



ENERGY IMPROVED NODE DISJOINT MULTIPATH ROUTING PROTOCOL FOR WIRELESS SENSOR NETWORK

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Abstract

Sensor nodes in Wireless Sensor Networks (WSNs) are energy constrained. Minimizing consumed energy at the sensor nodes is one of the major design challenges in WSNs. Therefore, a number of routing schemes are designed that make efficient use of limited energy of the sensor nodes. It has been observed that utilization of same path is not optimal as considered for network lifetime. Hence multipath Routing protocol which maximizing the lifetime of the wireless sensor networks by spreading the traffic among the multiple paths. In the wireless sensor network different nodes take different amount of energy for transmitting the same data packets. So, Energy Improved Node Disjoint Multipath Routing Protocol (EINDMRP) is proposed. In this technique, to save energy residual energy and energy drain rate of each sensor node is calculated. Based on this energy metric the path has to be chosen which improve the lifetime of networks.

Keywords: Multipath routing protocol, node-disjoint, security, wireless sensor network.

1 INTRODUCTION

WIRELESS SENSOR NETWORKS (WSNs) are widely used in many application fields such as health, military, home and industry. Capabilities of sensor nodes are given as data sensing, processing and communicating with other nodes using wireless links. Sensor nodes are able to sense physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants. WSN consists of densely and randomly deployed sensor nodes and sink node. Sink node is dedicated node used as destination for messages generated by the sensor nodes [1]. Energy sources in WSNs are limited and un rechargeable. Moreover, sensor nodes are deployed over large geographical area; it is not possible to recharge or replace these batteries. Hence, Energy conservation is one of the main design goals which determine the lifetime of WSNs. Lifetime of WSN is given as time spent until first node dies from deployment of network. Energy Improved Node Disjoint Multipath Routing Protocol (EINDMRP) is proposed. It is a proactive protocol which finds the multiple paths between the source and destination based on the residual energy and energy drain rate of the node.

2 ENERGY IMPROVED ROUTING

In EINDMRP N number of identical wireless sensor nodes are consider that are deployed randomly with single destination node. All the sensor nodes have the property of sensing the information and transmit to destination (sink node) over multipath. Each sensor node has a fixed transmission range R . Node-disjoint paths are selected by source node between the source and destination to route the sensed data. To prevent the formation of paths with loops node cannot communicate with the previous stage nodes Sti-1. The working of EINDMRP is discussed using three phases: (i) route construction phase (ii) energy calculation of node and (iii) data transmission phase.

2.1 Route Construction Phase in EINDMRP

Wireless sensor networks consist of small nodes with sensing, computation and wireless communications capabilities. Each

sensor node in the network broadcast Route CONstruction (RCON) packets between the nodes. EINDMRP is a proactive node disjoint multipath routing protocol. Exchanging of RCON packets in multipath is initiated by source node in order to maintain its own routing table. Energy Calculation in EINDMRP

1. Evaluation of Residual Energy of Node

Residual energy of each sensor node is calculated by reducing total energy consumed in the node from initial energy or battery capacity. The total energy consumed by each sensor nodes is calculated by sum of energy spent in receiving (E_{rx}), transmitting (E_{tx}), sampling data (E_d), sensing of data (E_{sen}) and energy spent in sleeping (E_{sleep}) mode.

$$E = E_{rx} + E_{tx} + E_{sen} + E_d + E_{sleep} \quad (2.1)$$

The energy consumed by transmitting (E_{tx}) is the length of the packet with the preamble times the packets rates,

$$E_{tx} = t_{tx} C_{txb} V \quad (2.2)$$

$$\text{Where, } t_{tx} = t \times (L_{preamble} + L_{packet}) t_{txb}$$

t_{tx} is the time to switch the transmitter, $L_{preamble}$ is the preamble length (bytes), L_{packet} is the packet length (bytes), t_{txb} is the time (s) to transmit 1 byte, C_{txb} is the current required to transmit 1 byte, V is the supply voltage.

Receiving data from neighbors shortens a node's lifetime. The total energy consumed by receiving data (E_{rx}) is given by

$$E_{rx} = t_{rx} C_{rxb} V \quad (2.3)$$

$$\text{Where, } t_{rx} \leq n t_r (L_{preamble} + L_{packet}) t_{rxb}$$

$$L_{preamble} \geq \lceil t_r / t_{rxb} \rceil$$

t_{rx} is the time (s) to switch the receiver, n is the neighborhood size of the node, t_{rxb} is the time (s) to receive 1 byte data, C_{rxb} is the current required to receive 1 byte data.

