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

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Abstract – **Quite extensive research is ongoing concerning enhancement of location tracking in Mobile environment and significant development have been put forward [35-50]. As and when new components for Mobile network are put forward, new functionalities will be devised or ways of doing existing activities will be improved. MAUC, however, still lacks the software engineering approaches into metrics and models development to sustain predictability and govern 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 sender node energy savings using location-aware MANET transmission provided in another paper [14]. The next set of investigation involves quantifying and modelling the extra energy savings achievable against Direct Node-to-Node transmission, the pattern of trend for this extra savings under different sets of node densities and method of predicting the trend equations for use in predictive probability calculations.**

The area of modelling in ubicomp involves much work and this paper adds to this area and will be used by designers to formulate better ubicomp architectures and components. This paper is a follow-up of previous papers [1-15] with more emphasis from papers [2, 14].

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

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1. Introduction

Energy consumption in MAUC is affected by several factors [2]. A major factor remains that energy for transmission varies proportional to the square of distance between sender and receiver. 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 [14].

Many researchers put forward that use of MANETs help in saving energy [51]. A plausible model for energy savings in MANET is provided in paper [14].

The question which will demarcate which of the two above mentioned types of transmission saves more energy in the event that MANET intermediate nodes are supplied as infrastructure and their energy consumptions are not of concern from sender's perspective remains: "How much extra energy savings does the sender node achieve for CBR transmission in MAANET transmission compared to direct node-to-node transmission?". Additional questions include:

- Which node densities give less good performance in MANET than in direct node-to-node transmission?
- Which node densities give better performance in MANET than in direct node-to-node transmission?
- Is a break-even point between the two parts above conceivable?

This study derived from 2 previous studies [2, 14] and results presented here remain empirical based.

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

2. New Derived Metric: Sender Less Node-to-Node Energy Savings (SLNTNES).

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.

SLNTNES is hence defined as the percentage savings achieved by the sender node only, in MANET (gauged against the BRE) less the percentage savings achieved by sender node in Direct node-to-node transmission (also gauged against the BRE).

SLNTNES value may be 0, as it would imply that the sender is using exactly same energy in MANET as in direct node-to-node transmission. The plausible case for this scenario is that the receiver is also the closest neighbour to the sender for the whole transmission duration, hence despite MANET transmission, the situation is reduced to direct node-to-node transmission.

SLNTNES value cannot be below 0, since the worst case reduction of the situation is until direct node-to-node transmission and nothing below this situation.

3. SLNTNES Trend Assessment over Varying Node Numbers.

3.0 Major Observations.

The trends for SLNTNES 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. Definitely, here, most senders have more energy savings than simple node-to-node energy savings; the smallest value reached is 0 (no negative values), even if % CBR reaching it is below 1%.

The maximum percentage Energy Savings achieved here are also high; 98 % for node number 7, 100% (i.e. 99.5% up to below 100) for others, though they are reached by under 1% of CBRs.

The % Energy Savings up to which 95% CBR is found has shown an increase with increasing node number. The mean value, c, has depicted an increasing 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, E→reduced Chi-square value of plot, F→ Corresponding figure number.

A	B	C	D	E	F
7	0.115 094	1.121 7	23.610 3	0.175 542	1
8	0.098 575 6	0.849 813	24.949 6	0.184 537	2
9	0.099 947 2	0.867 104	0.183 479	0.183 479	3
10	0.104 697	0.916 545	26.991 5	0.193 832	4
11	0.103 344	0.894 319	27.462 2	0.163 059	5
12	0.101 172	0863 583	27.835 4	0.153 64	6
13	0.102 503	0.884 31	28.164 1	0.191 423	7
14	0.102 328	0.881 492	28.441 3	0.193 181	8
15	0.102 189	0.878 639	28.696 3	0.204 202	9
16	0.103 407	0.893 325	28.777 4	0.206 374	10
17	0.102 78	0.883 308	29.154 8	0.211 211	11
18	0.103 352	0.890 601	29.313 2	0.206 604	12
19	0.103 6	0.892 506	29.404	0.187 203	13
20	0.103 697	0.895 421	29.513 2	0.197 409	14
21	0.103 321	0.888 943	29.621 6	0.195 152	15
22	0.103 562	0.891 98	29.700 2	0.216 898	16
23	0.103 562	0.891 492	29.790 3	0.216 578	17
24	0.103 679	0.893 045	29.871	0.237 072	18
25	0.104 167	0.897 533	29.934 6	0.234 623	19
26	0.105 409	0.912 16	29.963 2	0.218 54	20
27	0.104 949	0.904 579	30.066 6	0.220 081	21
28	0.105 686	0.915 497	30.116 1	0.233 553	22
29	0.105 071	0.905 932	30.200 1	0.223 627	23
30	0.105 313	0.909 197	30.266 2	0.217 424	24
31	0.103 479	0.884 986	30.285 6	0.210 636	25
32	0.103 197	0.880 918	30.352 7	0.205 128	26
33	0.103 841	0.889 367	30.392 3	0.208 168	27
34	0.104 076	0.892 206	30.456 5	0.208 579	28
35	0.104 546	0.899 165	30.488 3	0.206 275	29
36	0.104 962	0.905 061	30.501 2	0.208 291	30
37	0.105 489	0.909 549	30.535 1	0.220 989	31
38	0.105 986	0.915 888	30.569 1	0.227 069	32
39	0.105 783	0.912 838	30.620 7	0.228 045	33
40	0.105 548	0.909 354	30.667 1	0.222 024	34
41	0.105 472	0.906 489	30.719 7	0.222 487	35
42	0.105 813	0.910 789	30.756 1	0.210 435	36
43	0.105 972	0.912 274	30.768 6	0.223 416	37
44	0.106 523	0.919 577	30.778 3	0.231 383	38
45	0.107 021	0.926 194	30.7709	0.241 055	39
46	0.106 734	0.922 029	30.797 3	0.236 187	40
47	0.106 479	0.918 337	30.827 7	0.235 419	41
48	0.106 617	0.919 537	30.829 2	0.234 428	42
49	0.106 812	0.922 495	30.819 2	0.233 775	43
50	0.106 785	0.921 21	30.867 2	0.222 677	44
51	0.106 985	0.923 504	30.872 6	0.225 663	45
52	0.107 069	0.924 597	30.899 5	0.216 707	46
53	0.107 061	0.924 158	30.906 6	0.212 766	47
54	0.107 064	0.924 324	30.908	0.210 324	48
55	0.106 999 5	0.923 337	30.916 8	0.207 359	49
56	0.107 049	0.923 718	30.921 9	0.211 355	50

