Journal of Engineering Science and Technology
Vol. 17, No. 5 (2022) 3393 - 3409

CRITICAL ANALYSIS OF MODIFIED GAUSS MARKOV MOBILITY MODEL USING VARYING VALUES OF PARAMETERS TO CHECK THE IMPACT OF QOS IN MANET

MUNSIFA FIRDAUS KHAN*, INDRANI DAS

Department of Computer Science, Assam University, Silchar, Assam, India
*Corresponding Author: munsifa737@gmail.com

Abstract

The mobility of nodes highly influences the performance of MANETs. Simulation uses mobility models to control the movement of the nodes. In this paper, a huge experiment has been made on standard routing protocols, namely AODV and DSDV using Modified Gauss Markov (MGM) mobility model with two sets of nodes like 20 and 70 nodes as the small and the large sets of nodes to check the impact of QoS in MANET with QoS metrics like throughput, delay, and PDR in NS-3. Distinct values of parameters, namely distance and the tuning parameter are considered for experiment. We have taken five cases and considered the values of distance as 4 meters in Case I, 8 meters in Case II, 12 meters in Case III, 16 meters in Case IV and 20 meters in Case V and in each case, we have taken distinct values of tuning parameter, α, i.e., 0, 0.25, 0.5, 0.75 and 1. It is observed that the different values of parameters give different results on small and large group of nodes. It is noticed that for a smaller number of nodes, in AODV, the higher throughput and lower delay is attained using minimum distance, but the better PDR is attained using higher distance, whereas in DSDV, larger throughput and the PDR is gained using maximum distance, but better delay is achieved using minimum distance. It is concluded that for a small set of nodes, minimum distance gives lower delay for both AODV and DSDV. However, that for larger groups of nodes, in AODV, higher throughput and the PDR are achieved using larger distance, but lower delay is obtained using average distance, whereas in DSDV, better throughput, delay and the PDR is gained using maximum distance. This paper is for students, researchers to understand how to select parameters for the mobility model for better QoS in MANET. It will let them clearly understand the impact of different parameters on AODV and DSDV using Modified Gauss Markov mobility model.

Keywords: AODV, DSDV, Gauss Markov, MANETs, Mobility model, QoS.

1. Introduction

In Mobile Ad hoc Networks (MANETs) communication of nodes takes place through the broadcasting of data without using any base station. Here, movement of nodes is dynamic resulting in changing topology which in turn creates complexity in routing as a result of which QoS in MANET is affected. QoS is the performance level of a service provided by a network to the user. QoS parameters like throughput, maximum bandwidth, Packet Delivery Ratio, minimum delay, jitter, and Packet Loss Ratio, etc., are used to verify the performance level of a network [1-3].

It is essential to exploit mobility models for simulation of mobile nodes using any routing protocol [4]. Mobility model helps us to represent the node's position and movement with respect to speed, direction, time, and distance. In order to relate to real world scenarios, it is vital to represent mobile nodes with varying speed and direction because a mobile node does not move in a direct line with fixed speed and direction. Research is going world-wide in MANET.

Liang and Haas [5] proposed a predictive distance-based mobility management scheme where the next location and velocity of a node is determined using a probability density function provided by Gauss Markov mobility model based on the current node location and velocity. Alenazi et al. [6] modified the existing 3D Gauss Markov Mobility Model by adding a buffer zone in order to provide the similar characteristics with the original 2D Gauss Markov mobility model.

Zhang et al. [7] proposed a smooth Gauss-Semi Markov mobility model for mobile wireless networks. Simulation is done with different values of tuning parameters like $\alpha \in$ U [10, 20], $\alpha \in$ U [5, 10] and α=0 in NS-2. This model contains all the realistic movement statement of nodes and avoids all types of unrealistic node movements. Biomo et al. [8] proposes an Enhanced Gauss Markov (EGM) mobility model for UAANETs based on existing Gauss Markov mobility model. This model reduces unexpected stops and shard twists within the boundary and ensures even trajectories at the margins.

Broyles et al. [9] proposed Gauss Markov mobility model in 3D for Airborne Ad hoc Networks. Natarajan [10] proposed an algorithm OptPathTrans to determine stable paths between a particular source and destination. Using mobility models namely Gauss Markov and Random Way point on this algorithm, the author performed simulation analysis to check the connectivity of the network, route lifetime and hop count. These related works inspired us to analyse a realistic mobility model, namely Modified Gauss Markov mobility model in order to check the impact of QoS in MANET. This model is improved variant of the existing Gauss Markov mobility model. In this mobility model we have considered distance as a significant parameter, unlike Gauss Markov mobility model where time is used an important parameter.

The performance analysis of standard routing protocols, namely AODV and DSDV on two sets of nodes like 20 and 70 nodes as the small and the larger sets of nodes with QoS parameters throughput, delay, and PDR with different values of distance and tuning parameter for the MGM mobility model is done in NS-3. We have taken five cases and considered the values of distance as 4 meters in Case I, 8 meters in Case II, 12 meters in Case III, 16 meters in Case IV and 20 meters in Case V. We have also taken distinct values of tuning parameter, α, i.e., 0, 0.25, 0.5, 0.75 and 1 in each case. It is observed that different parameters give different results for AODV and DSDV.

It is noticed that for a smaller number of nodes, in AODV, the higher throughput and lower delay is attained using minimum distance, but the better PDR is attained using higher distance, whereas in DSDV, larger throughput and the PDR is gained using maximum distance, but better delay is achieved using minimum distance. It is concluded that for a small set of nodes, minimum distance gives lower delay for both AODV and DSDV. However, that for larger groups of nodes, in AODV, higher throughput and the PDR are achieved using larger distance, but lower delay is obtained using average distance, whereas in DSDV, better throughput, delay and the PDR is gained using maximum distance.

This paper is for students, researchers to understand the impact of various parameters using Modified Gauss Markov mobility model in AODV and DSDV. It also helps them to learn how the QoS varies with varying parameters in MANET. It will also make them understand how a single parameter influences the mobility model in MANET.

