MINIMUM DELAY MAXIMUM NODE LIFETIME ROUTING IN DUTY CYCLING WIRELESS SENSOR NETWORKS

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Abstract- In a energy constraint WSN, each sensor node has limited power energy for which enhancement of network lifetime becomes a major challenge. For maximum conservation of energy in sensor networks, one of the most effective approaches is duty cycling. Routing of packets in wireless sensor networks employing duty cycling is a challenging issue. .To deliver data in a timely manner while maintaining maximum lifetime for individual sensor nodes in duty cycling wireless sensor networks, communication among sensor nodes needs to be carefully managed . Forwarding data along a longer but faster path can be a better option if the data has to be urgently communicated towards the sink node while preserving the benefit of duty cycling. In this paper, the use of an energy efficient delay biased routing protocol for effectively maximizing sensor node lifetime with minimum end to end packet delivery delay in wireless sensor networks with duty cycling, is demonstrated. . Simulation results show that as the number of event detections increase the energy consumption per node is lesser when compared to shortest path routing. This leads to improved life period of individual sensor nodes Also, this protocol, can be adjusted to operate with an optimum threshold value so that in case of urgent data , the delay incurred in delivering the packet to the sink node will be significantly reduced. The protocol works through biasing the time threshold parameter depending on the preference of the data to be communicated.

Keywords- Duty Cycling, Time Threshold Biasing, Lifetime Maximization

I. INTRODUCTION

A wireless sensor network consists of spatially distributed autonomous sensor nodes deployed to cooperatively monitor any physical quantities or environmental conditions such as pressure, temperature, humidity, motion, pollutants etc. Each individual sensor node will be having a limited communication range and constrained energy capacity because of the small battery power. On detecting of an event , a sensor node will be generating data samples to be communicated towards the sink node. These data packets are to be routed to the sink node through the intermediate nodes along the path. The transmission of data packets must be lossless and must consume less amount of energy.

Since sensor nodes are generally battery powered, reduction in the usage of energy during data transmission could eventually increase the lifetime of the sensor nodes.. Since most of the energy is consumed by the transceivers which is the most power hungry component of a sensor node , A sleep awake scheduling technique like duty cycling is an effective mechanism for reducing battery power consumption and thus prolonging the lifetime of a sensor network.

However duty cycling could cause substantial increase in end to end message delivery delays because any transmitting node has to wait until the next hope neighbor node wakes up.

When the next hope neighbor node is sleeping, a node has only the option of buffering the message till the waking up of the neighbor node. This will be a critical issue in applications that require data samples to be promptly communicated to the sink.

Therefore in such duty cycling sensor networks, forwarding data over a longer but faster path would be always better. But these longer paths leads to an increased number of nodes waking up and involving in data forwarding which significantly increases node energy consumption even though duty cycling concept can be used as an effective solution for energy efficiency maximization. Therefore in such situations, the issue of decreasing node energy consumption for maintaining maximum node lifetime, needs to be addressed seriously by researchers. The need of a class of energy efficient minimum delay routing protocols is becoming more and more significant in the field of wireless sensor network routing protocol design. In his paper we address the issue of maximizing the lifetime of individual sensor nodes at the same time minimizing the end to end delivery delay for data that has to be urgently forwarded through WSNs. We demonstrate the design and implementation of an energy efficient delay biased routing protocol for effectively maximizing sensor node lifetime with minimum end to end packet delivery delay in wireless sensor networks with duty cycling. The implementation and analysis of the protocol has been done using MATLAB simulation tool.

II. RELATED WORK

In wireless sensor network the lifetime of network is more concentrated area for researchers. Many factors are taken into account for the maximization of life time of wireless sensor networks, such as minimizing

the power consumption, low cost operation, optimal routing algorithms, forwarding of residual power to every node to avoid the abbreviating of power in nodes, using improved version of protocols and also communication models.

To maximize the life time of networks, the mobility of sink node is one of the traditional method. The mobility of data collection points (sinks) for the purpose of increasing the lifetime of a wireless sensor network with energy constrained nodes. Linear programming is the solution for the joint problems of determining the movement of the sink and the joining time at different points in the network that induce the maximum network lifetime.

The probabilistic scheduling controllers that compensate for the effects of the decrease in power while maintaining an adequate probability of event detection under two sensing models. The imbalance in the energy of the wireless sensor network is a main problem. To network lifetime using a combination of a fuzzy approach and an approaches of star algorithm. The combination of both approaches is used to determine the optimal routing path from the source to the destination by favoring the highest remaining power in battery with least number of hops, and without overhead of traffic loads.

Network coding technique is a methodology for enhancing an lifetime of a wireless sensor network. Network coding was first introduced in an wired networks to solve bottleneck problem and to increase the throughput. However, The broadcast nature of wireless network and the variety of links make an network coding more enchanting in wireless sensor network . The duty cycle and network coding technique can be merged to utilize the network resources efficiently. Finally the network coding based approach which reduces the traffic flow inside the bottle neck zone for maximizing the lifetime of whole Wireless sensor network.

