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# Scalable and Cost Effective Solution to Minimum Cost Forwarding in WSN

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**Abstract:** *This paper introduces an improved routing protocol for wireless sensor networks (WSN), built on the basis of fundamental concepts in source based minimum cost forwarding protocol. Neither routing tables nor network topology information is maintained at the sensor level, which makes the proposed protocol part of the reactive routing protocol class. Despite the lack of routing information at the sensor, the packets from the sink node to sensors, and vice versa, always accompany the optimal communication path with minimal cost. Simulation results have proven that the proposed protocol performs better than existing protocol, and nodes always route the packets through the optimal path up to destination. In fact, according to the energy consumption, packet delivery ratio, end to end delay and throughput found by simulation, this protocol improves on the existing protocol for applications where the sink node, acting as a server or base station (BS), generates significant amounts of mesh traffic. All results are based on simulations and data treatment performed with Network Simulator (NS2).*

**Keywords:** *Minimum Cost Forwarding, Performance Parameter, Source Based Routing, Wireless Sensor Networks.*

## I. Introduction

Recent progress in wireless communication has enabled the development of low-cost, low-power, multifunctional sensor nodes, which furnish the solution to a variety of real-world problems. Sensors are low-cost tiny devices with limited memory, computational capability, and ability. Devices in sensor networks have a much smaller memory, constrained energy supply, less operation and communication bandwidth. Topologies of the sensor networks are constantly changing due to a high node failure rate, periodically shutdown, and abrupt communication interferences.

Wireless Sensor Network differs from other types of the network because they bridge the gap between the physical andthe virtual world. Due to the nature of the applications supported, sensor networks need to be densely deployed. In addition, energy conservation becomes the essence of focus due to the limited battery capacity and the impossibility of recharge in the hostile environment.

Routing protocols are classified on the basis of whether they are proactive and reactive protocols [1]. Proactive routing protocols keep track of paths to all destinations in routing tables. LEACH and PEGASIS are two examples of proactive routing protocols. Unlike proactive protocols, reactive protocols assume routes on demand and avoid saving information about the mesh topology. Flooding, Gossiping and Minimum Cost Forwarding [2] [3] are examples of reactive protocols.

This paper offers a reactive routing protocol where sensors have no information about the mesh topology, but packets from sensors to BS or vice-versa, always communicate over optimum paths with minimal cost. Since the proposed concept is the improvement in Source Routing for Minimum Cost Forwarding Protocol [4].

## II. Related Work

The Minimum Cost Forwarding protocol is a secure method for routing packets that have been proposed by Ye et al. [2] as an efficient protocol appropriate for simple WSN with limited resources and does not necessitate the storage of routing tables at the sensor nodes establishing optimal routing paths with few message exchanges and is scalable and simple to enforce. The Minimum Cost Forwarding is a cost field based approach and exploits the fact that the routing direction of data, flowing from sensors to sink, is always recognized and that cost is always minimized. So a sensor need not have a unique ID for maintaining a routing table. In fact, the cost of sending a message to the sink is the sole information required by a node to only implement the protocol. The simplicity of the Minimum Cost Forwarding is an advantage for sensor nodes with limited processing capability and/or memory. The link cost can be of any form such as hop count, consumed energy or delay.

In this method, sensor nodes have neither routing tables nor information about the mesh topology. For the BS to send information to a dedicated sensor, destination and routing path must be specified in the BS node like in source based routing (SBR) [5]. To implement source routing, the packet contains the address of each node along the routing path. Source routing requires decoding the address of all nodes and routing paths from source to destination, as is done with protocols like Dynamic Source Routing (DSR) [5] [6] for wireless ad hoc network and Link Quality Source Routing (LQSR) developed by Microsoft for wireless mesh networks. DSR and LQSR protocols are reactive approaches and do not call for routing tables. These protocols define a route on-demand, when the source node wants to transmit data to the destination node and hold on the routing information while transmitting.

