

# Model of Minimum CBR Distance Travelled by packets in MANETs using Location-Aware Transmission for UbiComp.

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**Abstract** – Management of energy consumption of nodes in ubiComp can be assisted by location-aware transmission strategies in MANETs [63]. Hence researchers believe that further development in location-aware transmission in MANETs must be undertaken. 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 enable proper tuning of transmission protocols or even to select appropriate protocols, and achieve optimal MANET performance, the applicability of known trends of distance coverages by packets in a ubiComp for varying node density remain considerable.

Two previous studies in this direction were made whereby two metrics were developed and their trend analyses put forward: PPD [26] and Max\_CBR\_Dist [27] which is derived from PPD.

This paper adds a third component after the metric PPD and Max\_CBR\_Dist 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 piece of research is a follow-up of previous work [1-27].

**Key terms:** UbiComp- Ubiquitous Computing, MAUC- Mobile and Ubiquitous Computing, MANET- Mobile Adhoc Network, PPD- Packets\_Per\_Distance, Max\_CBR\_Dist- Maximum CBR Distance, Min\_CBR\_Dist- Minimum\_CBR\_Distance, CBR- Constant Bit Rate.

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## 1. Introduction

Energy consumption in MAUC is predominantly affected by distance coverages. The effect of distance of transmission is very consequent since energy consumption varies proportional to the square of distance coverages by packets [15]. Using MANET strategy of transmission, the sender node along with all MANET route nodes forward packets corresponding to

each CBR. A considerable impact in the ubiComp topography is that total number of packets in circulation increases with increasing node density. The sender sends packets to its closest neighbour which in turn forwards the packets to its closest “yet unused” neighbour. Nodes are mobile here, and hence in the dynamic topology changes occurring, 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 forwarded here are: “What are the minimum hop distance experienced by each CBR? What is the trend observable for this minimum hop count and how does it vary with varying node densities?”

The work presented here, remains empirical based and is built over previous work [26, 27]. It follows from the statement that metric PPD is 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 and also drive research for refinement of relevant sections in the transmission protocols.

The key contributions of this paper is firstly, the development of a second derived metric Min\_CBR\_Dist, derived from PPD for CBR Packet Per Distance analyses. The definition and rationale of metric Min\_CBR\_Dist is put forward. Secondly, the model of trend is put forward for the metric Min\_CBR\_Dist with results for varying node densities from 7 until 56 in a topography of 300 x 300 m<sup>2</sup>. The plot for cumulative tendency for the metric Min\_CBR\_Dist give more observable trend. The model proposed is the increasing exponential model. The rest of this paper is organised as follows: section 2- New Derived Metric – Minimum\_CBR\_Distance, section 3- Min\_CBR\_Dist Trend Assessment over Varying Node Numbers, 4- Conclusion and References.

## 2. New Derived Metric – Minimum\_CBR\_Distance.

Following definition of PPD [26], Min\_CBR\_Dist is defined as the minimum distance coverage noted for the whole of a CBR along a MANET topography. It can also be termed as the shortest hop distance noted for a CBR.

MANET routes may vary during a CBR transmission. Here also, it is envisageable that value 0 for the metric Min\_CBR\_Dist may be obtained. It would mean that the hop distance is between 0.00 and below 0.50 m.

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

### 3. Min\_CBR\_Dist - Trend Assessment over Varying Node Numbers.

#### 3.0 Major Observations.

Plotting % CBR against Min\_CBR\_Dist values depict sparse distribution of plots whereby trend is unconvincing as depicted for node number 7 in figure 1(a). The plot for cumulative % CBR against Min\_CBR\_Dist shows much better observable trends.

Overall, the trend observable is a rapid increase from origin, followed by a flattening of the curve till reaching the 100 % y-axis value. The equation of the curve is:

$$F(x) = a * \exp ( b * ( x - c ) ) + d$$

#### 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, E→ value of parameter d, F→ reduced chi-square value of plot F(x), G→ Corresponding figure number.

A	B	C	D	E	F	G
7	-164.88	-0.030 704 9	-99.608 4	99.863 9	0.023 083 6	1(b)
8	-121.654	-0.013 789 7	-232.028	100.89	0.009 096 7	2
9	-138.623	-0.017 651 5	-199.515	100.379	0.009 963 31	3
10	-160.461	-0.027 738 9	-122.405	101.174	0.030 148 2	4
11	-160.461	-0.027 738 9	-122.405	101.174	0.030 148 2	5
12	-157.488	-0.025 014 2	-135.432	101.342	0.024 758 6	6
13	-162.673	-0.034 809 7	-113.377	100.488	0.012 853 7	7
14	-161.784	-0.033 265 3	-118.398	100.537	0.011 239 2	8
15	-163.187	-0.035 744 4	-110.35	100.466	0.009 149 71	9
16	-164.572	-0.039 250 9	-101.837	100.346	0.005 458 78	10
17	-166.845	-0.040 532 4	-87.594 3	101.346	0.028 278 6	11
18	-167.173	-0.042 145 4	-85.271 8	101.215	0.019 654 7	12
19	-167.133	-0.041 766 9	-85.616 2	101.26	0.020 204 1	13
20	-167.416	-0.042 821 3	-83.685 9	101.21	0.019 129	14
21	-168.74	-0.054 457 9	-71.594 8	100.564	0.022 603 2	15
22	-168.763	-0.055 539 9	-70.985 5	100.508	0.018 498 8	16
23	-168.183	-0.052 256 3	-75.732 6	100.557	0.020 499 7	17
24	-168.528	-0.054 324	-72.866 6	100.521	0.017 569 2	18
25	-169.094	-0.058 756 3	-67.746 2	100.433	0.013 795 2	19
26	-167.496	-0.045 557 9	-82.260 1	100.98	0.015 401 5	20
27	-166.44	-0.041 590 1	-89.703 6	101.118	0.017 418 8	21
28	-166.059	-0.040 071 5	-92.301 7	101.214	0.024 699 8	22
29	-167.174	-0.043 540 8	-84.807 5	101.102	0.020 550 5	23
30	-167.429	-0.045 432 6	-82.695 3	100.97	0.020 313 8	24
31	-171.721	-0.089 701 4	-43.382	100.258	0.011 023	25
32	-171.552	-0.088 534 8	-44.320 9	100.251	0.008 178 85	26
33	-171.411	-0.086 255	-45.598 3	100.27	0.008 866 24	27
34	-171.411	-0.086 255	-45.598 3	100.27	0.008 866 24	28
35	-171.61	-0.089 200 6	-43.902 8	100.251	0.012 370 3	29
36	-171.697	-0.089 641 1	-43.474 1	100.254	0.008 784 12	30