The rest of the paper is prepared in the subsequent way: Section 2 discusses the related work. Section 3 gives the brief overview of the existing mobility model. Section 4 discusses the standard routing protocols. Section 5 shows the experiment and the results. Section 6 discusses the Results and finally Section 7 concludes the paper.

2. Modified Gauss Markov Mobility Model

This is modified version of the original Gauss Markov mobility model. In this model, at a fixed distance 'd,' the speed, pitch and direction of each node is estimated on the basis of the previous value of pitch, direction and speed at $(d-1)^{th}$ distance. A tuning parameter, α is used to determine the degree of randomness for computing previous pitch, speed, and direction. Therefore, this model imitates the characteristics of temporal dependency. The speed, direction and pitch value are calculated by the following mathematical formulas:

$$S_d = \alpha S_{d-1} + (1-\alpha)\tilde{S} + \sqrt{(1-\alpha^2)}Sx_{d-1} \tag{1}$$

$$D_d = \alpha D_{d-1} + (1-\alpha)\widetilde{D} + \sqrt{(1-\alpha^2)}Dx_{d-1} \tag{2}$$

$$P_d = \alpha P_{d-1} + (1-\alpha)\tilde{P} + \sqrt{(1-\alpha^2)}Px_{d-1} \tag{3}$$

where S_d, D_d and P_d are the new speed, direction, and pitch at distance interval d, $\tilde{S}$, $\widetilde{D}$ and $\tilde{P}$ are the mean speed, mean direction and mean pitch, Sx_{d-1}, Dx_{d-1} and Px_{d-1} are random variables and α is a random variable whose value lies within the range of $0< \alpha <1$. With the varying values of α, randomness is determined [11].

3. Routing Protocols

We have considered here two types of routing protocol one is proactive and other is reactive namely DSDV and AODV, respectively. Proactive routing protocols maintain a routing table where the route to the destination is available, whereas reactive routing protocols does not have route information. It creates route when it is required.

3.1. Destination sequenced distance vector (DSDV) routing protocol

Destination Sequence Distance Vector (DSDV) is a proactive, i.e., table driven routing protocol where routes to destination are known. In this protocol, a routing table is exchanged among neighbor nodes to keep track of up-to-date information about the topology of the network [12, 13]. The table consists of distance of a node of its neighbouring nodes and sequence number. This protocol mainly resolves the count to infinity problem due to the use of a sequence number [14].

3.2. Ad Hoc on demand distance vector routing protocol

Ad Hoc On Demand Distance Vector (AODV) is a reactive routing protocol where a route is discovered whenever a node wants to exchange information with another node [15-20].

A node transmits Route Request (RREQ) packets to all the neighbor nodes during path finding. When the neighbor nodes accept the RREQ packets, if it has the path to the determined node or if it is the determined node then it sends a Route Reply (RREP) packet else it transmits the RREQ packet to its neighbor nodes [21]. A source may receive more than one RREP from its neighbour nodes in that case it selects the path with lesser number of hops because all the nodes in MANET are mobile so less hop count will lead to a more stable path.

Once the destination receives the RREQ packet a reverse path is created to transmit the RREP packet using that path. Once the path is discovered data can be transferred using that path. Due to the mobility of nodes, path breakage is obvious in MANET. Whenever a node detects path failure, then Route Error (RERR) packet is transmitted to its corresponding neighbor nodes so that all the associated nodes get information about the broken path [21].

4. Simulation Results

4.1. Simulation parameters

We have considered an AODV routing protocol to check the impact of distinct parameters using Modified-Gauss Markov mobility model. We have made huge experiment in NS-3 on two groups of nodes, namely, smallest group and largest group and the number of nodes considered for these two groups are 20 and 70, respectively. Many experiments have been done with different values of parameters like distance and tuning parameter to analyse the performance of AODV using Modified-Gauss Markov mobility model. Table 1 shows all the simulation parameters and values. Table 2 represents the parameters and corresponding values for Modified-Gauss Markov mobility model.

Table 1. Experimental parameters and its values.

Parameters	Values
Number of nodes	20 and 70
Routing Protocol	AODV
Number of flows	10
Transmission Power	7.5dBm
Total Simulation Time	90 seconds
Traffic	CBR
Data Rate	1024bps
Packet Size	64 kbps
Propagation Delay Model	Constant Speed Propagation Delay
Propagation Loss Model	Friss Propagation Loss

Position Allocator	Random Box X[0,180] Y[0,180] Z[0,120]
Mobility Models	Modified Gauss Markov

Table 2. Parameters for modified Gauss Markov mobility model.

Parameters	**Values**
Bounds	X[0, 180], Y[0, 180] and Z[0, 120]
Distance	4,8, 12, 16 and 20 meters
Tuning Parameter, α	0, 0.25, 0.5, 0.75 and 1
Mean Velocity	[0, 20]
Mean Direction	[0,6.283185307]
Mean Pitch	[0.02, 0.5]
Normal Velocity	Mean=0.4, Variance=0.2and Bound=0.5
Normal Direction	Mean=0.6, Variance=0.4 and Bound=0.8
Normal Pitch	Mean=0.5, Variance=0.5 and Bound=0.6
Parameters	**Values**
Bounds	X[0,180], Y[0,180] and Z[0,120]

4.2. Experimental results

For experimentation, we have considered parameters like throughput, PDR and delay to observe the various performances of AODV. We have done a huge number of experiments using different values of tuning parameter, α as 0, 0.25, 0.5, 0.75 and 1, distance as 4, 8, 12, 16 and 20 meters and two groups of nodes like 20 as smallest group and 70 as the largest group to check the impact of these parameters on Modified-Gauss-Markov mobility model to analyse the QoS support in MANET.

4.2.1. Throughput

It is interpreted as the number of bits transmitted per second during the exchange of information in a network. We have considered 5 cases like Case I, Case II, Case III, Case IV, and Case V for different values of distance as 4, 8, 12, 16 and 20 meters, respectively. In each case, we have taken different values of α like 0, 0.25, 0.5, 0.75 and 1. Different throughput values have been shown in tables and represented them in graphs. We have considered two set of nodes 20 and 70. For each set of nodes, we have tested the Modified Gauss Markov mobility with different cases to achieve throughput for AODV.

