EERA: Enhanced Efficient Routing Algorithm For Mobile Sensor Network

Hemalatha S[1†] and Dr.E.George Dharma Prakash Raj[2††],
hemalathasainidith@gmail.com georgeprakashraj@bdu.ac.in
Bishop Heber College , Bharathidasan University, Tiruchirappalli - India

Abstract:
A Mobile Sensor Network is widely used in real time applications. A critical need in Mobile Sensor Network is to achieve energy efficiency during routingas the sensor nodes have scarce energy resource. The nodes' mobility in MWSN poses a challenge todesign an energy efficient routing protocol. Clustering helps to achieve energy efficiency by reducing theorganization complexity overhead of the network which is proportional to the number of nodes in thenetwork. This paper proposes"EERA: Energy Efficient Routing Algorithm for Mobile Sensor Network" is divided into five phases. 1, Cluster Formation 2.Cluster head and Transmission head selection 3.Path Establishment / Route discovery and 4,Data Transmission. Experimental Analysis has been done and is found that the proposed method performs better than the existing method with respect to four parameters.

Keywords:
Mobile Sensor Networks, Clustering, Energy Efficiency.

1. Introduction:

The Mobile Sensor Network is an infrastructure-free system. Numerous mobile nodes, connected by radio frequency signals to form a Mobile Sensor Network. Because sensors are movable, they may change their location from time to time depending on the real-time application and their nature. Mobile Sensor Network ascertains the following characteristics: it is randomly deployed, self-configured, self-healing, self-maintaining, and has no set location for a long period. Nodes in this network are free to move around at will, and the network topology is constantly changing. Each node takes on the role of a router. It can be used for a variety of purposes, including instructional purposes, emergency applications, battlefield communications, and rescue operations, among others.
The remainder of this paper is organized as follows. In section II the Literature Survey is given. In section III, the Mobile Sensor Network Configuration is discussed followed by a description of the proposed algorithm in section IV. In section V, the Experimentation and Analysis is given. The conclusion is given in section VI.

2. Literature Survey:

Some of the existing Cluster based Routing algorithms in Mobile Sensor Networks which are used to address the packet loss, packet delivery and energy consumption problems faced in MSN are as discussed in an order.

Novel content-based publish/subscribe system that can be used in mobile sensor networks is given in this paper [1]. The essential concept behind the routing protocol for content-based publish/subscribe is that all sensor nodes in the network are separated into various clusters, with sensing data being transmitted between them. These clusters serve as the foundation for events. Event publication, subscription, matching, and unsubscribe are all part of the protocol. These clusters serve as the foundation for events. Event publication, subscription, matching, and unsubscribe are all part of the protocol. The problem that contents based publish/ subscribe protocol must address is how to get published events to reach interested subscribers as cheaply, efficiently, and reliably as feasible. Successful event transmission rate is the most essential design aim in transmission strategy. In addition, transmission delay and energy consumption also achieved by this algorithm.

Proactive Routing Protocol in Wildfire Detection Using Mobile Sensor Network proposed by Amar [2]. In this Proposed work, the Optimal Link State Routing (OLSR) protocol is used to detect sensors in virtual region, with limited nodes and coverage area. The number of links that utilized to forward packets is reduced in this work. OLSR routing protocol based proactive forest fire detection shows better results in terms of Packet Delivery Ratio, End-to-End Delay, energy consumption and routing overhead.

The proposed distributed cluster management scheme, cluster heads are elected as random, multi-hop routing method is applied, and mobile data collectors transfer data towards the base station.[3]. Author proposed this concept in 4 steps, cluster forming, selection of the cluster head, the discovery of the coverage void, and recovery and routing. Clusters are formed using the K-means method. CH is determined by residual energy (low, medium, high) as well as distance from the cluster to the base station. CH is chosen based on its energy.

Efficient Entropy Function is used to maintain clusters (cluster splitting and merging). For efficient packet transmission, a coverage hole was identified and recovered during cluster formation. A coverage hole problem author

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diagnosed by different ways. Within a cluster, between clusters, and on network's edge. The hole manager (HM), recover the coverage hole issue using fuzzy logic (energy, stability) model. Multi-Objective Emperor Penguin Algorithm Based (MO-EPO) selected for the multi-hop data transmission.

