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Trend Analyses of Parameters of Equations for Maximum Energy Consumption Ratio Achievable in Ubicomp MANETs Using Location-Aware Transmission.

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Abstract – **Location-tracking, ubicomp functionalities and MANET transmission strategies are subject to quite promising research [36-72]. It still remains a fact that the area of modelling in ubicomp to assess predictability features is at its beginning stages. The sub-field of energy management is especially important since in present technology level, battery power is still considered constrained. Previously, a research was carried out to quantify and model the maximum ratio of energy consumption (Max_R) recordable for a CBR gauged against the energy consumed by the sender, for node densities of 7 until 56. The corresponding model was observed to be linear previous to the peak value and decreasing exponential as from the peak value onwards.**

In this paper, the next milestone of probing is put forward as: "What are the trends of variation observable within each parameter of the equations of curves obtained for metric Max_R [20] over varying node densities?"

Studying the behaviour of components of applicable models for metric Max_R and accordingly model the behaviour of each component mathematically is of paramount importance since it will involve tremendous efforts and discord resolution among various researchers. The outcome put forward will assist designers towards better understanding of ubicomp and provision hardware and algorithmic tactics into ubicomp architecture for enhanced energy management. This paper is a follow-up of previous research [1-35].

Key terms: Ubicomp- Ubiquitous Computing, MAUC-Mobile and Ubiquitous Computing, MANET- Mobile Adhoc Network, CBR- Constant Bit Rate, ECR- Energy Consumption Ratio, Max_R- Maximum Ratio.

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1. Introduction

MANETs remain a promising solution to unplentiful resource availability in ubicomp. In MANETs, energy consumption load is distributed among all nodes present in the topography. The method of distribution remains ponderously influenced by node density. A former study [20] was endeavoured towards finding the trends observable for metric Max_R for node densities ranging from 7 until 56. The model suggested in that paper [20] was split into three:

- For node numbers 7 until 25, the exponential model has been observed of form:
  `G(x)= a * exp(b*(x - 1.0))+c`
- For node numbers 26 onwards, previous to the peak value observed, the tendency is linear of form:
  `F(x) = d * x + f`
- For node numbers 26 onwards, as from the peak value onwards, the tendency is exponential of form:
  `G(x)= a * exp(b * (x - 2.0)) + c`

Here, the equations of the model have involved 6 parameters: a, b, c, d, f and k. The next analysis required for metric Max_R is the formulation of model equations for the parameters of the equations mentioned above.

The key contributions of this paper is the settling of the trend of variation for each parameter of the equations involved in the model for metric Max_R presented in former paper [20] whose tables 1(a) and 1(b) are re-utilised here. The mathematical methods derived here may possibly be programmed into software simulators and provide an additional utility for designers to better understand the evolution and predictability of ubicomp characteristics to assist in equipping future ubicomp architecture. The rest of this paper is organised as follows: section 2- Parameter Trend Analysis- Metric Max_R, section 3- Conclusion and References.

2. Parameter Trend Analysis – Metric ECR.

2.0 General Procedure Adopted.

The tabulated data for each parameter of equations of model for Max_R is plotted on gnuplot. Graphical analyses are conducted and general observations are reported and various equations of fit are tried. Choice of best fit was made firstly based on chi-square value. Secondly, for parameters b, d and f most likely extendability at node numbers 80 and 100 is sought; for parameter 'a', extendability at node numbers 100 and

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150 is considered. Finally, the values of parameters for each Max_R parameter of equation is noted.

2.1 Trend Analysis – Max_R parameter "a".

The curve obtained shows a decreasing trend with decreasing rate of decrease.

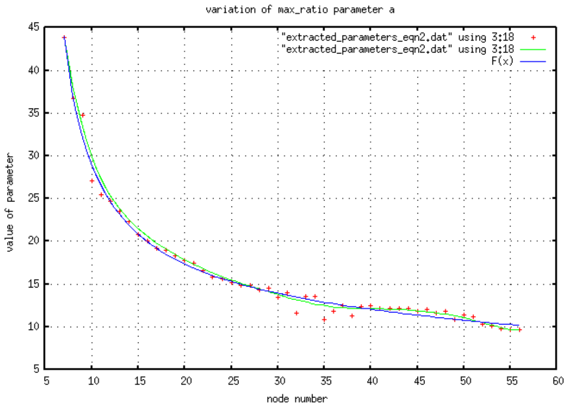

Figure 1: Max_R parameter a

The potentially applicable equations are:

1. $F(x) = (a*x^2+f)/(\exp((b*x)+c)+d)$

   Ch_sq = 0.677 346 F(100) = 4. …….

