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The Average End-to-End Delay and Average Through put Comparison of Multicast Routing Protocols in MANETs for Real-Time Streaming

N. N. HUSSAINI[++], H. KAZI, S. FAIZULLAH, M. A. SHAIKH, K. H. MOHAMMADANI

Department of Computer Science-Isra University, Hyderabad, Pakistan

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Abstract: Multicasting is an effective way to establish a group communication where each message is delivered from a sender to all the members of the group. These groups can be open or closed. A lot of multicast routing protocols have been developed yet for closed group applications. To avail live radio/TV or multimedia type transmission without any membership management, we call it open-MANETs. SLIM+ is proposed (Shaikh *et al*., 2014) , implemented (Hussaini, and Shaikh, *et al*, 2016), compared and evaluated in different scenarios and found a robust protocol (Hussaini, and Shaikh, *et al*, 2017). In this paper SLIM+ is compared with MAODV and PUMA multicast routing protocols and the Average Throughput and Average End-to-End Delay is presented after the comparative study. NS2-Version 2.35 is used for the comparative assessment of these protocols.

Keywords: MANETs; One-to-Many Multicasting; Multimedia Streaming; Local Area Social Networks; SLIM; PUMA; MAODV

1. INTRODUCTION

MANETs are self-organizing networks established between a group of wireless mobile nodes, dedicated for communication services without having any fixed infrastructure or centralized administration (Sutariya., 2016). These nodes can be a notebook, PDA, or some other devices able to transmit and or receive information (Moustafa and Labiod., 2004). MANETs are temporary networks; the nodes here are usually mobile thus may or may not be in the range of each other in the network (Nagendra *et al.,* 2013).

The communication among nodes in MANET is achieved either direct with single-hop transmission when the source node and the receiver node are in the range to one another or indirectly through intermediate nodes or in multi-hops (Junhai *et al.,* 2008).

In MANET, each node works as a host and as a router, and forwards information for the other nodes that may not be within direct wireless transmission range of one another (Mohammadani, *et al.,* 2013). Due to the dynamic environment of MANETs, implementation of a routing protocol is required in node's multi hop communication (Sutariya., 2016).

Multicasting is a way of communication, where a group of nodes would like to send and receive information to each other. The purpose of a multicast routing protocol for MANETs is to maintain the broadcasting of information from a source to all the destinations of a multicast group by efficiently using the existing bandwidth. Multicasting is very essential in MANET because it reduces the broadcasting cost of communication. The multicast routing protocols categorized into tree-based, mesh-based and hybrid-based depending upon how the paths among group nodes created (Ala and Kumari., 2015).

Some examples of Multicast applications include: disaster relief management, military networks, operations in a battlefield, outdoor entertainment activities, crowd control, video conferencing, traffic advisory, multimedia like live radio or TV streaming, and teleconferencing between rescue workers.

Further, MANETs were typically supposed to be a closed group of nodes with a well-defined membership. However with the adaptation of MANETs in vehicular networks and local area social networks (Stefan *et al.,* 2011) which are open group of nodes where new nodes keep arriving and existing nodes departing the network as and when they like, the routing protocols need to be re-addressed to include the openness of the node set. The existing MANET protocols also lack their performance due to maintaining the group membership which can be quite big and highly volatile in applications offering real-time streaming in open groups.

To address this gap SLIM (Simple, Lightweight and Intuitive Multicast) protocol is proposed earlier in (Shaikh *et al.*, 2014). However during its implementation it was realized that the performance of SLIM varies with the choice of underlying unicast routing protocol.

[++]Corresponding Author: Email nazish_hussaini@hotmail.com

Further, for open groups, some kind of advertisement mechanism is much needed that let the new comers inform about the availability of multicast stream. That gap was covered in (Hussaini. *et al.*, 2017) In this paper we are presenting the study and performance evaluation of SLIM+, MAODV and PUMA multicast routing protocols with respect to their Average throughput and Average End-to-end Delay. NS2-version 2.35 is used for the comparative assessment of these protocols.

The paper is further organized as follows: Section II , III, and IV describes the study of multicast routing protocols such as SLIM+, MAODV, and PUMA. Section V presents the simulation environment followed by the results and conclusion in sections VI and VII respectively.

