Vol 8. No. 2 Issue 2 – August, 2015
African Journal of Computing & ICT

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Analysis of Performance Enhancing Parameters of AODV Using NS-3

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ABSTRACT

A mobile ad hoc network usually symbolized as a MANET has a set of nodes that communicate to each other straightly without having access points or centralized control setup. The dynamic and infrastructure less nature of Mobile Ad hoc Networks postures a key challenge to efficient & accurate data packet routing. This leads to incredible expanse of research in routing protocols adjustable to the dynamic ad hoc network states such as: size of the network, density of traffic scenarios and network splitting. In ad hoc networks, routing protocols assumes communication between nodes which also acts as routers and facilitate these routers to select desired routes between the source and the destination. The routing algorithms perform route selection process between the nodes. In this paper, we have analyzed values of the default parameters of AODV (Ad-hoc On Demand Distance Vector Routing) with the revised parameter values by using network simulator-3 (NS-3). Our analysis is based on different performance metrics such as throughput, packet delivery ratio, end to end delay, packet loss and normalized routing load. Based on this analysis, we concluded performance enhancement of the AODV protocol of the mobile ad hoc network.

Keywords— MANET, AODV, DSDV,DSR, RREQ, RREP, RERR, NS-3, RWMM, PDR, EED, MN, NRL, Throughput, Packet delivery ratio, End to end delay, Packet loss, Routing, Node speed, Simulation, routing protocols,

African Journal of Computing & ICT Reference Format:
Lakshman Naik.L, R.U.Khan & R.B.Mishra (2015 Analysis of Performance Enhancing Parameters of AODV Using NS-3. Afr J. of Comp & ICTs. Vol 8, No. 2, Issue 2. Pp 87-94

1. INTRODUCTION

A Mobile ad hoc network (MANET) contains small set or large set of nodes that communicate each other directly without depending upon access points and any centralized control setup. In MANET, nodes are mobile in nature and their movements and speed can be random which makes them to have a dynamic network topology [1]. Routing in ad hoc networks becomes challenging as day by day portable device users are increasing. These portable network supported devices are technically advanced and bandwidth consuming with the high defined video graphics applications etc. Many researchers have motivated on the algorithmic complexity of ad-hoc routers [2, 3, 4]. Some other researchers have proposed new routing solutions [5, 6].

Protocols of MANET are optimized to reduce the number of hops from the source to the destination. Protocols in MANET are classified into three types based on route discovery procedure and maintenance of the routes [7]. These are reactive or on demand, proactive or table driven and hybrid. Hybrid protocols are developed by combining features of reactive and proactive protocols. Here, we have considered AODV (reactive protocol) for our investigations. AODV is a typical on demand type protocol, utilizes an on-demand methodology for finding routes.

In AODV, fresh routes are ensured with the help of sequence numbers associated with the routing information. On-demand routing protocols has lesser overheads as compare to table driven routing protocols [8]. In AODV, route between the source and the destination pair is expected to be symmetric and previous hop life time of the active route is updated along the reverse path back to the source. AODV does not work with multiple addresses over each interface. Selection of source address in AODV is complicated, when AODV does not have a route, the loop back route is returned, this results the packet to be looped backed and handled with cache [9]. Here, we have analysed default parameter values of AODV with certain modifications in parameter values and tested. As per obtained results from our experiments, we have noticed enhancement in performance of AODV routing protocol. Same have been concluded in the final conclusion section of this paper. Fig. 1 illustrates a simple mobile ad-hoc network with mobile nodes (MN).

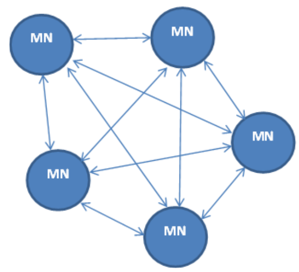

Figure 1 : A Simple Mobile Ad-hoc Network

2. ROUTING PROTOCOLS IN MANETs

Route discovery between the source and the destination takes place by means of Routing. Routing algorithms selects the routes between source and the destinations. Each MANET node acts as a router, routing protocols ensures creation of accurate and efficient routes. Routing protocols are responsible towards correct and timely delivery of data packets [10]. A routing protocol describes the method by which active links between mobile nodes established. Routing algorithm determines the way in which link paths are established between a source and the destination.

