RESEARCH ARTICLE OPEN ACCESS

Congestion Control Load Balancing Techniques in MANET: A Survey

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Abstract
In Mobile Ad hoc Network (MANET), there is no pre-existing communication infrastructure (no access points, no base stations) and the nodes can freely move and self-organize into a network topology. Such a network can contain two or more nodes. Hence, balancing the load in a MANET is important because the nodes in MANET have limited communication resources such as bandwidth, buffer space and battery power. Scalability is of particular interest to ad hoc network designers and users and is an issue with critical influence on capability and capacity. Where topologies include large numbers of nodes, routing packets will demand a large percentage of the limited wireless bandwidth and this is exaggerated and exacerbated by the mobility feature often resulting in a high frequency of failure regarding wireless links. In this paper we present a inclusive survey and categorization of recently published congestion handling and load sharing multipath techniques. These surveys focus on various load metrics and various load balancing routing protocols for efficient data transmission in MANET.
Index Terms—Survey, Load balancing, Mobile Ad hoc networks, routing, multipath.

I. INTRODUCTION

Mobile Ad hoc Network (MANET) is a decartelized wireless network, which consists of a collection of mobile nodes. It means nodes communicate with each other without the need of centralized access points or base stations. A MANET is self-organizing, and adaptive network. Due to the limited transmission range of the nodes, multiple hops may be needed in exchanging data between two nodes. Each node in a MANET acts both as a router and as a host. MANETs exhibit unique characteristics such as free node mobility, unpredictable link properties, dynamic topology, limited bandwidth, and limited energy resources. In fact, there are many restrictions that make MANET a network with complicated topology, especially the bandwidth, memory, and energy constrained. One of the most essential characteristics in MANETs is that each node in the network will have two rules at the same time; host role and router role. Ad hoc networks are widely used in the automated battlefields, search and rescue, crowd control, and disaster management [18].

The multipath routing appears an efficient solution for the ad hoc networks [2]. It can provide load balancing and route failure protection by distributing traffic among a set of diverse paths [3, 4]. But this repartition is more efficient if we use a load balancing mechanism allowing distributing the traffic through the less congested route. Due to their decentralized, self-configuring and dynamic nature, MANETs offer many advantages and are easy to install. But with this dynamic topology, mobile ad hoc networks have some challenges like the design of an efficient routing protocol. An example for this challenge is load balancing. The multipath routing protocol with load balancing provides a solution for the congestion network and increases its capacity. To consider the use of multiple paths simultaneously for transmission data allows improving the network performance.

However, the advantages of multipath routing come at a price as concurrent data transmission along multiple paths interfere with each other. Further, when network traffic starts increasing, there will be increased level of contention among nodes coupled with higher collision level consequently leading to packet drops and network level congestion. So a routing metric needs to be judiciously selected while constructing multiple paths that avoids high interference areas and high contention areas. To ease out the network wide congestion ,we adopt congestion aware metric for route selection combined with a good traffic distribution strategy that distributes the load according to quality of a path .

II. ROUTING PROTOCOLS CATEGORIZATION AND CLASSIFICATION

The routing protocols in MANET can be categorized in to three different groups like Table Driven or Proactive, On-demand or Reactive and Hybrid routing protocols.

In Table Driven routing protocols, each node stores and maintains routing information to every other node in the network. This is done by periodically exchanging routing table throughout the networks. These Protocol maintain tables at each node which store updated routing information for every node to every another node within the network.

In on-demand routing protocols, routes are created when required by the source node, rather than storing up-to-date routing tables.

Hybrid routing protocols are combine the basic properties of the two classes of protocols.

Routing protocols for MANETs can be classified in several ways one of the classifications is according to the number of paths, uni-path routing protocols and multipath routing protocols. In uni-path routing protocols ones route is used to deliver data from source node to destination node while in multipath routing protocols more than one route is used to deliver the data [5].

Due to the dynamic nature of the network, ad hoc routing faces many unique problems not present in wireless and wired networks. Due to node mobility, node failures, and the dynamic characteristics of the radio channel, links in a route may become temporarily unavailable and making the route invalid. The overhead of finding alternative routes may be high and extra delay in packet delivery may be introduced. The multipath routing addresses this problem by providing more than one route to a destination node. Multipath routing appears to be a promising technique for ad hoc routing protocols.