The energy spent in sensing the channel is the energy of a single channel sample times the channel sampling frequency.

$$t_{sen} = (t_{int} + t_{on} + t_{rx/tx} + t_{samp}) \times (1/t_i) \quad (2.4)$$

$$E_{sen} \leq E_{sample}(1/t_i)$$

Where, t_{int} is the initialize sensor node, t_{on} is the turn on sensor node, $t_{rx/tx}$ is switch to rx/tx time, t_{samp} is the time to sample data.

The energy associated with sampling data E_d , is

$$E_d = t_d C_{data} V \quad (2.5)$$

$$t_d = t_{data} \times r$$

t_d being the time of sampling data, t_{data} is the sample sensors, r is the sample rate (packets/s), C_{data} is the current of sample sensors (mA), V is the voltage.

The node must sleep for the rest of the time, so the sleep time t_{sleep} , is given by

$$E_{sleep} = t_{sleep} C_{sleep} V \quad (2.6)$$

$$t_{sleep} = 1 - t_{rx} - t_{tx} - t_d - t_{sen}$$

The Residual energy of sensor node (E_r)

$$E_r = C_{batt} - E \quad (2.7)$$

The lifetime of the node (L) depends on the capacity of the battery (C_{batt}) and the total energy consumed by the battery (E).

$$L = \frac{C_{batt} \cdot V}{E} \quad (2.8)$$

2. Evaluation of Drain rate

Draining rate of node is given as the amount of energy spent during each transmission. In order to get maximum lifetime of node, drain rate of node should be minimum. Energy drain rate of

$$\text{Energy drain rate of path} = \sum_{i=1}^n E_{dr_i} \quad (2.9)$$

2.2 Data transmission phase in EINDMRP

Selection of path between the source and destination is depending on maximum residual energy and minimum drain rate of sensor node.

$$PP = \max\{E_r\} \ \&\& \ \min\{\sum_{i=1}^n E_{dr_i}\} \quad (2.10)$$

3 RESULT AND DISCUSSION

The EINDMRP model is implemented using Network Simulator 2.35. The EINDMRP model is compared with the EENDMRP model.

3.1 Description of Simulation Area

The simulation area range is $200 \times 200 \text{ m}^2$ with 10 to 50 number of sensor nodes. Grid topology is considered with 802.15.4 MAC layer and two ray ground radio propagation models. Drop tail queue type is used to queue the packet in buffer queue limit is 100. Omni direction antenna is used which has transmission range of 15m. Constant Bit Rate (CBR) at the size of 512 bits is used as packet size. Rate of transmission is 100 KBPS. Run time of simulator is 500s. Initial energy of sensor node is considered as 5J. Transmission power of node is $36.00 \text{ e}^{-3}\text{W}$, Reception power is $20.00\text{e}^{-3}\text{W}$, idle power is equal to power consumed during reception $20.00\text{e}^{-3}\text{W}$ and power consumption during sleep mode of sensor node is $1.00\text{e}^{-6}\text{W}$.

3.2 Performance Evaluation

1. Packet Delivery Fraction

Packet Delivery Fraction (PDF) is defined as the ratio of the data packets delivered to the destinations to those generated by the constant bit rate (CBR) sources.

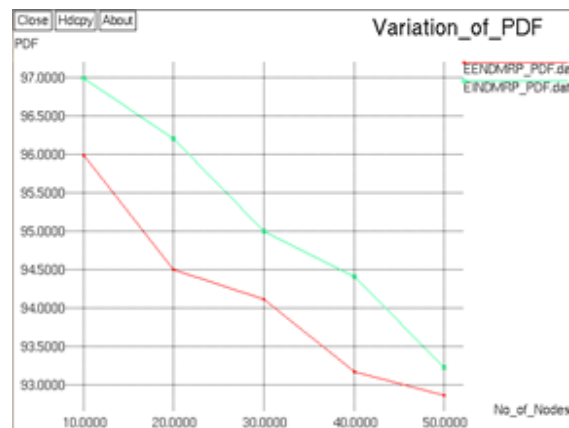


Figure 3.1: Variation of PDF with Number of Nodes

2. Average End-to-End Delay

Delays due to buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times of data packets are all included in average end-to-end delay.

