Wireless Temperature Monitoring Device

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ABSTRACT: ***Wireless radio frequency (RF) communication and Wireless Sensor Network (WSN) are currently shifting their trend towards human or object tracking capabilities to real-time monitoring capabilities, particularly in the healthcare sector. Monitoring the health of patients is one of the key tasks of every hospital of ensuring that patients are in safe and healthy health. Many researchers have been making efforts to use WSN to test temperature, heart rate, oxygen saturation, respiratory rate, and so on to track the condition of patients in hospitals remotely. This research focuses on incorporating a temperature sensor into a Zigbee wireless transceiver network and is used to calculate the body temperature of the patient from a remote location (the workstation of the nurse). Few thermistor temperature sensors were used to assess reliability, and their reading was compared with the thermometer and the one with accurate and stable reading was selected. Zigbee network or correctly referred to as IEEE 802.15.4/Zigbee is considered to be a low power consumption system with wider transmission range, greater network efficiency and a wide number of nodes. Through the experiments, the Zigbee network has proven itself capable of ensuring data transmission reliability at a longer range.***

KEYWORDS: ***Temperature monitoring; wireless technology; wireless sensor network; temperature sensors.***

INTRODUCTION

In most nations, health care of the elderly was a big concern. Elderly people have been referred to nursing homes or hospitals in the past to receive services and basic health care options, as well as for psychiatric treatment. However, the delivery of such healthcare is also difficult due to high costs and the effect on quality of life. These institutions also concentrate less on the welfare of elderly people. Medical care will still not be received in urgent circumstances. Such problems can be solved with the help of the new tele-monitoring technology that allows for continuous monitoring of health in private homes using wearable devices [1]. The elderly live in their homes with this new technology, rather than relocating to expensive aged care or nursing homes. In this method of health monitoring, by comparing the health data collected from wearable sensors in and data transmission period with the data from the previous cycle, the health status is captured by event-based monitoring. A health care practitioner at a remote facility monitors this in real time. Hence, the elderly will live with their families in their homes in a safe atmosphere without health issues [2].

It is believed the Internet of Things would have a large number of physical objects connected to the TCP/IP network. Cisco's Chief Futurist and Chief Technologist for the Cisco Internet Business Solutions Group (IBSG), predicts 50 billion Internet-connected devices will be available by 2020. Such a huge increase is showing a great business potential for suppliers of hardware, Internet service providers and developers of IoT applications. Standardization of the architecture is still a challenge for the IoT world but a large part of these devices will be linked via wireless sensor networks (WSN).

WSN provides the basic communication network between sensors to provide information on temperature, humidity, concentration of carbon dioxide, levels of public lighting and other environmental data. This sensing of data can be used in different situations such as travel, healthcare, or industrial automation. In most cases, all of this information is sent to a service layer utilizing an existing global TCP/IP network (smart grids, smart cities, cloud services, etc.); The

key issues regarding the integration of a WSN into the internet are the differences between the protocols, especially in the layers of physical, data link and network [3].

Nowadays, many networking protocols including Wi-Fi, Bluetooth, IEEE 802.15.4, Z-wave and LTE-Advanced are brought together by the WSN used for sensing and monitoring. Sadly, none of these systems carry the full wide spectrum of IoT applications. Each protocol is designed to facilitate communication within a limited area of coverage, bandwidth, data rates and consumption of energy. That being said, developers of IoT applications have to deal with several protocols to build IoT services which can be deployed. This work gives a network of wireless sensors for tracking the temperature. An IEEE 802.15.4 network gives the connection between the data tags. The tags sense and send the details about temperatures to the central computing device. This device acts as an IEEE 802.11 gateway which provides Internet access.

The overall work is carried out to create a wireless continuous monitoring system that consists of the development of hardware and software. This study explores the use of 802.15.4/Zigbee technology to wirelessly track human body temperature using thermistor as a measurement tool for temperatures. This study focuses on the reliability and accuracy of wireless technology and sensor where three investigation sets were conducted to satisfy those requirements. The investigation was carried out by introducing various temperature sensors for accuracy and stability at different ambient temperature and regular use levels.

