Congestion Control Multipath Load Balancing Techniques in Mobile Ad hoc Network: A Survey

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Abstract— Effective load balancing has been a challenging task in Mobile Ad hoc Networks (MANET) due to their dynamic and un-predictable behavior and topology change. Nodes in MANETs are different with each other in terms of communication and processing capabilities. Load balancing is a solution to avoid congestion in the network. If the load is balanced then it will provide effective use of the network, reduce packet delay and improve packet delivery ratio. Transferring load of congested route to less congested routes improves overall network performance. Ad hoc On-Demand Multipath Distance Vector (AOMDV) selects a path with a lower hop count and discards routes with higher hop count. This paper presents the survey of congestion control routing techniques to detect and avoid the possibility of congestion.

Index Terms—Congestion, Multipath, Load balancing, MANET.

I. INTRODUCTION

A Mobile Ad-hoc Network (MANET) is an autonomous system of mobile hosts connected by wireless links. The nodes that are present in the mobile ad hoc network moves arbitrarily that leads to frequent topology changes. Due to this, data transfer suffers from channel loses and reliable transfer is becoming a challenging task. Hence several routing protocols are developed. There is no static infrastructure such as base stations. Many routing protocols are used to manage the ad-hoc networks. Routing protocols are classified into three categories: flat, hierarchical, and geographic position [1]. There are two types of flat routing protocols: reactive and proactive. The Ad-hoc On-Demand Distance Vector (AODV) protocol is a reactive protocol designed for ad-hoc networks [2]. AODV uses a broadcast route discovery mechanism which relies on dynamically established routing table entries at intermediate nodes. AODV floods the whole network with Route Request (RREQ) packets and Route Reply (RREP) packets. This flooding leads to high overhead.

Multipath on-demand protocols try to improve these problems by computing and caching multiple paths obtained during a single route discovery process. The link failures in the primary path, through which data transmission is actually taking place, cause 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.

Current protocol provides multipath route discovery and path maintenance mechanism on the basis of a calculated cumulative metric value only on signal strength between two nodes in a path. This metric only address strength of link of the current path, does not address the durability of the path; which fully depends on the load of node .Also does not consider the consistency of node through the previous behaviour. Since it does not consider node's behaviour and energy, it cannot be applied in heterogeneous MANETS having high mobility nature. Fig. (1) Shows the basic structure of mobile ad hoc network.

Fig. (1) Mobile Ad hoc Network

II. MANET CHALLENGES & NEEDS

A. Autonomous

Decentralized administration entity is available to manage the operation of the different mobile nodes.

B. Dynamic topology

Nodes are mobile and can be connected dynamically in a random manner. Links of the network vary timely and are based on the proximity of one node to another node.

C. Device discovery

Identifying applicable newly moved in nodes and informing about their existence need dynamic update to facilitate automatic optimal route selection.

D. Poor Transmission Quality

This is a built-in problem of wireless communication caused by several error sources that result in degradation of the received signal.

E. Network configuration

The entire MANET infrastructure is dynamic and is the reason for dynamic connection and disconnection of the variable links.

F. Topology maintenance

Updating information of dynamic links among nodes in MANETs is a major challenge. Mobile Ad-hoc network is useful for providing cost less communication.

- Mine site operations
- Battle field area
- Wildlife monitoring
- For Vehicular ad hoc networks
- For Health monitoring

III. MULTIPATH ROUTING

Mobile ad hoc networks are characterized by a limited power at the nodes and dynamic topology and limited channel bandwidth .Because of these characteristics, paths connected source nodes with destinations may be very unstable and go downward at any time, making communication over ad hoc networks difficult. On the other side, since all nodes in an ad hoc network can be connected dynamically in a randomly manner, it is usually possible to establish more than one path between a source and a destination. This property of ad hoc networks is used in the routing process, we speak of multipath routing. The process of determining multiple routes among the distinct source and single destination at the time of single route discovery corresponds to multi-path routing [3]

In most cases [4], the ability of creating multiple routes from a source to a destination is used to provide a backing route. When the primary route fails to deliver the packets in some way, the backing is used. This provides a better fault tolerance in the sense of faster and efficient recovery from route failures. Multiple paths provide load balancing as well as route failure protection by distribution of traffic among a set of disjoint paths.

Paths can be disjoint in two ways: (a) link-disjoint and (b) node-disjoint. Node-disjoint paths do not have any common nodes, except the source and destination, hence the do not have any common link. Link-disjoint paths do not have any common link. They may, however, have one or more common nodes clearly shown Fig. (2) & Fig. (3).

