Model of Range CBR Distance Experienced by Transmissions in MANETs using Location-Aware Transmission for Ubicomp.

M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY

Abstract – Management of energy consumption of nodes in ubicomp can be assisted by location-aware transmission strategies in MANETs [64]. It is hence understandable that several development in this field will follow in the future. Among the developments projected, some refined location-aware transmission protocols may be expected. Such transmission protocols will consider several criteria to achieve successful optimal transmission, one of which is distance coverage required and selection of that protocol which best suit that distance coverage. For advanced ubicomp environment refinements of transmission protocols is projected to be granulated at 10 m accuracy as available in Bluetooth. Hence, even for a ubicomp topography of 300 x 300 m², many different protocols adopted for different distance coverages will be available.

To enable appropriate tuning of transmission in such a situation, it is desirable to know what the range of distance coverage that is being required for the CBR is and proactively activate the appropriate protocols. Such kinds of information will be based on known trends of occurrences of ranges for CBR in such topographies.

Three previous studies [26-28] had been carried out over which results for this study is built over. This paper adds a fourth component derived from 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 designing more successful proactive activations of appropriate transmission protocols in ubicomp. This research is a follow-up of several previous papers [1-28].

Key terms: Ubicomp- Ubiquitous Computing, MAUC- Mobile and Ubiquitous Computing, MANET- Mobile Adhoc Network, PPD- Packets_Per_Distance, Max_CBR_Dist- Maximum CBR Distance, Min_CBR_Dist- Minimum_CBR_Distance, CBR- Constant Bit Rate, R_CBR_Dist – Range_CBR_Distance.

1. Introduction

Energy consumption in MAUC is predominantly affected by distance coverages. The effect of distance of transmission is very consequent since energy consumption varies proportional to the square of distance coverages by packets [15]. In MANETs, sender node sends packets to its closest “yet unused” neighbour and this process of forwarding to yet unused neighbour is repeated until the receiver node is found. Nodes in ubicomp environment will be mobile and hence topology will be changing dynamically. Hop distances will not be of equal distances for each CBR.

Transmission may carried out using protocols which are optimised corresponding to distance coverage needs. Advanced ubicomp environment may have their transmission protocols granulated at 10 m accuracy (as in Bluetooth). As such it can imply that many protocols need to be activated to satisfy successful transmission needs. This scope of protocols to be activated will be directly concerned with duration of transmission and expected range of distance coverage for a CBR. In this research, the second consideration “expected range of distance coverage” is probed further. The research questions put forward are: “What are the ranges of hop distances experienced by each CBR? What are the observable trends for these ranges of hop distances and how they vary with varying node densities?”

Three preceding pieces of research have been carried out whereby in each, a metric for assessing distance coverages in MANET has been elaborated: PPD [26], Max_CBR_Dist [27] and Min_CBR_Dist [28]. At first glance, the range being looked for is obtained by the difference between Max_CBR_Dist and Min_CBR_Dist and hence results being required would be obtained by comparing the two previous papers [27, 28]. However, the exact correspondence for a Min_CBR_Dist value and Max_CBR_Dist value for each CBR is not obtainable with these 2 papers. As such, the values being required had to be processed separately in the experiments and tabular results generated separately. The results obtained were also of different order. It is also recalled that for Max_CBR_Dist assessment, the % CBR against Max_CBR_Dist was analysed whereas for Min_CBR_Dist, the cumulative % CBR against Min_CBR_Dist was analysed. Hence, comparing two intrinsically different assessment is very difficult and explicit processing and results generation for this study is necessary.
The key contributions of this paper is firstly, the development of a third derived metric R_CBR_Dist, derived from PPD for CBR Packet Per Distance analyses. The definition and rationale of metric R_CBR_Dist is put forward. Secondly, the model of trend is put forward for the metric R_CBR_Dist with results for varying node densities from 7 until 56 in a topography of 300 x 300 m$^2$. The model proposed is the normal distribution model. The rest of this paper is organised as follows: section 2- New Derived Metric – Minimum_CBR_Distance, section 3- R_CBR_Dist Trend Assessment over Varying Node Numbers, 4- Conclusion and References.

2. New Derived Metric – Minimum_CBR_Distance.

Following definition of PPD [26], Max_CBR_Dist [27] and Min_CBR_Dist [28], R_CBR_Dist is defined as

$$R_{CBR\_Dist} = Max_{CBR\_Dist} - Min_{CBR\_Dist}$$

MANET routes may vary during a CBR transmission. Here also, it is envisageable that value “0” for metric R_CBR_Dist may be obtained, corresponding to the following scenarios:

i. A sender transmitted directly to the receiver, being closest and both were immobile.

ii. A short duration CBR obtaining MANET nodes where each node is at the same distance from the previous node in the MANET route as the sender and first relay node. All nodes concerned are immobile. This possibility remains of extremely low probabilities.

The results of this study will serve same purposes as described in previous paper [26]. An additional purpose it can serve will be deciding the range of protocols that will be needed to be proactively enabled for a CBR for a sender and each of the CBR MANET Route nodes.


3.0 Major Observations.

Here, the plots for node numbers 7 until 56 are quite scattered but the normal distribution is clearly visible.

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

At first glance, the plots resemble those in previous paper [27] for corresponding node numbers but as depicted in the parameter values, they are different.

