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Performance Analysis of Routing Protocol Under Different Network Parameters In MANET

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ABSTRACT

Background: Mobile adhoc network (MANET) is an autonomous system of mobile nodes connected by wireless links. The mobile ad-hoc network does not have any fixed topology, in which the nodes are highly moving in the unrestricted domain. Routing is a critical issue in MANET. There is no single protocol that fits all networks perfectly. The protocols have to be chosen according to network characteristics, such as density, size and the mobility of the nodes. Hence the focus of this project along with the performance analysis of routing protocols, which specifically come under three categories, proactive, reactive and hybrid. OLSR, DSDV, AODV, and ZRP protocols are compared by using NS2 simulator. The performance is analyzed by three metrics: throughput, delay, and packet delivery ratio. Many situations are consider in MANET and at last conclusion will be presented, that which protocol is best suited for which type of network situation.

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INTRODUCTION

Mobile Ad-hoc Network is a decentralized autonomous wireless system which consists of free nodes. Nodes in mobile ad-hoc network are free to move and organize themselves in an arbitrary fashion. In such network, each mobile node operates not only as a host but also as a router, forwarding packets for other mobile nodes in the network that may not be within direct wireless transmission range of each other. Since the network is decentralized, where all network activity, including discovering the topology and delivering messages must be executed by the nodes themselves. Hence, the nodes need to be more intelligent so that they can function as routers as well as regular hosts.

The goal of a routing algorithm is to devise a scheme for transferring a packet from one node to another. One challenge is to define/choose which criteria to base the routing decisions on. Examples of such criteria include hop length, latency, bandwidth and transmission power.

The specific characteristics of routing protocols include

1. The manner in which they either prevent routing loops from forming or break them up if they do.
2. The manner in which they select preferred routes, using information about hop costs.
3. The time they take to converge.
4. How well they scale up.

A number of MANET routing protocols were proposed in the last decade. These protocols can be classified according to the “routing strategy” (Idris Skloul Ibrahim *et al*., 2009) that they follow to find a path “route” to the destination. These protocols perform variously depending on type of traffic, number of nodes, rate of mobility, etc... In Mobile ad hoc networks, nodes do not have a priori knowledge of topology of network around them, they have to discover it. There are two basic groups of routing protocols, Proactive MANET protocol (PMP), Reactive MANET Protocol (RMP), and whereas the third one is derived from both of these and called as Hybrid MANET protocol. In networks utilizing a Proactive MANET Protocol (PMPs), every node maintains one or more tables representing the entire topology of the network. These tables are updated regularly in order to maintain a up-to-date routing information from each node to every other node.

Reactive MANET Protocols (RMP) determine routing paths only when required. They are associated with lower protocol overheads but longer packet delays according to Zygmunt J. Haas and Marc R. Pearlman (1997).

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Hybrid routing protocol attempts to discover balance between the two such as proactive for neighborhood, reactive for far away. Based on proactive and reactive routing protocols, some hybrid routing protocols are proposed to combine their advantages (Jing Xie *et al.*, 2009).

The rest of this paper contains the related work in the modeling of routing protocols, performance metrics, results and conclusion

Routing protocols:

AODV Routing Protocol:

The Ad Hoc On-Demand Distance Vector Routing (AODV) Protocol is a reactive routing protocol (Idris Skloul Ibrahim *et al*., 2009) based on DSDV. AODV is designed for networks with tens to thousands of mobile nodes. One feature of AODV is the use of a destination sequence number for each routing table entry. The sequence number is created by the destination node. The sequence number included in a route request or route reply is sent to requesting nodes. Sequence number are very important because they ensures loop freedom and is simple to program. Sequence numbers are used by other nodes to determine the freshness of routing information. If a node has the choice between two routes to a destination, a node is required to select the one with the greatest sequence number. AODV deals with routing table. Every node has a routing table. When a node knows a route to the destination, it sends a route reply to the source node. Route Requests (RREQs), Route Replies (RREPs) and Route Errors (RERRs) are message types defined by AODV. The next pictures will give an example of AODV.