37	-171.355	-0.109 151	-38.664 3	100.128	0.012 041 3	31
38	-171.355	-0.109 151	-38.665 7	100.128	0.012 037 5	32
39	-171.149	-0.104 02	-40.666 5	100.156	0.015 096 3	33
40	-171.132 0621	-0.104 933	-40.463 739	100.143	0.012 664 3	34
41	-170.915	-0.099 861 4	-42.819 6	100.163	0.013 719 7	35
42	-171.137	-0.112 748	-38.275 2	100.076	0.011 872 7	36
43	-171.037	-0.153 615	-30.229 3	99.948 7	0.003 789 11	37
44	-171.038	-0.153 615	-30.225 2	99.948 6	0.003 793 92	38
45	-170.817	-0.138 435	-33.818 5	99.968 5	0.003 627 21	39
46	-170.817	-0.138 435	-33.818 5	99.968 5	0.003 627 21	40
47	-170.872	-0.144 242	-32.470 1	99.957 6	0.004 059 07	41
48	-171.044	-0.170 249	-27.539 7	99.927 6	0.005 074 4	42
49	-171.012	-0.187 778	-25.309 3	99.906 4	0.005 944 6	43
50	-169.923	-0.114 909	-43.710 1	100.088	0.002 989 51	44
51	-169.923	-0.114 909	-43.710 1	100.088	0.002 989 51	45
52	-169.631	-0.104 032	-48.373 6	100.116	0.003 482 7	46
53	-169.923	-0.114 909	-43.710 1	100.088	0.002 989 51	47
54	-169.75	-0.114 836	-44.742 9	100.066	0.001 740 02	48
55	-169.387	-0.098 721 6	-51.464 8	100.119	0.004 033 25	49
56	-169.387	-0.098 721 6	-51.464 8	100.119	0.004 033 25	50

Table 1: summary of results for Min\_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

