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MQARR-AODV: A NOVEL MULTIPATH QOS AWARE RELIABLE REVERSE ON-DEMAND DISTANCE VECTOR ROUTING PROTOCOL FOR MOBILE AD-HOC NETWORKS

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Abstract
MANET (Mobile Ad-hoc Network) is an infra structure less wireless ad-hoc network that does not require any basic central control. The topology of the network changes drastically due to very fast mobility of nodes. So an adaptive routing protocol is needed for routing in MANET. AODV (Ad-hoc On-demand Distance Vector) routing is the effective and prominent on-demand Ad-hoc routing protocols. During route establishment phase in traditional AODV, only one route reply message will be sent in the reverse path to establish routing path. The high mobility of nodes may affect the reply messages which lead to the retransmission of route request message by the sender which in turn leads to higher communication delay, power consumption and the reduction in the ratio of packets delivered. Sending multiple route reply messages and establishing multiple paths in a single path discovery will reduce the routing overhead involved in maintaining the connection between source and destination nodes. Multipath routing can render high scalability, end-to-end throughput and provide load balancing in MANET. The new proposed novel Multipath QoS aware reliable routing protocol establishes two routes of maximum node disjoint paths and the data transfer is carried out in the two paths simultaneously. To select best paths, the new proposed protocol uses three parameters Link Eminence, MAC overhead and node residual energy. The experimental values prove that the MQARR-AODV protocol achieves high reliability, stability, low latency and outperforms AODV by the less energy consumption, overhead and delay.

Keywords:
MANET, AODV, Reverse AODV, Multipath, Quality of Service

1. INTRODUCTION

A MANET is a multi-hop wireless network which does not require any basic infra structure. Due to very high mobility of nodes, the topology of the network changes drastically which make the routing process more difficult and crucial [1]. Many routing protocols are available for MANETs. There are two types of routing algorithms. One is Proactive routing algorithm (table driven) and reactive routing algorithm (On-demand)[2].

In proactive routing algorithm, the routing information needs to be exchanged between nodes at regular intervals and the routes are calculated whether the routes are needed or not. The main disadvantage of this method is the wastage of network resources [3].In on-demand routing algorithms, the nodes need not exchange routing information between them. The nodes find paths only when they are needed for data transfer.[4]

The very fast mobility of nodes leads to the unstable links between nodes. The unstable links may cause the loss of data packets as route reply control messages. The path establishment process has to be carried out several times by the source node [5][6].

The loss of route reply messages are not handled well by the available on-demand routing algorithms which leads to the reduction of network performance [7].

While establishing only shortest route between source and destination, the poor utilization of network resources is unavoidable. In order to maximize the usage of network usage, routing of network must find routes with high stability and sufficient energy level [8][9][10].

The main aim of the proposed protocol Novel Multipath QoS aware reliable routing protocol is to send multiple route replies and establishes multi path data transmission between source and destination and achieves high reliability, stability, low latency and outperforms AODV by less energy consumption, overhead and delay [11].

Our proposed MQARR-AODV routing algorithm works well and requires only minimum steps for path establishment.

In order to select a reliable route, proposed protocol uses three parameters, the MAC overhead, the Eminence of Link, node residual energy. It also provides high energy efficiency and load balancing thus prolongs the network life time and makes up high reliability communications.

2. MQARR-AODV: PROPOSED ROUTING PROTOCOL

MQARR-AODV is an on-demand multipath QoS Aware Reliable Reverse Path routing protocol for finding routes in MANET.

The new MQARR-AODV protocol establishes paths on-request using a reliable reverse path establishment method. During path establishment phase, the source node first sends the route requests through all available paths to the destination. The destination node upon receiving the path requests, inturn rebroadcasts the reverse path requests as like sender node has done. Upon receiving the multiple route replies from the destination, a path with high reliability is chosen by the source node using the three parameters, the MAC overhead, the Eminence of Link, node residual energy. After the link establishment, the source node will issue command to put the neighbouring nodes in sleep state; hence the node remaining energy will expand for long period.

This proposed protocol includes the following phases.

- Route Discovery
- Route Selection
- Route Maintenance

2.1 ROUTE DISCOVERY

The data transmission is initiated by the sender by broadcasting path request packets to all of the neighbouring nodes towards the destination node.

The ID for broadcasting each route request message is incremented. The ID for broadcasting is used to uniquely identify the RREQ packet [12]. The path request control packet is broadcasted by the source node of the neighbouring nodes. This process is repeated by all the neighbouring nodes. Duplicate copies of the path request may reach the intermediate nodes. In this case, the nodes checks for redundancy and drops the redundant packets, if any.

