Power Saving Algorithm for Long Life Wireless Sensor Networks

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Abstract **- Power management is a challenging factor in wireless sensor networks, and the radio is a major contributor to overall power consumption of a sensor node. So to reduce the power consumption of a node, it is essential to minimize the idle listening of the radio by keeping it to sleep mode when no communication takes place with it. This paper is mainly focused on reducing the idle listening of the radio by using an algorithm called power saving algorithm. In this paper, this algorithm is applied for object tracking system using RFID. The power values of the node during radio in active mode and sleep mode are measured.**

Index terms **– Wireless sensor network, power, microcontroller, radio, RFID.**

I. INTRODUCTION

A wireless sensor network consists of many nodes and energy efficiency is an important aspect to be considered since nodes' battery cannot be frequently replaced due to their cost and node accessibility constraints for certain applications. So it is necessary to reduce the power consumption of the node to increase its lifetime.

To increase the lifespan of sensor networks, power aware techniques are particularly important. In typical Wireless Sensor Network applications, a radio waiting to receive or send data results in highest power consumption. Since the actual data traffic in WSNs is generally very low, most of the energy is wasted in idle listening by a radio, i.e., while waiting to send or receive data. This makes minimizing the idle duration power consumption at a sensor node highly important. Radio duty cycling [1] is a popular solution in which, the radio is turned on and off according to a pre-defined scheme, specific to each MAC protocol [2]. However, there exists a trade-off between energy consumption and the corresponding latency for data communication in duty cycling MAC protocols. Lower duty cycles result in higher energy savings, but at the same time imply increased latency for data communication.

In this paper, an experimental set up is presented that uses the RFID reader to trigger the radio of sensor node and allows to keep radio module in low power mode until it is required to be used for data communication.

One of the most widely used approaches for reducing power consumption at sensor nodes is through power management schemes, which try to minimize energy consumption by switching off the unused peripherals and radio resource. Experimental studies on real sensor network deployments in various applications have shown that data communication characterize the highest energy consumption budget [3]. An evident drawback of duty cycling schemes is the increased latency compared to the always on mode. When the radio is always on in anticipation of a data packet, energy is wasted. One of the possible alternatives to minimize latency as well as energy consumption is through an additional wake-up radio hardware, which is thoroughly optimized for negligible power consumption and is capable of reacting instantly on an event of interest i.e. wireless channel activity.

II. EXPERIMENTAL SETUP

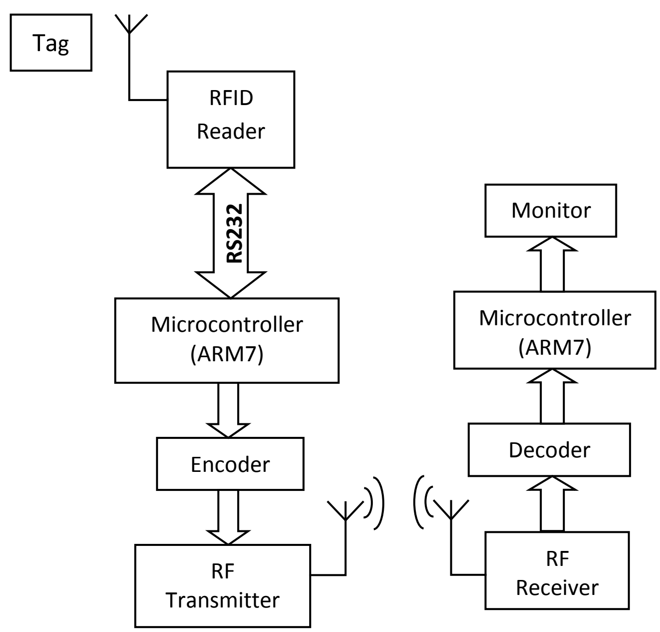

Figure – 1 System Architecture

The block diagram of object tracking system is shown in figure-1. The RFID tags are attached to the each object. The RFID reader in connected to every node. The nodes are deployed all around the area. Each node detects the object within a zone of radius of 50 meters approximately. Whenever the tagged object moves from one zone to other, the RFID reader reads the tag number of each object and interrupts the microcontroller to switch on the RF transmitter. The transmitter sends the tag data read by the reader to the receiver section. The receiver section consists of a database of all tag ID numbers and respective objects, nodes and respective zones where they are deployed. Once the detected tagged object ID number is received from the zone where it is located, using the database the name of the object and its zone can be determined.

A. Power saving algorithm

Power efficiency is very important in wireless sensor networks because the sensors typically run on batteries and long lifetime is highly desirable. The algorithm that is used here is to wake up the microcontroller and the radio in an on demand fashion. The PCON and PCONP registers of LPC2148 shown in figure-2 are configured to manage power consumption modes of microcontroller.

