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Performance Improvement of Energy Aware Hybrid Routing Protocol for Mobile Ad Hoc Networks

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ABSTRACT

Mobile ad hoc networks are infrastructure less network which are composed of wireless nodes of limited battery constraints with mobility and communication capabilities. Energy management is a challenging approach in such kind of wireless networks. It deals with controlling the battery discharge, adjusting the transmission power of the nodes, and scheduling of power source so as to reduce the energy consumption of individual nodes as much as possible. This paper proposes an Energy management algorithm for Zone Routing Protocol using the extended energy conservation technique called AFECA (Adaptive Fidelity Energy Conservation Algorithm) and Energy consumption is further optimized by using Distance based energy conservation algorithm by taking variable transmission range into consideration. These energy saving algorithms are incorporated with well-known Hybrid Routing Protocol called Energy Efficient Zone Routing Protocol to optimize the utilization of energy. The performance parameters such as energy, throughput, delay, data dropped of EEZRP (Energy Efficient Zone Routing Protocol) is compared with ZRP (Zone Routing Protocol), SHARP (Sharp Hybrid Adaptive Routing Protocol) and ZHLS (Zone Hierarchical Link State) using NS-2 simulator, which shows that EEZRP is well suited and an efficient protocol.

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INTRODUCTION

The Mobile Ad hoc Network composed of group of nodes with limited battery constraints where a node itself functions as a router instead of requiring an additional network component for routing process. It attempts to provide communication during some critical applications like emergency rescue operations, military applications etc, where no network coverage is available. The communication link between nodes relies on neighbor nodes and these nodes are responsible for routing of information from source to destination. If these information or data packet has to be delivered successfully, the nodes in this network must be consistent for long period of time. In order to make the nodes as consistent as long as possible, the source for these nodes must be properly utilized or it has to be properly managed (Ravi, 2013).

Battery utilization in ad hoc networks determines the life time of the network hence the battery power must be properly discharged. A suitable routing protocol which helps to establish routes and accomplish packet delivery process among randomly distributed nodes. Based on the behavior of routing, the routing protocol is primarily classified into three types as given below (Dinesh Ratan Gautam, 2011):

Proactive or Table Driven Routing Protocols:

Each node will proactively maintains a table which keeps information needed for routing process by periodically transmitting Beacon messages to it neighbour node. Examples of such protocols are Destination Sequenced Distance Vector Routing (DSDV), Optimized Link State Routing (OLSR) etc.

Reactive or On-Demand Routing Protocols:

Nodes does not maintain updated routing table at every instant of time. It establish network link whenever the connection is needed. Some reactive protocols are Dynamic Source Routing (DSR), Ad hoc On-Demand Distance Vector (AODV), Temporally Ordered Routing Algorithm (TORA).

Hybrid Routing Protocols:

This protocol comprises of both the Proactive and Reactive Mechanisms. Examples of hybrid routing are Zone Routing Protocol (ZRP), Sharp

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Hybrid Adaptive Routing Protocol (SHARP) and Zone Hierarchical Link State (ZHLS), etc.

The remainder of the paper is organized as follows. Section II summarizes the related work in this field. Section III deals with various Hybrid Routing Protocols. Section IV gives a detailed introduction and implementation of novel routing algorithm. The simulation setups are shown in Section V and the results analyzed in Section VI. Conclusions are drawn in Section VII.

Review of Related Works:

Many researchers have been carried out in recent years which focus to develop several energy conservation algorithms. This led to develop Enhanced Transmission Power Control Mechanism (ETPCM) [2], is an approach which calculates the required transmission power of the node based on RSSI (Received Signal Strength Indication). The calculation of transmission power for all nodes using RSSI will increase delay. In this case it is difficult to find the signal strength of non-neighbor nodes.

Minimum Battery Cost Routing (Javad Vazifehdan, 2013) which estimates the residual energy of individual nodes and retain this to select suitable path for routing process. In some cases this routing may lead selection of routes with less power nodes which result in path damage.

Modified Zone Routing Protocol based on Alternate Zone creation process (Ravilla Dilli, 2012) has utilized alternate Zones of various power levels to reduce the wastage of transmission power in case of absence of peripheral nodes in Reactive mechanism

Energy Efficient MANET routing (Suguna, 2013) proposed a novel approach based on AFECA and Span which eliminates multiple retransmission of request by coordinator node selection and overhearing process.

