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A Hybrid Cluster based Multipath Routing for Packet Delivery in Wireless Sensor Networks

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Abstract:

Wireless Sensor Networks consists of sensor nodes with or without base station. It may be static or dynamic according to user requirements. In previous cases, the packets are flooded without proper scheduling time. It leads to heavy packet losses and instability of the network. In the proposed scheme, Hybrid Cluster based Multipath Routing Approach (HCMRA) is to forward the packet with high density period. It is achieved by means of cluster topology. This topology provides condition for minimum energy consumption and constructing new center of cluster which is used to maximize the network lifetime. Sometimes due to dynamic nature, path failures may likely to occur. To avoid this, a gradient multipath routing is discovered based on packet forwarding rate, load balancing status etc. It provides efficient terminology for avoiding heavy packet dropping. Finally packet forwarding is initiated with high density condition. Packets are scheduled based on stability of multipath and retransmission of packets is reduced. Based on extensive simulation results, the proposed scheme HCMRA achieves better performance than existing and our previous schemes.

Keywords- Cluster topology, gradient multipath routing, packet forwarding, retransmission of packets, high packet density, load balancing status, stability of path etc.

1. INTRODUCTION

A wireless sensor network consists of a large number of sensor nodes distributed over a geographic area. A WSN is a collection of low- cost, low- power disposable devices. The main task of a sensor node in a sensor field is to detect events, perform quick local data processing and then transmit the data. Power consumption can be divided into three domains: Sensing, Communication and Data processing.

The sensor nodes usually operate with batteries and are often deployed into a harsh environment. Once deployed, it is hard or even impossible to recharge or replace the batteries of the sensor nodes. Therefore, extending the network lifetime by efficient use of energy is a critical requirement for a WSN. For any network the performance is the important and main focusing aspect ie is called as the performance metrics of the network including packet delivery ratio,end to end delay,network lifetime, packet loss ratio,throughput etc.In this paper we are focusing on parameter of network life and delay and their enhancement towards the performance improvement for the WSN by using anycast and sleep wake scheduling concept.The wireless sensor network consists of large number of sensing nodes equipped with various sensing devices to observe different phenomenon changes in real world. Wireless sensor networks (WSN) are used to remotely Sense the environment. Wireless sensor networks consists of many sensing nodes that captures the changes in the environment enclose data in data packets and gives these packets to sink node present in the network. Such network are present in hard to reach areas so they remain unattended for long duration. So key issue in such area is efficient use of node energy to extend the lifetime of network. It was focused here on event driven sensor networks for which events occur rarely.

Energy consumption these sources are: communication radios, data transmission and reception, sensors and transmission and reception of control packets. Fraction of total energy consumption for data transmission and reception is small for such systems because events occur so rarely. To sense the event, constant energy is required and it cannot be controlled. Hence energy required to keep communication system on means for listening the medium and control packets is dominant component of energy consumption which can be controlled to extend network lifetime. So sleep-wake scheduling is used to increase the lifetime of event driven sensor networks. Asynchronous sleep wake scheduling was used where each node wakes up independent of its neighboring nodes in order to save energy. But due to this independence of wake-up processes, additional delays encounter at each node along path to sink node because each node has to wait for its next hop node to wake up before transmitting the packet. Any cast packet forwarding scheme is used to reduce this event reporting delay to sink node and thus minimization of delay was done.

2. RELATED WORK

Vidya et.al [1] proposed the multiagent based multipath routing scheme in WSNs by employing localization technique, set of static and mobile agents. In this scheme, a source node triggers the route discovery mechanism by determining the intermediate nodes between source and destination node. The set of mobile agents are used to carry the partial topology information like node id, hop distance, residual energy and hop count etc., from source node to destination node through intermediate nodes by using location information. The partial topology information was used in computing the node disjoint routes by destination node. For node disjoint routes, the destination node computes the route weight factor based on the route efficiency, energy ratio and hop distance factor. Due to the presence of multi agents energy consumption, packet dropping rate may get increases.

Ramya and Shanthi [2] presented a new energy-efficient routing approach that combines the desired properties of minimum spanning tree and shortest weighted path tree-based routing schemes. This scheme uses the advantages of the powerful localized structures and provides simple solutions to the known problems in route setup and maintenance because of its distributed nature. This algorithm is robust, scalable, and self-organizing. It is appropriate for systems where all the nodes are not in direct communication range of each other.

