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# Extending Node Battery Availability in Ubicomp with Location-Aware Transmission Using Optimally Placed Relays.

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*Abstract* – **Ubiquitous computing is a fairly recent but fast developing field. One sub-component of research and development is the application of relays for enhancing a ubicomp topography. In a previous paper [12], an empirical analysis of suitability of relays for extending nodes' Battery Availability was proposed using a metric MBAEF. Placement of relays is of very big impact. Positioning relays or adding new relays at wrong positions may not give significant returns. Judicious methodical placement of relays has to be supported by appropriate metrics and obtained through good procedures.**

**The question put forward in previous paper [12] is extended here "By how much can nodes' batteries availability be extended with use of optimally placed relays?". The same method described previously [10] is used here over results presented in section 5 of previous paper [4], concerning optimised number of relays.**

**This paper is also a follow-up of several previous papers [2,3,10,11,12]. The objective of this paper is to present the MBAEF of batteries for varying numbers of optimally placed relays in a ubicomp topography. This information will reinforce reliability concepts in ubicomp architectures.**

**Key terms: Ubicomp-Ubiquitous Computing, ES-Energy Savings, EC-Energy Consumed, MES-Mean ES, MEC-Mean EC, BAEF-Battery Availability Extension Factor, MBAEF-Mean BAEF.**

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# 1. Introduction

The element of better energy savings being achieved with lesser but more judiciously placed relays in a ubicomp topography remains explainable and measurable. One such empirical study is presented in section 4 and 5 in previous paper [4]. Again, the next level question is "By how much will the Mean Battery Availability be extended when using optimally placed relays in a topography and Location-aware Transmission?".

The study aims at formulating the MBAEF derivable from 11 sets of experiments and results proposed in a previous paper [4]. Interpretation of results remains open for designers for further considerations. The results of this study may serve as follows:

i. Better boundings of MBAEF for circumstances of varying number of **"optimally"** positioned relays.
ii. Estimate what number of relays gives **most optimal MBAEF**.
iii. Subsequently, study requirements for node features and relay placement characteristics for future ubicomp architectures.

Here also, it is assumed that each relay is of abundant capacity, not facing any overload. It is acknowledged that more optimal placements may be found by trials and errors than presented in previous paper [4]. It remains a benefit to the one who has found it. The results presented in this paper will hence serve as a guidance of MBAEF reached until better placements achieving better MBAEF is put forward.

The rest of this paper is organised as follows: section 2-Experiment Result Used, section 3-Observation and Mathematical Method Applied, section 4- Graphical Analysis and section 5- Conclusion and References.

# 2. Experiment Used.

The same experiment as described in section 4 and 5 of previous paper [4] is used here. Again, the mathematical method proposed in section 3 of another previous paper [10] is applied here.

# 3. Observations and Mathematical method applied

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# for varying number of optimally positioned relays.

Here also, maximum Energy Savings reached in each of the 11 graphs presented in paper [4] are above 99.5%, percentage maximum BAEF will give erroneous results. Hence, here also, only the MBAEF is being looked into.

*3.1 Tabulated Results.*

This section follows from section 5 in previous paper [4]. The formulae used throughout will be as follows:

%MEC = 100% - %MES

MBAEF = (100%)/(%MES).

The results are presented in a tabular fashion.

| Optimal Relay Number | %MES | %MEC | MBAEF |
|---|---|---|---|
| 4 | 94 | 6.0 | 16.67 |
| 5 | 96 | 4.0 | 25.00 |
| 8 | 98 | 2.0 | 50.00 |
| 9 | 98 | 2.0 | 50.00 |
| 10 | 98 | 2.0 | 50.00 |
| 11 | 98 | 2.0 | 50.00 |
| 12 | 98 | 2.0 | 50.00 |
| 13 | 98 | 2.0 | 50.00 |
| 14 | 98 | 2.0 | 50.00 |
| 15 | 98 | 2.0 | 50.00 |
| 16 | 99 | 1.0 | 100.00 |

*3.2 General Observations.*

There is a tendency for the MBAEF values to increase with increasing number of relays. Here also, it should be noted that %MES values start at already very high values and increase to 99, i.e. nearly to maximum using integers at 16 relays. Values of %MES for relay numbers 8 until 15 suffer from lack of accuracy which creeps up to the percentage MEC values. The first 4 and last entries give the indication of steady increase.

# 4. Graphical Analysis.

This analysis is performed in gnuplot in Linux and the screenshot is shown in figure 1.

Taking more weightage on first 4 and last entries, the equation of best fit is set after several trials as follows:

$$F(x) = a*x + b$$

where x is the relay number and F(x) is the MBAEF. The constant values are a=6.7 and b=-10.

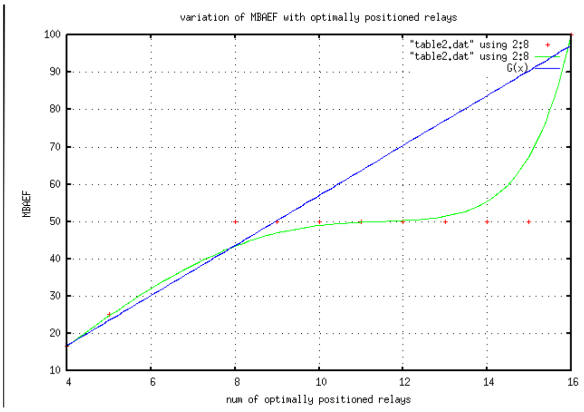


**Fig 1: Variation of MBAEF against number of Optimally positioned relays.**

It was already mentioned previously [12] that relays have high returns on investment. This continues to be the case for optimally placed number of relays. The highest MBAEF of 100.0 is noted here at 16 relays instead of 25 as in previous paper [12]. The impacts in terms of reliability remain high here also.

As mentioned previously [12], the linear model put forward here remains applicable in larger topographies with varying relay numbers with an additional processing of converting relay density in that larger topography to a corresponding relay density over 300 x 300 $m^2$.

Since finding better optimal position remains possible, one criterion that the better positioning should fulfill is that it must give better MBAEF values than projected in this model.

# 5. Conclusion.

In this piece of study, the question "By how much can nodes' battery availability be extended using Location-aware transmission strategy in a topography of varying number of **optimally** placed relays?", has been extended on more judicious placements of relays explained in previous paper [4]. This work remains empirical and is built over results presented previously [4] and using mathematical method introduced in previous paper [10]. In this paper, a graphical analysis has been carried out for the metric MBAEF and a linear model of behaviour with corresponding equation has been put forward.

**From the observations made in this paper, the suitability of relays for extending nodes Battery availability is reinforced.** Need for more accurate data for %MES is acknowledged here also, to yield more accurate graph plottings.

This paper extends one additional component introduced in previous paper [12], to the study of ubicomp from software engineering perspective. The suitability of relays is further reinforced by the metric MBAEF. The model put forward in this paper adds to the components for prediction and reliability assessment of ubicomp environment. It can also be used as a benchmarking component to rate other arrangements of optimally placed relays put forward by designers as being of better or less good returns. Ultimately, the results of this study will assist in formulating better reliability concepts towards reinforcing future ubicomp architectures.

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