AN EFFICIENT ENERGY MODELING IN WIRELESS SENSOR NETWORKS

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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 energy consumption is one of the most critical issues. Therefore, accurate energy model is required for the evaluation of wireless sensor networks. In this paper, the energy consumption for wireless sensor network (WSN) node is analyzed. To estimate the lifetime of sensor node, the energy characteristics of sensor node are measured. Research in this area has been growing in the past few years given the wide range of applications that can benefit from such a technology. In this paper, analysis of energy consumption of a WSN node is analyzed with a proposed node. Based on the proposed model, the estimated lifetime of a battery powered sensor node can be increased significantly.

Keywords: Wireless Sensor Networks, Energy Consumption.

1. INTRODUCTION

Lifetime of wireless *s*ensor node is correlated with the battery current usage profile. By being able to estimate the energy 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 energy consumption on sensor node platforms. Minimizing energy 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 energy 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. Another approach uses hybrid automata models for analyzing power consumption of a node at the operating system level [3]. In this paper describes an energy measurement system based on a node current consumption usage. To estimate the lifetime of activity monitoring system, the energy characteristics of sensor node is 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.

2. RELATED WORK

Energy management is important to the reliability of the network. The nature of the application may make it infeasible for interaction with the sensor once it has been deployed. Frequently the sensors are located in remote areas making it impossible to access them. In agricultural applications, it is unrealistic to think maintenance could be done on sensors. Sensors spread in a building damaged by an earthquake are also not reachable. An application that monitors the agricultural farms must not disturb the crop and soil. Economics is also a factor, when there are thousands of sensors; it is also unrealistic to have to be concerned with the power of a given sensor. Smart dust nodes are designed to be disposable, making it more cost effective to deploy additional new nodes rather than replace batteries in existing nodes. Many wireless sensor applications require the sensors to be operational for many years. It is thus essential that the sensors are reliable and work on their own for the duration of the application. If the sensor loses power, it is gone and so is the reliability of the network. Communication is the primary consumer of energy in wireless networks. [2] It has been observed that a node requires almost as much energy to listen as it does to transmit data in short-range RF communications. Energy management techniques include those that reduce communication and increase computation, power down certain components of the node or the entire node, nodes that cover smaller areas, and renewable sources of energy. The desire to save energy has also affected routing algorithms, scheduling, data collection and aggregation and MAC (Medium Access Control) protocol research. The tradeoff between energy savings and latency are of major concern. Some time critical applications cannot tolerate delay in packet delivery. It is desirable to reduce the amount of data that needs to be transmitted between nodes because the cost of transmission is high. Data aggregation methods are used to minimize the amount of redundancy in the data that needs to be transmitted. Although the processor consumes power during this process, it is much less than that consumed by the transmitting and receiving tasks. LEACH (Low-Energy Adaptive Clustering Hierarchy) is a cluster based protocol that uses hierarchy to reduce the data collected by the sensors before sending it on to a central base node. The energy load is evenly distributed among the sensors in the network. Simulations show energy dissipation can be reduced by much as a factor of 8 compared to conventional routing protocols. [12] The lifetime of the individual sensors is also increased because the energy is dissipated evenly among the sensors in the network.

3. SYSTEM NETWORK

It is desirable to reduce the amount of data that needs to be transmitted between nodes because the cost of transmission is high. Data aggregation methods are used to minimize the amount of redundancy in the data that needs to be transmitted. Although the processor consumes power during this process, it is much less than that consumed by the transmitting and receiving tasks. LEACH (Low-Energy Adaptive Clustering Hierarchy) is a cluster based protocol that uses hierarchy to reduce the data collected by the sensors before sending it on to a central base node. The energy load is evenly distributed among the sensors in the network. Simulations show energy dissipation can be reduced by much as a factor of 8 compared to conventional routing protocols. [12] The lifetime of the individual sensors is also increased because the energy is dissipated evenly among the sensors in the network. the nodes switched between active and sleeping mode independently of each other. The sensors are distributed based on a Poisson process. Nodes are responsible for sensing a particular area and sending data to the sink node in multiple hops, using other nodes to relay the message. The sink node is always connected. The network is always disconnected because the number of nodes active at any given time is very low. Nodes spend more time sleeping than awake. Once a node senses an event, it stays active and sends the information

to all of the nodes that are reachable in 1 hop. The node keeps transmitting the information until all of its immediate neighbors have received the information, since they can only receive the message if they are awake.
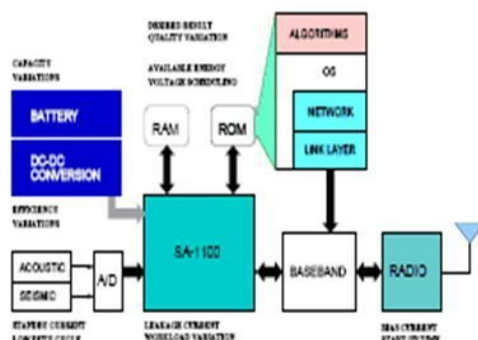

Figure 1. Architectural view of microsensor node

Once all of the neighbors have gotten the message, the node can go back to its schedule of active and sleep time. All of the neighbor nodes repeat this process until all of their immediate neighbors get the message. The process continues until the message reaches the sink node.One obvious problem is the delay (latency) introduced by a message trying to reach a sleeping node. Latency is acceptable in some applications such as those that gather statistical information. Time critical applications such as those that send an alarm when an unexpected event occurs are much less tolerant of latency. Latency is affected by random placement of the nodes, random radio range, sensing distance and random sleeping and active periods of the nodes. Even applications that can tolerate latency would not tolerate a high degree of variability in the amount of latency.