This method is followed for the reverse path request processing also. Upon the receipt of first route request message, the destination it first appends the RREQ packet information to its own routing table and after that the path request is made in reverse and broadcast to all of its neighbours as done previously.

When broadcasted Reverse-RREQ message arrives to intermediate node, it will check for redundancy. If it already received the same message, the message is dropped, otherwise forwards to next nodes.

2.2 ROUTE SELECTION METHOD

Upon receiving multiple Reverse Request packets from the destination, the initiator node finds reliable path with the three estimated parameters the MAC overhead, the Eminence of Link, node residual energy.

2.2.1 MAC Overhead Estimation:

In MANET, IEEE 802.11 MAC protocol is used. It has the packet sequence as Request-For-Sending (*RFS*), Clear-For-Sending (*CFS*), and data acknowledge (AD), Space Between Frames (*SBF*) which is the time gap between the transmission of two consecutive packets are used to calculate the Channel workload.

$$CW = tRFS + tCFS + tSBF \tag{1}$$

where *t* refers to the time period taken by each parameter. The MAC contention value calculated using Eq.(1) is used to calculate the MAC overhead *MOH* as follows,

$$MOH = CW + tac \tag{2}$$

where, *tac* is the amount of time consumed by the contention of access.

2.2.2 Eminence of Link- Estimation:

The eminence of each and every link while doing optimization will be computed at the physical layer, and will be accessed at the top layers for path establishment. This value is stored in the routing tables of nodes and is used for optimization when more than one node is inside the transmission range of the sending node. The link eminence optimizes the routing decisions and improves the capability of the networks.

The IEEE 802.11 is fairly reliable MAC protocol. The link eminence has reached every exposed node; it assumes the fixed utmost transmission power. Each sender node that transmits the Requestion-for-Sending (*RFS*) packet, attaches its transmissions power details. The receiving node estimates the link eminence received for the free space propagation model while receiving the *RFS* packet,

$$LE = \left(\frac{\lambda}{3.14} * \left[4 * D\right]\right) * Tg * Tr \tag{3}$$

where, λ is the wavelength of the transmission carrier, *D* gives the informaion about how far the source and receiver are from each other , *Tg* and *Tr* are variables that depicts the antenna's unity gain.

2.2.3 Estimation of Node Residual Energy:

The energy for one packet delivery relative to the node distance is given as,

$$TEP = k*dst\alpha \tag{4}$$

where, *k* is the constant value, *dst* depicts that how far the neighbouring nodes are and the parameter α depends on the physical location. Only less amount of energy is needed for the nearer nodes.

The *TEP* value calculated using the Eq.(4) is used to calculate the packet transmitting energy as follows,

$$E = \frac{DPS \times TEP}{WLB} \tag{5}$$

where, *DPS* is the size of each data packet, *TEP* is the packet transmitting energy and *WLB* is the bandwidth of the wireless link.

In each and every node, the Required Energy for Transmission is calculated using the following formula,

$$TER = pkts \times (TEP+EPP) \tag{6}$$

where, *pkts* is the amount of data packets. The Energy needed for Processing Packet (*EPP*) which is lesser than the *TEP*. Node Residual Energy (*NRE*) is calculated using the following formula,

$$NRE = IE - TER \tag{7}$$

where, *NRE* is the Node Residual Energy, *IE* is the Initial Energy and *TER* is the total energy required.

Upon receiving multiple Reverse Request packets from the destination, the initiator node finds reliable path with the three estimated parameters using the Eq.(2), Eq.(3), Eq.(6) and Eq.(7). They are MAC Overhead, Link Eminence and Node Residual Energy. After estimating the aforesaid parameters the following main parameter for route selection will be carried out using,

$$W = Min(\int_{i=1}^{i=nn} LE * \left(\frac{1}{MOH}\right) + NRE) \tag{8}$$

The route with the minimum weight value is selected as primary path using the Eq.(8) and starts data transmission and the path with next weight value is selected as secondary path and data transmission is carried out in that path also in parallel along with main path.

If a destination node receives RREP packet with 'P' flag value of one, it drops this packet. When an intermediate node receives RREQ packet with an 'P' flag value of one, it checks and compares <Source IP, Destination IP> in the Route Request packet with <Destination IP, Source IP> pairs in its routing table, if a match case is found and Route-Flag = 0, that is the node is of primary route and the Route Request packet is discarded. If a match case is not found, the traditional AODV technique is followed. 'Route-flag' value zero and one indicates the primary route and secondary route respectively.

