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

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Abstract – **A good future lies ahead as concerns research related to location-tracking, ubicomp functionalities and MANET transmission strategies [34-70]. Despite all present level progresses, the area of modelling in ubicomp to assess predictability features is being tackled by few researches and is hence still considered in its embryonic stages. One particular sub-area is energy considerations in ubicomp coupled by the fact that battery power is still considered constrained. A previous research was carried out to quantify and model the ratio of energy consumption for each node over 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 asymptotically decreasing exponential as from the peak value onwards.**

In this paper, the next level of research investigation is put forward as: "What are the trends of variation observable within each parameter of the equations of curves obtained for metric ECR [18] over varying node densities?"

The need for studying the behaviour of components of an applicable model for metric ECR and correspondingly model the behaviour of each component mathematically is required since it involves lots of efforts and conflict resolution between different researchers. Results obtained will assist designers towards better understanding of ubicomp and provision hardware, software and algorithmic support for ubicomp architectures. This paper is a follow-up of previous research [1-33].

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

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1. Introduction

MANET transmission is considered as a solution to poor resource availability in ubicomp. It does affect the distribution of energy consumption in ubicomp environment [2]. This feature is heavily influenced by node density. A previous study [18] was aimed at finding the trends observable for metric ECR for varying node densities of 7 until 56. The model suggested in that paper [18] was split into two:

- A straight line F(x) from left of the graph towards right until a peak value (at around ECR value 0.3)
  `F(x) = d*x + f`
- As from the peak value, the trend is smoothly exponentially decreasing towards asymptotic to the x-axis
  `G(x) = a * exp ( b * ( x -c ))`

Here, the equations of the model have involved five parameters: a, b, c, d and f. The next achievement in this research for metric ECR is to study the mathematical modelling of the parameters of the equations elicited above and accordingly deriving the model of variation of each parameter.

The key contributions of this paper is the establishment of the trend of variation for each parameter of the equations involved in the model for metric ECR presented in previous paper [18]. Re-use of tabular data in Table 1 in that paper [18] covering node numbers 7 until 56, is carried out here. The mathematical methods produced here may be programmed into software simulators and provide a tool for designers to better understand the evolution and predictability of ubicomp features to assist in provisioning of future ubicomp needs. The rest of this paper is organised as follows: section 2- Parameter Trend Analysis- Metric ECR, section 3- Conclusion and References.

2. Parameter Trend Analysis – Metric ECR.

2.0 General Procedure Adopted.

The tabulated data for each parameter of equation of model for ECR is plotted on gnuplot. Graphical analyses using the "fit" command is performed supported by the smooth bezier plot. For each graph obtained, the general observations are reported. Again, various equations of fit are attempted and their summary report is presented for each parameter of metric ECR. In the end, choice is made considering firstly value of least reduced chi-square and secondly on most plausible extendability produced at node

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numbers 80, 100 and 120. Finally, values of parameters for each ECR parameter of equation is also noted.

2.1 Trend Analysis – ECR parameter "a".

The curve depicts a rapid drop from node number 7 until about 14, then shows an increasing tendency towards flattening at about node number 43 and then continues with a slowly decreasing tendency. The curve is not a clean oscillation nor has symmetrical properties. Exponential and logarithmic trends are combined here.

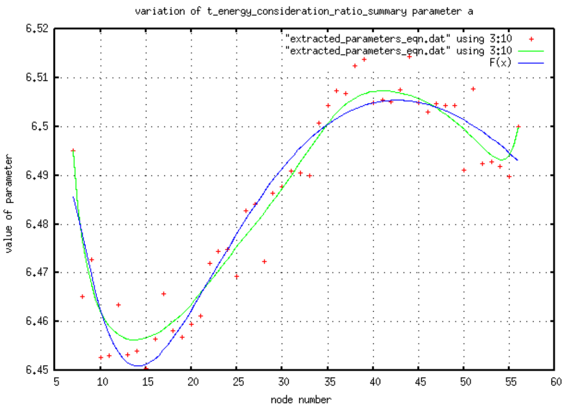

Figure 1: ECR parameter a

A summary of potentially applicable equations of trend is provided below:

