International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-3, September 2019

Congestion Control for Improved Cluster-head Gateway Switch Routing Protocol using Modified Ad-hoc on-demand Distance Vector Algorithm

U B Mahadevaswamy, Jananitha M P

Abstract: ***MANETs are a trending topic in the wireless communication network. MANETs are formed automatically by an autonomous system of mobile nodes that are connected via wireless links. Cluster-head gateway switch routing protocol (CGSR) is a proactive protocol which is also called table-driven protocol. It consists of routing table information before setting up a connection. Ad-hoc on-demand distance vector protocol (AODV) is a reactive protocol, it sets path only when demanded by the network. CGSR protocol forms a group of nodes into clusters and selects a node as cluster-head based on some clustering algorithms for each cluster. In this paper, we have proposed a protocol, which combines the advantages of both CGSR and AODV to minimize traffic congestion in an ad-hoc wireless network. The performance metrics such as routing overhead, end-end delay, packet delivery ratio, throughput, and average energy consumption are enhanced and compared with other clustering protocols such as CGSR and LEACH protocols. The comparison result reveals that the routing overhead, end-end delay, and the average energy consumption is reduced and packet delivery ratio, throughput is improved.***

Keywords: MAODV, CGSR, cluster-head, congestion control, Energy consumption, and MANETs.

I. INTRODUCTION

Mobile ad-hoc network (MANET) is a group of mobile nodes or moving nodes that establishes a communication network voluntarily through a shared wireless channel. MANETS have no pre-existing infrastructure and minimal central administration. In MANETs, every node acts as a router to initiate the connection between the source and the destination. The Mobile ad-hoc network is more feasible and easy maintenance when compared to the traditional communication method. For a MANET to be established, we need a node ready to send data to a node that is ready to accept the data. These networks often use in emergency and rescue operations like military, floods and other natural calamities to establish the network. Since MANETs don't have any infrastructure, hence the network security is poor, congestion is more, and the probability of link failure is high.

There are three types of routing protocols in MANETs. Proactive Routing protocols: These are well known as table-driven protocols as each mobile node maintains routing table which is useful for data traffic, path information, power consumption, etc. These protocols are not appropriate for large networks. Examples of proactive routing protocols are DSDV, WRP, CGSR, etc. Reactive Routing protocols: These are well known as demand routing protocol as nodes create routing table only when they are needed. These are best suited for larger networks. Example of reactive routing protocol is AODV, DSR, etc. Hybrid routing protocols: This protocol combines the advantage of proactive and reactive protocols. An example of Hybrid routing protocol is ZRP [14].

In this paper, the method of controlling congestion in the CGSR protocol using MAODV is implemented. AODV is a reactive protocol which establishes connection only on demand. CGSR is a proactive protocol that contains routing table information before the connection is established. The proposed method combines the advantages of the pro-active and reactive protocols to enhance the performance of the network [9]. MAODV is used as an algorithm to ICGSR which leads to the improvisation of performance of the CGSR protocol. By using MAODV algorithm, CGSR establishes path only when demanded by the network according to AODV method, which in-turn reduces congestion in terms of routing overhead, end-end delay, and packet delivery ratio, throughput, and average energy consumption.

II. LITERATURE SURVEY

Routing process can be controlled by allowing hops with maximum possible distances on the received signal strength in a route based protocol at each node by using topology-aware and power-aware AOMDV based on maximum transmission range [14]. A node waits for acknowledgment for the threshold period. If the acknowledgment is not received within the threshold period then the node broadcasts again to select an alternate path. By using this method, congestion can be controlled in AODV [4]. To achieve better route cost and smaller delay, piggyback mechanism and weighted neighbor stability algorithm respectively can be used [8]. Better route maintenance can be achieved by providing alternate routes by an extra broadcast in case of route failure. These alternate routes reduce the number of control packets in AODV for different time pause and source [1].