Table 1: results for SLNTNES 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

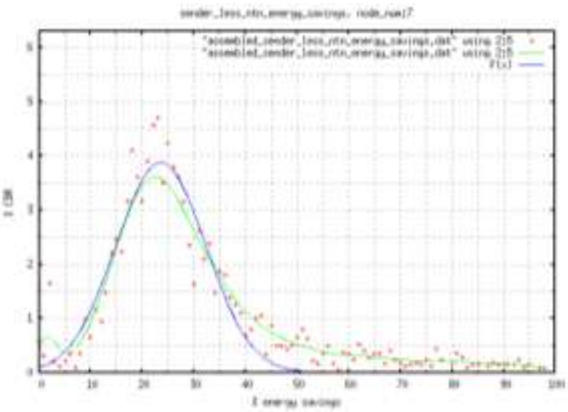

Figure 1: % cbr for SLNTNES node_number 7

2. Node Number 8

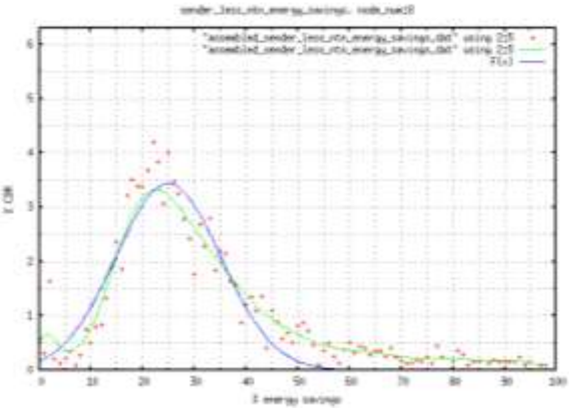

Figure 2: % cbr for SLNTNES node_number 8

3. Node Number 9

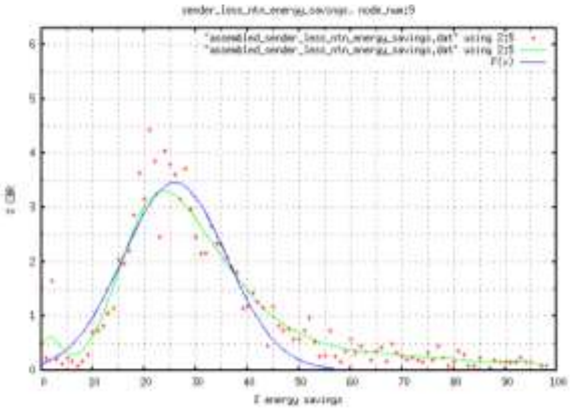

Figure 3: % cbr for SLNTNES node_number 9

4. Node Number 10

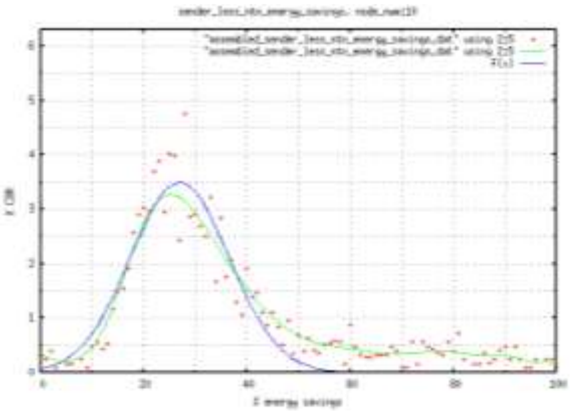

Figure 4: % cbr for SLNTNES node_number 10

5. Node Number 11

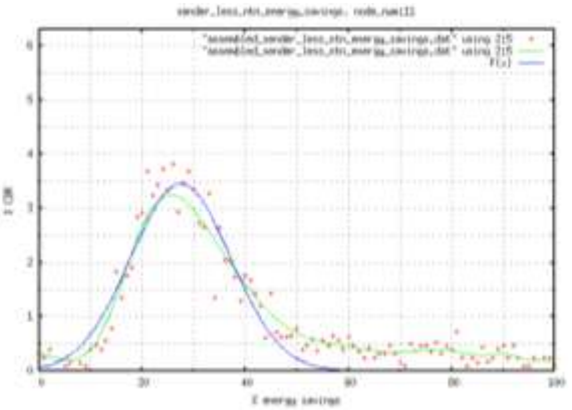

Figure 5: % cbr for SLNTNES node_number 11

6. Node Number 12

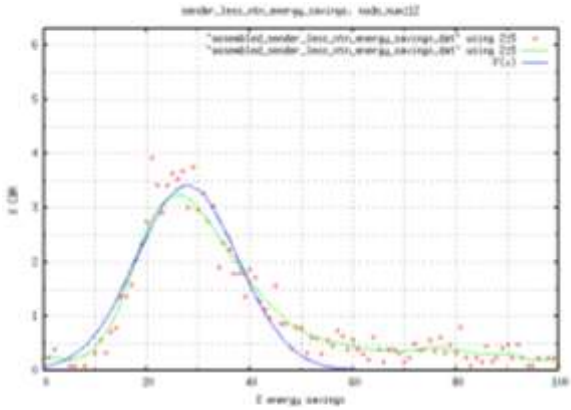

Figure 6: % cbr for SLNTNES node_number 12

7. Node Number 13

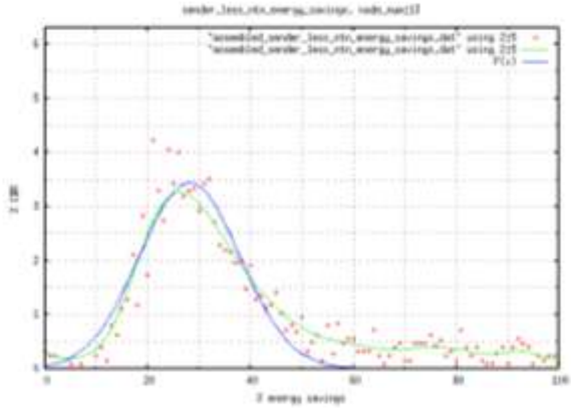

Figure 7: % cbr for SLNTNES node_number 13

8. Node Number 14

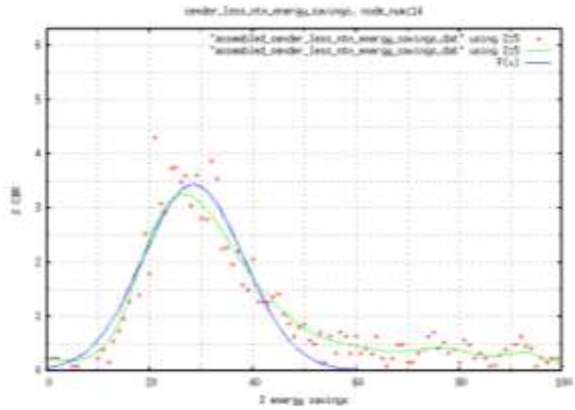

Figure 8: % cbr for SLNTNES node_number 14

9. Node Number 15

