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Extending Sender Node Battery Availability in Ubicomp with Location-Aware MANET Transmission.

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***Abstract* – Significant research is on the way for location-tracking in mobile environment [62-99]. Development is expected like devising new functionalities and applications and improving ways of doing existing activities [2] in mobile and ubicomp environment. Several questions will crop up in this area and whose answers depend on components not yet developed. As and when these components will be developed, more such questions will be credulously answered. In MANETs, user nodes may be freed from routing tasks of other sender nodes' CBRs if MANET nodes are supplied as infrastructure. In such circumstance, sender nodes will be achieving considerable energy savings over varying node densities, as presented in former paper [14] whereby metric SES was illustrated.**

Following results presented [14], the next level of probing is laid as: "By what factor can the sender nodes' battery availability be extended? How does this factor vary over varying node numbers in ubicomp topographies?"

The results of this study can serve towards better architecture formulations and alleviation of maintenance procedures required for ubicomp. The study follows from previous ones [1-61].

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

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1. Introduction

Energy consumption and savings are among the vital components in ubicomp. No matter how good or recently recharged a battery is, methods of using it which is prone to extend its availability or uptime is of importance at present levels of research and development. Towards this objective, one decisive area to optimise is spending just enough energy for transmission to cover a just exact range [2].

Location-awareness remains a matter of continual update of information. Current levels of technology imply overly high overheads to achieve high refresh rates. However, simulation models remain important to delimit bounds of achievements in this direction [2]. It still remains that, the more exact location refresh rates, assuming that the ability to channel this information into transmission strategies is present, the more efficient the savings until a stable limit is attained. Following this stable limit attained, forecasts of battery availability extensions can be undertaken, from empirical perspectives. This will serve as an upper bounding of the extension of battery uptime to further analyse how to enhance ubicomp architectures and decide directions of investments needed.

The key contributions of this paper is firstly, the illustration of application of a simple mathematical method introduced previously [10-13] for calculating the amount by which a sender node battery availability can be extended by applying exact location-aware transmission strategy in MANETs and secondly to model the trend of these extensions varying over different node numbers in a ubicomp topography of 300 x 300 m^2. 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] is used here. The components considerations were:

- Exact location tracking of node positions and optimisation concerns.
- MANET Route formulation and nodes energy expenditure.
- Processing of MANET_Route_Packets_Per_CBR.
- MANET Results generations.
- Automated Extractions of data from files.

One metric studied in this set of experiment [14] is Sender Energy Savings (SES)

3. Results Obtained.

The study here is split into four subsections: SES Minimum BAEF (Min_BAEF), SES Mean BAEF (MBAEF), SES 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 SES Min_BAEF

This section follows from section 3.1 in previous paper [46], i.e. SES critical value 1, representing minimum SES (Min_SES) obtained. Min_SES is obtained in a situation where the sender has a Maximum SEC (Max_SEC), following which the corresponding Min_BAEF is computed as follows:

```
Max_SEC = 100.00 - (Min_SES)
SES_Min_BAEF = 100.00/(Max_SEC)
```

The values of SES Min_BAEF for node numbers 7-56 have been computed and the corresponding plot is given in figure 1.

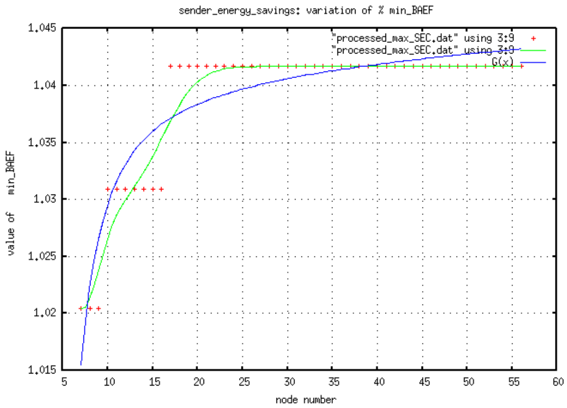

Figure 1: SES Min_BAEF Trend

The equation of best fit here, G(x), has also followed similar computation over the equation F(x) obtained in section 3.1 in previous paper [46] while retaining values of parameters a, b, c and d.

$$F(x) = a * \log((b*x) + c) + (d*x^{-3})$$
$$G(X) = 100.00/(10.00-F(x))$$

An observation here is that all values of G(x) are above 0, which implies that all nodes' battery availability will be extended. This corroborates with observation in section 4.0 of prior paper [14] where it was mentioned that minimum values of SES reached is 2.0 (above 0).

