An Adaptive Embedded System for Monitoring Patients

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Abstract

In this project, we propose the wireless sensor networks (WSN) to observe the human physiological signals by ZigBee, which is provided with lower power consumption, small volume, high expansion, stylization and two-way transmission, etc. ZigBee is generally used for home care, digital home control, industrial and security control. This paper developed a suite of home care sensor network system by ZigBee's characteristic, which is embedded sensors, such as the biosensor for observe heart rate and blood pressure. The biosensor transmits measured signals via ZigBee, and then sends to the remote wireless monitor for acquiring the observed human physiological signals. The remote wireless monitor is constructed of ZigBee and personal computer (PC). The measured signals send to the PC, which can be data collection. When the measured signals over the standard value, the personal computer sends Global System for Mobile Communication (GSM) short message to the manager. The manager can use the PC or personal digital assistant (PDA) to observe the observed human physiological signals in the remote place.

Keywords— Any cast, broadcast, ECG, multicast, patient monitoring, vital sign sensor, worldwide interoperability for microwave access (WiMAX), ZigBee module.

1.INTRODUCTION

In recent years, the world is facing a common problem that the number of elderly people is increasing. Hence, the problem of home-care for elderly people is very important. In recently, wireless sensor networks are used to structure home-care system in many researches. Wireless sensor networks application for physiological signals communication transmission has many technologies. Such as the Infrared, Bluetooth and ZigBee, etc. Because the angle limit problem of the infrared transmission, and the infrared have not be used for Physiological signal transmission. Although Bluetooth is better than ZigBee for transmission rate, but ZigBee has lower power consumption. Hence, ZigBee is generally used for 24 hours monitor of communication transmission systems. The first procedure of the system that we use the biosensor to measure heart rate and blood pressure from human body, Using Zigbee the measured signal sends to the PC via the RS-232 serial port communication interface. We can send the signal to remote PC or PDA from the internet. In particular, when measured signals over the standard value, the personal computer will send GSM short message to absent manager's mobile phone.
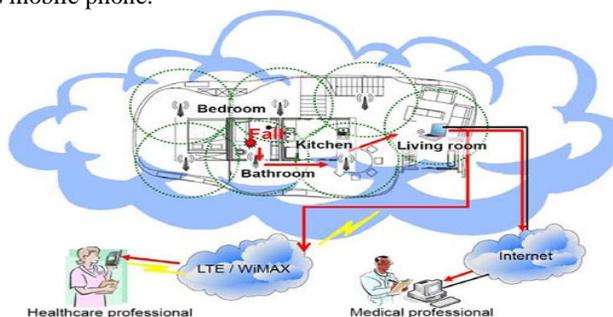

Figure 1: Architecture of Wireless patient monitoring

2. OVERVIEW Of THE WSPM SYSTEM

The wsn – zigbee has the following important module section. To observe the human physiological signals by zigbee, this is provided with lower power consumption, small volume, high expansion, stylization and two-way transmission, etc. Zigbee is generally used for home care, digital home control, industrial and security control. This paper developed a suite of home care sensor network system by zigbee's characteristic, which is embedded sensors, such as the biosensor for observe heart rate and blood pressure.

The biosensor transmits measured signals via zigbee, and then sends to the remote wireless monitor for acquiring the observed human physiological signals. The remote wireless monitor is constructed of zigbee and personal computer

(pc). The measured signals send to the pc, which can be data collection. When the measured signals over the standard value, the personal computer sends global system for mobile communication (gsm) short message to the manager. The manager can use the pc or personal digital assistant (pda) to observe the observed human physiological signals in the remote place
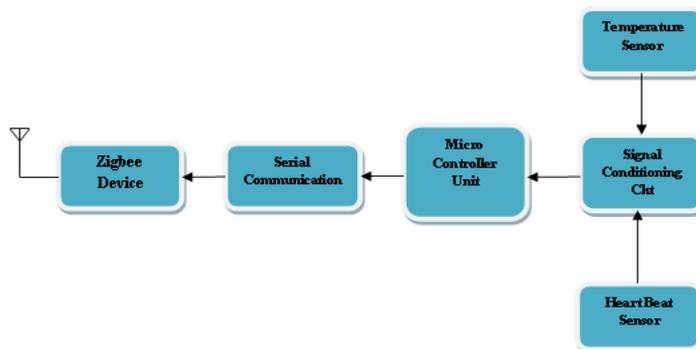

