Model of Maximum CBR Distance Travelled by packets in MANETs using Location-Aware Transmission for Ubicomp.

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Abstract – MANET transmission strategies in MANET are considered good for energy containment and management for ubicomp [62]. Hence research in location-awareness and MANETs remain very significant. It is projected that further development will involve technologies like land-based GPS systems, improved location refresh rates and location accuracy, along with developments of better protocols optimised for transmission following distance criteria. To better tune transmission protocols and achieve optimal MANET performance, one desirable knowledge would be the trends of distance coverages by packets in a ubicomp for varying node densities.

A previous study in this direction was made [26], whereby the metric PPD was devised. In this paper, another metric "Max_CBR_Dist", derived from PPD is defined and its corresponding trends over varying node densities are presented.

This paper adds a second component after the metric PPD [26] to the area of modelling for managing distance packets travel in ubicomp topography of varying node densities. Designers may use these results towards formulation of better transmission protocols for ubicomp. This research is a follow-up of previous work [1-26].

Key terms: Ubicomp- Ubiquitous Computing, MAUC-Mobile and Ubiquitous Computing, MANET- Mobile Adhoc Network, PPD- Packets_Per_Distance, Max_CBR_Dist – Maximum_CBR_Distance, CBR-Constant Bit Rate.

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1. Introduction

Distance coverage is a predominant factor affecting energy consumption in MAUC. This energy expenditure varies proportional to the square of distance a packet travels [15]. In MANET transmission, the sender node along with all MANET route nodes forward packets corresponding to each CBR. One impact in the topography is that total number of packets circulating within the MANET topography. With increasing node density, this total number of packets is expected to increase. The sender node forwards packets to the closest neighbour but there is no guarantee that all hops will be of equal distance nor that the first hop is the smallest or biggest one for each CBR. The research questions put forward here are: "What are the maximum hop distance experienced by each CBR? What is the trend observable for this maximum hop count and how does it vary with varying node densities?"

The work presented here, is also empirical based and is built over previous work [26]. It follows from the statement that metric PPD remains a wide scope metric from which other sub-component metrics could be formulated. Each such sub-component metric may have specific characteristics that may be utilised for specific decision making in protocols to be used.

The key contributions of this paper is firstly, the development of a derived metric Max_CBR_Dist, derived from PPD for CBR Packet Per Distance analyses. The definition and rationale of metric Max_CBR_Dist is put forward. Secondly, the model of trend is put forward for the metric Max_CBR_Dist with results for varying node densities from 7 until 56 in a topography of 300 x 300 m^2. The model proposed is the normal distribution model. The rest of this paper is organised as follows: section 2- New Derived Metric – Maximum_CBR_Distance, section 3- Max_CBR_Dist Trend Assessment over Varying Node Numbers, 4- Conclusion and References.

2. New Derived Metric – Maximum_CBR_Distance.

Following definition of PPD [26], Max_CBR_Dist is defined as the maximum distance coverage noted for the whole of a CBR along a MANET topography. It can also be termed as the longest hop distance noted for a CBR.

MANET routes may vary during a CBR transmission. It is envisageable to have the metric at value 0. This may occur for short durations of transmission with snapshot MANET topology whereby all hops are below 0.5 m even though distance between sender and receiver may be high.

The results of this study may serve towards the same purposes as described in previous paper [26].

3. Max_CBR_Dist - Trend Assessment over Varying Node Numbers.

3.0 Major Observations.

For most of the plots from node numbers 7 until 56, the least value of Max_CBR_Dist has revolved around 21.

The plots are very scattered but as depicted in figure 1(a) for node number 7, the plausible "S" shape of the normal distribution is clearly visible. Hence it is put forward that the metric Max_CBR_Dist follows normal distribution with equation 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 also be read as F(x) equals to a factor (b) times the equation of a normal curve.

The x-coordinate of the peak values tend to increase with increasing node number.

3.1 Tabular Summary of Results.

A tabular summary for results of equations of curves (F(x)) 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 adjusted mean), E→ reduced chi-square value of plot F(x), F→ Corresponding figure number.

A	B	C	D	E	F
7	0.016 438 9	0.028 232 1	205.829	0.048 409 1	1(b)
8	0.016 390 4	0.028 090 5	205.653	0.048 455 3	2
9	0.016 167 7	0.027 307 5	207.217	0.044 713 3	3
10	0.017 218 3	0.030 411 3	211.3	0.043 087	4
11	0.017 410 9	0.030 880 2	231.38	0.041 007 7	5
12	0.016 566 6	0.028 502 3	27.001	0.047 092	6
13	0.017 592 5	0.031 131 5	219.341	0.036 961 5	7
14	0.018 559 1	0.034 021 5	222.619	0.032 710 1	8
15	0.017 998 7	0.032 434 7	225.176	0.040 314 2	9
16	0.017 5	0.030 582 3	226.394	0.042 106 5	10
17	0.016 414 3	0.028 131 1	227.478	0.032 947 8	11
18	0.016 790 1	0.029 52	229.628	0.039 948 2	12
19	0.016 987 7	0.029 636 3	229.952	0.035 016 4	13
20	0.017 843 8	0.032 116 5	231.287	0.036 523 4	14
21	0.018 964 6	0.035 194 8	232.883	0.034 724	15
22	0.019 101 6	0.035 595	232.058	0.042 322 5	16
23	0.018 029 5	0.032 975 1	231.548	0.044 550 6	17
24	0.018 697 5	0.034 061 7	235.439	0.037 116 3	18
25	0.018 655 3	0.034 181	237.933	0.036 636	19
26	0.019 965 5	0.037 684 7	235.607	0.044 215 2	20
27	0.020 164 1	0.038 655 2	236.63	0.043 365 2	21
28	0.019 439	0.036 789 4	236.554	0.043 260 1	22
29	0.020 382 5	0.039 758 9	238.043	0.042 739 4	23
30	0.019 110 5	0.036 345 1	238.153	0.043 387	24
31	0.018 553 5	0.034 897 6	240.214	0.045 639	25
32	0.018 961 9	0.035 263 2	240.611	0.043 270 1	26
33	0.019 435 3	0.036 551	242.425	0.051 359 5	27
34	0.019 007 6	0.035 869 9	245.071	0.047 210 2	28
35	0.019 376 8	0.036 854 4	243.855	0.052 990 9	29
36	0.018 859 2	0.035 758 4	244.091	0.047 780 1	30
37	0.019 299	0.037 419 5	244.795	0.047 875 2	31
38	0.019 770 7	0.039 453	245.046	0.041 124 8	32
39	0.020 14	0.039 741 1	245.324	0.038 947 7	33

