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Trend Analyses of Parameters of Equations for Minimum CBR Distance Achievable in Ubicomp MANETs Using Location-Aware Transmission.

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Abstract **– Use of MANET transmission approaches symbolise a key towards solving the problem of sparsely available network and routing equipment in ubicomp environments, which is expected to be the case for many future environments specially outdoor ones. Good performance of MANET directly depends on correctly designed protocols and research is well on the way in this direction [79]. The adaptation of location-aware transmission strategies is prone to augment energy management standards and justifies all the effort put in by researchers. Among the technological enrichments looked forward in the future, the application of land-based GPS systems, improved location refresh rates and accuracy, development of fine-tuned transmission protocols and cheaper sophisticated hardware, are most awaited. Available scientific knowledge of trends of distance coverages by transmitted packets in a ubicomp over varying node densities, is undeniably favourable for refining transmission protocols in MANETs. Correspondingly, one such empirical study was carried out in a previous paper [28], whereby metric Min_CBR_Dist was explained.**

In this paper, the next piece of investigation required for metric Min_CBR_Dist is put forward as: "What are the trends of variation observable within each parameter of the equation of curves obtained for metric Min_CBR_Dist [28] over varying node densities?". The results presented here remain utilisable by designers for better developing ubicomp transmission protocols. This piece of research remains a follow-up of previous work [1-43].

Key terms: Ubicomp- Ubiquitous Computing, MAUC-Mobile and Ubiquitous Computing, MANET- Mobile Adhoc Network, CBR- Constant Bit Rate, Min_CBR_Dist – Minimum CBR Distance.

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1. Introduction

Ubicomp topographies may not all be sophisticatedly equipped with networking and routing devices. Many such topographies, specially outdoor ones and those in lesser developed regions, may be poorly equipped. It is also expected that, since ubicomp inherits from distributed systems, it will still be subject to lots of inherent heterogeneities [1]. MANET transmission may also be having such heterogeneities in their operating protocols. Nevertheless, MANET transmission remain a favourable choice for poor topographies. It remains possible to enhance MANET transmission with incorporation of location-aware transmission features. Methods of studying distance related characteristics experienced by CBRs in ubicomp may also be built from metrics. One such metric, Min_CBR_Dist was studied previously [28], whereby pattern followed was expressed as exponential model of form:

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

Here, the moderately complex equation of the model has involved 4 parameters: a, b, c and d. the next empirical formulation required for metric Min_CBR_Dist is the model equations for parameters of equation specified above.

The key contributions of this paper is the development of equations involved for the model for metric Min_CBR_Dist presented previously [28], from which table 1 is re-used here. The empirical methods provided here remain usable by designers and programmers, to be implemented into software simulators so that these can be further empowered for advanced investigations of the evolution and predictability of distance features in future ubicomp. The rest of this paper is organised as follows: section 2- Parameter Trend Analysis- Metric Min_CBR_Dist, section 3- Conclusion and References.

2. Parameter Trend Analysis – Metric Min_CBR_Dist.

2.0 General Procedure Adopted.

The procedure adopted consist of 4 steps:

i. The tabulated data for each parameter of the equation for the model for Min_CBR_Dist is plotted onto gnuplot.
ii. Graphical analyses are performed and general observations are noted.

iii. Different equations of fit are tried. Criteria of value of least reduced chi-square and most appreciable extendability at node numbers 80, 100 and 120.

iv. The parameter values for each Min_CBR_Dist parameter of equation is noted.

2.1 Trend Analysis – Min_CBR_Dist parameter "a".

Generally the tendency observed is a decreasing trend at a decreasing rate. A small oscillation along this trend is also depicted. However, the oscillation is of negligible amplitude. The plot at node number 7 appears as an outlier and different results may be obtained for trend, if reworked with different starting values of parameters.

