International Journal of Computer Networks and Communications Security

VOL. 4, NO. 5, MAY 2016, 146–152
Available online at: www.ijcncs.org
E-ISSN 2308-9830 (Online) / ISSN 2410-0595 (Print)

Energy Aware Congestion Adaptive Randomized Routing in MANETs with Sleep Mode

JINESH KUMAR SINGH[1], PRASUN CHAKRABARTI[2] and MUKESH KALLA[3]

[1, 3] Assistant Professor, Department of CSE, Sir Padampat Singhania University, Udaipur (Raj.)

[2] Professor and Head, Department of CSE, Sir Padampat Singhania University, Udaipur (Raj.)

E-mail: [1]jinesh.singh@spsu.ac.in, [2]prasun.chakrabarti@spsu.ac.in,[3]mukesh.kalla@spsu.ac.in

ABSTRACT

MANETs are typically limited in resources like available wireless transmission bandwidth, available node battery power etc which makes the routing complex compare to the normal infrastructure based wireless network. Node mobility also makes the routing decision further hard. A packet drop in such network can be due to: Node Mobility, Congestion on network or node failure (energy drain or hardware failure). The MANETs nodes are typically running on battery power and energy issue is one major concern in MANET operation. If a node's battery power drains completely, the node goes to power off state and thus the connectivity of the network is affected and network life time is reduced. The other concern in MANETs is Congestion. When a portion of a network has high incoming load then its capacity, packets start to drop and experience higher delay than normal, which reduces the throughput of the network and negatively affects the QoS parameters of the network. Congestion also causes low utilization of the network resources. In congestion, with each packet drop the energy used in transmission and reception is wasted. Thus higher energy efficiency can only be achieved, if energy issue and congestion issue are addressed together. This paper proposes a new Energy aware congestion adaptive randomized routing algorithm (EACAR-AODV) which addresses both the energy and congestion issue to achieve higher energy efficiency and QoS parameters. The proposed method is based on AODV and applies energy policy to include only high energy node, Random routing packet drop policy to control the RREQ flood to reduce energy consumption and congestion during path setup, and applies congestion policy based on current queue size of the node to find an alternate non-congested path. The proposed protocol is implemented in NS2 network simulator and compared with traditional AODV. The results show an improvement in both QoS parameters and Energy efficiency without introducing significant overhead.

Keywords: *Congestion Adaptive, Energy Aware, EACAR-AODV, Sleep Mode, Randomized MANET Routing.*

1 INTRODUCTION

The wireless technology allows users to exchange information and services without concerning connectivity with a pre established resource setup. This allow users to use network resources and services from any location such as internet from mobile phone, laptops etc. The wireless network with a central base station is called infrastructure network and requires the user to remain in the coverage area of the central base station. The other type is Ad hoc network where the infrastructure is not required and each node uses cooperative routing process to communicate with each other. These networks are generally referred to as MANETs (Mobile Ad-hoc Networks). Such networks are composed of an autonomous group of mobile users who communicate through relatively bandwidth constrained wireless links. The benefit of MANETs is that it is easier to establish and do not require any infrastructure resources. This makes them highly dynamic and deployable in many applications like human or nature induced disasters, battlefields, meeting rooms where either a wired network is unavailable or deploying a wired network is inconvenient.

The packet drop in MANETs can be caused by many reasons including link break due to mobility, congestion in network, no remaining node power. Due to mobility of nodes the network topology changes frequently over time [1]. The problem with node mobility is that it makes routing decision complex. Consistent network information cannot be maintained easily. MANETs consist of battery operated devices, which requires energy conservation during the routing process. To increase the lifetime of an ad hoc network, it is essential to lengthen each individual node life through minimizing the total transmission energy consumption for each communication request. Therefore, an efficient routing protocol must satisfy that the energy consumption rate at each node is evenly distributed so that low energy node is not selected in the routing path [2].

Congestion is one another related issue in MANET. When load on a node or link is increased beyond its capacity, packets starts to drop because of buffer overflow. Also packets suffer from high delay in congested route. The main objective of congestion control is to limit the delay and buffer overflow caused by network congestion and provide better performance of the network [3].

