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

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Abstract – **Managing energy consumption in ubicomp remains a significant topic of research. To assist in this issue, MANET transmission may be prone to future successes [74]. Despite all development of strategies for energy containment in MANETs, including application of location-aware transmission, it is still true that the software engineering notion of modelling in ubicomp is in its embryonic phases. Energy management is crucial because of constrained battery power of ubicomp nodes and its cost implications. A prior study was carried out [23] to quantify and model the Minimum Fairness Proportion (Min_FP) recordable for CBRs for node densities of 7 until 56. The corresponding model was perceived to be the decreasing exponential model.**

In this paper, the next level of investigation is set forth as: "What are the trends of variation observable within each parameter of the equation of curve obtained for metric Min_FP [23] over varying node densities?"

Studying the behaviour of components of applicable models for metric Min_FP and successively model the observed pattern for each component mathematically is a commendable task since it will involve lots of effort and especially tough disagreement resolution among researchers. The results put forward will assist ubicomp specialists in better understanding MANET features and prepare algorithmic support for energy management in ubicomp architectures. Specially adapted battery design and hardware surrogates may also follow. This paper is a follow-up of previous work [1-38].

Key terms: Ubicomp- Ubiquitous Computing, MAUC- Mobile and Ubiquitous Computing, MANET- Mobile Adhoc Network, CBR- Constant Bit Rate, Min_FP- Minimum Fairness Proportion.

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1. Introduction

Ubicomp environments may suffer from poorly equipped networking devices and hence MANETs remain a hopeful solution for future ubicomp environments. Energy consumption load is repartitioned among cooperative nodes in ubicomp. Following this type of arising collective operation, the criteria of Fairness must be well comprehended. Fairness may be viewed from several angles or metrics value. One such viewpoint was studied previously [23], whereby the behaviour of metric Min_FP was elicited. The trend followed in that paper was the decreasing exponential equation of form:

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G(x) = a * exp ( b * ( x – 0.1 )) + c
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Here, the equation of the model has involved 3 parameters: a, b and c. The next study required for metric Min_FP is the formulation of model equations for the parameters of the equation mentioned above.

The key contributions of this paper is the development of the trend of variation for each parameter of the equations involved in the model for metric Min_FP presented in a preceding paper [23], whose table 1 is referred to in this paper also. The mathematical procedures extended here may be inserted as an algorithm into software simulators, thus providing a utility for designers to more fruitfully study the progression and predictability of ubicomp characteristics and hence progress future ubicomp architecture. The rest of this paper is organised as follows: section 2- Parameter Trend Analysis- Metric Min_FP, section 3- Conclusion and References.

2. Parameter Trend Analysis – Metric Min_FP.

2.0 General Procedure Adopted.

The first step is to plot the tabulated data for each parameter of the equations for the model for Min_FP on gnuplot. The second step is to accomplish graphical analyses and report general observations. The third step is to explore the applicability of some selected equations of fit. Choice of best fit is made considering values of least reduced chi-square and most commendable extendability produced at node numbers 80 and 100. The fourth step is to record the values of parameters for each Min_FP parameter of equation.

2.1 Trend Analysis – Min_FP parameter "a".

Generally the curve shows increasing tendency at slowly decreasing rate. The curve does not tend

towards flattening enough to depict logarithmic trend. A slight oscillation is also noticed but is not consistent throughout and hence has been neglected.
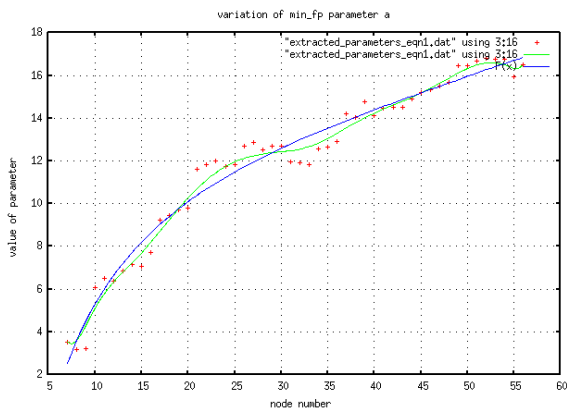

Figure 1: Min_FP parameter a

The potentially applicable equations of trend are:

1. `F(x) = a * x * exp (b*x) + c * x`$^{0.5}$
   Ch_sq = 0.613 726   F(80) = 16.365 5
   F(100) = 15.120 598
2. `F(x) = a * x * exp (b*x`$^{0.5}$`) + c*x`$^{0.5}$
   Ch_sq = 0.560 912   F(80) = 16.974 22
   F(100) = 16.351 227
3. `F(x) = a * x * exp (b*x`$^{0.5}$`)+c*x`$^{0.5}$`+d`
   Ch_sq = 0.460 783   F(80) = 20.349 4
   F(100) = 23.23