The source node establishes a route between source and destination nodes by transmitting a Route Request packet. When the destination node gets the Route Request packet, it responds with Route Reply packet to the source node. This packet transmits the routing path from the source node to the destination node. During the communication between the nodes, the intermediate nodes route the packets by using the routing information which is conveyed in the packet headers.

A higher connection frame-up delay in comparison with table-driven protocols, and the absence of a mechanism for local repair of failed connections are some of the disadvantages of the DSR and LQR protocols. The major difference between proposed protocol and other protocols is that proposed protocol is more scalable and cost effective.

## III. Simulation

The simulation will be performed using Network Simulator (NS-2). The model will be in a rectangular area of 4000m x 4000m with 100 nodes. During simulation, the user will enter the Transmitter node and Receiver node. Node 0 will start calculating the distance of all the nodes. Nodes will start the transmission and in case of mobility, within transmission mobile nodes will change their positions resulting change in configuration and topology of the network which will further affect the traffic and transmission.

Sensor Node selects the path by which transmission has minimum cost and more scalability. It is checked by the performance parameter which are as follows:

- Packet Delivery Ratio
- Normalized Routing Load
- Throughput
- Energy Consumption and
- End to End Delay

The model parameters will be used are as follows:

**Table 1** Model Parameters

| Parameters | Value |
|---|---|
| Simulator | NS2 |
| Channel | Channel / Wireless Channel |
| Propagation Model | Propagation / Two Ray Ground |
| Network Interface | Phy/Wireless Phy |
| MAC Type | Mac |
| Interface Queue Type | Queue / Droptail / Pri Queue |
| Link Layer Type | LL |
| Antenna | Antenna/Omni Antenna |
| Maximum Packet in Interface Queue Type | 50 |
| Routing Protocol | ISMCFP |
| Simulation Area | 400 x 400 |
| Simulation Time | 25sec |
| No. of mobile nodes | 30, 50, 60, 80, 100 |
| Energy | Energy Model |
| Energy in Joules | 1000 |
| Packet Size | 780 |
| Speed of Mobile nodes | 2m/s |

### 3.1 Packet Delivery Ratio

It can be defined as the ratio that is used to calculate the number of packets received by Receiver node to the number of packets transmitted by Transmitter node.

**PDR = ∑ Number of packets received/ ∑ Number of packets sent**

The packet delivery ratio of ISMCFP shows better performance than the SMCFP. The ratio of Packet Delivery in ISMCFP is almost increasing with increase in number of nodes.

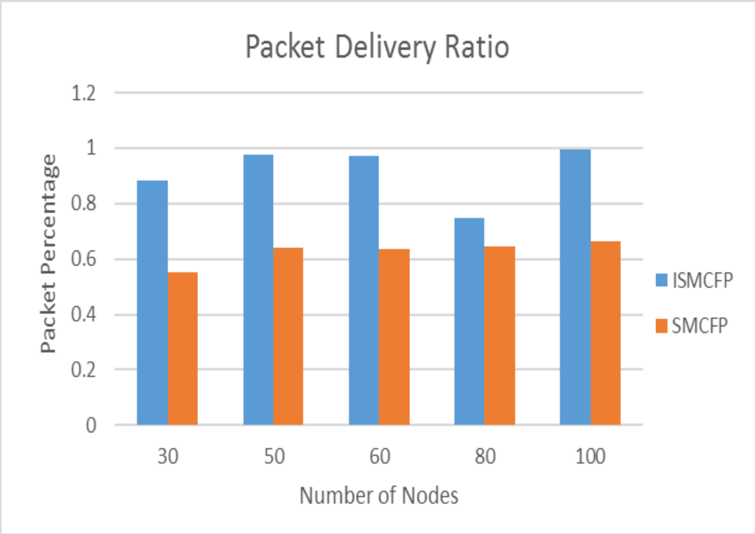


**Fig. 3.1** Packet Delivery Ratio

### 3.2 Normalized Routing Load

Normalized Routing Load is defined as the ratio of number of routing packets sent over the network to the total number of data packets received.

**NRL = □ Number of Routing Packet Sent/ □ Number of Packet Received**

The normalized routing load of ISMCFP is very less as compare to SMCFP.

