Analysis of Transmit Power Effects in Ad-hoc Network Protocols using Network Simulator-3

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Abstract – *Mobile ad-hoc networks (MANETs) have been the emphasis of research interest since last three decades. In ad-hoc network, nodes connect each other dynamically in a random manner. The dynamic topographies of mobile ad-hoc networks require improved version of routing protocols. MANET is a wireless ad hoc network, which has a routable networking scenario with self-forming and self-healing capabilities without a centralized infrastructure. In MANET, route choices are performed by the routing algorithms. This paper focuses on analysis of transmit power effects in three MANET routing protocols: Ad hoc on demand distance vector (AODV), Destination sequenced distance vector (DSDV) and Optimized link state routing (OLSR). We used different performance metrics in our analysis which are: Throughput, Packet delivery ratio, End to end delay, Packet loss and Normalized routing load.*

Key Words: MANET, RWMM, PDR,EED ,AODV, DSDV, OLSR, RREQ, RREP, RERR, DBF, MPR, TC, NS3, , Throughput, Packet delivery ratio, Simulation, End to end delay, Packet loss. Routing,

1.INTRODUCTION

The influence of transmit power in data propagation is presently one of the key issues in Mobile ad hoc networks. Transmission power is a key parameter for MANETs [1]. Characteristics of the Mobile ad hoc networks can be altered by altering the transmit power. "As power increases, the influence of mobility decreases and the effective density increases" [2]. Network survivability varies with different routing protocols in various environments like variable transmit power, mobility speed and node density. In this paper, we analyse impact of varying transmit power. A high transmit power influences higher connectivity by increasing the straight links realized by the member nodes of the network [3]. Prevailing MANET routing protocols are designed to determine routes by procedures of flooding at full transmission power. MANET protocols are optimized in order to reduce the number of hops from source to the destination. The protocols of MANET were simulated with NS-3 (Network Simulator-3) under Random waypoint mobility model (RWMM). In the past many researchers have performed analysis of MANET routing protocols by selecting node density, node pause time and node velocity. In this paper, we have considered transmit power as a factor for our studies. Earlier, we have tested these protocols in NS-3, considering node velocity as the test factor. Fig - 1 demonstrates a Mobile ad hoc network with member nodes.

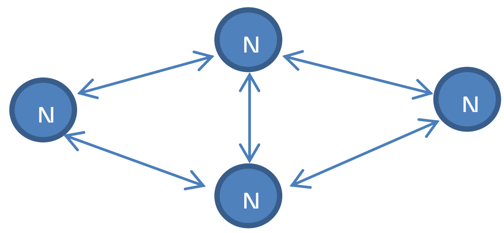

Fig - 1 : Mobile Ad hoc Network

1.1 Routing in MANETs

Routing is a process by which route discovery takes place between a source nodes to the destination nodes. In MANET, each mobile node acts as a router. The most important aim of routing algorithms in ad hoc network is to create an accurate and proficient route among all the member nodes and to make sure correct and timely discharge of packets [4]. MANET routing protocols can be categorized into three types based on procedure used for route discovery and route maintenance [5]: reactive or on demand, proactive or table driven and hybrid (combination of reactive and proactive) protocols. Here we have considered AODV (reactive protocol), DSDV and OLSR (proactive protocols) for our experiments.

1.2 Reactive and Proactive Routing Protocols

Reactive routing protocols are on demand routing protocols in which, route requests generated by the member nodes of the network are processed [6]. If a source sends a route request to a node, the protocol establishes a path between them. Proactive routing protocols are table driven, therefore, timely updated routing tables are helpful to establish a path between the source and the destination node. Routing tables holds the detailed information pertaining to every member node of the ad hoc network.

