Optimization of Energy Consumption in Opportunistic Routing Using Sleep Mode in Wireless Sensor Network

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Abstract: Wireless Sensor Network consist of a load of tiny nodes with sensing, computation, and wireless communications capabilities. Hence with the increase of these capabilities in every field, energy consumption is rising as an important issue in a wireless sensor network. However, on the basis of literature review large amount of work has not yet been done on low-duty-cycle wireless sensor networks in which nodes stays active in very less number of time slots and stays asleep mostly. Such a technique, while prolonging the network lifetime, and decrease the energy consumption of the nodes.

In this work, we discuss about the wireless sensor network, routing techniques or how the packet will be transfer from one node to another when these nodes are located in non linear position and we also work in low duty cycle in opportunistic routing algorithm and a routing technique has been investigated, by modifying the existing opportunistic routing technique, in which the data has been forwarded by seeing the shortest path from source to destination. The decision of forwarding the data packets has been taken through finding the distance between the nodes, which helps in evaluating the total energy consumption along with the network lifetime of the system in the sharing of data packets among each sensor node.

Compared with the existing algorithm, the results showed that our design consumes significantly less transmission energy, and increase the network lifetime.

Index terms: **Wireless Sensor Network, Low Duty Cycle, opportunistic routing algorithm, Dijkshtra's algorithm, dormant node.**

I. INTRODUCTION

Wireless sensor network (WSN) is a wireless network that introduces the various sensors to monitors substantial and environmental conditions. These sensors are not only used for collecting the data but it also transmitted the data from source to destination. In sensor networks, each sensor node plays the role of sensor and router. The computing ability and storage capacity, communication ability and power supply are limited in the WSN [1]. In wireless sensor network, routing is the process of selecting a path for traffic in a network, or across multiple networks.

Routing process is usually forwarding the packets on the basis of routing table, which maintain the records of the transmission of packet from source to destination.

As we know that minimum consumption of energy and maximize network lifetime is the crucial terms in wireless sensor network. Earlier and at present also researcher are working in the optimization of energy consumption of the various nodes in the wireless sensor network.

In this paper we work on energy saving via opportunistic routing algorithm with Dijkstra's algorithm and using sleep mode. Opportunistic routing is a routing where we choose the closest node to the target node for forwarding the packet. Here we use the term known as Energy

Equivalent Node (EEN) which select the relay nodes based on the opportunistic routing theory to derive optimal transmission distance for energy saving and maximizing lifetime of whole network[2].

Energy consumption in WSN is one of the main focuses of this paper therefore we are using Low Duty Cycle. In low duty cycle we have a two state: active state and dormant state. In active state, a node is able to sense an event, transmit or receive a packet where as in dormant, node turn all its functions except timer which is used to wake itself up. In dormant state, node is in a sleep mode until it had to receive a packet or send a packet that's why the sleep mode is helpful for the consumption of energy in WSN.

The idea to use Dijkstra's algorithm is to working in the nodes which are not linearly present. As Dijkstra's algorithm is used to find the minimum spanning tree, it is used to determine the shortest distance between the start node and any other node in a network/graph. With the help of Dijkstra's algorithm we can find the minimum distance or the minimum path from source node to the sink node. The contribution of the paper is to use of sleep mode and Dijkstra's algorithm with opportunistic routing in order to optimizing the energy consumption and maximizing the network lifetime.

MOTIVATION

[I] Dijkshtra's Algorithm

In my work we use dijkshtra's algorithm for transferring the packet among the nodes which are present in non-linear manner rather than in linear manner. With the help of dijkshtra's algorithm we can find the minimum spanning tree (MST) or the minimum distance among the source node to the destination node.

Dijkshtra's algorithm holds the unvisited vertex with the minimum distance from the source calculates the distance and updates the neighbours distance if smaller. Mark the node when visited by the neighbours. This algorithm generates a shortest path tree (SPT) with the source as root. We maintain two sets, one set involve vertices included in shortest path tree, other set contain vertices which are not visited yet. At every step we will calculate a minimum distance from neighbour vertex.

