Load Balancing and Congestion Control in MANET

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Abstract--This paper proposing the Load balancing congestion control with multipath routing, showing that in a static setting, where random path sets are chosen, coordinated controllers outperform uncoordinated ones. In a dynamic setting, by having limited set of routes, but allowing evolution to better routes over time, we can implement a distributed welfare maximization with coordinated controllers. This has implications for the design of practical multi-path rate control algorithms.

I. INTRODUCTION

– *Congestion Control Algorithm*

Summing the relative delay measurements over a period of data flow gives us an indication of the level of queuing at the bottleneck. If the sum of relative delays over an interval was 0, we would know that no additional congestion or queuing was present in the network at the end of the interval with respect to the beginning. Likewise, if we were to sum from the beginning of a session, and at any point if the summation was equal to zero, we would know that all of the data was contained in the links and not in the network queues. The congestion control algorithm of TCP-Santa Cruz operates by summing the relative delays from the beginning of a session, and then updating the measurements at intervals equal to the amount of time to transmit a windowful of data and receive the corresponding ACKs. The relative delay sum is then translated into the equivalent number of packets (queued at the bottleneck) represented by the sum of relative delays. In other words, the algorithm attempts to maintain the following condition:

The Load balancing congestion control algorithm may be divided into the link algorithm and the source algorithm .The link algorithm, running in the router, examines the congestion of the network, and produces congestion signals, such as dropped packets, delay, explicit congestion notification, explicit packet loss rate and explicit load factor. The source algorithm running in the end system, adjusts the sending rate of the end system according to the congestion signal. The main design issues of the congestion control algorithm are to select the appropriate Load balancing congestion signal for the link algorithm and in this project we have developed a novel Load balancing congestion control model consisting of the link algorithm and the source algorithm for high speed networks based on the logistic model. The key mechanism is based on bandwidth pre-assignment which is similar to XCP and MaxNet. The pre-assignment rate factor is computed based on the information of the router capacity, the aggregate incoming traffic and the queue length, and then senders adjust the sending rate based on the pre assignment rate

factor to strengthen the convergence and stability of transport protocol. We also discuss the convergence and stability through theoretical analysis. The performance of this algorithm is shown via simulation in terms of convergence, stability, fairness, queue length, link utilization, and packet loss ratio. We can provide fast convergence and strong stability, as well as high utilization and fair bandwidth allocation, all of which are desirable for high speed networks. In particular, it can reduce the computational overhead in routers compared to XCP and yet achieve better performance.

In Mobile Ad Hoc Networks (MANET), the network congestion can rigorously depreciate the network throughput. Also the network congestion results in the packet losses, bandwidth degradation and energy expenditure. Hence a load balancing scheme is required to prevent the network from congestion and exhaustion of resources of congested node. In this project, we propose a Load balancing congestion adaptive multi-path routing protocol for load balancing in MANET. When the source node wants to forward the data packet to the destination, it utilizes the reactive route discovery technique where the multiple paths are established using multi-path Dijkstra algorithm. In the discovered route, when any node detects congestion, it intimates the source with congestion notice message. The source node upon receiving the message distributes the data packets through the multiple paths available in its route cache using random transmission technique. If the source does not find any routes in its route cache, then it re-establishes multiple paths and distributes the traffic. By simulation results, we show that the proposed approach alleviates the network congestion.

A. *Mobile Ad hoc Network (MANET)*

Self-determining system of mobile routers and related hosts link by the wireless routes is termed as mobile ad hoc networks (MANET). It does not contain any base stations. Alternatively, a function of routing is included in every mobile host and multi-hops possibly will be essential to permit one node to interact with another node over the ad hoc network owing to the restricted transmission range. There is a possibility that wireless topology of the network may get varied randomly and quickly as the routes travel arbitrarily and systemize themselves randomly. Hence, MANETs are illustrated as active, multi-hop and continuously modifying topology.

Some examples of possible uses of a wireless ad-hoc network include military applications, law enforcement, emergency response efforts, commercial use, and education.

