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INTELLUCTUAL ENVIRONMENT MONITORING SYSTEM FOR INDUSTRIES BY ENERGY – AWARE SENSOR NODE IN WIRELESS SENSOR NETWORK

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Abstract: - Rapid development of system miniaturization, wireless Communication, and on-chip signal processing has promoted the development of wireless sensor technology, which has enabled its wide applications from condition based maintenance to industrial system monitoring and environmental sensing. The number of wireless sensors, which are typically considered as a Wireless Sensor Network (WSN), deployed for real-life applications has rapidly increased. Increase in the next years, energy consumption still remains as a major obstacle for the full deployment and exploitation of this technology. The traffic-adaptive medium access protocol has been designed to reduce energy consumption by allowing sensor nodes to assume a low-power idle state whenever they are not working In transmission or receiving mode. In this way, the energy Consumption for communication decreases as the data to be Transmitted decrease. For energy-efficient data acquisition, an adaptive sampling algorithm consisting of duty cycling and adaptive sampling is proposed to reduce energy consumption in a sensor network.

Keywords: - Energy efficiency, periodic sleep/wake-up scheme, received signal strength indication (RSSI), wireless sensornetwork (WSN).

I. INTRODUCTION

RAPID DEVELOPMENT of system miniaturization, wirelesscommunication, and on-chip signal processing has promoted the development of wireless sensor technology, which has enabled its wide applications from condition based maintenance to industrial system monitoring and environmental sensing . The number of wireless sensors, which are typically considered as a wireless sensor network (WSN), deployed for real-life applications has rapidly increased in recent years, and this trend is expected to even more increase in the next years . However, energy consumption still remains as a major obstacle for the full deployment and exploitation of this technology, although batteries can be recharged, e.g., through solar-energy-harvesting mechanisms . Prior researches have studied different approaches, such as duty-cycling and data-driven approaches , for reducing energy consumption. Duty cycling can be achieved through sleep/ wake-up protocols and media access control protocols with low duty cycle. For example, sparse topology and energy management approach has been proposed to improve the network lifetime by setting some redundant nodes to sleep mode .The traffic-adaptive medium access protocol has been designed to reduce energy consumption by allowing sensor nodes to assume a low-power idle state whenever they are not working in transmission or receiving mode. Data-driven approaches can be divided into two different categories: data compression and energy-efficient data acquisition. As an example, a variable data length coding method usingWalsh function was developed to compress the transmission data, and this has been proved to be effective in improving energy efficiency in signal transmission. In another study, the sensor network was divided into several subsystems, and only high-level inferences are communicated between the subsystems. In this way, the energy consumption for communication decreases as the data to be transmitted decrease . For energy-efficient data acquisition, an adaptive sampling algorithm consisting of duty cycling (the sensor board is switched off between two consecutive samples) and adaptive sampling (the optimal sampling frequency is estimated online) is proposed to reduce energy consumption in a sensor network. Researchers have also studied other approaches for energy-aware transmission, including modulation scaling schemes multihop routing schemes , network sectioning, and low-power hardware . Furthermore, a combination of sleep scheduling with block transmission approach has been proposed to achieve energy saving in a wireless multimedia sensor network .Motivated by the prior research, an energy-saving strategy consisting of node-level energy saving using adaptive radio frequency (RF) power setting and network-level energy saving through adaptive network configuration has been proposed in our conference paper . This paper is an extension of , in which theperiodic sleep/wake-up scheme is added into the sensor nodedesign to further achieve the node-level energy saving. The whole communication procedure and experimental test has also been updated with the new ultralow-power microcontroller MSP430F149 being used as the core for the designed sensor node.

II . SYSTEM DESIGN AND MODULES

The sensors are grouped into different clusters, and then obtained data from each sensor node are transmitted to the corresponding cluster head. Then, the cluster head will pack the data and transmit them to the CMU. The obtained data from the sensors are analog signal. The microcontroller known only the digital value, so the sensors are connected to the ADC to convert the analog signal to digital Signal. The digital signal are send to the WSN network with the help of UART cable. The Zigbee is as a wireless sensor network, this zigbee is a transceiver and it is works as a transmitter in the cluster nodes. Similarly the Zigbee is also worked as a Receiver in the CMU.

The CMU means control monitoring unit. It is used to receive the data from the different cluster nodes. And this data's were transferred to the PC to monitor the date received by the sensors. Although the energy consumption of each sensor node is individually minimized by its associate functional modules, the total energy consumption can be further reduced by using the appropriate sensing scheme for the whole sensor network.

