

An RTOS Architecture for Industrial Wireless Sensor Network Stacks with Multi-Processor Support

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Abstract:-This paper is an RTOS based architecture designed for the purpose of data transmission between two controlling units through IWSN without collision. RTOS is a Process which will be done between hardware and application. Here, stack is the one which is used to avoid the independency of the layers from one with another inside the protocol comes under the standard IEEE802.15.4.Stack having two techniques (PAL and NILI) we are using in the IEEE 802.15.4 to reduce the collision and timing. Mostly, during the packets transmission some collision may occur. This collision has to be avoided to prevent the data loss during the transmission. The project deals with the data transmission between two units in the exact time without any collision. The data transmission time is increased with the protocol standard. One of the section runs with RTOS and LPC2148 as master node and another as normal data acquisition node to which sensors are connected. Data acquisition node uses the Peripheral Interface controller. Communications between two nodes (hardware and application) are accomplished through IEEE 802.15.4.

Keywords:ROBOTICS, RTOS, GSM, ARM

INTRODUCTION

A period of time software (RTOS) is essential to several embedded systems these days and, provides a software package platform upon that to create applications. Not all embedded systems, however, are designed with an RTOS. Several embedded systems need some sort of programming, and these systems need an RTOS. In this project we have a tendency to are about to perform multitasking at the same time. We have a tendency to about to perform tasks like junction rectifier blinking, show LCD, digital display, alphanumeric display} message display, serial communication (UART0 and UART1), buzzer at the same time exploitation small C/OS – II kernel primarily based RTOS.

PROPOSED SYSTEM

The projected system contains a Master node controlled by the LPC2148 microcontroller. This can be a controller having an ARM7TDMI primarily based processor. The RTOS is ported into this microcontroller and management commands are input from this node. Real time temperature values, voltage levels at sensor node and intrusions that area unit relayed wirelessly from sensor node area unit, conjointly displayed on a Graphical liquid crystal display (GLCD). The master node is provided with slightly screen module which acts because the data input device for user input. Choice between various parameters like show of temperature, voltage, switching ON/OFF of motor on device node is done using

this bit screen. The master node communicates with sensor node exploitation bee modules which give a Zigbee communication protocol. The Xbee modules area unit connected to UART1 of the LPC2148 and so, knowledge is relayed to and from the microcontroller serially. At the opposite finish of the communication design lies the device node. The node is controlled by the PIC16F877A microcontroller that is an 8 bit microcontroller from semiconductor device. The node consists of temperature device, intrusion detector, buzzer (alarm), Motor actuator, and voltage level detector. The temperature values and voltage levels area unit captured and detected through the Analogue to Digital convertor severally and send to the Master node via Zigbee. For PIC, the Xbee modules are connected to the USART port that is once more a serial communications port. The author has borrowed ideas on zigbee wireless communication from some earlier add [7]and [9]. Figure one shows the block design of the Master Node whereas Figure a pair of illustrates the device Node

