WIRELESS ECG MONITORING WITH PARTIAL TIME TRANSCEIVER USE

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ABSTRACT

This work describes a portable electrocardiogram (ECG) monitor, intended for home monitoring of heart patients. It transmits the signal in bursts to a remote computer, using the wireless communication link only for a small fraction of the time, in order to lower power consumption and therefore expand battery life. It is projected to perform with no data loss, but with a delay of as much as about 30 seconds in normal operation, due to the buffering. The system's project, the choice of its components and the reasons for battery consumption control are explained and discussed. This project is currently under development.

1. INTRODUCTION

Patients with chronic heart diseases need constant monitoring, since they are at great risk of suffering a new event. Usually, these patients are kept under observation while hospitalized, then sent to their homes. Therefore, an efficient way of monitoring them at home is needed.

Monitoring systems with wearable medical sensor have many applications [1], including patient monitoring at home. Different solutions have been proposed: using mobile phones to send the data through the phone network [2], [3], a terminal for the patient themselves to view data and register events [4], transmission through the web [5], or direct use by nearby medical staff [6].

This paper presents a wearable device for home electrocardiogram (ECG) monitoring. It deals with the drawback of high power consumption of current ECG monitoring systems, proposing some innovations to extend battery autonomy.

2. PATIENT MONITORING SYSTEM

Our portable ECG device is part of Telemedicine Project for patient monitoring, which is also composed by the following elements:

- A remote computer, which receives the data transmitted by the portable device, executes some algorithms for ECG interpretation, and sends the ECG and the detected events through the Internet;
- A distant server located at a hospital or health center, which will save all the data in the electronic patient record and make it available to authorized persons.

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The structure of the patient monitoring system is presented in figure 1:

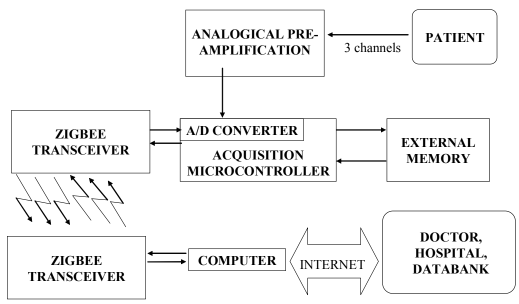

Figure 1: Structure of monitoring system

2.1. Embedded Device

The ECG signal (three channels) is acquired by electrodes placed on the patient's chest, and processed by an analogical circuit, which filters (band-pass) between 0,05 and 125 Hz [7] and amplifies it. The analogical signal is then converted to digital in order to be transmitted to the remote computer. For that, the ADuC841 was selected, since it has several 12 bit Analog-to-Digital (A/D) converters, as well as the necessary timers and I/O pins. The external memory is 24AA515, an i2c serial 512kbits memory, which is enough to store almost a minute of data. The transceiver is the XBee module, which uses the ZigBee standard. Preliminary tests indicate it can sustain a wireless connection 20 meters away with two or three walls in the way.

2.2. Embedded Microcontroller Operation

The flowchart of the embedded microcontroller is presented in figure 2.

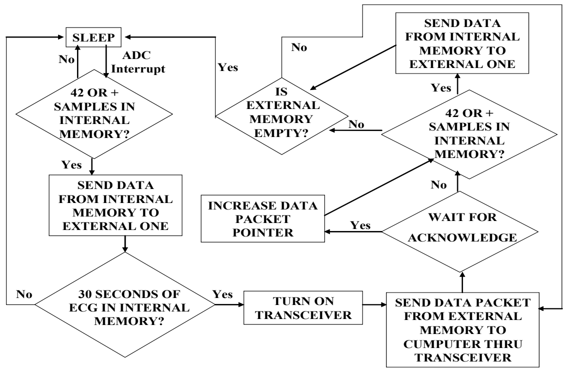

Figure 2: Flowchart of microcontroller operation

Every 3.9 milliseconds, the microcontroller samples at a 256 Hz rate all three ECG channels and stores them in its internal memory. When it completes 42 samples (about 55 ms of ECG), it transfers all the data to the external memory. When that memory stores 30 seconds of ECG, the transceiver is activated and all that data is sent to the remote computer through acknowledged bursts.