4. ANALYSIS

One observation is the "deeper" the sleep state, the greater the energy savings, and the longer the wakeup time. The research points out that care must be taken to make sure that more energy isn't consumed by putting the node to sleep and waking it up than leaving it awake constantly. Since current commercial radio transceivers have a high overhead to turn on and off, it is essential that wireless sensor networks allow the upper layers to adapt the hardware based on changes in the system in order to conserve energy at the node level.

State	WSN node µp	Sensor, A/D	Radio
Active (s_0)	Active	Sense	Tx/Rx
Ready (s_1)	Ideal	Sense	Rx
Monitor (s_2)	Sleep	Sense	Rx
Observe (s_3)	Sleep	Sense	Off
Deep Sleep (s_4)	Sleep	Off	Off

Table 1: Useful sleep states for the sensor nodes

In this event based communication model, nodes subscribe only to event types they are interested in. Each node is scheduled to receive data, transmit data and power its radio down to a low-power standby mode. An event scheduler dynamically schedules time slots for each type of event. There is a root node that acts as the base station with greater computational, transmission and storage capability. Nodes save

power by powering down their radio during those time slots that do not match the events they are interested in. The amount of power consumed by the processing and communications tasks is also dependent on the hardware. Researchers are trying to reduce energy consumption in Wireless Sensor Networks by concentrating on the hardware.
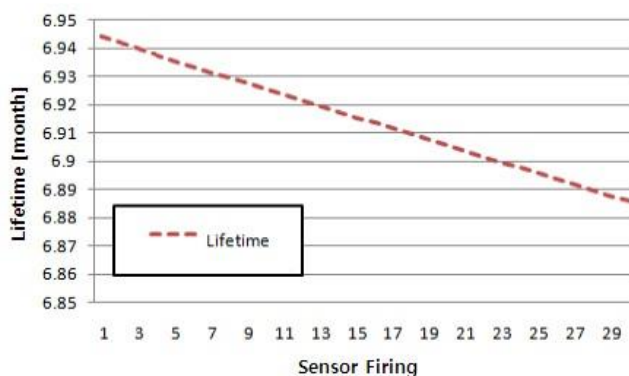

Figure 2. Lifetime vs. sensor firing

One method they are exploring is using custom RF integrated circuitry to *scavenge* energy from other resources such as solar and vibration sources. A study by [12] indicates that 100% of the necessary power can come from the sun, while vibration can contribute about 2.6% of the needed power. Radio uses the simplest processor, with hardware accelerators, and clocks with the lowest frequency, with a maximum operational voltage of 1 Volt.
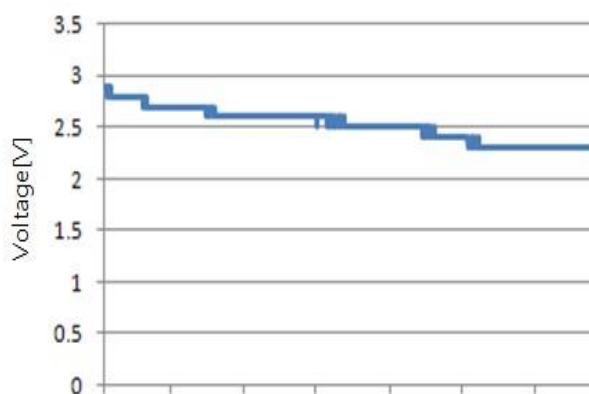

Figure 3. Battery voltage drop

They have also found that increasing the data rate reduces the overall power consumption of the WSN Node. The following table shows the power consumption by the various components of the WSN Node[15]. Full operation of the sensor requires an average of ~ 15ma of current. AA batteries are about 1800 mA, which means they would last about 120 hours or 5 days. Lithium batteries may also be used, but they are more expensive and decay more rapidly than AA batteries.

CONCLUSION

Many factors can influence the energy consumption in wireless sensor networks. A lot of research is being done in this area. It is apparent that focusing on any one of these things and ignoring all others

may result in consuming energy unnecessarily. In this paper, the energy consumption for wireless sensor networks is analyzed. To estimate the lifetime of sensor node, the energy characteristics of sensor node based on WSN node is measured. Based on the proposed model, the estimated lifetime of a battery powered sensor node can use about 6.5 months for 10 times sensor firing per hour. The simulation experiments showed that the sensor node works for approximately 7 months.

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