

A Review on Parameters of Internet Gateway Discovery in MANETS

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Abstract—Mobile ad hoc Networks researchers need to apply specific parameters in the simulation tools chosen to analyze and discuss their results. The challenge faced by multiple authors is on how to decide on the choice of particular parameters. A wrong choice could lead to a no credible result and a doubtful result by other researchers. A best practice is to follow what other authors are using as input parameters in their paper. This review analyses 72 proceeding papers and articles in different digital libraries: google scholar, IEEE Xplore, Elsevier, Springer, and snowball from 2010-2020. We present the result of our survey in this paper. We recommend the input parameters research should use base on the high utilization. Our review will also help the community in MANET and Internet gateway to improve the credibility of the input parameters.

Keywords—MANET, routing protocols, mobility model, metric, simulation tool, performance

1 Introduction

Mobile ad hoc networks (MANET) is a self-construction network that depends only on the node to form a network on the go. The MANET node has a double function; they can be routers and sender at the same time. MANET communication has many challenges based on the network's formation, which involves a rapid change of the topology, battery drainage, and link breakdown. Base on all the challenges mentioned above, scholars have created different protocols to improve communication in MANE. They developed proactive protocol [1], reactive protocol [2], and hybrid protocol [3].

The mobile ad hoc network cannot only rely on internal communication within the MANET. Sometimes node needs to communicate with other nodes outside the MANET, which is on the Internet (infrastructure network), to extend the communication. A mobile node in MANET needs to discover and communicate with the Internet gateway (IGW), which acts as hybrid equipment that understands both Infrastructure network and no infrastructure network (MANET). The node in IGW used three approaches to discover the IGW and communicate with it. The first one is the proactive approach [4], where the IGW broadcasts a packet periodically to announce its presence to the node within a transmission range based on time to live (TTL). The node outside the transmission range used a reactive approach [5]. The reactive approach node that

wants to communicate sends a solicitation message to the IGW. A hybrid approach [6] combines both the proactive and reactive to cover nodes within the IGW advertisement and those out of the range of IGW. A recent approach is to adapt the periodicity advertisement and time to life of Internet gateway packet base on the topology change. The choice of the selection of IGW in some research is based on some parameters [7], such as link break [8]. Other metrics [9, 10] involve the calculation of the best route to discover the Internet gateway.

To study, design, and propose a new algorithm or improve performance, scholars need to use simulation tools such as NS2, OPNET, MATLAB, and OMNET. The author needs to insert specific parameters as input, such as the number of nodes, the number of IGW, transmission range, traffic send rate, traffic type, mobility model, pause time, packet size, traffic rate, etc. These parameters must be described in their research to determine how the result has been collected. Describing the parameters will also help other researchers compare their work with the existing one by using the same parameters.

These parameters' choice is crucial to the researcher in deciding which parameters details to use for their works. Most research authors are not sure what parameter to use in their research to analyze their proposed algorithm. This review paper aims to show scenarios parameters scholars used in IGW discovery in MANET and help new researchers to have a global view of parameters used in IGW for a better decision. This review analyses 72 proceeding papers and articles in different digital libraries selected: google scholar, IEEE Xplore, Elsevier, Springer, and snowball from 2010-2020. The review result shows that missing input parameters are still observed in most papers, which made it difficult for other researchers to compare their work with the existing one.

In the literature, we can see that they have been some similar research. The majority of those research focuses on input parameters in general, like in (Kurkowski et al., 2005) survey proceeding paper from 2000 to 2005. Their result shows that Random waypoint (RWP) and NS2 were the most used; they also observed that some papers had missing parameters. Another research [11] conducted a review from 2006 to 2010. They found out that missing parameters are still observed in some papers. In [12] a survey was done on 280 papers in a peer-to-peer network and found out that custom simulators tools were more used than NS2.

The rest of this review is organized as follows: Section 2 gives detail of the review methodology, the result is provided in Section 3, Section 4 describe our recommendation, and finally, Section 5 conclude the review.

