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Performance Evaluation: MAODV (Tree-based) Vs. PUMA(Mesh-based) Multicast Protocols for MANETs

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Abstract: To achieve better performance of multicast routing protocols for MANETs in various scenarios is still a contemporary issue for the researchers to explore. Distribution structure created as tree or mesh may cause pros and cons in these protocols. Among them MAODV which creates Tree based structure and PUMA creating Mesh based structure are famous routing protocols for MANETs. The research paper evaluate these protocols, and their performance is arbitrated by applying various stress conditions. These stress conditions are based on exponentially increasing the number of simultaneous listeners and join-leave sessions per node to evaluate the appropriate distribution structured protocol surviving and maintaining its performance. Increasing the join/leave sessions in different scenarios particularly assesses the strategy of distribution structure. Packet delivery ratio (PDR) is taken as a metric to compare the performance of above mentioned MAODV and PUMA multicast routing protocols.

Keywords; MANETs; Multicast Routing Protocol; distribution structure, Simultaneous listener nodes, Stress, PDR.

1. INTRODUCTION

Wireless moveable nodes assemble the mobile adhoc network (MANET). It is an energetically arrangements of portable network without using some prevailing network setup or centralized management (Tyagi and Chauhan, 2010; Rangarajan, and Baskaran, 2011). Nodes that forms the MANET collaborate with the destination portable devices (within their transmission range) in order to perform routing of packets. Also when source and destination devices are not within their transmission range, then routing of packets is performed in multi-hop fashion, see **(Fig. 1(a) and (b)).**

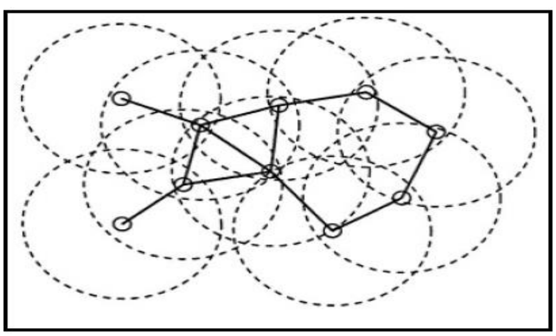

Fig. 1(a). MANET (Adapted from Mohapatra, P, et al. 2005)

Thus it is a multi-hop progression, and due in accordance with the restricted range over portable nodes(mobiles) or devices creating the network topology works as a router (Chitkara, and Ahmad, 2014). The overall end to end communication is, therefore, multi-hop in which intermediate nodes help to forward

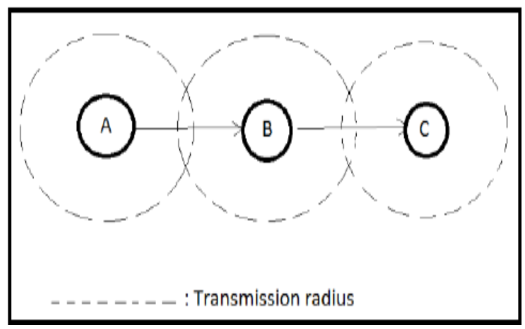

Fig. 1(b). Routing in MANET (Adapted from S. Sumathy et al., 2012)

the information for other nodes (Natarajan Meghanathan, 2011). Due to the lack of central administration and mobility the network topology becomes highly dynamic and unpredictable. Because of allowance of free movement of nodes irrespective of direction dependency in the network, eventually a node practices changes regarding its link with the other devices or nodes (Chitkara, and Ahmad, 2014).

Routing (Natarajan Meghana than, 2011; Nair, et al., 2013) is quite challenging in such environments where discovering and maintaining efficient routes is so difficult.

A type of common routing or network communication called unicast connects only a pair of

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two nodes in the network, **(Fig. 2)** where S represents sender (source node) and R represents receiver (destination node) so S and R can communicate directly without any help of intermediate node.

