

# Trend Analyses of Critical Values Obtained for Minimum CBR Distance Achievable in Ubicomp MANETs Using Location-Aware Transmission Strategies.

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**Abstract** – Pervasive computing constitute of many sub fields including location-tracking, ubicomp functionalities and MANET transmission strategies, which are stressed to serious research [1-59]. Albeit these efforts, their merging still has a long way to go before fruitfully materialising. More precisely here, the enforcement of location-aware transmission strategies is prospected to enhance energy management in ubicomp. Such enhancements expected [1] englobes improvements in location accuracy and refresh rates, the application of land-based GPS systems, development of better protocols optimised for transmission according to distance criteria and refining the precision of the distance criteria to apply the protocol. The learning of distance coverages by transmitted packets in ubicomp environments and corresponding variations over different node densities, is unquestionably advantageous for polishing transmission protocols in MANETs. One clear cut empirical study was conducted formerly [28] in which the metric Minimum CBR Distance, Min\_CBR\_Dist, was elaborated. This was strengthened by a study [44] where trends of parameters of equations for metric Min\_CBR\_Dist were analysed.

In this paper, the next level of probing is put as: “What are the observable critical values in Min\_CBR\_Dist trends? What are the trends of variation observable within each critical value for metric Min\_CBR\_Dist over varying node densities?” Designers will utilise these output towards producing augmented “realistic” ubicomp scenarios for future ubicomp tools.

This study remains a follow-up of previous studies [1-58].

**Key terms:** Ubicomp- Ubiquitous Computing, MAUC-Mobile and Ubiquitous Computing, Min\_CBR\_Dist-Minimum CBR Distance, CBR- Constant Bit Rate, MANET-Mobile Adhoc Network, CV- Critical Value.

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## 1. Introduction

It is supposed that for a considerable era in the future, many ubicomp environments may be having scanty network resources as one of the many heterogeneities they may suffer. Other determining differences include

accuracy level of distance measurement, location refresh rates and performance characteristics of existing protocols. For environments with poor networking supports, MANETs will be the most welcome solution. Moreover, the performance features of MANETs, more particularly energy consumption features, may be ameliorated with location-aware transmission. The angle of metrics analysis in ubicomp remains a primordial method of studying distance coverage attributes. One corresponding metric was developed in a prior paper [28] in which metric Min\_CBR\_Dist was put forward as following the exponential distribution:

$$F(x) = a * \exp ( b * ( x - c ) ) + d$$

The related follow-up study [44] was conducted to mathematically model the four parameters of equation observed above. Results will be subservient towards more proper understanding of the evolution and predictability of ubicomp environments. There are slowly ensuing progresses in this direction which will seemingly allow designers to produce more realistic scenarios for simulations, based on which more beneficial test cases can be conducted over experimental components for middleware and communication protocols.

The analysis hence wished for metric Min\_CBR\_Dist is the identification of observable critical values obtained during experiments execution and formulation of relative theoretical trend of such CVs over varying node densities. Two such CVs were observed.

The key contribution of this paper is the derivation of the trends of variations for each of the two CVs observed for metric Min\_CBR\_Dist elaborated formerly [28, 44] over node numbers ranging from 7 until 56. Such classification of information must obligatorily be made available in a conducive format to more successfully assist designers in understanding the evolution and predictability of ubicomp behaviour and be conveniently equipped to carry out reliable simulation scenarios testing of novel communication components. The rest of this paper is organised as follows: section 2- Min\_CBR\_Dist Critical Values, section 3- Critical Values Trend Analyses- Metric Min\_CBR\_Dist, section 4- Conclusion and References.

## 2. Min\_CBR\_Dist Critical Values.

### 2.0 Critical Values Identified.

Two CVs were identified as follows: Column headings are: C1→Min\_CBR\_Dist CV, C2→Meaning of Min\_CBR\_Dist CV, C3→Corresponding figure number for Min\_CBR\_Dist CV.

C1	C2	C3
1	% CBR at smallest distance	1
2	Largest distance noted	2

Table 1: Min\_CBR\_Dist Critical Values

### 2.1 Experimental Critical Values Obtained.

The values obtained during experiments have been summarised below. Values have been rounded to a maximum of 9 decimal places. Column heading NN → Node Number.

NN	CV1	CV2
7	92.222222222	111
8	95.813435212	111
9	96.158730159	111
10	95.984126984	60
11	95.984126984	60
12	96.136724960	60
13	97.158730159	60
14	97.317460317	60
15	97.238095238	60
16	97.238095238	60
17	96.666666667	38
18	96.666666667	38
19	96.746031746	38
20	96.666666667	38
21	97.444444444	44
22	97.523809524	44
23	97.603174603	44
24	97.539682540	44
25	97.539682540	44
26	97.190476190	35
27	97.269841270	35
28	97.269841270	35
29	96.952380952	35
30	97.031746032	35
31	96.873015873	32
32	96.952380952	32
33	97.047619048	32
34	97.047619048	32
35	97.047619048	32
36	96.968253968	32
37	97.777424988	28
38	97.777777778	28
39	97.857142857	28
40	97.857142857	28
41	97.936507937	28
42	97.857142857	28
43	98.253968254	28
44	98.252858958	28
45	98.333333333	28
46	98.333333333	28
47	98.333333333	28
48	98.333333333	28
49	98.412698413	28
50	98.968253968	22
51	98.968253968	22
52	99.047619048	22

53	98.968253968	22
54	99.047619048	22
55	99.047619048	22
56	99.047619048	22

Table 2: Experimental Critical Values Obtained

## 3. Critical Values Trend Analyses- Metric Min\_CBR\_Dist.

### 3.0 General Procedure Adopted.

The procedure adopted here consist of four steps:

- The tabulated data for each Min\_CBR\_Dist CV is plotted onto gnuplot.
- Graphical analyses are performed and general observations are noted.
- Different equations of fit are tried. Criteria of value of least reduced chi-square and most appreciable extendability produced at node numbers 80, 100 and 120 for both CVs.
- The parameter values for each Min\_CBR\_Dist CV equation are noted.

