A SURVEY ON QUALITY OF SERVICES AWARE ROUTING PROTOCOL IN MANET

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Abstract: The attractive infrastructure-less nature of mobile ad hoc networks (MANETs) has gained a lot of attention in the research community. With the success of solving the most basic but important problems in all network layers, people realize there is commercial value in MANETs. Most applications that attract interest for use in current wired networks (e.g., video conferencing, on-line live movies, and instant messenger with camera enabled) would attract interest for MANETs as well. However, ad hoc networks present unique advanced challenges, including the design of protocols for mobility management, effective routing, data transport, security, power management, and QoS provisioning. Once these problems are solved, the practical use of MANETs will be realizable. The overall design of a solution for all of these problems is currently too complex. In this paper, we discussed about supporting quality of service (QoS) in the routing protocols.

Keywords: MANET, QoS, Routing Protocols, Routing discovery and reservation, bandwidth

I.INTRODUCTION

Most real-time applications can optimize their performance based on feedback about network resource availability. For example, layered coding allows enhanced layers of different quality levels to be transmitted, provided a minimum bandwidth is guaranteed for transmitting the base layer. Therefore, these types of applications can benefit from QoS adaptation. By providing feedback to the application about available resources, the application can alter its coding strategy to provide the best quality for the current resource limitations.

Routing is used to set up and maintain paths between nodes to support data transmission. Early MANET routing protocols, such as AODV [1], DSR [2], TORA [3], and DSDV [4] focused on finding a feasible route from a source to a destination, without considering any optimization for utilizing the network resources or supporting specific application requirements. To support QoS, the essential problem is to find a route with sufficient available resources to meet the QoS constraints, and possibly add some additional optimizations such as finding the lowest cost or most stable of the routes that meet the QoS constraints. Given these goals, the following are the basic design considerations for a QoS-aware routing protocol.

- **Bandwidth Estimation:** To offer a bandwidth-guaranteed route, the key idea is to obtain information about the available bandwidth from lower layers. This bandwidth information helps in performing call admission and QoS adaptation. In MANETs, hosts share the bandwidth with their neighbor hosts, and thus the bandwidth available to a node is a dynamic value that is affected by its neighbors' traffic. Therefore, the two key problems in bandwidth estimation are how exactly to estimate the available bandwidth and how frequently to do the estimations. Also, the trade-off between the benefit from using bandwidth estimation and the cost in terms of packet overhead and computing resources used for bandwidth estimation is another key issue.
- **Route discovery:** There are two main approaches to routing in MANETS: reactive routing and proactive routing. Reactive routing reduces overhead at the expense of delay in finding a suitable route, whereas the reverse is true for proactive routing. For QoS-aware routing, another issue is determining what combination of reduced latency and reduced overhead is best for supporting QoS.
- **Resource reservation:** The bandwidth resources are shared by neighboring hosts in MANETs. Therefore, another challenging issue is how to allocate this shared resource and what type of resource reservation scheme should be used for setting up and maintaining the QoS-aware route.
- **Route maintenance:** The mobility of nodes in MANETs causes frequent topology changes in the network, making it difficult to meet the QoS constraints. Incorporating a fast route maintenance scheme into QoS-aware routing is the fourth design consideration. The typical approach to route maintenance, which entails waiting for the host to discover a route break, significantly affects the routing performance. Therefore, some prediction scheme or redundant routing is necessary to assist in route maintenance.
- **Route selection:** QoS-aware routing has more stringent requirements on route stability, since frequent route failures will adversely affect the end-to-end QoS. Thus, in some sense the path with the largest available bandwidth

is not the only consideration-path reliability should also be considered when selecting a suitable path for a QoS-aware routing protocol.

Several routing protocols [5] [6] [7] have been developed that support QoS by choosing routes with the largest available bandwidth, providing a all admission feature to deny route requests if there is not enough bandwidth available to support the request, or providing feedback to the application about available bandwidth resources. These protocols address all of the issues described above.

II. QOS-AWARE ROUTING PROTOCOLS

a) Core-Extraction Distributed Ad Hoc Routing (CEDAR)

CEDAR [5] is a routing protocol that dynamically establishes a core set for route setup, QoS provisioning, routing data, and route maintenance. A core is an approximation of a minimum dominating set, whereby all hosts in the network are either members of the core or one-hop neighbors of core hosts. CEDAR assumes that the MAC/link layer can estimate the available link bandwidth of each core host, and every core's available bandwidth information is disseminated to all other cores. CEDAR uses this core structure to reduce routing overhead, as only core nodes must keep track of bandwidth information. CEDAR employs increase waves and decrease waves to propagate the QoS state information, and it uses the state information to determine appropriate routes to support QoS.

