Performance Evaluation of Multicast Routing Protocols in Mobile Ad Hoc Networks

N. Padmavathy(✉), K. Srinivas, and P. Srinivas

Department of Electronics and Communication Engineering,
Vishnu Institute of Technology (A), Bhimavaram, AP, India
padmavathy.n@vishnu.edu.in

Abstract. Wireless Ad hoc networks are networks connecting mobile devices that are self-contained. It's these networks simplicity and ease of implementation make them the best choice for frontline communications, incident management, and other related applications when dependable infrastructure is not easily accessible. The applicability of such networks has been challenging due to partial bandwidth, energy restrictions, and unexpected system topologies. Recent years have seen resurgence in this area's research. Specifically in routing, security and multicast concerns. The paper focuses on multicast routing in peer-to-peer networks in this paper. In this work, the source packet dumping, a fresh multicast routing system has been presented. Based on restrictions on hop distance, the connectivity routes between providers and group members are established as a single hop/multihop. In order to ensure effective data dissemination, a probabilistic data forwarding mechanism has been suggested. The simulation results demonstrated the performance of suggested routing protocol comparison to factors that define an ad hoc network. It is evident from simulation results, that the suggested protocol delivers effective data distribution and is resistant to topology changes.

Keywords: Ad hoc network · Connectivity · Dynamic topology · Hop distance · Routing Protocols

1 Introduction

Ad hoc networks are nodes that self-organize and communicate with one another directly rather than through a fixed infrastructure [1]. As nodes move and come into range of one another, these networks can spontaneously form. Smart phones, laptops, and other portable devices, as well as sensors and actuators, can all function as nodes in an ad hoc network. The key characteristics of ad hoc networks include decentralization, changeable topology, infrastructure-less, resource constraints, and multi-hop. Ad hoc networks can be used for a variety of purposes, including automotive networks, wireless sensor networks, and disaster relief efforts [2–4]. Ad hoc networks, however, can present a number of technological difficulties, including routing, security, energy conservation, and quality of service (QoS).

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Routing protocols in mobile ad hoc networks (MANETs) are designed to handle the dynamic topology of the network, where nodes can move around and change their position frequently. And also responsible for discovering and maintaining routes to destinations, even as nodes move around or leave the network. Routing protocols can help improve the performance of the network by reducing delays, minimizing packet loss, and optimizing the use of network resources. Routing protocols can select the most efficient path for data transmission and avoid congested areas, which can lead to better network performance. Routing protocols are responsible for ensuring reliable communication between nodes in the network. Routing protocols can detect link failures, re-establish routes, and prevent data loss, which can improve the overall reliability of the network. Routing protocols can adapt to the changing network conditions, such as changes in topology, traffic load, and link quality. Routing protocols can adjust their behavior to optimize network performance, which can lead to better throughput and reduced latency.

The MANET ideal is a good fit for the multicast standard since hosts typically work together as a group in an ad hoc environment to complete a task. Additionally, the multicast paradigm boosts network efficiency through widespread data dissemination, making it perfect for MANETs and other networks with limited capacity. Consequently, multicast communicating in ad hoc networks is really essential. Hence, a novel multicast routing protocol for wireless ad hoc networks in this paper is proposed. These protocols' effectiveness as multicast protocols was assessed and contrasted with the effectiveness of conventional flooding. A variety of operational values for different characteristics that define a MANET, such as mobility speed, traffic load, network density, etc., based on trade-off curves has been considered. And also multicasting in a MANET with multihop connectivity [5] is significantly more complex than in wired networks due to aforementioned characteristics, addressing and deployment considerations etc.

Routing protocols are essential in mobile ad hoc networks (MANETs) because it enable nodes to communicate with each other and exchange data, even in the absence of a centralized infrastructure. MANETs are characterized by their dynamic topology, where nodes can move around and join or leave the network at any time. As a result, routing becomes a complex task in MANETs, and specialized routing protocols are needed to ensure efficient and reliable communication.