In mobile ad-hoc networks, network topologies are determined by the nodes as they are mobile in nature. A new node of MANET broadcasts its presence to all other nodes of the network, and it listens to broadcasts made by all other neighbor nodes. MANET routing protocols can be classified as reactive or on-demand, proactive or table driven and hybrid (combination of reactive and proactive protocols) [11]. Link overheads of mobile ad-hoc network protocols are reduced by having smaller routing tables. Here, we have simulated the AODV, the reactive routing protocol.

Examples:
1. Proactive protocols: DSDV, OLSR, WRP and CGSR.
2. Reactive protocols: AODV, DSR, SSA and ABR.
3. Hybrid protocols: CEDAR, ZRP and ZHLS

3. PERFORMANCE AFFECTING PARAMETERS

Various factors affect the performance of MANET routing protocols some of them are listed hereunder:

1. Transmit Power: In data propagation, transmit power is considered as major factor. Characteristics of the ad –hoc network can be changed by changing the transmitted power. "As power increases, the influence of mobility decreases and the effective density increases" [12].
2. Node Velocity: Mobility is the key factor in mobile ad-hoc networks. Every node of the MANET moves from one point to another. Performance degrades for higher values of node velocity due to multiple link failures [13].
3. Node Density: It is the population of nodes in an ad-hoc network. Lesser values of node density promote lower reachability and higher values do not gain improvements so, optimum values are considered [13].
4. Mobility Model: Mobility models drive the nodes in an ad-hoc network. Mobility model defines exact location of a mobile node. Performance variation occurs from one mobility model to another. Random way point is one of the mobility model used to evaluate mobile ad-hoc network protocols.
5. Transmission region: It is the region in which nodes move from one point to another.
6. No. of Source/Sink Pairs: These are the fixed connections which send data packets to the applications.
7. Type of Traffic: These are the different types of applications traffics. These traffics have their own parameters and these parameters also affect the performance of the MANET routing protocols. CBR, Exponential and Pareto are some types of traffic generators in the mobile ad-hoc networks.
8. Protocol parameters: Protocol parameters also considered in evaluating performance of MANET routing protocols. Some parameters of AODV have been discussed in this paper.

4. MOBILITY MODEL

In simulation experiments, we have considered Random Waypoint Mobility Model (RWMM). Random Waypoint Mobility Model was originally introduced by Johnson and Maltz. RWMM is one of the well-known models widely used to evaluate mobile ad-hoc network routing protocols because of its extensive and easy availability [14]. In random waypoint mobility model, each and every node begins with pause time of some fixed seconds. After the pause time, nodes select a random destination with in the simulation region and with the random speed between zero and some high speed. Node moves to the new destination and again encounters another pause time prior to proceed further for new random location with the random speed. This process repeats until the end of simulation time [15].

5. AD-HOC ON DEMAND DISTANCE VECTOR (AODV)

AODV is one of the routing protocols among mobile ad-hoc network routing protocols. It was developed by utilizing some main properties of DSR (Dynamic Source Routing) and DSDV (Destination Sequenced Distance Vector) routing protocols. It was cooperatively developed by C.Perkins, E.Belding-Royer and S.Das on July'2003 [14]. AODV is a reactive or on demand distance vector routing protocol. It provides routes only on –demand basis. In AODV, procedures of route finding and updated routing tables are used to maintain new routing information [16]. In ad-hoc on demand distance vector (AODV) routing, each and every node maintains a routing table which holds details of next hop address in order to reach specific destination.

In AODV, if a source node "S" wants to communicate with the destination node "D" without having destination address in its routing table then the source node "S" generates a RREQ (Route Request) message and broadcasts it throughout the network till it reaches the destination node "D". Then the destination node "D" generates a RREP (Route Reply) message and sends it to the source node "S" to confirm the path. If path break found for any reason, then the destination node generates RERR (Route Error) message and broadcasts it throughout the network. Fig. 1 demonstrates the propagation of RREQ between source node "S" and the destination node "D". The destination node "D" is propagating RREP message to the source node and it generates RERR message and broadcast it throughout the network when path break found

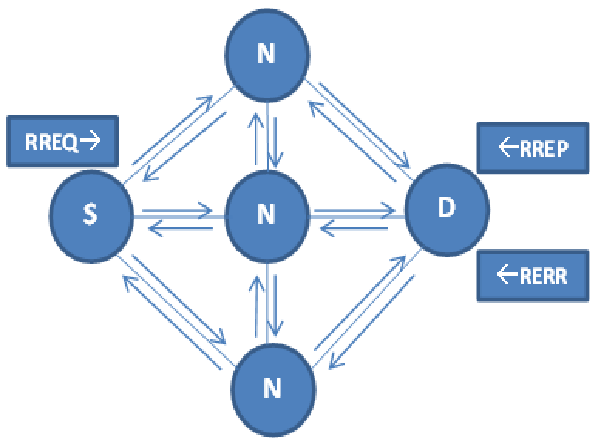

Figure 2 : Demonstration of AODV routing protocol.