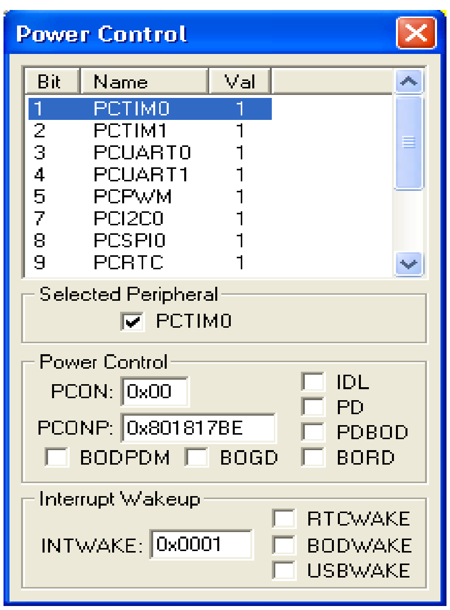

Figure – 2 Power Control Register

The PCON (Power Control Register) contains the Idle Mode bit (bit 0), and the Power Down mode bit (bit 1). The PCONP (Power Control Peripheral Register) contains the individual power control bits for all the peripherals in the list.

The IDL (Idle Mode) if set, stops the processor clock, but leaves the other peripherals active. Any interrupt starts the processor clock again. The PD (Power Down Mode) if set, stops the oscillator and all on-chip clocks to stop. A wakeup condition starts the oscillator and clocks again and resets this bit

The external interrupt registers of LPC2148 shown in figure-3 are configured to enable/disable interrupt and wakes up the MCU from different power modes. The EINTx (External Interrupt Flag 0-3) is set when an external interrupt (0-3) occurs. The EXTINT (External Interrupt Flag Register) contains the EINTx interrupt flags that set when an external interrupt occurs. The INTWAKE (Interrupt Wake-Up Register) contains the EXTWAKEx bits that allow external interrupts to wake up the MCU from Power Down mode.

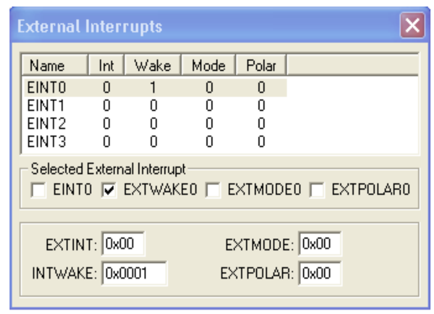

Figure – 3 External interrupt

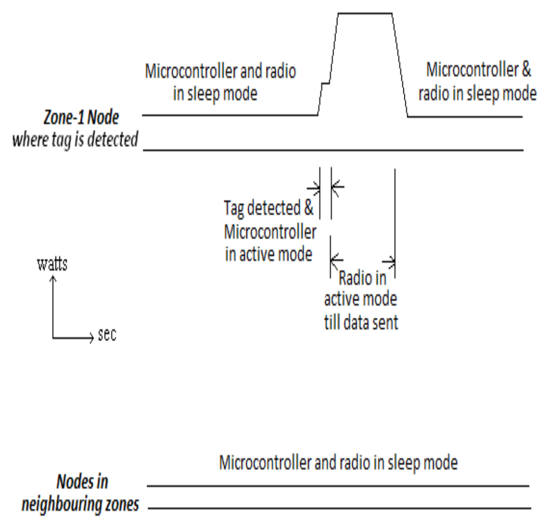

Figure – 4 Graph representing power consumption of node

The graph shown in figure-4 is a tentative representation of power consumed by microcontroller and radio of nodes present in the wireless sensor network. The first waveform shows that when the tag is detected, there exists a small time delay for both the microcontroller and radio to switch from power down mode to active mode.

B. Flowchart

The flow chart describes the process of interrupt system that takes place. Initially the microcontroller and radio are in sleep mode. The processor first checks whether an interrupt has occured or not. If the interrupt occurs, the microcontroller and the radio will enter into active mode, if not they stay in power down mode. Once the microcontroller and radio enter into active mode, the data from the reader is sent to the receiver section. After the data is sent, and still if there is any other data to be sent, then the microcontroller and radio will stay in active mode or else they enter into sleep mode.

