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

Modelof Energy Savings Achievable with Location-aware Transmission in Ubicomp using Optimised Number of Relays.

M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY

***Abstract*–There is no doubt that relays in aubicomp topography bring commendable support for communication and efficient reduction in energy consumption by transmitting nodes [4]. However, all these benefits are for transmitting nodes only. Less information is available as advantages or cost-effective sequence of steps for the development of the ubicomp architecture and topography. Investing into a network of relay will come with its costs and may not be achievable at one go. There is need for a phased method of investment starting from lesser number of relays but with more optimal returns including energy savings perspectives. To achieve this, a way to model and predict amount/proportion of energy saved and metrics concerned is required, from a software engineering perspective, when applying relays in aubicomp topography.**

This paper is a follow-up of 7 papers [1-7] with more focus from paper [4] and areas of investigation identified in paper [7]. This paper is aimed at producing models of energy savings achievable in various scenarios of optimised relays put forward in previous paper [7]. The results of experiments run are displayed graphically and relevant conclusions and equations derived are also put forward. These results will certainly help build more reliable architectures for future ubicomp.

Key terms: MAUC-Mobile and Ubiquitous Computing, CBR-Constant Bit Rate, Transit Relay-1st relay of transmission reached by sender node, SD- Standard Deviation, PVaM- Peak Value at Mean, PCSME- % CBR spending more energy, GNES- Greatest Negative Energy Savings, MoD- Mean of Distribution.

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

Assoc. Prof Nawaz Mohamudally
University of Technology Mauritius,
Mauritius

1. Introduction

1.1 Brief of Relay.

As mentioned in previous paper [4] relays can serve for many purposes, including aiding transmitting devices to save energy for transmissions and retransmissions. Specialised fixed relays have lots of advantages including cheapness, ease of installations, high power availability and heavy processing capacities. These advantages must be harnessed in aubicomp environment.

1.2Scope of this Study?.

This study aims at finding trends of energy savings achievable when relays are used in different scenarios of varying number of relays. Particular focus is given to arrangements identified in previous paper [7] whereby starting from a uniform arrangement of n^2 or n(n-1) relays, omission of least prominent relays is effected and the resultant scenario of relays is being subject to experimentation and analysis. The results of this study are expected to serve for:

i. Understanding the energy savings trends achievable with varying optimal numbers of non-uniformly placed relays.
ii. Better estimating the optimal relay densities that can be adopted as starting point or intermediate states, with known parameters of variations.
iii. Better estimate future optimal relay densities in cases of expansion, increases in node densities, changes in patterns of mobility and communication etc, and formulate ready solutions to predictable situations.
iv. Better plan for placement of relays in an optimal fashion. It can also be envisaged to reduce margins of uncertainties scientifically before attempting further refinements manually as to where placements are best.
v. Understand types of relays and corresponding power needs of relays at different placements despite omissions of least prominent ones. This will also foster possibilities of continued use of old relays with possible reshufflings needed.

The key contribution of this paper is the development of an empirical, simulation-based model of the % energy savings achievable in aubicomp topography of optimised numbers and placements of relays, taking into consideration exact location-aware transmission strategies. The model suggested in this paper has also followed from previous paper [4] and is the exponential model of the form:

$$g(x) = 0.1 * c * \exp(c*(x-d))$$

The rest of this paper is organised as follows: section 2-experiment design, section 3-'Results and observations' which is subdivided into 3 subsections: 3.1-Trend Analyses of Energy Savings, 3.2-Summary table of results obtained, 3.3- Specific Observations and Formulations, section 4- Conclusion and References.

2. Experiment Design

This follows from previous paper [4] where progresses from 2 previous papers [2][3] are made use of. A total of 11 sets of processing could be devised corresponding to the different optimal numbers of relays. The positioning of the relays are prefixed and their exact locations are pre-specified in programs for experimentations. Again CBR sending to nearest relay is considered for each packet. Energy spent is recorded and energy saved can be calculated. Again, here also, energy saved can be negative in case the closest relay is further than the receiver nodes.

Here also, for smaller number of relays, processing takes smaller time and for larger number of relays, more processing time is needed. The following provisions have also been made:

i. Keep track of relay positions for each number of relays concerned.
ii. For each CBR, number of packets being transmitted to each relay.
iii. Summary of total amount of data transiting through each relay.