40	0.020 245 9	0.039 970 8	246.846	0.038 108 2	34
41	0.020 833 2	0.041 880 1	245.93	0.041 547	35
42	0.019 763 1	0.039 043 5	245.945	0.045 446	36
43	0.021 308 3	0.043 440 7	247.991	0.039 989 4	37
44	0.019 129 4	0.037 092 8	248.662	0.052 026 1	38
45	0.019 242 3	0.037 322 7	248.86	0.047 408 7	39
46	0.020 648 2	0.041 103 8	248.45	0.046 211 2	40
47	0.020 284 4	0.040 292 9	248.463	0.040 269 1	41
48	0.020 725 5	0.041 485 5	249.838	0.046 532 3	42
49	0.020 261 9	0.039 907 2	250.208	0.048 259 1	43
50	0.020 024 7	0.038 805 2	251.711	0.043 092 4	44
51	0.020 356 7	0.039 840 3	251.43	0.041 831 2	45
52	0.020 559 5	0.041 242 4	252.115	0.036 330 1	46
53	0.021 108 6	0.042 735 6	252.346	0.037 203 5	47
54	0.021 072 1	0.042 558 1	253.197	0.033 080 3	48
55	0.019 685 8	0.038 248 2	252.23	0.034 012 4	49
56	0.020 209 5	0.039 817 5	254.371	0.037 182 2	50

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

3.2 Graphical Plots for Results Obtained.

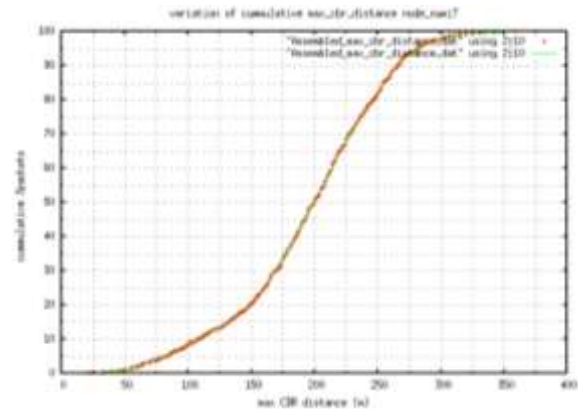This analysis is performed in gnuplot in Linux. x-axis distance is in meters.

1. Node Number 7

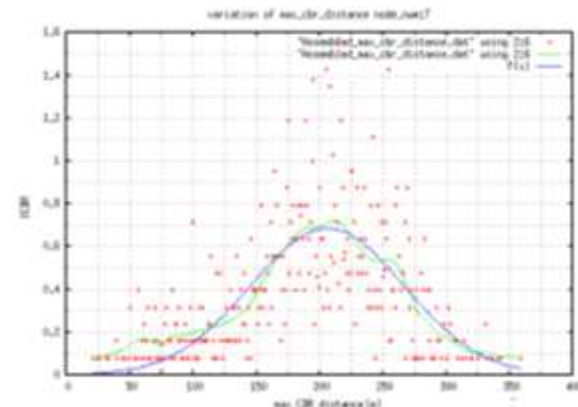**Figure 1(a): cumulative % CBR against max_CBR_distance : node_number 7**

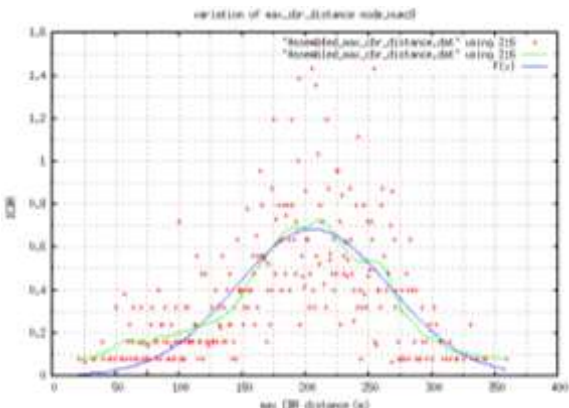**Figure 1(b): % cbr for Max_CBR_Dist: node_number 7**

2. Node Number 8

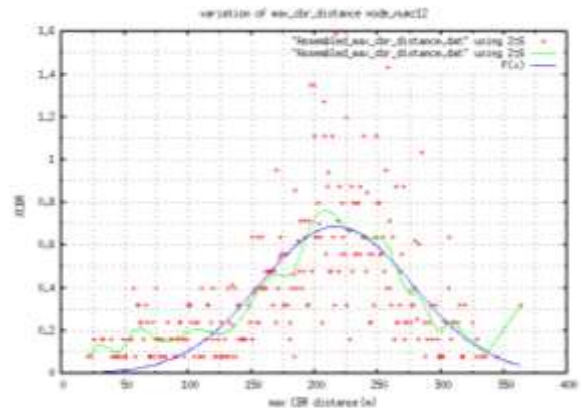**Figure 2: % cbr for Max_CBR_Dist: node_number 8**

3. Node Number 9

Figure 3: % cbr for Max_CBR_Dist: node_number 9
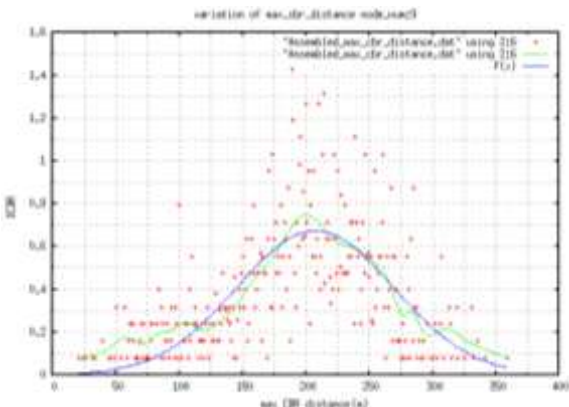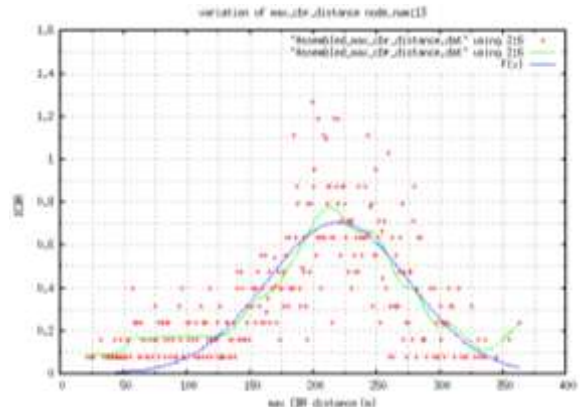
4. Node Number 10

