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

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***Abstract* – Significant Research is being carried out concerning location-tracking in mobile environment [10-26]. Several successive stages in this area is expected like devising new functionalities and applications and improving ways of doing existing activities [2]. In this path of research formulation, there can be many questions asked whose answer will depend on components, features and models that are themselves not yet well developed and stabilised. As and when these components are being put forward and hopefully acknowledged by research community, more of these questions can be pulled back and investigated into. One such "far-sighted" question is "*By how much can a node's battery availability be extended with Location-Aware Node-to-Node transmission in ubicomp?*".**

To answer to this question, sufficient information should be available as concerns energy consumption/savings achievable in such a ubicomp topography. One such component is supplied in a previous paper [2] whereby modelling of energy savings achievable is put forward. This information can be used to formulate better ubicomp architectures.

Key terms: Ubicomp-Ubiquitous Computing, CBR-Constant Bit Rate, 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

Energy Consumption and savings is among the vital components in ubicomp. No matter how good or recent a battery is, ways of work which have potential in extending its availability is not negligible at present levels of research and development. Towards this objective, one key 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 may not provide so high refresh rates but simulation models remain important to delimit bounds of achievements in this direction [2]. It remains that the more exact refresh rates, assuming that the ability to channel this information into transmission strategies is present, the better the savings until a stable limit is observed. Following this stable limit, projection of battery availability extensions can be made, from an empirical perspective. This can serve as an upper bounding of the extension to further analyse how to reinforce ubicomp architectures and decide directions of investments needed.

The key contribution of this paper is the development of a simple mathematical method of calculating the amount by which a node battery availability can be extended by applying exact location-aware transmission strategy in direct node-to-node communication in a ubicomp environment. This mathematical method is built over the model proposed in a previous paper [2].

The rest of this paper is organised as follows: section 2-Experiment Result Used, section 3-Observation and Mathematical method Formulation, section 4-Observation and Mathematical method applied for different time ranges, section 5-Conclusion and References.

2. Experiment Result Used.

The various issues here are as described in previous paper [2].

3. Observations and Mathematical Method Formulation.

This section follows from section 3.1 in previous paper [2].

i. 1.35% of CBR will be subject to 0% savings. This also implies that probability of a nodes' battery availability is not extended is 1.35%.

ii. From i above, it can be implied that the probability of a node's battery availability is extended is 98.65%.

iii. It is also put forward in previous paper [2] that Mean Energy Savings (MES) achievable is 67%. It directly implies that the mean energy consumed (MEC) is reduced to 33% (roughly 1/3).

If MEC is about 1/3, it directly implies that a node's battery availability will be extended by 3 times.

The mathematical procedure is hence put as follows:

Step i. %MEC = 100% - %MES
= 100% -67%
= 33%

Step ii. MBAEF = (100%)/(%MEC)
= 100/33
= 3.03 times

This result, i.e., the mean Battery Availability Extension Factor, is 3.03 in a ubicomp topography of 300 x 300 m^2 using exact location-aware transmission, is being put forward together with the following min-BAEF and max-BAEF.

iv. More than 80% of CBRs achieve more than 45% ES [2]. For this 80% of CBRs, and taking Minimum Energy Savings (min ES) at 45%

%min EC = 100% -(% min ES)
= (100-45)%
= 55%

Min BAEF = (100%)/(%min EC)
= 100/55
= 1.82

v. The maximum Energy Savings (Max ES) observed was at 89%, though it is achieved by 0.16% of CBRs [2]. For this situation, though its probability of occurrence is extremely low (0.16%).

% max EC = 100% -(%max ES)
= 100% - 89%
= 11%

Max BAEF = (100%)/(% max EC)
=100/11
= 9.09

4. Observations and Mathematical Method applied for different time ranges.

Under this section, an attempt to estimate the BAEF in circumstances of contained duration of transmission is made here. Containing duration of transmission will contain effects of other parameters like amount of mobility during transmission, effects of noise and needs of flow control strategies amongst others. This section follows directly from section 3.4 and 3.5 from previous paper [2].

i. For range 0-20 secs, most CBRs achieve around 10-45% ES. This implies that EC is around 55-90%.

Range of BAEF: between (100/90) and (100/55)
i.e. 1.11 and 1.82

If transmissions are contained for 0-20 sec, the BAEF achievable will mostly vary between 1.11 and 1.82.

ii. For range 20-40 secs, all CBRs have savings above 11%. Hence taking % min ES at 11%,

%min EC = 100 % - %min_ES
= 100 % - 11%
= 89 %

Min BAEF = (100%)/(%min EC)
= 100/89
= 1.12

Maximum %ES noted was at 76%, hence

%max EC = 100% - %max ES
= 100% -76%
= 24%

Max BAEF = (100%)/(%max EC)
= 100/24
= 4.17

Here, mean ES is observed at 40%, giving MBAEF of 1.67. **If transmissions are contained for 20-40 secs, the BAEF will range between 1.12 and 4.17 with MBAEF of 1.67.**

iii. For range 40-60 secs, min ES noted is 22% and max ES is about 82%.

% min EC = 100% - %min Es
= (100-22)%
= 78%

Min BAEF = (100%)/(%min EC)
= 100/78
= 1.28

%max EC = 100% - % max ES
= (100-82)%
= 18 %

Max BAEF = (100%)/(%max EC)
= 100/18
= 5.56

If transmissions are contained for 40-60 secs, the BAEF will range between 1.28 and 5.56 with a possible MBAEF at 2.5.

iv. For all ranges above 60 secs, they show similar characteristics: min ES at about 40%, maximum ES at about 80% and convincing peak ES at around 67%.

%min EC = 100% - %min ES
= 100% - 40%
= 60%

Min BAEF = (100%)/(%min EC)
= 100/60
= 1.67

%max EC = 100% - % max ES
= (100-80)%
= 20%

Max BAEF = (100%)/(% max EC)
= 100/20
= 5

MBAEF will be at 3.03, as calculated in part (iii) of section 3.

If transmission are contained between 60 s and 250 s, the BAEF will range between 1.67 and 5 with MBAEF at 3.03

5. Conclusion.

This piece of research has put forward a mathematical method of predicting the extents to which node's battery availability could be extended using location-aware transmission strategy over a ubicomp topography of 300 x 300 m^2. The method is applied over results put forward in a previous paper [2]. This paper adds to the study of ubicomp environment from a software engineering perspective. It also provides additional components for prediction and gauging reliability of ubicomp environment. It has also helped in formulating new metrics involved to further reinforce models in ubicomp and shaping the architecture of ubicomp.

This study is built over a previous empirical study done in simulations. Real environment implementations to reach to the mathematical method being put forward in this paper would depend on implementation of a vast range of components, concepts and models that have not yet reached a stable level.

This study is geared at providing values of BAEF in an objective mathematical way. Interpretation of values obtained, as to whether they are good/bad or workable/unworkable, are not provided. They are open for designers involved in ubicomp, to analyse their impacts in their ubicomp environments.

The further study works identified may include: repeating the study for nodes in a ubicomp topography with varying location refresh intervals, repeat the srudy in a topography using varying number of relays and redesign experiments for study of Battery Availability Extension Factor (BAEF) over complete ad-hoc environments with varying node densities.

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