An embedded sensor network is a network of embedded computers placed in the physical world that interacts with the environment. These embedded computers, or sensor nodes, are often physically small, relatively inexpensive computers, each with some set of sensors or actuators. These sensor nodes are deployed in situ, physically placed in the environment near the objects they are sensing. Sensor nodes are net worked, allowing them to communicate and cooperate with each other to monitor the environment and effect changes to it

These applications provide an ideal testing ground for sensor networks because they require fairly simple monitoring (light, temperature, sound, perhaps presence or absence of an animal) at tens of stations..

The concept of wireless sensor node implies that, except for the physical sensing capabilities, the nodes will also be able to process the obtained data and communicate the resultswirelessly. In recent years, many energy conservation schemes have been proposed in the literature (a detailed survey can be found in , which assume that data acquisition and processing have an energy consumption that is significantly lower than communication . In addition, since each of the sensor nodes in the network is energy constrained and each component in a sensor node consumes a certain amount of energy, power supply becomes important to ensure proper operation of the entire WSN as the number of sensors deployed in a network grows. Hence, constructing effective network structures for the application of WSN with consideration of energy efficiency is of critical importance.

A. Energy Consumption Calculation

After sensing the environmental parameters, the results should be transmitted to the central monitoring unit (CMU) or other sensor nodes. In order for two sensor nodes to communicate, the energy consumption needed for data transmission can be expressed as

$E_{Tx} = E_{e\_tx} \cdot k + \varepsilon_{amp} \cdot d_{\alpha}$ (1)

where k is the number of transmitted data bits; α is a factor valued from 2 to 5, depending on the environment of wireless transmission; d is the distance between two sensor nodes; ε_{amp} ($J/b/m2$) is the amplification coefficient to satisfy a minimum bit error rate to ensure reliable reception at the receiver; and E_{e_tx} (J/b) is the energy dissipated to operate the transceiver, which is given as

$E_{w\_tx} = V_{cc} \cdot I_{TP}/K_{data\_rate}$ (2)

where V_{cc} denotes the working voltage, I_{TP} denotes the current for transmission, and K_{data_rate} denotes the data transmission rate.

The energy consumed for receiving a data stream can be expressed as

$E_{Rx} = E_{e\_rx} \cdot k$. (3)

Equation (1) shows that, for a fixed distance, the energy consumed is proportional to the number of data bits. On the other hand, the longer the distance between two sensor nodes is, the more energy will be consumed.

B. *Sensing Schemes*

The network-level energy saving was realized mainly through the scheme switching of the network. Two different schemes of the network are shown as follows .

Scheme 1: The obtained data points are transmitted to the CMU from each sensor node. The energy consumption E_{dr} in this case is calculated as

$$E_{dr} = \sum_{n-1}^{N} E_{e\_tx} + \varepsilon_{amp} \cdot d_{\alpha n}) \cdot k_r] \;((4)$$

where N is the number of sensors, d_n is the distance between each sensor node and the CMU, and k_r is number of data bits from the obtained data.

For example, Fig. 1 shows scheme 1 being applied to theplatform of greenhouse management in which temperature is measured by the sensors. In each greenhouse, the sensor nodes acquire the temperature data and transmit the data to the CMU directly without routing and relay.

Scheme 2: The sensors are grouped into different clusters, and the obtained data from each sensor node are transmitted to the corresponding cluster head (it is defined as the sensor node that collects the data from others in the cluster). Then, the cluster head will pack the data and transmit them to the CMU.

III. DESIGN OF THE ENERGY-AWARE SENSOR NODE

A. *Communication Module*

In the two sensing schemes designed for the WSN, it is assumed that the transmission power is minimized to ensure reliable reception at the receiver end, according to the communication distance between two sensor nodes. Hence, awareness of the communication power as well as the adjustability of the transmitter's output power becomes critical in performing the sensing scheme for the designed sensor node. By assuming a unit signal gain provided by antennas, the output power of the communication module is dominated by the consumption for power amplifier Since all of the sensor nodes are equipped with both transmissionand receiving capabilities, we can estimate the distance between sensor nodes through received signal strength indication (RSSI).

