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Evaluation of Routing Overhead of SLIM+, PUMA, and MAODV Multicast Routing Protocols in MANETs

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Abstract: Many multicast routing protocols are created for Mobile Ad-hoc Networks(MANETs) but still issues related to deal with their group management is an active area to be focused by the researchers. Although MANETs are currently progressing to facilitate common people such as into VANETs with narrow range community networks. There is a great deal of utilizations to be considered where combined administration must not be entirely taken after; the applications types could befall of one-to-many multicast of live data steams like live radio or TV transmission. For these applications, a multicast routing protocol is proposed and its performance is evaluated and compared with PUMA in a mobility scenario (Hussaini *et al.* 2016) and the robustness as a metric is also evaluated and compared with PUMA and MAODV in a static scenario (Hussaini *et al.* 2017). In this research, we are further working on the routing overhead (Normalized Routing Load-NRL) of SLIM+ with its counter parts PUMA and MAODV.

Keywords: One-to-Many Multicast; VANETs; Local Area Social Networks; SLIM+.

1. INTRODUCTION

MANET is an infrastructure-less self-configuring wireless network, formed by collection of nodes communicating each other (Hussaini *et al.*, 2017, Kumar *et al.*, 2012). The nodes communicate in these networks in a multi-hop fashion where due to absence of a fixed router intermediate node works as router moreover forwards records in favor of the further nodes (Leung *et al.*, 2001). Because the nodes are linked remotely the network topology suddenly changes with the open movement of devices. Because of this dynamic nature and lack of infrastructure, it is difficult for the nodes to find routes or paths from source node(s) to destination node(s). Thus, routing is actually problematic in wireless networks, and many routing protocols are yet developed in recent years (Lee *et al.*, 2000). The discovery and maintenance of efficient routes or routing is quite challenging in the environment of MANET (Meghanathan, 2011).

The message delivery or the standards of communication in routing protocols can be classified as unicast, broadcast and multicast. In unicast routing protocols there is a one-to-one communication between sender and a receiver node. Here the information is sent from one node to one receiver only which is impractical for MANET scenarios, where the nodes may be in the direct or indirect range of each other due to topology changes and free movement of nodes. While in protocols possessing broadcast communication information is sent to all the nodes in the network which unnecessarily uses the network resources for the uninterested nodes even. Whereas, in multicast routing protocols information is sent from the source to the interested receivers only, and thus efficiently uses the network resources. As a consequence, multicasting is suitable for the real-time scenarios (Meghanathan, 2011; Perkins, 1997; Sumathy *et al.*, 2012).

Strict group management in multicast routing protocols for closed group of nodes is still an active rea for various researchers in MANETs. These types of protocols are proposed and developed for many-to-many type of multicast applications where multicast group members are well-defined. With the advent of VANETs (Mohammadani, *et al.*, 2017, Abbasi *et al.*, 2015) and local area social networks (Stieglitz *et al.*, 2011, Vasan *et al.*, 2013) MANETs for their openness are becoming popular in common people and evolved as open group MANETs i.e. group members need not to be well-defined and it is open for all. So, the multicast routing protocols need to be readdressed for the one-to-many type of applications where group management is less or not required. Such multicast applications are real-time multimedia streaming in open groups or TV/Radio streaming in open groups.

Research article is distributed into following sections. Presentstree-based and Mesh-based multicast routing protocols and the proposed multicast routing protocol SLIM+illustrate simulation results and concludes the article followed by references.

2. MATERIALS AND METHODS

The protocols, possessing tree-based structure contains a single path between sender(s) and multicast receiver (s) the paths when breaks require to be

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repaired. While the protocols, possessing mesh-based structure contains multiple path between sender (s) and multicast receiver (s) reducing the overhead. The multiple paths may create congestions in the network and affects the robustness of the protocols (Stieglitz *et al.,* 2011).

Since the tree-based multicast routing protocol MAODV and mesh-based PUMA multicast routing protocol developed, these are still in use by various researchers such as (Aparna, 2010; Kawadkar, 2012; Mohammadani, *et al.,* 2013; Shah, *et al.*, 2015; Lakshmi *et al.,* 2015, Gaurav *et al.,* 2015, Gopi *et al.,* 2016). Some have addressed their disadvantages to develop newor improved versions of these protocols and some focused on the advantages of these protocols to merge their qualities and develop enhanced protocols.