DSDV Routing Protocol:

The Destination Sequenced Distance Vector (DSDV) routing protocol is a proactive routing protocol, developed by Charles E. Perkins and Pravin Bhagwat (1994). Each node maintains its own routing table for the entire network. Based on Distributed Bellman-Ford Algorithm (Boomarani Malany *et al*., 2009). The design goals of DSDV are keep the simplicity of Bellman Ford algorithm and avoid the looping problem. Therefore, the approach that is followed to attain these goals is model each host as a router, tag each routing table entry with a sequence number. Routing information is advertised by broadcasting or multicasting the packets which are transmitted periodically as when the nodes move within the network. The DSDV protocol requires that each mobile station in the network must constantly; advertise to each of its neighbors, its own routing table. Since, the entries in the table my change very quickly, the advertisement should be made frequently to ensure that every node can locate its neighbors in the network. This agreement is placed, to ensure the shortest number of hops for a route to a destination; in this way the node can exchange its data even if there is no direct communication link. The broadcasting of the information in the DSDV protocol is of two types: Full dump, broadcasting will carry all the routing information and requires multiple NPDU’s (Network Protocol Data Units). Incremental dump The incremental dump will carry only information that has changed since last full dump. Incremental dump requires only one NPDU to fit in all the information. When the route is broken in a network, then immediately that metric is assigned an infinity metric there by determining that there is no hop and the sequence number is updated.

OLSR Routing Protocol:

The Optimized Link State Routing Protocol (OLSR) is a proactive routing protocol (Adjih *et al*., 2003). Every node sends periodically broadcast "Hello"-messages with information to specific nodes in the network to exchange neighbourhood information. The information includes the nodes IP, sequence number and a list of the distance information of the nodes neighbours. After receiving this information a node builds itself a routing table. Now the node can calculate with the shortest path algorithm the route to every node it wants to communicate. When a node receives an information packet with the same sequence number twice he is going to discard it. In these routing tables he stores the information of the route to each node in the network. The information is only updated:

1. A change in the neighbourhood is detected
2. A route to any destination is expired
3. A better (shorter) route is detected for a destination

The difference from OLSR to LSR (Links State Protocol) is that OLSR relies on Multi-Point Relays (MPR) (Ellis Horowitz *et al*., 2007). MPR is a node which is selected by its direct neighbour (one hop).The first idea of multipoint relays is to minimize the flooding of broadcast messages in the network. An information packet should not be sent twice in the same region of the network. MPR helps to optimize and reduce that problem. Each node informs its direct neighbors (one hop) about its MPR set in the "Hello"-messages. After receiving such a "Hello"-message, each node records the nodes MPR Selector that selects it as one of their MPRs. The second idea is that the size of the hello messages is reduced. It includes only the neighbors that select a node as one of their MPR nodes. In this way partial topology information is propagated. The selected node can be reached only from its MPR selectors. The required message types for the core functionality of OLSR are:

- HELLO-messages, performing the task of link sensing, neighbor detection and MPR signaling.
- TC-messages, performing the task of topology declaration (advertisement of link states).
- MID-messages, performing the task of declaring the presence of multiple interfaces on a node.

Zone Routing Protocol:

The *Zone Routing Protocol* combines the advantages of both into a *hybrid* scheme, taking advantage of pro-active discovery (Intrazone Routing Protocol (IARP)) within a node's local neighborhood, and using a reactive protocol (Interzone Routing Protocol(IERP)) for communication between these neighborhoods (Adjih *et al.*, 2003). While the idea of zones often seems to imply similarities with cellular phone services, it is important to point out that each node has its own zone, and does not rely on fixed nodes. The Broadcast Resolution Protocol (BRP) is responsible for the forwarding of a route request. ZRP divides its network in different zones. That's the nodes local neighborhood. Each node may be within multiple overlapping zones, and each zone may be of a different size. By dividing the network into overlapping, variable-size zones, ZRP avoid a hierarchical map of the network and the overhead involved in maintaining this map. The size of a zone is not determined by geographical measurement. It is given by a radius of length, where the number of hops is the perimeter of the zone. Each node has its own zone. The actual IARP is not specified and can include any number of protocols, such as the derivatives of Distance Vector Protocol (e.g., Ad Hoc On-Demand Distance Vector [AODV],) Shortest Path First (e.g., OSPF). In fact, different portions of an ad-hoc network may choose to operate based on different choice of the IARP protocol. IERP is responsible for finding routes between nodes located at distances larger than the zone radius. IERP relies on bordercasting. Bordercasting is possible as any node knows the identity and the distance to all the nodes in its routing zone by the virtue of the IARP protocol.