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

   Ch_sq = 4.571 46 (e^{-05}) F(80) = 6.461 169 549

   F(100) = 6.418 915 272 F(120) = 6.372 342 420

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

   Ch_sq = 4.110 43 (e^{-05}) F(80) = 6.428 815 497

   F(100) = 6.355 111 966 F(120) = 6.273 719

3. $F(x) = l*x^3 + m * x^2 + n*x + o$

   Ch_sq = 5.233 71 (e^{-05}) F(80) = 6.117 419 8

   F(100) = 5.307 807 F(120) = 3.838 0

4. $F(x) = l*(x-p)^3 + m * (x-p)^2 + n*(x-p) + o$

   Ch_sq = 5.350 02(e^{-05}) F(80) = 6.117 422

   F(100) = 5.307 815 F(120) = 3.838 058

Choice of best fit for ECR parameter a

The equation in part 2 above has been selected because of both smallest reduced chi-square value obtained and good extendability. The parameters for best fit are:

a = 11.972 , b = 77.297 3 , c = -75.653 9 , d = -3.313 17 , f = 32.011 4 , h = 0.036 268 2 , i = 1.647 25 , k = 3.268 36.

2.2 Trend Analysis – ECR parameter "b".

The curve depicts a rapidly increasing value towards reaching a maximum turning point at node number 20 after which a mild shade of damped oscillation with decreasing amplitude spread over wide range of node numbers. Curve does not show symmetrical properties.

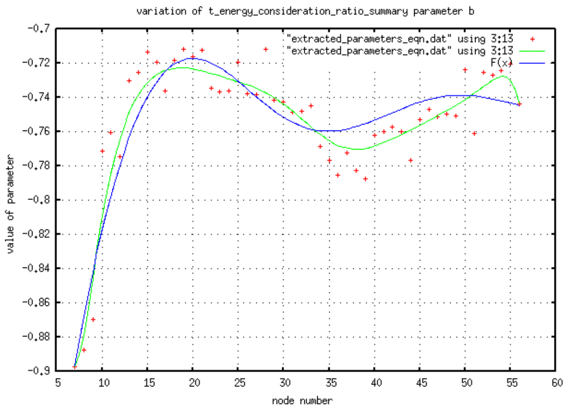

Figure 2: ECR parameter b

A summary of potentially applicable equations of trend is provided below:

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

   Ch_sq = 0.000 908 151 F(80) = -0.726 310 908

   F(100) = -0.788 728 752 F(120) = -0.746 401 523

2. $F(x) = (a/x) * \sin(b*x) + c$

   Ch_sq = 0.000 397 595 F(80) = -0.738 420

   F(100) = -0.753 486 F(120) = -0.752 390 747

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

   Ch_sq = 0.000 358 F(80) = -0.742 766

   F(100) = -0.746 630 8 F(120) = -0.748 413

Choice of best fit for ECR parameter b

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 = -2.820 55 , b = 0.219 344 , c = -0.746 475 , d=-1.505 57

2.3 Trend Analysis – ECR parameter "c".

The curve depicts an oscillation with minimum point at node number 15 and maximum point at node number 41. The curve does not show symmetrical properties.