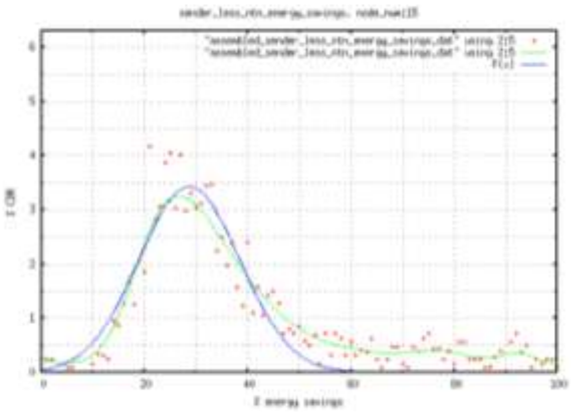

Figure 9: % cbr for SLNTNES node_number 15

10. Node Number 16

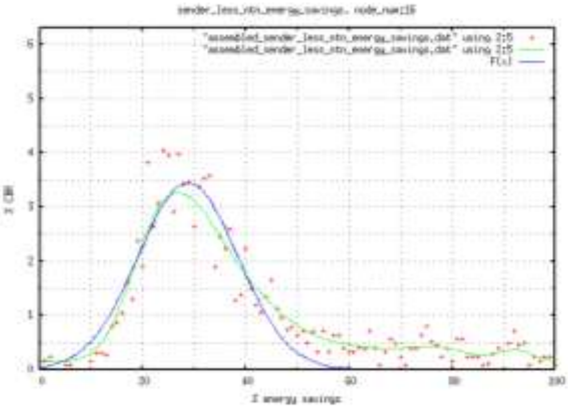

Figure 10: % cbr for SLNTNES node_number 16

11. Node Number 17

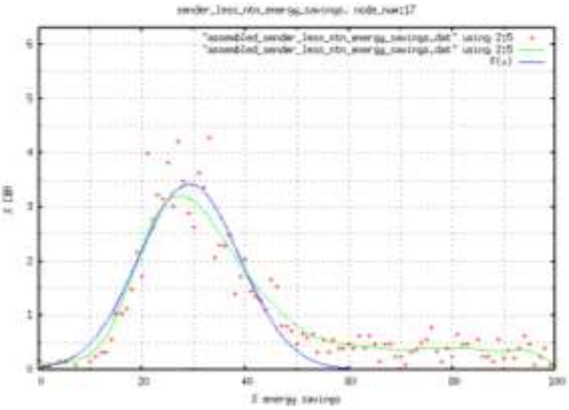

Figure 11: % cbr for SLNTNES node_number 17

12. Node Number 18

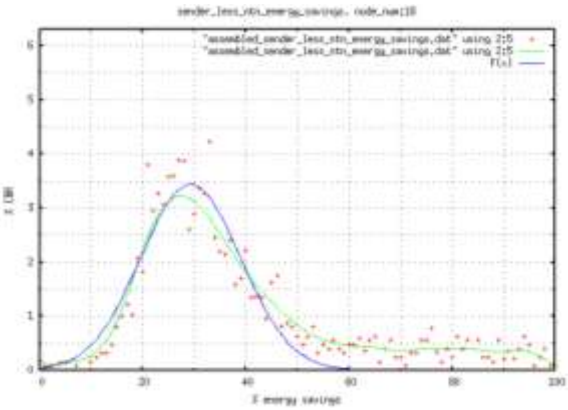

Figure 12: % cbr for SLNTNES node_number 18

13. Node Number 19

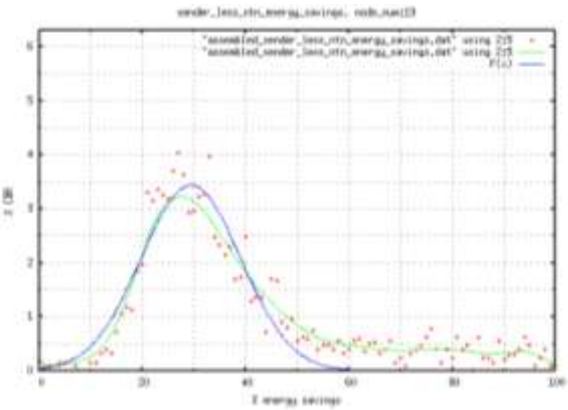

Figure 13: % cbr for SLNTNES node_number 19

14. Node Number 20

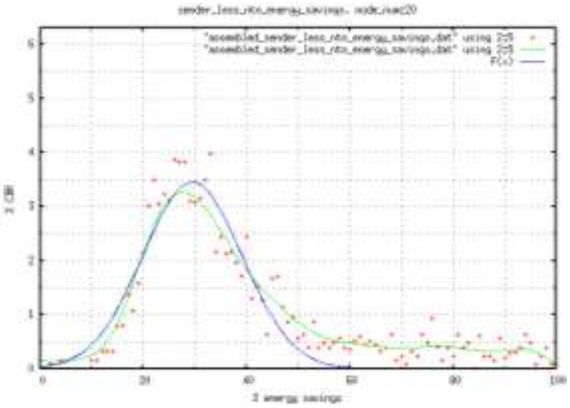

Figure 14: % cbr for SLNTNES node_number 20

15. Node Number 21

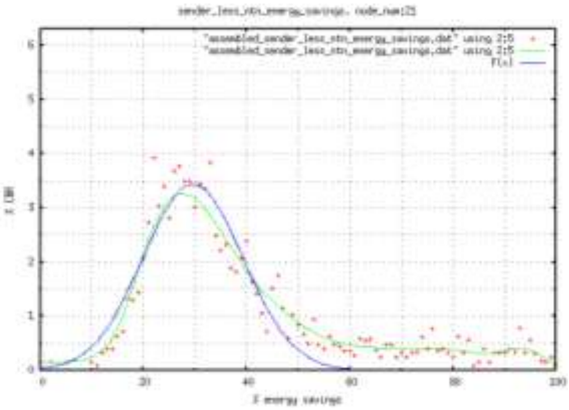

Figure 15: % cbr for SLNTNES node_number 21

16. Node Number 22

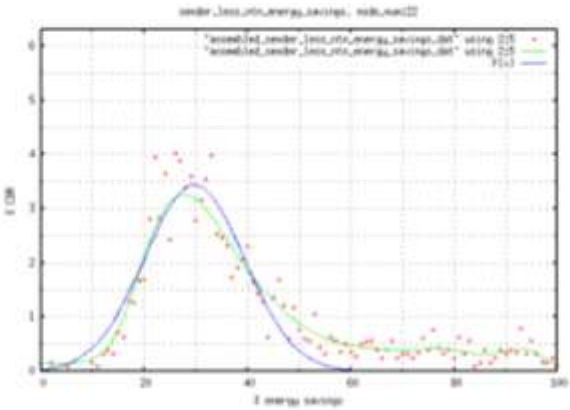

Figure 16: % cbr for SLNTNES node_number 22

17. Node Number 23

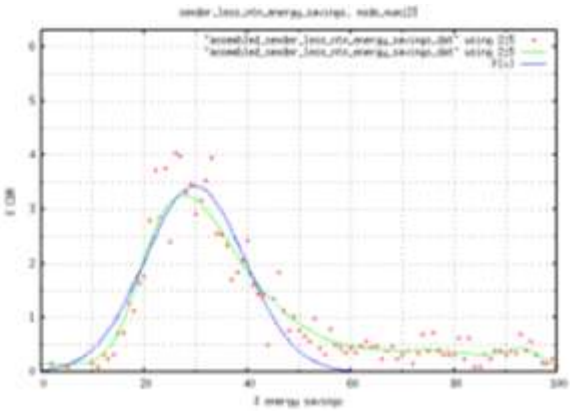

Figure 17: % cbr for SLNTNES node_number 23