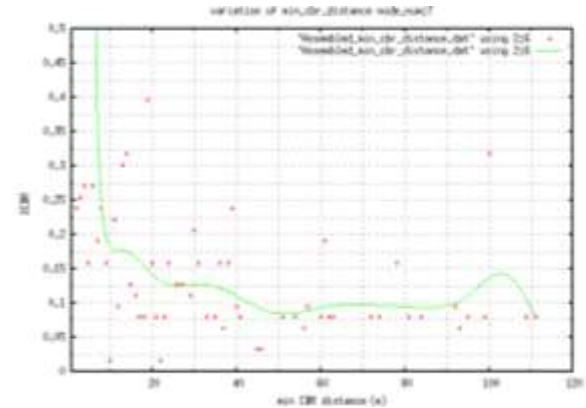


Figure 1(a): % CBR against min\_CBR\_distance : node\_num 7

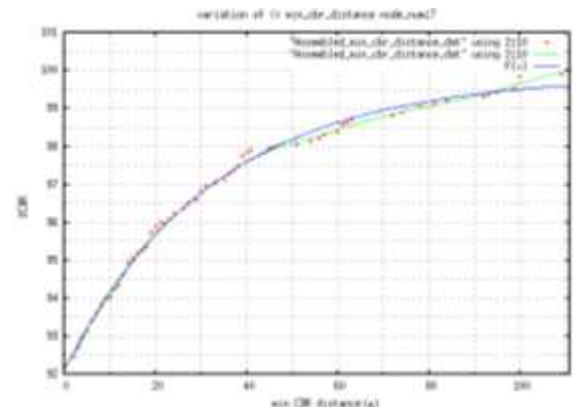


Figure 1(b): % CBR ≤ min\_CBR\_distance : node\_number 7

##### 2. Node Number 8

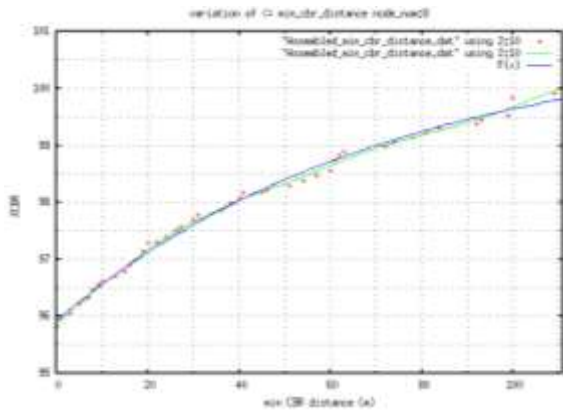


Figure 2: % CBR  $\leq$  min\_CBR\_distance: node\_num 8  
 3. Node Number 9

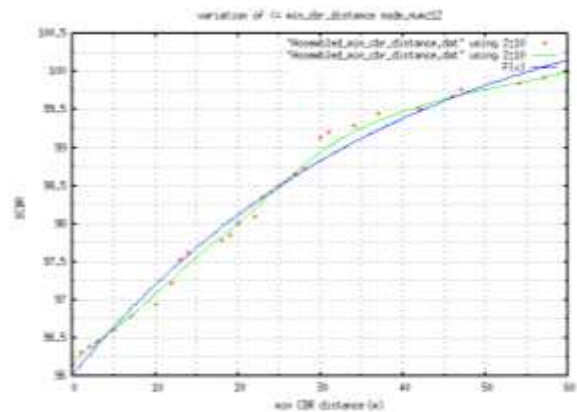


Figure 6: % CBR  $\leq$  min\_CBR\_distance: node\_num 12  
 7. Node Number 13

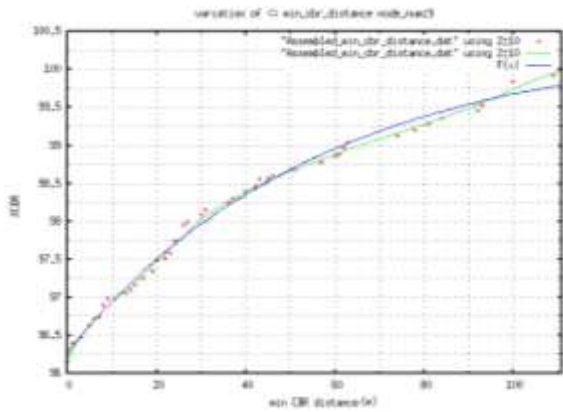


Figure 3: % CBR  $\leq$  min\_CBR\_distance: node\_num 9  
 4. Node Number 10

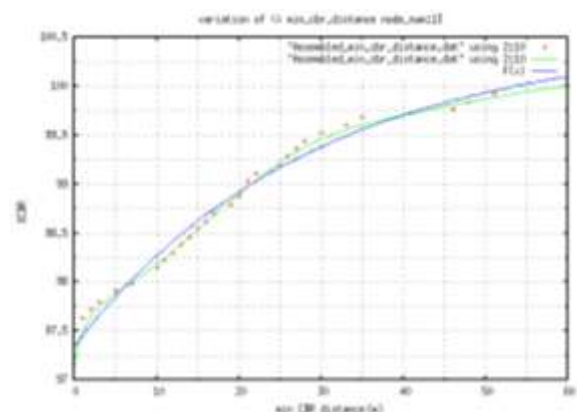


Figure 7: % CBR  $\leq$  min\_CBR\_distance: node\_num 13  
 8. Node Number 14

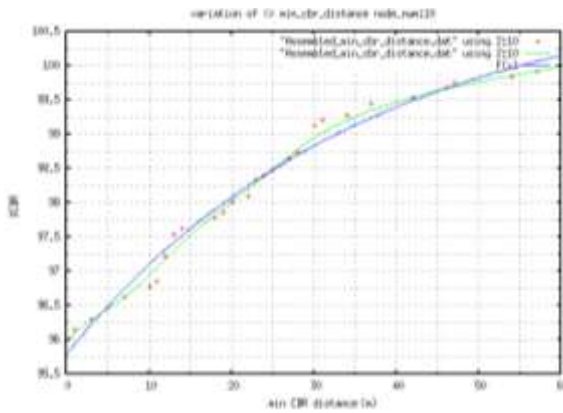


Figure 4: % CBR  $\leq$  min\_CBR\_distance: node\_num 10  
 5. Node Number 11

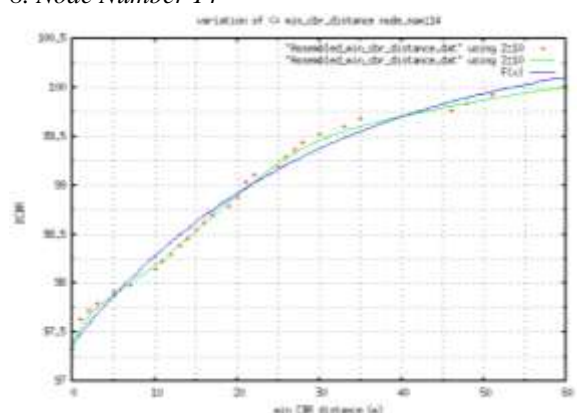


Figure 8: % CBR  $\leq$  min\_CBR\_distance: node\_num 14  
 9. Node Number 15

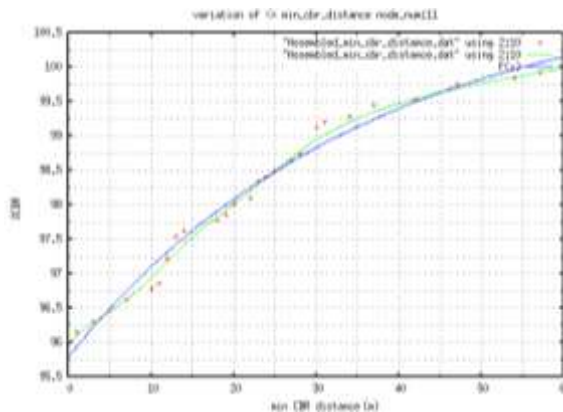


Figure 5: % CBR  $\leq$  min\_CBR\_distance: node\_num 11  
 6. Node Number 12

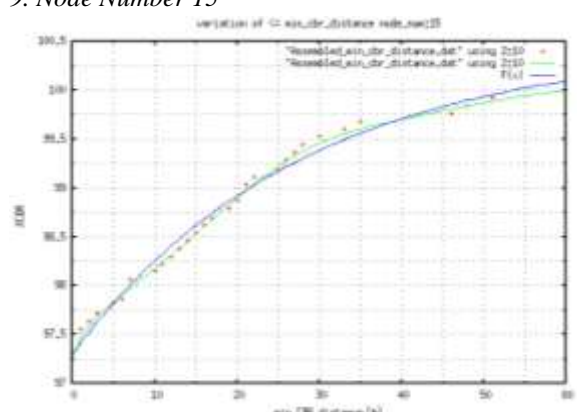


