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Fast, Intelligent and Secure an Embedded Health-care Supervisory System

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ABSTRACT

The world of medical supervisory system should remotely monitor various parameters of patients with help of electronics. This work aims at monitoring parameters in fast, intelligent and secure way. The work emphasizes on designing an embedded system which handles critical parameters of patients in hospital/nursing units. The data samples are processed using an ARM based CPU's and to achieve performance metrics TI RTOS is used and validated.The system generates interrupts based on the priority of each of critical parameters with a threshold in it and enables alarming/warning system. The data is then transferred to IoT layer using a CC3100 TI based SoC for further reference and processing.
In this paper, 4 parameters has been monitored for designing system such as measuring Respiratory rate for human breath, MMG signal for muscle movement, Blood pressure rate as well as Temperature.RTOS helps with scheduling as well as with interrupts also helps Wi-Fi module to work with it. Wi-Fi module provides many security options as WEP, WAP, and WAP2.

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1. INTRODUCTION

Now a day in medical cooperation equipment should behave in real time environment, also keep secrecy in data which is transmitted over media irrespective of its media type.

In supervisory system diagnosing many parameters simultaneously is crucial part. This project is all about the monitoring parameters of medical system for example the breath monitoring, BP, MMG etc. we can add more parameter to it as well, all these parameter measurement is created as task with priority assignment. And priority assignment should be dynamic because at any point of time one of its parameter pop ups emergency condition. For this real time environment plays an important role while handling many tasks. Real time OS is key component of this project. Detail study about real time OS is given literature review. Second key component of this project is data security while transmitting through the gateway. Many wireless techniques like Bluetooth, ZigBee, 6LowPan, Wi-Fi etc. can be used as gateway for data transmission. Each of the techniques is having its own advantage and disadvantage. In literature survey detail study about the techniques has been given.

Product failures do occur, either during testing or normal operation. With the growing complexity of embedded systems, smart diagnosis techniques are increasingly important. Use of interrupt service routine can solve this problem. Broken components must be quickly located so they can be repaired or replaced.

In component selection, sensory part do play role. Selecting appropriate sensor gives fast computation of data acquisition. While selecting a sensor we have considers the some points that it should be non-invasive, small in size (MEMS). Here non-invasive humidity sensor [9] and accelerometer sensor [1] used for measuring Human breath rate and MMG signal for muscle movement respectively. Even Temperature sensor, Blood pressure sensor are used as measuring parameter..

This can be process though the efficient data processing in microcontroller ARM MCUs unit.Where RTOS is ported on microcontroller.Use of Wi-Fi module (transceiver) can help for automatic data logging in system like PC.

However, traditional diagnosis is time-consuming and relies heavily on expert knowledge. To overcome this problem project has accepted following Challenges which are divided in 3 facts.

- How will make it to be fast?
- Why Intelligent System?
- How can it be Secure?

2. LITERATURE REVIEW

For this research the extensive literature is carried out in area of medical system, sensor selection, real time environment, and security. Most of the journal paper has been studied for selection of sensors that can be used for experiments very efficiently, for the real time environment various RTOS importance and microcontroller which has its own RTOS availability has been studied, on security issue various article, experimental result has been studied. They have mentions as follows.

A. Sensor Selection

Accelerometer sensor has been chosen over electrode sensor for measuring the MMG signal so that muscle movement can be easily determined. For this selection of sensor the IEEE sensor journal paper has been refereed.

Micro machine Humidity sensor has been selected for measurement of the respiratory system. This can be placed underneath of patient's nostril as it is used for extremely low power consumption technique. This selection has been carried out form IEEE sensor journal paper.

B. Real Time OS

For time critical application various RTOS has been developed.Importance of the RTOS and its requirement has been studied. As well as services provided by different RTOS with its advantage has been studied. Development of algorithm generating interrupt based on services provided by RTOS has been studied in various article as well as books.

