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

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Abstract **– The impact of location-tracking in mobile environments matters tremendously into performance of ubicomp functionalities and justifies research effort put in it [1-10]. Along with progresses in ubicomp, several questions will crop up and whose answers depend on components not yet put forward. Hence, empirical and simulator based supports to answer these questions are required as starting points. A prior such study was conducted to find trends of energy savings achievable by applying location-aware direct Node-To-Node (NTN) transmission strategies [2] from the perspective of overall nodes, whereby all user nodes in the topography contribute in routing tasks. Another follow-up study was carried out to model the trends of Overall Energy Savings achievable in location-aware MANET transmission [15] from the notion of all user nodes contributing to routing tasks of other user's transmissions, i.e. MANET nodes are NOT supplied as infrastructure.**

Following these two studies [2, 15], the next level of investigation required is: "By What extra amount can overall 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 present in a topography for ubicomp?

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 [1-64]

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, OES- Overall ES, OLNTNES- Overall Less NTN ES, EC-Energy consumed, OLNTNEC- Overall Less NTN EC, BAEF- Battery Availability Extension Factor, MBAEF- Mean BAEF.

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1. Introduction

Ubicomp designers may find the knowledge of the trends of energy consumption and energy savings achievable in ubicomp crucial for optimising future architecture design. Designing better hardware batteries will not be sufficient if proper methods of using them are not well devised. Such methods also englobe algorithmic methods prone to extend their availability or uptime, one of which is application of location-awareness in transmission strategies. Two such strategies of concern here, were formerly investigated from simulation perspective: one was direct Node-To-Node transmission at exact location-awareness [2] and another one was MANET transmission with MANET route nodes NOT supplied as infrastructure [17]

The feature of location-awareness is concerned with updating location information at good enough refresh rates. The granularity or exactness of this location varies as per technology used. Present levels of technology, nevertheless, operate at extraneously high overheads to obtain high refresh rates, which subsequently pressurise on energy needs. The fact remains that simulation models are important to theoretically delimit bounds of achievements in this research direction, following the assumption that there is significant software ability to channel exact location information into transmission strategies. Following the two strategies of transmission mentioned in previous paragraph, the investigation now required is to experimentally bound the extra energy savings achievable in MANET, with MANET route nodes NOT supplied as infrastructure, compared to direct Node-To-Node transmission. Results of such a study will in turn 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 overall nodes in MANETs with Route nodes NOT supplied as infrastructure compared to direct node-to-node transmission, with the application of location-aware transmission. Secondly, the 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.

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2. Experimental Set-Up Used.

The same experimental design used in previous paper [10] and referred to in another previous papers [62, 63, 64] is re-used here.

The metric of concern for this set of experiment is OLNTNES [16].

3. Results Obtained.

The study here is split into four subsections: OLNTNES Minimum BAEF (Min_BAEF), OLNTNES Mean BAEF (MBAEF), OLNTNES 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 for processing.

3.1 OLNTNES Min_BAEF

This section follows from section 3.1 in previous paper [49], i.e. OLNTNES critical value 1, representing minimum value of OLNTNES reached. Minimum OLNTNES is obtained in a situation of maximum value of Overall less node-to-node energy consumption (OLNTNEC). OLNTNES Min_BAEF is computed as:

```
Max_OLNTNEC = 100.00 - (Min_OLNTNES)
OLNTNES_Min_BAEF = 100.00/(Max_OLNTNEC)
```

The corresponding values for node number 7 until 56 and the applicable graphical plot is given in figure 1.

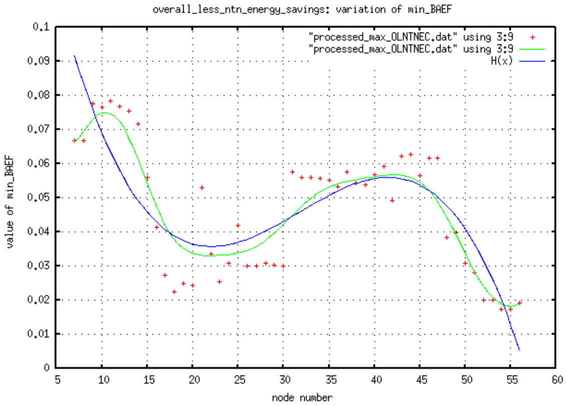

Figure 1: OLNTNES Min_BAEF

The equation of best fit is reworked as:

```
H(x) = a*sin (b*(x+c)) + (d*x) + f
```

The ch_sq is 0.000 130 468. The parameters of fit are: a= -2 091.55 , b= -0.002 515 64 , c=-31.790 8 , d= -5.260 01 , f= 167.266

The pertinent observation here, is that all values are below 0.1 which depicts worst case situation that some nodes may have their BAEF reduced to below one tenth of its value in direct NTN transmission strategy.

