Survey of Load Balancing and Load Sharing through AOMDV Protocol in MANET

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Abstract— Mobile ad hoc networks (MANET) are infrastructure less networks, dynamically formed by an autonomous system of mobile nodes that are connected via wireless links. The routers are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably MANET has no centralized control for distribution of load properly so Load Balancing becomes one of the most important research areas in the field of MANET. Load Balancing is the process of improving the performance of a network through a redistribution of load among different nodes. If a network is heavily loaded without any load balancing capability, it degrades the performance by causing Congestion, Delay and resource loss in network. A variety of algorithms have recently emerged that meet these requirements and were successfully applied to heavily loaded problems. This survey explores various load balancing protocols for efficient packet transmission and communication in MANETs. In recent years, multi-path routing protocols have attained more attention in mobile ad hoc networks as compared to other routing schemes due to their abilities and efficiency in improving bandwidth of communication, increasing delivery reliability, responding to congestion and heavy traffic.

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

1 INTRODUCTION

Mobile ad hoc networks (MANET) are composed of many mobile devices with wireless interfaces. The networks operate well without any infrastructure. The source node can relay packets to the destination node through other nodes in MANET. However, the misbehaviours of nodes are common phenomenon in MANET. These misbehaviours of the selfish nodes will impact the efficiency, the reliability, and the fairness in MANET. MANETs are networks without any fixed infrastructure, dynamically formed by a group of mobile nodes that are connected via wireless links. A mobile terminal in a MANET have the dual functions of a node as well as a router since there are no dedicated switching nodes as found in fixed networks. Since there is no central infrastructure in such networks, the control is distributed among all the mobile nodes in the network. The demands for quality real-time applications have resulted in considerable attention by researchers in the area of load balancing in MANETs [1].

Effective load balancing has been a challenging task in Mobile Ad hoc Networks (MANET) due to their dynamic and un-predictable behaviour and topology change. This paper presents a new approach based on multipath routing backbones for enhanced load balancing in MANETs. Nodes in MANETs greatly differ with each other in terms of communication and processing capabilities. In the proposed approach, multiple routing backbones are identified from source to destination using intermediate nodes that have better communication and processing capabilities to take part in the mobile routing backbones and efficiently participate in the routing process. In addition to enhanced load balancing, the new approach also provides better Quality of Service (QoS) support and congestion control according to current network traffic levels and nodes' processing loads. 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 utilised efficiently by distributing traffic evenly which ensures better load balancing and congestion control [1]. Ad-hoc on demand multipath distance vector (AOMDV) selects a path with a lower hop count and discards routes with higher hop count. The new scheme can be applied in most on-demand routing protocols.The AOMDV protocol finds node-disjoint or link-disjoint routes between source and destination. Link failures may occur because of node mobility, node failures, congestion in traffic, packet collisions, and so on. For finding node-disjoint routes, each node does not immediately reject duplicate RREQs. A node-disjoint path is obtained by each RREQ, arriving from different neighbor of the source because nodes cannot broadcast duplicate RREQs. Any two RREQs arriving at an intermediate node through a different neighbor of the source could not have traversed the same node. To get multiple link-disjoint routes, the destination sends RREP to duplicate RREQs regardless of their first hop. For ensuring link disjointness in the first hop of the RREP, the destination only replies to RREQs arriving through unique neighbors. The RREPs follow the reverse paths, which are node-disjoint and thus link-disjoint after the first hop. Each RREP intersects at an intermediate node and also takes a different reverse path to the source to ensure link-disjointness [2].

1.1 Applications of Ad Hoc Networks

MANETs are often used in cases where fixed networks are so expensive, they are also used in the situations where fixed networks are impractical because of some challenges [8].MANETs are frequently used in various applications due to their flexibility [9] such as :

- MANET in office: Files and emails are synchronized between the personal digital assistant (PDA) and the office desktop which allow transferring data in flexible way [9].

- Personal Area Networks: The personal area networks (PANs) are computer networks that are mainly focused for individual uses. PANS are shaped between different types of mobile devices [10]. The key rule of personal area networks (PANs) is to set up an embedded network using some nodes that are inside or near the human body; these nodes can easily exchange digital information [8]. Node communications in different PANS can utilize facilities of ad hoc network. As an example of PANs; a doctor can distribute a set of devices (sensors) on the patient's body in order to get medical information.
- MANET at home: Two ad hoc devices one with the user and the other in the home can communicate with each other in order to accomplish particular task such as activate lights on getting home [9].