Multipath Routing

The process of discovering multiple routes among the distinct source and single destination at the time of single route discovery corresponds to multi-path routing. In MANET, the prevailing issues such as scalability, security, network lifetime, etc. can be handled by the multi-path routing protocols.

This protocol enhances the end-to-end throughput and offers load balancing in MANETs.

Multipath Routing Issues

Multipath routing has some disadvantages:

1) Route Request Storm

A huge quantity of route request messages are created by the multipath reactive routing protocols. When the intermediate nodes requires to process the duplicate request messages, there is a chance of unnecessary overhead packets be set up in the networks.

2) Inefficient Route Discovery

Certain multi-path routing protocols avoid intermediate node from forwarding a reply from its route cache in order to determine node-disjoint or link disjoint paths. Hence the source has to wait till it gets a reply from destination. Thus the process of route discovery performed by the multipath routing protocol needs more time when compared with DSR or AODV protocols.

Congestion in MANET

When the requirements become greater than maximum capability of the communication link particularly during multiple hosts attempting to access a shared media, congestion occurs in the network. Congestion may also be caused during the following conditions.

- When the load in the link goes beyond the carrying capacity.
- When the broadcasting packets are surplus in nature
- When more number of packets field has becomes time out and retransmitted.
- When the number of node increases.
- During standard deviation of the packet delay [6].

The Load balancing congestion detected in the network can rigorously worsen network throughput. It results in the packet losses, bandwidth degradation and energy expenditure. When the congested network is left unattended i.e., when suitable congestion control technique is not executed, it results in congestion collapse of the network. So the data will not delivered to destined node in effective manner. When the routing protocols in MANET are not conscious about the congestion, it results in the following issues.

Long delay: This holds up the process of detecting the congestion. When the congestion is more rigorous, it is better to select an alternate new path. But the prevailing on-demand routing protocol delays the route searching process.

High overhead: More processing and communication attempts are required for a new route discovery. If the multi-path routing is utilized, its needs additional endeavor for upholding the multi-paths despite the existence of alternate route.

Many packet losses: The congestion control technique attempts to minimize the excess load in the network by either reducing the sending rate at the sender side or by dropping the packets at the intermediate nodes or by executing both the process. This causes increased packet loss rate or minimum throughput.

For a source-destination pair devoid of the demands of traffic, routes are defined priorly and the interference prevails between the links. This can lead to a congestion problem.

When the wireless links are not shared by the transport layer flows, they start competing for the links when the flows are approaching close to each other. This results in congestion. This can be compensated with the MAC protocol that performs random access to the physical shared medium and necessitates the effective usage and sharing of the network resources.

Owing to the above mentioned reasons, congestion is treated using congestion control technique once it is detected during the routing process [8].

B. *Load Balancing in MANET*

For improved utility of the resources of the MANET and also to enhance the performance of the MANET, load balancing technique is employed which is the significant tool. Using the load balancing technique, the network can reduce the traffic congestion and imbalance of the load. This is possible because the technique reduces the end-to-end delay, increase the nodes lifetime and optimizes the energy expenditure [9].

The main problem with existing routing protocols is concerned with consideration of minimum hop paths as best path for transmitting the data towards destination. But the mentioned approach is short of communicating the load and path quality while creating the route. The reduced number of innermost nodes turns out to be strength for entire traffic which further causes congestion in medium access control layer (MAC). Consequently it results in increased packet delays as some nodes possess more loads. There is a possibility that heavily loaded nodes acquire more power utilization which declines the batter power. Thus the load imbalance occurs on various routes depreciating the performance causing issues such as congestion, power exhaustion and queuing delay. Therefore, the importance of effective load balancing scheme is to reduce the variation among overloaded and under-loaded nodes based on workload. The load balancing scheme allocates the traffic among the mobile hosts preventing congestion and exhaustion of resources of congested nodes.

On the whole, load balancing scheme is required to perform following actions:

For choosing non-congested paths or to distribute excessive load of a node to its neighbor

DPre = Number of data packets received by the node after time t

And are constants in the range of [0, 1].