Sensor nodes may fall at the same location or at different locations, whose starting positions of traversal and traversal paths may differ from the pre-planned one. In the proposed “Mobile sensor nodes scheduling for bounded region coverage” [4] the authors observe reset places and collecting environmental data. Rectangle Region is formed tessellation-style again further partitioned into regular hexagons. Mobile sensor nodes are moved along the centre of regular hexagons. Scheduling and coverage work reduces the coverage hole issue.

In [5] the authors propose a unique virtual-force algorithm based on physical law. It is found that the hexagonal topology can achieve maximum coverage with a fixed number of sensor nodes, node deployment for mobile sensor networks. This paper aims to build a network topological structure while utilizing the least amount of energy by assisting deployment in complicated geometric areas or those recovering from disasters.

This paper “Bacteria Interactive Cost and Balanced Compromised Approach to Clustering and Transmission Boundary-Range Cognitive Routing in Mobile Heterogeneous Wireless Sensor Networks” [6] proposes two algorithms for diverse mobile networks: bacterial interaction-based cluster head (CH) selection and energy and transmission boundary range cognitive routing algorithm with innovative approach. This work aims to find the best mobile trajectories for an energy and transmission boundary.

Secure Trust Based Clustering Algorithm proposed to achieve energy efficiency in mobile sensor network is discussed in the paper “Energy Efficient Secure Trust Based Clustering Algorithm for Mobile Wireless Sensor Network”.[7] in which the Cluster head selection is based on the trust metric.

Trust metric is defined as node motility another way it is called direct trust. Indirect trust value is assigned for a node with other recommendations. Such that other metrics includes waiting time, connectivity degree, and distance among nodes. The cluster head selection is based on node weight. A weight consists of a number of parameters including trust computation, waiting time, degree of connectivity, and relative mobility nodes.

Hybrid Zone routing protocol is proposed for mobile networks to reduce to collision rate and the retransmission [8].

The authors apply a dispersive forwarder in order to reduce the collision in radio channel and to reduce the transmission of redundant packets. Enhanced Cluster Proxy Mobile IPv6 (E-CPMIPv6) group-based scheme proposed to achieve Mobility Management. [9].

Mobile Sensor network mobility management is a challenging task when roaming among different networks. Mobility management protocols ensures connectivity of the nodes either network based or host based. In the paper it is given that the handoff signalling burden is transferred to new entities called Local Mobility Anchor (LMA) and Mobile Access Gateway (MAG) and therefore the Mobile Node (MN) is shielded from the mobility related signalling when it moves between different networks.

3. Mobile Sensor Network Configuration

The Mobile Sensor Network Configuration for the simulation environment and its specifications is as follows:

- Sensor node deployed randomly, with various threshold value.
- All of the sensor nodes in the network are homogeneous, and energy of each sensor node can be replenished.
- Communication range of the network is defined with L, outside the communication range sensor nodes has topological structure to cover the neighbouring node.
- Sink node can randomly move in/out the sensing area, in case inside the coverage area route is established on time T, otherwise we rearrange the clustering process to find the sink node current location for the time interval T.
- Sensor nodes can identify route discovery and transfer data simultaneously in simulation time.

At initial stage of the self-organization phase, each node broadcasts randomly with three attributes, namely, geographic location information, residual energy level, and mobility level or velocity.

Sensor nodes n randomly deployed in region L, distance between the nodes measure with radius r. Nodes are assign with initial energy of 30 Jules, nodes threshold value is calculated at the stage, diagrammatical representation of the MSN shown in fig 1.

This broadcast is intended for the BS so that the BS can utilize those for cluster formation and CH panel selection.

The designer can use a suitable normalization function to compute the aggregate credit score earned by a node considering these three nonhomogeneous.

