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Trend Analyses of Parameters of Equations for Sender Node Extra Energy Savings Achievable in MANET against Direct Node-to-Node Location-Aware Transmission.

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Abstract – **Quite extensive research is ongoing concerning enhancement of Location-Tracking, functionalities and MANET transmission strategies in ubicomp environment [32-68]. Nonetheless, the area of modelling in ubicomp for sustaining behaviour predictability is still in its embryonic stages. One particular sub-area is energy considerations in ubicomp since as of present date devices battery power is still considered constrained. A previous research [16] was carried out to quantify and model the extra energy savings achievable in MANETs against direct node-to-node transmission under different sets of node densities in a ubicomp environment. The corresponding model was put forward as following a normal distribution just as in a previous research [31] for metric OES but with different parameter values.**

In this paper, the next level of question to be investigated is legitimately put forward as: "What are the trends of variation observable within each parameter of the equation of normal curve obtained for metric SLNTNES [16] over varying node densities?"

The need for studying the behaviour of components of an applicable model for metric SLNTNES and successively model the behaviour of each component mathematically is felt required since it will take lots of effort. Results obtained may be put to use by designers to better predict ubicomp behaviour and formulate necessary accompanying architectures. This paper is a follow-up of previous papers [1-31].

Key terms: Ubicomp- Ubiquitous Computing, MAUC-Mobile and Ubiquitous Computing, ES- Energy Savings, SES- Sender ES, OES-Overall ES, SLNTNES- Sender Less Node-to-Node ES, MANET- Mobile Adhoc Network, CBR- Constant Bit Rate.

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1. Introduction

Many factors and successively node density are pertinent factors affecting energy consumption in MAUC amongst others [2]. Following two previous work [14, 15], a third effort [16] was made to find the particular trend/model which depicts the sender node extra energy savings achievable against direct node-to-node transmission in MANET (SLNTNES) compared to the theoretical/empirical models derived in simulations. The model put forward for metric SLNTNES was the normal distribution model of form:

```
F(x)=b*(1/(a*sqrt(2*pi)))*exp(-(x-c)^2/2*a*a)
```

Here also, just like in previous paper [31], the equation of the model involves three parameters: a, b and c. The difference however is that these parameter values are not similar to those in previous paper [31]. The next step in this research for metric SLNTNES is to study the mathematical modelling of the parameters of the equation obtained above and successively 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 equation of the normal distribution model for metric SLNTNES presented in previous paper [16]. The tabular data in Table 1 in that paper [16] covering node number 7 until 56, is reused here. The mathematical methods produced here will assist designers in better understanding the evolution and predictability of ubicomp behaviour in such a way that they may easily be implemented into a software program for future adaptability requirements of ubicomp following varying situations observed. The rest of this paper is organised as follows: section 2- Parameter Trend Analysis- Metric SLNTNES, section 3- Conclusion and References.

2. Parameter Trend Analysis – Metric SLNTNES.

2.0 General Procedure Adopted.

The tabulated data for each parameter of equation of model for SLNTNES is plotted onto gnuplot over Linux. Graphical analysis using smooth bezier support and "fit" command is performed. General observations, for each such graph obtained is reported. Again, various equations of fit are attempted and their summary report is presented for parameters of metric SLNTNES. Ultimately, choice is made considering firstly the value of least reduced chi-square and secondly most plausible extendability produced at node numbers 80, 100 and 120. Finally, the values of parameters for each SLNTNES parameter of equation is also noted.

2.1 Trend Analysis – SLNTNES parameter "a".

Generally the curve depicts a linear trend with only one outlier at node number 7. A slight oscillation is also depicted but is difficult to work with as the y-axis values are very small.

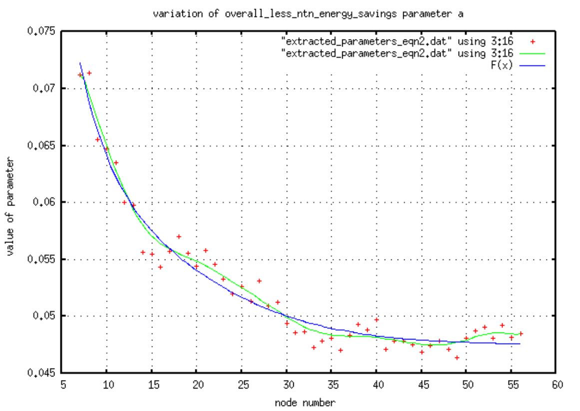

Figure 1: SLNTNES parameter a

The equation of best fit is:

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

Ch_sq = 4.278 27(e^{-06}) F(80) = 0.109 226 914
F(100) = 0.111 013 114 F(120) = 0.112 799 313

The parameters of fit are: d= 8.931(e^{-05}) , f=0.102 082

2.2 Trend Analysis – SLNTNES parameter "b".

A similar curve trend as for SLNTNES parameter 'a' is observable.