2. AODV (Ad hoc on demand distance vector)

AODV is a routing protocol designed for mobile ad hoc network and for other wireless ad hoc networks. It was jointly developed by C. Perkins, E. Belding-Royer and S. Das on July 2003 [9]. In AODV, route discovery take place only when route requests are received from the member nodes of the ad hoc network [7]. AODV uses route finding procedures and updated routing tables in order to maintain latest routing information [8]. In AODV, establishment of path between the sources to the destination take place when a source node broadcasts RREQ (Route Request) message throughout the network till it reaches the required destination. When RREQ message reaches the destination, the destination node generates a message called RREP (Route Reply) which is sent to the source to confirm the path. When path break occurs for any reason, then the destination node will generate a RERR (Route Error) message and broadcasts it throughout the network. Fig - 2 demonstrates the processing of Route Request message from the source node 1 to the destination node 8.

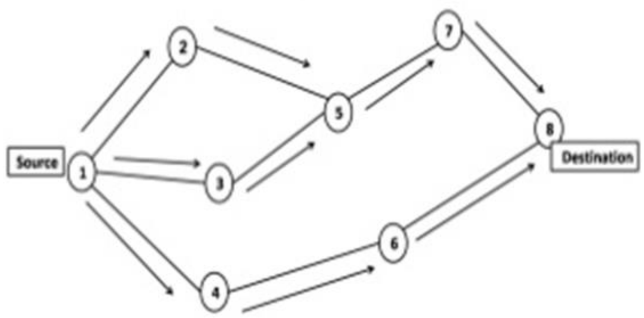

Fig - 2 : Processing of RREQ message in AODV[20]

Fig - 3 demonstrates the processing of Route Reply message from destination node 8 to the source node 1.

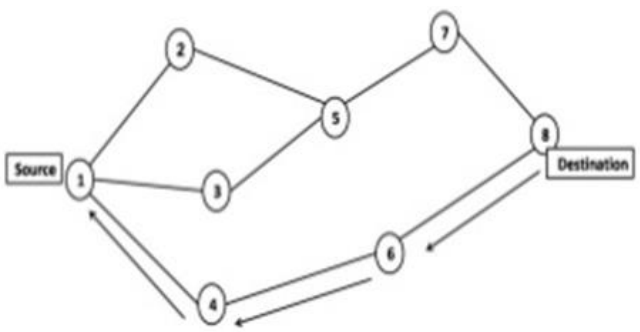

Fig - 3 : Processing of RREP message in AODV[20]

2.1 DSDV (Destination Sequenced distance vector)

DSDV is a proactive routing protocol originally based on the Bellman-Ford routing algorithm [10]. Distributed Bellman-Ford (DBF) technique was applied effectively in most of the packet switched networks and the DSDV routing protocol is a modified version of this technique. DBF technique is used to calculate the shortest path between source nodes to the destination nodes, it forms some routing loops. In DSDV, a new parameter called Destination Sequence Number (DSN) has been hosted to reduce routing loops problems of the DBF technique [11]. DSDV is almost same as conventional Routing Information Protocol (RIP) except above mentioned attribute in routing table and that is the destination sequence number [12]. In DSDV, network nodes transfer timely updated routing information and incremented sequence numbers to all their neighbors. This transfer process updates each and every node with up-to-date link information along with the routing table. Then the nodes of the network are able to create the path between the source nodes to the destination node. Distance vector shortest path algorithm selects the requested routes. DSDV protocol promotes two types of updated packets called "FULL DUMP" and "INCREMENTAL DUMP". Transmission overheads are reduced by the help of these two updated packets. These updated dump packets are broadcasted through the entire network by all the nodes. The "full dump" packet holds the routing data whereas the "incremental dump" holds only the changed data since the last "full dump". As compare to other MANET routing protocols, DSDV has much link overheads. This negative aspect of DSDV limits it for small scale deployments.

Table -1: Node N4 packet forwarding in DSDV

Destination	Next hop	Metric	Sequence No.
N1	N2	2	S406_N4
N2	N2	1	S128_N1
N3	N2	2	S564_N2
N4	N4	0	S710_N3
N5	N6	2	S392_N5
N6	N6	1	S076_N6
N7	N6	2	S128_N7
N8	N6	3	S050_N8

Table - 1 and Fig - 3 illustrates simple operation of DSDV routing protocol. In Table - 1, node N4 is forwarding destination sequence numbers to its neighbor nodes N6 and N2 [13]. Illustration figure has eight member nodes of the network: N1, N2, N3, N4, N5, N6, N7 and N8.