Many routing protocols have been proposed for MANETs. These routing protocols falls in three groups: proactive, reactive and hybrid. Proactive routing protocols, such as DSDV [4], try to maintain consistent and up-to-date routing information for network. In the on-demand routing protocols, such as AODV [5] and DSR [6] paths are discovered only when they are needed. The hybrid routing protocols [1] combines the features of both proactive and on-demand protocols. Hybrid routing protocols defines zone and each node maintains routing information about its zone using the proactive approach and uses on-demand routing approach outside the zone.

The current routing protocols are not congestion adaptive and do not include energy metric while selecting a routing path. If a path is selected, it will be used without considering congestion status or energy status of the intermediate nodes in the path. This can cause higher delays and higher packet loss which leads to low throughput and low QoS parameters.

The problem of congestion is also related with energy issue such that the node under congestion continuously transmitting high traffic, and if it is already low on battery, it will soon exhaust its remaining power and move to power off state, which may leads to partial network unreachable situation for some nodes in the network. Similarly each packet drop due to congestion situation in a wastage of energy used to transmit and receive the packet. These problems are more significant if the node is using high traffic load application like multimedia data transfer or streaming video.

This paper proposes a combined energy and congestion approaches for routing in MANETs. The rest of the paper is organized as follows. Section II shows the literature survey of the related work to energy aware congestion adaptive mechanism in Ad hoc networks. Section III briefly describes the idea and mechanism of propose work which increase the life time of network and improve the energy efficiency of MANET and adaptive mechanism to handle congestion in case it occurs in the network. Section IV introduces the simulation of the design network, shows the result of proposed work and compares it with existing AODV routing protocol. Section V draws the conclusion of the paper.

2 RELATED WORK

Li et al. [7] tested AODV in high traffic situations and found that is its performance degrades significantly under high load conditions. They proposed a modified version of AODV (called CAODV) which selects node with short queuing delays. This improves the QoS of network compare to traditional AODV.

Vinay Rishiwal et al [8] proposed QoS based power aware routing protocol (Q-PAR), which prefer route with high energy and high bandwidth availability. The protocol Q-PAR is based on DSR route discovery mechanism. If a link fails the protocol searches for an alternative energy stable path locally. This increases the network lifetime.

T.S. Kumaran et. al. [9] proposed another congestion control protocol for controlling congestion in AODV named as Early Detection Congestion and Control Routing in MANET (EDAODV) which detects congestion at the node. It calculates queue status value and thus finds the status of the congestion. Further, the non-congested predecessor and successor nodes of a congested node are used by it for initiating route finding process bi-directionally in order to find alternate non-congested path between them for sending data. It finds many alternate paths and then chooses the best path for sending data.

P.K. Suri et al [10] proposed a bandwidth-efficient power aware routing protocol “QEPAR”. The routing protocol minimizes bandwidth consumption and reduces delay. The packet loss is also decreases and thus throughput is increased. The proposed protocol is also helpful in finding out an optimal path without any loop.

Krishna Cheong Lau and Joseph H. Kang [11] the idea to increase energy efficiency, nodes in the network goes into a sleep mode and wake up at predetermined time slot(s) to snoop for transmissions from its instant neighbors. The knowledge of awakening slots for neighboring nodes is used to arrange the transmissions within the neighborhood. Finally, nodes adapt their sleeping cycles based on neighbor topology and remaining battery life in order to maximize the network lifetime also satisfying the latency requirements of sensor applications.

Arappali Nedumaran and V. Jeyalakshmi[12] proposed a 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. 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.

Sujatha P Terdal et al [13] proposed energy aware and load balancing multipath routing protocol (ELB-MRP) which formulates a combined traffic and energy cost to optimize he routing mechanism by encompassing interference caused due to neighbour effect into routing decisions along with energy conservation. Contention window size and queue size are used to assess the load at a node and its one hop neighbours. Energy is also used in routing decision. Simulation results show that the performance increased with the proposed method.