2. STUDY OF SLIM+

SLIM+ (Hussaini.*et al.*, 2016) is a multicast routing protocol for one-to-many type multicast applications in open MANETs. To let the Radio or TV type transmission open, the source node periodically advertises the availability of multicast stream by flooding an advertisement packet within the network. An important aspect of this advertisement packet is that its propagation defines a distribution tree structure.

Each node upon receiving this broadcasted packet, notes that the preceding node (that just relayed this packet) is actually the *Next Hop To Source* if it were to reach the source. Virtually this defines a dynamic distribution tree structure rooted at the source. The frequency of this Advertisement packet is soft defined and may be optimized to match with the mobility of the nodes in the network. Computing this frequency dynamically may be investigated separately. **(Fig-1)** shows a network of 18 mobile nodes. The node 17 being the multicast source transmits ADV packet in its antenna range. This packet is received by its immediate neighbors i.e.: nodes 12, 14, 15, 19, and 20. These nodes will re-transmit the packet to their immediate neighbors and so-on. Hence the ADV packet will get propagated like a wave front all across the network. Cycles are avoided by putting a sequence number in the ADV packet. This will create an optimal distribution tree.

The nodes which are interested in receiving the live multicast transmission send multicast transmission request (MTREQ) packet periodically after every T seconds, towards the source node via *Next Hop To Source*. Each node in addition to the source node in the path of this MTREQ message set its Forwarding Flag true which means it would be responsible to relay the multicast transmission within T+D seconds, where D is a bonus or extra time sufficient enough for the dependent subscribers to re-express their interest through subsequent MTREQ packets. The intermediate nodes which are no more in the path of active subscribers automatically stop relaying the stream when T+D commitment interval expires. Hence, nodes leaving the multicast session may simply stop sending their MTREQ packets. No information about the identification of the subscriber nodes is kept, hence resulting in a very low overhead.

(Fig-1) shows that node 21 and 26, being receivers, sends MTREQ packet towards node 17 (the source) hence committing nodes 23, 20 and 17 to relay the transmission for next T+D seconds by setting their Forwarding Flags. Each node including the source, will relay the data packets in its transmission range, only if its Forwarding Flag is set. Hence data forwarding is achieved along optimal paths.

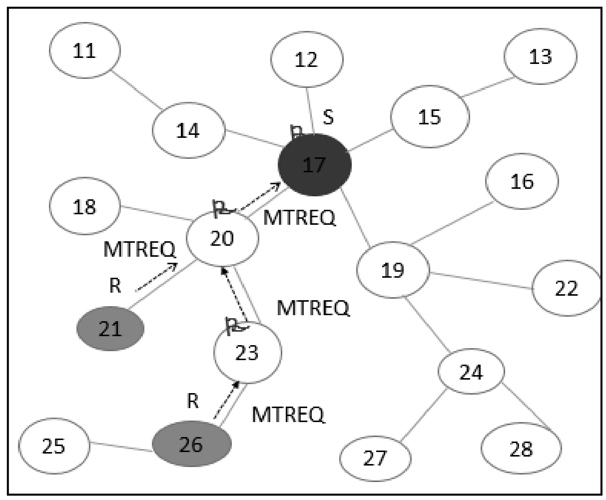

Fig.1. Nodes Receiving Live Data Streams through MTREQ and Forwarding Flag in SLIM+

3. STUDY OF MAODV

MAODV (Multicast Ad-hoc On-Demand Distance Vector) routing protocol is an enhancement to AODV (Moustafa, 2004) (Perkins, 1997). It uses a shared tree based approach.

The multicast The multicast routes in MAODV constructed through a mechanism called broadcast discovery. Here leader is the primary member of the group, which monitors multicast group sequence number and propagates group HELLO message to the group. Nodes to update their Route Request table consume this information. The expending ring search (ESR) used to keep the MAODV tree maintained. ESR repairs the broken links between nodes on circulating a RREQ packet through the downstream node. The node having the lesser/equal hop count towards the Multicast group leader, with respect to the value indicated in the

Route Request (RREQ) packet can response. The downstream node when does not get reply, it acknowledges when the multicast tree divided, and it becomes designated as the new leader of the multicast group. Until the reconnection, the multicast tree remains in parts, this may lead to problems (Royer and Perkins., 2000), **(Fig-2)**.

