Minimization of energy consumption design for wireless sensor nodes

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Abstract—**Nowadays wireless sensor networks play an important role in real time applications due to its small size, low-cost and efficient energy utilization. Prior researches are mainly aimed at energy conservation in sensor nodes. The main objective of proposed system is to design the construction of energy efficient sensor nodes. This paper presents the design and implementation of efficient energy utilization of sensor node design that results in an energy efficient wireless sensor networks (WSNs). In order to obtain energy efficient sensor node design, it should have the energy minimization both at sensor node level and network level. The energy consumption of sensor node is minimized by first, estimating the distance between transmitter and receiver and calculate lowest power needed to transmit the sensed data before transmission. The node level energy saving can be performed by using adaptive transmission power setting and periodic sleep/wake-up scheme. In periodic sleep/wake-up scheme, the sensor nodes are setted to sleep mode between two consecutive sensed data measurement in normal operating conditions. The network level energy saving can be achieved by adaptive network configuration. By using these two level of energy savings, energy consumption of whole network should be estimated and construct an energy efficient networks**.

***IndexTerms*— Node level energy saving, Periodic sleep/wake-up scheme, Network level energy saving, Wireless sensor network (WSN), Adaptive power setting.**

I. INTRODUCTION

Wireless sensor network (WSNs) is defined as the group of spatially distributed sensors for monitoring and recording the physical quantities of the environment and organizing the sensed data at a central node (central server) [1]. The sensor nodes are designed depend on its application. The major elements of WSN are the sensor nodes and the base stations. It is act as "sensing cells" and the "brain" of the network. Sensor nodes are in static as well as mobile depending on its application. If the sensing node detects an event, then each node surrounding the event will report to the base station through multihop links. Technologies from three different research areas such as sensing, communication, and computing which supports the development of sensor networks. i.e., it includes hardware, software, and algorithmic support. It facilitates monitoring and controlling of physical environments from remote locations with better accuracy. WSNs measures the environmental conditions like temperature, sound, humidity, wind, speed, pressure etc. Early sensor networks include radar networks for traffic control, national power grid, tracking and mission operations for defense purposes etc. Sensor nodes have energy and computational limits because of their inexpensive nature and adhoc method of deployment.

Most of the design engineers are required to design an energy efficient sensor node with minimum energy consumption. In many real-time applications, a number of wireless sensor nodes are deployed for the collaboration of sensed data. For the exploitation of energy for each node can be achieved through charged batteries. i.e., solar energy harvesting mechanisms [2]. There was new application architecture for continuous communication in real-time environment, utilized for condition-based maintenance in distributed wireless sensor networks [3]. The hybrid MAC protocol, that uses modified RTS-CTS contention mechanism known as UC-TDMA protocol which provides 100% collision avoidance [3]. Different approaches are studied for reducing energy consumption, includes duty cycling and data driven approach. In duty cycling approach, the life time of network can be increased by sleep/wake-up protocols and media access control protocols. In traffic-adaptive media access control protocols, the sensor nodes are assumed to be in low-power idle state while it is in transmitting and receiving mode [4].

In data driven approaches, energy consumption can be reduced by data compression and energy-efficient data acquisition. For energy efficient signal transmission, the sensed datas are compressed through variable length coding method. The main aim of all existing systems is focused for the conservation of energy in a sensor network. For energy-efficient data acquisition, adaptive sample values are taken (i.e., sensor nodes are switched off between two successive samples) using adaptive sampling algorithm with optimal sampling frequency. A new technique called Sparse Topology and Energy Management (STEM) [5], which improves the network lifetime and prevent the restriction of network capacity. This provides extensive energy savings and increased the latency to set up multi-hop communication. STEM topology can effectively integrate with other topology management techniques. By the combination of Geographic Adaptive Fidelity (GAF) and STEM can reduce 7% of energy consumption, thereby increase the node lifetime of a factor 14!. The researchers are also considered the problem of minimization of energy efficient packet transmission over a wireless link via lazy schedules [6]. Less amount of transmission power and code rate, which reduce the energy required for data transmission over a longer period of time. Lazy scheduling of packet transmission improves the energy conservation which is significantly for many channel coding schemes.

