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Model of Overall Node Extra Energy Savings Achievable in MANET against Direct Node-to-Node Transmission Using Location-Aware Transmission in Ubicomp.

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***Abstract* – Lots of new components to support location tracking in mobile environment are being put forward following widespread research [36-51]. Upon significant milestones being reached, subsequent novel functionalities are being devised and existing ones improved. However, still lacking in the field of MAUC is the software engineering approaches into metrics and models development to enable predictability bounding and governing future investments of resources for development and further research [2]. One particular sub-area within the area of energy considerations in ubicomp is modelling of overall node energy savings using location-aware MANET transmission provided in another paper [15]. The next set of investigation involves quantifying and modelling the extra overall nodes energy savings achievable against Direct node-to-node transmission, the pattern of trend for this extra saving under different sets of node densities and method of predicting the trend equations and using them for predictive probability calculations.**

The area of modelling in ubicomp will involve lots of work and investments and this paper does add a building block for designers to formulate better ubicomp architectures and components. This paper follows from previous work [1-16] with more emphasis from papers [2, 15].

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

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1. Introduction

Several factors affect energy consumption in MAUC [2]. A major factor remains the square of distance over which transmission occurs. Additional factors may include types of transmission, whereby 2 types are of concern here: direct node-to-node transmission [2] and MANET transmission at different node densities [15].

Researchers claim that use of MANETs help in saving energy [52]. When using MANETs, sender nodes together with those nodes forming part of MANET routes, are spending energy. These relay nodes could also be belonging to other users instead of being supplied as infrastructure nodes. A plausible model of energy savings achieved in MANET, considering total expenditure of energy by sender and MANET route nodes, is provided in paper [15]. Already in paper [15], it was mentioned that the mean energy savings was below 0. It is expected therefore that the difference between overall nodes energy savings achieved in MANETs and those achieved in direct node-to-node transmission will be even more significantly below 0.

It is hence expected that direct node-to-node energy transmission is more economic in terms of energy savings. It remains a desirable knowledge: “what is the extent of the difference in energy savings stated in last part of above paragraph? What are its corresponding trends observable at different node densities?” This study derived from 2 previous studies [2, 15] and results presented here remain empirical based.

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

2. New Derived Metric: Overall Less Node-to-Node Energy Savings (OLNTNES).

As stated in previous research [14], the term BRE is used here also. 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.

OLNTNES is hence defined as the percentage savings achieved by the overall nodes involved for a CBR transmission in MANET (gauged against BRE) less the percentage savings achieved by sender node in Direct node-to-node transmission (also gauged against BRE).

Quite a lot of OLNTNES values below 0 is expected.

3. OLNTNES Trend Assessment over Varying Node Numbers.

3.0 Major Observations.

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

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F(x)=b*(1/(a*sqrt(2*pi)))*exp(-(x-c)*(x-c)/2*a*a)
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It can be read as "a factor 'b' times the equation of a normal curve. The smallest energy savings reached (negative values) have depicted decreasing trend with increasing node number.

Very small percentage CBR have OLNTNES value 0, i.e. have achieved same energy expenditure in MANET as in direct node-to-node transmission.

The percentage CBR having value below 0 was already high for node number 7 and shows increasing tendency with increasing node number. Correspondingly, the % CBR showing positive value here decreases with increasing node number. The mean value, which is at -7 for node number 7, depicts decreasing trend with 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 (the mean), E→reduced Chi-square value of plot, F→ Corresponding figure number.

A	B	C	D	E	F
7	0.071 209 2	0.435 729	-7	0.102 964	1
8	0.071 343 3	0.437 047	-7	0.101 148	2
9	0.065 507 7	0.368 692	-9	0.112 8	3
10	0.064 731 7	0.348 212	-10	0.059 930 1	4
11	0.063 489 3	0.331 489	-10	0.053 965 6	5
12	0.059 992 7	0.301 122	-12	0.052 719 9	6
13	0.059 736 6	0.295 855	-12	0.055 874	7
14	0.055 592 6	0.260 328	-14	0.062 126 8	8
15	0.055 465 7	0.255 699	-14	0.053 855 1	9
16	0.054 287 6	0.248 446	-15	0.067 927 3	10
17	0.055 667 2	0.254 03	-16	0.056 855 2	11
18	0.056 971 9	0.264 25	-16	0.047 604 8	12
19	0.055 576 1	0.252 467	-17	0.049 043 7	13
20	0.054 429 6	0.243 911	-18	0.048 237 9	14
21	0.055 772 7	0.259 409	-17	0.059 276	15
22	0.054 540 8	0.248 143	-19	0.050 229 5	16
23	0.053 286 3	0.237 398	-19	0.055 841 4	17
24	0.051 983 3	0.229 54	-20	0.043 503 8	18
25	0.052 599 1	0.232 166	-20	0.045 746	19
26	0.051 355 7	0.221 415	-20	0.051 915 9	20
27	0.053 130 97	0.231 994	-20	0.040 897 9	21
28	0.050 915 8	0.215 372	-21	0.037 427 3	22
29	0.051 281	0.217 703	-21	0.042 088 4	23
30	0.049 395 7	0.204 274	-22	0.043 495 6	24
31	0.048 569 9	0.199 64	-21	0.047 033 8	25
32	0.048 613 8	0.199 659	-22	0.042 623 5	26
33	0.047 299 8	0.190 007	-23	0.040 657 4	27
34	0.047 804 1	0.192 238	-23	0.049 364 3	28
35	0.048 103 7	0.193 471	-23	0.037 369	29
36	0.047 057 2	0.187 237	-24	0.036 172 6	30
37	0.048 323 2	0.193 047	-24	0.045 127 2	31
38	0.049 271 5	0.199 425	-24	0.040 491 5	32
39	0.048 769 1	0.194 886	-24	0.038 985	33
40	0.049 679 8	0.200 786	-24	0.034 723 3	34
41	0.047 117 2	0.184 545	-25	0.038 851 4	35
42	0.047 855 6	0.189 481	-25	0.040 996 1	36
43	0.047 819 4	0.187 842	-25	0.041 007 8	37
44	0.047 536 5	0.185 373	-25	0.035 801 5	38
45	0.046 898	0.182 256	-25	0.036 977 2	39
46	0.047 446 3	0.184 704	-25	0.033 293 3	40
47	0.047 811 9	0.187 37	-25	0.033 338 6	41
48	0.047 080 1	0.182 709	-26	0.037 222 1	42
49	0.046 386 4	0.177 858	-26	0.036 440 6	43
50	0.048 072 6	0.189 068	-26	0.042 045 6	44
51	0.048 731 6	0.192 46	-26	0.044 323 5	45
52	0.049 061 6	0.195 127	-26	0.039 254 5	46
53	0.048 116 5	0.188 868	-26	0.040 008 6	47
54	0.049 179	0.194 367	-27	0.036 350 8	48
55	0.048 163 8	0.188 01	-27	0.033 832 8	49
56	0.048 448 4	0.190 172	-27	0.037 863 4	50

Table 1:results for OLNTNES equations of curves node num 7-56

3.2 Graphical Plots for Results Obtained.

This analysis is performed in gnuplot in Linux.

