Performance Comparison of Routing Protocol in MANET Based on Different Mobility Models

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ABSTRACT: **Wireless Mesh Networks (WMNs) have gained a lot of attention recently. Features such as self-configuration, self healing and the low cost of equipment and deployment make WMN technology a promising platform for a wide range of applications. They offer the flexibility of wireless access, combined with a high coverage area; they also offer communication between heterogeneous domains. Wireless mesh networks (WMNs) consist of mesh routers and mesh clients, where mesh routers have minimal mobility and form the backbone of WMNs. They provide network access for both mesh and conventional clients. WMN is a special kind of ad hoc networks and like any other ad hoc network one of the issues in WMNs is resource management which includes routing. For routing there are certain routing protocols that may give better performance when checked with certain parameters. These parameters include packet delivery ratio, delay, throughput, routing overhead and normalized routing load. This paper specifically aims to study the performance of routing protocols in a wireless mesh network, where static mesh routers and mobile clients collaborate to implement networks functionality such as routing and packet forwarding in different mobility scenarios. Based on extensive simulations, I present a comparative analysis covering performance metrics such as latency, throughput and routing overhead etc. This work allows us to arrive at an algorithm suitable for mesh networks to be implemented with and provides the basis to prove the applicability of these networks.**

Keywords **WMN L: Wireless Mesh Networks**

1. INTRODUCTION

Wireless communication has an enormous use these days and is still becoming popular from times immemorial. This is because of the latest technological demands now a days arising from laptops, wireless devices such as wireless local area networks (WLANs), etc. Because of its fast growing popularity day by day**,** it has led wireless communication data rates higher and prices cheaper. That is why wireless communication is growing so fast. Wireless communication can work between hosts by two methods; first is to allow the existing network carry data and voice, and second is to make ad hoc network so that hosts can communicate with each other [1]. Wireless Mesh Networks (WMNs) are one of the types of ad hoc networks. Ad hoc networks are also called as mobile ad hoc networks (MANETs).

WMNs are the latest technology that has lot of things in common with MANETs. Basically WMNs are consisted of wireless nodes; each node with its own packet, these nodes can communicate with each other by forwarding the packets to one another. This is very similar to MANETs; each node acts as a host and a router, which is basically a wireless router. In WMNs, if clients want to communicate with routers, they use the networking interfaces like Ethernet 802.11 and Bluetooth. There are some cases when WMNs router lies inside the network card, then clients can use the networking interfaces like peripheral component interconnect (PCI) or personal computer memory card international association (PCMCIA) bus, for the sake of communication. WMN nodes can provide internet connectivity and these nodes are termed as gateways. There are lot of advantages of WMNs over different other technologies, one of them is its least deployment time and other includes reliability and market coverage [2].Network is created by access points among wireless devices and provides a bridge between internet and this network [3]. Access points have some coverage area; this coverage area can be extended by allowing wireless devices to pass packets towards access points. This kind of multi-hop wireless access networks are called WMNs [4].

2. MULTI-HOP WIRELESS NETWORKS

The Multi-hop Wireless Networks consist of wireless networks that primarily use multi-hop wireless relaying. The major categories in the multi-hop wireless networks are:

- Ad hoc wireless networks
- Wireless sensor networks
- Hybrid wireless networks
- Wireless mesh networks [5].

2.1 Mobile Ad Hoc Networks (MANET)

In a MANET, devices are mobile nodes which provide the functionality required to connect users allowing them to exchange information in an environment with no pre-established infrastructure. Therefore, MANET is an infrastructure-less network with highly dynamic topology. Devices are free to move randomly and organize themselves arbitrarily; thus, the wireless network topology may change quickly and unpredictably. Also, some devices may be connected to other resources such as the Internet, file servers, etc., allowing users to gain access to these resources.

2.2 Wireless Sensor Networks (WSN)

Wireless sensor networks are formed by spatially distributed tiny sensor nodes that cooperatively can gather and monitor physical parameters or environmental conditions and transmit to a central monitoring node. In addition, sensor nodes are equipped with a radio transceiver or other wireless communication device, a small microcontroller, and usually a battery as an energy source. WSN can use either single-hop wireless communication or a multi-hop wireless relaying [5,6]. At first, military application was the motivation for developing WSN. Currently, WSN are used in civilian applications such as environmental and habitat monitoring, traffic control, healthcare applications, home automation, etc.

