Multicast Routing Protocol for MANET with Constrained Directional Forwarding For Less Energy Consumption

Praveen Kumar V #1 Rajendra Prasad Ch *2 Brahma Reddy B #3

 # PG Scholar in Master of Technology, Vignana Bharathi Institute of Technology, Aushapur, JNTU Hyderabad, Andhra Pradesh, India

 # Professor, Vignana Bharathi Institute of Technology, Aushapur, JNTU Hyderabad, Andhra Pradesh, India

[1]praveenvemula777@gmail.com,

[3]reddybb@hotmail.com

**Assistant Professor, Vignana Bharathi Institute of Technology, Aushapur, JNTU Hyderabad, Andhra Pradesh, India*

[2]prasad430@gmail.com

Abstract— **Mobile Ad hoc Network is a self- configured network of mobile nodes associated with wireless links in order to organize a random topology. The nodes travel in the random manner. Multicast routing protocol is greatly needed in order to carry out communication effectively among the mobile nodes in an Adhoc network. The routing protocol should assure minimum usage of network resources like wireless links bandwidths, power and should lead to better packet delivery ratio and end to end delay. This paper presents a multicast routing strategy for mobile Adhoc network to overcome the limitations in the above said resources that arise due to dynamic topology and primary path failures. The protocol conditionally forwards the route search packet and creates multipath during route searching. Multipaths can be useful if primary path brakes during transmission and the packet travels by alternative path, leads to better performance of routing protocol. Route recovery management can be effectively carried out in this protocol.**

Keywords— **Alternative path, Mobile ad-hoc networks, Multicast routing strategy, Multipath, Route recovery**

I. Introduction

An ad hoc network composed of mobile nodes which are connected by wireless links and in random manner to constitute a dynamic multihop network [1]. The mobile nodes travel in random manner due to dynamic topology. Quick Deployment, strength, flexibility and essential support for mobility are some merits of ad hoc networks. As ad hoc network is economically beneficial, it is utilized in the military application, collective and distributed computing, emergency services, and wireless mesh and sensor networks and even in hybrid networks. There is no fixed infrastructure like base stations in an ad hoc network. The mobile nodes directly interact with each other through wireless routes within the network. The issues in finding a route to destination node are unpredictable of environment, nodes that are resource-constrained and topology. The issues may result in errors in broadcast, links and node failures. Multicasting has great importance in ad hoc networks rather than unicasting due to its broadcasting nature [2]. So any routing protocol should assure effective utilization of bandwidth, reduction of packet drops and overhead.

The proposed Multicast Routing protocol for MANET with Constrained Directional Forwarding for Less energy Consumption (MPMCFLE) forwards the route search packet conditionally and creates multipath [3] between source and destination. Multipath Routing topology finds Disjoint nodes, links and non-disjoint routes. If the primary route vanishes then data packets will be lost. To overcome this issue, Route maintenance technique is developed. The recently discovered routes can be cached for using it again if similar route is needed. Two types of route caching techniques are Source route caching and intermediate path caching. Using of Route cache facilitates the availability of alternate route during link failure and overhead can be controlled. On demand routing protocols leads to more control traffic as route request packet (RREQ) floods the entire network.

Multiple path routing protocol caches multiple routes [4] to a destination in a single route discovery. So, we propose a hybrid routing topology which involves multiple path discovery and local error recovery. In this multipaths are established for each source and destination and they are cached in their route caches. When a route or link fails, a local error recovery is carried out to invoke alternate route selection. An alternate route is taken from route cache to have great bandwidth. So our proposed hybrid routing method reduces packet drops, recovery time, overhead and utilizes bandwidth effectively.

The paper is organized as follows: Section 2 describes the existing routing protocols for MANETs and their problems. The proposed, multicast routing protocol for MANET with constrained directional forwarding for less energy consumption (MPMCFLE) is discussed in Section 3.Section 4 analyses the performance of our proposed protocol in comparison to other protocol like MAODV. Section 5 summarizes the conclusions.

