MODIFIED SPEED PROTOCOL FOR WIRELESS SENSOR NETWORKS

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ABSTRACT

Nowadays wireless sensor networks (WSNs) have grown tremendously because of the easy deployment. In WSNs, sensor nodes monitor the area, and send the desired information to a remote sink for user access. Different protocols are used to select the route for data transmission in WSNs. These protocols might be different based upon WSNs applications and its architecture. In some of WSNs applications, data should be reached at the destination within the delay bound time; otherwise data will not be acceptable. T. He et al [26] have proposed a protocol called SPEED with considering delivery time. The main objective of SPEED protocol is to provide communication within given time. SPEED routing protocol is basically based on a single hop delay for real time traffic and energy metrics has not been considered as a key parameter during routing path selection. Consequently energy depletion of selected nodes will be faster. In present work the SPEED protocol is redefined incorporating the energy parameter as an additional factor and the modified protocol showed better results in terms of energy efficiency.

Keywords: *WSNs, Data routing in WSNs, QoS in routing protocol, SPEED routing protocol*

1 INTRODUCTION

Wireless sensor networks (WSNs) have got a lot of consideration for use in real environmental monitoring WSN applications, including sea depth measuring, metrological hazard detection, earthquake alerting, fire detection and enemy detection in battle field; some applications are summarized in [1]. WSNs are collection of a large number of sensor nodes having capabilities such as computation, sensing, and wireless communications.

Sensor nodes have limited resources in terms of energy, computation capability, and limited communication range that have been thoroughly discussed in [2]. Almost all the application areas where WSNs are deployed need to sense events in their surroundings and report them to a remote base station (Sink). In WSNs, routing protocols are used for communication between sensor nodes, so that sensor nodes can transmit their information to the remote Sink. Many protocols for routing the information in WSNs have been proposed in the literature [3]; and their function depends upon the type of network structure or the network operations for a specific application model. Almost all of these protocols can be categorized in 3 classes based on structure of the network: flat routing protocol, hierarchical routing protocol, and location-based routing protocol.

Flat-based routing protocols: All sensor nodes perform same function/role in the network. The protocols proposed in [4]-[12] belonging in this category.

Hierarchical-based routing protocols: In this category, sensor nodes perform different tasks in the network. For example, in clustered sensor network, cluster head nodes do some processing (aggregation) on the data to save energy. The protocols proposed in [13]-[21] belonging in this category.

Location-based routing protocols: In this category, sensor node selects the route for data transmission according to the location in the network. These protocols use the location information to send the data to destination instead of the whole network. The protocols proposed in [22]-[25] belonging in this category.

Up to now, most of the existing routing protocols for WSNs consider communication overhead reduction for improving energy efficiency. However, in some applications, the main requirement is a desired Quality of Service (QoS) in terms of bandwidth, delay and information throughput. However, these requirements will affect the selection of routing protocol for a specific application. For example, military applications: data should be reached at the destination within a specified time period.

The protocol 'SPEED' proposed in [26] is considered as most popular QoS routing protocol for WSNs. An extension of SPEED protocol has been proposed by Lee et al. called MMSPEED [27]. The protocol MMSPEED improves the SPEED protocol [26]. The MMSPEED guarantee message delivery in given timeliness by using multiple speeds and adopts probabilistic multipath forwarding strategy for reliability demands of different applications. But, these protocols did not consider the

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energy consumption. Since the network lifetime mainly depends on the battery life of sensor nodes, it is important to consider energy consumption while satisfying QoS requirements. In this research work we present an energy efficient protocol called modified SPEED protocol which is developed by incorporating energy consideration in the existing SPEED protocol, resulting enhancement in the network lifetime. Simulation results bring out that our modified SPEED protocol outperforms SPEED protocol in term of energy efficiency and overall throughput.

The rest of the paper is organized as follows. In Section 2, we discuss SPEED routing protocol in details and proposed improvements. In Section 3, we present the performance evaluation of proposed modified-SPEED protocol, and the paper is concluded in the Section 4.

2 'SPEED' PROTOCOL [26]

This protocol is a spatiotemporal communication protocol. The key difference from the other geographic location routing protocols is that SPEED takes into account the delivery time.

In SPEED protocol, each node maintains its neighbor list having information about one- hop neighbors and selects the path for data transmission using geographic forwarding. SPEED ensures a specific speed for each packet, which is used by nodes to calculate delay bound for that packet. This delay is evaluated as follows:

delay = distance between source to destination / speed **.(1)**

In this case the delay bound is proportional to the distance from source to destination. Furthermore, in congested networks, SPEED prevents voids. Figure 1 illustrates SPEED protocol, redrawn from [26].

