Dynamic Reliable Multipath Routing Protocol for MANET

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Abstract: A mobile ad hoc network (MANET) is a multi-hop wireless network which doesn’t require any basic infrastructure. In MANET nodes act as routers themselves. Due to high mobility of nodes, the routing problem in ad hoc networks becomes thornier. Many routing protocols have been proposed for MANET. AODV (Ad-hoc On-demand Distance Vector) routing protocol is the representative among the most widely available on-demand Ad-hoc routing protocols. In traditional unipath AODV a single route reply along the first reverse path is used to establish routing path between source and destination nodes. In high mobility, pre-decided reverse path can be disconnected and route reply message from destination to source may be lost. In this case, source node needs to re-initiate the route discovery procedure which leads to increase in communication delay and power consumption as well as decrease in packet delivery ratio. To address the aforesaid issues, a new Dynamic Reliable Multipath routing protocol (DRMRP) which sends multiple route replies and establishes multiple routes between source and destination nodes has been proposed. Simulation results show that the proposed protocol achieves high reliability, better packet delivery ratio, stability, low latency and outperforms AODV by reducing energy consumption, overhead and delay.

Introduction

A mobile ad hoc network is a multi-hop wireless network which doesn’t require any basic infrastructure. Due to high mobility of nodes, the routing problem in ad hoc networks becomes thornier. Many routing protocols have been proposed for MANET. These routing protocols are classified as proactive routing protocols (table driven) and reactive routing protocols (on-demand). In proactive routing protocols the nodes have to exchange the routing information periodically and calculate the routes continuously between any nodes in the network, regardless of route requirements. This leads to the wastage of energy and bandwidth, which is not desirable in MANET where the resources are constrained [1]-[5]. On the other hand, on-demand routing protocols don’t exchange routing information periodically. Instead, the route discovery procedure is carried out only on demand of routes between nodes [1],[6],[7]. Due to dynamic topology changes in ad hoc networks, links between nodes are not permanent. In occasions, a node cannot send packets to the intended next hop node and as a result packets may be lost. Loss of packets in a single path may affect on route performance in different ways.[8]-[12] Among these packet losses, loss of route reply brings much more problems, because source node needs to re-initiate route discovery procedure. A drawback of existing on-demand routing protocols is that their main route discovery mechanisms are not well concerned about a route reply message loss. More specifically, most of today’s on-demand routing is based on single route reply message. The lost of route reply message may cause a significant waste of performance [13]-[15].

A significant amount of current research has been directed to designing efficient dynamic routing protocols for ad hoc networks. The challenge here is to reduce routing overheads in spite of the changing topology. This is a critical issue as both link bandwidth and battery power are premium resources. Several new protocols focused on the issue of overhead reduction without compromising on application-visible performance metrics. Notable among them are a class of protocols called “on-demand” protocols, e.g., Dynamic Source Routing (DSR), Ad hoc On-demand Distance Vector (AODV). Unlike, more traditional “proactive” protocols such as link-state or distance vector — that run on the Internet, on-demand protocols attempt to reduce the routing overhead by maintaining routes only between nodes that
take part in data communication. Specifically, whenever a traffic source needs a route to a destination, the protocol initiates a route discovery process. Route discovery typically involves a network-wide flood of a route request and waiting for a route reply. Prior performance studies [2],[7] have shown that on-demand protocols have better overhead savings in comparison with their proactive counterparts. However, on-demand approach is not without problems. Since routes are computed only on-demand, route discovery latency can add to the end-to-end delay, unless a previously computed “cached” route is available.

Buffering of data packets during the route discovery process can also contribute to packet losses due to buffer overflow. With single path routing, this problem becomes severe as the network becomes more dynamic.

Frequency of route discoveries increases with increase in the rate of link failures. Also, since each route discovery incurs substantial packet overhead, its frequency impacts performance. The frequency can be controlled by computing multiple paths with a single route discovery. This will improve the overall performance.

