International Journal of Advances in Computer Networks and Its Security
Volume 6 : Issue 3 *[ISSN 2250-3757]*
Publication Date : 30 December, 2016

Model of Overall Node Energy Savings Achievable with Location-Aware MANET Transmission in Ubicomp.

M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY

Abstract **– Research on efficient, low-cost and reliable location tracking in mobile environment remains on-going [34-49]. As and when significant progresses are being achieved, new functionality/applications are being put on the market and ways of doing existing activities are improved. One key area affecting this sequence of development in MANET communication whereby a missing component is the Software Engineering approaches into metric development and forecast trend modelling techniques which may better gear future investments into further research [2]. The particular area of concern here is energy considerations in ubicomp. How much energy savings can be achieved by overall nodes participating in a transmission using location-aware MANET transmission? Is there any pattern of trend that the overall energy savings achieved follow under different sets of node densities? How to gather probabilities of saving below (or above) a particular percent of energy?**

Need for formulating applicable models remain considerable as it involves lots of work from many researchers and results put forward will help designers formulate better architectures of ubicomp components. This paper is a follow-up of previous papers [1-14].

Key terms: Ubicomp-Ubiquitous Computing, MAUC-Mobile and Ubiquitous Computing, OES-Overall Energy Savings, MANET-Mobile Adhoc Network, CBR-Constant Bit Rate, BRE-Basic Reference Energy.

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

Assoc. Prof Nawaz Mohamudally
University of Technology Mauritius,
Mauritius

1. Introduction

Energy consumption in MAUC is affected by several factors [2]. Additional factors may include type of transmission and if it is MANET transmission, a subsequent factor is node densities. An attempt, through simulation experiments, has been made to find a particular trend/model which depicts energy savings that can be reached by sender and other nodes in MANET routes in MAUC to rate effectiveness of location-aware MANET transmission strategies compared to the theoretical/empirical models derived in simulations specially as the extents to which energy savings are achieved, using same experiment design as in another paper [14]

The key contributions of this paper is firstly, the development of a new metric OES, including its definition and rationale, and secondly, the model of trend put forward for the metric OES with results for varying node densities from 7 until 56. The model suggested in this paper is the normal distribution model. The rest of this paper is organised as follows: section 2- New Metric- Overall Energy Savings, section 3- OES Trend Assessment over Varying Node Numbers, 4- Conclusion and References.

2. New Metric: Overall Energy Savings (OES).

When using MANETs, it is not only the sender node which is spending energy for a CBR transmission but all the nodes which have been part of the MANET routes. These MANET nodes may not all be infrastructure nodes provided by a service provider but may also be other user nodes themselves. Hence, a consideration of their individual and total energy expenditures must also be made. Many researchers put forward that use of MANETs help in saving energy and extending MANET lifetimes [50].

The term "BRE" introduced in another paper [14] is reused here. BRE is the amount of Energy spent by a sender in Direct Node-to-Node transmission if all CBR packets were transmitted at maximum distance noted between sender and receiver.

OES is hence defined as the result of computing the overall energy spent for each CBR and gauging it against the corresponding BRE to output the energy saving achieved and corresponding percentages. Overall nodes includes the sender node also.

It was observed here that % OES can also be negative, i.e. the MANET routes have resulted longer distances than node-to-node transmission and hence total energy spent in CBR transmission over a MANET exceeds the BRE. Hence energy savings become below 0.

3. OES Trend Assessment over Varying Node Numbers.

3.0 Major Observations.

The trends for OES achieved for node numbers 7-56 tend to follow a normal distribution of the form:

```
F(x)=b*(1/(a*sqrt(2*pi)))*exp(-(x-c)*(x-c)/2*a*a)
```

It can be read as "a factor 'b' times the equation of a normal curve. Some CBRs do not have negative energy savings, i.e. have spent more energy than the BRE. The % CBRs having negative energy savings tend to increase with increasing node numbers. Correspondingly, those having positive energy savings tend to decrease with increasing node numbers.

The % CBRs having 0 energy savings tend to be less than 1%. The maximum energy savings achievable is very significant, above 80% for all cases. The highest maximum overall Energy Savings noted is 90% for node number 7.

The mean energy savings is already below 0 for node number 7 and tends to decrease further for increasing node numbers.

3.1 Tabular Summary of Results.

A tabular summary for results of equations of curves (F(x)) observed here is shown below. Column headings are: A→node number, B→Value of parameter a, C→Value of parameter b, D→Value of parameter c (adjusted mean), E→reduced Chi-square value of plot, F→Corresponding figure number

A	B	C	D	E	F
7	0.059 707 2	0.299 02	59	0.109 804	1
8	0.059 498 9	0.297 537	59	0.108 967	2
9	0.054 286 7	0.255 037	57	0.104 504	3
10	0.055 917 1	0.264 163	57	0.063 339	4
11	0.051 093 7	0.227 366	56	0.071 954	5
12	0.051 369 6	0.225 598	54	0.070 422	6
13	0.049 298 4	0.212 863	54	0.068 778	7
14	0.046 912 1	0.194 174	52	0.062 420	8
15	0.046 872 4	0.191 451	51	0.072 693	9
16	0.044 958 6	0.179 7	51	0.070 614	10
17	0.047 964	0.197 461	51	0.056 690	11
18	0.050 509 9	0.211 667	51	0.076 773	12
19	0.050 356 9	0.210 085	50	0.062 146	13
20	0.049 05	0.201 822	49	0.054 583	14
21	0.045 520 8	0.179 195	49	0.051 047	15
22	0.045 452 6	0.177 675	48	0.064 406	16
23	0.044 044	0.170 329	48	0.058 969	17
24	0.045 694 2	0.179 05	47	0.053 003	18
25	0.046 971 3	0.187 005	47	0.057 182	19
26	0.045 406 5	0.176 961	47	0.049 022	20
27	0.045 496 2	0.176 885	46	0.058 209	21
28	0.043 865 3	0.166 343	46	0.058 713	22
29	0.046 397 4	0.179 532	46	0.058 452	23
30	0.044 608 7	0.169 072	45	0.060 580	24
31	0.042 184	0.155 773	45	0.054 817	25
32	0.042 835 1	0.159 097	45	0.066 840	26
33	0.042 505 5	0.157 049	45	0.059 563	27
34	0.042 595 8	0.156 615	44	0.059 241	28
35	0.041 785 5	0.152 067	44	0.055 913	29
36	0.043 106 8	0.159 532	43	0.053 160	30
37	0.044 262 8	0.167 022	44	0.053 333	31
38	0.046 566 9	0.180 111	44	0.058 995	32
39	0.047 415 4	0.183 654	44	0.054 552	33
40	0.046 277	0.177 521	44	0.047 202	34
41	0.047 472 8	0.183 871	43	0.053 405	35
42	0.045 798 8	0.174 94	43	0.050 672	36
43	0.045 864 5	0.173 103	43	0.061 551	37
44	0.044 632 7	0.165 681	43	0.053 503	38
45	0.045 581 4	0.170 747	43	0.061 777	39
46	0.045 584 5	0.170 85	43	0.060 593	40
47	0.043 891 3	0.161 977	43	0.047 379	41
48	0.043 166 5	0.158 572	43	0.050 970	42
49	0.044 86	0.165 806	42	0.048 798	43
50	0.046 409 6	0.175 575	42	0.045 680	44
51	0.045 84	0.172 382	41	0.051 251	45
52	0.045 500 1	0.169 889	41	0.040 333	46
53	0.045 622 6	0.170 309	41	0.053 407	47
54	0.046 013 6	0.171 641	41	0.059 561	48
55	0.044 745 6	0.165 551	41	0.056 525	49
56	0.044 35 8	0.162 862	40	0.048 686	50

Table 1: results for OES equations of curves node numbers 7-56

3.2 Graphical Plots for Results Obtained.

This analysis is performed in gnuplot in Linux.

