

An Approach to Increase Energy and Life Time Using Power Control Optimization in Wireless Sensor Networks

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Abstract

Wireless Sensor Networks monitors and manage the changes in the environments over wired sensor networks from inaccessible area. A wireless sensor networks has collections of sensor nodes. These nodes are tiny and low priced and are deployed in any zone or area. The Sensor collects the sensed data and transmits to other node in the system of network. The sensor nodes are rigid in various places and these nodes are passing the monitored information to a core node known as a sink. The sensors are deployed in inaccessible disaster area or terrains where recharge/replacement of battery is tedious and even impracticable [1]. For that network life span is mandatory to WSN. To improve network life span efficient power mechanism is needed to diminish the power utilization in nodes and energy efficient techniques must be engaged in all layers of the network[2]. The routing protocols are used to share the data to various nodes in the network. The focal point of the paper is, to study the routing protocols functions and its energy efficiency. In this paper, optimized power control for single dimensional and two dimensional network has implemented. The results of the simulation gives the best results which has increased the life time and lowest energy consumption in WSN [3].

Key Words:Sensors, energy, life time, efficiency, transmission.

1. Introduction

The Wireless Sensor Networks is the significant technology. In this technology, the collection of sensors are deployed in a region in order to monitor the changes occur in the field and provide security. The sensors are tiny, low priced and elegant[4]. The nodes in the sensor networks are outfitted with sensors which are implanted with processors and transceivers[5]. The sensors are sensed the data and process the information and transmit it to the central node. The sensors have its own distinctiveness characteristics and conditions such as deployment of node, Storage constraints, topology change, unreliable and data redundancy [6]. In future, WSN will become an integral part of our lives [7, 9]. The network lifetime can be extended by improving energy at a variety of protocol layers and operating system as well. Power mechanism has two categories such as active mechanisms and passive mechanisms. The Active mechanism acquires energy by using energy efficient network protocols instead of turning off the transceiver. The Passive power consumes energy by turning off the radio interface. Power control is a vital role to make longer network lifetime[10].

To increase the life time of the nodes most of the routing algorithm works depend on the energy efficient path[11]. The algorithm select the feasible path to transmit the data reduce the energy consumption[13]. According to single best path puts additional load and it causes the lower lifetime. This research control the power during the transmission and provides optimal solutions.

2. Optimal Transmission Method

This paper gives an idea to explore a situation where the deployment environment may not be suitable but still the nodes in the network have to use the resources to their best. The focus is given to all aspects of wireless networks like minimizing energy consumption, improving signal processing, transmission power control and protocols used at all levels. To enhance the network lifetime it is necessary to balance the power consumption in the network[14]. The transmission can be optimized by choosing short hops than long hops. Many short hops can be energy efficient than fewer long hops while transmitting data among the nodes. Setting the transmission power to the minimum will allow a network to remain connected[15].

The objective of this paper is to find a fixed network-wide transmission range. When the usage fixed transmission range in network applications the energy is imbalanced and a hot spot is created around the data sink. The nodes linked with the hot spot generate high network traffic and die at an early stage. If a particular region of the network is left unmonitored then the residual energy of the sensors at that time is wasted. The hot spot problem can be solved by varying the transmission range among nodes at different distances to the base station which can distribute the energy evenly in the network so as to extend its

lifetime[17]. The transmission range can be optimized by determining how a node should distribute its outgoing packets to multiple distances using minimum transmission power [19].