4.2.1.1. For smallest group of nodes

We have considered 20 nodes with different distance and tuning parameter values to check the throughput of AODV and DSDV using Modified Gauss Markov mobility model. The increasing values of throughput indicate better QoS. We have explained below the throughput values for different cases which are given in Tables 3 and 4 and their graphs are represented in Figs. 1 and 2. It is observed in Table 3 that the highest throughput for DSDV is 1.1234 kbps using distance as 20 meters (Case-V) and α=0.75 whereas the least is 0.8419 kbps using distance as 16 meters (Case-IV) and α=1. It is observed in Fig. 1 that with increasing value of tuning parameter the throughput is also increasing in Case-I. It is also analysed that the average highest throughput is achieved using α=0.75 whereas the least is achieved using α=0. Moreover, it is also noticed that with increasing distance the throughput is also increasing, i.e., in every case the average throughput is increasing. However, the average highest throughput is obtained in Case-V whereas the least is achieved in Case-I. On the other hand, it is observed in Table 4 that the highest throughput for AODV is 5.2045 kbps for α=0.75 (Fig. 2) whereas the least is 0.0891 kbps for α=0.5 using distance as 20 meters (Case-V). It is analysed that the average highest throughput is achieved using α=0.25 whereas the least is achieved using α=0.5. Furthermore, it is also noticed that Case-I gives the greatest throughput and Case-III gives the least.

Table 3. Throughput for DSDV.

Tuning Parameter	Case-I	Case-II	Case-III	Case-IV	Case-V
0	0.9336	0.8762	0.9964	0.9939	1.0803
0.25	0.9209	0.9174	0.9185	0.9452	1.0394
0.5	0.9081	0.9175	1.0024	1.0209	0.9839
0.75	0.8978	0.9488	1.0164	1.0816	1.1234
1	0.8538	0.9137	0.8505	0.8419	0.8756

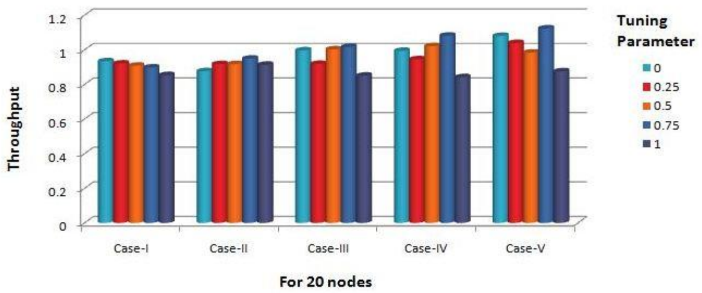

Fig. 1. Throughput for DSDV.

Table 4. Throughput for AODV.

Tuning Parameter	Case-I	Case-II	Case-III	Case-IV	Case-V
0	3.8336	0.1894	0.1500	0.2075	3.0141
0.25	3.9217	2.3165	2.8767	1.5650	0.1069
0.5	0.6455	0.7909	0.6665	3.5595	0.0891
0.75	2.8295	0.0925	1.1130	0.1867	5.2045
1	0.0901	4.3112	0.2409	2.1276	1.4087

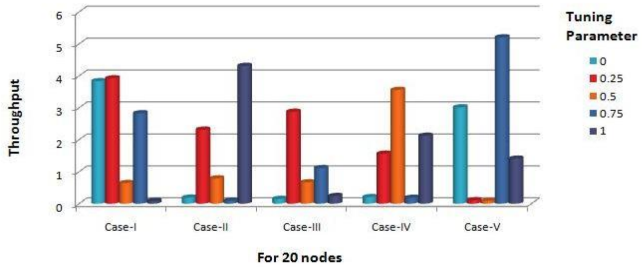

Fig. 2. Throughput for AODV.

4.2.1.2. For largest group of nodes

We have considered 70 nodes with different distance and tuning parameter values to check the throughput of AODV and DSDV using Modified Gauss Markov mobility model. We have explained below the throughput values for different cases which are given in Tables 5 and 6 and their graphs are represented in Figs. 3 and 4.

It is observed in Table 5 and Fig. 3 that the highest throughput for DSDV is 1.1877 kbps using distance as 16 meters (Case-IV) and α=0.5 whereas the least is 0.8655 kbps using distance as 4 meters (Case-I) and α=0. It is also analysed that the average highest throughput for DSDV is achieved using α=0.5 whereas the least is achieved using α=0.

Moreover, the average highest throughput is obtained in Case-V whereas the least is achieved in Case-I. On the other hand, it is observed in Table 6 that the maximum throughput for AODV is 30.6679 kbps for α=1 (Fig. 4) using distance as 12 meters (Case-III) whereas the least is 18.1294 kbps for α=0 using distance as 4 meters (Case-I).

It is analysed that the average highest throughput is achieved using α=1 whereas the least is achieved using α=0. Furthermore, it is also noticed that Case-V gives the average greatest throughput whereas Case-I gives the least.

Table 5. Throughput for DSDV.

Tuning Parameter	Case-I	Case-II	Case-III	Case-IV	Case-V
0	0.8655	0.9602	0.9145	1.0193	0.9881
0.25	0.9085	1.0002	0.9899	0.9748	0.9590
0.5	0.9391	0.9201	1.0033	1.1877	1.0131
0.75	0.9257	0.9215	1.0824	0.9029	1.0458
1	0.9354	0.9149	1.0214	0.8899	0.9894

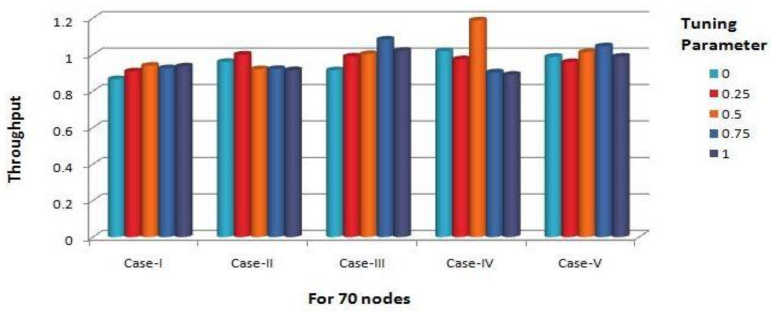

Fig. 3. Throughput for DSDV.