1. Node Number 7

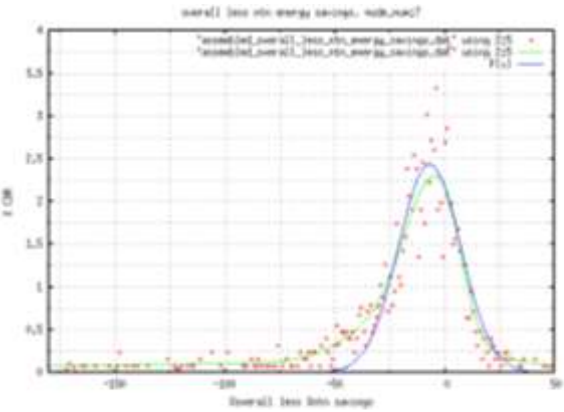

Figure 1: % cbr for OLNTNES node_number 7

2. Node Number 8

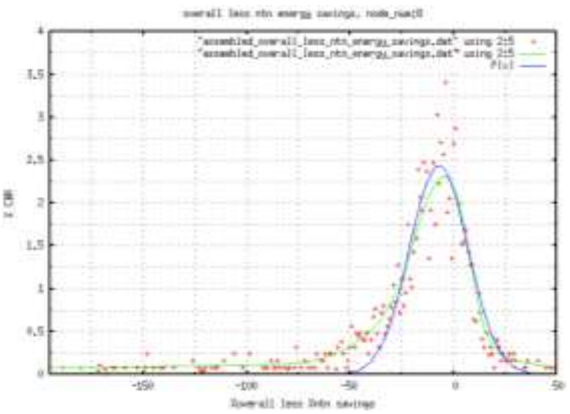

Figure 2: % cbr for OLNTNES node_number 8

3. Node Number 9

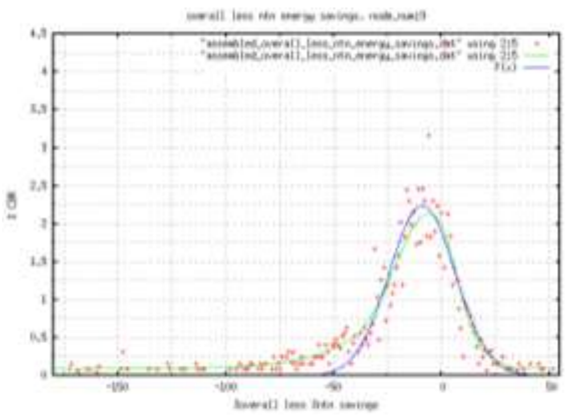

Figure 3: % cbr for OLNTNES node_number 9

4. Node Number 10

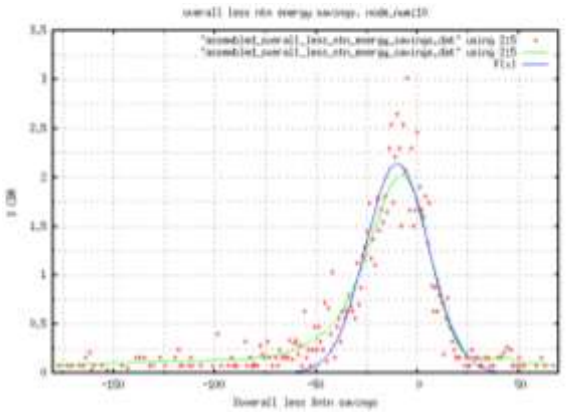

Figure 4: % cbr for OLNTNES node_number 10

5. Node Number 11

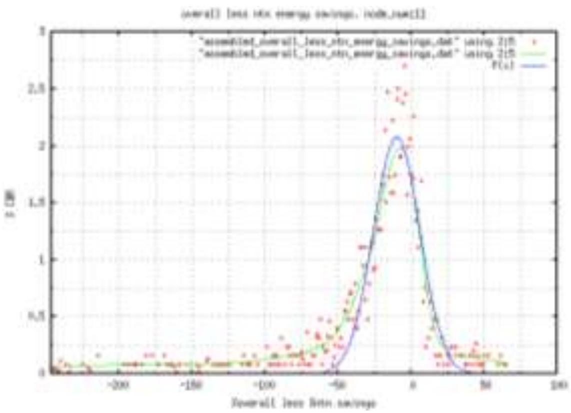

Figure 5: % cbr for OLNTNES node_number 11

6. Node Number 12

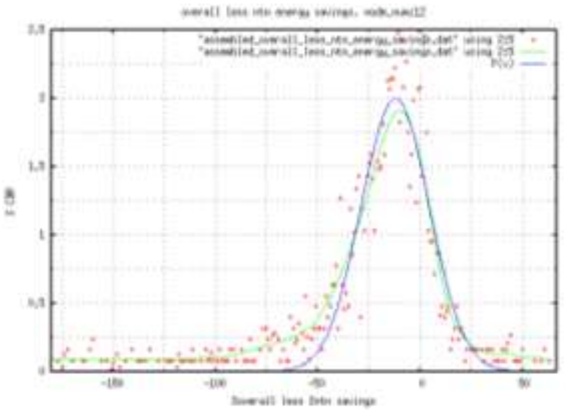

Figure 6: % cbr for OLNTNES node_number 12

7. Node Number 13

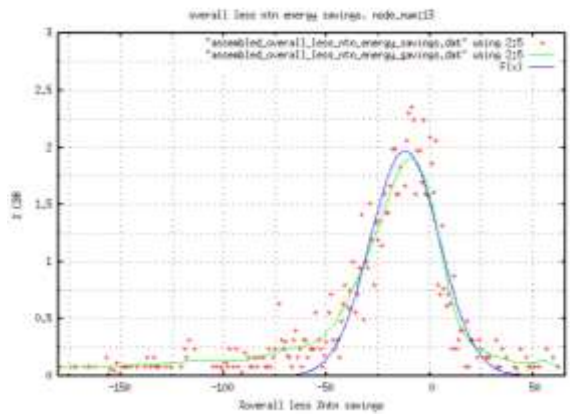

Figure 7: % cbr for OLNTNES node_number 13

8. Node Number 14

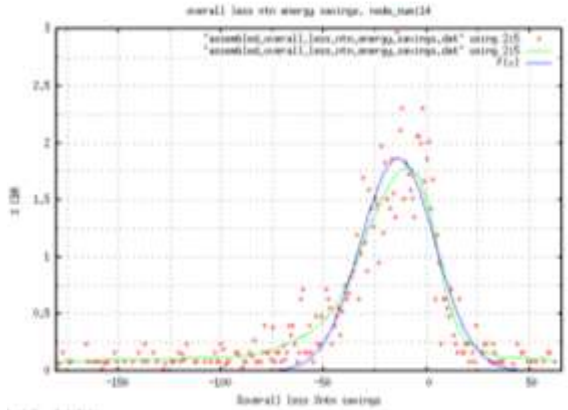

Figure 8: % cbr for OLNTNES node_number 14

9. Node Number 15

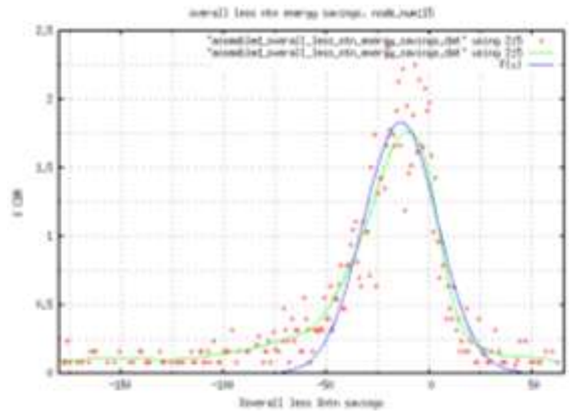

Figure 9: % cbr for OLNTNES node_number 15

10. Node Number 16

