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

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Abstract – **Many sub-fields concerned with ubicomp, like location-tracking, ubicomp functionalities and MANET transmission strategies, are being put to serious research [1-58]. However, their merging still is far from being fruitfully reached. Specifically, the enforcement of location-aware transmission strategies is hoped to enhance energy management in ubicomp. The enhancements being expected include [1] improvements in location refresh rates and accuracy, 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 understanding of distance coverages by transmitted packets in ubicomp environments and corresponding variations over different node densities, is undeniably gainful for refining transmission protocols in MANETs. One distinct empirical study was carried previously [27] in which metric Maximum CBR Distance, Max_CBR_Dist, was devised and probed in. This was succeeded by the study of trends of parameters of equations for metric Max_CBR_Dist [43].**

In this paper, the next level of probing is put as: "What are the observable critical values in Max_CBR_Dist trends? What are the trends of variation observable within each critical value for metric Max_CBR_Dist over varying node densities?" Designers will use the output presented here, towards deriving augmented "realistic" ubicomp scenarios for future ubicomp tools.

This piece of research stands as a follow-up of previous investigations [1-58].

Key terms: Ubicomp- Ubiquitous Computing, MAUC-Mobile and Ubiquitous Computing, Max_CBR_Dist-Maximum CBR Distance, CBR- Constant Bit Rate, MANET-Mobile Adhoc Network, CV- Critical Value.

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1. Introduction

For quite long in the future, ubicomp topographies are expected to experience serious heterogeneities, especially as concerns accuracy level of distance measurement, location refresh rates, performance characteristics of existing protocols and amounts of networking devices installed. For the latter case, if resources for networking is very sparse and of low capacity, the solution will lie in MANETs. The performance of MANETs, more notably energy consumption features, may be improved with location-aware transmission. The perspective of metrics in ubicomp remains one of the methods of studying distance coverage characteristics. One such metric was introduced before [27] whereby behaviour of metric Max_CBR_Dist was portrayed as following the Normal Distribution of form:

$$F(x)=b*(1/(a*sqrt(2*pi)))*exp(-(x-c)^2/2*a*a)$$

The corresponding follow-up study [43] was carried out to mathematically model the three parameters of equation observed above. Results will indubitably serve towards better understanding of the evolution and predictability of ubicomp environments. There are progresses occurring in this direction, though not as rapidly as desired, and these will better allow designers towards producing more realistic scenarios for simulations, based on which more precise test cases can be executed over experimental components for middleware and communication protocols.

The investigation henceforth desirable for metric Max_CBR_Dist is the identification of observable critical values obtained during experiments execution and formulation of corresponding theoretical trend of such CVs over varying node densities. Four such CVs were observed.

The key contribution of this paper is the formulation of the trends of variations for each of the four CVs observed for metric Max_CBR_Dist explained previously [27, 43] over node numbers ranging from 7 until 56. Such types of information must mandatorily be presented in a well structured format so as to unimpedingly assist designers to understand the evolution and predictability of ubicomp behaviour and be adequately equipped to carry reliable simulation scenarios testing of novel communication features. The rest of this paper is organised as follows: section 2- Max_CBR_Dist Critical Values, section 3- Critical Values Trend Analyses- Metric Max_CBR_Dist, section 4- Conclusion and References.

2. Max_CBR_Dist Critical Values.

2.0 Critical Values Identified.

Nine CVs were identified as follows: Column headings are: C1→Max_CBR_Dist CV, C2→Meaning of Max_CBR_Dist CV, C3→Corresponding figure number for Max_CBR_Dist CV.

C1	C2	C3
1	% CBR at peak value	1
2	% CBR with x-coordinate < peak value	2
3	% CBR with x-coordinate > peak value	3
4	Max_CBR_Distance that 95% CBR reach up to	4