2 Literature Review

Multicast routing is an important communication paradigm in mobile ad hoc networks (MANETs) that enables efficient group communication between multiple nodes. In this literature review, we will discuss some of the commonly used multicast routing protocols for MANETs are; On-Demand Multicast Routing Protocol (ODMRP): Ad Hoc Multicast Routing Protocol (AMRoute): Core-Assisted Mesh Protocol (CAMP): Zone-Based Hierarchical Link State (ZHLS). Comprehensive multitree routing proto-cols for connected/fixed networks include DVMRP [6], MOSPF [7], CBT [8], PIM-SM and PIM-DM [9]. Currently few researchers used Energy Constraint Secure Routing Protocol [10] used tree-based protocols [11–13] to reduce power constraint and dynamic connectivity.

Mesh protocols [14, 15, 18, 19] are used to establish and maintain mesh structures, or a group of network nodes that connect all the teammates. The Neighbour-Supporting Multicast mechanism (NSMP) [16, 17], a novel ad hoc multicast routing mechanism adopts a mesh topology to increases the resilience against mobility. In addition, NSMP also make use of node localization to lower the cost of route failure recovery and mesh maintenance. Due to redundant data transmission, this network's structure is more resistant to network dynamics thanks to the mesh of nodes that offers numerous paths to the group's members. According to a UCLA comparison mesh techniques are being studied for ad hoc multicast routing systems more resistant to topology changes since there are more channels to the destination [20], but performance is compromised because of terminated transmitting data. Grid protocols are said to be less efficient compared to tree-based protocols. In fact, interactive routing trees are the most efficient structure for moving data. Decision trees are subject to structural changes. During the tree update process, common topology modifications could lead to significant data loss and extreme control exchange. Mesh- based protocols have higher levels of dependability for a variety of mobility speeds. Extensions of unicast protocols include [11, 21–24] and other multicast routing protocols. The two functionalities are sufficiently different to merit independent attention, thus it is still debatable whether it is a smart idea to merge them [22].

An improved Dynamic Source Routing (DSR) Protocol with a new schema called as O-DSR was proposed in [25] to maximise the network lifetime [26–28] of mobile nodes and also overcoming the congestion simultaneously. LLECP-AOMDV lowers node energy consumption, and has a shorter average end-to-end delay [26]. The modified O-DSR algorithm called as MDSR [29] along with Ant Colony Optimization (ACO) finds the best path and optimises total weight (cost, delay, and hop count) of the network.

3 Multicast Routing Using Source Grouped Flooding

A new multicast routing system has been proposed for wireless mobile ad hoc networks that build a network of node which is built from a source called a flood set to deliver information from that source. Flood sets differ from routing sets in that the former are constructed using distance and hop enumeration metrics, while the latter are constructed using the inverse shortest path mechanism. Although the flooding cluster is a source crafted mesh, the routing group is also a grouping based lattice of nodes.

3.1 Flooding Group Creation

Each source in this protocol specifies routes to all other participants in the multicast group as needed. For the origin, the flood set is the result of the origin request phase and the set response phase. The resulting distance constraints dictate the creation of flood sets for sources, as given in (1) and (2)

$$D_{sn} \leq D_{sm} \quad (1)$$

$$D_{mn} \leq D_{sm} \quad (2)$$

The value of D_{sn} denotes the count of intermediary steps from input to central node. The number of hops that exist between the origin point as well as a multicast group participant is referred as D_{sm}. In between multicast attendee and the middle node, measured in hops is represented using D_{mn}. In the network, nodes decide whether to join the dive group (group of nodes operating as a cluster to standardize an IP routing protocol that is application specific) according to the distance using (1). During the request-reply process, the nodes acquire these distance metrics. A source periodically broadcasts a join request message whenever it has packets to send. The address of the multicast team with the count of a hop pitch is both included in the join request message. The flooding group is updated as follows by this recurring communication. Upon receiving a unique join request, a node will increase the hop count of the origin and save it in its own memory before relaying the packet.

Upon receipt of a request to join, a multicast group member takes note of the distance between the source D_{sm} and itself, adds a standard delay, and subsequently issues a response in the form of a "join" as a reply message. The reply to the accept request includes details regarding both the multicast group and the hop count between the source and destination nodes. Typically, the TTL in this message corresponds to the hop count of the origin (D_{sm}). Also, a node only forwards the response message if it's not being used to download things right now, it won't help with fixing the route, otherwise the information is lost. So, while doing something, given update command, the node reader only issues the first response message for each resource. As a result, the protocol generates for each source a flood set consisting of nodes subject to the hop distance (see Fig. 1).