18. Node Number 24

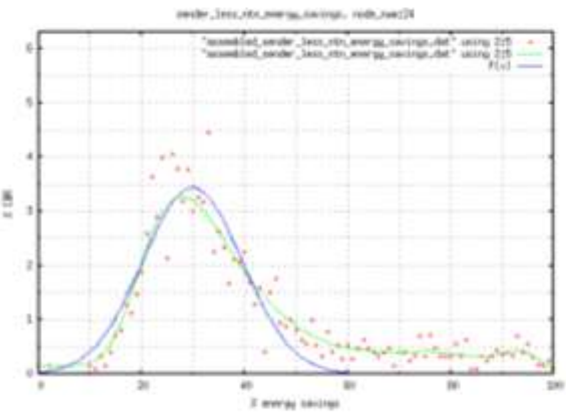

Figure 18: % cbr for SLNTNES node_number 24

19. Node Number 25

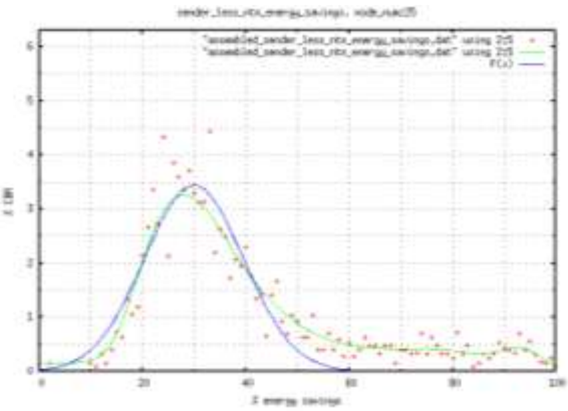

Figure 19: % cbr for SLNTNES node_number 25

20. Node Number 26

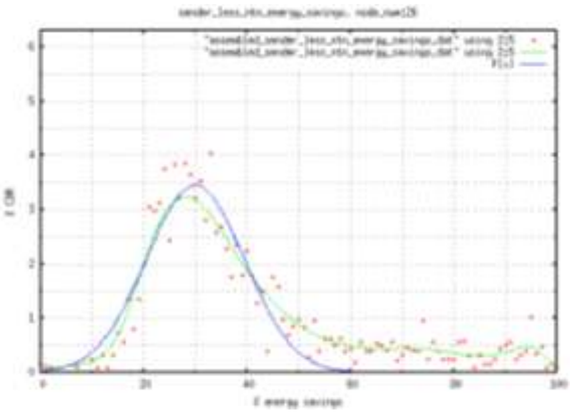

Figure 20: % cbr for SLNTNES node_number 26

21. Node Number 27

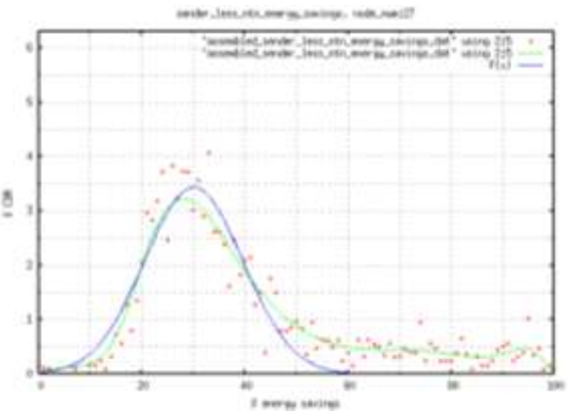

Figure 21: % cbr for SLNTNES node_number 27

22. Node Number 28

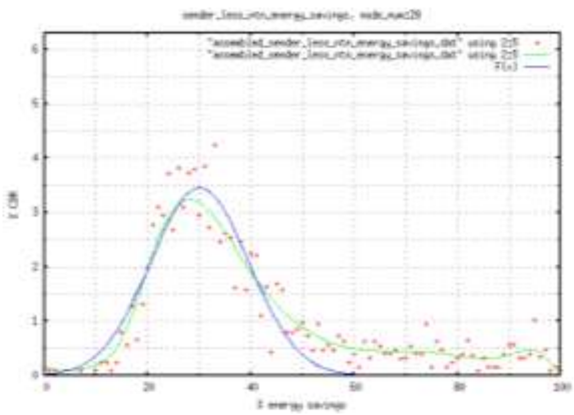

Figure 22: % cbr for SLNTNES node_number 28

23. Node Number 29

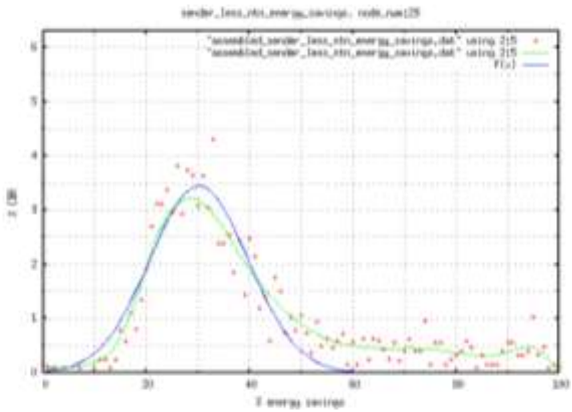

Figure 23: % cbr for SLNTNES node_number 29

24. Node Number 30

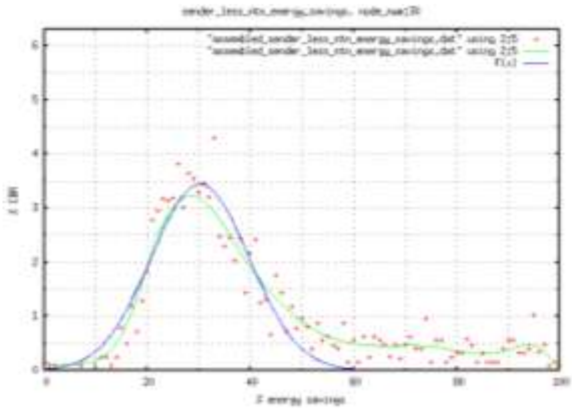

Figure 24: % cbr for SLNTNES node_number 30

25. Node Number 31

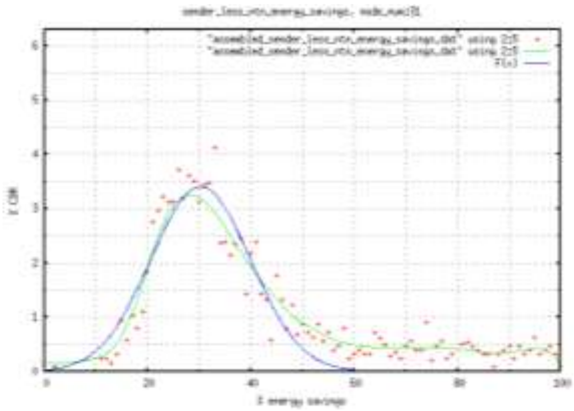

Figure 25: % cbr for SLNTNES node_number 31

26. Node Number 32

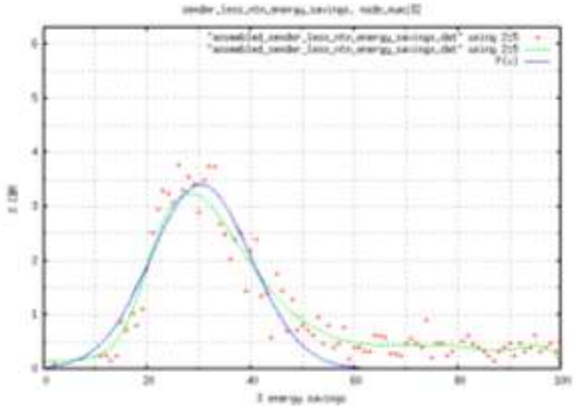

