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**Research Article**

# A Sector Based Energy Efficient Adaptive Routing Protocol for Large Scale MANET

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**Abstract:** A MANET is a type of ad-hoc network that can change locations and configure itself on the fly. A MANET involves mobile platforms which are free to move arbitrarily and there may be frequent link breakage due to battery. We propose a novel adhoc routing protocol named as Sector based Energy Efficient (SEA) routing protocol with high data throughput. To overcome the link breakage in MANET, the proposed protocol also uses the mathematical geometrical progression method, which minimizes the redundancy distance calculation and routing overhead. We also combine the mathematical model with weight based route estimation techniques. It selects the longest life span to estimate the route stability derived from received signal strength. The simulation results shows that the proposed SEA protocol yields better performance then the existing protocols namely EDRP, EDNR, DOA and AODV in terms of packet delivery ratio and energy consumption.

**Keywords:** Connectivity, flooding, MANET, network, routing overhead, routing protocols

## INTRODUCTION

Mobile ad hoc network consists of mobile nodes which are moving arbitrarily in a terrain space with limited or no-infrastructure. The characteristics of MANET includes dynamic topology, battery constrained and, limited resources. Developing routing protocol with reduced overhead towards improving reliable communication assurance is a major thrust research area in MANETs (Martin *et al*., 2007). Link failure which is the outcome of dynamic topology is one of the main reasons that results in frequent route failures and path reconstruction.

A new algorithm to evaluate the node lifetime and the link lifetime utilizing the dynamic nature such as the energy drain rate and the relative mobility estimation rate of nodes. The radio range is also limited and hence extending the range will not be the right solution. Due to all these above said factors the packet delivery ratio and throughput is decreased and end-to-end delay is extended.

The main objectives of study took placed in three methods. First, distance calculation minimization. Secondly, quality of service for link stability, finally power consumption correspondingly. The proposed scheme handles two techniques, such as weight based Route estimation (Labovitz *et al*., 2000) and Route life span mechanism. The first is to select the optimal paths, which helps to prolong network's life span based on weight calculation; the Second is a route discovering technique is used to minimize the routing overhead and increase the packet delivery ratio.

## LITERATURE REVIEW

A number of routing proposals for ad hoc networks took energy conservation into consideration so as to extend the lifetime of the wireless nodes by wisely using their battery capacity (Meléndez *et al*., 2003). In Meléndez *et al*. (2003), Minimum Total Power Routing (MTPR) is proposed. On the downside, this methodology will by and large have a tendency to select routes with a bigger number of hops than others. This is realizable due to the fact that transmission power is inversely proportional to distance (Meléndez *et al*., 2003). Thus, more energy may be wasted network-wide since a larger number of nodes are now involved in routing as all nodes that are neighbors to the intermediate nodes will also be affected, unless they were in sleep mode. Minimum Battery Cost Routing (MBCR) (Scott and Bambos, 1996) utilizes the sum of the inverse of the battery capacity for all intermediate nodes as the metric upon which the route is picked. Nonetheless, since it is the summation that must be insignificant, a few hosts may be abused in light of the fact that a route holding nodes with small remaining battery capacity may in any case be chosen. Min-Max Battery Cost Routing (MMBCR) (Scott and Bambos, 1996) treats nodes more fairly from the standpoint of their remaining battery capacity. Smaller remaining battery capacity nodes are avoided and ones with larger battery capacity are favored when choosing a route. Be that as it may, more general energy will be devoured all around the system since least aggregate transmission power routes are no more supported. In Sánchez and

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Ruiz (2006), MTPR is utilized when all the nodes framing a way (note that one way is sufficient) have remaining battery capacity that is over a purported battery protection threshold and MMBCR is utilized if no such way exists. The consolidated convention is called Contingent Max-Min Battery Capacity directing (CMMBCR). Moreover, the normal vitality used in dependably sending a packet over a particular link is considered in Ma and Yang (2005). In order to maximize the network life time, the cost function defined in Ma and Yang (2005) takes into account energy expenditure for one packet transmission and available battery capacity. Furthermore in Toh (2001), the queue load condition and the estimated energy spent to transmit all packets in the queue are considered. The study of various battery discharging property and possible applications are presented in Jaikaeo *et al*. (2006). Be that as it may, every one of them disregarded the mobility of mobile hosts and hence, it appears that they are more suitable for static networks.