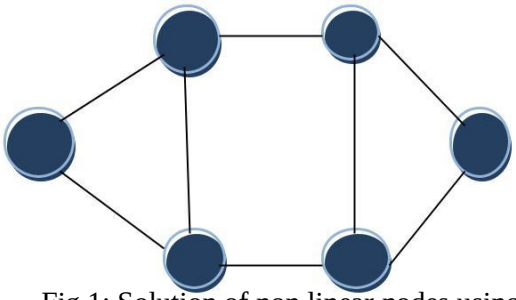


Fig 1: Solution of non linear nodes using SPT

[II] LOW DUTY CYCLE

The basic idea of low duty cycle protocols is to reduce the time a node is idle or spends overhearing an unnecessary activity by putting the node in the sleep state [4]. The ideal conditions of low duty cycle protocols are when the node is in the dormant state and wake up only when the node is ready to transmit or receive the packet. The concept behind the low duty cycle is look like a periodic scheme in which a node wakeup periodically to transmit or receive the packets from all nodes. Usually when a node wake up then it listen to its channel for any transmitting or receiving packets. If there is no packet to be transmitted or received, the node returns to its sleep state. This whole process consists of sleep and active mode and is known as sleep/wake up period given in figure (1)

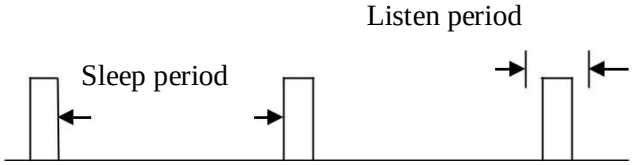


Fig 2: Process of Low Duty Cycle

OBJECTIVE

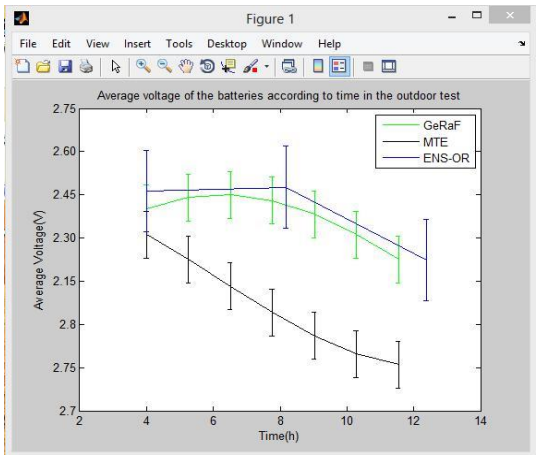
Our objective is to design an energy-efficient opportunistic routing strategy for each relay node that ensure minimum energy consumption and increase network lifetime. Different optimization objectives are used under different

constraints and scenarios, it is difficult to compare the performance of them all that is which is better than other. In this paper we have also work in the nodes which is not present in a linear manner, we have use Dijkshtra's algorithm for finding the minimum distance from the source to the other nodes and build the minimum spanning tree. The main goal of this thesis is how to use the data transmission in such a manner that it increases the network lifetime of the system and consumed low energy. So we have to consume the less energy and increase the network lifetime to overall increase the performance of the network.

EXPERIMENTS AND RESULTS

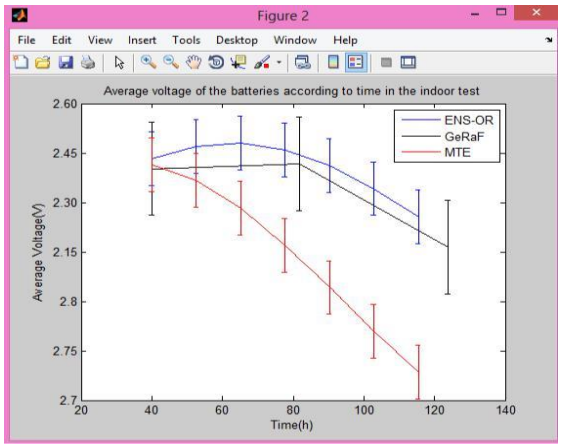
(A) Dijkshtra's Algorithm (for non-linear nodes)

