Analysis on the impact of different mobility models on the performance of a Mobile Ad-Hoc Network

Paul Crichton
Edinburgh Napier University
404435990

***Abstract*— This report contains discussion on how different mobility models impact the performance of a Mobile Ad-Hoc Network. The report looks at which mobility models performs better in terms of Packet Delivery Ratio, Throughput and End-to-end delay. Two chosen mobility models were used - Linear model and Random Waypoint Model. Results and research show that while the Linear Mobility model performs worse on paper there are still uses for both models depending on the scenario.**

Keyworkds - MANET, Mobility, Linear, RandomWP, Throughput, PDR, Delay

Word Count - 1815

I. Introduction

Mobile Ad-Hoc Networks (MANET) are un-reliant on traditional pre-existing network infrastructure. This means each node utilizes integrated networking equipment instead of routers or access points to communicate with other nodes. MANETs provide vastly different challenges compared to traditional networks, the biggest issue for MANETS is node mobility, this is where nodes within the network are able to move and must regularly connect and disconnect with different nodes to stay connected to the networks. When simulating the impact of mobility on a functioning MANET, it is necessary to define in the simulation tool how the nodes will behave when in motion. Mobility models are packages used to describe the motion of wireless nodes (INET, n.d.). This report discusses the impact of using different mobility models when simulating a MANET and how it impacts the performance of the network. This report discusses two different mobility models:
The linear mobility model is a model that positions nodes at a random (X)(Y)(Z) point in the pre-defined area. From this point, a random directional angle is determined to simulate the direction the node is “facing”, the node then moves with a constant velocity or constant acceleration along a linear line until it hits a boundary where the node is reflected off the boundary and continues along a new linear path at the same but reflected angle as before.
The Random Waypoint mobility (randomWPmobility) model is a model that positions nodes at a randomly chosen position over the pre-defined area. The nodes then follow a direct line at a randomly chosen velocity to random target point within the area. Once the node reaches the target point it will choose a new random target point and then move toward this new point. This repeats until the simulation ends
It can be said that both models will impact the performance of the MANET. This is due to the undeniable fact that when simulating mobility there will always be a significant drop in performance in all scenarios. This report aims to find which model has the greater overall impact

II. Related Works

Mobility of nodes is the one of the hardest challenges that affects every MANET, with many ad hoc routing protocols unable to provide services comparable to those of traditional static networks. As stated by Cadger, et al., 2015 ad hoc protocols are unable to provicde nessasary standards for streaming multimedia as the are unable to effectivly manage quality of serivce (QoS) due to node mobility (Cadger, et al., 2015). Some of the challenges created by mobile nodes (mobility) in MANETS are discussed in MANET: Vulnerabilities, Challenges, Attacks, Application by Goyal, et al. they include:

- Limited Power Supply (Goyal, et al., 2011) - for nodes to be able to move, they must be untethered by cables, this means they can only run for a limited period of time before needing to be recharged or in some cases require extra equipment such as solar panels
- Dynamic Topology (Goyal, et al., 2011) - Nodes must be able to frequently create new routes and form new neighbours/relationships if they wish to stay part of a network
- Bandwith Constraint (Goyal, et al., 2011) - links are susceptiable to external noise, interfernce and signal attenuation effects.

Different mobility models can provide insight into performance of induvidual protocols/networks under the impact of mobility over an area. In a study done in 2014 on random waypoint mobility model and random point group mobility model, it was found that the first model (RandomWP) showed better network performance than the second (Random Point Group), however, in some situations the second model also had scenarios where it showed better overall network performance (Gupta, et al., 2014). It was concluded that all models have their own significance (Gupta, et al., 2014). It can be said that there is a need for different mobility models to ensure issues that may not have been found using a single module are found through further testing using mutliple different models.

III. Setup And Analysis

A. Network Topology

The scenario network topology (MANET) utilized a maximum of 35 “moving” nodes and a singular “stationary” (sink) node. Each node has the capability to wirelessly receive and send packets to the stationary node. The network was configured to use DSDV as its routing protocol. The nodes were configured to send a UDP packet every 0.5 seconds to the sink node for the duration of the simulation. Each packet had 512B of data and would delay the next packet when a successful packet had already been sent and confirmation received. The nodes were confined to an area of 1000m x 1000m x 0m.

B. Simulation

The investigation uses Omnetpp++ to simulate the performance of a MANET using two different mobility models. Omnetpp++ is network simulation tool that can simulate a multitude of factors that might affect a MANET including but not limited to mobility of nodes, density of nodes, protocols used and, traffic types. Two identical scenarios were simulated one using the randomWPmobility model and one using the linear mobility model. Each scenario was performed 6 times increasing the density of nodes (starting with 5 nodes) by 5 with each run up to the maximum of 35 nodes.

C. Analysis

To analyse the performance of the network the packet delivery ratio (PDR), throughput and End to End Delay will be extracted. The data will then be plotted vs Node Density in Excel. Full data used in results will be included in the appendix. Discussion will follow results.