2.3 Wireless Mesh Networks (WMN)

Wireless Mesh Network (WMN) is a highly promising technology and it plays as an important architecture for the future wireless communications [1]. WMNs consist of mesh routers and mesh clients, and could be independently implemented or integrated with other communication systems such as the conventional cellular systems. In addition, WMN are dynamic, self-organized, self-healed and self-configured network that enables quick deployment. They provide easy maintenance, low cost, high scalability and reliable service. WMN is an ad hoc network extension and is becoming an important mode complimentary to the infrastructure based wireless networks because they can enhance network capacity, connectivity and resilience.

3. WMN ROUTING PROTOCOLS

3.1 Flooding-based Routing

The basic phenomenon is to distribute routing or control information by usage of spreading or disseminating method, in which source nodes have the responsibility to send packets to all nodes in the network. Flooding is basically the implementation of broadcast method in wireless scenario. The source node sends the information to all neighbor nodes in wireless network. The neighbor nodes then forward this information to the entire node within their approach. In this way, all the packets spread or flood within the entire network. The packets are sequenced in number to avoid stealing information and loops [6-7].

3.2 Proactive routing

In this approach nodes maintain global state information. That is routing information is stored in tabular form at all the nodes in the network. Proactive routing protocols update route information in their routing tables independent of actual demands. This means that nodes maintain routes to other nodes even if those routes are not currently needed for any data packets. Many proactive protocols are link state based. To keep routes up-to-date in the presence of node mobility and failures, nodes broadcast information about their network neighbors periodically or event-driven. The main advantage of proactive protocols is that they can allow for low data packet transmission delays.

The disadvantage of proactive routing protocols is their constant route maintenance traffic that can easily constitute a significant part of the overall traffic and can lead to an increased number of collisions with actual data packets. Since routes are also maintained even when they are not currently needed, proactive protocols are also not well-suited for stream-based traffic scenarios where nodes tend to communicate with an unchanging set of nodes over a certain period of time.

3.3 Reactive (On-Demand) Routing

Reactive routing discovers routes on-demand. This means that a route from some node S to another node D is only established when node S actually is about to send a packet to node D. When routes have not been used in a certain while, they usually expire and are expunged from the routing tables. A clear advantage of reactive routing protocols is that they do not generate any significant maintenance traffic. Only those routes are discovered/maintained that are currently needed. Thus, reactive protocols can scale to a large number of nodes as long as each source node tends to communicate with the same target node (or set of target nodes) over a longer period of time, so that costly route discoveries are limited and as long as node mobility is rather mild, recently discovered routes remain valid for a certain period. Another advantage of reactive routing protocols is that, in scarce or bursty traffic scenarios, nodes can usually significantly preserve energy as they will not have to consume any energy for the maintenance of currently unneeded routes. The main disadvantage of reactive protocols is that they do not scale well to high and arbitrary traffic. When nodes send out packets at a high rate to frequently changing target nodes, the network will be flooded with route discoveries [8].

4. MOBILITY MODELS

A mobility model specifies the movement pattern of the mobile nodes in an ad hoc or mesh network. The mobile nodes may move freely or their movement may be constrained. Mobility models I used in this paper for simulation are:

4.1 Random Waypoint Mobility Model

In this mobility model each host is initially placed at a random position within the simulation area. As the simulation progresses, each host pauses at its current location for a determinable period called the pause time. Pause time is used to overcome abrupt stopping and starting in the random walk model. Upon expiry of this pause time, the node will arbitrary select a new location to move towards it at a randomly selected velocity between a minimum and maximum value, which are stated at the start of the scene generation. Every host will continue this type of behavior throughout the entire duration of the simulation. Using this model, the hosts appear to move randomly within a confined compound. The random waypoint model is selected for its simplicity [7,9].