Kavitha and Wahidabanu [3] proposed a study on improved cluster head selection for efficient sensor networks data aggregation. The new Bacterial Foraging Optimization (BFO) based algorithm was incorporated in LEACH protocol. The simulation was performed with 40 nodes in single base station in a 2 sq. km area. An improved cluster head selection for efficient data aggregation in sensor networks achieved better performance.

Irin Kurian and Kavitha [4] developed an accurate and efficient algorithm called Iterative Multilateral Localization Based on Time Rounds. It uses time round as localizing time unit, localizes round after round, and limits the minimum number of neighbouring beacon nodes in different time rounds. When the number of neighbouring beacons of an unknown node equal to or more than the limited value, and apply all its neighbouring beacon nodes to localize the unknown node. Upon an unknown node has been localized, it become a beacon node and sends its own location information to its neighbouring nodes which will assist them to estimate their locations. This algorithm reduces location error from two aspects, one is to apply time rounds and anchor nodes triangular placement schemes to reduce error accumulations caused by iterative localization, and the other is to apply multilateral instead of trilateral localization to reduce localization errors and to prevent abnormal phenomenon caused by trilateral localization.

Sudhakar and Sangeetha [5] proposed the Extended Sink Scheduling Data Routing (E-SSDR) to schedule sinks. The Delay bounded Sink Mobility (DeSM) was solved with centralized and distributed scheduling schemes. The scheduling scheme was adapted to support multi sink based data collection mechanism. Energy consumption is minimized in the data collection scheme. The scheduling scheme was suitable for single and multiple mobile sink environment. Scheduling overhead is reduced in the multi sink model. Data collection latency is reduced in the sensor networks.

Patil Anil kumara and Hadalgi [6] proposed a novel energy-efficient beaconless geographic routing protocol EBGR that takes advantages of both geographic routing and power-aware routing to provide loop-free, stateless, and energy-efficient sensor-to-sink routing in dynamic WSNs. The performance of EBGR was evaluated through simulations. By taking the residual energy into account for making forwarding decision, our scheme can be extended to alleviate the unbalanced energy consumption in the network while still guarantee that the total energy consumption for sensor-to-sink data delivery is bounded. Another extension is to integrate other energy conserving schemes such as data aggregation to further reduce energy consumption and maximize network lifetime.

Sajjad et.al [7] dealt with a dead-end aware Table-less Position based Routing (TPR) scheme for data centric low power WSNs. Each sensor node was attached to a container comprises a GPS, GSM/UMTS, and short range RF communication system and reports the container data namely current location, and sensory data like acceleration, velocity, temperature, and humidity to the sink node. The availability of positions of nodes drives our motivation to develop a low power position based routing scheme for similar class of applications. The sink node broadcasts its current position to all other nodes at fixed time intervals. This broadcast was also used to compute accumulative cost towards the sink node by other nodes.

Hla Yin and Win [8] proposed the fault management mechanism for wireless sensor network to diagnose faults and perform appropriate measures to recover sensor network from failures. It maintained the connectivity of the network and the reliability of data transfer even when a node in the network runs out of energy. Hence the packet forwarding rate is less in this mechanism.

Sujeet et.al [9] focused on studies of load balancing algorithms for back-to-back packet transmission, reduce delay, solving the problem of dead end. It gives a brief introduction to various load balancing techniques.

Omid and Shapoor [10] proposed beaconless geographic routing (NBGR) is proposed. NBGR acts in two modes: a main mode and recovery mode. The neighbors in the positive progress area (PPA) that receive the RTS set a timer with appropriate delay function independently. So that the closest neighbor to destination responds first. This process is continued until the packet has received to node that don’t have any neighbor in its PPA, then routing shifted into recovery mode. In Recovery mode the packet is sent to the destination by traversing on the face of planar graph such as a relative neighborhood graph (RNG).

Adel et.al [11] proposed an efficient anchor-free protocol for localization in wireless sensor networks. Each node discovers its neighbors that are within its transmission range and estimates their ranges. This algorithm fuses local range measurements in order to form a network wide unified coordinate systems while minimizing the overhead incurred at the deployed sensors. Scalability is achieved through grouping sensors into clusters. This protocol achieved precise localization of sensors and maintains consistent error margins. It was captured that the effect of error accumulation of the node’s range estimates and network’s size and connectivity on the overall accuracy of the unified coordinate system.

Hongliang Ren and Meng [12] used the concept of probabilistic localization to infer position information from the correlations of the RF received signal strength indication (RSSI) and the distance between sensors under different power settings. The changing transmit-power-level information was incorporated into the localization process as a dynamic evidence using a particle filter. The power adaptive localization algorithm was also evaluated in the context of multiple power scheduling.