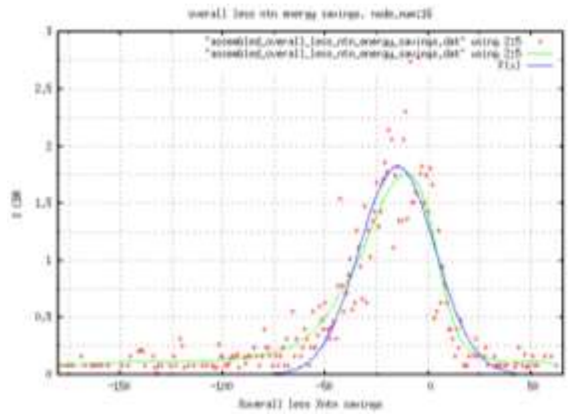

Figure 10: % cbr for OLNTNES node_number 16

11. Node Number 17

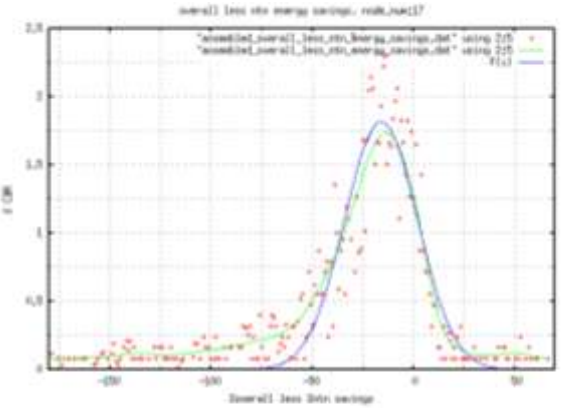

Figure 11: % cbr for OLNTNES node_number 17

12. Node Number 18

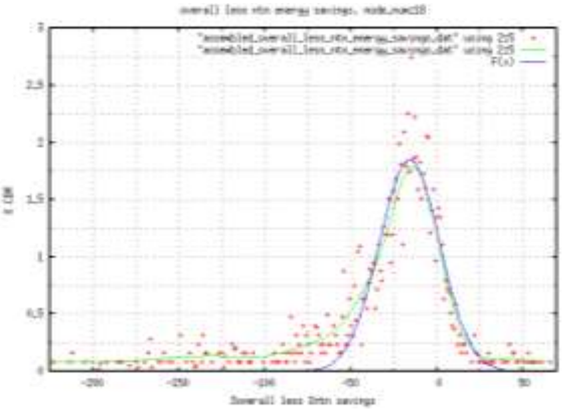

Figure 12: % cbr for OLNTNES node_number 18

13. Node Number 19

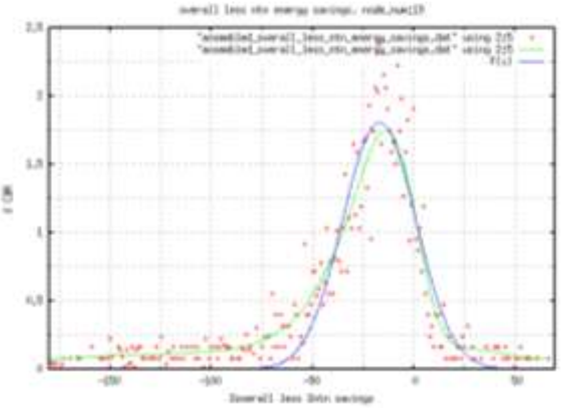

Figure 13: % cbr for OLNTNES node_number 19

14. Node Number 20

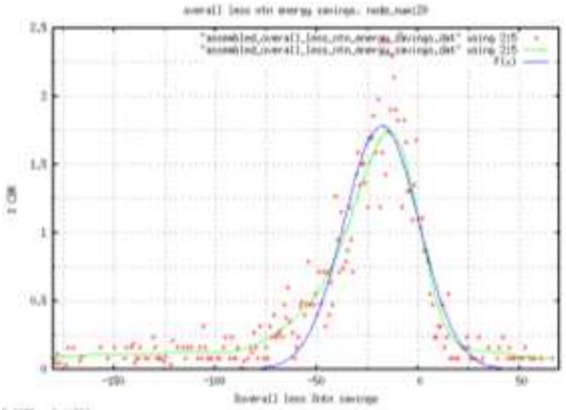

Figure 14: % cbr for OLNTNES node_number 20

15. Node Number 21

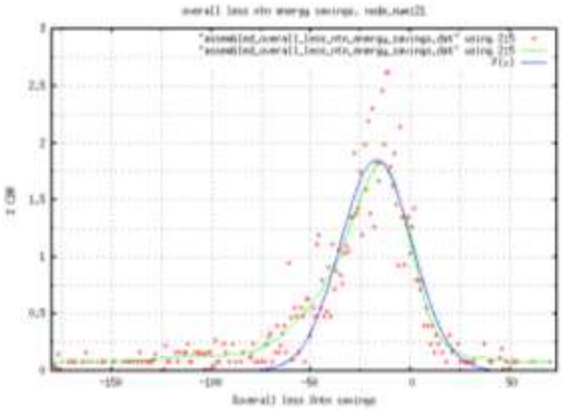

Figure 15: % cbr for OLNTNES node_number 21

16. Node Number 22

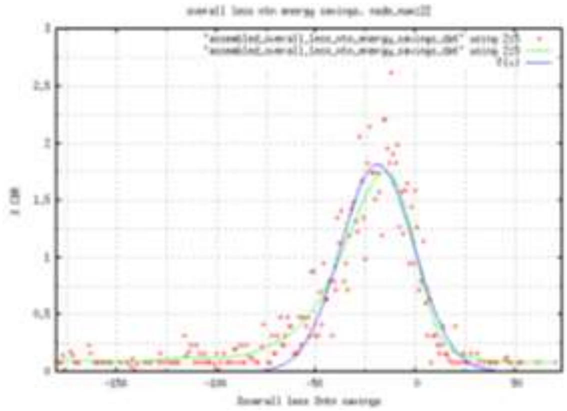

Figure 16: % cbr for OLNTNES node_number 22

17. Node Number 23

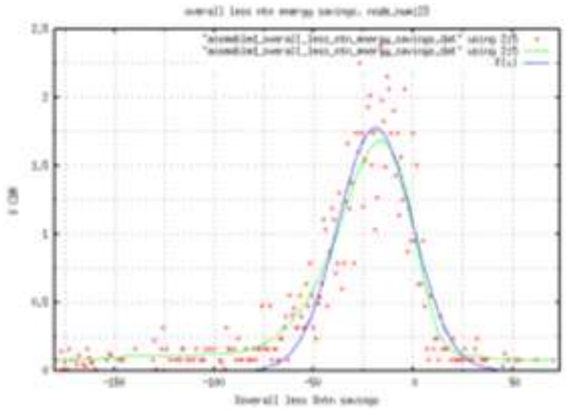

Figure 17: % cbr for OLNTNES node_number 23

18. Node Number 24

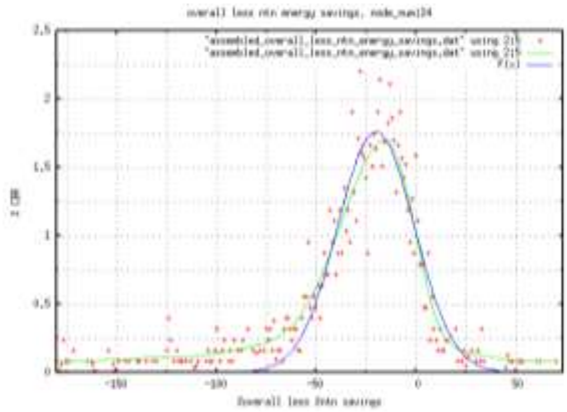

Figure 18: % cbr for OLNTNES node_number 24

19. Node Number 25

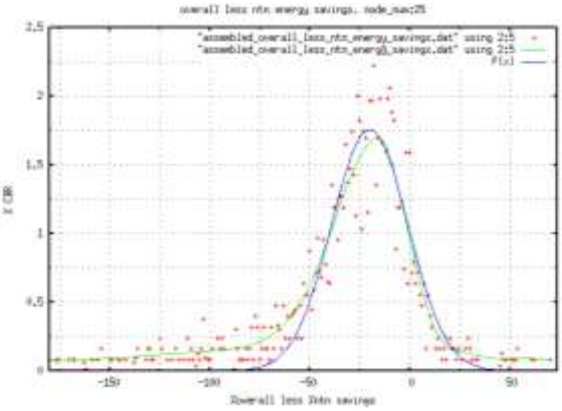