Manuscript published on 30 September 2019
* Correspondence Author
U B Mahadevaswamy*, B.E. degree in Electronics Engineering from Mysore University, Mysore, Karnataka, India
Jananitha M P, BE degree in electronics and communication from BGSIT B.G Nagar, Karnataka, India

The congestion counter label in the routing table increases the overhead, but it creates better performance in terms of packet delivery ratio, throughput, power consumption, packet loss, and end-end delay [3].

The clustering and queuing techniques strengthen the mobility effect and ad-hoc nature by controlling traffic congestion [12]. Improving wireless cluster algorithm and other similar algorithms with some analytical models and clustering schemes to get a better quality of clustering [7]. A dynamic list of nodes is maintained which helps in forming in clusters and electing the cluster-head faster [5]. If the frequency of cluster-head changing by applying a different range of speed and pause time for all mobile nodes is reduced, then the performance of cluster-based routing will improve and makes the cluster more stable [13].

III. METHODOLOGY

The objective of this paper is to control the congestion of the CGSR protocol by using a modified AODV algorithm. In CGSR, the rerouting process occurs often and often because of the mobility of the nodes [1]. This leads to change in cluster-head which in-turn maximizes the traffic congestion in the network. This proposed method minimizes the congestion which is proved by comparing some performance metrics like end-end delay, routing overhead, packet delivery ratio, throughput, and average energy consumption with the existing methods [9].

A. Improved cluster-head gateway switch routing protocol (ICGSR)

In Improved cluster-head gateway switch routing protocol (ICGSR) the path discovery is implemented using the Ad-hoc On-demand Distance vector (AODV) algorithm. CGSR being a proactive routing protocol it has a routing

Algorithm. 1: Cluster-head selection method

// convey the network 'n' number of nodes
// 'k' is a variable
//Compare the mobile nodes based on capacity of node
BEGIN {
Compare the mobile nodes and assign rank R_k
}
//compare the distances of all mobile nodes from sink {
Allocate the rank D_k for each mobile node
}
//assign rank for each mobile nodes based on energy level {
Assign rank based on energy level E_k
}
//evaluate the weight of mobile nodes {
$W_k = R_k + D_k + E_k$
}
//select cluster head based on the weights {
Assign cluster head with highest weight to each clusters
}
END

table set up before the path establishment. CGSR gives higher performance when compared to other protocols because of gateway-switch type traffic redirections [5]. Clusters provide a powerful membership of nodes for connectivity. Each node transmits data based on its sequence number. This is to assure the updates and new path discovery. Each node maintains tree topology of cluster members that narrate the next hop to find the cluster head of the destination. In clustering the nodes are assigned with groups based on distance, energy etc. there are three types of nodes in the CGSR protocol [13].

Cluster head: These are like the brain of the network and it works as a leader to nodes present in their cluster. Every node communicates with other nodes through the cluster-head. Its functions are inter-clustering, data packet forwarding, intra-clustering, and maintenance of the whole network. This node contains routing table information of its cluster members. The algorithm for the cluster-head selection method is shown in Algorithm 1.

Gateway Node: It acts as a communication medium between one clusters to another. Data packets transmission between one nodes to another is done via this node.

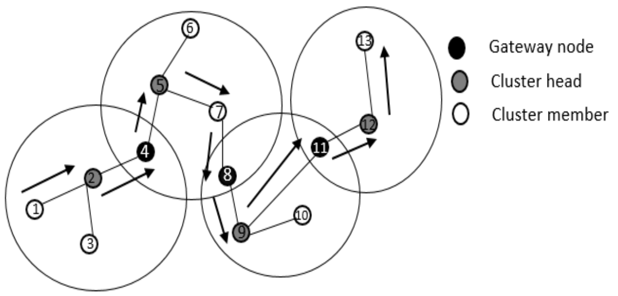

Fig. 1: CGSR routing from node 1 to 13

Cluster members: These are the common nodes present in the cluster. It doesn't have any inter-cluster links.

ICGSR uses DSDV as an underlying protocol and LCC algorithm for the clustering process. Most of the clustering process in many protocols is periodical. Re-clustering happens often and often to know some specific features of cluster-heads. LCC algorithm has two steps in the clustering process that is cluster formation and cluster maintenance.

