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Evaluating Degree of Hop in Wireless Sensor Networks under Geographical Routing Protocol

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***Abstract*— A Wireless sensor network (WSN) consists of many low-cost, low-power, and multifunctional wireless sensor nodes, with sensing, wireless communications and computation capabilities. These nodes communicate over short distance via a wireless medium and create common tasks. Traditional routing protocols have several shortcomings when applied to WSNs mainly due to issues involving network energy constraints. Geographic routing is a type of stateless routing, where it is not necessary for a node to perform maintenance functions for topological information beyond the one-hop neighborhood. So geographic routing is highly feasible for large-scale networks than topological routing that need network-wide control message dissemination. In this paper it is proposed to investigate performance of wireless sensor network having 3 degrees of hops with different transmission powers. The goal is to balance power within WSN to save energy on the nodes. This is very important in WSN as they typically use battery which may not be possible to replace in many cases.**

***Index Terms*—Wireless Sensor Network, Geographical Routing Protocol, Routing and Energy Saving**

I. Introduction

WIRELESS sensor network (WSN) is thought to be one of the most important technologies for the twenty-first century [1] and has received tremendous attention from both academia and industry globally. A WSN consists of many low-cost, low-power and multifunctional wireless sensor nodes, with sensing, wireless communications and computation capabilities [2], [3]. These communicate over short distance via a wireless medium and create a common task, for example, environment monitoring, military surveillance, and industrial process control [4]. The basic idea behind WSNs is that, while individual sensor node capability is limited, total power for the entire network is enough for the required mission.

In some WSN applications, deployment of sensor nodes is performed ad hoc without either planning or/and engineering. Once put to use, sensor nodes should organize themselves autonomously in to a wireless communication network. Sensor nodes are battery-powered and operate without attendance for a relatively long period. In most cases, it is difficult/impossible to change or recharge sensor node batteries. WSNs have denser levels of sensor node deployment, higher unreliability and severe power, computation, and memory constraints. Hence these constraints present challenges for WSNs development and application.

Because of great energy constraints of large number of densely deployed sensor nodes, it needs a slew of network protocols to affect various network control and management functions like synchronization, node localization, and network security. Traditional routing protocols have several shortcomings when applied to WSNs, and they mainly due to such networks energy constraints [4]. For example, flooding; a technique in which a node broadcasts data and control packets it has received to other nodes in the network. This process is repeated till the destination node is reached. This technique does account for the energy constraint by WSNs. So, when used for data routing in WSNs, it creates problems like implosion and overlap [5], [8]. As flooding is a blind technique, duplicated packets may circulate in the network, and there is a chance that sensors will receive duplicated packets, leading to an implosion. Also, when two sensors sense the same region and broadcast sensed data simultaneously, neighbors will receive duplicated packets. To overcome these flooding issues, another technique called gossiping is applied [6]. Here, on receipt of the packet, a sensor will select at random a neighbor and forward the packet to it. This is repeated till all sensors receive this packet. Using gossiping, a sensor will receive only a copy of the forwarded packet. While gossiping can handle implosion, there is a great delay for a packet to reach all network sensors. Also, these are highlighted when the network node number increases.

Designing routing protocols for WSNs is challenging due to many network constraints. WSNs suffer limitations of several network resources like energy, bandwidth, central processing unit, and storage. They involve the following aspects [4, 7, 9]:

Limited energy capacity: As sensor nodes are battery powered, their energy capacities are limited. Thus, routing protocols for sensors should be energy efficient to extend their lifetime and thereby prolong network life while at the same time guaranteeing overall good performance.

Sensor locations: Another challenge that designers face is managing sensor locations as most proposed protocols assume

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that sensors are either quipped with global positioning system (GPS) receivers [10] to learn their locations.

Limited hardware resources: Sensor nodes also have also limited processing and storage capacities and so can perform only limited computational functions.