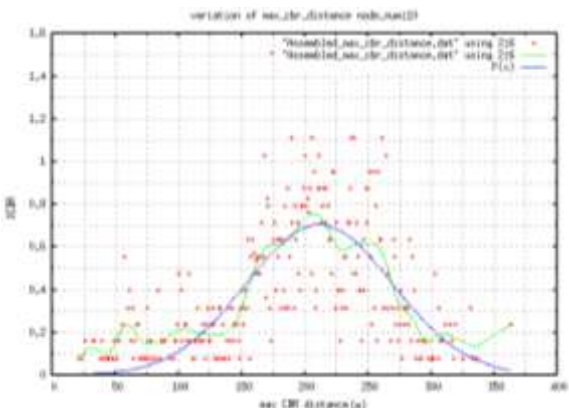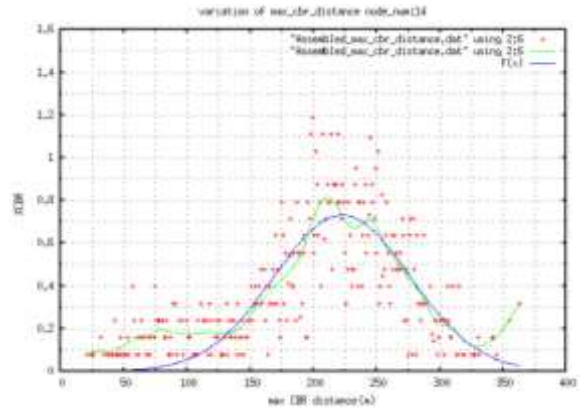**Figure 4: % cbr for Max_CBR_Dist: node_number 10**

5. Node Number 11

Figure 5: % cbr for Max_CBR_Dist: node_number 11
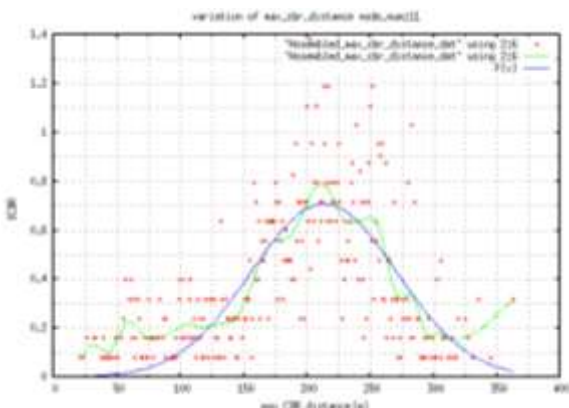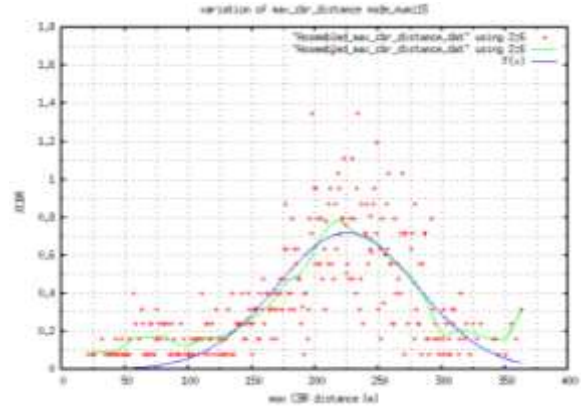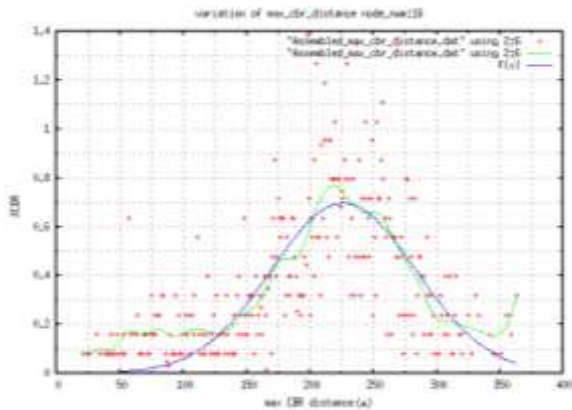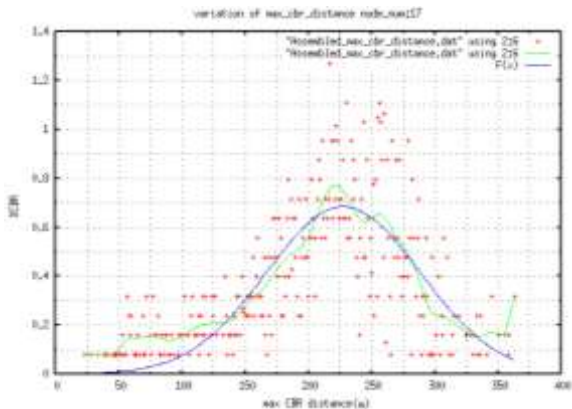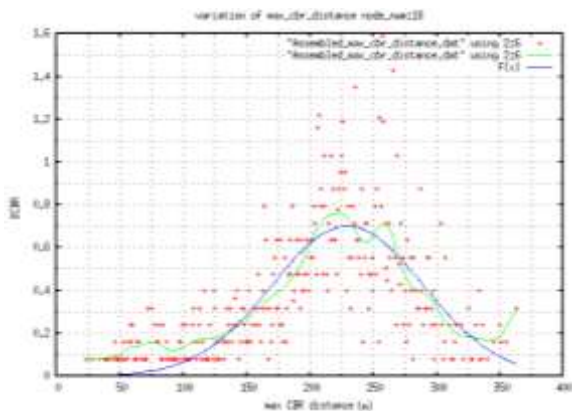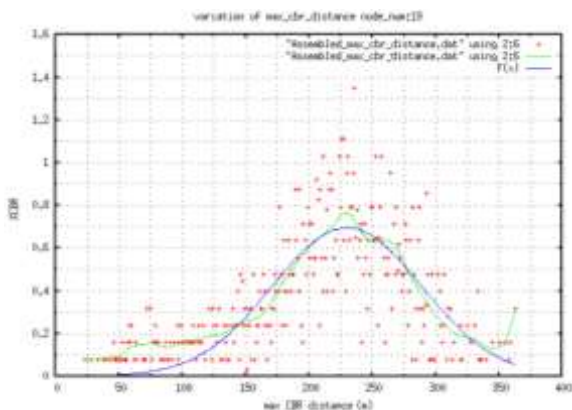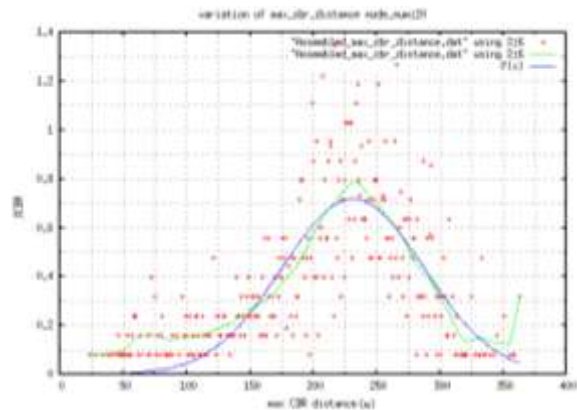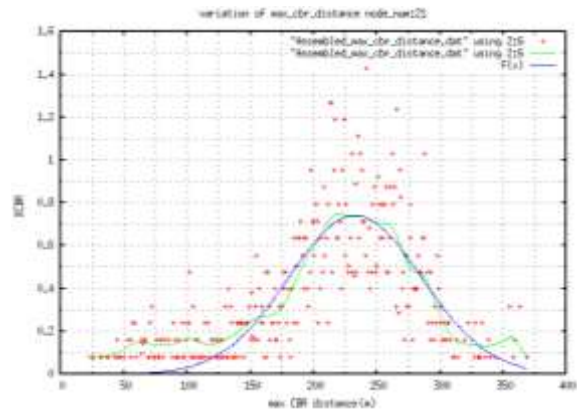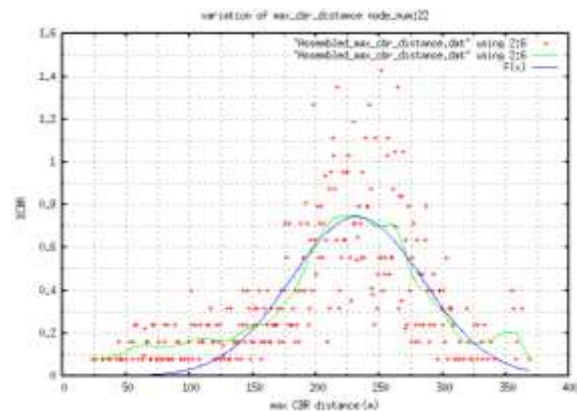
6. Node Number 12