1. Node Number 7

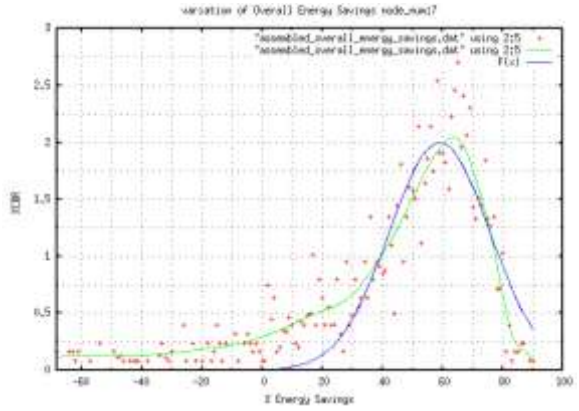

Figure 1: % cbr for OES node_number 7

2. Node Number 8

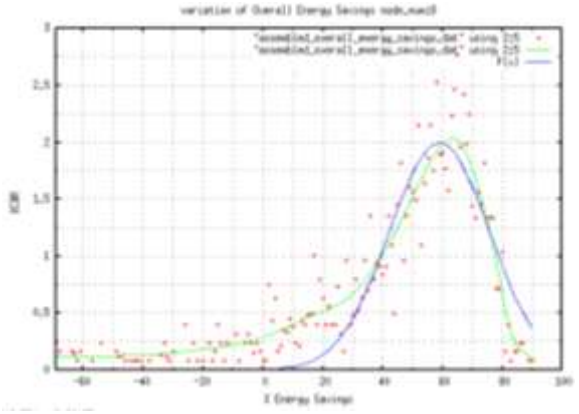

Figure 2: % cbr for OES node_number 8

3. Node Number 9

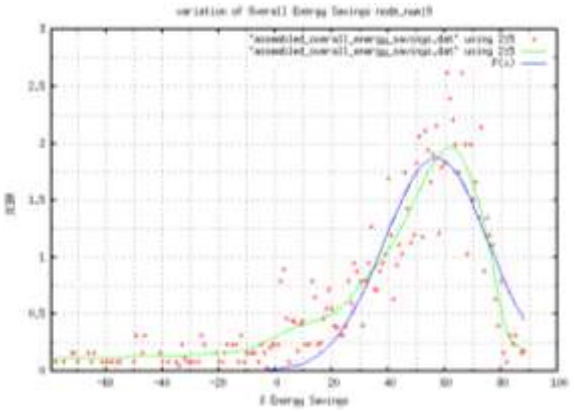

Figure 3: % cbr for OES node_number 9

4. Node Number 10

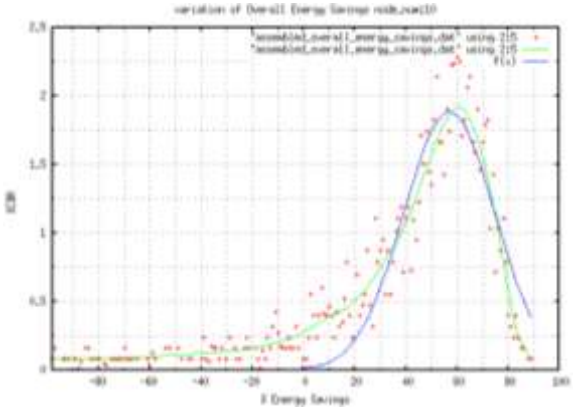

Figure 4: % cbr for OES node_number 10

5. Node Number 11

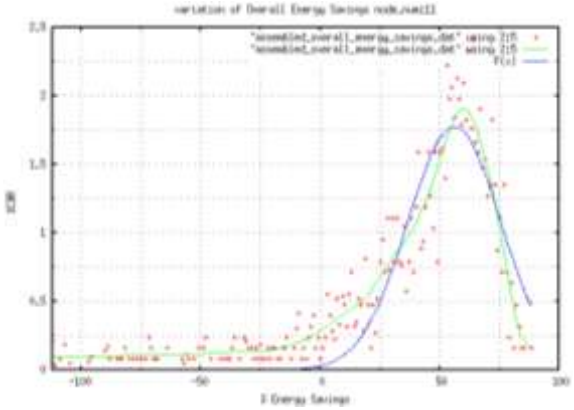

Figure 5: % cbr for OES node_number 11

6. Node Number 12

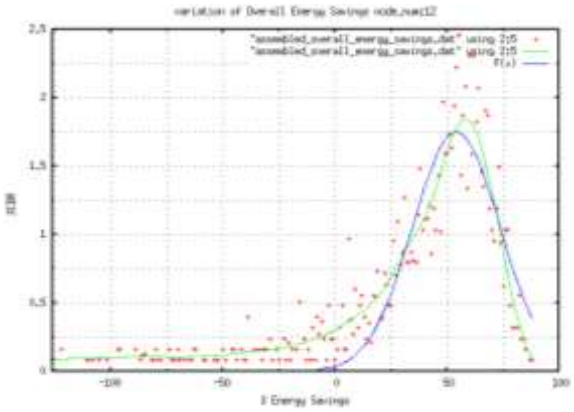

Figure 6: % cbr for OES node_number 12

7. Node Number 13

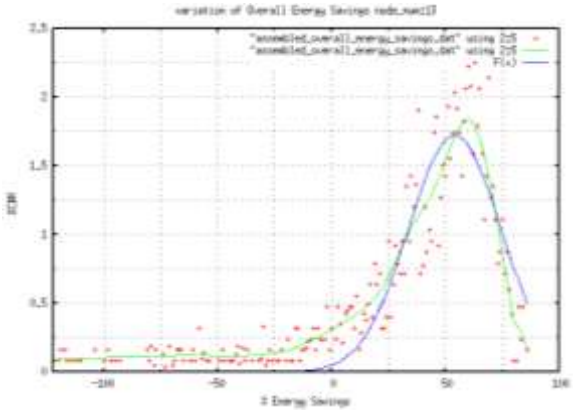

Figure 7: % cbr for OES node_number 13

8. Node Number 14

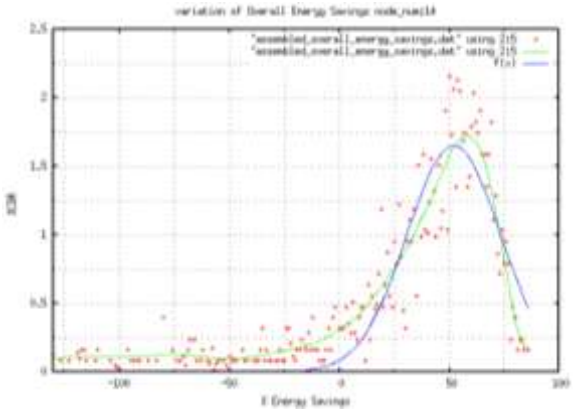

Figure 8: % cbr for OES node_number 14

9. Node Number 15

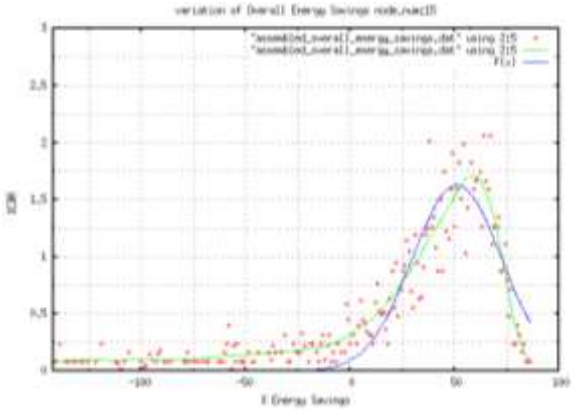

Figure 9: % cbr for OES node_number 15

10. Node Number 16

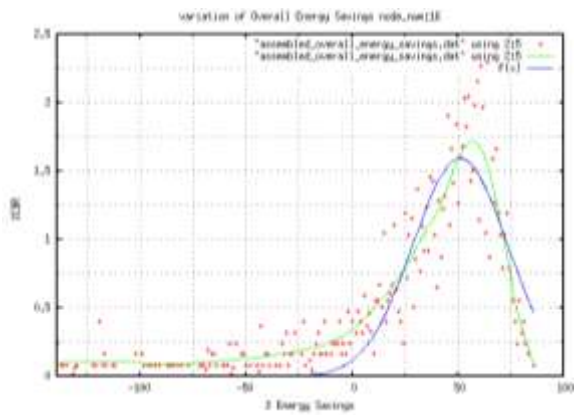

Figure 10: % cbr for OES node_number 16

11. Node Number 17

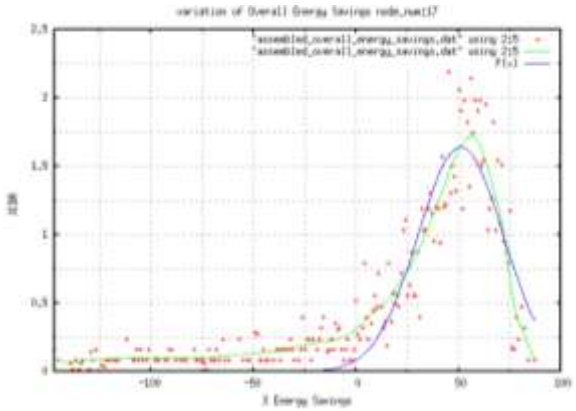

Figure 11: % cbr for OES node_number 17

12. Node Number 18

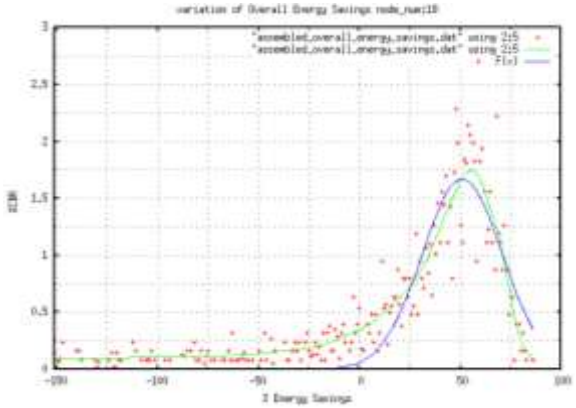

Figure 12: % cbr for OES node_number 18

13. Node Number 19

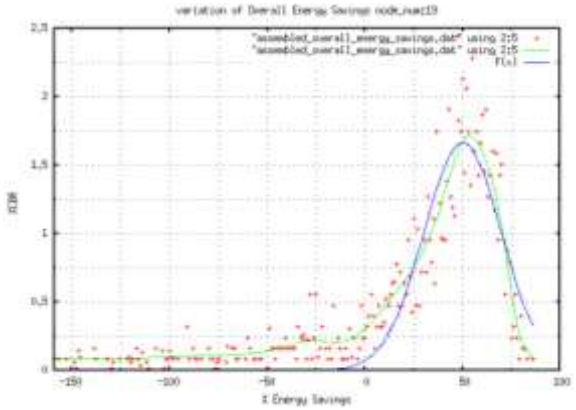

Figure 13: % cbr for OES node_number 19

14. Node Number 20

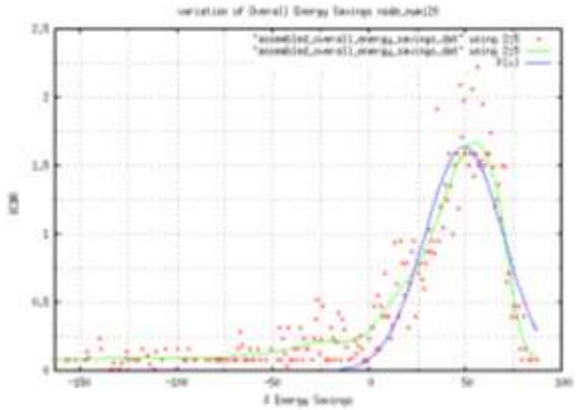

Figure 14: % cbr for OES node_number 20

15. Node Number 21

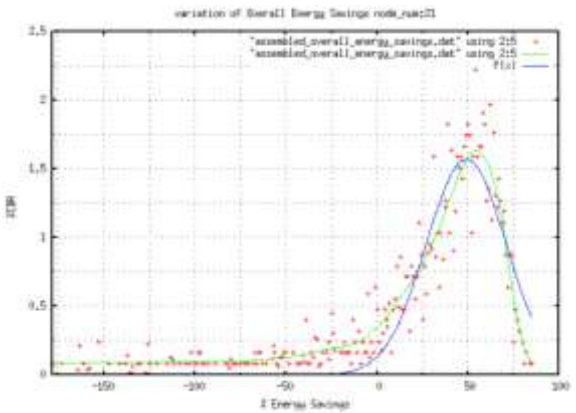

Figure 15: % cbr for OES node_number 21

16. Node Number 22

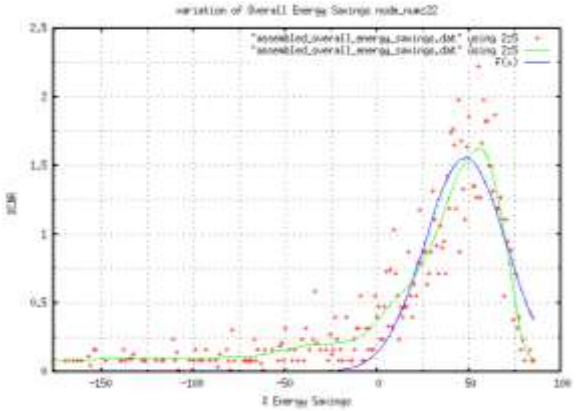

Figure 16: % cbr for OES node_number 22

17. Node Number 23

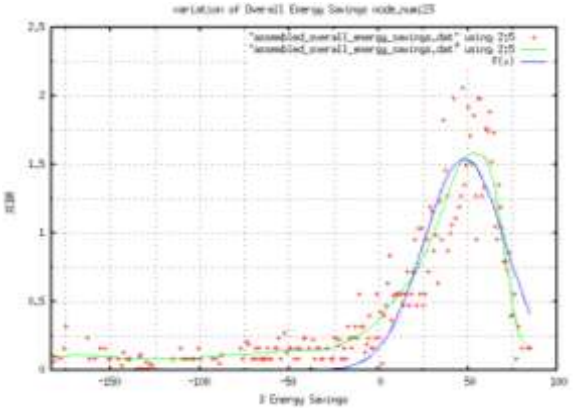

Figure 17: % cbr for OES node_number 23

18. Node Number 24

