Middle-East Journal of Scientific Research 24 (2): 244-250, 2016
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2016.24.02.22962

Region Split Duty Cycle Bound Routing Scheme for Energy Efficient MANET

[1]D. Maya and [2]C. Kalaiarasan

[1]Research Scholar, Anna University, Chennai, India
[2]Professor, Computer Science and Engineering, SNS College of Technology, Coimbatore, India

Abstract: Energy efficiency is a seriousconcern in mobile ad hoc networks (MANETs) for enhancing the lifetime of the every nodes as well as the overall network.Hence this paper proposes a Region Split Duty Cycle Bound Routing (RSDCBR) Scheme for energy efficient MANET. This scheme is based on the cluster based routing protocol, where the cluster heads has been selected based on the energy level, node connectivity and transmission range. The routing region has splitted and given priority based on the location informationof the destination and the cluster head will selects the relay node present in the highest priority region. Duty Cycle Based data transmission has been processed on the selected region by utilizing the MAC layer information. Moreover the scheme schedule the sleep/ active/ passive state to the nodes effectively in the network in order to minimize the energy consumption. Overall, the scheme effectively reduces the energy consumption of the nodes and enhance the network lifetime than the existing routing protocols used in MANET.

Key words: MANET · Energy efficiency · RSDCBR · Clustering · MAC layer · Duty cycle

INTRODUCTION

Mobile Ad Hoc Network (MANET) has been made up of mobile nodes, where the communication has been enabled among the nodes in the network without the existence of any centralized infrastructure [1]. Due to the limited communication range of the nodes, multihop communication has been required to reach other nodes, which is not in its communication region. Since the nodes are mobile the topology of the network changes abruptly. Network nodes are equipped with limited battery power, which restricts the capacity of CPU, bandwidth and memory. Energy is an important factor in the network communication. Hence the most essential factor for network performance is energy conservation. The desire to utilize the minimum power in the routing process contains too many benefits further than conserving battery power of the node. Various research efforts have been carried out to provide an energy efficient routing protocols in MANETs.

Cluster based routing has been designed to solve the issue of nodes' heterogeneity and also to restrict the amount of routing information disseminating over the network [2]. Furthermore, energy efficient communication can be achieved in it by distributing the energy resources in a balanced way. The basic function of clustering is to cluster the network nodes into a number of overlapping clusters, which consist of one cluster head and few cluster members.A new optimization techniques have to be developed to get a better network performance in cluster based routing protocols. Cross layer design has gotten more attention recently to be used as an integration technique to attain a significant enhancement in network performance [3]. Hence this paper utilizes the MAC layer information such as duty cycle into the network layer, where the cluster based routing protocol will perform the routing based on it to attain a minimal energy consumption in the routing process. The location information about the neighbor or other nodes does not intend by the mobile nodes in MANET. While the nodes are aware about the location information, minimum route request and route reply will be flooded in the network, where more energy consumed in connection establishment can be minimized. So the proposed Region Split Duty Cycle Bound Routing Scheme uses the location information to select the region for communication. Moreover the scheme schedule the sleep/ active/ passive state of the nodes effectively in the network in order to minimize the energy consumption.

Corresponding Author: D. Maya, Research Scholar, Anna University, Chennai, India.

The Rest of the Paper Is Organized as Follows: Section 2 presents the review about the recent routing protocols developed for the energy efficient MANET. The proposed Region Split Duty Cycle Bound Routing (RSDCBR) Scheme has been described in the section 3. The results and discussion has been given in the section 4. Finally, the section 5 renders the conclusion.

Related Work: In [4] author proposes an energy efficient multipath routing protocol for MANET. In this process the energy metrics such as the node transmission power and residual energy has been considered while performing routing. The main objective of this proposed work is to find an optimal route depends on tow energy metrics for packet transmission. The experimental result achieves extend the life-span of network when compared with fundamental Ad-Hoc On-Demand Multipath Distance Vector (AOMDV) routing protocol. In [5], the author proposed on improved AOMDV protocol for energy efficient MANET based on the metrics such as queuing delay, link availability, mobility and bit error rate. To select the feasible path for data transmission this approach uses the BAT meta-heuristic optimization in AOMDV.