Massive and random node deployment: Sensor node deployment in WSNs is application dependent and is either manual or random which affects performance of routing protocols. If this distribution of nodes is not uniform, optimal clustering is a must to ensure to allow connectivity and enable energy efficient network operations.

Network characteristics and unreliable environment: Network topology is defined by the sensors and the communication links between them change frequently due to sensor addition, deletion, node failure, damage, or energy depletion. Also, as sensor nodes are connected through a wireless medium, it is noisy, error prone, and time varying. *Data Aggregation:* As sensor nodes generate significant redundant data, similar packets from multiple nodes can be aggregated so that transmission numbers are reduced. Data aggregation techniques are used to achieve energy efficiency and data transfer optimization in many routing protocols.

Diverse sensing application requirements: Sensor networks have diverse applications. So routing protocols should guarantee data delivery and accuracy so that the sink can collect required knowledge about physical phenomena in time.

Scalability: Routing protocols must scale with network size. Again, sensors may not have the same capabilities with regard to energy, processing, sensing, and communication. So communication links between sensors may be asymmetric.

Geographic routing is a type of stateless routing, where it is not necessary for a node to perform maintenance functions for topological information beyond the one-hop neighborhood [11]. So geographic routing is highly feasible for large-scale networks than topological routing that need network-wide control message dissemination. Besides, geographic routing requires lower memory node usage by maintaining information locally. Although geographic routing research is recent than its topological routing counterpart, it gets special attention because of major improvement geographic information produces in routing performance.

In general, geographic routing has two parts: location service and geographic forwarding process. The former service determines the packet destination position to improve routing process while creating paths with source nodes using intermediary nodes. Consequently, the packet destination position can be added in the packet header so that intermediate hops know where the packet is bound for [12]. Similarly, geographic forwarding is performed in two modes; geographic greedy-forwarding mode and void-handling mode1. The greedy-forwarding mode defines a next-hop node for packet forwarding taking into account positions of the present node, neighboring nodes, and destination node. A node can get its position through a GPS receiver or through other localization algorithms. Neighboring node positions can be got from either a centralized neighborhood table at the node or through a distributed method via contention among neighboring nodes [13]. At last, the destination node position is included in the packet header from the source node. But if an intermediate node has a more accurate position of the destination, it can update the position in the packet header prior to forwarding it.

Geographic routing protocols are advantageous over traditional ad hoc routing strategies. To begin with, the geographic forwarding process allows path adaptation through selection of the next best hop, if a previously used intermediate node is unavailable. Because of the lack of a route creation process path selection has no need for table maintenance procedures other than intermediate neighbors and control packet propagation. Other advantages are related to its ability to use weight additional metrics for next hop selection and the route alteration node by accounting the QoS relation to neighbors, such as bandwidth and delay [14]. However, geographic routing has some challenges which are yet to be investigated [15]. The difficulty lies in controlling the required overhead for distributed location database service of geographic routing protocols. Although location based addressing is a convenient, naturally occurring, hierarchical address structure in relation to name, city, state and country, it could lead to excessive control overhead during high mobility.

In this paper it is proposed to investigate a wireless sensor network having 3 degrees of hops with different transmission powers .The goal of this work is to study the balance of overhead within WSN to save energy on the nodes. This is very important in WSN as they typically use battery which may not be possible to replace in many cases

II. Literature Review

Karp, et al., [16] presented Greedy Perimeter Stateless Routing (GPSR), a novel routing protocol to achieve scalability in wireless datagram networks. The proposed method uses the positions of routers and a packet's destination to make packet forwarding decisions. Greedy forwarding decisions in GPSR are based on the information about router’s immediate neighbors. When greedy forwarding is not possible, routing is achieved by forwarding the packet around the perimeter of the region. GPSR scales better in per-router state than the ad-hoc routing protocols with increase in the number of network destinations. New routes are identified using local topological information. Thus, GPRS produces a constant low volume of messages as mobility increases. The proposed GPSR protocol is simulated and its performance is compared with DSR. Simulation results show that the proposed GPSR protocol is scalable.