Cluster member finds the nearest cluster-head along the path to the destination according to the routing tree and the cluster member tree on receiving a packet as shown in Fig. 1. Source Cluster-head searches for destination cluster-head and also finds the next hop in the routing table for the destination path. Assigned cluster member transmits a packet to the destination cluster head [7]. If the source nodes move out of its cluster head range, then it will rediscover the route for the destination node and then transmit the data packet [6].

B. Modified AODV mechanism

Ad-hoc on-demand Distance Vector (AODV) protocol is a reactive protocol which establishes connection only when demanded by the network. It uses a route discovery and route maintenance process as in DSR and uses periodic beacons and sequence number for the transmission of data packets as in DSDV [15]. In AODV, when a node needs route information to a destination it broadcasts a Route Request message to its neighbors with a last known sequence number [4]. This message is then flooded through the network until it reaches the node which has information about the route to the destination.

This node generates a Route Reply message which contains the sequence number and number of nodes to the destination as shown in Fig. 2.
Each node that crosses the Route Request then participates in forwarding this Route Reply message towards the originator of the Route Request message and makes a 'forward route' entry in its routing tables pointing to the destination node. To keep the routing table updated, each node periodically sends a 'Hello" message once in a second. When a link goes down, the upstream node is notified through an "Unsolicited Route Reply" containing an infinity metrics for the destination. Whenever the route fails the RREP discards the old path and shortens the new path to the destination [2]. The MAODV algorithm is shown in Algorithm. 2. By following this method, the cluster-head establishes path whenever it is demanded by the network. This in turn reduces traffic congestion and gives better performance in the network.

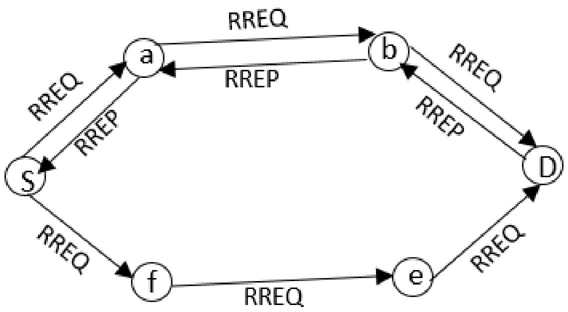

Fig. 2: Route discovery method in AODV

In Modified Ad-hoc On-demand Distance Vector (MAODV) the route request process in the AODV algorithm is modified. Whenever a node receives the RREQ message from its neighbor, the delay-time among the nodes is

Algorithm. 2: Modified AODV algorithm.

// Broadcast RREQ messages
1. BEGIN
2. Send RREQ (nodeP)
3. {SET sqn#_rq=1, Hop_Count_rq = 0
4. BROADCAST RREQ to Neighbors}
5. END
// Handling RREQ Messages
6. BEGIN
7. Delay time = ((current tie – timestamp)/ (Hop_Count))
8. IF (delay time > threshold) THEN
9. DISCARD THE RREQ message
10. END IF
11. END
// Broadcast RREP messages
12. BEGIN
13. SendRREP (nodeP, RREQ)
14. {SET sqn#_rp = sqn#_rq, Hop_Count_rp = 0
15. BROADCAST RREP to Neighbors}
16. END
// Handling RREP Messages
17. BEGIN
18. Receive RREP (RREP, nodeP)
19. {{IF (nodeP == source) UPDATE Route, DATA
20. IF (node x 1 = Destination) {
21. IF (sqn#_rp> sqn#_tb) OR (sqn#_rp == sqn#_tb) AND (Hop_Count_rp < Hop_Count_tb) UPDATE, FORWARD RREP
22. ELSE FORWARD RREP, UPDATE RREP: sqn#_tb = sqn#_rp, Hop_Count_tb = Hop_Count_rq+1}
23. UPDATE Route, Sqn#_tb = sqn#_rp, Hop_Count_tb = Hop_Count_rp}
24. END IF
25. END IF

