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Extension of Sender Node Battery Extra Availability in Ubicomp with Location-Aware MANET Transmission Compared to Direct Node-To-Node Transmission.

M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY

Abstract – **The field of location-tracking in mobile environments is of utmost necessity and justifies the research investments put in it [1-10] with correspondingly commendable output. With progresses in ubicomp happening, several questions will crop up and whose answers depend on components not yet developed and hence empirical supports to answer these questions may serve as welcome starting points. A previous such study was undertaken to find trends of energy savings achievable by applying location-aware direct Node-To-Node (NTN) transmission strategies [2]. Another study was conducted to model the trends of sender energy savings (SES) achievable in location-aware MANET transmission [14] from the perspective of user nodes being freed from routing tasks of other user's transmissions, i.e. MANET nodes are supplied as infrastructure.**

Following these two studies [2, 14], the next level of research is laid as: "By what extra amount can the sender nodes' battery availability be extended in location-aware ubicomp MANET transmission compared to direct Node-To-Node transmission? How does this extra amount vary over varying node numbers in a ubicomp topography?

The results of this study can serve towards better architecture formulations and alleviation of maintenance procedures required for ubicomp. This study follows from previous ones [1-63]

Key terms: Ubicomp- Ubiquitous Computing, MAUC-Mobile and Ubiquitous Computing, CBR- Constant Bit Rate, MANET- Mobile Adhoc Network, NTN- Node-To-Node, ES-Energy Savings, SES- Sender ES, SLNTNES- Sender Less NTN ES, EC-Energy consumed, SLNTNEC- Sender Less NTN EC, BAEF- Battery Availability Extension Factor, MBAEF- Mean BAEF.

M. Kaleem GALAMALI,
University of Technology Mauritius (student)
Mauritius
mkaleemg@gmail.com

Assoc. Prof Nawaz Mohamudally
University of Technology Mauritius,
Mauritius
alimohamudally@umail.utm.ac.mu

1. Introduction

Understanding the trends of energy consumption and energy savings in ubicomp is of crucial importance for future architecture design. Achieving better hardware batteries will not be so useful if appropriate methods of using them are not well devised. Such methods also include algorithmic methods prone to extend their availability or uptime, one of which is application of location awareness in transmission strategies. Two such strategies were studied formerly from an empirical perspective: one was direct Node-To-Node transmission at exact location awareness [2] and another one was MANET transmission with MANET route nodes supplied as infrastructure [16].

Location-awareness feature requires continual update of location information. The granularity or exactness of this location information varies as per technology used. Current levels of technology, however, operate at overly high overheads to obtain high refresh rates, which also has implications on energy needs. It still remains that simulation models are important to delimit bounds of achievements in this research direction, assuming that the ability to channel exact location information into transmission strategies is very achievable. Following the two strategies of transmission mentioned in previous paragraph, the logical probing that crops up is to experimentally bound the extra energy savings achievable in MANET, with MANET route nodes supplied as infrastructure, compared to direct Node-To-Node transmission. The results of such a study will subsequently serve towards enhancement of ubicomp architectures and decide correct channelling of resources needed.

The key contributions of this paper is firstly, the extension of the simple mathematical method, introduced previously [10-13], for calculating the extra amount of savings achievable by sender nodes in MANETs with Route nodes supplied as infrastructure compared to direct node-to-node transmission, with the application of location-aware transmission. Secondly, model of trend of this extra amount varying over different node numbers in a ubicomp topography of 300 x 300 m^2 is established. The rest of this paper is organised as follows: section 2- Experimental Set-up used, section 3- Results Obtained, section 4- Conclusion and References.

2. Experimental Set-Up Used.

The same experimental design used in previous paper [10] and referred to in another previous papers [62, 63] is re-used here.

Metric concerned for this set of experiment is SLNTNES [16].

3. Results Obtained.

The study here is split into four subsections: SLNTNES Minimum BAEF (Min_BAEF), SLNTNES Mean BAEF (MBAEF), SLNTNES Maximum BAEF (Max_BAEF) and certain critical values obtainable. The work is basically some further processing applied over certain results obtained previously. Floating points Values instead of integers, are used to get exact results.

3.1 SLNTNES Min_BAEF

This section follows from section 3.1 in previous paper [48], i.e. SLNTNES critical value 1, representing smallest value of SLNTNES reached. All SLNTNES values obtained here lie at 0 throughout. Minimum SLNTNES is obtained in a situation of maximum value of sender less node-to-node energy consumption (SLNTNEC). SLNTNES Min_BAEF is computed as:

```
Max_SLNTNEC = 100.00 - (Min_SLNTNES)
SLNTNES_Min_BAEF = 100.00/(Max_SLNTNEC)
```

Since Min_SLNTNES equals 0, i.e. a value between -0.5 and +0.5, Min_BAEF will vary between 0.995 024 875 and 1.005 025 126, i.e. remains at a rounded value of 1.00 for all node numbers. This value depicts that at worst case, nodes' batteries availability do not benefit from any extra extension.