Market Name	RFID	WI–FI	Bluetooth	Zigbee	UWB
Standard	802.11	802.15.4	802.11b	802.15.1	802.15.3
System Resources	250KB	1 MB+	250KB+	4KB – 32KB	110MB
Network Size	96	254	7	Unlimited (264)	15
Battery life (days)	1 – 10	5 – 6	1 – 7	100 – 1000+	10 – 50
Transmission range (meters)	1 – 100	1 – 100	1 – 10+	10 – 100+	1 – 30
Success metrics	Reliability, Convi-nience	Speed, Flexibility	Cost, Convenience	Reliability, Power, Cost, Flexibility	Reliability, Power

TABLE 1: Comparison of Wireless Technology

Wireless Technology

Wireless systems have evolved over time and with considerable degradation. The technology is almost difficult to keep up with. An overview of wireless technology was done and presented in Table 1 below. Taking into account devices such as RFID, Wi-Fi, Bluetooth, UWB and Zigbee are the most widely used in wireless surveillance today. Literature comparisons indicate that the Zigbee network system is a suitable system for enhancing application growth in future prospects. Zigbee module is classified as an Original Equipment Manufacturer (OEM) RF module in which the Xbee Pro module uses RF transceivers as its interface for transmission. The module was designed to meet IEEE 802.15.4 requirements and support the need for low-cost and low power consumption of the wireless sensor network, which also needs minimal power and is capable of transmitting data between devices reliably. Network technologies RF and Zigbee are used widely in many applications.

Body Temperature

Body core temperature is a measurement of average heat in a body where the body's inner component will continue to compare and respond to the variations between body temperature and external environment. The temperature of the human body varies according to one's behavior, one's fitness time of day and other psychological factors. Types of illnesses triggered by extreme body temperature rises include flu, malaria flu, hyperthermia, heat stroke, meningitis and so on. Heat-

related disease symptoms are based upon conditions such as headache, nausea, dizziness, muscle cramps, and even coma. The raised body temperature is mostly attributed to common cold virus or influenza infections, urinary tract infection, sinus or hepatitis issues, pneumonia, etc. These types of infection that causes elevating body temperature need to be closely and carefully controlled, as certain cases that cause fatality. The average human body temperature varies between 36.5 ° C and 37.2 ° C (97.8 ° F to 99 ° F).

When body temperature rises above the threshold value due to an unknown cause, multiple stages of heat-illness that result in various potential hazards for patients. Continuous monitoring of the temperature of patients is therefore very necessary to ensure that they are still in stable conditions. A variety of mediums such as gas thermometers, bimetallic thermometers, thermistor, thermocouples, liquid crystals, and infrared thermometry are used for calculating temperature. The armpit is the most suitable tool to be used during the calculation of body temperature, although it has been criticized for unreliability. Tests performed in this research where armpit shows positive results and read interpretation as the thermometer detects them. Several instruments are used to measure temperatures such as optical thermometer, infrared thermal imaging, basal thermometer, pacifier thermometer, thermometer of the forehead and thermometer of the tympanum. Thermometer is used to benchmark the prototype built for this test [1].

LITERATURE REVIEW

In This research is presented as the first proof of concept by a completely printed wearable human-interactive device called the "smart bandage." The app combines touch and temperature sensors to monitor safety, a health-enhancing drug delivery system and a contact-detecting wireless coil. The arrangement of the sensors, microelectromechanical systems (MEMS), and wireless coil is monolithically assembled on flexible substrates. It demonstrates a smart bandage on a human arm. These types of human-interactive wearable devices are a promising forum not only for interactive devices but also for mobile MEMS technology [2]. The monitoring of vital signs plays an significant role in long-term prevention and the recovery of the wellbeing of elderly people. Rehabilitation progress can be deduced in particular from the monitoring of an electrocardigram (ECG), blood pressure, and body temperature. This paper present a portable, coupled recording system to track these critical signals for a long time. It record the ECG, blood pressure and skin temperature, and provide a 3D-acceleration sensor for measuring motion determination and use data fusion to deny or fix skewed critical signals and deal with motion artefacts in all reported properties [3]. The goal of this project is to design and create a monitoring system for body temperature that can be monitored by the doctor in real time as well as background data through the internet with an alarm/indication in case of anomalies.

Wireless sensors for heart rate and body temperature were incorporated in the proposed health monitoring system, but this paper only focuses on wireless monitoring system for body temperature. Use Xbee wireless communication the temperature sensors send the readings to a microcontroller [4]. This paper aimed to explain the thesis which had been undertaken to enhance research possibilities and to open up new concepts. This paper addressed some advance stage from very simple parts of a WSN network to real life implementation. With XBee and Arduino, the effective reconfigurable security approach for Wireless Sensor Networks (WSN) is derived.

