POWER MEASUREMENTS OF WIRELESS SENSOR NETWORKS NODE

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ABSTRACT

Wireless sensor networks consist of small, autonomous devices with wireless networking capabilities. In order to further increase the applicability in real world applications, minimizing power consumption is one of the most critical issues. Therefore, accurate power model is required for the evaluation of wireless sensor networks. In this paper, the power consumption for wireless sensor networks node is analyzed. To estimate the lifetime of sensor node, the power characteristics of proposed sensor node are measured. Based on the proposed model, the estimated lifetime of a battery powered sensor node can use about 6.925 months for 10 times humidity detection per hour.

INDEX TERMS
wireless sensor networks, power consumption, humidity sensor

1. INTRODUCTION

A large scale wireless sensor network usually consists of thousands of motes which have low-memory, low processing power, and limited communication capacity. To collaboratively monitor environment and obtain global information, centralized data processing by base station is necessary. A base station is usually a powerful device which has much higher processing power, more memory and much higher communication capabilities. Energy savings is a top concern for wireless sensor networks. Sensors consume energy in their sensing, processing and communication tasks. The lifetime of the node is determined by how quickly its power is consumed. In most cases power is not a renewable resource.

Generally lifetime of wireless sensor node is correlated with the battery current usage profile. By being able to estimate the power consumption of the sensor nodes, applications and routing protocols are able to make informed decisions that increase the lifetime of the sensor network. However, it is in general not possible to measure the power consumption on sensor node platforms. Minimizing power consumption and size are important research topics in order to make wireless sensor networks (WSN) deployable. As most WSN nodes are battery powered, their lifetime is highly dependent on their power consumption. Due to the low cost of an individual node, it is more cost effective to replace the entire node than to locate the node and replace or recharge its battery supply [1-2].

Node lifetime is a frequently discussed topic in platform design and analysis. In the last couple of years new platforms have demonstrated several new techniques for reducing power leakage during sleep time. Hardware components are characterized at a very detailed level to simulate power consumption of a node as close as possible.

The rest of this paper is organized as follows: related work is given in Section 2, whereas Section 3 gives the system overview along with proposed humidity monitoring system diagram, functions of different blocks, their specifications and implementations, while section 4 gives the experimental framework, section 5 summarizes results and finally section 6 concludes the paper.

2. RELATED WORKS

The sensor node lifetime typically exhibits a strong dependency on battery life [12]. In many cases, the WSN node has a limited power source and replenishment of power may be limited or impossible altogether [3, 10]. Power consumption requires optimization. This paper describes a power consumption measurement system based on a node current consumption usage. To estimate the lifetime of humidity monitoring system, the power consumption characteristics of sensor node are measured indirectly. One node is connected in series to a resistor. Using oscilloscope, voltage drop over the resistor is measured. Current is calculated using values given by the oscilloscope. This approach has been employed in the past in other areas like in smart homes, appliances in smart cars, in smart production machines, in biomedical applications [15] like hand vibration measurement [5], stress management [16], in recognizing the tool flank wear state over a range of cutting conditions [7], in robotics etc., but is not used in WSN nodes yet. This approach introduces new challenges and new opportunities. In the domain of sensor system, many commercial sensors are available for measuring humidity [2]. These are highly accurate, but rather bulky and expensive, not targeted for low power WSN node.

3. SYSTEM OVERVIEW

Figure 1 shows the block diagram of humidity monitoring system. The humidity monitoring system is a remote monitoring system to assess the humidity of an agricultural field. As shown in the figure 1, the system is composed of a sensing module i.e. WSN nodes and server. The sensing module can be considered as a wireless sensor network which has a base station and nodes with a humidity sensor [8,9]. Each sensing module can detect a change in humidity in their sensing region. If a node detects, then transmits a packet to a receiving node. The monitoring system can provide only a simple statistics of the data such as summation of number of sensor detection per hour, day, and month.

