

Model of Minimum Energy Consumption Ratio Achievable in MANET Using Location-Aware Transmission in Ubicomp.

M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY

Abstract – Researchers claim that use of MANET transmission help to save energy in ubicomp [54]. Another strategy would be by applying location-aware transmission in MANET. The resulting method of operation remains a cooperation being required from all nodes present in the topography. A desirable feature in cooperation is to know “what is the proportion of energy being required by the MANET node compared with the sending node itself, together with corresponding trends?” Such a study is provided in another paper [18] whereby a future work identified was “How to gauge Fairness features being reached”, as concerns the proportion of nodes spending more or less energy than the sender node. To bring answers to this issue, in this paper, another metric *Min_R* is put forward together with the corresponding model of trend over varying node densities.

This paper adds up to the area of modelling in ubicomp and will be used by designers to better bound the resources and architecture needs for ubicomp. This paper is a follow-up of previous research [1-18].

Key terms: Ubicomp- Ubiquitous Computing, MAUC- Mobile and Ubiquitous Computing, ECR- Energy Consumption Ratio, *Min_R*- Minimum Ratio, MANET- Mobile Adhoc Network, CBR- Constant Bit Rate.

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1. Introduction

Many factors affect energy consumption in MAUC [2]. A very significant factor remains use of MANET transmission and a corresponding subsequent factor is node density. When using MANETs, sender nodes together with nodes forming part of MANET routes, are spending energy. Sender nodes transmit to closest neighbouring node, which in turn, relays data to next closest neighbour [18]. It is a form of cooperative strategy to achieve functionality of networking. It is legitimate for cooperating nodes to know how much assistance (in this case, energy requirements), they are being required to give compared to the sender’s own effort. Such a study has been provided in another paper [18], whereby a metric ECR was tackled. A question which builds up over that previous study [18] is “How

much fairness is being reached as concerns energy distribution among cooperating nodes”.

It is definitely important to devise more methods/metrics for analysing resulting situations evolving in MANETs as concerns fairness among cooperating nodes. One such metric identified is the *Min_R* derived from ECR [18] which also is heavily affected by same changes in MANET routes as mentioned in the other paper [18].

The key contributions of this paper is firstly, the development of a metric *Min_R*, which is derived from ECR [18], including its definition and rationale, and secondly, the model of trend put forward for the metric *Min_R* with results for varying node densities from 7 until 56. The model suggested in this paper is the exponential model. The rest of this paper is organised as follows: section 2- New Derived Metric- Minimum Ratio, section 3- *Min_R* Trend Assessment over Varying Node Numbers, 4- Conclusion and References.

2. New Derived Metric: Minimum_Ratio.

Min_R is defined as “the smallest ECR value that has been discovered during the whole of a CBR transmission”. *Min_R* values will also be positive values just as ECR values [18]. *Min_R* values can also be of 3 categories:

- i. *Min_R* values less than 1: it can imply that one or more nodes will spend less energy than the sender node. This can be the result of high rate of MANET topology change resulting in some nodes participating very briefly in a MANET route or even that the sender has its closest neighbours quite far and some support may be needed.
- ii. *Min_R* values equal to 1: it implies that at least one node is spending just as much energy as the sender.
- iii. *Min_R* values greater than 1: it implies that each of the node in the MANET routes, excluding the sender node itself, have spent more energy than the sender, which is a fully unfair situation.

The metric *Min_R*, if accurately gauged and tracked, can assist in purposes explained in another paper [18]. Additional purposes include QoS policy formulations:

- i. Sender may decide to delay transmission or adopt Ferry Transport Protocols [55].
- ii. Sender may decide to transmit in a piecemeal fashion spread over time expecting that by next piece of information, the network topology may improve in its favour.
- iii. MANET nodes may use this information to decide to forward or not forward packets, and a delay after which decision will be reviewed.
- iv. History tracking of Min_R into a “database” may help for further policy-based decision making, including extent of needs for infrastructure support.

3. Min_R Trend Assessment over Varying Node Numbers.

3.0 Major Observations.

The trends for Min_R achieved for node numbers 7 until 56 have followed the exponential model of form:

$$G(x) = a * \exp(b*(x - 0.01)) + c$$

In all the plots for node numbers 7 until 56, the leftmost plot at x-coordinate 0.00 has been very outlying with very high value of y-coordinate, though this decreases with increasing node numbers. This corresponds to same observation as in ECR [18]. Hence, this point has been ignored in trend analyses.