II. Routing Protocols for Mobile Ad Hoc Networks

Routing Protocols for mobile ad hoc networks can be classified based on topology, Routing information update mechanism, use of temporal information for routing and on utilization of specific resources. Routing information mechanism protocols can be typed into Table driven, On demand and Hybrid types. Table driven routing protocol such as Destination Sequenced Distance Vector Routing protocol [5] (DSDV), Wireless Routing Protocol (WRP) stores routing information in tables at each node. On Demand Routing protocols like Dynamic Source Routing [6] (DSR) and Ad Hoc On-Demand Distance-Vector Routing protocol [7] (AODV) initiates the route search process when ever route is needed. Core Extraction Distributed Adhoc Routing (CEDAR) comes under Hybrid category which uses both features of Table Driven and On Demand types.

Multicast Routing Protocols can be still categorized into mesh based and tree based ones based on their network structure. Core assisted Mesh based protocol [8] (CAMP) is Mesh based protocol and do not perform well when energy consumption is taken into account as overhead is more in broadcasting within the mesh. Tree based protocols again typed into Source tree and Shared tree protocols perform well in this scenario. AODV is a shred tree protocol. But tree based protocol has drawback of dependency on a core node and tree structure is fragile and thus need updation due to mobility of nodes. All these protocols do not perform well if primary route failure occurs as route maintenance is not carried out effectively.

To overcome these problems for efficient communication among mobile nodes in an ad hoc network, we propose a hybrid routing topology for effective route maintenance and local route recovery.

III. Proposed Protocol-MPMCFLE

In this**,** we propose multicast routing protocol for MANET with constrained directional forwarding for less energy consumption, which is a hybrid routing topology for better performance in terms of bandwidth usage, Packet delivery fraction and overhead. The protocol uses Global positioning System (GPS) in order to get the physical location of mobile nodes.

With the help of GPS, each node finds location of surrounding nodes in an ad hoc network. Usually a node with more energy and with less mobility constructs shared tree structure with itself as primary node of the tree.

A. Conditional Forwarding for Route Searching

After constructing the tree structure, the source node wants to find the route to destination. For this it forwards the Route request packet (RREQ) conditionally [9] to the neighbor nodes rather than flooding.

First the source node pixel locations are denoted by X(s), Y(s) in two dimensional structures. The protocol takes a threshold node as reference node and its locations are denoted by X (t), Y (t). It finds the new location values X, Y as

$$X=(X(s) + X(t))/2$$

$$Y=(Y(s) + Y(t))/2$$

After getting the new locations, the RREQ packet is sent from source to the nodes which are having their location values less than X, Y values. Then those nodes further send RREQ packet towards destination. The destination receives RREQ packet and replies back with RREP packet along the path created during RREQ transmission. Thus a route is created between source and destination and data transmission takes place.

Figure 1 shows the conditional forwarding in an ad hoc network, where source node S sends RREQ packet to nodes C, H but not to F node as its having location values greater than X, Y values.

If the source node does not find any nodes which are having less values than X, Y, then source node floods the RREQ packet rather than conditional forwarding. Destination node replies with RREP packet and data transmission takes place.

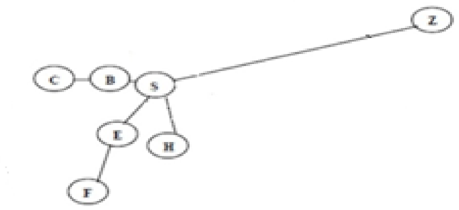

Fig1: Directional forwarding in ad hoc network

B. Multipath Routing

Unipath Routing protocols like AODV, DSR finds a single route between source and destination. But when that route or link fails, packet drop occurs until the new route is established. New route finding is a bit long process so the network resources like bandwidth and power are wasted.

To overcome this problem, we propose a protocol which creates multiple paths between source and destination during route search process .Multipath routing is proposed to increase reliability of transmission and for load balancing. Multipath routing [4] is used in several contexts such as Traditional circuit switched telephone networks and in data networks like Asynchronous Transfer Mode [10] (ATM) to overcome the problem that arises when primary path fails. Multiple paths can be used to compensate for the dynamic and unpredictable nature of ad hoc networks.

Figure 2 shows multipath routing in an adhoc network with S as source and D as destination and nodes X, Y, Z are intermediate nodes.

