Model of Energy Consumption Ratio Achievable in MANET Using Location-Aware Transmission in Ubicomp.

M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY

Abstract – Efficient Location tracking is still subject to research and new functionalities/applications depending on it are continuing to appear on the market [37-52]. An area where improvements will be very desirable is MANET communication over which ubicomp will rely. A big section missing in MAUC remains the software engineering approaches into metrics development and gathering appropriate models which can be used for prediction and better gearing of future investments and research [2]. A particular sub-section of concern here is energy considerations in MANETs. Quite some results of prior research has been put forward [14-17] which are more directly concerned with energy. The subsequent level is “metrics indirectly concerned with energy for transmission”. One such topic of research is: “What is the ratio of energy consumption for each node over the energy consumed by the sender? What are the corresponding patterns of trend observable for different sets of node densities? How to predict the trend equations and using them for predictive probability calculations.

The area of modelling in ubicomp involves much work and this paper adds to this area. Designers will use it to formulate better ubicomp architectures and components. This paper follows from previous work [1-17].

Key terms: Ubicomp- Ubiquitous Computing, MAUC- Mobile and Ubiquitous Computing, ECR- Energy Consumption Ratio, MANET- Mobile Adhoc Network, CBR- Constant Bit Rate, PCN_ECR_NN- % communicating nodes for ECR node_number.

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1. Introduction

Many pertinent factors affect energy consumption in MAUC [2]. One pertinent factor is type of transmission; the type of concern here is MANET transmission, probing into which, a consequent factor is node density. Researchers claim that MANET transmission helps to contain or even save energy required for transmission [53]. When using MANETs, sender nodes together with those nodes forming part of MANET routes, are spending energy. These relay nodes could also be other user nodes instead of infrastructure nodes. Sender nodes transmit to closest neighbouring node which subsequently transmits to next nearest neighbour. In effect, cooperation from MANET nodes is being expected. It is legitimate in cooperation to determine how much assistance, in this case energy requirements, it is being required to give compared to the sending node’s effort itself together with corresponding trends for varying nodes densities.

This may be considered for a whole CBR transmission instead of per packet transmission, in which case, an added complication will be changes in MANET routes during CBR transmission as follows:

i. The sequence of nodes in the MANET route till the destination has remained the same but the nodes locations have varied significantly.

ii. Certain nodes have been removed from the route and the number of nodes in the MANET path has reduced (reduced hop count).

iii. New nodes have been integrated into the route and hop count increases.

iv. A combination of part (ii) and (iii) giving a totally different MANET paths.

The key contributions of this paper is firstly, the development of a new metric ECR (though an empirical simulation-based experiment as in previous paper [14]), including its definition and rationale, and secondly, the model of trend put forward for the metric ECR with results for varying node densities from 7 until 56. The model suggested here is split into 2:

- 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 and asymptotic to the x-axis
  \[
  G(x) = a * \exp\left(b \cdot (x - c)\right)
  \]

The rest of this paper is organised as follows: section 2- New Derived Metric: Energy Consumption Ratio, section 3- ECR Trend Assessment over Varying Node Numbers, 4- Conclusion and References.

ECR is “the ratio of energy consumption for each node over the energy consumed by the sender node”.

The ratios obtained in the experiment [14] are positive values (rounded to 1 d.p.) subdivided into 3 categories:

i. ECR values less than 1: indicating that the corresponding MANET node has spent less energy than the sender for a CBR.

ii. ECR values equal to 1: indicating that the corresponding MANET node has spent just as much energy as the sender node.

iii. ECR values greater than 1: indicating that the corresponding MANET node has spent more energy than the sender node.

It is expected to have some significantly very high values of ratios. This metric and its trend model, if accurately gauged and tracked, can serve several purposes including:

i. Decision formulation if a particular sub area of the topography is not having enough MANET nodes and need of deploying some support infrastructure nodes.

ii. Decision formulation for sender nodes whether to continue transmission or to delay/reschedule a transmission in case excessively high ratios are encountered for long durations.

iii. Decision formulation for a MANET node with battery power limitations to accept being part of the MANET route or not, i.e. to forward or not forward packets.

iv. History tracking in each node about past ratios reached for each sender encountered before and formulate trust levels for each such node over suitable durations. This can also help in calibrating appropriate QoS in the MANET.

v. Better understanding the trends of battery power durations and “lesser expected” sudden battery unavailability.

vi. Traceability of nodes behaviour, whether user nodes in MANETs or Infrastructure nodes, of the reasons of certain odd behaviours like “refusal to forward”.

3. ECR Trend Assessment over Varying Node Numbers.

3.0 Major Observations.

In all plots for node numbers 7 until 56, the leftmost plot at x-coordinate 0.0 has been very outlying with very high value of y-coordinate, though it decreases with increasing node numbers. Hence, this point has been ignored in trend analyses.