B. *Sensor Node Design*

Each sensor node should be able to collect environmental parameters and communicate with each other. At the same time, its corresponding hardware and software should be energy efficient and include the functionality described in previous sections. Based on these requirements, the sensor node has been designed and implemented as shown In this design, the MSP430F149 microcontroller is chosen as the core for fulfilling computation and control functions of the sensor node; this is because it possesses the capability of ultralowpower consumption and short waking-up time (less than 6 μs) as compared to other commonly used microcontrollers listed in Table I. Also, from Tables I and II, the architecture of MSP430F149, combined with its five low-power modes (LPM0–LPM4), can be optimized to achieve extended battery life in portable measurement applications. Furthermore, when the CPU works at the same speed (1 MHz), the energy con-

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sumption ofMSP430F149 is lower than that of other commonly used microcontrollers .The supply voltage of the sensor node is 3.3 V, which is obtained using the AMS1117-3.3 voltage regulator with low intrinsic consumption current from two 3.7-V (2400-mAh) lithium batteries. The RS232 interface is designed for communication
with the PC in environment monitoring.

C. Network-Level Energy-Saving Realization

Although the energy consumption of each sensor node is individually minimized by its associate functional modules,the total energy consumption can be further reduced by usingthe appropriate sensing scheme for the whole sensor network. First, the sensor node is set to sleep mode until the timer overflows, and then, it is waked up to collect environmental parameters and waits to communicate with the CMU. Second, the proposed scheme initially estimates the minimum required transmission power P_{Tx} by using the test code from the CMU or the cluster head. Then, the CMU selects an appropriate sensing scheme by comparing the total energy consumption. By assuming a homogeneous hardware scheme for all of the sensor nodes, the variables representing distances between sensor nodes/cluster heads and CMU are aggregated by broadcasting request to all of the sensor nodes. After all information is collected, the CMU estimates overall energy consumption for each of the schemes and makes decision to choose the one with the best energy efficiency as the current network scheme. In this scheme, test code is defined as the command for sensor nodes to implement different tasks. Here, test code 1 informs all of the sensor nodes to estimate patable1, test code 2 informs all of the cluster heads to broadcast test code 3 in the local cluster, test code 3 informs the sensor nodes in the local cluster to estimate patable2, test code 4 informs all of the nodes to select patable1 as its transmission power and to set the CMU ID as its destination address, and test code 5 informs all of the nodes to select patable as its transmission power and to set its cluster head id as its destination address.

BLOCK DIAGRAM

Cluster node

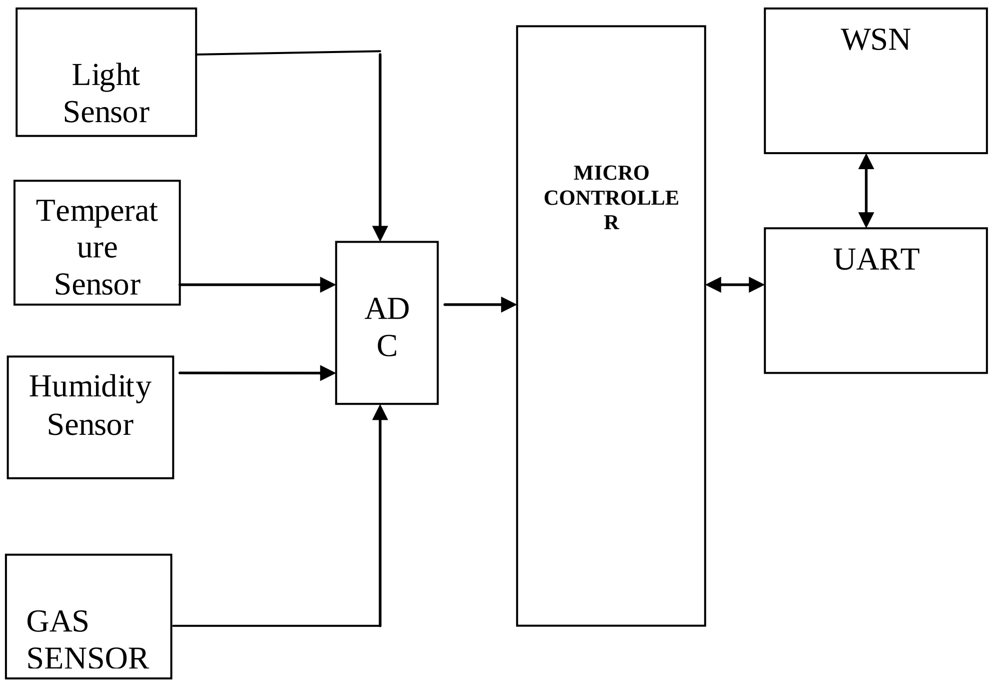

Figure1Block Diagram of Cluster Node Central Monitoring Unit

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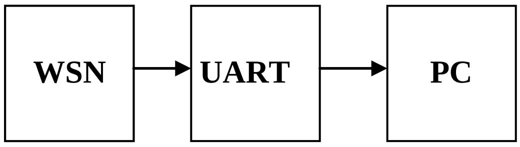