3. Network Model

The communication cost among the nodes dominates the power consumption of the nodes as the pressure and temperature sensors require very little energy. The model of the network and energy given below with the variable

Table 1: Network Model

A	Area of the Network
s	Sensor
N_s	The total number of sensor nodes
s_0	Single node
λ_e	Density of Energy
λ_a	Coverage Density
r	Rate of Traffic Generation
e_i^{init}	Initial Energy
$e^{init, total}$	Total Initial Energy
d	Distance
d^{max}	Maximum Distance
E_{tx}	Transmission of Energy Consumption
E_{rx}	Received Energy consumption
E_{elec}	Electronic Overhead
L	Normalized sensor network lifetime

All the nodes in the network can communicate with the data sink directly. The transmission power and the overhead related to the transmission have been ignored. In this case when we consider long lasting networks route updates should be done periodically and it must not affect the overall power consumption of the network. The potential overhead of the MAC layer has also been ignored for which the use of coordinated TDMA scheduling has been proposed. Though TDMA scheduling eliminates the overhead by idle listening and overhearing, it has a tendency to increase communication overheads in the form of collisions. We consider the channels are in this are lossless. When the network use minimum energy to transmit over a link, consider the packet loss rate will be below threshold. It may be possible to reduce transmission energy only when we introduce some non-zero packet loss rate.

4. Lifetime Optimization

The lifetime can be defined as the time at which a certain percentage of total nodes run out of energy[6]. When one sensor of a certain area dies, the neighboring sensors are expected to take the responsibilities of the dead sensor which will result in draining the energy of the neighboring sensors also. As a result all the nodes of that particular area run out of energy. In our network model a set of N_s sensors are deployed in a region to observe some physical phenomenon. The complete set of sensors deployed is $S = \{S_1, \dots, S_{N_s}\}$.

Sensor i generate traffic at a rate of r_i bits per second. The generated data must reach the data sink S_0 . The amount of energy to transmit a bit can be represented $E_{tx} = E_{elec} + E_{amp} d^\alpha$ and the amount of energy to receive a bit can be represented $E_{rx} = E_{elec}$ where E_{elec} is the electronics energy, E_{amp} is the transmitter's amplifier efficiency and channel conditions, d is the distance over which the data is communicated, α is the path loss exponent. The network scenario parameters include the traffic generation rate r_i for each sensor, distance d_{ij} between sensors and the maximum transmission distance d_{max} .

The goal of our network lifetime model is to explore maximum lifetime L , given a fixed deployment strategy and network scenario parameters[15]. This model optimizes the amount of traffic that each sensor should distribute to other sensors to balance the energy consumption. The traffic distribution is denoted t_{ij} that indicates sensor i transmits to sensor j where $t_{ii}=0$ for all i .

During network lifetime L , sensor i will generate a total of $r_i L$ traffic. The first constraint of our problem, related to the conservation of data flow at all sensor nodes, is

$$\sum_{j=1}^{N_s} t_{ji} + r_i L = \sum_{j=0}^{N_s} t_{ij} \quad \forall i \in \{1, \dots, N_s\} \quad \dots\dots\dots (1)$$

Equation 8.1 states that the sum of all traffic received at sensor i and generated by sensor i must be transmitted to other sensors or to the data sink (s_0). The energy consumed by sensor i includes the energy required for both transmitting and receiving data and can be expressed as

$$e_i = \sum_{j=0}^{N_s} (E_{elec} + \epsilon_{amp}(d_{ij}^\alpha)) t_{ij} + \sum_{j=1}^{N_s} E_{elec} t_{ji} \quad \dots\dots\dots (2)$$

The second constraint, related to the initial energy at each sensor, e_i^{init}

$$e_i \leq e_i^{init} \quad \forall i \in \{1, \dots, N_s\} \quad \dots\dots\dots (3)$$

The third constraint, related to the maximum transmission range d^{max} of each sensor, depends on the sensor's transmission power control capabilities. If the transmission power of the sensor varies based on the distance they must transmit then the transmission power needed to deliver a packet from sensor i to sensor j will be controlled such that the transmission d_{ij}^t equals the physical distance.