Overall, the trend of the plots have fairly followed normal distribution of the form:

$$F(x) = \frac{1}{\sqrt{2\pi}} e^{-(x-c)^2/2a^2}$$

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

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), G→ Corresponding figure number.

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3.2 Graphical Plots for Results Obtained.

This analysis is performed in gnuplot in Linux. x-axis distance is in meters.

1. Node Number 7

![Figure 1: % CBR against Range distance: node_number 7](image1)

2. Node Number 8

![Figure 2: % CBR Range distance: node_number 8](image2)

3. Node Number 9

![Figure 3: % CBR Range distance: node_number 9](image3)

4. Node Number 10

5. Node Number 11

![Figure 4: % CBR Range distance: node_number 10](image4)

6. Node Number 12

![Figure 5: % CBR Range distance: node_number 11](image5)

7. Node Number 13

![Figure 6: % CBR Range distance: node_number 12](image6)

8. Node Number 14

![Figure 7: % CBR Range distance: node_number 13](image7)

![Figure 8: % CBR Range distance: node_number 14](image8)

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

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Figure 1: % CBR against Range distance: node_number 7

Figure 2: % CBR Range distance: node_number 8

Figure 3: % CBR Range distance: node_number 9

Figure 4: % CBR Range distance: node_number 10

Figure 5: % CBR Range distance: node_number 11

Figure 6: % CBR Range distance: node_number 12

Figure 7: % CBR Range distance: node_number 13

Figure 8: % CBR Range distance: node_number 14
Figure 8: % CBR Range distance: node_number 14

9. Node Number 15

Figure 9: % CBR Range distance: node_number 15

10. Node Number 16

Figure 10: % CBR Range distance: node_number 16

11. Node Number 17

Figure 11: % CBR Range distance: node_number 17

12. Node Number 18

Figure 12: % CBR Range distance: node_number 18

13. Node Number 19

Figure 13: % CBR Range distance: node_number 19

14. Node Number 20

Figure 14: % CBR Range distance: node_number 20

15. Node Number 21

Figure 15: % CBR Range distance: node_number 21

16. Node Number 22
Figure 16: % CBR Range distance: node_number 22
17. Node Number 23

Figure 17: % CBR Range distance: node_number 23
18. Node Number 24

Figure 18: % CBR Range distance: node_number 24
19. Node Number 25

Figure 19: % CBR Range distance: node_number 25
20. Node Number 26

Figure 20: % CBR Range distance: node_number 26
21. Node Number 27

Figure 21: % CBR Range distance: node_number 27
22. Node Number 28

Figure 22: % CBR Range distance: node_number 28
23. Node Number 29

Figure 23: % CBR Range distance: node_number 29
24. Node Number 30
Figure 24: % CBR Range distance: node_number 30
25. Node Number 31

Figure 25: % CBR Range distance: node_number 31
26. Node Number 32

Figure 26: % CBR Range distance: node_number 32
27. Node Number 33

Figure 27: % CBR Range distance: node_number 33
28. Node Number 34

Figure 28: % CBR Range distance: node_number 34
29. Node Number 35

Figure 29: % CBR Range distance: node_number 35
30. Node Number 36

Figure 30: % CBR Range distance: node_number 36
31. Node Number 37

Figure 31: % CBR Range distance: node_number 37
32. Node Number 38
Figure 32: % CBR Range distance: node_number 38
33. Node Number 39

Figure 33: % CBR Range distance: node_number 39
34. Node Number 40

Figure 34: % CBR Range distance: node_number 40
35. Node Number 41

Figure 35: % CBR Range distance: node_number 41
36. Node Number 42

Figure 36: % CBR Range distance: node_number 42
37. Node Number 43

Figure 37: % CBR Range distance: node_number 43
38. Node Number 44

Figure 38: % CBR Range distance: node_number 44
39. Node Number 45

Figure 39: % CBR Range distance: node_number 45
40. Node Number 46
Figure 40: % CBR Range distance: node_number 46

41. Node Number 47

Figure 41: % CBR Range distance: node_number 47

42. Node Number 48

Figure 42: % CBR Range distance: node_number 48

43. Node Number 49

Figure 43: % CBR Range distance: node_number 49

44. Node Number 50

Figure 44: % CBR Range distance: node_number 50

45. Node Number 51

Figure 45: % CBR Range distance: node_number 51

46. Node Number 52

Figure 46: % CBR Range distance: node_number 52

47. Node Number 53

Figure 47: % CBR Range distance: node_number 53

48. Node Number 54
CBRs in a ubicomp topography with varying node densities, has been developed. The experimental results here are simulation based and hence remain empirical. The model put forward here for % CBR against \( R_{\text{CBR\_Dist}} \) 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 \( R_{\text{CBR\_Dist}} \) 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 proactive activations of MANET transmission protocols. Development of other sub-component metrics derived from metric PPD remain desirable.

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4. Conclusion.

This piece of study was aimed at studying yet another facet of distance coverages, rounded to nearest meter, experienced by CBRs in ubicomp using location-aware transmission strategies over varying node densities. This research results extends from previous research [26-28]. Though the topic of results here is directly derived after computing results of 2 previous papers [27, 28], a separate set of processing and plotting has been required.

More precisely here, a metric \( R_{\text{CBR\_Dist}} \), to assess the trend of range of distance coverages experienced by

![Figure 48: % CBR Range distance: node_number 54](image)

![Figure 49: % CBR Range distance: node_number 55](image)

![Figure 50: % CBR Range distance: node_number 56](image)
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