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ISSUES AND CHALLENGES INVOLVED IN MULTIPATH ROUTING WITH DYMO PROTOCOL

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ABSTRACT: A mobile ad-hoc network (MANET) is a wireless network in which nodes, in the absence of fixed access points, communicate via single or multi-hop paths. Each node in a MANET should thus be able to perform necessary routing functions, and a MANET routing protocol should be able to adapt fast and effectively to sudden changes in network layout. Multipath routing allows the establishment of multiple paths between a single source and single destination node, the knowledge of alternate paths allows to reduce the frequency of route discovery in the presence of link failures. It is typically proposed in order to increase the reliability of data transmission (i.e., fault tolerance) or to provide load balancing. Load balancing is of special importance in MANETs because of the limited bandwidth between the nodes. . Providing trustworthy quality of service guarantees in a MANET is very challenging due to the dynamic and uncertain nature of these networks. We propose to extend DYMO routing protocol for MANETs to a multi-path protocol which uses delay, traffic load etc instead of hop count, as metric for route selection.

1. INTRODUCTION

Mobile Ad hoc Networks are classified as single or multihop wireless networks in which nodes can freely move and dynamically self-organize, also the network is highly dynamic in terms of topological changes. Mobile nodes can communicate with themselves without any need of predefined infrastructure. But due to the dynamic nature of MANETs in terms of mobility and no infrastructure, they are provided with limited bandwidth and limited battery power. In the past and recent years, the usage of wireless devices becoming more and more important and necessary due to rise of mobile and wireless networks. There are three types of mobile networks are present. i.e., infrastructured, infrastructured less and hybrid networks[1].

MANETs have potential use in a wide variety of disparate situations. Such situations include moving battlefield communications to disposable sensors which are dropped from high altitudes and dispersed on the ground for hazardous materials detection. Civilian applications include simple scenarios such as people at a conference in a hotel where their laptops comprise a temporary MANET to more complicate scenarios such as highly mobile vehicles on the highway which form an ad hoc network in order to provide vehicular traffic management. MANET nodes are typically distinguished by their limited power, processing, and memory resources as well as high degree of mobility.

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Protocols in conventional wired networks are usually based upon either distance vector or link state routing algorithms. Both of these algorithms require periodic routing advertisements to be broadcast by each router. In distance vector routing [2], each router broadcasts to all of its neighbouring routers its view of the distance to all other nodes; the neighbouring routers then compute the shortest path to each node. In link-state routing each router broadcasts to its neighbouring nodes its view of the status of each of its adjacent links; the neighbouring routers then compute the shortest distance to each node based upon the complete topology of the network.

Figure 1: Infrastructure Network and Mobile Nodes

Routing multipath on-demand hop-by-hop protocol establishes multiple loop free disjoint paths between a source and a destination. Loop freedom is guaranteed by use of destination sequence numbers and hop count information. Utilizing alternate path information available during a single query flood, the protocol can establish multiple paths in one route discovery. These mechanisms permit multiple paths to be discovered with little additional overhead over DYMO. In this paper we analyze the benefits of discovering multiple paths and using them as backup routes in case of route breakage in DYMO. Multipath provides effective means of reducing route request overhead in DYMO, significantly reducing protocol overhead and increasing performance

2. MULTI PATH ROUTING IN MANETS

Multipath routing permits the establishment of multiple paths between a source and a destination for the purposes of routing data packets. The main advantages of these protocols in ad hoc networks are that they can be used for load balancing or to provide route resilience. Load balancing permits a source to send data concurrently along multiple paths, providing a higher aggregate bandwidth to cope with the limited capacity of MANETs. Mobile ad hoc networks present a potential drawback to achieve load balancing. This is because of route.

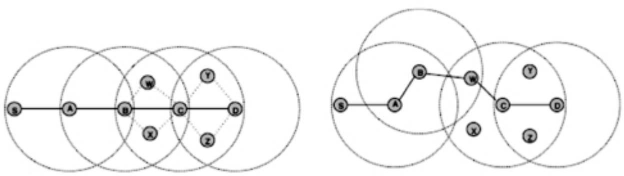

Figure 2: Multiple Paths and their Usage

This is because having multiple alternate paths in ad hoc networks is beneficial because wireless networks are prone to route breaks resulting from node mobility, fading environment, signal interference, high error rate, and packet collisions. Route resilience is specially helpful in MANETs where the dynamic nature of the network can translate into frequent link failures due to node mobility power failure and interference[6]. If a node has multiple alternate routes to a destination, when a route fails the source can switch to an alternate route, bypassing the significant overhead and latency of a new route discovery. Network-wide flooding accounts for a significant performance impact of reactive routing protocols. Disjointness of paths is highly desirable when using multipath protocols. From a fault tolerance perspective, in case of route failure the source must switch to an alternative route that doesn't include the broken link or node. Different degrees of disjointness can be considered, from non-disjoint paths to link-disjoint, node-disjoint. In node-disjoint path do not have any particular nodes in common, except the source and destination, whereas fail-safe is a path between source and destination if it bypasses at least one intermediate node on the primary path, which is the shortest path between the source and destination pair. Thus fail-safe path is different from node-disjoint and link-disjoint paths, in the sense that fail-safe path can have both nodes and links in common[9].