2 Review methodology

This work's literature review includes articles and proceeding papers selected from different digital journals: IEEEexplorer, Springer, Elsevier, Google scholar, and snowball from years 2010 to 2020. The criteria for selecting the paper were based on these keywords: "Internet gateway discovery in Mobile ad hoc networks", "Internet connectivity in MANET", "Hybrid network in MANET." We have collected 72 papers, and

from those papers, we have extracted input parameters, as you can see in Figure 1. The input parameters' selection to calculate the percentage includes parameters used by two (2) or more authors. Parameters used by less than one (1) author were not part of the calculation.

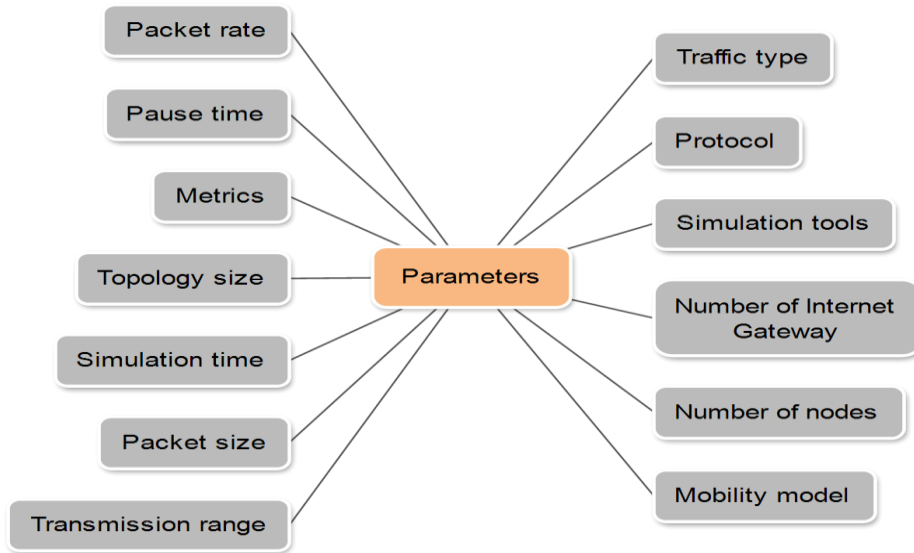


Fig. 1. Parameters extracted

This section describes some simulation parameters authors used in Internet Gateway discovery when designing their scenarios.

3 Simulation Environment and Parameters

This section describes the simulation parameters authors used in Internet Gateway discovery when designing their scenarios. It will analyze the parameters extracted in Figure 1.

Table 1 shows the simulation input parameters used in our review for all the 72 selected papers, and we have observed that missing parameters are still observed.

Table 1. Simulation input parameters usage over 72 papers

Papers	Percentage	Description
50 of 72	69.44	stated the protocol used
51 of 72	70.83	shows the number of nodes
38 of 72	52.78	shows the number of IGW
40 of 72	55.56	stated the transmission range
48 of 72	66.67	stated the simulation duration
43 of 72	59.72	stated the traffic type

Papers	Percentage	Description
49 of 72	68.06	stated the mobility model
34 of 72	47.22	stated the speed of the nodes
22 of 72	30.56	stated the pause time
60 of 72	83.33	shows the metrics
32 of 72	44.44	stated the Packet size
41 of 72	56.94	stated the topology size

3.1 Protocol

A MANET node who wants to communicate with a node on the Internet needs to use a protocol. AODV protocol was enhanced to support Internet messages and was called AODV+. It supports the discovery of an Internet gateway and the selection of it by the node in MANET. Table 2 shows a list of authors who used a particular protocol, and Figure 2 Shows 88% used AODV+, and 12% used weighted load balancing AODV protocol (WLB-AODV).