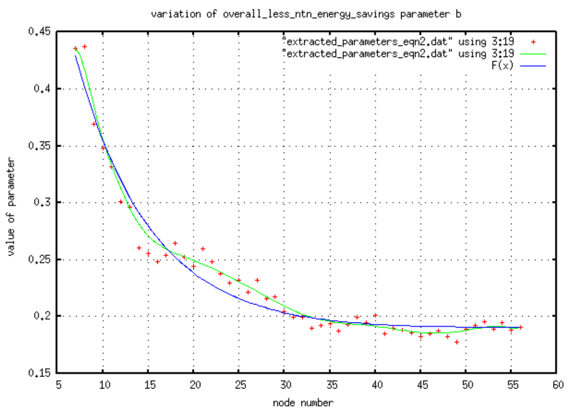

Figure 2: SLNTNES parameter b

Equation of best fit is:

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

Ch_sq = 0.001 260 92 F(80) = 0.929 283 100
F(100) = 0.938 513 F(120) = 0.947 744 689

Parameters of fit are: d = 0.000 461 54 , f = 0.892 36.

2.3 Trend Analysis – SLNTNES parameter "c".

Basically the curve obtained depicts a logarithmic increase and has a tendency to be flattening at high node numbers.

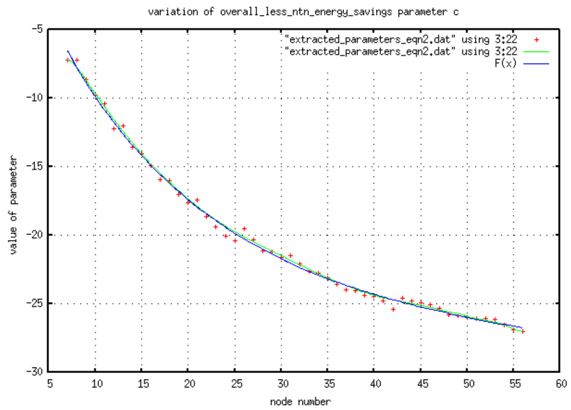

Figure 3: SLNTNES parameter c

The potentially applicable equations are

1. `F(x)= a * log (b*x +c)`

   Ch_sq = 0.052 309 8 F(80) = 31.900 947
   F(100) = 32.277 179 888 F(120) =32.580 070 455

2. `F(x)= (a/x) * log (b*x +c)`

   Ch_sq = 0.016 677 3 F(80) = 30.753 620
   F(100) = 30.571 599 F(120)=30.347 541 812

3. F(x)= $(a/x^{0.1})$ * log (b*x +c)

   Ch_sq = 0.003 624 57 F(80) = 31.202 321 534
   F(100) =31.304 307 990 F(120) =31.365 771 425

4. F(x)= (a/x^{f}) * log (b*x +c)

   Ch_sq = 0.003 428 66 F(80) = 31.138 570
   F(100) =31.211 020 684 F(120)=31.245 885 748

Choice of best fit for SLNTNES parameter c

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= 6.036 25 , b = 63.142 3 , c = -313.23, f = -0.112 981.

3. Conclusion.

This piece of research was aimed at and has developed the models of trends of the parameters of equations for the metric SLNTNES in a MANET topography of 300 x 300 m^2. The models put forward, which are constituted of mathematical equations of varying complexity levels, will assist in studying MANETs for MAUC environment from a software engineering perspective. These mathematical procedure can be used to formulate computational algorithms to be integrated in network simulators for better studying of MANET evolutions. The experiment concerned here was carried out in NS-2 over linux. The plottings and "fit" attempts were carried out in gnuplot. Criteria used for evaluating best fit are reduced chi-square values and best extendability of equations obtained.

Assumptions stated in previous paper [16] hold here also. Gnuplot is also assumed as appropriate in the sense that gnuplot constructs and accuracy levels are not criticised here.

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

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