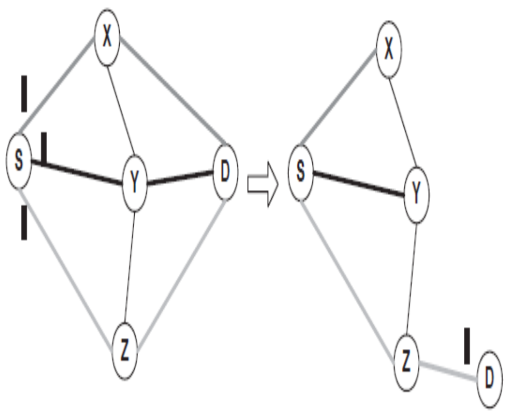

Fig 2: Multipath Routing in Ad hoc network

Here three routes are established between source S and destination D and those are SXD,SYD and SZD. The best path is selected first and if primary path fails it shifts to alternate paths. Even if node D moves, routes SXD, SYD break and SZD still alive to deliver packets to D.

C. Multipath Routing Components

Multipath routing consists of three components: route discovery, route maintenance, and traffic allocation.

1). Route Discovery: Route discovery and route maintenance [11] consists of finding multiple routes between a source and destination node. Multipath routing protocols can attempt to find node disjoint, link disjoint, or non-disjoint routes. Node disjoint routes, also known as totally disjoint routes, have no nodes or links in common. Link disjoint routes have no links in common, but may have nodes in common. Non-disjoint routes can have nodes and links in common.

Disjoint routes have certain advantages over non-disjoint routes. Non-disjoint routes may have lower aggregate resources than disjoint routes, because non-disjoint routes share links or nodes. Node disjoint routes offer the most aggregate resources, because neither links nor nodes are shared between the paths. Disjoint routes also provide higher fault-tolerance. When using non-disjoint routes, a single link or node failure can cause multiple routes to fail. In node or link disjoint routes, a link failure will only cause a single route to fail. However, with link disjoint routes, a node failure can cause multiple routes that share that node to fail. Thus, node disjoint routes offer the highest degree of fault-tolerance. In moderately dense networks, there may only exist a small number of node disjoint routes between any two arbitrary nodes, especially as the distance between the nodes increases

[12]. This is because there may be sparse areas between the two nodes that act as bottlenecks. Disjoint routes perform well when compared to non-disjoint routes.

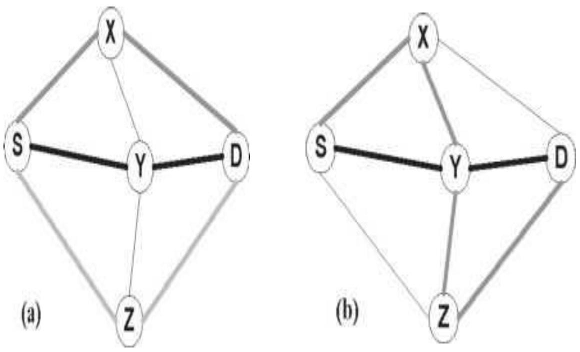

Fig 3.Different types of multipath routes

Figure 3 illustrates disjoint and non disjoint routes. Here Routes SXD, SYD, and SZD in (a) have no links or nodes in common and are therefore node disjoint. Routes SXYZD and SYD in (b) have node Y in common and are therefore only link disjoint.

2). Route Maintenance: During data transmission using multiple routes, when some or all of the routes fail. , then route discovery can be triggered each time one of the routes fails or only after all routes fail. Waiting for all routes to fail before performing a route discovery will result in delay before new routes are available. This may reduce QoS. However, initiating route discovery every time one of the routes fails may incur high overheads. Performing route discovery when N routes fail, where N is less than the number of paths available, may be a compromise.

3). Traffic Allocation: The traffic allocation strategy deals with how the data is distributed amongst the paths. The choice of allocation granularity is important in traffic allocation. The allocation granularity specifies the smallest unit of information allocated to each path. For instance, a per-connection granularity would allocate all traffic for one connection to a single path. A per-packet granularity would distribute the packets from multiple connections amongst the paths. A per-packet granularity results in the best performance [13]. This is because it allows for finer control over the network resources. It is difficult to evenly distribute traffic amongst the paths in the per-connection case, because all the connections experience different traffic rates. If a round-robin traffic allocation approach is used, however, a per- packet granularity may result in packets arriving out-of order destination.