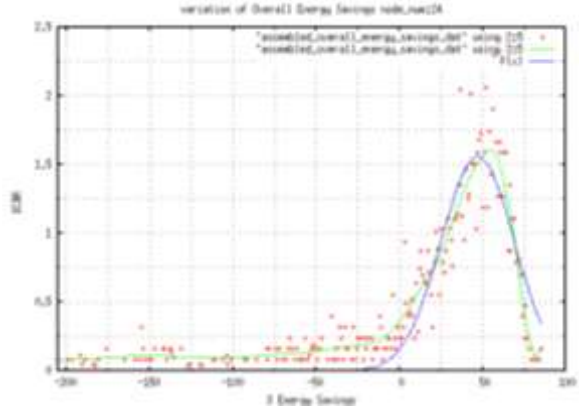

Figure 18: % cbr for OES node_number 24

19. Node Number 25

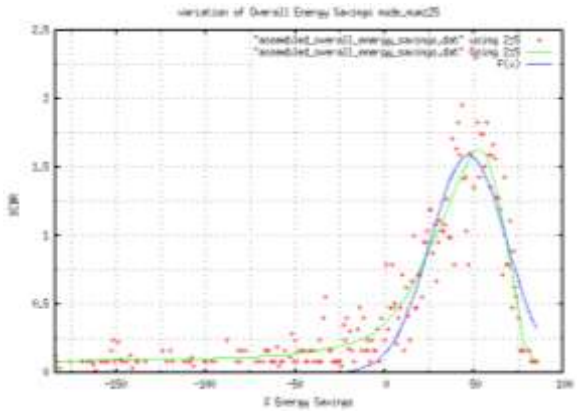

Figure 19: % cbr for OES node_number 25

20. Node Number 26

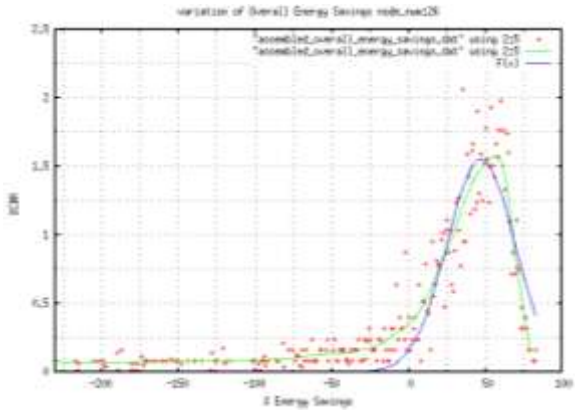

Figure 20: % cbr for OES node_number 26

21. Node Number 27

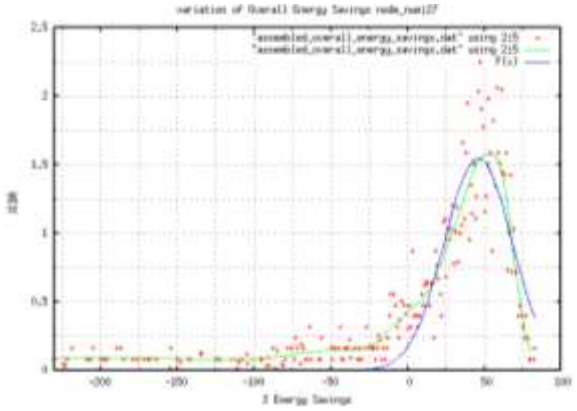

Figure 21: % cbr for OES node_number 27

22. Node Number 28

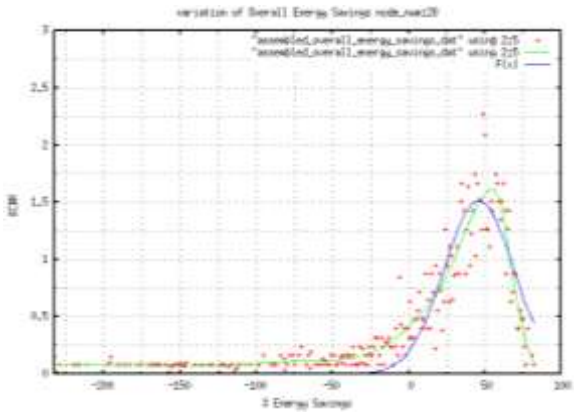

Figure 22: % cbr for OES node_number 28

23. Node Number 29

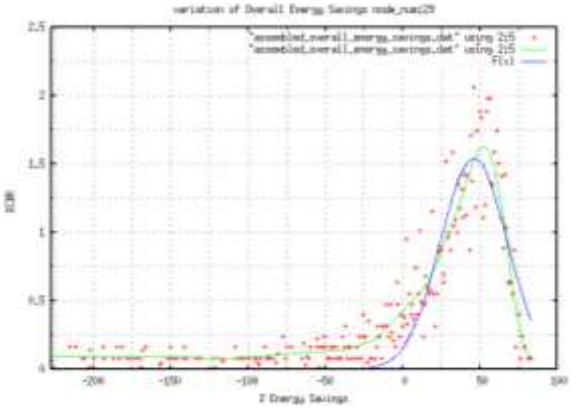

Figure 23: % cbr for OES node_number 29

24. Node Number 30

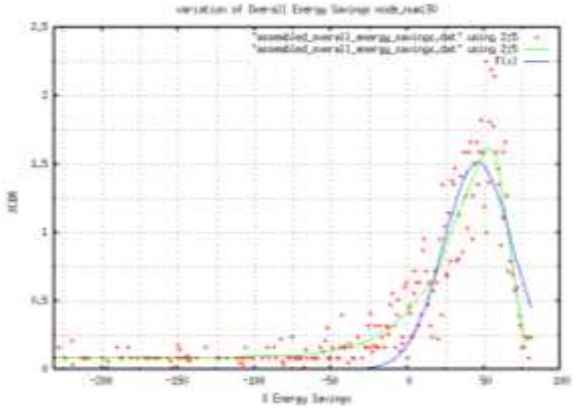

Figure 24: % cbr for OES node_number 30

25. Node Number 31

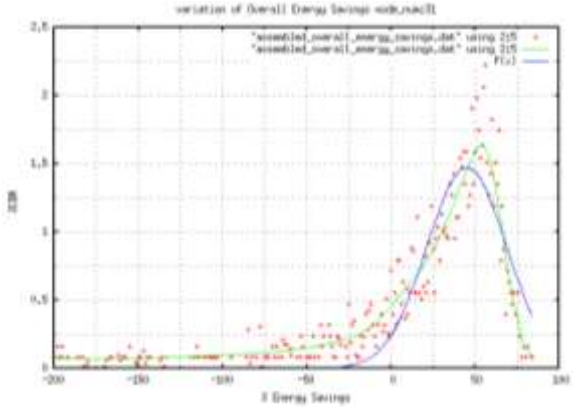

Figure 25: % cbr for OES node_number 31

26. Node Number 32

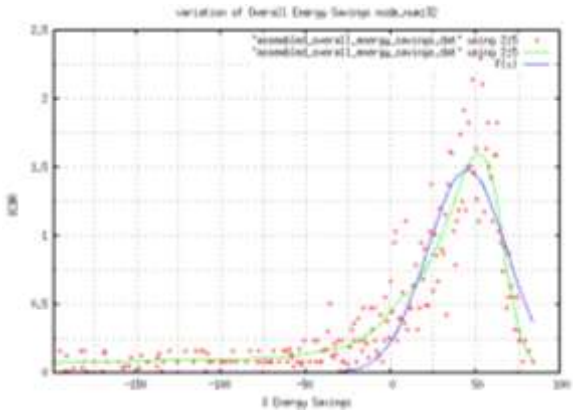

Figure 26: % cbr for OES node_number 32

27. Node Number 33

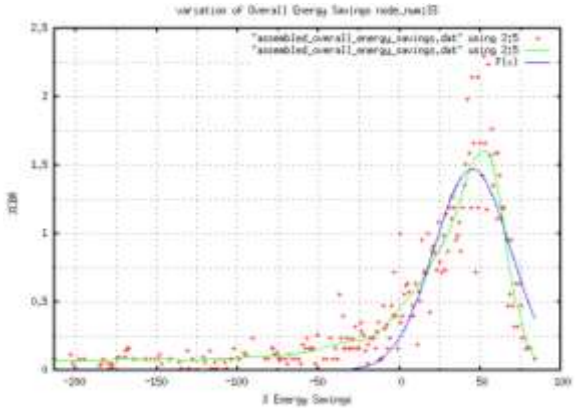

Figure 27: % cbr for OES node_number 33

28. Node Number 34

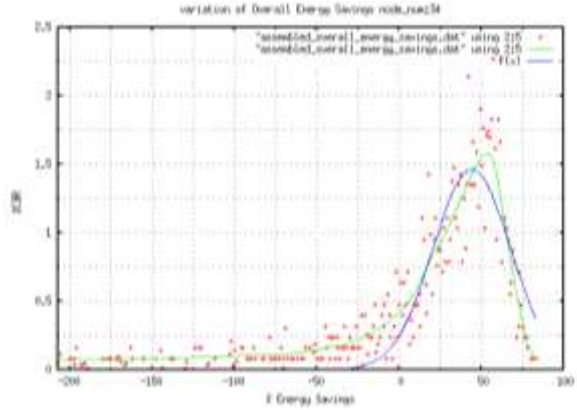

Figure 28: % cbr for OES node_number 34

29. Node Number 35

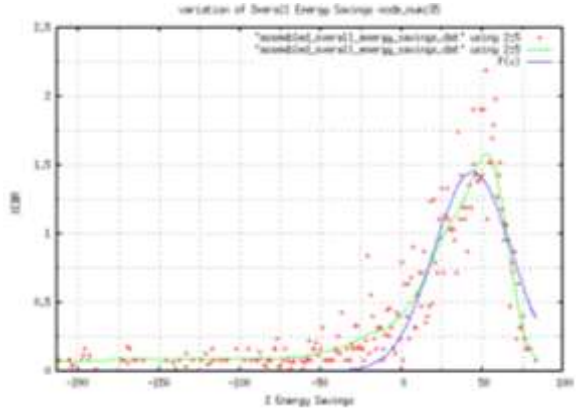

Figure 29: % cbr for OES node_number 35

30. Node Number 36

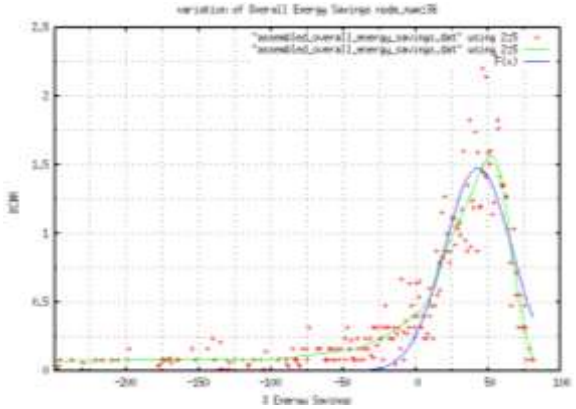

Figure 30: % cbr for OES node_number 36

31. Node Number 37

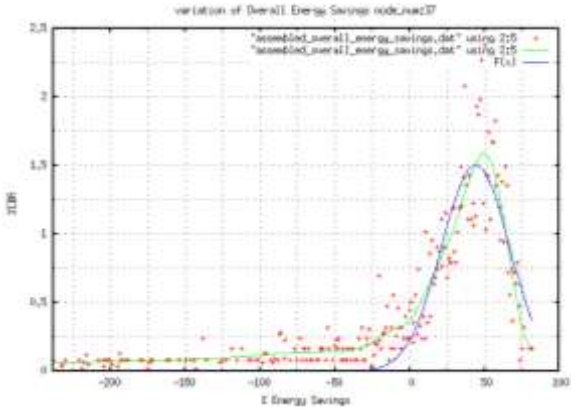

Figure 31: % cbr for OES node_number 37

32. Node Number 38

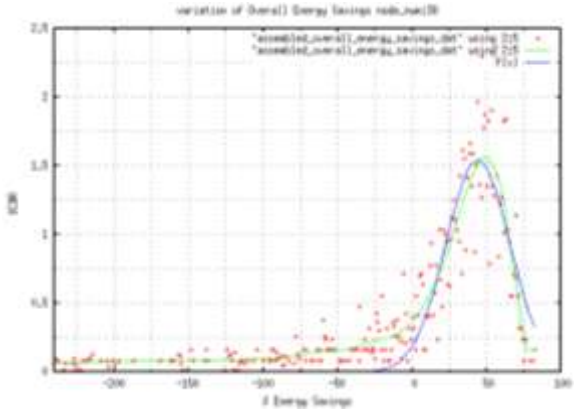

Figure 32: % cbr for OES node_number 38

33. Node Number 39

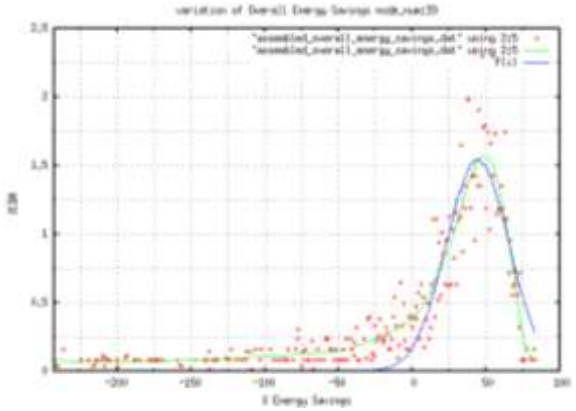

Figure 33: % cbr for OES node_number 39

34. Node Number 40

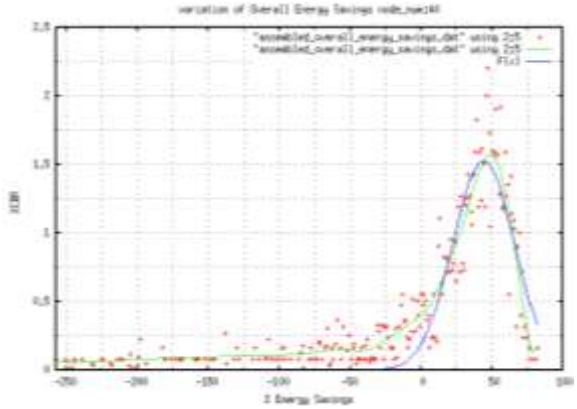

Figure 34: % cbr for OES node_number 40

35. Node Number 41