Figure 9: % CBR  $\leq$  min\_CBR\_distance: node\_num 15  
 10. Node Number 16

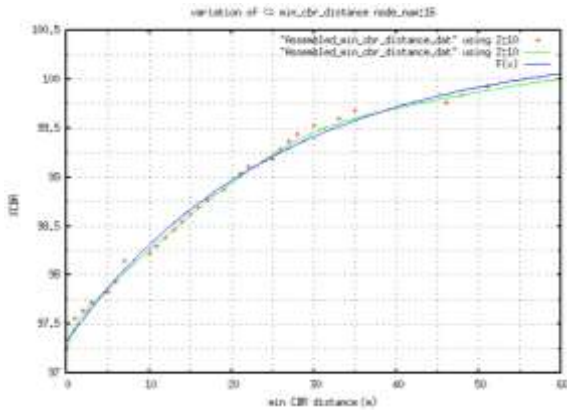


Figure 10: % CBR  $\leq$  min\_CBR\_distance: node\_num 16  
 11. Node Number 17

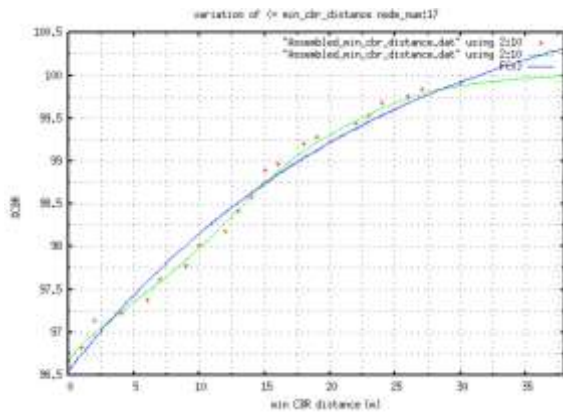


Figure 11: % CBR  $\leq$  min\_CBR\_distance: node\_num 17  
 12. Node Number 18

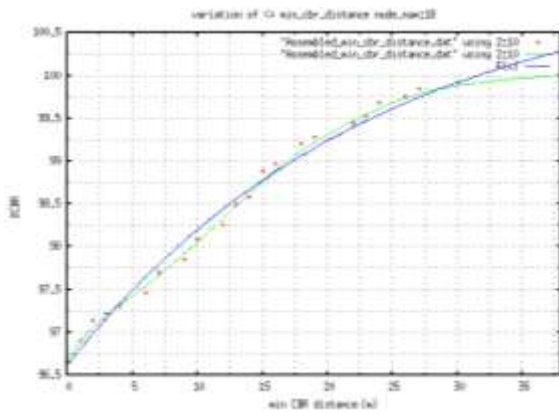


Figure 12: % CBR  $\leq$  min\_CBR\_distance: node\_num 18  
 13. Node Number 19

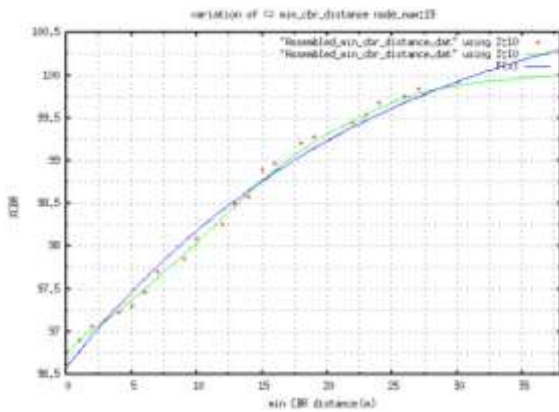


Figure 13: % CBR  $\leq$  min\_CBR\_distance: node\_num 19  
 14. Node Number 20

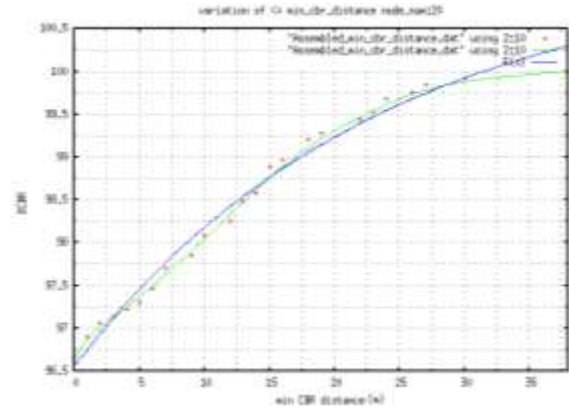


Figure 14: % CBR  $\leq$  min\_CBR\_distance: node\_num 20  
 15. Node Number 21

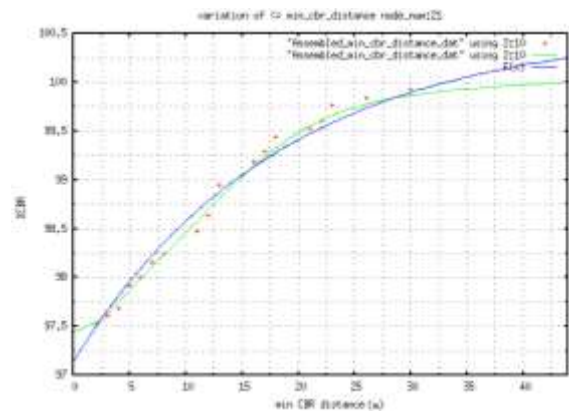


Figure 15: % CBR  $\leq$  min\_CBR\_distance: node\_num 21  
 16. Node Number 22

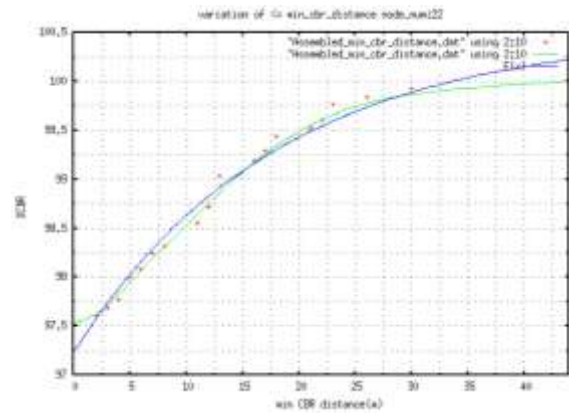


Figure 16: % CBR  $\leq$  min\_CBR\_distance: node\_num 22  
 17. Node Number 23

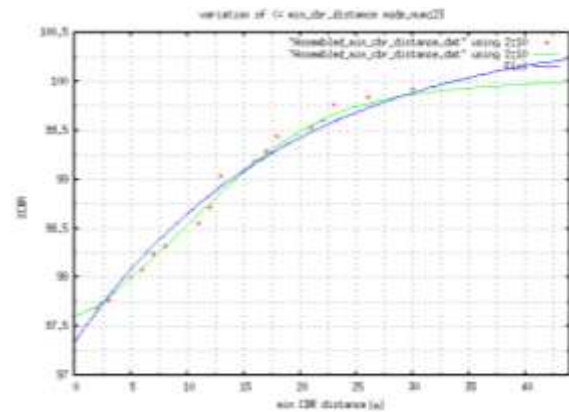


Figure 17: % CBR  $\leq$  min\_CBR\_distance: node\_num 23  
 18. Node Number 24

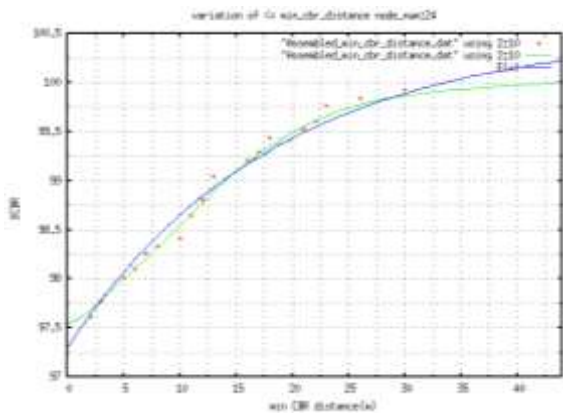


Figure 18: % CBR  $\leq$  min\_CBR\_distance: node\_num 24  