D. Issues in Multipath Routing

While implementing multipath routing, link layer issues should be addressed. It is important to choose paths that are as independent as possible to ensure least interference between paths as they use wireless links. Paths should be selected that have low coupling or correlation in order to improve the performance. Correlation and Coupling matrices are used to find degree of independence among a set of paths. The correlation factor between two node-disjoint paths is defined as the total number of links connecting the paths [14]. Note that the correlation factor only applies to node- disjoint paths. The coupling [15] between two paths is calculated as the average number of nodes that are blocked from receiving data along one of the paths when disjoint routes are considered highly coupled.

The other Link layer issues which are addressed are

- End to end reliability
- Path reliability
- Bandwidth requirements.

Figure 4 describes the process to find end to end reliabilities.

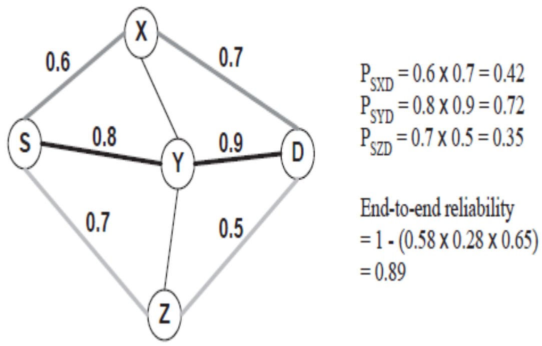

Fig 4: End to end reliability calculation

For satisfying bandwidth requirements, a reservation scheme [16] is used. The protocol attempts to find multiple paths that collectively satisfy the bandwidth requirements. The original bandwidth requirement is essentially split into multiple sub-bandwidth requirements. Each sub-path is then responsible for one sub-bandwidth requirement.

This protocol is on-demand and uses the local bandwidth information available at each node for discovering routes. A ticket-based approach is used to search for multiple paths. In this approach a number of probes are sent out from the source, each carrying a ticket. Each probe is responsible for searching one path. The number of tickets sent controls the amount of flooding that is done. Each probe travels along a path that contains the necessary bandwidth.

The source initially sends a certain number of tickets each containing the total bandwidth requirement. The tickets are sent along links that contain sufficient bandwidth to meet the requirement. When an intermediate node receives a ticket, it checks to see which links have enough bandwidth to meet the requirement. If it finds some, it then chooses a link, reserves the bandwidth, and forwards the ticket on the link. If no links have the required bandwidth, the node reserves bandwidth along multiple links such that the sum of the reserved band-widths equals the original requirement. In this way, the bandwidth requirement is split into sub-bandwidth requirements equaling the bandwidths reserved along each of the links.

E. Alternative path routing for effective local route recovery

Alternative path routing can be carried out in order to ensure effective local route recovery.

On the event of transmitting a data packet, if no route found then the source broadcasts the route request packets. If a unique RREQ reaches the intermediate nodes, it attaches the node ID to packet and continues broadcasting. If replicas of earlier received packets found, then drops if those replicated packets are not from local routes and this process we conclude as conditional dropping, which minimizes the packet loss. Even an intermediate node is aware of the path to target node, it is not allowed to initiate the root reply process since only the target node is eligible to perform route reply process. The destination node upon receiving all RREQ packets attaches the route code and feeds it back as RREP packets. Let n RREP packets are generated for the paths Pi, P_2,...,P_n. The route code is to recognize the available bandwidth. The RREP with route code RC1 has a maximum available bandwidth and RREP with route code RC2 has next maximum bandwidth availability and so on. The priority condition for bandwidth selection is as follows:

' $B_1 > B_2 > B_3 > B_4 .... > B_n$ ', where B_1, B_2, B_3,..., B_n are the available bandwidth of the routes.

After the intermediate node receives RREP packets, they store the routes P_1,P_2,.,P_n in their route caches and then forward them to subsequent nodes. Once the route reply process is completed then the primary path will be opted by the source node. Against to the failure of the route currently in use the restoration node detects it and establishes a local recovery path with maximum bandwidth (which is the first available path) from its route cache.

F. Route Recovery Management

The route recovery management technique [17] is handled to avoid the frequent collision and degradation in the network performance.

The network may possess many restoration nodes in the dense environment. In case of the route failure, all the existing restoration nodes attempts route recovery, by sending ' *drp* ' simultaneously. This results in frequent collisions and degradation of the network performance.

