The 4th IEEE International Conference on E-Health and Bioengineering - EHB 2013
Grigore T. Popa University of Medicine and Pharmacy, Iaşi, Romania, November 21-23, 2013

Wireless Skin Temperature Measurement System for Circadian Rhythm Monitoring

Cristian Rotariu, Hariton Costin, Alexandru Păsărică, Ciprian Cristea
Department of Biomedical Sciences
Grigore T. Popa University of Medicine and Pharmacy
Iasi, Romania
cristian.rotariu@bioinginerie.ro

Bogdan Dionisie
Department of Physiology
Grigore T. Popa University of Medicine and Pharmacy
Iasi, Romania

***Abstract*—Nowadays a significant part of the population suffers of sleep disorders, so the dynamic long term monitoring of skin temperature during sleep is very useful for analysis and understanding the circadian rhythm. In this paper we describe the realization of a patient skin temperature monitoring system, based on wireless devices, capable to measure and transmit the patient's skin temperature to a central monitoring station. The use of the proposed system is suitable for remote continuous long-time patient monitoring, in-hospital or at-home, as a part of a diagnostic procedure or during recovery. The described system uses custom developed wireless temperature measurement devices that perform the temperature measurements and wirelessly transmit them to the monitoring station. A graphical user interface running on the central monitoring station was developed, used for displaying the measurements and alerts, when patient temperature values exceed the preset limits.**

Keywords—circadian rhythm, patient monitoring, skin temperature, wireless sensors.

I. INTRODUCTION

Reliable long term patient monitoring is crucial for a number of medical conditions requiring circadian rhythm analysis [1], sleep-related disorders, hypertension, ischemic heart diseases, heart failures, and strokes. It is well known that sleep and body temperature are closely related and the human performances depend on body temperature [2]. Nowadays more and more people suffering from circadian rhythm sleep disorders have their timing of sleep affected, and usually are unable to sleep and wake at the times required for daily normal activities.

Wireless sensor networks (WSN) have great potential for continuous monitoring at hospital or even patient's home, early detection of abnormal conditions, and/or supervised rehabilitation [3]. The advances technologies are driven by the developments in wireless communications and wearable computing completed by the minimization of weight and size of sensors, portability, connectivity, reliability and easy integration into complex systems. The availability of low power short range RF transceivers in the unlicensed band allows the design of a small, low-cost, battery operated wireless sensors [4].

On the market, there is a significant increase in the number of various wireless temperature acquisition devices. Although these devices are used only to collect data, they still remains the most used. Data processing and analysis are performed offline, making them impractical for continual long term monitoring.

Monitoring the patient's temperature in hospital or at-home requires the use of temperature sensors attached by wires to medical devices, which limits the patient's movements. For example, a commonly used method uses for temperature measurement thermistors attached by wires to the temperature data logger. Although acceptable for shorter periods of time, this method is unacceptable for long term monitoring or monitoring of sleeping patients. In order to avoid these situations, we use WSNs, based on low power devices, having RF transceivers.

The patient's skin temperature is continuously measured by the proposed system and it is wirelessly transmitted to the central monitoring station using a standard low power WSN, avoiding using more expensive Bluetooth or WiFi nodes.

This paper describes a temperature remote monitoring system for circadian rhythm based on wireless sensor nodes. The sensor nodes contain commercially available temperature sensors and wireless modules, perform the temperature measurements and wirelessly transmit them to the monitoring station. The central monitoring station runs a patient temperature monitor application that displays the patient temperature and alerts, when patient temperature values exceed the preset limits.

II. MATERIALS AND METHODS

A conceptual view of the proposed system, as represented in Fig. 1, contains the following main components: a WSN of temperature acquisition devices, one sensor node for each monitored patient attached on his/her chest, an Access Point as a network coordinator, and a PC as a monitoring station.

Each temperature acquisition device contains an eZ430RF2500 wireless module (Fig. 2) [5]. The eZ430-RF2500 is a complete wireless development module for the MSP430F2274 microcontroller [6] and CC2500 wireless RF transceiver [7] that includes the HW and SW resources required to develop small WSN applications.