Table 2. Protocol used in IGW

Protocol	Authors
AODV+	[5, 6, 8-10, 14, 17, 21-42]
WLB-AODV	[7, 43-45]

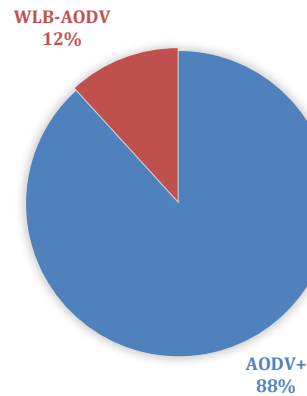


Fig. 2. Protocol usage in IGW

Other authors used different protocols, which is not shown in the table due to our review methodology selection. [13] used a RTMGwS to optimize the signal transmission to a specific area with no UTMS coverage. [14] created M-AODV+VRGSA, M-AODV+-VRSA to help vehicular ad hoc network (VANET) node to choose a better IGW base on the speed and signal strength. [15] improved DYMO to secure the transmission of a packet in the discovery of an Internet Gateway. [16] created QOSDSDV to reduce the packet drop by creating a temporary link when the route is broken. [17]

created AQA-AODV, [18] AGSA, [19] created a broadcast control-based routing protocol in VANET (BCRPV) for efficient bandwidth and link lifetime prediction. [20] created R-AODV+ for the selection of the IGW by calculating some metrics. Research in IGW compares their created protocols with the existing one AODV+ for performance has seen in Table 3.

Table 3. Protocol comparison

Protocol	Compared to	Authors
WLB-AODV	AODV+	[7, 43-45]
MAODV	AODV+	[25]
RTMGwS	CMGM-AODV-Trust SGS-AODV-Trust, SGS-AODV	[13]
AQA-AODV	AODV+	[17]
PLB,PLB-MS	AODV+	[6]
AGSA	AODV+	[18]
MMAMBA	AODMV	[46]
BCRPV	PRB,AODV+	[19]
R-AODV+	AODV+	[20]

3.2 Simulation tools

In ad hoc network simulation tools play an essential role because it does not involve money to buy material and select geographical places to simulated the scenarios. Simulation can be an excellent option to test a protocol or algorithm before implementing it in a real environment to reduce the cost. In IGW, 75% used NS2, 11% used OPNET, 7% used OMNET++, and 4% used MATLAB, as you can see in Figure 3. Some other simulation tools used by fewer authors are Veins [47] and Qualnet [15]. For a list of authors' usage, see Table 4. A previous survey in the ad hoc network [48] [12] found that 43.8% of the authors used NS2, [12] in their review found out that 10% of authors used NS2, and in IGW discovery majority of authors are still using NS2.

Table 4. Simulation comparison usage by author

Simulation	Author
NS2	[7, 9, 10, 13, 14, 16, 18, 19, 21, 22, 25-30, 32, 34, 35, 37, 38, 40, 41, 43, 44, 49-63]
MATLAB	[6, 64]
OMNET++	[4, 65-67]
OPNET	[5, 23, 36, 68-70]

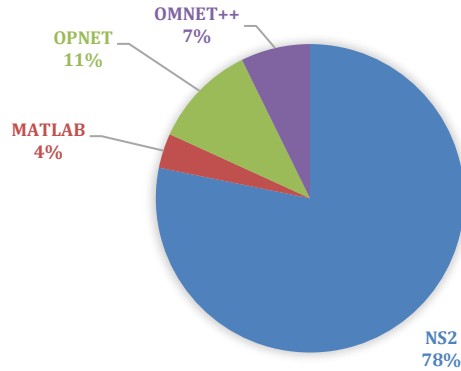


Fig. 3. Simulation comparison percentage

3.3 Topology Size

In Figure 4 we can see that a high percentage of utilization is on the 1000x1000m² with 28%, 800x500m² with 23%, 1200x1200m² with 11%, 1200x800m² with 9%, 1200x1200m² and 1200x1200m² with 7%, 800x700m², 1200x500m², and 1500x800m² with 5% as seen in Table 5. The smallest topology size was 11x11m² [6] used in MATLAB, and the bigger topology size was 3000x250m² [62] used in VANET. We have observed that few authors [7, 10, 38, 39, 43, 51] used two or three different topologies for the implementation of their proposed IGW protocol or algorithm for a better analysis when the size of the topology increase.