The rightmost plot was at 1.0 since in the experiment, Min_R was considered inclusive of the sender node also. Hence maximum value of Min_R could be 1.0. However, it also appeared as outlying, since the plot tends to be decreasing asymptotically. The x-range taken was therefore 0.01 until a value ensuring that at least 95 % of CBRs have been covered.

3.1 Tabular Summary of Results.

Below is a tabular summary for results of equations of curves. 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	1.646 87	-24.864 6	0.073 5534	0.009 473 2	1
8	1.646 84	-23.086 5	0.141 432	0.008 242 07	2
9	1.781 37	-24.817 3	0.145 397	0.008 954 01	3
10	6.350 21	-39.901 7	0.152 042	0.023 541 4	4
11	6.468 12	-39.412 8	0.158 373	0.177 031	5
12	6.724 78	-39.461 9	0.164 117	0.018 337 2	6
13	7.148 88	-45.240 9	0.162 89	0.030 332 3	7
14	7.004 7	-41.77	0.172 149	0.036 561 2	8
15	6.876 13	-39.343 7	0.164 934	0.016 824 1	9
16	6.853 53	-39.090 1	0.170 06	0.034 728 2	10
17	7.438 39	-35.788 2	0.190 177	0.027 929 8	11
18	7.583 33	-38.746 9	0.191 434	0.039 328	12
19	7.931 45	-41.085 7	0.212 465	0.053 757 6	13
20	7.722 02	-39.728	0.230 289	0.058 575	14
21	7.580 37	-34.876 5	0.192 683	0.038 721 3	15
22	7.303 81	-33.408 4	0.187 666	0.037 276 8	16
23	6.885 45	-30.863 4	0.201 145	0.035 507	17

24	6.735 16	-28.460 4	0.179 933	0.025 040 2	18
25	6.672 92	-28.714 2	0.189 215	0.037 783 1	19
26	7.056 73	-28.172 8	0.196 115	0.038 750 5	20
27	7.270 39	-29.897 7	0.207 749	0.044 448 4	21
28	7.581 35	-31.330 6	0.197 445	0.052 787 8	22
29	7.325 79	-29.697 1	0.208 124	0.063 060 2	23
30	7.359 3	-29.277 5	0.194 668	0.052 780 3	24
31	7.683 71	-28.827 1	0.184 567	0.062 428 6	25
32	7.394 02	-27.548 9	0.179 418	0.051 951 5	26
33	7.432 98	-28.296 2	0.194 431	0.051 588 9	27
34	7.344 57	-27.842 2	0.199 711	0.034 819 7	28
35	7.266	-26.861 8	0.179 291	0.036 495 1	29
36	7.536 29	-28.06	0.193 665	0.035 156 4	30
37	6.726 68	-26.197 6	0.197 014	0.061 209 8	31
38	6.482 43	-24.344 8	0.189 305	0.042 917 9	32
39	6.456 31	-24.733 2	0.198 88	0.039 691 5	33
40	6.229 4	-22.875 8	0.186 039	0.048 485 6	34
41	6.056 09	-21.722 4	0.199 071	0.048 789 9	35
42	6.567 81	-23.795 9	0.199 613	0.054 831 7	36
43	6.090 87	-22.171 1	0.196 554	0.069 600 5	37
44	5.123 55	-18.278 1	0.164 468	0.034 063 2	38
45	5.731 21	-19.9774	0.178 805	0.052 870 1	39
46	5.947 11	-21.911 2	0.200 792	0.056 867	40
47	5.869 32	-20.940 1	0.187 86	0.042 587 2	41
48	6.036 73	-22.052 3	0.200 332	0.049 270 2	42
49	5.749 47	-20.568 8	0.218 006	0.047 632	43
50	6.654 93	-19.886	0.194 392	0.041 542 6	44
51	5.455 89	-19.055	0.205 536	0.041 171 5	45
52	5.482 5	-18.728 3	0.186 848	0.046 815 8	46
53	5.507 23	-18.274	0.169 024	0.040 215 4	47
54	5.471 94	-18.491 4	0.185 193	0.058 343	48
55	5.314 69	-17.647 8	0.166 317	0.035 974 2	49
56	5.278 27	-17.181 5	0.166 944	0.032 123 9	50