Providing multiple paths [5, 6] specifically disjoint paths is beneficial in network communications, where routes are broken and the session is still active. Also because of mobility and poor wireless link quality, the source and intermediate nodes can use these routes as primary and backup routes. Alternatively, traffics can be distributed among multiple paths for maximizing network lifetime and enhancing load balancing.

Recent researches below in related work section have shown that the data flow between the source and destination MANET nodes could be speeded up if it is efficiently split on multiple paths between them. The source node will estimate how busy these paths are and send packets to these paths according to its estimation (load balancing).

III. OVERVIEW OF LOAD BALANCING

Because of congestion, it is essential to adjust the data rate used by each sender in order not to overload the network, where multiple senders compete for link bandwidth. Packets are dropped when they arrive at the router and cannot be forwarded. Many packets are dropped while excessive amount of packets arrive at a network bottleneck. The packets dropped would've traveled long way and in addition the lost packets often trigger retransmissions. This intimates that even more packets are sent into the network. And so, network throughput is still more worsened by the network congestion.

Load balancing [7] is a methodology to distribute workload across multiple paths, to achieve optimal resource utilization, maximize throughput, minimize response time, increase network life time, and avoid overload. Using multiple paths with load balancing, instead of a single [5] path, may increase reliability through redundancy. The load balancing service is usually provided by dedicated software or hardware, such as a multilayer switch or a Domain Name System server.

Load balancing techniques may have a variety of special features as:

A. Asymmetric Load:

A ratio can be manually assigned to cause some paths to get a greater share of the workload than others.

B. Priority Activation:

The workload is distributed according to paths priority as the size of free bandwidth and number of hops.

IV. RELATED WORK

In paper [1] present method for avoid congestion in MANET environment using bandwidth estimation technique. This approach uses acknowledgement time intervals for bandwidth estimation in TCP flow, this scheme monitors the time spacing between received acknowledgements (ACKs) at the sender node and find out the available bandwidth of the connection between sender to destination, if available bandwidth is less than the actual data size so they decrease the data size according to available bandwidth and avoid congestion, and same time other sender node try to communicate any destination through same available path which is used by previously senders so new sender node and all other previously communicated sender node sends data according to available bandwidth of the intermediate nodes. So they increase the network performance and provide congestion free communication.

In this paper [8] a technique for Multipath Load Balancing and Rate Based Congestion Control (MLBRBCC) is presented. On reception of the data packet at the intermediate node, percentage of channel utilization and queue length are estimated and node is verified for congestion status. This process is repeated at every intermediate node, and finally the packet reaches the destination node. After the reception of the data packet, the destination node checks for the rate information in the packets IP header fields. Along with other essential fields, estimated rate is copied to an acknowledgement packet and sent as a feedback to the sender. The sender performs rate control according to the estimated rate obtained from the destination.

In this paper [9], we have proposed congestion controlled adaptive multi-path routing protocol to achieve load balancing and avoid congestion in MANETs. The selected fail-safe multiple paths include the nodes with least load and more battery power and residual energy. When the average load of a node along the route increases beyond a threshold, it distributes the traffic over disjoint multi-path routes to reduce the traffic load on a congested link.

In [10] proposed a novel rate based end-to-end Congestion Control scheme (RBCC). Based on the novel use of channel busyness ratio, which is an accurate sign of the network utilization and congestion status, a new rate control scheme has been proposed to efficiently and reliably support the transport service in MANET. In RBCC, a sublayer consisting of a leaky bucket is added under TCP to control the sending rate based on the network layer feedback at the bottleneck node.

In [11] proposed a complete reliable rate-based protocol based on TCP-Friendly Rate Control (TFRC) and selective acknowledgement (SACK) mechanisms. This design also introduces a flow control variable, which regulates the sender to avoid packet loss at the receiver due to a slow receiver. In this mechanism, there is no packet loss due to flow control, at the receiver, and applies a smoothness criterion to demonstrate that the introduction of the flow control inside TFRC does not alter the smoothness property of this mechanism.