If Pi denotes the initial power of a node, the residual power PR of a node at time t, can be calculated as:

PR = Pi – P (t) [18] (2)

2)   Estimation of Queue Length
The traffic load of the mobile node can be demonstrated by knowing the number of packets in the queue [17]. When excess traffic flows through the mobile nodes, it reveals that the interface queue possesses more packets. Thus average

queue size that specifies the traffic load of the node can be computed as follows:

QL = * QLo+ (1-)* QLc

where QL = Average queue length

QLc = Current queue length,

QLo = Old queue length

= Constant in the range [0, 1]

B.   *Estimation of Residual Bandwidth*
Every node within the interference range holds the sufficient bandwidth for transmitting the data without congestion. Thus it is necessary to familiarize with the local and neighboring nodes within the interference range. Any node that has necessity to transmit the data must consider local bandwidth and interference range mutually. The process of predicting the bandwidth of local and neighboring nodes is explained below.

Since the bandwidth is shared among neighboring nodes, by taking channel into consideration, the nodes calculates bandwidth based on the ratio of idle and busy times projected for pre-defined interval of time (t)

The local bandwidth (Bl) is estimated as follows:

Bl = Cch * () (3) tti

Where Cch = channel capacity and

ti = idle time in t.

As the information regarding the neighboring nodes is gathered previously, the minimum bandwidth (Bmin) of all nodes within the transmission range can be recognized. Thus the residual bandwidth (BR) is defined as the difference between Bmin and Bl and is stored in the residual bandwidth register.

C.   *Multipath Route Discovery*
When the source S has a necessity to establish the route towards D through the intermediate nodes, route discovery phase is executed. The steps involved in the route discovery are as follows.

Step 1: When S requires forwarding a data packet to D, initially it verifies the topology information table (TIT) shown below [18]:

Source Node ID	1-hop neighbor node ID	2-hop neighbor node ID	Residual Energy	Queue length	Residual bandwidth

Table. 1: Topology Information Table (TIT)

Step 2: After verification, S gathers all the information about the nodes towards D.

Step 3: S computes the link metric (LM) using the data in its TIT which is as follows
LM = (1))*()*(*RRBPQL
Where, and represents the normalization factor.

Step 4: S chooses the nodes with minimum LM and initiates the packet transfer through the chosen node within 2-hop. The Multipath Dijkstra algorithm (Explained in section 3.1.4) is employed to transmit the data through multiple paths with the nodes holding minimum link metric. The process is demonstrated using Fig. 1
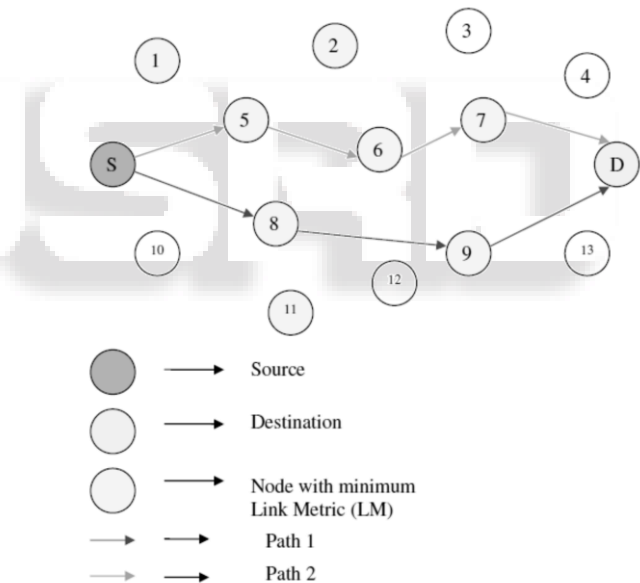
Fig. 1: Discovery of multiple paths using Multipath Dijkstra Algorithm.

The source after computing the LM, finds that the nodes 1, 2, 5, 6, 7, 8, and 9 possess minimum LM. Then utilizing the multi-path Dijkstra algorithm, the source forwards the data packet towards the destination. The path 1 is chosen as the primary path since the destination is reached within its two hop neighbors. The path 2 is chosen as the backup path.

a)   Reactive Multi-Path Routing
When any intermediate node (ni) does not recognize the next 2-hop information from TIT towards destination, the reactive multi-path routing protocol (like AOMDV) is performed for route discovery. The steps involved are as follows:

Step 1: The intermediate node (ni) broadcasts route request (RREQ) message to all neighboring nodes through the eligible links towards the destination (D) and waits for the route reply (RREP) message.