 19. Node Number 25

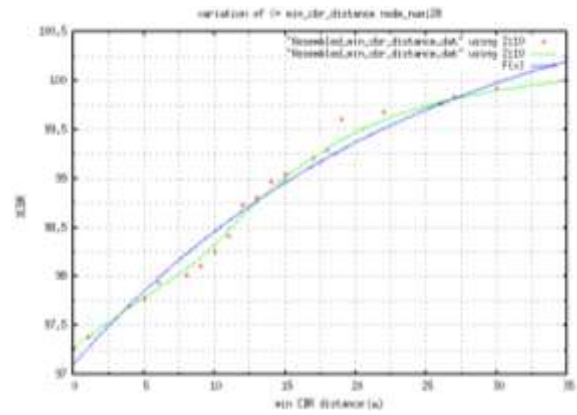


Figure 22: % CBR  $\leq$  min\_CBR\_distance: node\_num 28  
 23. Node Number 29

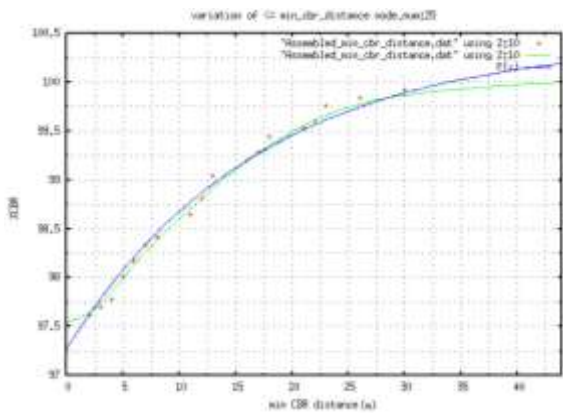


Figure 19: % CBR  $\leq$  min\_CBR\_distance: node\_num 25  
 20. Node Number 26

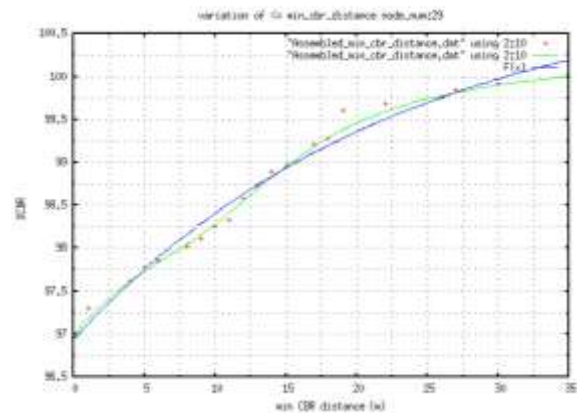


Figure 23: % CBR  $\leq$  min\_CBR\_distance: node\_num 29  
 24. Node Number 30

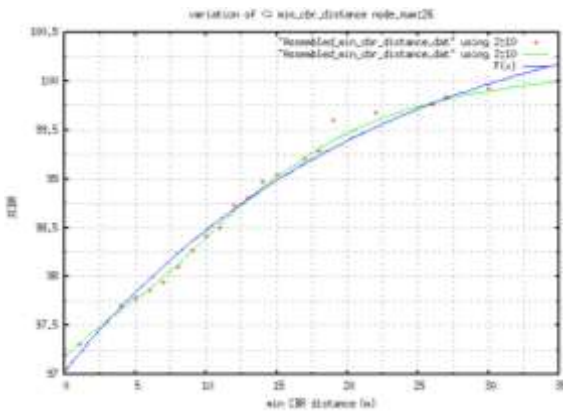


Figure 20: % CBR  $\leq$  min\_CBR\_distance: node\_num 26  
 21. Node Number 27

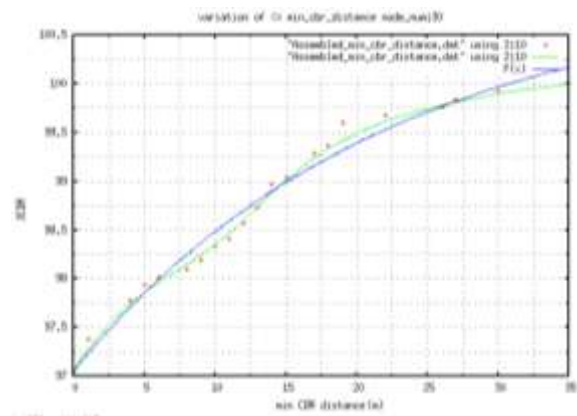


Figure 24: % CBR  $\leq$  min\_CBR\_distance: node\_num 30  
 25. Node Number 31

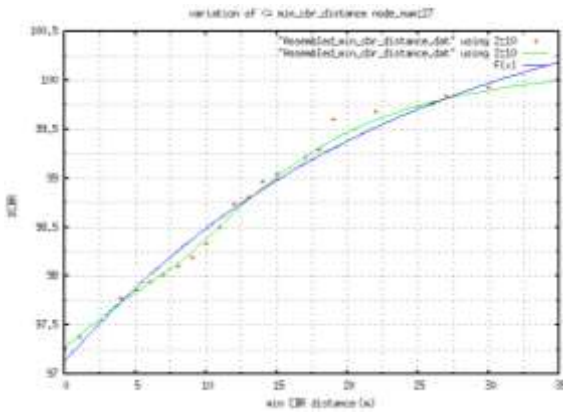


Figure 21: % CBR  $\leq$  min\_CBR\_distance: node\_num 27  
 22. Node Number 28

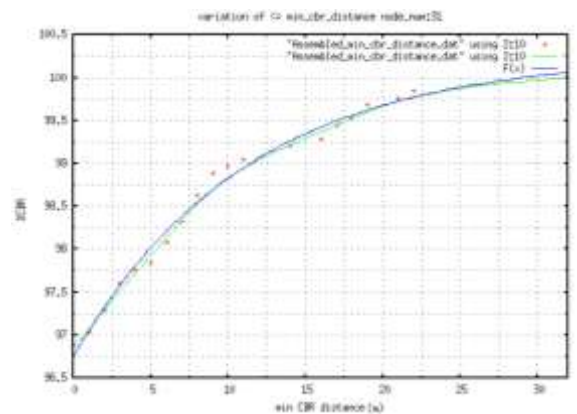


Figure 25: % CBR  $\leq$  min\_CBR\_distance: node\_num 31  
 26. Node Number 32

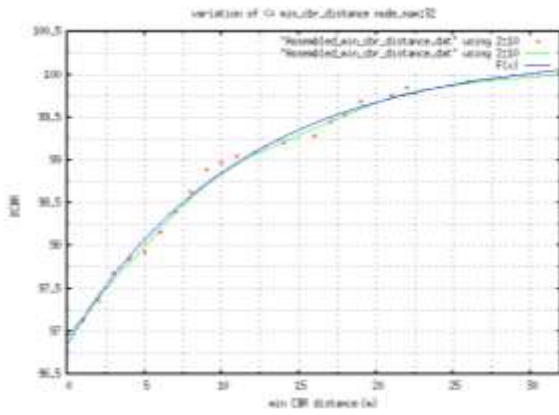


Figure 26: % CBR  $\leq$  min\_CBR\_distance: node\_num 32  
 27. Node Number 33

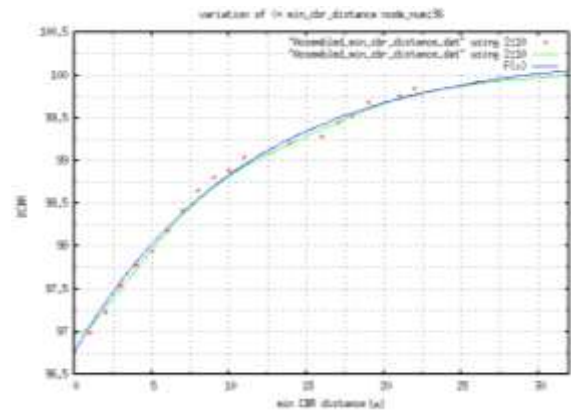


Figure 30: % CBR  $\leq$  min\_CBR\_distance: node\_num 36  
 31. Node Number 37

