International Journal of Advanced Information in Engineering and Technology ISSN: 2454 – 6933
Vol.5, No.12, December 2018

RTOS BASED INDUSTRIAL WIRELESS SENSOR NETWORK IMPLEMENTATION

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Abstract -- Industrial Monitoring is a must now days in order to maintain the industries for better functioning and for better performance. If industrial monitoring is done properly many major accidents and heavy loss which occurs can also be avoided. This paper describes how an embedded monitoring system based on µC/OS II RTOS operating system using ARM7. It deals with the porting of µC/OS II kernel in ARM powered microcontroller for the implementation of multitasking and time scheduling. Here real time kernel software that manages the time of a microcontroller to ensure that all time critical events are processed as efficiently as possible. Different interface modules of ARM7 microcontroller like UART, ADC, and LCD are used and data acquired is tested using µC/OS-II based on the real time operating system. This paper acts as a gateway to implement RTOS for high end applications.

Keywords – Nuvoton cortex M0 Microcontroller, ARM LPC2148, RTOS, Zigbee, Master control and data acquisition system.

I. INTRODUCTION

In Industries, system is becoming very complex. Industrial system needs to test the site equipment so it can identify total fail due to long duration of usage or any technical problem which give fatal results. So embedded monitoring system is used for continuously collecting data from onsite[4] and later analyzing that and eventually taking proper measures to solve the problem track state of system in real time. Industrial applications require multiple tasks to be executed for monitoring and controlling the industrial system, processing of data, storing of the data and transmission of the data where multi-tasking is involved [2]. RTOS is used here for scheduling various tasks [5]. An RTOS has an advanced algorithm for scheduling. Important factors of RTOS are minimal interrupt latency and thread switching latency, a RTOS is valued for more quickly or predictable response for the amount of work in a given period of time. As an example in the paper [9] an embedded system based monitoring system was designed for Nuclear Power Plants and large scale industries using RTOS.

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II. PROPOSED SYSTEM

A model embedded system based monitoring and controlling system is designed for a large scale industry. This paper is implemented in two sections. First one runs with µC/OS-II RTOS and LPC2148 as master node [1] and the second section deals with normal data acquisition [10] handled by Nuvoton microcontroller board. Communications between two microcontrollers is accomplished through wireless network zigbee protocol as in [6]. This is essential to reduce the possibility of collision, and to meet the critical requirements of industrial applications. The main aim of this paper is to monitor the industrial machine conditions. So, we are using inbuilt temperature sensor in Nuvoton microcontroller which determines the heat generated by the machine, gas sensor determines gas leakage detecting equipments for detecting of LPG and other gases and the MEMS sensor which senses the movement of the machine. From the above sensors we can know the condition of machines by converting the analog values into digital in order to monitor industrial parameters. In the interrupt based design, without priority the system may leave the most important task and it will perform some low priority task. To overcome this problem, priority based scheduling is given in this paper. µC/OS-II is used to assign priorities to the task. We use pre-emptive scheduling method to run the task according to its priority levels. When a low priority task is executing, if there is an arrival of higher priority task then the CPU will stop executing the current task and goes to higher priority task, executes it and returns to the lower priority task. This process is pre-emptive scheduling which is more efficient than the round robin scheduling.

A. Block Diagram

The below diagram consists of two boards which are master and slave boards. The slave board consists of sensors, microcontroller and Zigbee transmitter unit where analog value is converted to digital values and displayed in the LCD and transmitted via Zigbee to the master board. The mode consists of microcontroller and Zigbee. The transmitted value from slave board is received via Zigbee is received by the master board and they are compared with the threshold values in the controller and they are displayed in the LCD. In case of mismatch the workers will be informed to take precautions to handle the situation. This is a new approach using RTOS in order to avoid serious disasters in large scale industries which are without smart equipments and are primitive in design.