4.2 Manhattan Grid Mobility Model

The deficiency of the random waypoint model is clearly in its unrealistic modeling of real life activity. When people move from one point to another, they are somewhat driven by objectives and physical constraints within an environment. For example, it is necessary to walk around buildings and not through buildings.

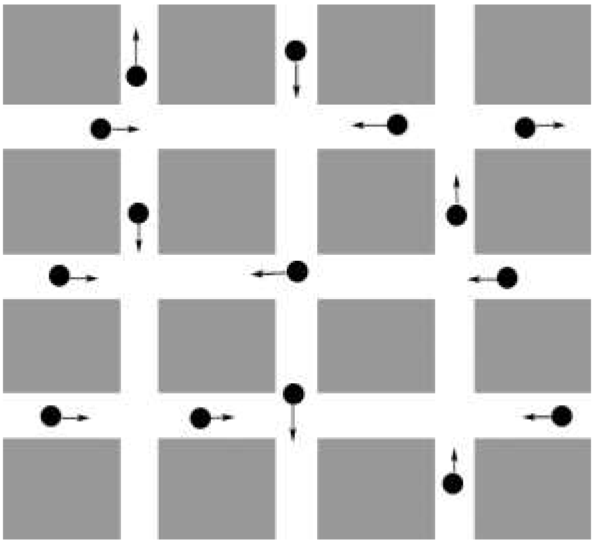

Figure1. Manhattan Grid Mobility Model

As such in urban landscapes, a random waypoint may be grossly ineffective in capturing the real movements of people. The Manhattan Grid model is proposed for the urban setup. A city is usually formed from "grids", which are actually area formed by intersecting lines running parallel and horizontal to each other. The size of the grid indicates, to a certain extent, the degree of urbanization of the city. A large city has small grids while some have larger ones. Although this model is not very accurate as far as older cities concerned [7].

5. SIMULATION AND RESULTS

5.1 First Scenario: Random Waypoint Mobility Model

In random waypoint mobility model for the simulation, a mesh client first waits for the pause interval and then moves to a randomly chosen position with a velocity randomly chosen between 0 m/s and the maximum speed. The mesh client waits at this location for the pause time, and then moves on to another random position. A maximum speed of 0 m/s correlates to a static network. Other test parameters are listed in Table1.

Table1. Simulation Parameters-Random waypoint scenario

Simulation Parameter	Value
Simulation Time	200 Seconds
Simulation Area	600m x 600m
Examined routing protocol	AODV, DSR, OLSR
Number of Mesh Routers	16 in grid formation
Number of Mesh Clients	30
Mobility model for Mesh Clients	Random waypoint
Propagation Model	Two ray ground reflection
Transmission Range	250m
Maximum Speed of Mesh Clients	0, 5, 10, 15, 20 m/s
Pause time	10s
Traffic Type	CBR (UDP)
Maximum Connections	12
Payload Size	512 bytes
Packet rate	4 ptks/sec

5.2. Second Scenario: Manhattan Mobility Model

Manhattan model emulates the movement pattern of mobile nodes on streets. It can be useful for modeling node movement in an urban area. This scenario is composed of a number of horizontal and vertical streets. Figure-1 shows the movement of nodes in Manhattan grid with fifteen nodes. For simulation I have considered 30 nodes. The map defines the roads along which the nodes can move. Other test parameters are listed in Table-2.

Table .2 Simulation Parameters-Manhattan mobility scenarios

Simulation Parameter	Value
Simulation Time	200 Seconds
Simulation Area	600m x 600m
Examined routing protocol	AODV, DSR, OLSR
Number of Mesh Routers	16 in grid formation
Number of Mesh Clients	30
Mobility model for Mesh Clients	Manhattan Mobility Model
Propagation Model	Two ray ground reflection
Transmission Range	250m
Maximum Speed of Mesh Clients	0, 5, 10, 15, 20 m/s
Pause time	10s
Traffic Type	CBR (UDP)
Maximum Connections	12
Payload Size	512 bytes
Packet rate	4 ptks/sec

5.3 Result and Analysis

After creating above mentioned scenarios simulations were performed in Ns-2 Simulator Version 2.34 by varying following parameters:

- mobility rate
- varying CBR connections (traffic load)

The performances of studied scenario have been analyzed in terms of five parameters that are packet delivery percent, delay, throughput, normalized routing load and routing overhead.

