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A Survey on Cross-Layer Reliable Routing Protocols in MANETs

Chintan Bhavsar

Assistant Professor, Computer Engineering Department, G. H Patel College of Engineering and Technology, V.V Nagar, Gujarat, India

Abstract: — A Mobile Ad Hoc Network (MANET) is a collection of self-configuring mobile nodes without any infrastructure. As the MANET is infrastructure less, it is having dynamic nature and random network topology. Due to Dynamic nature of MANET routing is very critical task. Random network topology also affects the performance of the network. Random movements of node causes route failures as the nodes moves out of each other's range. Due to frequent route failures and re-discovery the routing load of the network increases which can affect Quality of Service of the network. Many efforts have been made to design reliable routing protocols that enhance route stability of network. Some of recently published papers consider Cross-Layer design as an effective mechanism to enhance the route stability. In this paper, I surveyed on recently published papers regarding reliable routing protocols which uses Cross-Layer Design to improve stability of network.

Keywords: AODV, Routing, MANET, Stability, Signal strength, Cross-Layer, QOS

I. INTRODUCTION

A mobile ad hoc network (MANET) is a self configuring infrastructure less network of mobile devices connected by wireless links. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each node must forward traffic unrelated to its own use, and therefore be a router. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. Topology of the ad-hoc network depends on the transmission power of the nodes and the location of the mobile nodes, which may change from time to time [1].

The main goal of Ad Hoc routing is to send data packets among nodes distributed randomly in the network. Since mobile ad hoc networks have random topology, routing in such networks is a tough task. There is so much work has been done on routing in ad hoc networks [1].

Routing is the process of finding a path from a source to destination. The route request packets are broadcast in order to find a route for ad-hoc network. The route discovery process consists of sending a message from a source node to all the nodes in the network. Broadcast can be used to diffuse information to the whole network. It is also used for route discovery protocols in ad-hoc networks.
The routing protocols are classified as follows on the basis of the way the network information is obtained in these routing protocols.

1) Proactive (Table-Driven) Routing Protocol
2) Reactive (On-Demand) Routing Protocol
3) Hierarchical Routing Protocol
4) Hybrid Routing Protocol

Proactive (or Table-driven) routing protocols maintain routing information about each node in the network. The information is updated throughout the network periodically or when topology changes. Each node requires storing their routing information. For example: Destination sequenced Distance vector routing (DSDV) [11].

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Reactive or On-demand routing protocols look for the routes and are created as and when required. When a source wants to send to a destination, it invokes the route discovery mechanisms to find the path to the destination. For example: Ad-Hoc On-demand Distance Vector (AODV) [10], Dynamic Source Routing (DSR) [12]
In Hierarchical routing protocol Nodes are organized in clusters, Cluster head "controls" cluster, one or multiple levels of hierarchy In Hybrid routing protocol, Proactive for neighbourhood, Reactive for far away (Zone Routing Protocol), Proactive for long distance, Reactive for neighbourhood (Safari)

In Majority of routing protocols for mobile ad hoc network the route is based on minimum hop. These protocols try to find the route such that the route contains minimum number of intermediate node. Due to changing network conditions minimum hop route is prone to failure. The topology in MANET keeps changing because of its dynamic nature. Due to frequent changes in topology nodes will get out of each other's transmission range and the route may break.

The route with minimum hop contains weak links. Such links are tending to break after certain time interval. The route discovery process is initiated upon the failure of active route which consist of broadcasting route request packets. If the discovered route is not stable then it will lead to multiple route discoveries. The Frequent route discoveries increases a routing overhead of routing protocol which will affect the performance of the network. If such a route is found which is stable or whose life time is longer then there will be lesser route discoveries than usual and we may get good packet delivery ratio.

Various approaches had been used to achieve a reliable route in Ad Hoc Network routing protocols [2]. The different approaches used different parameters to achieve a reliable route like node residual energy, link expiration time , link available time, stability of nodes, node successful data transmission, received signal strength etc. Most of the approaches use Cross-Layer Mechanism to achieve reliable route.