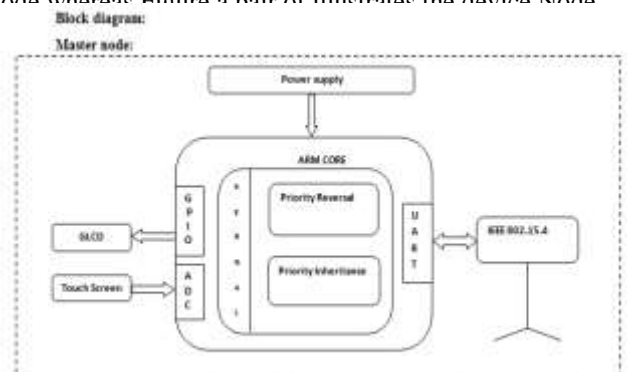


Fig 1. Block diagram

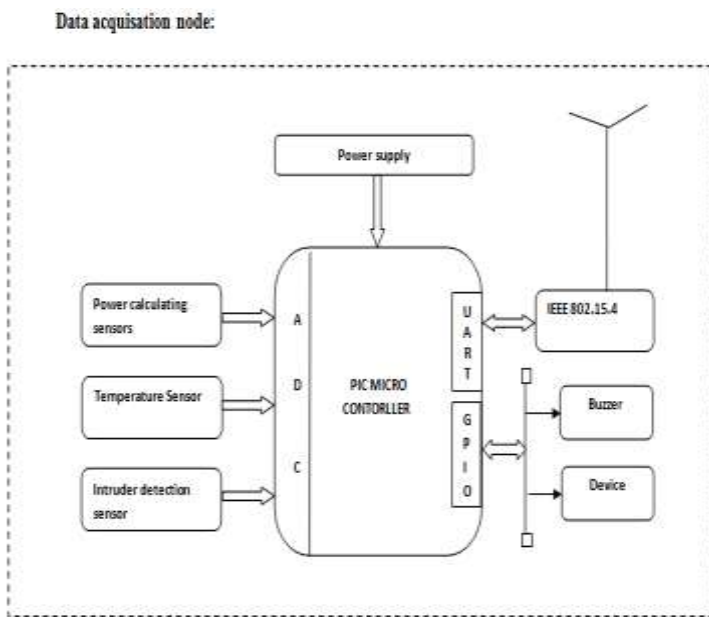


Fig 2.Data Acquisition Node

I. HARDWARE IMPLEMENTATION

1. LPC2148:

The LPC2148 is supported a 16/32 bit ARM7TDMI-S™ mainframe with period of time emulation and embedded trace support, along with 128/512 kilobytes of embedded high speed nonvolatile storage. A 128-bit wide memory interface and distinctive accelerator design change 32-bit code execution almost clock rate. For vital code size applications, the choice 16-bit Thumb Mode reduces code by over half-hour with least performance penalty. With their compact sixty four pin package, low power consumption, varied 32-bit timers, 4- channel 10-bit ADC, USB PORT, PWM channels and forty six GPIO lines with up to nine external interrupt pins these microcontrollers are significantly appropriate for industrial management, medical systems, access management and location. With a large vary of serial communications interfaces, they're additionally o.k. suited to communication gateways, protocol converters and embedded soft modems more over as several different general applications. This project uses 2 power provides, one is regulated 5V for modules and different one is three.3V for microcontroller 7805 3 terminal transformer is employed for voltage regulation. Bridge sort full Wave rectifier is used to rectify the ac output of secondary of 230/12V step down electrical device.

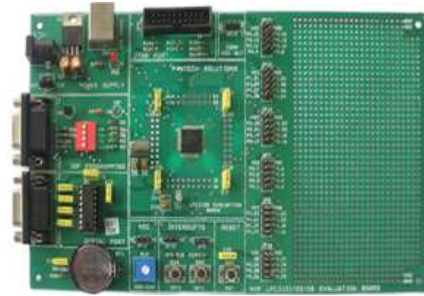


Fig 3.LPC2148 board

2. PIC controller:

This powerful yet easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC® architecture into an 40- or 44-pin package. The PIC16F887 features 256 bytes of EEPROM data memory, self-programming, an ICD, 2 Comparators, 14 channels of 10-bit Analog-to-Digital (A/D) converter, 1 capture/compare/PWM and 1 Enhanced capture/compare/PWM functions, a synchronous serial port that can be configured as either 3-wire Serial Peripheral Interface (SPI™) or the 2-wire Inter-Integrated Circuit (I²C™) bus and an Enhanced Universal Asynchronous Receiver Transmitter (EUSART). All of these features make it ideal for more advanced level A/D applications in automotive, industrial, appliances or consumer applications.

Special Microcontroller Features:

- Precision Internal Oscillator:
- Factory calibrated to ±1%
- Software selectable frequency range of 8 MHz to 32 kHz
- Software tunable
- Two-Speed Start-Up mode
- Fail-safe clock monitoring for critical applications
- Clock mode switching during operation for low-power operation
- Power-Saving Sleep mode
- Power-on Reset (POR)
- Selectable Brown-out Reset (BOR) voltage
- Extended Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- In-Circuit Serial Programming™ (ICSP™) via two pins
- In-Circuit Debug (ICD) via two pins
- High-endurance Flash/EEPROM cell:
- 100,000 erase/write cycle enhanced Flash program memory, typical
- 1,000,000 erase/write cycle data EEPROM memory, typical
- Data EEPROM retention > 40 years
- Self-reprogrammable under software control
- Programmable code protection
- Peripheral Features:
- Device Features:
- 1 input only pin
- 36 I/O
- High sink/source current 25 mA
- Interrupt-on-pin change option

