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EFFICIENT POSITION BASED PACKET FORWARDING PROTOCOL FOR WIRELESS SENSOR NETWORKS

[1] B.ANITHA, [2] DR.A.RAJARAM
[2] Research Scholar, Karpagam University, Coimbatore, India
[1] Associate Professor, Department of Electronics and Communication Engineering,
Karpagam University, Coimbatore, India.
E-mail: [1] anithakuphd@gmail.com, [2] gct143@gmail.com,

ABSTRACT

In Wireless Sensor Networks, sensor nodes are controlled by either base station or without bases station. In our scheme, the sensor nodes are not depends on the base station. Once the sensor node sent a packet to the destination node, the residual energy is calculated through the multipath routing approach. In this research work, an Efficient Position based Packet Forwarding Protocol (EPPFP) to increase packet delivery rate based on the position of sensor nodes. It consists of three phases. In first phase, multipath routing is implemented based on link with high packet forwarding capacity. In second phase, packet forwarding scheme is implemented to achieve high packet delivery rate and to schedule the packet transmissions to multiple packet forwarders. In third phase, packet forwarding verification is proposed to verify whether or not packets are successfully forwarded. Based on simulation results, the proposed EPPFP achieves high delivery ratio, increased network lifetime, less delay, minimum overhead and energy consumption in terms of mobility, time and number of nodes than existing schemes namely.

Keywords: *Packet forwarding, Packet verification, Network lifetime, End to End delay, Mobility, Communication Overhead, Energy Consumption, Packet Delivery ratio and pause time.*

1. INTRODUCTION

A. Wireless Sensor Networks (WSNs)

In recent years, wireless sensor networking is an emerging technology that has a wide range of potential applications including environment monitoring, smart spaces, medical systems and robotic exploration. Such a network normally consists of a large number of distributed nodes that organize themselves into a multi-hop wireless network. Each node has one or more sensors, embedded processors and low-power radios, and is normally battery operated. Typically, these nodes coordinate to perform a common task.

A wireless sensor network (WSN) consisting of many hundreds of low-cost devices, may for reasons of practicality and cost be deployed for multiple monitoring and data gathering tasks. These tasks would be unlikely to have the same requirements and priority with respect to the timeliness of data delivery or generally with respect to their quality of service (QoS) or, more generally, their quality of information.

B. Need for Position based Packet forwarding Protocol

Routing protocols in wireless sensor networks can be generally categorized into link based and location based routing methods. Link based routing uses the link information between nodes, and can be further divided into proactive and reactive routing. In proactive routing methods, each node keeps information of the network topology and finds the shortest route whenever it needs to transfer a packet. Nodes using reactive routing methods flood the network when needed to send a packet. The sink node determines the optimal route based on its specific algorithm, and then initiates a path between the source and the sink. This path is used until a disconnection is discovered, where the source initiates a flood to search for another path. When the network is highly mobile, like in a vehicular network, topology based methods are usually unstable since the link path is not sustained

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over a substantial period of time. The source repeatedly floods the network to initiate new paths, which increases the overall overhead in the network.
Position based routing methods assumes that each node has geographical location information of itself, its neighbors and the destination. When a message is needed to be sent, each node forwards the packet in a greedy fashion to the location of the final destination. Usually the requirement of a location service for the sensor nodes is an expensive assumption for wireless sensor networks.

2. RELATED WORK

In this paper [1], it was presented a position–based energy efficient greedy forwarding scheme for greedy forwarding in mobile wireless sensor networks. The forwarding node closest to the destination which also has greatest remaining energy is selected as the next node and the computation is processed by in a distributed manner. Each mobile node decides whether the node itself should be a relay node or not using a qualification score.

The focus of this paper [2] is to explain the use of trust and energy values for successful data delivery in WSN. Location based protocol uses trust values, energy levels and location information for finding the best paths towards the destination. Trust value of a node is provided by the Adaptive Trust Management Protocol (ATMP), which computes trust based on intrusion detection techniques.

In this paper [3], a Location Based Opportunistic Routing Protocol (LOR) was proposed to addresses the problem of delivering data packets for highly dynamic mobile ad hoc networks in a reliable and timely manner. It takes advantage of the stateless property of geographic routing and the broadcast nature of wireless medium. When a data packet is sent out, some of the neighbor nodes that have overheard the transmission will serve as forwarding candidates, and take turn to forward the packet if it is not relayed by the specific best forwarder within a certain period of time.