Figure 6: % cbr for Max_CBR_Dist: node_number 12
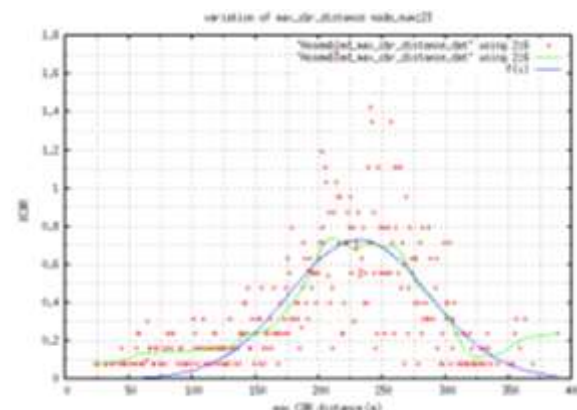
7. Node Number 13

Figure 7: % cbr for Max_CBR_Dist: node_number 13
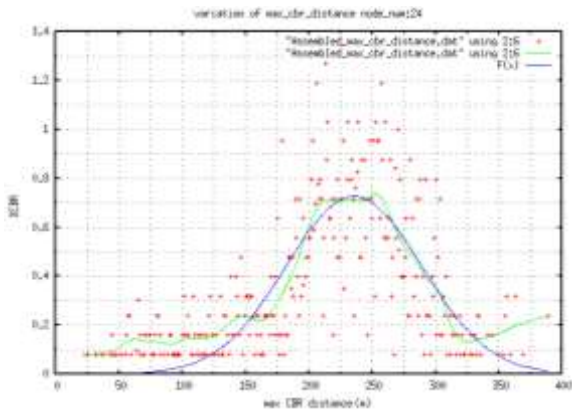
8. Node Number 14

Figure 8: % cbr for Max_CBR_Dist: node_number 14

9. Node Number 15

Figure 9: % cbr for Max_CBR_Dist: node_number 15

10. Node Number 16

Figure 10: % cbr for Max_CBR_Dist: node_number 16

11. Node Number 17

Figure 11: % cbr for Max_CBR_Dist: node_number 17

12. Node Number 18

Figure 12: % cbr for Max_CBR_Dist: node_number 18

13. Node Number 19

Figure 13: % cbr for Max_CBR_Dist: node_number 19

14. Node Number 20

Figure 14: % cbr for Max_CBR_Dist: node_number 20

15. Node Number 21

Figure 15: % cbr for Max_CBR_Dist: node_number 21

16. Node Number 22

Figure 16: % cbr for Max_CBR_Dist: node_number 22

17. Node Number 23

Figure 17: % cbr for Max_CBR_Dist: node_number 23

18. Node Number 24

Figure 18: % cbr for Max_CBR_Dist: node_number 24

19. Node Number 25

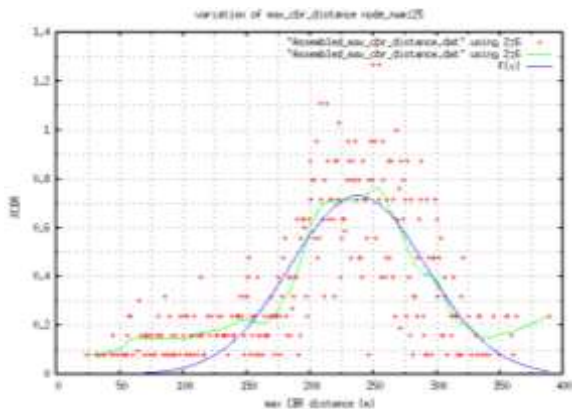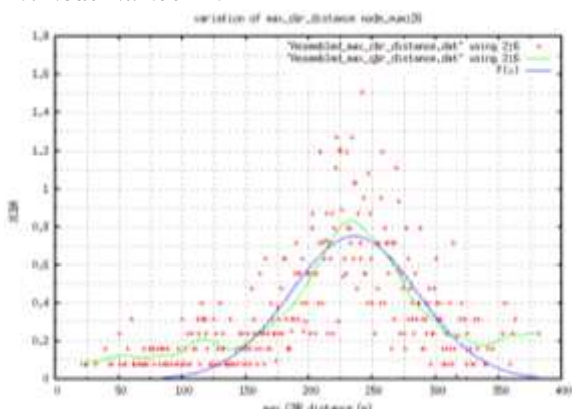**Figure 19: % cbr for Max_CBR_Dist: node_number 25**