Here we work on 100 numbers of nodes using MATLAB which are uniformly and independently distributed over a line. Each node has the same frequency B =1 Mbit/s, and firmware character Eelec and εamp is set as 50×10−9 J/bit and 100×10−12 J/bit/m2, respectively. Path-loss exponent of environment τ is 2. The value of optimal transmission distance dop is approximately equal to 31.6 m. The longest transmission distance of a single hop is 50 m.



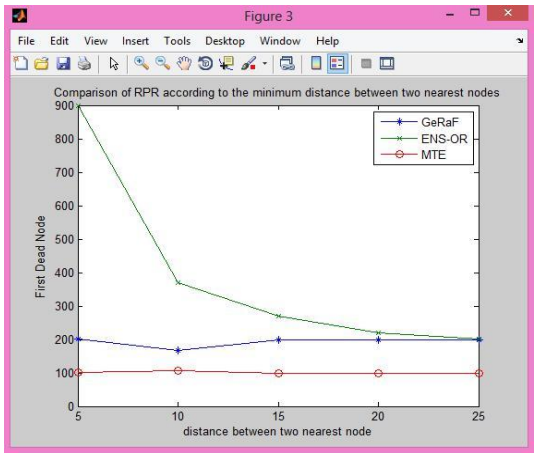
Result1: Average voltage of battery according to time in the outdoor test

In this result 1 we check how much average voltage is covered in a given time in the outdoor test. Among these three algorithms, ENS-OR algorithm has maximum average voltage. As we increase the time, average voltage of these algorithms will be decreases as shown in result.



Result 2: Average voltage of the batteries according to time in indoor test

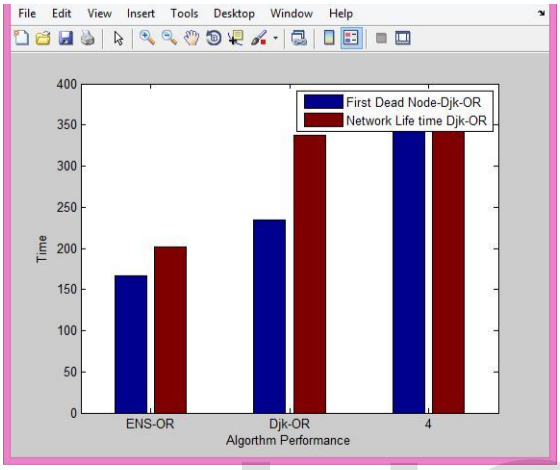
This is the result of average voltage of the batteries according to time in the indoor test. Here we also compare average voltage to the algorithm with respect to time. It is same as outdoor test as the time increases average voltage will be decreases but there will approximately difference in the result of outdoor test and indoor test.



Result 3: Comparison of RPR according to minimum distance between two nearest nodes

In this result, they are telling about the first dead node appear in the algorithm. Here RPR stand for Receiving Packet Ratio which defines as the ratio of amount of packet received by the

sink to the total amount of packet sent by the source. First Dead Node appear late in Energy Saving Opportunistic Routing algorithm as compared to others. Late the First Dead Node will be appearing then the efficiency of that algorithm will increase. As in the given result efficiency of the ENS-OR algorithm is increased.



