Indian Journal of Science and Technology, Vol 8(35), DOI: 10.17485/ijst/2015/v8i35/70014, December 2015
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

CAERP: A Congestion and Energy Aware Routing Protocol for Mobile Ad Hoc Network

Arappali Nedumaran[1]* and V. Jeyalakshmi[2]

[1]St. Peter's University, Avadi, Chennai - 600054, Tamil Nadu, India; maran.van@gmail.com
[2]Department of Electronics and Communication Engineering, Dr. M. G. R. University, Chennai - 600032, Tamil Nadu, India; jpjeya@gmail.com

Abstract

The Mobile Ad hoc Network (MANET) is composed of a large number of self-configuring mobile nodes to form the network. Due to the mobility of the nodes, the architecture has been changed frequently. Since the nodes are battery operated and limited in nature, hence it is too difficult to replace or charge the battery sooner possible. In order to extend the life time of the nodes in the network variety of energy efficient protocols have been proposed. This paper is analyzed the problem of congestion control in the nodes. In this work the congestion control is achieved by implementing the Congestion and Energy Aware Routing Protocol (CAERP). In order to achieve the congestion free communication with minimized energy utilization the data rate of the individual nodes are changed according to the queue state and signal strength identifier. If the value of the Received Signal Strength Indicator (RSSI) is low, it is assumed that the distance between the sources to sink is high and vice versa.The RSSI and the queue size of the nodes in the ongoing path are used to adjust the data rate of the intended node transmission. It achieves the high link reliability for current transmission path and optimum energy utilization. The proposed protocol is compared with existing techniques and implemented in NS2 network simulator. The simulation results proved that the proposed one reduces the packet drop, energy utilization, congestion and improves the life time of the entire network.

Keywords: Congestion Control, Energy Utilization, Manet, Routing Protocol, Throughput

1. Introduction

A Mobile Ad hoc Network is an infrastructure less network which are having collection of mobile nodes. The data packets are generated, initiated and transmitted across the nodes in the MANET. Since, the nodes in MANET act as router as well as transceivers. Each device in a MANET is free from static nature and to roam dynamically in all directions. It leads network partitioning frequently as well as change in transmission path. Due to frequent mobility the nodes are drained sooner possible. The main objective of constructing a MANET is maintaining every node in the network for continuously monitoring the necessary information required to optimally balance the path traffic[1,2]. This network can operate with themselves to connect other larger network. The nodes in the network may be of homogenous or heterogeneous as per the application requirements. The Figure 1 shows the general scenario of MANET with different nodes and their interconnections.

MANET is types of wireless ad hoc network that comprises of self-configuring and self-maintaining mobile devices. Each device in the network store and forward the route information to its neighbor devices[3,4]. Due to the continuous monitoring the energy of the node depleted soon. In order to prolong the life time of the nodes in MANET, There are various research efforts made by means of developing energy aware routing and MAC protocols[5].

*Author for correspondence

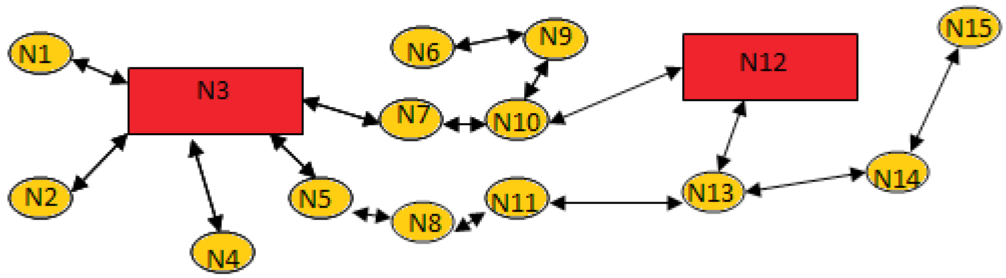

Figure 1. Heterogeneous MANET scenario.

