Trend Analyses of Parameters of Equations for Sender Node Energy Savings Achievable in ubicomp MANETs using Location-Aware Transmission.

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Abstract – Location-Tracking and correspondingly applications on it along with new functionalities are being developed in the field of ubicomp [30-66]. MANET transmission strategies are also subject to research. An area missing in the field of ubicomp is the software engineering approaches of metric development, analysis and modelling for predictability purposes and better gearing of future research investments. The particular area of concern here is energy considerations in ubicomp. A previous research [14] was carried out to assess how much energy savings can be achieved by a sender node in location-aware MANET transmission and the corresponding model was put forward as exponential.

In this paper, the next set of question investigated is legitimately put forward as: “What are the trends of variation observable within each parameter of the exponential equation obtained for metric SES [14] over varying node densities?”

The need for studying the behaviour of components of an applicable model and successively model the behaviour of each component mathematically is felt required since it involves a lot of work and results may be used by designers to better predict ubicomp behaviour and formulate correspondingly better architectures. This paper is a follow-up of previous papers [1-14].

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

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1. Introduction

Many factors affect energy consumption in MAUC [2]. Another pertinent factor is type of transmission; One such type is MANET transmission and correspondingly, the subsequent pertinent factor is node density. An attempt has been made in previous research [14] to find a particular trend/model which depicts energy savings that can be reached by senders in MAUC (SES) to rate the effectiveness of location-

aware MANET transmission strategies compared to the theoretical/empirical models derived in simulations. The model put forward for metric SES was the exponential model of form:

$$F(x) = a * \exp(b * (x-c))$$

Here the equation for this model comprises of three parameters: a, b and c. the next probing that is required is the study of modelling of the parameters of the equation obtained above and successively forming the model of variation for each parameter.

The key contributions of this paper is the establishment of the trend of variation for each parameter of the equation of the model of equation for metric SES presented in previous paper [14] by using the same tabular data presented in that same paper, covering node numbers 7 until 56. Availability of these data will in turn help designers to better understand the evolution and predictability of ubicomp environment in a manner that this understanding may be adapted into a software program for future adaptability requirements of ubicomp following different scenarios possible. The rest of this paper is organised as follows: section 2- Parameter Trend Analysis- Metric SES, section 3- Conclusion and References.

2. Parameter Trend Analysis – Metric SES.

2.0 General Procedure Adopted.

The tabulated data for each parameter of equation of model for SES is plotted onto gnuplot and analysed graphically with support from smooth bezier plot. General observations, for each such graph obtained is reported. Several equations of fits have been attempted and a summary is reported for each SES parameter of equation. Ultimately, choice has been based firstly on least reduced chi-square value and secondly on most plausible extendability produced at node numbers 80, 100 and 120. Finally, the values of parameters for each SES parameter of equation is also noted.

2.1 Trend Analysis – SES parameter “a”.

The curve obtained depicts an increasing tendency with a decreasing rate of increase reaching a maximum value

and then decreases very smoothly and slowly. The graph is not symmetrical.

Figure 1: SES parameter a

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

1. $F(x) = ((a \cdot x^d) / (\exp((b \cdot x^h) + c))) + (f/x) \cdot \log(x)$
 $Ch_{sq} = 0.0514985$ $F(80) = 1.493684$
 $F(100) = 0.898490$ $F(120) = 0.519443$
2. $F(x) = ((a \cdot x^2) / (\exp((b \cdot x^h) + c))) + (f/x) \cdot \log(x)$
 $Ch_{sq} = 0.0438668$ $F(80) = 1.836032$
 $F(100) = 1.348354$ $F(120) = 0.979047$
3. $F(x) = ((a \cdot x^3) / (\exp((b \cdot x^h) + c))) + (f/x) \cdot \log(x)$
 $Ch_{sq} = 0.0443925$ $F(80) = 1.9155$
 $F(100) = 1.465550$ $F(120) = 1.118004$
4. $F(x) = ((a \cdot x^4) / (\exp((b \cdot x^h) + c))) + (f/x) \cdot \log(x)$
 $Ch_{sq} = 0.0447282$ $F(80) = 1.918$
 $F(100) = 1.4745$ $F(120) = 1.132254$
5. $F(x) = ((a \cdot x^5) / (\exp((b \cdot x^h) + c))) + (f/x) \cdot \log(x)$
 $Ch_{sq} = 0.0612825$ $F(80) = 0.313$
 $F(100) = 0.1849$ $F(120) = 0.049307$
6. $F(x) = ((a \cdot x^4) / (\exp((b \cdot x^h) + c))) + (f/x^2) \cdot \log(x)$
 $Ch_{sq} = 0.0433888$ $F(80) = 1.908409$
 $F(100) = 1.452688$ $F(120) = 1.105501$
7. $F(x) = ((a \cdot x^4) / (\exp((b \cdot x^h) + c))) + (f/x^3) \cdot \log(x)$
 $Ch_{sq} = 0.0491963$ $F(80) = 1.667523$
 $F(100) = 1.149452$ $F(120) = 0.787498$

Choice of best fit for SES parameter a

The equation in part 6 above has been selected because of both smallest reduced chi-square value obtained and good extendability. The parameters for best fit are:

$a = 2.275$, $b = 6.68684$, $c = -2.46916$, $f = -16.802$, $h = 0.251917$.