Performance metrics:

Protocols need to be checked against certain parameters for their performance. The following metrics are used to evaluate the performance of routing protocols.

Throughput:

Throughput is defined as; the ratio of the total data reaches a receiver from the sender. The time it takes by the receiver to receive the last message is called as throughput (Boomarani Malany *et al.*, 2009). Throughput is expressed as bytes or bits per sec (byte/sec or bit/sec).

$$\text{Throughput} = \frac{\text{Number of packets delivered* packet size* 8}}{\text{Total duration of simulation}}$$

Packet Delivery Ratio:

The fraction of packets sent by the application that are received by the receivers (Idris Skloul Ibrahim *et al.*, 2009). This metric actually tells how much reliable the protocol is.
PDR= $\sum$ sending packets/ $\sum$ Receiving packets

Average End to End Delay:

The packet end-to-end delay is the time of generation of a packet by the source up to the destination reception. So this is the time that a packet takes to go across the network (Boomarani Malany *et al.*, 2009). This time is expressed in sec.

RESULTS AND DISCUSSIONS

Simulation Environment:

The simulation is carried out in Network Simulator NS 2.33. A campus network was modeled within an area of 600m x 600m. The mobile nodes were spread within the area. Mobile nodes move at various speeds between 100 to 200 m/s, but source and destination moves in a constant speed 50 m/s. TCP/IP Agent is used to create packets. We take the CBR traffic, with constant packet size, to analyze the effects on routing protocols. This environment has single source and destination. Here, we considered 16 different movements of source and destination and evaluate the key parameters i.e. delay, packet delivery ratio and throughput.

Simulation Results:

Performance of routing protocols is analyzed under three metrics namely, throughput, packet delivery ratio and average delay. These metrics are calculated from the tracefile of the protocol and plotted as a graph. X-axis values of graph show various movements of source and destination and Y-axis values show the performance metrics. The performance of the protocol is considered under two scenarios, less node density and higher node density, and plotted in the graph.

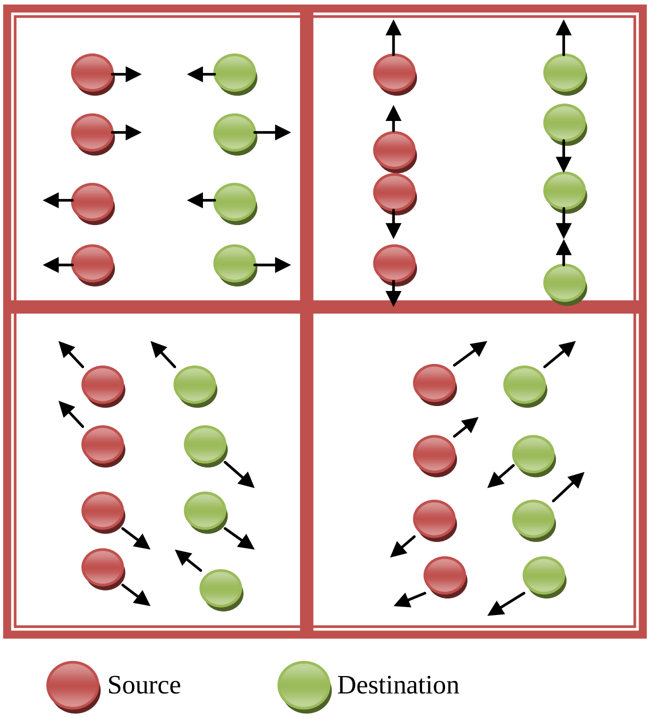

Fig. 1: Movements of Source and Destination.

Throughput is the main factor that should be considered in any network. All networks needs high throughput from the routing protocols. Among the four protocols, AODV provide higher PDR without any fail. Next to AODV, ZRP gives higher PDR but it fails in some points. In the case of throughput, OLSR has comparatively good throughput (Kiranveer Kaur *et al.*, 2014). But on the other hand, eventhough OLSR and DSDV produce high throughput with less delay, they are unsuccessful in many movements.