Figure 2: *Wireless patient monitoring Module*

3. METHODS

3.1. ARM Processor:

The ARM7 family includes the ARM7TDMI, ARM7TDMI-S, ARM720T, and ARM7EJ-S processors. The ARM7TDMI core is the industry's most widely used 32-bit embedded RISC microprocessor solution. Optimized for cost and power-sensitive applications, the ARM7TDMI solution provides the low power consumption, small size, and high performance needed in portable, embedded applications. The ARM7TDMI core uses a three-stage pipeline to increase the flow of instructions to the processor. This allows multiple simultaneous operations to take place and continuous operation of the processing and memory systems. As the processor is having a high speed it is easy to make the communication between the RF module and the Image acquisition module

Operating modes
The ARM7TDMI core has seven modes of operation:

➢ User mode is the usual program execution state
➢ Interrupt (IRQ) mode is used for general purpose interrupt handling
➢ Supervisor mode is a protected mode for the operating system
➢ Abort mode is entered after a data or instruction pre fetch abort.
The interrupt setting of ARM supports the DHLS to response to the interrupt coming from the server section.

Interrupt controller

The Vectored Interrupt Controller (VIC) accepts all of the interrupt request inputs from the home server section and categorizes them as Fast Interrupt Request (FIQ), vectored Interrupt Request (IRQ), and non-vectored IRQ as defined by programmable settings. These interrupt settings will give a quick response to the RF decoder. So that address verification will be very faster and signal for image processing will be given to the image acquisition module.

Wireless communication:
RF communication:

Radio Frequency,

Any frequency within the electromagnetic spectrum associated with radio wave propagation. When an RF current is supplied to an antenna, an electromagnetic field is created that then is able to propagate through space. Many wireless technologies are based on RF field propagation

Transmitter:

The TWS-434 extremely small, and are excellent for applications requiring short-range RF remote controls. The TWS-434 modules do not incorporate internal encoding. If simple control or status signals such as button presses or

switch closures want to send, consider using an encoder and decoder IC set that takes care of all encoding, error checking, and decoding functions. The transmitter output is up to 8mW at 433.92MHz with a range of approximately 400 foot (open area) outdoors. Indoors, the range is approximately 200 foot, and will go through most walls.

Figure 3: RF Transmitter

RF receiver:
RWS-434: The receiver also operates at 433.92MHz, and has a sensitivity of 3uV. The WS-434 receiver operates from 4.5 to 5.5 volts-DC, and has both linear and digital outputs.
A 0 volt to Vcc data output is available on pins. This output is normally used to drive a digital decoder IC or a microprocessor which is performing the data decoding. The receiver's output will only transition when valid data is present. In instances, when no carrier is present the output will remain low.
The RWS-434 modules do not incorporate internal decoding. If you want to receive Simple control or status signals such as button presses or switch closes, you can use the encoder and decoder IC set described above. Decoders with momentary and latched outputs are available
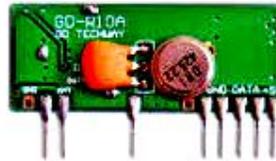

Figure 4: *RF receiver*

3.2. LPC2148 Microcontroller Architecture

LPC2148 Microcontroller Architecture. The ARM7TDMI-S is a general purpose 32-bit microprocessor, which offers high performance and very low power consumption. The ARM architecture is based on Reduced Instruction Set Computer (RISC) principles, and the instruction set and related decode mechanism are much simpler than those of micro programmed Complex Instruction Set Computers (CISC). This simplicity results in a high instruction throughput and impressive real-time interrupt response from a small and cost-effective processor core.
Pipeline techniques are employed so that all parts of the processing and memory systems can operate continuously. Typically, while one instruction is being executed, its successor is being decoded, and a third instruction is being fetched from memory. The ARM7TDMI-S processor also employs a unique architectural strategy known as Thumb, which makes it ideally suited to high-volume applications with memory restrictions, or applications where code density is an issue.
The key idea behind Thumb is that of a super-reduced instruction set. Essentially, the ARM7TDMI-S processor has two instruction sets:

• The standard 32-bit ARM set.
• A 16-bit Thumb set.

Figure 5: LPC2148

3.3. GSM

A GSM modem is a wireless modem that works with a GSM wireless network. Global system for mobile communication (GSM) is a globally accepted standard for digital cellular communication. GSM is the name of a standardization group established in 1982 to create a common European mobile telephone standard that would formulate specifications for a pan-European mobile cellular radio system operating at 900 MHz

GSM provides recommendations, not requirements. The GSM specifications define the functions and interface requirements in detail but do not address the hardware. The reason for this is to limit the designers as little as possible but still to make it possible for the operators to buy equipment from different suppliers. The GSM network is divided into three major systems: the switching system (SS), the base station system (BSS), and the operation and support system (OSS). The basic GSM network elements are shown in below.

Figure 6: GSM network Topology

GSM modems support an extended set of AT commands. These extended AT commands are defined in the GSM standards. With the extended AT commands, you can do things like:
❖ Reading, writing and deleting SMS messages.
❖ Sending SMS messages.
❖ Monitoring the signal strength.
❖ Monitoring the charging status and charge level of the battery.
❖ Reading, writing and searching phone book entries.