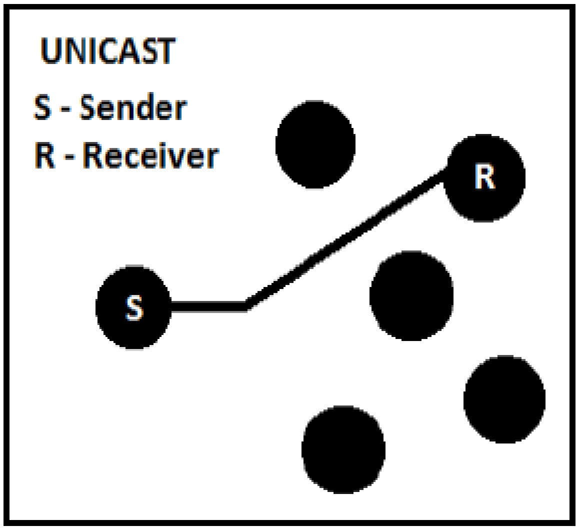

Fig. 2. Unicast Routing (Adapted from S. Sumathy et al., 2012)

While several real-time MANET applications needs multicast type of communication standard. Here, source node sends the same copy of messages to multiple destinations with help of multicasting technique (Natarajan Meghanathan, 2011). As in **(Fig 3).** where sender(S) sends same message to multiple receivers (R).

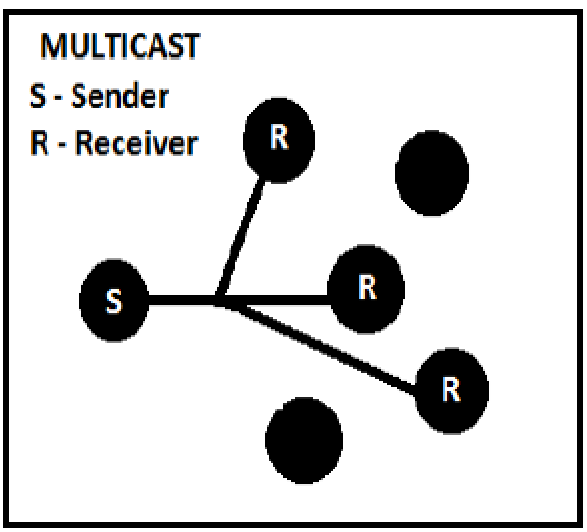

Fig. 3. Multicast routing (Adapted from S. Sumathy et al., 2012)

Some popular examples of Multicast applications are: tele-education, cooperative work, multimedia streaming like live radio or TV, teleconferencing between rescue workers, disaster management, and military operations and many others like in **(Fig 4).**

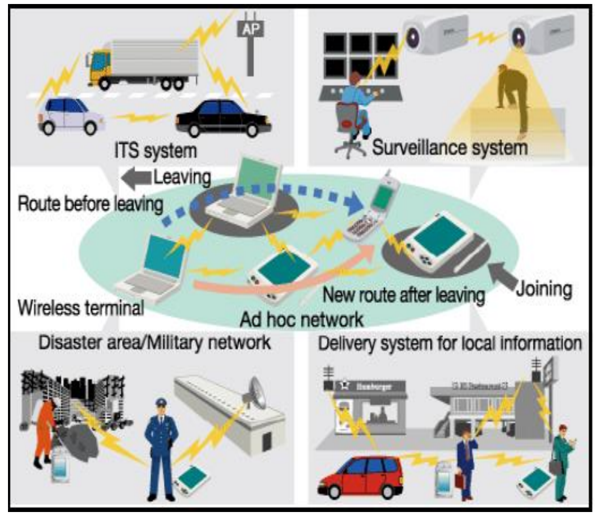

Fig. 4. Examples of MANETs (Adapted from Senthilkumar, P., et al., 2011).

Multicast routing establishes the group communication, reduces the cost of communication, and saves the resources of the network. Multicasting (in routing protocols) can be done by using any routing structure (tree-based and or mesh-based) (Natarajan Meghanathan, 2011;Kunz, and Cheng, 2001), as in **(Fig. 5).** There are a lot of routing protocols developed yet which multicasts in one-to many and many-to-many fashion. These protocols forms any of the said distribution or routing structure to avail foremost results according to the application specific need.