In one of the symposium an efficient scheduling based on RTOS has been given called Sloth-on-time [11]. In that, the interrupt routine is based on Sloth on time. Internally in the system, application tasks run as interrupt handlers this is main idea behind original event-triggered SLOTH kernel.

While compilation each task is statically mapped to a dedicated interrupt source of the underlying H/W platform. The IRQ source's priority is configured to the task priority and the corresponding interrupt handler is set to the user-provided task function. To implement SLOTH task system calls need to modify the state of the hardware IRQ controller.

Setting pending bit of the corresponding IRQ source will activate the task, for instance.

The interrupt controller automatically schedules and dispatches SLOTH tasks depending on the current system priority. Therefore low overheads can be achieved SLOTH-ON-TIME in its system calls both in terms of execution latency and in terms of binary code size and lines of source code.

After extensive study about the RTOS the Texas microcontroller with its own TI-RTOS has been used for implementation time critical application. Fast response time is needed in medical diagnosis so RTOS with various interrupt routine, scheduling techniques gives us solution for it. In next section detail of the tasks its scheduling based on priority have been explain.

C. Security Issue

Tackling with security issue in medical field is important; data should transfer through secure media. For this issue various data transmission technique has been studied which has its own security protocol. But for medical field data security is more. So we need powerful crypto engine which help with fast, secure as well as internet connection for data transmission. For this project various wireless techniques [16] have been studied like Bluetooth [15], ZigBee [14], and 6LowPan [15] and Wi-Fi [16] techniques. With help of Wi-Fi we found the most powerful crypto engine for secured data transmission. With Wi-Fi module many security types can be uses that are WEP, WPA and WPA2. Each different type is having its own encryption method to send a data through medium. In next section algorithm for Wi-Fi Web client connection have been given which helps with connecting controller to the cloud through mobile data server.

3. PROBLEM STATEMENT

A. Data Acquisition Process

Four parameters can be calculated in their respective units. Temperature in both degrees C as well as Fahrenheit F. MMG signal in motor units. Breathe rate in BPM. Blood pressure in Hg (mm). Setting the threshold value will help to allow priority through RTOS.

Following is table for the sensor reading.

Table 1. Sensor reading for patient

Sensor type	Min	Max	Actual	Unit
Accelerometer sensor	-1.7g	+1.7g	1.2	Motor unit
Humidity sensor	200ms/11s (Abs./desorpt)	200ms/11s (Abs./desorpt)		%RH
Blood pressure sensor	70	110	80	mm Hg
Temperature sensor(room)	10	30	18	C
	50	86	64	F

B. TI-RTOS use for Interrupt Generation

Using RTOS we can create a task with interrupt service routine. TI-RTOS helps to create Hardware and Software interrupt, semaphore, tasks etc. services.

Below flowchart in Figure 1 is for tasks scheduling in RTOS. Tasks are created with priority given to it. Then start scheduling based on the priority given to the task. And it is in continuous loop for non-stop monitoring. Tasks are configured for the critical parameter of each sensor.

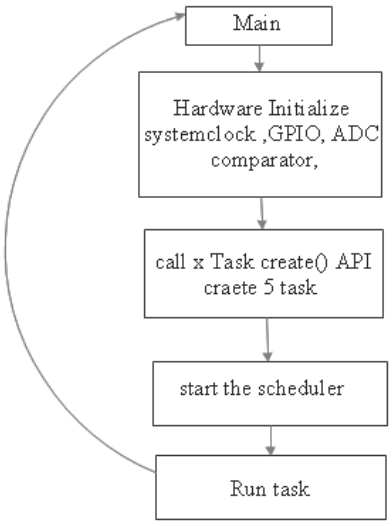

Figure 1. Tasks scheduling in RTOS.

In Figure 2 the tasks are checking for its threshold value condition for occurrence of interrupt to initiate alarm system. The algorithmic flowchart shows the tasks handling in critical condition.