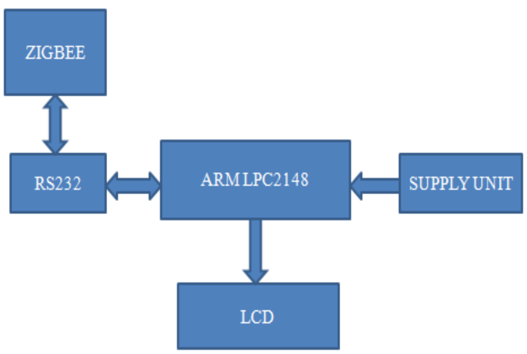

Figure 1. Master Board

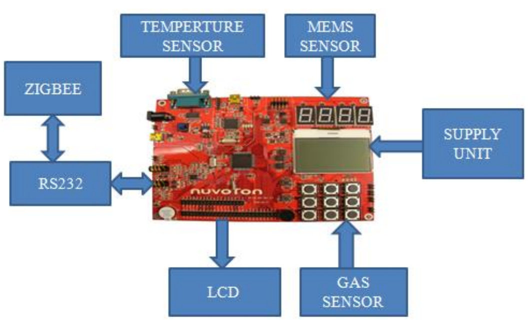

Figure 2. Slave Board

B. Nuvoton Cortex M0

The Nuvoton NUC140VE3CN is a 32-bit microcontroller with embedded ARM Cortex-M0 core for industrial control and applications which need rich communication interfaces. The Cortex-M0 is a powerful ARM embedded processor with 32-bit performance and at a cost equivalent to traditional 8-bit microcontroller.

C. ARM LPC2148

The LPC2148 microcontroller is a based on a 16-bit/32-bit ARM7 CPU with real-time emulation and embedded trace support, that combine the microcontroller with embedded high-speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. Serial communications interfaces ranging from a USB 2.0 full-speed device, multiple UARTs, SPI, SSP to I2C-bus and on-chip SRAM of 8 kB up to 40 kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power.

D. 3-Axis Mems Accelerometer Sensor (Adxl335)

An accelerometer is an electromechanical device that measures acceleration forces. These forces may be static, like the constant force of gravity pulling at our feet, or they could be dynamic, caused by moving or vibrating the accelerometer. MEMS sensor (ADXL335) [8] is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 g. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration.

E. Gas Sensor

Gas Sensor (MQ2) [8] module is used for gas leakage detection in home and industry. Due to its high sensitivity and fast response time, measurements can be taken as soon as possible. The sensitivity of the sensor can be adjusted by using the potentiometer. The sensor has excellent sensitivity combined with a quick response time. The sensor can also sense iso-butane, propane, LNG and cigarette smoke which will help to avoid fire accidents in industries.

F. Zigbee

XBee (S2) module is used for embedded solutions providing wireless end-point connectivity to devices. Series 2 modules allow you to create not only 802.15.4 firware based network but also more complex mesh networks when using ZigBee mesh firmware. XBee module is one of the lowest current drawing devices. However, the infrastructure of a ZigBee network is more complex and requires more configurations to fully implement the network. This module can give range of 40 meters indoor or 120 meters outdoor. The XBee wireless device can be directly connected to the serial port (at 3.3V level) of any microcontroller. This module supports data rates of up to 250kbps. XBee modules are designed for high-throughput (35kbps) applications which require low latency and predictable communication timing.

III. RTOS

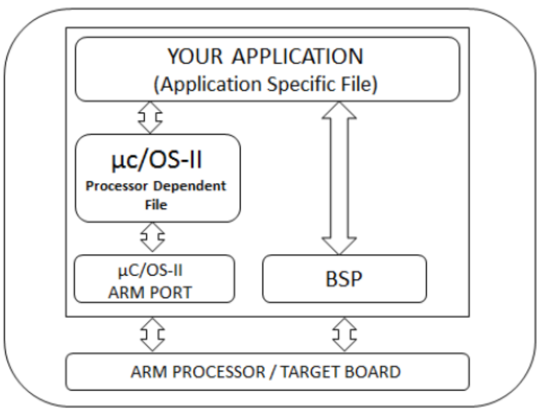

Figure 3: Hardware & µC/OS-II Interface
Reference: [3]

RTOS (µC/OS-II) [3] manages tasks. RTOS can be ported to the system so that a system can deal with much more complicated tasks. Real-Time (RT) [7] indicates an expectant response or reaction to an event on the instant of its evolution. RTOS (µC/OS-II) is very small whose memory footprint is about 20KB and source code is about 5,500 lines, mostly in ANSI C. µC/OS-II can be scaled to only contain the features you need for your application and thus provide a small footprint. Depending on the processor, on an ARM (thumb mode) µC/OS-II can be reduced to as little as 6K bytes of code space and 500 bytes of data space (excluding stacks). For most of the services the execution time is provided by µC/OS-II is both constant and deterministic.