The routing protocols are broadly classified into two categories namely, proactive and reactive routing. The proactive routing is also known as table driven routing. The routing table in proactive routing contains the routing information of all the nodes in the network. The routing table will be updated periodically or is there any change in existing route[6]. Whereas the reactive routing or on demand routing is not maintain any predefined route information. If any node wishes to transfer the data, it will initiate the route discovery and route maintenance process to achieve the efficient packet transmission. The network parameters like residual energy, RSSI, queue size and bandwidth are utilized to modify the existing routing protocols in order to achieve the energy efficient routing[7]. This kind of modifications yields the improved throughput, packet delivery ratio and reduced delay and energy consumption.

Although the routing protocols provides better energy utilization but, the cross layer approach gives more convenient design of protocol implementation. In the cross layer approach the network layer uses the information from transport, data link and physical layers. By combining the different layer information provides accurate estimation of network characteristics[9]. It fine tunes the routing protocol design and implementations[13,14].

The applications of the MANET are wild field monitoring, natural disasters, secured information transfers, and military surveillance. The quick configuration and easy deployment made the ad hoc networks more convenient to the above said applications. To enabling the dynamic and adaptive routing strategy provides the ad hoc networks to be configure easily[15,16].

2. Related Works

In[11] proposed a complete study on power aware routing protocol for mobile ad hoc network. In this work they analyze various power aware routing protocols in addition to diverse metrics which are responsible for power optimization in MANET. Finally they conclude that, a single protocol is not enough to provide the best performance in ad hoc network environment. The performance of the protocol varies according to choose the network parameters.

In[12] implemented the energy efficient multipath routing for mobile ad hoc networks. In this paper the authors proposed an energy efficient multipath routing protocol for choosing the transmission path which is the energy efficient one. This protocol also considering the parameters like transmission power and residual energy of the nodes in order to enhance the life time as well as reduce the energy utilization. This system is easily found the optimum transmission path for conveying the information packets.

Fuzzy based load and energy aware multipath routing for mobile ad hoc networks[10] develops a fuzzy based approach in order to ensure the parameters like delay, load, and energy utilization to avoid congestion and delay in MANET. The inputs to the fuzzy inference system are, forwarding delay, average load, available bandwidth and residual battery. Based on these inputs the inference system determines the traffic distribution probability. It yields to reduce the load at the congested nodes in the network.

In[9] present cross layer based energy aware routing and congestion control algorithm in MANET. In this work the authors surveyed different ad hoc routing protocols like DSR, TORA, AOMDV, and DSDV and evaluated in terms of energy consumption of the nodes in the network. After the evaluation process they modify the standard AOMDV protocol with cross layer approach, by which they reduce the packet retransmissions and losses. It provides increased life time of the nodes and reduces the energy utilization of the nodes in the entire network.

In[4] have implemented the ALERT: An anonymous location-based efficient routing protocol in MANETs. In this paper the authors develop the ALERT protocol; it adaptively divides the network into regions and randomly selects the relay nodes with in the regions. The relay nodes which are in the zones form a non-traceable anonymous path. It also hides the source and sinks from others in order to provide the anonymity. This route anonymity protection scheme is evaluated theoretically and experimentally. The outcomes are showed that this scheme provides better performance metrics compared to the existing one.

3. Proposed System

3.1 Congestion and Energy Aware Routing Protocol

Every node in the network is having network resources like, fixed number of queue size, initial energy, and bandwidth and so on. Due to the requirement of frequent node mobility, these network resources have to be changed accordingly. These changes impact the network topology, which leads to network partitioning, energy utilization, packet loss and bandwidth. If the nodes having more data in its queue compared to its stipulated queue size, leads the possibility of congestion on that particular node. It causes packet drop in that node and it should be transmitted again for successful delivery. The retransmission of dropped packets indirectly increases the energy utilization and delay. The standard DSR routing protocol is modified with network parameters like Received Signal Strength Indicator (RSSI) and Queue size for designing the proposed CAER protocol.

The CAERP produces the congestion by changing the data rate of the individual nodes in the current transmission path. The queue size and signal strength of the individual nodes is considered to fine-tune the data rate dynamically for reducing the congestion and ensure the link stability.