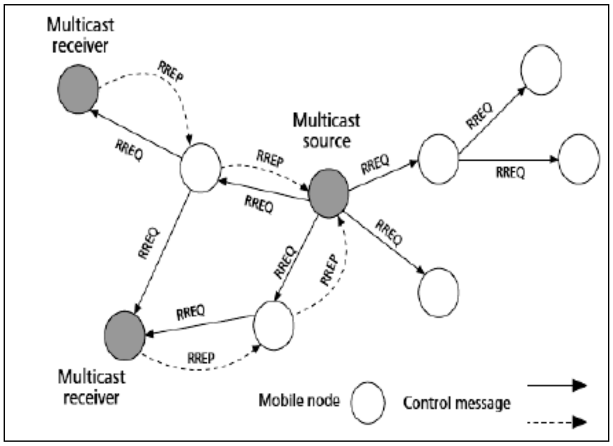

Fig.2. Route Discovery in MAODV Protocol adapted

MAODV is dependent on AODV. The protocols that uses shared tree based or core based approach, keeps more routing information and results to more overhead, this implies to MAODV also. MAODV behaves critical while fixing broken links. Also it suffers from long delays and high overheads in high mobility and traffic load situations (Sutariya., 2016).

4. STUDY OF PUMA

PUMA is (Protocol for Unified Multicasting through Announcements) proposed by Vaishampayan, and Garcia-Luna-Aceves, in 2004. It is still a most commonly used mesh-based multicast routing protocol for MANETs. Here a single packet called Multicast Announcement/MA used for the maintenance of all mesh routines. In this protocol, each source is eligible to send data packets towards a multicast group. Multicast Announcement or MA packet is composed of Group ID, Core ID, Distance To Core, parent node sending latest announcement and notifies other nodes while an announcement is been sent. Among the receiver nodes of the group, PUMA elects a node as a core node and inform every router about the relative next hop to the chosen core in each group. Each router might have one or more than one path towards the core, the receiver follows the shortest path towards the elected core. Each mesh member then flooded with the data packets and to avoid the duplicate transmission these packets are numbered. On receiving duplicate data packets, the numbers are checked and thus dropped if found redundant (M. Mohammed 2009), see **(Fig-3)**.

The M_Flag is set TRUE for all the receiver nodes, which are mesh members, initially. Whereas the non receiver nodes are considered as members of mesh if there is minimum of one mesh child in the connectivity list. A neighbor in that list is considered to be a child of mesh if the MFlag is true or the distance to core of neighbor is more than node's own distance to core. Here the MA must receive within an equivalent time to two MA intervals, ensuring that neighbor lies in the neighborhood. An immediate child of mesh is a mesh member whose path is the shortest path between receiver and core (Mohammed, 2009), (Wang and. Gupta., 2003), (Chiang and Huang., 2003).

Performance of the protocol may weaken if a multicast message once reaches a member of mesh and floods in the entire mesh. This flooding increases the overhead due to mesh-based distribution structure and may receive a redundant multicast message (Sumathy, *et al.*, 2012). Its group management may be challenging for the applications offering real-time streaming in open groups.

5. SIMULATION ENVIRONMENT

For the performance evaluation of SLIM+, PUMA, and MAODV the Network Simulator NS2.35 is used. Readers may request a patch of SLIM+ by sending email to the authors. For performance evaluation PUMA which is a mesh based multicast routing protocol (Vaishampayan, and Garcia-Luna-Aceves., 2004) and MAODV tree-based multicast routing protocol (Royer and Perkins, 2000) are chosen.

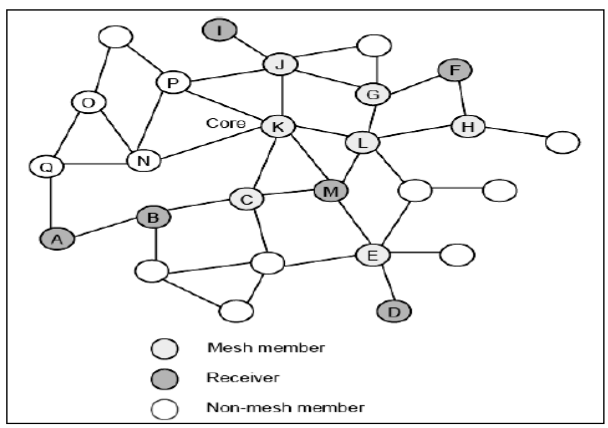

Fig-3. Mesh and Data Forwarding in PUMA adapted

The scenarios designed offers two types of stress to the multicast protocols under study. One is the size of the multicast group (i.e. the number of simultaneous listener nodes) and the other is the distribution structure reconfiguration frequency. The distribution structure (tree or mesh) is subject to change or reconfigure its topology each time a node joins or leaves the group. So the number of join-leave sessions per node used to vary the frequency of reconfiguration in distribution structure. Table summarizes the variations in the scenarios that we chose to compare the performance of SLIM+, PUMA, and MAODV protocols. The **(Table-1)** also displays other simulation parameters used in this study.