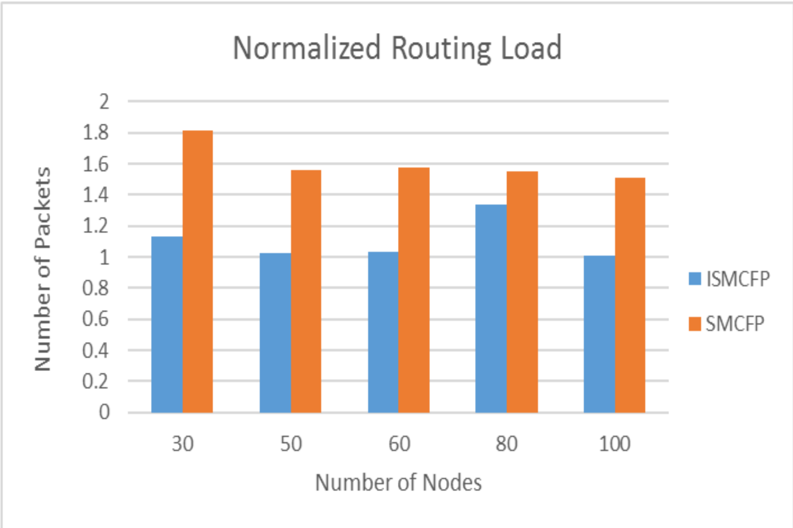


**Fig. 3.2** Normalized Routing Load

### 3.3 Average Throughput

It is the calculation of number of packets received by receiver in data transmission time. It is represented in bits/bytes per second.

**Throughput = Number of Packet Received / Transmission Time (kbps)**

The Throughput of ISMCFP is much higher than SMCFP. The value of throughput is almost increasing with increase number of nodes.

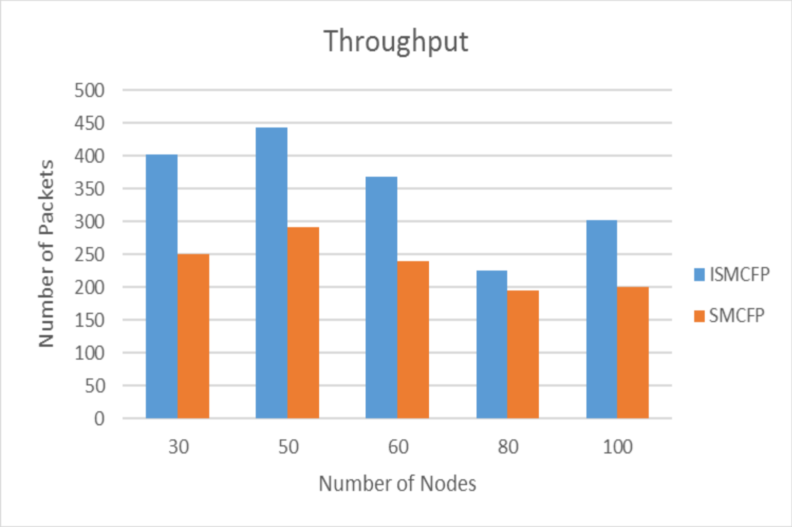


**Fig. 3.3** Throughput

### 3.4 Average End to End Delay

It is the total time taken by packet from source node to the destination node.

**Av. End to End Delay = (Start time(ij) - End time(ij) ) / N**

Where ij is the time when sending/receiving of packet j at node i starts/stops and N is the total number of nodes. The average delay in ISMCFP is negligible as compared to SMCFP. The average delay is decreasing with increase in number of nodes.