Military Applications: Military communication in battle fields can be considered as one of the most popular application of ad hoc networks in battle fields. This is because we extremely need an infrastructure less network that offers a reliable communication and fast failure recovery in such environments. In fact, it is not efficient and very complicated to build a fixed network for military communication in battle fields. Ad hoc networks can present a very robust solution to the required communication under these conditions [5, 8].

- Other Civil and Commercial Applications: such as car tracking, monitors its mechanical components, and keep in touch with other vehicles in the area. We can also mention the application that detects for road safety messages, navigation purposes, and other peer to peer applications [10].

1.2 Limitations of Ad Hoc Networks

There are many restrictions that make routing techniques for MANETs rather complicated:

- Limited CPU capacity [5, 6]: Nodes have limited processing operations.
- Limited storage capacity [5, 6]: Memory resources are normally restricted in the mobile nodes.
- Limited battery power [6, 7, 8]: where each node has a limited life time battery.
- Limited bandwidth [5, 7]: Bandwidth is shared by a number of mobile nodes.
- Nodes have limited transmission range since they depend on the radio waves [8].
- Rapidly changing topology, where the nodes are continuously moving and changing their places.

1.3 Routing for Ad Hoc Networks

Routing is a principle component of any ad hoc network as it is responsible for load balancing between the source and destination. Routing is the mechanism of finding an optimum route in order to transfer messages (or packets). Routing protocols are divided into two basic types by [4], which are:

Static routing: In this type of routing the administrator manually assigns the routes in order to forward the data packets in the network, which means there are fixed routes between sources and destinations, these routes are changed by the administrator on demand, since that the router is not responsible for building the routing table.

Dynamic Routing: The router is responsible for building and exchanging the routing table information according to the changes that occur in the network topology, since that the router should be aware of the network status in order to take its decision. There is no doubt that dynamic routing is more flexible than static routing since it can detect the congestion paths [4]. Dynamic routing protocols are categorized by [4, 11] into three different types:

Reactive Protocols

Reactive protocols are on demand routing protocols where the network does not aware by the routes between its nodes until a source node request a route to transmit data for a destination node, at that time just the source node initiates a route request. The high latency is the main disadvantage of the reactive algorithm. The following four characteristics describe the reactive protocols [11]:

- The route should be found just on demanded.
- Flooding technique is used in order to broadcast the
- route request.
- Saving bandwidth by decreasing the number of control packets.
- Bandwidth is used when a source node decides to transmit data for destination node. Ad Hoc On-demand Distance Vector Routing Protocol (AODV) is an example of on-demand routing protocol which we improve in this paper.

Proactive Protocols

Networks designed by proactive routing protocols should have full information about the routes between each pair of nodes regardless of whether or not the nodes need to transmit data between each other or not. The networks also should be aware of each change that occurs in the network topology in order to update all of the nodes route tables. The full

information about the routes in the network is obtained by sending control messages within periodically intervals.

Hybrid Protocols

Hybrid protocols are described as a mixed between the reactive and proactive protocols where they can combine the advantage of each one [4, 11, 12].

Single and Multi-Path routing algorithms is another classified for routing algorithms where the algorithms detect multi paths between each pair of source and destination instead of a single path . The main purposes of using Multipath algorithms are allowing load balancing, fault-tolerance [8] and gives high quality services [13].

2. NEEDS OF LOAD BALANCING IN MANET

A vital part of the optimal network is the load balancing. For instance, job completion becomes complex, if huge load is given to the nodes with less processing capabilities and which do not have any means to share the load [3]. There is a possibility of load imbalance due to that the computing/processing power of the systems are non-uniform (i.e.,) few nodes maybe idle and few will be overloaded. A node which has high processing power finishes its own work quickly and is estimated to have less or no load at all most of the time. So, in the presence of under-loaded nodes, the need for over-loaded nodes is undesirable [4].

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 possible 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 infeasible to build such a system it is economical for discovering and maintaining a large number of paths. Load balance is not improved by using multiple shortest path routes instead of a single path. So, for a better load balanced network distributed multi-path load splitting strategies need to be carefully designed [5].

Load balancing 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:

- Asymmetric Load: A ratio can be manually assigned to cause some paths to get a greater share of the workload than others.
- Priority Activation: the workload is distributed according to paths priority as the size of free bandwidth and number of hops.