calculated. This delay-time is compared with the predefined threshold value as shown in the Algorithm 2. The delay time is defined as the time difference between the current time at the destination and the timestamp at the sending node. This value is normalized by the hop- count value which is carried in the RREQ message. Hence, in this case, it is the average value. Also, the predefined threshold value is the average time that the RREQ message generates in the network layer from sending the node to the receiving node in case of no background traffic intervention. The node will discard the RREQ message when the delay time is higher than the predefined threshold value. Here, using this method, the broadcasting of the RREQ message to the bulky-load path is averted by the relay node. Hence, both the data and the routing messages continuously transmitted through the path with a very low congestion level. Hence, this method can minimize the risk of packet collision in the network as well as the number of route establishment trials. As a result, average energy consumption is less than original AODV approach. The threshold can be calculated using the equations mentioned in equation (1)

$$T_{Threshold} = T_{MAC\ to\ MAC} + T_{MAC\ to\ Network} + T_{Network\ to\ MAC} \quad (1)$$

$$T_{Network\ to\ MAC} = 0.01*(\text{random variable: uniform } [0,1]) \quad (2)$$

$$T_{MAC\ to\ MAC} = T_{BO} + T_{frame} + T_{CCA} + T_{IFS} \quad (3)$$

$$T_{BO} = BO_{slots} + T_{BOslots} \quad (4)$$

$$T_{frame} = (RREQ_{packet\_size} * 8)/\text{Data Rate} \quad (5)$$

Here, $T_{Network\ to\ MAC}$ and $T_{MAC\ to\ Network}$ in equation (1) is very small, so it can be ignored and it is set to mean values. $T_{MAC\ to\ MAC}$ does not contains propagation delay and other parameters used in the above equations are all calculated as per the IEEE 802.15.4 standard at the 2.4 GHz ISM band.

Table I: Notations

Notations	Notation Description
$T_{Threshold}$	Threshold value
$T_{Network\ to\ MAC}$	Average time required to propagate the RREQ message from the network layer to the MAC layer at the sender side
$T_{MAC\ to\ MAC}$	Average time required to propagate the RREQ message from the MAC layer at the sender side to the MAC layer at the receiver side
$T_{MAC\ to\ Network}$	Average time required to propagate the RREQ message from the MAC layer to the network layer at the receiver side
T_{BO}	Average back off time
T_{CCA}	Clear channel assessment time
T_{frame}	Transmission time for the RREQ message
T_{IFS}	Inter frame spacing time
BO_{slots}	Number of back off slots
$RREQ_{packet\ size}$	RREQ packet size
Data_rate	Data rate

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Here, T_{IFS} is the long frame spacing time and this is used when the packet size is greater than 18 bytes. The notations given in the formulae are described in Table I.

If the route table entry to the destination is created or updated, then the following actions occur:

- Route is marked as active,
- Destination sequence number is marked as valid,
- Next hop in the route entry is assigned to be the node from which the RREP is received, which is indicated by the source IP address field in the IP header,
- Hop count is set to the value of the New Hop Count,
- Expiry time is set to the current time plus the value of the Lifetime in the RREP message,
- Destination sequence number is the Destination Sequence Number in the RREP message.
- Current node can subsequently use this route to forward data packets to the destination.

IV. SIMULATION RESULTS AND DISCUSSIONS

The proposed work is simulated using the tool Network Simulator 2 (NS2). The obtained results of ICGSR are compared with CGSR and LEACH protocols. The simulation parameters are shown in Table II. The performance of the protocols in terms of end-end delay, packet delivery ratio, routing overhead, throughput, and average energy consumption are compared and plotted in graphs. NS-2 is an open-source discrete event simulator used for simulation of both wired and wireless network designs. The back-end programs in NS2 is written in C++ and the front-end program is written in Tool Command Language (TCL). When we run a TCL program, it generates two types of files namely, Network Animator (NAM) file and Trace file. These files define the behavior of the nodes and keep the record of connection type, number of packets send and received, number of hops between any two nodes, etc. at any instance of time.