In many real radio transmitters that employ transmission power control, transmission power can only be set at a number of discrete levels, rather than at any arbitrary continuous value. However, these levels can be rather finely spaced, and we model the sensors as being able to set their transmission power

arbitrarily to simplify analysis.

$$d_{ij}^t = d_{ij} \quad \forall i \in \{1, \dots, N_s\}, \forall j \in \{0, \dots, N_s\} \quad \dots\dots (4)$$

If nodes must use a fixed transmission range d^{max} , then the constraint simply becomes

$$d_{ij}^t = d^{max} \quad \forall i \in \{1, \dots, N_s\}, \forall j \in \{0, \dots, N_s\} \quad \dots\dots\dots (5)$$

Note that if $d_{ij} > d^{max}$ then no traffic can be sent between sensors i and j and the following constraint must be applied.

$$t_{ij} = 0 \quad \forall (i, j) : d_{ij} > d^{max} \quad \dots\dots\dots (6)$$

The last constraint, related to the energy distribution at each sensor, depends on how freely energy can be assigned to each sensor. If energy can be freely assigned, then the total energy consumption of all sensors must simply satisfy

$$\sum_{i=1}^{N_s} e_i^{init} = e^{init, total} \quad \dots\dots\dots (7)$$

If sensors are initially assigned the same amount of energy, then

$$e_i^{init} = \frac{e^{init, total}}{N_s} \quad \forall i \in \{1, \dots, N_s\} \quad \dots\dots\dots (8)$$

The optimal network lifetime can be obtained using a linear programming approach that sets the constraints as in Equations 1, 3, 4 (or 5), 6, and 7 (or 8), and sets the goal of maximizing L . The linear program finds the maximum lifetime for a given scenario, and it also discovers the traffic distribution t_{ij} , indicating how this lifetime can be obtained through intelligent traffic distribution[18].

5. Simulation

The simulation results are given in order to observe the optimal transmission range distributions under several deployment scenarios. The values used for simulations are $E_{elec} = 100nJ/bit$ and $\epsilon_{fs} = 10pJ/bit/m^2$. The transmission range for nodes in a general and ad hoc network would be 100m. The initial energy and data generation rate of all nodes in the network is set to 1J and 1bit/sec. The simulation time is 100 seconds with 50 nodes. The transmission range is 10 meter and its bandwidth is 2Mbps

6. Results

The sensors can be separated into three regions namely near field, far field and mid field. The areas of dense probability are shown as dark areas of distribution. Nodes at farther distance and mid field range transmit packets using multiple hops. The distribution of packets becomes concentrated at a distance increases based on the distance from the base station. Nodes at the farthest region split their packets and transmit to the base station. We can allocate the same amount of initial energy to the individual nodes but still use a fraction of the total network energy to attain maximum lifetime as shown in Fig 1.

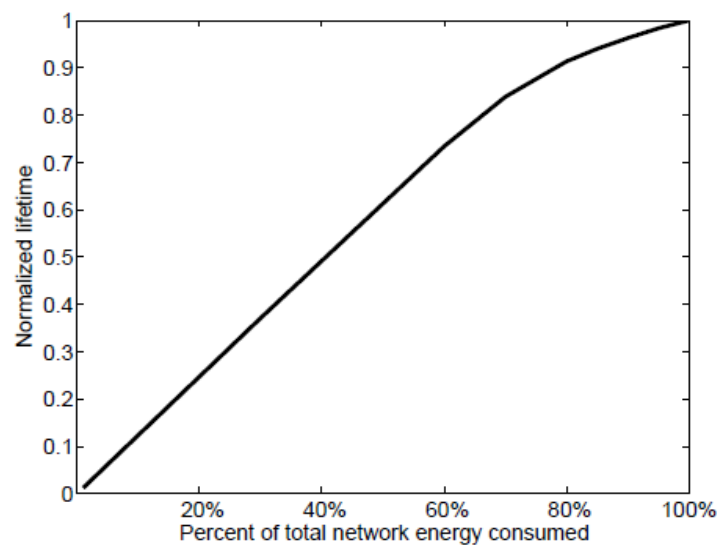


Figure 1: Life Time Vs Energy Consumed

The energy inefficiency is caused by the nodes in the farthest and mid-field regions. Nodes near the base station must forward more traffic than the nodes far away. The nodes that are far send only their traffic and hence they consume only least energy. So to balance the energy and enhance the lifetime and the packets that were transmitted over “reasonable” transmission range are sent through long distances to balance the load in the intermediate nodes. The packets that are sent through long distances instead of “reasonable” transmission range are the primary ones to be transferred to a more energy-efficient range as the energy consumption of the network drops from 100% to 90%. Nodes that are far and in the mid-field region transmit their packets to the nodes that are very near to the base station contributing energy inefficiency.