Table 1: results for Min_R 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

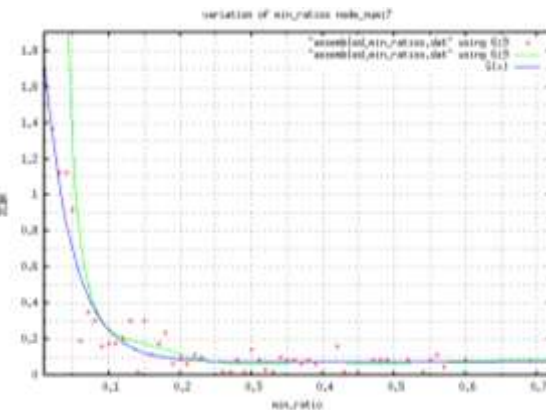


Figure 1: % cbr for Min_R node_number 7

2. Node Number 8

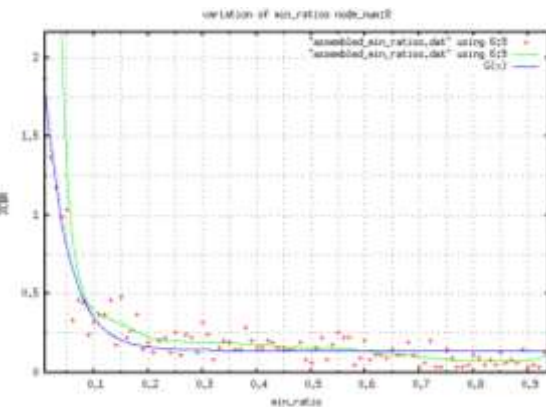


Figure 2: % cbr for Min_R node_number 8

3. Node Number 9

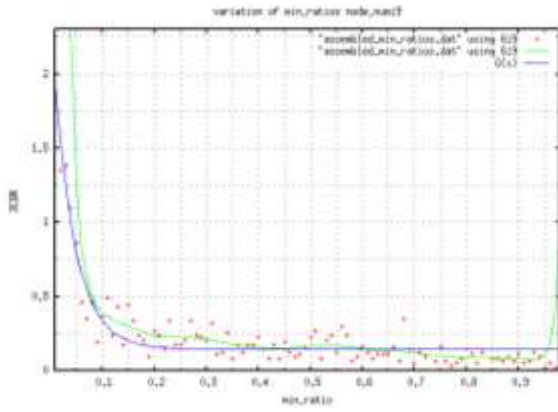


Figure 3: % cbr for Min_R node_number 9

7. Node Number 13

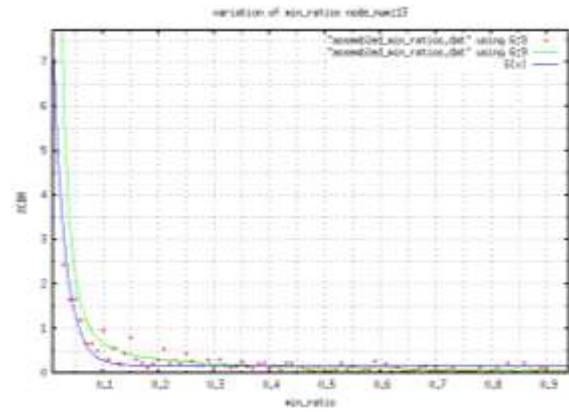


Figure 7: % cbr for Min_R node_number 13

4. Node Number 10

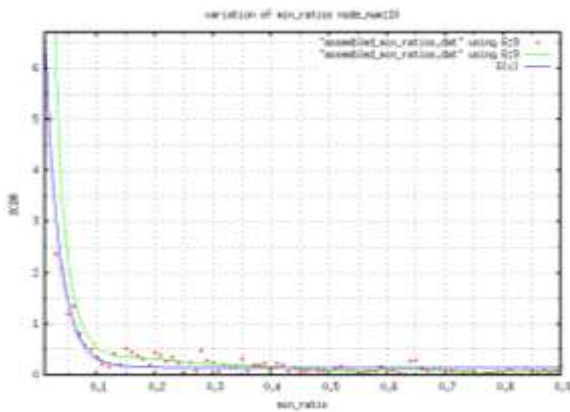


Figure 4: % cbr for Min_R node_number 10