Step 2: When any neigh possessing an eligible route receives the RREQ, it replies requested ni with the RREP message.

Step 3: On receiving the RREP, ni computes its link metrics and compares the link metrics with the value already stored in its TIT, and if satisfies the requirement, it start sending data following that route and discard duplicate RREP packets received in other feasible paths.

Fig 2: Route Request and Route Reply Phase

From Fig. 2 Intermediate node 5, 1, 8 start broadcasting RREQ packets. Upon receiving the RREQ packet, the neighbor nodes reply with the RREP packet to the requested node. The node 5, 1 and 8 verifies the RREP and computes its link metrics and if the link metrics matches with the value already stored in its TIT, it start sending data following that route and discard other duplicate RREP packets

Fig. 3. Reactive Multi-path Routing

b) Load balancing Congestion Detection

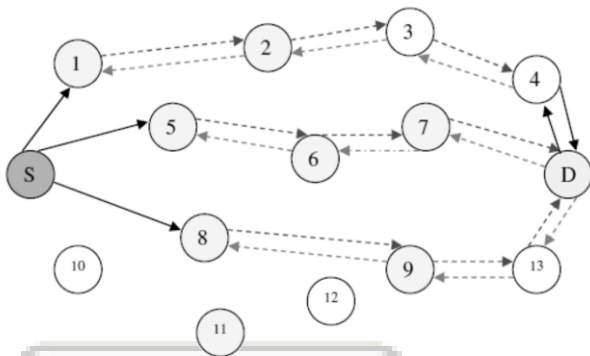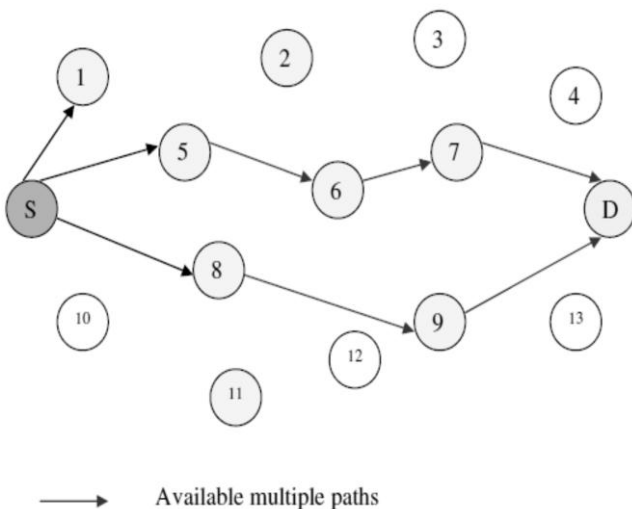In the discovered route, the node is likely to be congested during any of the following cases.

Case 1: When the nodes receive excess data packets, the nodes queue length (QL) increases.
i.e.

If QL>QLth Then Congestion occurs
End if
Here QLth represent the threshold value of queue length.

Case 2: When the nodes residual bandwidth is below the threshold, then the node suffers from lack of bandwidth during transmission of data.
i.e.

If BR < BRth Then
Congestion Detected
End if
Here BRth represent the threshold value of the residual bandwidth.

Case 3: Congestion occurs when the nodes residual battery power is below the threshold value.
i.e.

PR < PRth
where PRth = Threshold value of the residual battery power. On the whole, the above condition can be simplified as follows.
If (QL>QLth) || (BR < BRth) || (PR < PRth)
Then
Congestion detected
End if

The Load balancing congestion may result in increased packet loss rate, channel quality degradation, and increased delays. In order to overcome these drawbacks, the following congestion mitigating technique is considered.

c) Load balancing Congestion Mitigation Technique

When any node in the discovered route detects that the congestion has occurred, it performs the following action.
- The node intimates the source with the congestion notice (CN) message.
- Upon receiving CN message, the source node stops sending the data packet through the route containing the congested node.
- Then the source verifies its route cache for other possible paths for transmitting the data packet.
- If source node finds that the routes are available in its route cache, then it utilizes the direct random transmission technique to proceed with packet transmission through the multiple paths for balancing the load. The direct random transmission technique is explained in the section below.