In AODV, path between the source and destination pair is expected to be symmetric [20]. The updating of routing table is carried out for the active route life time for the last hop through the reverse path back to the source. AODV does not work with multiple addresses through the single interface. In AODV, selection of source address is tricky, when AODV does not have a route, the loop back route is returned. This causes the packet to go for loop back and cached when route is found. TCP (Transmission control protocol, a connection oriented protocol) needs to build endpoint four tuples and build a pseudo-header for the purpose of check-summing. Therefore, AODV required guessing the eventual source address. This problem does not occur for single interface and nodes with single addresses. During processing of multiple outgoing interfaces, AODV follows to pick the first available interface of the AODV. In AODV, nodes verify to determine whether or not it has received a RREQ with the same source address and RREQ ID (Route Request Identity). When such RREQ received, then the node discards the new RREQ received. During the creation or updating of the reverse route, the following actions are taken over the route [20]:

1. From the RREQ, originating source sequence number is compared with the corresponding sequence number of the destination in the routing table and copied it if there exist greater value.
2. The valid sequence number is therefore set as true.
3. In the routing table, next hop entry becomes RREQ received from the node.
4. Hop count entry of the routing table then copied to the RREQ message.
5. Life time is set to the maximum of existing life time and minimal life time.

In AODV, if the RREQ has the incremented value, then the destination node should increase its own sequence number by one. Else, sequence number of the destination node does not change prior to the generation of RREP message. During routing table of the destination created or updated then the following actions takes place:

1. The created route is marked as active route.
2. The sequence number of the destination is marked as valid one.
3. In the routing table, next hop entry is the address of the node from which RREP is received.
4. Value of the hop counter is set to be hop count of RREP+1.
5. The Expiry time is set to the real time plus the life time value of RREP.

In AODV, when a member node of the network receives hello message from any of its neighbors then that node ensures the active route to that neighbor. If no active routes are present then it will create a route for that neighbor. When a route discovery tried at RREQ retries with the maximum TTL without receiving RREP, then all the data packets of that destination are dropped and destination unreachable message is delivered to the source [20].

6. PERFORMANCE METRICS

There are different performance metrics are available to evaluate mobile ad-hoc network protocols, out of which we have used the Throughput, Packet delivery ratio, End to end delay, Packet loss and Normalized routing load [18].

1. Throughput:
Amount of data transported from the source node to the destination node through the network in a unit time expressed in Kbps (Kilobits per second) is called throughput.

Throughput = (8 ×Bytes received) ÷ (1024 × Simulation time) - (1)

Larger values of throughput give better and enhanced performance. Throughput is derived in Kbps.

2. Packet Delivery Ratio (PDR):
Fraction of total received packets to that of total sent packets is called packet delivery ratio.

PDR = (total packets received) ÷ (total packets sent) × 100% - (2)
Large values of PDR provide better and enhanced performance. PDR is derived in % (percentage).

3. End to End Delay (EED):
Average time interval between packets produced at the source node and effective delivery of these packets at the destination node is called end to end time delay.

EED = (sum of delay) ÷ (total packets received) (3)

Lesser values of end to end delay provide better and enhanced performance. EED is derived in ms (mille second).

4. Packet Loss:
Difference between the total packets sent and the total packets received is called packet loss.

Packet loss = (total packets sent) – (total packets received)- (4)
Packet loss is derived as number of packets.

5. Normalized Routing Load (NRL):
The ratio of no. of routing packets transported to the total data packets received is called normalized routing load [19].

NRL = (No. of routing packets sent) ÷ (No. of total data packets received) (5)

Higher values of Normalized routing load leads to lesser efficiency in terms of bandwidth consumption.

6. SIMULATION ENVIRONMENT

For our experimentation, we have used 3.13 version of NS-3 (Network Simulator-3) to simulate AODV parameters. NS-3 is a discrete-event open source network simulator [9]. It is developed using C++ programming language with optional bindings of the python. NS-3 has enhanced simulation capabilities. NS-3 is not rearward adjusted with the NS-2 (Network Simulator-2). NS-3 was built from the scratch to replace APIs (Application program Interfaces) of the NS-2. Some NS-2 modules have been ported to the NS-3. NS-3 does not support NS-2 APIs [18]. We have used CENTOS Linux (open source Linux) operating system here.