- Timers:
- TMR0: 8-bit timer/counter with 8-bit prescaler
- TMR1 enhanced: 16-bit timer/counter with prescaler, External Gate Input mode and dedicated low-power 32 kHz oscillator
- TMR2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Capture/Compare/PWM (CCP) module
- Enhanced Capture/Compare/PWM (ECCP) module with auto-shutdown and PWM steering
- Master Synchronous Serial Port (MSSP) module SPI™ mode, I2C™ mode with address mask capability
- Enhanced Universal Synchronous Asynchronous Receiver Transmitter (EUSART) module:
- Supports RS-485, RS-232 and LIN compatibility
- Auto-Baud Detect
- Auto-wake-up on Start bit
- Ultra Low-Power Wake-up (ULPWU)

Analog Features:

- 10-bit 14 channel Analog-to-Digital (A/D) Converter
- 2 Analog Comparator modules with:
- Programmable on-chip Voltage Reference (CVREF) module (% of VDD)
- Fixed 0.6 Vref
- Comparator inputs and outputs externally accessible
- SR Latch mode

3. IMPLEMENTATION:

a. Hardware Approach:

In the proposed system comprises a Master node controlled by the LPC2148 microcontroller which is having an ARM7TDMI based processor. μ COSII RTOS is ported into this microcontroller and control commands can be given from this section. Environment Real time temperature value, voltage levels at sensor node and intrusions which are relayed wirelessly from sensor node are, also displayed on a Graphical LCD.

Also the master node is equipped with a touch screen module which acts as the input device for user input. Selection between various parameters such as display of temperature, voltage, switching ON/OFF of motor on sensor node can be done using this touch screen. This master node communicates with Sensornode using Xbee modules, which provide a serial wireless communication protocol. This Xbee module is connected to UART of the LPC2148 and thus, data is relayed to and from the microcontroller serially.

The Interface Module of the System:

Temperature Sensing Element:

The LM35 series are a unit exactitude integrated-circuit temperature sensors, whose output voltage is linearly proportional stargazer (Centigrade) temperature. The LM35 thus has a bonus over linear temperature sensors calibrated in $^{\circ}$ Kelvin, because the user isn't needed to calculate a large constant voltage from its output to get convenient Centigrade scaling[6]. The LM35 doesn't need any external standardization or trimming to produce typical accuracies of $\pm 1/4^{\circ}$ C at area

temperature and $\pm 3/4^{\circ}$ C over a full -55 to +150 $^{\circ}$ C temperature range. Low value is assured by trimming and standardization at the wafer level. The LM35's low output electrical resistance, linear output, and precise inherent standardization build interfacing to readout or management electronic

equipment particularly straightforward. It will be used with single power provides, or with and and minus provides. As it attracts solely sixty μ A from its provide, it's terribly low self-heating, but zero.1 $^{\circ}$ C in still air. The LM35 is rated to operate over a -55 $^{\circ}$ to +150 $^{\circ}$ C temperature vary, while the LM35C is rated for a -40 $^{\circ}$ to +110 $^{\circ}$ C vary. The LM35 series is accessible packaged in tight TO-46 transistor packages, whereas the LM35C, LM35CA, and LM35D also are accessible within the plastic TO-92 semiconductor device package. The LM35D is additionally accessible in associate degree 8-lead surface mount little define package and a plastic TO-220 package.

Infrared Sensing Element:

The hardware module of IR sensing element contains a TX-RX try. An IR semiconductor diode acts as a supply for emitting IR rays. A reverse biased IR sensing element is there for police investigation this IR rays. IR LED emits infrared emission. This radiation illuminates the surface in front of semiconductor diode. Surface reflects the actinic ray. Depending on reflectivity of the surface, quantity of sunshine mirrored varies. This mirrored light-weight is created incident on reverse biased Sensor. once photons area unit incident on reverse biased junction of this diode, electron-hole pairs area unit generated, which ends up in reverse outflow current. quantity of electron-hole pairs generated depends on intensity of incident IR radiation [7]. additional intense radiation leads to additional reverse outflow current. This current will be more experienced a electrical device therefore on get proportional voltage. so as intensity of incident rays varies, voltage across electrical device can vary consequently.