Figure 2 illustrates the packet transmission from source to sink by using CAERP. The node N1 initiates the data transmission to the sink N11. The N1 broadcast the route request (R_rq) packet. All the nodes within the vicinity receive the R_rq and estimate the queue size and RSSI values. Based on the protocol requirement the node found the congestion. In this Figure congestion is occurred in node 6. Hence the node 6 excluded from the current transmission path. The upstream node N5 send the route error message to the source for initiating the new route discovery process.

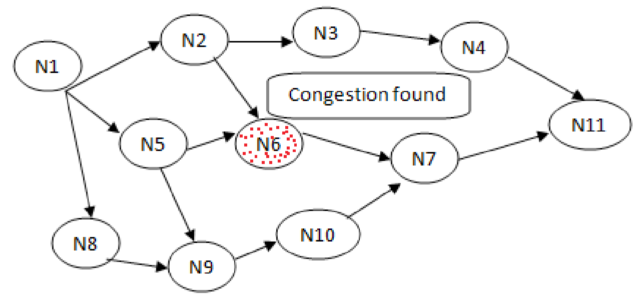

Figure 2. Congestion estimation.

The received signal strength of the node will be calculated by Friis transmission equation, and is given in Equation 1.

$$\frac{p_r}{p_t} = G_t G_r \left(\frac{\lambda}{4\pi R}\right)^2 \qquad (1)$$

Let, Q_s Q_m be the queue size and stipulated queue size of the nodes respectively.

Let Q_{th} be the threshold queue size which is fixed and assigned to all the nodes.

The Q_{th} is calculated by Equation 2.

$$Q_{th} = Q_m(0.75) \qquad (2)$$

By using the Equation 2, the congestion will be estimated in the node level.

The overloading of the queue size will be estimated by the below algorithm.

If $Q_s > Q_m$ then

The node does not take part in the communication.

Else if

$Q_s < Q_{th}$ then

The nodes take part in the communication.

Else

$Q_s = Q_{th}$ then

The nodes take part in the communication.

End if

After receiving the route request packet, each node in the network executes the above said algorithm. The present queue size of the node will compared with the maximum queue size which is already stipulated. Based on the outcome of the comparison, the node has to be decided whether to take part in the communication or not. If the node takes part in the communication, the RSSI of the particular node is calculated for assuring the link stability by Equation 2.

The RSSI and the queue size of the nodes in the current path are utilized to vary the data rate of the intended node transmission. If the value of the RSSI is low, it is assumed to the distance between the sources to destination is high and vice versa. Hence, the nodes which are having low RSSI values need to accommodate high data rate.

The data rate of the node is varied according to the Table 1. The RSSI and the queue size of the nodes are given as the input and the data rate is estimated as output.

Let D_r, D_{th} be the Data rate and stipulated threshold Data rate of the nodes respectively.

Table 1. Data rate computing

RSSI Value	queue size (Q_s)	Data rate
Low	Low ($Q_s < Q_{th}$)	$D_r <= D_{th}$
Medium	Low ($Q_s < Q_{th}$)	$D_r = D_{th}$
High	Low ($Q_s < Q_{th}$)	$D_r < D_{th}$
Low	Medium ($Q_s = Q_{th}$)	$D_r >= D_{th}$
Medium	Medium ($Q_s = Q_{th}$)	$D_r = D_{th}$
High	Medium ($Q_s = Q_{th}$)	$D_r <= D_{th}$
Low	High ($Q_s > Q_{th}$)	Node excluded
Medium	High ($Q_s > Q_{th}$)	Node excluded
High	High ($Q_s > Q_{th}$)	Node excluded

3.2 Estimation of Energy Metrics

E_r and E_i are the Remaining energy and initial energy of the node respectively.

E_{txi} and E_{rxi} are the Energy consumed by the node for transmission and reception.

The Remaining energy of the node will be calculated by Equation 3.

$$E_r = E_i - (E_{txi} + E_{rxi}) \quad (3)$$

Let E_{total}, E_{uti} be the total energy and energy utilization of the node respectively.

The energy utilization of the individual node will be calculated by Equation 4.

$$E_{utilization} = E_{total} - E_r \quad (4)$$

Let N_x be the set of nodes in the network, and N_y be the number of nodes effectively take part in the communication.

$$N_y \in N_x \text{ Where, x=1 to N.} \quad (5)$$

Where, N is the number of nodes in the network.