We surveyed the reliable routing protocols which are using Cross-Layer Mechanism to improve the stability of the route. Various protocols which find Reliable route using Cross-Layer Mechanism are described in Following Sections.

II. CROSS-LAYER RELIABLE ROUTING PROTOCOLS

A. *ENERGY AWARE RELIABLE ROUTING*

EARR is a cross-layer reactive routing protocol that focuses on node residual energy in order to decide the route. It reduces the route-reconstructions due to residual energy shortages [3].

All nodes in EARR are assumed to be equipped with a residual energy detection device. It is also assumed that each node uses some energy consumption model to estimate whether its remaining battery capacity is sufficient to relay the traffic. RREQ packets carry additional information regarding traffic which is gathered from application layer.

In order to find a route source node sends RREQ packets to its neighbours. The nodes which have sufficient residual energy to complete the task will take part in the propagation of RREQ packet. Finally after all RREP packets received, source node picks the optimum path with maximal bottleneck energy to route data packets. (Bottleneck energy refers to the minimal residual energy of all nodes along one path)

In EARR, when a source node wants to establish a route with destination and already it has a route available for that destination, then protocol will check each node on the path for sufficient residual energy to complete the forwarding task. The route is considered as a valid route only when all nodes on the path have enough residual energy. If several paths are valid, the one with maximal bottleneck energy is chosen to transmit data packets.

Like many conventional reactive routing protocols periodical information exchange and error report are used in EARR to maintain routes. Additionally in EARR current residual energy info is carried by hello messages along with address information when nodes exchange information with neighbours, so that each node is able to obtain the most up-to-date energy information of neighbours.

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B. ***STABLE AND ENERGY EFFICIENT RELIABLE ROUTING***

SBNRP is a reactive on demand routing protocol that uses a new concept of backbone nodes with power factor [4]. This protocol joins two different concepts like Stability and Energy Efficiency together to make an efficient protocol. In this scheme backbone nodes are used for route stability and power factor is used to determine active nodes to participate in routing. Each route table has an entry for number of backbone nodes attached to it and their battery status. Parameters such as availability of nodes and battery status are considered for selection of backbone nodes.

Suppose there is a shortest path from source to destination. If some intermediate nodes having power status in critical or danger zone, then instead of shortest path other path with better active power is chosen. This may lead to slight delay but improves overall efficiency of the protocol by sending more packets without link break than the state when some node is unable to process route due to inadequate battery power. Backbone nodes are used to re-establish the route when some intermediate node moves out of the range and link break occurs. Using backbone nodes route is established again without much overhead.
The protocol is divided into three phases. Route Request (REQ), Route Repair (REP) and Error Phase (ERR).
REQ phase operates like route discovery operation of reactive routing protocols.

When an Intermediate node of an active route receives a new RREQ packet, it records the previous hop and the source node information in its route table. If it has an active route to the destination then a RREP packet is sent to the source otherwise the packet is broadcasted. The destination node sends a RREP packet via the selected route when it receives the first RREQ or subsequent RREQ packets that traversed a more stable route.
The two major aspects which determine stability of route are Lifetime and Power status. A node promiscuously overhears packets that are transmitted by their neighbouring nodes due to broadcast nature of wireless communications. When a RREP packet is overheard by a node that is not part of the route, it records that neighbour as the next hop to the destination in its alternate route table. From these packets, a node obtains alternate path information and makes entries of these backbone nodes (BN) in its route table.
When a link break is detected by a node, it performs a one hop data broadcast to its immediate neighbours. In the data header the node specifies that the link is disconnected and thus the packet is candidate for alternate routing. Route maintenance phase starts by selecting alternate path and checking power status when the packet is received by the neighbour. During local repair data packets will be buffered at local originator. If, at the end of the discovery period, the repairing node has not received a reply message REP it proceeds in by transmitting a route error ERR to the originating node.

