Multipath routing and QoS of UNIPATH AND MULTIPATH REACTIVE ROUTING PROTOCOL IN MANET

Dr. KOPPARTHI SURESH,
Professor
Bhimavaram Institute of Engg. & Tech.
PENNADA, BHIMAVARAM,
sureshkgrl@gmail.com

S.KOTESWARI,
ASSOCIATE PROFESSOR
CHAITANYA ENGINEERING COLLEGE,
BHIMAVARAM, WEST GODAVARI DISTRICT
eshwari.ngr@gmail.com

Abstract- Mobile Ad hoc Networks are self-configuring, self-organizing and self-maintaining networks comprising of mobile nodes which are free to move in and out of the network. A MANET is an interconnection of mobile devices by wireless links forming a dynamic topology without much physical network infrastructure such as routers, servers, access points/cables or centralized administration. Routing is a mechanism of exchanging data between the source node and the destination node. Several protocols are used to perform routing the information from the source node to the destination node. The main aim of this paper is to explore the working principles of each Uni-path routing protocol. The Uni-path routing protocols are divided into Table-Driven (Proactive), On-demand (Reactive), Hybrid routing protocols.

I. Introduction

Mobile Ad hoc network also called self-organized network, is a multi-hop wireless network where nodes can move arbitrary in the topology. It consists of a set of wireless nodes which dynamically exchange data among themselves without reliance on some fixed base stations or a wired backbone network. It has great difference between the wired network, including the unpredictability of environment, the unreliability of wireless medium, the resource-constrained nodes, the dynamic topology, limited bandwidth and limited security. Because of the features of MANET, the research of the routing protocol has been one of the most concerned topics in the MANET. The conventional routing algorithms for wired networks are not efficient for the dynamic changes. For the recent years, people have developed a lot of routing protocol which can be used in MANET, and here some typical protocols are summarized. One of the most important aspects of the communications process is the design of the routing protocols used to establish and maintain multi-hop routes to allow the communication of data between nodes. As the MANETs are dynamic in nature, designing protocols for these networks is a challenging process. A considerable amount of research has been done in this area, and many multi-hop routing protocols have been developed. Most of these routing protocols build and rely on a uni-path route for each data transmission. The protocols are classified into two categories: table-driven, on-demand. While these protocols might be sufficient for a certain class of MANET applications, but are not adequate for the support of more demanding applications such as multimedia audio and video. Such applications require the network to provide guarantees on the QoS. This is achieved by using some mechanism such as QoS routing to find the best route which satisfies these requirements in the best way. QoS routing appears to be a solution to handle these problems. QoS routing requires not only finding a route from a source to a destination, but a route that satisfies the end-to-end QoS requirement, often given in terms of bandwidth, delay or loss probability. Quality of service is more difficult to achieve in ad hoc networks than in wired networks. According to [6], QoS is a set of service requirements to be met by the network while transporting a flow. A flow is a packet stream from a source to a destination with an associated QoS. A fundamental requirement of any QoS mechanism is a measurable performance metric. Typical QoS
metrics include available bandwidth, packet loss rate, estimated delay, packet jitter, hop count and path reliability. The key issue in providing QoS guarantees is how to determine paths that satisfy QoS constraints and solving this problem is referred as QoS aware routing.

II. Related Work

In MANETs communication between nodes is done through the wireless medium. Because nodes are mobile and may join or leave the network, MANETs have a dynamic topology. Nodes that are in transmission range of each other are called neighbors. Neighbors can send data directly to each other. However, when a node needs to send data to another non-neighboring node, the data is routed through a sequence of multiple hops, with intermediate nodes acting as routers. Routing protocols are used to find and maintain routes between source and destination nodes. Two main classes of ad hoc routing protocols are Table-based (Proactive) and On-demand (Reactive) protocols [1]. In Table-based protocols each node maintains a routing table containing routes to all nodes in the network. Nodes must periodically exchange messages with routing information to keep routing tables up-to-date. Therefore, routes between nodes are computed and stored, even when they are not needed. Examples of Proactive Protocols are DSDV (Destination Sequested Distance Vector) algorithm, WRP (Wireless Routing Protocol), CGSR (Cluster Gateway Switch Routing). In on-demand protocols, nodes only compute routes when they are needed. Therefore, on-demand protocols are more scalable to dynamic, large networks. When a node needs a route to another node, it initiates a route discovery process to find a route. On-demand protocols consist of the following two main phases:
1. Route discovery is the process of finding a route between two nodes
2. Route maintenance is the process of repairing a broken route or finding a new route in the presence of a route failure.