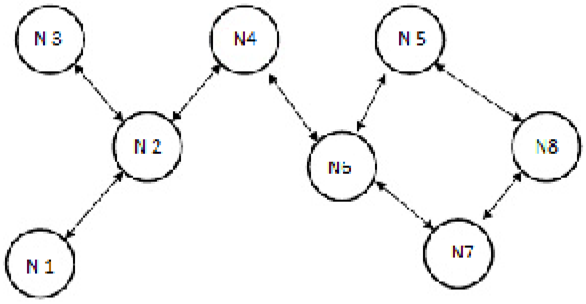

Fig - 4 : DSDV in operation

2.2 OLSR (Optimized Link State Routing)

OLSR is a table driven proactive ad-hoc network protocol. It uses optimized technique in extracting topology related information. OLSR is based on link state algorithm [14]. In OLSR, change in topology reasons to flooding of information to all the nodes of the network. To reduce this flooding, Multi Point Relays (MPR) are used. Table driven feature of OLSR helps it to have updated routing information in various tables [15]. In OLSR, there are four types of control messages: HELLO, TC, MID and HNA.

HELLO: This message is transmitted to all the neighbors periodically. This message helps in getting information related to link status and the neighbor of the host.

TC (Topology Control): This message is sent periodically to the neighbors, it helps in broadcasting neighbors of the member nodes of the network.

HNA (Host and Network Association): HNA message is broadcasted to share information pertaining to the external routing. It holds network related information.

MID (Multiple Interface Declaration): This message is broadcasted throughout the network to inform all the member nodes that the host can have multiple interfaces of the OLSR. MID message lists the connection log of a node.

In OLSR, each node transmits control messages periodically. Therefore, OLSR does not necessitate using reliable control message delivery; henceforth OLSR protocol can endure reasonable control message losses.

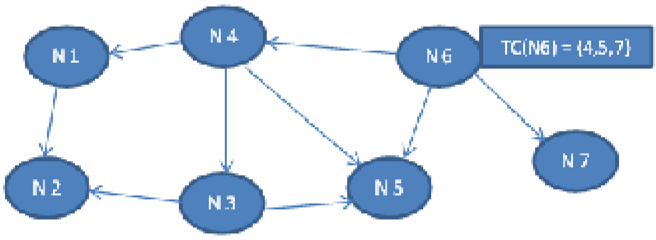

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Fig - 5 : OLSR in operation

Fig - 4 illustrates the operation of OLSR routing protocol. Node N6 generates a TC message broadcasting its neighbor set that is TC (N6) = { 4, 5 ,7 } and sends to its neighbors N4, N5 and N7. Node N4 forwards the message TC (N6) to its neighbors N1, N3 and N5. Node N3 then forwards the message TC (N6) to its neighbors and so on until the message reaches every node [16].

2.3 Consumption of Energy in MANET

The process of communication and computation involves consumption of energy in nodes of the network. Exists mobile nodes in the network are in four modes as given in equation 1. While communication proceeds the nodes undertake different transition states. From equation 2 we could notice that in sleep mode, the mobile node consume low power as compare to other states of the nodes [17].

$$E_{pt} = E_{oh} + E_a + E_i + E_s \quad (1)$$

$$E_a = E_t + E_r \quad (2)$$

$$E_s \cong 0 \quad (3)$$

$$E_t = E_{pt} + E_{pd} \quad (4)$$

Where,

E_{pt} = packet transmission energy

E_{oh} = packet over hear

E_a = active packet energy

E_i = idle packet energy

E_s = sleeping packet energy

E_t = transmit packet energy

E_r = received packet energy

E_{pd} = path discovery energy

2.4 Consumption of Power in Transmission mode

During transmission, a source node sends data packets to the destination node. Transmission energy refers to the energy required by a node to transmit the data packet. Transmission energy is totally depends on the size of the data packet. Therefore, the transmission energy has the following formula [17]:

$$E_t = (PL \times 330) \div (2\times10^6) \quad (5)$$

$$P_T = E_t \div T_t \quad (6)$$

Where,
E_t = transmit packet energy
PL= packet length
P_T = transmission Power
T_t = time taken to transmit the data packet