Table 5. Topology size usage by author

Topology size m ²	Author
500x500	[25, 69, 71]
800x500	[7, 9, 10, 29, 40, 43, 45, 51, 63, 72]
800x700	[21, 49]
1000x1000	[4, 5, 10, 18, 27, 32, 36, 39, 41, 49, 51, 68]
1200x500	[44, 73]
1200x800	[37, 55, 57, 66]
1200x1200	[7, 16, 42, 43, 60]
1500x300	[8, 33, 53]
1500x800	[22, 61]
2000x2000	[39, 54, 74]

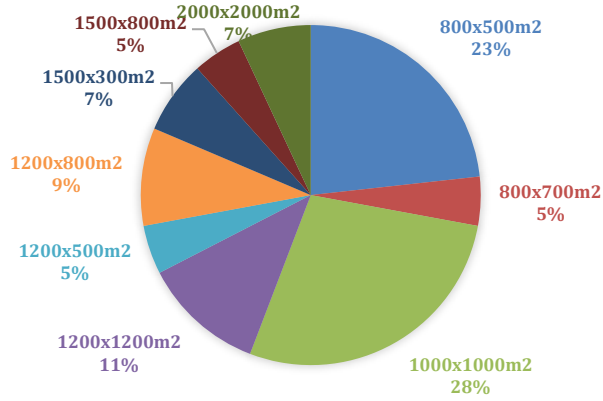


Fig. 4. Topology size percentage

3.4 Pause time

Figure 5 shows 45% used 10s, 23% used 5s, 14% used 60s and 9% used 20 and 30s. Table 6 shows the pause time usage by authors.

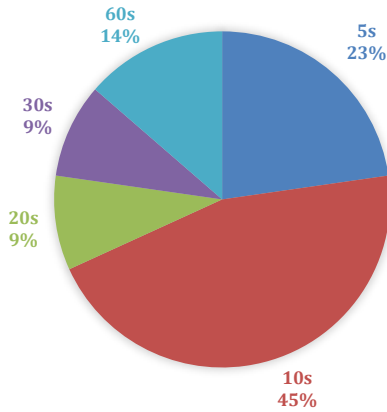


Fig. 5. Pause time percentage

Table 6. Pause Time usage by author

Pause time in second	Author
5	[7, 10, 16, 44, 73]
10	[8, 17, 22, 29, 33, 39, 42, 52, 56, 61]
20	[32, 70]
30	[5, 33]
60	[9, 43, 45]

3.5 Transmission Range

Figure 6 shows 82% used 250m, 8% used 150m, 100, and 300 was used 5%. The highest transmission range was 500 used by [67] in OMNET++ simulation tools, and the work was done in VANET, where the focus was on the increase of the transmission range to cover a maximum of cars in VANET.

We have observed that a high percentage of authors used 250m, as seen in Table 7. We encourage authors to used different transmission range to provide the performance of the protocol base on the transmission range so that an improvement could be made.

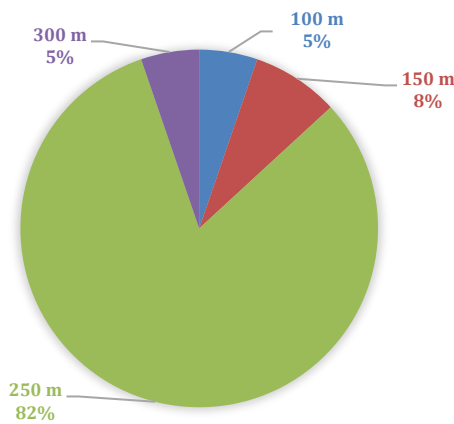


Fig. 6. Transmission range percentage usage by author

Table 7. Transmission range usage by author

Transmission Range	Author
100	[59, 71]
150	[39, 41, 75]
250	[8-10, 16, 18, 19, 21, 22, 28, 29, 32, 33, 36, 40, 43-45, 49, 51, 53, 54, 56, 57, 60-62, 66, 68, 69, 72, 73]
300	[14, 70]

3.6 Simulation time

The scenarios implemented need a specific time to show the performance analysis of a protocol. In Figure 7 shows that 29% used 900s, 22% used 1000s, 19% used 600s, 15% used 500s, 10% used 300s, and 5% used 120s. The high time simulation was 3600 used in a cluster discovery approach [68]. Table 8 lists authors who used a simulation time which was part of the calculation percentage.

In MANET, no predefined simulation time as standard has been proposed. The author choose any simulation time they want, which makes doubtful the result proposed.

