

Optimizations To Multipath Routing Protocols In Mobile Ad hoc Networks

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Abstract – Mobile Ad hoc Networks are typically characterized by high mobility and frequent link failures. As a result, routing algorithms selecting a single path during route creation have to make frequent route discoveries resulting in decreased throughput and high end-to-end delay. Multipath routing approaches like AOMDV make use of pre-computed routes determined during route discovery. This solution, however, suffers during high mobility because the alternate paths are not actively maintained. Hence, precisely when needed, the routes are often broken. In this paper, the information gathered by a node about its neighbor, in addition to those proposed in [1], is used to dynamically determine the node to which a particular data packet has to be forwarded. Using this approach a better load balancing can be obtained in addition to utilization of the additional routes, if feasible, and in the process maintaining these routes. We also explore the possibility of implementing QoS using such a scheme.

I. OVERVIEW

A Mobile Ad hoc network is an instantly deployable wireless network without any base station or infrastructure support. Because the Ad hoc networks can be easily deployed, they are used in applications such as automated battlefields, search and rescue, crowd control, and disaster management. These situations are characterized by dynamic topologies, bandwidth-constrained, variable capacity links, energy constrained operation and limited physical security [2]. In these scenarios, it is essential to perform routing with maximal throughput and, at the same time, with minimal control overhead. Overhead here is defined in terms of the routing protocol control messages which consume both channel bandwidth as well as the battery power of nodes for communication/processing.

The most popular routing strategy, for reducing the overhead, is on demand routing wherein the routing protocols build and maintain only needed routes. Examples include Ad hoc On-demand Distance Vector routing (AODV) [3, 4], Dynamic Source Routing (DSR) [5], and Temporally-Ordered Routing Algorithm (TORA) [6]. Several performance studies [8, 9] of ad hoc networks have shown that on-demand protocols incur lower routing overheads compared to their proactive counterparts as Destination-Sequenced Distance-Vector Routing protocol (DSDV) [10]. However, they are not without performance problems. High route discovery latency together with frequent

route discovery attempts in dynamic networks can affect the performance adversely. Also, frequent route breaks cause the intermediate nodes to drop packets because no alternate path to the destination is available. This reduces the overall throughput and the packet delivery ratio. Moreover, in high mobility scenarios, the average end-to-end delay can be significantly high due to frequent route discoveries.

Multipath on-demand protocols, like Adaptive On-demand Multipath Distance Vector (AOMDV) routing [7], try to alleviate these problems by computing and caching multiple paths obtained during a single route discovery process. The performance of these protocols tends to increase with node density; at higher node densities, a greater number of alternate paths are available. In such protocols a link failure in the primary path, through which data transmission is actually taking place, causes the source to switch to an alternate path instead of initiating another route discovery. A new route discovery occurs only when all pre-computed paths break. This approach can result in reduced delay since packets do not need to be buffered at the source when an alternate path is available. But one problem with these Multipath protocols like [7] is that although during the route discovery process multiple paths are discovered, only the best path based on some metric is chosen and is used for data transmission. The other paths are used only when the primary path fails. But in most cases, due to non-maintenance of these paths, the alternate paths are rendered invalid by the time they are required. Using such stale or invalid paths result in more dropped packets as each of the alternate routes is tried in succession.

In [1], Roy et al suggested the introduction of a new layer between the routing entity in the Network Layer and the MAC Sublayer to add certain functionalities to the routing protocols in the Ad hoc networks. In this paper we propose to augment the functionality of this New Layer by obtaining the strength of the signals from the neighbors and resource usage statistics of the neighboring nodes in addition to the stability information as proposed in [1].

The rest of the paper is organized as follows: Section 2 gives a brief summary of motivation and previous works, Section 3 provides a detailed description of the proposed changes while Section 4 concludes the paper.

IP Address	MAC Address	Beacon counter	Time stamp	Neighbor State	Fractional Resource Usage	Battery Power Left	Signal Strength
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Fig. 1. Table header of the Neighbor Information Table

II. MOTIVATION AND RELATED WORK

As proposed by [7], Ad Hoc On-Demand Multipath Distance Vector Routing (AOMDV) protocol discovers multiple routes during route discovery. AOMDV creates multiple loop-free link disjoint paths. However one limitation is that all the routes are not maintained simultaneously and as a result they timeout, thereby nullifying the advantage of multiple paths. In [11] Sambasivam et al propose to use periodic update packets unicast along each path which are used to measure the signal strength of each hop along the alternate paths and at any point, only the path with the strongest signal strength is used for data transmission.

In [1], Roy et al propose a New Layer that is capable of gathering Neighbor Stability information which can be used to modify the routing algorithms like AODV so as to refrain them from accepting spurious route update messages (like the route updates broadcast by nodes passing by) to avoid unstable neighbors to be identified as the forwarding node. For this purpose, a *Protocol Specific Beacon* has been used. In this paper, we propose to augment this beacon so that the nodes in the network can piggy-back their status information like the current fractional usage of its available bandwidth, available battery power etc. In addition to the neighbor stability information as in [1], a neighboring node's signal strength is also measured as a metric for node stability, as proposed in [12]. Using these additional pieces of information, the routing entity in the Network Layer can decide to select the optimal paths, from the set of available multiple paths, through which the packet has to be forwarded. Stated otherwise, the routing entity does not statically select a route to be optimal at the time of route discovery. Instead it dynamically determines the optimal route every time a data packet has to be forwarded. This dynamic selection of forwarding path has a two fold advantage in addition to those provided by the traditional Multipath routing algorithms as [7]: first, it allows a proper load distribution throughout the network by using the additional paths to carry some traffic provided it is feasible, and second, as in most cases, the alternate routes are being used for data transfer and hence are updates thereby preventing the timing out of these routes.