Result 3: Algorithm performance

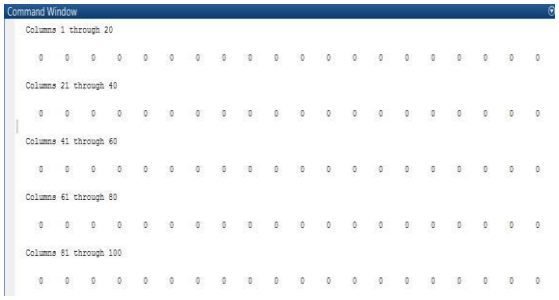
Here we compare MTE, GeRaF and Djk-OR algorithm with respect to time and algorithm performance. This graph tells the relationship between the First Dead Node and network lifetime. Network lifetime of a node is defined as in how much time the first dead node will appear. So in this result First Dead Node will appear late as compare to other two algorithms

(B) Low Duty Cycle

In low duty cycle we have two states: Active state and dormant state. Active state is the state where the node is in wake up state for transmitting or receiving the data or packet from one to node to another whereas in Dormant state is the state where the node is in sleeping mode, it only become active when it has to receive or transmit the packet.

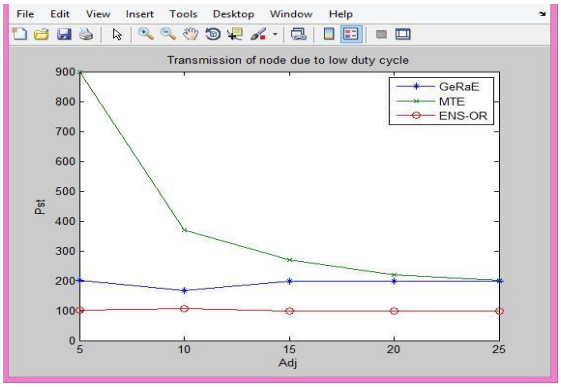
Here we work on 100 numbers of nodes using MATLAB which are uniformly and independently distributed over a line. Among number of nodes we have 30 active nodes and cycle length of the node or the total distance from source node to sink node is 50. Each node has the same frequency B =1 Mbit/s, and firmware character E_{elec} and ε_{amp} is set as $50\times10-9$ J/bit and $100\times10-12$ J/bit/m2, respectively. Path-loss exponent of environment τ is 2. The value of optimal transmission distance d_{op} is approximately equal to 31.6 m.

Output comes from implementing the low duty cycle in opportunistic routing algorithm. The output in the command prompt shows that these are the nodes between 1 to 20 columns which are in the dormant state s given below:



Result 4: Output in Command prompt

In this result, this is the graph of packet due to low duty cycle. Here in the graph the active node are highlighted from the circle notation. Circle notation specifies that the node is active in this state. Between these two active nodes there are various dormant nodes.



Result 5 Output from transmission of packet using low duty cycle

CONCLUSION

Routing is a momentous issue in Wireless Sensor Networks. It is quite important to know the performance matrices of a wireless sensor network, where there are a huge number of sensor nodes. Routing done in minimum time is very crucial for any transmission.

The work on this dissertation has been motivated by the importance of minimum energy consumption and increasing the network lifetime in a wireless sensor network. The research efforts have been directed towards modifying and implementing algorithms, which are particularly designed for low- duty-cycle wireless sensor network, where each node makes probabilistic forwarding decisions based on the delay distribution of next nodes that lead the sensor nodes to consume less amount of energy on keeping an eye on transmission delay too, in the sharing of information. We have also work with dijkstra algorithm for finding the shortest path from source node to another node where these nodes are not located in the linear manner. These node are located in a non linear manner that why we use dijkstra algorithm so that we find the shortest path from source node to the target node where we have to send tha packet With the results of trace graph, we can conclude that in the case of low duty cycle energy cost of delivered packets is quite less than in the case of other algorithm.
Hence it can be concluded that, the technique discussed in our work proved to be quite remarkable in terms of performance matrix, as it is providing very less energy consumption compare to traditional routing algorithm

In future we will extend our work to improvement in the energy efficiency and the delivery ratio. This technique needs to be implemented in a wireless sensor network with mobile nodes, since mobility was not considered in this work.

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