Design of Software for Wireless Central Patient Monitoring System

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***Abstract*— Measuring and monitoring the bio-parameters of patient is one of effective method to assist doctor during diagnosis and treatment now. This paper presents a research result about using the patient monitor devices in the hospitals today. Since, we proposed and designed a model of a wireless central patient monitoring system for the hospitals in Vietnam. From the single patient monitoring devices, the devices are connected to a WiFi standard single-channel transmitter module. The received data will be transmitted to a multi-channel wireless receiver (Access-Point). At the central station, the multi-channel wireless receiver will be connected to a computer. The received data channels will be stored and displayed simultaneously on software. Here, doctors and nurses can monitor the status of all patients with their device connected to the system. Besides, the software also allows doctors to set alert thresholds for each patient. When measured parameters from a patient outside the allowed range, the system will automatically give warning to help doctor handle in time.**

Keywords—patient monitor, bio-parameters, wireless

I. Introduction

Over the last few years, investment on contemporary medical equipments has increased rapidly. These equipments gradually play a very important role in helping doctors and clinician's works. Patient monitoring system is one of essential devices in hospitals. They measure vital biological signals such as ECG, RESP, SpO2, Blood pressure NIBP and temperature TEMP… almost hospitals from urban to rural sector has been equipped patient monitoring system from several to tens system based on hospital scale [1]. However, all these devices are working separately which monitor and measure individual parameters from single patient. From studies in several clinics and opinions from healthcare authorities, we propose and design a WiFi central patient monitoring system. Data from individual monitor has been retrieved and send to wireless transmitter. In centre wireless receiver, data from different monitoring systems has been archiving and then display parameters from different monitoring systems simultaneously. In the centre monitor, doctors can read and review data from many patients which facilitate monitoring and therapy process. Besides, doctors can respond to urgent cases rapidly, effectively and precisely. With this model, clinics can easily employ and implement without affect to current workflow of hospitals and with low investment cost.

II. Design System

A. *Analysis of patient monitoring system usage at clinics and hospitals*

According to studies at several big publish hospitals in Hanoi which include: Viet Duc Hospital, Bach Mai Hospital; E Hospital, ICU in Huu Nghi Hospital and some province hospital nearby including Vinh Phuc, Ninh Binh, we found that these hospital had recently bought a large number of patients monitoring system which are tens system on average as we investigated. These equipments are manufactured from various suppliers (Philips, Nihonkohden, Bionet, Siemens…). All of these equipments are delivered to departments and institutes and most of them working separately. If the doctors want to know patients biological parameters, they need to move to patient bed for observing these parameters. Normally doctors has been taken care several patient in a specific scheduled period of time. This cause many difficulties to doctors in some urgent cases. Besides, as we researched, almost doctors has personal computer in their office but only for document- related works. These above surveys are basis that lead our research team to design a system that easily implemented and increase device's usability.

Figure 1. The patient monitor devices are used separately in the hospitals

B. *System architecture design*

We propose and design a system architecture that is illustrated in figure 2. In each separated monitoring system, a measured signal has been retrieved from devices and wirelessly transmitted to centre unit by single channel transmitter module. Multi-channel receiver then receive all data flows from various single channel transmitter and in turn, send these data to archive server and display data flows on computer simultaneously. Transmitting and receiving process are followed WiFi standards. In display software, each data flows received from bedside monitoring has been archived and display in real-time that doctors can observe and analysis. A unique IP has been assigned to each single channel transmitter. Therefore, we know exactly in centre computer where the patient located [2].

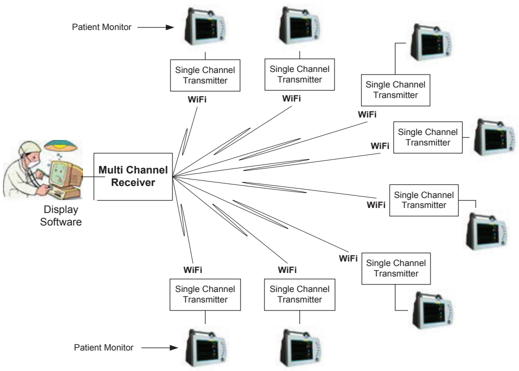

Figure 2. The 8 beds system architecture mode

III. Hardware Design

A. Single channel transmitter design

The single channel transmitter is responsible for two main tasks. It first retrieves data from patient monitor across RS232 standards. Then data has been encapsulated into UDP packets. Data then send to WiFi transmitter module ZG2100M followed SPI protocol. The figure 3 illustrates transmission of data within this module.

