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A Comprehensive Model for Better Multicast Routing Protocol (BMRP-QoS) to Improve Qos in Manets

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Abstract

Mobile Ad Hoc Network (MANET) is a collection of N wireless mobile stations which will not require any wired infrastructure or centralized administration. To face the real time needs and challenges, MANETs must provide more rapid services with better Quality of Service (QoS). Routing is one of the best criteria to improve the performance of ad-hoc networks. Multicast routing protocols provide more reliable paths, which are more resilient to link failures, mobility of nodes and are more suitable for MANETs. The objective of this article is to improve the QoS in MANETs by a comprehensive model. The model consists of the following phases: (1) IAK(Infallible Adjacent Key) phase (2) Discovering phase (3) PA (Priority Allocation) phase (4) Route maintenance phase. Additionally, the phases are simulated using a standard simulation tool and produced standard results accurately. The results presented by the existing models would differ significantly from the proposed, comprehensive model. This comprehensive model could improve the performance of MANETs. Evaluations and simulations prove that the proposed system could convert the existing system's discredits to credits.

Keywords: MANETs; Multicast routing; Overhead; Packet Delivery Ratio; Transmission capacity

INTRODUCTION

MANET is a group of N wireless nodes, which does not have any central administrator. Initially, MANET has been introduced for communicating in disaster areas, rescue sites, military applications and battlefields, etc., the places where infrastructure based networks are not possible. Later, it has been used for group communications like conferences, business meets, online services, etc. But, as the nodes of MANETs are having limited battery capacity, limited memory and processing power, varying channel conditions, less stability, unpredictable and high mobility (C.Biradar & S.Manvi, Review of multicast routing mechanisms in mobile ad hoc networks, 2012), they are not providing better network performances and QoS, when comparing with wired networks. Though the nodes of MANETs have challenging characteristics, efficient route establishment and proper route maintenance will balance the difficulty of achieving better data delivery services. Identifying an efficient route is not an easy or a single step process.

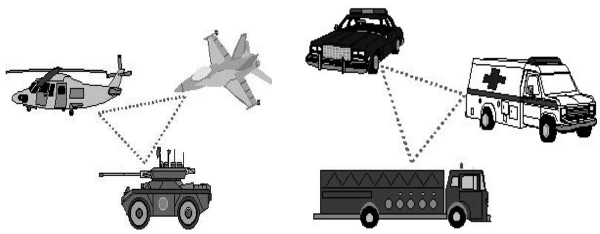

Figure 1: MANET

The nodes which are involved in the established route should be placed in stable positions, so that the link between those nodes will be more reliable and survivable to function during and after failures. The group communication services such as audio/video conferencing and surveillance applications require reliable adjacent nodes on the multicast path for continuous transfer of prioritized and non-prioritized packets (C.Biradar & S.Manvi, 2012).

In multipath routing, multiple paths will be established between source and destination nodes. In multicast routing, a single message is routed to multiple receivers in a network. Multicasting is an important operation in a variety of wireless network settings. Places where multicasting is used are: (1) Disseminating network state for updating routing tables and allocating network resources, (2) Communicating with groups of users in applications such as emergency response networking, where teams of users must coordinate search and rescue operations, (3) Distributing popular live media content to interested parties, and (4) Implementing emergency alert services such as Amber alerts and weather emergency information (Lertpratchya & Blough, 2016). Multiple paths will balance the difficulties like unpredictable mobility, link failures, etc of MANETs.

Various multicast, multipath routing protocols are defined in MANETs. The taxonomy of multicast routing protocols is shown in Figure. 2.