In [6] author proposes an energy efficient route discovery process in Ad-Hoc On-Demand Distance Vector Routing Protocol (AODV), where it achieved by using Expanding Ring Search (ERS). In this work, the scheme mainly saves the node energy by eliminating the redundant rebroadcasting process. This process minimizes the overhead of the routing process at the time of route discovery. The experimental results show that performance of Energy Efficient AODV (E2AODV) protocol using GloMoSim which is done by using Global Mobile Simulator. The experimental result achieves reduces energy consumption by75-85% when compared with the traditional AODV.

A routing protocol has been developed in [7] while identifying the drawbacks exist in the improved location-aided routing protocol (ILAR) [8]. A power balance scheme has been integrated with this routing protocol to solve the issues in ILAR, where the energy has been balanced in each node. Additionally, the location information has been provided to select the relay nodes for data transmission. In order to reduce the load of the network, a cluster-based routing scheme has been proposed in [7].

A location based clustering scheme has been proposed in [9] for energy efficiency and better stability of clusters using position management. An efficient and fact routing process has been provided by this scheme whenever there is a link failure. A two different cluster heads with uniques key has been used in this approach such as primary and secondary cluster heads. The energy efficiency has been attained by using the defined threshold level for power, capacity and link duration. In order to manage the location service for the inter cluster and intra cluster table, each node has been equipped with GPS.

A mobile node ranking scheme has been proposed in [10] based on the integration of two multi-criteria decision making schemes in fuzzy environments. The Fuzzy analytic hierarchy process (AHP) has been utilized to study the structure of clusterheadelection issue and to finding weights of the criteria, whereas the Fuzzy TOPSIS technique has been used to acquire the last mobile node ranking value. Based on the node ranking, a cluster based routing algorithm has been processed to elect the best cluster heads and the optimum routing path.

In [11], the author proposed an energy-efficient cross-layer design for MANET to optimize the energy consumption in MAC and Network layer. The roting protocol namely MTEC has been proposed to minimize the transmission energy in the network layer relied upon the proportion of effective data transmissions, the amount of channel events, the residual energy of the nodes and traffic load at the nodes. An adaptive contention window has been designed for the MAC layer to attain a maximum successful transmission rates along huge opportunity for compete for channel to minimize energy wastage.

In [12], a crosslayer optimization framework has been proposed to acquire the received signal strength information about the nodes with hello packets. A dynamic transmission power control algorithm has been introduced in this framework, where a link breakages has been predicted and new route has been discovered and it has been updated in the routing table. A three transmission ranges has been set based on the neighbors RSSI value according to it the transmission power has been altered.

A cross-layer based stablerouting scheme has been proposed in [13] for MANET using the fuzzy logic system. The QoS monitoring agent has been used in this approach to aggregate and compute the link reliability metrics. These factors helps to find the feasible link and reduces the amount of route reconstructions in MANET. Additionally, in order to maintain the energy efficiency they uses the residual energy as one of the metric. Finally, the probability of electing the path has been computed based on the above link reliable metrics and residual energy using the fuzzy logic system.

Region Split Duty Cycle Bound Routing Scheme: In this section, Region Split Duty Cycle Bound Routing (RSDCBR) Scheme has been introduced for energy efficient MANET. A cluster based routing methodology has been introduced in this routing scheme, where minimum routing overhead can be produced than the flat routing for MANET. The proposed RSDCBR scheme consists of three phases such as Cluster head selection and maintenance phase, Region split routing, Duty Cycle Based Transmission.