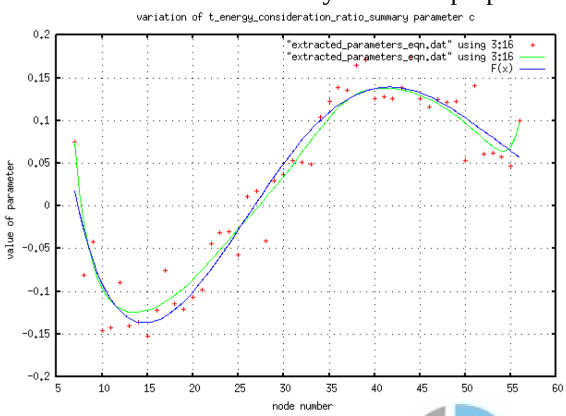

Figure 3: ECR parameter c

A summary of potentially applicable equations of trend is provided below:

1. $F(x) = a*x^3 + b*x^2 + c*x + d$
   Ch_sq = 0.001 382 9
2. $F(x)=a*x^3 +b*x^2+c*x + (d*x)/exp(x)$
   Ch_sq= 0.000 901 577 F(80) = -1.563 695
   F(100) = -5.010 69 F(120) = -11.208 026
3. $F(x)=a*sin (b*x) + d$
   Ch_sq = 0.001 239 68 F(80) = -0.057 833
   F(100) = 0.148 319 F(120) = -0.057 993
4. $F(x)= a * sin (b*(x - c)) + d$
   Ch_sq = 0.001 214 65 F(80) = -0.029 634
   F(100) = 0.145 116 F(120) = -0.096 009 5
5. $F(x)=a * x * sin (b*(x - c)) + d$
   Ch_sq = 0.001 581 81 F(80) = -0.413 238 330
   F(100) = 0.197 394 F(120) = 0.368 505
6. $F(x)=a*log(x) *sin (b*(x - c))+d$
   Ch_sq = 0.001 308 48 F(80) = -0.118 045 820
   F(100) =0.185 035 948 F(120) = -0.073 590
7. $F(x)= (a/x) * sin (b*(x - c))+d$
   Ch_sq = 0.000 840 F(80) = 0.061 816 010
   F(100) = 0.079 216 F(120)= 0.036 205 056
8. $F(x)=a * x^f * sin (b*(x - c))+d$
   Ch_sq = 0.000 851 317 F(80) = 0.064 518
   F(100) = 0.080 213 F(120) = 0.044 621

Choice of best fit for ECR parameter c
The equation in part 7 above has been selected for smallest ch_sq and good extendability. The parameters of best fit are:

a = -3.302 23 , b= 0.127 968 , c=6.264 47 , d= 0.061 361 9

2.4 Trend Analysis – ECR parameter "d".
The curve depicts generally an increasing tendency with some unclean non symmetrical oscillations.

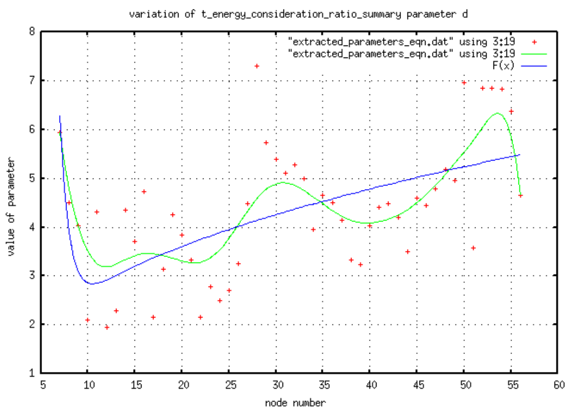

Figure 4: ECR parameter d

A summary of potentially applicable equations of trend is provided below:

1. $F(x)= d * x + f$
   Ch_sq = 1.405 34 F(80) = 6.553
   F(100) = 7.467 F(120) = 8.380 9
2. $F(x)=d * x + (f/x)$
   Ch_sq = 1.261 56 F(80) = 8.164
   F(100) = 10.041 F(120) = 11.942 895
3. $F(x)=a * x + (b/exp(x)) + c$
   Ch_sq = 1.207 62 F(80) = 7.034 015 658
   F(100) = 8.189 198 F(120) = 9.344 381 708
4. $F(x)= a * x + b/(x * exp (c*x^d))$
   Ch_sq = 1.322 17 F(80) = 7.926 667
   F(100) = 9.979 631 957 F(120) = 12.342 619
5. $F(x)=a * x+(b/(x* exp (c*x^d)))+ f$
   Ch_sq = 1.263 29 F(80) = 7.262
   F(100) = 8.540 319 5 F(120) = 9.818 652
6. $F(x)=a * x+b/(exp(x))+ c * log (x)$
   Ch_sq = 1.235 04 F(80) = 6.401 732 374
   F(100) = 7.080 460 367 F(120) = 7.716 057 421