The total energy utilization (E_{totuti}) of the entire network will be calculated by Equation 6.

$$E_{totuti} = N_p \times E_{utilization} \quad (6)$$

4. Performance Evaluation

The performance characteristics of the proposed CAERP compared and evaluated with existing cross layer routing protocol[8].

Table 2. Simulation settings

Parameters	Values
Number of Nodes	20, 40, 60, 80 and 100
Area	1250 X 1250 m
MAC Protocol	IEEE 802.11 DCF
Radio Range	250m
Simulation Time	90 s
Routing Protocol	CAERP
Packet Size	512 B
Speed	10 m/s
Pause Time	5 sec
Rate	250 Kb/s to 450 Kb/s
Mobility Model	Random Way Point
Tx Power	0.660 W
Rx Power	0.395 W
Initial Energy	14.1 J

The metrics like energy utilization, delay, throughput, and packet loss are measured and compared with the existing one. The Table 2 shows the simulation settings of the proposed system. The CAERP implemented with the ns2 simulation environment and the results are illustrated and discussed in this section.

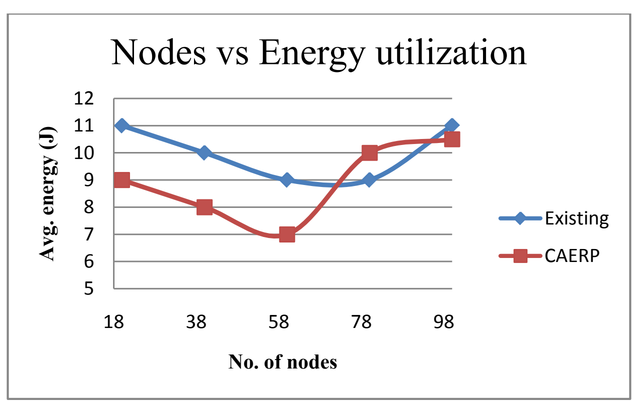

Figure 3. No of nodes vs energy utilization.

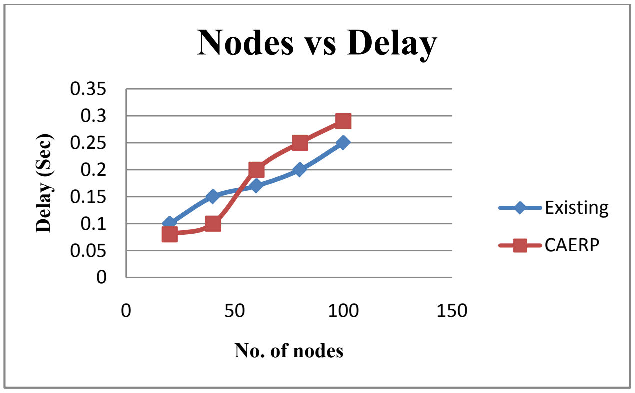

Figure 4. No of nodes vs delay.

Figure 3 and 4 demonstrates the metrics no. of nodes versus energy consumption and delay. From the Figure 3, it shows that the average energy utilization of the proposed system gradually increases when the number of nodes increases above half of the total number of nodes deployed. However that the energy consumption is reduced the number of nodes is minimal. From the Figure 4, it shows that the delay of the proposed system is getting contradicted when the number of nodes increases. The delay is reduced when the number of nodes is minimal. According to the Figure 4 the delay difference between the above said two is very minimal deviation.

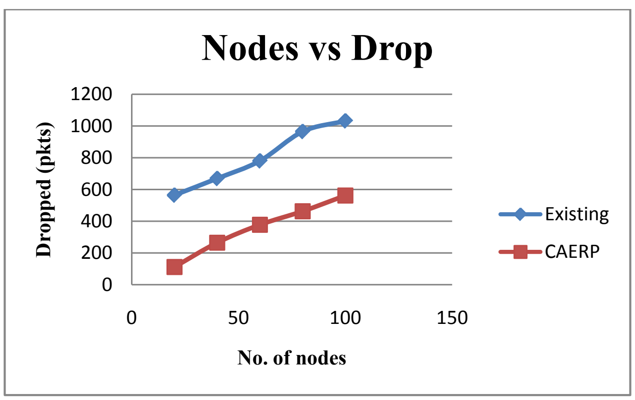

Figure 5. No of nodes vs drop.