This paper [4] considers both sides of Link-quality and Energy (PBLE), an optimal routing protocol that balances modified link-quality, distance and energy. Including this, a node scheduling method called PBLE is proposed which achieves a longer lifetime than previous routing protocols and is more energy-efficient. PBLE uses energy, local information and both sides of PRR in a 1-hop distance.

In this research work [5], energy efficient inter cluster coordination protocol was developed for the wireless sensor networks has been proposed. Based on the topology, longevity and the scalability of the network, the network performance can be improved. Clustering sensor node is an effective topology for the energy constrained networks. So cluster based algorithm had been developed in which different levels of clusters are considered on the basis of received signal strength to recognize the distance of the clusters from the Base Station and to determine the number of cluster coordinators to make routes for the Cluster Head to transmit the data.

In this paper [6], new forwarding algorithm was proposed based on the Chinese Remainder Theorem. This proposed technique significantly reduces the energy consumed for each node and consequently improves network life time. This approach is also used to reduce the computation time.

This paper [7] focused on anycast packet-forwarding scheme that reduces the event-reporting delay and prolongs the lifetime of wireless sensor networks employing asynchronous sleep–wake scheduling. Specifically, two optimization problems are focused. First, when the wake-up rates of the sensor nodes are given, an efficient and distributed algorithm is developed to minimize the expected event-reporting delay from all sensor nodes to the sink. Second, using a specific definition of the network lifetime, lifetime-maximization problem is handled to optimally control the sleep–wake scheduling policy and the anycast policy in order to maximize the network lifetime subject to an upper limit on the expected end-to-end delay.

In this paper [8],a light-weight opportunistic forwarding (LWOF) scheme was proposed to mitigate the impact of highly dynamic topology on reliable data delivery in wireless sensor networks. Differing from other recently proposed schemes, it neither employs historical network information nor a contention process to select a forwarder prior to data transmissions. It takes advantage of the preamble in MAC protocols and dual channel communication to remove the overhead of making a forwarding decision prior to data transmission.

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In this paper [9]. a novel wireless sensor routing protocol called Self-Selecting Reliable Paths (SRP) was proposed for Wireless Sensor Network (WSN) routing, that addresses both challenges at once. It is evolved from the Self- Selecting Routing (SSR) protocol which is essentially memory-less. In the first generation of SSR protocol each packet selects the forwarding node at each hop on its path from the source to destination. The protocol takes advantage of broadcast communication commonly used in WSNs as a communication primitive. It also uses a prioritized transmission back-off delay to uniquely identify the neighbor of the forwarder that will forward the packet.

In this paper [10], the event-reporting delay was reduced and the lifetime of wireless sensor networks was improved using anycast packet forwarding scheme that employs asynchronous sleep–wake scheduling.

In this paper [11], the delay of event-driven wireless sensor networks was optimized, for which events does not occur frequently. In such systems, most of the energy is consumed when the radios are on, waiting for an arrival to occur. It was used that Sleep-Wake up Scheduling to prolong the lifetime of this energy constrained wireless sensor networks by optimization of the delay in the network but this scheme could result in substantial delays because a transmitting node needs to wait for its next-hop relay node to wake up.

In this paper [12], Self-Localized Packet Forwarding Algorithm was proposed to control redundancy in WSNs. The proposed algorithm infuses the aspects of the gossip protocol for forwarding packets and the end to end performance.

In this paper [13], an optimal path forwarding is proposed for real time routing protocol. It uses the optimal combination of packet velocity, link quality and remaining power in order to forward the real-time packet from the source to the destination. The optimal path forwarding is applied to select the optimal forwarding choice based on velocity of a packet moving through one-hop, the link quality and remaining power (remaining battery voltage) for every one-hop neighbours.

In this paper [14], it was proposed that new efficient routing protocol, called multi-path routing (MPR) protocol, for Underwater Wireless Sensor Networks to improve the transmission delay. Multipath is utilized during the path construction from the source node to the destination node. Each multi-subpath is a sub-path from a sending node to its two-hop neighboring node, called receiving node, by one more relay nodes, where these relay nodes simultaneously are neighboring nodes of sending and receiving nodes.