Table 1

Parameter	Value
Simulation Time	60 Seconds
Number of Nodes	5, 10, 15, 20, 25, 30, 35
Packet Send Interval	0.5 Seconds
Traffic Type	CBR (UDP)
Maximum Speed	10mps
Packet Size	512 bytes
Routing Protocol	DSDV

IV. Results

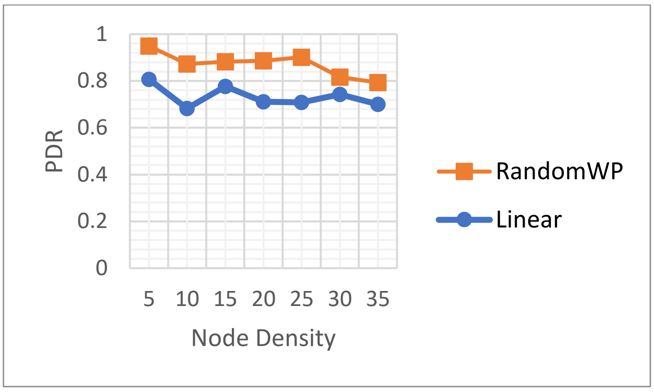

Figure 1

The above graph shows the calculated packet delivery ratio (PDR) results compared with Node Density. The results show the linear mobility model had a lower PDR when compared on each individual level of density. On average the linear model had a lower PDR by 0.139 (3sf). The randomWP model had the largest range with a high of 0.949 (3sf) and a low of 0.793 (3sf) a difference of 0.156 (3sf) this being compared to 0.125 (3sf) for the linear model.

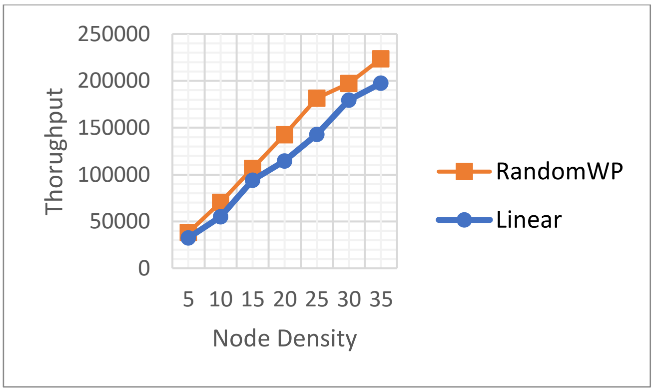

Figure 2

The above graph shows the mean Throughput compared with Node Density. Similar to the PDR results, the linear model has a lower overall throughput, on average 20650 (3sf) lower than the randomWP model. The RandomWP model had the largest range with a high of 223000 (3sf) and a low of 38200 (3sf) a difference of 185000 (3sf) compared to 164000 (3sf).

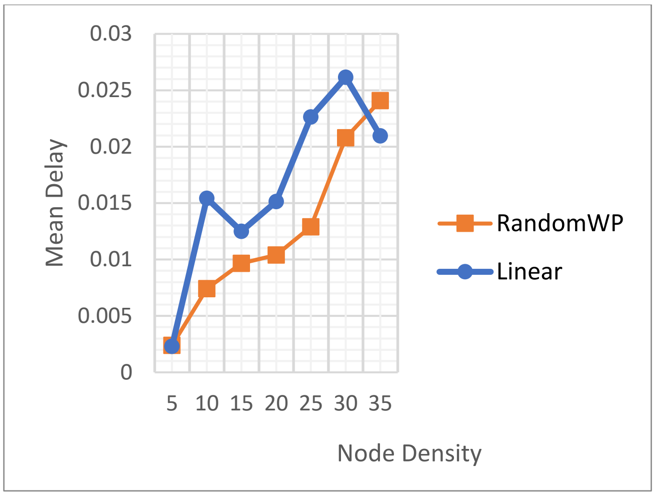

Figure 3

The above graph shows Mean Delay compared with node density. The linear model had a higher mean delay on all levels of density with the exception of 5 and 35 where it was lower by 0.0000689 (3sf) and 0.00314 (3sf) respectivly. The linear model had the highest range with a high of 0.0261 (3sf) and a low of 0.00232 (3sf) a difference of 0.238 (3sf) compared to 0.0217 (3sf).

V. Discussion

Looking at the results obtained in Figure 1 it is suggested that the linear mobility model has a negative impact on packet delivery. This claim can be supported by looking at the average PDR for both models [Linear: 0.8071 (3sf), RandomWP: 0.871 (3sf)]. This means that, on average, packets are more likely to not reach their destination when using the linear model, this is compared to using the RandomWP model. Increasing the density of nodes had a low impact on the PDRs of both models with a difference of less than 2% (1 = 100%) between the highest and lowest delivery ratios in each of the scenarios.