Engin Mas et.al [13] developed and compared two different sensor selection schemes for static source localization. The first scheme iteratively activates those non-anchor sensors that maximize the mutual information between source location and the quantized sensor measurements. In the second sensor selection scheme, at each iteration a number of non-anchor sensors are activated whose quantized data minimization.

Kerem Kucuk et.al [14] introduced a new localization technique for WSNs where only a central node has to be installed with a adaptive antenna system. This technique doesn't require any additional software or hardware in the sensor nodes unlike other methods such as GPS based or beacon based. This method was based on performing two dimensional scanning of the sensor field. In azimuth scanning, beam direction and beam width of the localization beam is changed while maintaining the same RSSI level. In the radial scanning, for the same beam direction, transmit power (RSSI level for sensor nodes) level was changed.

In this paper [15], an energy-balanced routing method was proposed based on forward-aware factor (FAF-EBRM) is proposed in this paper. In this method, the next-hop node is selected according to the awareness of link weight and forward energy density. Including this, a spontaneous reconstruction mechanism for local topology is designed additionally. Nodes can vary transmission power according to the distance to its receiver. The sink node can broadcast message to all sensor nodes in the sensing field. The distance between the signal source and receiver can be computed based on the received signal strength. Regional central nodes are not selected at the beginning, on the contrary, they spring up during the topology evolution.

III. OVERVIEW OF PROPOSED SCHEME

The proposed scheme consists of cluster topology, gradient multipath route construction and packet forwarding with high density procedure. The description of this scheme is as follows.

Constructing Clustering topology

In the proposed scheme, cluster topology is formed based on negihbor connectivity. The nodes which are closer to the destination is tied with high probability, and then smaller and medium connected nodes are located near the destination region. Clustering topology is finally established until the clustering results are no longer changing. It means that based on iterations through random selection of cluster heads, the optimized clustering topology can be established with good performance of compactness. Hops between the cluster head to destination node are calculated by the flooding packets among cluster heads. The cluster heads are divided into hierarchical areas and clusters are split in to larger clustering probability. Based on clustering optimization procedure, smaller scale and more quantity of clusters are formed. Energy consumption issues are totally avoided by using clustering topology. The formation of clustering topology is described as follows,

Step 1: Choose the parameters namely transmission probability, initial energy, transmitting amplifier, transmission energy and receiving energy. Randomly select nodes as the initial clustering centers C_0, $C_1 \ldots C_k$ by the probability $p=0.2$. it is determined by the scale of network and quantity of cluster heads.

Step 2: Partition each node with minimum power consumption to the nearest clusters $C_i(1,\ldots k)$. Sensor nodes are assigned to the same center belong to the same cluster. Therefore, clusters are formed.
Step 3: Calculate new center of the clusters
Step 4: Flood the interest packets among cluster heads and learn minimum hops from each cluster head to the destination node.
Step 5: Choose the cluster heads randomly in until the clustering optimization for all nodes in hierarchical areas has been finished.

Multipath Selection Phase
Due to the presence of path's poor quality, packets will be retransmitted or lost. It will cause more local energy consumption and serious congestion. Path quality decides the reliability of packets forwarding. The remaining energy of all sensor nodes determines the survival time of the network. Therefore, the way only using hops as a criterion to evaluate the quality of routing has failed to meet the requirements of the network service quality. By selecting the hops to the destination node, residual energy and transmission delay to comprehensively evaluate the nodes' quality, the preferred cluster heads are selected to establish the optimal transmission path. This has great significance to improve the transmission reliability. Angle value is used to restrict the direction of interest packets' broadcasting and data transmission. When packets are need to transmit, global optimal paths must be distributed and established from the source node to the destination node according to the cluster heads residual energy. It mainly includes the phases of topology establishment, nodes' residual energy calculation, multipath route discovery, routing maintenance, and so forth. Before transmission starts, the source node has data packets, it firstly reports to its cluster head. The cluster head chooses the sensor node with the minimum hop distance and the next hop within the transmission power coverage to discover the first optimal transmission path. Then the cluster head selects one node as the next hop which is with the minimum hop distance and within the transmission power coverage.
Step 1: Choose the parameters namely hop count, load balancing status, packet forwarding rate and packet loss rate based on the communication between source node, cluster head and destination node.
Step 2: Add Cluster Route Request (CR_{REQ}) and Cluster Route Reply (CR_{REP}) messages. CR_{REQ} is initiated from the source mobile node when it needs to send data and the route to destination mobile node is still unknown.
Step 3: The source node first sends a multicast CR_{REQ} message to its cluster head, which upon receiving the CR_{REQ} message, will check its membership table for the destination node.
Step 4: Cluster Route Reply (CR_{REP}) will then be sent by the cluster head back to the source. If the destination node is found in the cluster, CR_{REP} message is set to true.
Step 5: To discover the first optimal multipath, the cluster head selects the nearest cluster head on the contour line within its transmission power coverage. It represents neighbor hierarchical cluster heads on the established path and the transmission power coverage of cluster head. Hence the first optimal multipath to the destination node is established.