Table-1 Simulation Parameters

Parameter	Value
Number of Nodes	100
Area	800m x 800m
Simulation Time	110 sec
Transmission range	180m (optimized)
Data Traffic Type	CBR
Data Rate	128 Kbps
Packet Size	512 bytes
MAC Protocol	IEEE 802.11b
Protocols Used	SLIM+, MAODV, PUMA
Simultaneous Listeners (Avg group size)	20, 40, 80
Num. of sessions (join-leave) per node	5, 10, 20

6. RESULTS

SLIM SLIM+, MAODV and PUMA protocols simulated under the nine stress conditions i.e., Number of sessions per node (frequency of reconfiguration of distribution structure) for each of the simultaneous listeners (group size), as indicated in Table. Two QoS parameters –viz. Avg. Throughput, Avg. End-to-End Delay observed as performance metrics. In the following sub sections a brief definition of each of these metrics discussed and the observations and shown in their respective graphs.

6.1 Average Throughput

Average Throughput is the rate with which the network was able to ship data from the source to the destination. The throughput is usually measured in Kilo bits per second (Kbps). The throughput usually measured in Kilobits per second (Kbps). SLIM+ protocol outperformed PUMA with respect to the Average Throughput in all the stress scenarios. The Average throughput of both the protocols i.e., SLIM+ and PUMA shows no or little variation with respect to the number of join/leave sessions (i.e.: the frequency of changes in the distribution structure). However for both the protocols the Average throughput was found increasing with the increase in stress with respect to simultaneous listeners; which is an indicative of the available capacity in the network, see **(Fig-4), (Fig-5) and (Fig-6).**