XBEE Module:

In associate degree business throughout bound hazards it'll be terribly difficult to watch the parameter through wires and analog devices like transducers. to beat this drawback we tend touse wireless device to watch the parameters in order that we are able to take bound steps even in worst case[11]. Few years back the use of wireless device was terribly less, however owing to the speedy development in technology currently a days we tend to use most of our knowledge transfer through wireless like Wi-Fi, Bluetooth, Wimax, etc. in sight of all this things, the planning of wireless parameter progress helps in associate degree business to watch the parameter in real time with the utilization of zigbee, is an easy installation platform, value effective technique for the low bitrate transmission, therefore with the assistance of the prepared zigbee platform by exploitation the PSoC Designer we tend to interface the module with the computer and that we monitor the parameters within the system. during this project we tend to deal to watch the parameter through wireless by exploitation zigbee prepared platform that is based on the

IEEE 802.15.4, 2.4 GHz [12]. The operating of this module is straightforward in theory, the changes in bound place is monitored in real time method that is incredibly correct in observance and their no alternative interface and alternative disturbance.

The Potentiometer:

The most unremarkably used of all the “Position Sensors”, is that the potentiometer as a result of it’s a cheap and straightforward to use position detector. it’s a wiper contact coupled to a mechanical shaft which will be either angular (rotational) or linear (slider type) in its movement, associated that causes the resistance worth between the wiper/slider and also the 2 finish connections to vary giving an electrical signal output that contains a proportional relationship between the particular wiper position on the resistive track and its resistance worth. In different words, resistance is proportional to position. This configuration produces a possible or resistance sort circuit output that is proportional to the shaft position. Then as an example, if you apply a voltage of say tens across the resistive component of the potentiometer the utmost output voltage would be up to the provision voltage at 10 volts, with the minimum output voltage up to zero volts. Then the potentiometer wiper can vary the signaling from zero to ten volts, with five volts indicating that the wiper or slider is at its half-way or center position. The signaling (Vout) from the potentiometer is taken from the center wiper association because it moves on the resistive track, and is proportional to the spatial relation of the shaft.

b. Software Approach:

In any application $\mu\text{C}/\text{OS-II}$ is started as shown in the below figure. Initially the hardware and software are initialized. The hardware is the ARM core and software is the $\mu\text{C}/\text{OS-II}$. The resources are allocated for the tasks defined in the application. Then the scheduler is started and it aligns tasks in pre-emptive manner. All these are carried out using specified Functions defined in $\mu\text{C}/\text{OS-II}$. As shown in the figure.

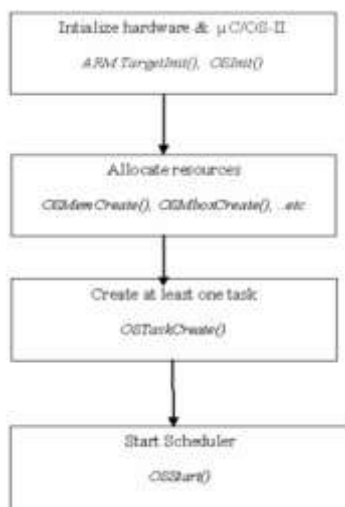


Fig 4. Software Approach

Initialization of the task1 and task2 is been done. Although supports for total 64 tasks all of them are not used

at a time in application therefore with respect to demand the task must be created. $\mu\text{C}/\text{OS-II}$ can run with maximum number of tasks of 64. The figure shown below the application has six threads.