3. RELATED WORK

Several authors have studied the load balancing problem in MANETs. M. Ali et al. [6] have proposed a QoS aware routing protocol employing multi path routing backbones 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 across multiple routing backbones.

Soundararajan et. al. in his titled "**Adaptive Multi-Path Routing for Load Balancing in Mobile Ad Hoc Networks" [3]** they propose congestion controlled adaptive multi-path routing protocol to achieve load balancing and avoid congestion in MANETs. The algorithm for finding multi-path routes computes fail-safe multiple paths, which provide all the intermediate nodes on the primary path with multiple routes to destination. The 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.

Jung et. al. in his proposed work "**Energy Efficiency of Load Balancing in MANET Routing Protocols" [7]** They considers energy constrained routing protocols and workload balancing techniques for improving MANET routing protocols and energy efficiency. They give new routing protocol that employs adaptive load balancing technique to the MANET routing protocols with node caching enhancement. Also, they show new application of energy efficiency metrics to MANET routing protocols for energy efficiency evaluation of the protocols with limited power supply.

Sivakumar and Duraiswamy [8] have proposed a new distributed load based routing algorithm intended for a variety of traffic classes to establish the best routing paths. This approach calculates the cost metric based on the link loads. Here multimedia traffic is considered as high priority traffic and its routing is carried out over the lightly loaded links such that the links at the lighter loads are selected as an alternative to links holding heavier loads. Also the resources are shared among the high and low (normal traffic) priority traffic. The lightly loaded path is used by normal traffic in the lack of multimedia traffic.

Bin *et al*. [9] have proposed a novel adaptive load balancing routing algorithm in ad hoc networks based on a gossiping mechanism. This algorithm merges gossip based routing and load balancing scheme efficiently. It adjusts the forwarding probability of the routing messages adaptively as per the load

status and distribution of the nodes in the phase of route discovery.

Rajbhupinder Kaur et. al. in his titled "**Load Balancing of Ant Based Algorithm in MANET" [10]** Their objective is to do use the ant based algorithm for load balancing by calculating threshold value of each routing table through average number of requests accepted by each node. According to this threshold value, they can control the number of ants that has been send. If the threshold value is less, it means the average number of requests to that particular node is low. Then they simply broadcast the ants for updating their pheromone table. If the average number of requests is high, then a data packet will be send according to the pheromone table of that particular node. Their work presents a new dynamic and adaptive routing algorithm for MANETs inspired by the ant colony paradigm.

Souihli et al. [11], extending the work of Pham and Perreau [12], have proposed a load-balancing mechanism that pushes the traffic farther from the center of the network, using a routing metric that takes into account a node's degree of centrality, for both proactive and reactive routing protocols. Their approach improves the load distribution and significantly enhances the network performances in terms of average delay and reliability. However this approach use only single path routing, which may cause extra overhead under high node mobility due to frequent route breaks.

Sohn et al. [13] have presented a multipath routing scheme that was designed to increase throughput and alleviate congestion in networks employing shortest path routing. Their scheme, however, detects the congestion based on current load of the node only and does not consider its bandwidth or residual energy.

Reddy and Raghavan [14] have proposed a scalable multipath on-demand routing protocol (SMORT), which reduces the routing overhead incurred in recovering from route breaks, by using secondary paths. Though it provides fail-safe multiple paths, it does not consider the individual QoS characteristics of the nodes like bandwidth, energy, load etc..

A. Tsirigos, Z. J Hass [15] have found that, under certain constraints on the path failure probabilities, the probability of successful communication of packets between source and destination increases with number of paths used and can, in the limit, approach 100 percent. They have proposed a multipath scheme which finds the optimal way to fragment and then distribute the packets to the paths so that the probability of reconstructing the original information at the destination is maximised.

Marina and Das [16] have proposed the multipath version of the AODV protocol called AOMDV. It is designed primarily for highly dynamic ad hoc networks where frequent link failures and route breaks occur. With multiple redundant paths, new route discovery is needed only when all paths to the destination fail, unlike AODV where a new route discovery is needed in response to every route break. The AOMDV algorithm finds multiple loop free link disjoint routes from source to destination in the MANET. AOMDV performs better in terms of delay, routing load and route discovery time compared to the single path AODV. However these multiple paths need not satisfy the QoS requirements of the flow as the intermediate nodes taking part in the multiple paths are not selected based on their ability to support the QoS requirements.