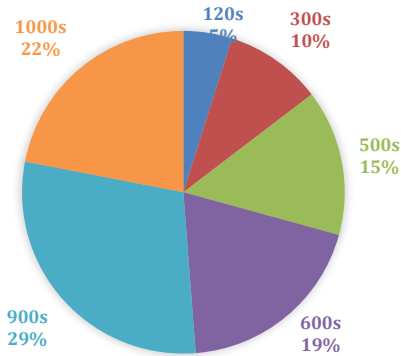


Fig. 7. Simulation time percentage usage

Table 8. Simulation time usage by author

Simulation Time	Author
120	[29, 46]
300	[17-19, 62]
500	[14, 32, 54, 56, 73]
600	[4, 5, 30, 41, 49, 60, 65, 70]
900	[9, 10, 36, 40, 43, 45, 49, 51, 57, 66, 72]
1000	[8, 22, 26, 28, 33, 38, 42, 53, 61]

3.7 Metrics

The metrics are used for the analysis of a protocol or algorithm created. Figure 8 shows that 38% used End to End Delay (E2ED), 21% used Packet Delivery Ratio (PDR), 15% used Overhead, 10% Throughput and Network Routing Load (NRL), and 6% used Packet Delivery Fraction (PDF). Table 9 list the authors associated with the metrics used.

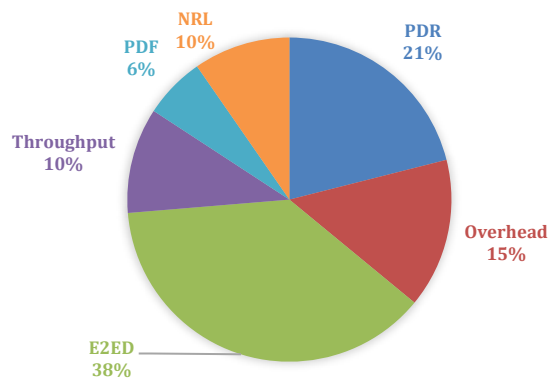


Fig. 8. Metrics percentage usage by author

We have observed a combination of different metrics for the analysis of the performance of the network. Some specific metrics were also used like slot time [73], number of gateway broadcast operation [61], Balanced load Index[33], connectivity duration [67], handovers [47], bandwidth usage [59], Number of selected IGW[30]

Table 9. Metrics usage by author

Metrics used	Author
PDR	[4, 7, 14, 16, 18, 19, 27, 29, 32, 34, 37, 38, 41, 43-45, 49, 51, 54-56, 61, 66, 72]
NRO, OVH	[8, 13, 14, 16, 26, 32, 33, 39, 40, 42, 49, 53-56, 62, 72]
E2ED	[4, 7-9, 13-17, 19, 21, 25, 27-30, 32-34, 36, 38, 40-46, 49, 51, 54-57, 61-63, 65, 68-70, 72, 73]
Throughput	[4, 5, 13, 21, 27, 30, 36, 38, 66, 68, 69, 73]
PDF	[13, 25, 30, 40, 57, 62, 63]
NRL	[6, 7, 9, 19, 25, 28, 29, 44, 51, 57, 63]

3.8 Number of Nodes

In ad hoc networks, nodes are essential for communication; choosing the number of nodes will also impact the network’s performance. Figure 9 shows 22% used 15 nodes, 21% used 50 nodes, 14% used 25 and 30 nodes, 11% used 100 nodes, 6% used 60 nodes, 3% used 12, 40, 45 and 200 nodes as calculate base on Table 11. The lowest number of nodes was 3 [56] used a topology size of $1000 \times 800m^2$, and the highest one was 200 [67, 75] used in VANET. Table 10 shows authors who used a fixed number of the node with fixed topology. The number of nodes for certain authors varied with a different topology size. Some authors author did not vary the node with the topology size, and other authors used a fixed number of nodes with fixed topology size, as shown in Table 10. We can observe that most authors used fixed number of nodes with a fixed topology size. This approach is good but will not show the performance when the number of nodes increases or if the network’s topology size increases.