2.2 Trend Analysis – SES parameter “b”.

Generally the curve obtained for node number 8 and above depict an increasing tendency with a small decrease in rate of increase. It is possible that for node number 7, a different behaviour is obtained since the plot appears as an outlier.

Figure 2: SES parameter b

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

1. $F(x) = d \cdot x + f$
 $Ch_{sq} = 0.000203527$
2. $F(x) = a \cdot \exp(b \cdot (x-c)) + d$
 $Ch_{sq} = 0.000216866$
3. $F(x) = a \cdot \log(b \cdot (x-c)) + d \cdot x$
 $Ch_{sq} = 0.000138148$
4. $F(x) = a \cdot \log(b \cdot (x-c)) + d$
 $Ch_{sq} = 0.000136938$
5. $F(x) = a \cdot \log(b \cdot (x-c)) + d \cdot x + f$
 $Ch_{sq} = 0.00014105$
6. $F(x) = a \cdot x^{0.5} \cdot \log(b \cdot (x-c)) + d$
 $Ch_{sq} = 0.0001418$
7. $F(x) = a \cdot x^{0.5} \cdot \log(b \cdot (x-c)) + d$
 $Ch_{sq} = 9.99445$ $F(80) = 0.468$
 $F(100) = 0.506$ $F(120) = 0.536$

Choice of best fit for SES parameter b

The equation in part 7 above has been selected because of both smallest reduced chi-square value obtained and good extendability. The parameters for best fit are:

$a = -0.84466$, $b = 4.1453$, $c = 3.3687$, $d = 1.01263$

2.3 Trend Analysis – SES parameter “c”.

The curve depicts an increasing tendency from node number 7 until about node number 22 with decreasing rate of increase, after which the curve tends to flatten.

Figure 3: SES parameter c

The summary of potentially applicable equations is given below:

1. $F(x) = a * \exp(b * (x + c)) + (d/x) + f$
 $Ch_{sq} = 0.752\ 005$ $F(80) = 95.022\ 617\ 396$
 $F(100) = 95.756\ 213\ 552$ $F(120) = 96.295\ 471\ 578$
2. $F(x) = a * \exp(b * (x + c)) + (d * x^{-1.5}) + f$
 $Ch_{sq} = 0.835\ 083$ $F(80) = 92.703\ 836\ 399$
 $F(100) = 92.062\ 709\ 654$ $F(120) = 91.361\ 384\ 306$
3. $F(x) = a * x * \exp(b * (x + c)) + (d * x^{-1}) + f$
 $Ch_{sq} = 0.764\ 577$ $F(80) = 95.131\ 321\ 686$
 $F(100) = 95.744\ 845\ 642$ $F(120) = 96.161\ 046\ 600$
4. $F(x) = a * x^2 * \exp(b * (x + c)) + (d * x^{-1}) + f$
 $Ch_{sq} = 0.783\ 841$
5. $F(x) = a * x^{0.5} * \exp(b * (x + c)) + (d * x^{-1}) + f$
 $Ch_{sq} = 0.757\ 23$ $F(80) = 95.085\ 660\ 843$
 $F(100) = 95.749\ 790\ 884$ $F(120) = 96.211\ 888\ 541$

Choice of best fit for SES parameter c

The equation in part 5 above has been selected even if its reduced ch_{sq} is second smallest; its extendability is more stable. The parameters of best fit are:

$a = 11.157\ 6$, $b = -0.093\ 546\ 6$, $c = 1.819\ 28$, $d = -281.322$, $f = 98.554\ 9$

3. Conclusion.

This piece of study was aimed at and has developed the models of trend of the parameters of equations for the metric SES in a MANET topography of $300 \times 300\ m^2$. The models put forward will help to study MANETs for MAUC environment from a software engineering perspective. The models put forward in this paper, are mathematical in nature and can be mapped onto programming algorithms. The experiment was carried out in NS-2 over Linux. The plottings and “fit”

attempts were done in gnuplot. Best fit was evaluated from reduced chi-square values and best extendability of equations obtained.

Assumptions stated in previous paper [14] hold here also. Gnuplot is also assumed as appropriate. The intrinsic constructs of gnuplot is not questioned here.

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

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