The LLT directing calculations are utilized to gauge the lifetime of remote connections between every two neighboring nodes and after that to select an ideal way. In the affiliated based steering calculation, a connection is considered to be steady when its lifetime surpasses a particular limit that relies on upon the relative rate of mobile hosts. In the Signal Strength based versatile (SSA) steering (Duel-Hallen, 2000), each one connection is named a strong one or a weak one, contingent upon the received signal strength measured when a node accepts data packets from the comparing upstream node. Mobile node just methods a course ask for (RREQ) that is received from a strong connection. Figured Duel-Hallen (2000) the delicacy of a connection as the distinction of the received signal strengths of continuous packets spilling out of the same root to check if these two nodes are getting closer or moving separated. In anticipated Meléndez *et al*. (2003), the lifetime of a connection between two nearby mobile hosts through online factual examination of the watched connections.

In Zhang *et al*. (2010) proposed calculation comprises of the accompanying three stages: Route discovery, Data forwarding and Route maintenance, there are seven primary contrasts between the EDNR and the AODV. To begin with, in the EDNR convention, each node spares the accepted indicator quality and the gained time of the RREQ packet in its neighborhood memory and includes this data into the RREP packet header in a piggyback way when it gets the RREP for the comparing RREQ packet to meet the prerequisite of the association lifetime-forecast calculation. Second, node operators need to upgrade their anticipated node lifetime throughout every period. Third the node lifetime data in the RREP packet is upgraded when the RREP packet is come back from an end of the line node to the source node.

In Latiff *et al*. (2007) a cross layer between the network layer directing convention and the data link layer are carried out. That is restricted flooding algorithm called Q-DIR is cross layered with the CWA mechanism.

In this section, selecting the route path with the least Transmission energy for reliable communication we calculate the sector based distance using geometrical progression and infinite Distance based on geometrical series possibility of the proposed protocol. We utilize the upstream common proportion of a RREQ parcel accepted from the past node to compute the distance based on geometrical progression, which obliges that every node needs its 1-hop neighborhood information.

## MATERIALS AND METHODS

**Sector based energy efficient adaptive routing protocol:** SEA is an energy efficient adaptive routing protocol that concentrates on a specified sector and minimize the frequent distance calculation using infinite geometrical progression provided by a location service (Hu and Fei, 2010). In SEA Route discovery operation, the area data of the source and destination nodes is piggy-backed in the course ask for (RREQ) bundle and then showed after accepting the RREQ, intermediate nodes will come close utilizing a geometrical series common ratio based on the weight metric is to be able to route around the nodes that are running in low battery for which alternate routes are available. In the persistent data forwarding period, a source node tends to select the path with the longest lifetime (the path with the maximum Path Life Time-PLT value) from multiple paths as a source route for data forwarding. Also it selects the least dynamic route with the longest lifespan for persistent data forwarding and coordinates the source, destination and the current node that points the packet to the destination, therefore number of nodes participating in the route discovery will be reduced and hence reduces the routing overhead, Correlation failure and consequently total energy consumption Fig. 1 shows the participating of nodes in the network.

**Weight based route estimation:** The main objective of route selection is to select the optimal paths to prolong network's life span based on weight calculation. The main objective to give more weight to node with less energy to prolong its life time (Banu, 2010). Let $r_{it}$ be the residual energy of a node $n_i$ at time t. Let $w_i$ ($r_{it}$) be the battery weight Estimation of node $n_i$ at time t. The weight of node $n_i$ is equal to value of battery weight estimate function, which in turn inversely propositional to residual energy of the node $n_i$:

$$w_i(r_{it}) \alpha \ 1/r_{it} \qquad (1)$$

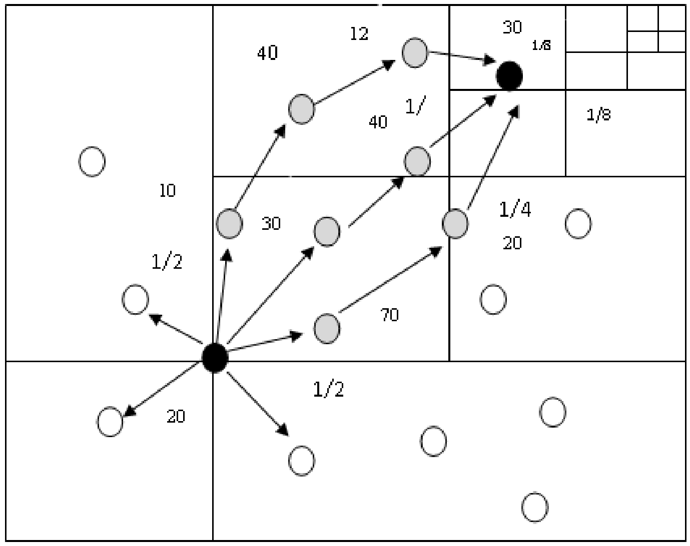


Fig. 1: Participating of nodes in the network

$$w_i(r_{it}) = \rho_i \text{ x } (w_i/r_{it}) \text{ x } L_{iq} \quad (2)$$

where,

- $w_i(rit)$ : Weight of node $n_i$ at time t
- $\rho_i$ : Transmit power of node $n_i$
- $w_i$ : Battery capacity of node $n_i$
- $r_{it}$ : Residual energy of a node $n_i$ at time t
- $L_{iq}$ : Weight factor which depends life span of the battery's capacity

We consider two different weights for the route path selection. The first weight is chosen as maximum life span of any intermediate node on the Route path $P_j$, it is denoted by:

$$w_1(P_j) = \max \{wi(r_{it})\} \; \forall n_i \in P_j \quad (3)$$

The second weight is sum of life span of all intermediate nodes on the path $P_j$, it is denoted by:

$$w_2(P_j) = \sum_{i=0}^{k} w_i(r_{it}) \quad (4)$$

Let $\gamma$ be threshold value power of battery of a node and it is considered that this threshold power of battery is identical for all the nodes irrespective of their battery capacity. Let G be the set of node Sector based Route path that were found during route discovery from source s to destination d at time t, then a sufficient path is given by:

$$P_s = min\,(w_1(P_j)) \; \forall P_j \in G \quad (5)$$

where, min is a function that selects least weight. Let S be the set of all Sufficient Route paths based Eq. (5). The best Path ($P_b$) is the practicable path with smallest amount total weight, it denoted by:

$$P_b = min\,(w_2(P_j)) \; \forall P_j \in G \quad (6)$$

For example, in Fig. 1 there are three route paths say $P_1$, $P_2$, $P_3$ from source node to destination node , As per Eq. (3) their weight are $w(p_1) = 40$, $w(p_2) = 40$ and $w(p_3) = 70$. According to Eq. (5) $P_1$ and $P_2$ are sufficient route paths. According to Eq. (4), the total weight of $P_1$ and $P_2$ are $w_2(p_1) = 10 + 40 + 12 = 62$, $w_2(p_2) = 30 + 40 = 70$. According to Eq. (6), a best possible path is $P_1$.

In route selection every node is based on weight estimation function it spares the received signal strength and the received time of the RREQ packet in its nearby memory and includes this data into the RREP packet header in a piggyback manner when it gets the RREP for the relating RREQ packet to meet the prerequisite of the correlation life span. And each host agents need to update their estimated host life span during every period. The Host-lifespan information in the RREP packet is upgraded when the RREP packet is come back from a destination node to the source node. The intermediate node figures the weight to embed its area by supplanting the source node arranges and attach its address and succession number at the end of the RREQ packet. It will then telecast the packet this procedure will rehash at each one intermediate node until it achieves the destination. The substitution of the source node area information with the intermediate node directions will make the packet more steered towards the destination since the examination now is focused around the previous node. At long last upon accepting the RREQ, destination node will send a Route Reply message (RREP) again to source through

Table 1: RREQ format for SEA protocol

| Type | R D G | Reserved | Hop count |
|---|---|---|---|
| RREQ ID | | | |
| $X_s$ | $Y_s$ | $X_d$ | $Y_d$ |
| RREQ time | RREQ recv strength | | RREQ info |
| Destination IP address | | | |
| Destination sequence number | | | |
| Originator IP address | | | |
| Originator sequence number | | | |
| Path node IP address | | | |
| Path node sequence number | | | |

the way taken to achieve the destination that was affixed in the RREQ as it crosses over the network. There is no requirement for the course disclosure to the source node. Table 1 show the arrangement of the RREQ parcel in SEA where the source and destination nodes area data are embedded and highlighted.

where, $X_s$, $Y_s$, $X_d$, $Y_d$ are the locality information of the source and Destination Type: RREQ:

R : Repair Flag; reserved for multicast
D : Destination only Flag
G : Gratuitous Flag

**Route life span mechanism:** We select the least dynamic route with the longest lifetime for persistent data forwarding. Finally, we implement our proposed route lifetime-prediction algorithm in SEA routing mechanism. Here, we focus on the routing mechanism in SEA, including the route discovery and route maintenance. In the route disclosure, the route to the destination could be acquired viably focused around weight Based route estimation. In the route maintenance procedure, we deal with cases such as route failure.