3.2 SLNTNES MBAEF

This section follows from section 2.3 in previous paper [32], i.e. SLNTNES parameter c of SLNTNES equation of trend. Corresponding Modal BAEF is computed as:

```
Modal_SLNTNEC=100.00-(Modal SLNTNES)
SLNTNES_Modal_BAEF=100.00/(Modal_SLNTNEC)
```

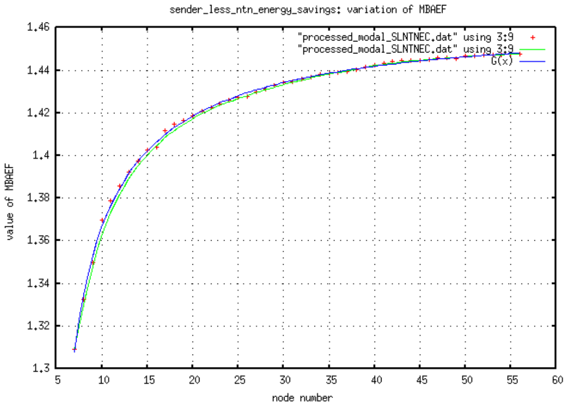

Figure 1: SLNTNES MBAEF

The values of SLNTNES_Modal_BAEF were computed for node numbers 7 until 56 and corresponding plot is given in figure 1.

The equation of best fit here, G(x), has also followed similar computation over F(x) obtained in section 2.3 of previous paper [32], retaining the values of parameters a, b, c and f.

$$F(x) = (a/x^f) * \log (b*x + c)$$

$$G(x) = 100.00/(100.00 - F(x))$$

3.3 SLNTNES Max_BAEF.

This section follows from section 3.2 in previous paper [48], i.e. SLNTNES critical value 2 representing highest value of SLNTNES reached. Maximum SLNTNES is obtained corresponding to minimum sender less Node-to-Node Energy consumed, SLNTNEC. Max_BAEF is computed as follows:

```
Min_SLNTNEC = 100.00 -(Max_SLNTNES)
SLNTNES_Max_BAEF = 100.00/(Min_SLNTNEC)
```

The values of SLNTNES Max_BAEF were computed for node numbers 7 until 56 and corresponding plot is given in figure 2.

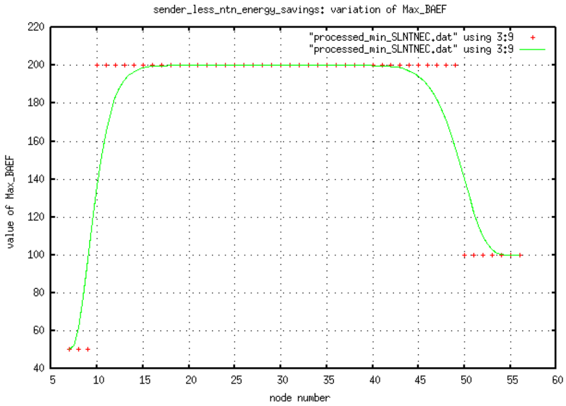

Figure 2: SLNTNES Max_BAEF Trend

Three ranges are visible in the plot. The applicable equations are:

$$G(x) = \begin{cases} 50 & 7 \le x \le 9 \\ 200 & 10 \le x \le 49 \\ 100 & x \ge 50 \end{cases}$$

3.4 Certain OES BAEF Critical Values.

Four critical values have been identified as presented in Table 1, which correspond to certain critical values studied previously [48]. Colum headings are: C1→ SLNTNES BAEF critical value, C2→ Meaning of SLNTNES BAEF critical value, C3→ section in previous paper [48] the SLNTNES BAEF critical value corresponds to.

C1	C2	C3
1	% nodes reaching Max_BAEF.	3.3
2	% nodes reaching MBAEF.	3.5
3	% nodes with BAEF < MBAEF	3.6
4	% nodes with BAEF > MBAEF	3.7

Table 1: SLNTNES BAEF Critical Values

4. Conclusion.

This study has probed into the extension of a mathematical method for predicting the extra proportion to which battery availability of sender nodes present in a ubicomp topography of 300 x 300 m^2 could be extended using MANETs, with MANET route nodes supplied as infrastructure, compared to direct Node-To-Node transmission, both using exact location-aware transmission strategies. The method introduced formerly [10] and extended here, has been applied over results put forward in previous papers [16, 32, 48]. This study complements to the study of ubicomp components from the broad view of software engineering. It also provides for supplementary components for prediction and measuring reliability of ubicomp environment. Moreover, in this probing, certain new metrics developed previously [10] to strengthen models in ubicomp and more judiciously fashion the architecture of ubicomp, are elaborated.

This study has been devised over previous empirical studies done in simulator software NS-2 over Linux. Gnuplot is the tool used for graphical analysis. Floating point calculations have been used to obtain accurate answers. This study was aimed at providing value of BAEF in an unbiased mathematical perspective. The values and trends obtained have not been subjected to interpretations of being good/bad, workable/unworkable or efficient/inefficient. Designers using these models will determine their interpretations as they apply them properly in their topographies.

Further work identified remains refinement of the model and equations of trend obtained and subjecting the metrics defined to more rigorous software engineering approaches.

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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.