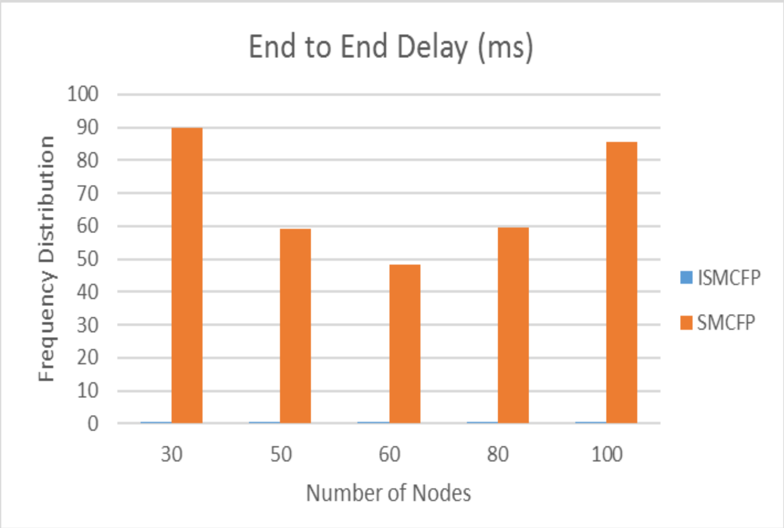


**Fig. 3.4** End to End Delay

### 3.5 Total Energy Consumption

The energy model represents the energy level of nodes in the network. The energy model defined in a node has an initial value that is the level of energy the node has at the beginning of the simulation. This energy is termed as initial Energy. In simulation, the variable "energy" represents the energy level in a node at any specified time. The value of initial Energy is passed as an input argument. A node loses a particular amount of energy for every packet transmitted and every packet received. As a result, the value of initial Energy in a node gets decreased. The energy consumption level of a node at any time of the simulation can be determined by finding the difference between the current energy value and initial Energy value. If an energy level of a node reaches zero, it cannot receive or transmit anymore packets. The amount of energy consumption in a node can be printed in the trace file. The energy level of a network can be determined by summing the entire node's energy level in the network.

**Energy Consumption = Current Energy Value – Initial Energy value**

Total Energy Consumption of ISMCFP is almost decreases as compared to SMCFP. The value of energy decreases with increase in number of nodes.

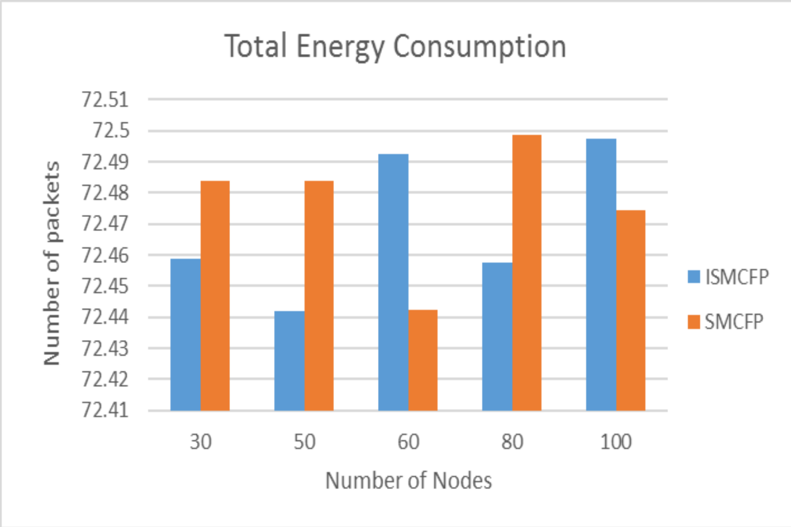


**Fig. 3.5** Total Energy Consumption

## IV. Conclusion

This paper identifies a routing protocol for wireless sensor networks based on the inclusion of routing information in the packets when the minimum cost forwarding method is practiced. With the previous protocol, and except for the BS node, there is no need to maintain explicit forwarding path tables in the intermediate nodes. The routing table on BS is formed in the network setup phase and updated after any modification in network topology reported by sensor nodes. The intermediate nodes to acquire routing information from the packets originating from the BS without having to recognize the network topology. In comparison with the existing protocol, the simulation results indicate that not just the proposed protocol has negligible end to end delay and normalized routing load, high throughput and ratio of packet delivery than existing protocol, but also dissipates less energy.

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