To conquer this drawback, we consider recovery route management technique which is as follows.

Every node has a various contention window (C) dimensions as per the overhearing count's number. If the number is large, the nodes C dimension is small. This reveals that the restoration node related to the primary route is more stable than other routes. The restoration node selects C in a random manner and waits for time t. In case restoration node hears ' *drp* ' message sends by another restoration node, the timer is stopped. If ' *drp* ' is not sent by any node within the time interval t, then the restoration node forwards ' *drp* ' to discover the route.

In particular, our route management scheme restricts the collision avoidance to be performed by the first ' *drp* ' message. There may be probability that first ' *drp* ' may collide with ' *drp* ' of other restoration nodes having the similar C value.

The mobility of restoration node causes it to misunderstand that route as failed even though original route is available to transmit the data. If the restoration node forwards ' *drp* ' message to a node which connects to the subsequent node well, it discards the ' *drp* ' and further restoration node is conscious about its misjudgment because it does not receive the ' *ack* '.

G. Mechanisms for Multipath Routing

We propose basically two mechanisms for multipath routing and those are

- Disjoint Multipaths
- Tressed Multipaths

1). Disjoint Multipath: The first multipath mechanism we consider constructs a small number of alternate paths that are *node-disjoint* [18] with the primary path, and with each other. These alternate paths are thus unaffected by failures on the primary path, but can potentially be less desirable *(e.g.,* have longer latency) than the primary path.

A constructive definition for node-disjoint multipath is:
Construct the primary path between source and sink.

1. The first alternate disjoint path Pi is the best path node-disjoint with.
2. The second alternate disjoint path is the best path that is node disjoint with, and so on.

We call this the *idealized* algorithm for constructing disjoint multipaths, and the resulting multipath the *idealized k-disjoint multipath.*
To realize node disjoint paths we should use one mechanism, which uses two kinds of reinforcements. Assume for the moment that some low-rate samples have initially been flooded throughout the network. The sink then has some empirical information about which of its neighbors can provide it with the highest quality data (lowest loss or lowest delay). To this most preferred neighbor, it sends out a *primary-path* reinforcement. As with the basic directed diffusion scheme, that neighbor then locally determines its most preferred neighbor in the direction of the source, and so on.
After it starts receiving data along the primary path, or perhaps a shortly after sending the primary-path reinforcement, the sink sends an *alternate path* reinforcement to its next most preferred neighbor. This neighbor A propagates the alternate path reinforcement to its most preferred neighbor in the direction of the source. If happens to already be on the primary path between the source and the sink (and it can determine this entirely from local state), it sends a *negative reinforcement,* then selects its next best preferred neighbor. Otherwise, *B* propagates the alternate path reinforcement to its most preferred neighbor and so on. Nodes other than the sink do not originate alternate path reinforcements.
This mechanism can be extended to construct disjoint multipath, by sending out alternate path reinforcements from the sink, each separated from the next by a small delay. Each node would then be constrained to receive only one reinforcement of either type-primary path, or alternate path. If it receives more than one reinforcement, the node negatively reinforces these, ensuring disjointed-ness.
We call this as *localized* disjoint multipath. In the idealized algorithm, the first alternate path is the primary path which is node- disjoint with the primary path. However, because the localized construction has only local knowledge of alternative paths, it's search procedure may discover longer alternate paths.

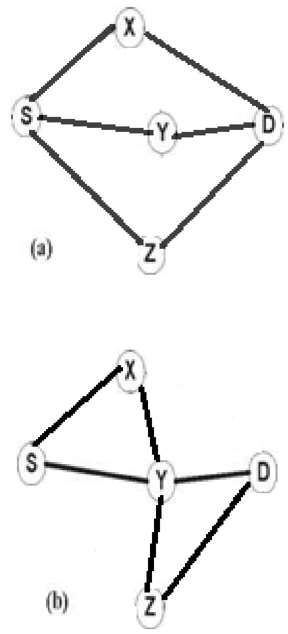

Fig 5(a & b): Node disjoint and Link Disjoint Multipath

Figure 5 describes node disjoint and link disjoint paths. In fig 5(a), Routes SXD, SYD, and SZD have no links or nodes in common and are therefore *node-disjoint.* In fig 5(b), Routes SXYZD and SYD have node Y in common and are therefore only *link disjoint.*