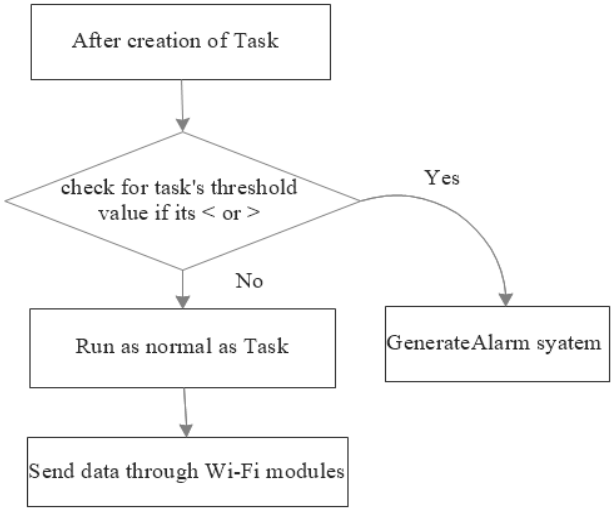

Figure 2. Tasks Generating Interrupts for alarm system

C. Wi-Fi Shield for Secure Transmission

It is important to use Wi-Fi shield with controller for sending data via secure media. Use Wi-Fi module as Wi-Fi web client connect to your mobile internet. Web client connects to a website http://www.google.com using a Wi-Fi shield.For security shield should use strong encryption engine like WPA, WPA2 etc.

The following algorithm for Wi-Fi web client

- Connect controller n Wi-Fi shield through SPI interface
- Give SSID and password for our network.
- Use the numeric IP instead of the name for the server: IP Address server (50, 62, 217, 1);Name address for google using DNS.
- Initialize the Ethernet client library with the IP address and port of the server that you want to connect to (PORT 80 which is default for HTTP)
- Initialize serial and wait for port to open;
- Attempt to connect to Wi-Fi network.
- Print the network name(SSID)
- Connect to WPA/WPA2 network.
- Print dots while we wait-to connect
- Print dots while we wait for an IP address.
- If you get a connection, report back via serial
- Make a HTTP request.
- If there are incoming bytes available from the server, then read them and print data.
- If the server's disconnected stop the client.
- Do nothing forevermore.
- Print the SSID of the N/W you're attached to:
- Print your Wi-Fi shield's IP address
- Print the received signal strength.

D. Display and Alarm System an Algorithmic Flowchart

In medical system whatever data is getting from sensor need to calibrate through microcontroller so that required value which helps with diagnosing should display it on any display device. Here is flow char for the systems displaying device with the help of keypad as well as LCD we can ask controller to show the value on screen.

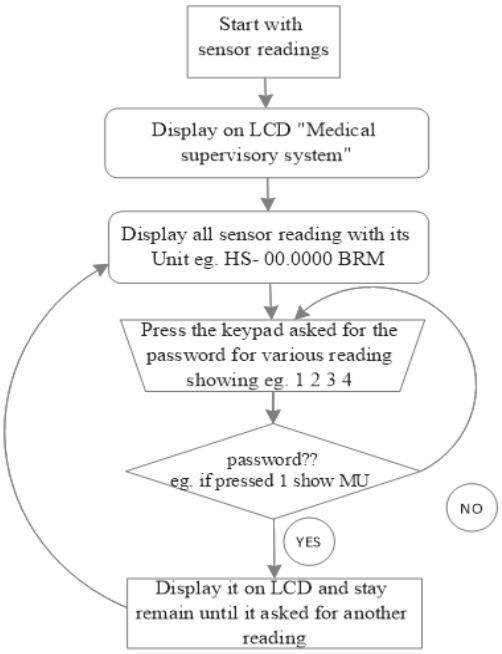

Figure 3. Algorithmic Flow chart for displaying the output

4. METHOD

A. MMG Signal Detection using Accelerometer Sensor

In the medical field the dentist normally consults patients who are suffering from this disorder. But the dentist can't analyse the percentage or at what extent it happens. So the new developing techniques used to diagnose patient's condition i.e. it will determine that patient has major problem or minor problem. For this one can use accelerometer suitable for the diagnosis. The system may consist of uniaxial or biaxial accelerometer to record masseter muscle activity, based on the relative activity to maximum voluntary contraction (MVC).