3.2 OLNTNES MBAEF

This section follows from section 2.3 in previous paper [33], i.e. OLNTNES parameter c of OLNTNES equation of trend. Corresponding Modal BAEF is computed as follows:

```
Modal_OLNTNEC=100.00-(Modal OLNTNES)
OLNTNES_Modal_BAEF=100.00/(Modal_OLNTNEC)
```

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

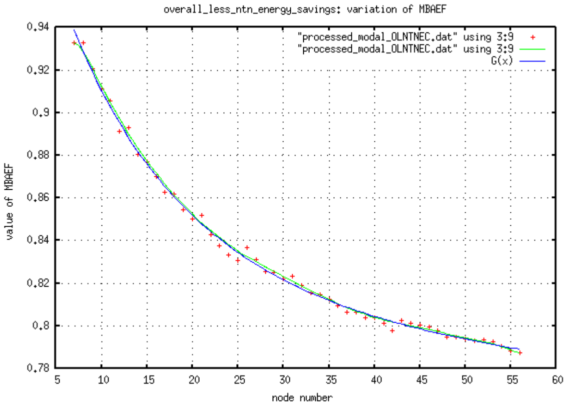

Figure 2: OLNTNES MBAEF

The equation of best fit here, G(x), has also followed similar computation over F(x) obtained in section 2.3 of previous paper [33], retaining the values of parameters a, b, c and d.

$$F(x) = a*x^{1.5} * \exp(b*x^{0.5}) + (c*x) + d$$
$$G(x) = 100.00/(100.00 - F(x))$$

The pertinent observation here, is that all values are below 1, i.e. Modal number of nodes will have their battery availability reduced rather than extended. This tends to be more severe with increasing node number.

3.3 OLNTNES Max_BAEF.

This section follows from section 3.2 in previous paper [49], i.e. OLNTNES critical value 2 representing highest value of OLNTNES reached. Maximum OLNTNES is obtained corresponding to minimum sender less Node-to-Node Energy consumed, OLNTNEC. Max_BAEF is computed as follows:

```
Min_OLNTNEC = 100.00 -(Max_OLNTNES)
OLNTNES_Max_BAEF = 100.00/(Min_OLNTNEC)
```

The values of OLNTNES Max_BAEF were computed for node numbers 7 until 56 and corresponding plot is given in figure 3.

The equation of best fit, H(x), is reworked as

```
H(x) = a*sin (b*(x+ c)) + (d*x) + f
```

The ch_sq is 0.052 414 4 . The parameters of fit are: a= 0.391 957 , b= -0.181 283 , c=34.495 9 , d= 0.023 248 5 , f= 2.514 95

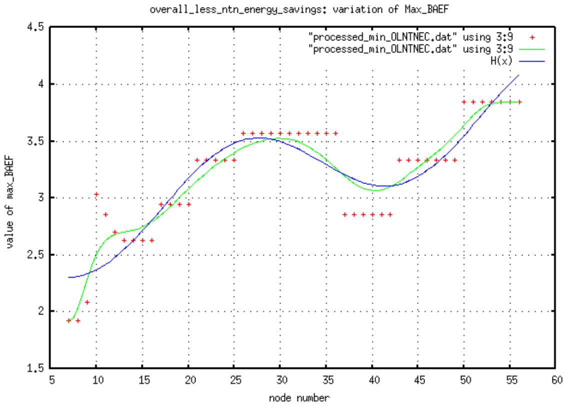

Figure 3: OLNTNES Max_BAEF Trend

3.4 Certain OLNTNES BAEF Critical Values.

Five critical values have been identified as presented in Table 1, which correspond to certain critical values studied previously [49]. Colum headings are: C1→ OLNTNES BAEF critical value, C2→ Meaning of OLNTNES BAEF critical value, C3→ section in previous paper [49] the OLNTNES BAEF critical value corresponds to.

C1	C2	C3
1	% nodes with BAEF < MBAEF.	3.4
2	% nodes with BAEF > MBAEF.	3.5
3	% nodes with BAEF < 1	3.6
4	% nodes with BAEF = 1	3.7
5	% nodes with BAEF > 1	3.8

Table 1: OLNTNES BAEF Critical Values

4. Conclusion.

This piece of investigation has depicted the extension of a mathematical method for predicting the extents to which user nodes' battery availability could be extended using location-aware transmission strategy in MANETs over a ubicomp topography of 300 x 300 m^2 over varying node densities. MANET nodes are assumed to be other user nodes and NOT supplied as infrastructure nodes in this investigation. The method extended here has been applied over results reported in previous papers [17, 33, 49]. This paper contributes more to the study of ubicomp environment from a software engineering perspective. It also offers some supplementary components for prediction and calibrating reliability of ubicomp environments. Certain new metrics developed previously [10] to heighten the subfield of models in ubicomp and to better shape future architecture of ubicomp.

This study is built over a prior empirical investigation performed in simulator software NS-2 over Linux. Graphical analysis software opted was gnuplot. Floating point calculations have been used to derive accurate answers. This study is geared at depicting values of BAEF in an impartial mathematical way. Interpretation of values and trends reported, are not given here such as good/bad or workable/unworkable or worthy/unworthy to invest in. Designers are free to interpret as per their own analysis.

Further work identified remains further polishing of the model and equations of trends obtained and applying more rigorous software engineering validation approaches to the metrics defined and extended here.

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