978-1-4799-2373-1/13/$31.00 ©2013 IEEE

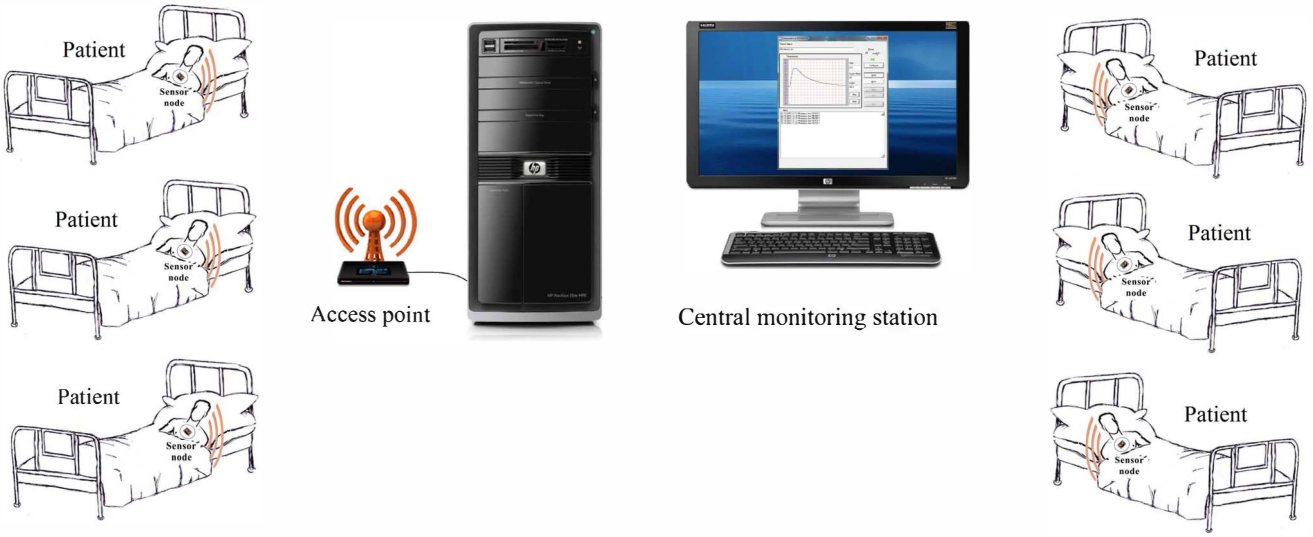

Fig. 1. Wireless Skin Temperature Measurement System

The MSP430F2274 is a 16-bit RISC ultra-low-power mixed signal microcontroller, optimized to achieve extended battery life in portable measurement applications. It has an internal memory structure of 32 kb flash memory and 1kb on-chip static RAM. Other features of the MSP430F2274 include: two internal 16-bit timers, a fast 10 bit 200 kbps A/D converters with internal reference, enhanced universal serial communication interfaces USART, I2C, SPI. The internal digitally controlled oscillator allows wake-up from low-power modes to active mode very fast, facility that is used to extend batteries life. Typical applications of MSP430F2274 include sensor systems that capture analog signals, convert them to digital values, and then process the data for display or for transmission to a host system. Stand-alone radio-frequency sensor front ends are another area of application.

Fig. 2. The eZ430-RF2500 wireless module

The CC2500 is a low-cost 2.4 GHz wireless RF transceiver designed for low-power wireless applications. The circuit uses for data transmission the ISM (Industrial, Scientific and Medical) and SRD (Short Range Device) frequency bands, supports various modulation formats, has a configurable data rate up to 500 kBaud, and consumes less than 21.2 mA in transmission mode at 0 dBm output power and 17.0 mA in receiving mode. The CC2500 is connected to the MSP430F2274 microcontroller by using the SPI interface and has an indoor line-of-sight range up to 50 meters.

We used the SimpliciTi protocol (Fig. 3) from Texas Instruments to transfer data from sensor node to central monitoring station [8]. SimpliciTI is an open source low-power network protocol used with battery-operated devices. As wireless network protocol, SimpliciTI supports End Devices in a peer-to-peer network topology, an Access Point as a network coordinator to store and forward the measured temperature to the PC, and Range Extenders used to extend the range of the wireless network.

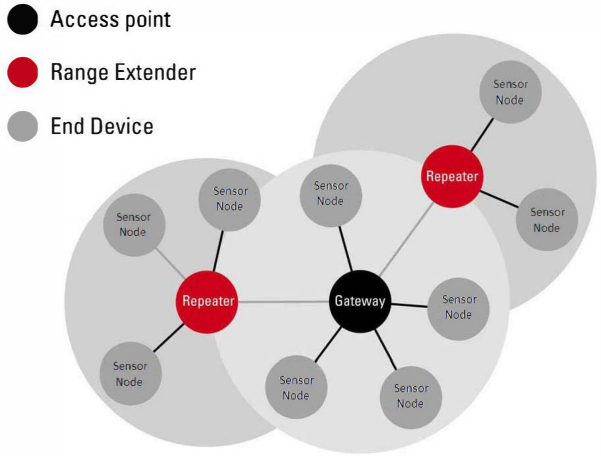

Fig. 3. The SimpliciTi wireless protocol

For the skin temperature measurement we use TMP275 temperature sensor (Texas Instruments). The TMP 275 is a high precision 0.5 °C accurate, two-wire temperature sensor with serial output, capable of reading temperatures with a resolution of 0.0625°C. The TMP275 is directly connected to