A Comparative study of SLIM+ and PUMA protocols for multicasting in Open-MANETs

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Abstract
Multicasting in MANETs is an emerging research area for the network researchers and several routing protocols have been proposed that are still in their evolving stages. Most of these routing protocols are optimized for applications of many-to-many type multicast applications ignoring the need of one-to-many type multicast applications like TV/Radio streaming media. Moreover with the application of MANETs in large open groups like VANETs and local area social networks, it is difficult for these protocols to maintain the group membership for such highly volatile environments and hence results in degraded performance [1]. Earlier in [2] we proposed SLIM+ to fill this this gap and show some initial results in support of our proposal. In this paper we have done a thorough and comparative study to evaluate the performance of SLIM+ against the leading multicast routing protocol PUMA in a mobile scenario. The results are very promising.
Keywords
One-to-Many Multicasting; VANETs; Local Area Social Networks; SLIM

1. Introduction

Mobile Ad-Hoc Networks/MANETs are self-organizing networks, consist of mobile nodes communicating through wireless links to neighboring nodes present in their antenna range without any fixed infrastructure[3][4]. The communication between nodes in these networks is therefore multi-hop in which intermediate nodes are routers also and forward data packets for other nodes [5]. As the intermediate nodes acts as routers, the network topology becomes highly dynamic and unpredictable. Routing (i.e.: discovery and maintenance of efficient routes [5]) is quite challenging in such environments. While unicast routing can connect a single source to a single destination in the network, several real-time applications of MANETs require multicasting [6][7][11] which enables a group of nodes to receive data sent by a single sender. Some examples of Multicast applications include: Traffic advisory, Multimedia streaming like live radio or TV, and teleconferencing between rescue workers. Amongst the existing multicast routing protocols for MANETs most of them are focused towards teleconferencing type many-to-many multicast applications ignoring the need of streaming type one-to-many multicast applications.

MANETs can be classified particularly with respect to group management. Typically MANETs used to be a closed group of hosts communicating each other. In closed group multicast, group members are well-defined, anyone else cannot join or leave the network due to group management. With the passage of time as MANETs are becoming popular in common people, we see VANETs [8] and local area social networks [9] evolving as open group MANETs. In open group multicast, anyone can join and be the member of the group, as group management is unnecessary for real-time streaming in open groups like TV/Radio streaming.The routing protocols need to be re-addressed to include the openness of the node set. The existing MANET protocols lack their performance in maintaining the group membership which can be quite big and highly volatile in applications offering real-time streaming.

The paper is structured as: Section 2 and 3 will describes SLIM+ and the protocol to be compared with i.e., PUMA. Section 4 will present the simulation environment followed by the results and conclusion in sections 5 and 6 respectively.

2.SLIM+

In SLIM+ protocol, the source node periodically advertises the availability of multimedia stream multicast by flooding an advertisement packet. An important aspect of this advertisement packet is that its propagation defines a distribution tree structure. Each node in the tree transmits the multicast data packets in its antenna range on receiving a Multicast Transmission Request from the interested listeners. This is done by keeping only a single flag active in each node for the multicast streaming. The source of the multicast transmission periodically floods an advertisement packet and thus announces the availability of the live multimedia stream. On receiving this broadcasted packet each node notes its preceding node as the NextHopToSource to reach the source. Nodes which are interested in receiving the multicast transmission,

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periodically send multicast transmission request /MTREQ packet say after every T seconds towards the source node via NextHopToSource. Each node including the source node in the path of this MTREQ message set its Forwarding Flag and thus agree to transmit the multicast stream for the next (T+D) seconds, where D is a cushion time for the dependent subscribers to re-show their interest through subsequent MTREQ packets. The intermediate nodes which does not exist in the path of active subscribers automatically stops relaying the stream after the expiry of T+D commitment interval, See Fig. 1.
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.

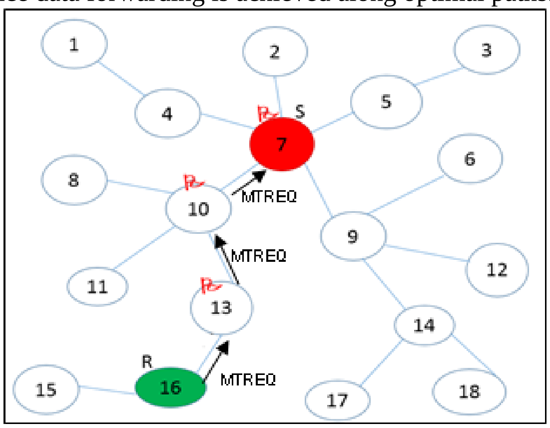

Fig. 1. Propagation of MTREQ within Tree

In Fig. 2, the packet sent by node 7 as shown in Fig.2. to be received by all of its neighbors 4, 2, 5, 9 and 10; however, only nodes 9 and 10 will retransmit the packet as their forwarding Flag is set and the other nodes will ignore the packet. The