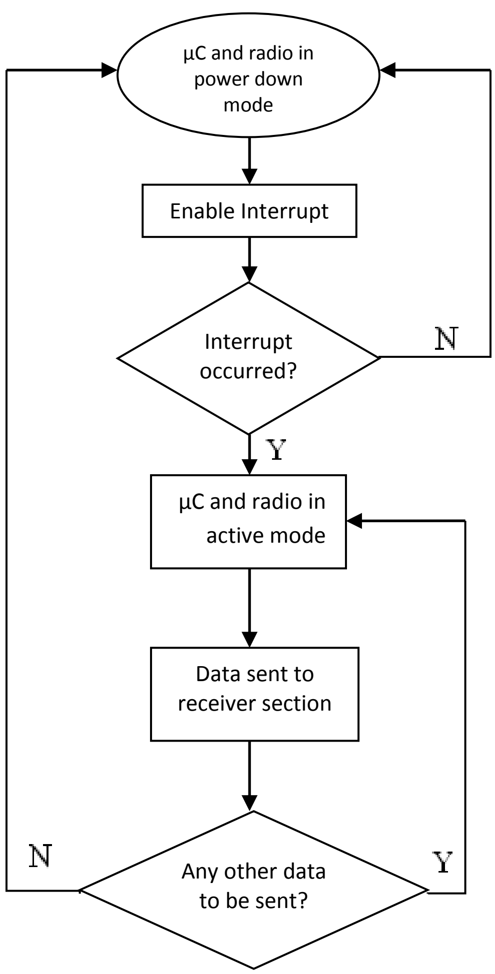

Figure – 5 Flow chart for the proposed system

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III. EXPERIMENTAL RESULT

The microcontroller used in our application is LPC2148 (ARM7). This is a low power microcontroller that has three modes – active mode, idle mode and power down mode. The microcontroller stays in power down mode till any event occurs. When an interrupt occurs, the microcontroller enters into active mode, performs the necessary function and re-enters the power down mode. The power of the node measured during an event and without occurrence of event is measured and tabulated below. Here, an event is the moment when the tag is detected and data is communicated

	Active mode	Power down mode
Microcontroller	V=3 I=6mA	V=3 I= 200uA
RF transmitter	V=3 I=12mA	---

IV. MICROCONTROLLER UNIT ENERGY

$$\mathbf{E_{mcu}^{off} = T_{mcu}^{off} \times I_{mcu}^{off} \times V}$$

T_{mcu}^{off} is the total time during which the MCU is off, I_{mcu}^{off} is the current draw of the MCU while the node is idle, and V is the supply voltage.

$$\mathbf{E_{mcu}^{on} = T_{mcu}^{on} \times I_{mcu}^{on} \times V}$$

T_{mcu}^{on} is the total time during which the MCU is on, and I_{mcu}^{on} is the MCU current draw during normal operation mode. The total MCU energy consumption, then, is simply the sum of E_{mcu}^{off} and E_{mcu}^{on}.

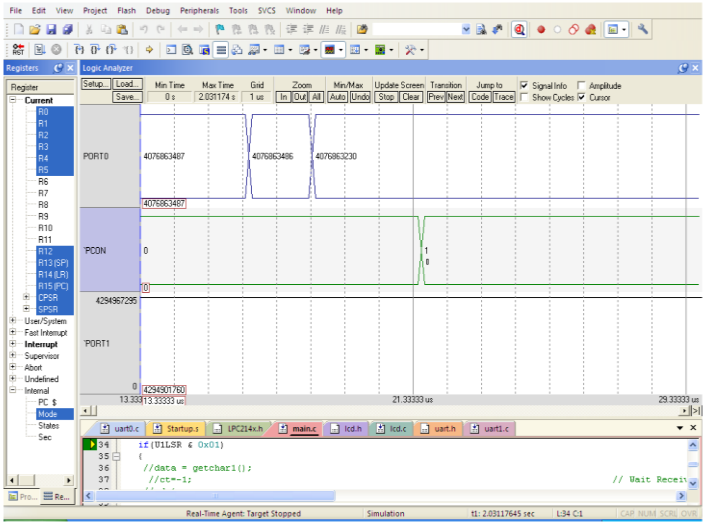

Figure- 6 PCON register is in low power mode

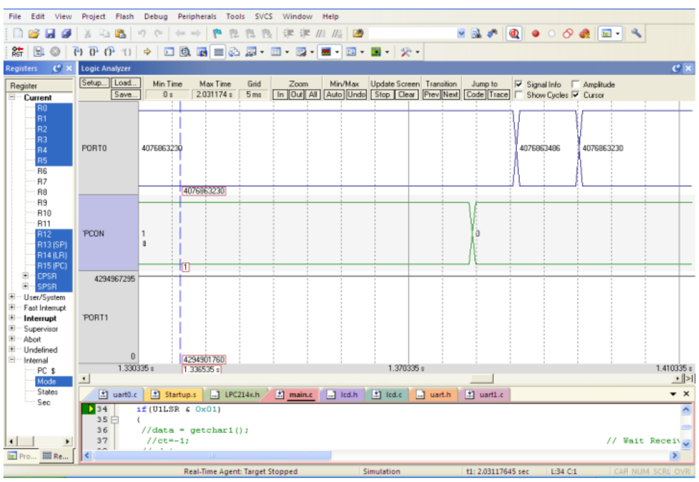

Figure – 7 ARM Processor in Active mode.

The figure-6 represents that when the PCON register is in low state, the data is transmitted through port 0. The PCON in low state represents that the microcontroller is in active mode. As soon as the data is transmitted, the PCON register goes high, indicating the microcontroller in power down mode.

Figure – 7 represents that when the data has to be sent, the microcontroller is interrupted and the PCON register goes low, indicating that the microcontroller is in active mode.

V. CONCLUSION

In this paper, an object tracking system is presented which uses low power components and reduces the power consumption by minimizing the idle listening. A new algorithm called power saving algorithm is used in this paper which reduces the amount of power consumption. The power consumption details of microcontroller and transceiver are determined and tabulated.

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