
M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY

Abstract – Quite extensive research is ongoing concerning enhancement of location tracking in Mobile environment and significant development have been put forward [35-50]. As and when new components for Mobile network are put forward, new functionalities will be devised or ways of doing existing activities will be improved. MAUC, however, still lacks the software engineering approaches into metrics and models development to sustain predictability and govern future investments of resources for development and further research [2]. One particular sub-area within the area of energy considerations in ubicomp is modelling of sender node energy savings using location-aware MANET transmission provided in another paper [14]. The next set of investigation involves quantifying and modelling the extra energy savings achievable against Direct Node-to-Node transmission, the pattern of trend for this extra savings under different sets of node densities and method of predicting the trend equations for use in predictive probability calculations.

The area of modelling in ubicomp involves much work and this paper adds to this area and will be used by designers to formulate better ubicomp architectures and components. This paper is a follow-up of previous papers [1-15] with more emphasis from papers [2, 14].


Many researchers put forward that use of MANETs help in saving energy [51]. A plausible model for energy savings in MANET is provided in paper [14].

The question which will demarcate which of the two above mentioned types of transmission saves more energy in the event that MANET intermediate nodes are supplied as infrastructure and their energy consumptions are not of concern from sender’s perspective remains: “How much extra energy savings does the sender node achieve for CBR transmission in MAANET transmission compared to direct node-to-node transmission?”. Additional questions include:

- Which node densities give less good performance in MANET than in direct node-to-node transmission?
- Which node densities give better performance in MANET than in direct node-to-node transmission?
- Is a break-even point between the two parts above conceivable?

This study derived from 2 previous studies [2, 14] and results presented here remain empirical based.

The key contributions of this paper is firstly, the development of a new metric SLNTNES (derived from other metrics), including its definition and rationale, and secondly, the model of trend put forward for the metric SLNTNES with results for varying node densities from 7 until 56. The model suggested in this paper is the normal distribution model (with some positive skewness). The rest of this paper is organised as follows: section 2- New Derived Metric- Sender Less Node-to-Node Energy Savings, section 3- SLNTNES Trend Assessment over Varying Node Numbers, 4- Conclusion and References.

1. Introduction

Energy consumption in MAUC is affected by several factors [2]. A major factor remains that energy for transmission varies proportional to the square of distance between sender and receiver. Additional factors may include types of transmission, whereby 2 types are of concern here: direct node-to-node transmission [2] and MANET transmission at different node densities [14].


As stated in previous research [14], the term BRE is used here also. BRE is the amount of energy spent by a sender in direct node-to-node transmission if all CBR packets were transmitted at maximum distance noted between sender and receiver.
SLNTNES is hence defined as the percentage savings achieved by the sender node only, in MANET (gauged against the BRE) less the percentage savings achieved by sender node in Direct node-to-node transmission (also gauged against the BRE).

SLNTNES value may be 0, as it would imply that the sender is using exactly same energy in MANET as in direct node-to-node transmission. The plausible case for this scenario is that the receiver is also the closest neighbour to the sender for the whole transmission duration, hence despite MANET transmission, the situation is reduced to direct node-to-node transmission.

SLNTNES value cannot be below 0, since the worst case reduction of the situation is until direct node

3. SLNTNES Trend Assessment over Varying Node Numbers.

3.0 Major Observations.

The trends for SLNTNES achieved for node numbers 7-56 tend to follow a normal distribution of the form:

\[ F(x) = \frac{1}{\sqrt{2\pi}a} e^{-\frac{(x-c)^2}{2a^2}} \]

It can be read as “a factor ‘b’ times the equation of a normal curve. Definitely, here, most senders have more energy savings than simple node-to-node energy savings; the smallest value reached is 0 (no negative values), even if % CBR reaching it is below 1%.

The maximum percentage Energy Savings achieved here are also high: 98% for node number 7, 100% (i.e. 99.5% up to below 100) for others, though they are reached by under 1% of CBRs.

The % Energy Savings up to which 95% CBR is found has shown an increasing with increasing node number. The mean value, c, has depicted an increasing trend with increasing node numbers.

3.1 Tabular Summary of Results.

A tabular summary for results of equations of curves (F(x)) observed here is shown below. Column headings are: A=node number, B=Value of parameter a, C=Value of parameter b, D=Value of parameter c, E=Reduced Chi-square value of plot, F=Corresponding figure number.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>0.119 084</td>
<td>1.121 7</td>
<td>23.603</td>
<td>0.175 542</td>
</tr>
<tr>
<td>8</td>
<td>0.098 575 6</td>
<td>0.849 813</td>
<td>24.949 6</td>
<td>0.184 537</td>
</tr>
</tbody>
</table>

Table 1: results for SLNTNES equations of curves node num 7-56

3.2 Graphical Plots for Results Obtained.

This analysis is performed in gnuplot in Linux.