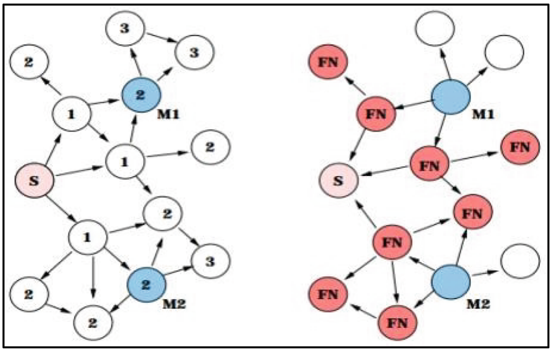

Fig. 1. Flooding Group Creation.

3.2 Flooding Group Update and Soft-State

The join request message will be periodically rebroadcast, reinforcing the flooding group for apiece source. This route restores takes into consideration topology variations brought on by member discovery and mobility. The protocol records what group members remember, but one's memory may change over time. To become part of or exit a group, members do not send public messages.

3.3 Detection of Duplicate Packets

Every packet from apiece source contains a broadcast order number. The broadcast structure number, which uniquely identifies each packet produced by the source and is made up of the source address and a counter assessment. Any node that gets a packet by a categorization 18 number higher than the significance that is currently stored processes the packet and updates the cache. If not, the package will be removed because it is a duplicate.

3.4 Data Forwarding

A source has new, active routes to every associate of the multicast group after the flooding group has been created. Only nodes in that source's forwarding group will assume that the packet was sent by that source. Using the distinct source broadcast ID, all duplicate data packets are detected and deleted. The data forwarding mechanism and potential issues brought on by redundant data transmissions are revealed in Fig. 2.

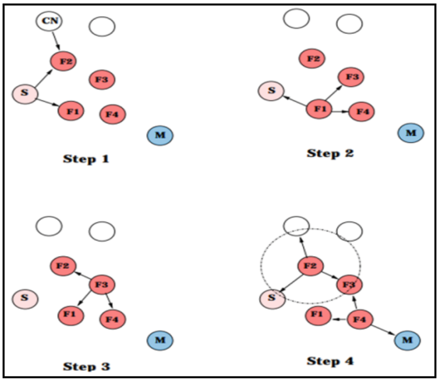

Fig. 2. Contention and Collision during Data Forwarding.

3.5 Hop Count Data Forwarding (HCDF)

Care has been taken to add a hop count pitch to the data packets to reduce the MAC layer clogging and collisions caused by redundant data transmission. The increased data passing mechanism is shown in Fig. 3. The hop count distances discovered through the request response switch phase are represented by the numerical numbers inside the nodes. The axes represent where a given broadcast will go, while the arrow values represent the number of packet hops. Steps 1 through 3 correspond to Fig. 3.

The hop count of the packet that node F2 receives from node F3 is set to 2 in step 4. Even though the packet is original, node F2 won't forward it in this scheme since the hop count it has stored is less than the hop count in the data packet. Thus, extra communication that could cause conflict and a collision is prevented

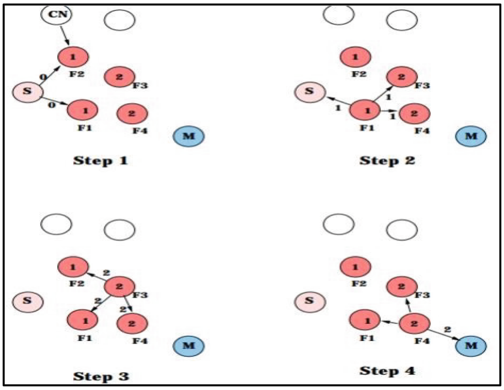

Fig. 3. Hop count based Data Forwarding.