Sending the message:
To send the SMS message, type the following command:
AT+CMGS="+31638740161" <ENTER>
Replace the above phone number with your own cell phone number. The modem will respond with:
>   (Response from the modem)
You can now type the message text and send the message using the <CTRL>-<Z> key combination:
Hello World ! <CTRL-Z>
Here CTRL-Z is keyword for sending an sms through the mobile device. After some seconds the modem will respond with the message ID of the message, indicating that the message was sent correctly:
+CMGS: 62

4. TEMPERATURE SENSOR

Figure 7: Temperature Sensor

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 μA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a −55° to +150°C temperature range, while the LM35C is rated for a −40° to +110°C range (−10° with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-220 package.
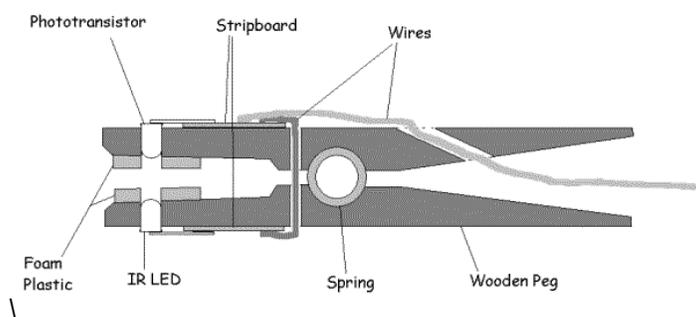
5. HEART BEAT SENSORS

Figure 8: Heart Beat Sensor

The sensor consists of a light source and photo detector; light is shone through the tissues and variation in blood volume alters the amount of light falling on the detector. The source and detector can be mounted side by side to look at changes in reflected light or on either side of a finger or earlobe to detect changes in transmitted light. The particular arrangement here uses a wooden clothes peg to hold an infra red light emitting diode and a matched phototransistor. The infra red filter of the phototransistor reduces interference from fluorescent lights, which have a large AC component in their output

The skin may be illuminated with visible (red) or infrared LEDs using transmitted or reflected light for detection. The very small changes in reflectivity or in transmittance caused by the varying blood content of human tissue are almost invisible. Various noise sources may produce disturbance signals with amplitudes equal or even higher than the amplitude of the pulse signal. Valid pulse measurement therefore requires extensive preprocessing of the raw signal.

The setup described here uses a red LED for transmitted light illumination and a pin Photodiode as detector. With only slight changes in the preamplifier circuit the same hard- and software could be used with other illumination and detection   concepts.

The detectors photo current (AC Part) is converted to voltage and amplified by an inexpensive operational amplifier (LM358). A PIC16F877 microcontroller converts the analog signal with 10 bits resolution to a digital signal. An average is calculated from 250 readings taken over a 20 milliseconds period (This equals one period of the European power line frequency of 50 Hz).
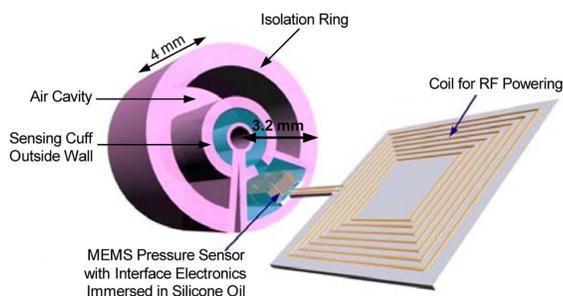
6. BLOOD PRESSURE

Figure 9: Implantable Blood Pressure Monitor

To miniaturize the large-model prototype design presented in pervious section, a miniature implantable blood pressure monitoring cuff is designed and fabricated. Fig. 6 shows a detailed 3-D configuration of the implantable blood pressure monitoring cuff with a sensor, interface electronics and RF powering coil. As illustrated in the figure, a silicone rigid isolation ring is used to decouple the sensing cuff, which is located at the structural center, from environmental variations in animal body. Because

of the soft nature of the sensing cuff outside wall, the pressure inside the sensing cuff is susceptible to environmental variations, such as animal muscle and tissue movement, without the isolation ring. The sensing cuff outside wall can be made more rigid to decrease this effect, however, at the same time the blood vessel restraint will be increased, thus leading to a tradeoff between blood pressure baseline drift and the vessel restraint. However, it is difficult to quantify this tradeoff due to limited research data currently available regarding the long-term influence

of laboratory animals with different amount of vessel restraint. Therefore, a rigid isolation ring is employed to suppress low-frequency baseline drift

7. ZIGBEE MODULE

The XBee/XBee-PRO RF Modules are designed to operate within the ZigBee protocol and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between remote devices. The modules operate within the ISM 2.4 GHz frequency band and are compatible with the following:

XBee RS-232 Adapter
XBee RS-232 PH (Power Harvester) Adapter
XBee RS-485 Adapter
XBee Analog I/O Adapter
XBee Digital I/O Adapter
XBee Sensor Adapter
XBee USB Adapter
XStick
Connect Port X Gateways
XBee Wall Router.