8. Node Number 14

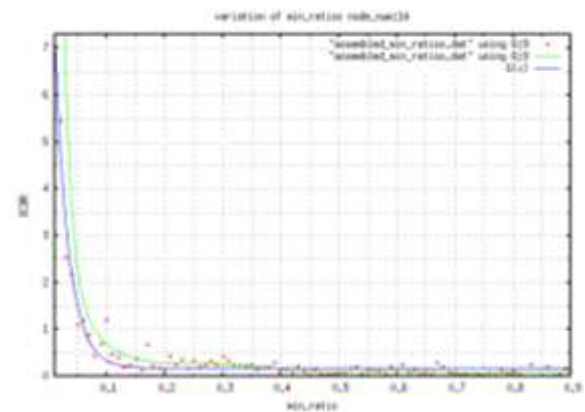


Figure 8: % cbr for Min_R node_number 14

5. Node Number 11

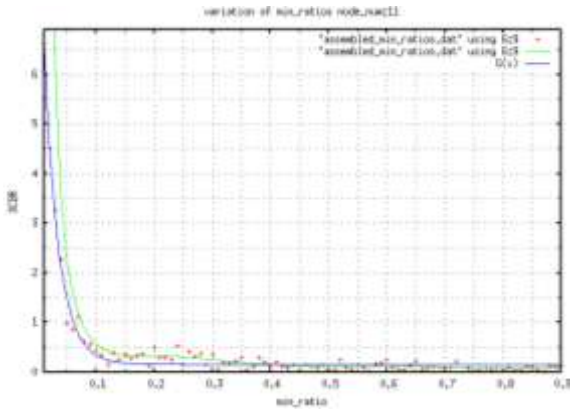


Figure 5: % cbr for Min_R node_number 11

9. Node Number 15

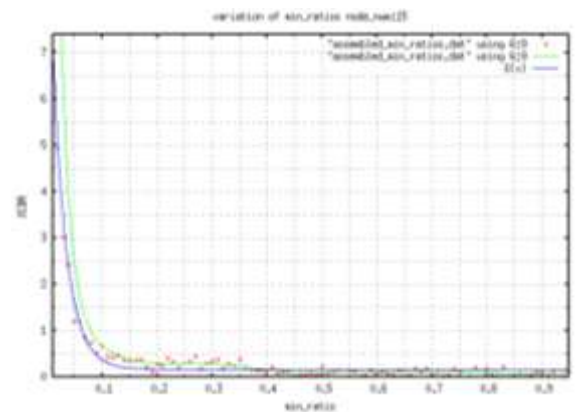


Figure 9: % cbr for Min_R node_number 15

6. Node Number 12

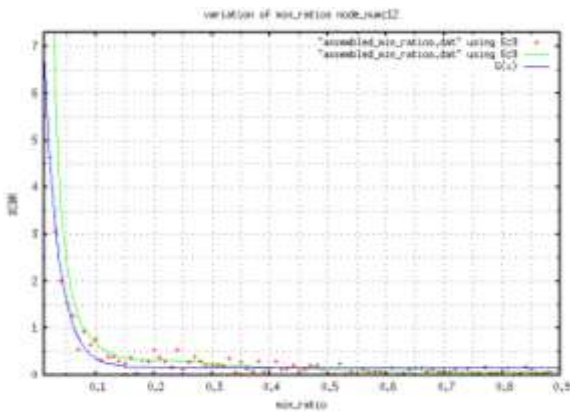


Figure 6: % cbr for Min_R node_number 12

10. Node Number 16

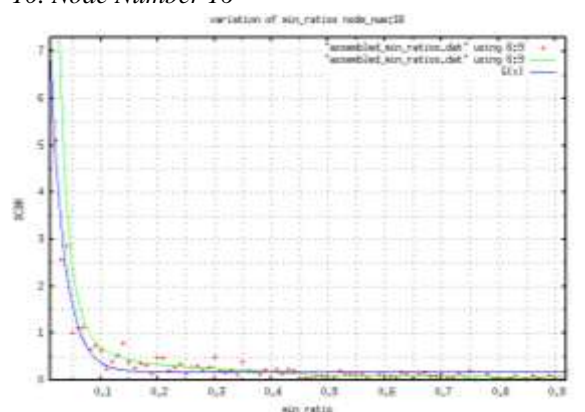


Figure 10: % cbr for Min_R node_number 16

11. Node Number 17