One can select the sensor based on its capability that it works withsound/vibration generated by the muscle. It is also small enough, so that one can place it on to muscle of interest.One has to take a point into consideration that noise floor that can be measure in the mg/√Hz, where g is gravity. So the bandwidth selection for both axes must be minfor better signal to noise ratio of the accelerometer. The experimental set up for bruxism described using ADXL203 MEMS accelerometer sensor of biaxial.

Signal conditioning is necessary for amplification and filtering of MMG signal. The accelerometer output gives a static signal (gravity). And it is a combination of the DC signal, and AC signal which is consider as dynamic signal (vibration). Amplification is required because initially MMG signals generated by accelerometer are very small in magnitude, around 100mVpp, and they also contain Gaussian white noise which is Stochastic in nature, and it is also present across all frequency.

For given accelerometer ADXL203 one should select the bandwidth it would be based on the capacitor value on both the axes along with internal register. In case of Bruxism the bandwidth can limit up to 100Hz. DC component can be removed from the MMG signal by passing it through the signal conditioning circuit. Digital potentiometer can be used to adjust the gain, that gain gets added into a signal. This amplified signal then filtered through 5 pole Butterworth low pass filter, because it provides maximally flat magnitude response in pass band. Because of better pulse response and a better rate of attenuation makes them more suitable for MMG application. Further it goes for signal processing.

B. Humidity Sensor Testing

The HIH-4030 Humidity sensor measures relative humidity (%RH) and delivers it as output voltage. A humidity sensor measures the humidity level by measuring the change in the resistance of an element or the change in the electrostatic capacity of that element as it absorbs or releases moisture. They are important for extremely environment where water or vapor has vital influence.

Relative humidity sensors are used to measure the ratio of water vapor pressure to the saturated water vapor pressure at a fixed temperatureMedical Setup would be and its measure in the BRM.

C. Wi-Fi CC3100 Booster Pack Module

The CC3100 Internet-on-a-chip can add Wi-Fi and internet to any microcontroller (MCU).The Wi-Fi network processor sub-system in both Simple Link Wi-Fi devices integratesall protocols for Wi-Fi and Internet, greatly minimizing MCU software requirements. With built-in securityprotocols, Simple Link Wi-Fi provides a simple yet robust security experience.

D. Overall Setup Block Diagram

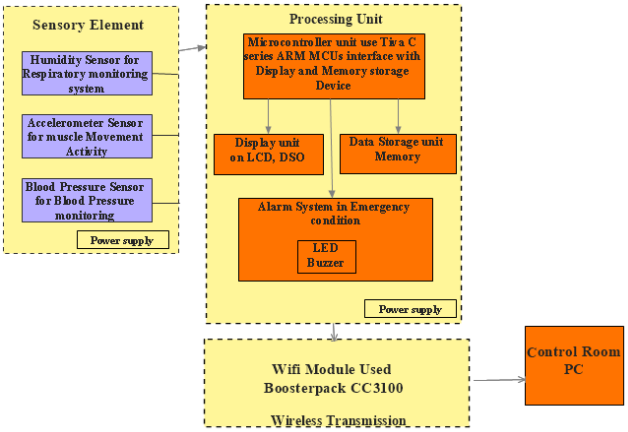

Figure 4. Block diagram

The block diagram showed in Figure 3 is Overall system with its key components include sensory element, processing unit, wireless transmission unit. In sensory elements various sensors are included like humidity sensors, accelerometer sensor, and blood pressure sensor. In processing unit Microcontroller of Tiva C series has been used with RTOS ported on it. Display unit, data storage unit, and alarm system for emergency condition also included in processing unit. In wireless transmission unit Wi-Fi module of Booster pack CC3100 has been used for secured transmission.