In conclusion all previous works deal with power management effectively, but all of them lack in the fact that change in route is not an instantaneous process. The Adaptive Fidelity Energy Conserving Algorithm (AFECA) overcomes these drawbacks and provides an effective power saving techniques. Moreover, all other techniques work based on power saving alone, while AFECA deals with node failure, which is a good way of preventing link breakages. In this AFECA optimized by Distance based energy conservation algorithm in zone routing protocol which makes it an effective routing compared to all other techniques.

Overview of Hybrid Routing Protocols:

Zone Routing Protocol:

The Zone Routing Protocol (ZRP) is a hybrid protocol, which combines both proactive and reactive protocols. ZRP seems to overcome the disadvantages in the proactive and reactive protocol. There are two types of routing in ZRP. They are Intra zone routing and Inter zone routing. In intra zone routing the node transmits data within its radius by proactive mechanism by maintaining a routing table within the zone. In inter zone routing node transmits outside its zone radius by reactive mechanism of establishing a path by route request and route reply. It sets a zone for each node and acts proactively within that zone and operates reactively when transmission is to occur outside the zone (Mads Darø Kristensen 2008). Energy conservation in the Zone Routing Protocol is very efficient as it saves power by transmitting data through peripheral nodes. Transmission through peripheral nodes reduces energy consumption of intermediate nodes while transmitting data. Moreover maintaining route update is confined to a small zone instead of maintaining route (Seema Verma, 2012).

The nodes of Zones are classified as peripheral and interior nodes. Node inside the zone is called interior nodes where the peripheral nodes are outer node whose minimum distance with central node is equal to zone radius. In Fig. 1 nodes A-E are interior nodes, the nodes F-J called peripheral nodes. Nodes K and L are outside the zone of S. Node S is the source node with a radius of 2. Node S wants to transmit data to the nodes within its radius through a proactive mechanism by maintaining a routing table by IARP. If not found, it uses IERP. The request is forwarded by bordercast to the peripheral Nodes. Data forwarding to K and L occur reactively by Border casting technique. This helps in establishing a link between nodes S and K. The BRP uses very special query control mechanisms to steer route request away from areas of the network that have already covered by the query.

Sharp Hybrid Routing Protocol:

The Sharp Hybrid Adaptive Routing Protocol (SHARP) adapts efficiently and seamlessly between proactive and reactive routing strategies by varying the amount of routing information shared proactively. Around the node, zone radius is specified which determines the number of nodes within a proactive zone. A node will be the member of the proactive zone if it has distance less than or equal to the zone radius. Nodes outside the proactive zone of a given destination use reactive routing protocols to establish the routes to that node. Within a proactive zone, node specified proactive routing is employed. SHARP creates proactive zones automatically around hot destinations. The proactive zones act as collectors of packets, forwarding the packets efficiently to the destination, once the packets reach any node at the zone (Jun Zhang, 2011).

It shows the SHARP topology, in which it maintains proactive zones around the destinations A, B and C. The vertices represent the nodes and directed edges represent route table entries. The size of proactive zone is adjusted by each node independently. The nodes with little or no load like nodes D, E and F will have no proactive zone and will rely on reactive routing (Subhankar Mishra, 2011).

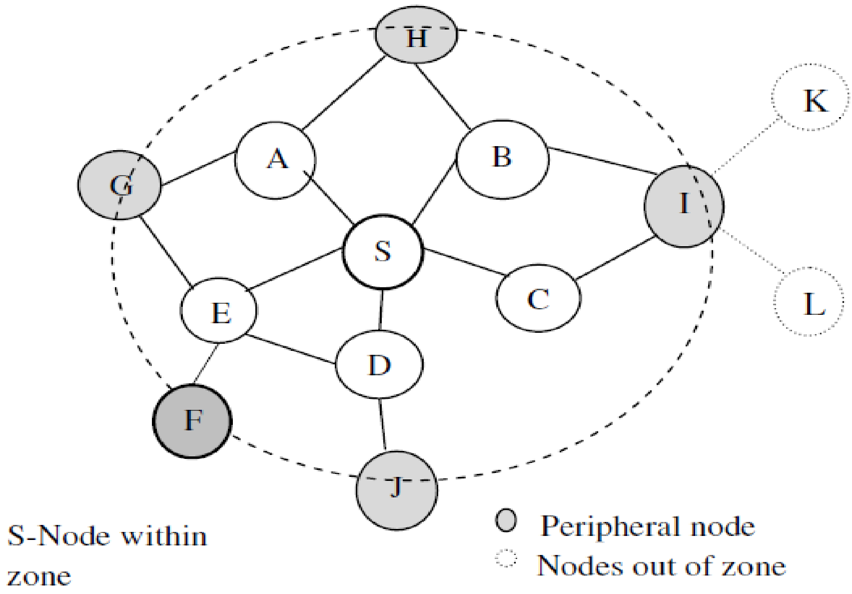

Fig. 1: Zone Routing Protocol.