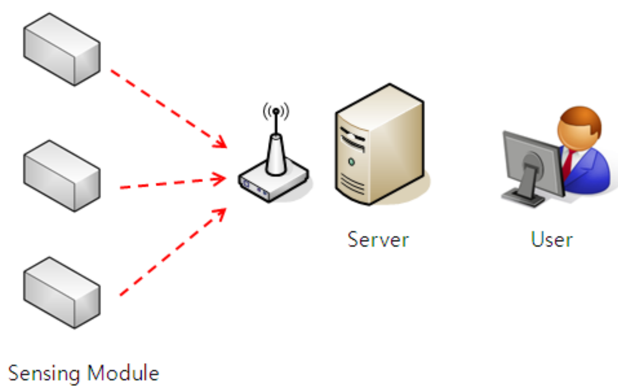

Fig 1. Humidity monitoring system

Figure 2 shows the developed sensing module. The sensing module is implemented using a microcontroller at89c51, a RF chip CC2420, and a motion humidity sensor [4-5].

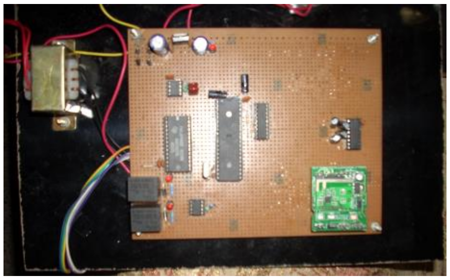

Fig 2. Sensing module

The server is composed of a database program and a monitoring program. The data from each sensing module were collected into a database at first, and then the data are processed to visualize the humidity on day to day basis.

Fig 3. Transmitter and receiver For WSN node

Figure 3 shows the transmitter and receiver pair used in WSN node and Figure 4 shows the receiving module of the monitoring system, [6].

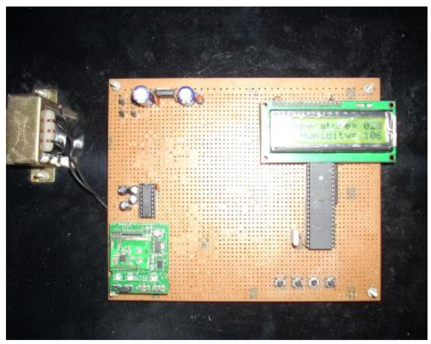

Fig 4. Receiving Module(Base station node)

3. EXPERIMENTAL FRAMEWORK

To capture the power consumption, a digital oscilloscope Tektronics was set up to measure the voltage v(t) over a series resistor R. A small resistance value was chosen in order to minimize additional voltage drop. The setting is shown in Figure 5.

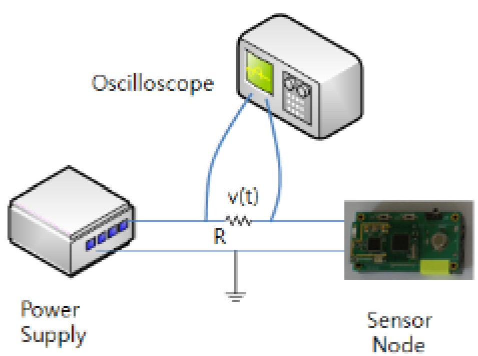

Fig 5. Measurement configuration

During measurement the oscilloscope has been setup to use as much as possible of the available resolution. There is CF card interface for exporting screenshots and measured data. The resistor was chosen to 10 Ohm to get a reasonably large signal to measure while keeping the voltage fluctuation. Figure 6 illustrates the experimental measurement set-up.

Fig 6. Measurement set-up

Figure 7 shows measured voltage profile v(t) across resistor R.

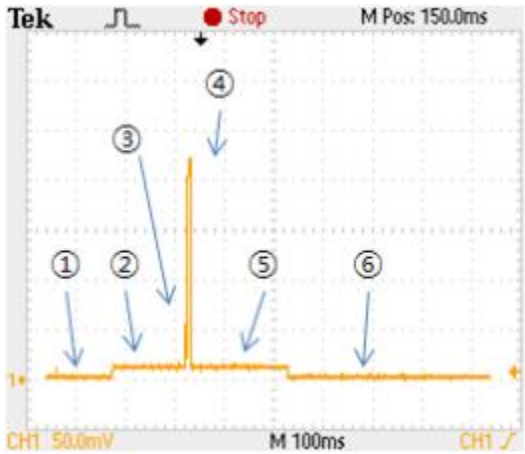

Fig 7. Measured voltage profile

Table 1 gives approximate values for power consumption. EPIR_LED is power consumption of LED while humidity sensing, ETX_PIR is power consumption while data transmission, ESleep is power consumption while sleeping, and ETX_PIR is power consumption while time stamp data transmission. ISleep is current consumption while sleeping.