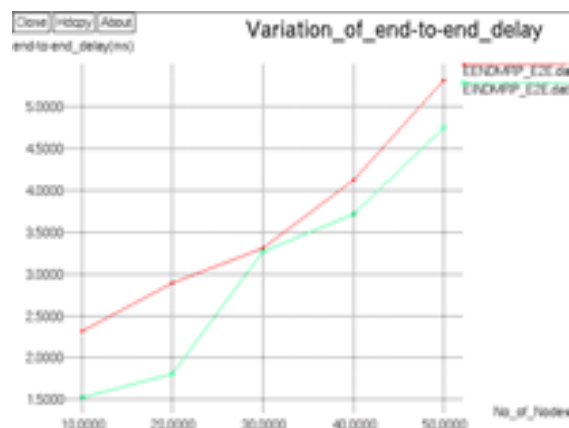


Figure 3.2: Variation of End-to-End Delay with Number of Nodes

From Fig 3.2 there is $2.319e^4$ ms and 5.3064 ms end-to-end delay in EENDMRP when number of node is 10 and 50. But, end-to-end delay in EINDMRP is $1.527e^4$ ms and $4.743e^4$ ms when the number of nodes is 10 and 50 respectively. There is reduction of delay in EINDMRP as compared to EENDMRP.

3. Average Energy Spent

Average energy spent by the sensor nodes in the network is one of the important metrics to evaluate energy efficiency of the proposed routing protocol.

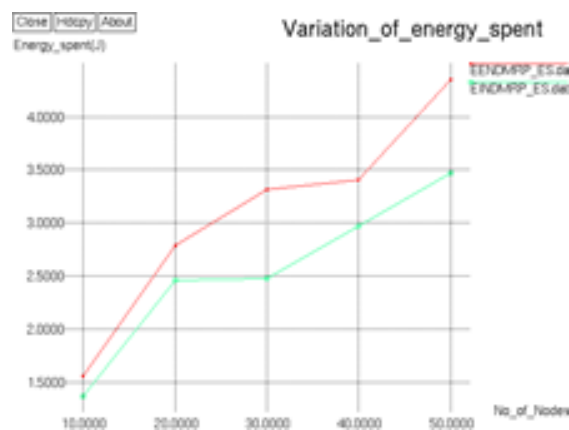


Figure 3.3: Variation of Energy Spent with Number of Nodes

4. Network Lifetime

The sensor node's lifetime is determined by its overall energy consumption. If the energy consumption is minimized, then the lifetime is maximized. The lifetime of the sensor node is inversely proportional to the drain rate of the sensor node. Lifetime of 10 and 50 nodes in EENDMRP is 6.944 hours and 1.468 hours and in EINDMRP lifetime of node increased to 7.085 hours and 3.681 hours. The lifetime of node in EINDMRP is increased when compared to the EENDMRP model.

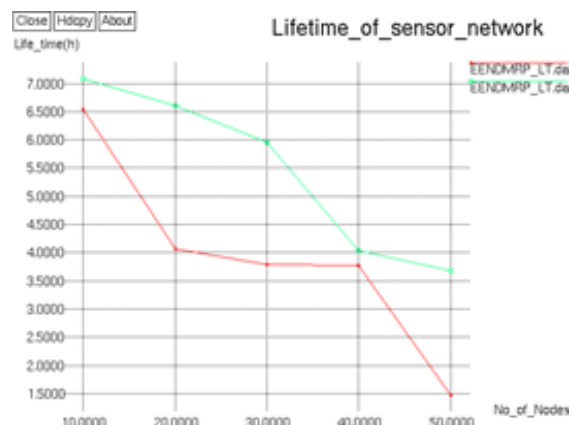


Figure 3.4: Variation of Lifetime with Number of Nodes

4 CONCLUSION

The Energy Improved Node-Disjoint Multipath Routing Protocol (EINDMRP) increased the network lifetime. The effective routing metrics like residual energy, drain rate and shortest path are used in selecting the primary path in the EINDMRP. EINDMRP performs better than EENDMRP and AOMDV protocol. There is an improvement in packet delivery fraction, reduction in end-to-end delay, reduction of normalized routing load and energy spent is reduced than EENDMRP protocol. The lifetime of sensor node in network is increased in EINDMRP than in EENDMRP.

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