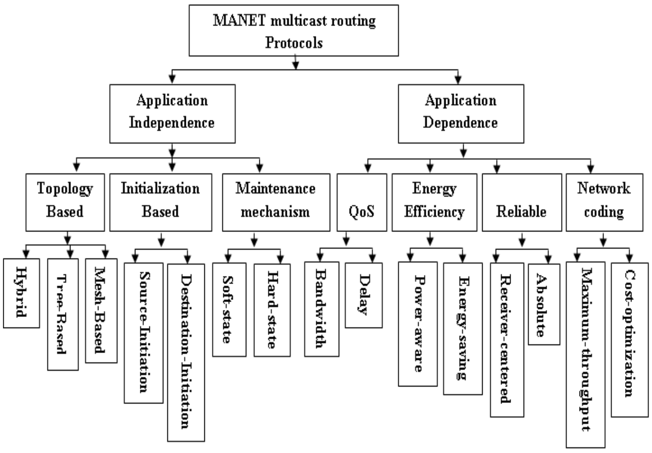

Figure 2: Taxanomy of Multicast Routing Protocols

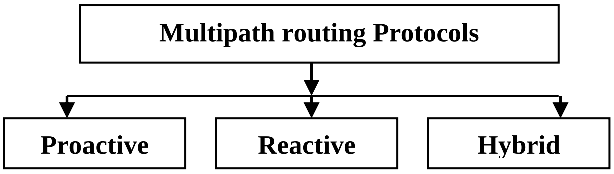

Figure 3: Taxanomy of Multpath Routing Protocols

A proper mixture of multipath-multicast routing will improve the performance level of MANET definitely. In (C.Biradar & S.Manvi, 2012), the authors have proposed a multipath multicast routing (MMRNS) mechanism and proved that their work has improved various QoS parameters of MANETs. Various QoS metrics like PDR(Packet Delivery Ratio), delay, jitter, throughput and overheads like message overhead, control overhead, total overheads has to be measured accurately by using standard formulas to judge the real time performances of a group communication in MANETs. In this proposed work, a new robust mesh based multicast-multipath routing mechanism is established to improve QoS in MANETs.

ORGANIZATION OF THE PAPER

The remaining parts of this paper are organized as follows: Section II summarizes most of the existing works in this discipline. Section III calculates IAK value and prunes the fallible nodes by keeping a threshold value. Section IV discovers multipath multicast routes, assigns priority to the paths, balances the data load among the paths, transfers information and maintains the established route against link or node failures. Section V simulates the proposed work and compares the results with the performance of MMRNS (C.Biradar & S.Manvi, Neighbor supported reliable multipath multicast routing in MANETs, 2012), SLMRP (Abdulwahid, Dai, Huang, & chen, 2016). In route maintenance phase, hidden nodes and malicious nodes are identified and pruned periodically. Section VI presents the conclusion.

RELATED WORK

Some of the existing works in this discipline are as follows: On-Demand Multicast routing Protocol (ODMRP) for Ad Hoc Networks is a flooding based multicast routing protocol developed by (Gerla & Guangyu Pei, 1998) . In this method, the transmission of data is possible only through a set of specially chosen ad hoc nodes which are collectively called as forwarding group. This group is used to forward multicast traffic for a particular multicast group. This is continuously maintained by control messages. Multiple paths through forwarding groups are available to manage at the situation of link break.

In this ODMRP, an efficient route discovery technique has been included by (Kharraz, Azad, & Zomaya, 2012). This mechanism improves the performance and multicast efficiency of On-Demand Multicast Routing Protocol (ODMRP). This ODMRP + Efficient route discovery mechanism is named as Limited flooding ODMRP. The flooding mechanisms have been efficiently managed in this framework based on the delay characteristics like random packet arrival, random channel access of the nodes which are involved in the routes. Limited flooding ODMRP drastically reduces the packet overhead and produces best results under various simulation scenarios as compared to original ODMRP.

Similarly, Power-aware Multicast Routing protocol (PMRP) (Nen-chung, Jong-Shin, Yung-Fa, & Yu-Li, 2007) is using battery power and link expiration time as metrics to find a feasible route from the source to destination. But in this protocol, the probability of link breakage is high and often a new route has to be discovered. In this situation, the consumed battery power and other radio resources will be wasted in this protocol.

Neighbour supported reliable multipath multicast routing (MMRNS) is proposed by (C.Biradar & S.Manvi, Review of multicast routing mechanisms in mobile ad hoc networks, 2012). Their proposed mechanism says that the reliability of a neighbour is depending on mobility, power and signal strength. They have not considered some other important parameters like transmission capacity of a node, the lifetime of a link. In the established multicast route, they include only reliable neighbours. One of the major demerits of their mechanism is very less concentration on route maintenance.