5.3.1 Simulation 1-Varying Mobility Rate

To evaluate the performance of routing algorithms in WMN with Random waypoint mobility and Manhattan mobility models, mesh network with 16 routers (node number 30 to 45 in Figure-1) in grid topology was considered. Performance metrics were computed for mesh clients with mobility rate of 0, 5, 10, 15 and 20 m/s.

5.3.1.1 Performance metrics in Random Waypoint Mobility Scenario

Graph in Figure-2 shows that packet delivery percent of DSR is 100 % when network is static, but degrades gracefully to 99 % at maximum speed of 20 m/s. Up to the speed of 10 m/s performance of all the protocols is comparable. OLSR has poor performance at higher speed. This is because at very high levels of mobility more timeouts expires before a failure link is declared lost.

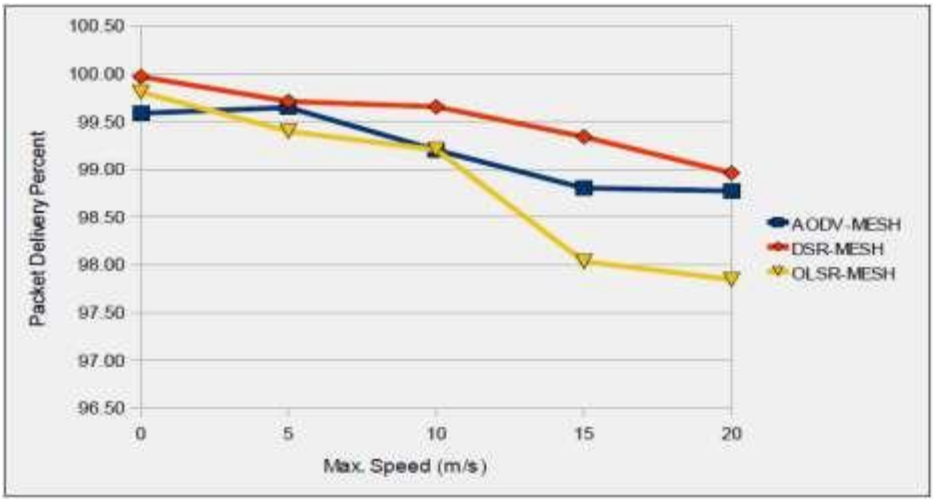

Figure-2 Packet Delivery Percent versus Mobility Rate

It is found that DSR routing protocol outperforms in terms of throughput. When maximum speed of all mesh clients is 0, network is static and all of the protocols give same throughput. But as the maximum speed is varied from 0 to 20 m/s, DSR gives better throughput at high speeds too. Throughput of AODV and OLSR is comparable and is almost steady (Figure-3). Average end-to-end delay of OLSR is always less as compared to the other protocols because it is a proactive protocol (Figure-4). Average end-to-end delay of OLSR and DSR is comparable but AODV's performance is poor.