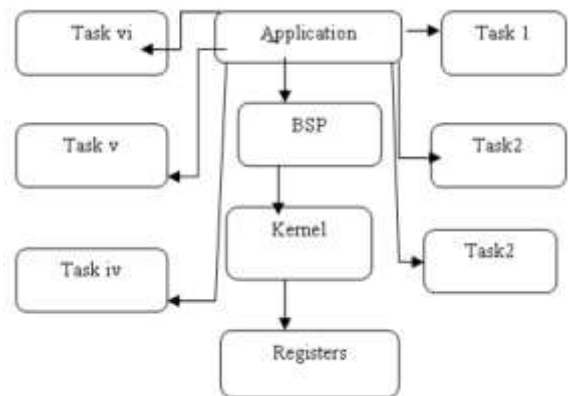


Fig 5. initialization of task

Based On the required application the number of tasks may varies. For demonstrating a sample experiment to understand the porting of $\mu\text{C}/\text{OS-II}$ we can perform simple tasks like Temperature sensor (ADC) Graphical LCD (degree to graphical Fahrenheit) UART (Serial communication) LED toggle(8bit data flow control) Buzzer (alarm device).

ARM runs the Real time operating system to collect information from the external events. RTOS is used to achieve real time data acquisitions. $\mu\text{C}/\text{OS-II}$ kernel is ported in ARM powered microcontroller for the implementation of multitasking and time scheduling as shown in previous sections.

These two tasks (temperature and touch input) will acquire the values from the inbuilt ADC through channels 6 and channel 7. As soon as the values has been taken from ADC semaphore will be acquired by the tasks 1 and 2.

The data to be sent to the hyper Terminal is to be converted firstly into the ASCII by Hex to ASCII conversion at the intermediated stage.

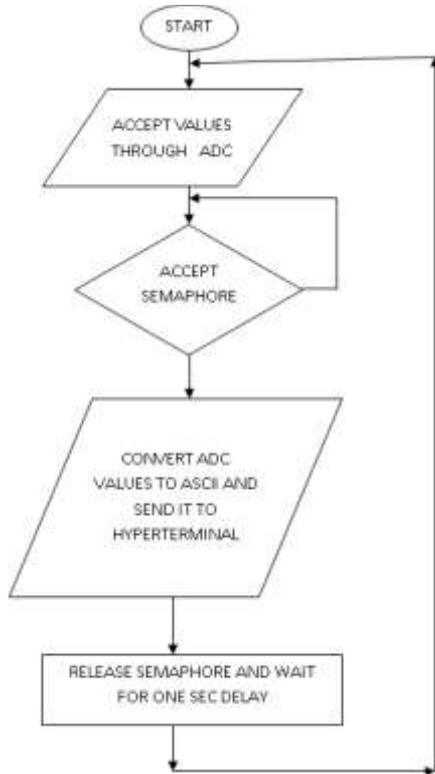


Fig 6.Flow Chart

When once it is sent data to the hyper terminal semaphores acquired by the tasks will be released and in order to have the continuous check for all the above process the delay of 1 second is taken and all the will be repeated always. In order to focus on the features of RTOS task 3 is been reserved for the keypad application and similar to that the task 4 is been reserved with the GLCD. Whenever the task 3 is activated at the same time task5 will be triggered which will simply implement the mutex by semaphore of previous task.

Now the next task5 will communicate to task 4 and Value receives through the task 3 it simply display it on to the GLCD at the same time it is also checked that whether the pressed key accordingly the current value related to it will be transferred to the hyper terminal serially.

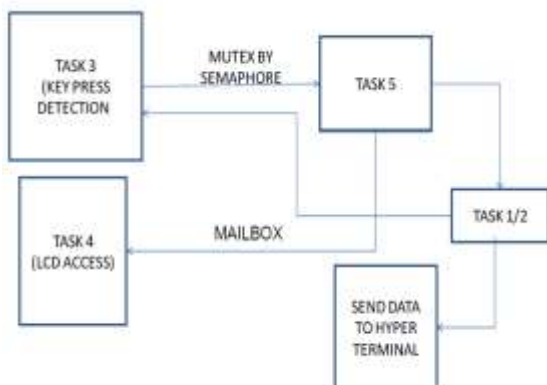


Fig 7. Scheduling of tasks

II. WORKING PRINCIPLE

Support is an ideal system for issues related to timing integrity, the extra traffic caused by the inter layer interaction in large industries. In the existing prototype, we have noticed that, bulks of messages are transmitted

between nodes so there are chances of message collision in transmission. In the proposed system we avoid this problem by optimizing the architecture and enhancing the system resources by implementing Real Time Operating System which manages the shared resources in real time environments, Besides the RTOS this system also provides power efficiency.