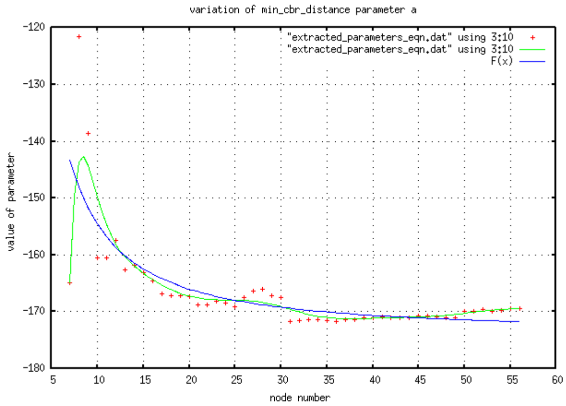

Figure 1: Min_CBR_Dist parameter a

The potentially applicable equations of trend are :

1. $F(x) = (a/x) * \log(b * x) + c$

   Ch_sq = 32.748 7 F(80) = -173.898

   F(100)= -174.534 559 F(120)= -174.966 459

2. $F(x) = (a * x^{-1.5}) * \log(b*x) + c$

   Ch_sq = 31.746 9 F(80) = -172.484 578

   F(100)= -172.792 915 F(120)= -172.984 049

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

   Ch_sq = 32.435 1 F(80) = -172.335 116

   F(100)= -172.618 633 F(120)= -172.792 926

Choice of best fit for Min_CBR_Dist Parameter a

The equation in part 2 above has been selected because of smallest ch_sq and good extendability over larger node numbers. The parameters obtained for best fit are:

a = 113.292 , b = 20.602 , c = -173.657

2.2 Trend Analysis – Min_CBR_Dist parameter "b".

Generally, the plots depict a decreasing tendency. A slight non-uniform oscillation is also depicted and a few plots appear as outliers.

The equation of best fit is:

$F(x) = a * x + b$

Ch_sq= 0.000 465 458 F(80)= -0.207 555 245

F(100) = -0.260 474 F(120)= -0.313 392 767

The parameters of fit are :

a = -0.002 645 94 , b = 0.004 119 8

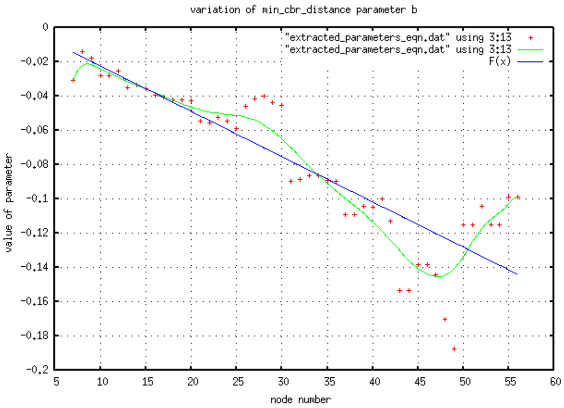

Figure 2: Min _CBR_Dist parameter b

2.3 Trend Analysis – Min _CBR_Dist parameter "c".

Generally the plot depicts an increasing tendency at a decreasing rate. The plot for node number 7 appears as an outlier.

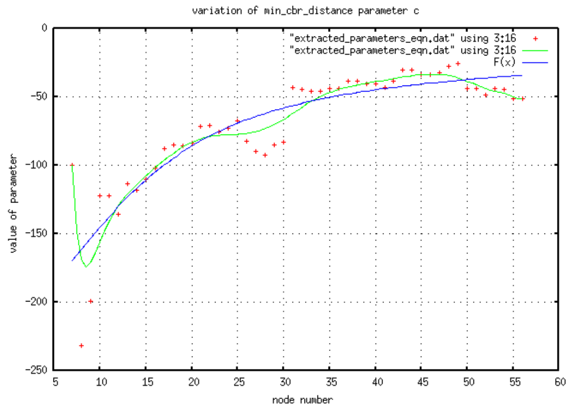

Figure 3: Min _CBR_Dist parameter c

The potentially applicable equations of trend are:

1. $F(x) = ((a * x^{2})/(\exp((b * x^{h}) + c))) + f * x^{-1} * \log(x)$

   Ch_sq = 415.844 F(80) = -25.836 324

   F(100) = -21.717 133 F(120)=-18.813 776 037

2. $F(x) = ((a * x^{3})/(\exp((b * x^{h}) + c))) + f * x^{-1} * \log(x)$

   Ch_sq = 429.191 F(80) = -18.484

   F(100) = -13.112 886 F(120) = -9.712 348

3. $F(x) = ((a * x^{4})/(\exp((b * x^{h}) + c))) + f * x^{-1} * \log(x)$

   Ch_sq = 426.716

Choice of best fit for Min_CBR_Dist parameter c

The equation in part 1 above has been selected because of both smallest reduced chi-square value obtained and good extendability. The parameters for best fit are:

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a = -1.927 19 , b = 0.515 555 , c = -1.480 59 , f = -471.572 , h = 0.784 663 .

2.4 Trend Analysis – Min _CBR_Dist parameter "d".

The plot depicts an early rapidly increasing tendency reaching a maximum point after which the curve depicts a smoothly decreasing tendency.

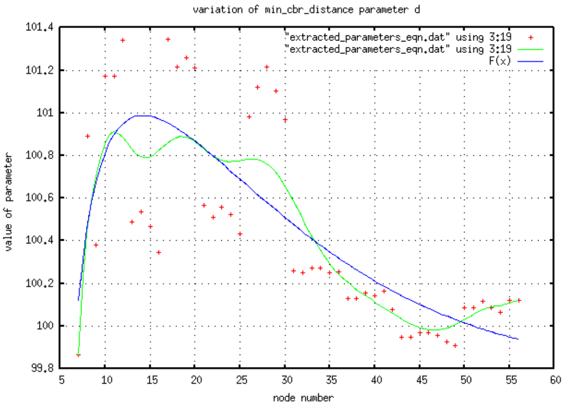

Figure 4: Min _CBR_Dist parameter d

The potentially applicable equations are:

1. $F(x)= ((a*x+f)/(exp((b*x)+c)))+d$

   Ch_sq = 0.097 689 5 F(80) = 99.848 642

   F(100) = 99.835 076 F(120) = 99.832 552

2. $F(x)=((a*x^{-2}+f)/(exp((b*x)+c)))+d$

   Ch_sq = 0.097 160 1 F(80) = 99.687 830

   F(100) = 99.598 580 F(120) = 99.554 372

3. $F(x)=((a*x^{-3}+f)/(exp((b*x)+c)))+d$

   Ch_sq = 0.099 963 5 F(80) = 99.234 648

   F(100) = 98.807 891 F(120) = 98.428 515

4. $F(x)=((a*x^{-2}+f)/(exp((b*x^{1.5})+c)))+d$

   Ch_sq =0.096 139 5 F(80) = 99.804 774

   F(100) = 99.783 585 F(120) = 99.779 752

Choice of best fit for Min_CBR_Dist parameter d

The equation in part 4 above has been selected because of both smallest reduced chi-square value obtained and good extendability. The parameters for best fit are:

a = -2.732 57 , b = 0.006 143 03 , c = -3.423 6 , d = 99.779 1 , f = 0.068 283 2

3. Conclusion.

This work of further empirical analysis was designed to and has supplied applicable models of trends of the parameters of equations for the metric Min_CBR_Dist in a MANET topography of 300 x 300 m^2. The models detailed here, encompass mathematical equations of varying complexity. Such theoretical information may impel refined development of processing algorithms for simulator packages for the purpose of advanced studies of MANETs. This empirical research was conducted in gnuplot. Values of least reduced chi-square and best extendability produced at higher node numbers have been used as criteria for selecting best fit.

The sound assumptions made in previous paper [28] are applied here also. The capability and accuracy level of gnuplot is deemed as adequate for the purpose of this investigation.

Additional work identified here remain: formulating a suitable method of predictability for metric Min_CBR_Dist and its trend and reporting specific observations of pertinent critical values highlighted.

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