20. Node Number 26

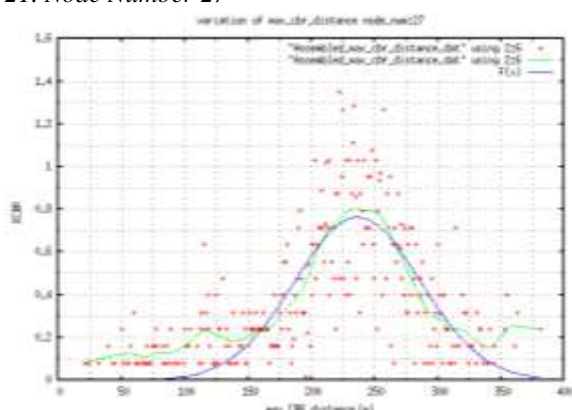**Figure 20: % cbr for Max_CBR_Dist: node_number 26**

21. Node Number 27

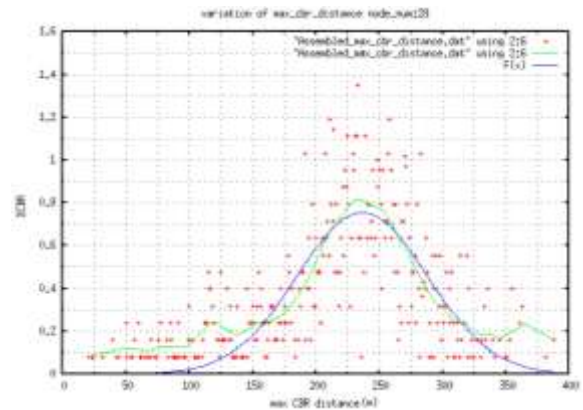**Figure 21: % cbr for Max_CBR_Dist: node_number 27**

22. Node Number 28

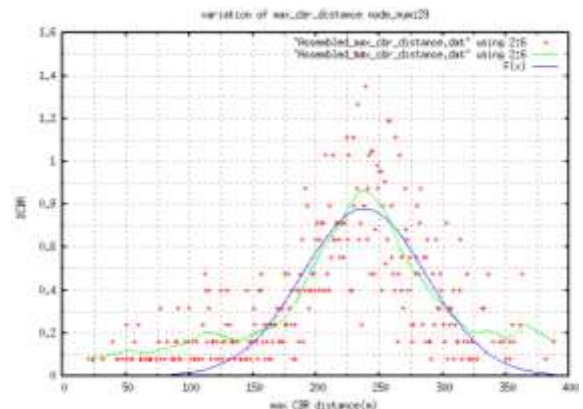**Figure 22: % cbr for Max_CBR_Dist: node_number 28**

23. Node Number 29

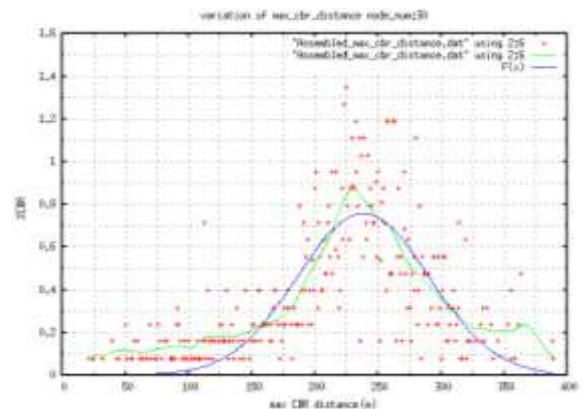**Figure 23: % cbr for Max_CBR_Dist: node_number 29**

24. Node Number 30

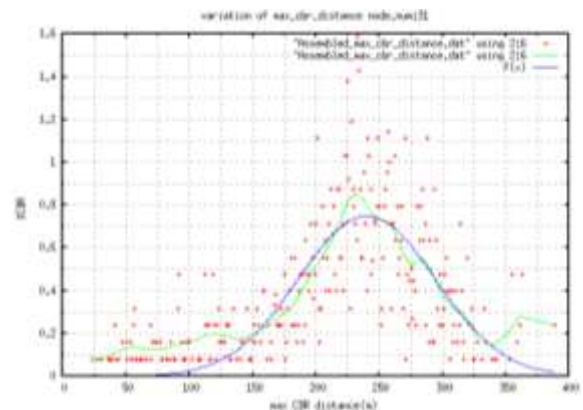**Figure 24: % cbr for Max_CBR_Dist: node_number 30**

25. Node Number 31

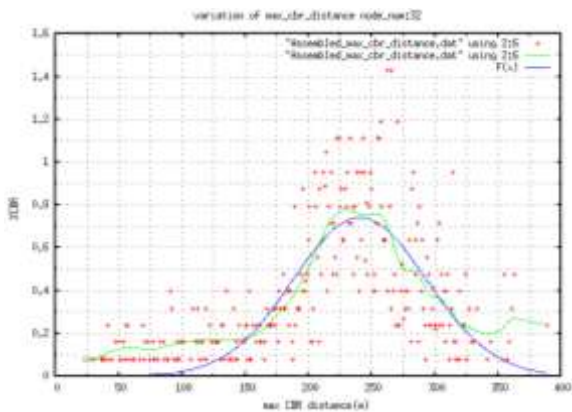**Figure 25: % cbr for Max_CBR_Dist: node_number 31**

26. Node Number 32

Figure 26: % cbr for Max_CBR_Dist: node_number 32

27. Node Number 33

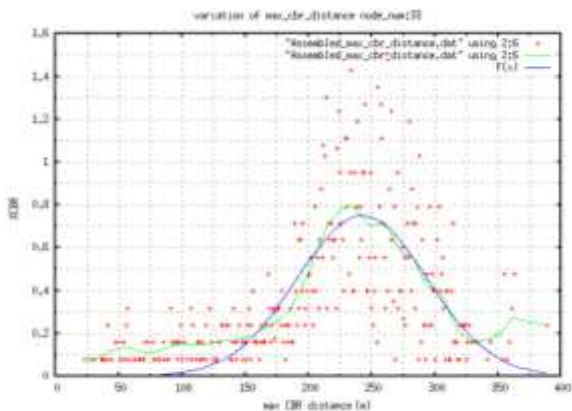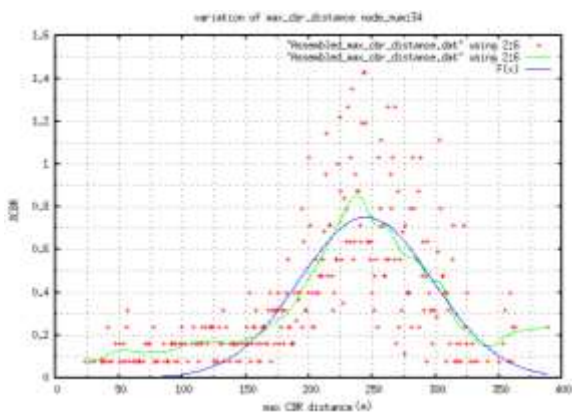**Figure 27: % cbr for Max_CBR_Dist: node_number 33**

