A Survey on Delay-Aware Multicast Routing Protocols in MANET

[1]R. Suganya, [2]Dr. Vasantha Kalyani David

[1]Assistant Professor, [2]Associate Professor
[1,2]Department of Computer Science,
[1]Sri Krishna Arts and Science College, Coimbatore, India.
[2]Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, India.

Abstract: Few MAC standards like 802.11a, 802.11b and 802.11g can operate with multiple data rates due to significant advances in wireless modulation technologies for Quality-of-Service (QoS)-constrained multimedia communication in order to utilize the limited resources of MANETs more efficiently. In multirate MANETs, the neighborhood of a host may differ which causes it more complex to estimate the one-hop delay as well as end-to-end delay. For real-time applications in multirate MANETs, different delay-aware multicast routing protocol have been proposed to increase the network capacity, QoS guarantees and reduce the end-to-end delay. Also, a QoS routing or multicasting protocols for a MANET have been designed in which its neighboring information must be maintained to estimate the resource consumed by the designed QoS path and its neighbors. It is also desired that the designed QoS routing or multicasting protocol can use the limited wireless resources more efficiently. In this paper, a survey on different delay-aware multicast routing protocols in adhoc networks is presented. As well, a comparative analysis is presented to investigate the limitations in those conventional protocols and suggest the solutions for further improvement on multicast routing in MANET.

***IndexTerms*–MANET, Routing, Multicast, Multirate MANET, QoS, Delay-aware protocol.**

I. INTRODUCTION

Mobile Adhoc Networks (MANETs) are a type of wireless networks which do not need any backbone structure to transmit the data packets between mobile nodes such as an access point or a base station. Each mobile node acts as both host and router. The complexities and constraints known in traditional wireless networks are more prominent in MANETs due to dynamic topological changes, energy and bandwidth constraint. Some of these complexities are interference, environment noise, collision, congestion and security problems. A wide range of potential applications has been presented for adhoc networks of which distributed computing, disaster recovery, mobile access internet, defense applications, vehicles communication, healthcare systems, sensor networks and multimedia applications are few examples. In recent years, the utilization of MANETs has become increased that leads to intensive research in the Quality-of-Service (QoS) provisions to fully achieve QoS guarantees as required by application according to its scenario requirements. However, an efficient path selection during routing the data packets when adhering to multiple QoS requirements is typically complex.

MANETs routing are based on unique addresses in the network. The network routing service creates a routing path that contain multiple intermediate nodes between the source and destination. Routing protocols are classified as either unicast or multicast depending on the mechanism used in delivering data packets. Unicast transmission is the delivery of packets to a single destination whereas multicast transmission is the delivery of data packets to a group of destinations simultaneously in a single transmission [1]. Multicast routing in MANETs can be implemented in the network layer, the MAC layer and the application layer. Therefore, the multicast routing protocols can be classified into three types such as Network (IP) Layer Multicast (IPLM), Application Layer Multicast (ALM) and MAC Layer Multicast (MACLM). Multicasting can minimize the channel capacity consumption, sender and router processing, energy consumption and communication delay [2]. A recent trend for information-sharing applications is to transmit the data packets in terms of multicast. In order to multicast the data packets, creating a multicast tree is more efficient than transmitting the similar packets independently from the source to destination. In modern digital world, there are several applications that rely on real-time multicast services.

Delay-sensitive multicast protocols are crucial to such multicast services. A multicast protocol is delay-sensitive, if the delay requirements of the requested multicast services can be satisfied with specified confidence levels i.e., specified percentages of data packets whose end-to-end delays are smaller than few predefined values. Over the past decades, different delay-aware or delay-sensitive multicast routing protocols have been proposed for MANETs. This paper presents the detailed survey on different delay-aware multicast routing protocols in adhoc networks. Initially, different routing protocols related to delay-aware multicasting are studied in brief. Then, a comparative analysis is presented to evaluate the performance efficiency and address the challenges in those protocols for further improvement on multicasting in MANET.

The rest of the article is structured as follows: Section II presents the detailed study on previous researches related to the delay-aware multicast routing protocol in MANET. Section III illustrates the comparative analysis of those protocols and Section IV concludes the entire discussion.

II. SURVEY ON DELAY-AWARE MULTICAST ROUTING PROTOCOLS IN MANET

Hanzo et al. [3] proposed QoS-aware routing and admission control in shadow-fading environments in multirate MANETs. Initially, a low-overhead extension to the Staggered Admission Control (StAC) protocol was proposed that uses pretested backup paths to support uphold throughput guarantees during path failures. Then, a multirate-aware version of StAC was also proposed that cooperates with the modified rate switching mechanism at the MAC layer and a QAR protocol for helping in coping with shadow-fading-induced signal strength fluctuations.