Table II: Simulation Parameters

Parameters	Values
Simulation area	1000m2
Number of nodes	100,150,200,250
Size of packets	5000
Simulation time	175ms
Packet rate	250kb
Initial energy	100J

A. Routing Overhead

In MANETs, link breakage occurs frequently due to the mobility of nodes, which leads to frequent route discovery. In MANETs, nodes move in the selected path for packet transmission and that might get interrupted [6]. This, in turn, leads to the rerouting of the route to the destination whenever a node moves from one cluster to another. This increases the traffic on the channel which leads to routing overhead. The results are compared with the other protocol as shown in Table III.

$$\text{Routing overhead} = PL + SN + TR \quad (6)$$

Table III: Routing Overhead

No of nodes	CGSR	LEACH	ICGSR
100	8.425	8.35	8.257
150	8.369	8.3	8.136
200	8.628	8.5	8.454
250	8.599	8.5	8.352

The routing overhead is defined as the total number of routing packets transmitted through a channel at one instance of time. It is measured using equation (6). PL indicates Packets lost before reaching the destination, SN indicates Messages contains serial numbers, and TR indicates Triggered messages. The simulation result of the routing overhead is shown in the Fig. 3. The routing overhead of the proposed protocol is less by when compared to the other protocols.

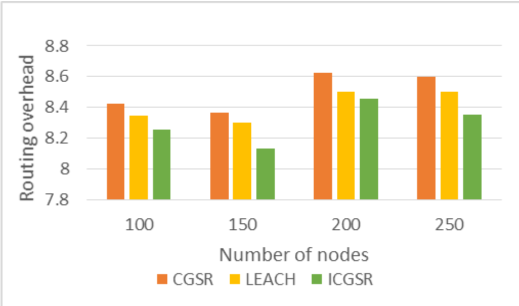

Fig. 3: Routing overhead

B. End-End Delay

The end-end delay is defined as the time taken by the packet to travel from source to destination across a network. Since the nodes are mobile in MANETS, it leads to frequent route discovery & queue in the transmission of a data packet and re-routing of the data packets [3]. As a result, a delay is developed in transmitting the packet from source to destination. This delay in transmission is called end-end delay. This end-end delay in a network is calculated using equation (7). The results are compared with the other protocol as shown in Table IV.

$$\text{End-End Delay} = \frac{\sum(\text{arrival time} - \text{transmitted time})}{\sum \text{Number of connections}} \quad (7)$$

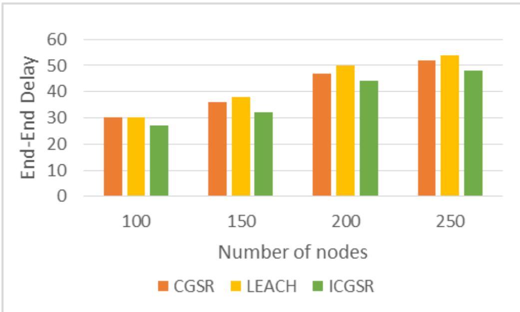

Fig. 4: End-End Delay

Table IV: End-End Delay

No of nodes	CGSR	LEACH	ICGSR
100	30	30	27
150	36	38	32
200	47	50	44
250	52	54	48

As the end-end delay decreases the throughput of the network increases, this leads to better performance of the protocol. The end-end delay of the ICGSR protocol is shown in the Fig. 4. The end-end delay of the ICGSR is less than other protocols. As a result, network performance gets better.

C. Packet delivery ratio

It is the ratio of the number of the data packets sent to the number of data packets received by the destination as shown in equation (8). PDR also represents the minimization of the packet drop in the network.

$$PDR = \frac{\sum(Number\ of\ data\ packets\ received}{\sum\ number\ of\ data\ packets\ sent} \quad (8)$$

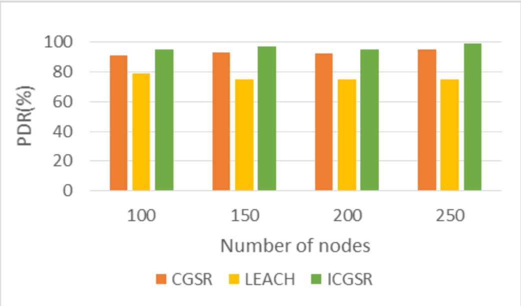

Fig. 5: Packet delivery ratio

The packet delivery ratio of ICGSR compared with other protocols is shown in Fig. 5. The results are compared with the other protocol as shown in Table V. The result shows ICGSR PDR is better than other protocols.