Roosta, et al., [17] proposed a Probabilistic Geographic Routing (PGR) for power aware routing in WSN. The proposed protocol forwards the packet to the next hop based on the local information only. Nodes keep track of its neighbors by beaconing. The node chooses a set of candidate nodes, to which the data packets are forwarded. The candidate nodes are allocated a probability proportional for its residual energy and link reliability. The proposed protocol was implemented in NS-2 simulator and compared with GPSR and

Probabilistic Flooding. Simulation results demonstrate the efficiency of the proposed protocol. PGR increases throughput and decreases end-to-end delay. The proposed method also increases the network lifetime and has built-in security advantage.

Yu, et al., [18] proposed Geographic and Energy Aware Routing (GEAR) algorithm that forwards query without flooding for WSN. The proposed protocol is based on energy aware algorithm for neighbor selection while forwarding data packets to destination region and restricted flooding algorithm to broadcast the packet in the destination region. The proposed GEAR also balances energy consumption due to which the network lifetime increases. The proposed method was evaluated and compared with GPSR in a discrete event-driven simulator. Simulation results show that the proposed protocol GEAR delivers 70 to 80% more packets than GPSR.

III. Methodology

In the proposed method, based on the network load carried by each node the transmitted power is automatically increased or decreased such that any node carrying more than 20% of the total network load will be assigned 5mw and nodes carrying less than 20% of the total network load are given 2 mw transmitted power. OPNET simulator was used to test the scenarios. There are 4 nodes which are 1 hop neighbour to sink, 3 nodes which are 2 hop neighbour to sink and 3 nodes which are 3 hop neighbours to sink. The setup is shown in Fig. 1.

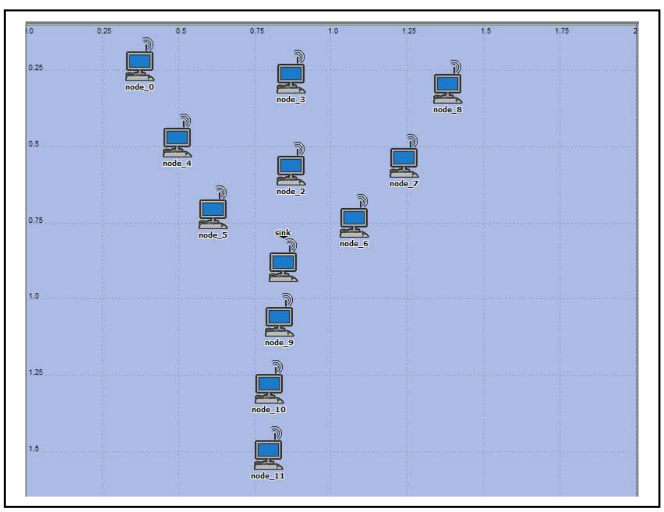

Fig. 1: The experimental setup

The maximum number of hops from the sink node to any node in the WSN is 3. The first hop consists of nodes 2,5,6 & 9 having high transmission power. The second hop consists of nodes 4,7 & 10 having less transmission power. The third hop consists of nodes 0,3,8 & 11 having very less transmission power. The third hop directs its path to the second hop, the second hop directs its path to the first hop and the first hop finally directs collected traffic to the final node i.e., sink node.

IV. Results and Discussion

The proposed methodology was compared with two more scenarios with each node having transmission power of 2mW and 5mW respectively. Simulations were carried out for 600 seconds. The throughput obtained from the three methods is shown in Fig. 2.