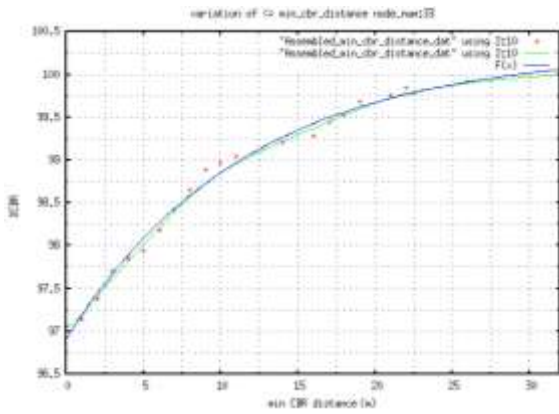


Figure 27: % CBR  $\leq$  min\_CBR\_distance: node\_num 33  
 28. Node Number 34

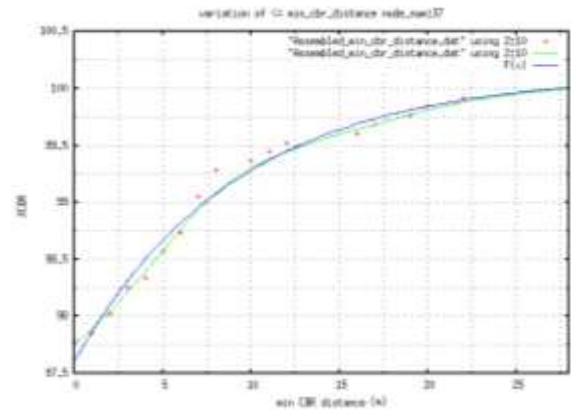


Figure 31: % CBR  $\leq$  min\_CBR\_distance: node\_num 37  
 32. Node Number 38

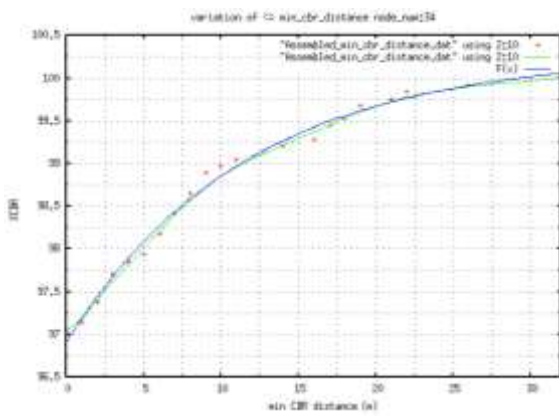


Figure 28: % CBR  $\leq$  min\_CBR\_distance: node\_num 34  
 29. Node Number 35

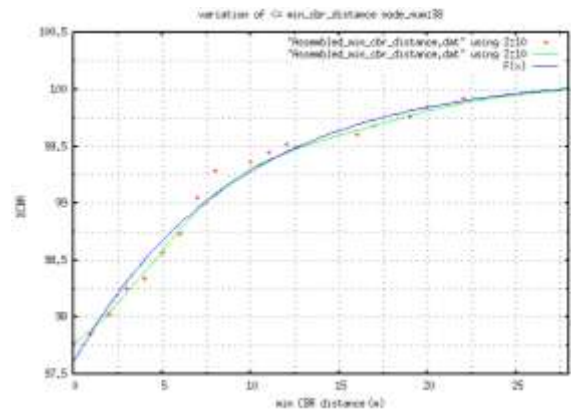


Figure 32: % CBR  $\leq$  min\_CBR\_distance: node\_num 38  
 33. Node Number 39

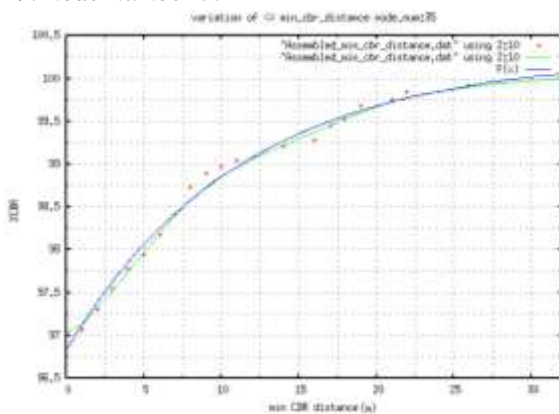


Figure 29: % CBR  $\leq$  min\_CBR\_distance: node\_num 35  
 30. Node Number 36

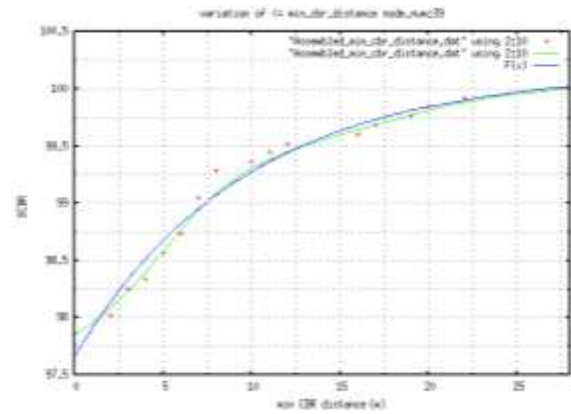


Figure 33: % CBR  $\leq$  min\_CBR\_distance: node\_num 39  
 34. Node Number 40

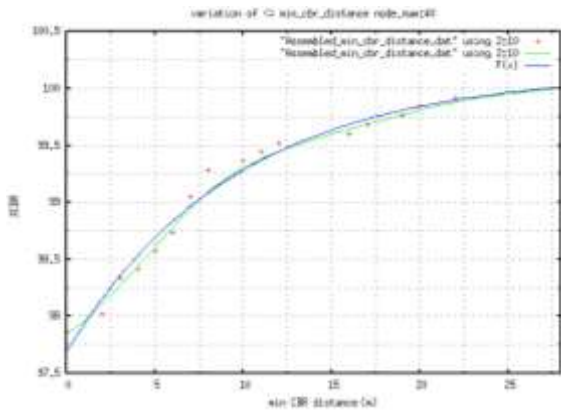


Figure 34: % CBR  $\leq$  min\_CBR\_distance: node\_num 40  
 35. Node Number 41

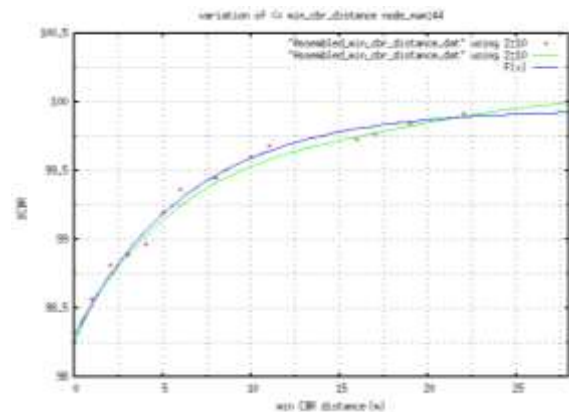


Figure 38: % CBR  $\leq$  min\_CBR\_distance: node\_num 44  
 39. Node Number 45

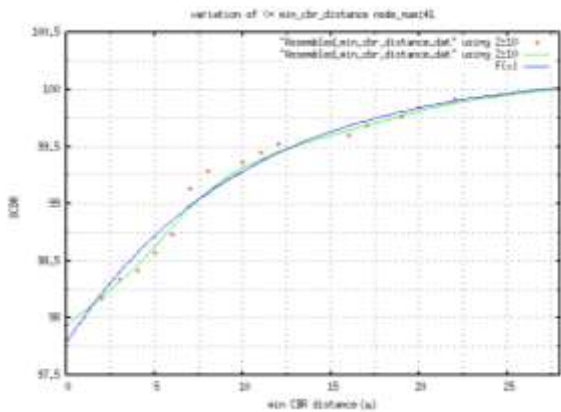


Figure 35: % CBR  $\leq$  min\_CBR\_distance: node\_num 41  
 36. Node Number 42

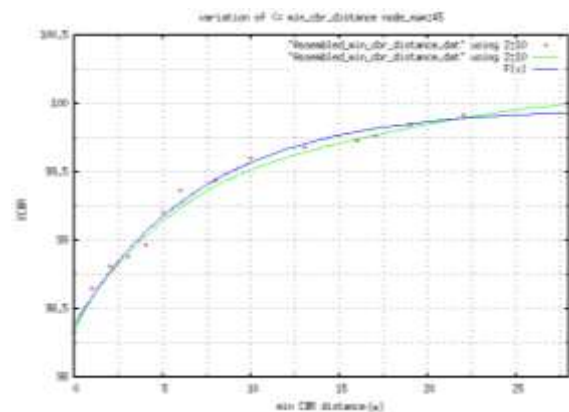