Examples of Reactive protocols are the Dynamic Source Routing (DSR), Ad hoc On-demand Distance Vector (AODV) protocols and Temporally Ordered Routing Algorithm (TORA). In addition to proactive and reactive protocols are Hybrid Protocols [2] protocols that use both the approaches to find a route from the source to the destination. Example of hybrid protocol is Zone-Based hierarchical Link State Routing Protocol (ZRP).

III. MANET - Routing protocol

Routing protocols for MANETs can be categorized in various ways. They can be classified as proactive and reactive routing depending on several factors. Such factors can be for example the time taken for routes discovery or routing information update mechanism. Figure 1 presents some routing protocols for MANETs.

![Fig1. MANET Routing Protocol.](image)

In proactive routing, every host maintains at least one routing table to represent the whole topology of the network. The tables (of each host) are updated continuously. Therefore, routes are already available at any time some hosts want to communicate with each other. In order to maintain up-to-date routing information at all hosts, topology information has to be exchanged between all hosts on a regular basis. This increases the overhead in the network. On one hand, substantial bandwidth is used for the large control traffic; on the other hand, routes are always available in shortly for any communication request. This reduces the delays of data transmissions. One of the most important proactive protocols is the Optimized Link State Routing protocol (OLSR) [18]. Unlike proactive routing protocols, reactive routing protocols initiate a route discovery process when needed. This reduces the overhead as compared to proactive routing protocols, but it increases the transmission delay. Another classification can be made according to number of paths a routing protocol delivers per source destination pair. There exist uni-path and multipath routing protocols. Uni-path routing protocol: one route is used to deliver data from source node to destination node. Multipath routing protocol: more than one route is used to deliver the data.
Uni-path Routing Protocols
There exist two major classes of on-demand routing algorithms, namely distance vector and source routing. A distance vector algorithm uses some similar features as the Bellman-Ford algorithm to calculate the routing paths. It requires that a node informs its neighbors periodically. The packets include the next-hop in their header and each intermediate node adapts this information accordingly along the path. A source routing algorithm requires that a node knows the complete paths to the destination. AODV - Ad hoc On-Demand Distance Vector [6, 7]. AODV protocol is defined by the RFC 3561, written by Charles Perkins and Elizabeth Ford. AODV has some similar features as the Bellman-Ford distant vector algorithm, but it has been improved to work in a mobile environment [7]. AODV uses hop-by-hop routing (AODV Route Discovery Process - Figure 2.3). Every node forwards data packets towards a destination node according to its routing table (Figure 2.2). The routes in the AODV routing table are kept up to date as long as they are needed by the source. AODV maintains a single path per a destination. The routing is divided into two basic mechanisms. The first one is the route discovery. It is responsible for finding a route to the destination if none is currently available in the routing table of the node. The second one is the route maintenance which keeps the routes up-to-date, e.g. removes broken paths. AODV protocol only works in a network where the communication links are bidirectional because if an (intermediate) node receives either a Route REQuest (RREQ) packet or a Route REPLY(RREP) packet, it caches the previous node.

AODV Route Discovery
If a source has no entry for a destination in its routing cache, it starts a route discovery process. It floods a RREQ packet in the network. The RREQ includes header fields with the following parameters: request ID, source node ID, destination node ID, hop count, sequence number of the source node, sequence number of the destination node and TTL (time-to-live). If an intermediate node receives a RREQ packet, it checks if it is the destination node. If not, it checks if it has seen this RREQ before by checking the request ID and source node ID. If this is the case the node just drops the packet and does not forward the RREQ any further. This avoids loops in the route. If the RREQ packet is not dropped, the intermediate node searches in its route cache table. If there is an active route to the destination, it sends back a RREP with its route entity. Otherwise it just rebroadcasts the received RREQ. If the destination node has received the RREQ, it generates a RREP packet and sends it back in reverse way to the source. If an intermediate node receives either a RREQ or a RREP packet, it stores information about the previous node from which the packet was received in its routing. With this mechanism, hop-by-hop routing, a node can therefore decide which next hop it can use to reach a destination node. [13]

AODV Route Maintenance
If a node tries to forward a message, but detects that there is a link break, i.e., the next node is not more reachable, the forwarding node sends back a RERR message towards the source node. Whenever a node receives a RERR message, it deletes all routes containing this broken link in its routing table. When the source receives the RERR packet, it also updates its routing table, but it does not send the RERR packet anywhere. If the data session has not yet been completed and the source does not have any other route to the destination, the node starts the route discovery process.