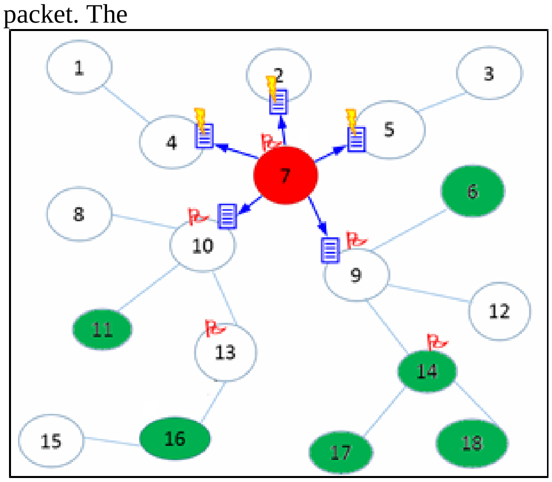

Fig. 2. Data Forwarding

packets forwarded by nodes 9 and 10 will subsequently be received by nodes 6, 12, 14, 13, 11 and 8; of these, nodes 6, 14 and 11 will consume the packet and 14 and 13 will relay it again in their neighborhood delivering it to the rest of the recipients.

3.PUMA: the RElative/comparative Multicast protocol

PUMA is a mesh-based Protocol proposed by R. Vaishampayan, et al, in 2004 [10]. The uniqueness in PUMA is the multicast announcements for the creation and maintenance of its mesh-based distribution structure in MANET. PUMA uses receiver initiated approach to construct mesh.
Like SLIM+, PUMA also performs independently without depending on any underlying unicast routing protocol to operate. As PUMA protocol uses mesh-based distribution structure [13] it has more than one path to send packets from senders to receivers and that feature is advantageous to achieve greater packet delivery ratio/PDR. However the mesh can be disadvantageous when packet transmission is redundant and may be wasteful sometimes.
For the announcement of multicast, PUMA elects core from its group of receivers, see Fig. 3. and informs every intermediate node which is of at least one NextHop to the elected core of each group. When the data packet reaches a mesh member, it is flooded within the mesh. As the packet ID is maintained duplicate data packets are avoided. The receiver nodes are considered as mesh members if the Flag is set TRUE. Non receiver nodes consider themselves as mesh members if they have at least one mesh child in their connectivity list. Connectivity list is established for every node to form a mesh topology and to route multicast data packets from senders to receivers. A neighbor in the connectivity list is a mesh child if its mesh member flag is set or the distance to core of the neighbor is larger than the node's distance to core.

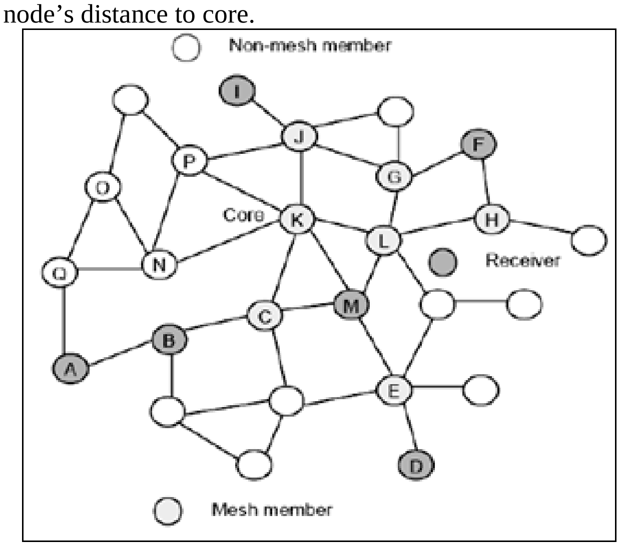

Fig.3. Mesh and Data Forwarding in PUMA adapted from [14]

The protocol is advantageous as the control overhead is less In PUMA, data packets floods within the receiving-mesh only, however its performance may weakens when this flooding increases the overhead due to mesh-based distribution structure and may receive a redundant multicast message [12]. Its group management may be challenging for the applications offering real-time streaming.