3. DYMO OVERVIEW

DYMO is a reactive unicast protocol for MANETs. It is a simplified combination of previous reactive routing protocols. DYMO creates loop-free unicast routes, using distance vector routing like AODV. DYMO defines only the basic elements required for reactive routing: route discovery and route management. It is intended to be extensible. When a source needs a route to a destination it initiates a query flood in the form of a route request (RREQ) dissemination. This message is flooded through the network until it reaches the destination. In the process, reverse routes toward the source are formed. When this message reaches the destination it replies with a route reply (RREP) sent via unicast to the source, forming forward routes to the destination along the path. Nodes receiving routing information in the form of RREQs and RREPs check its usefulness via update rules. If it is loop free and better than previous information the route is updated and the routing message propagated, or in the case of the destination a RREP is generated. Only one path is maintained at a node at any given time. Loop-freedom is guaranteed by use of destination sequence numbers. Sequence numbers enable nodes to determine the order of DYMO route discovery messages, thereby avoiding use of stale routing information. A new route is deemed superior if it is loop-free and shorter than a previous route.

3.1. Processing of Route Message

When a node processes a RM it will start the processing by incrementing the message header hop count with one and decrement message header hop limit with one. Then it will process all address header blocks that the message contains and increment the corresponding address TLV block hop count, except for the target node address block. Next it will look at the source node address block and check whether the information contained in that source address TLV block is better than the information contained in the local routing table (RT). If the information in that TLV block is not considered better than the residing RT information all the remaining address blocks will be processed and possibly result in RT updates or insertions and then this frame is discarded. Each address TLV block that does not result in a RT update or insertion will be removed from the RM, except the target node address block. Removing blocks that does not result in a change of the local RT ensures that "stale" information is not propagated throughout the network[8].

If this node is the intended destination and the RM is a RREQ then this node will create a RREP and use the RREQ source address as the new destination address and use the RREQ destination node as the source address. In case of multiple network interface cards the creator of the RREP must use the same address as was used in RREQ destination address.

In the case that the processing node is not the destination and the RM is a RREQ and processing node has a route to the destination it may send a RREP. When such a intermediate node sends a RREP it should send RREP both to the target and the source with the additional information necessary to create RT entries locally on the target and the source. No further action on this RM is taken after this[7].

After processing a RM a node is recommended to add additional address blocks with information about itself and additional routing information, to other hosts, in address TLVs to alleviate the need to send additional RREQ in the future. Prior to adding additional information processing node is recommended to increment its own sequence number, if this increment is not done the additional routing information may not be considered better than existing information when received by nodes that already have RT entries to additional hosts.

If this node is not the intended destination and the message header hop limit is greater or equal to one and RM is a RREQ it is forwarded to DYMO broadcast address.

If the RM is a RREP and message header hop limit is greater or equal to one and processing node is not the intended destination the RM will be forwarded to the next hop indicated by the RT of the Target Node's Address.

3.2. How Multiple Paths are Selected

As shown in figure, number of multiple paths between source node S and destination D can be discovered during route discovery process. After completion of route discovery process, there will be a primary path (S-N1-N2-N3-D); two node disjoint paths (S-N5-N6-N7-D) and (S-N10-N11 N12 -D) and a number of fail-safe paths (S-N5-N2-N7-D), (S-N1-N6-N3-D), (S-N1-N2-N12-D), (S-N10-N11-N3-D).

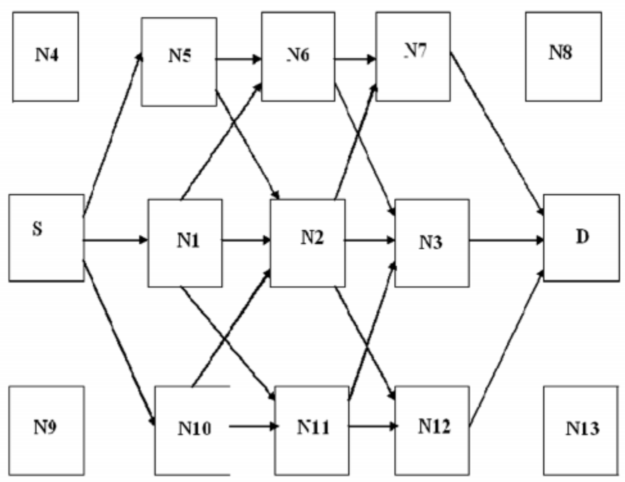

Figure 3: Multipath in an Network

3.3. When to Update the Routing Table

Dymo uses sequence numbers[8] as the main determination if incoming information is better than the existing route table information. If the sequence numbers are the same DYMO will use hop count to the node under consideration and the type of RM, RREQ or RREP, to determine if the incoming information is better than the existing.