Figure 39: % CBR  $\leq$  min\_CBR\_distance: node\_num 45  
 40. Node Number 46

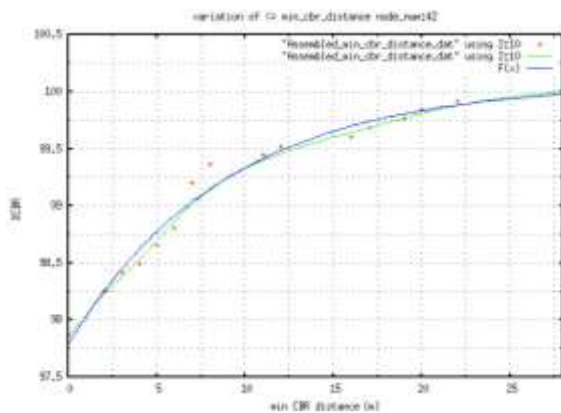


Figure 36: % CBR  $\leq$  min\_CBR\_distance: node\_num 42  
 37. Node Number 43

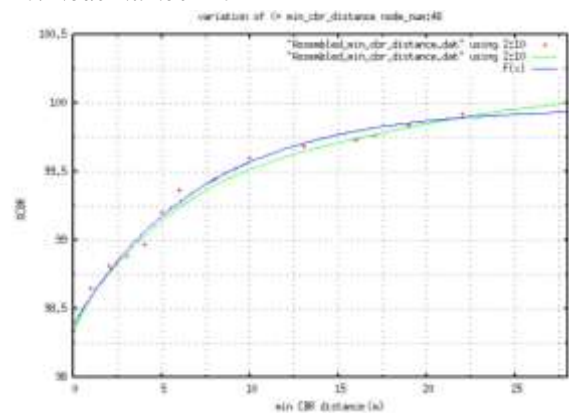


Figure 40: % CBR  $\leq$  min\_CBR\_distance: node\_num 46  
 41. Node Number 47

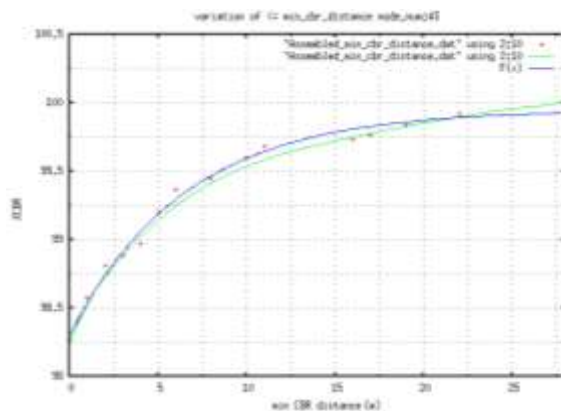


Figure 37: % CBR  $\leq$  min\_CBR\_distance: node\_num 43  
 38. Node Number 44

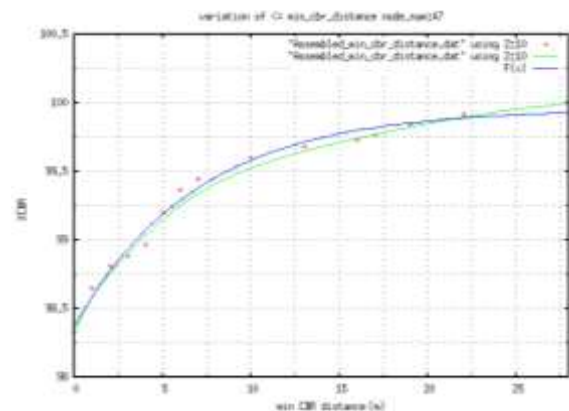


Figure 41: % CBR  $\leq$  min\_CBR\_distance: node\_num 47  
 42. Node Number 48

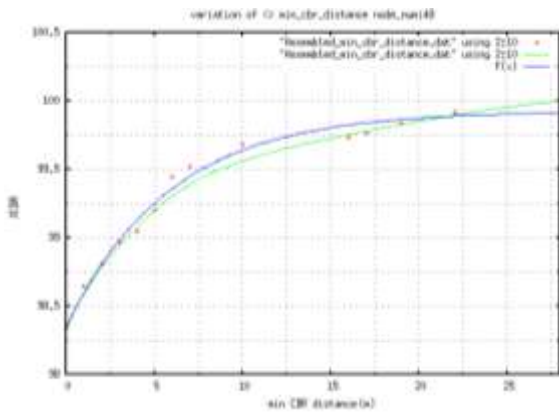


Figure 42: % CBR  $\leq$  min\_CBR\_distance: node\_num 48  
 43. Node Number 49

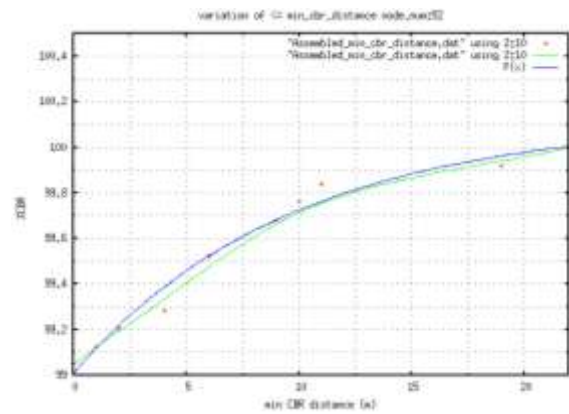


Figure 46: % CBR  $\leq$  min\_CBR\_distance: node\_num 52  
 47. Node Number 53

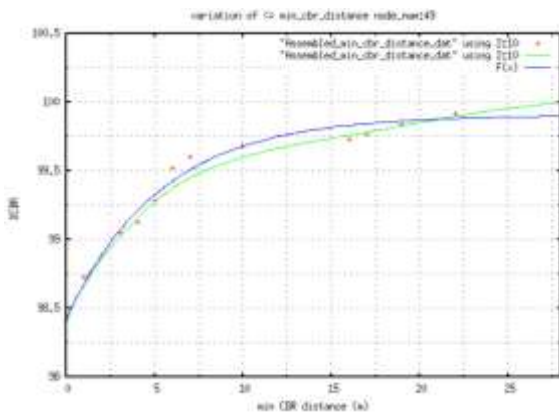


Figure 43: % CBR  $\leq$  min\_CBR\_distance: node\_num 49  
 44. Node Number 50

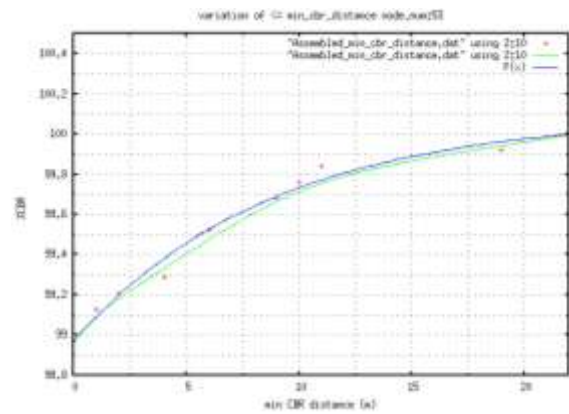


Figure 47: % CBR  $\leq$  min\_CBR\_distance: node\_num 53  
 48. Node Number 54

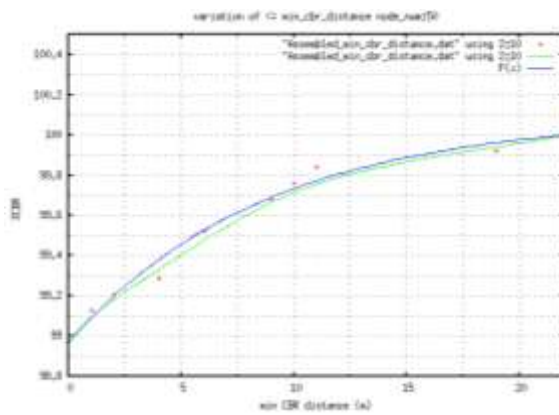