- **Core Extraction**
  The core structure is used to limit the number of nodes that must participate in the exchange of topology and available bandwidth information. The goal of setting up the core is to proactively create a core set such that every node is either a core node or a neighbor of a core node. To generate the core, a greedy algorithm is used to select core nodes to obtain a good approximation of a minimum dominating set. Each core node maintains local topology information and performs route discovery, route maintenance and call admission on behalf of these nodes.
- **Link State Propagation**
  To propagate state information (available bandwidth) among the core nodes, *increase waves* and *decrease waves* are used. These waves are generated when a core node's available bandwidth has changed by a certain amount. Therefore, information about small changes in available bandwidth is kept locally, and only relatively stable bandwidth information is propagated among the core hosts. Increase waves, which provide information about an increase in a core node's available bandwidth, are propagated periodically, whereas decrease waves, which provide information about a decrease in a core node's available bandwidth, are propagated immediately so that core nodes never overestimate another core node's available bandwidth.
- **Route Computation**
  Route computation includes establishment of the core path from the source to the destination via the core nodes, QoS route computation using local information cached by the core hosts along the core path for call admission, and dynamic re-routing for ongoing connections. To establish a route, a source node sends a request to its dominator, the node's selected core host, and the dominator initiates a core broadcast. The core hosts who relay this broadcast attach their ID in the packet. The dominator of the destination will send a *core path ack* message to the dominator of the source. The *core path ack* indicates a path from the dominator of the source to the dominator of the destination and thus sets up a valid core route from the source to the destination via the core nodes.

b) Ticket-based QoS Routing

Chen and Nahrstedt propose a distributed, ticket-based QoS routing protocol [6] that uses tickets to find delay-constrained or bandwidth-constrained routes. Tickets are distributed during route discovery to provide a means to measure bandwidth/delay and limit the flooding for route request packets. Two types of tickets are used during route discovery: yellow and green tickets. Yellow tickets are used for finding a feasible route with certain delay/bandwidth constraints. Green tickets are used for determining low cost routes. The number of tickets indicates the number of probes made to find a feasible path. Therefore, when a source node wants to find a QoS-aware path, it first decides the number of tickets it should issue according to the QoS constraint. More tickets are issued by the source host to increase the chance of finding a feasible path if the constraints are strict. In order to find a delay-constrained path, intermediate hosts forward more yellow tickets to their neighbors that have lower delay links and more green tickets to their neighbors that have lower cost links. If the delay in a certain intermediate host exceeds the maximum delay allowed, this intermediate host sets the ticket as invalid. The destination chooses the path with the lowest cost among the paths that have valid tickets.

In order to find a bandwidth-constrained path, the intermediate hosts relay the yellow tickets to their neighbors according to their neighbors' residual bandwidth, and they forward the green tickets to their neighbor according to their neighbors' link cost. Thus, neighbors whose bandwidth exceeds the request more get more yellow tickets and neighbors whose cost is lower get greener tickets. If none of the neighbors has sufficient bandwidth, the yellow tickets are marked as invalid. Similar to the delay constrained path, the destination chooses the lowest-cost feasible path. This approach incorporates the imprecision of each node's estimate of their neighbors' available resources for delay-aware and bandwidth-aware routing by using an imprecision model. The imprecision model uses a weight function with the variables of old bandwidth/delay state and new bandwidth/delay state to estimate the current bandwidth/ delay within some precision tolerance. Furthermore, tickets are forwarded so as to provide multi-path searching for paths that satisfy the QoS constraints, thereby adding redundancy for fault tolerance.

c) Ad Hoc QoS On-demand Routing (AQOR)

AQOR [8] is a QoS-aware routing protocol with the following features: (1) available bandwidth estimation and end-to-end delay measurement, (2) bandwidth reservation, and (3) adaptive route recovery. AQOR is an on-demand QoS-aware routing protocol. When a route is needed, the source host initiates a route request, in which the bandwidth and delay requirements are specified. The intermediate hosts check their available bandwidth and perform bandwidth admission hop-by-hop. If the bandwidth at the intermediate host is sufficient to support the request, an entry will be created in the routing table with an expiration time. If the reply packet does not arrive in the allotted time, the entry will be deleted. Using this approach, a reply packet whose delay exceeds the requirement will be deleted immediately in order to reduce overhead.

To estimate available bandwidth for assisting in call admission, each node puts its reserved bandwidth in periodic Hello messages that are sent to their neighbors. AQOR uses the sum of a node's neighbors' traffic as the estimated total traffic affecting the node. Note that this estimated traffic can be larger than the real overall traffic. This overestimation imposes a stringent bandwidth admission control threshold. The available bandwidth is thus a lower bound on the real available bandwidth. End-to-end one way downstream delay is approximated by using half the round trip delay. With the knowledge of available bandwidth and end-to-end delay, the smallest delay path with sufficient bandwidth is chosen as the QoS route.