Cluster Head Selection and Maintenance: The Region Split Duty Cycle Bound Routing(RSDCBR) Scheme selects the cluster head based on the nodes energy level, node connectivity and transmission range. The network is considered as a Hetrogeneous network, where the nodes will have a various energy resources and communication range. Remaining energy level of a node at a time period t can be obtained by using the initial energy IE of the node during the deployment and the transmission energy TE and reception energy RE spent during the time period t and it can be given as follows

$$RME = IE - (TE + RE) \quad (1)$$

The node connectivity has been calculated based on the degree of the node and the node speed. The degree D of the node can be acquired by broadcasting hello message to its neighbor with a time stamp and the node position. The neighbor nodes will Acknowledge for that message with their location information. After a time stamp, how many acknowledgement received will be the node degree, ie the number of neighbor nodes. Relative speed of the node can be computed based on the current coordinate position and the previous coordinate position and it can be given as follows

$$S = \frac{\sqrt{(x_2 - x_2)^2 + (y_2 - y_1)^2}}{t_2 - t_1} \quad (2)$$

Where (x_1, y_1) is the previous coordinate position at time t_1, (x_2, y_2) is the current coordinate position at time t_2.

Based on the node degree and the speed, the node connectivity can be measured as follows

$$NC = (\alpha \times S) + (\beta \times D) \quad (3)$$

Where α and β are weight metrics

The transmission range of the node has been computed after getting the last acknowledgement from the far away node. With the help of the coordinate system, the distance between the node and the far away neighbor can be computed as follows

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (4)$$

Then the transmission Tr can be computed using the following equation

$$Tr = \Pi \times d^2 \quad (5)$$

Using these metrics, a weighted sum has been calculated as follows

$$W_{CH} = w_1 \times RME + w_2 \times NC + w_3 \times Tr \quad (6)$$

The node with highest weighted sum will be elected as the cluster head. The nodes that are present inside the communication range of the CHs will be the cluster membrs for the corresponding cluster heads. The Cluster head will holds the information about its cluster members. Whenever the CH has a lesser weighted sum from all of its cluster member, the cluster reformation has been taken place by changing the node with heighest weighted sum as cluster head and the cluster head as the cluster member.

Region Split Routing: When a source node wishes to transmit a data packets and a valid route is not obtainable in the routing table, then the route discovery procedure has been carried out to set up the path. It sends a route request packet RREQ to its cluster head with the destination location information. If the destination node present in the same cluster, the cluster head will transmit the RREQ directly to the destination, otherwise the cluster head will splitits coverage area into a number of regions. Based on the destination location information, two regions have been selected and it has been processed at every CH level. Cluster Head performs a broadcast and initializes the route through the cluster member or gateway node insisted path (two selected regions) to connect the destination. Figure 1 shows the pictorial representation for the proposed region split routing.