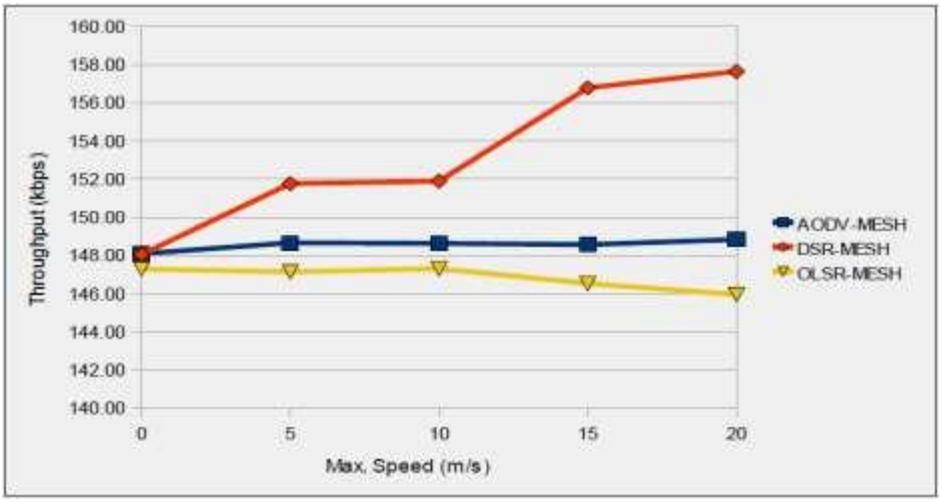

Figure-3 Throughput versus Mobility Rate

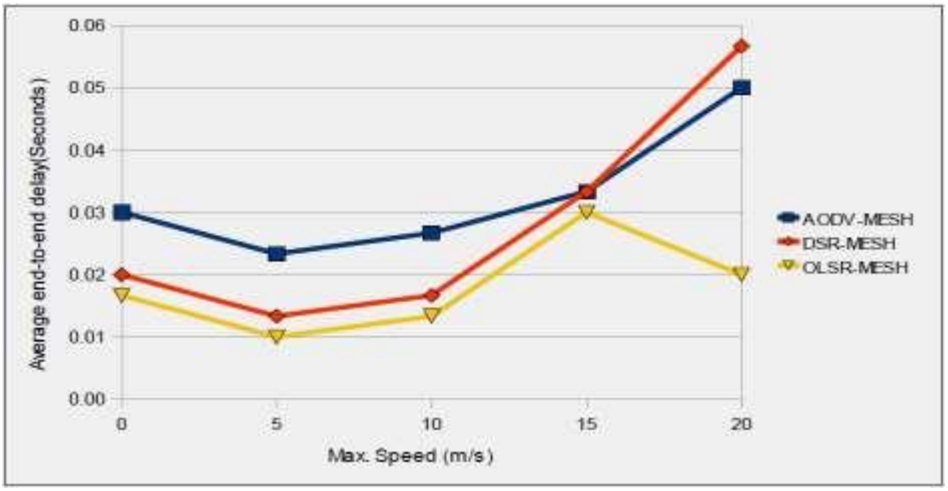

Figure-4 AED versus Mobility Rate

5.3.1.2 Performance Metrics in Manhattan Mobility Scenario

To evaluate the performance of routing algorithms in WMN with Manhattan Mobility model, mesh network with 16 routers in grid topology was considered. Performance metrics were computed for mesh clients with mobility rate of 0, 5, 10, 15 and 20 m/s. Manhattan model represents more realistic scenario as compared to Random waypoint model, therefore results of this scenario are more significant when we really want to implement the network physically.

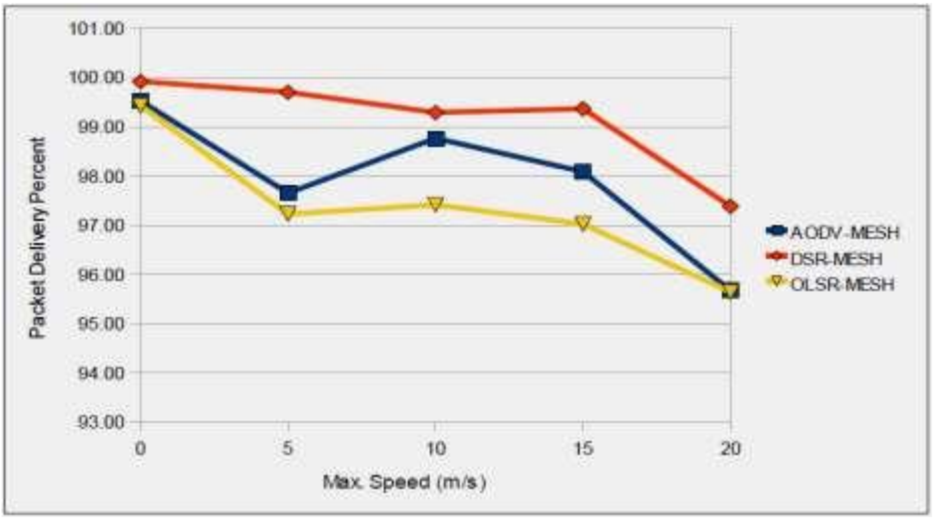

Figure-7 Packet Delivery Percent versus Mobility Rate

Packet delivery percent of DSR mesh is between 99 to 100 % when mobility rate is below 15 m/s but reduces to almost 97% due to high mobility rate. All the three protocols have nearly 100% packet delivery when the network is static. At higher mobility rates performance of AODV and OLSR is poor as compared to DSR (Figure-7).