3.6 Size Controlling of the Flooding Group

If the distance between that node and the start point, plus the distance between that node and the end point, is less than or equal to the total distance between the start and end point, then that node is on the shortest path, which is represented using (3) a controlled dive group (shortest path) has been represented using Fig. 4.

$$D_{sn} + \left(D_{sm} - TTL_{rep}\right) \leq D_{sm} \rightarrow D_{sn} \leq TTL_{rep} \tag{3}$$

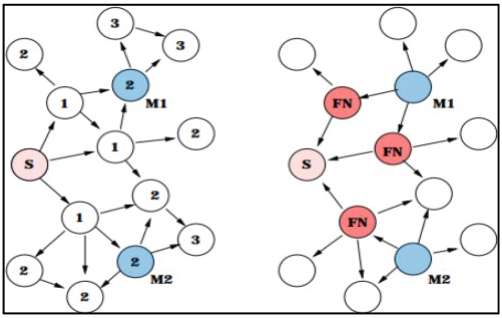

Fig. 4. Creation of Controlled Flooding Group.

3.7 Probabilistic Data Forwarding

The group flooding offers several routes after the source to the group's participants. To reduce data overhead a probabilistic data forwarding mechanism has been proposed and presented how to figure out the chance of a packet being sent again (P_{send}). The probability that a node chooses to retransmit a packet is P_{send}, and the probability that a node chooses to discard the packet is (1 - P_{send}) (Fig. 6).

$$P_{send} = \frac{1}{1+N} \tag{4}$$

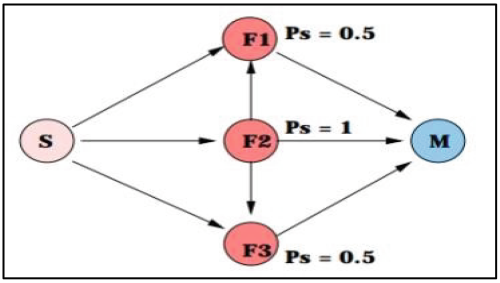

Fig. 5. Probabilistic data forwarding.

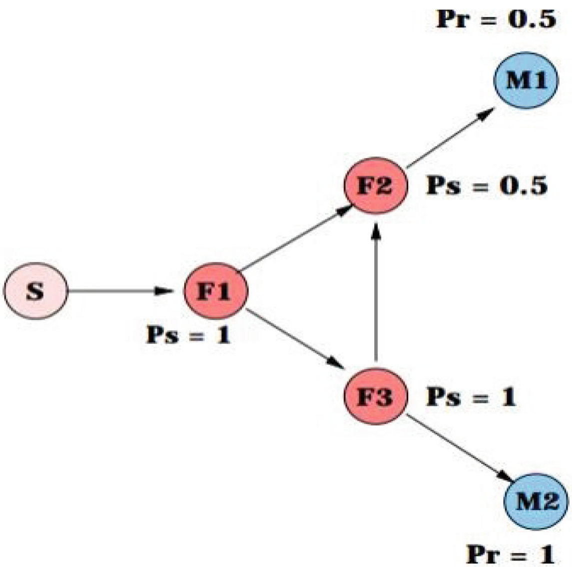

Fig. 6. Non-Guaranteed data delivery.

All duplicate data packets, regardless of hop count number, are dropped after a data packet has been retransmitted which is represented using (4). Where, N is the amount of packets that are the same and expected to leap the same number of times on that layer.

4 Algorithm

Based on grouped flooding protocol, an algorithm for evaluating the performance of MANET has been developed based on flooding protocol design.

4.1 Basic Source Grouped Flooding Protocol (BSGFF)

By using a rule called distance constraint (1) the algorithm creates groups that make you feel like you're inside them. The algorithm is described in the flowchart below, which also describes the methods used to generate flood sets and transfer data

4.2 Shortest Path Source Grouped Flooding Protocol

Using distance constraint (3), this algorithm creates the flooding groups with the shortest paths. This algorithm is employed to determine whether shortest path flooding groups are advantageous based on shortest path (see Fig. 4).

4.3 Probabilistic BSGFF (PBSGFF)

This algorithm makes use of the basic flooding group's probabilistic data advancing mechanism. Similar to Fig. 7, the routing has been established based on probabilistic data forwarding (see Fig. 5).