The issue of minimum latency data delivery under duty cycling nodes has been addressed by several research papers. The existing approaches suggested so far are divided into two categories. One is coordinated sleeping mechanism and the other is random sleeping mechanism. In the first mechanism nodes communicate with each other to adjust their sleeping schedules in order to meet the requirements, for example, coverage. Geographic Adaptive Fidelity (GAF). In the later mechanism known as random sleeping mechanisms, sensor nodes enter the sleeping state in a random manner and independently from each other. For example, the Randomized Independent Sleeping (RIS) mechanism

Biased random walk is used for the performance model of the protocol. Random walk on a given network is a sequential process in which a walker moves from one node of the network to another, selected at random among its neighbors. The rest of the paper includes the design and implementation of this threshold based random walk protocol and the performance results obtained using Matlab tool shows that the protocol contributes to significantly reduce the end to end packet delivery delay in duty cycling sensor networks.

III. PROBLEM FORMULATION

For the maximum conservation of energy, one of the most effective approaches is duty cycling. This technique relies on how to keep sensor nodes in the Sleeping state as long as possible while satisfying application requirements. Obviously a node cannot communicate if it is not active. Therefore, to deliver data in a timely manner for such duty-cycling sensor networks, communication needs to be carefully managed among sensor nodes.

Beside constraints on energy consumption by sensor nodes, some applications require real-time data delivery, which usually has delay constraints in the form of end to- end (E2E) communication deadlines To resolve the conflict between the limited power supply of sensor nodes and this real time data delivery deadline of applications, it is essential to design routing protocols that can achieve designated data delivery deadline with the minimum energy consumption, so as to prolong the individual sensor node lifetime.

A. The time threshold based forwarding protocol

A simple random walk time threshold based forwarding protocol which performs routing with minimum energy consumption per node as well as significantly reduced end to end packet delivery delay at the sink, is designed and implemented.. In this , a parameter called threshold waiting time value is defined and by appropriately varying the value of this threshold parameter the protocol routing behavior can be adjusted between that of the hot potato routing and the classical shortest path routing.

According to this protocol, the node which holds a message to be forwarded is always interested in passing the message to a neighbor quickly . However, if it knows that its next hope neighbor node which lies on the shortest possible path towards the sink will wake up within a threshold amount of time, the node will be forwarding the message to that particular node.. Otherwise, it will be forwarding the message to some neighbor node that will be becoming active at the first.

The value for threshold can be set according to the delivery requirements and the preference of data. If an event contains data that has to be urgently

communicated to the sink, then the threshold value can be set to zero or sum minimum value so as to forward the data with minimum required delay. On the other hand , if the event generates data that are to be normally communicated to the sink, with no delay constraints the threshold parameter can be set to the optimum value so as to reduce the end to end delay without significantly increasing the number of transmissions.

B. Methodology

This protocol works based on a time parameter called threshold which is set according to the requirement of the application. By varying the value of the threshold, the delivery delay for data to the destination can be controlled.

The protocol works as follows. If we denote the forwarding node as F, and any generic neighbor of this forwarding node as G, then let P be the neighbor of F which is on the shortest path from F to the sink. Moreover, let DF be the forwarding delay through P, which is the time elapsed from when F received the message until P will wake up. The key step of the protocol is that F forwards the message to P only if DF is not larger than the threshold time value TH ." Otherwise, F sends the message to the first neighbor that becomes active. The rule based on what the forwarding of the message from the current node to a neighbor node is performed is as follows:

- If DF< T, then F sends the message to P.
- Otherwise, F sends the message to the first node G that becomes active (ties are broken at random).

Algorithm

The outline of the algorithm is as follows

F: The node which has the message to be forwarded

G: A neighbor of F

P: The shortest path neighbor node of F

DF: Forwarding delay , i.e., the time elapsed from when F received the message until P will wake up.

TH: Threshold time value

```
If(DF<TH)
        {
Forward the message to P
        }
Else
        {
Forward the packet to G which is the first to become awake
        }
```

IV. IMPLEMENTATION

In the simulation experiments, we have considered a random deployment model in which nodes are located at random positions on a square field and all nodes have the same normalized transmission range r. Links are established between any two nodes at distance less than the constant value r from each other. It is assumed that the clocks of the sensors are synchronized. The protocol works according to a time slot model, where slots are synchronized. Moreover, it requires that a sensor knows the identity of its next hop nodes. Also it is assume that packet transmission requires one time slot, i.e., medium access protocol, collisions, etc., are all such that they can be managed within a time slot. Here we have done the implementation of the algorithm based on which the routing process is carried out. .This implementation has been done using Matlab simulation tool for which Windows XP or Windows 7 is the working platform.