Figure 44: % CBR  $\leq$  min\_CBR\_distance: node\_num 50  
 45. Node Number 51

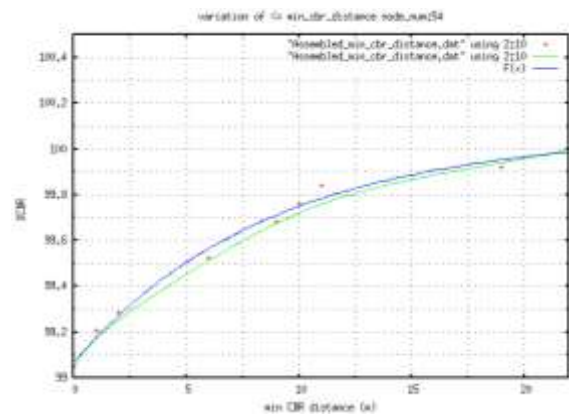


Figure 48: % CBR  $\leq$  min\_CBR\_distance: node\_num 54  
 49. Node Number 55

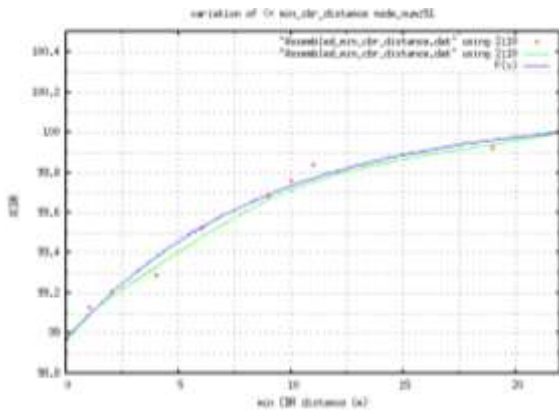


Figure 45: % CBR  $\leq$  min\_CBR\_distance: node\_num 51  
 46. Node Number 52

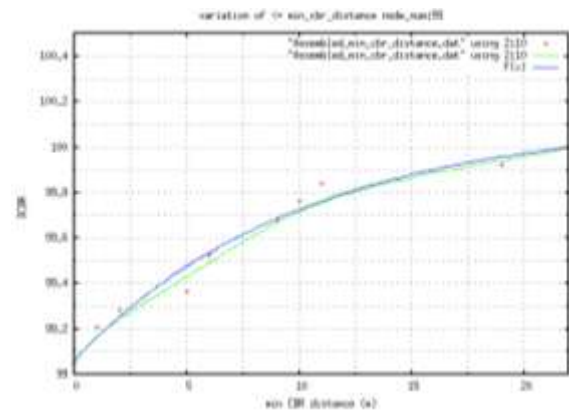


Figure 49: % CBR  $\leq$  min\_CBR\_distance: node\_num 55  
 50. Node Number 56



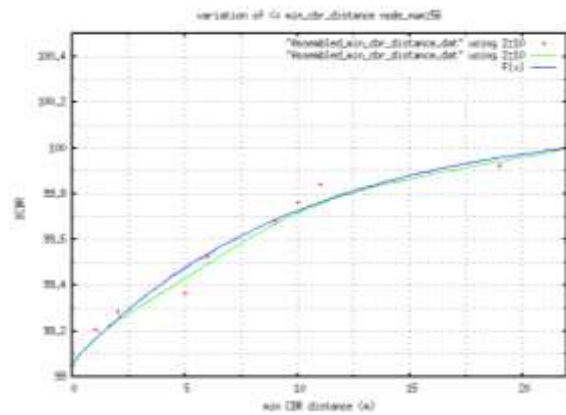


Figure 50: % CBR  $\leq$  min\_CBR\_distance: node\_num 56

## 4. Conclusion.

This piece of study was aimed at studying another 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, 27].

More precisely here, a metric Min\_CBR\_Dist, to assess the trend of minimum hop distance by packets in a ubicomp topography with varying node densities, has been developed. The experimental results presented here remain empirical based. The model put forward for cumulative % CBR against Min\_CBR\_Dist is the exponential 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 Min\_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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