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

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Abstract **– The field of management of energy consumption in ubicomp is a serious topic of research. MANET transmission may assist in energy containment in ubicomp [73]. Despite the development of several strategies for energy containment, including application of location-aware transmission, it still subsist that the engineering notion of modelling in ubicomp is in its preliminary phases. Energy management is important due to constrained battery power of present hardware. A preceding investigation was carried out [22] to quantify and model the Energy Consumption Fairness Proportion (ECFP) recordable for CBRs for node densities of 7 until 56. The corresponding model was observed to be a combination of exponential and linear tendencies.**

In this paper, the next milestone of investigation is put forward as: "What are the trends of variation observable within each parameter of the equations of curves obtained for metric ECFP [22] over varying node densities?"

Studying the behaviour of components of applicable models for metric ECFP and successively model the observed behaviour for each component mathematically is very notable as it will consume lots of effort and require durable disagreement resolution among researchers. The results put forward will help designers towards better understanding of ubicomp and prepare algorithmic support for energy management in ubicomp architectures. Specifically adapted battery designs may also follow. This paper is a follow-up of previous research [1-37].

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

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1. Introduction

Due to poor and constantly changing amount of resources available in current ubicomp environments, MANETs remain a plausible solution, whereby energy consumption load distributed among cooperating node in ubicomp. In such a situation, the criteria of Fairness crops up. One such angle for Fairness was studied previously [22], whereby trends for metric ECFP was studied. Trend followed in that paper was split in two:

- Previous to the peak value, trend is linear of form:
  `F(x) = d * x + f`
- From the peak onwards, the trend is exponential:
  `G(x) = a * exp (b * ( x – c ))`

Here, the equations of the model has involved 5 parameters: a, b, c, d and f. The next study required for metric ECFP is the derivation 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 ECFP presented in a preceding paper [22] from which table 1 is re-used here. The mathematical procedures produced here may be programmed into software simulators, producing in turn, a utility for designers to better understand the evolution and predictability of ubicomp characteristics and hence elevate future ubicomp architecture. The rest of this paper is organised as follows: section 2- Parameter Trend Analysis- Metric ECFP, section 3- Conclusion and References.

2. Parameter Trend Analysis – Metric ECFP.

2.0 General Procedure Adopted.

First of all, the tabulated data for each parameter of the equations for the model for ECFP is plotted on gnuplot. Second, graphical analyses are performed and general observations reported. Third, quite some equations of fit are examined. Choice of best fit was made following values of reduced chi-square. For parameters a, b and c, most plausible extendability produced at node numbers 80, 100 and 120. Fourth, the values of parameters for each ECFP parameter of equation is noted.

2.1 Trend Analysis – ECFP parameter "a".

The curve obtained depicts a smoothly decreasing tendency at a decreasing rate. A slight oscillation is also noticed but this is negligible as the scale height of the y-axis is very small.

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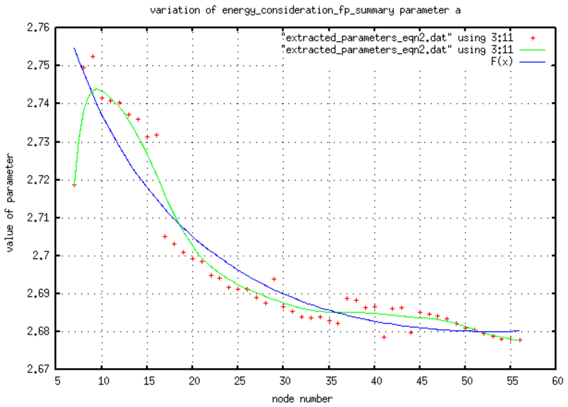

Figure 1: ECFP parameter a

The potentially applicable equations of trend are:

1. $F(x) = a * \exp(b * x + c) + d$
   Ch_sq= 6.417 06(e^{-05}) F(80) = 2.676 807 61
   F(100)=2.676 551 621 F(120) = 2.676 494 021
2. $F(x) = a * x * \exp(b * x + c) + d$
   Ch_sq=6.055 67(e^{-05}) F(80) = 2.699
   F(100) = 2.716 794 F(120)= 2.733 296 013
3. $F(x) = a * x^{0.25} * \exp(b * x + c) + d$
   Ch_sq = 6.780 9(e^{-05}) F(80) = 2.687 123
   F(100) = 2.698 034 4 F(120)= 2.711 261 142
4. $F(x) = a * x^{f} * \exp(b * x + c) + d$
   Ch_sq=7.355 94(e^{-05}) F(80)= 2.681 549 134
   F(100)= 2.688 057 1 F(120)=2.697 034 096