Figure 26: % cbr for SLNTNES node_number 32

27. Node Number 33

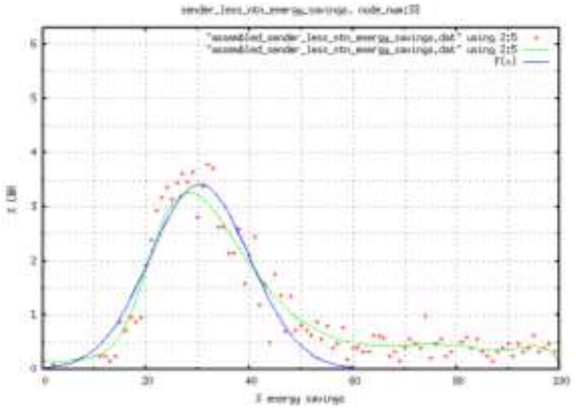

Figure 27: % cbr for SLNTNES node_number 33

28. Node Number 34

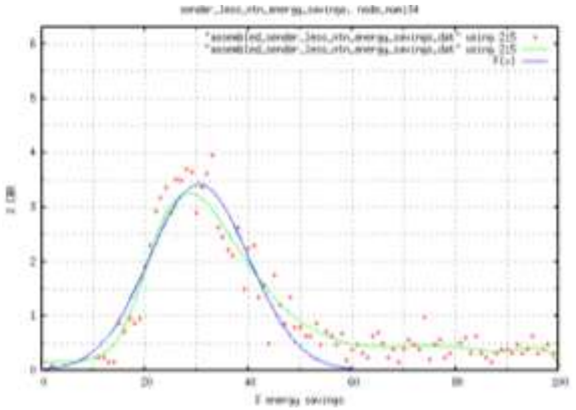

Figure 28: % cbr for SLNTNES node_number 34

29. Node Number 35

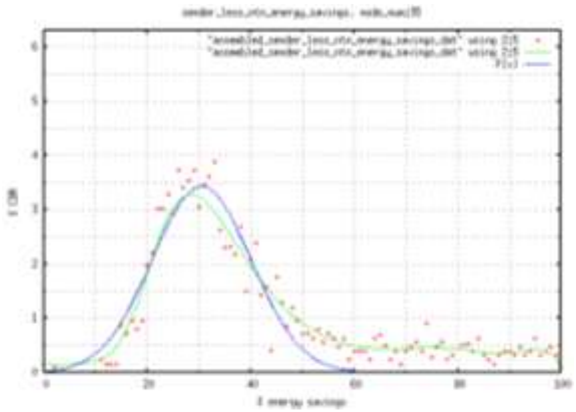

Figure 29: % cbr for SLNTNES node_number 35

30. Node Number 36

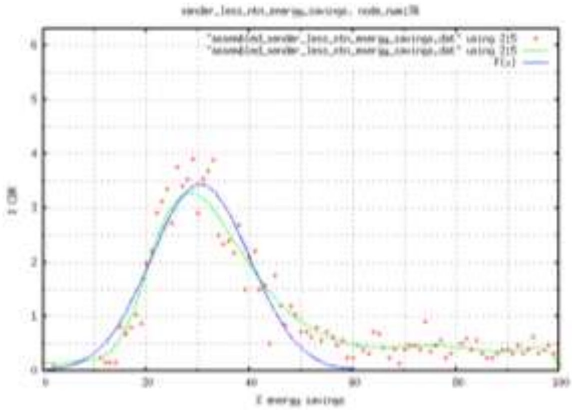

Figure 30: % cbr for SLNTNES node_number 36

31. Node Number 37

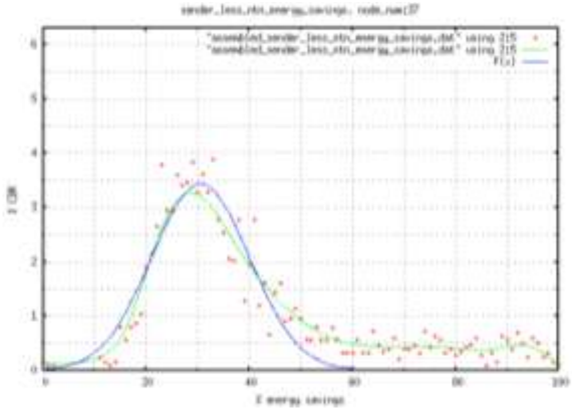

Figure 31: % cbr for SLNTNES node_number 37

32. Node Number 38

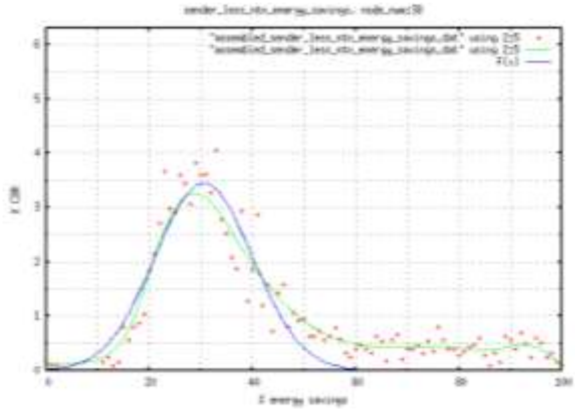

Figure 32: % cbr for SLNTNES node_number 38

33. Node Number 39

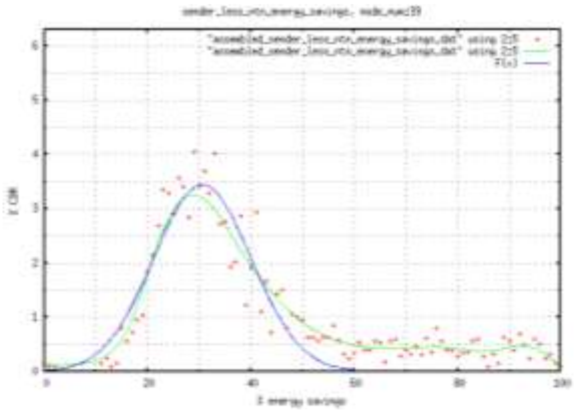

Figure 33: % cbr for SLNTNES node_number 39

34. Node Number 40

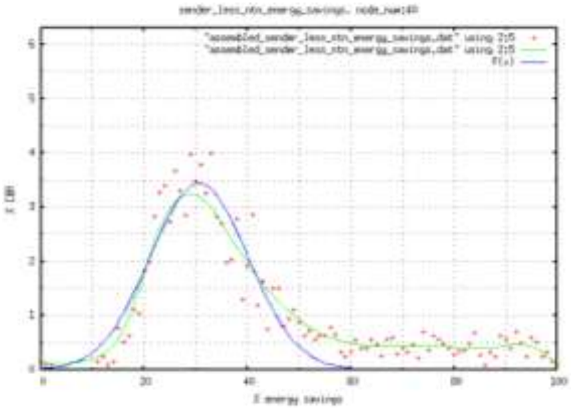

Figure 34: % cbr for SLNTNES node_number 40

35. Node Number 41