Table 1: Max_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	CV3	CV4
7	1.555555556	59.603174603	38.841269841	282
8	1.560012735	59.710283349	38.729703916	283
9	1.428571429	39.269841270	59.301587302	285
10	1.507936508	29.126984127	69.365079365	285
11	1.380952381	44.523809524	54.095238095	285
12	1.589825119	54.260731320	44.149443561	296
13	1.507936508	81.031746032	17.460317460	296
14	1.507936508	43.507936508	54.984126984	295
15	1.666666667	46.031746032	52.301587302	298
16	1.380952381	33.952380952	64.666666667	303
17	1.269841270	46.269841270	52.460317460	303
18	1.587301587	74.126984127	24.285714286	303
19	1.507936508	78.492063492	20.000000000	303
20	1.349206349	43.000000000	55.650793651	303
21	1.428571429	62.365079365	36.206349206	299
22	1.428571429	68.206349206	30.365079365	304
23	1.714285714	39.873015873	58.412698413	306
24	1.349206349	46.507936508	52.142857143	308
25	1.349206349	65.825396825	32.825396825	312
26	1.666666667	65.873015873	32.460317460	314
27	1.507936508	70.873015873	27.619047619	314
28	1.507936508	53.206349206	45.285714286	314
29	1.507936508	47.380952381	51.111111111	314
30	1.507936508	41.492063492	57.000000000	314
31	1.587301587	48.730158730	49.682539683	314
32	1.428571429	70.158730159	28.412698413	314
33	1.507936508	68.650793651	29.841269841	314
34	1.428571429	54.603174603	43.968253968	314
35	1.460317460	54.174603175	44.365079365	314
36	1.349206349	46.111111111	52.539682540	314
37	1.508175901	90.315923162	8.175900937	314
38	1.587301587	56.190476190	42.222222222	315
39	1.507936508	33.968253968	64.523809524	317
40	1.587301587	33.095238095	65.317460317	320
41	1.666666667	42.301587302	56.031746032	319
42	1.587301587	41.666666667	56.746031746	322
43	1.507936508	61.190476190	37.301587302	319
44	2.303049555	59.593392630	38.103557814	319
45	1.507936508	59.682539683	38.809523810	317
46	1.746031746	60.079365079	38.174603175	318
47	1.428571429	63.809523810	34.761904762	318
48	1.507936508	79.920634921	18.571428571	320
49	1.428571429	73.412698413	25.158730159	322
50	1.666666667	58.412698413	39.920634921	323
51	1.428571429	64.523809524	34.047619048	323
52	1.507936508	48.888888889	49.603174603	321
53	1.746031746	43.015873016	55.238095238	323
54	1.587301587	57.777777778	40.634920635	323
55	1.349206349	36.031746032	62.619047619	322
56	1.587301587	57.460317460	40.952380952	321

Table 2: Experimental Critical Values Obtained

3. Critical Values Trend Analyses- Metric Max_CBR_Dist.

3.0 General Procedure Adopted.

The procedure adopted consist of breaking the work required into four stages as follows:

i. Plot the tabulated data for each Max_CBR_Dist CV onto gnuplot.
ii. Graphical analyses are performed and general observations are noted.
iii. Different equations of fit are noted. For all CVs, best fit is chosen based on values of least reduced chi-square and most acceptable extendability at node numbers 80, 100 and 120.
iv. The parameter values for each Max_CBR_Dist CV equations are noted.

3.1 Trend Analysis – Max_CBR_Dist CV1.

The plots depict a very mildly increasing tendency with a tolerance limit of ± 0.1 (very small).

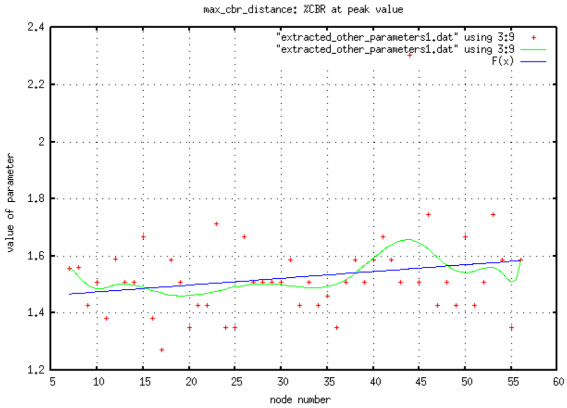

Figure 1: Max_CBR_Dist Critical Value 1

The applicable equation is: `F(x) = d*x + f`

Ch_sq = 0.023 702 2   F(80) = 1.641 058 526

F(100)= 1.688 682 466   F(120)= 1.736 306 406

Parameters of best fit are: d = 0.002 381 2 , f= 1.450 56

3.2 Trend Analysis – Max_CBR_Dist CV2.

The plots here are quite scattered but overall a mild increase is perceived.

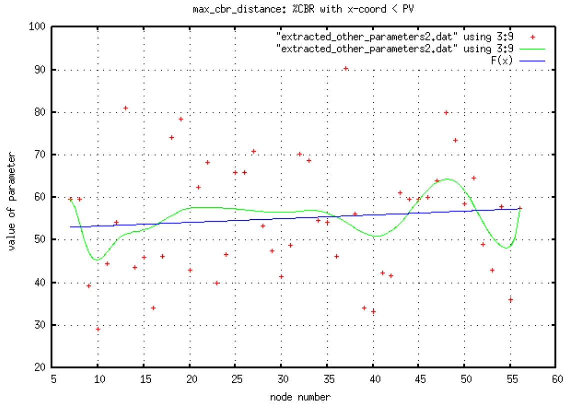

Figure 2: Max_CBR_Dist Critical Value 2

The applicable equation is: `F(x) = d*x + f`

Ch_sq = 199.305 F(80) = 59.445 777 855

F(100)= 61.210 823 108 F(120)= 62.975 868 362

Parameters of best fit are: d= 0.088 252 3 , f= 52.385 6

Predicted values may be subject to tolerance of ± 25

3.3 Trend Analysis – Max_CBR_Dist CV3.

The plots here are quite scattered but overall, a mild decrease is visible. The plot is closely related to CV 2.