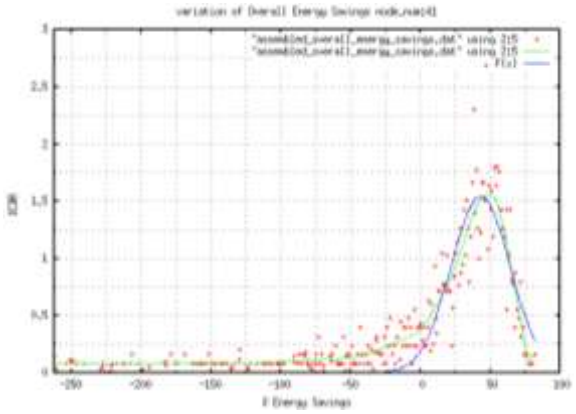

Figure 35: % cbr for OES node_number 41

36. Node Number 42

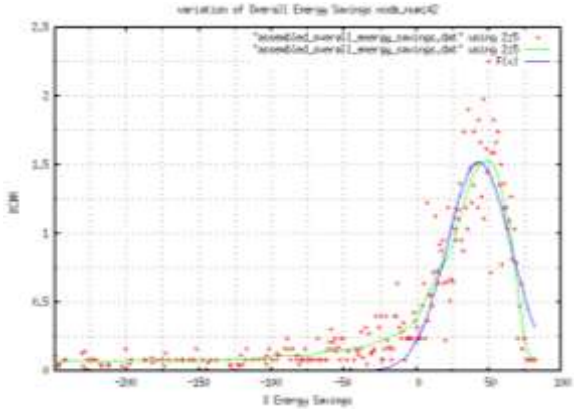

Figure 36: % cbr for OES node_number 42

37. Node Number 43

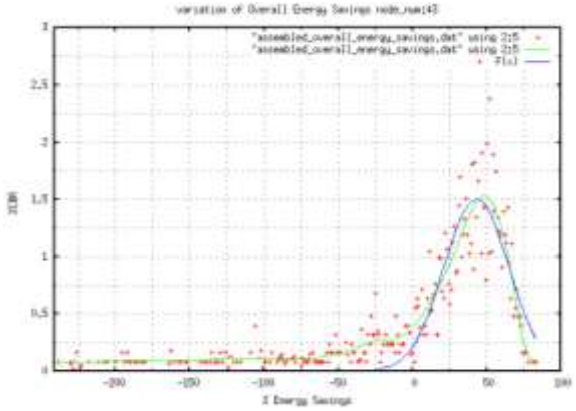

Figure 37: % cbr for OES node_number 43

38. Node Number 44

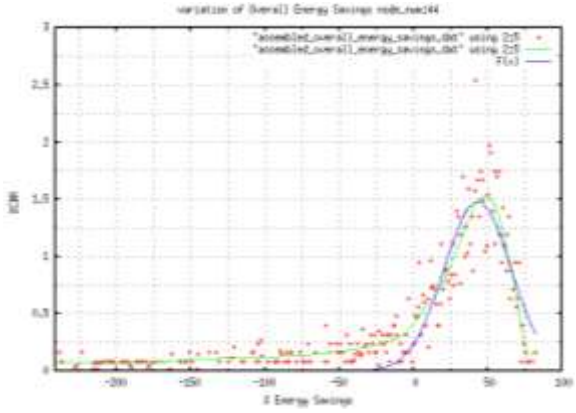

Figure 38: % cbr for OES node_number 44

39. Node Number 45

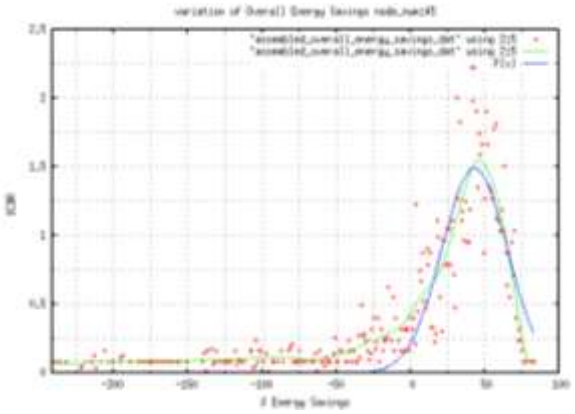

Figure 39: % cbr for OES node_number 45

40. Node Number 46

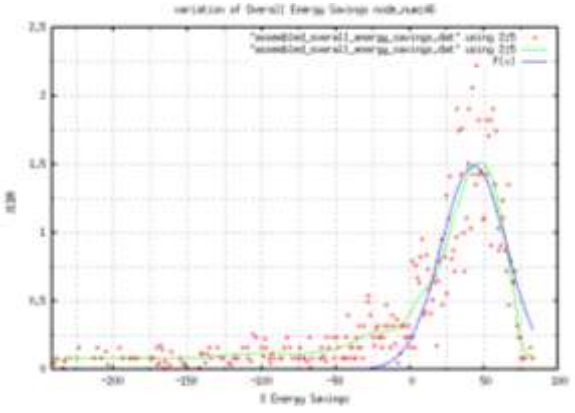

Figure 40: % cbr for OES node_number 46

41. Node Number 47

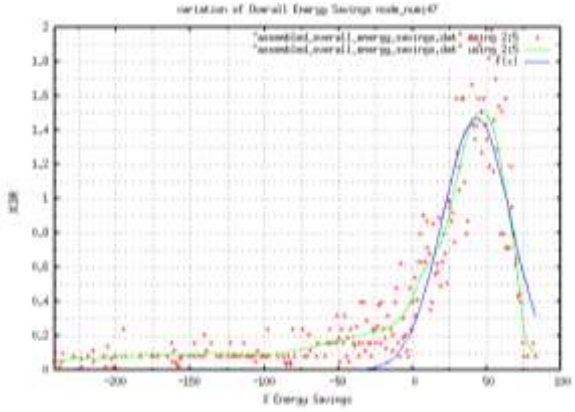

Figure 41: % cbr for OES node_number 47

42. Node Number 48

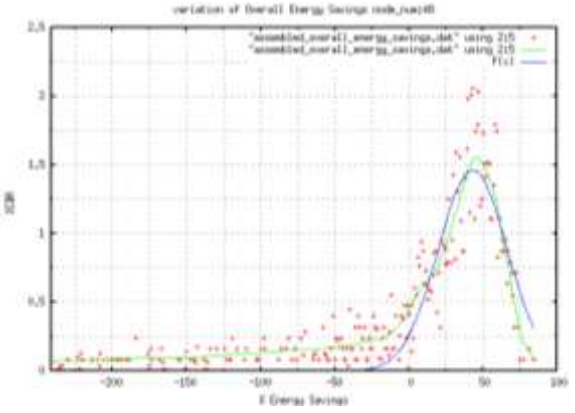

Figure 42: % cbr for OES node_number 48

43. Node Number 49

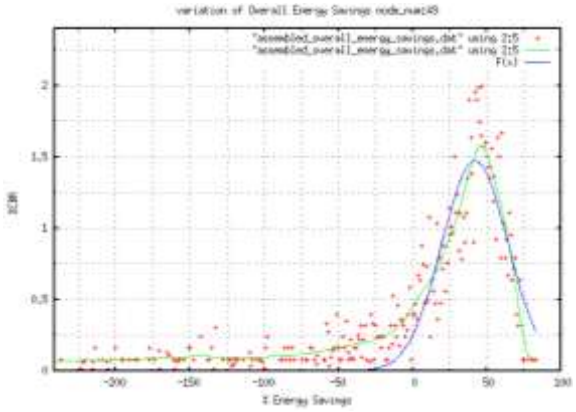

Figure 43: % cbr for OES node_number 49

44. Node Number 50

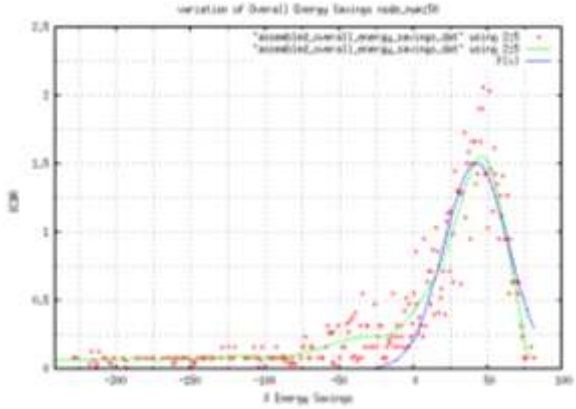

Figure 44: % cbr for OES node_number 50

45. Node Number 51

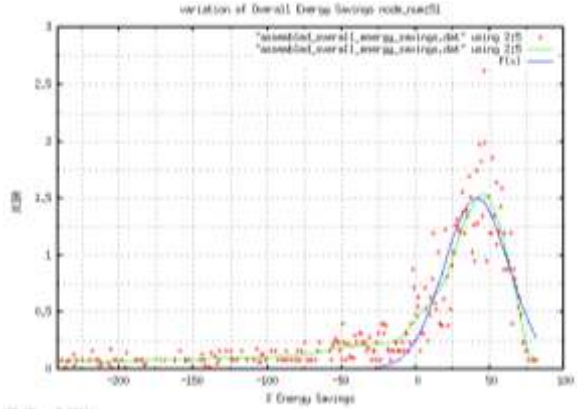

Figure 45: % cbr for OES node_number 51

46. Node Number 52

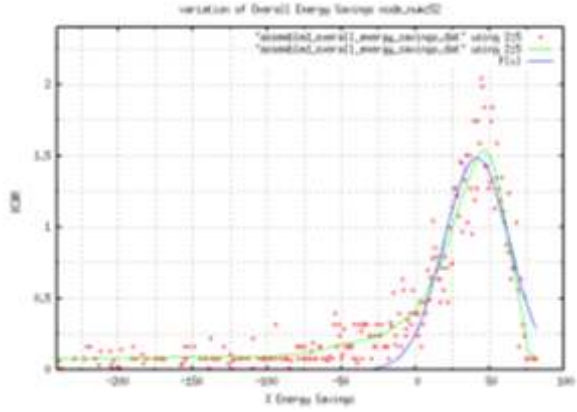

Figure 46: % cbr for OES node_number 52

47. Node Number 53

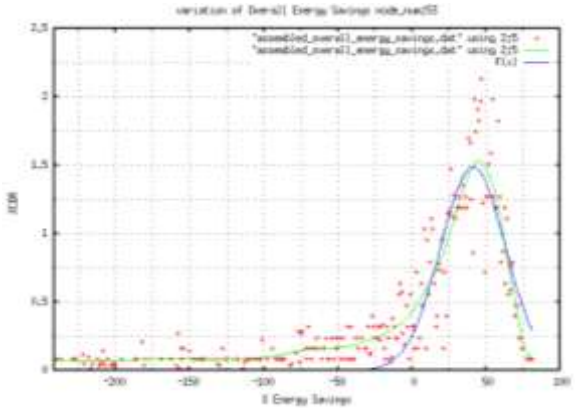

Figure 47: % cbr for OES node_number 53

48. Node Number 54

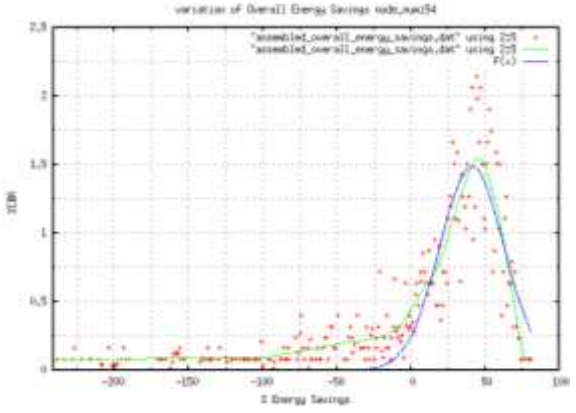

Figure 48: % cbr for OES node_number 54

49. Node Number 55

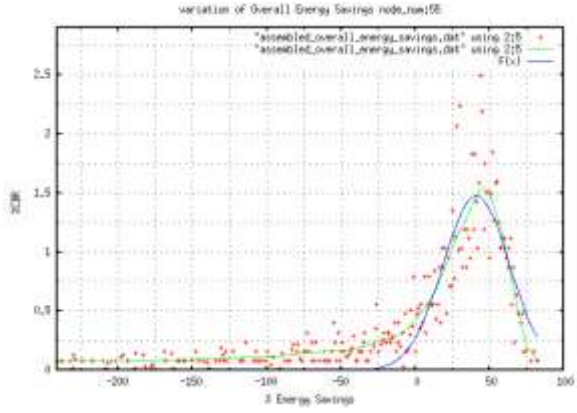

Figure 49: % cbr for OES node_number 55

50. Node Number 56

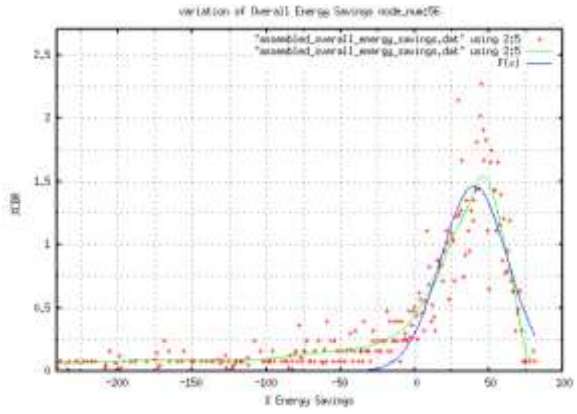

Figure 50: % cbr for OES node_number 56

4. Conclusion.