   F(150) = 1.19…..

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

   Ch_sq = 0.613 511 F(100)=7.047 411 235

   F(150)=4.817 554 527

Choice of best fit for Max_R parameter a

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

a = 0.386 479 , b = 0.011 277 6 , c = 1.059 97 , d = -2.991 43 , f = 3.097 67

2.2 Trend Analysis – Max_R parameter "b".

Generally the curve depicts an increasing tendency with decreasing rate until about node number 20, after which (mostly) a straight line with a small positive gradient is observed.

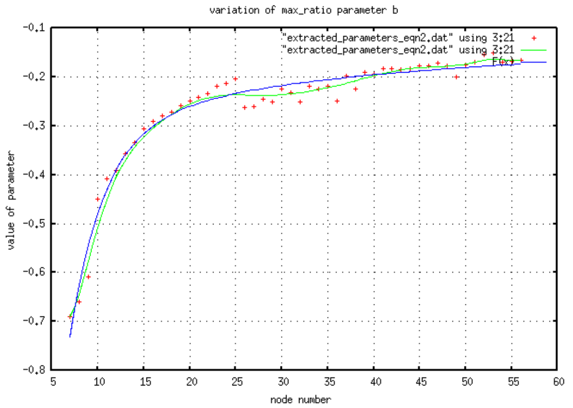

Figure 2: Max_R parameter b

The equation of best fit is:

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

Ch_sq = 0.000 500 F(80) = -0.152 118 551 5

F(100) = -0.140 335 3

The parameters obtained for best fit are:

a = -2.655 35 , b = -0.283 551 , c = -0.740 97 , d = -0.361 317

2.3 Trend Analysis – Max_R parameter "c".

The curve depicts a damped oscillation.

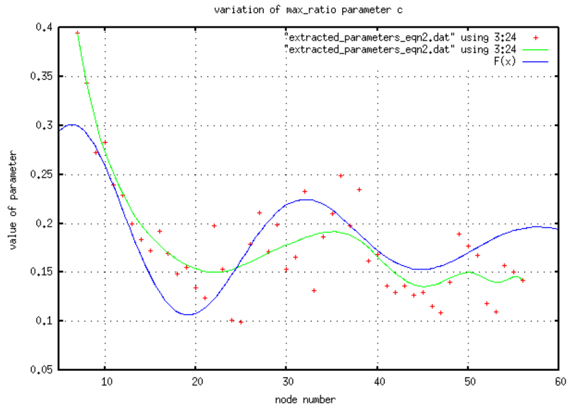

Figure 3: Max_R parameter c

The problem faced in this particular situation is that the "fit" command in gnuplot conflicts with an internal file. The manual attempt has however been quite convincing. The result remains open for further refinement here.

$F(x) = a * \exp(-b*(x-7)) * \cos(2*pi*(x-7)*b) + c$

The parameters obtained for best fit are: a = 0.12 , b = 0.039 , c = 0.18

2.4 Trend Analysis – Max_R parameter "d".

The curve obtained from a very sparse plotting, depicts a very slight decreasing linear trend.

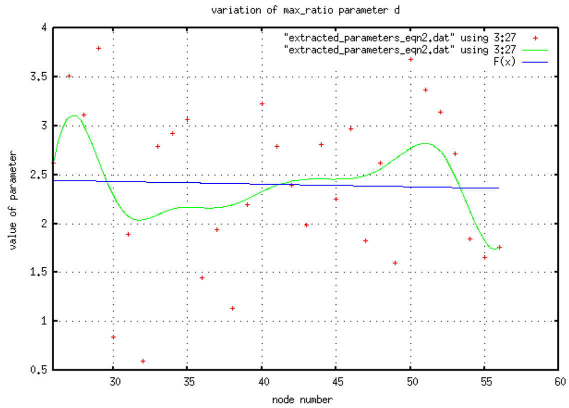

Figure 4: Max_R parameter d

The equation of best fit is:

$F(x) = d*x + f$

Ch_sq = 0.701 358 F(80) = 2.293 626 35

F(100) = 2.237 912

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The parameters obtained for best fit are: d = -0.002 785 72 , f = 2.516 48

2.5 Trend Analysis – Max_R parameter "f".

The curve obtained shows a decreasing trend. The rate of decrease also decreases with increasing node number.