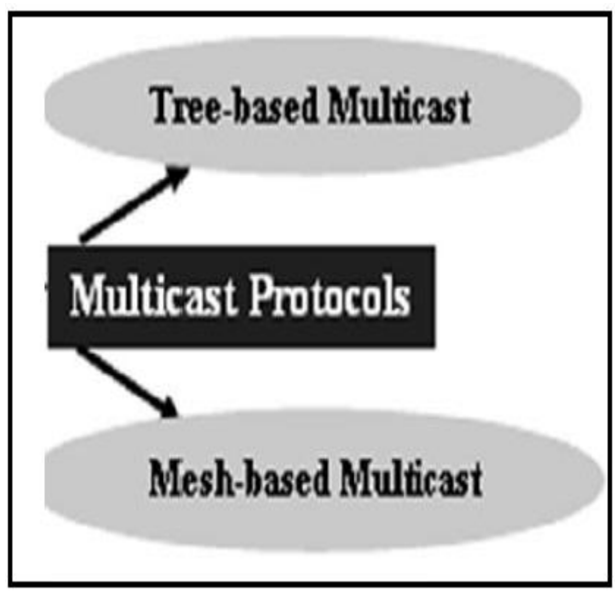

Fig. 5. Multicast Type Routing Protocols

In some situation the compromise for the routing structure is taken to acquire the desired results. Thus a large contribution towards the promotion of multicast routing protocols surveyed (Wong, and Wan, 2019)and is till on its evolving phaseForsome of the routing protocols adopting Tree based distribution structure the connection between sender to receiver exists via a single path only. These protocols are multicast efficient. The disadvantage of these protocols is that while facing unacceptable routes, the tree based routing is less forbearing as having only one path amongst the source-destination pair. The Mesh based multicast routing protocol contains more than one route to connect any pair of nodes. These protocols are more tolerant by permitting a node in forming more than one path(s) to the source or destination and can thus adjust a route, when necessary, to evade intercepted data transmission. The disadvantage of these protocols is they are more complex and consume more network resources.

The other sections in the paper are structured as: Section 2 contains the analysis of protocol creating tree like structure i.e., MAODV and the protocol creating mesh like structure i.e., PUMA for multicast type routing.Also describes the performance analysis of these both as literature yet reviewed by other researchers. Section 3 will present the simulation environment followed by the results and conclusion in sections 4 and 5 respectively.

2. ANALYSIS OF A TREE BASED AND A MESH BASED MULTICAST ROUTING PROTOCOL

Since, the mesh basedand tree basedrouting protocols yet developed for multicast routing, these are still in use by various researchers. Some addresses their disadvantages and some focuses on their advantages, hence determinedly evolving these protocols. Following is a brief review which shows that these are still the comparative protocols for the newly developed protocols.A number of multicast routing protocols are used by the researchers till now but their performance observed is application specific. Despite of this MAODV as a tree based and PUMA as a mesh based protocols are taken as customary for MANETs.

2.1 Multicast Ad-Hoc on-Demand Distance Vector (MAODV):

Traditional Ad-hoc On-Demand Distance Vector (AODV) routing protocol supports unicast transmission. MAODV is an extension of traditional AODV routing protocol (Royer,and Perkins,1999) and support multicast transmission. MAODV scheme creates a group leader among the nodes. Group leader buildsconnectivity in the network. Group leader node propagates its presence by flooding the Group-Hello-message. If the Group-Hello-message is unsent by any of the nodes of multicast group, each node then broadcasts a Hello message. The multicast tree is created very well and fast due to unicast routes are used in this protocol for the circulation of information (Huang,and Lo,2008). The expanding ring search or ESR is used to keep the MAODV tree maintained. The broken links between nodes is repaired on circulating a RREQ packet by ESR through the downstream node. A node with the lesser or equal hop count towards the multicast group leader respecting the value designated in the RREQ packet can response, see **(Fig 6).** The multicast tree divides when there is no reply by the downstream node, it acknowledges as the multicast tree is divided, and it becomes designated as the new leader of the multicast group.

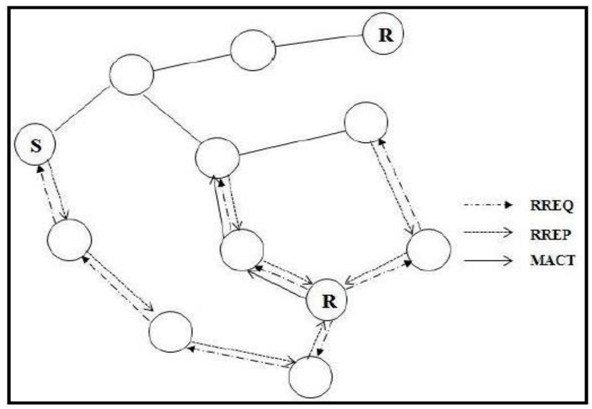

Fig.6. MAODV Tree-Formation (Adopted from Nair, K.et al., 2013)

Disadvantages/Comments/GAP:

- The group leader continuously floods Group Hello messages without taking care of sender whether it exist or not (Huang, and Lo, ,2008).
- Dependent on a unicast routing protocol AODV (Huang, and Lo,2008).
- Till the reconnection, the multicast tree remains in parts which may lead to problems.
- Poor packet delivery, packets do not travel in the shortest pathsthrough the shared tree thus may face high delay (Jain, and Agrawal, 2014).