Z. Wu et al [14] proposed a new routing protocol called energy-aware grid multipath routing (EAGMR) which can conserve energy and provide the best path to route according to probability. Simulation results indicate that this new energy-aware protocol can save energy of mobile hosts and improve data packet delivery ratio.

D.A. Tran et al [15] proposed Congestion–adaptive Routing Protocol (CRP). It is suggested that congestion in the main reason of packet loss in MANETs in high load conditions. The proposed protocol prevents the congestion from occurring in the first place by using the bypass concept where a bypass is a sub-path connecting a node and the next non-congested node.

3 PROPOSED WORK

The basic AODV protocol is modified to enforce energy policy and congestion policy. The residual power and congestion status (defined by queue size) parameters are added in RREQ. Each intermediate node monitors its energy status and congestion status (queue size). Node is classified in three states Green, Blue and Red according to the energy and congestion status. Initially all node's status is Green. (flag =0 (Green), 1(Blue), 2(Red)).

Green state is initial state where node is not having residual power problem and congestion problem. Randomized RREQ Forward mechanism is applied in this state. The nodes in this state follow the conditions: Residual energy is greater than 20% of initial energy and queue size is below 80% of total buffer capacity

***Randomized RREQ forward*:** Traditional AODV protocol uses flooding of RREQ in which a route request packet (RREQ) is broadcasted from a source node to other nodes in the network. This often results in unnecessary re-transmissions and congestion in the network (called broadcast storm). This energy loss in transmission and reception can be saved by selectively forwarding RREQs based on some probability like Bayesian probability [16] or hop count based probability [17]. For each received RREQ by a node in green state, it calculates a forward probability for RREQ which depends on neighbor nodes and hop counts. This forward probability lies in the range of 0 to 1. A random number is also generated and if the random number is lower than forward probability, the node forwards the RREQ packet. Otherwise, the RREQ packet is discarded and dropped. Here the aim is to minimize these unnecessary RREQ packets. The forward policy is conservative and only a small number of RREQ are dropped. This will reduce the RREQ flood and save energy in transmission and reception of RREQs. It also reduce load on network during connection setup and avoid congestion in network.

Blue state is intermediate state where node is approaching to low power state or congestion state. (Residual energy<=20% of initial energy or queue size=>80% of total buffer capacity). Thus we start dropping RREQ packets to disallow new connection through such nodes. If the node recovers from congestion and have energy > 20% then it will move to green state and again start forwarding the RREQs to allow new connection through it.

Red state is final state where node is having either low energy level or high congestion level and not suitable for further routing. (Residual energy<=10% of initial energy or queue size=>90% of total buffer capacity). An alternate path is selected in such case. REDZONE packet is added which include the previous node, next hop node in the path etc. (source S, destination D, previous node in the path, Next node in the path). These packets are used to find alternate path using bidirectional path discovery mechanism [9]. If the node recovers from congestion and have energy > 20% then it will move to green state or blue state depending on current queue size and act according to the new state. To find alternate path each node maintain neighbour table which include the neighbour nodes and their energy and congestion status. Only green nodes are kept in the table, RED are not included because these node are already engaged in 90% congestion or 10% remaining power. BLUE nodes are not included because these are at 20% power or 80% congestion and will not allow any new connection.

Sleep mode: After forwarding a data packet a node checks if residual power is less than 10% and the queue is empty and neighbour count is more than two (atleast 2 nodes are already neighbour because node is on the routing path) then the node goes into sleep mode to save power because we are already not allowing any new connection through it.and referenced in text.

Routing Algorithm:

1. For each RREQ packet arrived:

If node status is GREEN: calculate forward probability and generate random number.

if forward_prob => random_no

Forward RREQ and exit;

else Drop RREQ and exit.

Else (node status is either BLUE or RED):

Drop RREQ and exit.

2. For each data packet arrived:

If node status is GREEN or BLUE:

Forward the packet to the next hop (Normal AODV Flow) and exit.

Else (node status is RED):

Broadcast REDZONE packet to neighbour nodes. Neighbours try to find alternate path and update Routing table to bypass the node. Forward the current packet and exit.

