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Energy Efficient Routing Scheme for Wireless Sensor Networks

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Abstract—In recent years, Wireless Sensor Networks (closely deployed nodes) are widely used in applications ranging from weather forecasting to defense. It comprises of data gathering nodes (source), transmitting nodes (routers) and data collecting node. Wide research sprang in this area for improving the efficiency of these networks in terms of packet delivery ratio, throughput and reliability by modifying the conventional routing protocols. Also as the nodes come with limited battery major emphasis is also given to develop energy efficient algorithms. In this paper, an energy efficient adaptive routing protocol is developed for improving the Packet Delivery Ratio and decreasing the packet drop and delay. The proposed technique used RSSI, unused energy and congestion degree for choosing the router. PDR has increased by 0.178% and delay has decreased by 4.1ms.

Index terms—WSN, RSSI, UE, PDR, Delay

I. INTRODUCTION

Wireless Sensor Network (WSN) is defined as the cluster of closely deployed sensor nodes. It is used in security, agriculture, weather forecasting, disaster board. A typical WSN consists of source nodes that collect the data, routers that transmit the data efficiently and a sink that collects the data for further processing. These networks can be time driven or event driven. In the former irrespective of whether an event has occurred or not, routers transmit the data periodically. In the later, the routers transmit the data once an event has occurred. In early days, data packets were transmitted directly from the source to the sink. It resulted in higher energy consumption because of overhearing and hence reduced the overall lifetime of the network. In order to overcome the disadvantages, multi hop routing was proposed for WSN. In Multi hop routing, earlier Dijikstra's shortest path algorithm was used for routing the data packets. It led to overuse of certain nodes and links resulting in congestion and hence packet drops. Hence Ad-Hoc On-Demand Distance Vector (AODV) protocol is used wherein a routing table is maintained at the router and the adjacent node is chosen based on shortest distance. Probability of congestion is still significant in conventional AODV. I.e., the performance of multi hop technique is directly dependent on the efficient selection of adjacent nodes for data transmission. Congestion leads to packet drop and hence retransmission of these packets is necessitated. It further results in energy depletion which in turn leads to reduction in network lifetime. Inspite of technological advances, sensor nodes with unlimited battery is yet to be developed. Hence it is necessary to develop energy efficient routing protocols that consider the node parameters and the packet drop factor for efficient transmission of data. Packet drops may occur at the node if the number of packets receivedis greater than the buffer occupancy. Packet drops may also occur at the link level when the same link is used by different paths as shown in Figure 1.

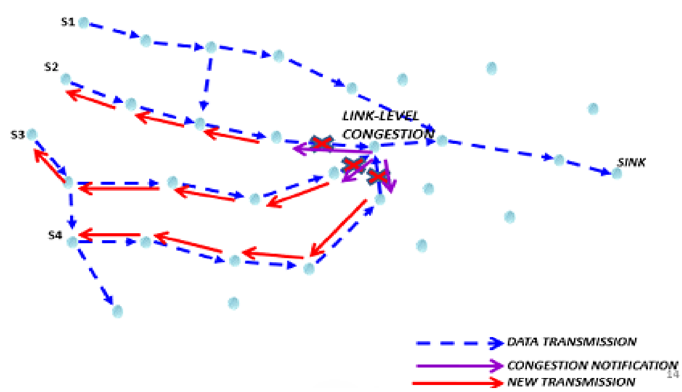


Fig. 1. Link Level Congestion

In the above cases, packet drops could be measured in terms of buffer occupancy and congestion degree respectively. Buffer occupancy may not be a major factor as sensors with larger memory are now available. However link level packet drops play a drastic role in decreasing the efficiency and throughput, unless an efficient routing protocol is designed. Considerable research is carried out in this area to develop an energy aware routing protocol that considers not only the node level parameters but also packet drop ratio. However there is a major compromise in energy consumption due to overhead involved in determining the packet drops. Hence in this paper, an energy efficient adaptive routing algorithm is proposed for high throughput data transmission in WSN.

This paper is organized as follows: Section 2 provides a detailed literature survey on the existing techniques for adaptive routing in WSN. In section 3, the proposed methodology is explained. Results are discussed in section 4. Conclusion and future work is provided in section 5.

2 RELATED WORK

The Neighbor based distributed protocols determine the number of neighbors, transmission power adjustment, link quality estimation, distance calculation etc. The main idea of these algorithms is to produce a connected topology by connecting each node with the smallest necessary set of neighbors, and with minimum transmission power possible [1],[2],[3],[4],[5].