The rightmost plot was also very outlying with very low y-coordinate value. The x-range of plot was therefore set from 0.1 to a particular value covering more than 90% of CBRs concerned. A peak value is observed in each plot at about ECR value of 0.3

3.1 Tabular Summary of Results.

A tabular summary for results of equations of curves, F(x) and G(x), observed here is shown below. Column headings are: A—node number, B—Value of parameter d, C—Value of parameter f, D—reduced Chi-square value of plot F(x), E—ECR value of peak value, F—Value of parameter a, G—Value of parameter b, H—Value of parameter c, I—reduced chi-sq value of plot G(x), J—Corresponding figure number.

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Table 1(a): results for ECR equations of curves node num 7-56

77
3. Node Number 7

This analysis is performed in gnuplot in Linux.

4. Graphical Plots for Results Obtained.

Table 1(b): results for ECR 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: PCN_ECR_NN 7](image1)

2. Node Number 8

![Figure 2: PCN_ECR_NN 8](image2)

3. Node Number 9

![Figure 3: PCN_ECR_NN 9](image3)

4. Node Number 10

![Figure 4: PCN_ECR_NN 10](image4)

5. Node Number 11

![Figure 5: PCN_ECR_NN 11](image5)

6. Node Number 12

![Figure 6: PCN_ECR_NN 12](image6)
Figure 6: PCN_ECR_NN 12
Figure 7: PCN_ECR_NN 13
Figure 8: PCN_ECR_NN 14
Figure 9: PCN_ECR_NN 15
7. Node Number 13
8. Node Number 14
9. Node Number 15

Figure 10: PCN_ECR_NN 16
Figure 11: PCN_ECR_NN 17
Figure 12: PCN_ECR_NN 18
Figure 13: PCN_ECR_NN 19
11. Node Number 17
12. Node Number 18
13. Node Number 19
14. Node Number 20
Figure 14: PCN_ECR_NN 20
15. Node Number 21

Figure 15: PCN_ECR_NN 21
16. Node Number 22

Figure 16: PCN_ECR_NN 22
17. Node Number 23

Figure 17: PCN_ECR_NN 23
18. Node Number 24

Figure 18: PCN_ECR_NN 24
19. Node Number 25

Figure 19: PCN_ECR_NN 25
20. Node Number 26

Figure 20: PCN_ECR_NN 26
21. Node Number 27

Figure 21: PCN_ECR_NN 27
22. Node Number 28
Figure 22: PCN_ECR_NN 28

23. Node Number 29

Figure 23: PCN_ECR_NN 29

24. Node Number 30

Figure 24: PCN_ECR_NN 30

25. Node Number 31

Figure 25: PCN_ECR_NN 31

26. Node Number 32

Figure 26: PCN_ECR_NN 32

27. Node Number 33

Figure 27: PCN_ECR_NN 33

28. Node Number 34

Figure 28: PCN_ECR_NN 34

29. Node Number 35

Figure 29: PCN_ECR_NN 35

30. Node Number 36
Figure 30: PCN_ECR_NN 36
31. Node Number 37

Figure 31: PCN_ECR_NN 37
32. Node Number 38

Figure 32: PCN_ECR_NN 38
33. Node Number 39

Figure 33: PCN_ECR_NN 39
34. Node Number 40

Figure 34: PCN_ECR_NN 40
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Figure 35: PCN_ECR_NN 41
36. Node Number 42

Figure 36: PCN_ECR_NN 42
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Figure 37: PCN_ECR_NN 43
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Figure 38: PCN_ECR_NN 44
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Figure 39: PCN_ECR_NN 45
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Figure 40: PCN_ECR_NN 46
41. Node Number 47

Figure 41: PCN_ECR_NN 47
42. Node Number 48

Figure 42: PCN_ECR_NN 48
43. Node Number 49

Figure 43: PCN_ECR_NN 49
44. Node Number 50

Figure 44: PCN_ECR_NN 50
45. Node Number 51

Figure 45: PCN_ECR_NN 51
46. Node Number 52
4. Conclusion.

This piece of research was aimed at studying a resulting situation of transmission over MANET topography of 300 x 300 m². For this purpose, one metric was devised: ECR and corresponding model of trend over varying number of node densities have been put forward. The purposes that this metric and its trend analysis will serve have also been put forward. This research remains empirical based and was implemented over same components as explained in another paper [15]. The model put forward comprises of 2 equations F(x) and G(x) which applies with respect to a peak value. Here also, many components are assumed as available even if they remain subjects of research, e.g. lightweight algorithms for location-aware transmission in mobile environments, lightweight MAUC OS support for efficient and very rapid binding/unbinding of MANET nodes and appropriate multi-threading communication module in MANET nodes.

The further works identified may include: trend analyses of parameters of equation for the model, formulating method of predictability for metric ECR and its trend and reporting observations of certain values identified. Other research questions also crop up, e.g. “Is the CBR transmission achieving overall fairness towards sender node? Or, are the MANET nodes spending much more energy than proportionately to the sender?” Further probing remains desirable.

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