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

M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY

Abstract – **Ubiquitous computing is a fairly recent field of development and quite much achievements have been reached [12-28]. Research remains open for newer batteries, better compression strategies, better processors for ubicomp devices, better communication strategies and surrogate support, one specific field of study is location-aware transmission strategies in ubicomp topographies with varying number of uniformly positioned relays. Indeed, wireless communication is highly energy consuming and it varies proportional to the square of distance between sender and receiver and relays can help by reducing the maximum distances for transmission.**

A more far-sighted question remains "By how much can nodes' batteries availability be extended with use of uniformly placed relays?". Such an issue can be tackled once underlying components of trends of energy savings/consumed are available. One such component has been put forward in a previous paper [4]. The method to be applied is explained in another previous paper [10]. This paper is a follow-up of several previous papers [2,3,10,11] where one future work identified in paper [10] is tackled here. The objective of this paper is to present the MBAEF of batteries for varying numbers of uniformly placed relays in a ubicomp topography. This information will help towards formulation of reliability components 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.

M. Kaleem GALAMALI,
University of Technology Mauritius (student)
Mauritius

Assoc. Prof Nawaz Mohamudally
University of Technology Mauritius,
Mauritius

1. Introduction

Though the element of energy being used for individual transmissions is not tangible by users of mobile computing devices, the element of "how long the battery availability lasted", remains perceptible. The user community is aware of need of ways to make batteries last longer [29,30]. Whichever technology to better contain energy consumption is put forward will definitely face the question "By how much will the mean Battery Availability be extended?". Such is the case for location-aware transmission in ubicomp using relays or access points.

The study aims at formulating the MBAEF derivable from 17 sets of experiments and results proposed in a previous paper [4]. Interpretation of results remains open for designers' further considerations. The results of this study may serve as follows:

i. Better boundings of MBAEF for circumstances of varying number of **"uniformly"** positioned relays.
ii. Estimate what number of relays gives optimal MBAEF.
iii. Subsequently, study requirements for node features, environment support, bandwidth support and transmission strategies for future ubicomp architectures.

In this study, it is assumed that each relay is of abundant capacity, not facing any overload.

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 previous paper [4] is worked over in this paper. The mathematical method proposed in section 3 of another previous paper [10] is applied here also in this paper as applied previously [11].

3. Observations and Mathematical method applied

International Journal of Advances in Computer Science & Its Applications– IJCSIA
Volume 5 : Issue 2 [ISSN : 2250-3765]
Publication Date: 30 October, 2015

for varying number of uniformly positioned relays.

It is noted here that maximum energy savings reached in each of the 17 graphs presented in paper [4] are above 99.5% (i.e. nearing 100%). This would make percentage Energy Consumed less than 0.5% and give max BAEF, using method elaborated in previous paper [11] very erroneous and unworkable. Hence only the MBAEF is being looked into.

3.1 Tabulated Results.

This section follows from section 3 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.

Relay Number	%MES	%MEC	MBAEF
1	85	15.0	6.67
2	91	9.0	11.11
3	93	7.0	14.29
4	95	5.0	20.00
5	96	4.0	25.00
6	96	4.0	25.00
7	97	3.0	33.33
8	97	3.0	33.33
9	97	3.0	33.33
10	97	3.0	33.33
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	98	2.0	50.00
25	99	1.0	100.00

3.2 General Observations.

There is a tendency for the MBAEF values to increase with increasing number of relays. It should be noted that %MES values start at an already very high value and increase steadily to almost the limit (at 100 if %MES is worked at integer level). This makes %MEC values become corresponding smaller and the MBAEF values grow large.

It is acknowledged that several entries may be having same %MES values and correspondingly same %MEC and MBAEF values (e.g. record 7-10 have %MES of 97). It is understood that this is due to rounding off feature applied in previous paper [4]. The values would have varied more 'elegantly' if the %MES was recorded at 2 or more decimal places. This would have been reflected in the MBAEF values.