The XBee/XBee-PRO ZB firmware release can be installed on XBee modules. This firmware is compatible with the ZigBee 2007 specification, while the ZNet 2.5 firmware is based on Ember's proprietary "designed for ZigBee" mesh stack (EmberZNet 2.5). ZB and ZNet 2.5 firmware are similar in nature, but not over-the-air compatible. Devices running ZNet 2.5 firmware cannot talk to devices running the ZB firmware.
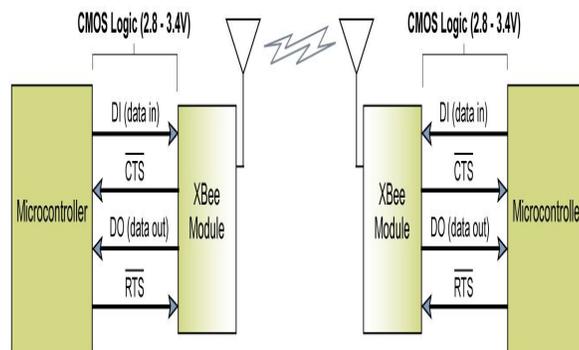

Figure 10: Zigbee Module (Tx & Rx)

8. MAX232

The MAX232 from Maxim was the first IC which in one package contains the necessary drivers (two) and receivers (also two), to adapt the RS-232 signal voltage levels to TTL logic. It became popular, because it just needs one voltage (+5V) and generates the necessary RS-232 voltage levels (approx. -10V and +10V) internally. This greatly simplified the design of circuitry. Circuitry designers no longer need to design and build a power supply with three voltages (e.g. -12V, +5V, and +12V), but could just provide one +5V power supply, e.g. with the help of a simple 78x05 voltage converter.

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The MAX232 has a successor, the MAX232A. The ICs are almost identical, however, the MAX232A is much more often used (and easier to get) than the original MAX232, and the MAX232A only needs external capacitors 1/10th the capacity of what the original MAX232 needs.
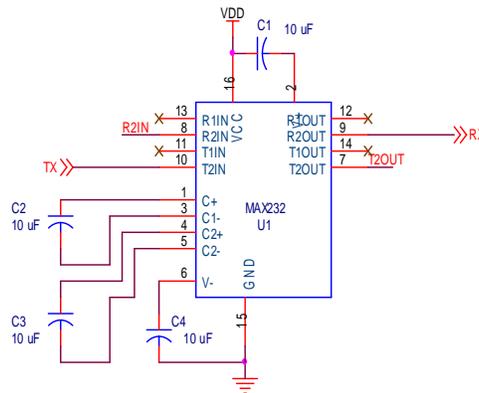
Figure 11: *RS232 Pin Diagram*

Features of MAX232

- Meet or Exceed TIA/EIA-232-F and ITU Recommendation V.28
- Operate With Single 5-V Power Supply
- Operate Up to 120 kbit/s
- Two Drivers and Two Receivers
- ±30-V Input Levels
- Low Supply Current 8 mA Typical
- Designed to be Interchangeable With Maxim MAX232
- ESD Protection Exceeds JESD 22 -2000-V Human-Body Model (A114-A)

Figure 12: *RS232*
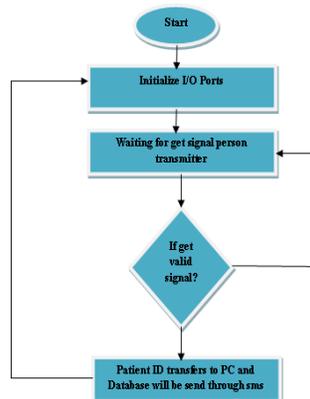
9. FLOW CHART

Figure 13: *Flow Diagram of WSPM*

10. CONCLUSION

In this time, model biotelemetry system is being implemented into working solution. Nevertheless, there is Space for improvements in both concept and implementation details of this system. Model biotelemetry system is currently designed for indoor use by one patient only. More nearby instances of inner part of model biotelemetry system managed by single outer part of system are possible, but there exists one to one mapping between patient and ZigBee network. Future improvements may include support for outdoor operation with communication implemented using 3G mobile technology and patient's tracking by GPS system. With advancements in low-power high-density FPGA solutions, FPGA programmable system on chip technology seems to be promising for purpose of this biotelemetry system.

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