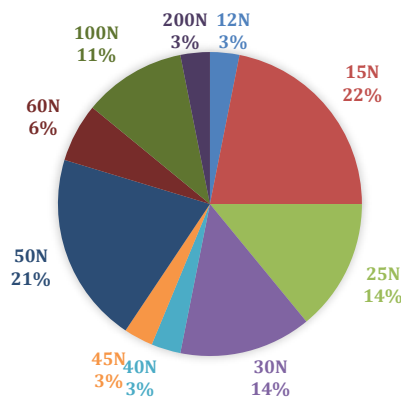


Fig. 9. Number of node percentage

Table 10. Number of node base on topology change

	Author
Fixed number of nodes with fixed topology size	[5, 6, 8, 9, 15-18, 21, 22, 28, 29, 32-34, 36, 37, 40-42, 49, 55-57, 60, 63, 66, 68-70, 72, 73, 76]
Varies number of node with fixed topology size	[23, 25, 53, 54, 61, 63, 71]
Varies number of node and varies the topology size	[7, 10, 38, 39, 43, 51]

Table 11. Number of node usage by author

Number of Node	Author
12	[38, 77]
15	[7, 9, 10, 21, 23, 29, 40, 43, 49, 51, 63, 72, 73, 76]
25	[5, 7, 10, 25, 34, 36, 38, 44, 51]
30	[6, 16, 17, 23, 32, 39, 59, 70, 71]
40	[53, 71]
45	[23, 53]
50	[8, 22, 25, 33, 37, 39, 41, 43, 47, 53, 55, 57, 71]
60	[23, 28, 54, 63]
100	[15, 25, 39, 42, 54, 60, 66]
200	[67, 75]

3.9 Number of IGW

In Figure 10, 44% used two (2) internet gateway, 18% used three (3), 14% used four (4), 11% used five (5) and 4% used one (1), Nine (9) and ten (10) IGW. Some author used a variation of the number of internet gateway in their simulation [7, 10, 15, 25, 43, 46, 51, 53, 54, 58, 60, 61, 63]. The lowest number of IGW was one (1), as you can see in the table 12, and the highest number of IGW nodes used was 100 [58] applied in VANET.

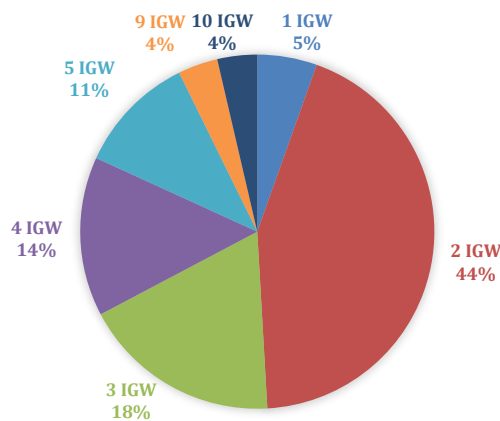


Fig. 10. Number of Internet Gateway percentage

Table 12. Number of Internet gateway usage by author

Number of IGW	Author
1	[15, 46, 71]
2	[7, 9, 10, 17, 21, 28, 29, 37, 38, 40, 42, 43, 49, 51, 53, 54, 56, 57, 60-63, 73, 76]
3	[5, 10, 25, 44, 46, 51, 53, 61, 63, 66]
4	[15, 32, 39, 49, 53, 54, 60, 70]
5	[7, 25, 41, 43, 46, 53]
9	[15, 59]
10	[25, 58]

3.10 Packet Size

The size of a packet is essential when sending a message in an ad hoc network. Table 13 shows the packet size and those authors who utilize it. Figure 11 show that 86% of authors used 512b and 7% used 1024b and 128b. The majority of authors used the pre-defined parameter settings from some simulation tools such as Network simulation 2 (NS2), which is 512b as a default parameter. Other authors also used the same packet size in OPNET [5, 69] and OMNET++ [66]. The smallest packet size was 120b[42], where they focus on stable links to discover the IGW in MANET with a topology size of $1200 \times 1200m^2$. The largest packet size was 1024, as shown in Table 13, which they implemented in OPNET with a topology size vary from $600 \times 600m^2$ and $800 \times 800m^2$. We have observed that not authors have been using a different type of packet size for comparative analysis of their created protocol.

