, controller, data manager which are in the control logical layer.

Having done all these above steps, we have completed the addition of a function module. In the horizontal layers, add content related to the additional module to every layer, it has a good layer structured, and a clear function structure. So when the system is large, it's not easy to lead to a disordered software architecture. In the vertical layers, when we add information in every layer, the function and information of other existing function module will not be changed and affected. So far, we have seen the application advantages of the model we designed.

4. Implement

The implement of the model's hardware platform adopted Friendly ARM mini2440 development board, with a processor of SumsungS3C2440.Function modules include blood pressure module, blood oxygen module, ECG module, breath module, 3G module, key module, display module. Among them, blood pressure module and blood oxygen module use serial port to connect with the system, ECG module and breath module use system bus interface to connect with the system, 3G module use USB interface, and display module use LCD data line to connect. On the monitoring terminal, blood pressure values (systolic pressure/diastolic pressure), blood oxygen value, heart rate value, breath rate can be displayed. It has three keys, including turn on/off the machine, save, connect/disconnect the 3G network. 3G module is a 3G network card. The display module is a 3.5 inch LCD screen.

The doctor workstation part use PC as display terminal. The interface can monitor eight patients' condition at the same time. In every patient's channel, there are blood pressure values (systolic pressure/diastolic pressure), blood oxygen value, heart rate value and breath rate. It also can display three leads curve of ECG and blood oxygen curve. Change device channel then it can display different physiological parameter curve. Besides this, the doctor can send remote commands to monitoring terminals, including start blood pressure measurement and switch ECG leads. Doctors can also enter patients' basic information, look over patients' history illness information and history monitoring data. Furthermore, doctors can configure the interface, such as the adjustment of the baseline, the adjustment of the paper speed, the adjustment of the range. It's mainly used when the doctor view and diagnose by the curve. The interfaces' data of patient monitoring terminal and doctor workstation can be refreshed in real time.

5. Conclusion

In this paper, we have presented a kind of latticed model based on the utility of the telemonitoring system. And we have applied it to a real system. This system can transmit data and signal getting from the monitor terminal to doctor workstation through 3G network accurately in real time. So the doctor can diagnose many patients by their physiological parameters at the same time. This model has a good expandability. It makes the system not only can measure and transmit the physiological parameters accurately, but also can meet individual requirements of different users. The model laid a good foundation for the expansion of different patterns of sensor devices and other function modules in the future.

6. Acknowledgment

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7. References

[1] http://baike.baidu.com/view/266364.htm

[2] http://baike.baidu.com/view/1241145.htm

[3] Jingsheng Liao, Chao Hu, Guan Guan and Max Q.-H. Meng. An extensible telemonitoring architecture based on mobile agent method. IEEE Robotics and Biomimetics (ROBIO), pp: 1537 – 1542, 2009.

[4] Yuechun Chu and Aura Gans. A Mobile Teletrauma System Using 3G Networks. IEEE TRANSACTIONS ON INFORMATION TECHNOLOGY IN BIOMEDICINE, vol:8(4), December 2004.

[5] Yao JC,Schmitz R, and Warren S, A Wearable Point-of-Care System for Home Use That Incorporates Plug-and-Play and Wireless Standards, IEEE T INF TECHNOL B,vol:9(3), pp:363-371,2005.

[6] Blount M, Batra VM, Capella AN, Ebling MR, Jerome MF, Martin SM, Nidd M, Niemi MR, Wright SP, Remote health-care monitoring using Personal Care Connect, IBM Systems Journal, vol:46(1), pp:95-113,2007.

[7] HUANG LIAN XIE CUNXI ZHANG TIE. Multiple Physiological Parameter Monitoring Embedded System Based on ARM. Microcomputer Information（Embedded and SOC）2007，23（7-2）.

[8] J.Michael Fitzmaurice. Telehealth Research and Evaluation: Implications for Decision Makers[J」. Pacific Medical Technology Symposium， 1998. Proceedings. Pacific 17-20 Aug.1998， 344-352.

[9] Jing Bai. Intelligent Community Health Care System[J]. CHINA MEDICAL DEVICES INFORMATION，2000， 6(2):14-16.

[10] Zou Yanbiao Xie Cunxi. Development in Home Heath Telemonitoring System[J]. Computer Engineering and Applications, 2005,30(10):20-34