The proposed algorithm for MQARR is as follows:

Algorithm (MQARR):

// **S-IP**: Source IP address in the received packet,
// **D-IP**: Destination IP address in the received packet
// **My-IP**: The current node's IP address
// **path**: available paths from source to destination
//**fpath**: Node disjointed paths from source to destination
// **n**: number of nodes in each path,
// **k**: number of paths
// **LE:** Link Eminence
// **MOH**: MAC Overhead
// **RTE**: Required Total Energy
//**NRE**: Node Residual Energy
// **C**: Total number of final valid paths between source and destination

Path:={ }, fpath:={},temp={},i=1;j=1;t:= 0, n:=0, k:=1

// ROUTE DISCOVERY PROCESS

Input : RREQ packet from Source or Intermediate node

```
For each path (i)
    For every neighbor j of i
        If (Packet's D-IP<>My-IP)
            Broadcast the RREQ packet to the neighbours
            n(i) := n(i) + 1
            path(i):= path(i) U {j}
        endif
    Endfor(j)
Endfor(i)
For every path j from D to S
    For every node k in j
        Broadcast the R-RREQ packet to the neighbours with D-IP=S-IP
        If (Packet's D-IP<>My-IP)
            Broadcast the R-RREQ packet to the neighbours
            n(j):= n(j) + 1
            path(j):= path(j) U {k}
        endif
    Endfor(k)
Endfor(j)
```

// ROUTE SELECTION PROCESS AT SOURCE NODE

Input : R-RREQ packets from Destination

```
For every path i from D to S
    For k=1 to n(i) // Every node in path i
        W(i) = W(i)+LE(k)*(1/MOH(k))+NRE(k);
//Calculate Weight value W for every node k in path(i) using LE,
  MOH, NRE   values collected from each node.
    Endfor(k)
Endfor(i)
C=1;
For every path i from D to S
    If(path(i) is completely node disjoint path with all other
       available paths in path{})
        Fpath(c).path=path (i)
        Fpath(c).W=W (i)
        C=C+1
    End if
End for(i)
For i= 1 to C-1 // Rearrange the paths based on their Weight
                   values
  for j=i+1 to C
    If fpath(i).W > fpath(j).W
        temp=fpath (i)
        fpath (i)=fpath(j)
        fpath (j)=temp
  End for(j)
End for(i)
```

// The first two paths with minimum weight value are selected from the fpath list as best paths and data transmission is carried out in parallel in the selected paths.

2.3 ROUTE MAINTENANCE

Route maintenance in MQARR is a simple extension to AODV route maintenance. Like AODV, MQARR also uses RERR packets. A node generates or forwards a RERR for a destination when the last path to the destination breaks. Then MQARR removes the broken route from the list and redirect the data packets in the backup path. Avoidance of re-route discovery contributes to reduction in overhead.

3. RESULTS

Extensive simulation experiments were conducted using the simulator Qualnet. The following list shows the simulation environment.

Simulation parameters:

Terrain Dimension	:	1500*1500
Number of nodes	:	50
Mobility model	:	Random way point

Propagation model	:	Two-ray Rayleigh fading
MAC protocol	:	IEEE 802.11 DCF
Simulation time	:	300 sec
Antenna type	:	Omni directional
Transmission range (m)	:	200
Node speed (m/s)	:	0, 5, 10, 15, 20
Traffic type	:	CBR
Traffic rate	:	10 packets/s
Initial Energy	:	0.5Joules