Table 6. Throughput for AODV.

Tuning Parameter	Case-I	Case-II	Case-III	Case-IV	Case-V
0	18.1294	23.9727	18.9920	25.0086	22.1583
0.25	21.2612	20.4035	23.4113	22.5159	24.5088
0.5	21.3234	24.8752	22.6303	26.3861	28.2246
0.75	21.8267	20.6862	28.7225	20.5075	26.1029
1	25.9269	20.6141	30.6679	19.4254	27.2179

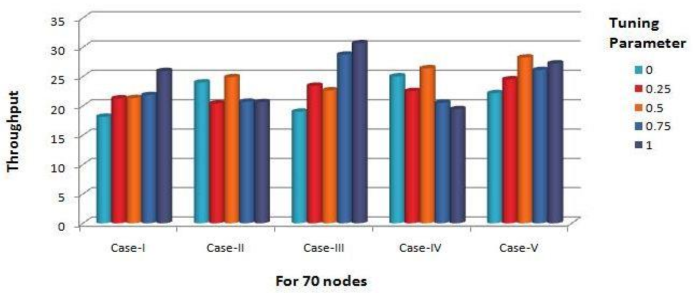

Fig. 4. Throughput for AODV.

4.2.2. Delay

It is termed as the total time spends by a node during transmission of data to its destination. We have considered 5 cases like Case I, Case II, Case III, Case IV and Case V for different values of distance as 4, 8, 12, 16 and 20 meters, respectively. In each case, we have taken different values of α like 0, 0.25, 0.5, 0.75 and 1. Different delay values have been discussed. We have considered two sets of nodes 20 and 70. For each set of nodes, we have tested the Modified Gauss Markov mobility with different cases to achieve delays for AODV and DSDV.

4.2.2.1. For smallest group of nodes

We have considered 20 nodes with different distance and tuning parameter values to check the delay of AODV and DSDV using Modified Gauss Markov mobility model. We have explained below the delay values for different cases which are given in Tables 7 and 8 and their graphs are represented in Figs. 5 and 6.

It is observed in Table 7 and Fig. 5 that the least delay for DSDV is 307.1 seconds using distance as 16 meters (Case-IV) and α=0.75 whereas the greatest delay is 2232.2 seconds using distance as 4 meters (Case-I) and α=1. It is known that the higher the delay value the lower is the QoS in MANET.

It is also analysed that the average highest delay for DSDV is achieved using α=1 whereas the least is achieved using α=0.25. Moreover, the average highest delay is obtained in Case-III, whereas the least is achieved in Case-I.

On the other hand, it is observed in Table 8 and Fig. 6 that the least delay for AODV is 419.0 seconds using distance as 8 meters (Case-II) and α=0.75 whereas the greatest delay is 678.5 seconds using distance as 16 meters (Case-IV) and α=0.25. It is also noticed that the average highest delay for AODV is achieved using α=0.25 whereas the least is achieved using α=0.5. Moreover, the average highest delay is obtained in Case-IV, whereas the least is achieved in Case-I.

Table 7.Delay for DSDV.

Tuning Parameter	Case-I	Case-II	Case-III	Case-IV	Case-V
0	484.7	1123.3	1271.5	1906.6	1070.1
0.25	458.1	918.2	575.4	394.0	549.2
0.5	581.3	715.8	924.5	524. 9	546.9
0.75	688.4	717.0	587.8	307.1	903.3
1	2232.2	946.7	1825.6	1173.4	1097.1

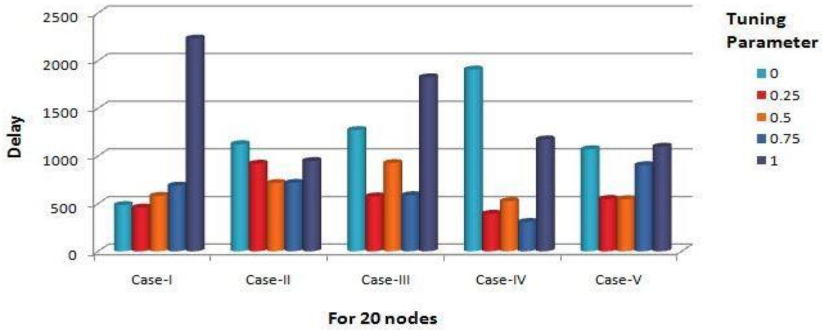

Fig. 5. Delay for DSDV.

Table 8. Delay for AODV.

Tuning Parameter	Case-I	Case-II	Case-III	Case-IV	Case-V
0	433.5	484.3	519.7	575.5	501.9
0.25	540.4	532.6	446.4	526.8	678.5
0.5	474.9	526.7	455.1	470.1	425.1
0.75	437.3	419.0	542.7	601.7	467.4
1	483.6	453.5	589.7	553.2	537.9

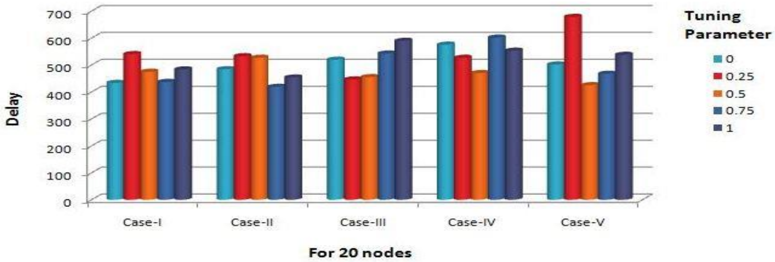

Fig. 6. Delay for AODV.

4.2.2.2. For largest group of nodes

We have considered 70 nodes with different distance and tuning parameter values to check the delay of AODV and DSDV using Modified Gauss Markov mobility model. We have explained below the delay values for different cases which are given in Tables 9 and 10 and their graphs are represented in Figs.7 and 8.