3.Results and observations.

<u>*3.1 Trend Analyses of Energy Savings.*</u>

1. Using 4 Optimal relays.

This follows from part 6 under section 3.1 in previous paper [7].

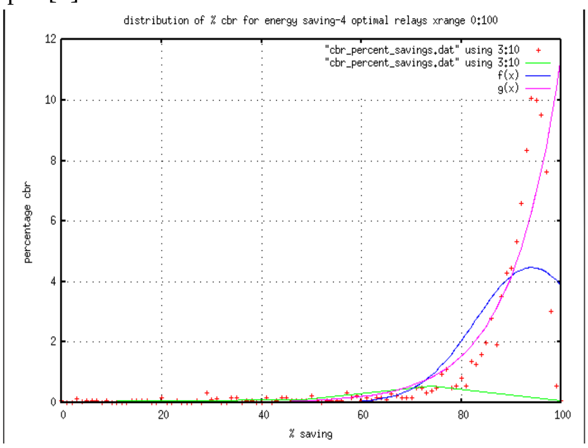

Fig 1: Trends of energy savings achieved – 4 optimal relays

PCSME is 3.016, GNES is 24.6 times higher. MoD is at 94% and PVaM is at 10.06. Normal Curve fitting gives a SD of 0.0892484 but is not really successful, as will be the case for successive observations. What is interesting here is that even in this case of reduced uniformity, the exponential distribution model, as put forward in previous paper [4], seems applicable here also with equation.

$$g(x)=0.01006 * \exp(0.1006*(x-30))$$

The experiment is successful in proving applicability of the exponential distribution. However, this attempt of optimisation is giving worse results than observed in part 4 under section 3.1 in previous paper [4]. The MoD is not so much affected but the PVaM is very much reduced, together with value of d.

2. Using 5 Optimal relays.

This follows from part 9 under section 3.1 in previous paper [7].

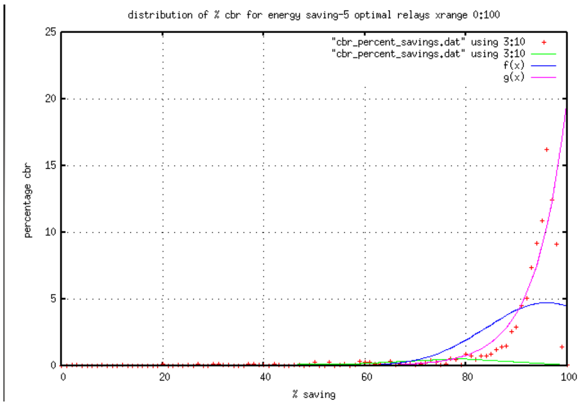

Fig 2: Trends of energy savings achieved – 5 optimal relays

PCSME is 2.06. GNES is about 20.2 times higher. MoD is at 96% and PVaM is at 16.19. Exponential curve fits with equation:

$$g(x)=0.01619 * \exp(0.1619*(x-56))$$

This attempt to optimisation is clearly more successful as it gives better performance than identified in part 5 under section 3.1 in previous paper [4]. Though the MoD is the same at 96%, the PVaM is better and value of d also is at a higher value. It is comparatively nearly as good as 6 relays used in part 6 in previous paper [4], but is far from the performance given by 9 relays in part 9 in previous paper [4]. Still, it remains a very solid starting point if later additional relays will be used. It also gives grounds for the notion of central axes mentioned in previous paper [7].

3. Using 8 optimal relays.

This follows from part 12 under section 3.1 in previous paper [7].