Shan Lin et al (2006) described a lightweight algorithm of Adaptive Transmission Power Control (ATPC) based on Received Signal Strength Indicator (RSSI) / Link Quality Indicator (LQI) for WSN. Each node constructs a model for each of its neighbors, describing the interrelation between transmission power and link quality. Beacon messages were transmitted to the neighbor nodes. In the neighbor node, they use RSSI to calculate the transmission range and the link quality from the received messages. Here the transmission range is adjusted according to the threshold link quality. When the threshold value is attained, a NOTIFICATION signal is given as acknowledgement. Thus the neighbors are discovered and connected for the data transmission. Also this protocol suffers from initialization overhead [6].

Kim et al (2008) proposed a new algorithm namely, the On-Demand Transmission Power Control (ODTPC) that attempts to reduce the initialization overhead in determining the optimal transmission power level while providing good link qualities. A link quality between a pair of nodes is measured after the sender and the receiver exchange data-ACK packets rather than measuring link quality to every neighbor in the starting phase. There is no additional pack exchange to maintain good link quality and adjust the transmission power level. ODTPC algorithm can dramatically reduce the transmission energy consumption while maintaining good link qualities [7].

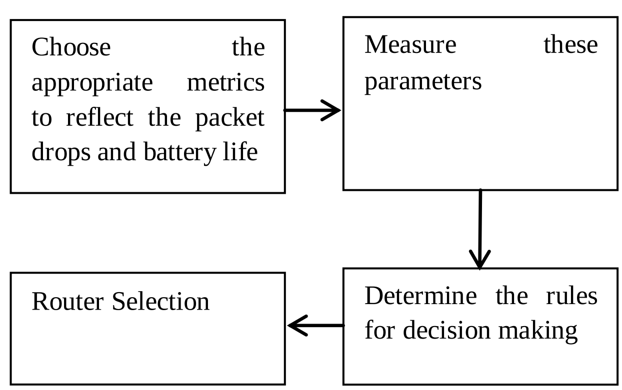
Michael et al (2003) introduced a simple distributed TC algorithm that assigns appropriate individual transmission powers, based on the neighborhood information. Each node maintains a critical set of neighbor's k for obtaining a connected topology. Nodes with neighbors < k is defined as critical nodes. Critical node signals a special HELP packet to the surrounding neighbor nodes by arbitrarily increasing its transmission power, until k neighbors are heard. The neighbor nodes on receiving HELP signal, include the critical node in their neighbor list. The critical node uses a SATISFY packet to notify neighbors, whenever a node is no longer critical. If a critical node finds more number of neighbors above k value, it reduces the transmission range. By doing this once again, the number of neighbors may become less than k, when the new neighbors are at the same distance. Thus an oscillatory behavior was established. Increasing or decreasing the neighbor count via transmission power adjustment involves additional overhead, which leads to increased energy consumption [8].

Costa et al (2009) presented distributed approach to adaptively tune the transmission power of sensors in order to match local connectivity constraints. To avoid the oscillatory behavior, the proposed protocol leverages the neighbor list provided by each node in its beacons. In the course of the detectionstage, when a node R receives a beacon from node S, it computes the size of S's neighborhood and if it is lower than k, S is marked as critical. Through the up-to-datestage, critical nodes are involved as neighbors and transmission range is modified accordingly. In some cases two or more nodes decide to accept a critical node as neighbor, for instance only one would suffice. During the next discovery phase, the critical node will receive beacons from these nodes and will decide which one more is nearer. This way, in the subsequent discovery phase the critical node will show its new neighbor list, enclosing the neighbors well-arranged from the closest to the farthest. Consequently, all other nodes can recognize, that they are not required and can diminish their collection. Since the nearer nodes were always involved, maximum energy drain occurs in those nodes. To overcome this, hierarchy of nodes based on its characteristics can be considered [9].

3 METHODOLOGY

In this work, the node parameters and packet drop parameters are measured using appropriate metrics. Of the various metrics cited in literature, Received Signal Strength Indicator (RSSI) and unused energy are chosen to reduce the retransmission rate and to increase the lifetime of the battery. Congestion degree is chosen to reflect the packet drops. In order to measure RSSI and unused energy, a pilot packet is sent to the adjacent nodes. The adjacent nodes reply by piggybacking the RSSI and unused energy values. Congestion degree is measured as the ratio of service time to arrival time.

The block illustration of the projected work is shown in Figure 2.



Assessment is established by the following rules:

Step 1

If RSSI > -20dB then “Not a Forwarder”

else

If UE < 50% then “Not a Forwarder”

else

If Congestion degree > 0.5 then “ Not a Forwarder”

else

“It is a Forwarder”

Based on the above set of IF THEN rules, the adjacent router is chosen for data transmission.