**Route discovery procedure:** At the point when source node S needs to send a data bundle to destination node D, S first hunts whether the route to D exists in its Sector route cache. In the event that the route exists specifically sends the data parcel. Overall S initiates the route discovery method to discover a route to D utilizing geometric progression method. The proportion of progressive terms in the arrangement is consistent. This relationship allows for the representation of a geometric series using only two terms, q and p. The term q is the common ratio and p is the first term of the series:

$$p + pq + pq^2 + pq^3 ..., with\, q = \frac{1}{2} and\ p = \frac{1}{2} \tag{7}$$

RREQ Forwarding event For node $n_i$, we assume that the node sequence associated with the discovered path in the received RREQ packet is n1→n2→⋯→ni-1; then, the RREQ packet will be processed as follows The total area is divided into sector and Minimize the mobility distance calculation on each node location service on common ratio:

$$\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\frac{1}{16}+...$$

If q is between -1 and +1, the terms of the series become smaller and smaller, approaching zero in the limit and the series converges to a sum.

In the case above, where q is one half, the series has the sum one. If q is greater than one or less than minus one the terms of the series become larger and larger in magnitude. The sum of the terms additionally gets bigger and bigger and the series has no sum. The series diverges if q is equivalent to one; the greater part of the terms of the series are the same then it might be apply to vast scale thick and meager network and minimize the Routing overhead utilizing infinite geometrical series. Whose progressive terms have a common ratio such a series merges if and if unquestionably the worth of the common ratio is short of what one (|q|<1). Its quality can then be figured from the finite sum formulae:

$$\sum_{k=0}^{\infty} pq^k = \lim_{n\to\infty}\sum_{k=0}^{n} pq^k = \lim_{n\to\infty}\frac{p(1-q^{n+1})}{1-q} = \lim_{n\to\infty}\frac{p}{1-q} - \lim_{n\to\infty}\frac{pq^{n+1}}{1-q} \tag{8}$$

Also, the infinite series 1/2 + 1/4 + 1/8 + 1/16 + … is an elementary example of a series that converges absolutely.

It is a geometric series whose first term is 1/2 and whose Common ratio is 1/2, so its sum is:

$$\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\frac{1}{16}+... = \frac{1/2}{1-(+1/2)} = 1$$

In the case for a finite sum, we can differentiate to calculate formulae for related sums. For example:

$$\frac{d}{dr}\sum_{k=0}^{\infty} q^k = \sum_{k=0}^{\infty} kq^{k-1} = \frac{1}{(1-q)^2} \tag{9}$$

At last the route discovery methods for each one Node that normally change their movement need to intermittently redesign their neighbors, since their areas are evolving alterably. On the dissimilar, $q^2$ nodes which move gradually don't have to send regular upgrades. The RREQ Format redesign strategy can fulfill both these necessities all the while, since a little overhaul interim will be taken for mobile nodes it will prompt exact area administration data for the very mobile nodes utilizing weight based route estimation.

**Route maintenance procedure:** Whenever a link is broken or newly formed, the information will be propagated with a hop limit. In the event that a route failure distinguishes a connection breakage along its source route to a destination node. When the source node demonstrates the presence of a softened connection up the route, it can utilize an alternate route another route finding methodology. Route maintenance is used only with active route based on weight based route estimation if distance between two nodes is larger than the communication range. Otherwise, all links have a constant quality, in which the probability of successful transmissions through this link is equal to P. To handle packet sufferers caused by node mobility. When a link break in an active route occurs, the node upstream of that break MAY choose to repair the link locally if the destination was no farther than MAX_REPAIR_TTL hops away. To repair the link break, the node increments the sequence number for the destination and then broadcasts a RREQ for that destination:

Lifespan = allowed_hello_loss*hello_interval

A node may determine connectivity by listening for packets from its set of neighbors. In our simulation we assume the allowed hello loss is 2 msec and hello interval is 1 msec. To repair the link break, the node increments the sequence number for the destination and then broadcasts a RREQ for that destination.