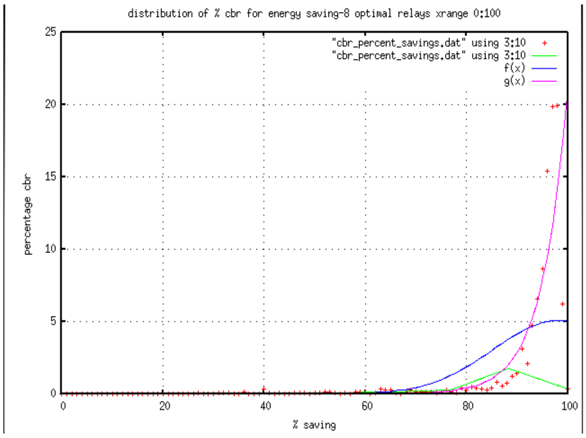

Fig 3: Trends of energy savings achieved – 8 optimal relays

PCSME is 0.95 (less than 1%) and GNES is about 11.25 times higher. MoD is at 98% and PVaM is at 19.92. Again, exponential curve fits with equation

$$g(x)=0.01992 * \exp(0.1992*(x-65))$$

This attempt for optimisation gives a fairly good improvement compared to what is observed in part 8 under section 3.1 in previous paper [4]. The MoD has increased from 97 to 98 though PVaM decreased from 23.16 to 19.92. Also, this optimisation tends to increase the number of CBRs making savings above the MoD value and hence remains a considerable arrangement. It also reinforces notion of relays close to central axes.

4. Using 9 Optimal relays.

This follows from part 16 under section 3.1 in previous paper [7].

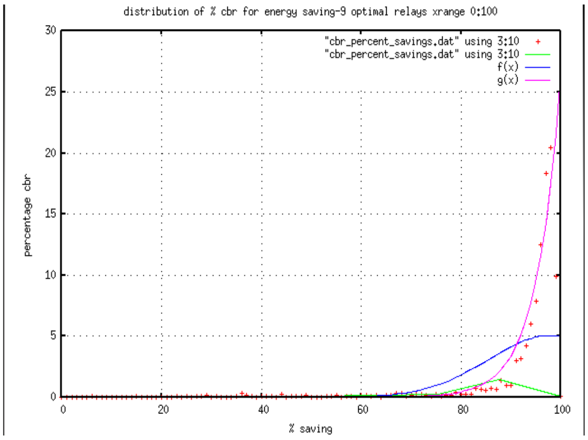

Fig 4: Trends of energy savings achieved – 9 optimal relays

PCSME is 0.95 (less than 1%). GNES is at about 9 times higher. MoD is at 98% and PVaM is 20.48. Again, the exponential curve is very fitting with equation

$$g(x)=0.02048 * \exp(0.2048*(x-65))$$

Compared to situation in part 9 under section 3.1 in previous paper [4], the mean value has improved from 97% to 98% but the number of CBRs making savings above the mean value is not significantly increased and hence this arrangement is not so valuable.

5. Using 10 Optimal relays.

This follows from part 16 under section 3.1 in previous paper [7].

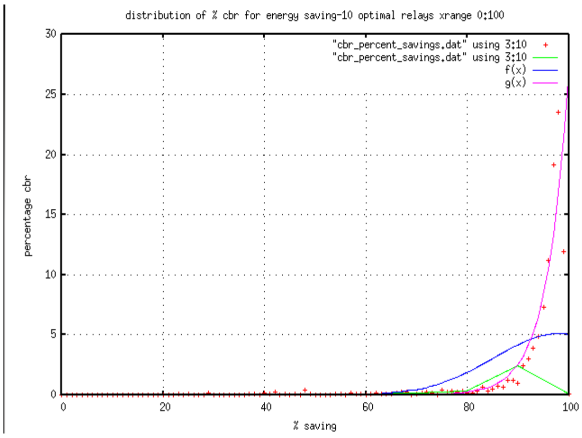

Fig 5: Trends of energy savings achieved – 10 optimal relays

PCSME is 0.64 (less than 1%). GNES is at about 9 times higher. MoD is at 98% and PVaM is 23.50. Again, exponential curve fits with equation.

$$g(x)=0.02350 * \exp(0.2350*(x-70))$$

Compared to situation in part 10 under section 3.1 in previous paper [4], MoD has improved from 97% to 98% but remaining factors are mostly unchanged. Already in part 10 of previous paper [7], mention was made that the arrangement was not successful enough. Hence, here also, the arrangement is considered not successful enough but can be envisaged as initial or intermediary arrangement if an upgrade in near future is expected.

6. Using 11 optimal relays.

This follows from part 16 under section 3.1 in previous paper [7].