Multiple paths can be useful in improving the effective bandwidth of communication pairs, responding to congestion and bursty traffic, and increasing delivery reliability. In QoS routing in wired networks, multipath routing has been widely developed [3],[5][18]. These protocols use table-driven algorithms (link state or distance vector) to compute multiple routes. Studies show however, that proactive protocols perform poorly in mobile networks because of excessive routing overhead [1],[5]. Multipath routing in ad hoc networks has been proposed in [3],[5]. Although these protocols build multiple routes on demand, the traffic is not distributed into multipaths; only one route is primarily used and alternate paths are utilized only when the primary route is broken.

Related Work

Over the last few years, several routing protocols are proposed for MANET [1],[3],[4],[6],[8],[12]. A number of performance comparison studies [2],[7] have revealed that the on-demand routing protocols perform better in terms of packet delivery ratio and routing overhead than proactive routing schemes especially in the presence of node mobility. Proactive and hybrid schemes do not perform well in dynamic topologies because of the two major factors Slow detection of broken links and periodic exchange of route updates even when routes are not required.

Wesam AlMobaideen [16] has presented a Stability based Partially Disjoint AOMDV (SPDA) protocol which is a modification of the AOMDV protocol. His SPDA finds partially disjoint paths based on links stability. His idea is that accepting partially disjointed paths that are more stable than other maximally disjoint ones could increase paths lifetime. This in turn improves MANET performance in terms of delay, routing packets overhead, and the network throughput.

Kambiz Homayounfar [17] has described an algorithm that helps MANET routing in two ways. First, it provides a metric that by its nature warns of the possibility that links can break. This metric, which can be considered a link stability index, accumulates at each node to form a path stability index. Therefore, his algorithm enables intermediate nodes to balance stability of the route with end-to-end delay. His principle is that intermediate nodes must wait before they re-broadcast a request they just picked up from a neighbour. This waiting mechanism has, in turn, two advantages. First, in case a better link comes along, there is no need for re-broadcast. This reduces overhead of redundant broadcasts. Second, by using a simple waiting mechanism that depends on link stability, end-to-end delay reduces.

Multipath routing and its applications [13] have been well studied in the networking literature, wired networks in particular. In a broad sense, multipath routing facilitates load balancing and enables fault tolerance. An early work by Maxemchuk [13] on an application of multipath routing known as dispersity routing discusses how a message can be dispersed along multiple paths by splitting it in order to achieve smaller average delay and delay variance. Since then there has been a significant amount of work done on multipath routing for both connection-oriented and connection-less technologies.

Proposed Protocol (DRMRP)

The proposed protocol (DRMRP) discovers routes on-demand using a reverse route discovery procedure. During route discovery process, source and destination node plays same role from the point of sending control messages. After receiving the route request message from the sender, destination node broadcasts Reverse Route Request message in all available paths. Upon receiving the multiple route replies from the destination, the source node selects the best pathsand starts data transmission simultaneously through them.
A. Total Energy Consumption

The amount of energy consumption is lesser if the sender and the receiver nodes are nearer to each other. At each node, the total energy required for data transmission is given by

\[ TE = N \times (PTE + PPE) \]  

where \( N \) is the number of packets. The energy required for packet processing (PPE) is much smaller than that required for packet transmitting (PTE).

B. Route Establishment Process

When a source node wants to transmit data to a destination node and if there is no routing information regarding the destination, it initiates the route discovery process by broadcasting route request (RREQ) packets to its neighbouring nodes until they reach to the destination.

The source node broadcasts the RREQ to all nodes within its transmission range. These neighbouring nodes will then pass on the RREQ to other nodes in the same manner. As the RREQ is broadcasted in the whole network, some nodes may receive several copies of the same RREQ. When an intermediate node receives a RREQ, the node checks if already received a RREQ with the same broadcast id and source address. The node cashes broadcast id and source address for first time and drops redundant RREQ messages. The procedure is the same with the RREQ of AODV.

When the destination node receives first route request message, it first appends the RREQ packet information to its own routing table and after that it generates so called reverse request (R-RREQ) message and rebroadcasts it to all neighbour nodes within transmission range like the RREQ of source node does.

When broadcasted R-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. This process is repeated until the R-RREQ messages reach the source.