3.2 SES MBAEF

This section follows from section 3.3 in previous paper [46], i.e. SES critical value 3, representing modal SES obtained. The corresponding modal SEC and modal BAEF is computed as follows:

```
Modal_SEC = 100.00 - (Modal SES)
SES_Modal_BAEF = 100.00/(Modal_SEC)
```

The plot of corresponding results for node number 7 until 56 is given in figure 2.

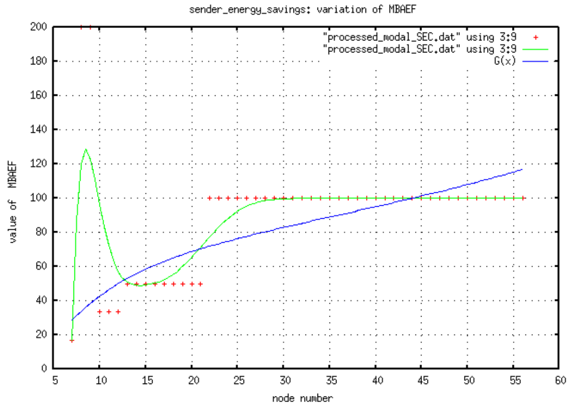

Figure 2: SES MBAEF

The equation of best fit here, G(x), has also followed similar computation over the equation F(x) obtained in section 3.3 of previous paper [46] while retaining values of parameters a, b, c and d.

$$F(x) = a * \log((b*x)+ c) + (d*x^{-2})$$
$$G(x) = 100.00/(100.00 - F(x))$$

3.3 SES Max_BAEF.

Maximum SES (Max_SES) is obtained where sender has a minimum SEC (Min_SEC), following which the corresponding SES Max_BAEF is computed as:

```
Min_SEC = 100.00 -(Max_SES)
SES_Max_BAEF = 100.00/(Min_SEC)
```

It has, however, been noted here that maximum SES value in experiment is at 100%. This theoretically implies values between 99.5% and just less than 100%. Hence, for calculation purpose, the maximum SES is thus assumed at 99.5%.
Min_SEC = 100.00 – (99.5) = 0.50
SES_Max_BAEF = 100.00/(0.5) = 200.0
SES values above 99.5% which will give Min_SEC less than 0.5 and hence will correspondingly yield SES_Max_BAEF values significantly higher than 200.0. However, the proportion of nodes reaching Max_BAEF values above 200.0 will be negligible.

3.4 Certain SES BAEF Critical Values.

Three critical values have been identified as presented in Table 1, which correspond to certain critical values studied previously [46]. Colum headings are: C1→ SES BAEF critical value, C2→ Meaning of SES BAEF critical value, C3→ section in previous paper [46] to which the SES BAEF critical value corresponds.

C1	C2	C3
1	% nodes reaching MBAEF	3.4
2	% nodes with BAEF < MBAEF	3.5
3	% nodes with BAEF > MBAEF	3.6

Table 1: SES BAEF Critical Values

4. Conclusion.

This piece of research has illustrated 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 as supplied as infrastructure nodes in this study. The method extended here has been applied over results put forward in previous papers [14, 30, 46]. This paper adds to the study of ubicomp environment from a software engineering perspective. It also provides supplementary components for prediction and gauging reliability of ubicomp environment. It has also adapted certain new metrics developed previously [10] to further reinforce models in ubicomp and shaping the architecture of ubicomp.

This study is built over a previous empirical study done in simulator software NS-2 over Linux. Graphical analysis software has been gnuplot. Floating point calculations have been used to get accurate answers. This study is geared at providing values of BAEF in an objective mathematical way. Interpretation of values and trends obtained, as to whether they are good/bad or workable/unworkable, are not provided. These are open for designer's analysis.

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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