In this paper [15], a grid-clustering routing protocol was proposed that provides scalable and efficient packet routing for large-scale wireless sensor networks. The sink proactively, dynamically and randomly builds a cluster grid structure. Only small part of all sensor nods will participate in election of cluster heads. It can distribute the energy load among the sensors in the network, and provide in-network processing support to reduce the amount of information that must be transmitted to the sink.

In this paper [16], a novel multi-relay beaconless position-based packet forwarding protocol was proposed for WSNs. It couples the use of an OFDM-based PHY with position-based routing to create an improved end-to-end performance over traditional beaconless protocols. Including with this, a statistical framework had been provided to study the hopping dynamics and behavior of the protocol.

The paper is organized as follows. The Section 1 describes introduction about WSNs, Need for position based packet forwarding protocol. Section 2 deals with the previous work which is related to the multipath routing and position based packet forwarding scheme. Section 3 is devoted for the implementation of proposed protocols. Section 4 describes the performance analysis and the last section concludes the work

3. IMPLEMENTATION OF PROPOSED ALGORITHM

In this proposed packet forwarding scheme, multipath routing is proposed to improve the load balancing and delivery rate based on position of sensor nodes. Packet forwarding scheme is proposed to increase packet delivery ratio and reduce the packet loss rate. Packet forwarding verification is implemented based on position of sensor node and independent of anchor node. The schemes are explained below.

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A. Proposed Multipath Routing Scheme

It is intended to forward packets from well-behaving nodes, which respect to rate bound, to the honest next hops that have relatively high trust values.

1. When a source s wants to transmit a packet towards a destination d for the first time, it establishes a shared secret with a local anchor via a cryptography-based link layer protocol. It also queries the anchor to get the verified geographic information of the neighbors in a certain range, e.g., twice its radio range, if it does not have the information already. The location information can be encrypted and authenticated using the shared key.
2. The source broadcasts a transmission initiation packet, which can be an authenticated RTS (Request To Send) packet including the source and destination locations.
3. Upon receiving the initiation packet, a neighbor verifies the authenticity and integrity of the received packet and adds the source and destination information to the routing table. In addition, it returns an authenticated CTS (Clear To Send) packet to s.
4. The source s verifies the authenticity of the CTS packet received from the neighbor. If the verification is successful, it adds the ID and location information of the neighbor to the routing table unless it already exists.
5. Compute the probability P_i of forwarding a packet to a one hop neighbor i that is the set of nodes that are geographically closer to d than s is and its trust level T_i is greater than or equal to the threshold θ_1. Specifically, we set $P_i = T_i/\sum_{i=1}^{N} T_i$ where N is the cardinality of the forwarding sensor node. Given $\{P_1, P_2, \ldots, P_N\}$, s independently selects k neighbors in FS to which it will forward the packet where k is the required level of redundancy. If the source detects that a neighbor node i has successfully forwarded a packet towards d, it will increase the trust level of node i:

$$T_{ik} = \begin{cases} T_i + \lambda t & T_i + \lambda t \le 1 \\ 1 & otherwise \end{cases} \qquad (1)$$

where λt is the specified step size, e.g., 0.01.

6. The source selectively floods the packet to the k neighbors and overhears them, while waiting for the corresponding ACKs. If s overhears a neighbor forward a packet, it checks whether the packet has been forwarded to a legitimate location by looking up its cache or querying the anchor, if the needed information is not cached. According to the verification results, it also adjusts the trust level of the neighbor.
7. If s finds a node i whose trust level T_i ¸ θ_2 where $\theta_1 < \theta_2$, it periodically exchanges the trust information with node i in a cryptographically secure manner to build more global trust information that can further improve the source's own trust information and vice versa.
8. When node i receives the packet, it becomes a new source and recursively applies this procedure to forward the packet towards d. Position based multipath routing is illustrated in figure 1.