4RESULTS AND DISCUSSIONS

In this paper, a network is created with 10 nodes that are deployed randomly. The network parameters considered for simulation are shown in Table I. Figures 3–5 represent the various network scenarios involved in this work. Scenario 1 depicts the deployment of sensor nodes, scenarios 2 and 3 depict the data transmission between the source and the sink through appropriate routers. Performance of the proposed work is measured in terms of Packet drop, Packet Delivery Ratio, Delay and energy. Also the performance of the proposed approach is compared with that of the conventional approach as shown in Figures 6-9.

Table I:

Simulation Parameters

Channel type	Channel/wireless channel
Radio propagation	Two ray ground
Network interface	Phy/Wireless phy
MAC Protocol	Mac 802.11
Interface queue	Queue/Pri queue/Drop tail
Antenna model	Antenna/ Omni antenna
Routing Protocol	Ad-hoc On demand Distance Vector
Simulation start time&stop time	1.0& 80
Active source	4-8
Packet size	512
Number of nodes	10
Total area	1000*1000
Buffer size	50 packets
Sink	1

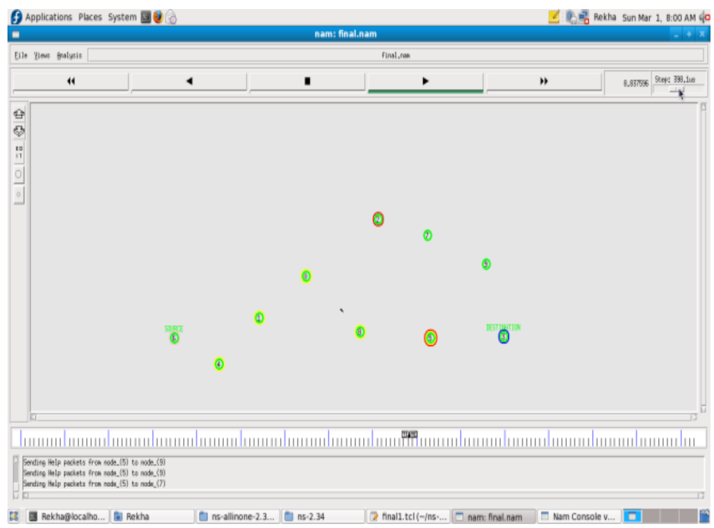


Fig. 3. Data Transmission (Scenario 1)

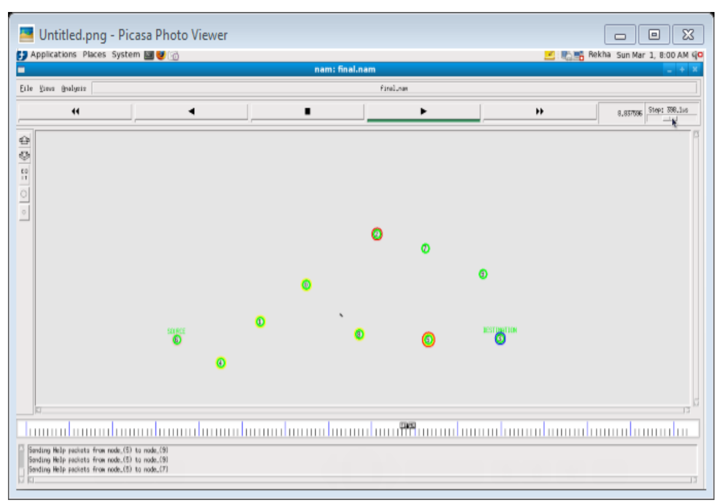


Fig. 4. Data Transmission (Scenario 2)

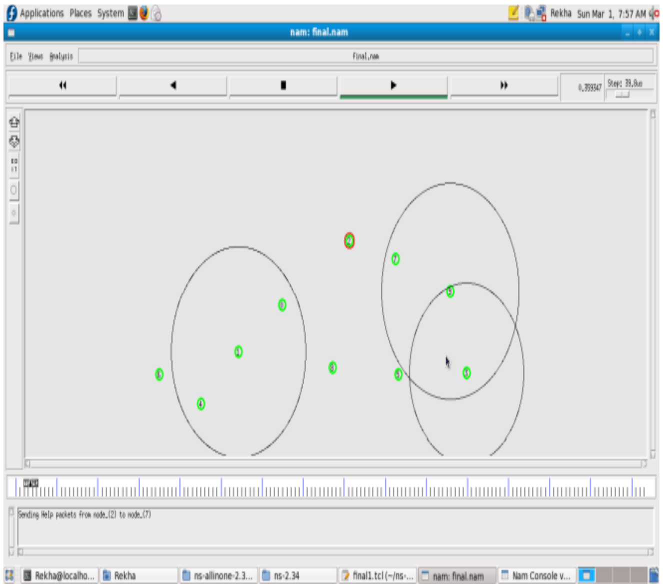


Fig. 5. Data Transmission (Scenario 3)