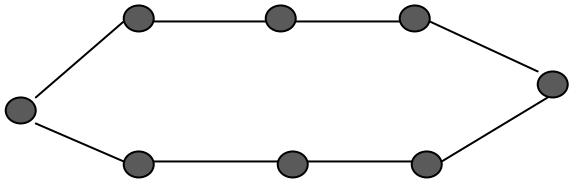

Fig. (2) Node-disjoint paths from source S to destination D

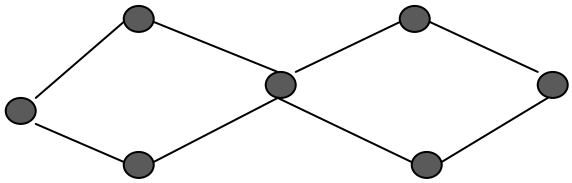

Fig.(3) Link-disjoint paths from source S to destination D

Multipath routing allows the establishment of multiple paths between a single source and single destination node. Multipath routing is generally proposed in order to increase the reliability of data transmission (i.e., fault tolerance) or to provide load balancing. Load balancing is an important in MANETs because of the limited bandwidth between the nodes [5, 6].

A. Benefits of Multipath Routing

As mentioned before, multiple paths can provide fault-tolerance and load balancing and higher aggregate bandwidth. Load balancing technique can be achieved by spreading the traffic along multiple routes. This can be alleviating congestion and bottlenecks. From a fault tolerance perspective, multipath routing provides route resilience.

To demonstrate this, consider Fig. 4 (a) and (b), where node S has established three paths to node D. If sender node S sends the same packet along all three 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 demonstrates how multipath routing can provide fault tolerance in the presence of route failures. Since bandwidth of node may be limited in a wireless network, routing on a single path may not provide sufficient bandwidth

for a connection. However, if multiple path may satisfy the bandwidth requirement of the application, there is more bandwidth available, a minimum end-to-end delay may be achieved. Source node S routes the same packet to destination node D along the routes SAGD, SBED, and SCFD. When node D moves routes SAGD and SBED break, but route SCFD is still able to deliver the packet to node D.

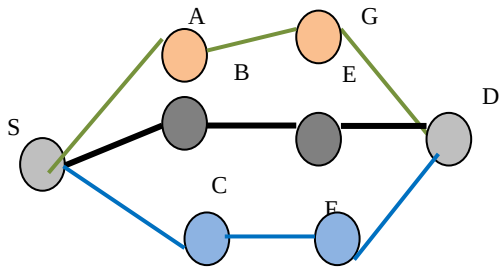

Fig. 4(a) Multipath Routing Establishment

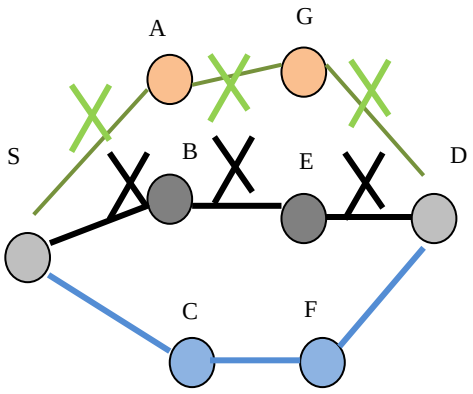

Fig. 4(b) Alternative path for data delivery

Due to issues at the link layer, to achieve higher bandwidth by using multiple path in ad hoc network may not be as straightforward as in wired network. 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 limitation of the achieved throughput. However, results show that using multipath routing in ad hoc networks of high density result in better throughput in comparison of using unipath routing [7]

Multi-path routing can balance the load better than the single path routing in ad hoc networks, where the first selective shortest paths are used for routing. This is dependent only for the networks having a huge number of nodes (i.e., a large fraction of the total number of nodes in the network) between any source-destination pair of nodes. It is impractical to build such a system it is economical for discovering and maintaining a large number of paths. Load balance is not enhanced by using multiple shortest path routes instead of a single path [8].

IV. Congestion In Manet

Every node in MANET can become aware of the presence of other nodes within its range. In ad hoc network with shared resources, where multiple senders are compete for link bandwidth, it is almost necessary to adjust the data rate used by each sender in order not to overload the network. Packets that arrive at a router and can't be forward are dropped, consequently an excessive amount of packets arriving at a network bottleneck leads to many packet drops. The particular dropped packets might already have travelled a long way in the network and thus consumed significant resources.

Additionally, the lost packets often trigger retransmission, which means that more packets are sent into the network. Network congestion can severely deteriorate throughput of network. If no appropriate congestion control is performed this can lead to a congestion collapse of the network, where most no data is successfully delivered.

- When the load in the link goes beyond the carrying capacity.
- When the broadcasting packets in network are surplus in the nature.
- When more number of packets field has becomes time out and retransmitted.
- When the number of node increases.

Furthermore, due to the comparatively low bandwidth of mobile ad-hoc networks, one single sender is able to be it unintentionally or intentionally cause a collapse of the network due to congestion. The maximum effect of a single traffic flow on the network condition can cause severe unfairness between flows. Wireless multi hop networks are much more prone to overload-related problems than traditional wire line networks like the Internet. Therefore an applicable congestion control is absolutely basic for network stability and acceptable performance.

V. Literature Review

This section presents survey about existing work done in the field of MANET routing protocol and congestion control. Every research has some contribution in improving the performance of network but has some drawbacks also, that are mentioned in Table 1.