So, the main concept of this paper is to minimize the energy consumption both at sensor node level energy saving and network level energy savings are utilized [7], there by constructing an energy efficient wireless sensor networks (WSNs).

II. PROPOSED SYSTEM

A. *NODE-LEVEL ENERGY SAVING*

a. *Energy consumption calculation:*

The sensor nodes are capable for sensing the physical quantities such as temperature, pressure, sound etc. After sensing these environmental parameters and the sensed datas are transmitted to the central monitoring unit (CMU) or to other nodes. In order to minimize the energy consumption needed for communication, first estimate the distance between transmitter and receiver and then, calculate the transmission power required to transmit the sensed data. Thus the energy consumption needed for transmission of sensed data can be expressed as,

$$ETx = Ee\_tx .k + \square amp. d^{\alpha} \qquad (1)$$

; where k is the number of data bits transmitted; α is a factor have value ranging from 2 to 5, depends on environment of wireless transmission; d is the distance between sensor nodes; $\square amp$ (J/b/m^2) is the amplification coefficient in order to satisfy minimum bit error rate to ensure reliable transmission and reception; Ee_tx (J/b) is the energy dissipated to operate each node which is given as

$$Ee\_tx = Vcc. Itp / K\ data\_rate \qquad (2)$$

; where Vcc is the working voltage of a node; Itp denotes the transmission current; K denotes data transmission rate. At the receiver node, the energy consumed can be calculated as,

$$ERx = Ee\_rx. K \qquad (3)$$

From equation (1) it is observed that the energy consumption is proportional to data bits for a fixed distance. i.e., as the distance increases, more energy will be consumed.

b. *Periodic sleep/wake-up scheme*

The node-level energy saving can also achieved through the periodic sleep/wake-up scheme. A WSN is deployed in remote fields or under harsh environments where it is impractical to manual recharging of batteries. There is an alternative approach is to activate (turned on) only when the necessary sensors nodes which provide accurate parameter variations. So the timer put sensor nodes into sleep mode and it will wake-up at the instant of timer overflows.

B. *NETWORK-LEVEL ENERGY SAVING*

a. *Sensing schemes:*

Each of the sensor nodes in the network is energy constrained and each component in a sensor node consumes a certain amount of energy, hence energy utilization becomes important to ensure proper operation of the entire WSN. Hence an effective network structures for the application of WSN with the consideration of energy efficiency. The network-level energy saving can be realized mainly through the network switching scheme. There are two sensing schemes that discussed here as follow:

i. *Scheme 1:*

In figure 1, the obtained data points are transmitted to the CMU from each sensor node. The energy consumption Edr in this case is calculated as

$$Edr = \sum_{n=1}^{N} [(Ee\_tx + \square amp. dn^{\alpha}) Kr] \qquad (4)$$

; where N is the number of sensors; dn is the distance between each sensor node and the CMU; kr is the number of data bits from the obtained data. Consider an example in a greenhouse management; the variable parameter is the temperature which is measured by the sensor nodes and these datas are transmitted to the server for further processing.

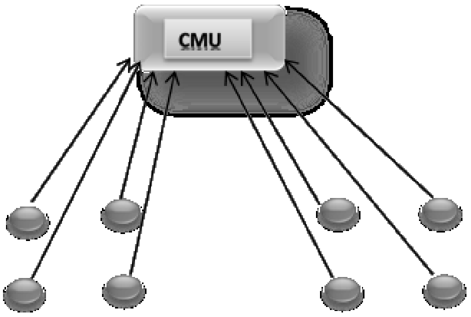

Fig: 1 sensing scheme

ii. Scheme 2:

In figure 2, the sensors are grouped into different clusters, and the obtained data from each sensor nodes 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 fuse the collected data and it to the CMU. The energy consumption Edr in this case is calculated as

$$Eds = \sum_{m=1}^{M} [\sum_{j=1}^{Nm-1} Ee\_tx + \square amp. d^{\alpha}j + Ee\_rx\ Kr + (Ee\_tx + \square amp. d^{\alpha}m)]. Km \qquad (5)$$

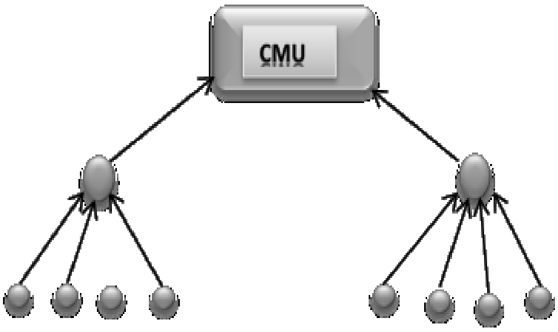

Fig 2: sensing scheme 2

III. DESIGN OF ENERGY EFFICIENT SENSOR NODE:

By using two sensing schemes, the WSNs are designed here. 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, the 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 gain signal provided in a simulation environment, the output power and received power to transmit 1 bit can be expressed as,

$$PTx = (\square\text{amp}.\ R)\ .\text{Þ}\hat{}\alpha \tag{6}$$

$$PRx = PTx\ /\ d\hat{}\alpha = (\square\text{amp}.\ R).\ \text{Þ}\hat{}\alpha\ /\ d\hat{}\alpha = Ps.\ \text{Þ}\hat{}\alpha\ /\ d\hat{}\alpha \tag{7}$$

; where R denotes the data transmission rate; Þ and d are the estimated and actual transmission distances between the transmitter and the receiver respectively; Ps = □amp . R is the receiver sensitivity denoting the minimum signal power that the receiver can discern. From equation 7, it is seen that if the estimated distance $\text{Þ} < d$, then the received signal cannot be identified and the communication between the sensor node fails. On the other hand, if $\text{Þ} > d$ (overestimation), which means a received power that is higher than R, then a portion of the transmission energy will be lost on the propagation path while not affecting the results of signal reception.

IV. SIMULATION RESULT

This section provides the simulated results of proposed system. The simulation environment was created with network simulation tool, NS-2 (Network simulator-2). The proposed method is deals with the node-level energy saving and network-level energy saving. The results are presented as a series of graphs below.

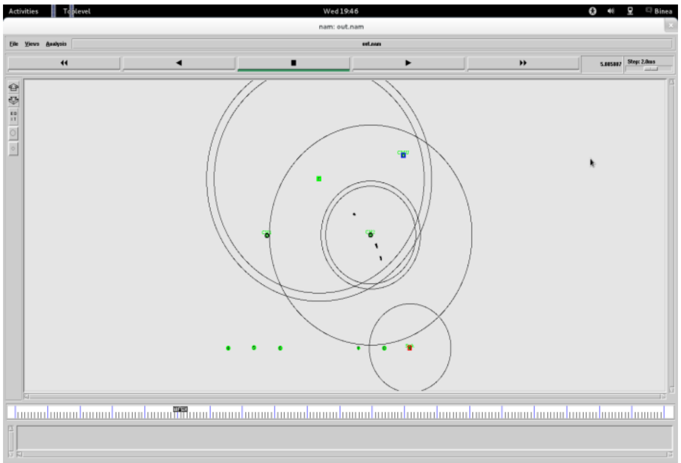

Fig 3: Distance calculation of sensor nodes

As seen in figure 3, sensor nodes are being initialized and performing the distance calculation. By this calculated distance under different trials, the energy consumption of each sensor node is estimated.