Figure 2 also suggests lower performance using the linear model with the throughput to the sink node being less on average by 20560 (3sf). The lower the throughput the less packets of data successfully received by the sink node. This in turn can lower the overall performance of the network with different services having to wait on data being re-sent causing backlog and buffering.

The linear model showed an unusually large fall in PDR at 10 nodes. One of many reasons for this could be, the model created a scenario where many of nodes spent most of the allotted time at the boundaries of the area. The further away the mobile nodes were from the sink node the weaker the transmission signal strength would have been. This was a likely scenario as the simulated area did not include any obstacles other than distance. This is again suggested by looking at Figure 3 where at 10 nodes the end-to-end delay spiked higher than both 15 and 20 nodes. This suggests that packets were allowed to propagate causing a substantial amount of delay over the large distance. Propagation can cause longer wait times causing slower loading of certain services such as JavaScript elements on websites.

Figure 3 shows the linear model is subject to more delay than the randomWPmodel being an average of 0.00393 (3sf) higher. The graph also suggests the linear model may cause unnatural fluctuations in delay vs the consistent trend line of the randomWPmodel. This is shown through the large fluctuations that don’t conform to a trend or pattern. This can mean that portions of the overall performance of the network is left to pure chance when the model is first configuring the initial angles of each node. This can be taken as both positive or negative depending on how random the mobility of the simulation was intended to be.

Overall, the results showed that both models impacted the performance of the network, however, the linear model showed the greatest decrease in performance. The randomWPmodel showed the greatest consistency of results with clear trends suggesting better predictability and reliability when used in a scenario.

VI. Conclusion

Both models did in fact show drops in performance with the linear model showing the greatest impact. The randomWP model behaved rationally with clear downward trends when increasing nodes and minor changes between increments of density. This representation is closer to what would be expected in a real-life situation. The linear model behaved erratically with large variations in PDR, throughput, and delay between increments in node density. This made it difficutl to come up with a clear explantion for why the linear model caused a negitive impact on the overall performance of the network. In a real-life MANET using a similar configuration, both models have also again confirmed that mobility would cause a noticeable impact particularly when services such as multimedia which rely on UDP are used. These models represent a tiny fraction of the different available models but show how different the impact on performance can be.

VII. Future Study

Open ended questions were raised within results and analysis, particularly about unusually large falls and spikes in data concerning the linear model. It is suggested that to answer these questions, further study on movement of nodes in the linear model using visual aids offered by Omnetpp++. This would help to answer if nodes do gravitate towards the edges of the boundary in some scenarios. Furthermore, it would be beneficial to obtain results with a larger sample-set of node density. This will help to confirm if the reason for the large fluctuations in delay are left to pure chance in the linear model. This will be more prevalent over more intervals.

VIII. References

Cadger, F., Curran, K., Santos, J. & Moffet, S., 2015. Location and Mobility-Aware Routing for Improving Multimedia Streaming Performance in MANETs. *Wireless personal communications,* 86(3), pp. 1653-1672.

Goyal, P., Parmar, V. & Rishi, R., 2011. MANET: Vulnerabilities, Challenges, Attacks, Application. *IJCEM International Journal of Computational Engineering & Management,* Volume 11, pp. 32-37.

Gupta, A., Kosta, A. & Kumar, A., 2014. Performance Comparisons of Node Mobility Models on Routing Protocols on MANET. *Research Journal of Engineering and Technology,* 5(3), pp. 151-157.

INET, n.d. *INET omnetpp.* [Online] Available at: https://inet.omnetpp.org/docs/showcases/mobility/basic/doc/ [Accessed 14 Febuary 2022].

Li, J. et al., 2012. Swarm mobility and its impact on performance of routing protocols in MANETs. *Computer communications,* 35(6), pp. 709-719.

IX. Appendix

A. RandomWP

Density	The sum of all Packets sent by the source hosts	Packets Received	PDR	Throughput	Delay
5	302592	287232	0.94923858	38297.6	0.002388684
10	604672	527872	0.87298899	70382.93333	0.007420708
15	906752	799744	0.88198758	106632.5333	0.009656942
20	1208832	1070592	0.88564168	142745.6	0.010395814
25	1510912	1360896	0.90071162	181452.8	0.012903382
30	1812992	1479168	0.81587122	197222.4	0.020787133
35	2115072	1677824	0.79327039	223709.8667	0.024087644

B. Linear

Density	The sum of all Packets sent by the source hosts	Packets Received	PDR	Throughput	Delay
5	302592	244224	0.8071066	32563.2	0.002319701
10	604672	412672	0.68247248	55022.9333	0.015426202
15	906752	704512	0.77696217	93934.9333	0.012512178
20	1208832	859136	0.7107158	114551.467	0.015140886
25	1510912	1071104	0.70891223	142813.867	0.022647108
30	1812992	1346560	0.74272804	179541.333	0.02614622
35	2115072	1481216	0.70031469	197495.467	0.020951643