Protocol for Unified Multicasting through Announcements (PUMA):

PUMA (Vaishampayan, and Garcia-Luna-Aceves, 2004) is still a most commonly approached mesh based multicast routing protocol for MANETs. With a single unique control packet MA i.e., Multicast Announcement, PUMA maintains the mesh routines. Also the protocol allows every sender to deliver multicast data packets towards a multicast group. The unique announcement in PUMA is capable of performing the multicast announcement through MA packet, the parent node sends 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 preferred core node in each group. Each router may have one or more than one path towards the core. Receiver follows the shortest path towards the elected core node. Each mesh member then flooded with the data packets and to avoid the duplicate transmission these packets are numbered. On receiving duplicate data packets, theirnumbers are checked and thus dropped if redundant. The MA here is expected to be received in a period of two MA intervals, ensuring that neighbor lies in the neighborhood, see Fig.7. An immediate mesh child is a mesh member whose path is shorter path thanthe path between receiver to core,(Astier, *et al*, 2012) and (Liu, *et al.*, 2014) also worked and still working on design and implementation of PUMA.

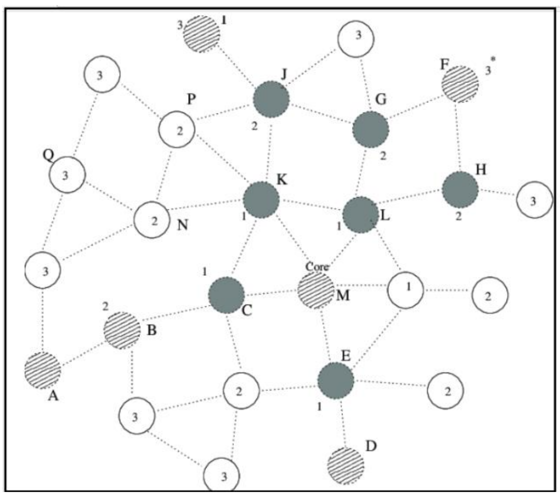

Fig.7. Mesh creation in PUMA (Adopted from Vaishampayan, R. and J. J. Garcia-Luna-Aceves, 2004)

Disadvantages/Comments/GAP:

- A multicast message when received by a mesh member, it floods inside the whole mesh. This process leads to unusual overhead if a certain node is covered by not a single neighbor node due to its mesh based structure. Thus receives multicast message from multiple source (s) (Astier, E*et al*, 2012; Sumathy,2012).

2.4 MAODV Vs PUMA:

A lot of studies and surveys are shepherded to gauge the performances of several multicast routing protocols w.r.t different metrics. Among them MAODV as tree based multicast routing protocol is still mostly approached protocol by various researchers. Whereas PUMA as Mesh based multicast routing protocol is also focused by the researchers to work on Some researchers compared these protocols according to their category like MAODV with other tree-based multicast protocols and MAODV with other mesh-based multicast protocols. While some researchers compare these protocols with each other regardless of their different distribution structures. Some of the surveys that shows these protocols as representative of all multicast protocols are discussed below: (Kunz, and Cheng, in 2001) in their research discussed ODMRP /On-Demand Multicast Routing Protocol and MAODV as well-known existing multicast routing protocols.Thus by considering the merits of both of these protocols they found MAODV is more scalable than ODMRP, also MAODV has low overhead than ODMRP. Research proved regarding the PUMA protocol with a more appropriate route discovery that avoids the congestion in the route(Vaishampayan, and Garcia-Luna-Aceves, 2004; Astier, *et al.*, 2012). Hitherto PUMA is identified as the preeminent multicast routing protocol over any other mesh/tree based multicast protocols. But when the point comes to the security issue (Arepalli, and Erukula, 2016),another proposed mechanism is acquaint with to improve PUMA, called Elliptic Curve Group Diffie-Hellman (ECGDH). The concerned researchers experimented that on covering up the security matters performance of the protocol W.R.T its PDR is also greater than before (Liu,2014). (Adhvaryu, and Kamboj, in 2017) also compared MAODV with their proposed protocol Optimized Expanding Ring Search (OERS). In this research MAODV is compared with PUMA. The performance metric used in the research study is PDR in mobility scenario with varying stress conditions.