Users can reconfigure the safety scheme and algorithms by reloading the software to a programmable processor in the sensor node. To provide security services, first a check is performed in system with RC4 stream cipher and modified RC4-Based Hash feature [5]. This paper introduces wireless Temperature Tracking sensor network. Which can announce the emergency to users in various ways, such as computer screen pop-ups, mobile phone SMS, etc. Because of this versatility of monitoring low cost wireless sensor network designed for potential

emergency response system. This paper will create three wireless sensor nodes and have to place them in different locations in the house, and will notify the master node or control node about the temperature at each sensor node [6]. This paper shows an integrated Xbee arduino and differential evolution approach to localization in wireless sensor networks, and the creation of a differential evolution localization algorithm to minimize localization error. The algorithm is simple to implement and is using fewer control variables [7]. In this paper, the performance analysis of ZigBee networks based on XBee ZB modules was evaluated with respect to the following performance metrics: received signal strength (RSSI), network latency, packet delay, mesh routing recovery time, and indoor energy consumption.

Two major network scenario classes were evaluated: direct transmissions between the coordinator and the remote nodes; and (ii) router transmissions that transmit the packet between the coordinator and the remote nodes [8]. Heart Rate Monitors (HRMs) have been used regularly over the last two decades. It used different forms of sports as training assist. And the production of new HRMs has been fast evolving. Thus, HRMs are primarily used to assess the exercise strength of the training session or competition. Heart rate is easy to track, convenient to use in most cases and fairly cheap compared to the other measure of exercise strength. Thus, if wireless sensor network can be integrated into the device, it is most beneficial [9]. In several different areas of the medicine such as cardiopulmonary, renal, endocrine, neurological function and recovery medicine, smart wearable sensors are efficient and accurate for preventive methods. These sensors were also shown to be reliable and useful for medicinal perioperative monitoring and rehabilitation [10].

METHODOLOGY

A brief overview of the techniques used in this research work, including the implementation of wireless technology for the Zigbee Network, Arduino Microcontroller and several temperature sensors. Here section addresses descriptions of the hardware architecture used in this work.

System Architecture

The system hardware design begins with a few subjects put in a closed environment where each subject is fitted with a transceiver module Zigbee Xbee-Pro S1 embedded with temperature sensor. The data collected by the transceiver microcontroller will then be forwarded to the SKXBEE (receiver) Zigbee. The transmitted data should proceed from the receiver through the Ethernet network route used by the device. One route is via the Wireless Area Network (WAN) which will be connected to the device which will send the signal to the accessible mobile nurse. The other route is where all the data collected are stored for future reference in the machine database.

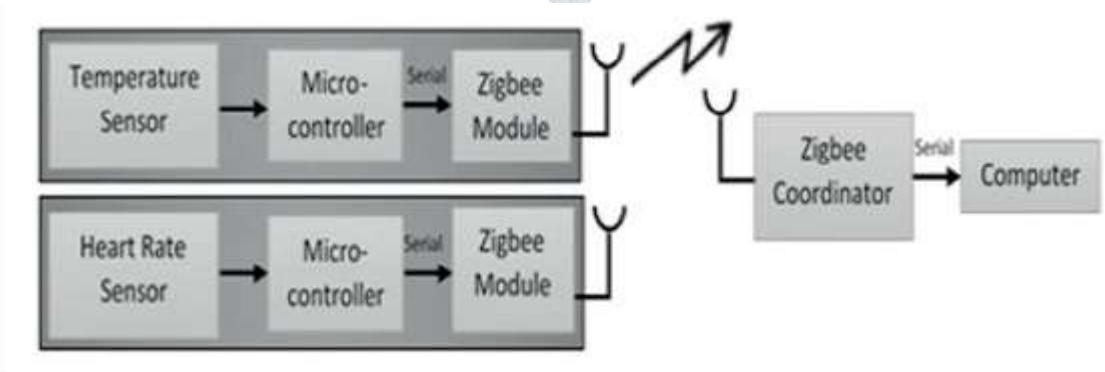

FIGURE 1: Block Diagram of System Hardware

The Xbee – Pro OEM RF Module, a Zigbee-based interface for wireless devices helps minimize the cost of implementation by simplifying communication protocols and reducing data rate. The module uses 2.4GHz frequency RF transceivers for data transmission, and uses the standard Zigbee

protocol for networking, application, and protection layers. The Xbee – Pro OEM RF Module comes with a Digi International interface program that allows a simple and user-friendly GUI and communicates with the firmware files found on Digi's RF products.