It is observed in Table 9 and Fig. 7 that the least delay for DSDV is 321.0 seconds using distance as 4 meters (Case-I) and α=0.75 whereas the greatest delay is 2097.8 seconds using distance as 20 meters (Case-V) and α=1.

It is also analysed that the average highest delay for DSDV is achieved using α=0.75, whereas the least is achieved using α=0. Moreover, the average highest delay is obtained in Case-III, whereas the least is achieved in Case-I.

On the other hand, it is observed in Table 10 and Fig. 8 that the least delay for AODV is 550.8 seconds using distance as 12 meters (Case-III) and α=1, whereas the greatest delay is 752.5 seconds using distance as 16 meters (Case-IV) and α=0.75. It is also noticed that the average highest delay for AODV is achieved using

α=0.75, whereas the least is achieved using α=0.5. Moreover, the average highest delay is obtained in Case-IV, whereas the least is achieved in Case-III.

Table 9. Delay for DSDV.

Tuning Parameter	Case-I	Case-II	Case-III	Case-IV	Case-V
0	857. 9	752.6	955.0	344.3	666.6
0.25	570.2	840.7	1288.8	1262.4	631.1
0.5	631. 9	1399.7	1227. 9	1013.5	610.0
0.75	321.0	765.7	1971.7	1544.1	1033.7
1	341.4	1532.4	951.6	683.2	2097.8

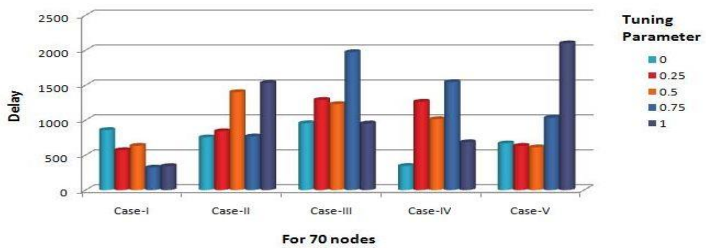

Fig. 7. Delay for DSDV.

Table 10. Delay for AODV.

Tuning Parameter	Case-I	Case-II	Case-III	Case-IV	Case-V
0	736.7	626.1	625.4	662.5	630.9
0.25	609.7	608.3	599.7	668.9	617.3
0.5	636.3	590.9	642.6	597.1	602.1
0.75	658.8	663.8	689.9	752.5	671.9
1	654.4	637.3	550.8	641.4	643.4

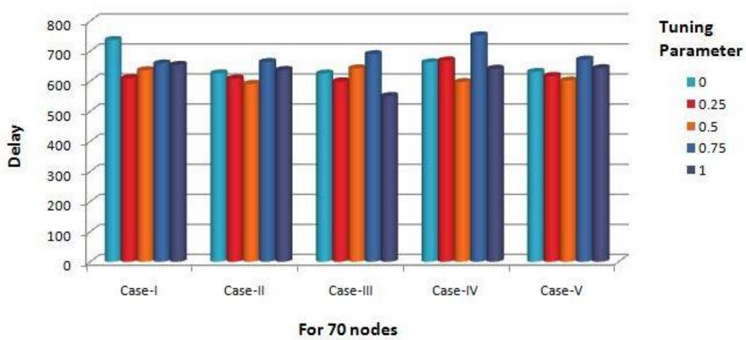

Fig. 8. Delay for AODV.

4.2.3. Packet-delivery-ratio

It is expressed as the ratio of total number of data transmitted at the destination to the total number of sources generated at the source. We have considered 5 cases like Case I, Case II, Case III, Case IV, and Case V for different values of distance as 4, 8, 12, 16 and 20 meters, respectively. In each case, we have taken different values of α like 0, 0.25, 0.5, 0.75 and 1. Different PDR values have been discussed. We have considered two sets of nodes 20 and 70. For each set of nodes, we have tested the Modified Gauss Markov mobility with different cases to achieve PDR for AODV and DSDV.

4.2.3.1. For smallest group of nodes

We have considered 20 nodes with different distance and tuning parameter values to check the PDR of AODV and DSDV using Modified Gauss Markov mobility model. We have explained below the PDR values for different cases which are given in Tables 11 and 12 and their graphs are represented in Figs. 9 and 10.

It is observed in Table11 and Fig. 9 that the highest PDR for DSDV is 0.8299 using distance as 16 meters (Case-IV) and α=0.5 whereas the least PDR is 0.6551 using distance as 4 meters (Case-I) and α=1.

It is also analysed that the average highest PDR for DSDV is achieved using α=0.5 whereas the least is achieved using α=1. Moreover, the average highest PDR is obtained in Case-V whereas the least is achieved in Case-II.

On the other hand, it is observed in Table 12 and Fig. 10 that the highest PDR for AODV is 0.8966 using distance as 16 meters (Case-IV) and α=0, whereas the least PDR is 0.7869 using distance as 20 meters (Case-V) and α=1. It is also noticed that the average highest PDR for AODV is achieved using α=0, whereas the least is achieved using α=1. Moreover, the average highest PDR is obtained in Case-IV, whereas the least is achieved in Case-V.

Table 11. PDR for DSDV.

Tuning Parameter	Case-I	Case-II	Case-III	Case-IV	Case-V
0	0.7293	0.6911	0.7945	0.7803	0.8075
0.25	0.7326	0.6809	0.7463	0.7483	0.8048
0.5	0.7184	0.7163	0.8027	0.8299	0.7612
0.75	0.7102	0.7367	0.8224	0.7245	0.8116
1	0.6551	0.6891	0.6891	0.6626	0.7020

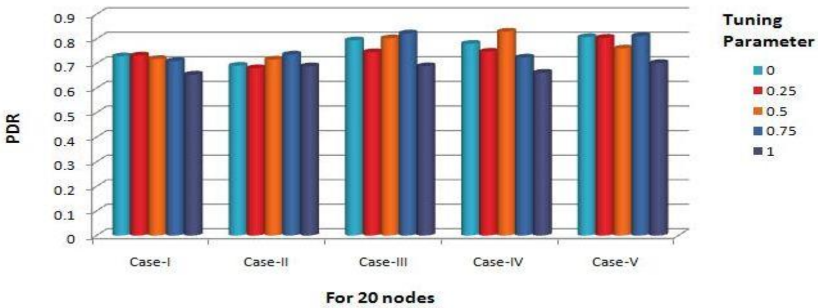

Fig. 9. PDR for DSDV.