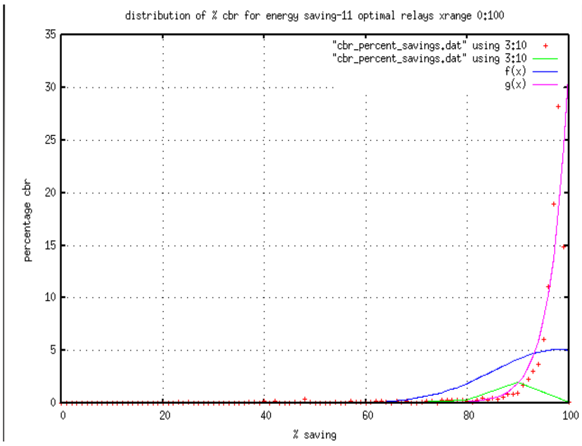

Fig 6: Trends of energy savings achieved – 11 optimal relays

PCSME is 0.64 (less than 1%). GNES is at about 9 times higher. MoD is at 98% and PVaM is 28.18. Exponential distribution fits with equation:

g(x)=0.02818 * exp (0.2818*(x-75))

Compared to situation studied in part 11 under section 3.1 in previous paper [4], PVaM has regressed from 31.35 to 28.18 and value of d has also regressed from 76 to 75. This attempt of optimisation is hence not successful.

7. Using 12 optimal relays.

This follows from part 16 under section 3.1 in previous paper [7].

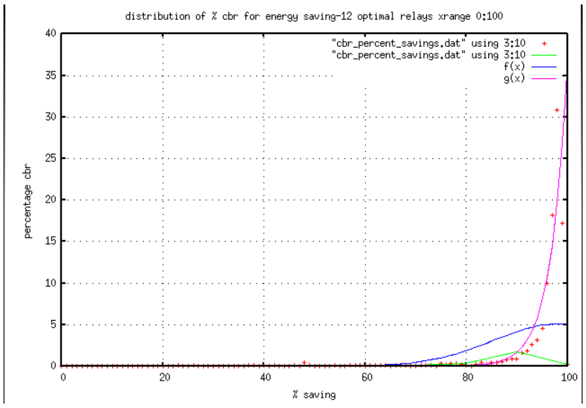

Fig 7: Trends of energy savings achieved – 12 optimal relays

PCSME is 0.64. GNES is about 9 times higher. MoD is at 98% and PVaM is 30.80. Exponential curve fitting is successful with equation:

g(x)=0.03080 * exp (0.3080*(x-77))

Compared to situation studied in part 12 under section 3.1 in previous paper [4], PVaM has regressed from 33.418 to 30.80 and value of d has regressed from 78 to 77. This attempt of optimisation is hence not successful.

8. Using 13 optimal relays.

This follows from part 17 under section 3.1 in previous paper [7].

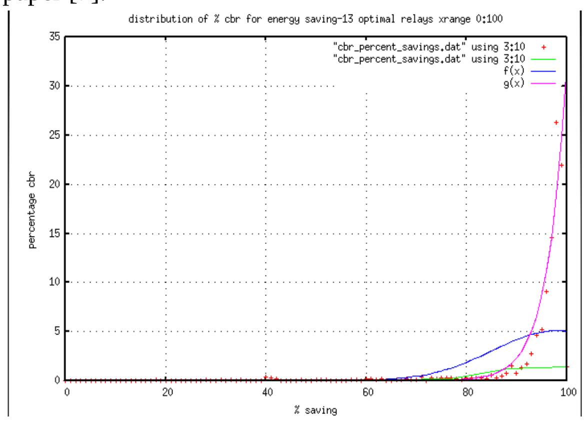

Fig 8: Trends of energy savings achieved – 13 optimal relays

PCSME is 0.56 (less than 1%). GNES is about 10.5 times higher. MoD is at 98% and PVaM is at 26.34. Exponential curve fitting is successful with equation:

g(x)=0.02634 * exp (0.2634*(x-73))

Compared to situation studied in part 13 under section 3.1 in previous paper [4], PVaM has regressed from 29.592 to 26.34 and value of d has regressed from 76 to 73. This attempt of optimisation is hence not successful.

9. Using 14optimal relays.

This follows from part 17 under section 3.1 in previous paper [7].