4. Graphical Analysis.

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

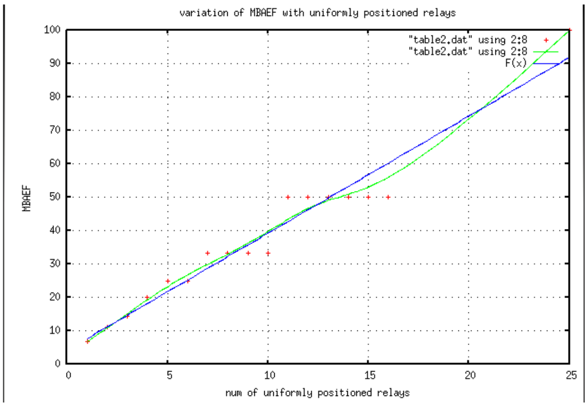

Fig 1: Variation of MBAEF against number of uniformly positioned relays.

The initial values for relay number 1 until 8 depict a strong linear relationship. The later values suffer from the reduced accuracy applied for %MES (available as raw data). The increasing tendency is clear however until relay number 25. The equation of best fit is hypothesised as follows in gnuplot

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

where x is the relay number and F(x) is the MBAEF. The constant values are a=3.50952 and b=4.1391. The reduced chi-square value is 24.9333 (a quite moderate value expected due to reduced accuracy of raw data).

There is really high return in investing into relays if the objective of extending nodes' battery availability is to be fulfilled. With as small relay density of 1 relay per topography of 300 x 300 m^2, most nodes will experience a MBAEF of 6.67 for battery lifetime. The increase is very drastic for increasing number of relays until for 25 relays where the MBAEF is 100.0, i.e. with this relay density, the nodes can operate for 100 times longer. This is really of big consequences in reliability of MANET operations and impacts heavily on future way of life of users and technical methods of operations to be applied in such a topography.

This graphical analysis and method put forward can remain 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.

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 **uniformly** placed relays?", has been tackled empirically using results presented in a previous paper [4] and a mathematical method put forward previously [10]. In this paper, a graphical analysis has been performed for the metric MBAEF and a linear equation of best fit has been put forward, depicting that MBEAF and relay numbers vary in a linear model.

Definitely use of relays will increase Battery Availability by many times and from these observations, it can be suggested that future "stable" ubicomp topographies be equipped with judiciously calculated relay densities. It has been acknowledged that use of more accurate raw data for %MES would have given more accurate plottings on the graph.

This paper describes one additional component to the study of ubicomp environment from a software engineering perspective. The suitability of relays in ubicomp is reinforced with this knowledge presented. The model put forward in this paper adds to the components for prediction and reliability assessment of ubicomp environment. Ultimately, the results of this study will assist in formulating better reliability concepts, as concerns suitability of relays, towards shaping future architecture of ubicomp.

References

[1] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Towards Dependable Pervasive Systems-A Position and Vision Paper, CEET 2014

[2] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Energy Savings achievable with Location-aware Node-to-Node Transmission in UbiComp , CEET 2014

[3] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Energy Savings achievable with Location-aware Node-to-Node Transmission in UbiComp Using Location Refresh Intervals, CEET 2014

[4] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Energy Savings achievable with Location-aware Transmission in UbiComp Using Relays, CEET 2014

[5] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Mathematical modeling of need of exact number of relays to ensure seamless mobility in mobile computing, CEET 2014

[6] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Modelling of need for multiple relays for ensuring seamless mobility, CEET 2014

[7] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Investigation of prominence of placements of relays in a ubicomp topography,

[8] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of energy savings achievable with location-aware transmission in ubicomp using optimised number of relays.

[9] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Investigation of Prominence of Placements of Optimised Number of Relays in a Ubicomp Topography using Location-Aware Transmission, CEET 2015.

[10] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Extending Node Battery Availability in Ubicomp with Location-Aware Transmission.

[11] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Extending Node Battery Availability in Ubicomp with Location-Aware Transmission using Location Refresh Intervals.