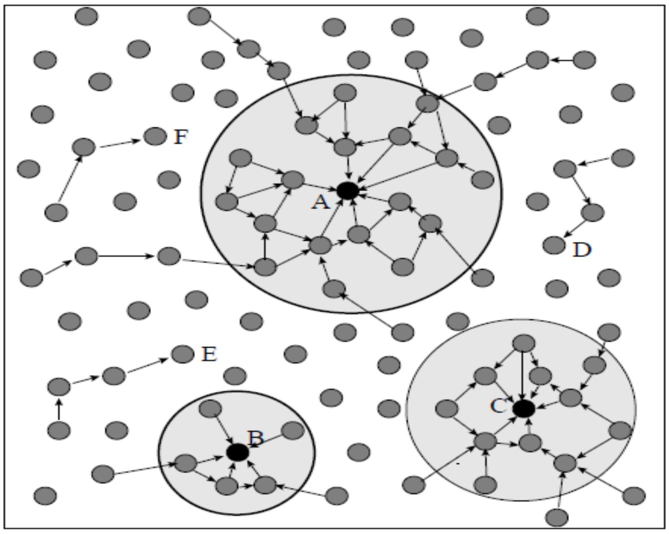

Fig. 2: Proactive zones of node A, B, C in SHARP.

Zone – Based Hierarchical Link State Routing Protocol:

In ZHLS, a particular area is divided into different zones. A node determines in which zone it exists with the help of Global positioning System (GPS). This GPS is used to calculate the node ID as well as the zone ID of each and every node. Each node floods its Link State Packet (LSP) in the form of above said node ID and zone ID. The different zones created by dividing the area is further divided into subzones, which is regarded an suitable topology of significant MANET. With the advancement in GPS technology and also due to reduced cost of GPS, its receiver can be attached to any movable device without any difficulty and within a distance of at least one meter, the geographical location of the device can be exactly calculated. So, ZHLS generates low overhead as compared to the flooding in reactive protocols (Zygmunt Haas, 2001).

Proposed Work:

In this paper we have proposed an energy conservation algorithm for ZRP which focuses to reduce utilization of unwanted energy by proper scheduling and effective utilization of transmission power. The scheduling process involves assigning of three periodic time slots such as Ts, Tl, Ta, to all nodes in order to conserve the energy of individual nodes as much as possible. In accordance with AFECA technique every node in ZRP are operated with effective sleep schedule approach as shown in fig 3. The effective sleep schedule approach aims to put the node in sleep mode for a pre assigned time period (Ts) when it is not in use. As soon as a node finds that no traffic or request from its neighbor during its listening period (Tl) it switches over to sleep mode.

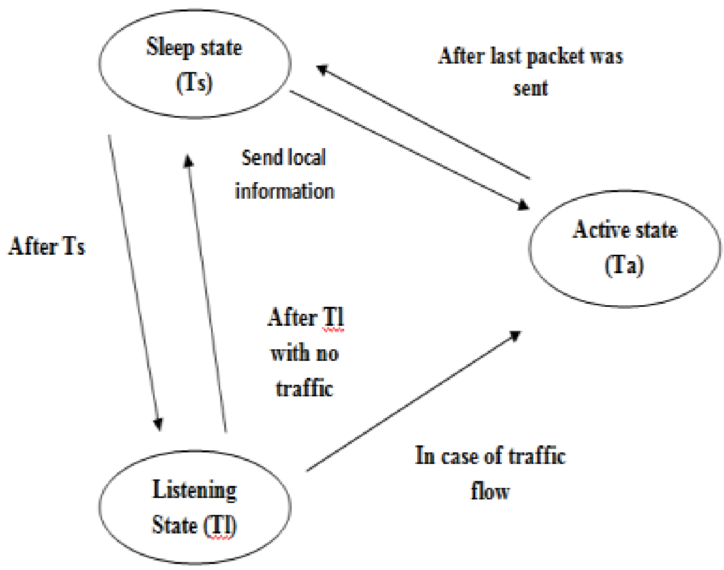

Fig. 3: State Diagram for Sleep Schedule Approach.