Choice of best fit for ECFP parameter a

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

a = -0.141 342 , b = -0.004 707 45 , c = -0.000 528 06 , d = 2.977 03

2.2 Trend Analysis – ECFP parameter "b".

Here also, the curve depicts a decreasing tendency at a decreasing rate. Again, a negligible amount of oscillation is perceived.

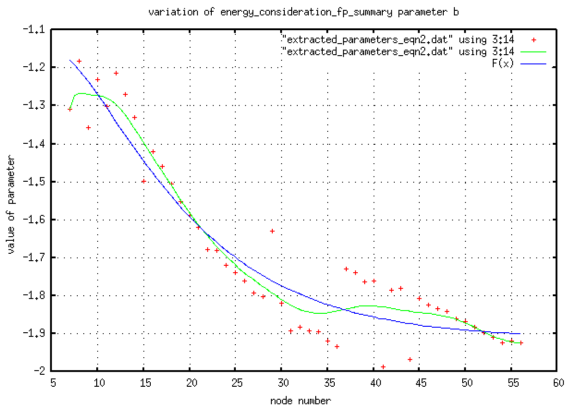

Figure 2: ECFP parameter b

The potentially applicable equations of trend are:

1. $F(x) = a * x^{0.25} * \exp(b * x + c) + d$
   Ch_sq = 0.006 857 98 F(80) = -1.912 354 289
   F(100) = -1.803 366 247 F(120)=-1.704 399 798
2. $F(x) = a * x^{0.5} * \exp(b * x + c) + d$
   Ch_sq = 0.005 609 02 F(80) = -1.912 354 289
   F(100) = -1.913 440 F(120) = -1.913 592 907
3. $F(x) = a * x * \exp(b * x + c) + d$
   Ch_sq = 0.006 131 53 F(80) = -1.743 338
   F(100) = -1.583 198 F(120)= -1.422 996 660
4. $F(x) = a * x^{f} * \exp(b * x + c) + d$
   Ch_sq = 0.006 000 31 F(80) = -1.639 199 749
   F(100) = -1.450 243 F(120)= -1.303 393 228 9

Choice of best fit for ECFP parameter b

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 = 0.607 038 , b = -0.103 882 , c = -0.055 621 1 , d = -1.913 62

2.3 Trend Analysis – ECFP parameter "c".

Mostly the curve depicts a decreasing trend at a decreasing rate. The plot at node number 7 appears to be an outlier.

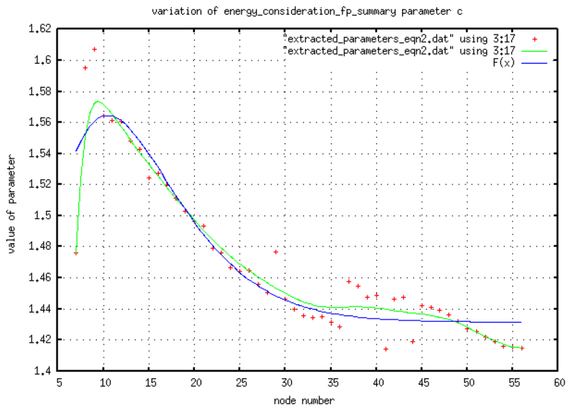

Figure 3: ECFP parameter c

The potentially applicable equations of trend are:

1. $F(x) = a * x^{0.5} * \exp(b * x + c) + d$
   Ch_sq = 0.000 442 521 F(80)=1.416 525 089 960
   F(100) = 1.425 983 160 F(120)=1.441 434 775 741
2. $F(x) = a * x^{0.25} * \exp(b * x + c) + d$
   Ch_sq = 0.000 398 329 F(80) = 1.413 195 107
   F(100)= 1.411 915 564 F(120) = 1.411 585 692
3. $F(x) = a * x^{f} * \exp(b * x + c) + d$
   Ch_sq = 0.000 293 824 F(80) = 1.431 507 188 696
   F(100)=1.431 506 756 110 F(120) = 1.431 506 751 834

Choice of best fit for ECFP parameter c

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 = 0.003 114 8 , b = -0.261 307 , c = 0.087 836 1 , d = 1.431 51

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2.4 Trend Analysis – ECFP parameter "d".