The MAODV (Multicast Ad-hoc On-Demand Distance Vector) routing protocol is an enhancement AODV uncast routing protocol (Moustafa, 2004). MAODV uses a shared tree-based approach and routes are created in MAODV via broadcast discovery mechanism. The first member of the multicast group is a group leader that takes account of the multicast group sequence number and propagates a group HELLO message to the multicast group. This information is consumed by nodes to update their Route-Request table.

The MAODV tree is maintained by expending ring search method or ESR. Through the downstream node ESR repairs the broken links among nodes on circulating a RREQ packet. Only the nodes with the smaller or equal Hop count denoted in its RREQ packet towards the multicast group leader can response. If the downstream node does not get reply, it acknowledges as the multicast tree is divided, and it becomes designated as the new leader of the multicast group.

Until the reconnection of broken tree MAODV suffers from long delays. Due to the shared tree based approach the protocol keeps more routing information which leads to overhead (Sutariya, 2016).

PUMA (Vaishampayan, *et al.,* 2004) is a most commonly approached mesh-based multicast routing protocol for MANETs by the researchers. A unique control packet called Multicast Announcement/MA is used for all mesh creation/maintenance routines. This packet contains GroupID, CoreID, Distance to Core, parent node sending latest announcement and notifies other nodes while an announcement is being sent. Every source here is eligible to send multicast data packets towards a multicast group.The MA packet is capable of performing dynamic election of core node. A core node in PUMA is elected from the group of receiver nodes, to let every router know about the qualified subsequent hop to the elected core in every institution. These routers (nodes) may have multiple paths towards the core. 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 thus dropped if redundant. The MA packet also constructs and maintains a mesh. To do this a flag called M-Flag is set as TRUE initially for the node to indicate that the node is a mesh member. The non-receiver nodes are also considered as mesh members when there is a minimum of one mesh child exists in the connectivity list. A node in the neighborhood is also considered as a mesh child if it is in the connectivity list and the M-Flag is TRUE or the distance to neighbor's core is more than the nodes own distance to core.

The performance of the protocol may weaken if a multicast message once reaches a mesh member; it floods in the entire mesh. This flooding increases the overhead due to mesh-based distribution structure and may receive a redundant multicast message. Its group management may be challenging for the applications offering real-time streaming in open groups (Amuthan, and Abirami, 2011; Sumathy *et al.*, 2012).

SLIM+ is actually an advanced version of SLIM (Simple lightweight Intuitive Multicast Protocol). SLIM is proposed for real-time video multicast in 2014. SLIM's novelty is its multicasting in MANETs for live multimedia streams. SLIM observed to be dependent on any underlying unicast routing protocol (Shaikh, *et al.*, 2014). Also, it lacks an advertisement feature which is much needed for live multimedia streaming. So, these shortcomings were a big reason in implementing SLIM as SLIM+. The source node in SLIM+ periodically advertises or announces for the multicast stream via flooding an ADV packet in the neighborhood. Then the receiver nodes again floods ADV to their neighbors and this process continues like a wave front. This creates a distribution tree structure. To avoid repetition the ADV packets contains unique ID numbers. The nodes in the distribution tree structure takes responsibility of transmitting the multicast data packets to the receiver nodes using optimal paths. Actually, the ADV packet is periodically flooded by the source node to show the availability of live transmission. Upon receiving the ADV packet each node notes its preceding node as the Next-Hop-To-Source, and in this way, it reaches to source. The frequency of the advertisement packet is soft defined and may be optimized to match with the mobility of the nodes in the network (Hussaini *et al.*, 2016). When a receiver requests for the live transmission it creates a Multicast-Transmission Request or MTREQ packet through Next-Hop-To-

Source, after every T seconds periodically. After receiving MTREQ the nodes in the path set their Forwarding-Flag TRUE. That flag relays the transmission for the next T+D seconds, i.e., D is the bonus time for the receivers to re-express their interest in receiving the live Multicast transmission. The uninterested or out of the path nodes automatically stops sending their MTREQ packets. 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 see **(Fig. 1).**