Table 12. PDR for AODV.

Tuning Parameter	Case-I	Case-II	Case-III	Case-IV	Case-V
0	0.8458	0.8874	0.8747	0.8966	0.8459
0.25	0.8692	0.8832	0.8425	0.8447	0.8872
0.5	0.8598	0.8789	0.8364	0.8855	0.8526
0.75	0.8529	0.8287	0.8755	0.8648	0.8156
1	0.8310	0.8379	0.8425	0.8572	0.7869

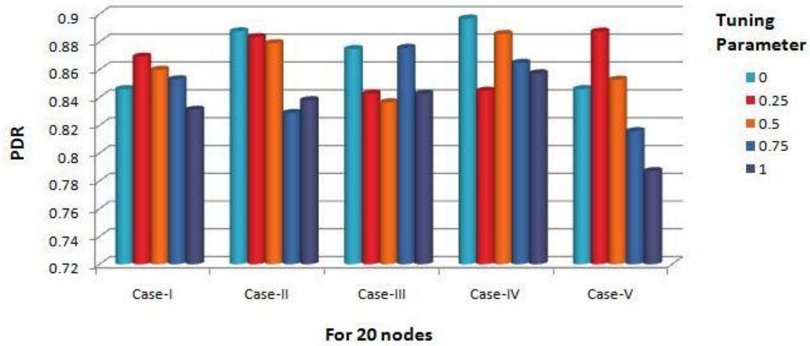

Fig. 10. PDR for AODV.

4.2.3.2. For largest group of nodes

We have considered 70 nodes with different distance and tuning parameter values to check the PDR of AODV and DSDV using Modified Gauss Markov mobility model. We have explained below the PDR values for different cases which are given in Tables 13 and 14 and their graphs are represented in Figs. 11 and 12.

It is observed in Table 13 and Fig. 11 that the highest PDR for DSDV is 0.7612 using distance as 20 meters (Case-V) whereas the least PDR is 0.5789 using distance as 12 meters (Case-III) for α=0.75. It is also analysed that the average highest PDR for DSDV is achieved using α=0.25, whereas the least is achieved using α=0.75. Moreover, the average highest PDR is obtained in Case-V, whereas the least is achieved in Case-III.

On the other hand, it is observed in Table 14 and Fig. 12 that the highest PDR for AODV is 0.7513 for α=0 whereas the least PDR is 0.6583 for α=1 using distance as 12 meters (Case-III). It is also noticed that the average highest PDR for AODV is achieved using α=0.5 whereas the least is achieved using α=1. Moreover, the average highest PDR is obtained in Case-IV, whereas the least is achieved in Case-III.

Table 13. PDR for DSDV.

Tuning Parameter	Case-I	Case-II	Case-III	Case-IV	Case-V
0	0.6319	0.6435	0.6592	0.7571	0.6986
0.25	0.6796	0.6646	0.7041	0.7476	0.7422
0.5	0.6748	0.7347	0.6381	0.6850	0.7456
0.75	0.6918	0.6483	0.5789	0.6380	0.7612
1	0.6735	0.6843	0.7027	0.5891	0.6884

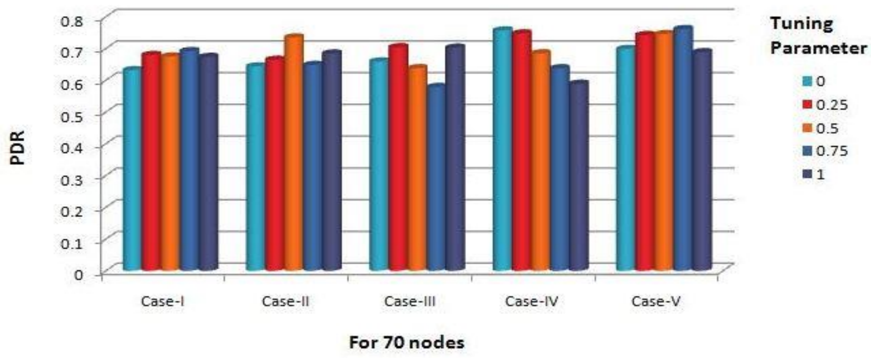

Fig. 11. PDR for DSDV.

Table 14. PDR for AODV.

Tuning Parameter	Case-I	Case-II	Case-III	Case-IV	Case-V
0	0.7129	0.7096	0.7513	0.7415	0.7062
0.25	0.7335	0.7120	0.7126	0.7182	0.7269
0.5	0.7326	0.7199	0.7088	0.7453	0.7292
0.75	0.7033	0.7460	0.7158	0.7189	0.7091
1	0.6838	0.6882	0.6583	0.6815	0.6807

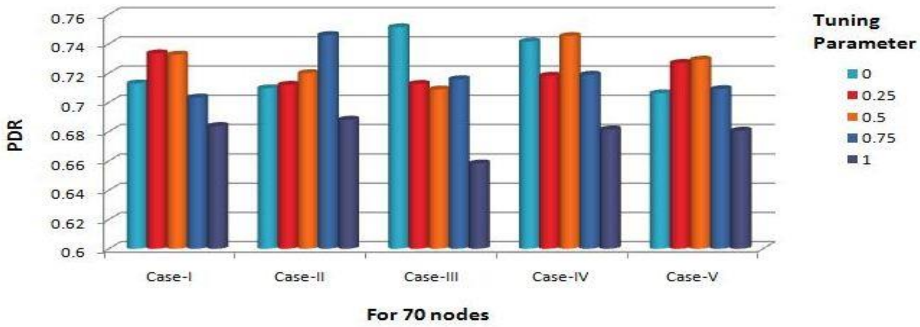

Fig. 12. PDR for AODV.