Mostly the curve depicts an increasing trend at a slowly decreasing rate. This is characteristic of logarithmic tendency.

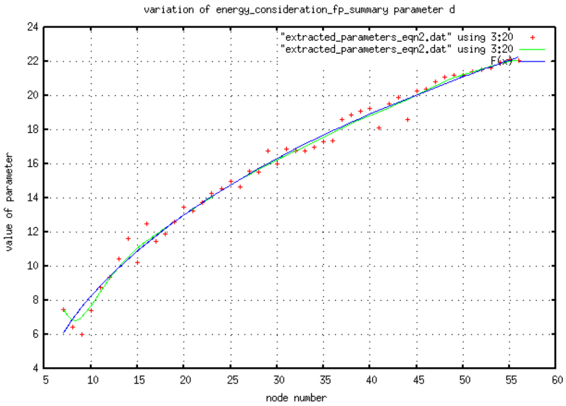

Figure 4: ECFP parameter d

The potentially applicable equations of trend are:

1. F(x) = d * x + f
   Ch_sq = 0.952 923
2. F(x) = a * log (x) + b
   Ch_sq = 0.454 896
3. F(x) = a * $x^{-0.5}$ * log (x) + b
   Ch_sq = 0.421 632
4. F(x) = a * x^{c} * log (x) + b
   Ch_sq = 0.316 184
5. F(x) = a * x^{c} * log (x) + (b*x)
   Ch_sq = 0.318 198
6. F(x) = a * x^{c} * log (x) + (b/x)
   Ch_sq = 0.317 194

Choice of best fit for ECFP 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 = 2.864 87 , b = -1.848 79 , c = 0.183 315

2.5 Trend Analysis – ECFP parameter "f".

The curve depicts a decreasing tendency. The potentially applicable equations of trend are:

1. F(x) = d * x + f
   Ch_sq = 0.050 425 1
2. F(x) = d * x + (f * log (x))
   Ch_sq = 0.41 878 5
3. F(x) = d * x + (f * log (x))+k
   Ch_sq = 0.039 819
4. F(x) = d*x +(f * x * log (x))+k
   Ch_sq = 0.042 243 1
5. F(x) = d * x + (f/log (x)) + k
   Ch_sq = 0.038 506 5

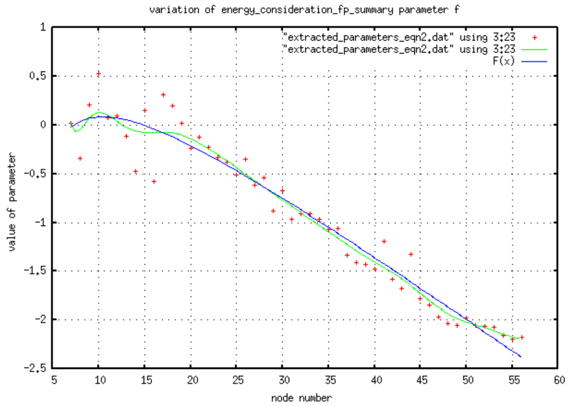

Figure 5: ECFP parameter f

Choice of best fit for ECFP parameter f

The equation in part 5 above has been selected because of smallest reduced chi-square value obtained. The parameters for best fit are:

d = -0.069 836 3 , f = -3.991 63 , k = 2.516 7

3. Conclusion.

This piece of investigation was aimed at and has achieved the development of applicable models of trends of the parameters of equations for the metric ECFP in a MANET topography of 300 x 300 m^2. These models, consisting of mathematical equations of varying complexity levels, will assist in further studying of MANETs for MAUC environment from software engineering perspective. Such development may, in turn, help in formulating computational algorithms to be executed into simulators for further studies of MANETs. This experiment was conducted in NS-2 over Linux. The plottings and "fit" attempts were carried out in gnuplot. Criteria for selecting best fit have been reduced chi-square values and best extendability of equations obtained.

Assumptions stated in former paper [22] are maintained in this paper also. Gnuplot is assumed as suitable for this study.

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

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