This piece of research was aimed at and has developed a new model of expected trend of Overall energy savings in a MANET topography of 300 x 300 m^2. The model obtained will help to study MANETs for MAUC environment from a software engineering perspective. This model, though empirical based, has put forward novel results which would necessitate quite huge investments if experimented in real environment implementations. This perspective still suffers from present inadequacies of technical components using which such an implementation based study could be performed, e.g. lightweight algorithms for location-aware transmission in a MAUC environment, land-based location support with appropriate algorithms and surrogate devices and lightweight efficient OS support.

The major conclusion of this study remains that MANET transmission using send to closest unused neighbour is not convincingly achieving overall nodes energy savings; instead, more energy than the BRE may be required. In itself, it does not prove that MANET transmission is bad since for some situations, it may be the only solution.

The further works identified may include: trend analysis of parameters of equation for the model, formulating method of predictability for metric OES and its trend and reporting observations of certain critical values. Other research topics may include development of enhanced energy efficient MANET transmission algorithms.

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, CEET 2015.

[11] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Extending Node Battery Availability in Ubicomp with Location-Aware Transmission using Location Refresh Intervals, CEET 2015.

[12] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Extending Node Battery Availability in Ubicomp with Location-Aware Transmission using Uniformly Placed Relays, CEET 2015.