Average end to end Delay, helps to analyze the four protocol performance. According to Mandeep Singh and Balwinder Singh (2013), the delay in OLSR is less when compared to AODV. In our results also DSDV and OLSR route's packet with less delay than AODV and ZRP. But we should consider the failure of the protocols due to mobility.

Table 1: Throughput- 10 Nodes.

Movements of source and destination	AODV	DSDV	OLSR	ZRP
Horizontal Away	234.49	676.13	0	650
Horizontal towards	260.07	0	0	244.74
Horizontal dest following source	381.27	672.38	0	648.20
Horizontal source following dest	345.80	670.63	575.26	648.20
Vertical away	254.43	670.22	0	650.36
Vertical towards	280.32	0	0	150.20
Vertical dest following source	366.59	673.89	0	657.27
Vertical source following dest	459.67	671.64	0	650.24
Diagonal1 away	387.77	678.81	0	661.35
Diagonal1 towards	349.16	0	0	0
Diagonal1 dest following source	217.02	0	0	0
Diagonal1 source following dest	670.74	663.32	666.02	625.26
Diagonal2 away	275.55	678.59	0	650
Diagonal2 towards	140.06	0	0	277.53
Diagonal2 dest following source	303.69	0	0	320.44
Diagonal2 source following dest	254.11	0	0	0

Table 2: PDR- 10 Nodes

Movements of source and destination	AODV	DSDV	OLSR	ZRP
Horizontal Away	84.2105	72.919	0	650
Horizontal towards	90.3101	0	0	244.74
Horizontal dest following source	87.2818	86.5031	0	648.20
Horizontal source following dest	88.6486	86.5854	0	77.6699
Vertical away	83.9506	63.6364	0	77.4510
Vertical towards	87.0504	0	33.3333	87.7095
Vertical dest following source	86.2903	86.8263	91.8367	87.7095
Vertical source following dest	92.5059	92.5424	0	77.6699

Diagonal1 away	86.6013	88.60	0	68.4211
Diagonal1 towards	93.8697	0	0	89.3204
Diagonal1 dest following source	84.7829	0	0	93.3934
Diagonal1 source following dest	96.9512	96.9925	0	88.2979
Diagonal2 away	86.6667	77.6596	0	60
Diagonal2 towards	85.6	0	33.3333	50
Diagonal2 dest following source	85.3755	0	92.4419	96.732
Diagonal2 source following dest	87.6812	0	0	88.601

Table 3: Delay- 10 Nodes

Movements of source and destination	AODV	DSDV	OLSR	ZRP
Horizontal Away	0.08072	0.05974	-	0.5158
Horizontal towards	0.23609	-	-	0.18264
Horizontal dest following source	0.07712	0.09803	0.00428	0.08581
Horizontal src following dest	0.06931	0.09663	0.05023	0.08581
Vertical away	0.09278	0.03951	-	0.05158
Vertical towards	0.22609	-	-	0.23791
Vertical dest following src	0.09482	0.10014	-	0.10199
Vertical source following dest	0.10933	0.1121	-	0.11006
Diagonal1 away	0.12645	0.09175	-	0.10018
Diagonal1 towards	0.09008	-	-	1.13883
Diagonal1 dest following source	0.13759	-	0.00999	1.28739
Diagonal1 source following dest	0.11615	0.11346	0.04339	0.12365
Diagonal2 away	0.0837	0.07473	-	0.09244
Diagonal2 towards	0.11716	-	-	0.09765
Diagonal2 dest following source	0.22341	-	-	0.14759
Diagonal2 source following dest	0.10737	-	-	

Table 4: Throughput- 20 Nodes.

Movements of source and destination	AODV	DSDV	OLSR	ZRP
Horizontal Away	231.28	688.04	0	678.66
Horizontal towards	291.45	0	0	0
Horizontal dest following source	334.09	0	0	656.51
Horizontal source following dest	359.91	0	0	656.51
Vertical away	184.67	0	0	678.66
Vertical towards	0	367.34	367.34	557.14
Vertical dest following source	302.58	0	0	66.16
Vertical source following dest	481.35	481.35	0	650.84
Diagonal1 away	432.73	0	0	432.73
Diagonal1 towards	199.17	0	0	0
Diagonal1 dest following source	394.36	0	0	0
Diagonal1 source following dest	670.74	668.49	668.49	642.16
Diagonal2 away	276.17	276.17	0	657.16
Diagonal2 towards	137.27	0	0	278.48
Diagonal2 dest following source	306.82	328.11	328.11	223.84
Diagonal2 source following dest	0	0	0	0

Table 5: PDR- 20 Nodes.