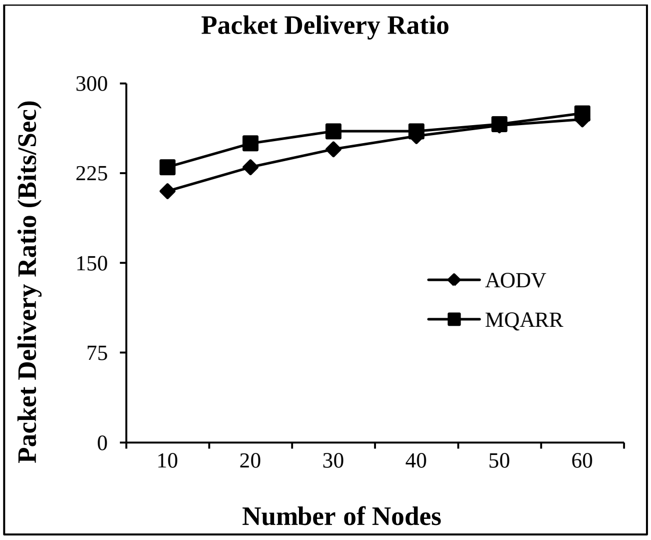

Fig.1. Packet Delivery Ratio Vs. Number of Nodes

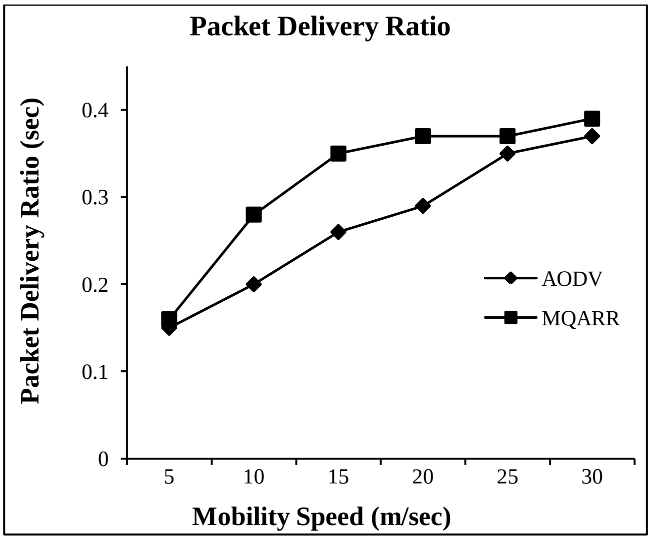

Fig.2. Packet Delivery Ratio Vs. Mobility Speed

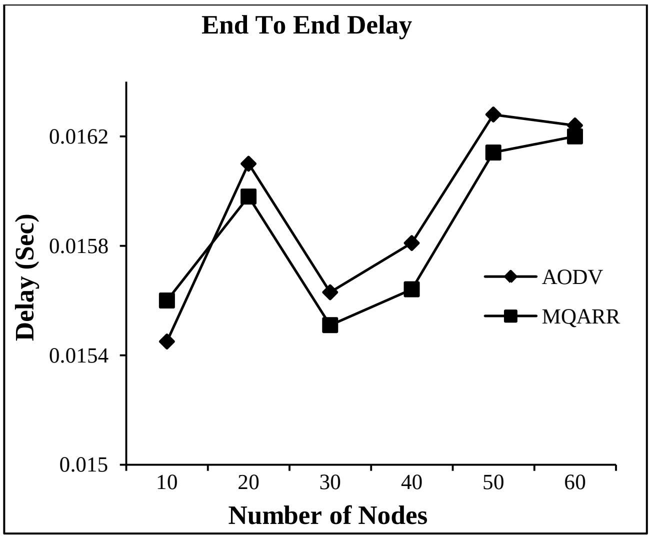

Fig.3. End to End Delay Vs. Number of Nodes

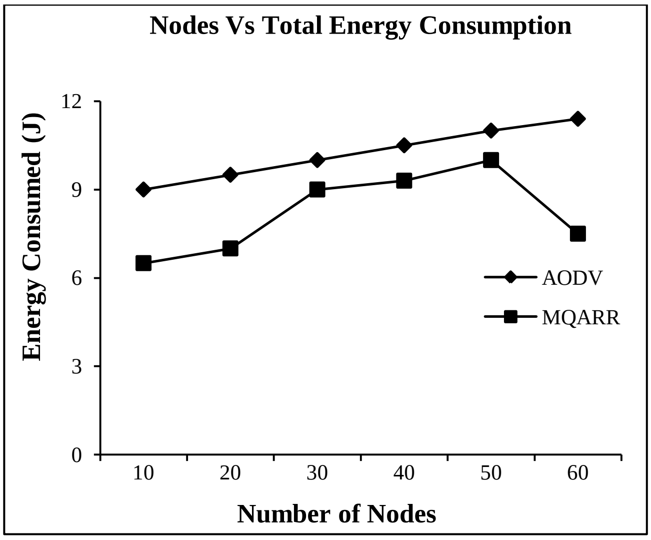

Fig.4. Number of Nodes Vs. Total Energy Consumption

4. CONCLUSION

In this paper a novel multipath QoS-aware reliable reverse on-demand distance vector routing protocol (MQARR-AODV) for MANET has been proposed. MQARR discovers two paths and perform the data transmission along the two paths in parallel. In order to select best two reliable routes, proposed protocol uses three parameters, the MAC overhead, the Eminence of Link, node residual energy. The proposed protocol provides high energy efficiency, security and load balancing thus prolongs the network life time and makes up high reliability communications. If one path fails, the data transmission will be continued in the backup path automatically. Simultaneously, finding multiple paths in a single route discovery reduces the routing overhead incurred in maintaining the connection between source and destination nodes and reduces the routing process overhead. The simulation results show that the proposed scheme is better than AODV in discovering and maintaining routes. The performance analysis shows that the frequency of an on demand route discovery for multipath routing is less than that for single path routing and outperforms AODV in most metrics such as the packet delivery ratio, end to end delay, and energy consumption.

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