C. ***RECEIVED SIGNAL STRENGTH BASED CROSS-LAYER DESIGN FOR MOBILE AD HOC NETWORK***

B.Ramchandran and et al. [5] used received signal strength as a parameter in cross layer design. In a cross layer design the parameter received at a one layer can be communicated to other layer. The authors presented the design in which the Received signal strength measured at the physical layer is communicated to network and MAC layer.

The author indicates that using the received signal strength we can address various issues like energy conservation, unidirectional link rejection and reliable route formation. For reliable route discovery the RREQ (route request) packet is only forwarded to the destination if it is having the received signal strength which is higher than some predefined Threshold. Thus the links on which the received signal strength is low will not participate in formation of route.

There are two types of threshold policies has been used in the paper which is

(1) Fixed threshold

(2) Adaptive threshold

In fixed threshold methodology the predefined threshold remains fixed for different speeds of mobile node while in Adaptive threshold policy the threshold value change according to the speed of mobile nodes. The adaptive threshold policy also considers the moving direction of nodes.

In order to find the moving direction of mobile node the received signal strength of RREQ packet is stored in the neighbor table against the neighbor from which it is received. Whenever any node receives RREQ from its neighbors

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the current received strength is compared with stored received signal strength , if current received signal strength is better than previous received signal strength then it indicates the nodes are approaching otherwise they are going away from each other. If the nodes are approaching and even if their received signal strength is less than threshold the RREQ packet is processed and forwarded to the next node.

D. ***ROUTE STABILITY BASED QOS ROUTING IN MOBILE AD HOC NETWORKS***

Nityananda Sharma et al. [6] have proposed a Route Stability based QoS Routing (RSQR) protocol in Mobile Ad Hoc Networks (MANETs) which is an extension of QoS routing with throughput and delay constraints. In order to guarantee the suitable data path for adequate longer duration in MANET, they have proposed easy model for measuring the link stability and route stability depending on received signal strengths. They have proposed a route stability model which considers node mobility and signal strengths for computing the probability of link failure rather than using probability distribution of link lifetimes.

When a node receives RREQ packet it measures the received signal strength and also records that in Neighbour information table (NIT). It also compares current received signal strength with previous received signal strength. The protocol compares received signal strength with two thresholds Thr1 and Thr2. If the received signal strength is greater than Thr1 then the link is considered as 'stable'. If the received signal strength is less than Thr2 then the link is considered as less stable. Using current and previous received signal strength and two Thresholds Thr1 and Thr2 link stability is determined. Some additional fields in route request/ reply packets is taken into consideration so that the route stability information can be used to choose a route with increased stability when compared to all possible routes among existing source destination pair.

The use of a simple route stability model in the proposed routing significantly reduces the number of route recoveries required during data transmission. The protocol achieves significant performance improvements in terms of control overhead, average end-to-end delay and packet delivery ratio especially in highly mobile scenarios.

E. ***LONG LIVED PATH ROUTING WITH MOBILE AD HOC NETWORKS (AODV-RSS)***

Ruay-Shiung Chang et al. [7] have illustrated about new protocol AODV-RSS, which is a modified version of AODV protocol. This protocol also utilizes cross layer design to achieve received signal strength information.

The aim of this protocol is to determine paths that are long lived means to find a route that can sustain for a longer time. The long-lived path routing algorithm uses the Received Signal Strength (RSS) and Received Signal Strength changing rate (Δ RSS) to predict the link available time (LAT) between two mobile nodes. If Δ RSS between two nodes is positive, means the nodes are moving towards each other. The Δ RSS gives negative value when the nodes are moving away from each other. Δ RSS is an effective means of knowing the moving direction of the nodes.

Distance between two nodes, transmission range of the nodes and signal strength of the node is the parameters which are used to achieve link available time (LAT). Depending upon the moving direction of the nodes link available time (LAT) is determined. The calculated LAT represents a measurement of how long two nodes can keep connected. LAT constraint can be defined such that only those links which satisfies the constraints take part in route formation. If LAT constraint is high there can be less number of links which satisfies the constraint. On the other hand if LAT constraint is low then there can be less stable links. The LAT constraint must be chosen carefully.