Movements of source and destination	AODV	DSDV	OLSR	ZRP
Horizontal Away	80.7107	71.9512	0	75.7895
Horizontal towards	88.3871	0	0	0
Horizontal dest following source	86.6667	33.3333	33.333	87.4286
Horizontal source following dest	89.6175	0	0	87.4286
Vertical away	79.1444	0	0	75.7895
Vertical towards	0	60	60	91.1111
Vertical dest following src	85.9375	0	0	89
Vertical source following dest	92.2078	92.2078	0	93.7126
Diagonal1 away	88.1443	0	0	88.1443
Diagonal1 towards	92.1053	0	0	0
Diagonal1 dest following src	60	0	0	33.3333
Diagonal1 src following dest	96.9512	92.3077	92.3077	72.7273
Diagonal2 away	86.0806	86.0806	0	72.7273
Diagonal2 towards	83.3333	0	0	84.6154
Diagonal2 dest following source	83.1776	54.5455	54.5455	70.5852
Diagonal2 source following dest	0	0	0	0

Table 6: Delay- 20 Nodes

Movements of source and destination	AODV	DSDV	OLSR	ZRP
Horizontal Away	0.04636	0.05997	-	0.06771
Horizontal towards	0.06884	-	-	-
Horizontal dest following source	0.09058	0.00993	0.00993	0.09765
Horizontal source following dest	0.09379	-	-	0.09765
Vertical away	0.07293	-	-	0.06771
Vertical towards	0	0.01337	0.01337	0.0448
Vertical dest following source	0.09995	-	-	0.10419
Vertical source following dest	0.10593	0.10593	-	0.1102
Diagonal1 away	0.09565	-	-	0.09565
Diagonal1 towards	0.10002	-	-	-
Diagonal1 dest following source	0.68682	-	-	0.05984
Diagonal1 source following dest	0.11615	0.04594	0.04594	0.17025
Diagonal2 away	0.08688	0.08688	-	0.17025
Diagonal2 towards	0.11229	-	-	0.23024
Diagonal2 dest following source	0.11855	0.01830	0.01830	0.18908
Diagonal2 source following dest	0	-	-	-

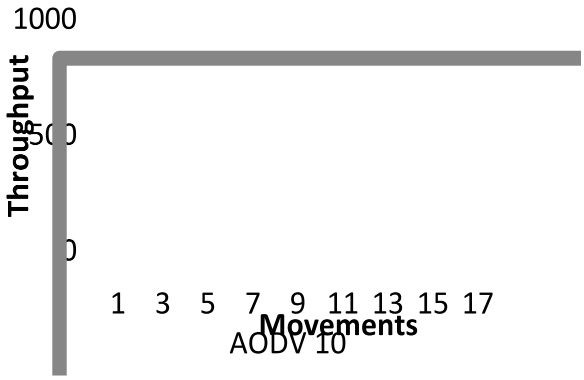

Fig. 2: Throughput –AODV.

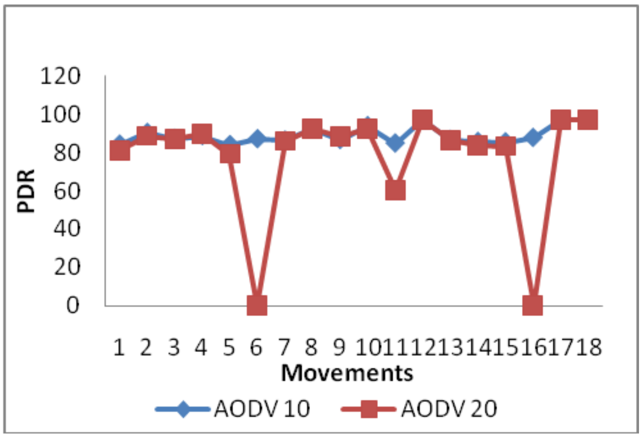

Fig. 3: PDR- AODV.