5. Results and Discussion

We have done a critical analysis on Modified Gauss Markov mobility model with different values of distance like 4, 8, 12, 16 and 20 meters and tuning parameters like 0, 0.25, 0.5, 0.75 and 1 on two sets of nodes such as 70 and 20 nodes as the large and small set of nodes, respectively. We have done a huge number of experiments on standard routing protocols, namely AODV and DSDV to check the impact of QoS in MANET with distinct parameters.

For small set of nodes, i.e., 20 nodes we have observed that the largest throughput for DSDV is 1.1234 kbps for Case-V using α=0.75 and the least is 0.8419 kbps for Case-IV using α=1whereas the highest throughput for AODV is 5.2045 kbps for α=0.75 and the least is 0.0891 kbps for α=0.5 for Case-V. It is also noticed that the average highest throughput for DSDV is achieved using α=0.75 which implies that the tuning parameter reaching to its maximal value provides better QoS whereas for AODV it is obtained using α=0.25 which means that the tuning parameter reaching its minimal value gives better QoS.

Moreover, the average throughput of DSDV is better in Case-V which indicates that the larger distance gives better QoS as Case-V consists of the highest distance, i.e., 20 meters, whereas Case-I is the better that implies smaller distance gives better QoS as in Case-I we have considered the smallest distance as 4 meters. Furthermore, it is seen that the least delay for DSDV is 307.1 seconds for Case-IV using α=0.75 and the greatest delay is 2232.2 for Case-I using α=1 whereas the least delay for AODV is 419.0 for Case-II using α=0.75 and the greatest delay is 678.5 seconds for Case-IV using α=0.25.

It is also analysed that the average least delay for DSDV is achieved using α=0.25, i.e., the tuning parameter reaching to its minimal gives better QoS whereas for AODV the least delay is obtained using α=0.5, i.e., the median value of tuning parameter gives better QoS.

Additionally, it is noticed that the average minimum delay for both AODV and DSDV is obtained in Case-I, i.e., the least distance gives better QoS. Moreover, the highest PDR for DSDV is 0.8299 for Case-IV using α=0.5 and the least PDR is 0.6551 for Case-I using α=1 whereas the highest PDR for AODV is 0.8966 for Case-IV using α=0 and the least PDR is 0.7869 for Case-V using α=1. It is also seen that the average highest PDR for DSDV is achieved using α=0.5, i.e., the median value of tuning parameter gives better QoS whereas the average highest PDR for AODV is achieved using α=0 which implies that the minimum value of tuning parameter gives the better QoS.

Moreover, the average highest PDR for DSDV is obtained in Case-V, i.e., the maximum distance gives the better QoS, whereas for AODV the average PDR is better in Case-IV which means that the higher distance gives better QoS. On the other hand, for the largest set of nodes, i.e., 70 nodes we have observed that the highest throughput for DSDV is 1.1877 kbps for Case-IV using α=0.5 and the least is 0.8655 kbps for Case-I using α=0, whereas the highest throughput for AODV is 30.6679 kbps for α=1 for Case-III and the least is 18.1294 kbps for Case-I using α=0. It is also analysed that the average highest throughput for DSDV is achieved using α=0.5, i.e., the median value of tuning parameter gives better QoS, whereas for AODV the average largest throughput is obtained using α=1, i.e., the maximum value of tuning parameter gives the better QoS.

Moreover, the average highest throughput for both AODV and DSDV is obtained in Case-V, i.e., the maximum distance gives the better QoS. Furthermore, it is observed that the least delay for DSDV is 321.0 seconds for Case-I using α=0.75 and the greatest delay is 2097.8 seconds for Case-V using α=1 whereas the least delay for AODV is 550.8 seconds for Case-III using α=1 and the greatest delay is 752.5 seconds for Case-IV using α=0.75. It is also analysed that the average least delay for DSDV is achieved using α=0, i.e., the minimum value of tuning parameter gives the better QoS whereas for AODV the delay is better using α=0.5, i.e., the median value of tuning parameter gives better QoS.

Additionally, for DSDV, the average delay is better in Case-I, i.e., the minimum value of distance gives the better QoS whereas for AODV the least average delay is obtained in Case-III, i.e., the higher distance gives better QoS. In addition to that, it is observed that the highest PDR for DSDV is 0.7612 for Case-V and the least

PDR is 0.5789 for Case-III using α=0.75 whereas the highest PDR for AODV is 0.7513 for α=0 and the least PDR is 0.6583 for α=1 in Case-III. It is also noticed that the average highest PDR for DSDV is achieved using α=0.25, i.e., the value of tuning parameter closing to minimum gives better QoS whereas the average highest PDR for AODV is achieved using α=0.5, i.e., the median value of tuning parameter gives better QoS. Furthermore, the average highest PDR for DSDV is obtained in Case-V, i.e., the maximum distance gives the better QoS whereas for AODV it is obtained in Case-IV, i.e., the higher distance gives better QoS.

6. Conclusion and Future Work

In a MANET, nodes are mobile most of the time. Mobility models influences the performance of routing in MANET. It is used to determine a node position, speed, and direction so that efficient communication can take place. These models have great impact on QoS in MANET. We have taken Modified Gauss Markov mobility model for critical analyses in order to check the impact of QoS in MANET.

This paper discusses the various cases where different values of distance, such as 4, 8, 12, 16 and 20 meters and tuning parameter such as 0, 0.25, 0.5, 0.75 and 1 are considered to check the impact of QoS using QoS metrics like throughput, delay, and PDR in routing protocol AODV.

It is observed that for a small set of nodes, the average highest throughput and PDR of AODV is obtained using lower value of tuning parameter and lower delay for AODV is obtained using median value of tuning parameter whereas for DSDV the average throughput and PDR is better using larger values of tuning parameter, but delay is better using lower value of tuning parameter.