The information can be classified into three different states that are inferior to the existing RT information [5]:

1. Stale: If the information's sequence number - RT sequence number is less than zero the information is stale.
2. Loop-possible: If they have the same sequence number and node hop count is unknown or node hop count > RT hop count+1 or RT hop count is unknown this information could introduce loops in the network and are classified as loop-possible.
3. Inferior: If the information is not stale or loop possible, sequence numbers are equal and the hop counts are equal and the route is not broken and message under consideration is a RREQ the information is inferior. If the same as earlier applies but message hop count = RT hop count+1 and message is a RREQ or a RREP the information is also inferior.

4. ISSUES AND CHALLENGES

4.1. Fault Tolerance

Fault tolerance perspective, can be from a packets point of view. To demonstrate this, consider above Figure, where node S has established multiple paths to node D. If node S sends the same packet along all paths, as long as at least one of the paths does not fail, node D will receive the packet. While routing redundant packets is not the only way to utilize multiple paths, it also demonstrates how multipath routing can provide fault tolerance in the presence of route failures and this is the sense in which we must use multipath in Manets.

4.2. Bandwidth

Bandwidth may be limited in a wireless network, routing along a single path may not provide enough bandwidth for a connection. However, if multiple paths are used simultaneously to route data, the aggregate bandwidth of the paths may satisfy the bandwidth requirement of the application. Also, since there is more bandwidth available, a smaller end-to-end delay may be achieved.

Due to issues at the link layer, using multiple paths in ad hoc networks to achieve higher bandwidth may not be as straightforward as in wired networks. Because nodes in the network communicate through the wireless medium, radio interference must be taken into account. Transmissions from a node along one path may interfere with transmissions from a node along another path, thereby limiting the achievable throughput. However, using multipath routing in ad hoc networks of high density results in better throughput than using unipath routing[9][10] .

4.3. 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. Once we have multiple routes then maintenance of them is also a issue which must be addressed, for example when to initiate route discovery i.e., after how many route failures.

4.4. Disjoint Routes

These offer certain advantages over non-disjoint routes. For instance, non-disjoint routes may have lower aggregate resources than disjoint routes, because non-disjoint routes share links or nodes. In principle, node disjoint routes offer the most aggregate resources, because neither links nor nodes are shared between the paths. Disjoint routes also provide higher fault-tolerance. When using non-disjoint routes, a single link or node failure can cause multiple routes to fail. In node or link disjoint routes, a link failure will only cause a single route to fail. The main advantage of non-disjoint routes is that they can be more easily discovered and they still provide alternative when non shared resources fail.

4.5. Intelligent Path Selection

This feature can be used to enhance the performance of multipath routing. For instance, a certain subset of paths may be selected for use based on a variety of criteria such as characteristics of the paths and interactions with the link layer. From a fault tolerance perspective, more reliable paths should be selected to reduce the chance of routes failures. Path selection also plays an important role for QoS routing. Paths can be selected on the basis of traffic, battery energy and other parameters like these

4.6. Route Discovery

As discussed previously 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. Waiting for all the routes to fail before performing a route discovery would result in a delay before new routes are available. This may degrade the QoS of the application. However, initiating route discovery every time one of the routes fails will involve high overheads. Performing route discovery when x no of routes fail, where x is less than the number of paths available, may be a good solution.

4.7. 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. It tries to optimize bandwidth allocation from networks point of view and allows for finer control over the network resources. It is difficult to evenly distribute traffic amongst the paths in the per-connection case, because all the connections experience different traffic rates.

4.7. Coupling and Correlation

This issue relates to the degree of similarity between fail safe paths. Means what degree of node and link sharing be allowed between multipath sets so that it is useful to keep them as separate paths.

4.8. Collision

In case of link disjoint Nodes communicate through the wireless medium. If a shared channel is used, neighbouring nodes must contend for the channel. When the channel is in use by a transmitting node, neighbouring nodes hear the transmission and are blocked from receiving from other sources. Furthermore, depending on the link layer protocol, neighbouring nodes may have to defer transmission until the channel is free. Even when multiple channels are used, the quality of neighbouring transmissions may be degraded due to interference.

5. CONCLUSIONS

Multipath routing is an effective means of improving the performance of on-demand routing protocols in MANETs. Having backup routes to a destination helps reduce packet loss and the frequency of route discovery (specially in the presence of mobility-induced failures), which is a major source of performance loss and latency in on-demand protocols like DYMO. Simultaneously, finding multiple paths in a single route discovery reduces the routing overhead incurred in maintaining the connection between source and destination nodes. Multipath routing can provide load balancing under actual traffic conditions. Quality of service should be measured multiple metrics, not in terms of specific metrics, such as bandwidth, delay, or reliability. For instance, when searching for multiple paths that have the required bandwidth, it is desirable to find reliable and non energy constraint paths. Given the faulty nature of MANETs, constructing a multipath route that meets the bandwidth requirements while also meeting certain other requirements would result in better performance. It would be desirable to develop a multipath protocol that can provide delay bounds or guarantees.

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