Step 6: To discover the second suboptimal disjoint path, the cluster head chooses the second nearest nodes on the contour line with but not on the established paths also within its transmission power coverage.
Step 7: Once all the necessary paths are discovered, the destination node will forward the paths' information back to the source node along the established multiple paths and it includes nodes' energy information, transmission delay, success rate, packet forwarding rate and packet loss rate of the data transmission, and so forth. Source node then encodes the packet using linear erasure coding algorithm and allocates the coded fragments into multiple paths using load balance mechanism.
Step 8: In the time interval, the destination node decodes the received encoded fragments and reconstructs them into the source packet, where is the setting time parameter, the time interval of unit packet required at each node, and normalized value of success rate of data transmission on each link.
Step 9: Cluster flag is set to false. Once receives the CR_{REP} message, the source will check the value of the cluster flag. If the flag indicates a true value, the source node will transmit data packets by using the path set up during the propagation of CR_{REQ} message.
Step 10: Otherwise, the source node will initiate a network-wide flooding of RREQ messages to search for the route to destination node. This additional routine will reduce the number of network wide RREQ messages initiated by the source node if both the source and destinations nodes belong to the same cluster.

1. High Density Packet Forwarding Procedure
In the proposed scheme, packet forwarding with high density is achieved in WSNs. Scalability is a critical issue in sensor networks, which are composed of hundreds and thousands of densely deployed sensor nodes. Initially location information of the neighboring nodes are updated and sensor node will make packet forwarding decision according to the localizaiton of sensor nodes. In the proposed scheme, it is assumed that it does not require any topology information. In this topology, it is kept communication and sensing range as constant, the overhead is getting reduced. In arbitrary coordinate system, the position of each deployed sensor node is not known. Hence it is assumed that the neighbors of a particular sensor node are determined based on the packet forwarding and the sensor nodes are static in nature. Based on this, the source node decides locally whether or not to forward the packets or to ignore the previously received packets. If redundant packet forwarding means each sensor node in the network that has already received the same packet at an earlier time. This type of packet forwarding occurs in the accurate estimation of redundant packet counts for a varying number of sensor nodes within the network. These are confined to the total number of forwarded packets. The proposed scheme is based on the assumption that the sensor nodes M are deployed within a specified area G. Broadcast message m, for event MK, due to the increase in the number of sensor nodes corresponding to a high density wireless sensor network.

1: **START**
2: Define G, M and m

3: where m and *M* □ *G*
4: **Initialize** *M* =100 and *m* = 5,
5: define MK
6: deploy *M* such that *M* □ *G*.
7: **Start**
8: packet forwarding
9: forward initial packet, *m*
10: select the neighbor sensor node as anchor nodes, *n*
11: **If** the neighbor sensor node receives packets for the first time, proceed to packet forwarding;
Or else go to step 14
A packet at k can be scheduled for transmission to i only if it passes the following test.
Rate Limit Test()
(1) c <- min{c + (current clock value − t) × lk,i, b}
(2) t Ã current clock value
(3) **if** (c ¸ packet size)
(4) schedule the packet for transmission
(5) c Ã c − packet size
(6) **else**
(7) wait for (packet size −c)/lk,i before trying the test again
12: **End**
13: **If the** neighbor sensor node receives the packet twice,
14: **Then** discard packet forwarding;
update, if *M* abandons its attempt to re-forward a packet
15: repeat step 8 for *N* ={100,150, 200, 250, 300, 350, 400, 450 and 500} with m = 5
16. Calculate Packet forwarding rate and throughput.
17. Determine path stability rate.
18. Proceed for next route maintenance process
19. **STOP**

D. Packet format of the proposed HCMRA

Source ID	Destination ID	Hop Count	Packet forwarding status	Delay status	FCS
2	2	1	4	4	2

Fig 3.HCMRA Packet format

In figure 3, the proposed packet format of HCMRA is shown. Here the source and destination node ID carries 2 bytes. The third field hop count determines the number of nodes connected to the particular node in the cluster. It occupies 1 byte. The packet forwarding of 4 bytes size indicates whether packets are successfully forwarded or not. Status of delay is verified during the route maintenance phase. It occupies 4 bytes. The last filed FCS i.e. Frame Check Sequence which is for error correction and detection in the packet while transmission.