Table 1. Power consumption parameters

Interval		Power Consumption
②	E_{PIR_LED}	0.80568
⑤	E_{PIR_LED}	0.29760
③, ④	E_{TX_PIR}	0.73877
①, ⑥	E_{Sleep}	0.60418
-	E_{TX_Time}	0.61572
	I_{Sleep}	0.401 [mA]

The power consumption W was measured in six representative operating modes, based on these measurement the model was formulated. The expression is given in Equation 1 with a description of the variables given in Table 1.

$$W = (N \cdot (E_{TX\_PIR} + E_{PIR\_LED} + E_{Sleep}) + E_{TX\_Time} + 3V \cdot I_{Sleep} \cdot (3600 - (N+1)\sec)) / (3600\sec/h) \quad (1)$$

Where N is a number of movements per one hour.
Sensing modules powered two 1.5V (2000mAh) AA batteries. Total lifetime is given Equation 2.

$$Lifetime[h] = \frac{3V \times 2000mAh}{W} \quad (2)$$

4. RESULTS AND DISCUSSIONS

The lifetime trend at different number of sensor firing is shown in Figure 8.

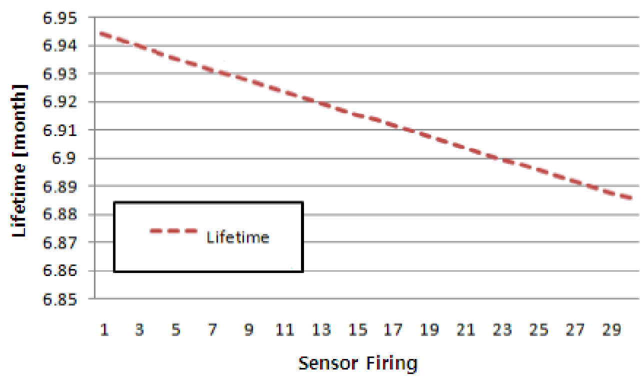

Fig 8. Lifetime vs. sensor firing

In the experiments for 4 months from, average number of sensor firing is 10 times per hour. Based on the proposed model, the estimated lifetime of a battery powered sensor node can use about 6.925 months for 10 times motion detection per hour.
In order to check battery voltage in sensing module, we measured interval voltage of MCU from ADC and recorded in server. Figure 9 shows the battery voltage drop. The sensor module works for 6.8 months.

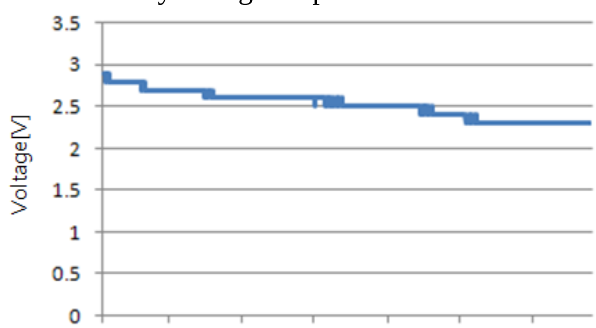

Fig 9. Battery voltage drop

5. CONCLUSION

In this paper, we analyzed the power consumption for wireless sensor networks. To estimate the lifetime of sensor node, the power characteristics of sensor node were measured using oscilloscope by calculating voltage drop over the resistor measured and calculated the current. Based on the proposed model, the estimated lifetime of a battery powered sensor node can use about 6.925 months for 10 times humidity sensing per hour.

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Kshitij Shinghal has 11 Years of experience in the field of Academic and is actively involved in research & development activities. He obtained his Masters degree (Digital Communication) in 2006 from UPTU, Lucknow. He started his career from MIT, Moradabad. Presently he is working as an Associate Professor & Head, Deptt of E&C Engg., at MIT Moradabad. He has published number of papers in national journals, conferences and seminars. He has guided two Masters, more than sixty students of B. Tech, and guiding three M. Tech. theses. He is an active Member of Various Professional Societies such as ISTE, IACSIT, IAENG etc.

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