### 3.1 Trend Analysis – Min\_CBR\_Dist CV1.

The plots depict a small oscillation with decreasing amplitude perceived along an axis with increasing tendency. The applicable equation is

$$F(x) = a * x^{-1.5} * \sin((b*x)+c) + d*x + f$$

Ch\_sq = 0.261 418      F(80) = 100.398 264  
 F(100) = 101.543.....      F(120) = 102.758 573

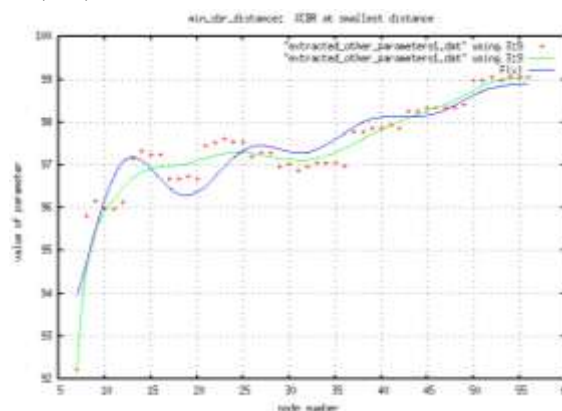


Figure 1: Min\_CBR\_Dist Critical Value 1

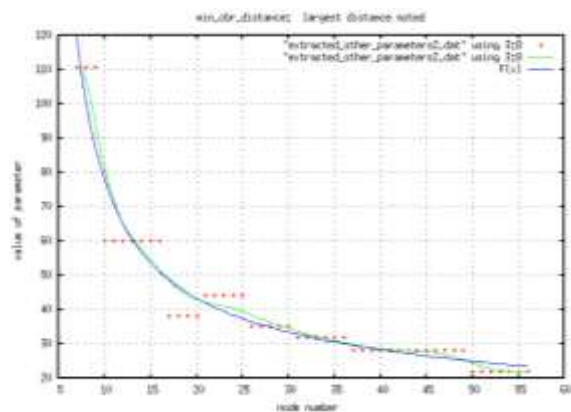
The projected values beyond node number 56 tend to be greater than 100%, which is nonsensical. It is safe to say that beyond node number 56, the CVs lie between 99 and 100, possibly asymptotically increasing.

Other equations attempted gave ch\_sq values greater than 0.45 and hence were rejected. The parameters obtained for best fit are:

$$a = 38.621 2, b = -0.483 786, c = 1.675 58, d = 0.059 723 4, f = 95.586 8$$

### 3.2 Trend Analysis – Min\_CBR\_Dist CV2.

Here, a curve with decreasing tendency at a decreasing rate is observed.



**Figure 2: Min\_CBR\_Dist Critical Value 2**

The potentially applicable equations are:

1.  $F(x) = ((a*x) + f) / (\exp((b*x) + c) + d)$   
 $Ch\_sq = 39.9527$        $F(80) = 18.805047552$   
 $F(100) = 16.056292410$        $F(120) = 13.832243524$
2.  $F(x) = ((a*x^2) + f) / (\exp((b*x) + c) + d)$   
 $Ch\_sq = 38.643$        $F(80) = 13.154$   
 $F(100) = 7.858$        $F(120) = 4.414$
3.  $F(x) = ((a*x^{1.5}) + f) / (\exp((b*x) + c) + d)$   
 $Ch\_sq = 39.3021$        $F(80) = 15.95$   
 $F(100) = 11.572$        $F(120) = 8.17$

#### Choice of best fit for Min\_CBR\_Dist Critical value 2

The equation in part 1 above has been selected because of more smooth extendability even if ch\_sq is not least.

The parameters for best fit are:

$a = 0.0870458$ ,  $b = 0.0103923$ ,  $c = -1.06248$ ,  $d = -0.355979$ ,  $f = 1.26702$

## 4. Conclusion.

This work of further empirical analysis, though with few novel outputs, was aimed at identifying the relevant CVs observable for metric Min\_CBR\_Dist and scrutinise their corresponding trends over varying node densities in a MANET topography of 300 x 300 m<sup>2</sup>. The models portrayed in this paper, consist of quite complex mathematical equations. The output delivered here will reinforce the existing tools for better studies of MANETs for ubicomp environments from the viewpoint of software engineering. These output may be admissibly incorporated into computational algorithms to produce better simulation scenarios which will consequently serve for enabling more refined testing methodologies over communication and middleware components.

This experiment was carried out in NS-2 over Linux. Attempts for plottings and “Fit” were done with

gnuplot. Choice of best fit was based on values of least reduced chi-square and most acceptable extendability produced at higher node numbers for both CVs. Assumptions stated earlier [28, 44] are continued here.

This study is positioned as a follow-up of prior studies [1-59]. The results extended here are open for future upgrades. One possible future work identified remains the formulation of predictability for metric Min\_CBR\_Dist and its trend.

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