1. Node Number 7

Figure 1: % cbr for SLNTNES node number 7

2. Node Number 8

Figure 2: Graphical Plots for Results Obtained.
Figure 2: % cbr for SLNTNES node_number 8
3. Node Number 9

Figure 3: % cbr for SLNTNES node_number 9
4. Node Number 10

Figure 4: % cbr for SLNTNES node_number 10
5. Node Number 11

Figure 5: % cbr for SLNTNES node_number 11
6. Node Number 12

Figure 6: % cbr for SLNTNES node_number 12
7. Node Number 13

Figure 7: % cbr for SLNTNES node_number 13
8. Node Number 14

Figure 8: % cbr for SLNTNES node_number 14
9. Node Number 15

Figure 9: % cbr for SLNTNES node_number 15
10. Node Number 16
Figure 10: % cbr for SLNTNES node_number 16
11. Node Number 17

Figure 11: % cbr for SLNTNES node_number 17
12. Node Number 18

Figure 12: % cbr for SLNTNES node_number 18
13. Node Number 19

Figure 13: % cbr for SLNTNES node_number 19
14. Node Number 20

Figure 14: % cbr for SLNTNES node_number 20
15. Node Number 21

Figure 15: % cbr for SLNTNES node_number 21
16. Node Number 22

Figure 16: % cbr for SLNTNES node_number 22
17. Node Number 23

Figure 17: % cbr for SLNTNES node_number 23
18. Node Number 24
Figure 18: % cbr for SLNTNES node_number 24
19. Node Number 25

Figure 19: % cbr for SLNTNES node_number 25
20. Node Number 26

Figure 20: % cbr for SLNTNES node_number 26
21. Node Number 27

Figure 21: % cbr for SLNTNES node_number 27
22. Node Number 28

Figure 22: % cbr for SLNTNES node_number 28
23. Node Number 29

Figure 23: % cbr for SLNTNES node_number 29
24. Node Number 30

Figure 24: % cbr for SLNTNES node_number 30
25. Node Number 31

Figure 25: % cbr for SLNTNES node_number 31
26. Node Number 32
Figure 42: % cbr for SLNTNES node_number 48
Figure 43: % cbr for SLNTNES node_number 49
Figure 44: % cbr for SLNTNES node_number 50
Figure 45: % cbr for SLNTNES node_number 51
Figure 46: % cbr for SLNTNES node_number 52
Figure 47: % cbr for SLNTNES node_number 53
Figure 48: % cbr for SLNTNES node_number 54
Figure 49: % cbr for SLNTNES node_number 55
Figure 50: % cbr for SLNTNES node_number 56
This piece of research was aimed at and has developed a new model of expected trend of sender node extra energy savings achievable in a MANET topography of 300 x 300 m² compared against those achieved in direct node-to-node transmission. This piece of research was derived from previous research with more emphasis from two papers [2, 14]. The model obtained will add to the components to study MANETs for MAUC environment from a software engineering perspective. Again, the result produced is derived from previous empirical results and hence retains the empirical nature. For this study, certain high-end components are assumed as widely available even though they are still subject to research, e.g. lightweight algorithms for location-aware transmission in mobile environments, land-based or infrastructure-based location support with appropriate algorithms and lightweight OS support.

The major conclusion of this study remain that, firstly, if MANET nodes are supplied as infrastructure, a great majority of sending nodes in MANETs with varying node densities will be saving more energy than in direct node-to-node transmission. Secondly, for less than 1% of CBR does a break-even point between MANET transmission and direct node-to-node transmission and hence may be considered negligible.

The further works identified may include: trend analyses of parameters of equation for the model, formulating method of predictability for metric SLNTNES and its trend and reporting observations of certain values identified.

References

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Figure 50: % cbr for SLNTNES node number 56

4. Conclusion.
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About Author (s): Associate Professor Nawaz Mohamudally works at University of Technology, Mauritius (UTM) and has undertaken supervision of MPhil/PhD Students for many years.

M. Kaleem Galamali is a part-time student (achieved M Phil Transfer on 28.10.2014, currently PhD student) at UTM under supervision of A.P. Nawaz Mohamudally.