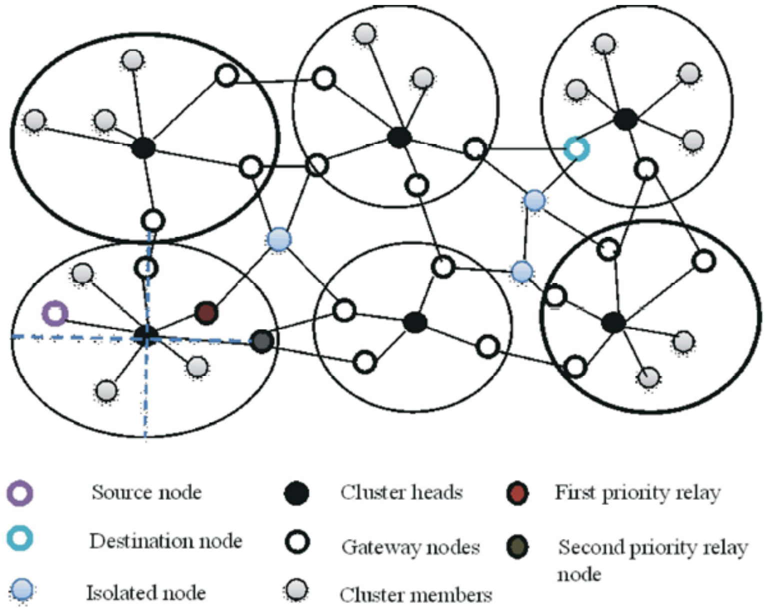

Fig. 1: Region split routing process

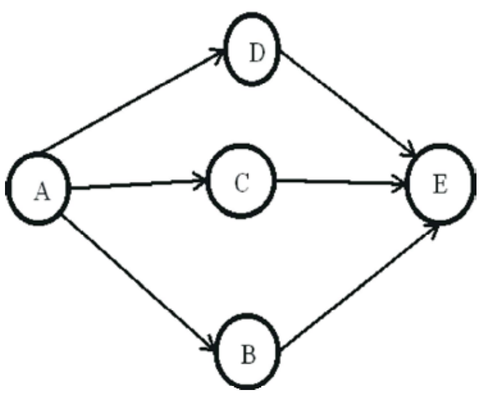

Fig. 2: Tree Traversal to connect the next node

The number of paths discovered using two regions has been accounted. The region selection has been based on the nodes count dependant that is number of higher energy nodes concentrated in a particular region. The energy level of the nodes can be obtained using Cross Layer Energy sharing MAC, which will be described in the next subsection. As the number of paths in a region increases, the possibility of transmission in that region is high, whereas the energy utilization in that particular region is high which may drain the energy of almost all the nodes in one particular region. Therefore, the number of selectionsof nodes in that region must alone be in tree traversal. Here, the preorder traversal has been used, where the left child of the node will be selected for first transmission and the right child will be selected for the next transmission. For example, consider the figure 2, the node A contains 3 neighbors B, C, D to connect to D. Using the preorder traversal, the node B is selected for the current data transmission, when the energy level of the B comes under a 3/4th of its Initial energy, the node C will be elected and afterwards the node D will be selected.The nodes, which does not come under the selected region will be put into the sleep state. The primary path using the tree traversal will be put into the active state and the rest of the path, which has been discovered will be put into the passive state, where it avoids the unnecessary collisions and unexpected link failures. Moreover the Region attention has been variable and ceasing. Variable is duty cycle dependant and ceasing occurs when a node denies the broadcast or forwarding due to zero TX Energy. Then the region's concentration also decreases. The cluster head then prefers the alternate region through its own broadcas

Duty Cycle Based Transmission: In this section, the process of duty cycle based data transmission has been discussed in detail. A duty cycle is the fraction of a period, where a signal will be in active.The time required for a data transmission and the energy consumption of the network is closely associated with the duty cycle values used. Greater duty cycle values offer more number of nodes obtainable for data routing. Since, the CH divide its communication region into N priority region and every priority region is allocated a contention slot that is the highest priority region will be allocated the i[th] slot in the contention window [14], which reduces the collision of CTS packet, where the nodes present in the priority region will select any one of the contention slot for their CTS packet.Interval time of the duty cycle is marked as quantum time. Same quantum is marked for the next duty cycle process which may vary based on the number of nodes in the region (larger the nodes, larger is the quantum value and vice versa). The number of duty cycle a node encounters and the energy utilized in the time period is also computed [14]. Based on the computed values, the node's available time for the next transmission is broadcasted in the next sequential duty cycles to the previous nodes. The nodes can now be able to select nodes based on the priority of their availability and energy and therefore the number of drops due to the probability of selecting a

RESULTS AND DISCUSSION

The proposed RSDCBR protocol tries to extend the entire network lifetime. The performance of the proposed RSDCBR has been evaluated using the NS2 simulation. Table 1 shows the simulation setup. The performance of RSDCBR has been compared with the existing cluster based routing protocols such as Adaptive Cluster-Based Routing (ACBR) [3], Context-Aware Routing Protocol (CARP). The metrics used to evaluate these protocols are routing overhead, cluster reaffilation, residual energy.

Figure 3 shows the average number of CH variations with respect different network size, this metric is a best indicator for the overall cluster organization stability (Cluster head change frequently then the algorithm results

Table 1: Simulation Setup

Simulation Parameter	Value
Simulator	NS-2 (v2.34)
Topology size	1000 × 1000 m
Number of nodes	20, 40, 60, 80, 100, 120
Transmission range	200 m
Bandwidth	2Mbps
Interface queue length	100
Traffic type	CBR
MAC type	802.11
Packet size	512 bytes
Paused time	0s
Speed	5 m/s