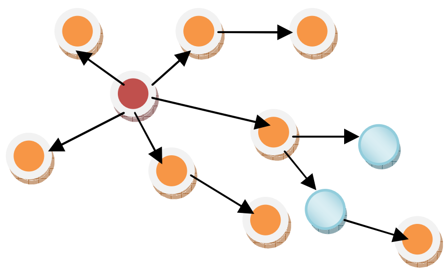

Figure 1. Position based Multipath Routing

B. Packet Forwarding Scheme

In this phase, packet forwarding is performed based on the, different sizes of the packet transmission window that leads to different levels of energy consumption and PDR. The goal of packet forwarding scheme is to increase delivery rate while keeping minimum energy cost. The total energy budget is distributed to multiple packet forwarders, which wake up before a delay response, so that the expected delivery rate can be maximized. In case of one hop delivery of a packet, it is assumed that energy budget and the delay constraint are predefined application specific constant. So the hop count from a node to the sink denotes the maximum energy cost and end-to-end delay to deliver a packet to the sink. It is defined ADV (*accepted delivery value*) as a routing metric. It is defined as the ratio of APDR (*accepted packet delivery ratio*) and hop count of the successful path.

It is expressed as follows,

$$ADV = \frac{APDR}{Hopcount} \qquad (2)$$

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In the following expressions, it is used as ADV_i, $APDR_i$ and Hop $Count_i$, to denote ADV, APDR and Hop Count of node *i*, respectively.

If ADV greater means, it represents a higher delivery rate or a lower energy cost and delay. The ADV of a node can be calculated recursively. Specifically, for the sink, its APDR is 1 and HOP is 0. $APDR_{sink} = 1$; Hop $Count_{sink} = 0$

Suppose node p is one of node q's neighbors, we use $APDR_q(p)$, Hop $Count_q(p)$ and ADV $_q$ (p) to respectively denote APDR, Hop count and ADV obtained when forwarding the data to p. If the size of transmission window is set as r, the Qos metrics can be calculated as,

$$APDR_p(q) = APDR_p \bullet P_q^r(q);$$
$$HopCount_q(p) = HopCount_p + 1 \quad (3)$$

$$ADV_q(p) = \frac{APDR_q(p)}{HopCount_q(p)} = \frac{ADV_q \bullet P_q^r(p)}{1 + \frac{1}{HopCount_p}} \quad (4)$$

A source node should involve all possible neighbor nodes for forwarding a packet, as long as the candidate forwarder's ADV is not less than the best forwarder. In this way, one can enhance delivery rate while do not build up o the energy cost or delay of packet forwarding. To schedule packet transmissions to multiple packet forwarders, the minimum energy cost will be maintained.

C. Packet Forwarding Verification

The intermediate nodes in the particular route are responsible for sending feedback for packet dropping cases in order to avoid black hole and selective forwarding attacks. The other possible approach is overhearing. When a sensor node M sends a packet to node N, which is one of its one hop neighbors, M waits for the acknowledgment (ACK) from N. At the same time, M overhears N to observe whether or not N forwards the packet. The overhearing can be easily done due to the presence of omni-directional nature of radio communications. This basic verification scheme may not be perfect for two primary reasons:

• Node M may miss node N's transmission due to a collision
with another packet

• Node N may forward the packet, but to a node in the incorrect direction or even to a non-existing node. Since M does not know N's neighbors, it is not able to determine that N is misdirecting the packet. To address the first issue, a node needs to monitor a neighbor's behavior for multiple packets to evaluate its trustworthiness.

Packet forwarding verification can be improved based on overhearing, it is considered the following approaches:

• Node M can query an anchor about the location of the destination to which N is forwarding a packet to determine whether it exists and it is closer to the destination node.

If N forwarded a packet to node L and L exists, M can cache L's Identity and location. In this same way, M can incrementally build the two hop neighbor information. Hence, it can perform the forwarding verification without querying the anchor when N forwards another packet to L.

• In another way, reliable information can be built more quickly by allowing mutually reliable forwarding nodes to periodically exchange the reputation about their neighbors in a cryptographically secure manner to form reliable groups.

• In this way, an individual node can get more trustworthy information about its neighbors derived from the broader perspectives of its trusted neighbors. Since this is an optional feature, sensor nodes can be configured to only rely on its own trust information if the environment, e.g., a battle field, is highly hostile.

D. Proposed packet format

Source ID	Destination ID	Node Position status	Packet forwarding status	Packet dropping rate	CRC
2	2	4	4	4	2

Figure 2.Proposed Packet format

In fig 2. the proposed packet format is shown. Here the source and destination node ID carries 2 bytes. Third one is scheduling status of the node. The node position status induces whether nodes are located inside the region or not. In fourth field, the packet forwarding status is added to determine number of packets is successfully forwarded to destination node. In fifth, the packet dropping rate is calculated to know status of link. The last filed CRC i.e. Cyclic Redundancy Check which is for error correction and detection in packet during transmission and reception.