Table V: Packet Delivery Ratio

No of nodes	CGSR	LEACH	ICGSR
100	91	79	95
150	93	75	97
200	92	75	95
250	95	75	99

D. Throughput

It is defined as the number of packets transferred from source to destination successfully. In MANETs, Higher the throughput, better the performance of the network. Throughput can be calculated using equation (9). The throughput of the ICGSR protocol is shown in Fig. 6. The results are compared with the other protocol as shown in Table VI.

$$Throughput = \frac{\sum Number\ of\ packets\ successfully\ received}{\sum\ number\ of\ packets\ transferred} \quad (9)$$

Table VI: Throughput

No of nodes	CGSR	LEACH	ICGSR
100	292.65	250	330.62
150	340.54	260	380.21
200	430.14	280	480.01
250	583.42	350	620.54

AODV adapts hop by hop routing, hence throughput is high at higher traffic load. Whereas, proactive protocols maintains up-to-date and consistent routing table. This requires substantial messaging overhead, which in turn consumes bandwidth and power, and decreases throughput. This shows the performance of ICGSR is better than CGSR and LEACH.

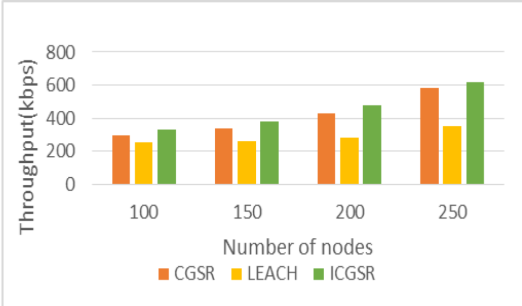

Fig. 6: Throughput

E. Average Energy Consumption

In MANET energy consumption is the major issue. The average energy consumed by the network for the transmission of the packet is considered as average energy consumption. If energy consumption is more it drains out the power from the network which leads to less network lifetime. In a word, Energy consumption, last dissipation, and network lifetime are all inter-related. The results are compared with the other protocol as shown in Table VII.

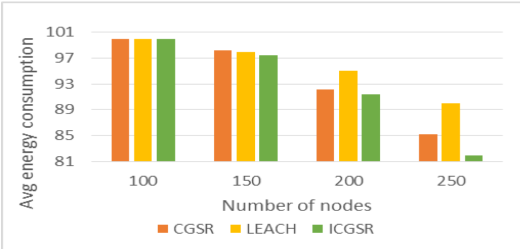

Fig. 7: Average Energy Consumption

The result of average energy consumption is compared with CGSR and LEACH protocols as shown in Fig. 7. The result shows that the energy consumption of the ICGSR is less than other protocols which give better performance.

Table VII: Energy Consumption

No of nodes	CGSR	LEACH	ICGSR
100	100	100	100
150	98.15	98	97.50
200	92.47	95	91.43
250	85.22	90	81.94

V. CONCLUSION AND FUTURE WORK

In this work, an Improved CGSR protocol is implemented using modified AODV algorithm to minimize the congestion in the network. AODV algorithm is modified in such a manner that, it helps in path establishment in CGSR protocol and minimizes the link failure, which leads to minimization of traffic congestion. Since two protocols are used in the network the energy consumption is pretty much high, a mathematical model is introduced to minimize the energy consumption. The obtained result shows that, routing overhead, end-end delay, and average energy consumption is decreased with increasing the packet delivery ratio and throughput, when compared to the other clustering protocols such as CGSR and LEACH.

The present research work can be extended to design and develop new routing protocol with advanced algorithms. In future, an attempt can be made to provide security for proposed network. Also, lifetime enhancement of the nodes can be incorporated.