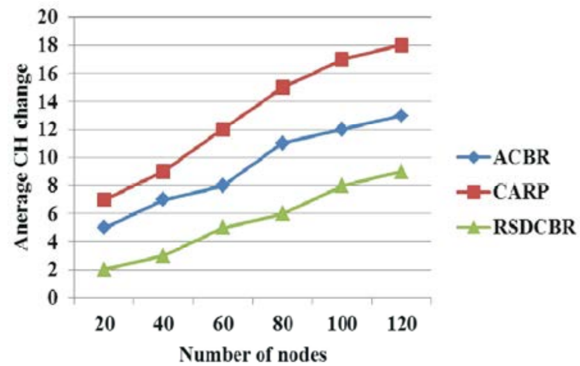

Fig. 3: Cluster reaffilation with respect to Network size

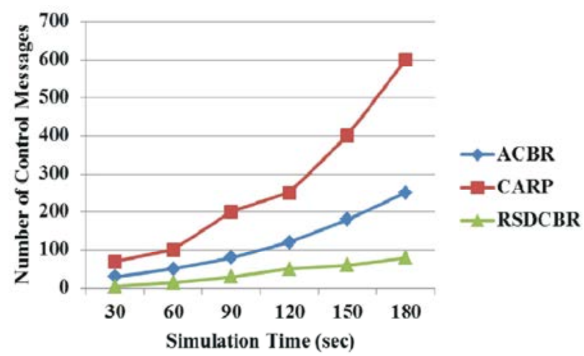

Fig. 4: Routing Overhead with respect to Simulation time

a minimum stability clusters). In ACBR, they does not concentrate highly on the cluster head selection while they aims to reduce the load in the network. So there occurs frequent change in CHs. In the CARP, two multi decision making system has been used to form the cluster with effective maintenance, so they acquires optimal cluster head changes. Without using the threshold value and using the connectivity as a metric, the proposed RSDCBR acquires a minimum cluster head change when compared to the ACBR and CARP. The RSDCBR faces 9 cluster head change for 120 nodes, while ACBR, CARP faces 13, 18 cluster head changes respectively.

Normalized routing overhead is the number of control packets for one data packets diffused in the network. The CARP incur highest routing overhead when compared to the ACBR and RSDCBR, since they use the location information for diffusing the control packets. In ACBR, the location information of the destination node has been used to transmit the control packets, while the RSDCBR acquires splits the region and performs the broadcast at each cluster head, which ultimately reduces the control packets. Figure 4 shows the average number of control messages transmitted over the network with respect to simulation time. The RSDCBR disseminates 80 control message for 180s, while the ACBR and CARP dissiminates 250 control messages, 600 control messages respectively.

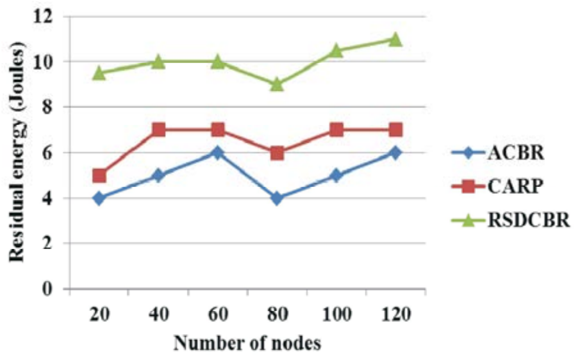

Fig. 5: Residual energy with respect to network size

Average residual energy of the network is the remaining energy of the entire nodes in the network after the simulation period. In ACBR and CARP, the enrgy optimization has been concentrated only on the cluster formation and maintenance. While the RSDCBR optimizes the energy with the aid of duty cycle, control messages minimization and cluster formation and maintenance. As expected the RSDCBR performs better than the ACBR and CARPinterms of energy efficiency. Figure 5 shows the residual energy with respect to network size. The RSDCBR has the residual energy of 11J for 120 nodes, while the ACBR, CARP has the residual energy of 6 J, 7J respectively.