Temporary reservation is used to free the reserved resources efficiently at each node when the existing routes are broken. If a node does not receive data packets in a certain interval, the node immediately invalidates the reservation. This avoids using explicit resource release control packets upon route changes. The adaptive route recovery procedure includes detection of broken links and triggered route recovery at the destination, which occurs when the destination node detects a QoS violation or a time-out of the destination's resource reservation.

d) Trigger-based Distributed QoS Routing (TDR)

TDR is a location-based routing protocol proposed by Ge et al. [10]. This protocol distinguishes itself from other location-based protocols by using a local neighborhood database, an activity-based database, call admission during route discovery, soft reservations, and route break prediction to support QoS.

Every host keeps two databases: a local neighbor database and an activity-based database. Hosts are required to periodically broadcast beacons that carry their location and mobility information. The neighbors that receive these beacons record the power level of the received beacon and the location and mobility information in their local neighbor database. Besides the neighborhood database, every node that participates in a data transmission session keeps an activity-based database. In the activity based database, session ID, source ID, destination ID, source location, maximum bandwidth demand, maximum acceptable delay, destination location, next node ID, previous node ID, distance from source and activity flag are recorded for every session. The activity-based database is refreshed by in-session data packets, which makes this a soft-state database.

When the source node wants to initiates a route discovery, it floods route discovery packets to its neighbors, but to ensure stable routes, only neighbors who receive the packet with power greater than a certain threshold will be considered as possible links in the route. When the destination location is available in the source cache, selective forwarding based route discovery is used. During the process of forwarding the route discovery packet, intermediate hosts check whether their residual bandwidth is sufficient to meet the request. If not, the intermediate hosts do not forward the route discovery packet. Thus admission control is performed according to the resources available in the network.

The destination node sends back a route acknowledgement when it receives the first discovery packet. Upon receiving this acknowledgement packet, the reserved bandwidth in the databases of all intermediate nodes is updated. The destination also sends its location update via the route acknowledgement packet when there has been an appreciable change in its location (based on the destination's own GPS information).

To predict route breaks, three different receive power levels are defined: $Pth1 > Pth2 > Pcr$. When the receive power level at a particular link is lower than Pcr, the upstream active node initiates a rerouting process, which is called link degradation triggered rerouting. When the power level is between $Pth2$ and Pcr, the intermediate node sends a rerouting request to the source node. Upon receiving the request, the source initiates a rerouting procedure. When the power level is between $Pth1$ and $Pth2$, the intermediate node initiates the rerouting.

e) TDMA Scheduling Supported QoS Routing

In the DSDV/TDMA routing protocol, the source host sends a reservation packet to the destination. The intermediate hosts, who are chosen to participate in the data forwarding for this flow, are asked to calculate their available bandwidth before forwarding the reservation packet. If the intermediate node's available bandwidth is sufficient to support the request, the corresponding resources are reserved using a slot scheduling scheme. Otherwise, a RESET message is sent back to the source to free the reserved time slots hop-by-hop. Once the reservation packet reaches the destination and passes the bandwidth check, the destination sends back a REPLY packet along the reserved path set up by the reservation packet. If the REPLY does not go through the hosts that reserved bandwidth for this flow within a certain expiration time, the time slots are freed. After the source host receives the REPLY packet, the path is set up. To enable fast route rerouting in the event of route failure, a standby path is always found in addition to the main path.

The Reactive/TDMA protocol uses the same techniques as the DSDV/TDMA protocol, namely bandwidth calculation and slot assignment. To initiate a route discovery, the source broadcasts a RREQ with fields _ *packet type, source addr,* *dest addr, sequence number, route list, slot array list, data, TTL* _. The hosts that receive the RREQ append themselves in the *route list*, calculate their available bandwidth, and record their available time slots in the *slot array list*. Once the destination receives a RREQ, it returns a route reply (RREP) to the source. Resources are reserved on a hop-by-hop basis as the RREP packet is sent from the destination to the source. If resource reservation cannot be accomplished due to time slots reserved by other flows, a RESERVE FAIL packet is sent back to the destination. The destination will restart the reservation by choosing another path. If all the trials fail, a NO ROUTE packet will be sent to the source. If a route is broken, a ROUTE BROKEN packet will be sent to both the source and the destination to release the reserved bandwidth.

III.CONCLUSION

The MANET Issue in QoS-aware routing is bandwidth/delay estimation, route discovery, resource reservation and rerouting. The challenge in wireless ad hoc networks is that neighboring hosts must share the bandwidth, and there is no centralized control for allocating bandwidth among the nodes. Furthermore, intermediate hosts take part in forwarding packets. Therefore, the total effective capacity achievable is not only limited by the raw channel capacity, but it is also limited by the interaction and interference among neighboring hosts. Most QoS-aware routing protocols, such as CEDAR, Ticket-based QoS Routing, ADQR and TDR, assume that the available bandwidth is known. However, some routing protocols try to propose an appropriate way to estimate the available bandwidth, such as OLSR-based QoS routing, AQDR, DSDV/TDMA and Reactive/TDMA.

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