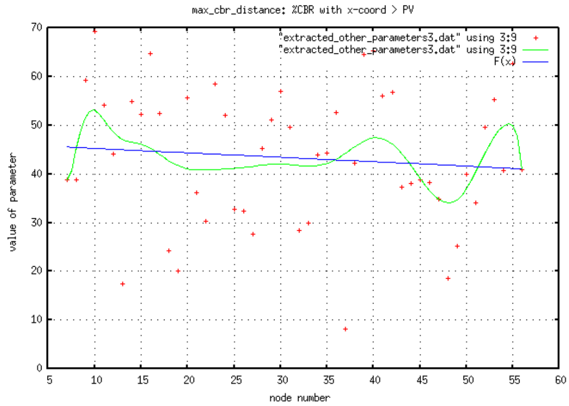

Figure 3: Max_CBR_Dist Critical Value 3

The applicable equation is: `F(x) = d*x + f`

Ch_sq = 199.417 F(80) = 38.913 163 617

F(100)= 37.100 494 424 F(120)= 35.287 825 231

Parameters of best fit are: d= -0.090 633 5 , f= 46.163 8

Predicted values may be subject to tolerance of ± 20

3.4 Trend Analysis – Max_CBR_Dist CV4.

The plots depict an increasing tendency at a decreasing rate. Some staircase features are observed due to rounding off of distance values.

The potentially applicable equations are:

1. `F(x)= a * log ((b*x) + c) + d`

   Ch_sq = 5.870 03 F(80) = 329.910 734 899

   F(100)= 333.799 355 886 F(120)= 336.953 832 213

2. `F(x)= a * log ((b*x) + c) + (d*x)`

   Ch_sq = 5.324 38 F(80) = 324.132 113 899

   F(100)= 323.358 918 897 F(120)= 321.282 940 355

3. $F(x) = a*x^{-1} * \log((b*x) + c) + d$

   Ch_sq =5.178 01 F(80) = 324.915 488 619

   F(100)= 326.421 172 003 F(120)= 327.447 143 756

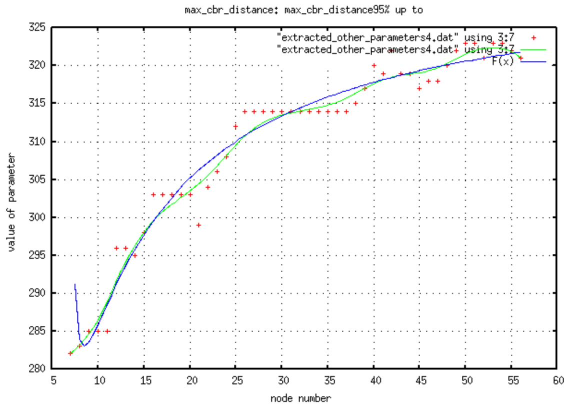

Figure 4: Max_CBR_Dist Critical Value 4

Choice of best fit for Max_CBR_Dist CV4

The equation in part 3 above has been selected because of smallest ch_sq and good extendability over larger node numbers. The parameters obtained for best fit are: a= -55.800 1 ,b = 1 772.45 ,c = -13 004.1 ,d = 333.122

4. Conclusion.

This work of scrutiny was targeted at determining the relevant CVs observable for metric Max_CBR_Dist and analyse their corresponding trends over varying node densities in a MANET topography of 300 x 300 m^2. The models depicted in this paper, are formulated with mathematical equations of quite complex levels. The output articulated here will join to the amount of existing tools for more proper studies of MANETs for ubicomp environments as portrayed from software engineering perspective. These output can judiciously be implemented into software methods to produce better simulation scenarios which will in turn 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. The preference for best fit was based on values of least reduced chi-square and most conforming extendability produced at higher node numbers for all the four CVs observed. Assumptions expounded in earlier papers [27, 43] are upheld here also.

This study remains a follow-up of previous studies [1-58]. The results presented here remain open for future upgrades. One possible future work identified remains the formulation of predictability for metric Max_CBR_Dist and its trend.

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