5. RESULT

Result is purely based on the experimental set up output, for this project Texas instruments Tiva c series microcontroller TM4C123G has been used. Figure 4 shows the overall setup for the project. Figure 5 displays the in-build temperature sensor output in degree C as well as F. In Figure 6 the cc3100 Wi-Fi booster pack has been interface with microcontroller for secure transmission. In Figure 7 Wi-Fi module use as client which is connected to the own mobile network who will act as server. With help of this we can send the sensor data on cloud.

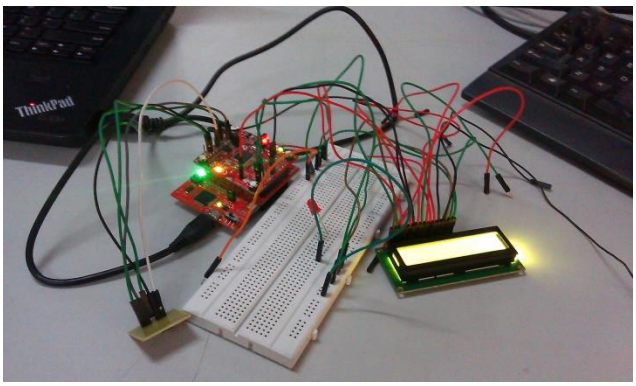

Figure 5. Overall sensors and LCD interfacing diagram

(x)= Variables | Expressions | Registers

Name	Type	Value
ui32ADC0Value	unsigned int[4]	0x200001E0
ui32TempAvg	unsigned int	2142
ui32TempValueC	unsigned int	18
ui32TempValueF	unsigned int	64

Figure 6. Temperature Display in C and F

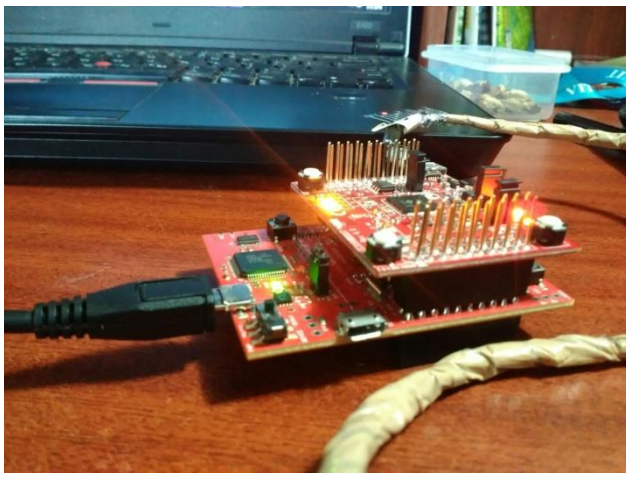

Figure 7. Wi-Fi module with Launch pad

COM3

Send

```
ttempting to connect to Network named: NEHA
..
You're connected to the network
Waiting for an ip address

IP Address obtained
SSID: NEHA
IP Address: 192.168.43.97
signal strength (RSSI):0 dBm

Starting connection to server...
connected to server
HTTP/1.1 200 OK
Date: Fri, 29 Apr 2016 01:39:19 GMT
Server: Apache
Accept-Ranges: bytes
Cache-Control: max-age=3600, public, must-revalidate, proxy-revalidate
Expires: Fri, 29 Apr 2016 02:39:19 GMT
Vary: Accept-Encoding
Pragma: public
Content-Length: 178
Connection: close
Content-Type: text/html

<!DOCTYPE html PUBLIC "-//IETF//DTD HTML 2.0//EN">
<HTML>
   <HEAD>
      <TITLE>
         Hello, World!
      </TITLE>
   </HEAD>
<BODY>
   <P>Hello, world!</P>
</BODY>
</HTML>

disconnecting from server.
```

Figure 8. Wi-Fi module connected to the host server

6. CONCLUSIONS

Thus in medical supervisory system fast access to patient's data leads to better diagnosis. This paper gives you the better understanding of the importance of the selection of the sensors, RTOS. This paper also describe about securely sending the data through Wi-Fi also help for betterment of system.