Throughput is much better in case of Manhattan scenario as compared to Random waypoint. As shown by the graph (Figure-8), DSR outperforms in terms of throughput in comparison to other two protocols. At zero mobility throughput with all of the three protocols is about 150 kbps and does not fall below that as the mobility rate is varied from 0 to 20 m/s. Throughput is almost close to 180 kbps at the highest mobility rate of 20 m/s. AODV and OLSR better their throughput at high mobility rates in comparison to their performance in Random waypoint scenario. This is due to the fact that mesh routers are placed at the cross points of lanes and streets in this scenario and routing occurs through these mesh points, which was not the case in previous scenario where mesh client also sometimes acted as router.

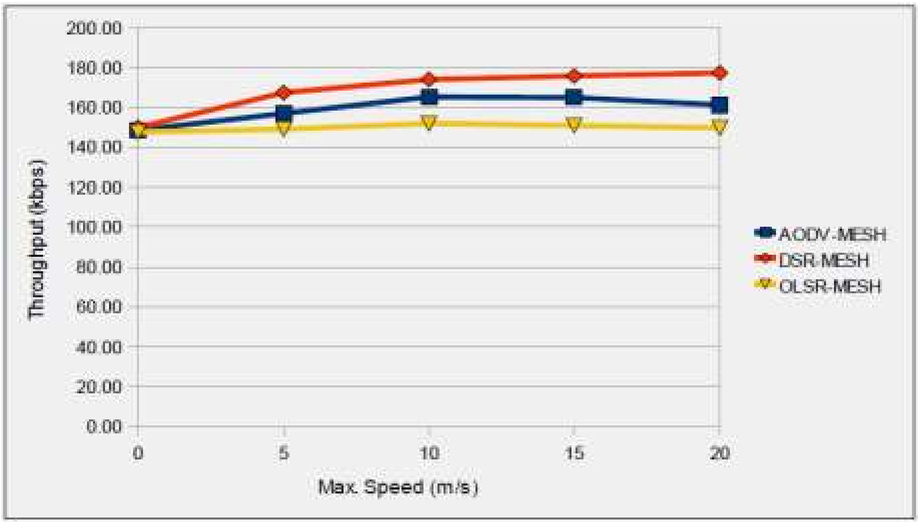

Figure-8 Throughput versus Mobility Rate

Average end-to-end delay is low in case of OLSR protocol and does not vary much with mobility (Figure-9). DSR gives longer delays in case of high mobility. A source node executing DSR makes use of the cached routing information and is therefore able to quickly find routes initially. However, with the increase in node mobility the cached routes tend to become stale. This causes more route discoveries to be initiated, which increases the latency in the network. Both DSR and AODV perform poorly as compared to OLSR. Delay in OLSR remains steady because the MPRs selected are always the mesh router.