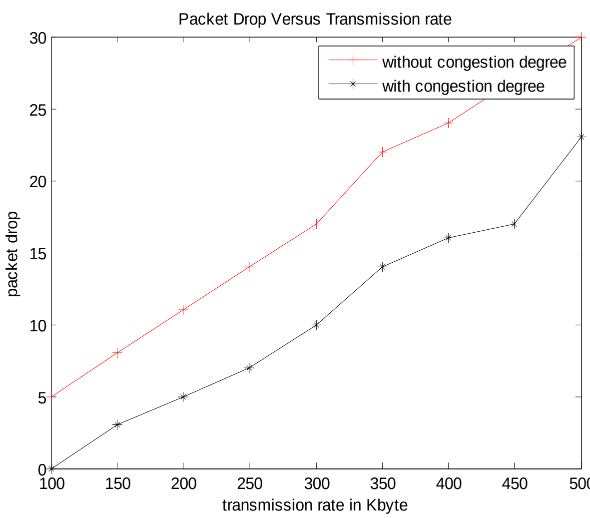


Fig. 6. Packet Drop versus Transmission Rate

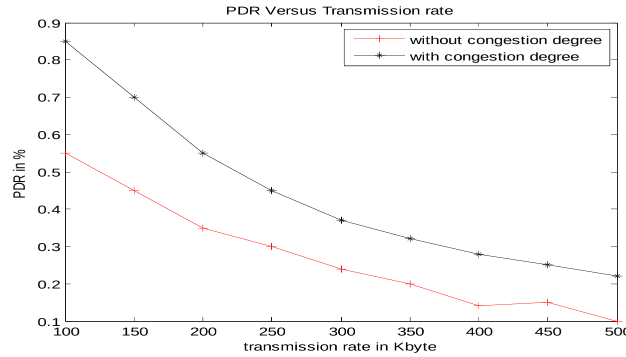


Fig. 7. PDR versus Transmission Rate

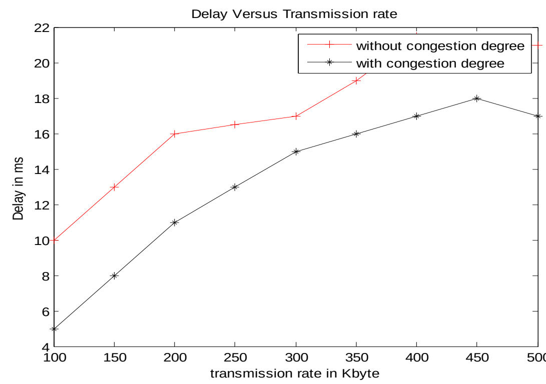


Fig. 8. Delay versus Transmission Rate

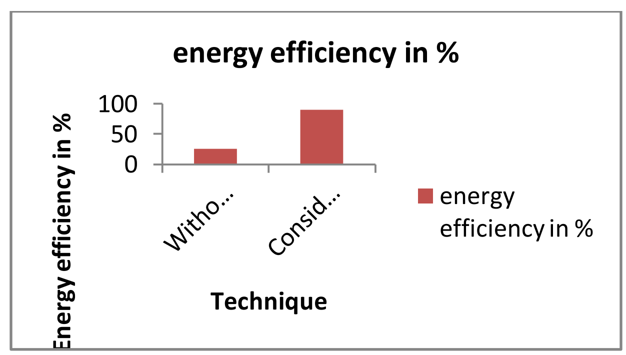


Fig. 9. Energy efficiency for conventional and proposed techniques

From the Figures 6-9, it is found that the number of packet drops and consumed energy has decreased and packet Delivery Ratio has increased. Irrespective of the transmission rate, Number of dropped packets has decreased for the proposed technique. Also PDR increases by 0.178% compared to conventional technique and delay has decreased by 4.1ms compared to Conventional technique.

5 CONCLUSION

In this paper, adaptive routing protocol for multi-hop WSN is proposed for efficient transmission of data packets. The routing technique is made adaptive by considering the link level congestion factor to improve the packet delivery ration, number of packets transmitted successfully. Performance of the proposed technique is compared with that of the conventional routing technique. It is found that the adaptive routing technique outperforms the previous technique with 0.178% increase in PDR and 4.1ms decrease in delay. However the performance of the routing technique can be improved by considering the node level congestion parameter. Also in this paper the work stopped at the simulation level. The proposed routing technique can be validated in terms of hardware implementation. Reliable data communication can be obtained by introducing security in data transmission.

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