A simple method that has been proposed by (M.Maruthupandiyan & K.Jagadish, 2015) to improve routing efficiency in MANETs. But they defined that the latency and various overheads can be reduced by route stability.

Scheduled-links multicast routing protocol (SLMRP) is one more existing multicast routing protocol proposed by (Abdulwahid, Dai, Huang, & chen, 2016) which is based on mobility prediction. It concentrates on reliable, load balanced, loop-free and disjoint paths. Multicast routing activation timer (MRAT) and Path time out timer (PTT) are used in this protocol to control the activation and deactivation of these paths.

Efficient Backbone Based Quick Link Failure Recovery Multicast Routing Protocol is developed by Deepika Vodnala et al. (2016). This protocol has four phases: Group Formation, Backbone Construction, On-demand Route Discovery and Route Maintenance. Whenever a link failure occurs, immediately this protocol will establish an alternate path from the point of failure to the destination.

Various routing protocols are proposed in the research field of MANETs to increase the routing efficiency through that they tried to achieve a maximum level of QoS. But achieving an optimal level of QoS is not a single layer responsibility, a multilayer approach. In this work, a comprehensive model has been proposed which has the following phases i) First phase selects the most favourable neighbours by considering various standard parameters of nodes ii) Other unfavourable neighbours are pruned iii) Multicast-Multiple paths have been established between source and destinations by using REQ and REP packet algorithms. iv) Paths are sorted based on certain priority and the data has been sent through the established path in an order. Data will be sent through multiple paths and the impact of heavy traffic and overloading in a single path will be avoided without any side effects.

PROPOSED ROUTING ALGORITHM - BMRP-QOS

In this paper, we propose a new multicast-multipath routing algorithm for MANETs. In each and every step of this algorithm, we are carefully considering various important parameters that are improving the QoS of our network communication.

A. Major steps of the proposed routing algorithm are given below:

- The IAK value of all the nodes will be calculated based on certain parameters and stored in a database.
- A standard threshold value for IAK will be set by the administrator as per their requirements.
- The nodes whose IAK value is lesser than the threshold value will be pruned and the pruned nodes will not be considered for routing. Only the non-pruned nodes will be considered as better serving neighbours and their details will be maintained in a separate database.
- Multicast-multipath routes are constructed by using request and reply packets.
- Based on the IAK value of the node, priority will be set to the discovered routes.
- Data to be sent will be divided into various data streams and prioritized. Based on the priority, data streams will be transmitted among the prioritized routes.
- If any link or node failure occurs in the path, instantly the next optimal path will be invoked at the failure point itself and the data transmission will be proceeded. If no path exists, information will be sent to the sender.

B. Calculation of IAK:

Basically, the MANET nodes are having most challenging features like frequent mobility, unpredictable link failures, dynamicity, limited power… etc.. So achieving the maximum level of QoS is a critical task in it. In this environment, multicast group communication is one of the best routing methods to utilize a node's resource efficiently. Member nodes of the paths are 100% responsible for the success of group communication. Therefore, the primary responsibility of the source node is to identify the efficient neighbours before sending its data.

The Efficiency of a neighbour node can be defined by various important parameters like distance from the source, transmission range, battery level, receiving signal strength of the node, the cost of the link, the amount of time those two nodes are staying connected, bandwidth… etc. We are calculating the infallible adjacent key (IAK) value for the neighbour nodes by considering some of the important parameters. A standard threshold will be fixed by the administrator as per the requirements. The nodes whose IAK value is less than the threshold will be pruned and the pruned nodes will not be included in the discovered route in which the data will be transmitted.

- Formula for calculating IAK

Let m be the source node which has to transmit its data to various destinations, n is one of its neighbours.

$$IAK = \frac{(RBP+RSS+TC+BW+LLT)}{D}$$

Where RBP-Residual Battery Power of a node n

RSS-Receiving Signal Strength of n

TC-Transmission Capacity of n

BW-Bandwidth of n

LLT-Lifetime of the Link between m and n

D-Distance between m and n

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- Calculation of RBP

Initially at time t=0, full battery power F=RBP.

