Load Balancing in MANET : A Survey

Asif Ahmed Mir[1], Khusboo Bansal[2],
[1]*M.Tech Student, Desh Bhagat University,Mandi Gobindgarh*
[2] *Assistant Professor, Desh Bhagat University,Mandi Gobindgarh*
(E-mail: asifmir06@gmail.com)

Abstract—A mobile ad hoc network is a group of wireless mobile hosts forming a temporary network without the aid of any stand-alone infrastructure administration. Mobile Ad-hoc networks are self organizing and self-configuring multihop wireless networks where the network structure changed dynamically. This is mainly due to the mobility of the nodes. Nodes in these networks cooperating in a gracious manner to engaging themselves in multihop forwarding. The nodes in the network not only act as hosts but also act as routers that route data to/from other nodes in network. Mobile ad hoc networks (MANETs) pose particular challenges in terms of Quality of Service (QoS) and performance. This is due to the effect of numerous parameters such as; bandwidth and power constrains, delays, security issues, etc. On the there hand, the degree of freedom enables the wireless mobile nodes to enter and leave the network dynamically. The latter offers redundant paths and dynamic coverage. Particular attention is given to the multipath transmission capability as well as load balancing to have efficient routing possible for heavy multimedia traffics. In this paper, we mainly focuses on survey of various load balanced Routing protocols for efficient data transmission in MANETs

Keywords— *MANET,Load balancing, Network Traffic, QoS, Throughput.*

I. INTRODUCTION

With the development of mobile communications and Internet technology, there is a strong need to provide connectivity for roaming devices to communicate continuously with other devices on the Internet. However, the mobility of Internet hosts is usually within the same broadcast domain where the Internet gateway is located, referred to as 1-hop Internet mobility management. Technology advances have taken to the use of mobile ad hoc networks (MANETs) as the access networks for the Internet, where MANETs are used to either cover the empty areas or extend the access networks from 1-hop to multihop in the current access technologies such as wireless LANs or cellular networks [1-2].

Typically, the connection between a MANET node and an Internet gateway (IGW) is multihop. Therefore, there is normally no direct wireless link from this MANET node to the IGW. Instead, they are connected via other intermediate nodes. Thus, different problems, e.g., inconsistent context, cascading effect, can happen during the mobility of ad-hoc nodes within a MANET domain if multiple IGWs exist [3-5].

Since a MANET might be used for both direct communication between MANET nodes and for Internet connectivity, it might be useful to make a distinction between the intra-MANET traffic, which is the traffic constrained within a MANET, and the inter MANET traffic, which is the traffic between the MANET and the Internet. (In fact, inter-MANET traffic might also include traffic between two different MANET domains, or between a MANET domain and another type of external network, such as a local wired LAN. However, this paper assumes for simplicity that all inter-MANET traffic is traffic between a MANET and the Internet). Research has been in-progress for the load-balance of intra-MANET traffic within a MANET domain [25-26], and that of inter-MANET traffic over multiple IGWs [12].

However, intra/inter-MANET traffic are considered separately. Moreover, the load-balance of inter-MANET traffic over multiple IGWs does not consider many realistic problems like inconsistent context [3-5]. In this paper, we want to control together these types of traffic. For this purpose, a hybrid metric for the load balance of intra/inter-MANET traffic among multiple IGWs, and alternative solutions to reduce realistic problems [3-5] in the implementation, are proposed and evaluted through the simulation.

II. WIRED AND WIRELESS ROUTING

Routing protocols are divided into two major groups; wired and wireless routing protocols. Routing was initially based on IPv4 and therefore wired routing protocols were easily implemented using IPv4. Wireless routing protocols, on the other hand, require modifications, optimizations and alterations of the schemes to fit the needs of moving nodes, which were not considered in the nature of IPv4. Our objective in this paper is to discuss the functionality of wireless and ad hoc routing protocols.

A. Distance-Vector versus Link State Protocols

Both routing protocols were designed in late 80s beginning of 90s. Distance-vector protocols are based on Bellman-Ford algorithm to find the shortest path from the source to the destination based on specific metrics. On the other, hand link-state protocols are based on Dijkstra Algorithm that nodes flooding the network with information about their local links so that the network will maintain a complete image of the links between routers [6,7].