Choice of best fit for Min_FP parameter a

The equation in part 3 above has been selected because of both smallest reduced chi-square value obtained and good extendability. The parameters for best fit are:
a = 5.714 16 , b = -0.536 204 , c = 3.771 33 , d = -17.159 7

2.2 Trend Analysis – Min_FP parameter "b".

Generally the curve shows decreasing tendency at a slowly decreasing rate. Again, a non-uniform oscillation is noticed but is more complicated to accommodate and is hence neglected.
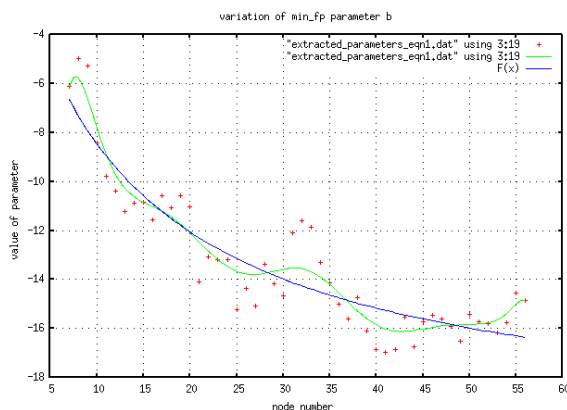

Figure 2: Min_FP parameter b

The potentially applicable equations of trend are:

1. `F(x) = (a*x)/log ((b*x)+c)`
   Ch_sq = 1.525 95
2. `F(x) = (a * x`$^{1.5}$` )/log ((b*x)+c)`
   Ch_sq = 1.408 56   F(100) = -12. ……
   Note: curve increases drastically after some time
3. `F(x) = (a * x)/log ((b*x)+c)+d`
   Ch_sq = 1.522 17   F(80) = -17.396 67
   F(100)=-17.931 414

Choice of best fit for Min_FP parameter b

The equation in part 3 above has been selected because it has better extendability feature even if the ch_sq value is not smallest. The parameters for best fit are:

a =-0.003 084 34, b =0.000 146 133, c =1.001 81, d = 1

2.3 Trend Analysis – Min_FP parameter "c".

Generally the curve depicts a general increasing tendency despite the scattered plots. Here also, an inconsistent non-uniform and small oscillation is visible but is neglected since the y-axis intervals are already very small.
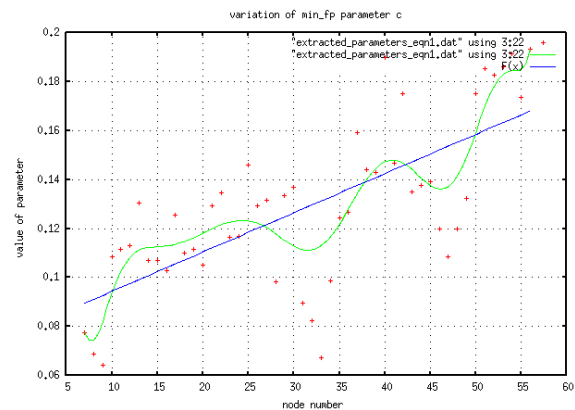

Figure 3: Min_FP parameter c

The applicable equation here is
   `F(x) = d * x + f`
   Ch_sq = 0.000 572 429   F(80) = 0.206 619
   F(100) = 0.238 696 959

The parameters for best fit are:
   d = 0.001 603 88 , f = 0.078 308 6

3. Conclusion.

This investigation was targeted at and has achieved the establishment of applicable models of trends of the parameters of equations for the metric Min_FP in a MANET topography of 300 x 300 m^2. These models, illustrated as mathematical equations of varying complexity levels, will enable further study of MANETs for MAUC environments from a software engineering approach. Such development may then help in formulating computational algorithms to be fed

into simulators for further studies of MANETs. This experiment was undertaken in NS-2 over linux. The plottings and "fit" attempts were conducted in gnuplot. Criteria for selecting best fit have been reduced chi-square values and best extendability of equations attained.

The credible assumptions mentioned in previous paper [23] are carried forward in this paper too. Gnuplot is justly assumed as sutiable for the scope of this study.

Further work identified remain: formulating methods of predictability for metric Min_FP and its trend and reporting observations of certain critical values identified.

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