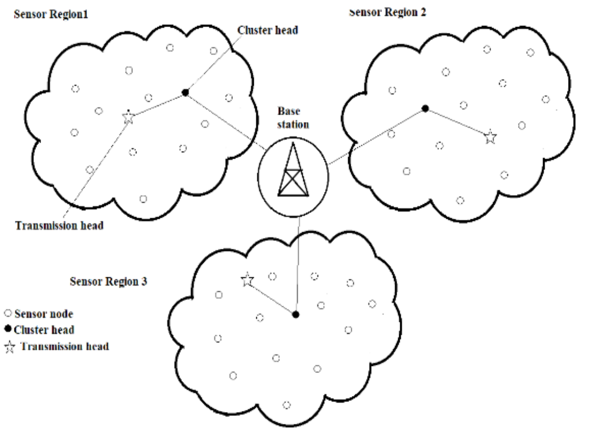


Fig:1. Model Mobile Sensor Network Diagram.

An ideal node suitable for CH role should have higher residual energy, higher degree (i.e., more numbers of neighbours), and low mobility.

Calculate aggregate credit score was used in MSN. Then, the BS prepares the CH panel consisting of nodes having an aggregate credit score all sensor node in the network. MSN configuration the nodes connected with bi directional signal communication, it signals propagation is listed in table 1. Each CH in the communication range is connected with Base station, and each CH is connected with the TH, rest of all sensor nodes are connected to the CH in particular region.

Table 1. Signal prorogation.

Possible ways	Signal Indicator	
	CH	TH
BS->CH	Y	N
BS->CH->TH	Y	Y
TH->CH	Y	Y
TH->CH->BS	Y	Y

Sensor node Mobility classified with 2 ways based on the application.

1. Unrestricted Path: This case proposes the distributed algorithm. The sink moves in autonomous path. The data gathering is done in rounds using clustering method.
2. Restricted Path: Adaptive method is used to calculate the sink current position for find the path.

The next movement of sink is determined by localised algorithm which considers the energy of the immediate neighbour of the sink node. Also, the best location of sink is determined inside the cluster. A new algorithm is invoked to check the connectivity of sink. Threshold value will automatically leave in each node, during the cluster formation. Sensor node residual energy is calculated by initial residual energy with threshold value. On the other hand, the selection of the normalization function shall also influence the threshold value. Then, the node with highest aggregate credit score is selected as the current CH node. The next two nodes in the list with second highest aggregate credit score, respectively, are selected as TH nodes for the same cluster. This set of nodes with different roles such as CH or TH is valid for a given round. The duration of a given round is equal to the next time interval that is set initially. Thus, a particular cluster setup is valid for the next time interval. In other words, cluster setup validity period is equal to the next time interval.

The procedure with regard to computation of aggregate credit score is as follows. A node earns aggregate credit score from three parameters, namely, residual energy level of the node, degree of the node (i.e., the number of neighbours), and mobility level of the node (high, medium, low). These three parameters are non-homogeneous, and therefore, a normalization method is required in order to compute the aggregate credit score. Ideally, a CH node should have higher residual energy, higher degree, and low mobility.

In this paper, the following algorithm is used to compute the aggregate credit score of a node. It is important to mention that the algorithm gets executed by the BS for each cluster in the field. Three different criteria used at the time of selecting the CH and TH nodes are residual energy level of the node, number of neighbours, and mobility level of the node. Ideally, a CH node is expected to be equipped with maximum energy level, relative maximum number of neighbours, and minimum mobility level. Thus, one such parameter is not directly linked or correlated with the other parameters. All the three parameters are independent of each other.

Role of CH: The CH node is responsible for gathering sensed data from the cluster members, aggregate those, and forward toward the BS through TH either directly or in a multi hop fashion. This part of data forwarding will take place according to the communication pattern or the route distributed by the BS.

Role of TH: The TH keep monitoring the sensor nodes data transmission. TH nodes are also called cluster management nodes as they take a major responsibility of collecting current location information from the cluster members and communicating it to the BS. Based on this information, the BS computes the actual recent topology. The initial state of the topology based on which the BS creates various clusters is an estimation only.

Moreover, in the event of the immediate link or node failure occur in the route of the CH toward the BS, the CH may seek the aid of one of the two (CH/TH) to forward the data toward the BS.