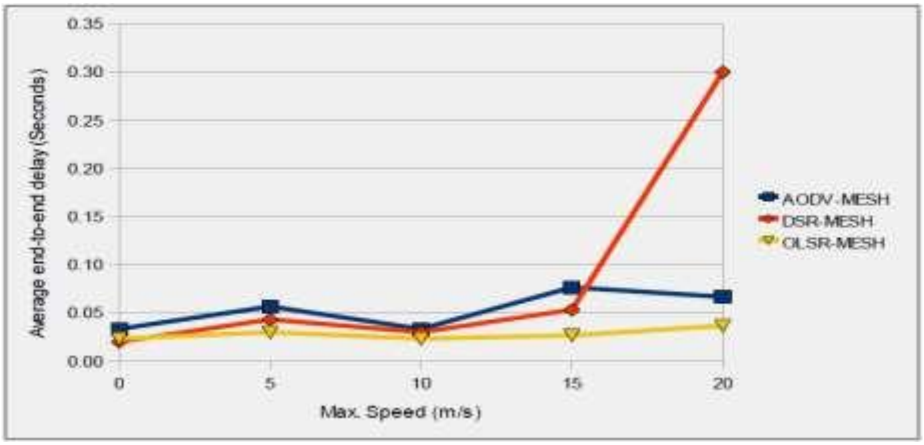

Figure-9 AED versus Mobility Rate

5.3.2 Simulation 2 - Varying Traffic Load

To study the impact of varying traffic load on the performance metrics, simulations were performed with 5, 10 15 and 20 CBR connections in both the scenarios keeping other parameters unchanged. Simulations was performed for 200s with 16 mesh routers placed in grid topology and mesh clients moving at the maximum speed of 10m/s.

5.3.2.1 Performance metrics in Random Waypoint Mobility Scenario

Packet delivery percent first increases with the increase in traffic load in all three protocols but as the traffic increase further, there is congestion and so PDR drops after specific number of connections. Still DSR performs comparatively better and gives maximum PDR of 99.8% which is close to 100%. AODV and OLSR also perform well up to 10 connections but then lose their reliability to some extent in delivering packets with greater traffic load (Figure-10).

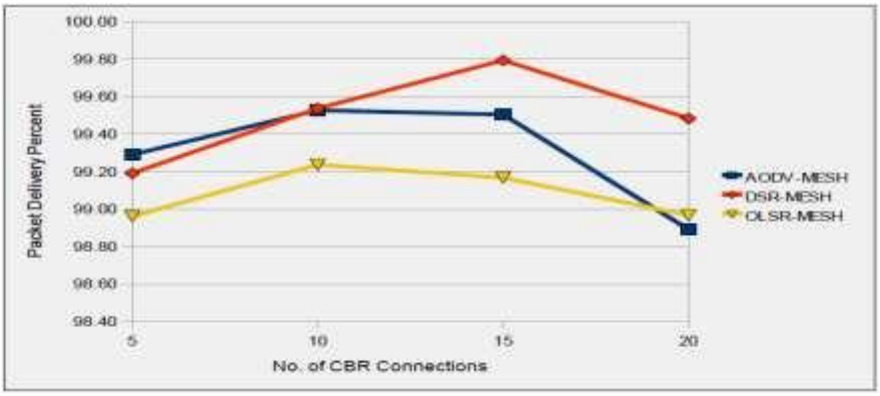

Figure-10 Packet Delivery Percent versus No. of CBR Connections

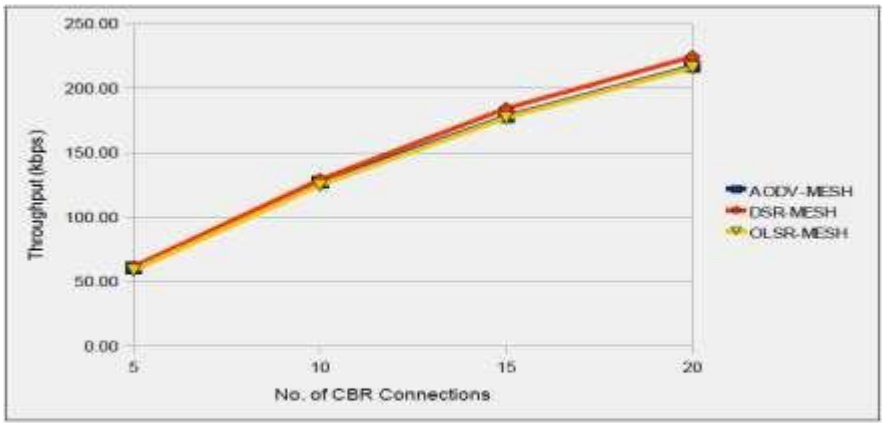

Figure-11 Throughput versus No. of CBR Connections

As shown by the graph is Figure-11, throughput of all the three protocols scale well with the increase in traffic load in terms of CBR connection.