Figure 19: % cbr for OLNTNES node_number 25

20. Node Number 26

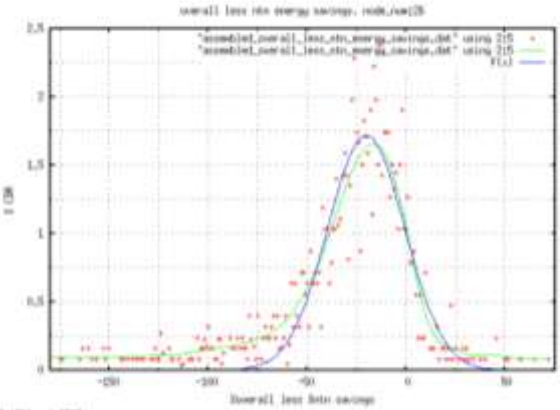

Figure 20: % cbr for OLNTNES node_number 26

21. Node Number 27

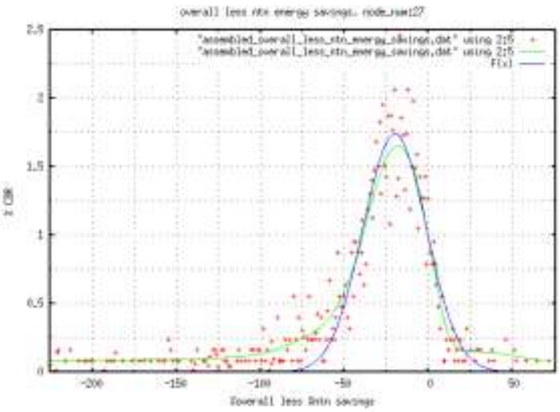

Figure 21: % cbr for OLNTNES node_number 27

22. Node Number 28

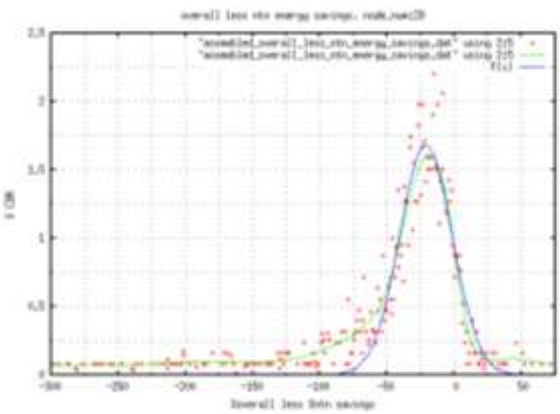

Figure 22: % cbr for OLNTNES node_number 28

23. Node Number 29

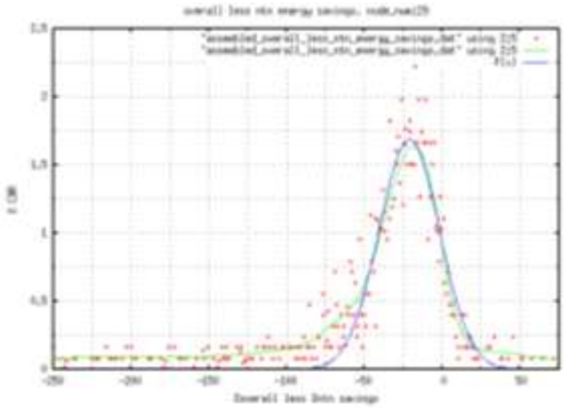

Figure 23: % cbr for OLNTNES node_number 29

24. Node Number 30

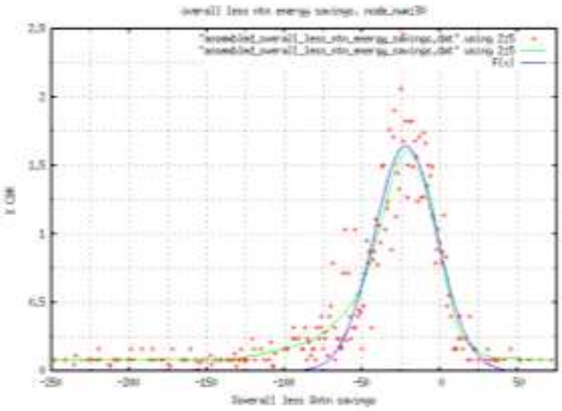

Figure 24: % cbr for OLNTNES node_number 30

25. Node Number 31

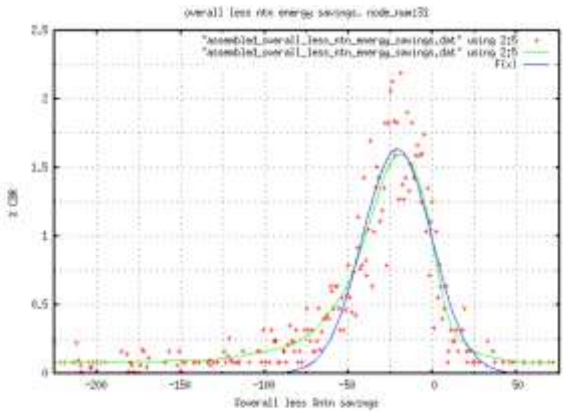

Figure 25: % cbr for OLNTNES node_number 31

26. Node Number 32

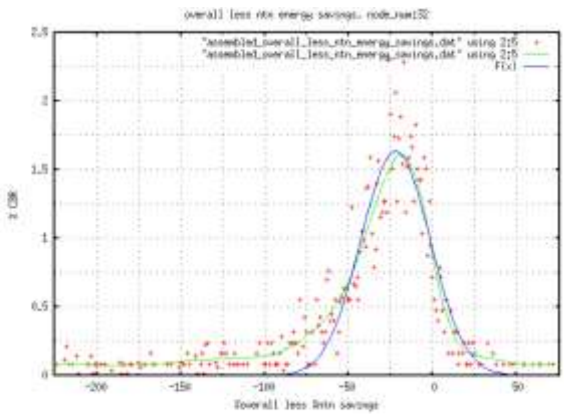

Figure 26: % cbr for OLNTNES node_number 32

27. Node Number 33

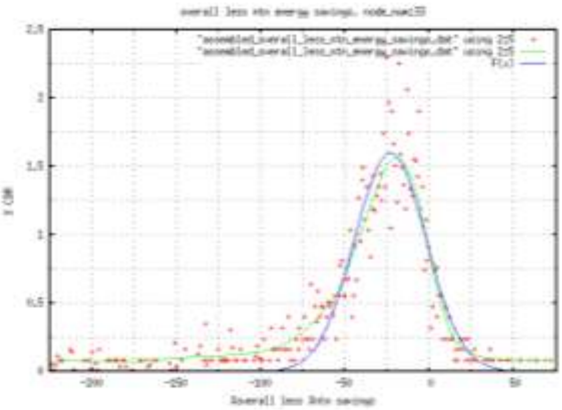

Figure 27: % cbr for OLNTNES node_number 33

28. Node Number 34

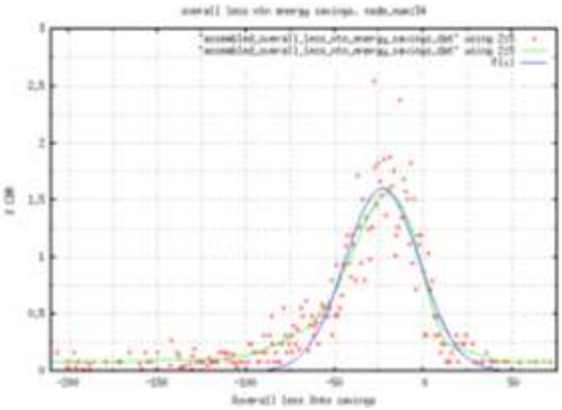