The reason behind selecting two nodes is the necessity to maintain load balancing inside the clusters. Ideally, the two nodes (CH, TH) may not the same each cluster. In such a situation, it is highly probable that the CH is connected to either of the TH nodes all the time. Moreover, location information collection and dissemination to the BS is an energy-consuming task. In addition, such a task is too heavy for one node. Since this task is jointly carried out by the two nodes, the work load in each is shared among each other. Load balancing of CH and TH adequately enforce packet delivery ratio, reduce packet loss and delay time.

4. EERA Enhanced Efficient Routing algorithm for Mobile Sensor Network:

The five phases of the proposed 'EERA: Enhanced Efficient Routing algorithm for Mobile Sensor Network' 1, Cluster Formation 2. Cluster head and Transmission head selection 3. Path Establishment / Route discovery 4, Data Transmission and 5. Path Maintenance is discussed in this section

4.1 Cluster Formation

Sensor network is partitioned into L virtual regions, distance between nodes called radius r is established. The sensor group consists of n nodes with various mobility and energy factors. This is given in Algorithm 1.

Algorithm 1: Cluster Formation

1. N nodes Randomly deployed in L*L region
2. Sensor nodes segmented into N clusters with radial factor r
3. Min_energy = 20 jules
4. For each node in the network
5. SN_mobility() = $\frac{\text{SN\_current\_position()} - \text{SN\_previous\_position()}}{time\ interval\ t}$

//Calculate node mobility

6. Endfor

4.2 Cluster Head and Transmission Head Selection:

The sensor group selects a Cluster head based on the node mobility, degree of node (no. of neighbouring node), and residual energy. So, the Procedures for Neighbour Calculation, Energy and Mobility are included in this phase. Aggregate credit score-ACS is calculated and based on ACS score; the cluster head is got selected. The sensor node with low mobility, a greater number of neighbouring node and highest residual energy node is selected as cluster head. The next order ACS node gets selected as Transmission head. Algorithm 2 is used to calculate the CH/TH.

Procedure Neighbour (t,n,r,Θ)
1.For every time interval T seconds
2.For each node in the cluster
3. If (SN_neighbour ( ) ≠ NULL)then
4.count_neigh = count_neigh+1
5.Else
6.Assign count_neigh = 0
7.Endif
7.Endfor
8.Endfor
9.Return(count_neigh)
10.End procedure

Procedure Energy (SN, n)
1. For each time interval T seconds
2. For each node in the cluster
3. if (SN_energy( ) > Nxt_SN_energy( )) then
4.temp = SN_energy()
5. SN_energy() = Nxt_SN_energy()
6.Nxt_SN_energy( )= temp
7. Endif
8. Endfor
9. Endfor
10.For each node in the network
// CH and TH selection for n clusters
11. Return(SN_energy())
12.Endfor
13.End function

Procedure Mobility (SN,n,t)
1. For each node in the network do
2. SN_mobility ( ) = $\frac{\text{SN\_current\_position()} - \text{SN\_previous\_position( )}}{timeintervalt}$

//Calculate node mobility of each SN
3. For each node in the cluster
4. if (SN_mobility( ) < Nxt_SN_mobility( ) then
5. temp_mob= SN_mobility( )
6. SN_mobility( )=Nxt_SN_mobility()
7. Nxt_SN_mobility( )= temp_mob
8. Endif
9. Endfor
10.For each node in the cluster do
11.Return(SN_mobility( ))
12.Endfor
13.End function

Algorithm 2: Selection CH/TH (N, SN_energy, SN_mobility)
1. Let CH=TH=ACS=NULL
2. Re_calculate_ACS ;
3. For i=1 to n do
4. For j=i+1 to n do
5.if Boolean((SN_neighbour[i][j] >= count_neighbour) && (SN_mobility[i][j]<SN_mobility[n][n]) && SN_energy[i]) then
6. ACS = 1 // Aggregate credit score calculated
7. else ACS = 0
8. Endif

9. Endfor
10. Endfor
11. If (ACS == 1) then// ACS is either high(1) or low (0)
12. CH=SN_id[i][j]
13. TH=SN_id[i][j]+1
14. Else
15. goto Recalculate_ACS :
16. Endif
17. End procedure

4.3 Path Establishment / Route Discovery:

Based on the Aggregate credit score Cluster and transmission head is get selected. Once the heads is identified, path is calculated by using algorithm 3. This algorithm calculates the next hop from the Source SN (SSN), where it may be single hop or multi hop from source to sink. CH is responsible to identify the route.