5.3.3.2 Performance metrics in Manhattan Mobility Scenario

Manhattan mobility model emulates the movement of mesh clients in an urban scenario. As shown in Figure-12 packet delivery percent remain steady till 15 connections within a set of 30 traffic nodes and is close to 100%, but as soon as the number of connections grows to 20 connections PDR drops between 90 to 80%. This is because of congestion due in the number of CBR connections.

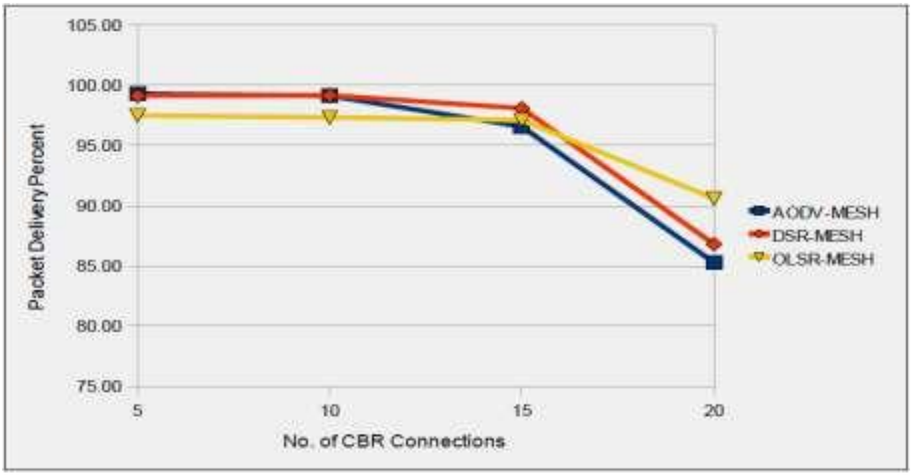

Figure-12 Packet Delivery Percent versus No. of CBR Connections

Throughput grows with the increase in number of connection, which again depicts that all protocols scale well with increasing traffic load in Manhattan model too. Here also DSR outperforms AODV and OLSR (Figure-13).

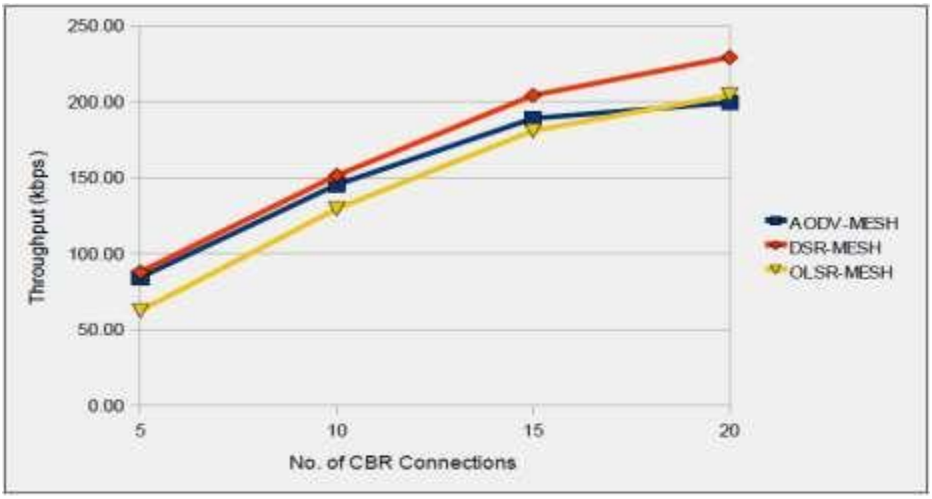

Figure-13 Throughput versus No. of CBR Connection

6. Conclusion

In both scenarios with varying mobility, all protocols give almost 100% packet delivery when mobility of mesh clients is zero. Packet delivery percent decrease with increasing mobility due to frequent link failure at higher mobility. DSR outperforms in both scenarios in terms of packet delivery percent and throughput. OLSR gives shorter average end-to-end delay in both scenarios as compared to the other two protocols. Throughput in case of Manhattan model with mesh is outstandingly greater in comparison to random waypoint mobility model. Simulations with varied number of connections showed that all the performance metrics scale well with the increase in traffic load. This increase is up to 15 CBR connections only. After that performance of all protocols is wavered.

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