B. Mobile Ad-Hoc Networks and Protocols

Mobile ad hoc networks (MANETs) are the most flexible non-structural types of networks with the collection of variety of wireless mobile hosts with IP connectivity forming temporary networks without a central administration. In most MANETs, multipath protocols are needed to facilitate efficient connectivity between transmitters that are not necessarily within each other's wireless range. MANET routing protocols are divided into the following categories:

Flat Routing Protocols

o Proactive Routing (Table-Driven)

o Reactive Routing (On-Demand)

o Hybrid Routing (blend of Reactive and Proactive)

- Hierarchical (Zone/Cluster-Based) Routing Protocols
- Geographic Position Assisted Routing Protocols
- Power-Aware Routing Protocols
- Security-Aware Routing Protocols
- Routing Protocols with Efficient FM
- Multicasting Routing Protocols

o Geographical Multicast (Geocasting)

o Tree-Based o Mesh-Based

o Zone Routing o Associativity-Based

o Differential-Destination

o Weight-Based

o Preferred Link-based

All these routing protocols are primarily based on flavors of distance-vector or link-state routing plus additional functionalities to assist the routing operations in particular ways. The goals of these protocols could be summarized as [8]:

- Minimal Control Overhead
- Minimal Processing Overhead
- Multihop Routing Capability
- Dynamic Topology Maintenance
- Loop Prevention

III. MULTIPATH ROUTING PROTOCOLS

Most routing protocols maintain routing tables to store the next hop towards the desired destination. Many routing protocols preserve a caching mechanism by which multiple routing paths to the same destination are stored. Multipath routing is essential for load balancing and offering quality of service. Other benefits of multipath routing include [9]: the reduction of computing time that routers' CPUs require, high resilience to path breaks, high call acceptance ratio (in voice applications) and better security. Special attention should be given to transport layer protocols as duplicate acknowledgments (DUPACKs) could occur, which might lead to excessive power consumption and congestion.

A. Multipath routing in Reactive Protocols

On-demand routing protocols are inherently attractive for multipath routing, because of faster and more efficient recovery from route failures. MSR "Multipath Source Routing Protocol" [10] is an example of such protocols that supports multipath routing. MSR is a direct descendant of DSR. By incorporating the multipath mechanism into DSR and employing a probing based load-balancing mechanism, the throughput, end-to-end delay, and drop-rate have been improved greatly.

The drawback of MSR would be the processing overload of originating the packets, which could become more negligible as the processing power of computers increase day-by-day. Another routing protocol offering multipath routing in this category is the AOMDV "On-Demand Multipath Distance Vector Protocol" [11], that extends the single path AODV protocol to compute multiple paths. There are two parts in AOMDV contributing to multipath routing, one of which is the notion of an advertised hop-count to maintain multiple loop-free paths at each nodes and the other is the modification of route discovery mechanism in the AODV protocol for link-disjoint multiple paths from source and intermediate nodes to the destination. Under wide range of mobility traffic scenarios, AOMDV offers a significant reduction in delay and up to 20% reduction in the routing load and the frequency of route discoveries.

B. Multipath Routing in Proactive Protocols

Proactive routing algorithms, such as DSDV "DestinationSequenced Distance-Vector Routing" [12], maintain route updates among all nodes all the time. In fact, many proactive protocols tend to offer shortest path to each destinations. This is done by continuously monitoring the network topology. Unlike reactive routing algorithms, proactive routing protocols are capable of repairing broken routes in a short time. This is done by collecting network topology continuously.

The drawback of DSDV however is the requirement of parameters such as the periodic update interval, maximum value of the "settling time" for a destination and the number of update intervals, which may become known before a route is considered stale. These parameters will likely represent a tradeoff between the latency of valid routing information and excessive communication overhead [14]. Another example of proactive routing protocol is discussed in [13]. TERA "Tree Exchange Routing Algorithm" is an extension to standard distance vector routing algorithms, which is based on multipath. This paper discusses the necessary modifications to enable multipath routing. This modification does not require any additional messages, therefore no extra cost is incurred to add multipath capability to the scheme.