2.4 Consumption of Power in Reception mode

Reception energy is refer to the energy required by a node to receive a data packet from the other node of the network. The energy in received mode is formulated as follows [17]:

$$E_r = (PL \times 230) \div (2\times10^6) \quad (7)$$

$$P_r = (E_r) \div (T_r) \quad (8)$$

Where,

E_r = reception energy

P_r = reception power

T_r = time taken to receive the data packet

PL = packet length

2.4 Consumption of Power in Idle mode

In idle mode, a packet will be in idle mode that is it neither transmit a packet nor receive any packet. In idle mode, the packet in idle mode consumes same amount of energy as an active node takes to receive the packet. In idle mode, nodes which are in idle state does not involve in data communication [17]. The power consumption in idle mode is given by :

$$P_i = P_r \quad (9)$$

Where,

P_i = power consumed in idle mode
P_r = power consumed in reception mode

2.5 Consumption of Power in overhearing mode

In overhearing state, a node hears to the packet which is not sent for it. Consumption of energy in this mode is equal to energy consumed in reception mode. Therefore, consumption of power in overhearing mode is given by [17] :

$$P_o = P_r \quad (10)$$

Where,
P_o = power consumed in overhearing mode

P_r = power consumed in receiving mode

3. Performance Metrics

Different performance matrices are available to analyze the performances of MANET routing protocols. Here, we have considered the following metrics [10].

a) Throughput:

It is the amount of data transferred from source node to the destination node in a unit time stated in Kbps (Kilobits per second).

Throughput = (Received Bytes*8) / (Simulation time*1024) (11)

It is calculated in Kbps. Larger value of the throughput delivers improved performance.

b) PDR (Packet Delivery Ratio) :

It is the ratio of total received packets to the total packets sent.

PDR = (total received packets) / (total sent packets) * 100 % (12)

It is calculated in percentage (%). Larger value of PDR delivers improved performance.

c) EED (End to End Delay) :

It is the average time interval between packets generated at the source node and delivery of the packets at the destination node. It is the fraction of delay sum to the received packets.

End to end delay = (delay sum) / (received packets) (13)

It is calculated in ms (mille second). Lesser values of end to end delay delivers improved performance.

d) Packet loss :

It is the difference of total sent packets and the total received packets.

Packet loss = (total sent packets) – (total received packets) (14)

It is calculated as number of packets.

e) NRL (Normalized Routing Load) :

It is the ratio of number of transmitted routing packets to the number of received data packets [18].

NRL = (No. of routing packets sent) / (No. of received data packets)

Larger NRL values give lesser efficiency of the routing protocol in terms of bandwidth consumption.

4. Simulation environment

For our experiments we have used 3.13 version of the Network Simulator (NS3). Using NS3, we carried out simulation based analysis of MANET routing protocols: AODV, DSDV and OLSR. NS3 is an open source discrete-event network simulator [19]. NS3 is developed by the help of high level programming language that is C++ with some optional bindings of the python. It has enhanced simulation reliability. NS3 was built from the scratch to replace Application Program Interfaces (APIs) of NS2. NS3 does not support APIs of NS2 [10]. We used CENTOS Linux platform to execute our simulation experiments.

4.1 Simulation Results

The simulation experiments of the MANET routing protocols have been carried out by fixing 10 number of source/sink connections, while varying transmit power as 3.5dBm, 4.5dBm, 5.5dBm, 6.5dBm, 7.5 dBm, 8.5dBm and 9.5dBm. The simulation scenario and gained results are revealed in the following tables and graphs.