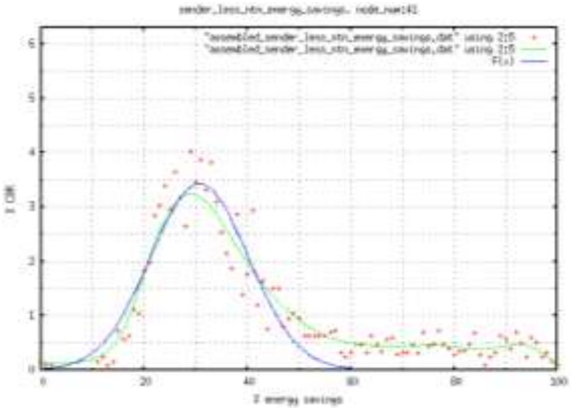

Figure 35: % cbr for SLNTNES node_number 41

36. Node Number 42

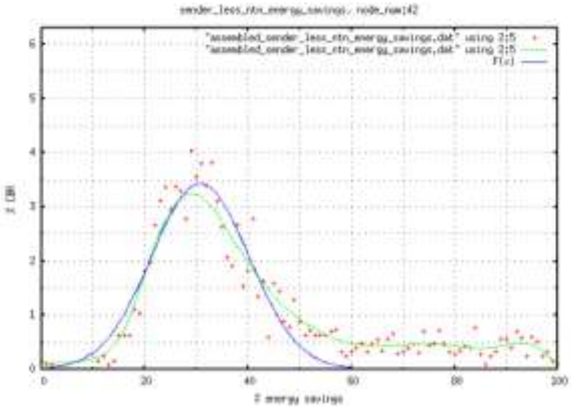

Figure 36: % cbr for SLNTNES node_number 42

37. Node Number 43

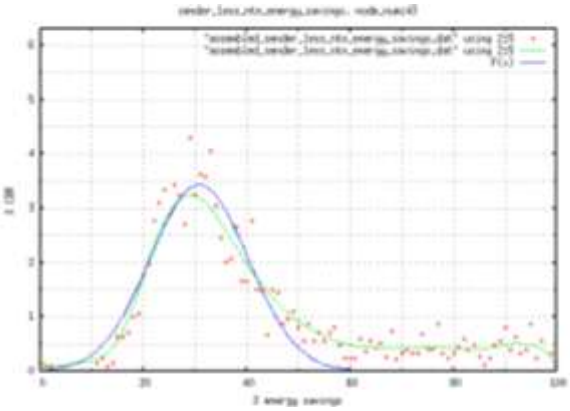

Figure 37: % cbr for SLNTNES node_number 43

38. Node Number 44

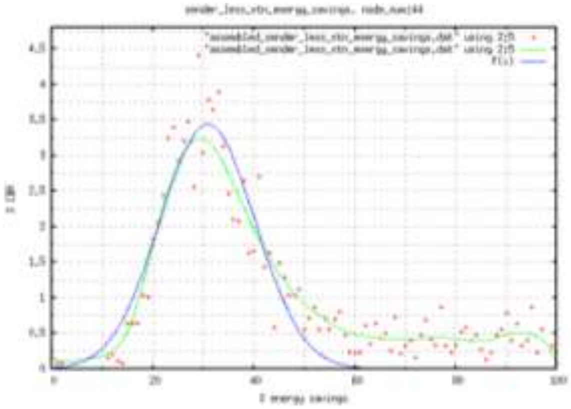

Figure 38: % cbr for SLNTNES node_number 44

39. Node Number 45

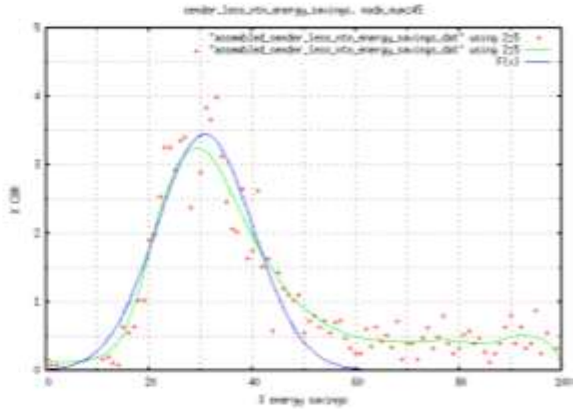

Figure 39: % cbr for SLNTNES node_number 45

40. Node Number 46

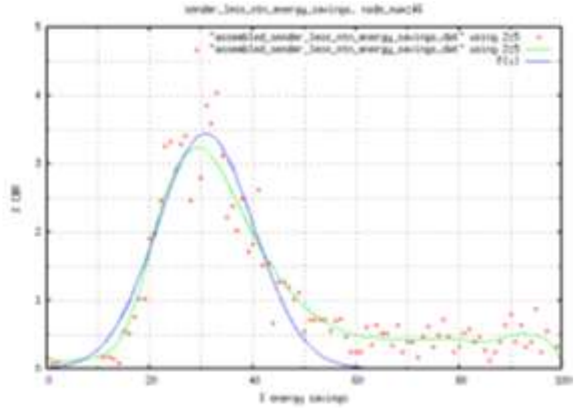

Figure 40: % cbr for SLNTNES node_number 46

41. Node Number 47

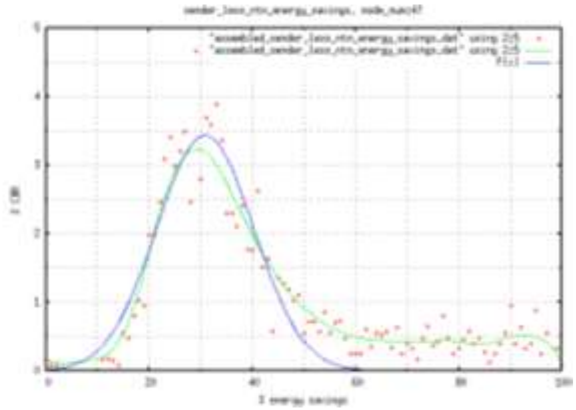

Figure 41: % cbr for SLNTNES node_number 47

42. Node Number 48

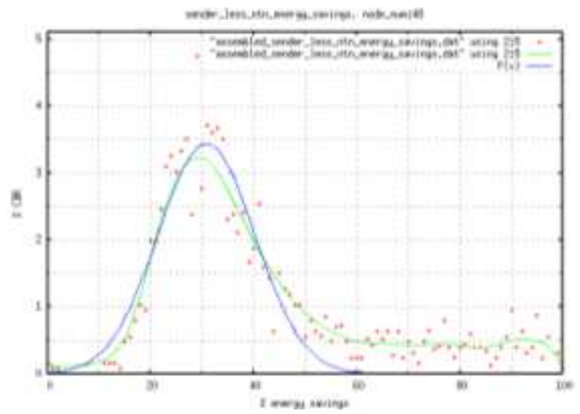

Figure 42: % cbr for SLNTNES node_number 48

43. Node Number 49

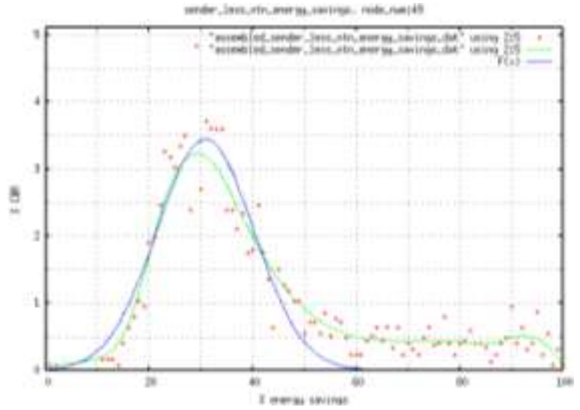