If the source node does not find the routes in its route cache, then it re-establishes multiple routes
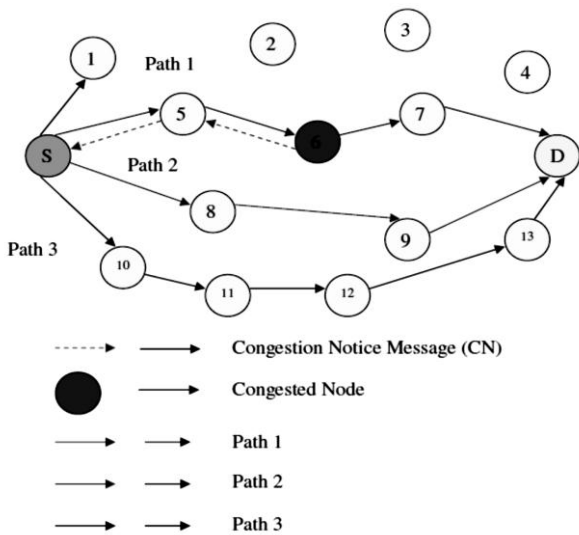
Fig 4: Congestion Detection

From Fig 4, in path 1, congestion is detected in node 6. Then node 6 sends the congestion notice message (CN) to source node. The source node stops sending the data packet through the path 1 and checks its route cache for other possible routes. It finds the existence of path 2 and path 3 and begins the data packet transmission through both the paths utilizing the random transmission technique in order to balance the load.

d) *Direct Random Transmission Technique:*

This technique involves the transmission of data packets via multiple paths based on the two-hop neighborhood information. Each node in the network holds the topology information table (TIT) that contains the ids of the nodes within the two-hop distance [18].

The steps involved in the direct random transmission technique is as follows

Step 1: When a source wants to transmit the data packets to the destination, it adds a time-to-live (TTL) field to each data packet. The initial value of TTL field is set by the source node for controlling the total number of randomized transmission.

Step 2: The source node also adds the lists of last hop neighbor nodes (Hneigh) to the packet header. The format of the data packet is shown in Table 2.

Source Node ID	Time to live (TTL)	Last hop neighbor node

Table. 2: Data Packet Format

Step 3: After updating both TTL and Hneigh, the source node starts transmitting the data packet.

Step 4: When any intermediate node receives the data packet, it compares the Hneigh field against its own neighbor list and randomly selects one node from its neighbors that are not included in the Hneigh.

Step 5: The intermediate then decrements the TTL value, updates the Hneigh field, and transmits the data packet to

the next hop node, and this process continues till the overlapping of the Hneigh field occurs.

Step 6: If Hneigh field completely overlaps or it possess the transmitting node's neighbor list,

Then A random neighbor is drawn from the neighbor list and transmits the packet to it. End if

This technique proves to be very efficient load balancing technique and improves the performance efficiency.
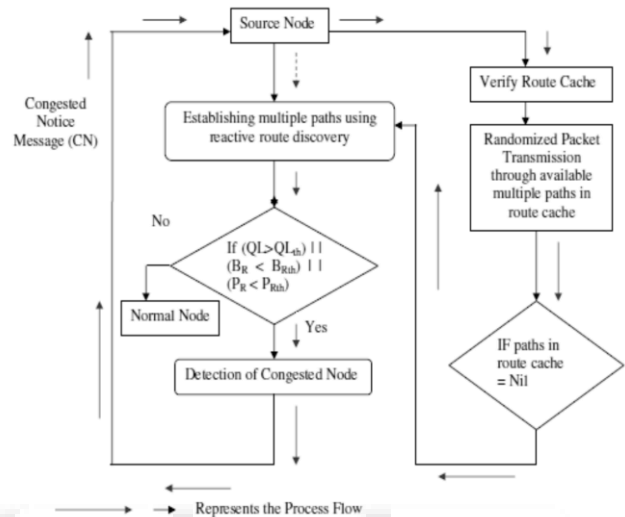