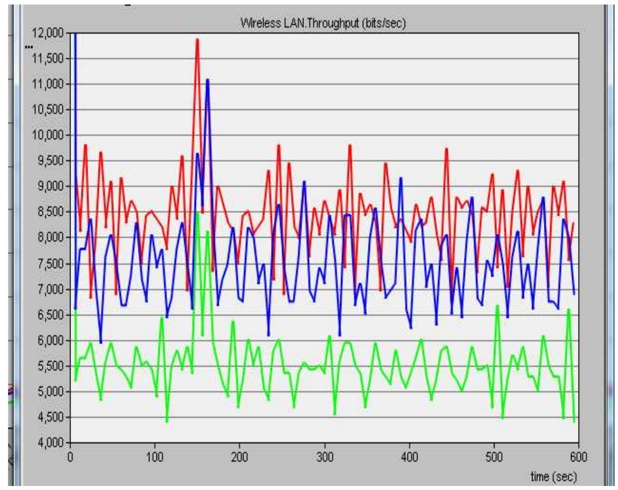

Fig. 2: The throughput of the three scenarios

The throughput in the proposed system (red) improves due to the lower congestion in the one hop neighbors. Similarly it can be seen that the throughput is lowest for scenario consisting of nodes with 2mW transmit power. The proposed method not only avoids congestion but also improves the load balancing. The average media access delay to reach the sink by each method is shown in Fig. 3. The proposed method shows a slight increase in the media access delay by roughly 10% which is manageable for the WSN.

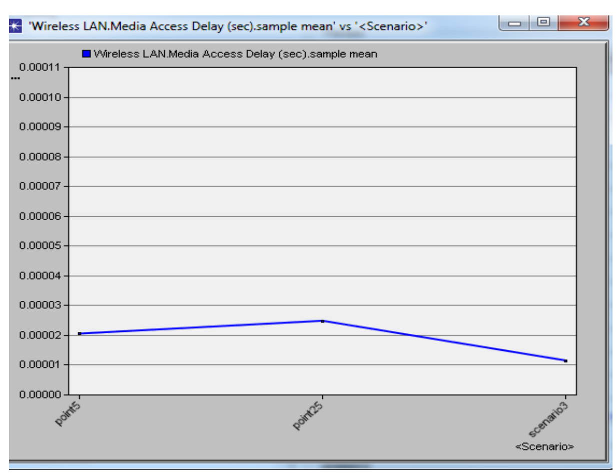

Fig. 3: The overall control traffic sent in the network for all the three scenarios

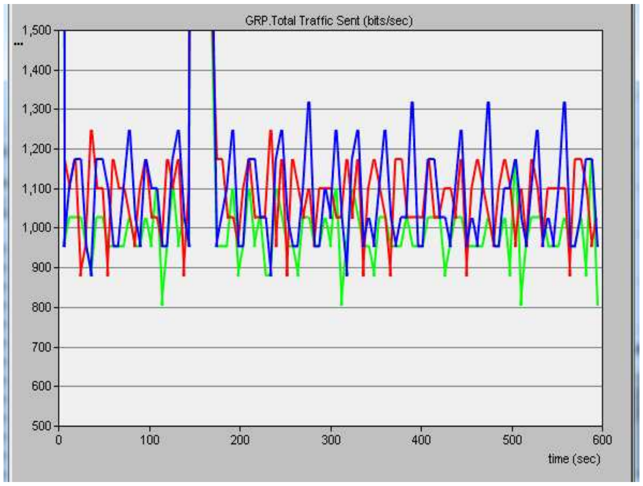

Fig. 4: The total routing traffic sent by nodes

The control overheads do not increase in the proposed method as seen in Fig. 4.

V. Conclusion

In this paper it was proposed to study the effect of transmission power in a wireless sensor network with multiple hops. A total of 3 hops to reach the destination were used for simulation. Two transmission power scenarios of 2mW and 5mW per node was considered and studied. A novel power scheme was proposed such that nodes carrying more than 20% of the network load were programmed at 5mW transmission power and others at 2 mW. The proposed method performs well compared to a network consisting only of 2mW or 5mW nodes. This work shows local optimization of nodes play a very important role in the overall performance of the network. Further work needs to be done to investigate larger networks consisting of many heterogeneous nodes.

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