Multipath Routing Components
Multipath routing consists of three components: Route discovery, Route maintenance, and Traffic allocation. Route Discovery and Maintenance. Route discovery and route maintenance 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 [4]. 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 also provide higher fault-tolerance. Traffic Allocation. Once the source node has selected a set of paths to the destination, it can begin sending data to the destination along the paths. The traffic allocation strategy used 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.

IV. UNIPATH ROUTING Vs MULTIPATH ROUTING
The primary disadvantages of multipath routing protocols compared to unipath protocols are complexity and overhead. In the case of multipath extensions to AODV, maintaining multiple routes to a destination results in larger routing tables at intermediate nodes. In multipath routing, the method by which packets are allocated to the multiple routes must be taken into account. Multipath routing can result in packet reordering. In unipath routing, traffic allocation is not an issue, since only one route is used. After a source begins sending data along multiple routes, some or all of the routes may break due to node mobility and/or link and node failures. For unipath routing route discovery can be triggered upon failure of the route. In the case of multipath routing, route discovery can be triggered each time one of the routes fails or only after all the routes fail. Nodes in an ad hoc network communicate through the wireless medium. When choosing multiple paths, it is important to choose paths that are as independent as possible to ensure the least interference between the paths. Multiple metrics can be used to calculate the relative degree of independence among a set of paths, namely correlation [5] and coupling [6]. The correlation factor between two node-disjoint paths is defined as the total number of links connecting the paths. The coupling between two paths is calculated as the average number of nodes that are blocked from receiving data along one of the paths when a node in the other path is transmitting. The advantage of using coupling as a metric is that it can be used for both disjoint and non-disjoint routes. Non-disjoint routes are considered highly coupled. Choosing paths that have low coupling or correlation can improve the performance of multipath routing.

V. APPLICATIONS OF MULTIPATH ROUTING
Multipath routing can be used to support a variety of applications in MANETs. Such as fault tolerance, energy conservation, minimization of end-to-end delay, and satisfying bandwidth requirements.

FAULT TOLERANCE
Satisfying Reliability Requirements: MP-DSR [7] is a multipath QoS-aware extension to DSR, the protocol attempts to provide end-to-end reliability as the QoS metric. End-to-end reliability is defined as the probability of sending data successfully within a time window. The end-to-end reliability is calculated from the reliabilities of the paths used for routing. The path reliability is calculated from the link availabilities. Link availability is defined as the probability that a link is available from time t0+t, given that it is an active link at time t0. Path reliability is the product of the link availabilities along the path, assuming the link availabilities are independent. The end-to-end reliability is the probability that at least one path does not fail within the given time window. Generally the end-to-end reliability is higher than any of the path reliabilities. Hybrid Network for Enhanced Reliability: It may be difficult to find a suitable number of node disjoint paths between two nodes to provide the necessary fault tolerance and reliability. However, some ad hoc networks may contain heterogeneous nodes, where some nodes are more reliable than other nodes. Reliable nodes [8] are deployed to provide reliable paths. The objective is to position reliable nodes such that the probability of establishing a reliable path between any two arbitrary nodes is maximized. The reliable nodes gather topology information from surrounding nodes to determine where to position themselves. Depending on the mobility of the nodes, the reliable nodes may have to reposition themselves. The reliable nodes should be faster than the other nodes, such that they can adapt to node mobility in a timely fashion. Packet Salvaging for Fault Tolerance: With packet salvaging intermediate nodes maintain multiple routes to the destination, and a RERR message propagates upstream only until an intermediate node can forward the packet along an alternate route. Multipath protocol called CHAMP (Caching and Multipath Routing) [9] uses round-robin traffic allocation to keep routes fresh. A node only accepts the shortest routes to the destination, and the routes must be of equal length. When routing a packet to a destination, a node sends the packet along the least used route, thereby spreading data packets over all the available routes. Routes are of equal length in order to help reduce out-of-order packets arriving at the destination. CHAMP allows for non-disjoint paths. CHAMP takes advantage of temporal locality in routing, where a dropped packet is a recently sent packet. Each node keeps a cache of packets it recently forwarded. Diversity Coding: A multipath traffic allocation scheme for ad hoc networks that uses M-for-N
diversity coding is proposed in [10]. In this scheme, a packet is split up into N equal size blocks. Then, M blocks of the same size are added to the packet as overhead. The additional blocks are calculated from the N blocks, and provide redundant information. The N + M total blocks are then allocated to the multiple available paths. Based on the M-for-N coding scheme, if no more than M blocks are lost, the original packet can be reconstructed from the received blocks. The main idea behind this scheme is to allocate the blocks amongst the routes such that the probability of losing no more than M blocks is maximized.