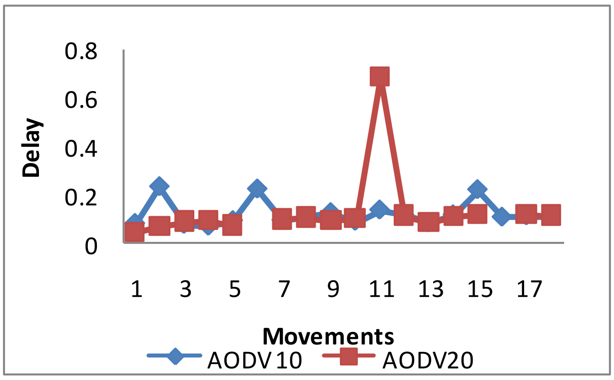

Fig. 4: Delay- AODV

Increase in node density decreases the throughput and also in some movements it goes to Zero (but in very few points). The packet delivery ratio is not affected much by the node density while it affects the delay slightly.

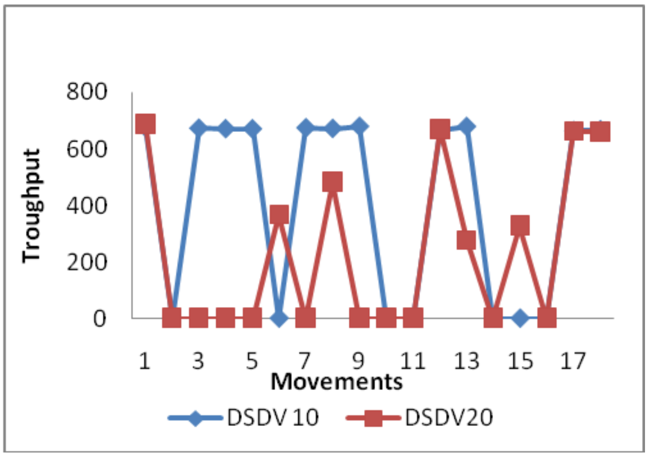

Fig. 5: Throughput- DSDV.

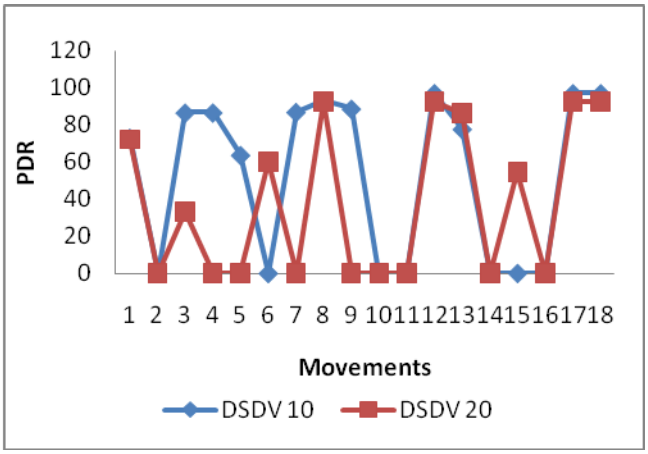

Fig. 6: PDR- DSDV

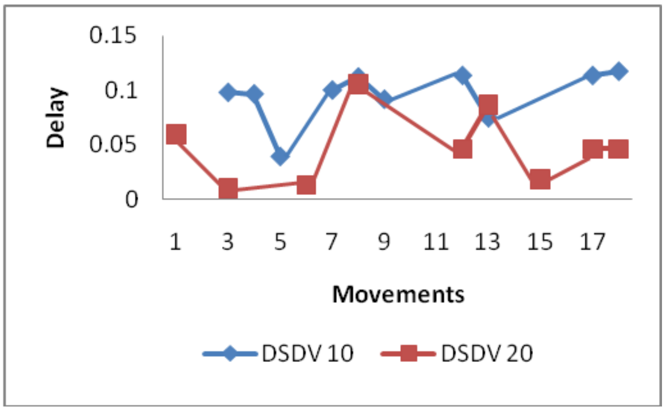

Fig. 7: Delay- DSDV.