3. DISCUSSION

The data storage in an external memory instead of continuous transmission is justified by energy efficiency. To allow the patient to move around in their own house, the device should be portable, therefore battery-powered. These batteries cannot be too big or heavy since they will be carried by the patient at all times. However, they must last a long time, at least long enough to enjoy an ininterrupt night's sleep between battery changes. To enable small batteries to last a long time, the device must save as much power as possible. Since the greatest power consumer is the transceiver, it is good to use it only a fraction of the time, storing the data and transmitting it in bursts. This is possible because the data acquisition rate is much less then the transmission rate. However, this procedure introduces a delay in the availability of the data, and this delay cannot be too large as it will affect the response to an emergency. We have decided to store 30 seconds of ECG between bursts. When we have a functioning prototype the impact of that on consumption will be determined.

The memory can store almost a minute of data; however it will be unloaded after 30 seconds. Thus, if the wireless link fails, there will be enough time for several transmission retries before the memory fills up and data is lost. Obviously, during those retries the transceiver will remain active, consuming power.

The samples are coded in 12 bits; however the microcontroller, memory and transceiver operate with bytes (8-bit arrays). Using two bytes for each sample would waste memory space, transmission efficiency and, ultimately, energy. To avoid that, the microcontroller fits each two samples into three bytes. These are then grouped into one 63-byte, 42-samples array, and added a one-byte header to form a package.

Another measure to save energy would be the use of a dynamic transmission power control, that is, to increase power at each transmission failure and decrease it after a number of successes. That way, as the patient moves around the home, the system would automatically choose from a set of possible power values the least one great enough. If the patient is using the computer to which the data is being transmitted, for example, the power needed would be much smaller than that necessary to reach the other side of the house. Unfortunately, implementing that would require a different transceiver, one that would allow us to change the transmission power faster.

4. CONCLUSION

This article presented a proposal for a wearable home monitoring system, which emphasizes power saving, through less use of transceiver. This project is under development, and we plan to have a functioning prototype within a few months.

5. REFERENCES

[1] A. Reisner, P. Shaltis, D. McCombie, H. Asada, "A Critical Appraisal of Opportunities for Wearable Medical Sensors," In Proceedings of the 26th Annual International Conference of the IEEE EMBS, San Francisco, CA, USA, 2004

[2] R. S. H. Istepanian, B. Woodward, C. I. Richards, "Advances in Telemedicine Using Mobile Communications," In Proceedings of the 23rd Annual EMBS International Conference, Istambul, Turquia, 2001

[3] L. Boquete, I. Bravo, R. Barea, J. M. R.Ascariz, J. L. Martín, "Practical Laboratory Project in Telemedicine: Supervision of Electrocardiograms by Mobile Telephony," IEEE Transactions on Education, vol. 48, no. 2, 2005

[4] J. J. Segura-Juárez, D. Cuesta-Frau, L. Samblas-Pena, and M. Aboy, "A Microcontroller-Based Portable Electrocardiograph Recorder," IEEE Transactions on Biomedical Engineering, vol. 51, no. 9, 2004

[5] R. Fensli, E. Gunnarson, T. Gundersen, "A Wearable ECG-recording System for Continuous Arrhythmia Monitoring in a Wireless Tele-Home-Care Situation," In Proceedings of the 18th IEEE Symposium on Computer-Based Medical Systems, 2005

[6] F. C. A. Paim, R. S. Correa e J. L. B. Marques, "Proposta de um Sistema de Monitoração de Pacientes em Programas de Reabilitação Cardíaca," In proc. III CLAEB, João Pessoa, 2004

[7] J. J. Bailey, A. S. Berson et al, "Recommendations for Standardization and Specifications in Automated Electrocardiography: Bandwidth and Digital Signal Processing," Circulation, vol 81, no 2, 1990

[8] S. Led, J. Fernández, L. Serrano, "Design of a Wearable Device for ECG Continuous Monitoring Using Wireless Technology," In Proc. 26th Annual International Conference of the IEEE EMBS San Francisco, CA, USA, 2004