Algorithm 3: PathAnnouncement (SourceSN_id, SinkSN_id, CH,TH, SN_energy, Ө)

1.Path = null
2.Tot_time = 200 // Total time for simulation for 200 rnds approx
3. Do
4. For each time interval t to Tot_time do
// Time interval for N nodes
5. If (SinkSN_id ≠ NULL) then// check sink node is availability
6. For each node in the cluster do //all nodes in each cluster
7. If (SinkSN_id = neighbour(CH)) then
8. TH = *path(x,y, with its clockwise and anti-clockwise to the cluster)*
9. Else if (SinkSN_id = Nxt_neighbour(CH)) then
10. TH=*path(x,y, with its clockwise & anti-clockwise to the cluster)*
11. Endif
12. Endif
13. Endfor
14. While until Tot_time >=200
15. End function

4.4 Data Transmission:

Once the path is established, the actual packet transmission is performed by the transmission head. CH instructs TH regarding the routing path, so in that route packets are transmitted from source to the destination. This is given in Algorithm 4.

Algorithm 4:
1.Path = NULL
2.Tot_time=200 rounds
3. For each time interval t do
4. If(CH || TH == NULL)the // due to mobility check CH/TH availability
5. call Procedure Selection_CH/TH( )
6. Endif
7. Endfor
8. While until Tot_time >=200
9. End function

5. Experimentation and Analysis:

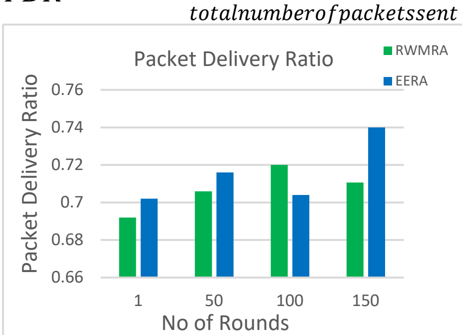
The Experimentation and Analysis done with the simulation for the proposed “EERA: Energy Efficient Routing Algorithm for Mobile Sensor Network” is given in this section.

Table 1. Simulation Parameters:

Parameters	Values
Network area (M × M)	200 × 200 m2
Number of sensor nodes (N)	120 nodes
Node density (nodes per square meter)	0.003
Initial energy of deployed node	30 Jules
Transmission range, r (meters)	20 meters
Time Interval	20 seconds
Maximum node velocity(meters per sec)	5, 10, 15, 20, 25
Packet size (bytes)	32 bits for AODV 64 bits for OLSR
Speed Interval	0.2 to 2.2 seconds
Direction Interval	-180, 180 Degree
Simulation interval	200 rounds
Simulation Tool	Mat lab

5.1 Packet Delivery Ratio:
It is defined as the ratio between the total numbers of packets received by the total number of packets actually sent.

$$PDR = \frac{totalnumberofpacketreceived}{totalnumberofpacketssent} * 100$$



5.2 Packet Loss Ratio (PLR):

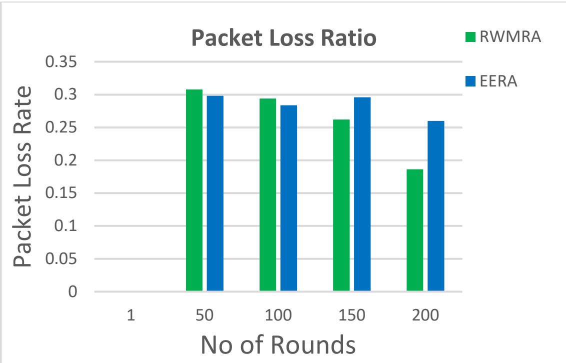
It represents the number of packets lost during transmission. It is the ratio between the total numbers of packets lost by the total number of packets received.