DSDV is heavily affected by the mobility of the nodes. Increase in node density produce a notable reduction in the throughput and failure pointes are also increased. The packet delivery ratio is also affected much by the node density.

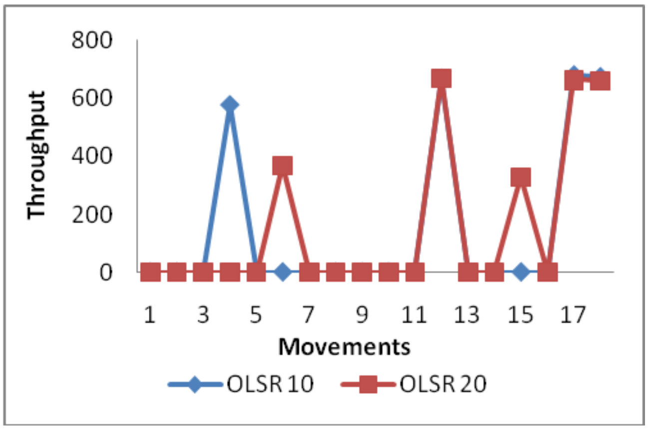

Fig. 8: Throughput- OLSR.

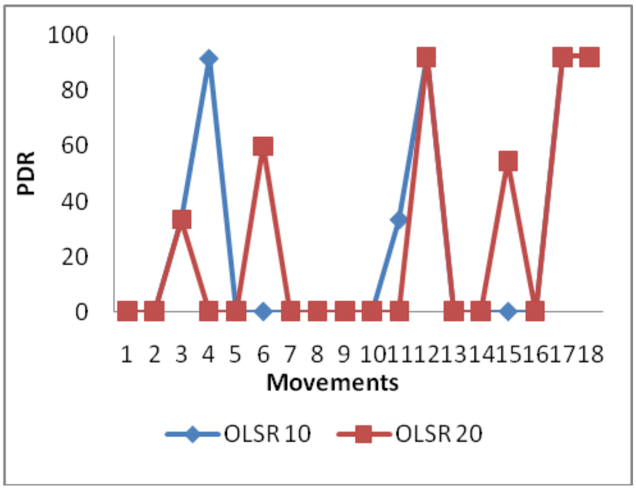

Fig. 9: PDR- OLSR

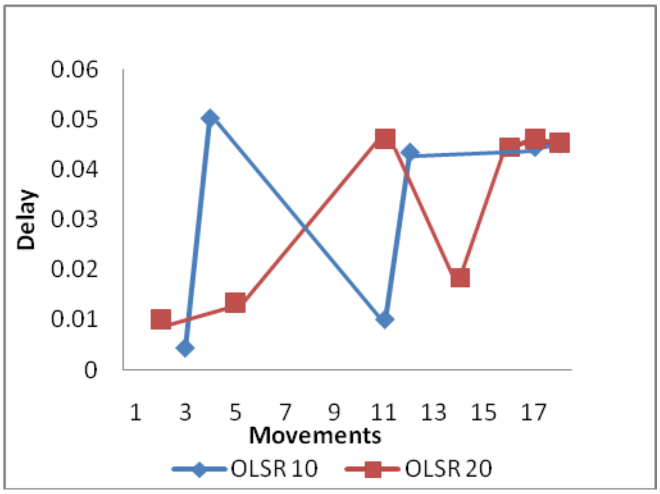

Fig. 10: Delay- OLSR.

OLSR gain higher throughput in both small and large networks, but fails frequently for several movements. The packet delivery ratio is poor in most situations only few point have higher PDR. OLSR produce fairly less delay and also delay is minimized when node density is increased. OLSR outperforms in large networks with less mobility and less traffic.

The mobility affects the ZRP's throughput. It produce higher throughput when the distance between source and destination is less. The PDR is also affected deeply by various types of node movements. But both are slightly affected by increase in node density.