[12] Markus Bylund and Zary Segall, Towards seamless mobility with personal servers, 2004.

[13] Masugi Inoue, Mikio Hasegawa, Nobuo Ryoki and Hiroyuki Morikawa, Context-Based Seamless Network and Application Control, 2004

[14] Xiang Song, Umakishore Ramachandran, MobiGo: A Middleware for Seamless Mobility, College of Computing Georgia Institute of Technology, Atlanta, GA, USA, August 2007

[15] Budzisz, Ferrús, R., Brunstrom A., Grinnemo, K, Fracchia, R., Galante, G., and Casadevall, F. Towards transport-layer mobility: Evolution of SCTP multihoming, March 2008

[16] Paul Dourish & Genevieve Bell, Divining a digital future, 2011.

[17] Xiang Song, Seamless Mobility In Ubiquitous Computing Environments, PhD Thesis, Georgia Institute of Technology, August 2008

[18] Kevin O Mahony, Jian Liang, Kieran Delaney, User-Centric Personalization and Autonomous Reconfiguration Across Ubiquitous Computing Environments, NIMBUS Centre Cork Institute of Technology, Cork, Ireland, UBICOMM 2012

[19] Pablo Vidales, Seamless mobility in 4G systems, *Technical Report, University of Cambridge*, Computer Laboratory, Number 656, November 2005

[20] João Pedro Sousa and David Garlan, Aura: An Architectural Framework for User Mobility in Ubiquitous Computing Environments, School of Computer Science, Carnegie Mellon University, USA, *August 2002*

[21] Dennis Lupiana, Ciaran O'Driscoll, Fredrick Mtenzi, Defining Smart Space in the Context of Ubiquitous Computing, Dublin Institute of Technology, Ireland, Special Issue on ICIT 2009 Conference - Web and Agent Systems, 2009

[22] N.S.V.Shet1, Prof.K.Chandrasekaran2 and Prof. K.C.Shet3, *WAP Based Seamless Roaming In Urban Environment with Wise Handoff Technique,* International Journal of UbiComp (IJU), Vol.1, No.4, October 2010

[23] Yipeng Yu Dan He Weidong Hua Shijian Li Yu Qi Yueming Wang Gang Pan, FlyingBuddy2: A Brain-controlledAssistant for the Handicapped, Zhejiang University, *UbiComp'12,* September 5-8, 2012.

[24] Jing Su, James Scott, Pan Hui, Jon Crowcroft, Eyal de Lara Christophe Diot, Ashvin Goel, Meng How Lim, and Eben Upton, Haggle: Seamless Networking for Mobile Applications, 2007

[25] Rui Han, Moustafa M. Ghanem, Li Guo, Yike Guo∗, Michelle Osmond, Enabling cost-aware and adaptive elasticity of multi-tier cloud applications, Future Generation Computer Systems, 2012

[26] Byrav Ramamurthy, K. K. Ramakrishnan , Rakesh K. Sinha, Cost and Reliability Considerations in Designing the Next-Generation IP over WDM Backbone Networks, 2012.

[27] Bhavish Aggarwal, Aditya Akella, Ashok Anand, Athula Balachandran, Pushkar Chitnis, Chitra Muthukrishnan, Ram Ramjee and George Varghese, EndRE: An End-System Redundancy Elimination Service for Enterprises, NSDI

2010, San Jose, CA

[28] Ashok Anand, Vyas Sekar and Aditya Akella, SmartRE: An Architecture for Coordinated Network-wide Redundancy Elimination, SIGCOMM 2009, Barcelona, Spain

[29] John Breeden II, "Smart-phone battery life could double – without better batteries", Nov 14, 2012

[30] Andy Boxall, "When will your phone battery last as long as your kindle", December 5, 2012.

About Author (s):

Associate Professor Nawaz Mohamudally works at University of Technology, Mauritius and has undertaken supervision of MPhil/PhD Students for many years.

M. Kaleem Galamali is a part-time student at University of Technology, Mauritius under the supervision of A.P. Nawaz Mohamudally.