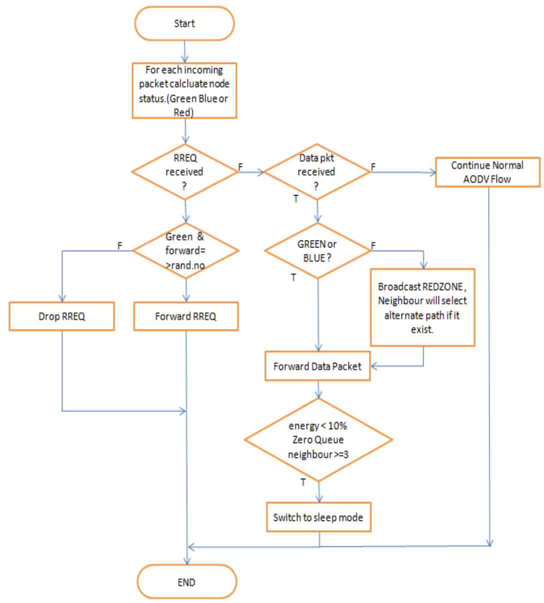
3. For each node after forwarding the current data packet:

If residual power<10% of initial energy and queue is empty. (No more data packets to forward):

Check neighbour count: if neighbour count is >=3:

go to sleep mode; exit;

Flow Chart:



4 SIMULATION AND RESULTS

The EACAR-AODV protocol is implemented in NS2 [18] and compared with traditional AODV. Energy model is used in NS2 to initialize transmission range (250 m), initial power (100J) etc. Table1 shows the parameters setting for the simulation setup. The channel bandwidth is set to 2Mbps and transmission range of node is 250 meter. The traffic type is CBR with packet size 512 bytes. The Random-Waypoint node mobility model is used with maximum speed 25 m/s.

Table 1: Simulation Parameters

Type	Values
Channel	Channel/Wireless Channel
Radio Propagation Model	Propagation/Tworayground
Network Interface	Physical/Wirlessphy
MAC	MAC/802_11
Interface Queue	Queue/DropTail/PriQueue
Antenna	Antenna/Omniantenna
Link Layer	LL
Interface Queue Length	50
Routing Protocol	AODV
Simulation Time	100s

The experiments are performed with:
(i) Variable number of connections (10 to 40)
(ii) Variable number of nodes (From 20 to 50)
(i) Variable number of connections: Here 50 nodes are used which are randomly scattered in a region of 1000m X 1000m. The load on the network is increased in terms of number of connections from 10 to 40. The cbrgen.tcl and setdest utility is used for traffic and mobility model generation. The performance of the proposed algorithm is evaluated and compared with the traditional AODV.

Figure 1 shows that at low load (10 and 20 number of connections) the performance of both AODV and EACAR-AODV is same. But as the load on the network increase (number of connection from 30 to 40) the packet delivery ratio of AODV and EACAR-AODV reduces because of more number of packet losses at higher load. As the result indicates the performance of EACAR-AODV is higher compare to traditional AODV.

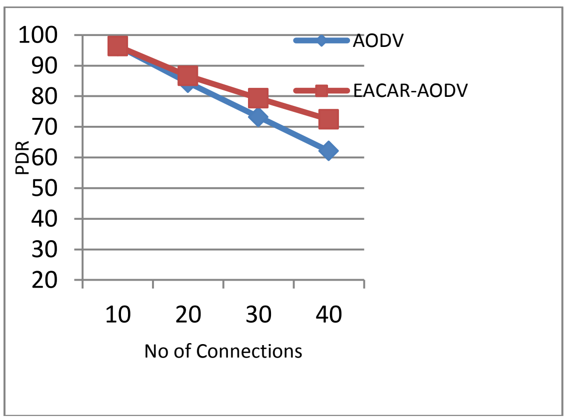


Fig. 1. PDR and No of Connections

Figure 2 shows the End to End Delay for the proposed EACAR-AODV and Traditional AODV for variable number of connections. At low load the delay metric is same for both the protocols but as the load increases (30 to 40 connections), the traditional AODV suffers from higher delay compare to EACAE-AODV. The alternate path discovery and Forward- probability reduce the congestion and thus delay is slightly better in case of EACAR-AODV.