4. PERFORMANCE EVALUATION

We use Network Simulator (NS 2.34) to simulate our proposed EPPFP algorithm. Network

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Simulator-2(NS2.34) is used in this work for simulation.NS2 is one of the best simulation tools available for Wireless sensor Networks. We can easily implement the designed protocols either by using the oTCL (Tool command Language) coding or by writing the C++ Program. In either way, the tool helps to prove our theory analytically.

In our simulation, 200 mobile nodes move in a 1200 meter x 1200 meter square region for 60 seconds simulation time. All nodes have the same transmission range of 250 meters. Our simulation settings and parameters are summarized in table 2.

A. Performance Metrics

We evaluate mainly the performance according to the following metrics.

End-to-end delay: The end-to-end-delay is averaged over all surviving data packets from the sources to the destinations.

Packet Delivery Ratio: It is defined as the ratio of packet received with respect to the packet sent.

Throughput: It is defined as the number of packets received at a particular point of time

The simulation results are presented in the next part. We compare our proposed algorithm EPPFP with existing scheme OMR [16] in presence of energy consumption.

Table 1. Simulation Settings And Parameters Of Proposed Protocol.

No. of Nodes	100
Area Size	1200 X 1200
Mac	802.11
Radio Range	500m
Simulation Time	60 sec
Traffic Source	CBR
Packet Size	512 bytes
Mobility Model	Random Way Point
Protocol	LEACH

Figure 3 shows the results of average residual energy for varying the mobility from 10 to 50 s. From the results, we can see that scheme EPPFP has minimal energy consumption than existing scheme OMR.

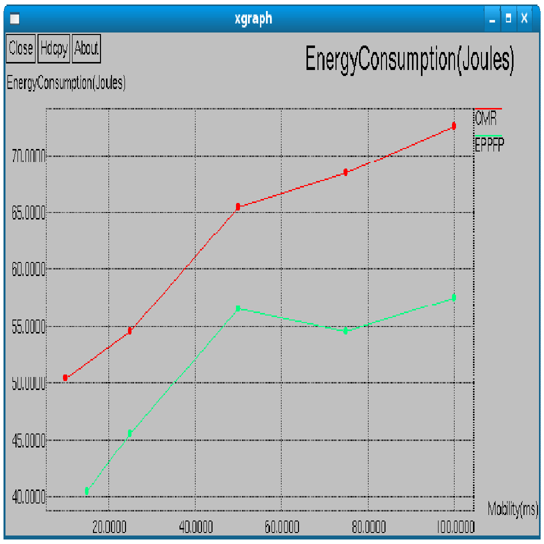

Figure 3. Mobility Vs Energy Consumption

Figure 4 presents the delivery ratio comparison for EPPFP, and OMR. It is clearly seen that number of epochs consumed by EPPFP is high compared to OMR.

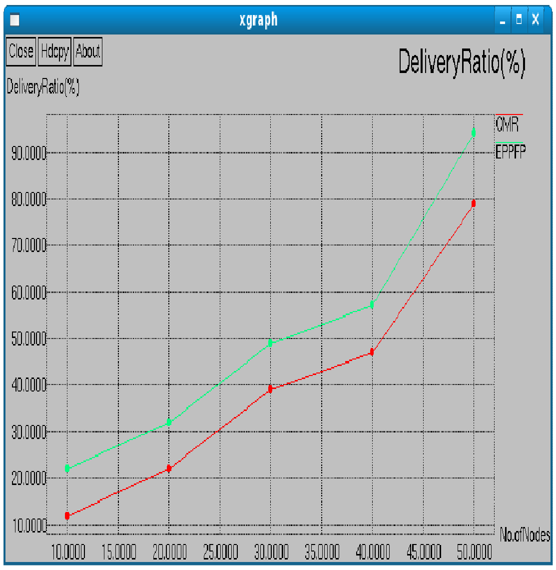

Figure 4. No.Of Nodes Vs Packet Delivery Ratio

Figure 5, presents the comparison of network lifetime. It is clearly shown that the network lifetime of EPPFP is higher than OMR.