The Figure 5 is plotted between numbers of nodes versus number of packet dropped. It shows that the proposed system reduces the packets drop in a considerable amount, since proposed system uses the new congestion control mechanism.

Figure 6 and 7 illustrate the metrics data rate versus energy consumption and delay. From the Figure 6, it shows that the average energy utilization of the proposed

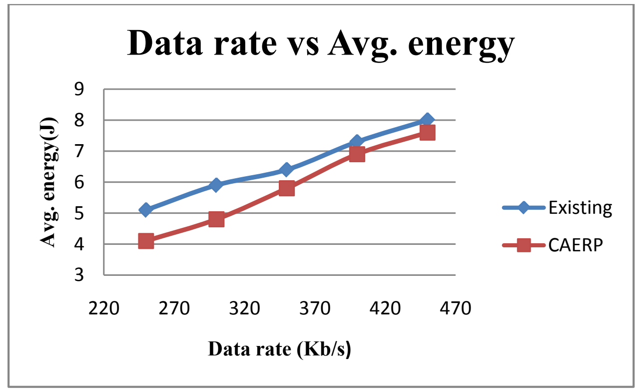

Figure 6. Data rate vs energy utilization.

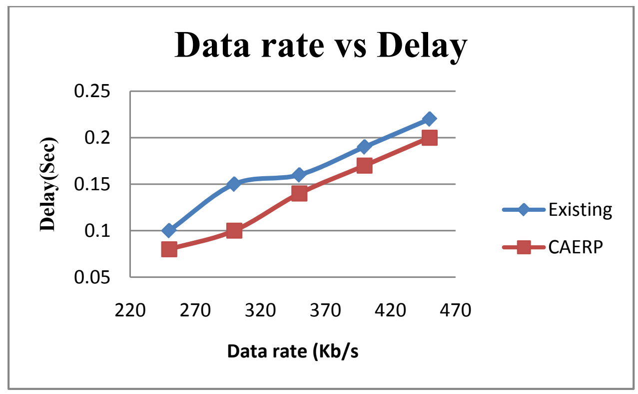

Figure 7. Data rate vs delay.

system reduces compared to the existing one. From the Figure 7, it shows that the delay of the proposed system is reduced. The delay is increased when the data rate of nodes is increased.

The Figure 8 and 9 are plotted between data rates versus number of packet dropped, throughput respectively. It shows that the proposed system reduces the packets drop compared to the existing stated technique. In Figure 9

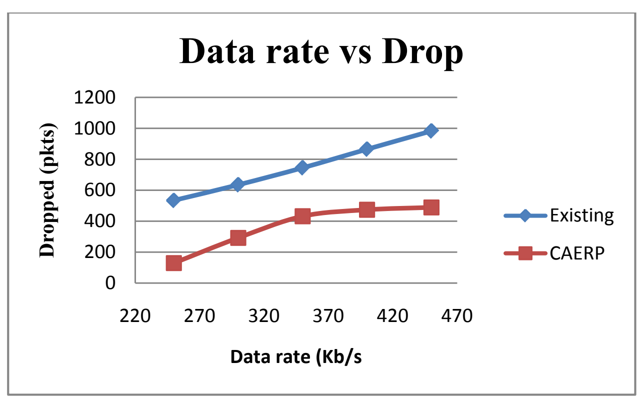

Figure 8. Data rate vs drop.