At time t=t,

RBP = F – RBP - (BTR * PR * PINR)

Where BTR-Total number of bits transmitted between t-1 to t

PR= battery power required to transmit a single bit

PINR= battery power required to perform internal operations while transmitting a single bit

- Calculation of RSS

RSS is represented by two values -1 and 1 based on the distance between two nodes m and n. If the distance between the nodes m and n is high, RSS= -1 else RSS=1.

- Calculation of TC

The transmission capacity (TC) of each node depends on its distance from another node $\boldsymbol{Tc \propto D}$ and it can be calculated by using the below equation: ie., $\boldsymbol{Tc = kD}$ Where k is constant (R.Vadivel & Bhaskaran, 2012).

- Calculation of BW

$$BW = \frac{Amount\ of\ Data\ sent}{Total\ consumed\ Tine}$$

- Calculation of distance at various intervals

Initially at time t=0, the positions of nodes m and n are x1, y1 and x2, y2 respectively.

Distance d_0 between m and n at t=0 is

$$d_0 = \sqrt{|x1 - x2|^2 + |y1 - y2|^2}$$

At t=t, they travelled to new positions, node m to x1`,y1` with speed v_m and in the angle □$_1$.

$$x1' = x1 + v_m * t * \cos \emptyset_1$$

$$y1' = y1 + v_m * t * \sin \emptyset_1$$

Node n to x2`, y2` with speed v_n and in the angle □□□

$$x2' = x2 + v_n * t * \cos \emptyset_2$$

$$y2' = y2 + v_n * t * \sin \emptyset_2$$

Distance between m and n at t = t is

$$d_t = \sqrt{|x1 - x2|^2 + |y1 - y2|^2}$$

- Calculation of link life time

LLT-Link Life time represents the amount of time that the two nodes stay connected. This will be calculated by using the formula (S.Rappaport, 1995):

$$LLT = \frac{-(ab + cd) + \sqrt{(a^2 + c^2)T^2 - (ad - bc)^2}}{a^2 + c^2}$$

Where a = $v_m \cos \theta_1 - v_n \cos\theta_2$

b = $x_1 - x_2$

c = $v_m \sin\theta_1 - v_n \sin\theta_2$

d = $y_1 - y_2$

- The Pruning the infallible nodes

The success of a transmission is highly depending on the favourable neighbours. To identify the supporting neighbours, we calculated the IAK value of all the nodes. A standard threshold (IAK_{Th}) will be fixed by the administrator as per their requirements and the neighbour nodes whose threshold value is greater than the IAK_{Th} are only considered for the route construction and the other weak nodes are pruned properly. The IAK values of all the nodes are maintained in a database called as IAT [ ]. The format of IAT is shown in Table1:

Table I: Infallible adjacent key Table (IAT)

Neighbor IP	RBP	RSS	TC	BW	Dist from S	LLT	IAK	PF
128.46.23.95								0
128.0.0.99								0

FORMATION OF MULTICAST ROUTE

The standard REQ and REP algorithms are used to form the multicast route for data transmission.

Table II: REQ Packet

Sraddr	MCid	Packet id	PF	VN[ ]	IAK min	RC
128.54.23.4	228.45.67.4	101	0	128.54.23.4, 128.0.0.99...	2.5	10

Table III: REP PACKET

Sraddr	**Dnaddr**	**MCid**	**Packet id**	**PF**	**VN[ ]**	**IAK min**	**RC**
128.54.23.4	124.45.54.7	228.45.67.4	101	0	128.54.23.4, 128.0.0.99...	2.5	10

- Nomenclatures used in REQ and REP algorithms

REQ- Request packet send by the source node, Snaddr-source node address, MCid-Multicast group id , Dnaddr-Destination node, Packet id, PF- Flag to identify whether the node is pruned or not, PF=0 if not pruned, PF=1 for pruned node. IAKmin-Minimum value of IAK, VNT [ ]-List of nodes that are visited by REQ packets, Sn-Strong neighbours, Prevnode-Previous node, DUP-Duplicate packet, RC- Travelling Capacity of the Request packet.

Totally 3 tables are maintained at a node.

I. IAT-Infallible Adjacent key Table- Details of the Neighbour node are stored to identify the strong neighbour and weak neighbour.

II. MMRT-Multicast –Multipath routing Table-Details about the discovered routes are stored.

III. VNT- Visited Node Table-List of nodes that are visited by REQ packets are stored and as the route we are travelling consists only the favourable neighbour nodes, the REP packets can also be transmitted in that way itself.