2). Tressed Multipaths: Disjoint multipath often can be energy inefficient. So, we propose a different mechanism called *tressed multipath.* [19]

A constructive definition for our *tressed* multipath is as follows:
For each node on the primary path, find the best path from source to sink that does *not* contain that node. This alternate best path need not necessarily be completely node-disjoint with the primary path. We call the resulting set of paths (including the primary path) the *idealized* tressed multipath. As its name implies, the links constituting a braid either lie on the primary path, or can be expected to be geographically close to the primary path. In this sense, the alternate paths forming a braid would expend energy comparable to the primary path.
One localized technique for constructing braids is described

below. Like the idealized algorithm for disjoint multipath, this technique also utilizes two types of reinforcements. However, its local rules are slightly different, resulting in an entirely different multipath structure. The sink sends out primary path reinforcement to its most preferred neighbor A. In addition, the sink sends alternate path reinforcement to its next preferred neighbor. Again, as before, propagates the primary path reinforcement to its most preferred neighbor and so on. In addition, (and recursively each other node on the primary path) *originates an alternate path reinforcement* to its next most preferred neighbor. By doing this, each node thus tries to route around its immediate neighbor on the primary path towards the source. When a node, such as, not on the primary path receives alternate path reinforcement, it propagates it towards its most preferred neighbor. When a node already on the primary path receives alternate path reinforcement, it does not propagate the received alternate path reinforcement any further.

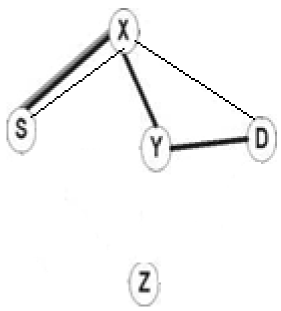

Fig 6: Tressed multipath

Figure 6 shows non-disjoint multipath and sometimes called as Tressed multipath. In this case, Routes SXD and SXYD have node X and link SX in common and are therefore non-disjoint.

IV. Performance Analysis

A. Simulation Model and Parameters

For the simulation of the proposed protocol, we use NS2.34 simulation tool. We use 802.11 DCF for MAC Layer as it can inform network layer about link failure. The nodes are placed at random locations which are placed in 1000x1000 region. Mobile nodes of count 5 to 55 with increment of 5 are taken with channel capacity set to 2Mb/s. Random way point mobility model with node speed of 10m/s is used. Each Simulation is run for 20 seconds with CBR generated traffic. The nodes can have radio range of 250m with data rate as 100kb/s with maximum packets in queue as 150.

B. Performance Parameters

For the performance comparison of our proposed protocol, the parameters considered are (i) Packet drop, (ii) Average end-to-end delay (iii) Control overhead, (iv) Packet Delivery fraction.

Figures compare the performance of our proposed protocol with that of MAODV protocol. Figure 7(a) and 7(b) shows the packet drops and it is less for proposed MPMCFLE. Figure 8 shows the comparison of end-to-end delay for both protocols and delay is less for our protocol. In figure 9, the comparison is done for Control overhead. Here normalized load can describe the overhead and it is less for MPMCFLE. This can represent the energy consumption of nodes. Figure 10 is used to compare both protocols for Packet delivery fraction and it is high for MPMCFLE protocol.

In all the above cases, our proposed routing technique-MPMCFLE outperforms MAODV protocol due to conditional forwarding and multipath routing mechanisms which effectively ensures for the alternative path selection whenever primary path fails. Route recovery management is carried out in such a way that overhead on nodes can be decreased. The packet drops are less as transmission goes through the second best path within less time if primary path fails.