3. SIMULATION ENVIRONMENT

In order to gauge the performance, PUMA and MAODV multicast routing protocols were implemented in the Network Simulator NS2.35 using Tcl/Tk and C++, **(Fig 8).**

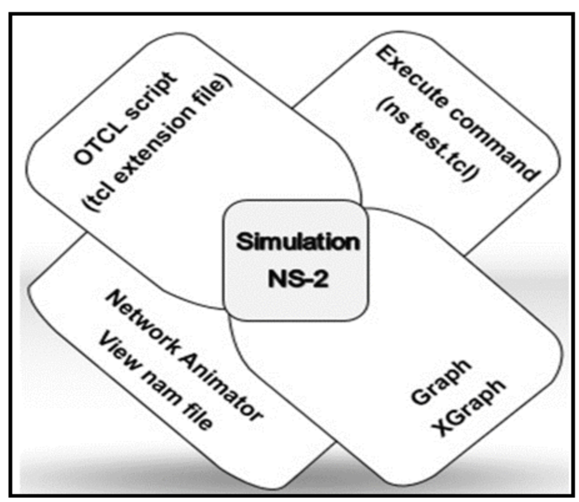

Fig. 8 NS2 Network Simulator

Several studies stated above and the given (Vaishampayan, and Garcia-Luna-Aceves, 2004) shows that PUMA has outperformed other multicast protocols mainly MAODV in terms of increased PDR and less overhead. The network scenarios designed to evaluate performances of PUMA and MAODV enforces stress of two types. In which increasing the number of simultaneous listener nodes is one of the stress condition. These simultaneous listener nodes were initially 20 and then they get doubled as 40 simultaneous listeners or the group size. The other stress was to quantify how frequently the distribution structure in both (PUMA and MAODV) multicast routing protocols are reconfigured. Each time when a node joins the multicast session and or leaves the session the topology changes. These join leave session are also increased exponentially such as 01,02,04,08 and 16 sessions. And among both of these protocol which ever tolerates and maintains their performances is measured via PDR. **(Table 1).** summarizes the variations in the scenarios that we chose to analysis the MAODV and PUMA protocols. The table also displays other simulation parameters are used for research work.

TABLE 1. SIMULATION PARAMETERS

Parameter	Value
Simulator	NS2.35
No. of Nodes	100
Time of Simulation	600 Sec
Node Placement	Random
Area of Simulation	800*800m²
MAC protocol	IEEE-802.11b
Transmission Range	180 meters
Mobility(Speed)	15m/s
Mobility Model	Random Waypoint Model
Data Traffic Type	CBR 128 kbps
Data Packet Size	512 bytes
Multicast Routing Protocols used	MAODV, PUMA
Stress1(Simultaneous Listeners Nodes)	20, 40, 80 nodes
Stress2(Reconfiguration of Distribution Structure)	01, 02, 04, 08, 16 join/leave session per node

4. RESULTS

Both MAODV and PUMA protocols were experimented under the various stress conditions indicated in **(Table 1). (Table 2(a),(b))** presents the results and Graph(s) in rest of the figures compares the observations made from these tables. Following sub-sections includes brief definitions for each of the parameters discussed in the observations.

4.1 Packet Delivery Ratio/PDR

The ratio of total packets delivered to destinations/ total data packets expected to be received is equal to PDR (Kunz, and Cheng, 2001). As shown in **Fig. 9(a), 9(b), 9(c), and 9(d),** PUMA outperformed than MAODV with respect to their PDR. It means PUMA has successfully delivered data packets when number of simultaneous listener nodes were 20 and even increased to 40 and then 80 simultaneous listener nodes.

TABLE 2(A) PERFORMANCE EVALUATION RESULTS

Protocol	Sim.Lis Node	Stress	PDR
MAODV	20	01 sessions	0.672
MAODV	20	02 sessions	0.676
MAODV	20	04 sessions	0.653
MAODV	20	08 sessions	0.648
MAODV	20	16 sessions	0.423
MAODV	40	01 sessions	0.621
MAODV	40	02 sessions	0.637
MAODV	40	04 sessions	0.612
MAODV	40	08 sessions	0.488
MAODV	40	16 sessions	0.323
MAODV	80	01 sessions	0.57
MAODV	80	02 sessions	0.572
MAODV	80	04 sessions	0.459
MAODV	80	08 sessions	0.248
MAODV	80	16 sessions	0.222