IV. IMPLEMENTATION

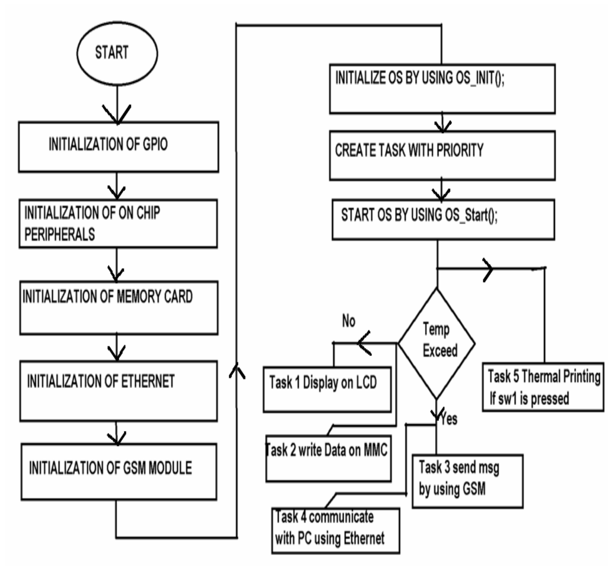

Figure 4 Flow chart of Hardware & µCOS II Implementation
Reference: [11]

The heart of the system is a real-time kernel that uses preemptive scheduling to achieve multitasking on hardware platform. The previous sections deal with µCOS_II porting to the application desired. Depending on the required application the number of tasks may vary. By porting of µC/OS-II we can perform simple tasks like Temperature sensor (i.e., ADC), 16x2 LCD (i.e., degree to Fahrenheit), UART & Zigbee (i.e. to send real time data to wireless nodes). We have assumed three different tasks consisting of one or more different sensor inputs and variable operating conditions as governing rules for the different situations in industry. In that assumption each task has different priority numbers in different situations that may arrives in the industry.

V. EXPERIMENTAL SETUP

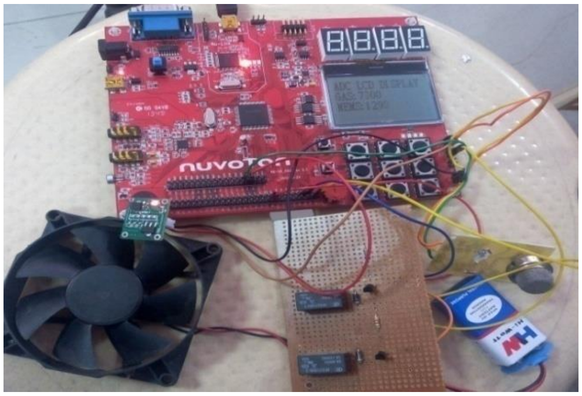

Figure 5 Data Acquisition

The above setup shows the full setup overview of the sensors such as GAS and MEMS sensors which are interfaced with the Nuvoton Microcontroller for controlling and monitoring industrial applications. The inputs obtained from the GAS and MEMS sensors where verified for their operating limits by giving their outputs to the standard output devices such as buzzer and dc motor fan. The wireless Zigbee based transmission was verified between two ARM processor boards making them act one as master board and one as slave board as shown in figure 6.

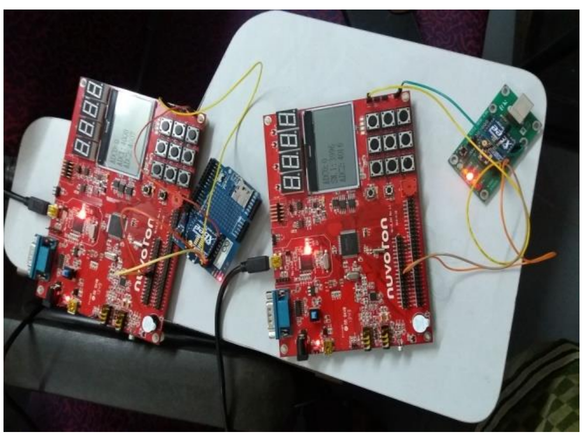

Figure 6 Wireless Zigbee transmission

VI. CONCLUSION

In this paper RTOS based industrial wireless sensor network is implemented. The basic connectivity between the two ARM boards has been verified using Zigbee network. In future implementing the preemptive scheduling is to be done for the already verified sensor inputs. Also more relevant sensors can be added for improved operations and control.

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