6.1 Simulation Results
Investigations on AODV have been carried out by keeping 10 number of source/sink fixed connections and varying number of nodes. The simulation scenarios and obtained results are presented in the following tables and graphs.

Table 1 : General simulation parameters

Parameter	Assigned Value
Number of Nodes	50
Simulation Time	150 seconds
Pause Time	No pause time
Wi-Fi mode	Ad-hoc
Wi-Fi Rate	2Mbps (802.11b)
Transmit Power	7.5 dBm
Mobility model	Random Waypoint mobility model
No. of Source/Sink	10
Sent Data Rate	2048 bits per second (2.048Kbps)
Packet Size	64 Bytes
Node Speed	20 m/s
Protocols used	AODV
Region	300x1500 m

Revised parameters values of AODV routing protocol are mentioned in Table 2 [20].

Table 2 : Revised values of AODV parameters

Parameter	Assigned Value
RREQ Retries	3
RREQ Rate Limit	20 RREQ per second
Active Route Timeout	5 seconds
Net Diameter	45
Node Traversal Time	50 ms
Net Traversal Time	4.5 seconds
Path Discovery Time	9 seconds
My Route Timeout	18 seconds
Hello Interval	2 seconds
Allowed Hello Loss	3
Delete Period	25 seconds
Next Hop Wait	60 mille seconds
Timeout Buffer	3
Blacklist Timeout	13.5 seconds
Max Queue Time	30 seconds (Default used)
Max Queue Length	64 (Default used)

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AODV Parameter Metrics [20]:

1. Net Traversal Time = (2 × Net Diameter) × (Node Traversal time) (6)
2. Path Discovery Time = (2 × Net Traversal Time) (7)
3. My Route Timeout = (2 × max(Path Discovery Time, Active Route Timeout) (8)
4. 4. Delete Period = (5 × max(Active Route Timeout, Hello Interval) (9)
5. Next Hop Wait = (Node Traversal Time + 10 Milliseconds) (10)

6. Blacklist Timeout = (RREQ Retries × Net Traversal Time) (11)

Table 3: Throughput (in Kbps)

No. of Nodes	AODV (Default)	AODV (Modified)
30	16.04	17.02
40	17.93	16.18
50	14.47	13.69
60	1.87	13.58
70	9.73	13.82
80	11.62	16.40
90	0.68	3.50
100	1.42	12.81

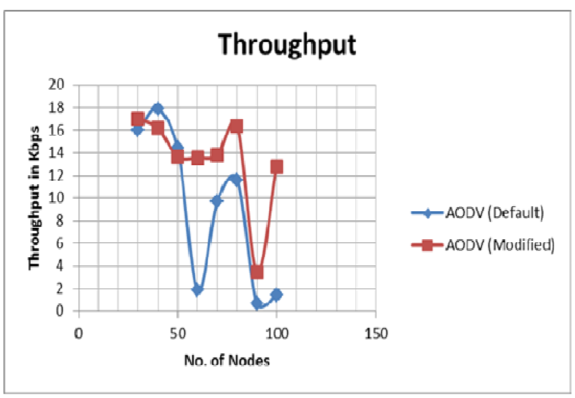

Figure 3 : Throughput over No. of nodes.

Table 4: Packet Delivery Ratio (in %)

No. of Nodes	AODV (Default)	AODV (Modified)
30	80.22	85.10
40	89.63	80.88
50	72.33	68.45
60	9.35	67.88
70	48.63	69.10
80	58.08	82.10
90	3.42	17.48
100	7.08	64.05

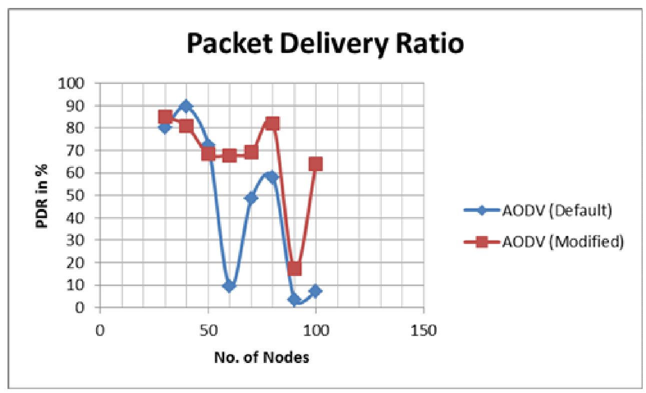

Figure 4 : PDR over No. of nodes

Table 5: End to End Delay (in ms)