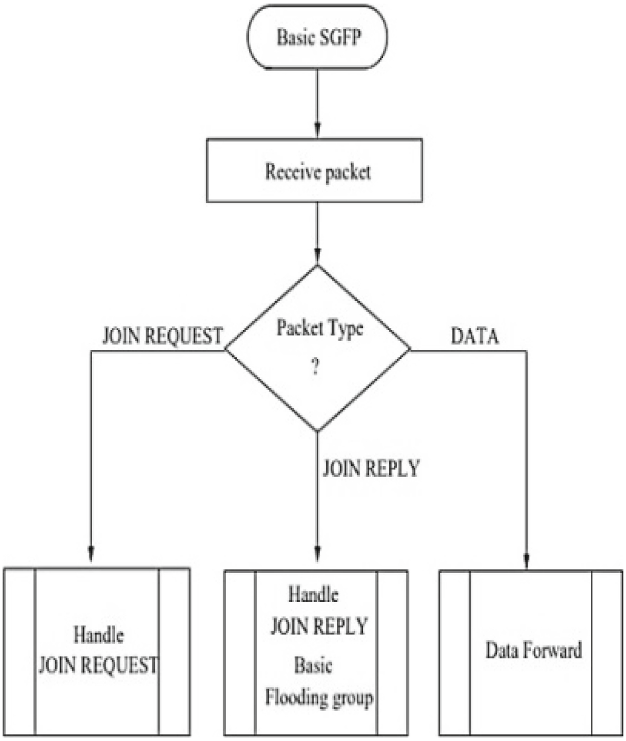

Fig. 7. BSGFF Flow Diagram.

5 Simulation Parameters

The performance investigations of the multicast protocols through simulation have been performed using Matlab 2018a in Windows 10 environment at speed of 3.91 GHz. The simulation parameters adaption for the study are listed in Table 1,

Table 1. Simulation Parameters

Parameters	Specification
Simulation area	1000000 m^2
Network Size	1 to 70 Nodes
No. of Source Nodes	1 – 20 Nodes
Mobility	Static Network
Node Speed	0–5 m/s
Transmission Range	250 m
Run time	100 secs Flooding Basic-sgfp
Protocol	Sp-sgfp p-sgfp psp-sgfp

6 Simulation Results

The proposed algorithms were simulated using MATLAB. The simulation represented a network of nodes that were dispersed at random over an area of 1000 × 1000 Sq. Metres. As a simulation parameter, the network thickness, or the amount of nodes in the network, was changed. The reach of the radio on each point was 250 m and the amount of information it could send was 1 million bits per second. If there is no special space for sending messages in our setup, when two or more messages are sent at the same time, they are not delivered. Nodes have two-way connectivity and broadcast are the communication medium. The extent of each replication was 100 s. For each situation, multiple runs were performed using various seed values, and the gathered data was be around throughout these runs. The OPNET routing layer protocols used for the multicast algorithms were developed separately. The goodput of proposed algorithm for various network attributes have been analyzed.

The source grouped protocols appear to work best in the mobility range of 0−5 m/s. The protocols are most efficient (best Goodput) and effective in this range (least total overhead). We can see that the most effective protocol for maintaining good throughput within 10% of flooding is the psp-sgfp scheme (see Fig. 8).

The trade-off among Goodput and overall slide for various sources sending packets to the multicast group is depicted in Fig. 9. It can see that the overall overhead for every

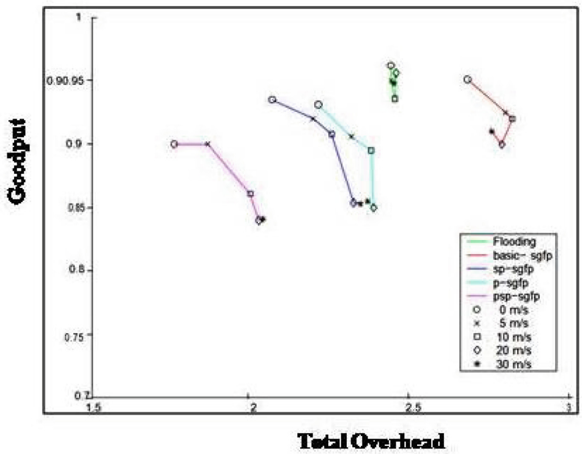

Fig. 8. Total Overhead Vs Goodput for different mobility speeds.

scheme is essentially unchanged. With an increase in sources, the output falls off linearly. For 1–5 network sources, all schemes exhibit minor variations in Goodput. The Goodput decreases slightly for 10 sources. Therefore, for 1–10 sources, the protocols' efficacy is comparatively stable. The most effective scheme is the psp-sgfp scheme. Additionally, it achieves a good output that is 6% less than flooding's.