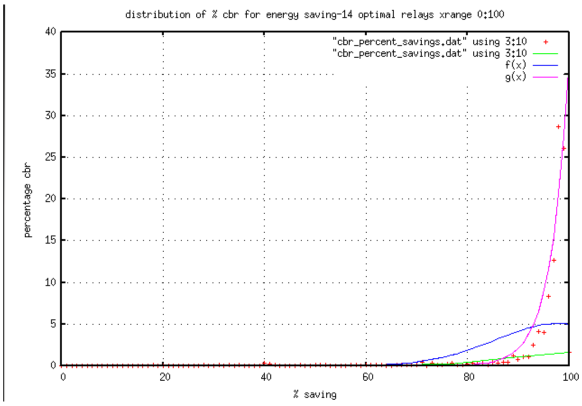

Fig 9: Trends of energy savings achieved – 14 optimal relays

PCSME is 0.56 (less than 1%). GNES reached is 10.5 times higher. MoD is at 98% and PVaM is 28.64. Exponential curve fits with equation:

g(x)=0.02864 * exp (0.2864*(x-75))

Compared to situation studied in part 14 under section 3.1 in previous paper [4], the PVaM has regressed from 32.688 to 28.64 and the value of d also regressed from 78 to 75. This attempt to optimisation is not successful but can serve as intermediate one for future upgrades.

10. Using 15optimal relays.

This follows from part 17 under section 3.1 in previous paper [7].

PCSME is 0.56 (less than 1%). GNES is about 10.5 times higher. MoD is at 98% and PVaM is 29.43. Exponential curve fitting is successful with equation:

g(x)=0.02943 * exp (0.2943*(x-76))

Compared to situation studied in part 15 under section 3.1 in previous paper, the PVaM has regressed from 35.46% to 29.43% and value of d has regressed from 80 to 76. This attempt to optimisation is not successful but can serve as intermediate state for future upgrades.

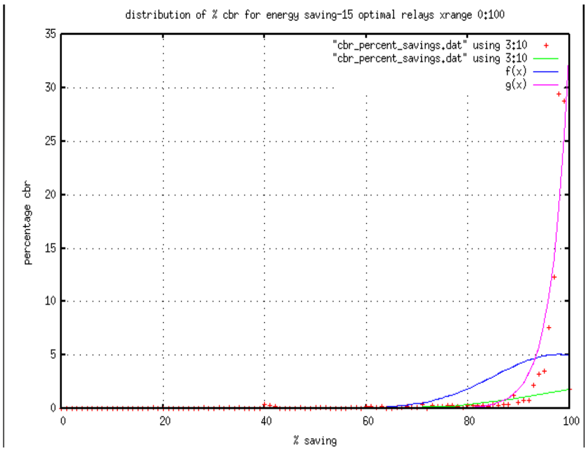

Fig 10: Trends of energy savings achieved – 15 optimal relays

11. Using 16 optimal relays.

This follows from part 17 under section 3.1 in previous paper [7].

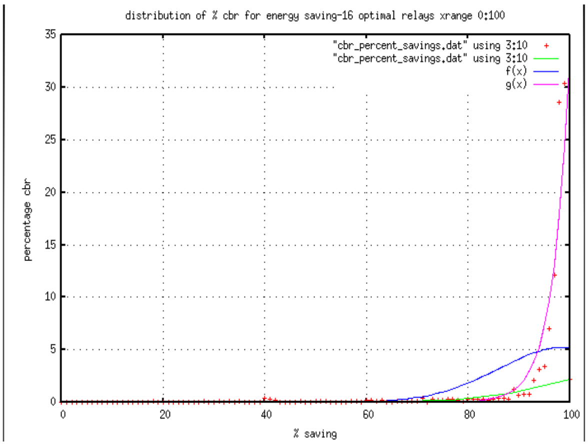

Fig 11: Trends of energy savings achieved – 16 optimal relays

PCSME is 0.56 (less than 1%). GNES is about 10.5 times higher. MoD is at 99% and PVaM is 30.40. Exponential curve fits with equation:

$$g(x)=0.03040 * \exp(0.3040*(x-77))$$

Compared to situation studied in part 16 under section 3.1 in previous paper [4], the MoD has regressed from 80 to 77 and PVaM has also regressed from 35.545 to 30.40. The interesting observation here is that % CBR making energy savings above MoD value has significantly improved.