Figure 43: % cbr for SLNTNES node_number 49

44. Node Number 50

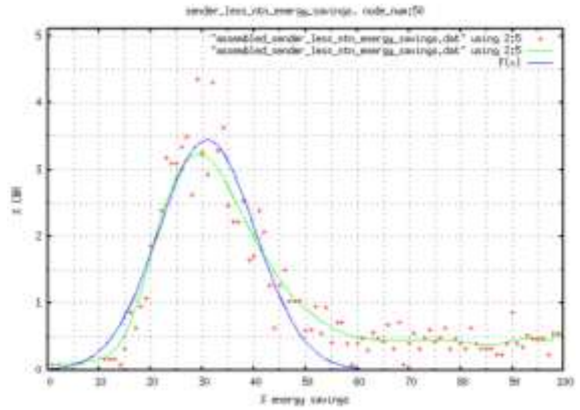

Figure 44: % cbr for SLNTNES node_number 50

45. Node Number 51

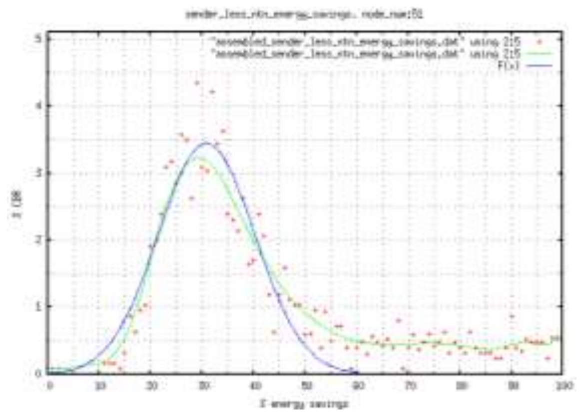

Figure 45: % cbr for SLNTNES node_number 51

46. Node Number 52

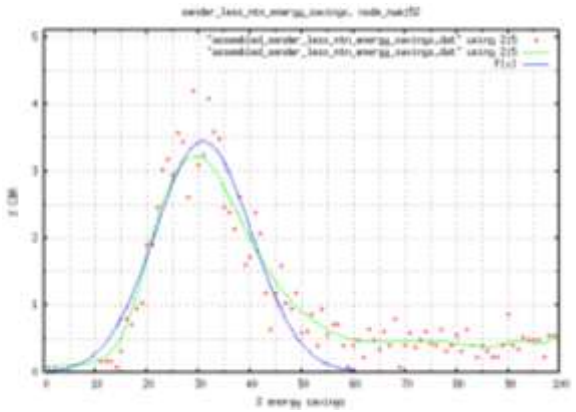

Figure 46: % cbr for SLNTNES node_number 52

47. Node Number 53

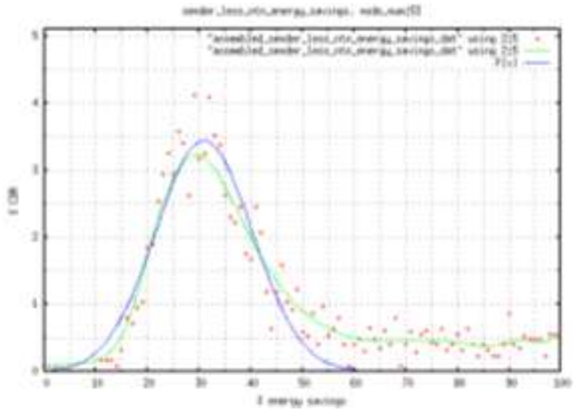

Figure 47: % cbr for SLNTNES node_number 53

48. Node Number 54

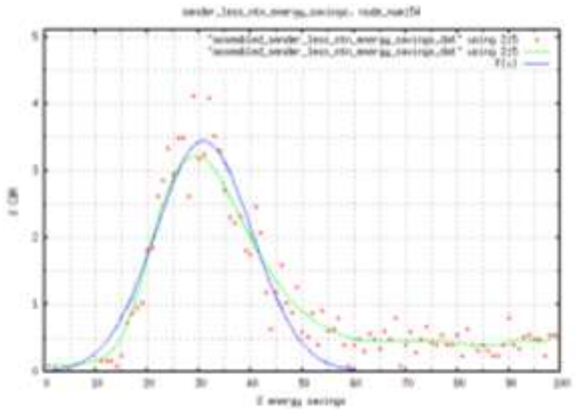

Figure 48: % cbr for SLNTNES node_number 54

49. Node Number 55

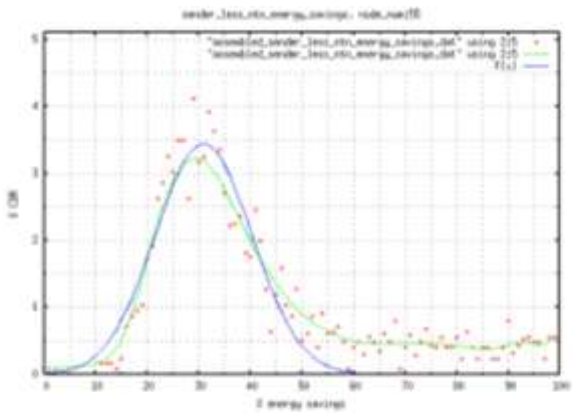

Figure 49: % cbr for SLNTNES node_number 55

50. Node Number 56

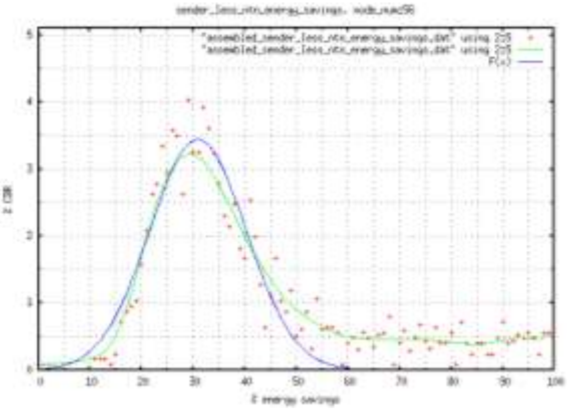

Figure 50: % cbr for SLNTNES node_number 56

4. Conclusion.

This piece of research was aimed at and has developed a new model of expected trend of sender 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 add to the components to study MANETs for MAUC environment from a software engineering perspective. Again, the result produced is derived from previous empirical results and hence retains the empirical nature. For this study, certain high-end components are assumed as widely available even though they are still subject to 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 support.

The major conclusion of this study remain that, firstly, if MANET nodes are supplied as infrastructure, a great majority of sending nodes in MANETs with varying node densities will be saving more energy than in direct node-to-node transmission. Secondly, for less than 1 % of CBR does a break-even point between MANET transmission and direct node-to-node transmission and hence may be considered negligible.

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

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