In the Graphical User Interface (GUI) running on a device, the values of the detected readings are shown in a graphical form. The built interface is not only user-friendly, but is also a web-based interface where the user can control and access the interface as needed in a continuous monitoring framework at any time and on any day. If the person with the tag is suffering from medical distress, the device will automatically trigger an alarm that warns medical professionals on duty.

Temperature Sensors

Many types of temperature sensors that can be used to monitor body temperature, such as miniature piezo film sensors, micro-thermocouple sensors, temperature resistance detectors (RTDs), thermistor sensors and integrated circuit (IC) sensors. Table 2 addresses the advantages and disadvantages of the individual sensors.

Type of sensor	Advantages	Disadvantages
Thermo-couple	Self-powered, Simple, Inexpensive, Wide variety of physical forms and Wide temperature range	Non-linear, Low voltage, Reference required, Least stable, Least sensitive
RTD	Most stable, Most accurate, More linear than thermocouple	Expensive, Slow, Current source required, Small resistance change
Thermistor	High output, Fast, Inexpensive, Highly accurate	Non-linear, Limited temperature range, Fragile, Current source required, Self-heating
IC	Most Linear, Highest output, Inexpensive	Power supply required, Slow, Self-heating, Limited configurations

TABLE 2: Types of Temperature Sensors

According to Table 2 and knowledge of the maximum core body temperature range, the thermocouple sensor and IC sensor option can be removed even if their ability to provide a wider temperature range (almost 250 °) can be removed. This study's main objective is only to investigate using a low temperature value; therefore both RTD and thermistor are appropriate for this method. RTD is considered to be expensive, however, and provides poor response time. Considering cost, quick response time and accuracy, thermistor is found to be the most appropriate option. In addition, the downside of restricted temperature range and self-heating would not be important due to the small range of temperature to be measured and will use low-power devices as power source.

The thermistor is a passive transducer where its resistance depends on the heat thermistors supplied, negative temperature coefficient (NTC) sensors have been selected for this purpose. NTC is a portion of two terminal solid state that exhibits a broad, predictable resistance change corresponding to changes in absolute body temperature. It is thus an appropriate material to be used as a temperature measuring component due to its rapid changes in temperature.

Proposed Circuit Design

The NTC is located at the human body's armpit and is attached to the end circuitry of the transmitter. Whenever the sensor senses the body temperature at a certain time interval, the microcontroller will send the digitized signal to the receiver for transmission to the Xbee module. If the receiver receives the signal, the read of the sensed temperature will then be displayed via the X-CTU interface. The first technique conveyed was the implementation of multiple NTC sensors for precision measurement by simultaneously using the standard thermometer as a benchmark unit. Furthermore, the test proceeds to calculate the full range transmitting capacity and read accuracy with respect to various sets of temperature setting. Eventually, the process continues by monitoring

the capability of the system (durability and sustainability) to measure the temperature of random subjects using gender as the key category when used at a regular rate.

CONCLUSION

In conclusion, from the multiple analyzes of different NTC sensor capacities, maximum temperature reaction, range capacity, stability and reliability of wireless monitoring using Zigbee technology, it is shown that the Zigbee module (Xbee) is capable of transmitting stable and reliable data at different temperatures or conditions, as well as being capable of transmitting data at a specific range. The thermistor used as a sensor is proved to be reliable where it is sensitive to changed temperature and capable of providing fast response. The system proved to produce reliable results after being tested in various environments according to the changes that occurred in the core temperature of the body.

However, it is advised to look at the nature of the tag in order to make the prototype suitable and ensure patients are comfortable to wear. The research is also to provide two other parameters of vital signs, heart rate and blood pressure monitoring in different transceiver sets, as well as to allow repeater use to further expand the contact range. The Zigbee module (Xbee) and the NTC sensors enable researchers to quickly, effectively and accurately build and analyze the wireless monitoring application in real time.

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