**Model of Maximum CBR Distance Travelled by packets in MANETs using Location-Aware Transmission for Ubicomp.**

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**Abstract** – MANET transmission strategies in MANET are considered good for energy containment and management for ubicomp [62]. Hence research in location-awareness and MANETs remain very significant. It is projected that further development will involve technologies like land-based GPS systems, improved location refresh rates and location accuracy, along with developments of better protocols optimised for transmission following distance criteria. To better tune transmission protocols and achieve optimal MANET performance, one desirable knowledge would be the trends of distance coverages by packets in a ubicomp for varying node densities.

A previous study in this direction was made [26], whereby the metric PPD was devised. In this paper, another metric “Max_CBR_Dist”, derived from PPD is defined and its corresponding trends over varying node densities are presented.

This paper adds a second component after the metric PPD [26] to the area of modelling for managing distance packets travel in ubicomp topography of varying node densities. Designers may use these results towards formulation of better transmission protocols for ubicomp. This research is a follow-up of previous work [1-26].

**Key terms:** Ubicomp- Ubiquitous Computing, MAUC-Mobile and Ubiquitous Computing, MANET- Mobile Adhoc Network, PPD- Packets_Per_Distance, Max_CBR_Dist – Maximum_CBR_Distance, CBR- Constant Bit Rate.

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**1. Introduction**

Distance coverage is a predominant factor affecting energy consumption in MAUC. This energy expenditure varies proportional to the square of distance a packet travels [15]. In MANET transmission, the sender node along with all MANET route nodes forward packets corresponding to each CBR. One impact in the topography is that total number of packets circulating within the MANET topography. With increasing node density, this total number of packets is expected to increase. The sender node forwards packets to the closest neighbour but there is no guarantee that all hops will be of equal distance nor that the first hop is the smallest or biggest one for each CBR. The research questions put forward here are: “What are the maximum hop distance experienced by each CBR? What is the trend observable for this maximum hop count and how does it vary with varying node densities?”

The key contributions of this paper is firstly, the development of a derived metric Max_CBR_Dist, derived from PPD for CBR Packet Per Distance analyses. The definition and rationale of metric Max_CBR_Dist is put forward. Secondly, the model of trend is put forward for the metric Max_CBR_Dist with results for varying node densities from 7 until 56 in a topography of 300 x 300 m². The model proposed is the normal distribution model. The rest of this paper is organised as follows: section 2- New Derived Metric – Maximum_CBR_Distance, section 3—Max_CBR_Dist Trend Assessment over Varying Node Numbers, 4- Conclusion and References.

**2. New Derived Metric – Maximum_CBR_Distance.**

Following definition of PPD [26], Max_CBR_Dist is defined as the maximum distance coverage noted for the whole of a CBR along a MANET topography. It can also be termed as the longest hop distance noted for a CBR.

MANET routes may vary during a CBR transmission. It is envisageable to have the metric at value 0. This may occur for short durations of transmission with snapshot MANET topology whereby all hops are below 0.5 m even though distance between sender and receiver may be high.

The results of this study may serve towards the same purposes as described in previous paper [26].

3.0 Major Observations.
For most of the plots from node numbers 7 until 56, the least value of Max_CBR_Dist has revolved around 21.

The plots are very scattered but as depicted in figure 1(a) for node number 7, the plausible “S” shape of the normal distribution is clearly visible. Hence it is put forward that the metric Max_CBR_Dist follows normal distribution with equation of the form:

\[ F(x) = b \times \frac{1}{\sqrt{2\pi}} \times \exp\left(-\frac{(x-a)^2}{2b^2}\right) \]

It can also be read as \( F(x) \) equals to a factor (b) times the equation of a normal curve.

The x-coordinate of the peak values tend to increase with increasing node number.

3.1 Tabular Summary of Results.
A tabular summary for results of equations of curves \( F(x) \) is shown below. Column headings are: A→node number, B→Value of parameter a, C→Value of parameter b, D→value of parameter c (the adjusted mean), E→reduced chi-square value of plot \( F(x) \), F→Corresponding figure number.

Table 1: summary of results for Max_CBR_Dist equations of curves node numbers 7-56

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
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<tbody>
<tr>
<td>7</td>
<td>0.016 438 9</td>
<td>0.028 232 1</td>
<td>205.829</td>
<td>0.048 409 1</td>
<td>(b)</td>
</tr>
<tr>
<td>8</td>
<td>0.018 390 4</td>
<td>0.028 069 3</td>
<td>205.653</td>
<td>0.048 355 3</td>
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<td>8</td>
<td>0.016 107 7</td>
<td>0.037 901 3</td>
<td>207.077</td>
<td>0.044 713 5</td>
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<td>9</td>
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<td>0.030 411 3</td>
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<td>0.043 067 4</td>
<td>4</td>
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<td>0.030 880 2</td>
<td>231.38</td>
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<td>5</td>
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<td>0.028 502 3</td>
<td>27.001</td>
<td>0.047 092 6</td>
<td>6</td>
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<td>0.017 111 5</td>
<td>219.341</td>
<td>0.036 961 3</td>
<td>7</td>
</tr>
<tr>
<td>13</td>
<td>0.018 149 7</td>
<td>0.016 231 3</td>
<td>223.019</td>
<td>0.032 170 7</td>
<td>8</td>
</tr>
<tr>
<td>14</td>
<td>0.019 950 7</td>
<td>0.032 343 7</td>
<td>225.176</td>
<td>0.046 314 9</td>
<td>9</td>
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<tr>
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<td>0.029 532</td>
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<td>232.883</td>
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<td>0.042 739 4</td>
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<td>240.611</td>
<td>0.043 270 3</td>
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<td>0.036 551</td>
<td>242.325</td>
<td>0.051 359 3</td>
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<td>0.035 869 9</td>
<td>245.071</td>
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<td>0.039 741 1</td>
<td>245.324</td>
<td>0.038 947 3</td>
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</table>