C. Multipath Routing in Hybrid Protocols

Hybrid routing protocols incorporate the merits of both on-demand and proactive routing protocols. An example of this category is Zone Routing Protocol “ZRP”, which is similar to a cluster with the exception that each node acts as a cluster head and a member of other clusters. The routing zone 985 forms a few mobile ad hoc nodes within one, two or more hops away where the central node is located. The fact that both reactive and proactive schemes are found in the functionality of hybrid routing protocols, better performance is expected. However, due to hierarchical nature of the schemes more memory will be required compared to the identical reactive or proactive scheme [9]. Reference [15] describes another hybrid algorithm, AntHocNet “Ant Agents for Hybrid Multipath Routing in Mobile Ad Hoc Networks”, an ACO algorithm for routing in MANETs.

The route setup of this scheme is performed by reactive algorithm and the route probing and exploration are done by proactive scheme. The related simulation experiments show that AntHocNet can outperform AODV in terms of delivery ratio and average delay, especially in more mobile and larger networks. Scalability is also promising in this scheme. However, relatively large amount of overhead could be mentioned as a drawback and also less adaptability to the network situation.

D. Multipath Routing in Hierarchical Protocols

Hierarchical routing protocols tend to avoid excessive overhead by limiting the local traffic to the local management and only global movements are reported between zones/hierarchical layers. This, on the other hand, increases the complexity of the routing schemes. In [16] a technique is proposed to reduce the computational complexity of maxflow routing, based on a hierarchical decomposition of the network (Hierarchical Max-Flow Routing “HMFR”). Maxflow routing forwards packets in such a way that the impact of failures is minimized. However, the computational complexity of max-flow routing is quite high, making it not reasonable for moderate size networks. Other hierarchical routing protocols such as Hierarchical State Routing “HSR”, Zone-based Hierarchical Link State Routing Protocol (ZHLS), and Clusterhead Gateway Switch Routing (CGSR) also fall under the same category.

E. Multipath Routing in Geographic Position Assisted Routing Protocols

There are presently several ad hoc routing algorithms such as; Multipath Location-Aided Routing “MLAR”, which is a multipath routing version of LAR; that uses position information (2D or 3D) to make routing decisions at each node. The proposed algorithm in [17] uses a 3D approach, which is a new hierarchical, zone-based 3D routing algorithm based on GRID by Liao, Tseng and Sheu [18]. The approach proposes a replacement of LAR with Multipath LAR (MLAR) in GRID. It is expected to have significant performance differences in 3D and as to whether single or multi-path algorithms should be used in a particular scenario. The simulation results demonstrate the performance benefits of MLAR Over LAR and AODV in most mobility situations. AOMDV delivers more packets compared to MLAR, however it does it at a cost of more frequent flooding to control packets and thus higher bandwidth usage than MLAR.

F. Multipath Routing in Power-Aware Protocols

The fact that ad hoc nodes are battery operated and have limited energy resources, make energy efficiency a key concern in the operation of such networks. Further studies have shown that the subsystem communication consumes a large fraction of total energy and therefore solutions for energy efficient communication are of great interest. Energy and power related issues are primarily physical layer topics and their effects on efficient routing open a new door into Cross-Layer issues, which are relatively new topics. An interesting insight of power-aware ad hoc protocols has been presented in [19] in which optimization at the network layer is of major concern. The research is classified into three categories based on the different aspects and they address: power control, routing, and sleep mode (stand-by) control.

This paper further tries to investigate open issues of crosslayer, one of which is the understanding of the bottleneck, which is possibly because of topology discovery overhead, the routing protocol overhead, the actual transmission of data and the idle radio listening. Wireless contention, measuring available power, and CPU overhead are also said to contribute as well. Occasionally traffic control in poweraware nodes for traffic based sleep mode control for lightly loaded networks was also introduced. Multipath Power Sensitive Routing Protocol “MPSR” [20] is another ad hoc routing protocol with interest in poweraware communication. MPSR shows how an efficient heuristic-based multipath technique can improve the meantime-to-node-failure and maintain the variance in the power of all the nodes as low as possible. MPSR is a flat topology in which every node is treated equally and stability and end-toend delay reduction are of critical concern. The simulation results show performance optimized in MPSR protocol compared to the Dynamic Source Routing “DSR”.