28. Node Number 34

Figure 28: % cbr for Max_CBR_Dist: node_number 34

29. Node Number 35

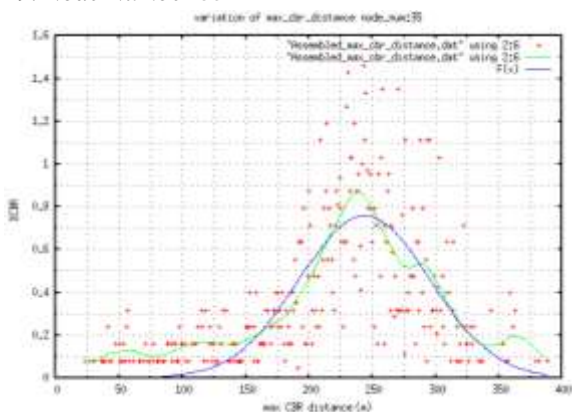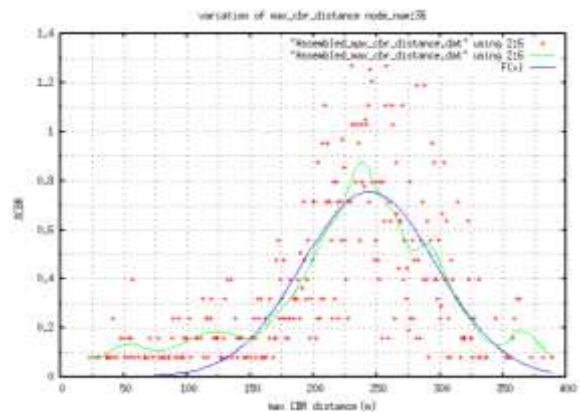**Figure 29: % cbr for Max_CBR_Dist: node_number 35**

30. Node Number 36

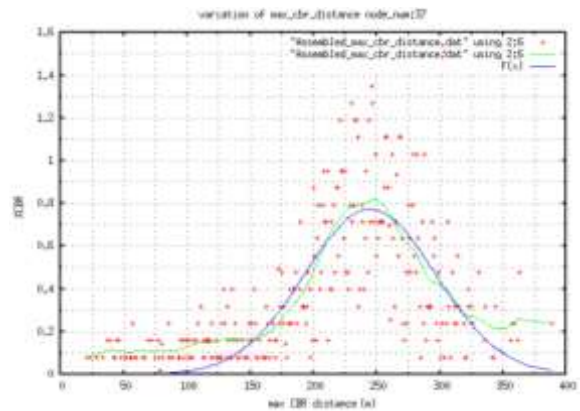**Figure 30: % cbr for Max_CBR_Dist: node_number 36**

31. Node Number 37

Figure 31: % cbr for Max_CBR_Dist: node_number 37

32. Node Number 38

Figure 32: % cbr for Max_CBR_Dist: node_number 38

33. Node Number 39

Figure 33: % cbr for Max_CBR_Dist: node_number 39

34. Node Number 40

Figure 34: % cbr for Max_CBR_Dist: node_number 40

35. Node Number 41

Figure 35: % cbr for Max_CBR_Dist: node_number 41

36. Node Number 42

Figure 36: % cbr for Max_CBR_Dist: node_number 42

37. Node Number 43

Figure 37: % cbr for Max_CBR_Dist: node_number 43

38. Node Number 44

Figure 38: % cbr for Max_CBR_Dist: node_number 44

39. Node Number 45

Figure 39: % cbr for Max_CBR_Dist: node_number 45

40. Node Number 46

Figure 40: % cbr for Max_CBR_Dist: node_number 46

41. Node Number 47

Figure 41: % cbr for Max_CBR_Dist: node_number 47
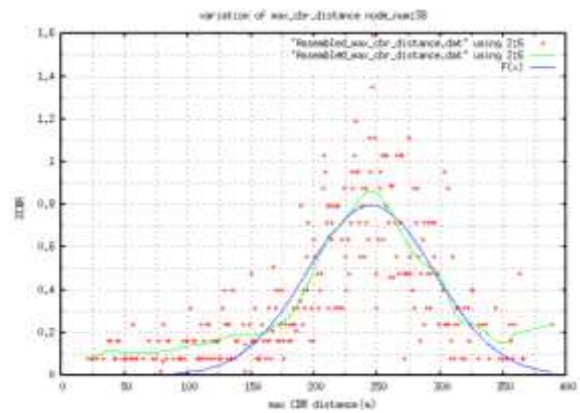
42. Node Number 48

Figure 42: % cbr for Max_CBR_Dist: node_number 48

43. Node Number 49

Figure 43: % cbr for Max_CBR_Dist: node_number 49

44. Node Number 50

Figure 44: % cbr for Max_CBR_Dist: node_number 50

45. Node Number 51

Figure 45: % cbr for Max_CBR_Dist: node_number 51

46. Node Number 52

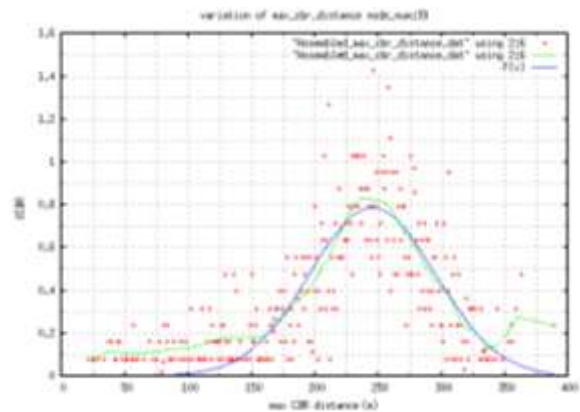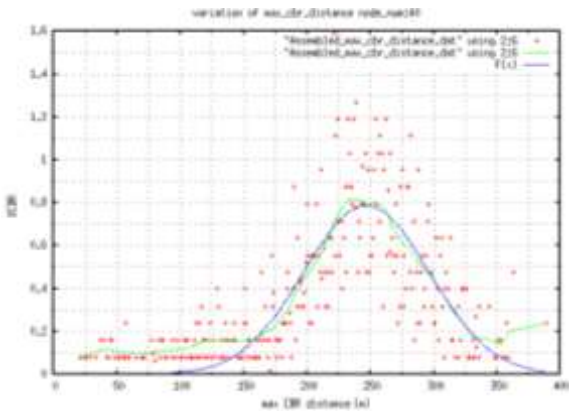**Figure 46: % cbr for Max_CBR_Dist: node_number 52**