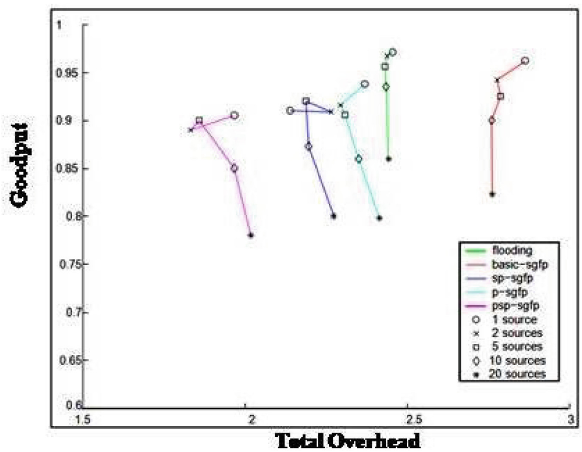

Fig. 9. Total Overhead Vs Goodput for different number of sources.

Figure 10 shows good performance and general tradeoffs for different multiplex group sizes. Flood mode records a stable output as the pool size increases. Full flooding occurs when there are 40 (or around 1.2) members in the cluster, indicating that flooding is effective when 70% or more of the network nodes are cluster members. Overall, flood values for flood events categorized by source are good, falling between 6 and 10%. Flood continues to be superior to psp-sgfp. Psp-sgfp seems to be the most effective of these techniques for MANETs when more than 40% of nodes are cluster members.

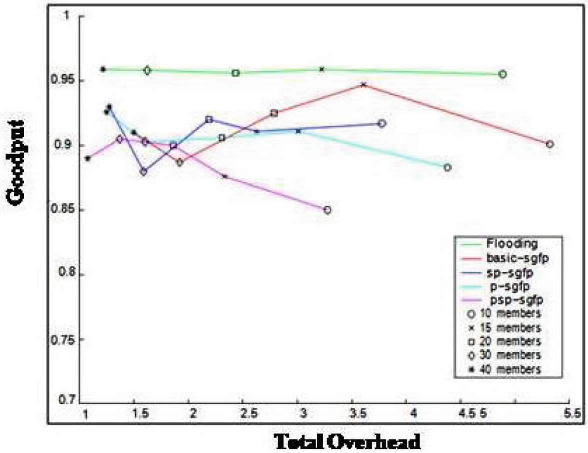

Fig. 10. Total Overhead Vs Goodput for different number of members.

In the Fig. 11, it is clearly depicted that, how producing more or less affects the cost depending on how often updates are made. The floods analyze has not been done because it doesn't happen during softening periods. However when it is updated over interval longer, fewer control packets are generated. This helps in decreasing the amount of overall overhead. The figure shows that even with different update intervals, the important information stays mostly the same. The best times for sending loits of packets to fix a problem are every 6, 8, or 10 s.

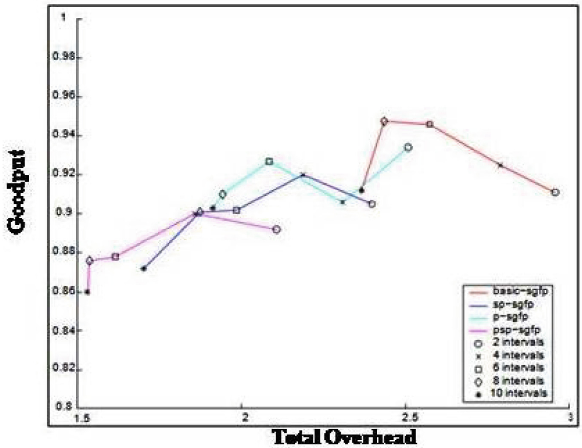

Fig. 11. Total Overhead Vs Goodput for different refresh intervals.