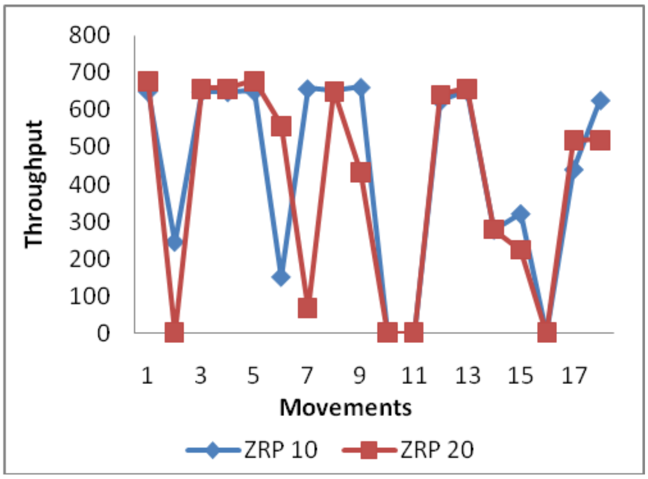

Fig. 11: Throughput- ZRP.

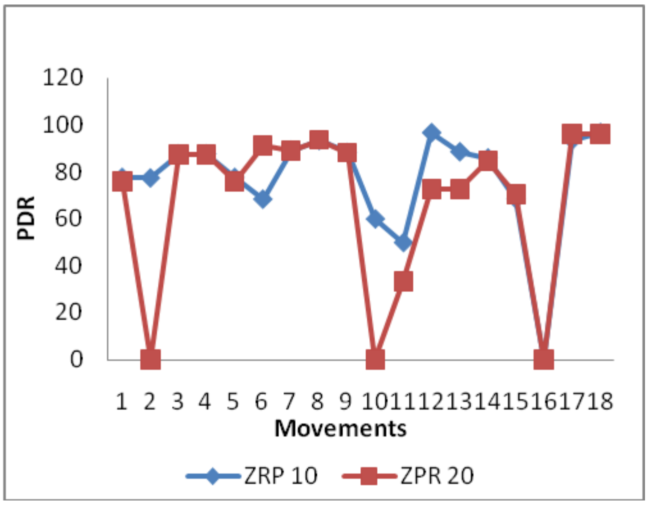

Fig. 12: PDR- ZRP.

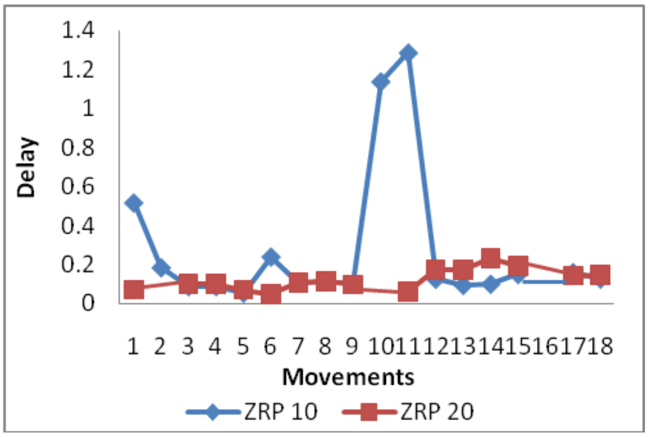

Fig. 13: Delay- ZRP.

AODV performs well without very less failure. ZRP gives higher throughput than AODV but number of failures also higher than AODV. OLSR and DSDV fail frequently but OLSR gives very high throughput when it gets suitable situation. The average delay is less for proactive protocols. In increased node density also they outperforms. AODV and ZRP give more or less same delay for various movements of nodes except some outliers.

Conclusion:

The simulation study consists of four routing protocols AODV, DSDV, OLSR and ZRP deployed over MANET using CBR traffic, analyzing their behavior with respect to three parameters, delay, packet delivery ratio and throughput. Results from experiments in different mobility and different node densities, AODV produce more or less constant performance and also the failure is fairly less when compared to other protocols. ZRP gives higher performance but in some situation it performs poor and the delay is also high compared to others. DSDV and OLSR gives very high performance with less delay but it is highly unsuccessful when mobility is high. When mobility is high it not even deliver a single packet, it fails completely.

From this, we found that, Reactive protocol is best for small as well as large networks with high mobility, which requires reliable communication without any failure and minimum of 70% PDR is expected always. Large networks with less mobility, less traffic and it requires very high throughput with less delay, then we can go for proactive protocols. Hybrid protocols best support large networks in which mobility and traffic are high in one particular area (zone) and delay is not a critical factor.

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