Ivascu et al. [17] have presented an approach based on mobile routing backbone (MRB) for supporting QoS in MANETs. Their QMRB-AODV protocol identifies the nodes which have capabilities and characteristics that will enable them to take part in the MRB and efficiently participate in the routing process. Their approach improves network throughput and packet delivery ratio by directing traffic through lowly congested regions of the network that are rich in resources. To build routing backbones, they classify the nodes in the network based on their characteristics as either QoS routing nodes, simple routing nodes that route packets without any QoS guarantee or transceiver nodes. However since only a single MRB is identified between a source and destination, frequent route breaks may happen in highly dynamics networks leading to more frequent route re-discovery processes and hence increased overheads.

Sambasivam, Murthy and M. Belding-Royer [19] in their paper obtain multiple paths during the route discovery process. Each path maintained using the unicast periodic update packets. The unicast periodic update packets goal is to compute the signal strength for each hop that composes the alternatives paths. At any point of time, their algorithm selects the path that has the highest signal strength in order to transmit data packets. The main advantage in their approach that they can keep track of the quality of all the paths exist in the network topology to particular destination and using the best paths, since that they can discard the weakness paths which lead to increase the data delivery ratio due to avoid such paths .

Ahn, Chung, etal. [18] depends on find the main route using the AODV mechanism, when the primary route is detected, the source node starts sending the data packets over this paths while another process are initiated in order to find the backup paths. This backup path process excludes the nodes available on the main route which we called the node-disjoint paths. As soon as the main route is broken, the source node starts to send the data packets through the back up route.

Karthikeyan etal. [20], they presents an overview of the broadcasting techniques in mobile ad hoc networks, and they makes their experiments on each the simple Flooding algorithm and Probability based flooding algorithm using the NS2 simulator ,in the simple flooding mechanism each node

involves in the network should rebroadcast all packets. The Probability based mechanisms use a part of the network topology in order to send the data packets depend on some basic ideas such as the node density in order to assign the probability of the rebroadcast node.

The Load Balancing Using Multiple Paths was proposed by Al-Tarazi [21], if we have n routes sorted in the nondecreasing order of their hop counts, they will be respectively assigned the priority values: n…, 2, 1. The transmitted packets should be distributed depending on these priorities.

Sridhar and Chan propose the Channel-aware Packet Scheduling for MANETs (CaSMA), they depend on two major criteria in their work which are the congestion state and the end-to-end path duration, congestion area should be avoided and packets flow during short-lived paths should b given high priority [22].

To improve the performance of AODV protocol, a multipath version of AODV called AODVM has been proposed in Marina et al. [23]. In the AODVM protocol, a destination node selects paths that pass through more reliable nodes. AODVM uses a method to find a pair of link-disjoint paths by selecting a route, which has a less number of common intermediate nodes on its path. In route discovery process, which sets up a reverse route using the RREQ arriving first. In route utilization process, the AODVM lets each neighboring node of a primary route to maintain its own backup route. This multipath method provides load balancing and avoids the inefficiency of AODV that needs a new route discovery during a path breaks. In route maintenance process, this method introduces a keep-alive packet that is periodically inserted to prevent timeout expiration of backup routes.

Simple Load-Balancing Ad hoc Routing (SLAR) [24] protocol is based on the autonomy of each node. Although it may not provide the network-wide optimized solution but it may reduce the overhead incurred by load balancing and prevent from severe battery power consumption caused by forwarding packets. In SLAR, each node determines whether it is under heavy forwarding load condition, and in that case it gives up forwarding packets and lets some other nodes take over the role. In MANETs, since nodes have limited resources, the message overhead for load balancing is more critical than that of the wired network, i.e., in the ad hoc network, the network-wide optimized load balancing approach of the wired network may be inappropriate. SLAR is designed not as an entirely new routing protocol but as an enhancement of any existing ad hoc routing protocols like AODV, DSR etc

4. CONCLUSION

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 resource. In this paper we have discussed some important issues related to the load-balanced routing protocols for mobile ad hoc networks Load balanced routing protocols have different load metric as route selection criteria to better use MANET recourses and improves MANET performance. Many areas of research in this field which deserve further investigation include robustness, security, energy efficiency, low overhead, reliability and scalability. Effective and efficient solutions to these issues require the design and development of new multipath routing protocols in MANETs.

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