Figure 1(a): cumulative % CBR against max_CBR_distance : node_number 7

Figure 1(b): % cbr for Max_CBR_Dist: node_number 7

2. Node Number 8
Figure 2: % cbr for Max_CBR_Dist: node_number 8
3. Node Number 9

Figure 3: % cbr for Max_CBR_Dist: node_number 9
4. Node Number 10

Figure 4: % cbr for Max_CBR_Dist: node_number 10
5. Node Number 11

Figure 5: % cbr for Max_CBR_Dist: node_number 11
6. Node Number 12

Figure 6: % cbr for Max_CBR_Dist: node_number 12
7. Node Number 13

Figure 7: % cbr for Max_CBR_Dist: node_number 13
8. Node Number 14

Figure 8: % cbr for Max_CBR_Dist: node_number 14
9. Node Number 15

Figure 9: % cbr for Max_CBR_Dist: node_number 15
10. Node Number 16

Figure 10: % cbr for Max_CBR_Dist: node_number 16
11. Node Number 16
Figure 10: % cbr for Max_CBR_Dist: node_number 16

11. Node Number 17

Figure 11: % cbr for Max_CBR_Dist: node_number 17

12. Node Number 18

Figure 12: % cbr for Max_CBR_Dist: node_number 18

13. Node Number 19

Figure 13: % cbr for Max_CBR_Dist: node_number 19

14. Node Number 20

Figure 14: % cbr for Max_CBR_Dist: node_number 20

15. Node Number 21

Figure 15: % cbr for Max_CBR_Dist: node_number 21

16. Node Number 22

Figure 16: % cbr for Max_CBR_Dist: node_number 22

17. Node Number 23

Figure 17: % cbr for Max_CBR_Dist: node_number 23

18. Node Number 24
19. Node Number 25

20. Node Number 26

21. Node Number 27

22. Node Number 28

23. Node Number 29

24. Node Number 30

25. Node Number 31

26. Node Number 32
27. Node Number 33

28. Node Number 34

29. Node Number 35

30. Node Number 36

31. Node Number 37

32. Node Number 38

33. Node Number 39

34. Node Number 40
Figure 34: % cbr for Max_CBR_Dist: node_number 40
35. Node Number 41

Figure 35: % cbr for Max_CBR_Dist: node_number 41
36. Node Number 42

Figure 36: % cbr for Max_CBR_Dist: node_number 42
37. Node Number 43

Figure 37: % cbr for Max_CBR_Dist: node_number 43
38. Node Number 44

Figure 38: % cbr for Max_CBR_Dist: node_number 44
39. Node Number 45

Figure 39: % cbr for Max_CBR_Dist: node_number 45
40. Node Number 46

Figure 40: % cbr for Max_CBR_Dist: node_number 46
41. Node Number 47

Figure 41: % cbr for Max_CBR_Dist: node_number 47
42. Node Number 48
Figure 42: % cbr for Max_CBR_Dist: node_number 48
43. Node Number 49

Figure 43: % cbr for Max_CBR_Dist: node_number 49
44. Node Number 50

Figure 44: % cbr for Max_CBR_Dist: node_number 50
45. Node Number 51

Figure 45: % cbr for Max_CBR_Dist: node_number 51
46. Node Number 52

Figure 46: % cbr for Max_CBR_Dist: node_number 52
47. Node Number 53

Figure 47: % cbr for Max_CBR_Dist: node_number 53
48. Node Number 54

Figure 48: % cbr for Max_CBR_Dist: node_number 54
49. Node Number 55

Figure 49: % cbr for Max_CBR_Dist: node_number 55
50. Node Number 56
4. Conclusion.

This piece of research was aimed at studying a facet of distance coverage, rounded to nearest meter, by packets in ubicomp in situation of MANET transmission over varying Node densities. This work extends from a previous work [26].

More precisely here, a metric Max_CBR_Dist, to assess the trend of maximum hop distance by packets in a ubicomp topography with varying node densities, is developed. The experimental results presented here remain empirical based. The model put forward is the normal distribution model.

The assumptions stated in previous paper [21] hold, e.g. availability of lightweight algorithms for location-aware transmission in mobile environments, lightweight MAUC OS supports for efficient binding/unbinding of MANET nodes and appropriate multi-threading/parallel communication in modules of MANET nodes.

The further work identified may include: trend analyses of parameters of equations for the model, formulating methods of predictability for metric Max_CBR_Dist and its trend and reporting observations of certain critical values identified. The purposes of this metric is also open for refinement together with its applicability in MANET transmission protocols. Development of further sub-component metrics for metric PPD remain desirable.

References

[7] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Investigation of prominence of placements of relays in a ubicomp topography,
[22] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Overall Energy Consumption Fairness Proportion Achievable in MANET Using Location-
Aware Transmission for Ubicomp.


[26] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Distance Traveled by packets in MANETs using Location-Aware Transmission for Ubicomp.


[28] Masagi Inoue, Mikio Hasegawa, Nobuo Ryoki and Hiyoriuki Morikawa, Context-Based Seamless Network and Application Control, 2004

[29] Xiang Song, Umakishore Ramachandran, MobiGo: A Middleware for Seamless Mobility, College of Computing Georgia Institute of Technology, Atlanta, GA, USA, August 2007


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