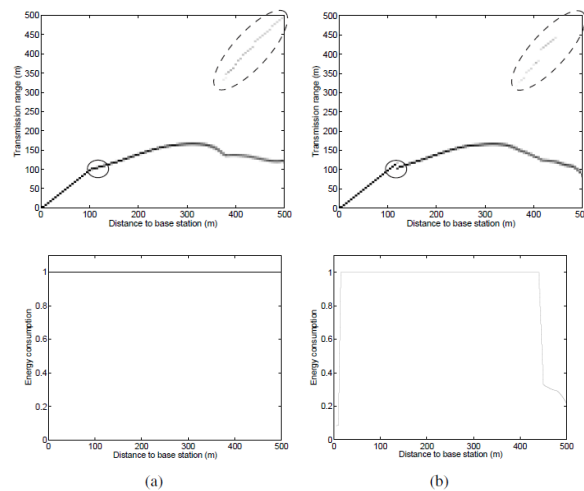


Figure 2: Optimal Transmission Range in Single Dimension

When nodes that are far send packets to the nodes that are close to the base station, the energy consumed will be high and when these nodes send the packets directly to the base station the energy consumed will be less. When we avoid the two hop communication the farthest nodes consume more energy than the nearest nodes where as when the node nearer to the data sinks forwards traffic it consumes more energy than the farthest nodes. The reduction of energy consumption would be at the receiving nodes than the nodes that transmitted packets. The impact of node density would be minimal on the optical transmission distribution. As density increases the nodes rotate activities and generate data at a lesser rate which can contribute to extend the lifetime of the network. If the density is increased uniformly throughout the network then all the nodes additionally deployed should exhibit similar behavior throughout the network.

We also need to know how the network radius effects the network lifetime. In large network the nodes that are far must operate more at the inefficient points so as to balance energy consumption.

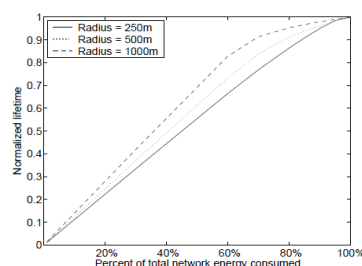


Figure 3: Life Time Vs Energy Consumption with different Radius in Single Dimension

In the two dimensional sensor field the base station is located at the center of the field. A dense two dimensional field is modeled with non-uniform spacing. Since the sensor deployment is dense we assume that the sensor nodes send their packets to the base station at a thin angle.

Simulations were done to find the optimal range distribution for two dimensional sensor fields. In these simulations the numbers of nodes were kept constant and the spacing between the nodes was done based on the network radius. In this scenario the larger portion of the packets are sent from long distances. Since there are fewer nodes near the base station to forward traffic and the maximum data is forwarded by the nodes that are far which reflects inefficiency in the network lifetime.

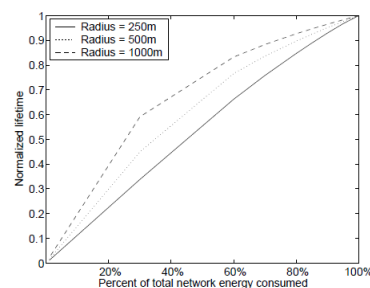


Figure 4: Life Time Vs Energy Consumption with Different Radius in Two Dimension

7. Conclusion

In the far field region the nodes directly transmit data to the base station because the nodes do not find the other nodes in the same line to the base station. When transmission is done in multiple hops the transmission distances vary thus blurring this region in the optimal range transmission. As a solution the nodes at the farther region are kept dense to avoid the hot spot problem. Hence energy inefficiency is more in two-dimensional field compared to the one-dimensional field. It increase the network life time in a simple transmission does not waste the system resource.

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