The route establishment procedure in AODV-RSS is almost similar to AODV protocol. The AODV-RSS algorithm just sends an RREQ packet to the nodes, who's LAT satisfies the criteria. AODV-RSS can improve the route quality in route connection time, and route reestablishment frequency.

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F. ***ROUTING TECHNIQUE WITH CROSS-LAYER APPROACH IN AD HOC NETWORKS***

Boumetjout et al. [8] had introduced a new routing protocol AodvPw which uses the received signal strength information to enhance the stability of ad hoc network.

In AodvPw protocol, the received signal strength information is used to compute path loss incurred to choose reliable links by monitoring the signal quality to judge which route is chosen in the route discovery process. The aodv protocol has hop count as metric but AodvPw has path loss as metric experienced as,

Path loss= PT - PR (1)

Where PR is Received Power and PT is Transmission Power.

The path loss metric is incorporated in Aodv protocol by adding a path loss field to the RReq and RRep Aodv packets to sum the path loss from the source to the destination and vice versa. Another field called Rt_puissloss is adding to the Aodv routing table to save the average path loss from the source to the destination node experienced as,

Rt_puissloss= path loss (from source to destination) /hop count (2)

Noted that the source node initialize the path loss field in the RREQ Packet to 0.

When a sending node broadcasting RREQ packet, it piggy backs its transmission power PT. On receiving the RREQ packet, the intended receiving node measures the received signal strength PR according to the using propagation model. Hence the receiving node calculates the path loss using formula (1), adds it to the RREQ's path loss field calculates the average path loss using formula (2) and stores it in its routing table.

Even If the receiving node has already received this RREQ packet it verify if it has fresher sequence number than the one saving in its routing table or lesser average path loss with the same sequence number, if it's the case it updates its routing table by fresh RREQ information such as sequence number, hop count and average path loss experienced by RREQ's path loss / RREQ's hop count. So the route selected to forward information is the one with lesser average path loss not the one with lesser hop count from the source to destination.

The destination node sends the RREP packet with the adding field path loss to sum the path loss in the reverse route and updates the nod's routing table by the average path loss of the selected path.

G. ***SIGNAL STRENGTH BASED CONGESTION CONTROL IN MANET***

Prof. Shitalkumar Jain et al. [9] have reviewed a signal strength based measurements to improve upon packet losses and retransmission of packets. Their goal was to improve TCP performance by using signal strength based cross layer approach which obviously resolves the congestion. Node based and link based signal strength can be measured. If a link fails due to mobility, then signal strength measurement provides temporary higher transmission power to keep link alive. When a route is likely to fail due to weak signal strength of a node, it will find alternate path. Consequently avoids congestion. They made changes at MAC routing and routing layer to predict link failure. They have selected two routing protocols AODV and DSR. Packet Delivery Ratio, Packet Drop, Throughput and end to end delay are the metrics used for performance analysis of the AODV routing protocols.

As a result of their studies, they found increase performance of TCP which automatically improves congestion. Cross layer approach, TCP performance, signal strength and mobility these four parameters can be used to improve congestion control. They make a temporary increase in the transmit power level when a node moves out of range to temporarily re-establish the failed link. This would enable the TCP packets that are already in flight to traverse the link. Their algorithms can considerably reduce the number of packet losses. Consequently the number of TCP re-transmission time-outs is reduced and the TCP sources send more packets.

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III. CONCLUSION

Majority of the routing protocols for mobile ad hoc network achieves a route with minimum number of hops. If the selected route contains weak links then the route is prone to failure. The route discovery process is initiated in order to find a new route which consists of broadcasting route request packets. Repeated failure of route may increase the number of route discovery, which will in turn increase the routing load of the network. There is a need to consider other approaches rather than minimum hop which can find a route with longer life time. There is several routing protocol which uses Cross-Layer approach to find a stable path. The route found by using Cross-layer mechanism is more stable or reliable compared to route found by some existing MANET routing protocols. The reliable route minimizes chances of route failures, which in turn reduces routing load of the network. The packet delivery ratio and throughput of the network can also be improved by using reliable routes.

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