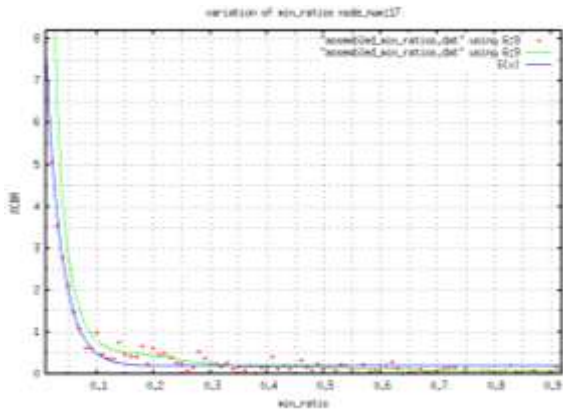


Figure 11: % cbr for Min_R node_number 17

12. Node Number 18

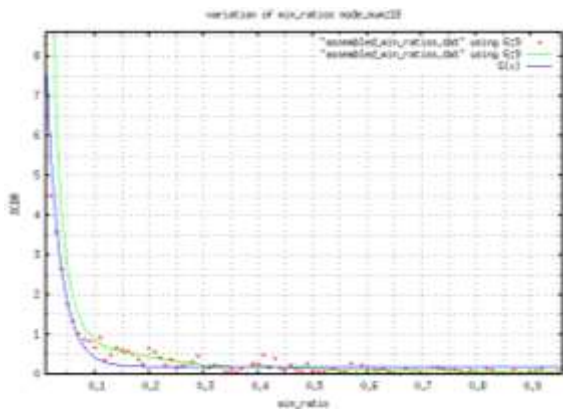


Figure 12: % cbr for Min_R node_number 18

13. Node Number 19

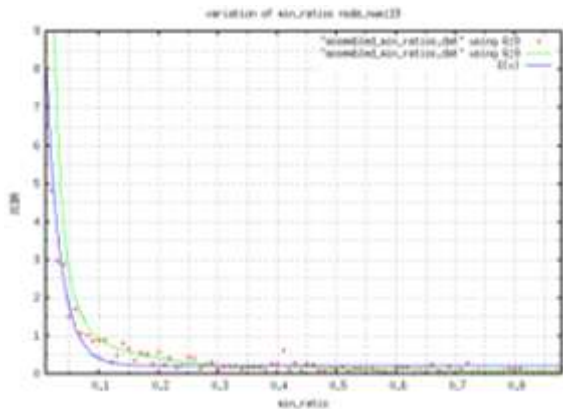


Figure 13: % cbr for Min_R node_number 19

14. Node Number 20

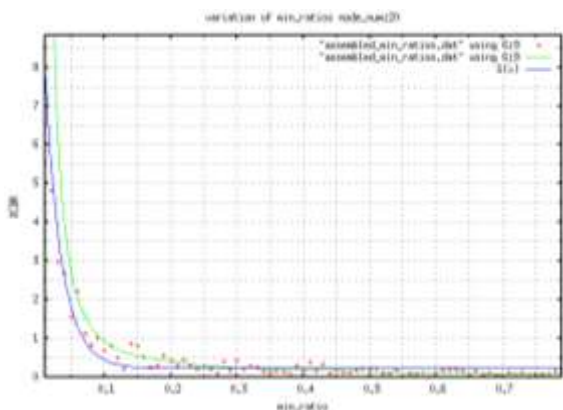


Figure 14: % cbr for Min_R node_number 20

15. Node Number 21

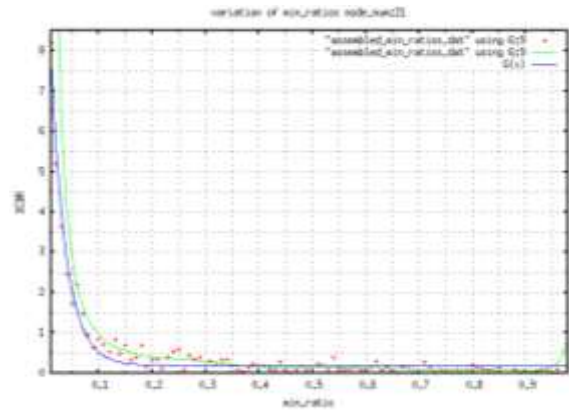


Figure 15: % cbr for Min_R node_number 21

16. Node Number 22

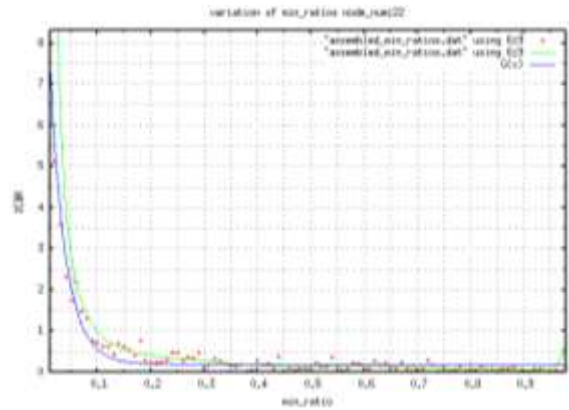