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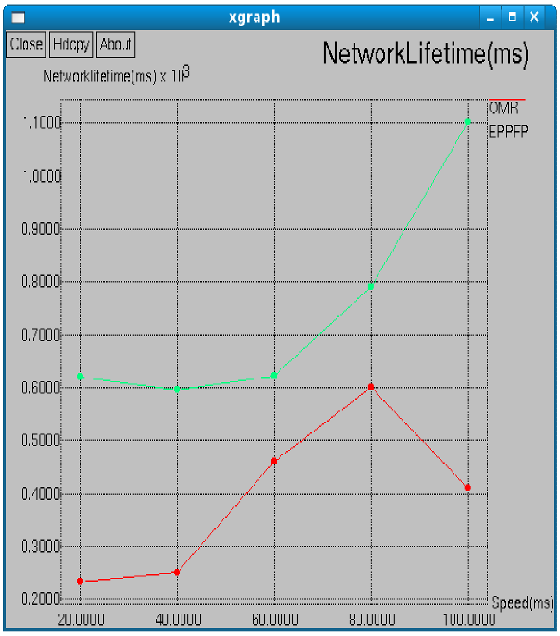

Figure 5. Speed Vs Network Lifetime

Figure 6 shows the results of Speed Vs End to end delay. From the results, we can see that EPPFP scheme has slightly lower delay than OMR.

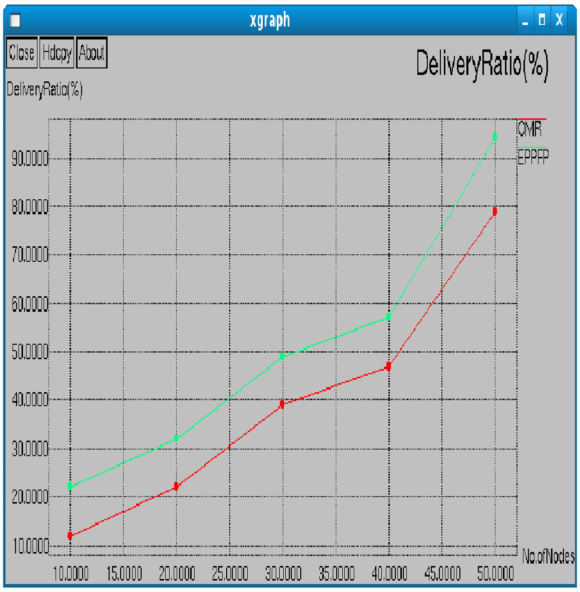

Figure 6. Speed Vs End to end delay

Figure 7, presents the comparison of packet forwarding status while varying simulation time from 10 to 50 seconds. It is clearly shown that the packet forwarding status of EPPFP is higher than OMR.

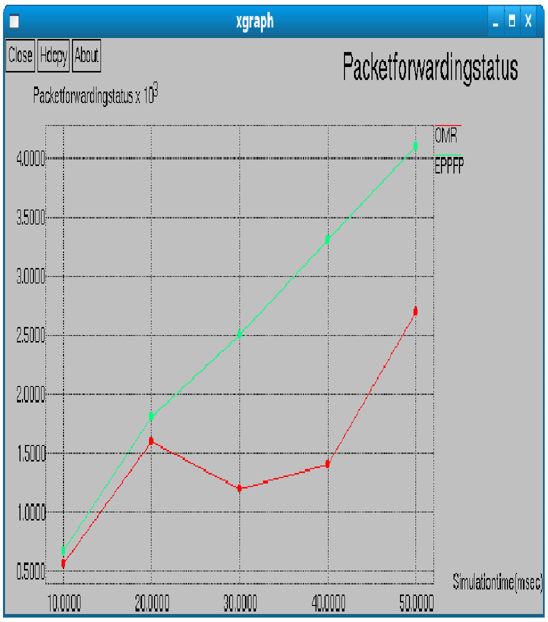

Figure 7. Simulation time Vs Packet forwarding status

5. CONCLUSION

In WSN, packets are forwarded based on position of sensor node. In this paper, we have developed a Efficient Position based Packet Forwarding Protocol which attains balance between energy consumption and packet delivery rate to the sensor nodes. In the first phase of the scheme, concept of proposed multipath routing is explained. In second phase, we propose packet forwarding scheme to increase packet delivery rate. In third phase, packet forwarding verification is proposed to ensure that packets are successfully forwarded. Based on simulation results we have shown that the EPPFP achieves better performance than the existing scheme.

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