CONCLUSION

This paper proposed a Region Split Duty Cycle Bound Routing (RSDCBR) Scheme for energy efficient MANET. The RSDCBR composed of three phases such as Cluster formation, region split routing and duty cycle based data transmission. The cluster formation based on a weighted sum that includes the node connectivity, coverage region and energy level and the reaffilation has been carried out with limited overhead. The region split routing has been processed, where the region has been splitted up and selecting the region based on the priority for data transmission. The nodes in the region which does not process any data transmission will be schedule in the sleep state. Based on the duty cycle, the energy level of the node and the available time of the node has been estimated, which used to select the node as a relay node for data transmission. Overall, the RSDCBR scheme efficientlyminimizes the energy consumption of the nodes and improves the network lifetime than the existing cluster based routing protocols such as ACBR, CARP.

REFERENCES

1. Yuxin Mao, Ping Zhu, 2015. A Game Theoretical Model for Energy-Aware DTN Routing in MANETs with Nodes' Selfishness, Mobile Networks and Applications, Springer, 20(5): 593-603.
2. Senthilnathan Palaniappan and Kalaiarasan Chellan, 2015. Energy-efficient stable routing using QoS monitoring agents in MANET, Journal on Wireless Communications and Networking, Springer, 2015.
3. Sheeja, S. and Ramachandra V. Pujeri, 2013. Cross Layer based Congestion Control Scheme for Mobile Ad hoc Networks, International Journal of Computer Applications (IJCA), vol. 67, no. 9.
4. May Cho Aye and Aye Moe Aung, 2014. Energy Efficient Multipath Routing For Mobile Ad Hoc Networks, International Journal of Information Technology, Modeling and Computing (IJITMC) Vol. 2, No.3.
5. Prabha, R. and N. Ramaraj, 2015. An improved multipath MANET routing using link estimation and swarm intelligence, EURASIP Journal on Wireless Communications and Networking, 173: 1-9.
6. Rupali Mahajan and Rupali Jagtap, 2013. Energy Efficient Routing Protocols for Mobile Ad-Hoc Networks, International Journal of Science and Modern Engineering (IJISME), Vol-1, Issue-3.
7. Sheng-Tzong Cheng, Jian-Pan Li and Gwo-JiunHorng, 2013. An Adaptive Cluster-Based Routing Mechanism for Energy Conservation in Mobile Ad Hoc Networks, Wireless Personal Communications, Springer, 70(2): 561-579.
8. Neng-Chung Wang, Yung-Fa Huang, Jong-Shin Chen, Si-Ming Wang and Chin-Ling Chen, 2009. An Improved Location-Aided Routing Protocol for Mobile Ad Hoc Networks with Greedy Approach, WSEAS Transactions on Communications, vol.8, no.8.
9. Anubhuti Roda Mohindra and Charu Kumar, 2013. A Stable Energy-Efficient Location Based Clustering Scheme for Ad Hoc Networks, Quality, Reliability, Security and Robustness in Heterogeneous Networks, Springer, 115: 75-85.
10. Ahmed. A.A. Gad-ElRab, T.A.A. Alzohairy and Almohammady S. Alsharkawy, 2015. Cluster-Based Context-Aware Routing Protocol for Mobile Environments, International Journal of Advanced Computer Science and Applications (IJACSA), vol. 6, no. 1.

11. Chuan-Chi, Ching-Wen Chen, Po-Yueh Chen and Kuei-Chung Chang, 2013. Design of an energy-efficient cross-layer protocol for mobile ad hoc networks, Communications, Institution of Engineering and Technology, IEEE, vol. 7, no. 3.
12. Sarfaraz Ahmeda, A., T. Senthil Kumaranb, S. Syed Abdul Syeda and S. Subburamb, 2015. Cross-Layer Design Approach for Power Control in Mobile Ad Hoc Networks, Egyptian Informatics Journal, 16(1): 1-7.
13. Senthilnathan Palaniappan and Kalaiarasan Chellan, 2015. Energy-efficient stable routing using QoS monitoring agents in MANET", Journal on Wireless Communications and Networking, Springer.
14. Yuqun Zhang, Chen-Hsiang Feng, I. Demirkol and W.B. Heinzelman, 2010. Energy-Efficient Duty Cycle Assignment for Receiver-Based Convergecast in Wireless Sensor Networks, Global Telecommunications Conference (GLOBECOM 2010), Miami, FL, IEEE, pp: 1-5.