TABLE 2(B). PERFORMANCE EVALUATION RESULTS

Protocol	Sim.Lis Node	Stress	PDR
PUMA	20	01 sessions	0.705
PUMA	20	02 sessions	0.701
PUMA	20	04 sessions	0.707
PUMA	20	08 sessions	0.683
PUMA	20	16 sessions	0.67
PUMA	40	01 sessions	0.637
PUMA	40	02 sessions	0.63
PUMA	40	04 sessions	0.619
PUMA	40	08 sessions	0.61
PUMA	40	16 sessions	0.476
PUMA	80	01 sessions	0.539
PUMA	80	02 sessions	0.541
PUMA	80	04 sessions	0.522
PUMA	80	08 sessions	0.47
PUMA	80	16 sessions	0.394

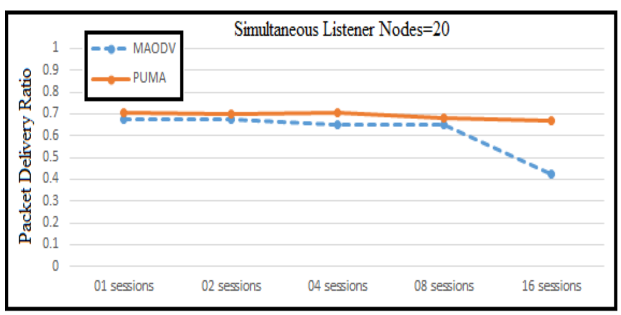

Fig. 9(a) PDR of MAOD and PUMA: Simultaneous listeners=20

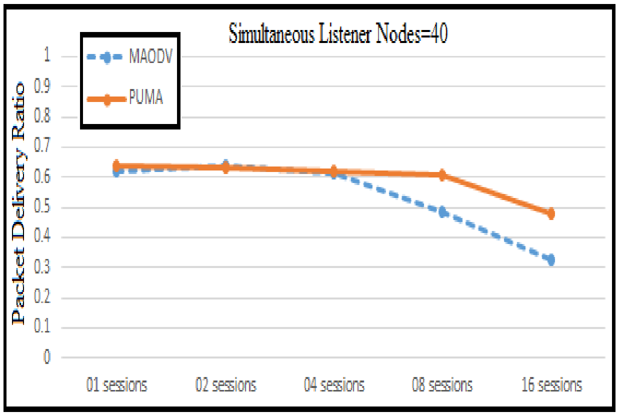

Fig. 9(b) PDR of MAOD and PUMA: Simultaneous listeners=40

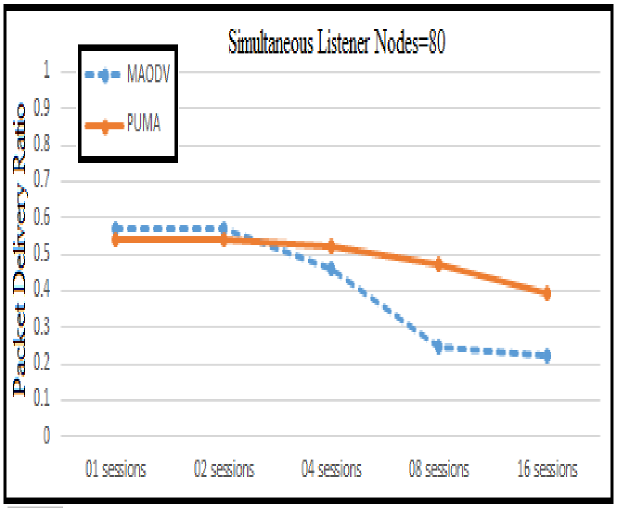

Fig. 9(c) PDR of MAOD and PUMA: Simultaneous listeners=80

5. CONCLUSION

In the comparative study the performance against a mesh based multicast routing protocol(PUMA) and a tree based multicast routing protocol (MAODV) is evaluated. These protocols were identified as the leading protocols for achieving multicast in MANETs. Both protocols presented at the same kind of stress conditions and were observed for PDR. It was noted that under all stress conditions the PUMA was more stable protocol than MAODV in all varying stress conditions applied. As we studied in literature review of PUMA and MAODV, and analyzed that they are the mostly approached multicast protocols in MANETs. For the robustness with PDR performance evaluation various stress conditions were posed.

It is observed that PUMA successfully delivered packets to the destinations with the exponential increase in the number of simultaneous listeners. Whereas MAODV in the same scenario get crashed and failed to deliver the packets to the destinations. From the results we have observed with respect to the number of join-leave session of nodes the behavior of PUMA is more stable than MAODV. Also as some of the studies observed MAODV as more scalable than another mesh based protocol. But here in this study PUMA is found more scalable (on increased number of simultaneous listener nodes) than MAODV.

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