4. Simulation Environment

In order to gauge the performance of SLIM+ and PUMA Network Simulator NS2.35 [14] is used. Readers may request a patch of SLIM+ by sending email to the authors. Several studies have shown that PUMA has out performed other multicast protocols [10][12] particularly in achieving high PDR, low NRL and low End to end delay due to its mesh-based structure.

The scenarios we designed offer 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 change frequency. The distribution structure (tree or 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+ and PUMA protocols. The table also displays other simulation parameters used in this study.

Table 1. Simulation Parameters

Parameter (s)	Value (s)
No. of Nodes	100
Area	810m x 810m
MAC Protocol	IEEE 802.11b
Simulation Time	110 sec
Transmission range	180m (optimized)
Data Traffic Type	CBR
DataRate	128 Kbps
PacketSize	512 bytes
Node Placement	Random
Speed-Mobility	5m/s Random Way Point Mobility
Simultaneous Listeners Stress1 (Avg group size)	20, 40, 80
Num. of sessions Stress 2 (join-leave) per node	5, 10, 20

5. Results

Both SLIM+ and PUMA protocols were simulated under two types of stress conditions indicated in Table 1. Four QoS parameters –viz. Packet delivery ratio, Average throughput, Average end-to-end delay, and Normalized routing load were observed as measures of performance. Graph in Fig. 4 compares the observations made. In the following sub sections we will give a brief a definition of each of these parameters discuss the observations.

A. Packet Delivery Ratio

Packet Delivery Ratio (PDR) is the ratio of the number of data packets delivered to the number of data packets sent, however in the case of multicast the denominator is replaced by the number of data packets that were supposed to be delivered [12]. As depicted in the graph in Fig. 4, the PDR of SLIM+ protocol outperformed PUMA in all the stress situations posed. Given that PUMA is a mesh based protocol [10] which are known for reliability and high PDR, the performance of our tree based SLIM+ protocol is quite impressive. SLIM+ outperformed as the stress increases i.e., listeners increased and joins or leaves sessions per node increased.

B. Average Throughput

Average Throughput is the rate with which the network was able to ship data from the source to the destination [12]. It is usually measured in Kilobits per second (Kbps). As depicted in the graph in Fig. 4, the SLIM+ protocol outperformed PUMA with respect to the Average Throughput in all the stress scenarios. The Average throughput of both the protocols 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.

C. 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 [12]. According to the graph in Fig. 4, the Average End-t-End Delay for SLIM+ protocol shows no variation and remained significantly low as compared to that of PUMA in all the stress conditions posed. The Delay for PUMA was found increasing with the increase in stress with respect to the number of simultaneous listeners.

D. Normalized Routing Load

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 [12]. As depicted in the graph in Fig. 4, the NRL of SLIM+ protocol shows no variation with any of the stress situation posed to it. However the NRL of PUMA was observed decreasing with the increase in stress with respect to the number if simultaneous listeners. However this is the case that SLIM+ protocol additionally advertises the availability of the multicast stream which was not the case with PUMA.

6. Conclusion

Existing multicast protocols in MANETs are targeted towards many-to-many type of multicast applications and there was a need for a protocol that is particularly optimized for one-to-many type of multicast applications (like TV/radio streaming). Further MANETs are typically considered to be a closed group of nodes, but with the shift of focus toward VANETs and Local Area Social Networks, a multicast protocol was a need. A protocol that could deliver to an open-group of nodes and scalable enough to support large number of nodes without keeping membership information. SLIM+ is thus proved to be a scalable, lightweight and simple multicast protocol for open MANETs. The performance of SLIM+ is then compared with PUMA. The results in a mobile scenario are quite promising.