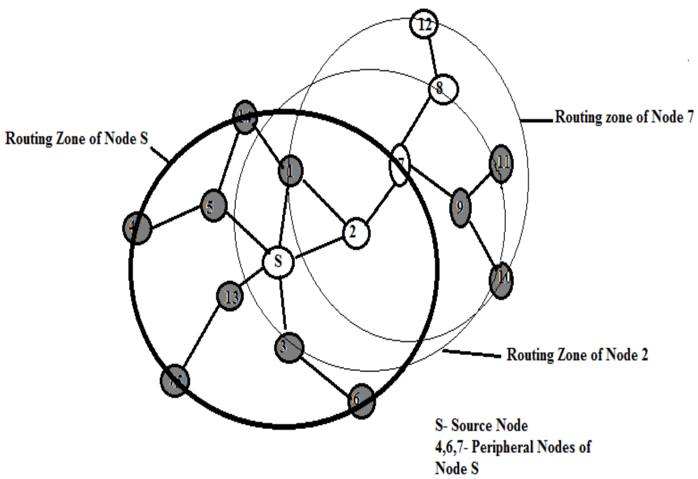

Fig. 4: Process Diagram for Sleep Schedule Approach.

In case if it finds any messages or traffic from its neighbors it immediately processes the request by entering in to active mode (Ta).

Tl= It is the time over which the node Listen for traffic.

Ts= It is the time over which the node is in Sleep mode.

Ta= It is the time over which the node participates in Active Packet Delivery Process.

In order to ensure the successful delivery of data packets, repeated transmission of requests to K+1 times would be necessary. This ensures that a node will reply for any one of the K+1 request when it is in sleep mode. This may slightly increase overhead in the network. Once the node wakes up it will not give much impact on latency and overhead.

The time interval for sleep mode has been increased by the factor which is proportional to the density of neighbor nodes.

TSA = Random (1, N) * Ts

where, Ts= K* Tl

N= Number of nodes

TSA= new sleep time

Since it is an extended energy conservation technique we need to take node density into consideration. A node calculates its node density by tracking the number of packets seen during the listening time.

Active time of a node depends upon the length of the data packet that has to be delivered. A node in this network will be active until it finds no more packets to be processed. Once it detects that no more packet waiting in the queue, it allows the node to sleep for a particular period of time (Ts). The node wakes up from sleep mode after the time period (Ts) gets over.

Consider a network consist of 15 nodes of radius 2 hops as shown in Fig 4. This shows how the nodes are responsible for sleep schedule approach. In this node S is Source and node 12 is destination. When the source S has the data to deliver to the destination, node S checks the destination in its routing table and it found that the destination node is not covered by the source Zone region. so it follows IERP. Node S broadcast request to its peripheral nodes (nodes 4, 6, 7, 14, 15) directly by using BRP (Border cast Resolution Protocol).

As soon as the peripheral node 7 finds the destination in its routing table, it sends reply back to the source node S. The nodes S, 2, 7, 8, and 12 are involved in this process and the remaining nodes are not participated in this process so it goes to sleep mode or low power mode indicated as a grey circle. These nodes conserve their energy by switching into sleep mode when no traffic occurs.

Along with the scheduling approach a suitable technique has been incorporated to further optimize the power by taking distance between source and destination into consideration. This algorithm helps to decide the sufficient energy level for delivering of data packet to the particular destination based on the hop distance. It is based on “Distance based energy conservation algorithm”.

A node adjusts its transmission power based on the distance between the corresponding node and the node it wish to deliver the data packet. Hence the destination node which is nearer to the source node would require less energy than the node which is far away from the source node. The distance and corresponding power levels can be calculated using Frris relation. The distance between corresponding nodes can be calculated by finding out the nodes position in terms of X and Y. The transmission power levels are calculated based on the distance between the source and destination which are shown in Table 1.

Table I: Transmission Power Levels In Joules.

Distance between Source and Destination (M)	Transmission Power Level in Joules
Distance<50 50<Distance<80 80<Distance<100 Distance>100	0.09 0.12 0.15 0.2

Table III: Simulation Parameters.