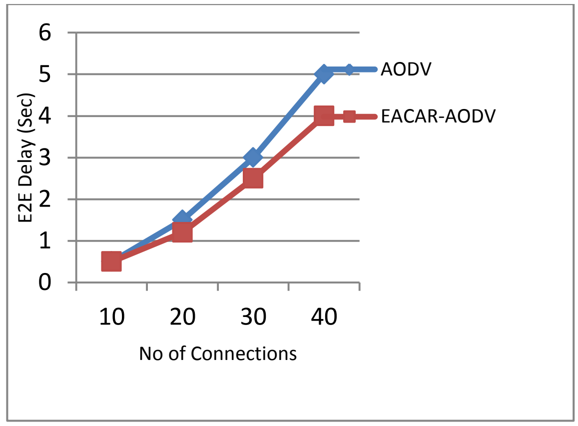


Fig. 2. E2E Delay and No of Connections

Figure 3 shows the normalized routing overhead for traditional AODV and EACAR-AODV. The routing overhead is lower in EACAR-AODV because of alternate path bypass before the path actually breaks, which saves RREQ and RRER. The difference is also because of RREQ flood control. Some overhead is also produced by REDZONE packet and bi-directional path discovery, which make the difference small.

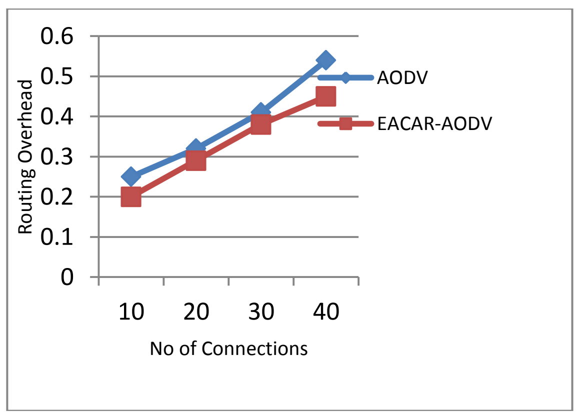


Fig. 3. Routing overhead and No of connections

Figure 4 shows the number of nodes survived with increase in the number of connections. The traditional AODV protocol do not search for alternate path until node exhausts, thus the survived node in AODV are lesser compare to EACAR-AODV which bypass a node if it is in low energy state and do not select low energy node in routing path.

J. K. Singh et. al / International Journal of Computer Networks and Communications Security, 4 (5), May 2016

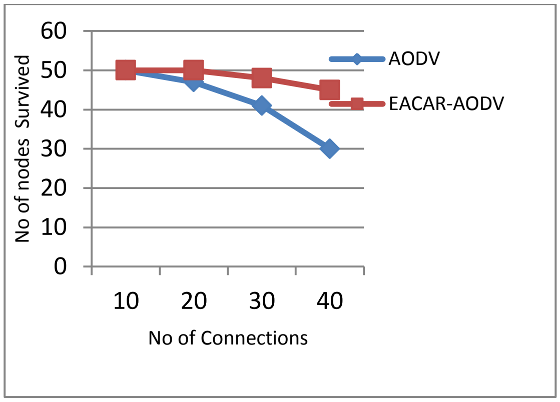


Fig. 4. Survived Node and No of connections

(ii) Variable number of nodes (From 20 to 50): Here number of nodes is variable from 20 to 50, which are randomly scattered in a region of 1000m X 1000m. The load on the network is kept constant, 15 connections. The cbrgen.tcl and setdest utility is used for traffic and mobility model generation. The performance of the proposed algorithm is evaluated and compared with the traditional AODV.

Figure 5 compare the PDR of traditional AODV with EACAR-AODV for variable number of nodes. The initial condition of network is at high load (20 nodes and 15 connections), which decrease the PDR for both routing protocols. But as the number of nodes increases the load on the network decrease and distributed evenly on more number of nodes, the PDR increase. At 50 number of nodes the performance of both protocols is same as the load on the network is light (50 node, 15 connection).