Table -2: Simulation Scenario of AODV, DSDV and OLSR

1	Number of Nodes	50
2	Simulation Time	150 seconds
3	Pause Time	No pause time
4	Wi-Fi mode	Ad-hoc
5	Wi-Fi Rate	2Mbps (802.11b)
6	Transmit Power	3.5dBm,4.5dBm,5.5dBm, 6.5dBm,7.5 dBm, 8.5dBm and 9.5dBm.
7	Mobility model	Random Waypoint mobility model
8	No.of Source/Sink	10
9	Sent Data Rate	2048 bits per second (2.048Kbps)
10	Packet Size	64 Bytes
11	Node Speed	20 m/s
12	Protocols used	AODV,DSDV and OLSR
13	Region	300x1500 m
14	Loss Model	Friis loss model

a) Throughput:

Table – 3: Throughput

Transmit power in dBm	Throughput in Kbps		
	AODV	DSDV	OLSR
3.5	11.22	10.81	13.30
4.5	13.60	12.29	15.18
5.5	10.61	12.61	16.07
6.5	15.25	11.38	17.22
7.5	14.46	12.64	17.98
8.5	17.71	14.45	18.16
9.5	3.74	16.80	19.18

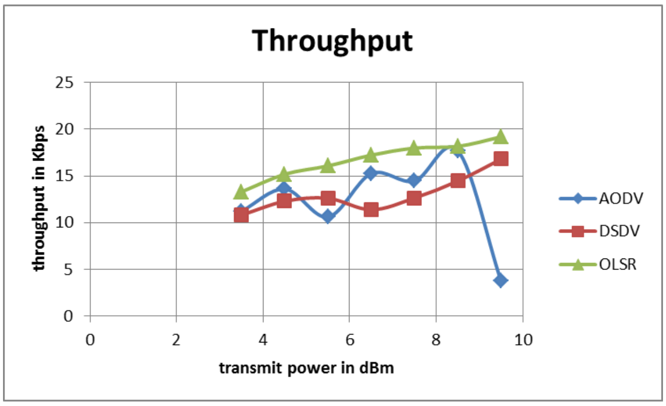

Fig - 6 : Throughput over transmit power

b) Packet Delivery Ratio:

Table – 4: Packet delivery ratio

Transmit power in dBm	Packet delivery ratio in %		
	AODV	DSDV	OLSR
3.5	56.11	54.08	66.53
4.5	68.03	61.46	75.90
5.5	53.05	63.08	80.38
6.5	76.26	56.93	86.13
7.5	72.33	63.21	89.93
8.5	88.58	72.28	90.81
9.5	18.71	84.01	95.90

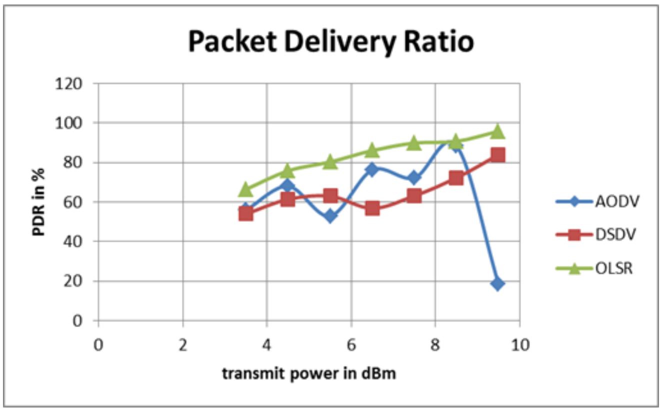

Fig - 7 : PDR over transmit power.

c) End to End Delay:

Table – 5: End to end delay

Transmit power in dBm	End to end delay in ms		
	AODV	DSDV	OLSR
3.5	19.55	21.22	12.57
4.5	11.74	15.67	7.93
5.5	22.12	14.63	6.10
6.5	7.77	18.91	4.02
7.5	9.56	14.54	2.79
8.5	3.22	9.58	2.52
9.5	108.57	4.75	1.06