This proposed system comprises a Master node controlled by a micro controller having ARM7 processor. Ucos-II RTOS is ported into the micro controller and control commands can be input from this section. Various sensors like temperature voltage fire and infrared are placed on data acquisition node and Real time temperature values voltage levels at Data acquisition node are wirelessly relayed and also displayed on GLCD at Master node which is works on touch screen module. Master node communicates with data acquisition node using Zigbee communication and sensors works on their basic principles individually like IR sensor alarms a buzzer when any object is detected.

The prototype consist of two nodes one works with PIC and other with ARM7 TDMIS to measure the sensor values of industrial machines all of these sensors are connected to PIC where all of the analog values are converted to digital i.e the temperature and pot values. Which can done by ADCON0 and ADCON1 with 10 bit resolution in burst conversion and keeps track of the analog sensor values in burst mode. This conversion requires 2.44μs of time to convert one analog sample to 10bit digital data, further this configuration of ADC requires frequency which must be less than or equal to 4.5M.Hz in order to sample effectively. Now the converted digital values represent the conditions of the data acquisition section to monitor these values at the ARM node we have to transmit these values serially through UART with 9600 baud rate at 8 bit data transfer and 1 stop bit with no parity.

This is the functionality of the node one. In order to monitor the machine parameters we have to receive the sensor values which are transmitted through PIC section here in order to efficiently establish communication between two nodes ARM node is also configured with same UART configuration just as PIC, i.e. with 9600 baud rate, 8 bit, 1 stop bit, and no parity, this is done by configuring U0LCR register initially with DLAB=1, 8bit, 1stop bit, and no parity bits. When this configuration we have to load the latch register values as $U0DLL = [pclk/(16*baud\ rate)]\%256$ and finally disable the DLAB bit.

The values which are received serially are stored in **U0RBR** register, now these have to display on GLCD as graph that too depending on user input selection which is done on Touch screen. This touch screen consists of four pins in them two pins are connected to ADC pins of ARM which calibrates the touch position with change of resistance. So we would be fixing two values with calculated X & Y position of the screen. So depending on the value the respective sensor values can be displayed on the serene, this graph display is configured through page selection and data driven to **GLCD**. This is the complete system configuration.

Now ARM node which works with RTOS has the following resources:

- 1) Touch resolution(ADC)
- 2) Serial data reception(UART)
- 3) Graph display (GPIO)

To get these resource functions we have to create a task in UCOS2, this is done as follows:

```
INT8U OSTaskCreate(void (*task)(void *pd),
                  void *pdata,
                  OS_STK *ptos,
                  INT8U prio);
```

In Ucos2 kernal we can assign priorities for each of these tasks here the highest priority we can give to touch screen, and lowest to GLCD.

III. Conclusion

This study has conferred associate degree analysis within the use of a trueTime OS. Basing on this analysis the author is undertaking a tutorial project which includes associate degree RTOS ported into a master node with the aim of monitoring associate degree dominant an industrial setup. These temporal order simulations were meant to produce a concrete basis on whether it's helpful to use associate degree OS within the design. The analysis has been with success administrated for the response to serial knowledge. Priority assignments will serve for fast response functions for time essential industrial processes since some processes will cause disaster if not felt in time. It will be noted that the utilization of the RTOS presents a whole lot of angles from that the analysis will be created. Simulations will be administrated to determine the time taken in executing every task and build calculations to visualize what proportional task will enter the wait state for pre-emption. This will additionally be used as a benchmark to create associate degree analysis into the propagation delays incurred within the transmission of knowledge over the wireless network. This will so be planned as associate degree initiative for future work/scope into the analysis of temporal order simulations in microcontroller programming and communication. The study can even be extended into a situation whereby varied sensing element nodes area unit controlled by the same master node and temporal order analysis done to determine the response of the system since associate degree industrial setup would possibly comprise sensing element nodes stationed at totally different locations. This will on the general lead to longer essential system performance.

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