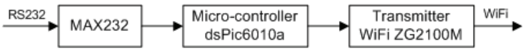

Figure 3. The single channel transmitter diagram

To functions single channel transmitter, we use microcontroller dsPic6010a. Dspic6010a will connect and retrieve data from individual patient monitor through RS232 standards and encapsulate data. IC MAX232's function is to connect patient monitor with dsPic. TCP/IP standard is used to set up this model to suit with WiFi ZG2100M. WiFi ZG2100M is transmitter that supply physical layer for network include MAC address, base bandwidth, RF and power amplifier for WiFi transmitter [2,3].

In order to retrieve data from patient monitor through COM port, data frame structure need to be analyze and identify. Terminal is software that allows send and receive signal from COM port and display in document form or Hexa format. Hexa format display is suitable for analyze data from patient monitor that show byte ordering and value of each byte has been sent from devices [4]. Figure 4 is software interface that display real-time data from Philips patient monitor device in Bach Mai hospital.

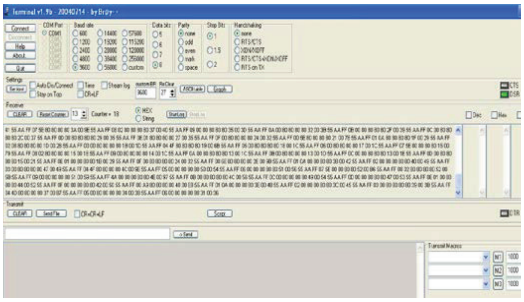

Figure 4. Acquirement data software interface from patient monitor device output

As the result, the data has been structured as follow: data has been received as consequently frame flow, each frame has 12Byte. The first 2byte is 0x55 and 0xAA, and last byte is CHECKSUM. These bytes are important to identify start and end byte of a data frame. Moreover, we can start receive data from a device after the first two byte (0x55, 0xAA). Then we can build a data receiving algorithm for dsPic6010a. Figure 5 is the algorithm block of dsPic6010a.

Another task of dsPic6010a is to set up network protocols to contact with WiFi transmitter module ZG2100M. WiFi Standard protocol is currently used is 802.11.b/g. From TCP/IP Stack, we built the following protocols: ICMP, IP, ARP, UDP and TCP.

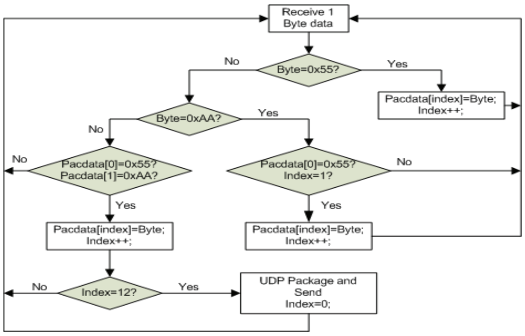

Figure 5. Retrieve data algorithm diagram from the patient monitor device of dsPic6010a

To do this, we use library of TCP/IP supplied by Microchip. This library is built to support network protocols for some micro controller of Microchip that has all network protocols and services. But the configuration need to be altered depend on hardware architecture. Hence, network protocol dsPic are designed to be suitable with hardware architecture in order to functions system correctly. We separated network protocols in TCP/IP Stack to smaller modules that required some specific files to operate. Figure 6 is protocol that has been set to dsPic6010a.

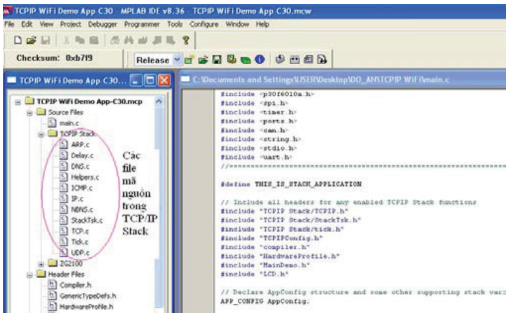

Figure 6. Setup TCP/IP protocol to dsPic6010a

B. Multi-channel receiver design

Multi-channel receiver we used is Access Point WiFi JCG, 802.11b/g, data speed up to 54Mbps, that allow multiple connections from single-channel transmitter. 4 LAN 100Mbps ports have integrated that used security modes: WEP, WPA-PSK, and MAC address filter.

IV. Software Design At Central Monitor

Software at centre computer are necessary to receive, archive and display real-time data from many single–channel transmitter to multi-channel receiver through network protocol. The consideration here is how to display simultaneously several channel and different parameters and graphs include: waveforms, and numbers. Besides, it need alarm function to warn doctors when preset threshold of those parameters are reached.