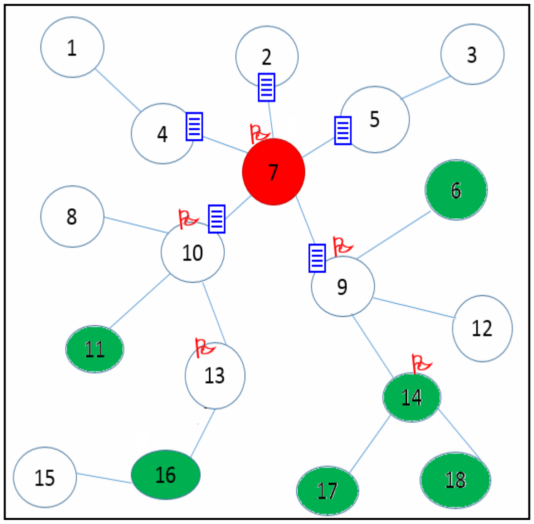

Fig. 1.Data Forwarding

As we have discussed the multicast routing protocols in detail. In order to see the robustness we have already worked in (Hussaini *et al.*, 2017). Let us check the routing overhead of these protocols in our experiments.

We saw that SLIM+ is the only protocol offers live multimedia transmission for open groups. So, the results are conducted for the overhead taken by SLIM+ with advertisement and without advertisement and compare it to MAODV and PUMA protocols.

3. RESULTS AND DISCUSSIONS

In order to gauge the performance of SLIM+, MAODV and PUMA Network Simulator NS2.35 (Shaikh *et al.*, 2013; NS2 Versus NS3)is used. The scenarios designed offer two types of stress to the multicast protocols under study. One is the size of the multicast group which is the number of simultaneous listener nodes and the other the other is the join leave sessions per node. The distribution structure (tree/mesh) is subject to change its topology each time a node joins or leaves the group. So number of join-leave session per node was used to vary the frequency of change in distribution structure. **(Table-1)** summarizes the variations in the scenarios that we chose to compare the performance of SLIM+ MAODV, and PUMA protocols. The table also displays other simulation parameters used in this study.

The advertisement or ADV mechanism is an exceptional functionality, which let the new nodes know

Table.1. Simulation Parameters

Simulation Parameters	Parameters Values
No. of Nodes	100
Simulation Time	110 sec
Environment Size	810m x 810m
Transmission range	180m (optimized)
DataRate	128 Kbps
PacketSize	512 bytes
MAC Protocol	IEEE 802.11b
Node Placement	Random
Protocols Used	SLIM+, MAODV, PUMA
Simultaneous Listeners Stress1 (Avg group size)	20, 40, 80
Num. of sessions (join-leave) per node Stress2	5, 10, 20

about the availability of live multimedia streaming. This functionality is performed by SLIM+ among the other two comparative routing protocols MAODV and PUMA, thus SLIM+'s NRL is evaluated with ADV as NRL of SLIM+ and without ADV or NRL of SLIM+ w/o ADV. In order to see the instability in the performance of the comparative protocols and stability in SLIM+, various stress types are imposed. Then finally Stress1 of simultaneous listener nodes varies from 20, 40, and 80 is considered for performance evaluation. The stress2 is posed by the reconfiguration of distribution structure as 5, 10, and 20in the graph (s) of **(Fig. 2 a,b,c);** each time when a node joins, it creates a link or a branch in the distribution structure and when the node leaves the distribution structure must prone that branch.

Normalized Routing Load (NRL) is an estimate of the number of control packets used to deliver a data packet. It is obtained by dividing the total number of data packets delivered by the total number of control packets (Sumathy *et al.*, 2012). As depicted in the graph in **(Fig. 2 a,b,c),** the NRL of SLIM+ w/o ADV is very low among the others and shows no variation with any of the stress situation posed to it. However, the NRL of PUMA was observed high initially but with the increase in stress with respect to the number if simultaneous listeners it remains same as NRL of SLIM+ w/o ADV. As shown in the graph, if we exclude the advertisement packet load, the NRL of SLIM+ outperforms PUMA. While NRL of MAODV is abruptly high when number of simultaneous listener nodes are 20, and 40. MAODV remained high with respect to NRL ofother protocols but little stable when number of simultaneous listeners are 80. It is of advertisement for open groups NRL of SLIM+ is not very high, thus performed good as compared to MAODV and PUMA with unnoticeable little high but stable overhead as NRL.