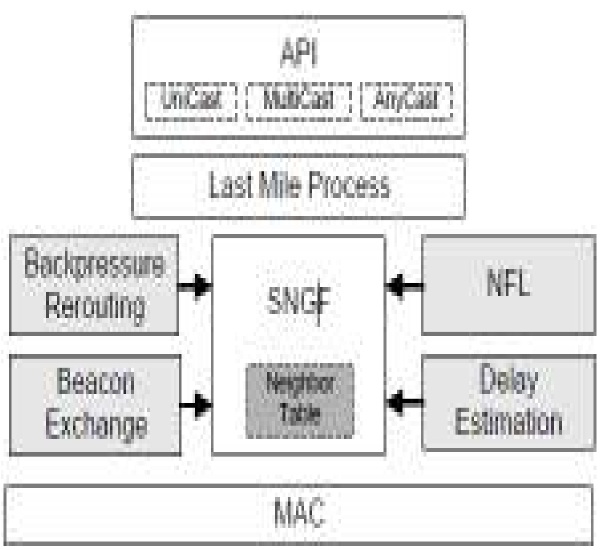

Figure 1: SPEED routing protocol [26]

There are four **API (application-levels):** (i) AreaMulti-castSend (ii) AreaAnyCast-Send (iii) Uni-castSend, and (iv) Speed-Receive.

The neighbor beacon exchange scheme provides information about its neighbors and their location. In SPEED, each node sends a beacon packet periodically to exchange information with its neighbors locally. On receiving beacon packet, the node maintains the list of neighbors with their information (i.e., NeighborID, Position, SendToDelay, ExpireTime). Position field contains the distance from each neighbor to the destination node.

When a node receives an ACK form its neighbor node as a reply of transmitted data packet, it calculates the delay bound by calculating the elapsed time during transmission of data packet and reception of ACK. SPEED uses single hop delay that is the delay across one route.

The SNGF chooses the neighbor node, which achieves speed requirement according to the calculated delay values. If SNGF did not find the neighbor node based on delay values, then it checks the relay ratio of the node.

The relay ratio of the node is provided by Neighborhood Feedback Loop (NFL) module. The NFL calculates the relay ration by looking the miss ratios of the neighbors of a node and is transmitted to the SNGF module. The packet will be dropped, when relay ratio of the node is less than a randomly generated number (i.e., b/w 0 and 1).

Backpressure-rerouting module prevents voids, if a node fails to find next hop node. In SPEED, this module is used to remove congestion by transmitting messages back to source and use new routes to reroute messages.

Although SPEED protocol achieves the goal end-to-end delay bound data transmission, but it does not consider energy of sensors which affects network lifetime.

2.1 Improvements Considering Energy

The existing SPEED protocol considers Quality of Service (QoS) parameters for delay bound. In original SPEED protocol, the routes are always taken based on delay bound from source to destination. In the existing SPEED protocol, energy efficiency is not taken in account. However, in WSNs, the energy efficiency is an important issue. Therefore, we propose a modified SPEED protocol for WSNs. In our proposed modified SPEED protocol, routing decision will be taken based on two metrics: remaining energy of neighbor node to balance energy load on sensor nodes and end-to-end delay to maintain QoS requirements. This called as weight and is calculated by adding delay with remaining energy of neighbor node. The Figure 2 illustrates the use of weight notion in modified SPEED protocol. (A is source node and D is destination node)

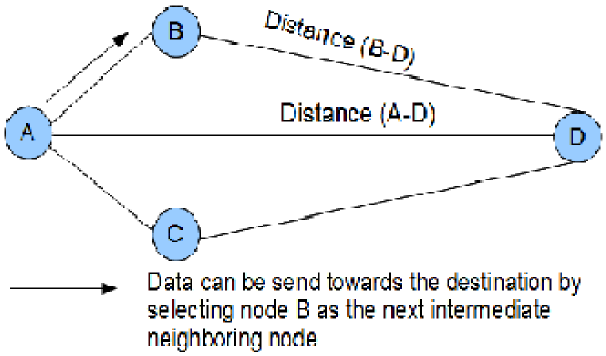

Figure 2: Modified SPEED protocol

Suppose, node A (source node) sends data packet to D (Destination node). **Node A will select its intermediate neighboring node according to estimated weight over link calculated in terms of energy strength of neighboring node. Following relationship was used to find the energy strength of each node.**

$$\text{weight} = \frac{e}{dv} \quad \text{.................. (2)}$$

where,

d = distance between intermediate neighboring node to destination node (m)

v = speed (m/s)

e = residual energy of intermediate neighboring node (J)

The sensor node with the greatest value (weight) will be next hop. As a result the sensor network lifetime is increased with greater throughput in QoS and energy load balancing way.

3 PERFORMANCE EVALUATIONS

3.1 Network Architecture

In the paper, network with 100 sensor nodes and single base station are deployed in area of 100 x 100 $m^{2.}$ All sensor nodes are homogeneous.