In [12] proposed a fully distributed congestion control algorithm to balance throughput and fairness for TCP flows in multihop ad hoc networks. The interactions between the hidden nodes and network congestion are mainly focused. A distributed algorithm to improve the end-to-end throughput, and at the same time, provide per-flow fairness by exploiting cross-layer information is proposed. In the link layer, each node uses a proportional controller to determine the ECN marking probability for the purpose of notifying incipient congestion. Then the rate based TCP sender adjusts its sending rate according to the feedbacks from the link layer.

In this paper [13] the protocol preserved the multiple paths carrying a higher hop count value and used them as alternate routes in case of link failure. The major problem of node failure is congestion. Queue Length detects congestion in the network. Queue Length and Hop Count value are together used to select a route from source to destination that avoids congestion and load balancing. If Queue length crosses a certain threshold value then Load balancing via alternate paths is carried out. The protocol will avoid congestion on routes by carrying a good route discovery technique, balance load on account of congestion that would definitely to an extent avoid node failures and has improved packet delivery ratio, throughput, reduced packet delay and packet drop.

This paper [14] presents a novel approach called Multipath QoS Mobile Routing Backbones (MP-QMRB) for enhanced load balancing in MANETs. The approach we propose employs multiple mobile routing backbones (MRB) between a pair of source and destination nodes using intermediate nodes which are rich in resources like bandwidth, processing power, residual energy etc. The protocol ensures that the available bandwidth in the network is utilized efficiently by distributing traffic evenly which ensures better load balancing and congestion control. This approach improves network throughput and packet delivery ratio and reduces end-to-end delay considerably by directing traffic through lowly congested multiple routing backbones that are rich in resources.

In this paper [15] we present a congestion adaptive multipath routing protocol to increase the throughput and avoid congestion in MANETs. In our approach when the average load of an existing link increases beyond a defined threshold and the available bandwidth and residual battery energy decreases below a defined threshold, traffic is distributed over fail-safe multiple routes to reduce the traffic load on a congested link. Through simulation results, we show that our proposed approach achieves better throughput and packet delivery ratio with reduced delay for constant bit rate (CBR) traffic when compared with QMRB, a protocol using mobile routing backbones.

DLAR [16] discussed that the destination sends the load information attached in the RREP packet to source. After receiving the RREP packet the least congested route will be used as the primary route. DLAR periodically monitors the congestion status of active data sessions and dynamically reconfigures the routes that are being congested. The least loaded routes help us to balance the load of the network node and utilize the network resources efficiently. Here the problem is that it does not allow intermediate nodes to reply from cache so even if the intermediate nodes possess the route to the destination it is not allowed to send a reply which leads to excessive and unnecessary route discoveries.

Work Load-Based Adaptive Load-Balancing [17], proposed that the nodes forward or broadcast the RREQ packet on the condition that they do not have a route to the destination. If they have a route to the destination the RREP packet containing the route is sent to the node running the route discovery. The protocol proves that the maximum congestion and bandwidth utilization is caused by the broadcast done by RREQ. When a node receives a RREQ, if the interface queue length of a node is greater than the threshold value, the node drops the RREQ. If not greater, the node forwards the RREQ. In doing so, additional traffic flows are not allowed to set up through overloaded nodes, and therefore, the overloaded nodes are naturally excluded from the newly requested paths. The threshold value is initially set to a pre-determined value. The threshold value keeps changing according to the load status of a node. If a node experiences overload to an extent, its threshold value decreases. When the node senses that its load has been low for a long enough period, it is considered as an indication that the node's overloaded status is dissolved, and its threshold value returns to the initial value.

V. STATEMENT OF PROBLEM

In this paper we describe survey about various congestion control technique under multipath as well as uni-path routing, and those existing technique base here we consider to minimize congestion using TCP rate control as well as dynamic queue base scheme and analyze the performance of the network.