Figure 28: % cbr for OLNTNES node_number 34

29. Node Number 35

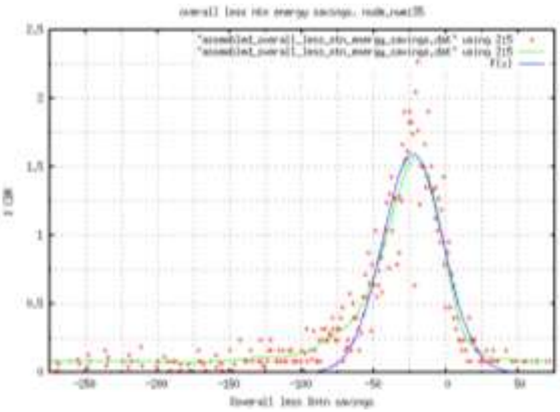

Figure 29: % cbr for OLNTNES node_number 35

30. Node Number 36

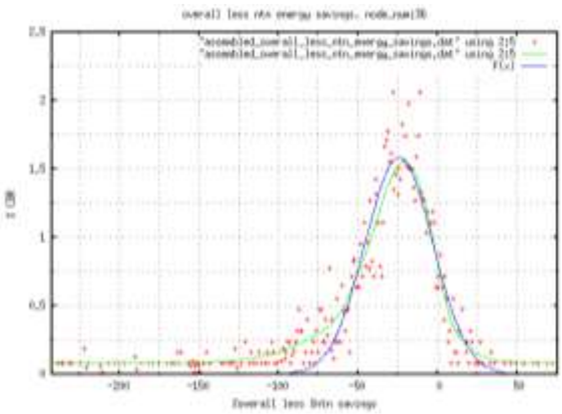

Figure 30: % cbr for OLNTNES node_number 36

31. Node Number 37

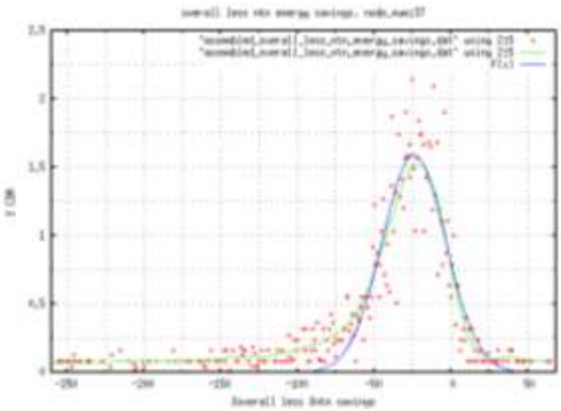

Figure 31: % cbr for OLNTNES node_number 37

32. Node Number 38

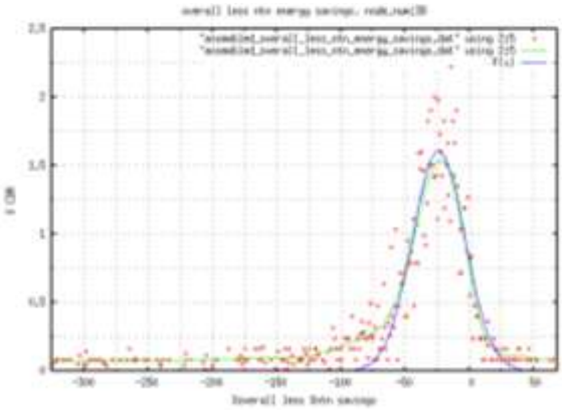

Figure 32: % cbr for OLNTNES node_number 38

33. Node Number 39

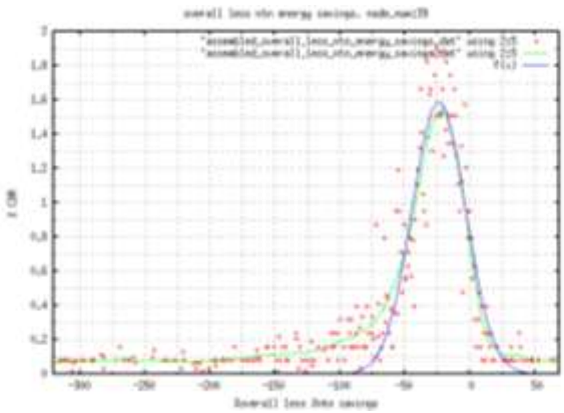

Figure 33: % cbr for OLNTNES node_number 39

34. Node Number 40

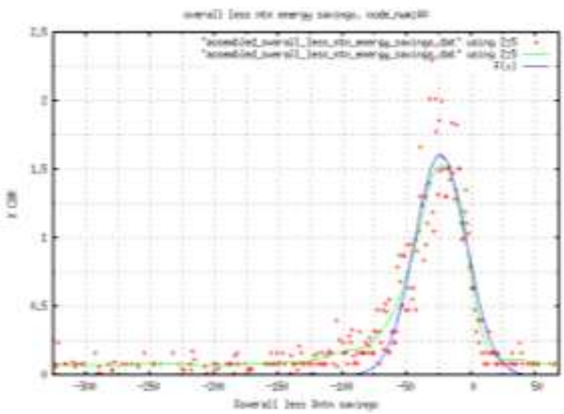

Figure 34: % cbr for OLNTNES node_number 40

35. Node Number 41

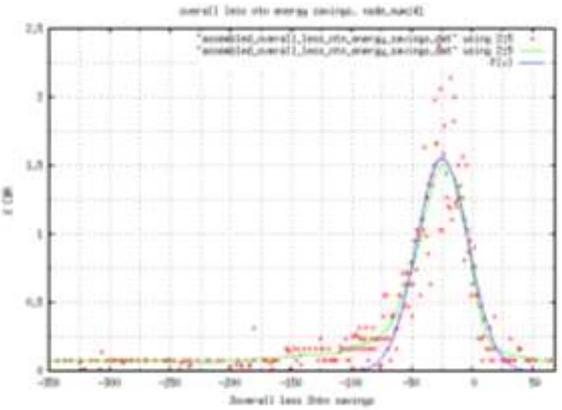

Figure 35: % cbr for OLNTNES node_number 41

36. Node Number 42

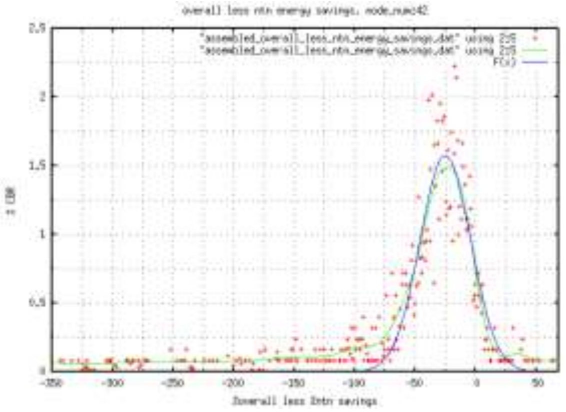

Figure 36: % cbr for OLNTNES node_number 42

37. Node Number 43

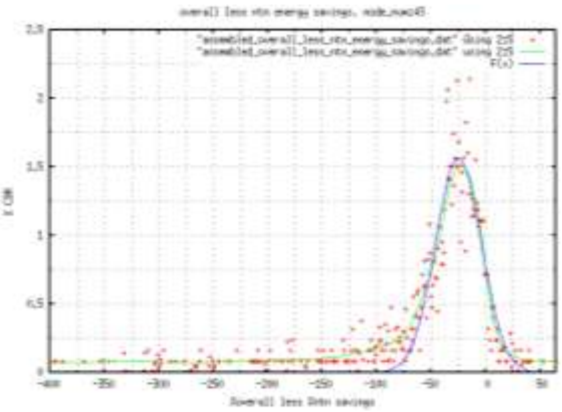