Zhao et al. [4] proposed a high-throughput routing metric for achieving reliable multicast in multirate wireless mesh networks. This new multicast routing metric called Expected Multicast Transmission Time (EMTT) captures the combined effects of MAC layer retransmission-based reliability, transmission rate diversity, wireless broadcast merit and link quality awareness. The EMTT of one-hop transmission of a multicast packet reduces the amount of expected transmission time by facilitating the sender to adapt its bit-rate for each ongoing transmission/retransmission. The rate adaptation process was modeled as a Markov Decision Process (MDP) and an efficient process was derived to compute the EMTT from the theory of MDP.

Biradar & Manvi [5] proposed a scheme for Multipath Multicast Routing in MANETs using reliable Neighbor Selection (MMRNS) mechanism. In this mechanism, a mesh of multipath routes were established from source to multicast destinations by using neighbors that have high reliability pair factor. It consists of following five phases: (i) Computation of reliability pair factor based on node power level and received differential signal strength between the nodes and mobility. (ii) Pruning neighbor nodes that have reliability pair factor smaller than a threshold. (iii) Discovery of multipath multicast mesh routes with the help of request and reply packets. (iv) Multipath priority assignment based on minimum value of reliability pair factor of a path and information transfer from source to the multicast destinations and (v) route maintenance against link/node failures.

Fareena et al. [6] proposed a new multicast routing protocol known as Mobility based Energy Efficient Multicast Protocol (M-EEMC). The main objective of this protocol was reducing the energy dissipation of the MANET. This protocol was a combination of tree and mesh based routing scheme. Mainly, this protocol was used for establishing and maintaining an active multicast tree surrounded by a passive mesh within a MANET by effectively using the knowledge of neighbourhood node density and mobility. The multicast mesh was generated by path discovery process. Also, pruning mechanism was used for removing the redundancies of mesh that increases the energy efficiency.

Wang & Lee [7] proposed a Multi-path QoS Multicast Routing (MQMR) protocol with slot assignment for MANET. In this protocol, dynamic time slot control was provided by using a multi-path tree or a unipath tree for achieving the bandwidth requirements of a call. The QoS and bandwidth requirements of a call were achieved by using the final multi-path QoS multicast tree and the aggregate bandwidth of the routes. The hidden terminal problem or inadequate bandwidth in the bandwidth reservation process was avoided by using a decision rule for each destination. Further, a bandwidth reservation scheme was used to select the reserved time slots on each node in the multi-path QoS multicast tree.

Gopinath & Nagarajan [8] proposed Residual Energy based Reliable Multicast Routing Protocol (RERMR) to attain more network lifetime, increased packet delivery and forwarding rate. In this protocol, a multicast backbone was constructed to achieve more stability based on node familiarity and trustable loop. Also, reliable path criterion was estimated to choose best reliable path among all available paths. After that, the data packets were forwarded to the destination.

Robinson et al. [9] proposed a bandwidth and delay aware routing protocol with scheduling algorithm for multihop MANET to avoid the link failure. The main aim of this protocol was introducing a cross-layer protocol that integrates the routing with priority-based traffic management and distributed transmission scheduling. The reservation scheme was based on ID. This protocol was ensured that bandwidth reserved time slot was used by other packet in which end-to-end reservation was achieved. Moreover, bandwidth and delay-aware routing protocol was combined with scheduling algorithm for allocating the channels efficiently.

Singal et al. [10] proposed an improved multicast routing in MANET using link stability and path stability. The link stability was used identify a stable link from the available links to the next hop and determine a stable end-to-end path. The probability of successful transmission of periodic packets was used as link stability metric to assess the stable route. Acknowledgement-free packets were used for verifying connectivity in the network. By using the selected stable link, the possibility of retransmission, end-to-end delay and control overhead were reduced.

Yadav et al. [11] designed a protocol called design of Efficient Fuzzy-based Multi-constraint Multicast Routing Protocol (EFMMRP) for wireless ad-hoc network. In this protocol, multiple QoS performance constraints were considered in terms of end-to-end delay, channel bandwidth and energy. These constraints were converted into a single metric called fuzzy cost. The multicast path was assigned for transmitting the data packets from source to a set of receiver nodes having minimum fuzzy cost value.