VI. PROPOSED WORK

In our proposed work we use acknowledgement time intervals to estimation available bandwidth for congestion control. This available bandwidth estimation helps to avoid congestion in the network. The available bandwidth is the amount of the share of the bandwidth that the flow can occupy without affecting other flows. In case of fully congested situation over intermediate path node, the delay of acknowledgments reception per estimated time period at the sender node can be affected to the fair share of bandwidth. In a fully congested situation, fair share cannot be higher than achieved throughput as it will affect other flows. But for partial congestion or no congestion, the fair share is certainly higher than the achieved throughput. means if we transmit data packet in ideal case (without congestion) means normal data delivery to the destination, but if any intermediate path node use by the any other sender node at the same time on the same route due to increase data packet sending load on intermediate path node because first node already sending data packet on same intermediate path node so first sender data delivery delay will be increases and also if both sender send's data greater than the available bandwidth so grunted that data has been dropped and acknowledgement of sending packet will be delay due to congestion on intermediate path node, to avoid this situation we used bandwidth estimation technique to obtain available bandwidth of intermediate path nodes. If the delay of received acknowledgment of the sending packet at the sender node is increases, then in our approach we calculate delay difference between previous acknowledgment Ack_{n-1} and current acknowledgment Ack_n send by the destination node, we assume Δt is delay difference of two acknowledgement. So, we can calculate Δt as follows.

$$\Delta t = (Ack_n - Ack_{n-1}) \qquad \ldots\ldots\ldots (1)$$

This delay difference used to estimate available bandwidth of intermediate paths node for set new data sending rate according to the available bandwidth of the intermediate path node to avoid congestion in the network. At the beginning when we create connection and decide sender node and destination node we considered **d** is data packet, t1 is time taken to data packet sending from sender node to destination node through intermediate path node and t2 is time taken to acknowledgement to sender node from destination node through intermediate path node and we assume U_{BDSR} is ideal case basic data sending rate**.** So we can calculate U_{BDSR} in bps from following equation (2).

$$U_{BDSR} = d/\,(t1 + t2) \qquad \ldots(2)$$

When acknowledgments of sending packets are delayed caused by congestion over heavy loaded route, then in our scheme we estimate available bandwidth from delay difference between two received acknowledgements. We calculate it by subtracting delayed current acknowledgement time from previous acknowledgement time. If increase and decrease difference between these two acknowledgements we required set new data rate to avoid congestion over heavy loaded route in the network. from following equation (3)

$$N_{Threshold} = int((U_{BDSR} \times (W/\,\Delta t))/W) \qquad \ldots\ldots. (3)$$

Where W is window size. with equation (2) the new data sending rate for next packets will be changed according to that equation, and if the acknowledgment delay time increase then the $N_{Threshold}$ value will be decreases so the packets will be sent in network through the available bandwidth hence congestion will not occur in the path and every time this calculation automatically adjust the data sending rate that method also called dynamic window base congestion control technique.

In our proposal we also control congestion through buffering scheme in that scheme we apply queue at each node and buffer of data packet and increases the performance of the network that buffer work dynamic behavior base means demand bases queue increases and decreases .

VII. CONCLUSION

In Mobile ad hoc networks (MANET), dynamic topology and decentralized connectivity make routing a challenging task. Moreover, overloaded nodes may deplete their energy in forwarding others packets resulting in unstable network and performance degradation. Heavily-loaded nodes may cause congestion and large delays or even wastage of resources. Therefore, routing protocols that can evenly distribute the traffic among mobile nodes and hence can improve the performance of MANETs are needed. In this paper, we present a survey of schemes for load balancing in mobile ad hoc networks. These schemes are based on a new metrics. In these strategies a load balanced routing path is selected among all feasible paths on the basis of weight value calculated for each path. In a feasible path, the higher the weight value, the higher is its suitability for traffic distribution. Multipath routing is to achieve load balance and avoid congestion in network.

VIII. EXPECTED OUTCOMES

The Multipath protocol preserved the multiple paths carrying a next minimum or equal to hop count value and used them as alternate routes in case of link failure. The major problem of node failure is congestion. The proposed scheme will reduces the possibility of congestion by choosing non congested routes to send RREQ and data packets and to transfer the load to higher hop count alternate paths if the nodes or route turn out to be congested. The proposed scheme will avoid congestion on routes by carrying a good route discovery technique, balance load on account of congestion that would definitely to an extent avoid node failures and has improved packet delivery ratio, throughput, reduced packet delay and packet drop.

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