The system called psp-sgfp worked best when the time to refresh was either 8 or 10 s, even when the loads were very low at 1.5. Execution of unused pool individuals must be deferred until another way overhaul cycle until the asset enrollment asks has been replied. This implies that on the off chance that the bunch enrollment is exceptionally energetic; a lower esteem for the upgrade interim ought to be utilized.

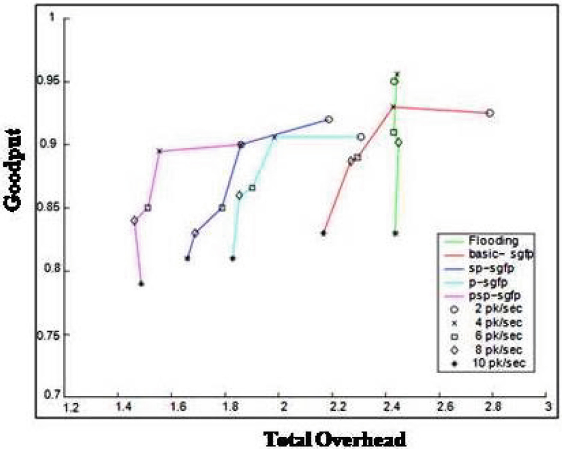

Fig. 12. Total Overhead Vs Goodput for different traffic load.

Figure 12, displays the exchange between doing well and how much work it takes, which is measured in packets per second. Diverse Traffic load in packets/s. Increase, the total amount of flooding mentioned above remains unchanged. When using source-grouped flooding schemes, the overall overhead originally drops as the load rises before slowly stabilizing at a constant overhead. The ideal traffic loads for source grouped schemes appear to be between 2 and 5 packets per second. The most effective scheme is once again psp-sgfp. The exchange between doing well and how much work it takes is measured in packets per second. Additionally, the goodput for all of the schemes is almost the same when the traffic is very high (10 packets/sec).

The graph pattern with respect to total overhead and goodput is depicted in Fig.13, as the network compactness in terms of changing nodes size. Obviously, all schemes perform better when the network contains more than 50 nodes. When there are 60 and 70 nodes in the network, the flooding scheme performs slightly better, but the overall overhead goes up noticeably. The most effective source-grouped scheme is psp-sgfp, and its throughput is within 8% of flooding's. A 1000 m $\times$ 1000 m network seems to have a good network density of about 50 nodes with transmission range as 250 m.

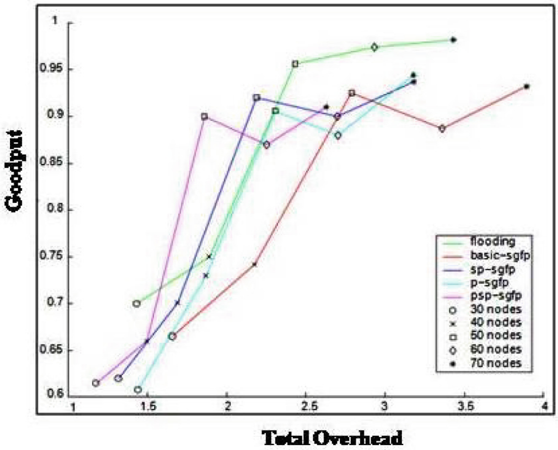

Fig. 13. Total Overhead Vs Goodput for different network density.

7 Conclusion

The design of multicast routing protocols faces significant challenges due to the significant limitations of mobile-targeted wireless networks, namely mobility, bandwidth, and power limitations. Hence, a multicast routing system for a MANET should accomplish effective data distribution and be resistant to changes in topology. In this work a source collection dump methods for multicast routing in MANET have been proposed. For each source, flood groups are generated using a finite distance diagram. The flooding group is an efficient and resistant to mobility each source, multiple path, and mesh construction. We showed that the protocol is more effective when a probabilistic data forwarding mechanism is used, which is based on probabilities obtained from the network. Moreover, the shortest path flooding strategy increases protocol effectiveness by reducing the need for rebroadcasts. It's understood that psp-sgfp (Source Shortest Probable Path Packet Flooding Protocol) is 8% faster than flooding.

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