V. RESULTS

The results are obtained by simulating the algorithm using Matlab simulation Tool.. The Deployment of the network, Event Generation and Routing process are all simulated. The user can generate multiple events on the same run of the simulation and for each event, the routing process will be shown .The routing destination is always a single sing node. Simulations are carried out for different number of nodes and different sensing and transmission ranges. Fig 1 shows the routing of packets from source node to sink node.

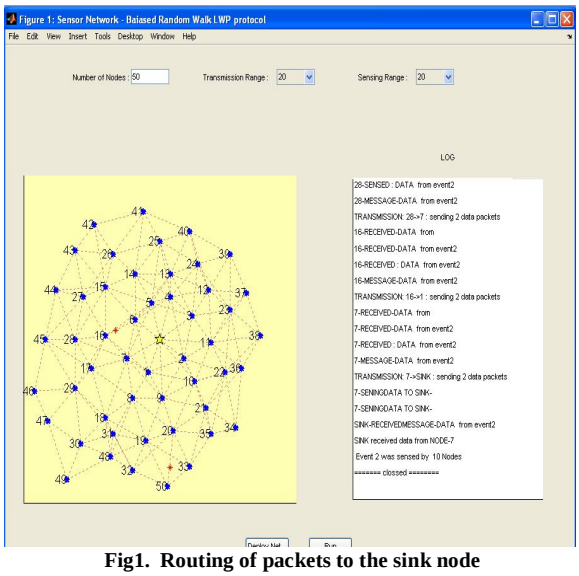


Fig1. Routing of packets to the sink node

VI. PERFORMANCE ANALYSIS

For the analysis of the performance of the algorithm, the total energy consumption and the energy consumption per node are taken as the two parameters. Simulation results shown in the Fig 3 and Fig 4 shows that, even though the total energy consumed is higher as compared to the classical shortest path routing,(as the number of event detections in the network increases), the energy consumed per node is lesser than that in shortest path

routing. So if the energy consumption per node is minimized it can lead to prolonging of lifetime of a sensor node. The comparison of the implemented algorithm with the classical shortest path algorithm is obtained in the following figures. The red line represents classical shortest path routing and the blue line represents the minimum delay threshold based protocol.

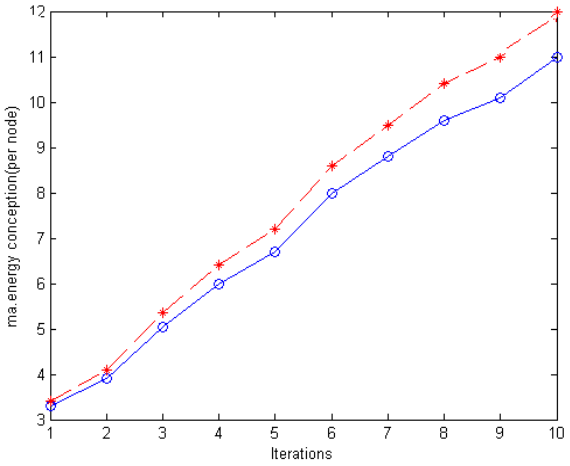


Fig 2. Energy consumption per node Vs number of events

The graph in fig 3 shows the average delay as a function of the threshold T.

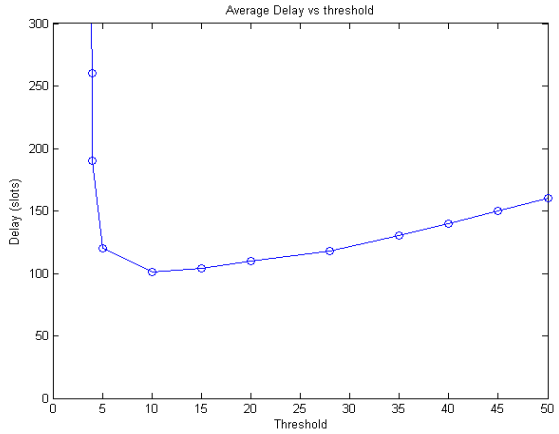


Fig 3. Average delay versus threshold

CONCLUSION

Duty cycling is a widely used approach to reduce energy consumption and prolong the life of a sensor network. Since in most of the cases there comes the detection of an urgent data, forwarding data along a longer but faster path can be a better option to obtain faster delivery while preserving the benefit of duty cycling. These longer paths leads to an increased number of nodes waking up and involving in data forwarding which significantly increases node energy consumption even though duty cycling concept can be used for energy efficiency maximization. In this paper, we used an energy efficient threshold based routing protocol that effectively maximizes the node lifetime in wireless sensor networks with duty cycling. The simulation results shows a comparison of the this protocol with the classical shortest path routing. It is found that as the number of event detections increase the energy consumption per node is lesser when compared to shortest path routing. This leads to improved life period of individual sensor nodes. Also there is the advantage of this protocol that the delay involved in delivering the data to the destination can be varied according to the urgency of data delivery. But the protocol requires more number of data transmissions . This issue can be addressed by researchers in order to improve the protocol.

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