Figure 37: % cbr for OLNTNES node_number 43

38. Node Number 44

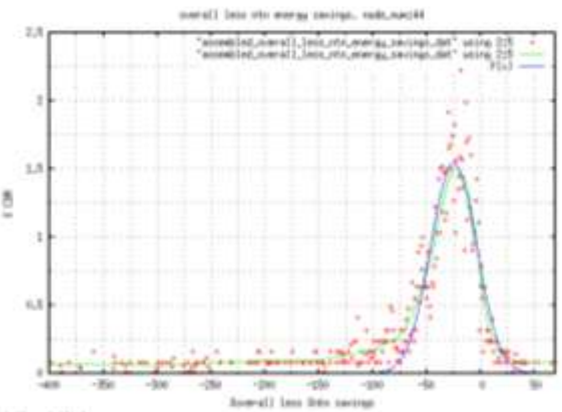

Figure 38: % cbr for OLNTNES node_number 44

39. Node Number 45

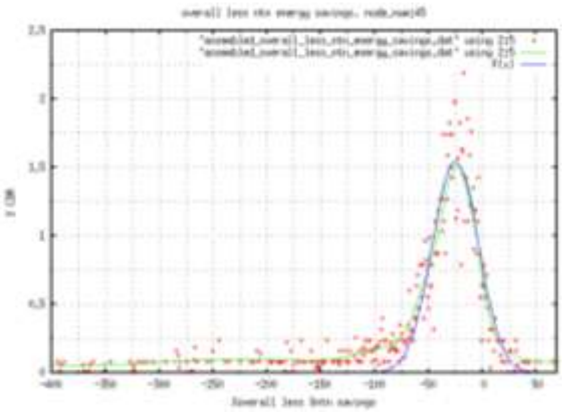

Figure 39: % cbr for OLNTNES node_number 45

40. Node Number 46

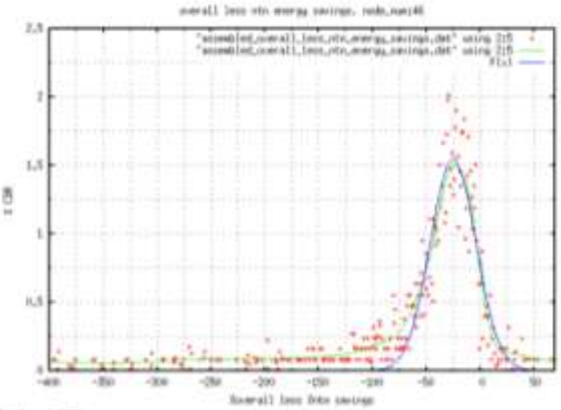

Figure 40: % cbr for OLNTNES node_number 46

41. Node Number 47

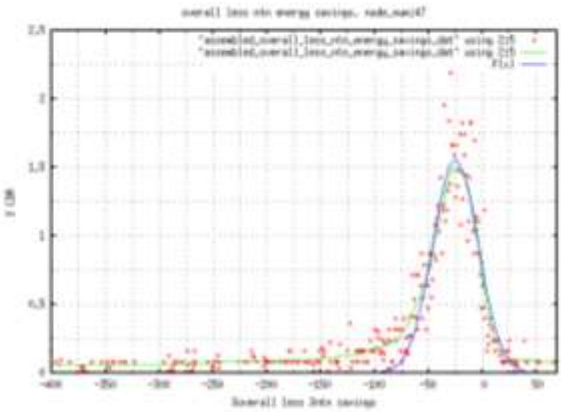

Figure 41: % cbr for OLNTNES node_number 47

42. Node Number 48

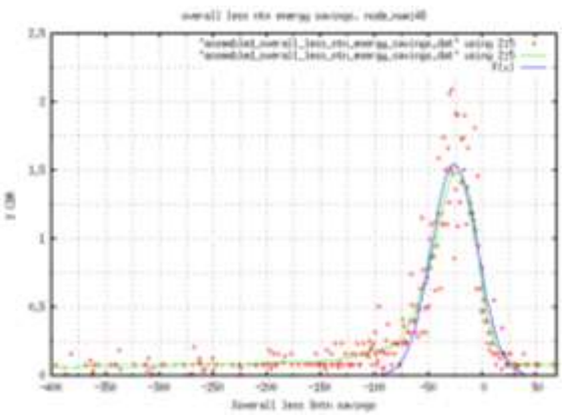

Figure 42: % cbr for OLNTNES node_number 48

43. Node Number 49

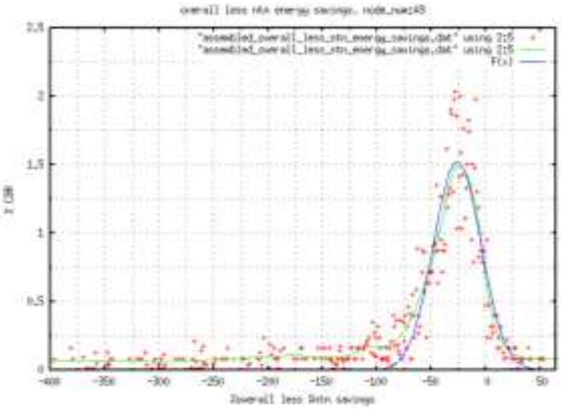

Figure 43: % cbr for OLNTNES node_number 49

44. Node Number 50

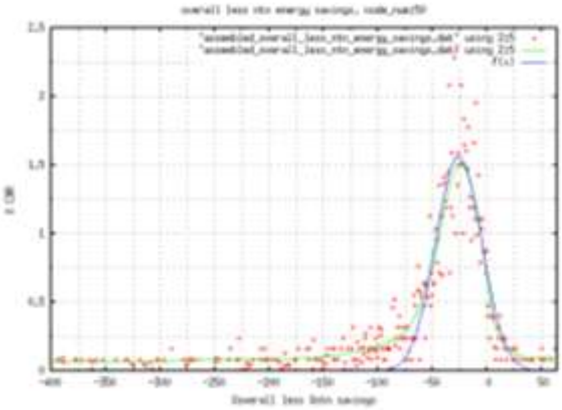

Figure 44: % cbr for OLNTNES node_number 50

45. Node Number 51

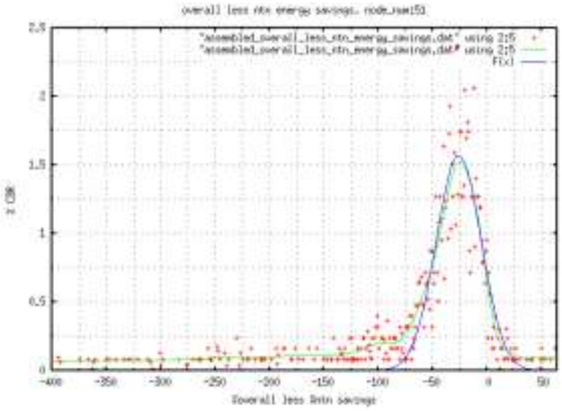

Figure 45: % cbr for OLNTNES node_number 51

46. Node Number 52

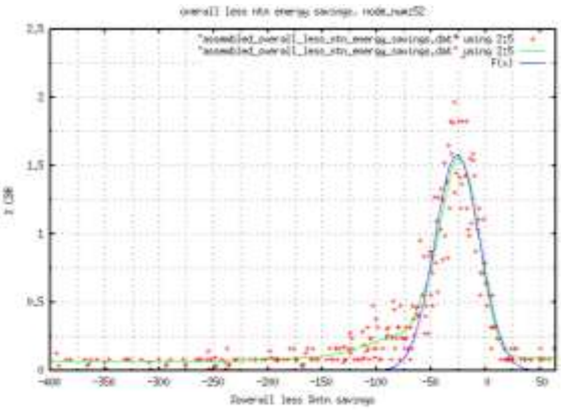

Figure 46: % cbr for OLNTNES node_number 52