47. Node Number 53

Figure 47: % cbr for Max_CBR_Dist: node_number 53

48. Node Number 54

Figure 48: % cbr for Max_CBR_Dist: node_number 54

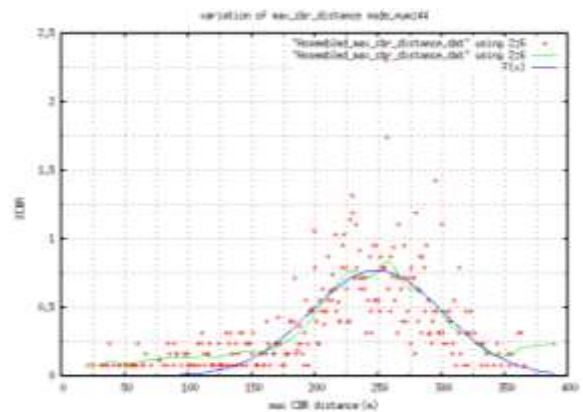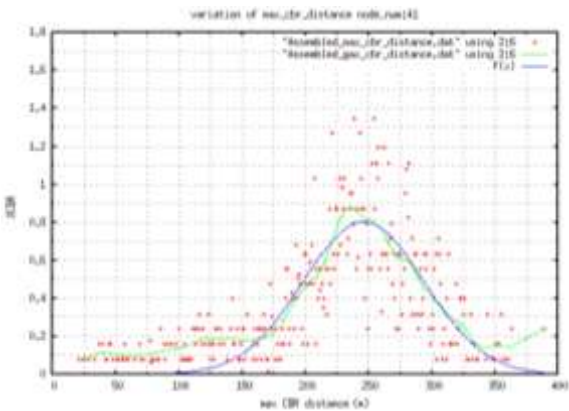*49. Node Number 55*