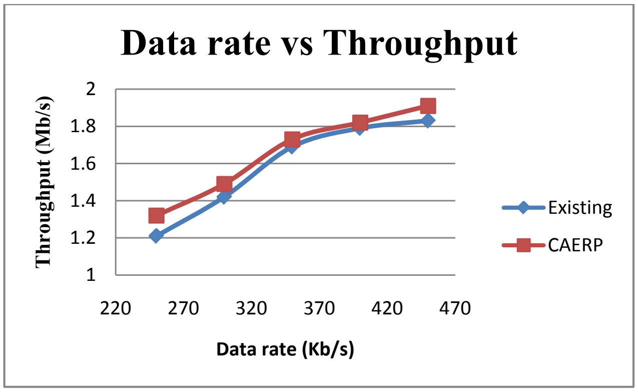

Figure 9. Data rate vs throughput.

the throughput metric of CAERP getting improved minimal compare to the existing system. The overall numeric simulation results show that the proposed technique enhances the parameters like energy utilization, delay, drop and throughput.

5. Conclusion

The proposed CAERP implemented with NS2 event driven simulator and compared with existing cross layer routing protocol[8]. In this protocol, the data rate is adjusted based on the queue size and RSSI values of the individual nodes in the network. It leads reduced congestion, energy utilization and improved throughput. The numerical results of the performance parameters like energy utilization, delay, throughput, packet drop of the proposed system are analyzed. It shows that, the CAERP outperforms existing stated routing protocols.

6. References

1. Alslaim MN, Alaqel HA, Zaghloul SSA. Comparative study of MANET routing protocols. 3rd International Conference on e-Technologies and Networks for Development; Beirut. 2014 Apr 29-May 1. p. 178–82.
2. Nishanthini C, Rajkumar G. Congestion avoidance through cooperative routing in MANETs. International Conference on Information Communication and Embedded Systems; Chennai. 2013 Feb 21-22. p. 1169–72.
3. Defrawy K, Tsudik G. ALARM: Anonymous location-aided routing in suspicious MANET. IEEE Transactions on Mobile Computing. 2011; 10(9):1345–58.
4. Haiying S, Zhao L. ALERT: An anonymous location-based efficient routing protocol in MANETs. IEEE Transactions on Mobile Computing. 2013; 12(6): 1079–93.
5. Suresh HN, Varaprasad G, Jayanthi G. Designing energy routing protocol with power consumption optimization in MANET. IEEE Transactions on Emerging Topics in Computing. 2014; 2(2):192 –7.
6. Xu H, Wu X, Sadjadpour HR, Garcia-Luna-Aceves JJ. A unified analysis of routing protocols in MANETs. IEEE Transactions on Communications. 2010; 58(3):911–22.
7. Carofiglio G, Chiasserini C, Garetto M, Leonardi E. Route stability in MANETs under the random direction mobility model. IEEE Transactions on Mobile Computing. 2009; 8(9):1167–79.
8. Nishanthini C, Rajkumar G. Congestion avoidance through cooperative routing in MANETs. International Conference on Information Communication and Embedded Systems; 2013. p. 1169 – 1172.
9. Natarajan E, Devi L. Cross layer based energy aware routing and congestion control algorithm in MANET. International Journal of Computer Science and Mobile Computing. 2014; 3(10):700–9.
10. Ali M, Stewartet BG. Fuzzy based load and energy aware multipath routing for mobile ad hoc networks. International Journal of Computer Applications. 2015; 114(16):25–33.
11. Kumaravel A, Chandrasekaran M. A complete study on power aware routing protocol for mobile adhoc network. IOSR Journal of Electrical and Electronics Engineering. 2014; 1(1):71–5.
12. Cho AM, Moe A A. Energy efficient multipath routing for mobile ad hoc networks. International Journal of Information Technology Modeling and Computing. 2014; 2(3):11–8.
13. Parthesh SR, Mitesh T, Kalpesh W. Energy aware routing protocol for MANET. International Journal of Engineering Development and Research. 2014; 2(2):1673–7.
14. Deepthy J, Krishnan N. Performance improvement of energy aware and adaptive routing protocols for MANETs – A survey. International Journal of Research in Engineering and Technology. 2014; 03(01):119–23.
15. Rajendiran M, Srivatsa SK. Route efficient on demand multicast routing protocol with stability link for MANETs. Indian Journal of Science and Technology. 2012; 5(6):2866–71.
16. Marjan KR. Generalized mechanism for intrusion detection in mobile ad hoc networks. Indian Journal of Science and Technology. 2010; 3(10):1098–101.