III. PROPOSED MODIFICATIONS

The New Layer in [1] does the task of neighbor detection by sending periodic beacons. When a node receives a beacon from a neighboring node, it updates

the fields in a table, which we call *Neighbor Information Table* (NIT). In this paper, we augment this beacon to carry information about its present status, as hinted in Section 2. Whenever a node receives a beacon from a node within its radio range, it will update the corresponding fields in the neighbor table with the information extracted from the beacon. Also, from the link layer measurements, the strength of signal from the neighboring node can also be obtained and the corresponding field in the NIT can be updated. It is this NIT which the new layer shares with the routing entity and is used by it to dynamically determine to which node a data packet would be forwarded. A detailed description of the proposed mechanism is discussed in the following subsections.

A. Finding multiple loop-free link-disjoint paths

In this paper we propose an optimization over the existing Ad Hoc On-Demand Multipath Distance Vector Routing (AOMDV) protocol [7]. So we use the route discovery scheme proposed by Marina et al in [7]. This ensures the creation of multiple paths during the query/reply based route discovery process. This algorithm creates loop-free routes using the notion of "*advertised hopcount*", and ensures link-disjointness of the multiple paths computed during a single route discovery as proposed in [7].

B. Structure of the Neighbor Information Table

The NIT is used to store stability information about the neighboring nodes which is used by the routing entity for dynamically determining the next hop for a particular packet. This table is maintained by the New Layer, as proposed in [1], by augmenting the protocol specific beacons to carry the node status information. A node creates a beacon message containing information of its battery power and the fraction of its available bandwidth currently being used. It then periodically broadcasts these messages to its neighbors, i.e. the nodes within the range of its antenna. These messages, in addition to notifying its presence, provide these additional data to its neighbors. The table header is provided in Fig 1.

The IP address and MAC address uniquely identify a neighbor about which information is being maintained. Beacon Counter gives a count of the number of beacons received by the node. The Time Stamp gives the time at which the table was last updated; Fractional Resource Usage provides the fraction of the Node's bandwidth which is currently being used. The other field names are self

explanatory and provide information about the neighboring node.

C. *Creating and maintaining the Neighbor Information Table*

Whenever a node receives a beacon from a neighbor, it extracts the data from it and updates the NIT with the information corresponding to that node. The strength of the signal from a neighbor can be determined by link layer feedback as proposed by [12]. For updating the State of the neighbors, the scheme proposed in [1] is used. The New Layer periodically updates this table to reflect the present status of the neighbors. The modified AOMDV routing protocol uses information from this table to select, from the list of nodes available from the possible multiple paths in the Route Table, the node to which the data packet has to be forwarded.

D. *Routing decisions*

Whenever a node has to send a data to some destination, it takes the following routing decisions while forwarding the packet:

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if (no route to destination) {
    initiate route discovery as in AOMDV;
}
if (single known route) {
    forward data packet to specified next hop;
} else {
    forward data packet to best neighbor1;
}
```

E. *Incorporating Quality of Service (QoS)*

The gathered information in the NIT equips a node to provide Quality of Service wherever required by the layers above. For example, for transmission of real-time data like streaming video or audio on demand, the loss of a segment is not as fatal as a delayed segment. For such applications the node can forward these segments to the neighbor that provides a route with minimum number of hops and minimum delay. The delay may be determined from the Resources Usage field in the NIT.

Another scheme as proposed in [13] is the Maximum Delay Extension, maximum time allowed

for a transmission from the source to destination, which can be appended to a RREQ by a node requesting a QoS route in order to place a maximum bound on the acceptable time delay experienced on any acceptable path from the source to the destination. Before forwarding the AOMDV RREQ, an intermediate node compares its Node Traversal Time to the remaining delay indicated in the Maximum Delay Extension. If the Delay is less, the node must discard the RREQ and not process it any further. Otherwise, the node subtracts Node Traversal Time from the Delay value in the extension and continues processing the RREQ.

IV. CONCLUSION AND FUTURE ENHANCEMENTS

In this paper we propose a possible optimization to the AOMDV routing protocol in order that the alternate routes, discovered during the route discovery process, are maintained and the load can be effectively distributed so that no node is overburdened i.e. it is made to carry most of the traffic from a particular node. This is true only when an alternate route exists. Data transmission through these alternate routes helps maintain them and prevent them from timing out. We have proposed an approach for selecting the best possible next hop from a list of neighbors. In future we aim to find out an expression that would select the optimal next hop based on the various values obtained from the NIT. We also aim to evaluate how this optimized algorithm performs based on some metrics like Packet Delivery Ratio, Average End-to-End Delay and Control Overhead.

In this paper we also propose a scheme to incorporate QoS using this technique. We hope to explore this issue in greater detail in future papers. We also aim to explore the impact of other link state metric such as error rates, jitter etc on QoS routing.

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¹ The determination of best neighbor is based on the type of service required by the Application Layer. For instance, long lived connections like FTP require a reliable connection; hence a Stable Neighbor with better signal strength is selected for forwarding the packet. The selection of the next hop may be done by some invocation of certain functions. For the purpose of load balancing, a node with smaller fractional resource usage is given priority. As a result, the over-burdening of certain nodes can be avoided.

VI. REFERENCE

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