Table 13. Packet size usage by author

Packet Size	Author
128	[33, 71]
512	[5, 14, 17-19, 21, 22, 28, 29, 32, 38, 41, 44, 46, 49, 54-57, 60, 62, 66, 69, 72, 73]
1024	[23, 70]

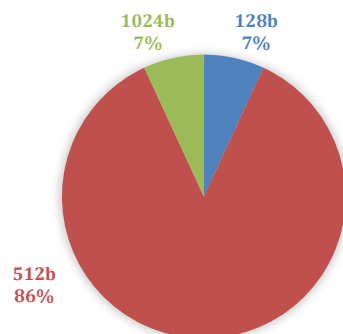


Fig. 11. Packet size Percentage

3.11 Traffic Type

Figure 12 shows that 93% of the authors used the constant bit rate (CBR), and 7% used the Variable Bit Rate (VBR) as shown in Table 14.

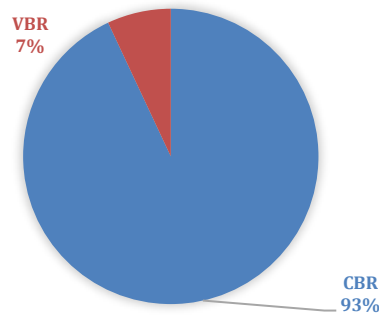


Fig. 12. Traffic type percentage

Table 14. Traffic type usage by author

Traffic Type	Author
CBR	[4-6, 9, 10, 14, 16-19, 22, 27-29, 32, 33, 36, 38, 40, 41, 43, 44, 46, 49, 51, 53-57, 60-62, 66, 68-70, 72, 73, 76]
VBR	[8, 26, 42]

3.12 Mobility Model

Figure 13 shows that 73% used Random Way Point Mobility (RWP), 14% used SUMO, 9% used Manhattan and 4% used Reference Point Group Mobility (RPGM), and 4% used SUMO. Other mobility were Freeway mobility model [19], Radom direction mobile mobility (RDMM) [64], Time variant community mobility model (TVCM) [53], Radom Trip model [26]. For a list of authors who used a specific mobility model, see Table 15. We have observed that only one author used two different mobility models for the performance of their work [42].

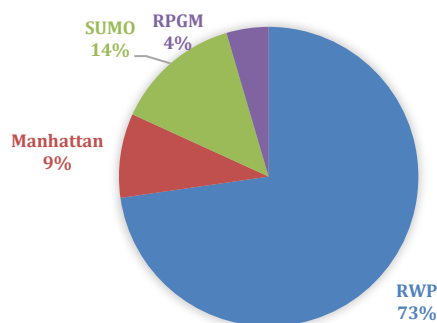


Fig. 13. Mobility model percentage

Table 15. Mobility Model usage by author

Mobility Model	Author
RWP	[5, 7-10, 15-17, 21-23, 28, 29, 32, 33, 38, 39, 41-44, 49, 51, 60, 61, 63, 66, 69-71, 73, 76]
Manhattan	[50, 54, 58, 59]
SUMO	[13, 14, 30, 47, 62, 67]
RPGM	[36, 68]

3.13 Packet rate

Figure 14 shows that 56% used 5 packets per second (p/s), 31% used 10 p/s, and 13% used 20 p/s, see Table 16 for a list of authors.

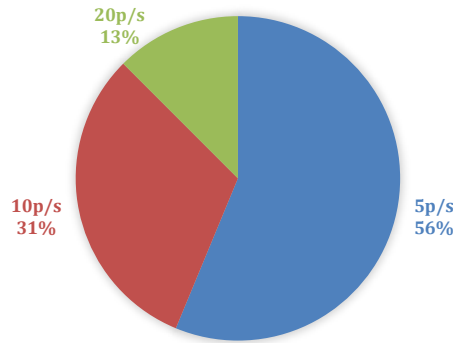


Fig. 14. Packet rate percentage

Table 16. Packet rate usage by author

Packet rate in p/s	Author
5	[9, 16, 43, 55-57, 62, 72, 76]
10	[15, 26, 32, 49, 53]
20	[26, 61]

4 Recommendation

We have observed that some parameters and protocols had a high percentage of authors’ usage, making it a better choice to use by other authors in their simulation. However, the choice of parameters and protocol used in simulation tools depends on the research objective.