Choice of best fit for ECR parameter d
The equation in part 6 above has been selected even if its reduced ch_sq is not smallest; its extendability is more stable. The parameters of best fit are:

a = 0.022 148 2 , b = 4 469.27 , c=1.056 56

2.5 Trend Analysis – ECR parameter "f".
Generally the curve depicts a decreasing tendency with some slight oscillations. The curve does not show symmetrical properties.

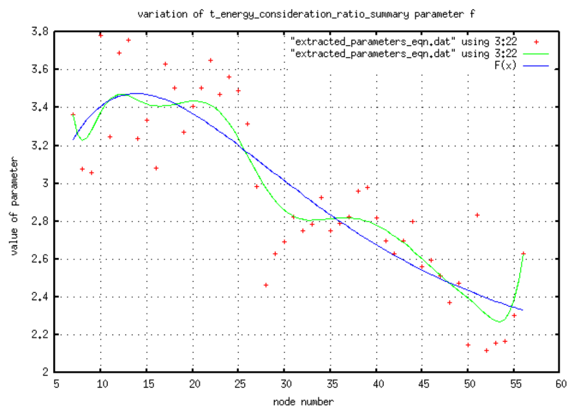

Figure 5: ECR parameter f

A summary of potentially applicable equations of trend is provided below:

1. $F(x)= d * x + f$
   Ch_sq = 0.065 797 5 F(80) = 1.668 744 035
   F(100)= 1.142 174 472 F(120)=0.615 604 908
2. $F(x)= a / exp ((b*x) + c) + d$

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Ch_sq = 0.069 518 6 F(80) = 1.768 888 961
F(100) = 1.341 777 667 F(120) = 0.943 264 949

3. $F(x) = a/\exp((b*x^{0.75})+c) + d$
Ch_sq = 0.072 980 8 F(80) = 1.898 321
F(100) = 1.552 367 555 F(120) = 1.234 098 811

4. $F(x) = (a*x)/\exp((b*x) + c) + d$
Ch_sq = 0.058 059 5 F(80) = 2.125 580 666
F(100) = 2.077 057 266 F(120) = 2.062 519 946

5. $F(x) = ((a*x^{f})+h)/\exp((b*x)+c)+d$
Ch_sq = 0.065 510 5 F(80) = 1.430 777 002
F(100) = 0.832 043 412 F(120) = 0.288 542 710

6. $F(x) = (a*x^{f})/\exp((b*x)+c) + d$
Ch_sq = 0.059 137 F(80) = 2.198 520
F(100) = 2.170 586 F(120) = 2.164 044

Choice of best fit for ECR parameter f

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

a = 0.013 973 , b = 0.072 252 2 , c = -2.992 16 , d = 2.056 79

3. Conclusion.

This piece of research was aimed at and has developed the applicable models of trends of the parameters of equations for the metric ECR in a MANET topography of 300 x 300 m^2. The models put forward comprise of advanced mathematical equations which may assist in studying MANETs for MAUC environment from a software engineering view. The proposed mathematical procedure can be used to formulate computational algorithms to be integrated in software simulators for appropriate studies of MANET evolutions. The experiments here were executed in NS-2 over linux. The plottings and "fit" attempts were carried out in gnuplot. Criteria used for evaluating best fit remain smallest reduced chi-square values and best extendability of equations obtained.

Assumptions stated in previous paper [18] are carried forward here also. The applicability of gnuplot and its accuracy levels for such studies is also assumed as correct.

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

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