Parameters	Value
Number of Nodes	20,30,40,50,60. 80,100
Grid Area	1000*1000
Initial Energy	100J
Transmitter Power	0.2J
Receiver Power	0.1J
Data Packet Size	2000 bits
Antenna Type	Omni directional Antenna
MAC Type	IEEE 802.11
Simulation Time	200 sec
Listening time (Tl)	1s
Sleep time (Ts)	3s
Active time (Ta)	20s
Idle Power	0.0005J
Routing Protocol	EEZRP, ZRP, SHARP and ZHLS
Simulation Tool	NS-2

Consider the node S as source node and node 1 as destination node. The destination node (Node 1) is nearer to the source node(S) and the distance between node S and node 1 is almost less than 50 m, so the transmission power of the source node is adjusted based on the predefined power as given in table 1. At initial we have assigned transmission power of 0.2J to the nodes. After adjusting the transmission power it consumes 0.09J to deliver the data successfully to the destination node (Node 1).

Let us take the network by assuming node S is the source node and Node 8 as destination. Once the route(S-7-8) has been established to the node 4 using IERP and IARP, the source node calculate the distance to the node 7 and adjust the transmission power and node 7 calculates the distance to the node 8 and adjusts its transmission power according to the pre-defined power values as given in Table I.

Simulation Setup:

The Network Simulator-2 is used to analyses the parametric performance of EEZRP, ZRP, SHARP and ZHLS. The IEEE 802.11 for wireless LAN is used as MAC layer protocol. The 100 mobile nodes are placed over the simulation area of 1000 m × 1000 m with constant traffic load and constant pause time. Simulation parameters used for the implementation of protocols are shown in Table II.

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RESULTS AND DISCUSSIONS

Energy:

Energy consumption is the major parameter which decides life time of the network and it contributes more than remaining parameters. The graph shows that Energy Efficient Zone Routing Protocol utilizes less amount of energy when compared to ZRP, SHARP and ZHLS in Fig 5. EEZRP conserves maximum amount of energy by putting the mobile nodes into sleep mode when it is idle and extend its energy conservation during Active mode by taking distance between source and destination into consideration. With the help of this proposed technique we can conserve 48% of energy under low density and 46% of energy under high density of nodes when compared with ZRP. Similarly it is very high when compared to other protocols.

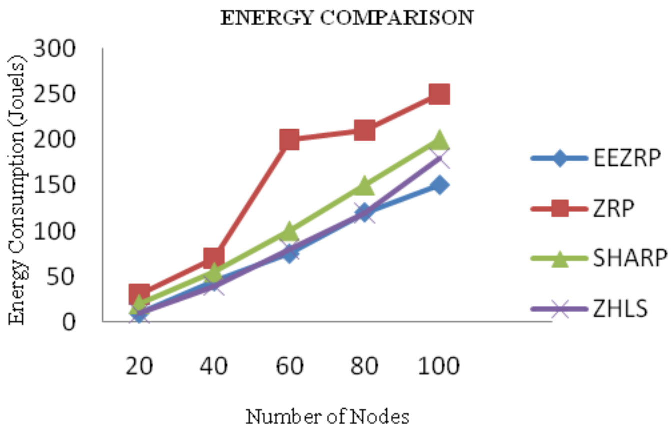

Fig. 5: Energy Comparison between EEZRP, ZRP, SHARP and ZHLS.

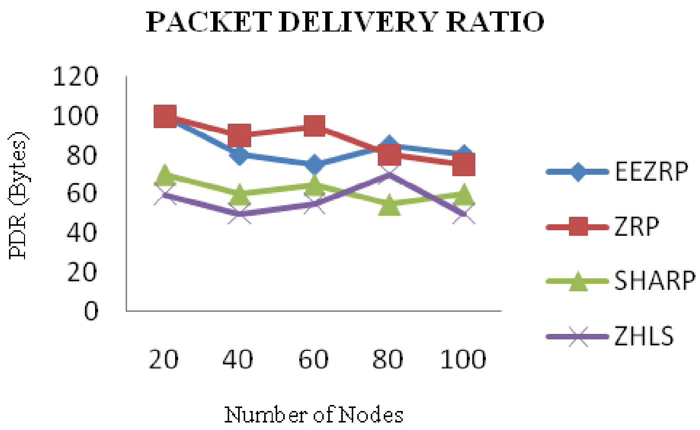

Fig. 6: PDR Comparison between EEZRP, ZRP, SHARP and ZHLS

Packet Delivery Ratio:

The Packet Delivery Ratio shown in Fig 6, pure ZRP maintains its PDR as an average of 90% and 83% in low and high density of nodes respectively. The Energy Efficient Zone Routing Protocol has the PDR of 87% and 81% under low and high density of nodes respectively.