REFERENCES

1. Ajay Pratap Singh, Sreenu Naik Bhukya: HP-AODV: An enhanced AODV routing protocol for high mobility MANETs, pp 0975-8887. Advanced Computing and Communication Techniques for High Performance Applications (2014)
2. Anju & Sugandha Singh: Modified AODV for Congestion Control in MANET. Vol. 4, Issue 6. International Journal of Computer Science and Mobile Computing (2015)
3. Ashraf Abu-Ein & Jihad Nader: An enhanced AODV routing protocol for MANETs. Vol. 11, Issue 1. International Journal of Computer Science Issues (2014)
4. Heena & Deepak Goyal: Congestion control using Enhanced AODV Routing mechanism in MANET. Vol. 3, Issue 8. International Journal of Computer Science and Mobile Computing (2014)
5. J. Sathiamoorthy & B. Ramakrishnan: Energy and delay efficient dynamic cluster formation using hybrid AGA with FACO in EAACK MANETs. pp 371-385. Wireless Networks (Springer) (2017)
6. K. Devarajan & V. Padmathilagam: An enhanced cluster-head gateway switch routing protocol (ECGSR) for congestion control using AODV algorithm in MANET". Volume 123 Issue 3. International Journal of Computer Applications (2015)
7. Mohamed Aissaa & Abdelfettah Belghith: Quality of Clustering in mobile Ad Hoc networks. pp 245-252. 5th International Conference on Ambient Systems. Network and Technologies (2014)
8. Mrs. Smita A. Mungare & Dr. Rekha S. Patil: Review of Enhanced AODV routing protocol for mobile adhoc wireless networks. Vol. 1, Issue 5. International Journal of Advanced Research in Electronics and Communication Engineering (2012)
9. Neelam Phate, Madhvi Saxena & M.A. Rizvi: Minimizing congestion and Improved QoS of AODV using clustering in MANET. IEEE International Conference on Recent Advances and Innovations in Engineering (2014)
10. S. Leemaroselin et al: A review on congestion control algorithm in MANET. Vol. 6, Issue 4. International Journal of Computer Science & Engineering Technology. (2015)
11. Sangita Kurundkar, Sangeeta Joshi & Laxman Waghmare: Performance Evaluation of Improved Directional Ad Hoc on Demand Distance Vector Routing Protocol. pp. 1985-1996. Wireless Personal Communications (Springer) (2017)
12. Saurabh Sharma, Dipti Jindal & Dr. Rashi Agarwal: An approach for Congestion Control in Mobile Ad hoc Networks. pp. 2249-6149. International Journal of Emerging Trends in Engineering and Development (2017)
13. Sunil Pathak, Nitul Dutta & Sonal Jain: An improved cluster maintenance scheme for MANET. International Conference on Advances in Computing, Communications and Informatics (2014)
14. V.Lalitha & Dr.R.S.Rajesh: Power aware and topology aware ad-hoc on demand multipath distance vector routing for MANET. IEEE 8th International Conference on Intelligent Systems and Control (2015)
15. Vinay Rishiwal, Mitul Yadav, Omkar Singh & Mano Yadav: Analysis of ADHOC routing protocols: A Retroscopic view. International Conference on Advances in Computing, Communication, & Automation (2016)

AUTHORS PROFILE

U B Mahadevaswamy received his B.E. degree in Electronics Engineering from Mysore University, Mysore, Karnataka, India in 1988 and M.Tech degree in Industrial Electronics, NITK Surathkal, Mangalore University, Karnataka in 1995 and PhD degree in Electronics Engineering from Mysore University, Mysore, Karnataka, India in 2013, respectively. He presently works as Professor in Electronics and Communication Department of Sri Jayachamarajendra College of Engineering, Mysore. His Research interests include analog and mixed mode VLSI circuits.

Jananitha M P received her BE degree in electronics and communication from BGSIT B.G Nagar, Karnataka, India in the year 2016. She is pursuing M.Tech in Networking and Internet Engineering at JSSS&TU, Mysuru, Karnataka, India.