$$PLR = \sum T_{PS} - \sum T_{PR} * 100$$

$T_{PS} - total\ nuber\ of\ packets\ send$

T_{PR}

$- total\ number\ of\ packets\ received$



5.3 Average End to End Delay:

Average Delay in transmission of a packet between nodes is calculated by,

$$AED = \frac{1}{n}\sum_{i=1}^{n}(Tr_i - Ts_i) \quad * 1000\ ms$$

$N_{-\ Number\ of\ packets\ successfully\ Delivered}$

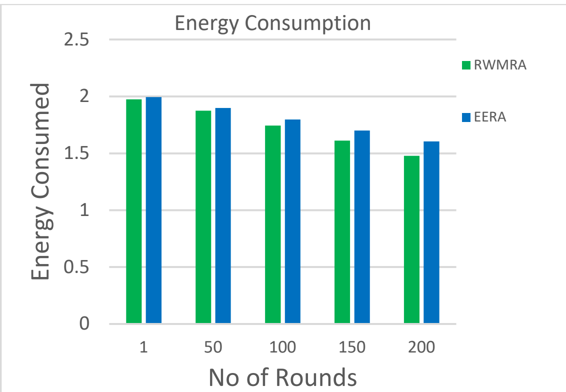
$Tr_i - Reception\ time\ of\ packet\ i$

$Ts_i - Sending\ time\ of\ Packet\ ii - Packet\ identifier$

5.4 Energy Consumption:

Sensor node energy consumption is calculated by,

$$EC = \frac{node\ initial\ energy - finalenergy}{timeintervalT}$$



The Experimentation and Analysis of the proposed EERA shows that it gives better results compared to the existing RWMRA.

6. Conclusion:

This paper proposes “EERA: Energy Efficient Routing Algorithm for Mobile Sensor Network”. In the Cluster Formation phase, the sensor network is partitioned into L virtual regions, distance between nodes called radius r is established. Sensor group consists of n nodes with various mobility and energy factors. In the Cluster Head and Transmission Head Selection phase, The sensor group selects a Cluster head based on the node mobility, degree of node (no. of neighbouring node), and residual energy. So, the Procedures for Neighbour Calculation, Energy and Mobility are included in this phase. Aggregate Credit Score (ACS) is calculated and based on ACS score; the cluster head is got selected. The sensor node with low mobility, a greater number of neighbouring node and highest residual energy node is selected as cluster head.

The next order ACS node gets selected as Transmission Head. Based on the Aggregate Credit Score (ACS), the Cluster and Transmission Head is selected. Once the heads are identified, the path is calculated in the next phase which calculates the next hop from the Source SN (SSN), where it may be Single hop or Multi hop from source to sink. The Cluster Head is responsible to identify the route. In the final phase, once the path is established, the actual packet transmission is performed by the transmission head. CH instructs TH regarding the routing path, so in that route packets are transmitted from source to the destination. As a future work, this can be extended with a Security for the transmission of packets.

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Hemalatha S is currently working in as a Programmer, Dept.of Information Technology, Bishop Heber College, Tiruchirappalli – 17. She has completed her Master of Computer Applications in 2002 at Vivekananadha Arts and science college, Trichengode, She has also completed her M.Phil. Computer Science in 2004 under Bharathidasan University. At present she is pursuing Ph.D. in Computer Science under Bharathidasan University. She had nine years of teaching experience among four years in worked in United Arab Emirates in various schools and 5 years of teaching experience in colleges in India. A Her areas of interest are Mobile Sensor Networks and Algorithms and Special Needs Education in education for students with disabilities, in consideration of their individual educational needs, which aims at full development of their capabilities.

Dr .E. George Dharma Prakash Raj completed his Master's Degree in Computer Science and Masters of Philosophy in Computer Science in the years 1990 and 1998. He has also completed his Doctorate in Computer Science in the year 2008. He has around thirty two years of Academic experience and twenty four years of Research experience in the field of Computer Science. Currently he is working as an Associate. Professor in the School of Computer Science and Engineering at Bharathidasan University, Tiruchirappalli, India. He is an Editorial Board Member, Reviewer and International Programme Committee Member in many International Journals and Conferences. He has published several papers in International Journals and Conferences related to Computer Science He has convened many National and International Conferences related to Computer Science. His Areas of Interest are Computer Networks, Big Data, Cloud Computing and Internet of Things