4. PERFORMANCE EVALUATION

The performance of the proposed approach is evaluated in this section. The simulation model is discussed and the simulated results are presented and described below. We have simulated our results using ns 2.34 simulator. Here we made the assumption that adopted for simulation is all nodes are moving dynamically including the direction and speed of nodes. Mobility scenario is generated by using random way point model with 100 nodes in an area of 1200 m × 1200 m. The simulation parameters are mentioned below in Table 1

A. Performance Metrics

We evaluate mainly the performance according to the following metrics.

Packet Delivery Ratio: The delivery rate is defined as the ratio of numbers of messages received by the destination and sent by senders. The best routing methods employing this metric are those that guarantee delivery in which message delivery is guaranteed assuming "reasonably" accurate destination and neighbor location and no message collisions.

Control Overhead: The control overhead is defined as the total number of routing control packets normalized by the total number of received data packets.

End-to-End Delay: This is also referred to as latency, and is the time needed to deliver the message. Data delay can be divided into queuing delay and propagation delay. If queuing delay is ignored, propagation delay can be replaced by hop count, because of proportionality.

Communication overhead: Communication overhead can be defined as the average number of control and data bits transmitted per data bits delivered. Control bits include the cost of location updates in the preparation step and destination searches and retransmission during the routing process.

Computation Overhead: It is defined as that a node takes time to pass control packets to destination node.

Our simulation settings and parameters are summarized in table 1.

Table1. Simulation and Settings parameters of HCMRA

No. of Nodes	100
Area Size	1200 X 1200
Mac	802.11
Radio Range	250m
Simulation Time	100 sec
Traffic Source	CBR
Packet Size	512 bytes
Mobility Model	Random Way Point
Protocol	LEACH

The simulation results are presented in the next part. We compare our proposed approach HCMRA with EEMCRP, CMRP, OMAS and FAF-EBRM in presence of energy consumption.

Figure 1 shows the results of average end-to-end delay for varying the mobility from 20 to 100. From the results, we can see that scheme HCMRA has slightly lower delay than our previous work OMAS, CMRP, EEMCRP and FAF-EBRM [15] scheme because of stable routing.

Figure 2, presents the residual energy while varying the time. The Comparison of HCMRA, OMAS, CMRP, FAF-EBRM and EEMCRP energy consumption is shown. It is clearly seen that energy consumed by HCMRA is less compared to OMAS, FAF-EBRM, CMRP and EEMCRP.

Fig. 3, presents the comparison of communication overhead. It is clearly shown that the overhead of HCMRA has low overhead than OMAS, CMRP, EEMCRP and FAF-EBRM scheme.

Figure 4 show the results of average packet delivery ratio for the stability weight 10, 20…50 for the 100 nodes scenario. Clearly our scheme HCMRA achieves more delivery ratio than the OMAS, CMRP, EEMCRP and FAF-EBRM scheme since it has both reliability and stability features.

Figure 5 show the results of average network lifetime for the nodes from 10 to 50. Clearly our scheme HCMRA achieves more network lifetime than the OMAS, CMRP, EEMCRP and FAF-EBRM scheme since it has more residual energy.