Figure 16: % cbr for Min_R node_number 22

17. Node Number 23

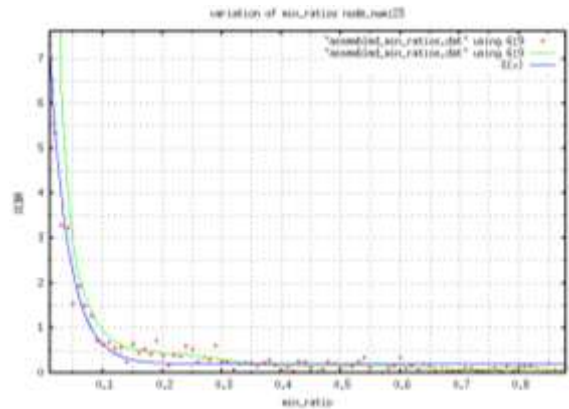


Figure 17: % cbr for Min_R node_number 23

18. Node Number 24

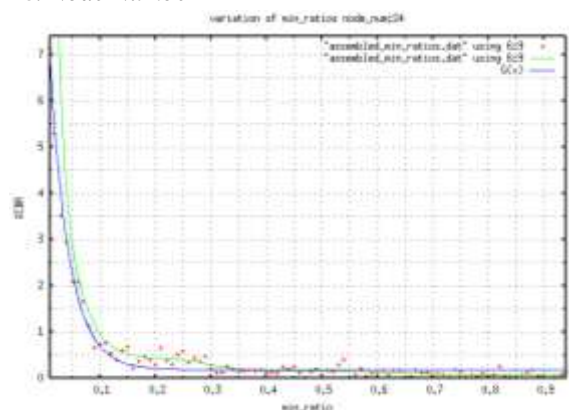


Figure 18: % cbr for Min_R node_number 24

19. Node Number 25

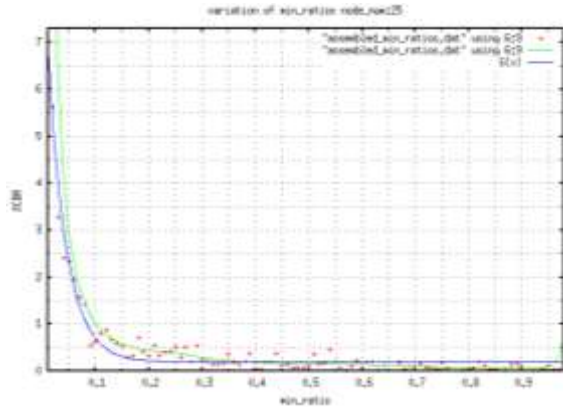


Figure 19: % cbr for Min_R node_number 25

20. Node Number 26

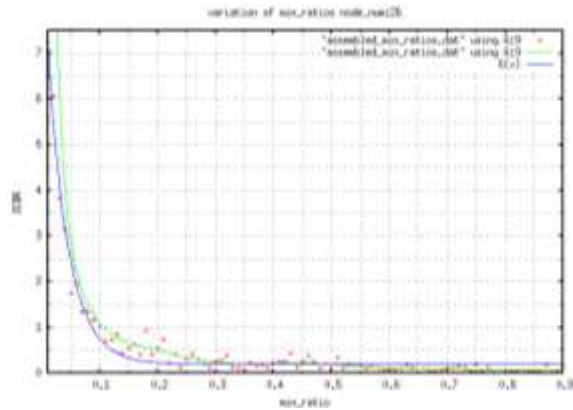


Figure 20: % cbr for Min_R node_number 26

21. Node Number 27

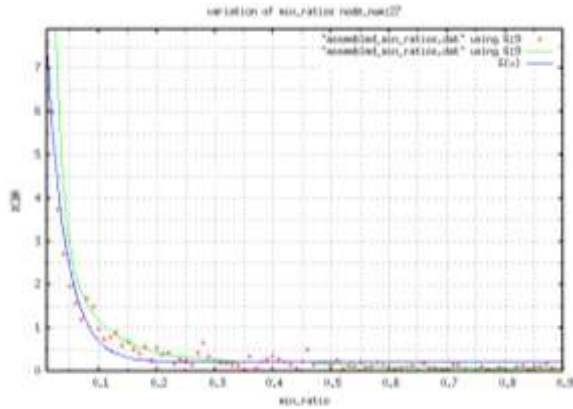