No.of nodes	AODV (Default)	AODV (Modified)
30	6.17	4.38
40	2.89	5.91
50	9.56	11.52
60	242.38	11.83
70	26.41	11.18
80	18.04	5.48
90	706.71	117.99
100	327.94	14.03

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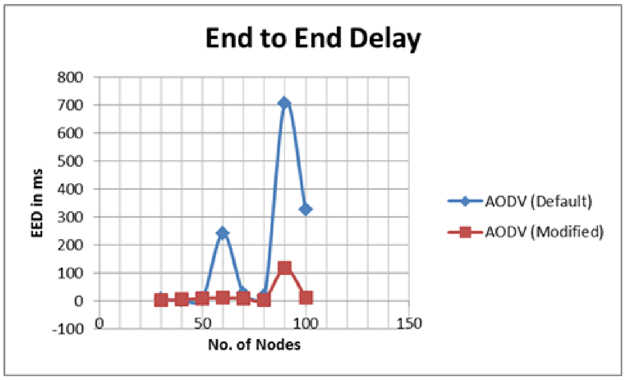

Figure 5 : EED over No. of nodes

Table 6: Packet Loss (in No. of packets)

No. of Nodes	AODV (Default)	AODV (Modified)
30	1187	894
40	622	1147
50	1660	1893
60	5439	1927
70	3082	1854
80	2515	1079
90	5795	4951
100	5575	2157

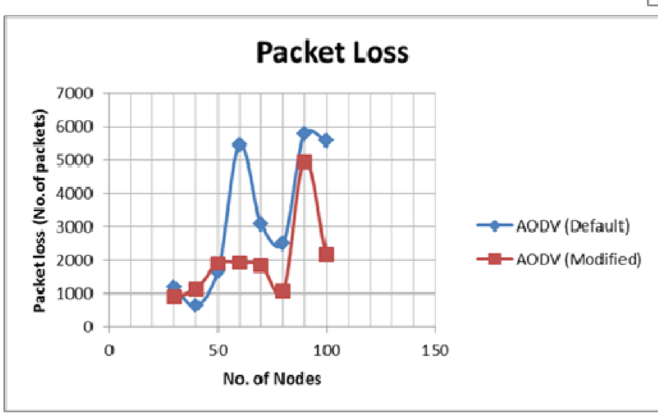

Figure 6 : Packet loss over No. of nodes

Table 7 Normalized Routing Load

No. of Nodes	AODV (Default)	AODV (Modified)
30	0.802	0.851
40	0.896	0.809
50	0.723	0.685
60	0.094	0.679
70	0.486	0.691
80	0.581	0.82
90	0.034	0.175
100	0.071	0.641

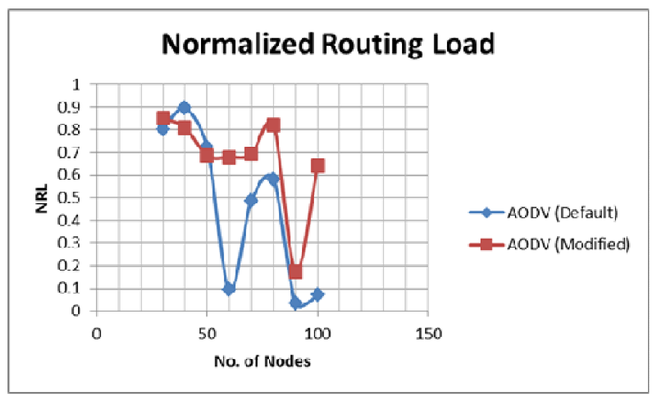

Figure 7 : NRL over No. of nodes

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7. CONCLUSION

According to the simulation results obtained and metric calculations, throughput, packet delivery ratio, end to end delay, packet loss and normalized routing load of the revised AODV have shown enhanced performances as compare to the AODV with default parameter values. These results are based on the general simulation parameters used and the value changed parameters of the AODV. Parameter values of the AODV have been changed only for the testing purposes. In future, further research can be taken ahead using different simulation scenarios including varied parameters of the node density, transmission region, transmit power, no. of source/sink pairs, transmission range, mobility models, Wi-Fi rate and different traffic generators.

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