Figure 2 Block Diagram of CMU

CIRCUIT DIAGRAM

Cluster node circuit

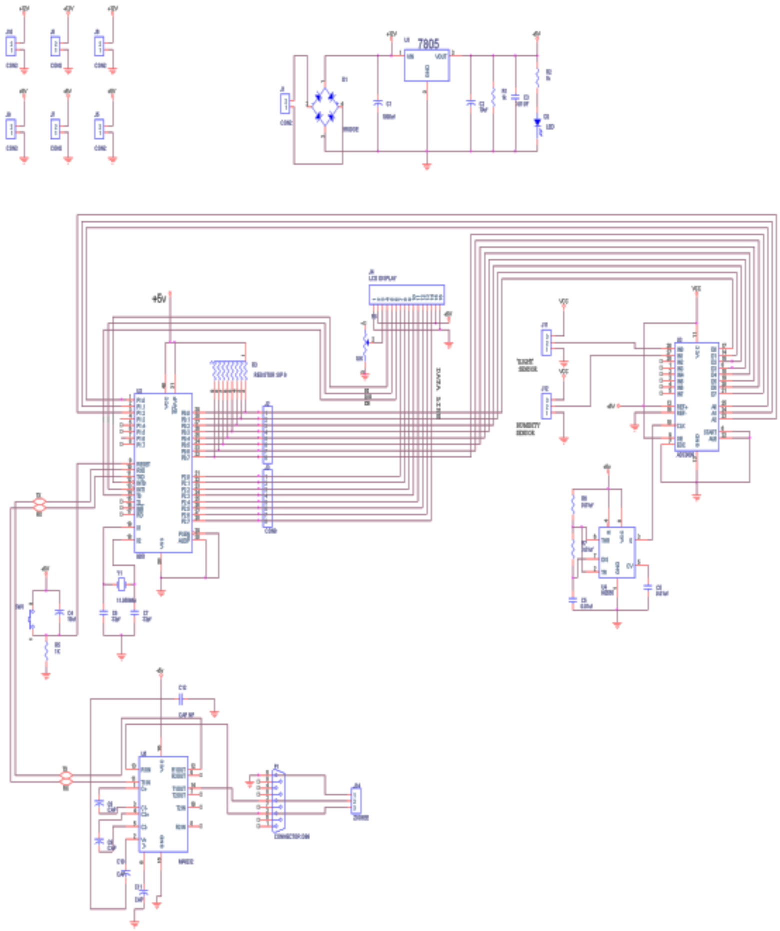

Figure 3 Circuit Diagram of Cluster Node

IV SIMULATION RESULTS

COMPARISON OF TRANSMISSION POWER

The comparison of the Fixed transmission power and the adaptive transmission power is shown on the below graph. The energy consumption of the wireless sensor network is reduced.

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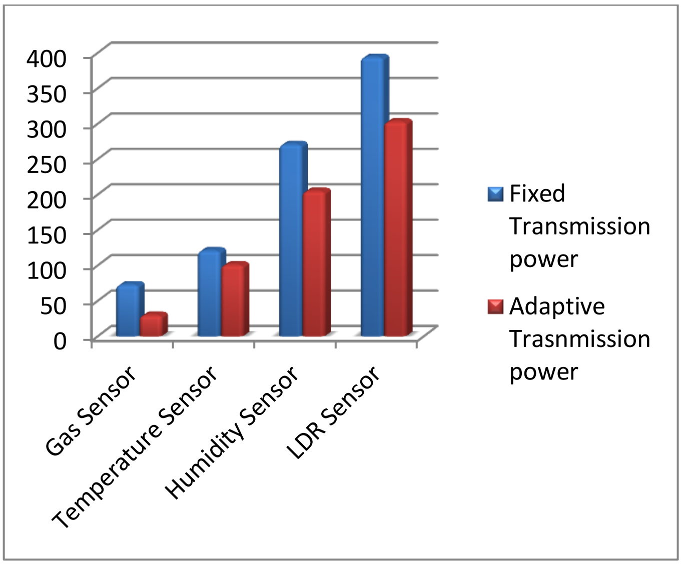

Figure 3.1 Comparison of Transmission Power

V CONCLUSION

We have presented the design and implementation of an energy-aware sensor node, which can help in constructing an energy-efficient WSN through "node-level energy saving" and "network-level energy saving." The "node level energy saving" is achieved by adaptive transmission power setting and by the periodic sleep/wake-up scheme, while the "network-level energy saving" is achieved by adaptive network configuration. The experimental tests have confirmed the effectiveness of the presented schemes for energy saving in a WSN.

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