Fig. 5: Flow chart of Congestion Adaptive Multi-path Routing Approach

D. *Simulation Parameters*

Our proposed load balancing Congestion Adaptive Hybrid Multi-path Routing Protocol (CAHMRP). In this simulation, the channel capacity of mobile hosts is set to the value of 2 Mbps. We use the distributed coordination function (DCF) of IEEE 802.11 for wireless LANs as the MAC layer protocol. It has the functionality to notify the network layer about link breakage. In our simulation, the number of flows is varied as 2, 4, 6 and 8. The mobile nodes move in a 1250 meter x 1250 meter square region for 50 seconds simulation time. We assume each node moves independently with the same average speed. All nodes have the same transmission range of 250 meters. In our simulation, the speed is 10 m/s and the transmission rate is varied from 250 to 500 kb/s. Random Way Point mobility model is used. The simulated traffic is Constant Bit Rate (CBR).

Our simulation settings and parameters are summarized in Table 3.

No. of Nodes	50
Area	1250 X 1250
MAC	802.11
Radio Range	250m
Simulation Time	50 sec
Traffic Source	CBR
Rate	250,300,350,400,450 and 500 kb/s
Packet Size	512 B
No. of connections	7
Mobility Model	Random Way Point
Speed	10 m/s
Pause time	5 seconds

RxPower	0.395
TxPower	0.660
IdlePower	0.035
Initial Energy	10.3
No. of Flows	2, 4, 6 and 8.

Table. 3: Simulation Parameters

E. *Performance Metrics*

We evaluate performance of the new protocol mainly according to the following parameters. We compare the Adaptive Routing Protocols routing protocol with our proposed LBCAHMRP protocol.

Average Packet Delivery Ratio: It is the ratio of the number of packets received successfully and the total number of packets transmitted.

Average end-to-end delay: The end-to-end-delay is averaged over all surviving data packets from the sources to the destinations.

Control overhead: The control overhead is defined as the total number of routing control packets normalized by the total number of received data packets.

Throughput: It is the number of packets successfully received by the receiver.

The simulation results are presented in the next section.

The average end to end delay of our proposed LBCAHMRP is 10% less than the existing Adaptive Routing protocol. we can see that the delivery ratio of our proposed CAHMRP is 31% higher than the existing Adaptive Routing protocol. From Fig. 12, we can see that the overhead of our proposed LBCAHMRP is 23% less than the existing Adaptive Routing protocol. From Fig. we can see that the throughput of out proposed LBCAHMRP is 32% higher than the existing Adaptive Routing protocol.

IV.CONCLUSION

We have proposed a congestion adaptive multi-path routing protocol for load balancing in MANET. When the source node wants to forward the data packet to the destination, it utilizes the reactive route discovery technique where the multiple paths are established using multi-path Dijkstra algorithm. When any intermediate node does not recognize the next 2-hop information from TIT towards destination, the new multi-path route discovery is performed. In the discovered route, when any node detects that congestion has occurred, it intimates the source with the congestion notice (CN) message.

Upon receiving CN message, the source node stops sending the data packet through the route containing the congested node and distributes the data packets through the multiple paths available in its route cache using random transmission technique. If the source node does not find the routes in its route cache, then it re-establishes multiple routes and proceeds with traffic distribution. By simulation results, we show that the proposed approach alleviates the network congestion. The proposed approach is very efficient load balancing technique that improves network performance.

REFERENCES

[1] Premalatha.J and Bala Subramanie.P, "Enhancingthe quality of service in MANETs by effective routing", ICWCSC, 2010.

[2] Moon Jeong Kim, Dong Hoon Lee, and Young Ik Eom, "Enhanced Non-disjoint Multi-path Source Routing Protocol for Wireless Ad-Hoc Networks", Proceedings: International International Journal of Computer Science and Telecommunications [Volume 3, Issue 12, December 2012] 19 conference on Computational science and its applications - Volume Part III (ICCSA), 2007.