Moreover, it is also noticed that for AODV, higher throughput and lower delay is attained using minimum distance, but better PDR is attained using higher distance, whereas for DSDV, larger throughput and the PDR is gained using maximum distance, but better delay is achieved using minimum distance. So, it is concluded that for a small set of nodes, minimum distance gives lower delay for both AODV and DSDV. On the other hand, for largest set of nodes, the average highest throughput of AODV is obtained using maximum value of tuning parameter and better PDR and delay is obtained using median value of tuning parameter whereas for DSDV the average throughput is better using median value of tuning parameter, but PDR and delay is better using lower value of tuning parameter.

Furthermore, it is also seen that for AODV, higher throughput and the PDR is achieved using larger distance, but lower delay is obtained using average distance, whereas for DSDV, better throughput, delay and the PDR is gained using maximum distance. This paper explains how different parameters impact the performances of standard routing protocols. This will help all the students and researchers for better selection of parameters based on the scenario. This paper can be further extended by improving the mobility model so that the QoS metrics like throughput, delay and PDR can be improved further.

Nomenclatures

$\widetilde{D}$	Mean direction
D_d	New direction at a fixed distance interval d

Dx_{d-1}	Random variable for direction determined from a Gaussian distribution at distance (d-1)
$\tilde{P}$	Mean pitch
P_d	New pitch at a fixed distance interval d
Px_{d-1}	Random variable for pitch determined from a Gaussian distribution at distance (d-1)
$\tilde{S}$	mean speed
S_d	new speed at a fixed distance interval d
Sx_{d-1}	Random variable for speed determined from a Gaussian distribution at distance (d-1)

References

1. Khan, M.F.; and Das, I. (2019). Effect of different propagation models in routing protocols. *International Journal of Engineering and Advanced Technology* (*IJEAT*),9(2), 3975-3980.
2. Khan, M.F.; and Das, I. (2019). *An investigation on existing protocols in MANET*. © Springer Nature Singapore Pte Ltd. Saini, H.S. et al. (eds.). *Innovations in Computer Science and Engineering, Lecture Notes in Networks and Systems* 74, 215-224.
3. Khan, M.F.; and Das, I. (2017). A study on quality-of-service routing protocols in mobile ad hoc networks. *In: Proceedings of* 2017 *International Conference on Computing and Communication Technologies for Smart Nation* (*IC*3*TSN*), Gurgaon, India, 95-98.
4. Camp, T.; Jeff, B.; and Davies, V. (2002). A survey of mobility models for ad hoc network research. *Wireless Communications and Mobile Computing*, 2(5), 483-502.
5. Liang, B.; and Hass, Z.J. (2003). Predictive distance-based mobility management for multidimensional PCS networks. *IEEE*/*ACM Transactions on Networking*, 11(5), 718-732.
6. Alenazi, M.J.F.; Cahin, C.; and Sterbenz, J.P.G. (2012). Design improvement and implementation of 3D Gauss-Markov mobility model. *Proceedings of International Telemetering Conference*, 1-10.
7. Zhang, H.; Zheng, B.; and Zhou, K. (2015). A. Novel smooth Gauss-semi-Markov mobility model for mobile wireless networks. *Frequenz*, 69(5-6), 245-262.
8. Biomo, J.-D.M.M.; Kunz, T.; and St-Hilaire, M. (2014). An enhanced Gauss-Markov mobility model for simulations of unmanned aerial Ad hoc networks. *Proceedings of* 2014 7*th IFIP Wireless and Mobile Networking Conference* (*WMNC*), Vilamoura, Portugal, 1-8.
9. Broyles, D.; Jabbar, A.; Sterbenz, J.P.G. (2010). Design and analysis of a 3-D gauss-Markov mobility model for highly-dynamic airborne networks. *Proceedings of International Telemetering Conference*, 1-10.
10. Natarajan, M. (2010). Impact of the Gauss-Markov mobility model on network connectivity, lifetime and hop count of routes for mobile ad hoc networks. *Journal of Networks*, 5(5), 509-516.

11. Khan, M.F.; and Das, I. (2022). Performance analysis of improved mobility models to check their impact on QoS in MANET. *In: Advanced Computing and Intelligent Technologies*, 914, 173-182
12. Murthy, C.S.R.; and Manoj, B.S. (2004). Ad hoc wireless networks: Architectures and protocols. (1st ed.). *Prentice Hall PTR*.
13. Ahmed, G.F.; Barskar, R.; and Barskar, N. (2012). An improved DSDV routing protocol for wireless ad hoc networks. *Procedia Technology*, 6, 822-831.
14. Khan, M.F.; and Das, I. (2020). Performance evaluation of routing protocols in NS-2 and NS-3 simulators. *International Journal of Advanced Trends in Computer Science and Engineering*,. 9(4), 6509-6517.
15. Landge, P.; and Nigavekar, A. (2016). Modified AODV protocol for energy efficient routing in manet. *International Journal of Engineering Sciences & Research Technology*, 5(3), 523-529.
16. Ahmed, A.; Hanan, A.; and Osman, I. (2015). AODV routing protocol working process. *Journal of Convergence Information Technology*, 10(2), 1-8
17. Maurya, P.K.; Sharma, G.; Sahu, V.; Roberts, A.; and Srivastava, M. (2012). An overview of AODV routing protocol. *International Journal of Modern Engineering Research* (*IJMER*), 2(3), 728-732.
18. Khan, M.F.; and Das, I. (2020). Implementation of random direction-3D mobility model to achieve better QoS support in MANET. *International Journal of Advanced Computer Science and Applications*(*IJACSA*), 11(10), 195-203.
19. Khan, M.F.; and Das, I. (2021). Analysis of various mobility models and their impact on QoS in MANET. *Computationally Intelligent Systems and their Applications*, 950,131-141.
20. Khan, M.F.; and Das, I. (2022). *Impact of various parameters on Gauss Markov mobility model to support QoS in MANET*. In Das, S.; Rao, R.S.; Das, I.; Jain, V.; and Singh, N. (eds.). *Cloud Computing Enabled Big-Data Analytics in Wireless Ad-hoc Networks*, CRC Press, 85-101
21. Chakeres, I.D.; and Belding-Royer, E.M. (2004). AODV routing protocol implementation design. *Proceedings of the* 24*th International Conference on Distributed Computing Systems Workshops*, 2004, Tokyo, Japan, 698-703.