Figure 21: % cbr for Min_R node_number 27

22. Node Number 28

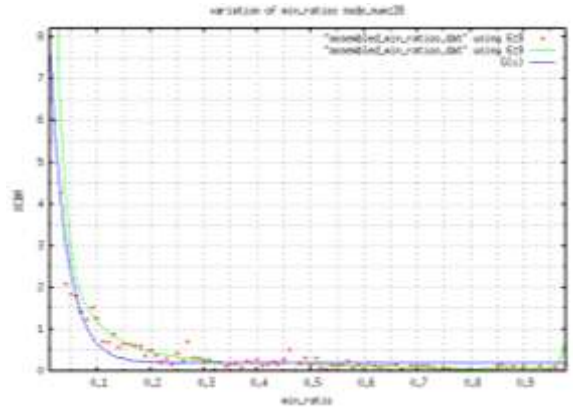


Figure 22: % cbr for Min_R node_number 28

23. Node Number 29

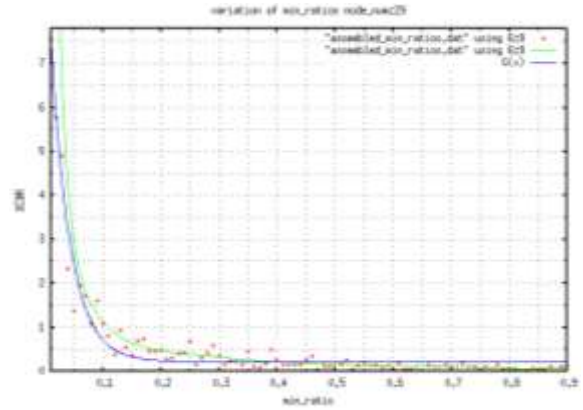


Figure 23: % cbr for Min_R node_number 29

24. Node Number 30

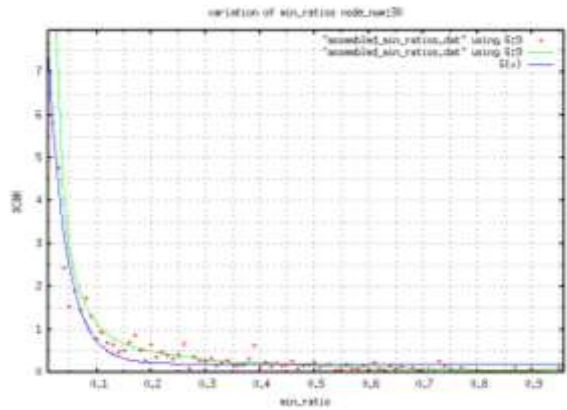


Figure 24: % cbr for Min_R node_number 30

25. Node Number 31

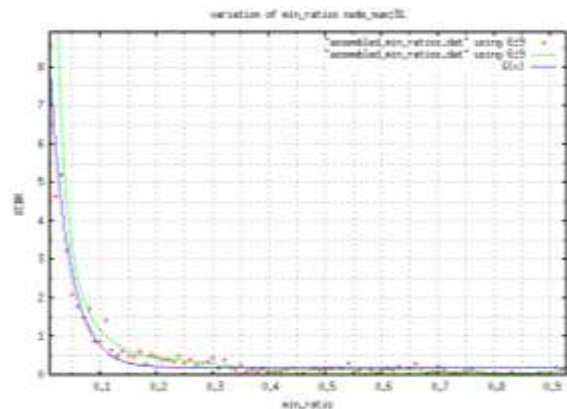


Figure 25: % cbr for Min_R node_number 31

26. Node Number 32

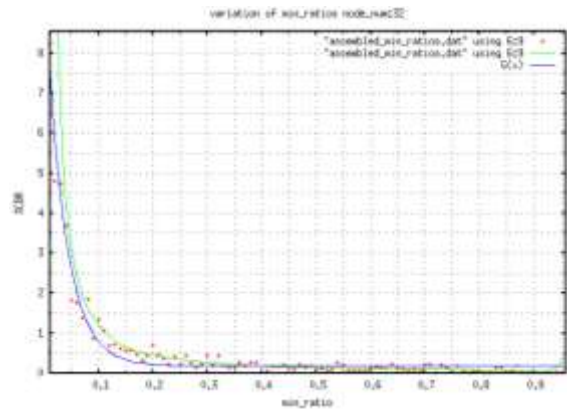


Figure 26: % cbr for Min_R node_number 32