3.2 Simulator

WSNet simulator [28] is used as a simulation platform to evaluate the proposed. WSNet is the modular event-driven wireless network simulator, developed at the CITI Laboratory of INSA Lyon. It is largely similar to other event-driven simulators such as ns2, JiST, GloMoSim, GTNetS, omnet++, though it differentiates itself with various functionalities, a precise radio medium simulation and the simulated node internals. Node, environment and radio medium blocks are developed in independent dynamic libraries. Moreover, the addition of new models does not require modifying the core of WSNet and can be done easily.

3.3 Simulation parameters

Table 1. Simulation parameters

Parameter	Value
Time for Simulation	50 to 500 seconds
Environment area (m x n)	100 x 100 m^2
Number of Nodes	100 nodes
Node deployment	Random
Performance parameters	Remaining Energy, Packet reached at the destination
Type of Antenna	Omni-directional
Medium Access Control Layer	802.11
Energy at each sensor node (initially)	1 J
Energy to transmit and receive a packet	0.003 Joules
Transmission range	30 m
Packet size	128 bytes

3.4 Simulation Results

In this subsection, we show the energy efficiency of modified SPEED protocol by comparing with the original SPEED protocol. For the evaluation, we consider remaining energy and the number of packets reached at the destination. We run simulations for 50 times and plotted the average results in the graphs.

In first scenario, we compared the remaining energy of sensor nodes by varying simulation time in our proposed modified SPEED scheme to original SPEED scheme. We determine total residual energy of nodes (i.e., remaining energy of nodes) and considered that as the metric to prove energy efficiency of our proposed protocol. Figure 3 shows the simulation results.

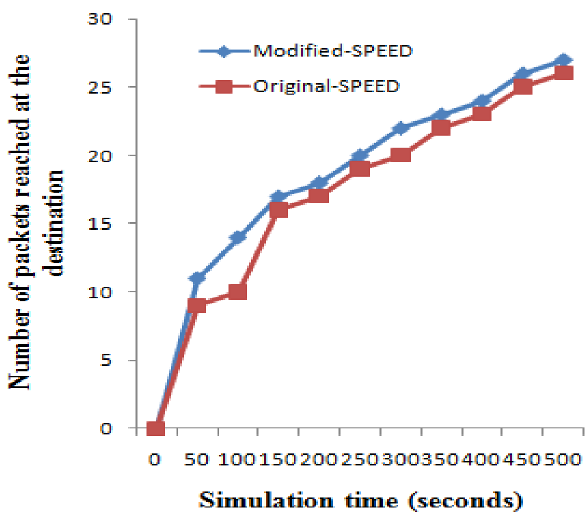

Figure 3: Total remaining energy

From Figure 3, it is proved that our proposed modified SPEED scheme saves more energy than the original SPEED scheme which will lead to an increase in the network lifetime.

In the second scenario we compared the packets reached at the destination by varying simulation time in our proposed modified SPEED scheme to original SPEED scheme. Figure 4 shows simulation results.

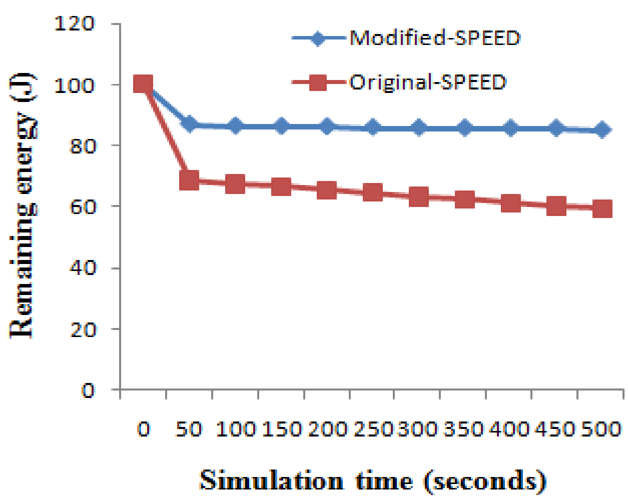

Figure 4: Packets reached at the destination

From Figure 4, it is proved that our proposed scheme is better than the original SPEED scheme.

4. CONCLUSIONS

In the paper, we have demonstrated most popular protocol for data routing in WSNs, called SPEED protocol that considers QoS parameters. Followed by an overview of SPEED protocol implementations, then we proposed a modified version of SPEED protocol. Through simulation results, we observed the performance of proposed protocol. Compared to the Original SPEED, 'Modified SPEED' conserves energy. Furthermore, the throughput (i.e., number of packets reached at the destination) of proposed protocol is more than the original protocol. That means the modified version of SPEED protocol outperforms the original version of SPEED protocol.

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