[3] Chengyong Liu, Kezhong Liu, Layuan Li, "Research of QoS –aware Routing Protocol with Load Balancing for Mobile Adhoc Networks", WiCom' 08, 4th International Conference on Wireless communication, 2008.

[4] Yi, J., Adnane, A., David, S. and Parrein, B.," Multipath optimized link state routing for mobile ad hoc networks", Ad Hoc Networks 9, pp-28-47, 2011.

[5] G.Vijaya Lakshmi Dr. C.Shoba Bindhu, " Congestion Control Avoidance in Ad hoc network using queuing model", International Journal of Computer Technology and Applications, pp 750-760, vol 2, Issue 4, 2011.

[6] Vijayaragavan Shanmugam and Duraiswamy Karuppaswamy, " An Analysis of Power Aware Congestion Control Multipath Multicast Protocol for Mobile Ad hoc Network", Journal of Computer Science, pp 1381-1388, 2010.

[7] S.Santhosh baboo and B.Narasimhan, " A Hop-by-Hop Congestion-Aware Routing Protocol for Heterogeneous Mobile Ad-hoc Networks", International Journal of Computer Science and Information Security (IJCSIS), Vol. 3, No. 1, 2009.

[8] V. Thilagavathe and Dr. K. Duraiswamy, "Cross Layer based Congestion Control Technique for Reliable and Energy Aware Routing in MANET", International Journal of Computer Applications, Volume 36– No.12, December 2011.

[9] Shashank Bharadwaj, Vipin Kumar, and Ankit Verma, " A Review of Load Balanced Routing Protocols in Mobile Adhoc Networks", International Journal of Engineering Trends and Technology, 2011

[10] Shruti Sangwan, Nitin Goel, and Ajay Jangra, " AELB: Adaptive and Efficient Load Balancing Schemes to Achieve Fair Routing in Mobile Ad hoc Networks (MANETs)", International Journal of Computer science and technology, Vol- 2 Issue– 3 (Version 1) , 2011.

[11] A. Valarmathi and RM. Chandrasekaran, "Congestion Aware and Adaptive Dynamic Source Routing Algorithm with Load-balancing in MANETs",

International Journal of Computer Applications, Volume 8– No.5, October 2010.

[12] Duc A. Tran, and Harish Raghavendra, " Congestion Adaptive Routing in Mobile Ad Hoc Networks", IEEE Transactions on parallel and distributed systems Vol. 17, No. 11, 2006.

[13] Zhijing Xu, Kang Wang, Liu Qi, " Adaptive Threshold Routing Algorithm with Load-balancing for Ad Hoc Networks", Proceedings of the 2009 International Symposium on Web Information Systems and Applications (WISA), pp. 351-354, 2009.

[14] R. Vinod Kumar and Dr.R.S.D.Wahida Banu, " Load-balancing Approach for AOMDV in Ad-hoc Networks", International Journal of Computer Applications, pp 200-205, 2010.

[15] P. P. Tandon and Bibhudatta Sahoo, " A Novel Congestion Avoidance Based Load Balanced Routing with Optimal Flooding in Mobile Ad hoc Network", International Conference on Contemporary Computing (2008).

[16] Rajbhupinder Kaur, Ranjit Singh Dhillon, Harwinder Singh Sohal, Amarpreet Singh Gill, " Load Balancing of Ant Based Algorithm in MANET", IJCST Vol. 1, Issue 2, December 2010.

[17] Vishnu Kumar Sharma and Dr. Sarita Singh Bhadauria, "Congestion and Power Control Technique Based on Mobile Agent and Effect of Varying Rates in MANET", International Journal of Advancements in Computer Science and Information Technology, Vol. 01, No. 1, 2011.

[18] Ramadevi, "QoS Enhanced Hybrid Multipath Routing Protocol for Mobile Ad hoc Networks", Accepted for publication in International Journal of Computer Science and Telecommunications Vol. 03, No. 12, 2012.