Table IV: Multicast Multipath Routing Table(MMRT)

MC id	**Source IP**	**Next Node**	**Priority**
228.45.67.4	128.54.23.4	128.0.0.99	1

Table V: Visited Node Table

MC id	**Packet Id**	**VN[ ]**
228.45.67.4	101	128.54.23.4, 128.0.0.99-,-,-, 128.46.23.95

In the below REQ algorithm, first the source node selects the strong neighbors based on their IAK value, and then sends the REQ packets to its neighbors. REQ packets will be rebroadcast by the neighbor nodes until any of the following state occurs:

i) REQ packet reaches the destination

ii) RC value of the REQ packet is zero

VNT and MMRT are updated at every node. When REQ packet reaches the destination, a better route has been discovered and the IP addresses of the nodes involved in the new route are stored in the table VN [ ]. If a node cannot find a strong neighbour, current node will inform regarding this to the Prevnode. The Prevnode will look for alternate route forwarding.

```
Begin
Initialize IAKmin = 100, VN[ ]=[S,__,__,_] and other fields of REQ at Sr;
Sr broadcasts REQ to Strong neighbours (Sn);
for Every REQ arrived at Sn do
  if There are no neighbours to Sn except Prevnode then
        Goto END;
 else
       Compare MCgroup in REQ with MCgroup of Snaddr;
            if MCgroup in REQ ≠ MCgroup of Snaddr then
            if [REQ ≠ DUP] OR [(REQ == DUP AND (has different VN)]
            then
            AAA:        RC = RC-1;
                        if RC  > 0 then
                                   if IAKPrevnode < IAKmin of REQ then
                                             IAKmin = IAKPrevnode ;
                                   end if
                                   Append Snaddr to VN[ ] in REQ;
                                  Rebroadcast REQ to Strong neighbors;
                        else
                                  Discarded REQ and goto END;
                        end if
            else
                        Discard REQ and goto END;
            BBB: end if
            else
                   Repeat AAA to BBB; CALL Algorithm 2;
            end if
            end if
 end for
END: End
```

Algorithm REQ: Processing of REQ packet at a node

In the following REP algorithm, all the multicast destinations will generate the REP packet. REP packets will be sent through the nodes that are stored in VN [ ]. If a node cannot find its next node, it will wait for a time. After time out, it will inform the destination about this technical failure.

```
Begin
    Generate REP packet using received REQ packet at Dn;
    Initialize RC = number of addresses in VN, RQF=0, D=Destination
    node address generating REP packet, and other fields same as in
    received REQ packet;
    for RC > 0 do
        RC=RC-1;
        Update MMRT;
        if VN[RC]      S then
                Transmit REP to node at address VN[RC];
        else
                Deliver REP to Sr and goto END;
        end if
    end for
END: End
```

Algorithm REP: Processing of REP packet at a node

In both of the above algorithms, as we are considering only strong neighbours, the possibility of failure is very less in number.

DATA TRANSMISSION

After discovering the full path, source assigns priority to all paths. The information to be transmitted has to be partitioned in to various packet streams and the packets are also prioritized. The high priority information will be sent through the high priority path and the enduring nodes and packets are also following the same procedure for transmission.

ROUTE MAINTENANCE

Maintaining a route will consist of the following node operations:

- Node join
- Node deletion
- Link failure
- Malicious node removal

- **Node join-** Any node can send a REQ packet to its strong neighbour, as usual the REQ will be rebroadcast until it reaches on any one of the existing multicast route node. That existing node will send the REP packet to the new node, so that the new node becomes the member of that multicast route.
- **Node deletion-** If any of the multicast nodes is not responding for a long time, they will be considered as malicious node and automatically removed from the multicast route.
- **Link failure-** As the nodes in a MANET are not stable, link failure is quite normal in it. In MANET, the nodes are not controlled by any central coordinator. So some of the nodes may be malicious and selfish. Periodically, the IAK value will be updated at each node in our mechanism. As the parameters that are used to calculate the IAK will depict the performance level of the nodes, the fallible nodes will be pruned. This will be done at regular intervals. Link failures will be tolerated up to a certain extent, and then a new route will be found. Because recovery overhead may be high, comparing with new route construction.
- **Malicious node removal-** The nodes which are not responding for a long time (considered as malicious nodes) will be checked and removed from the multicast routes based on their performance.