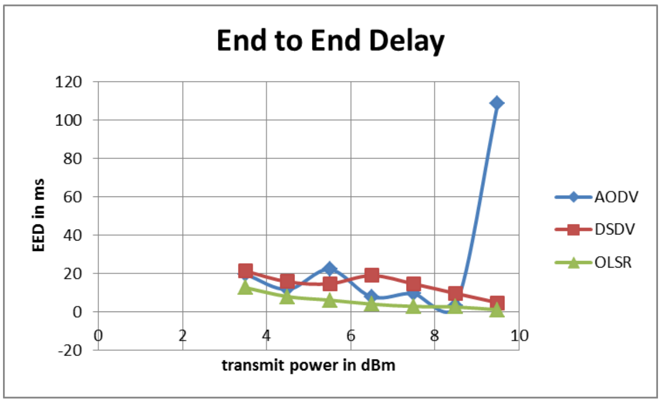

Fig - 8 : End to end delay over transmit power

d) Packet Loss :

Table – 6: Packet loss

Transmit power in dBm	Packet loss in No. of packets		
	AODV	DSDV	OLSR
3.5	2633	2755	2008
4.5	1918	2312	1446
5.5	2817	2215	1177
6.5	1424	2584	832
7.5	1660	2207	604
8.5	685	1663	551
9.5	4877	959	246

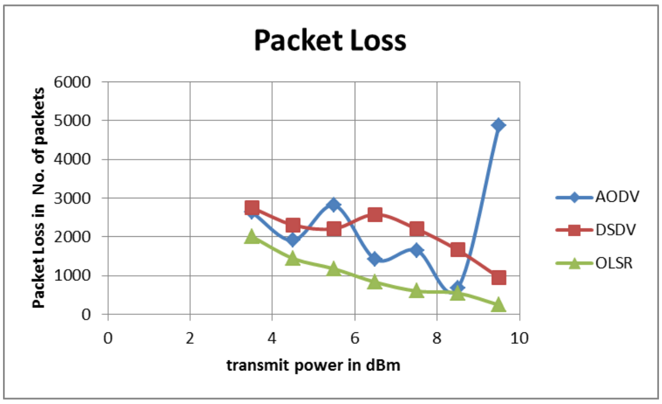

Fig - 9 : Packet loss over transmit power

e) Normalized Routing Load :

Table – 7: NRL

Transmit power in dBm	NRL		
	AODV	DSDV	OLSR
3.5	0.561	0.541	0.665
4.5	0.680	0.615	0.759
5.5	0.531	0.631	0.804
6.5	0.763	0.569	0.861
7.5	0.723	0.632	0.899
8.5	0.886	0.723	0.908
9.5	0.187	0.840	0.959

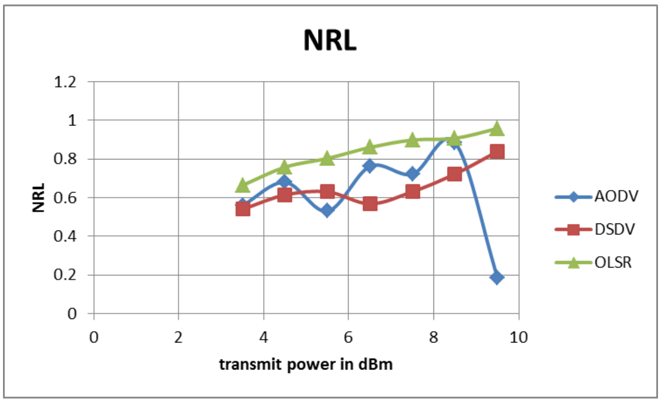

Fig - 10 : NRL over transmit power

5. Conclusion

As per our test setup scenarios and gained results, we observed that, as compare to AODV and DSDV, OLSR protocol has shown better performance in terms of all the metrics calculated. Whereas AODV is also shown better performance, but performance of the AODV degrades as transmit power increases. As for as DSDV is concerned, we observed that the performance of DSDV is improving with the increase of transmit power. However, performance of the routing protocols rest on various technical aspects like, network size, transmission range, transmission region, no. of source/sink connections, speed of the nodes, mobility models, Wi-Fi rate, traffic scenarios etc. Further, our current research is focussing towards improving parameters of the weak protocols.

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