A Novel Approach to Predict Mobility Pattern of Mobile Nodes in Mobile Ad-hoc Networks

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Received 5 September 2017; revised 26 May 2018; accepted 14 September 2018

The foundation of the simulation study is mobility models in Mobile Ad-hoc Network (MANET). A new approach to predict the mobility for city scenario which includes a realistic model of column behavior of nodes is proposed. The comparison of this model with those of other available mobility models is encouraging. We believe that it can enhance the performance of the specified routing protocol in MANET. The network topology and link failures prediction is very difficult in the case of high mobility networks. We try to predict the node mobility for better mapping in the network. A stable route can be constructed with stable links. The simulation results of the new mobility model over routing protocol are compared with existing mobility model. NS2.35 simulator is used for network simulation. Bonnmotion-3.0.1 is used to generate the mobility of nodes. The improvement has shown in QoS metrics like throughput, average end-to-end delay, and also packet delivery ratio.

\textbf{Keywords:} MANET, Mobility Models, AODV, DSR, DSDV, Mobility Prediction

\section*{Introduction}

In today’s era, wireless multiple hop networks which include ad-hoc networks, sensor networks and vehicular networks are concerned subject for research. The collective wireless mobile terminals make a temporary network without any centralized entity known as Mobile ad-hoc network (MANET). MANETs uses the key concept of multiple hop relaying method\textsuperscript{1}. Since the nodes are mobile in nature, link failure probability is always there. The mobile node can move out of the range from its neighbour nodes, so mobility issue is always there. The desired challenges in MANET includes unreliable wireless links, dynamic topologies, shortage of secure boundaries, malicious nodes\textsuperscript{2}. Lacking of the centralized entity, limited power supply, and scalability\textsuperscript{3, 4, 5}. Our objective is to determine the mobility speed of a node with the reliable links. First Come First Serve (FCFS) algorithms\textsuperscript{6} are used while creating new routes.

\section*{Objective and contribution}

The main purpose of doing this research to construct a route in a pair of nodes. In this way, we can manage dynamic topology and maintain end-to-end delay, packet overhead and data’s quality. We proposed a new method of calculating the mobility speed of a mobile node in Manhattan mobility model which is a reliable mobility model in the related work. If we can suppose the road is free, then a mobile node can travel with a maximum speed instead of mean speed as mentioned in the previous model. The major contributions of this research are:

\begin{itemize}
  \item A new speed calculating formula of a mobile node.
  \item Random Next Double () method is used to calculate the speed of a mobile node.
  \item Estimation of total distance of a mobile node.
  \item Estimation of mobile node’s average speed.
  \item Estimation of travel time of a mobile node.
\end{itemize}

The paper organization covers following sections: section 3 discusses the Modified Manhattan mobility model with the proposed algorithm. Section 4 discusses the performance evaluation followed by concluding remarks in section 5.

\section*{Introduction to modified manhattan mobility model (mmmm)}

Mobility prediction with modified Manhattan mobility model is the enhancement of the Manhattan model regarding speed. This enhancement overcomes the limitation of the Manhattan model to make it suitable for the maximum speed with MANET routing.
protocols. Manhattan Mobility Model emulates the movement pattern of mobile nodes on the streets. Under this model, the scenario is composed of some rows and columns in the form of streets. The displacement of nodes is to along with the grid of horizontal and vertical streets. The position of the mobile node must be known for calculating the total distance travelled by a node. The various possibilities of movements of node N are three. At every intersection point, the node has three possible probabilities to move left, right, and go straight respectively (Left=0.25, Right=0.25, and Straight=0.5) by paths A, B, and C. Total distance travelled, average speed, total active time, and speed calculation formulas are given in following equations:

\[
\text{Total Distance Traveled} = \sum_{i=0}^{n-1} \text{sum} + \text{Next Position} - \text{Previous Position} \quad \ldots (1)
\]

\[
\text{Average Speed} = \sum_{i=0}^{n-1} \left( \text{sum} + (\text{Next Position} - \text{Previous Position}) \div N \right) \quad \ldots (2)
\]

\[
\text{Total Active Time} = \frac{\text{Total Distance Traveled}}{\text{Average Speed}} \quad \ldots (3)
\]

\[
\text{Speed} = (\text{maxspeed} - \text{minspeed}) \times \text{randomNextDouble()} + \text{minspeed} \quad \ldots (4)
\]

where \text{randomNextDouble()} is a java function used to create a next pseudorandom number, uniformly distributed between the values 0 and 1; max speed and min speed are the maximum and minimum speeds of a mobile node.

**Route discovery process and mobility prediction**

The route discovery process between the source and a destination is shown in algorithm a. We are selecting a node which has maximum active time for reliable communication.

Algorithm a: Algorithm for predicting and estimating stable link.

**Input:**

N= \{Set of nodes\}

s= \{Source node\}

d= \{Destination node\}

**Output:** Select a Stable path between source s and destination d.

1. Initially, Path is assigned to zero.
2. The source node s broadcasts Route Request Message.
3. For every neighbor of s, Repeat steps 4 to 7.
4. If this is the first packet from s then
5. Calculate the active time by a message.
6. Set the active time of v as the current time.
7. Set the Timer time as the Current time of v.
8. Otherwise, Calculate the Interval time (By subtracting the Timer Time from a Current time)
9. If the expiry time occurs, then ignore the RREQ packet.
10. Choose the mobile node with ‘Maximum Active Time.’
11. End If
12. End if
13. Unite this link to preceding link.
14. If this s is not the destination, then choose the next neighbor.
15. Go to step 3.
16. End if

Algorithm b calculates the total speed, average speed, and total travel time of a source node in the simulation area. The source node periodically broadcasts the messages after a specified interval.