[13] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Extending Node Battery Availability in Ubicomp with Location-Aware Transmission Using Optimally Placed Relays, CEET 2015.

[14] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Sender Node Energy Savings Achievable with Location-Aware MANET Transmission in Ubicomp, ACCN 2016

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

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

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

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

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

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

[21] 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

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

[23] 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*

[24] 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

[25] 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

[26] 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.

[27] 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

[28] 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

[29] Byrav Ramamurthy, K. K. Ramakrishnan , Rakesh K. Sinha, Cost and Reliability Considerations in Designing the Next-Generation IP over WDM Backbone Networks, 2012.
[30] 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
[31] Ashok Anand, Vyas Sekar and Aditya Akella, SmartRE: An Architecture for Coordinated Network-wide Redundancy Elimination, SIGCOMM 2009, Barcelona, Spain
[32] John Breeden II, "Smart-phone battery life could double – without better batteries", Nov 14, 2012
[33] Andy Boxall, "When will your phone battery last as long as your kindle", December 5, 2012.
[34] Imielinski, T. and Navas, J.C. (1999). GPS-based geographic addressing, routing, and resource discovery. *Comms. ACM*, Vol. 42, No. 4, pp. 86-92.
[35] Hightower, J. and Borriello, G. (2001). Location Systems for Ubiquitous Computing. *IEEE Computer*, Vol. 34, No. 8, August, pp. 57-66.
[36] Harter, A., Hopper, A., Steggles, P., Ward, A. and Webster, P. (2002). The Anatomy of a Context-Aware Application. Wireless Networks, Vol. 8, No. 2-3, Mar-May, pp. 187-197.
[37] Hightower, J., Brumitt, B. and Borriello, G. (2002). The Location Stack: A Layered Model for Location in Ubiquitous Computing. *Proceedings of the 4th IEEE Workshop on Mobile Computing Systems & Applications (WMCSA 2002)*, Callicoon, NY, USA, June, pp. 22-28.
[38] Graumann, D., Lara, W., Hightower, J. and Borriello, G. (2003). Real-world implementation of the Location Stack: The Universal Location Framework. *Proceedings of the 5th IEEE Workshop on Mobile Computing Systems & Applications (WMCSA 2003)*, Monterey, CA, USA, October, pp. 122-128.
[39] Ko, Y., & Vaidya, N. H. (2000). Location-aided routing (LAR) in mobile ad hoc networks. *Wireless Networks*, *6*(4), 307-321.
[40] Liao, W.-H., Tseng, Y.-C., & Sheu, J.-P. (2001). GRID: a fully location-aware routing protocol for mobile ad hoc networks. *Telecommunication Systems*, *18*(1), 37-60.
[41] Kuhn, F., Wattenhofer, R., Zhang, Y., & Zollinger, A. (2003). Geometric ad-hoc routing: of theory and practice. In *Proceedings of the ACM (PODC'03)* (pp. 63-72).
[42] Jiang, X., & Camp, T. (2002). Review of geocasting protocols for a mobile ad hoc network. In Proceedings of the *Grace Hopper Celebration (GHC)*.
[43] Ko, Y. & Vaidya, N. H. (1999). Geocasting in mobile ad hoc networks: location-based multicast algorithms. In *Proceedings of the IEEE (WMCSA'99)* (pp. 101).