REFERENCES

[1] AI-Rehab Res. Group, Univ. Malaysia Perlis, Kangar, Malaysia Sundaraj, K.; Ahmad, R.B.; Ahamed, N.U.; Ali, M.A. Islam, M.A., "M, echanomyography Sensor Development, Related Signal Processing, and Applications:A Systematic Review", *IEEE Sensors Journal*,vol.13,NO. 7, July 2013.
[2] Santiago Lopez "Blood Pressure Monitor Fundamentals and Design", Freescale Semiconductor Document Number: AN4328 Application Note Rev. 2, 12/2012
[3] D.T. Barry, "Acoustic signals from frog muscle", *Biophys. J*., vol. 51, no. 5, pp. 769–773, May 1987.
[4] J.V. Frangioni, T.S. Kwan-Gett, L.E. Dobrunz, and T.A. McMahon, "The mechanism of low-frequency sound production in muscle", *Biophys. J.*, vol. 51, no. 5, pp. 775–783, May 1987.
[5] Texas Instruments, "CC3100 SimpleLink™ Wi-Fi® Network Processor, Internet-of-Things Solution for MCU Applications", Swas031d –June 2013–Revised February 2015.
[6] D.T. Barry and N.M. Cole, "Muscle sounds are emitted at the resonant frequencies of skeletal muscle", *IEEE Trans. Biomed. Eng*., vol. 37, no. 5, pp. 525–531, May 1990.
[7] Google search. [online]. Available: http://galleryhip.com/temporalis-muscle-masseter.html.
[8] Roberto Marani and Anna Gina Perri, "An intelligent system for continuousblood pressure monitoring on remote multi-patients in real time", Electrical and Information Engineering Department, Electronic Devices Laboratory, Polytechnic University of Bari, via E. Orabona 4, Bari – Italy.
[9] Nicolas André, Member, IEEE, Sylvain Druart, Pascal Dupuis, Member, IEEE, Bertrand Rue, Pierre Gérard, Denis Flandre, Senior Member, IEEE, Jean-Pierre Raskin, Senior Member, IEEE, and Laurent A. Francis, Member, IEEE. "Dew-Based Wireless Mini Module for Respiratory Rate Monitoring", *IEEE Sensors Journal*, Vol. 12, No.3, March 2012.
[10] Tiva™ TM4C123GH6PM Microcontroller.
[11] Wanja Hofer, Daniel Danner, Rainer Müller, Fabian Scheler, Wolfgang Schröder-Preikschat, Daniel Lohmann Friedrich–Alexander University Erlangen–Nuremberg, Germany *"SLOTH ON TIME: Efficient Hardware-Based Scheduling for Time-Triggered RTOS*"*. IEEE 33rd Real-Time Systems Symposium, 2012.
[12] Texas Instruments, Intro to the TI-RTOS Kernel Workshop Lab Manual.
[13] Analog Devices, Precision ±1.7 g Single-/Dual-Axis i MEMS® Accelerometer, ADXL103/ADXL203.
[14] Google Search. [online]. Available: https://www.quora.com/What-are-the-differences-between-6LoWPAN-and-ZigBee.
[15] Google Search. [online]. Available: http://www.diffen.com/difference/Bluetooth_vs_Wifi.
[16] Google Search. [online]. Available:https://blog.ecoventsystems.com/2015/03/wirelessprotocols/