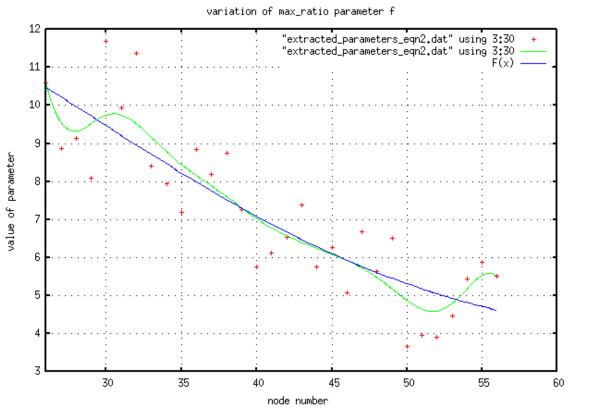

Figure 5: Max_R parameter f

Potentially applicable equations of trend are

1. `F(x)= d * x + f`
   Ch_sq = 1.277 66 F(80) = -0.647 ….
   F(100) = -4.63……..
2. `F(x)= a * exp ( b * x ) + c`
   Ch_sq = 1.276 68
3. `F(x)=a * exp ( b *` x^2 `) + c`
   Ch_sq = 1.248 09
4. `F(x)=a * exp (b *` x^2`) + (c * x)`
   Ch_sq = 1.241 65 F(80) = 3.987 3
   F(100) = 4.68…..
5. `F(x)=a * exp (b*`x^2`)+(c * x) +d`
   Ch_sq = 1.239 83
   Curve increases seriously after some time, i.e. not good for projection.

Choice of best fit for Max_R parameter f

The equation in part 4 above has been selected because of better extendability even if ch_sq is not smallest. Parameters for best fit are:

a = 14.119 4 , b= -0.000 622 13 , c= 0.046 549 2 .

2.6 Trend Analysis – Max_R parameter "k".

Parameter k is the integer value from where G(x) starts. The curve obtained depicts mostly a staircase diagram with increasing tendency. This is so because value of k is measured to nearest integer and hence accuracy requirements for trend observation is not fully appropriate. The solution adopted here is to derive value of k obtained from equation and round it off before being used.

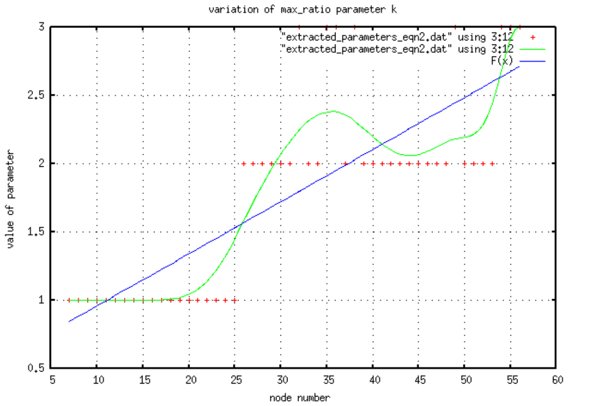

Figure 6: Max_R parameter k

The equation of best fit is:

`F(x) = d*x + f`

Ch_sq = 0.195 944

The parameters obtained for best fit are: d = 0.038 175 3 , f = 0.577 479

3. Conclusion.

This piece of probing was intended to and has developed the applicable models of trends of the parameters of equations for the metric Max_R in a MANET topography of 300 x 300 m^2. The models have been founded with quite complex mathematical equations. These will certainly support in studying MANETs for MAUC environment from a software engineering notion, together with formulating computational algorithms to be incorporated into simulators for appropriate studies of MANET. This experiment was run in NS-2 over linux. The plottings and "fit" attempts were practised in gnuplot. Criteria used for evaluating best fit stay the smallest reduced chi-square values and most recommendable extendability of equations obtained.

Assumptions stated in previous paper [20] are carried forward in this paper also. Correctness of gnuplot and its accuracy features are assumed as good, even if it generated a conflict for Max_R parameter 'c'. Solving this problem over more sophisticated mathematical software is desirable.

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

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