47. Node Number 53

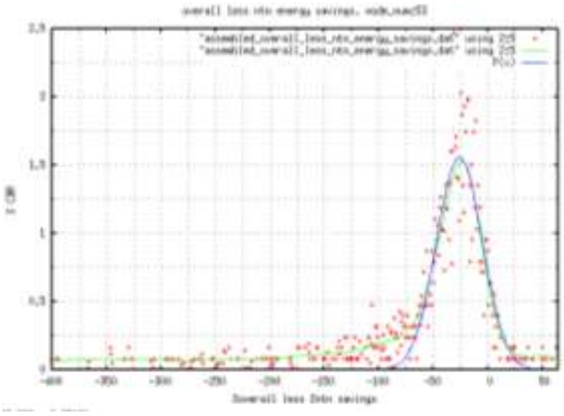

Figure 47: % cbr for OLNTNES node_number 53

48. Node Number 54

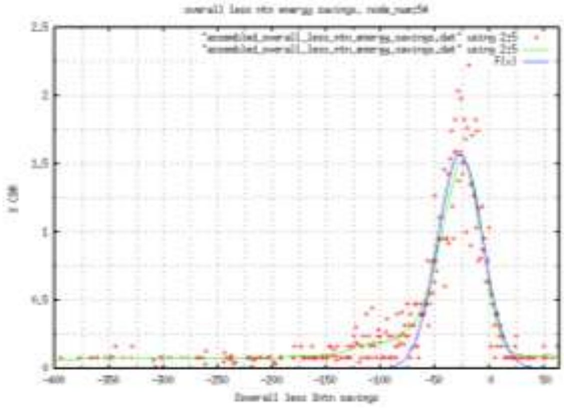

Figure 48: % cbr for OLNTNES node_number 54

49. Node Number 55

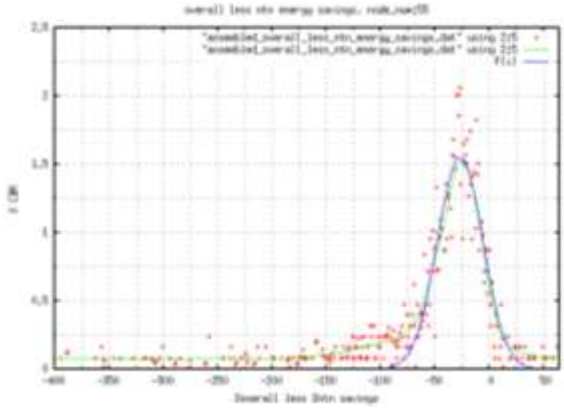

Figure 49: % cbr for OLNTNES node_number 55

50. Node Number 56

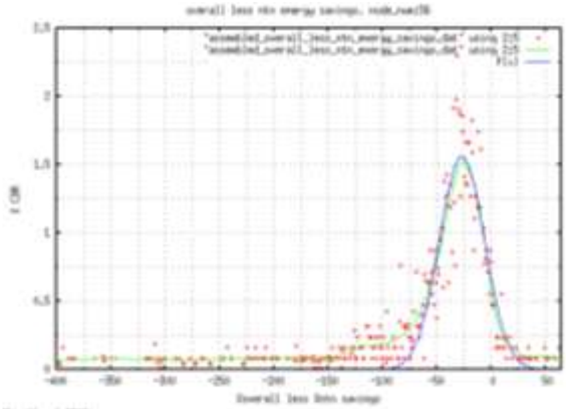

Figure 50: % cbr for OLNTNES node_number 56

4. Conclusion.

This piece of research was aimed at and has developed a new model of expected trend of overall node extra energy savings achievable in a MANET topography of 300 x 300 m^2 compared against those achieved in direct node-to-node transmission. This piece of research was derived from previous research with more emphasis from two papers [2, 14]. The model obtained will help designers better understand the impact of additional energy requirements required for MANET transmission from software engineering perspective of reliability and predictability. Here also, the results produced are empirical since they are derived from previous empirical results. For this study, many high-end components are assumed as available even if they are still subjects of research, e.g. lightweight algorithms for location-aware transmission in mobile environments, land-based or infrastructure-based location support with appropriate algorithms and lightweight OS supports.

The major conclusion of this study remain that, firstly, if MANET nodes are not supplied as infrastructure and their energy expenditure is of great concern, a great majority of CBRs will be requiring more energy for transmission than direct node-to-node transmission.

The further works identified may include: trend analyses of parameters of equation for the model, formulating method of predictability for metric OLNTNES and its trend and reporting observations of certain values identified.

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