Upon receiving multiple reverse request (R-RREQ) packets from the destination, the source node selects only the node disjoint paths and filters reliable paths based on the two estimated parameters Total Energy Consumption and Number of Hops (H). Only after estimating the aforesaid parameters, the main parameter RW (Route Weight) for each route will be carried out using the formula,

\[ RW = \min_{i=1}^{n}(TE + H) \]  

The routes are arranged based on their RW value and the required number of paths for data transmission are selected from the list.

ALGORITHM FOR THE PROPOSED MODEL

Algorithm:

// S : Source IP address in the received packet,
// D : Destination IP address in the received packet
// My-IP : The current node’s IP address
// pathlist : available paths from source to destination
//finalpath : Node disjointed paths from source to destination
// n : number of nodes in each path,
// p : number of paths
// H : number of Hops
// TE : Required Total Energy
// NRE : Node Residual Energy
// FVP : Total number of final valid paths between source and destination

pathlist:={}, finalpath={}, temp={}, i=1; j=1; t:= 0, n:=0, k:=1

// ROUTE DISCOVERY PROCESS

Input: RREQ packets from Source or Intermediate node

For each pathlist (i)
    For every neighbor j of i
        If (RReq’s Dest-Id is = Current Nodes’ IP)
            ‘Broadcast the RREQ packet to the neighbours
            ‘Include this node in the current path
            ‘Include this path in the pathlist array
        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
        Endif
    Endfor(k)
Endfor(j)
// ROUTE WEIGHT VALUE CALCULATION 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
      RW=TE+H //Calculate Route Weight Value RW for every node k in pathlist(i) using the TE and H values collected from each node.
   Endfor(k)
Endfor(i)

// ROUTE SELECTION PROCESS AT SOURCE NODE

For every node disjoint path i from D to S // Arrange the paths based on the RW value
Endfor(i)

The required number of paths with minimum weight value are selected from the final path list as best paths and data transmission is carried out in the selected paths.

ROUTE MAINTENANCE

Route maintenance in the proposed model (DRMRP) is a simple extension to AODV route maintenance. Like AODV, DRMRP also uses RERR packets. A node generates or forwards a RERR for a destination when the last path to the destination breaks. Then the proposed protocol (DRMRP) removes the broken route from the list and redirects the data packets in the remaining available paths. Avoidance of re-route discovery contributes to reduction in overhead.

RESULTS

Performance Metrics

The following key performance metrics are considered for the evaluation of the proposed protocol:
- Packet Delivery Ratio — Ratio of the data packets delivered to the destination to those generated by the source; or a related metric received throughput in kb/sec received at the destination.
- Average End-to-End delay of data packets — this includes all possible delays caused by buffering during route discovery, queuing delay at the interface, retransmission delays at the MAC, propagation and transfer times;
- Mobility Speed — the varying speed of the mobile nodes
- Total Energy Consumed: The average amount of energy consumed by every node.

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 : 0.5 Joules

Simulation Results

![End To End Delay Vs Number Of Nodes](Fig 1)

![Packet Delivery Ratio Vs Mobility Speed](Fig 2)
Results & Discussions

From Fig.1, the End-to-End Delay of the new proposed protocol is less when compared to the existing AODV protocol.

Fig.2 depicts that the new proposed protocol’s packet delivery ratio regarding the mobility speed is high when compared to the existing protocol AODV.

Fig.3 shows that the new proposed protocol’s packet delivery ratio regarding the number of nodes is high when compared to the existing protocol AODV.

Conclusion

In this paper a new Dynamic Reliable Multipath routing protocol for MANET has been proposed. Successful delivery of RREP messages are important in on-demand routing protocols for ad hoc networks. The loss of RREPs causes serious impairment on the routing performance. Furthermore, the single route establishment between source and destination leads to frequent route discovery processes. The proposed protocol discovers routes in fewer tries than AODV. Using this approach, multiple routes are established between source and destination. In order to select best reliable routes, proposed protocol uses two parameters, Total Energy Required for data transmission and the Number of hops. It also provides high energy efficiency and load balancing thus prolongs the network life time and makes up high reliability communications. The simulation results show that the proposed protocol is better than AODV in discovering and maintaining routes and outperforms AODV.

References