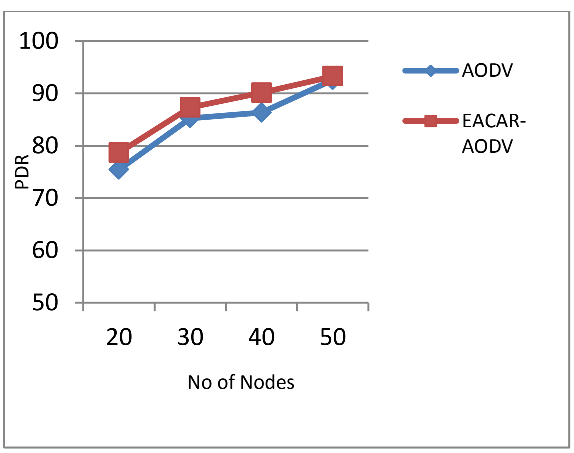


Fig. 5. PDR and No of Nodes

Figure 6 also shows similar results where initial delay is high but it decreases as the load decreases. EACAR-AODV perform better in high load conditional as it is adaptive to congestion, energy aware and control RREQ flood. When the number of nodes increases, the performance of both the protocols is same.

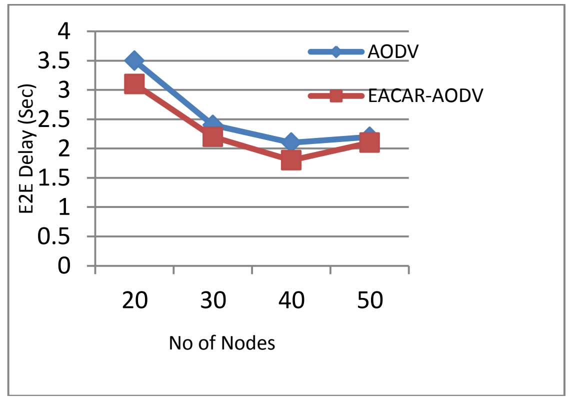


Fig. 6. E2E Delay and No of Nodes

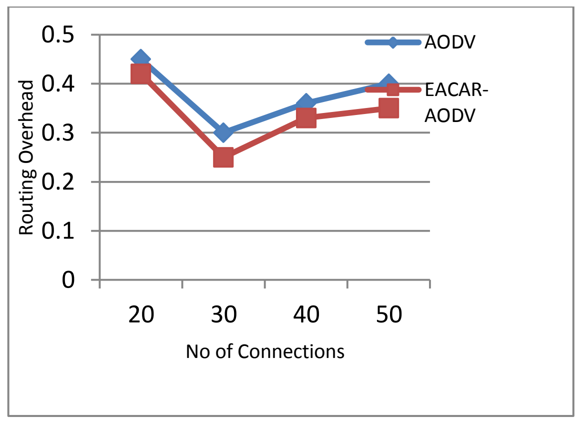


Fig. 7. Routing overhead and No of Nodes

However, the routing overhead remain lower in EACAR-AODV compare to traditional AODV protocol as indicated in Figure 7 because of less number of control packet are required and alternate path discovery before the route breaks, which saves lot of RRER and RREQ to find new path.

5 CONCLUSION AND FUTURE WORK

An energy adaptive and congestion aware routing approach is proposed in the paper with randomized probability for flood control in the network and sleep mode for low energy nodes to save node power. The results indicate the proposed protocol is better in terms of QoS parameters and also increase number of live nodes and network life time. The sleep node power can be used to transfer hi-priority traffic only as a future extension. Further cross-layer approach can be integrated into EACAR-AODV for further improvements.

6 REFERENCES

[1] S. R. Murthy and B. S. Manoj, "Ad hoc Wireless Networks Architectures and Protocols", Pearson Education, 2007.