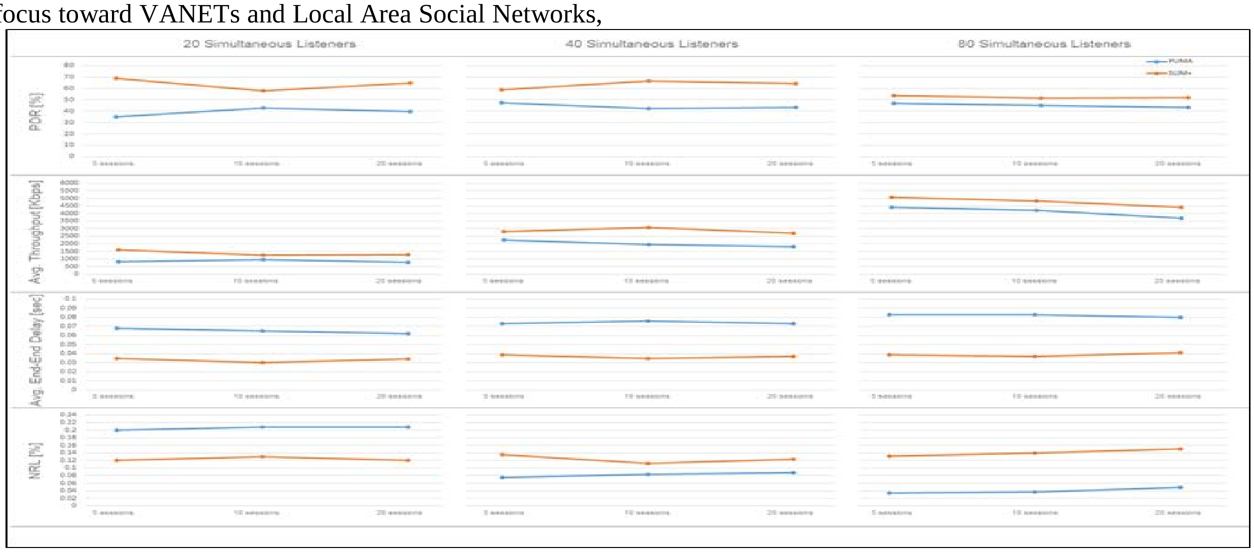

Fig. 4. Graph to show PDR[%], Avg. Throughput[Kbps], Avg. End-to-End Delay[sec], and NRL[%]

References

[1] A. Shaikh, S. Faizullah, D. Vasan, and Z. Ahmed, "SLIM - Simple Lightweight and Intuitive Multicast Protocol for MANETs", International Journal of Computer Applications, vol. 94, 2014.

[2] N. N. Hussaini, H. Kazi, A.Shaikh, S.Faizullah, "SLIM+: Advanced Simple Lightweight and Intuitive Multicast Protocol for MANETs", Proceedings of IEEE Interntional Conference on Computer, Control, Informatics and its Applications, IC3INA 2016.

[3] A. Mukherjee, S. Bandyopadhyay, and D. Saha, "Location management and routing in mobile wireless networks", Artech House, 2003.

[4] V. Kumar, and A. Kush, "A new scheme for secured on demand routing", IISTE Network and Complex Systems 2, vol. 2, 2012.

[5] R. Leung., J. Liu, E. Poon, A. Chan, and B. Li,. "A QoS-aware Multi-path Dynamic Source Routing Protocol for Ad-hoc Networks", In the Proceedings of the 26th IEEE Annual Conference on Local Computer Networks (LCN-01), pp. 132-141.

[6] A. Kumar Mishra, and A. Dev, "Ad-Hoc Network Protocols: A comparative Study", International Journal of Engineering Technology Science and Research, 2014.

[7] N. Meghanathan, "Survey of topology-based multicast routing protocols for mobile ad hoc networks", International Journal of Communication Networks and Information Security, vol. 2, 2011.

[8] S. Memon, H. Kazi, M. I. Channa, M. A. Shaikh, performance Evaluation of MANETs Reactive and Proactive Routing Protocols in High Speed VANETs, International Journal of Modern Communication Technologies and Research, vol. 2, 2014.

[9] S. Stieglitz , C. Fuch, "Challenges of MANET for Mobile Social Networks, 6th International Symposium on Intelligent Systems Techniques for Ad hoc and Wireless Sensor Networks", Procedia Computer Science , Vol. 5, 2011.

[10] R. Vaishampayan, and J. J. Garcia-Luna-Aceves, "Protocol for unified multicasting through announcements (PUMA)", In Proceedings of the IEEE international conference on mobile ad-hoc and sensor systems pp. 304-313, 2004.

[11] S. Rajarajeswari, P. Angaiyarkanni, and A. Arockia Selvaraj, "Survey on Tree Based, Mesh Based and Stateless Multicast Protocols in MANET", International Journal of Innovative Research in Computer and Communication Engineering, vol. 2, Special Issue 3, 2014.

[12] S. Sumathy, Beegalayuvaraj, and E. Sri Harsha, "Analysis of Multicast Routing Protocols", International Journal of Modern Engineering Research (IJMER), Vol.2, Issue.6, pp-4613-4621 ISSN: 2249-6645, 2012.

[13] J. Rangarajan, and K. Baskaran, "Performance analysis of multicast protocols: ODMRP, PUMA and OBAMP", International Journal of Computer Science and Communication vol. 2, pp- 577-581, 2011.

[14] http://www.isi.edu/nsnam/ns/ns-documentation.html, The Network Simulator ns-2 Documentation.