Algorithm b: Calculate ‘Active Time’

**Input:** S → N \{Link between nodes\}

(x, y) initial coordinates of a Node S.

**Output:** Active time of a Node in Network

1. Repeat for until the simulation time ends
2. Source node S broadcasts RREQ to its neighbors.
3. Neighbor node N receives first RREQ packet from node S.
4. Sum:=0
5. For i=0 to n-1 do
6. Speed = (maxspeed - minSpeed) * random Next Double( ) + minSpeed;
7. Total_Distance=sum + speed;
8. End For
9. End For
10. Average_Speed=Total_Distance /n
11. Total_Travel_Time=Total_Distance/Average_Speed
12. Return Total_Travel_Time

**Performance evaluation**

The simulation study has been performed on NS2.35 network simulator. The list of network parameters is shown in Table 1. The proposed modified mobility model is compared with an existing model based on QoS metrics like throughput, average end-to-end delay, and Packet Delivery Ratio (PDR).
Packet Delivery Ratio (PDR)
The total number of data packets which are received by a destination over sent packets by the source node.

Throughput
During simulation time, number of packets received is called throughput.

Average end-to-end delay
It is total time a packet takes to travel from source node to the destination node. The packet delivery ratio (PDR) of Manhattan and MMMM mobility models of AODV, DSDV, and DSR routing protocols is shown in Figure 1. The routing protocols are compared with node density from 10 to 100 nodes with variation in speed of 0-10 (m/s). In mobility scenario, MMMM outperforms all protocols with enhancement. DSR protocol is giving a better result than AODV, and DSDV with Manhattan model. In highly dynamic scenarios, MMMM exceeds its performance regarding terms of successful transmissions. Figure 2 shows the performance variation in throughput of Manhattan and MMMM models over AODV, DSR, and DSDV routing protocols. In case of 10 nodes, the node’s average speed variation is 0.0 to 1.14 (m/s) in Manhattan and 0.05 to 2.3 (m/s) in MMMM. The average speed variation with 50 nodes is 0.3 to 6.4 (m/s) in Manhattan and 9.8 to 10.13 (m/s) with MMMM. With 100 nodes, average node’s speed in Manhattan is 9.93 to 10.1 (m/s) and 0.02 to 8.9 (m/s) in MMMM. The average speed of nodes improves the throughput of MMMM in different cases.

Table 1 — Simulation Parameter List

<table>
<thead>
<tr>
<th>Parameters List</th>
<th>Description</th>
<th>Value</th>
<th>Analysis Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulator</td>
<td>Network Simulator</td>
<td>NS2.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobility Generator</td>
<td>Mobility Generator Tool</td>
<td>Bonnmotion-3.0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simulation Time</td>
<td>Simulation Duration</td>
<td>10, 50, 100 Seconds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terrain Dimension</td>
<td>X, Y Dimension of motion</td>
<td>15229*1300 m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of mobile nodes</td>
<td>Number of nodes in a network</td>
<td>10, 50, 100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobility Speed</td>
<td>Mobility of nodes</td>
<td>0-10 meter per second</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Connections</td>
<td>Connections</td>
<td>5, 25, 50</td>
<td></td>
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<tr>
<td>Mobility Model</td>
<td>Mobility Direction</td>
<td>Manhattan, Modified Manhattan</td>
<td></td>
<td></td>
</tr>
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<td>Routing Protocols</td>
<td>Path-finding</td>
<td>AODV, DSDV, DSR</td>
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<td>MAC Protocol</td>
<td>Wireless Protocol</td>
<td>802.11</td>
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</tr>
<tr>
<td>Channel</td>
<td>Wireless Channel</td>
<td>WirelessChannel</td>
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<tr>
<td>Propagation Method</td>
<td>Propagation Model</td>
<td>TwoRayGround</td>
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<tr>
<td>Antenna</td>
<td>Type of Antenna</td>
<td>OmniAntenna</td>
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<td></td>
</tr>
<tr>
<td>Queue</td>
<td>Type of Queue</td>
<td>DropTail/PriQueue, CMUPriQueue</td>
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<td></td>
</tr>
<tr>
<td>Queue Length</td>
<td>Length of Queue</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The comparative delay of MMMM with Manhattan is shown in Figure 3. MMMM also shows improvement in delay with all routing protocols except DSR in 100 nodes scenario. The reason behind this is its source routing property. With average speed 0-7 (m/s) in MMMM in 100 nodes, 0.8% to 39% delay rate
decreases. With average speed 9-10 (m/s) in 50 nodes, MMMM gives 8% to 94% less delay for DSDV and DSR respectively.

Conclusions and challenges for future

The researchers always has great concerned about mobility prediction. Some issues and problems regarding mobility prediction are discussed here. A new mobility prediction method for mobile nodes has been proposed. A thorough prediction of distance covered by a mobile node in the defined scenarios has been predicted. We have created reliable links between a set of nodes to reduce link and route failures. There is no concern about exact node position using any fixed device like Global Positioning System, which makes it more energy efficient. The comparison of proposed mobility model over the existing model is encouraging. The proposed mobility model is giving 0.8% to 94% less average end-to-end delay in different scenarios. MMMM outperforms enhancement around 9% in PDR. MMMM mobility pattern improves throughput by 13% to 20% in different cases. The limitation of the proposed model is that it is giving more average end-to-end delay. The reason behind this delay is the values generated by randomNextGaussian() and randomNextDouble() methods used in Manhattan and MMMM, respectively. Next, other mobility-based metrics (relative speed, link duration, total links, and path availability) can be explored to improve network throughput. In the future, different standard deviation values can be applied to decrease the average end-to-end delay.

Acknowledgments

We are thankful to GNDU Regional Campus, Sathiala, and SLIET, Longowal for providing us with infrastructure and facilities to do this research.

References