[2] Stephanie Lindsey , Krishna M. Sivalingam , Cauligi S. Raghavendra, "Power Optimization in Routing Protocols for Wireless and Mobile Networks", Handbook of Wireless Networks and Mobile Computing, John Wiley & Sons Inc., New York, NY, 2002.

[3] D. A. Tran and H. Raghavendra, "Congestion Adaptive Routing in Mobile Ad Hoc Networks", IEEE Trans Parallel Distributed Systems, Vol. 17, No. 11, 2006, pp. 16-28.

[4] C. E. Perkins and P. Bhagwat, "Highly Dynamic Destination-Sequenced Distance-Vector Routing (DSDV) for Mobile Computers", In Proceedings of the SIGCOMM' 94 Conference on Communications Architectures, Protocols and Applications, August 1994, pp. 234–244.

[5] C. E. Perkins and E. M. Royer, "Ad-hoc On-Demand Distance Vector Routing", Proceedings of the Second IEEE Workshop on Mobile Computer Systems and Applications, February 25-26, 1999, pp. 90.

[6] D.B. Johnson, D. A. Maltz and J. Broch, "DSR: The Dynamic Source Routing Protocol for Multihop Wireless Ad hoc Networks", Ad hoc Networking, Addison-Wesley Longman Publishing Co., Inc., Boston, MA. 2001.

[7] Li Vok and Lu Zhenxin, "Ad Hoc Network Routing 2004", IEEE International Conference on Networking, Sensing and Control, Vol. 1, 2004, pp. 100-105.

[8] V. Rishiwal, S. Verma and S. K. Bajpai, "QoS Based Power Aware Routing in MANETs", International Journal of Computer Theory and Engineering (IJCTE), Vol. 1, No. 1, 2009, pp. 47-54.

[9] T. S. Kumaran and V. Sankaranarayanan, "Early Congestion Detection and Adaptive Routing in MANET", Egyptian Informatics Journal, Elsevier, Vol. 12, No. 3, November 2011, pp. 165-175.

[10] P.K.Suri, M.K.Soni and P. Tomar, "QoS Enabled Power Aware Routing Protocol (QEPAR)", International Journal of Engineering Science and Technology, Vol. 2, No. 9, 2010, pp 4880-4885.

[11] K. Balachandran, J. H. Kang, and W. C. Lau, "Adaptive Sleeping and Awakening Protocol (ASAP) for Energy Efficient Ad Hoc Sensor Networks". In Proceedings of ICC 2005-IEEE International Conference on Communications, IEEE press, vol. 2, 2005, pp 1068-1074.

[12] A. Nedumaran and V. Jeyalakshmi, "CAERP: A Congestion and Energy Aware Routing Protocol for Mobile Ad Hoc Network", Indian Journal of Science and Technology, Vol. 8, No. 35, 2015.

[13] S. P Terdal, V. D. Mytri and A. Damodaram, "A Load Aware Routing Mechanism for Improving Energy Efficiency in Mobile Ad Hoc Networks", International Journal of Computer Applications, Vol. 10, No. 3, November 2010, pp 6–11.

[14] Z. Wu, H. Song, S. Jiang and X. Xu, "Energy-Aware Grid Multipath Routing Protocol in MANET", Proceedings of the First Asia International Conference on Modelling & Simulation, 2007, pp. 36-41.

[15] D. A. Tran and H. Raghavendra, "Routing with Congestion Awareness and Adaptivity in Mobile Ad hoc Networks", University of Dayton, Dayton, 2005, pp. 1988-1994.

[16] V. Kanakaris, D. L. Ndzi, K. Ovaliadis and Y. Yang, "A New RREQ Message Forwarding Technique Based on Bayesian Probability Theory", EURASIP Journal on Wireless Communications and Networking, 2012, pp. 1-12.

[17] A. Boukerche. "A Performance Comparison of Routing Protocols for Ad Hoc Networks", Proceeding IEEE Internalional Parallel and Distributed Processing Symp., (IPDPS), 2001, pp. 1940-1946.

[18] NS -2, The ns Manual, Available at http: //www. isi.edu/nsnam/ns/doc.