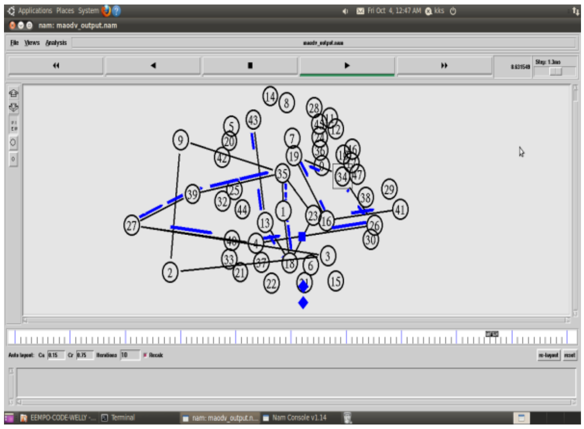

Fig 7(a): More packet drops for MAODV

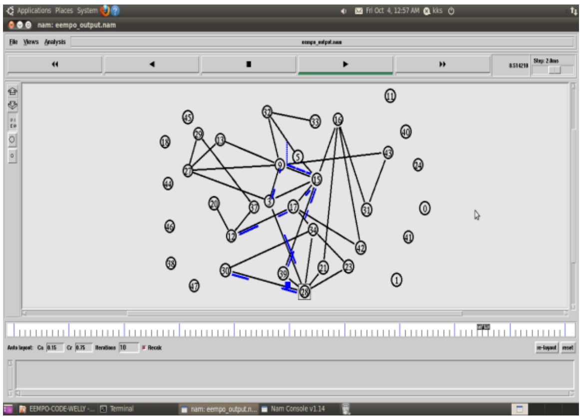

Fig 7(b): Less packet drop for proposed protocol

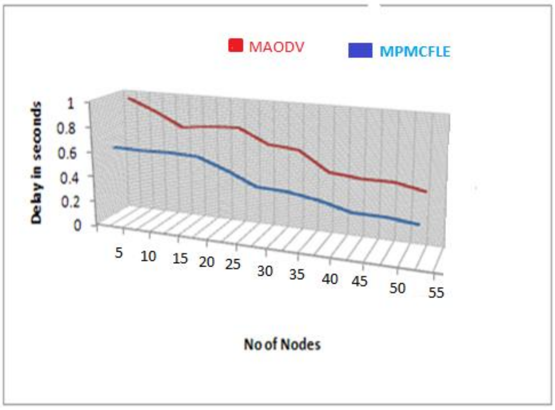

Fig 8: Average End-to-end Delay

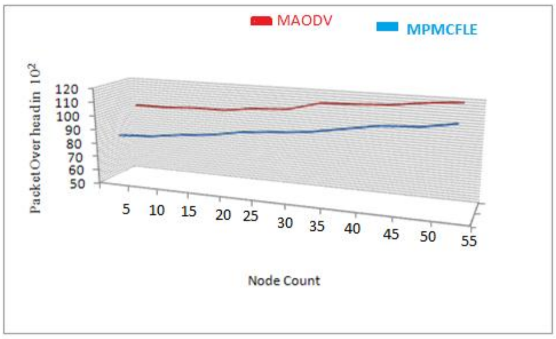

Fig 9: Control Overhead

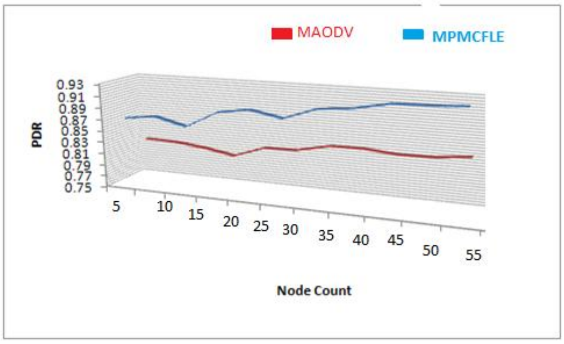

Fig 10: Packet Delivery Fraction

V. Conclusion

Our proposed, Multicast Routing protocol for MANET with Constrained Directional forwarding for less energy consumption (MPMCFLE) is compared with shred tree multicast protocol like MAODV with end-to-end delay, PDF, Overhead and Packet drops parameters are taken into account.

Proposed protocol-MPMCFLE overcomes the problems arise due to network wide flooding of data packets by conditional forwarding of packets. It also reduces packet drops whenever primary path fails by selecting alternative path. Effective local route recovery is done in order to decrease the delays in the network. The information in the route cache is used to select second best path if primary link or path fails.

The proposed protocol can be used to achieve scalability when numerous number of nodes are employed in the network.

References

[1]. A.K. Sharma and Amit Goel, ―Moment to Moment Node Transition Awareness Protocol (MOMENTAP)‖, International Journal of Computer Applications (IJCA) Special Issue, IASTED, Vol. 27/1, Jan 2005, pp. 1-9.