[44] Mauve, M., Fuler, H., Widmer, J., & Lang, T. (2003). *Position-based multicast routing for mobile ad-hoc networks* (Technical Report TR-03-004). Department of Computer Science, University of Mannheim.
[45] Xu, Y., Heidemann, J., & Estrin, D. (2001). Geography-informed energy conservation for adhoc routing. In *Proceedings of the ACM/IEEE (MOBICOM'01)* (pp. 70-84).
[46] Hu, Y.-C., Perrig, A., & Johnson, D. (2003). Packet leashes: a defense against wormhole attacks in wireless ad hoc networks. In *Proceedings of the INFOCOM' 03* (pp. 1976-1986).
[47] Patwari, N., Hero III, A. O., Perkins, M., Correal, N. S., & O'Dea, R. J. (2003). Relative location estimation in wireless sensor networks. *IEEE Transactions on Signal Processing*, *51*(8), 2137-2148.
[48] Baldauf, M., Dustdar, S., & Rosenberg, F. (2007). A Survey on Context Aware Systems. *International Journal of Ad Hoc and Ubiquitous Computing*, Inderscience Publishers. forthcoming. Pre-print from: http://www.vitalab.tuwien.ac.at/~florian/papers/ijahuc2007.pdf
[49] Hong, D., Chiu, D.K.W., & Shen, V.Y. (2005). Requirements elicitation for the design of context-aware applications in a ubiquitous environment. In *Proceedings of ICEC'05* (pp. 590-596).
[50] Neeraj Tantubay, Dinesh Ratan Gautam and Mukesh Kumar Dhariwal, A Review of Power Conservation in Wireless Mobile Ad hoc Network (MANET)", International Journal of computer Science Issues, Vol 8, Issue 4, No 1, July 2011.

About Author (s):

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

M. Kaleem Galamali is a part-time student (achieved M Phil Transfer on 28.10.2014, currently PhD student) at UTM under supervision of A.P. Nawaz Mohamudally.