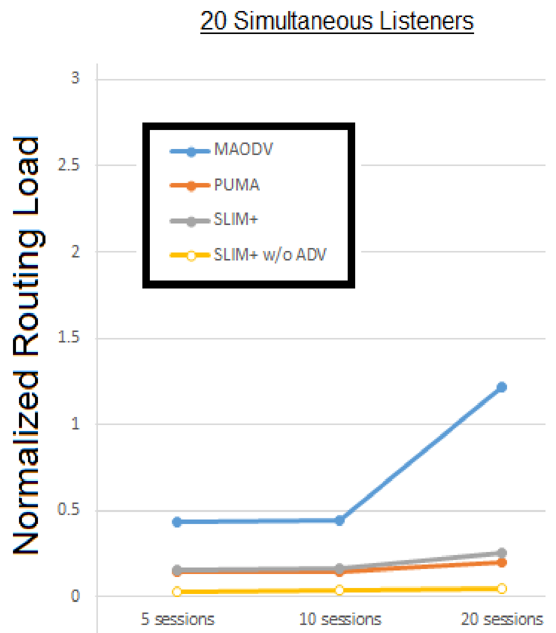

Fig. 2 (a). NRL of protocols with 20 simultaneous listeners

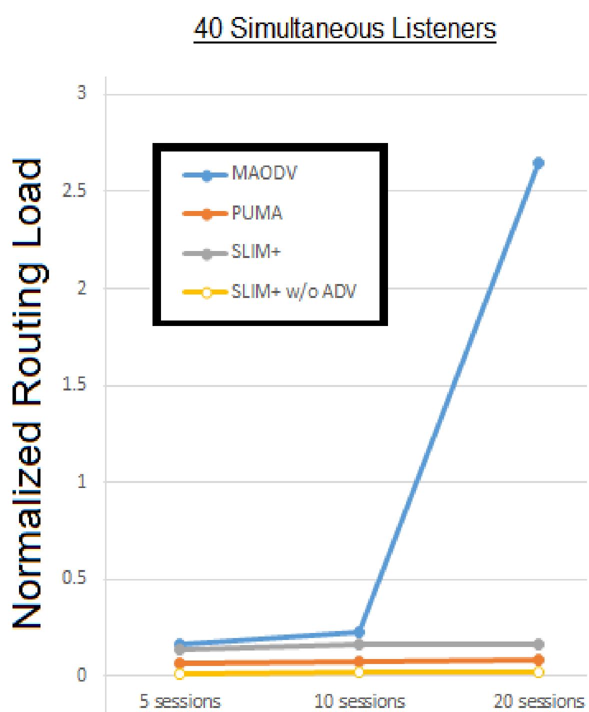

Fig. 2 (b). NRL of protocols with 40 simultaneous listeners

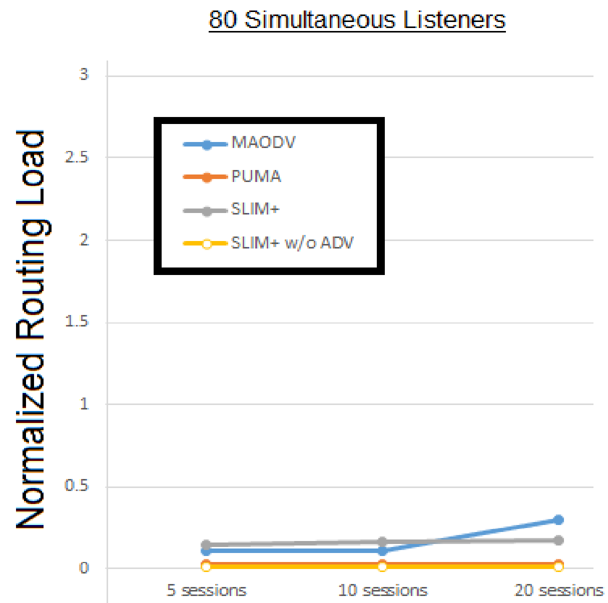

Fig. 2 (c). NRL of protocols with 80 simultaneous listeners

4. CONCLUSION

SLIM+ uses a novel approach for creating and maintaining multicast distribution structure in MANETs for open groups. While experimental evaluation it is found most robust multicast routing protocol among the mostly used PUMA and MAODV protocols with respect to the routing overhead. From the initial investigations about the protocol it appears entirely hopeful including high delivery ratio (Hussaini *et al.*, 2016; Hussaini *et al.*, 2017). SLIM+ with advertisement, which is an extra feature shows a little high but stable overhead excluding this feature SLIM+ outperforms on PUMA and MAODV. Our after-action includes the empirical assessment on the proposed protocol, analyzing the scalability as well as reliability concerning the protocol, in contrast of rest of former schemes.

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