This attempt to optimisation has given some improvements and is hence considerable.

3.2 Summary Table of Results Obtained.

The following table provides a summary of results obtained in section 3.1 above. The table headers are as follows: a- Relay Number, b-MoD, c-PVaM, d-%saving above which 97.5% CBRs lie, e-Number of CBRs less than 0% energy savings, f- %CBRs with less than 0% energy savings, g- %GNES.

a	b	c	d	e	f	g
4	94	10.06	30	190	3.016	2463
5	96	16.19	56	130	2.064	2015
8	98	19.92	65	60	0.953	1054
9	98	20.48	65	60	0.953	1125
10	98	23.50	70	40	0.635	899
11	98	28.18	75	40	0.635	899
12	98	30.80	77	40	0.635	899
13	98	26.34	73	35	0.556	1049
14	98	28.64	75	35	0.556	1049
15	98	29.43	76	35	0.556	1049
16	99	30.40	77	35	0.556	1049

3.3Specific Observations and Formulations. .

i. Confirmation of Exponential Model.

Despite removal of certain lesser prominent relays, we can observe the continued applicability of exponential distribution conforming to:

$$\mathbf{g(x) = 0.1 * c * \exp(c*(x-d))}$$

where c is the PVaM and d is the % saving above and including which the majority of the distribution lies (about 97.5%).

It is also true that many attempts to optimisation have not given high success because values of c and d have regressed but it remains that the exponential model has continued to apply and the fits on the graphs are very convincing.

This is the **biggest success** of this section of study.

ii. Confirmation of better suitability of relays along Central Axes.

In the previous paper [7], mention was made about suitability of placements close to central axes in the topography. Parts 2, 3 and 11 under section 3.1 in this paper, have given good levels of success for optimisation. It is hence suggested that bringing relays closer to the central axes will be more prone to successful optimisations.

This may also be a ground for further experimentation open to discover better models applicable as from 8 relays and above.

iii. All arrangements acceptable for future upgrades.

All arrangements, despite lowered performance of some of them, remain suitable as starting point or intermediate state considering expected future enhancement. This is further supported by the fact that the mean values have mostly not regressed at all and that %CBR spending more energy is mostly as low as below 3%.

iv. Significance of Number of Relays.

For relays up to 16 in a topography of 300 x 300 m^2, i.e. a relay density of 16/(300x300) relays/m^2, each relay, even the least prominent ones, may bring very significant contribution in the model of energy savings achievable. They do affect the MoD value and specially the PVaM. The technique of optimisation devised by omitting least prominent relays will be more successful if starting from high numbers of relays. An example would be: start with a high number of relays like 40 or 50, keep track of prominence of each relay while computing energy consumptions for transmissions and then calculate which one may be omitted.

4. Conclusion.

This piece of study is a follow-up of 7 previous papers [1-7] with more focus from papers [4][7]. The nature of this study has been to experiment over 11 scenarios of varying number of relays and placements towards finding trends of energy savings achievable. Results have been analysed graphically to produce equations of trends observed, hence the presence of the number of graphs in this paper.

This piece of study has provided **three** main observations: **First** is continued applicability of the exponential model of the form:

$$g(x) = 0.1 * c * \exp(c*(x-d))$$

Second, is the reinforcement of placement of relays along or close to central axes and **third**, applicability of arrangements despite lowered performance of energy savings as initial or intermediate states for future improvement.

The results of this study will assist in prediction in a MAUC environment and preparing more refined groundwork for more advanced attempts for optimisation for placement of relays. It can also serve in formulating base models to build appropriate communication policies against a known projected This model will assist in prediction in a MAUC environment and preparing more refined groundwork for more advanced experiments. It can also serve in formulating base models to build appropriate communication policies against a known projected model of success rate or as a reference against which some reliability features of MAUC can be rated. It can ultimately help in formulation of appropriate metrics and new architecture support in a MAUC.

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] Markus Bylund and ZarySegall, Towards seamless mobility with personal servers, 2004.

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

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

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

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

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

[14] 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

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

[16] 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*

[17] 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

[18] 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

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

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

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