The basic reason behind this reduction in PDR is the receiving node could be in sleep mode when the packet arrives and natural packet collision. But it is higher than other two protocols.

Throughput:

An efficient routing protocol should achieve high throughput and low delay. The throughput is always correlated with delay. As the throughput increases the delay will be low. The Energy Efficient Zone Routing Protocol (EEZRP) has higher throughput than ZRP, SHARP and ZHLS and it has less delay as shown in Fig 7.

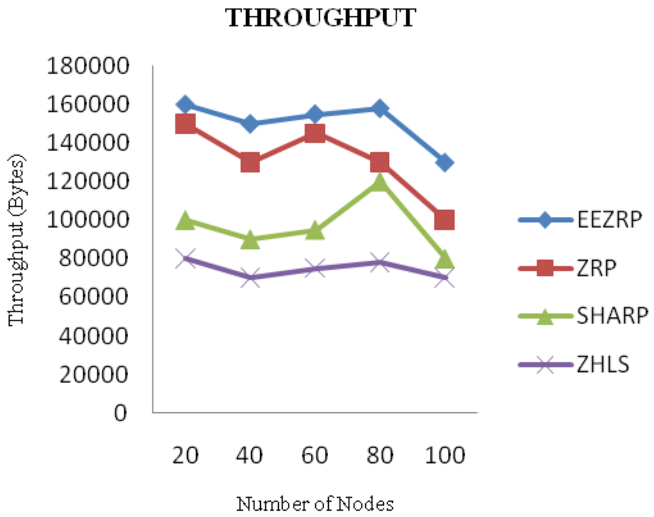

Fig. 7: Throughput Comparison between EEZRP, ZRP, SHARP and ZHLS.

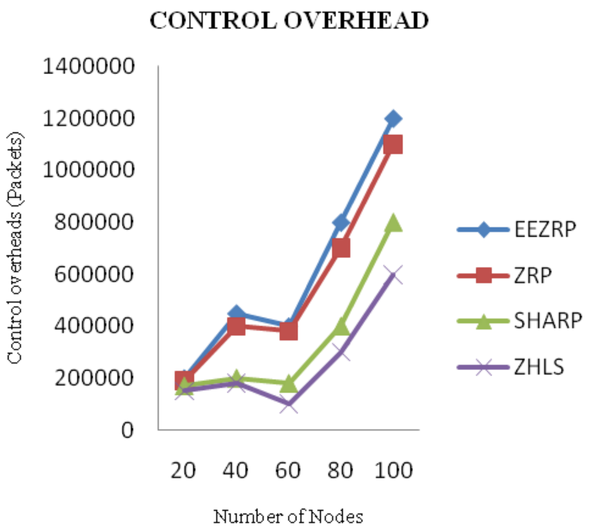

Fig. 8: Control Overhead Comparison between EEZRP, ZRP, SHARP and ZHLS

Control Overhead:

When EEZRP control overhead is compared with ZRP, the overhead of EEZRP is slightly higher than ZRP, because of transmission of queries. Once the route has established it will not give much impact on overhead. The control overhead of EEZRP is very higher than SHARP and ZHLS shown in Fig.8.

Conclusions:

In this paper we have proposed a novel approach which conserves the energy of the mobile nodes as much as possible by following sleep schedule approach and Distance based energy conservation algorithm. In simulation results with 100 mobile nodes, a very high throughput is observed in EEZRP. The throughput of ZPR is less than EEZRP but very high than SHARP and ZHLS. Minimum throughput is observed for ZHLS. With the increase in load, delay also increases. Maximum delay is in SHARP and the delay in ZHLS is low. A very high amount of data is dropped in ZHLS. Minimum data is dropped in EEZRP. So from the results it is concluded that the performance of EEZRP is better than ZRP, SHARP and ZHLS protocols. It ensures that Energy Efficient ZRP is effectively suitable for wide range of applications.

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