G. Multipath Routing in Multicasting Protocols

Multicast Routing Protocols are of great interest as the demand for such communication is on the rise. Multipath Multicast Routing Algorithm “MRPM” [21] is an example of this category. In MERM, a method chooses the next hop when multiple equal cost next hops are present. Through the simulation, it was investigated that this quick distributed dynamic algorithm can manage network resources efficiently. Multi-Flow Real-Time Transport Protocol “MRTP” [22] is another example of a mesh-based ad hoc-based protocol that offers multipath routing for multicast application. It is based on Real-Time Protocol “RTP” and Real-Time Transport Control Protocol “RTCP”. RTP itself is a multicast-oriented protocol for real-time applications. MRTP is motivated by the observations of effective path diversity in combating transmission errors in ad hoc networks, and effective data partitioning techniques in improving the queuing performance of real-time traffic.

The simulation 986 results show performance improvement in lost packets per frame and buffer management. Multi-Objective Multipath Routing Algorithm for Multicast Flows "MMRAM" [23] proposes a multi-objective traffic-engineering scheme using different distribution trees to multicast several flows. MMRAM tries to combine maximum link utilization, hop count, total bandwidth consumption, and total end-to-end delay into a single aggregated flow. This combination makes MMRAM an attractive candidate for Multiprotocol Label Switching "MPLS". This multi-tree routing protocol uses a multicast transmission with load balancing.

H. Multipath Routing in Security Protocols

Security has gained a lot of attentions recently and many attempts in proposing end-to-end security schemes have been carried out, one of which is by the use of multipath routing. The scheme presented in [24] tries to tackle the security issue by presenting trust and key management models for intrusion detection and prevention. The existence of multiple paths between nodes in an Ad hoc network is exploited to increase the robustness of transmitted data confidentiality. The proposed algorithm is tested against time for intrusion detection and robustness. Another multipath routing algorithm for data security enhancement, Multipath TCP Security "MTS", is discussed in [25]. In MTS, the source node chooses the available routes adaptively rather than testing the "stored routes" one by one exhaustively. Simulation results show that the algorithm provides a reasonably good level of security and performance. Compared to AODV and DSR, MTS has a better number of participating nodes and highest interception ratio.

The average end-to-end delay between MTS, AODV and DSR shows that beyond speeds of 1.7 m/s, MTS delay drops rapidly and performs better in respect to the other two routing protocols. So far, security options for ad hoc elements from the transport layer point of view was discussed, however the security option could be implemented in the application running on wireless nodes. The reference [26] shows a scheme in which a secret message is divided into multiple shares and through the use of multipath routing, the shares can be delivered to the destination via multiple paths. This enhances data confidentiality in a mobile ad hoc network and is expected to reduce the message compromising and eavesdropping probability. This is done by the distribution of a secret among multiple independent paths while it is transmitted across the network. As drawbacks, it shows that multipath routing causes more collision among correlated routes themselves thus degrades network performance such as packet delivery ratio.

IV. CONCLUSION

Multipath routing was the main focus of this paper and we investigated its effects of multipath routing in variety of protocols including flat topologies (reactive, proactive and hybrid), hierarchical topologies, geographic position assisted routing protocols, power-aware and security enhancement routing protocols. In all these, performance enhancements were observed and promising results pointed to the better deployment of the schemes when multipath routing is used. In this we have discussed some important issues related to the load-balanced routing protocols for mobile ad hoc networks (MANET). Nodes in MANET have limited bandwidth, buffer space, battery power etc. So it is essential to distribute the traffic among the mobile host. There are different metrics used for the route selection. Load balancing algorithms are delay based, traffic based or hybrid based. In MANET, to improve the performance, it is very essential to balance the load. Load balancing is used to increase throughput of the network. Also it is possible to maximize nodes lifetime, packet delivery ratio, and minimize traffic congestion and load unbalance, as a result, end-to-end packet delay can be minimized, and energy consumption can be balanced.

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