A. Database design

Database management system is to archive information received from patient monitor. Normally, a output data frame from monitoring system consist of ECG waveform, SPO2 (SATW), respiratory (RESPW), and parameters within byte Status1 include: Heart rate (HR), Pulse rate (PR), Respiratory rate (RR), SpO2, temperature T1, temperature T2, systole pressure (S), diastole pressure (D) and average blood pressure (M).

B. Analysis and software design

DATA has been received across LAN interface and send to computer to unpack and archive to database. Important bytes among others are: STATUS1, DATA, ECGW3, ECGW2, ECGW1, ECGW0, SATW and RESPW. The software then process data to extract complete patient's parameters include: HR, SpO2, PR, RR, S, D, M, TEMP1, TEMP2 and waveforms: ECG, SpO2 and RESP. Numbers parameters are extracted from 3rd and 4th byte which are STATUS1 and DATA while ECG waveforms are from 5th to 8th byte (ECGW0, ECGW1, ECGW2, ECGW3). 9th and 10th bytes are SATW and RESPW that carry waveform of SpO2 and RESP respectively. These parameters and waveforms are then sent to display unit. The display station has been separated to different channel that have correlation with patient bed. Channel display selection is depended on user requirements. In each channel, to facilitate parameters and waveform reading process, we divide front panel into two main area for numbers display and waveform display [4, 5]. Numbers and text display area, in turn, has been divided into smaller parts for each individual parameter. Waveform display area has 3 parts that doctors can observe ECG, SpO2, RESP waveform respectively. Each area has its own co-ordinate axis and used mm unit. Practical unit has been converted to mm unit of display station. Figure 7 and 8 illustrated software algorithm for displaying numbers, text and waveform [6-9].

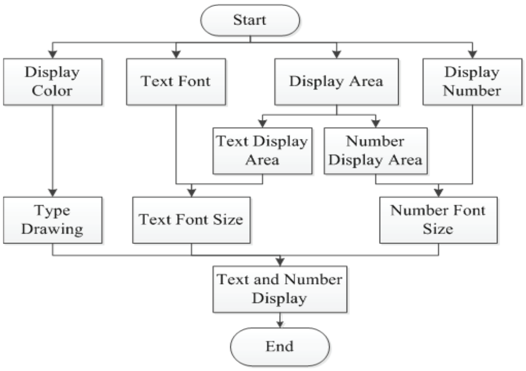

Figure 7. Text and number display diagram of the software

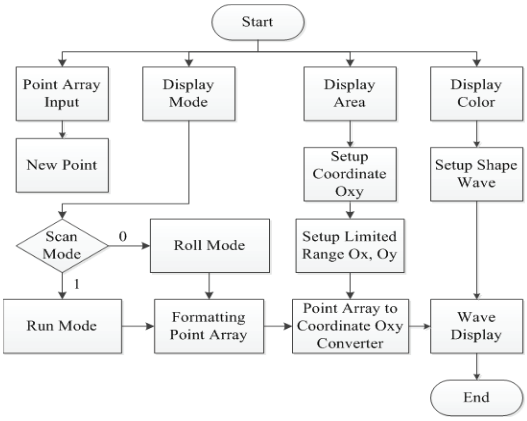

Figure 8. Waveform display diagram of the software

V. Results

System has been conducted following the proposed design. Hardware and software module has been designed and fabricated. The 8 patient monitoring systems has been successful connected in Viet Duc, Ninh Binh and Vinh Phuc hospitals. Wireless receiving and transmitting process and display 8 channels are accuracy and reliable.

Figure 9. The single transmitter prototype to acquire and transmit data from the patient monitor devices

Figure 10. The central display software interface for 8 real-time data channels from 8 different patient monitor devices

Figure 11. Implementation of a system at Viet Duc Hospital

Figure 12. Implementation of a system at Ninh Binh Hospital

VI. Conclusion

By attached single channel transmitter to individual patient monitor which has its own IP address, in the centre computer, multi-channel receiver will receive and send to computer for display. Software on central computer will archive, display parameters and waveforms simultaneously from different devices based on their IP address. This design is helpful for doctors in monitoring and therapy process. Besides, patient data are stored in centre computer for analysis and statistic work. This System has been tested with 8 different channels receiving and displaying. However we can expand to a larger scale application (up to 256 channel, base on IP protocols). With this result, this system is definitely implemented in hospitals in Vietnam.

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