We have observed in Table 17 that the topology size does not vary accordingly to the number of nodes. A high number of nodes can have a small topology size; for example, number 10 shows 40 nodes used with a topology size of 500x500m², and the same goes for number 15 with 50 nodes, but the topology size still 500x500m². The same goes for Internet gateway numbers and simulation times. Arbitrary choice of parameters is more used in IGW, and this shows how the need for standardization of simulation

parameters has to be put in place. Our proposition of recommended input parameters in Table 18 is based on the high utilization percentage in all the parameters described here. We also include the percentage with is closer to each other despite the high utilization.

Table 17. Summary of some parameters used in IGW

No.	Nodes	Topology (M X M)	IGW	Range (M)	Simulation Time (S)	Packet Size (B)
1	3	1000 x 800	2	250	500	512
2	10	1000 x 1000	4	250	500	512
3	15	800x700m	2	250	900	512
4	15	1200 x 500	2	250	500	512
5	15	800 x 500	2	250	120	512
6	25	1200 x 500	3	250	900	512
7	30	800 x 800	4	300	600	1024
8	30	1000 x 1000	4	250	500	512
9	30	500 x 500	1	100	180	128
10	40	500 x 500	1	100	180	128
11	40	1500 x 300	2	250	1000	320
12	45	1500 x 300	3	250	1000	320
13	50	1200 x 800	2	250	900	512
14	50	1000 x 1000	5	150	600	512
15	50	500 x 500	1	100	180	128
16	50	1500 x 300	4	250	1000	320
17	55	1500 x 300	5	250	1000	320
18	60	1300 x 800	2	250	1000	512
19	60	2000 x 2000	2	250	500	512
20	100	1200 x 1200	2	250	600	512
21	100	1200 x 1200	4	250	600	512
22	100	1200 x 1200	8	250	600	512
23	100	1200 x 800	3	250	900	512
24	100	2000 x 2000	4	250	500	512

Our recommendation to scholars in the Mobile ad hoc network and specifically in IGW is to ensure that all the parameters are well described and shown in the paper to facilitate comparative analysis. We encourage authors in Internet gateway to vary the number of the node with different topology sizes, vary the number of the internet gateway, use different mobility models, and vary the pause time to evaluate their proposed protocol better. We recommend the MANET community to develop a standardized simulation and environment input to make the result credible and acceptable by all researchers.

Table 18. Proposed input parameters

Parameter	Value
Simulation tools	NS2
Number of mobile nodes	15, 50, 25, 30
Number of Gateway nodes	2,3,4
Topology size	1000x100, 800x500
Traffic type	CBR
Packet Size	512
Transmission range	250m
Pause time	10s
Mobility model	RWP
Simulation time	900s, 1000s, 600s
Ad hoc Routing protocol	AODV+
Packet rate	5p/s
Metrics	E2ED, PDR, Overhead

5 Conclusion

The performance analysis of the IGW protocol depends on a variety of parameters that need to be taken into consideration before deciding what number of nodes, topology size, simulation time, and other parameters to choose. We found out that 88% of the author still used AODV+ as their base protocol for comparison or enhancement. NS2 had 78% of usage in terms of simulation tools, 250m was the transmission range used with 82%, 900 seconds was the simulation time with 25% of usage, 28% used 1000x100m2 as the topology size. E2ED got 38% as the high metrics used in IGW, the number of Internet gateway used was two (2) with 44%, 512byte was the Packet size with 86%, traffic type was CBR with 93%, RWP was the mobility model used with 70%, 10 second was the pause time used with 45%, and the packet rate was 5p/s. We have observed that some authors did not justify the choice of the parameters used in their paper. Other parameters were not given in some papers, as you can see in Table 1, making it difficult for the researcher to compare their work with the existing one. In Section 4 we recommended the input parameters future research needs to use in their work. However, other parameters can be added based on the research objective of the authors. We hope that our review result will help the MANET community develop standardized Internet gateway researcher parameters as a reference.

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