**DELAY AWARENESS**

Pre-emptive Route Discoveries: A multipath extension to DSR called MSR [11] is used by the source node to find multiple paths to the destination. Disjoint paths are preferred to ensure path independence. The scheme attempts to minimize the end-to-end delay for sending a volume of data from source to destination by using multipath routing and intelligent traffic allocation. In this scheme, data is routed along multiple paths in sequential blocks. Since routes may break before all the data is transmitted, new paths must be discovered. Pre-emptive route discoveries are done to find new paths before route errors occur. In order to determine how to distribute data amongst the paths, the scheme uses a mechanism to predict the lifetime of a path. The lifetime of a path is determined by the link affinity, which is a prediction of the life span of a link. Prioritize Multipath routing: Multiple paths are selected between a source and a destination depending upon the type of traffic [12]. The protocol assumes that a source node is aware of the importance of a packet that it sends to a destination. A source node uses an indicator to classify a packet depending on its importance. Routing decisions are made based on this priority indicator. A low priority packet travels a longer path compared to a higher priority packet. The priorities are assigned from 1 to M, where M is the indication of the highest priority. A packet with the highest priority is sent using the optimal path among all M paths. The optimal path is defined as the path that has the shortest end-to-end delay.

**Multipath Reactive Routing Algorithm**

1: if numOfForwardedMsg[RREQ] > m0 then
2: return ;
3: end i
4: Pacc = Pacc ¥ Aij(tw);
5: Li(tw) = Plower / Pacc;
6: n = num of the neighbors of the intermediate node;
7: Pend_to_end = {{n1, v1}, ............., (nn, vn)};
{where the list is sorted according to vj}
8: for k = 1 to n do
9: if Pend_to_end[k].neighbor CE pathVector then
10: continue;
11: end if
12: if Ai,k(tw) ³ Lk(tw) then
13: numOfForwardedMsg[RREQ] + ;
14: forward(RREQ, Pend-to-end[k].neighbor);
15: return ;
16: end if
17: end

It improves the Multipath reactive routing protocol with cost based route discovery scheme. The fuzzy logic techniques are used for the cost estimation. Bandwidth and traffic factors are used in the route discovery process. The proposed system improves the end-to-end reliability. Multipath route discovery is designed in the system. Cost factor is used for route discovery process. Dynamic source routing protocol is used in the system. Alternate route is selected in node failure state. The system is divided into three major modules. They are Route discovery, Route maintenance and Cost estimation.

a MANET may consist of nodes which cannot be charged in an expected time period, energy conservation is crucial to maintaining the lifetime of such a node. In networks consisting of these nodes, where it is impossible to replenish the nodes’ power, techniques for MANET Reactive routing as well as efficient data dissemination between nodes is crucial. MANET Reactive Routing : The mobility aware geographical multipath routing (MRR) protocol proposed in [15]. The authors suggested that while selecting the next hop, a mobile node should consider the remaining battery capacity, mobility and distance of that next hop to the destination. Based on these parameters, a fuzzy logic system is developed and applied to the next hop selection mechanism. Braided Multipath : A multipath routing technique which uses braided multi-paths is also proposed in...
Braided multi-paths [16] relax the requirement for node disjoint. Multiple paths in a braid are only partially disjoint from each other and are not completely node-disjoint. These paths are usually shorter than node-disjoint multipaths and thus consume less energy resources; alternate paths should consume an amount of energy comparable to the primary path. It was found in that multipath routing using the braided multipath approach expends only 33% of the energy of disjoint paths for alternate path maintenance in some cases, and have a 50% higher resilience to isolated failures.

VI. Conclusion
In this paper we reviewed the challenges and basic concepts behind QoS routing in MANETs and provided a thorough overview of QoS routing metrics and design considerations. MANETs are likely to expand their applications in the future communication environments. It is clear from the benefits of multipath routing that it is a better choice than single path routing as it can increase the network operation lifetime by distributing load among nodes and not overusing some set of nodes so as to be in case of unipath routing. It is desirable that rather than satisfying one QoS at a time, multiple requirements should be satisfied. Thus a protocol that may satisfy bandwidth requirements should also be able to balance load and in turn conserve network’s energy. Further, an adaptive QoS approach depending on the type of data to be transmitted can also be employed for multipath routing.

References