[2]. Song Guo, Member, IEEE, and Oliver Yang, Senior Member, IEEE, ―Maximizing Multicast Communication Lifetime in Wireless Mobile Ad Hoc Networks‖, IEEE Transactions on Vehicular Technology, vol. 57, no. 4, July 2008.

[3]. Stephen Mueller, Rose P. Tsang and Dipak Ghosal, ―Multipath Routing in Mobile Ad Hoc Networks: Issues and Challenges.

[4]. Juanwei, L., J. Chen and Y. Kuo, 2009. Multiple path routing topology for network lifetime maximization in ad-hoc networks. Proceedings of the 5th International Conference on Wireless Communications, Networking and Mobile Computing, (WCNMC' 09), IEEE Xplore Press, Piscataway, NJ, USA, pp: 2713-2716. DOI: 10.1109/WIC0M.2009.5305828In

[5]. Perkins, C.E., Bhagwat, P.: Highly Dynamic Destination-Sequenced Distance- Vector Routing (DSDV) for Mobile Computers. ACM SIGCOMM (1994) 234-244

[6]. Johnson, D.B., Maltz, D.A.: Dynamic Source Routing in Ad Hoc

Wireless Networks. Mobile Computing. (1996) 153-181

[7]. Perkins, C.E., Royer, E.M.: Ad-hoc On-Demand Distance Vector Routing. Proceedings of the 2nd IEEE Workshop on Mobile Computing Systems and Applications (1999)

[8]. J.J Garcia-Luna-Aceves and E.L. Madruga, The Core-Assisted Mesh Protocol,‖ IEEE Journal on Selected Areas in Communication, vol. 17, no. 8, August 1999.

[9]. Intanagonwiwat, C., Govindan, R., Estrin, D.: Directed Diffusion: A Scalable and Robust Communication Paradigm for Sensor Networks. Proceedings of ACM Mobicom (2000)

[10]. ATM Forum. ATM user-network interface specification, Version 3.0.

[11]. Seethalakshmi, P., M.J.A. Jude and G. Rajendran, 2011. An optimal path management strategy in a mobile ad hoc network using fuzzy and rough set theory. Am. J. Applied Sci., 1314-1321. DOI: 10.3844/ajassp. 2011.1314.1321

[12]. Ye, Z., Krishnamurthy, S.V., Tripathi, S.K.: A Framework for Reliable Routing in Mobile Ad Hoc Networks. IEEE INFOCOM (2003)

[13]. Krishnan, R., Silvester, J.A.: Choice of Allocation Granularity in Multipath Source Routing Schemes. IEEE INFOCOM (1993)

[14]. Wu, K., Harms, J.: Performance Study of a Multipath Routing Method for Wireless Mobile Ad Hoc Networks. Proceedings of Symposium on Modeling, Analysis and simulation on Computer and Telecommunication Systems (2001) 99-107

[15]. Pearlman, M.R., Haas, Z.J., Sholander, P., Tabrizi, S.S.: On the Impact of Alternate Path Routing for Load Balancing in Mobile Ad Hoc Networks. Proceedings of the ACM MobiHoc, (2000) 3-10

[16]. Keming, D.U. and Y. Yang, 2010. A QoS routing for maximum bandwidth in ad hoc networks. Proceedings of the 2nd International Conference on Future Networks (ICFN), Jan. 22-24, Sanya, Hainan, pp: 343-345. DOI: 10.1109/ICFN.2010.11.

[17]. Kang, B.S. and I.Y. Ko, 2010. Effective route maintenance and restoration schemes in mobile ad hoc networks. Sensors, 10: 808-821.

[18]. Suganthi, P. and A. Tamilarasi, 2012. Impact of malicious nodes under different route refresh intervals in ad hoc network. Am. J. Applied Sci., 18-23. DOI: 10.3844/ajassp. 2012.18.23.

[19]. Sung-Won, L., J.Y. Choi, K.W. Lim, Y. Ko and B. Roh, 2010. A reliable and hybrid multi-path routing topology for multi-interface tactical ad hoc networks. Proceedings of the Conference on Military Communication Unclassified Program Networking Protocols and Performance Track, (MCUPNPP' 10), pp: 1531-1536.