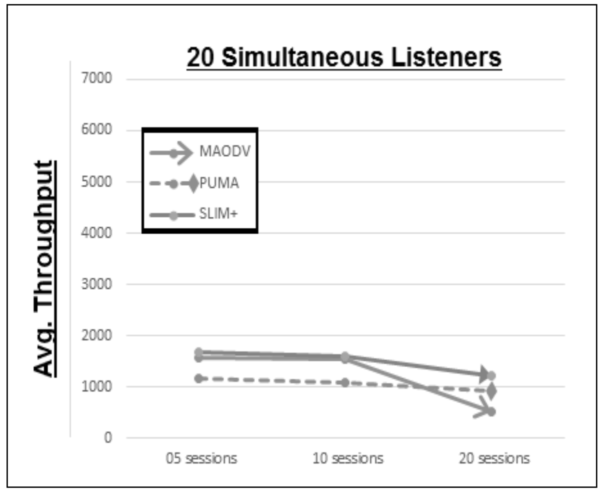

Fig.4. Average Throughput with stress of 20 Simultaneous listener Nodes

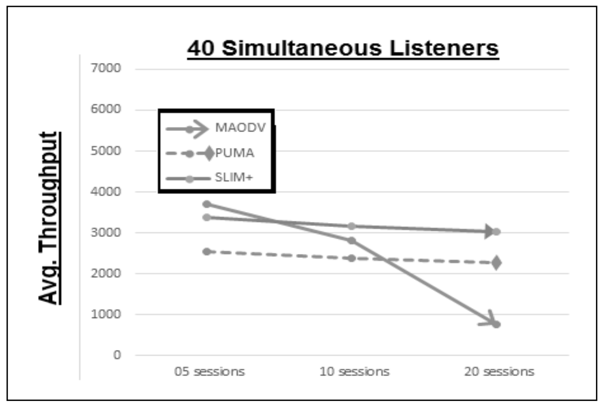

Fig.5. Average Throughput with stress of 40 Simultaneous listener Nodes

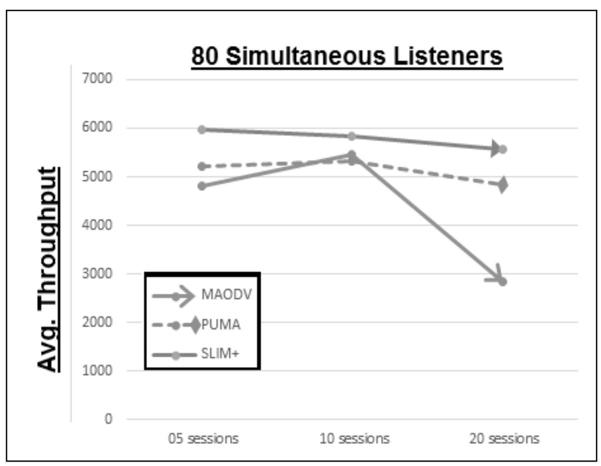

Fig. 6. Average Throughput with stress of 80 Simultaneous listener Nodes

6.2 Average End to End Delay

Average End-to-End Delay is the average time a data packet takes to move from source to the receiver. SLIM+ protocol shows no variation and remained significantly low as compared to that of PUMA in all the stress conditions posed. The Delay for MAODV found increasing with the increase in stress with respect to the number of simultaneous listeners, see graph in **(Fig-7), (Fig-8), and (Fig-9)**.

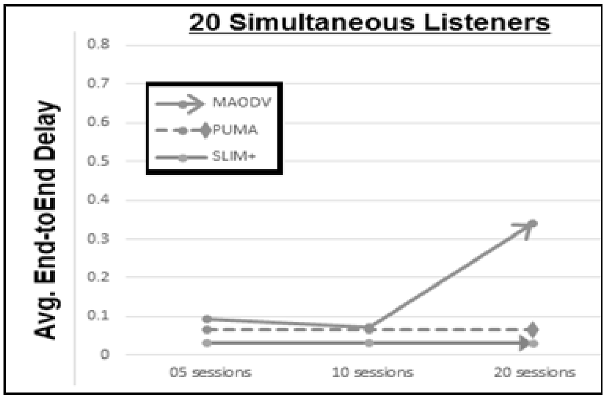

Fig.7. Average End-to-End Delay with stress of 20 Simultaneous listener Nodes

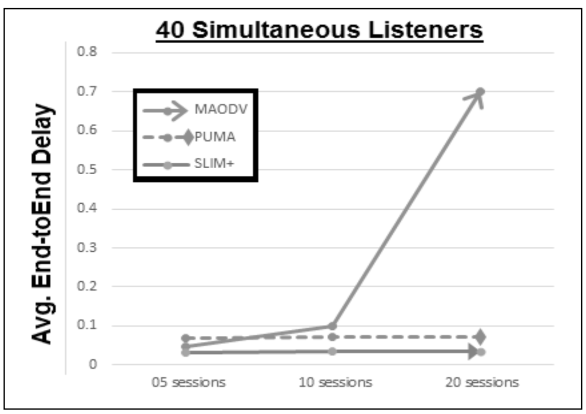

Fig. 8. Average End-to-End Delay with stress of 40 Simultaneous listener Nodes

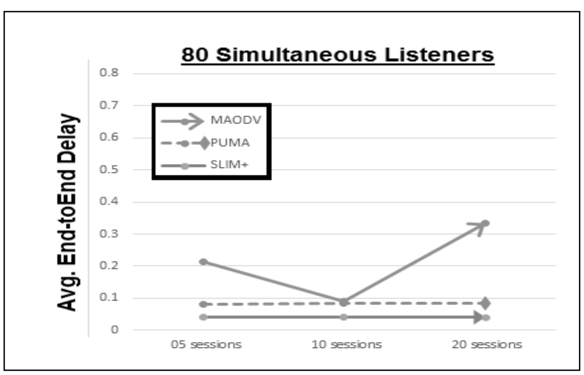

Fig.9. Average End-to-End Delay with stress of 80 Simultaneous listener Nodes

7. CONCLUSION

Existing multicast protocols in MANETs are targeted towards many-to-many type of multicast applications (e.g. teleconferencing) and a need for a protocol that is particularly optimized for one-to-many type of multicast applications (like TV/radio streaming) was there. Further MANETs are typically focus toward VANETs and Local Area Social Networks, a multicast protocol was needed that could deliver to an open-group of nodes and scalable enough to support large number of nodes without keeping membership information. We have proposed SLIM+ as a solution to this problem and showed that it is indeed a scalable, lightweight and simple multicast protocol. The initial results are quite promising.

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