The goal of our proposed framework is to select a path which keeps going for a long time and in this way staying away from system distress due to extermination of nodes. This device likewise increases the helpful running life of a MANET. This is exceedingly attractive since extermination of specific nodes prompts a plausibility of system parts, rendering other live nodes inaccessible.

**Algorithm:** The formal description of the Sector based energy efficient Adaptive RREQ and RREP procedure where:

ni = NodeID
*w*i = Weight Estimation
R = Transmission Range
IF NodeID (ni) ! = SourceID
{
Discard Packet p
}
Else IF ni Received a new RREQs
{
IF (Xs, Ys) < = ($X_i$, $Y_i$) < ($X_d$ + R, $Y_d$ + R)
Update location and packet information
}
Else IF ($w_i$>0)
{
IF (node id = = Destination id)
{
Calculate the Transmission power, battery capacity for current path;
Source selects the minimum weight path;
}
Else IF (Nodeid ! = Destination id)
{
Monitor remaining power into battery capacity list;
Flood RREQ;
}
}
}

## RESULTS AND DISCUSSION

**Simulation model:** With a specific end goal to assess the execution of the proposed SEA protocol, we contrast it and some different protocols utilizing the NS-2 simulator. Broadcasting is an essential and viable information dispersal instrument for some requisitions in MANETS. In this study, we simply examine one of the provisions: route asks for in route discovery. Keeping in mind the end goal to think about the directing execution of the proposed SEA protocol, we pick the An Estimated Distance-Based Routing Protocol for Mobile Ad hoc Networks (Hu *et al*., 2002) which is a streamlining plan for diminishing the overhead of RREQ packet acquired in route discovery in the late writing and the customary AODV protocol. Reenactment parameters are as takes after: The Distributed Coordination Function (DCF) of the IEEE 802.11 protocol is utilized as the MAC layer protocol. We think about steady Bit Rate (CBR) information activity and haphazardly pick distinctive source-terminus associations. The portability of hubs takes after an irregular way-point model. The source-destination association examples are produced utilizing cbrgen. tcl as a part of Ns2. The nitty gritty reenactment parameters are indicated in Table 2.

Table 2: Simulation parameters

| Simulation parameter | Value |
|---|---|
| Simulator | NS-2 (v2.34) |
| Topology size | 1200×1200 m |
| Number of nodes | 100, 200, 300, 400, 500 |
| Transmission range | 200 m |
| Bandwidth | 2 Mbps |
| Interface queue length | 100 |
| Traffic type | CBR |
| Mac type | 802.11 |
| Packet size | 512 bytes |
| Pause time | 0 sec |
| Speed | 5 m/sec |