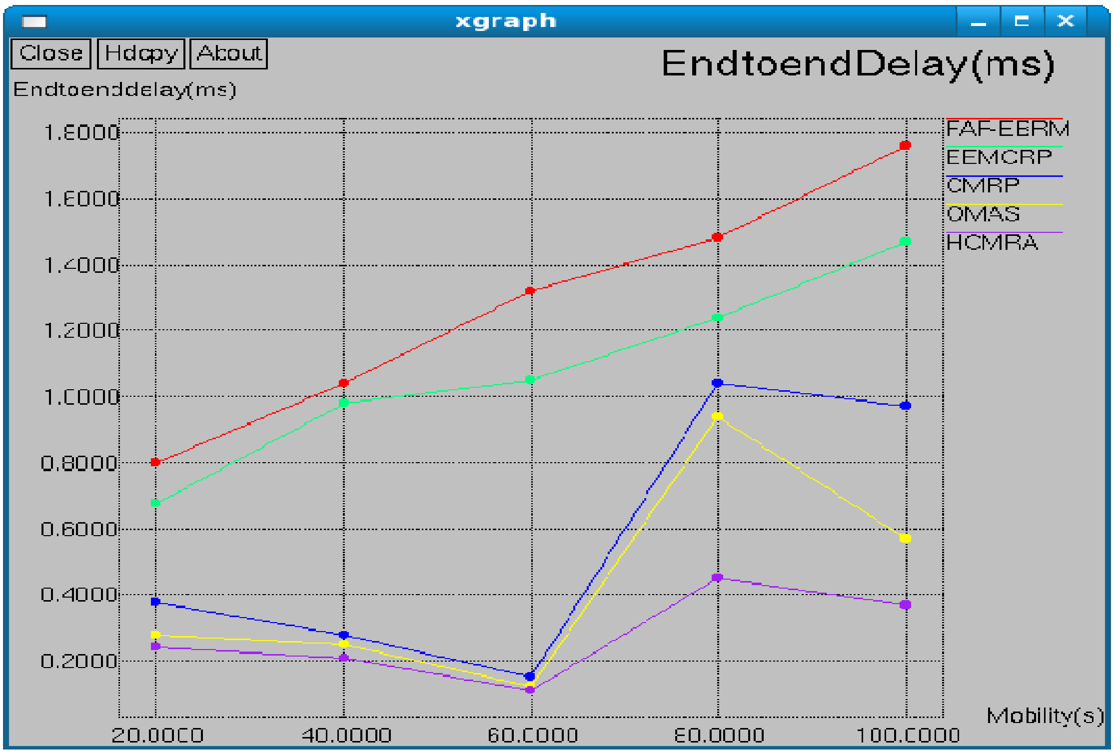

Fig. 1. Mobility Vs End to end Delay

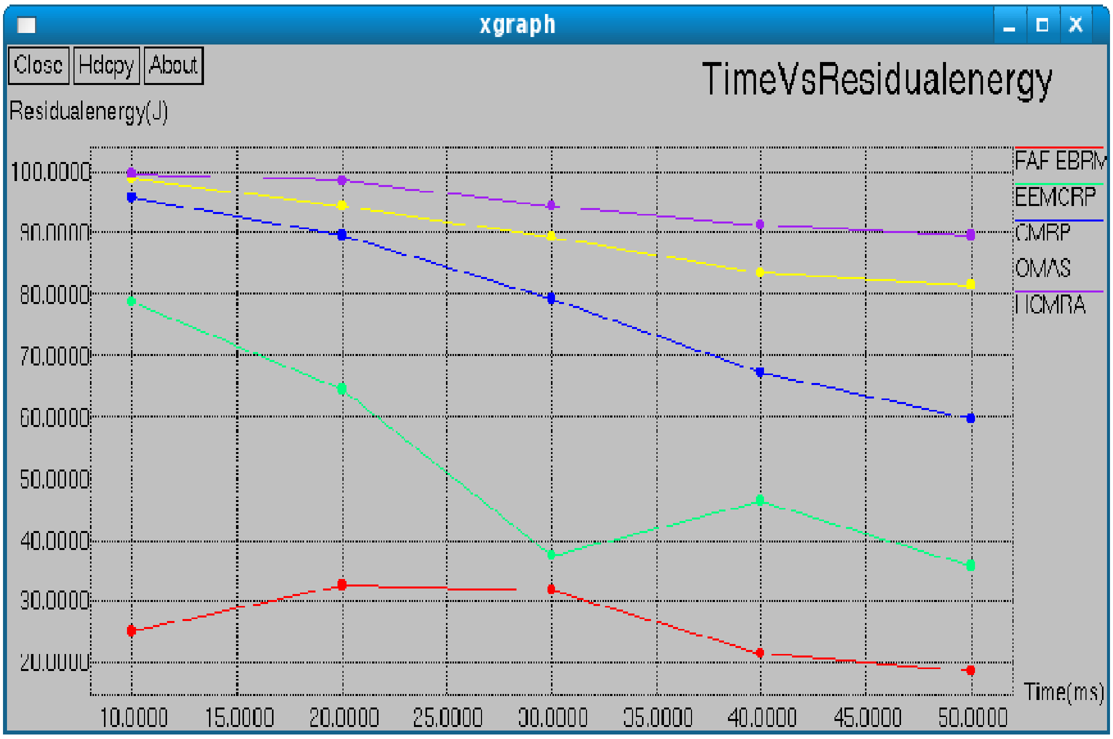

Fig. 2. Time Vs Residual Energy

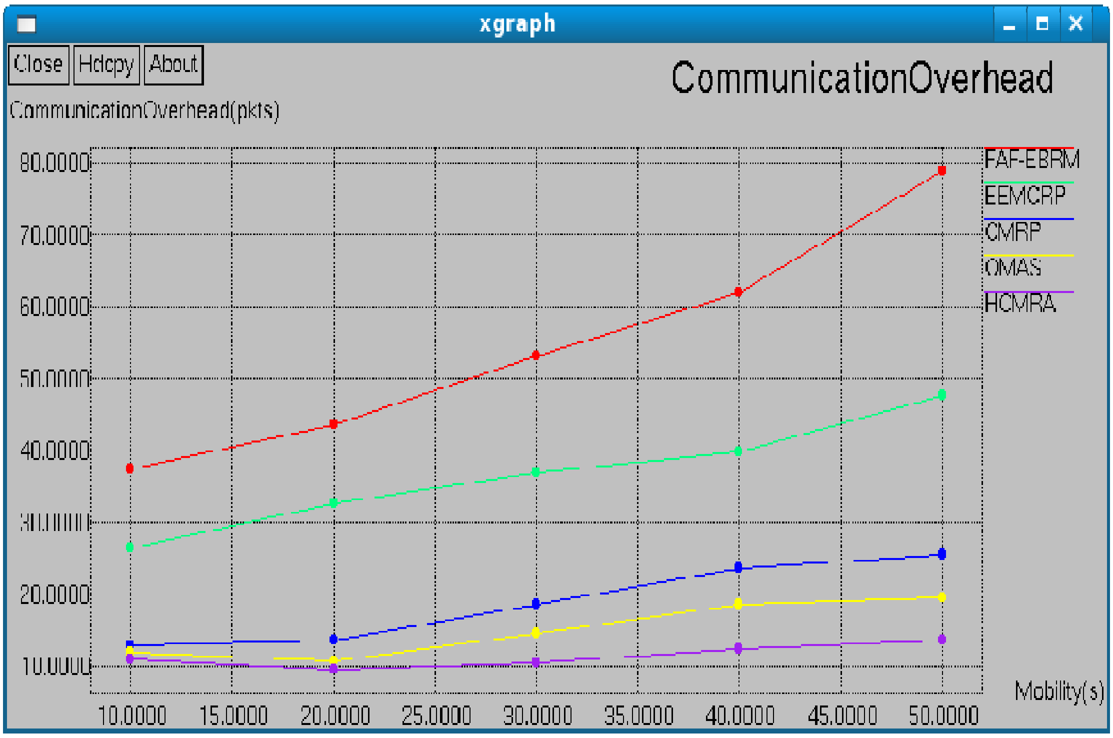

Fig. 3. Mobility Vs Communication Overhead

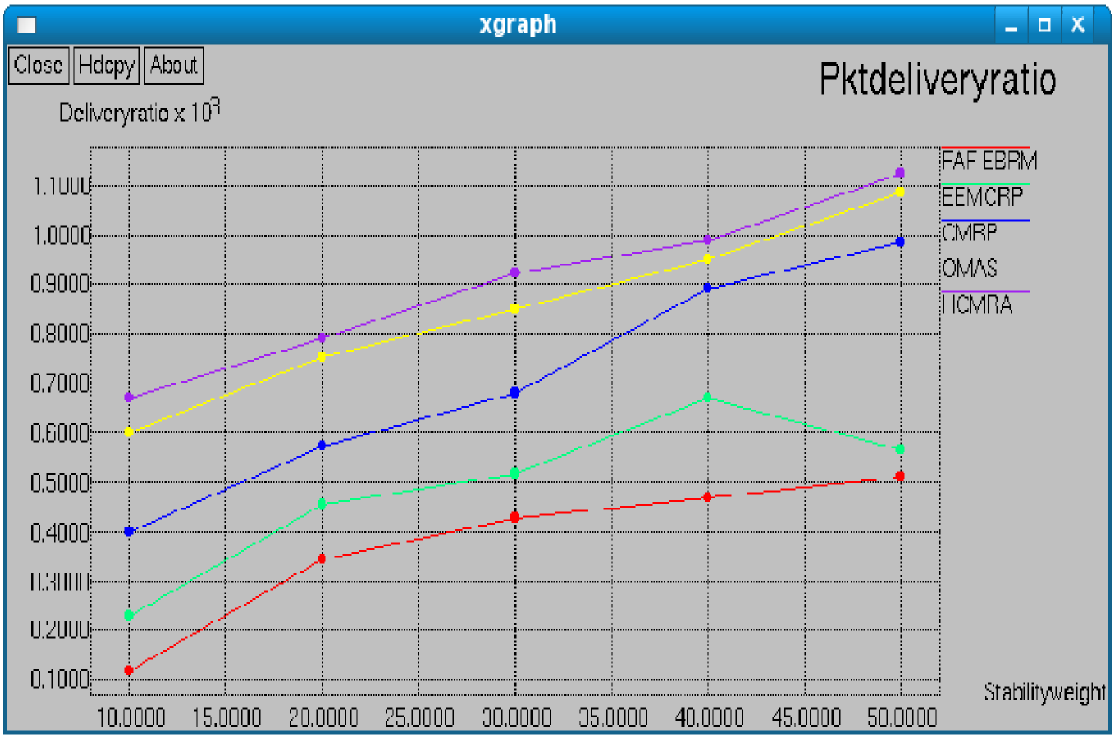

Fig.4. Stability Vs Packet Delivery Ratio

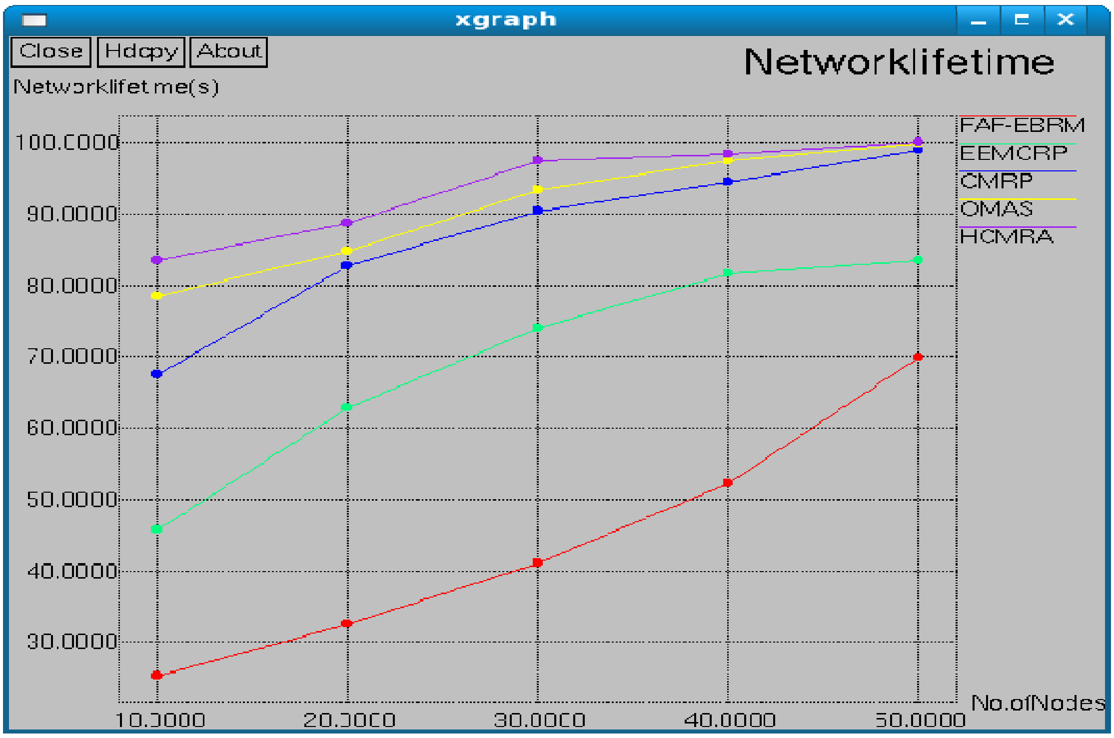

Fig.5. No.of Nodes Vs Network Lifetime

V. CONCLUSION

In this research work, we have developed a hybrid cluster based multipath routing approach for efficient packet forwarding and successful delivery has been achieved. The proposed scheme consists of cluster construction based on remaining energy, hop count between the nodes and finding center of clusters. It avoids more energy consumption during route maintenance phase. Multipath has been constructed based on stability of link, packet loss rate etc. It provides reduced path failures and packet dropping rate. In packet forwarding phase, packets are scheduled according to slot time that provides high energy efficiency. Packet forwarding has been successfully achieved during high density period. We have demonstrated the multipath route discovery procedure of each node. By simulation results we have shown that the HCMRA achieves good throughput, high network lifetime, high packet integrity rate, good data delivery rate while attaining low end to end delay, low overhead than the existing schemes CMRP, OMAS, EEMCRP and FAF-EBRM while varying the number of nodes, speed, mobility and pause time.

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