As it can be seen in figure 4, it is clear that the energy consumption for fixed transmission power setting (red line) and adaptive power setting (green line) in node-level energy saving. Along with this, the timer is still working to provide minimum energy utilization. It is seen that the fixed transmission power setting provide decreasing curve of energy consumption as node increases, but in adaptive transmission power setting give less energy consumption as compared to fixed transmission power setting for given trials.In fact, as the sensor node increases, the distance between the sensor node decreases and this will decrease the consumption needed for data transmission.

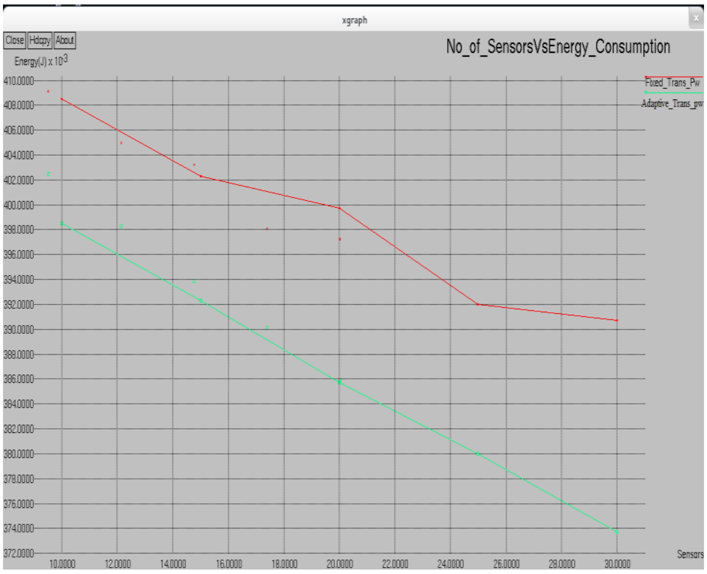

Fig 4: Energy consumption of adaptive transmission power setting with fixed transmission setting

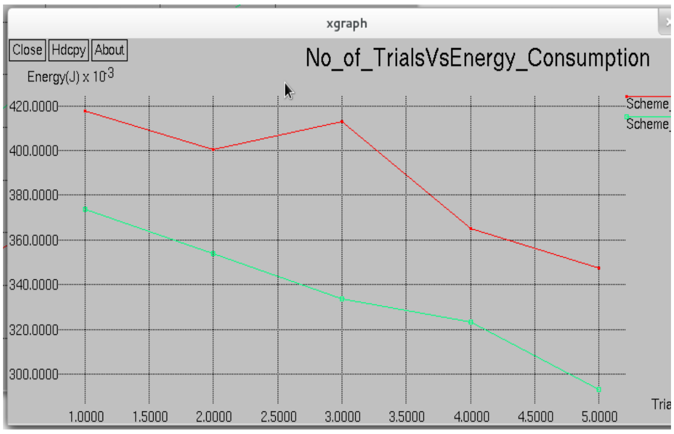

Fig 5: comparison of sensing schemes

It can seen in figure 5, it provide the comparison of sensing scheme1 (red line) and 2 (green line) in network-level enrgy saving. Using this result, it is able to choose highly energy efficient network. As shown in figure 5, scheme 2 is better energy consumption scheme than the other.

V. CONCLUSION

In this paper, we have designed a minimized energy consumption of sensor nodes on focus to node-level energy saving and network-level energy saving. The node-levl saving can be achieved by adaptive transmission power setting and periodic sleep/wake-up scheme and the network-level energy saving can adopted by using the senssing schemes for the whole network. For future enhancement, an accurate data collection algorithm with minimum redundancy will be added to the design a sensor node.

ACKNOWLEDGMENT

We are greatly thankful to Chairman Dr. James Prem Kumar and to the Principal Dr. C. Prabu Ramakrishna, James College of Engineering and Technology, Navalcaud and for their constant encouragementand providing the proper infrastructure and lab facility.This acknowledgement would be incomplete without thanking the Department of electronics and communication, James College of engineering and technology. Its well-equipped labs and well stocked library literally brought information to our fingertips. Above all, we are grateful to the supreme grace, without which we couldn't accomplish anything.

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