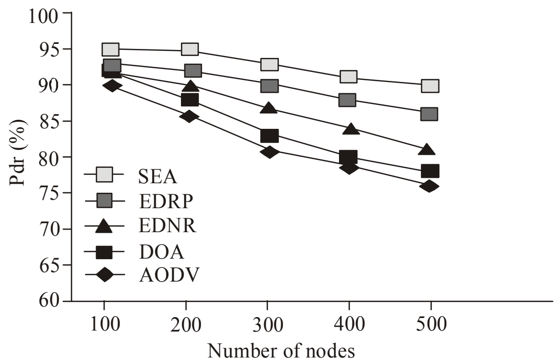


Fig. 2: Packet delivery ratio with varied number of nodes

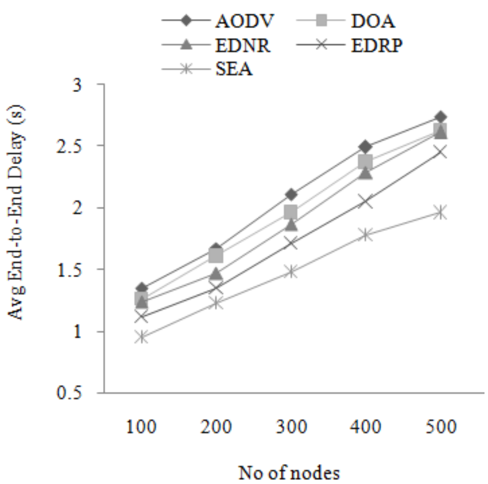


Fig. 3: Average end-to-end delay with varied number of nodes

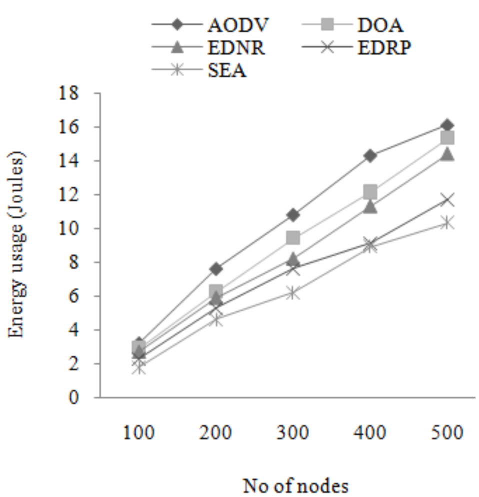


Fig. 4: Average energy consumption with varied number of nodes

**Performance metric and simulation analysis:** The performances of routing protocols are evaluated using the following performance metric.

**Packet delivery ratio:** The proportion of the amount of data packets effectively accepted by the CBR destinations to the amount of data packets created by the CBR sources:

$$\frac{\text{Total number of packets successfuliy delivered}}{\text{Total number of packets sent}} \times 100\%$$

**End-to-end delay:** The postponement of effectively conveyed CBR packets from source to end hub. It incorporates all conceivable postponements from the CBR sources to destinations:

$$\frac{\sum Individual\ data\ packet\ latency}{Total\ number\ of\ packets\ delivered}$$

**Energy consumption:** The energy consumed by overhearing the packet transmitted by neighboring nodes in idle sleep and transmitting and receiving state of routes and the remaining power of nodes:

$$\frac{\sum Energy\ expended\ by\ each\ node}{Total\ number\ of\ packets\ delivered}$$

Figure 2 shows the packet delivery ratio with expanding system thickness. The SEA protocol can expand the packet delivery ratio on the grounds that it altogether decreases the amount of excess Transmission, which is indicated in Fig. 2, so it lessens the amount of packet drops created by crashes. On average, the packet delivery ratio is upgraded by about 4% in the SEA protocol when compared with the conventional EDRP protocol. And in the same situation, the SEA protocol expands the packet delivery ratio by about 4.1% when compared with the EDRP protocol. When network is dense, the SEA protocol increases the packet delivery ratio about 5, 2.4, 2 and 2% when compared with the EDNR, EDRP, DOA and AODV protocols, respectively.

Figure 3 measures the normal end-to-end delay of CBR packets gained at the destinations with expanding system thickness. The SEA protocol diminishes the normal end-to-end delay because of a decline in the amount of repetitive transmission packets. The excess transmission increments delay on the grounds that:

- It acquires too numerous impacts and impedance, which prompts unreasonable packet drops, as well as builds the amount of retransmissions in MAC layer in order to expand the delay.
- It causes too numerous channel contentions, which expands the backoff clock in MAC layer, to build the delay.

Consequently, diminishing the repetitive rebroadcast can diminish the delay. On average, the end-to-end delay is compact by about 1.2% in the SEA protocol when compared with the conventional EDRP protocol.

Under the same network conditions, the delay is reduced by about 0.5% when the SEA protocol is compared with the EDRP, EDNR, DOA, AODV protocol. When network is dense, the SEA protocol reduces the average end-to-end delay by about 0.4, 0.3, 0.1 and 0.2% when compared with the EDRP, EDNR, DOA and AODV protocols, respectively.

Figure 4 measures the average Energy usage of CBR packets received at the destinations with aggregate network density. Energy consumption, which measures the total energy consumed in the network. We adopt the widely used energy consumption model, which estimates the energy consumption for each basic operation (e.g., transmitting, receiving and overhearing in promiscuous mode) based on empirical data collected from commercial wireless cards, the SEA protocol minimize the Energy usage by about 1.4% when compared with the EDRP protocol. When network is dense, the SEA protocol reduces the Energy usage about 1.4, 3, 1 and 0.8% when compared with the EDNR, EDRP, DOA and AODV protocols, respectively.

## CONCLUSION

The Proposed SEA protocol outperforms the existing protocols namely EDRP, EDNR, DOA and AODV. All the conventional methods yield an almost of 89% in terms of packet delivery ratio. Whereas SEA yields 92% due to the involvement of weight based route estimation. The proposed method also outperforms in terms of average end-to-end delay and energy consumption when compared with existing methods. In future cross layer based intrusion detection system can be used identify the malicious nodes. The accuracy detection can be enhanced by exploiting the information available across different layers of the protocol stack by triggering multiple levels of detection.

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