Wireless Sensor Networks for Monitoring Physiological Signals of Multiple Patients

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AUGUST 2011

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- Data：2011/12/14
Outline

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The principal reason for a lengthy stay in the hospital is simply continual observation.

In recent years, emergency admissions and long lengths of stay have become extremely costly.

Investment in technologies that enable remote monitoring would lead to long-term gains in terms of hospital finances and patient care.
Introduction (2/2)

- Wireless monitoring systems (patient’s side)
  - PC
  - PDA
  - Mobile phone

- The main drawbacks
  - Costs
  - Accessibility
Purpose

- A new design of the monitoring system
  - Drastic reduction in costs
  - Ease of use
  - Eliminates the need for a PC and PDA to send patients’ data
Material and methods
Material and methods

- Two main sections in the system
  - Wireless patient portable unit (WPPU)
  - Wireless-access point unit (WAPU)
It consists of two main parts

1. ECG amplifier and noise cancellation
2. Microcontroller and a low-power wireless radio transceiver
ECG amplifier and noise cancellation

- The ECG signals captured by the sensors have amplitudes of around 1 mV peak-to-peak.

- The differential signals from the sensors are amplified by an INA2322 cored circuit while rejecting almost all of the common-mode noise.
ECG signal sampling

Most useful ECG information lies between 0.05 Hz and 150 Hz

The Nyquist criterion, the sampling rate must be 0.1 Hz ~ 300 Hz.

Assume the acceptable sampling rate to be 200 samples/s.
AD converter:
- The sampling rate is equal to the calling of the ADC10 interrupt service routine which can be obtained by configuring the ADC10 control registers.

Packetization
- The four other bits in both bytes of the wireless packet are used for packet numbering.
As can be seen, the WAPU contains two main boards (1) the RF network-access point (RFNAP) board. (2) Internet connection board (ICB), which creates TCP/IP packets.
The three main requirements for the RFNAP firmware:

1. Network connection management.
2. Reception of wireless packets.
3. Sending the received wireless packets toward the ICB through a serial port.

Once a connection is established between the Link-To and the Link-Listener structures, the RF Network Access Point firmware handles the received packets from RF Network End Devices.
The ICB firmware contains three main parts:

- The firmware saves the received ECG signals from the "RF Network Access Point" board.
- Creates TCP/IP packets.
- The TCP packets are prepared and then sent to the hospital via the Internet.
TCP/IP Packetization

Fig. 6. TCP data format for ECG signals.
HOSPITAL

- The Windows server is used as the operating system on the computer server and the database is the SQL server.

- These three main parts:
  - (1) ECG server
  - (2) ECG database
  - (3) ECG monitoring
ECG Server Application

- This application is implemented in the Microsoft Development Environment—Microsoft Visual C#.

- For each patient, a specific TCP port is assigned.

- This software is a real-time client server application.

- Security information is processed in order to verify the sessions and packet’s authenticity.
ECG Database

- ECG signal records for a particular patient can be retrieved via its “PatientID” in the ECGSignal table.

- Each ECG signal record includes 64 ECG samples.
ECG Monitoring

- Some of the functionalities of this application are as follows:
  - Patient database: ability to add, delete, and modify patient information
  - Online plotting: online ECG signals are visualized for more than one patient at any time
  - Offline plotting: plotting of saved ECG signals and the ability to move signals forward and backward
End-to-end activity for transmitting ECG signals.

- this diagram clearly shows that 64 ECG samples are converted into a single packet for transmission.
This figure also shows that the wireless-link packet loss is less than 5% for distances less than 20 m.
As one can infer from this equation, the packet retransmission can mitigate the impact of a lossy channel.

\[ p_L = P_e^{C_r + 1} \]
CONCLUSION

- Currently available systems for monitoring physiological signals suffer from technical limitations.

- A novel wireless sensor network structure. remote monitoring system of physiological signals was presented.

- It also lowers the cost involved with monitoring patients and increases the efficient exploitation of physiological data.
References

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