TABLE 1. PREVIOUS WORK DETAIL AND RESEARCH GAPS

AUTHOR	Work Accomplished	Drawbacks
M. Ali et al. [9]	This 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.	The proposed work has compared with unipath protocol. However, the routing overhead is not discussed.
M Ali et al. [10]	This paper presents a congestion adaptive multipath routing protocol to increase the throughput and avoid congestion in MANETs. In this 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 determine threshold, traffic is distributed over fail-safe multiple routes to reduce the traffic load on a congested link.	This scheme distributes the data rate on multiple selected paths by that all paths are reserved for communication. The energy consumption parameters are not mentioned here like transmission power, receiving power etc.
S. Soundararajan, R.S. Bhuvaneswaran [11]	This paper presents a new approach Multipath Load Balancing and Rate Based Congestion Control (MLBRBCC) based on rate control mechanism for avoiding congestion in network communication flows. In this technique the destination node copies the estimated rate from the intermediate nodes and the feedback is forwarded to the sender through an acknowledgement packet. Since the sending rate is balanced based on the estimated rate, this technique is better than the standard congestion control technique.	Only Delay and Delivery ration in different rate are measured. The throughput, routing load are included in result.
Fubao Yang [12]	This paper proposes a Network Coding-based AOMDV routing algorithm in MANET (NC-AOMDV). It is typically proposed in order to increase the reliability of data transmission, and by applying network coding, which allows packet encoding at a broadcast node. Because the encoding packet is generated by a broadcast node, the source node does not need to encode the packets and sends only data packets to each route.	Packet overhead, PDR and end to end delay are measured with different mobility but in ad hoc, the mobility of nodes are random. The proposed concept not showed the load on each node and throughput.
Shalini Puri et al [13]	The proposed protocol (AODV-Multipath) preserves the higher hop count routes in the routing table and utilizes it as alternate path as link failure exit. AOMDV does not provide any means to avoid congestion and load balancing in the network. Queue Length finds congestion in the network. Queue Length and Hop Count value are jointly used to select a route from source to destination that avoids congestion and load balancing.	Only the summary of research is mentioned. The resultant values are not discussed.
Soundararajan [14]	This paper presents a new approach Multipath Load Balancing and Rate Based Congestion Control (MLBRBCC) based on rate control mechanism for avoiding congestion in network communication flows.	Only rate based congestion scheme is proposed. No discussion on node energy factor.
Tekaya et al. [15]	This paper presents the multipath routing and the load balancing on this network as well as some strategy proposed to put the emphasis on two multipath protocols MSR (Multipath Source Routing) and AOMDV (Ad Hoc On demand Multipath Distance Vector) . Afterwards, it proposes a solution called LB-AOMDV (Load Balancing-AOMDV) that support at once multipath routing and load balancing.	The main drawback of this paper is that performance is not measured with AOMDV protocol and the maximum buffer size (50) is not considered.

Amjad Ali, Wang Huiqiang [16]	This paper focuses on reducing the overall routing overhead while achieving load balancing. In case of congestion, their proposed protocol stops the broadcasting of RREQ packets which is another advantage since in a dense and congested environment it is highly desirable to reduce routing overhead.	In this paper, the proposed work is compared with normal AODV protocol. However, the multipath AODV has gives the better result than the proposed work. The delay difference is negligible. Remaining performance metrics are missing like throughput, PDF, Load analysis.
Mohannad Ayash et al. [17]	This paper enhances AODV protocol by proposing two protocols which minimize control overhead of AODV. Both of these protocols use Global Positioning System (GPS). It is used to determine the geographical location of source and destination nodes.	The performance can be improved more if the AOMD is used in place of AODV. Nodes location table are not mentioned.
Tuan Anh Le et al. [18]	It proposed an energy-aware congestion control algorithm for various path TCP called ecMTCP. It moves traffic from the maximum congested paths to the more lightly loaded paths, further from higher energy cost paths to the lower ones, thus produces load-balancing and energy-savings.	Here the total energy saving in network is not measured and only the performance of TCP protocol is measured which is already a reliable protocol for communication. The experiment ID is not clearly shown and only the drop % is measured in two links..

VI. CONCLUSION

The reason for the growing importance of multipath load balancing is that this strategy could be used as a means to enhance efficient bandwidth utilization for mass distribution of data. As there is an imperative need to conserve scarce bandwidth over wireless media, it is natural that multipath routing should receive some attention for ad hoc networks. So, it is, in most of the cases, advantageous to use multipath rather than multiple unipath, especially in ad hoc environment where bandwidth comes at a premium. Survey has notify about, if we reduce 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. Congestion control mechanisms have improved over time. This paper gives an overview over congestion control mechanisms. Many researchers have done valuable research in the field of congestion control with some drawbacks.

AOMDV came up with the advantage of multiple routes being discovered and the route carrying the minimum hop count value is selected but again suffered with the disadvantage of source running the route discovery on node failure. These protocols will avoid congestion on routes by carrying a good route detection 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 performance metrics.

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