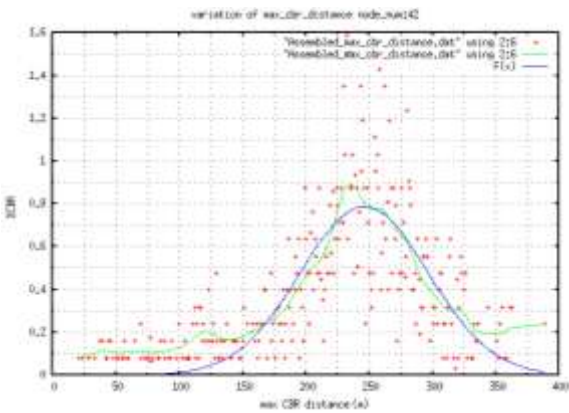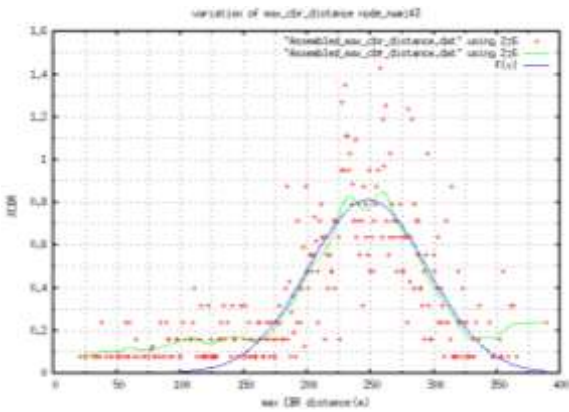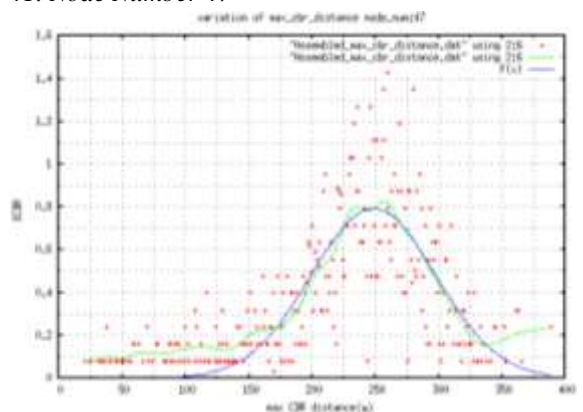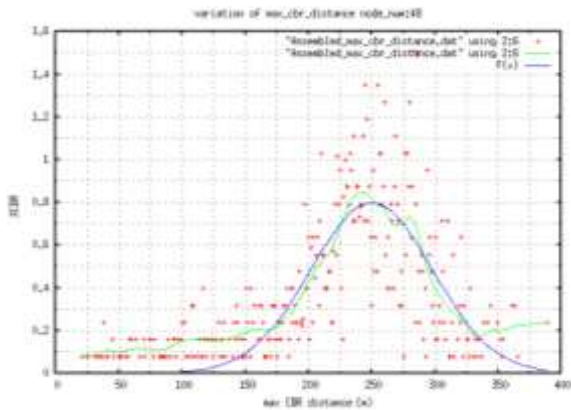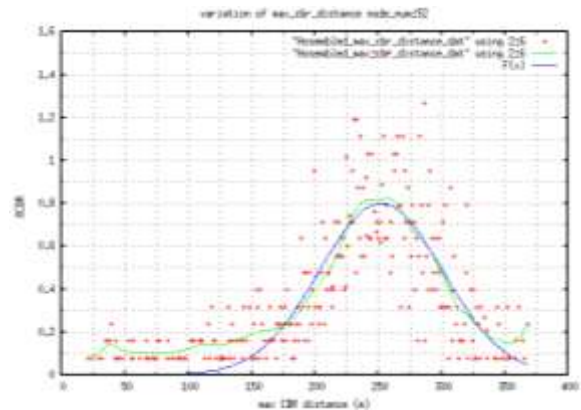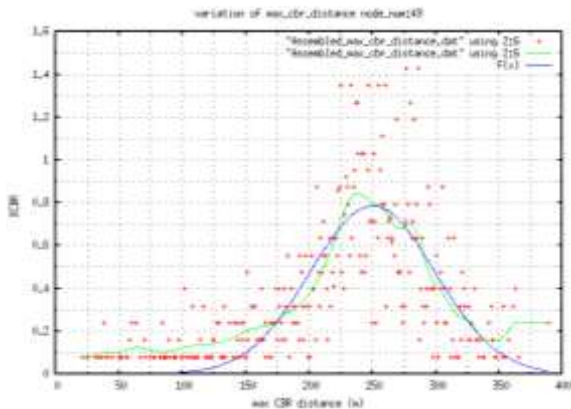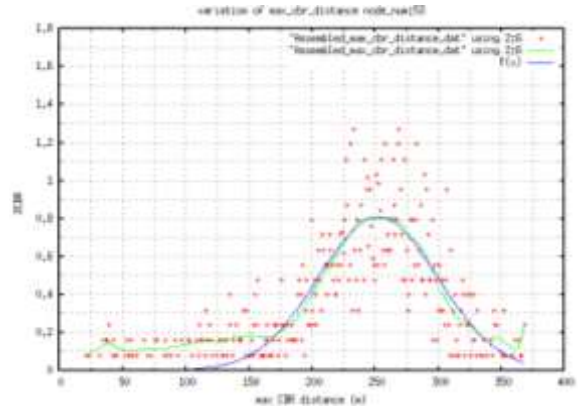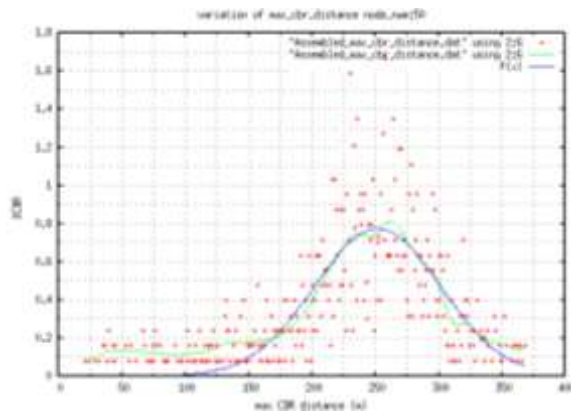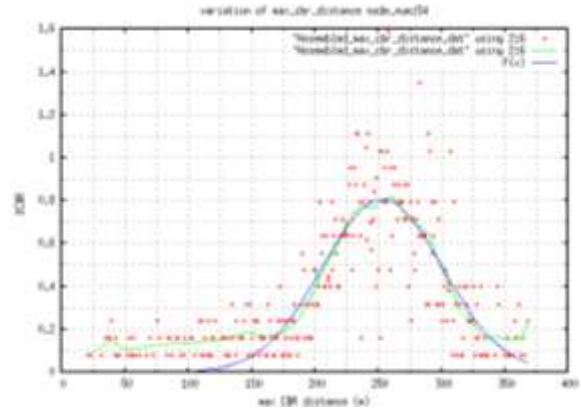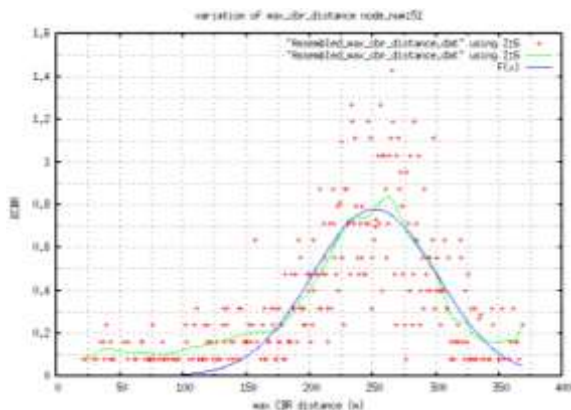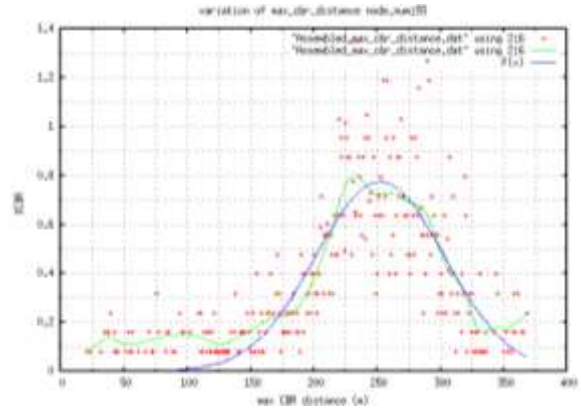**Figure 49: % cbr for Max_CBR_Dist: node_number 55**
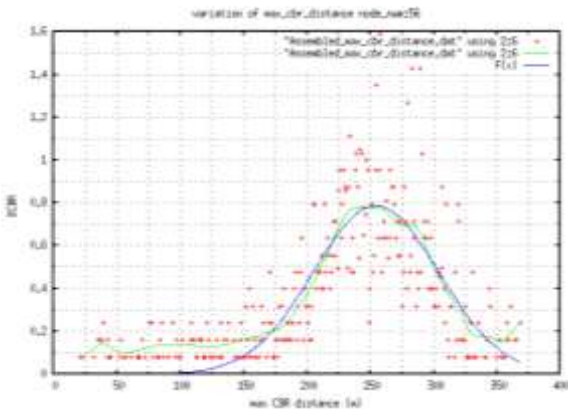
50. Node Number 56

Figure 50: % cbr for Max_CBR_Dist: node_number 56

4. Conclusion.

This piece of research was aimed at studying a facet of distance coverage, rounded to nearest meter, by packets in ubicomp in situation of MANET transmission over varying Node densities. This work extends from a previous work [26].

More precisely here, a metric Max_CBR_Dist, to assess the trend of maximum hop distance by packets in a ubicomp topography with varying node densities, is developed. The experimental results presented here remain empirical based. The model put forward is the normal distribution model.

The assumptions stated in previous paper [21] hold, e.g availability of lightweight algorithms for location-aware transmission in mobile environments, lightweight MAUC OS supports for efficient binding/unbinding of MANET nodes and appropriate multi-threading/parallel communication in modules of MANET nodes.

The further work identified may include: trend analyses of parameters of equations for the model, formulating methods of predictability for metric Max_CBR_Dist and its trend and reporting observations of certain critical values identified. The purposes of this metric is also open for refinement together with its applicability in MANET transmission protocols. Development of further sub-component metrics for metric PPD remain desirable.

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