SIMULATION

The above work has been simulated by using the standard simulation tool ns2.35.

Various steps of simulation

1. An ad hoc environment is set. The nodes are randomly placed in that environment. Periodically, the performance evaluation will be done.
2. IAK value has been calculated by using the above mentioned standard formulas.
3. The strong neighbours and multiple efficient routes has been identified between the source and destinations.
4. The proposed scheme is implemented and following parameters are evaluated:

i) Packet delivery ratio (PDR) :

$$\frac{\text{Total Number of packets received at the Destination}}{\text{Total number of packets sent from the Source}}$$

ii) Control overhead: The number of control packets (REQ/REP packets) needed to establish routes to all destinations from a source.

iii) Memory overhead: The total number of bytes to be stored in various node databases to establish and maintain the routes for a multicast group.

iv) Message overhead: Average number of messages exchanged between every non-pruned node and its neighbours at a given time.

v) Computation overhead: Average number of computations needed by all nodes to calculate IAK and routing information.

vi) Total overhead:

$$\frac{\text{Transmitted (Control Packets + Data packets)}}{\text{Delivered Data Packets}}$$

vii) Packet delay: Average time taken to transmit the predefined number of packets from source to multicast destinations.

viii) Jitter: Difference between the delay of the current packet and the delay of the previous packet.

The simulation outputs of this techniques are compared with MMRNS ((C.Biradar & S.Manvi, Neighbor supported reliable multipath multicast routing in MANETs, 2012), and SLMRP (Abdulwahid, Dai, Huang, & chen, 2016). The following figures show the graphical comparison of BMRP, MMRNS, and SLMRP routing mechanisms based on some important parameters:

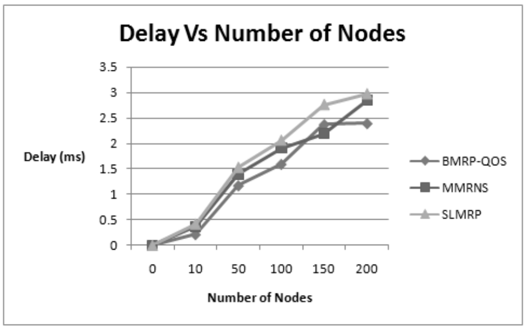

Figure 4: Delay Vs Number of Nodes

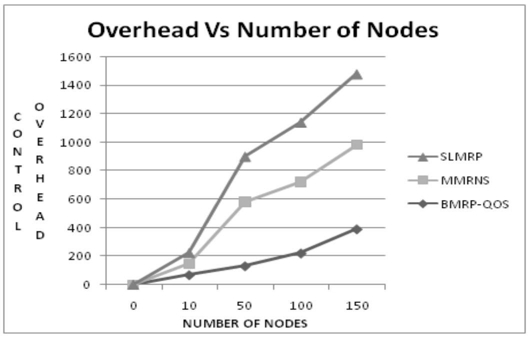

Figure 5: Overhead Vs Number of Nodes

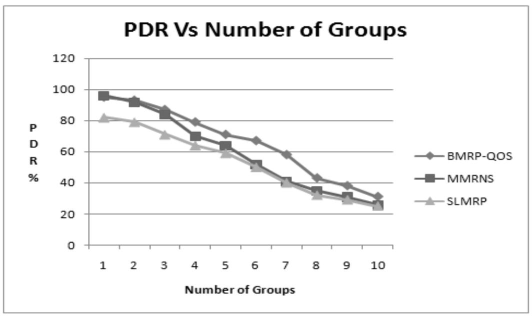

Figure 5: PDR Vs Number of Groups

From the above graph, we can conclude that the Better Multicast routing Protocol which improves the QoS of MANETs is really a better protocol comparing with various standard routing mechanisms.

CONCLUSION

In this work, a comprehensive model has been developed to improve various performance parameters of MANETS. A standard simulation has been done and the simulation results shown that the proposed BMRP-QoS protocol is really better than various good routing protocols.

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