Chen et al. [12] proposed a Delay-Sensitive Multicast (DSM) protocol for network capacity enhancement in multirate MANET. Initially, a method for estimating one-hop delay was proposed by measuring the busy/idle ratio of the shared radio channel. After that, a delay-sensitive multicast protocol was proposed for real-time applications in multirate MANETs by constructing a multicast tree. This proposed multicast protocol was intended to reduce the sum of the total transmission time of the forwarders and the total blocking time of the blocked hosts by considering the neighboring information of the forwarders and properly adjusting the data rates of the forwarders. A multicasting route with less total transmission time and total blocking time can reduce the resource consumption to the network so that the network capacity was increased i.e., more flows were admitted into the network.

III. Comparative Analysis

In this section, the comparative analysis of different delay-aware multicast routing protocols is presented. The merits and demerits of the above-mentioned delay-aware multicast routing protocols in MANETs are shown in Table 3.1.

Table 3.1: Comparison of Different Delay-Aware Multicast Routing Protocols in MANET/Adhoc Networks

Ref. No.	Protocols	Merits	Demerits	Performance Metrics
[3]	StAC protocol, Modified rate switching mechanism	Reduced end-to-end delay and PLR.	The throughput assurance reliability was still not efficiently improved.	**Shadowing variation standard deviation=2dB:** Session Admission Ratio (SAR)=0.22; Throughput requirement upheld time ratio=0.89; Packet Loss Ratio (PLR)=0.04; Average end-to-end delay=0.05sec
[4]	EMTT metric-based routing	High PDR.	The performance of throughput and PLR was not analyzed.	**Multicast group size=40:** Total EMTT=98msec; End-to-end delay=1.2sec; Packet Delivery Ratio (PDR)=97%

[5]	MMRNS mechanism	It achieves minimum packet delay.	Computation overhead and memory overhead were high	**Multicast group size=20:** PDR=97%; **Number of nodes=100:** Control overhead=300 control packets; **Simulation time=1000sec:** Message overhead=250messages; Memory overhead=140bytes; Computation overhead=154computations; **Mobility=24m/s:** Packet delay=0.001sec
[6]	M-EEMC protocol	Less energy dissipation.	The Packet Delivery Ratio (PDR) was still less.	**Multicast group size=20:** Energy dissipation=1mJ; PDR=80%
[7]	MQMR protocol, slot assignment	Better utilization of network resources.	The performance of success ratio under varying number of nodes and mobility was not effective.	**Multicast group size=20:** Success ratio=0.92; **Number of nodes=100:** Success ratio=0.76; **Mobility=10m/s:** Success ratio=0.5
[8]	RERMR protocol	Better performance in the presence of high mobility environment.	The path reliability and network reliability were not efficiently increased.	**Speed=50mbps:** End-to-end delay=20ms; End-to-end transmission=65packets/ms; **Number of paths=100:** Path reliability=85%; **Throughput=100packets:** Network lifetime=68ms
[9]	Bandwidth and delay aware routing protocol with scheduling algorithm	Reduced energy consumption.	High delay and less PDR.	**Number of nodes=100:** Energy consumption=188×10^3J; PDR=4.48; Delay=585×10^3sec
[10]	Improved multicast routing using link and path stability	Achieves minimum end-to-end delay and maximum PDR.	The possibility of link failure due to mobility of nodes was not reduced.	**Node mobility=20m/s:** PDR=95%; Average end-to-end delay=0.01sec; Control overhead=8.41%; Memory overhead=1.1kB
[11]	EFMMRP	Reduced packet delivery delay.	The control overhead of this protocol was still high.	**Mobility=20m/s:** PDR=76%; Packet delivery delay=0.06sec; Control overhead=300 **Number of nodes=40:** PDR=93%; Packet delivery delay=0.03
[12]	Delay-sensitive multicast protocol	Minimized end-to-end delay and control overhead.	It requires additional metrics like bandwidth, jitter, etc., to improve the QoS guarantees of network.	**Number of multicast flows=5:** End-to-end delay=0.03; Admission ratio=0.95; **Number of hosts=100:** Number of control bytes=6×10^4; Admission ratio=0.85; **Speed=5m/s:** Success ratio=0.97

IV. CONCLUSION

In this article, a detailed comparative analysis on delay-aware multicast routing in MANET is presented. From this comparative analysis, it is obviously noticed that all researchers have experienced on reducing the end-to-end delay and increasing the success ratio during packet transmission via multicasting routing. Among those many protocols, DSM based routing protocol achieves better network performance in terms of minimized end-to-end delay and control overhead from the analysis of performance metrics. Still, this protocol has few limitations such as it requires QoS satisfied multicasting to further improve the network performance. Therefore, the future extension of this study could focus on enhancing DSM protocol based on additional metrics such as bandwidth, packet dropping rate and jitter. Also, the transmission rate would increase by considering the network lifetime.

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