27. Node Number 33

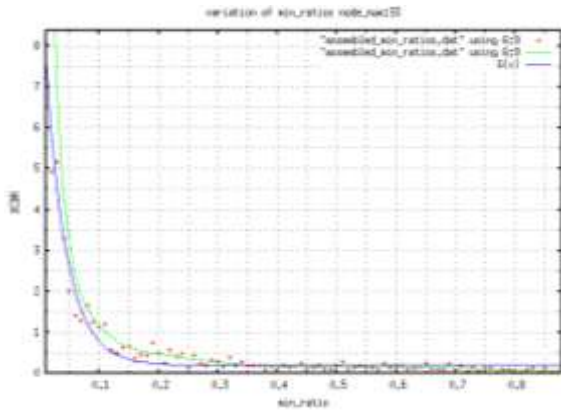


Figure 27: % cbr for Min_R node_number 33

28. Node Number 34

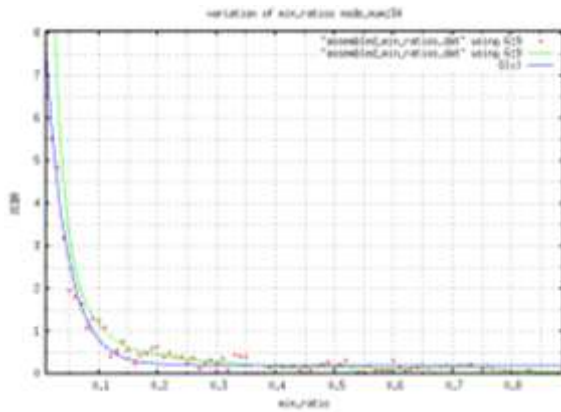


Figure 28: % cbr for Min_R node_number 34

29. Node Number 35

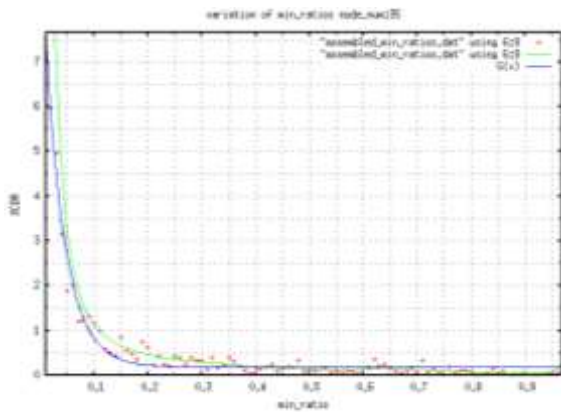


Figure 29: % cbr for Min_R node_number 35

30. Node Number 36

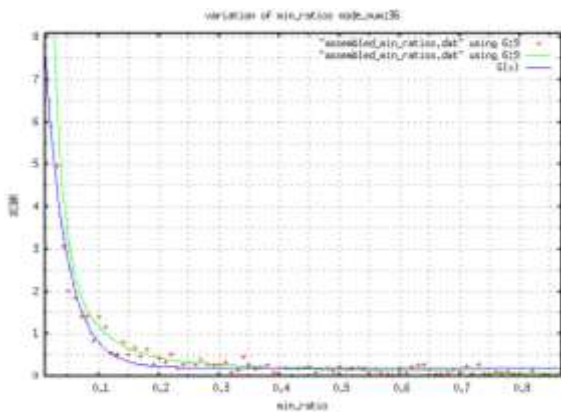


Figure 30: % cbr for Min_R node_number 36

31. Node Number 37

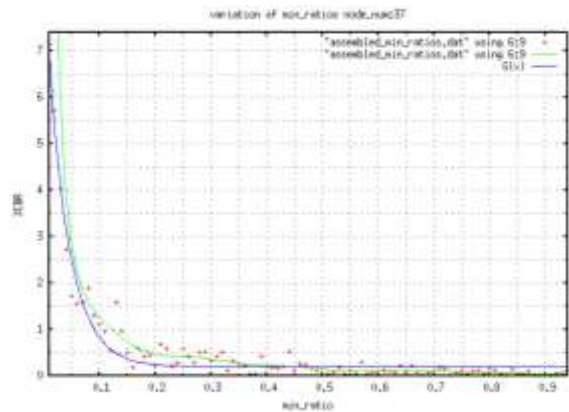


Figure 31: % cbr for Min_R node_number 37

32. Node Number 38

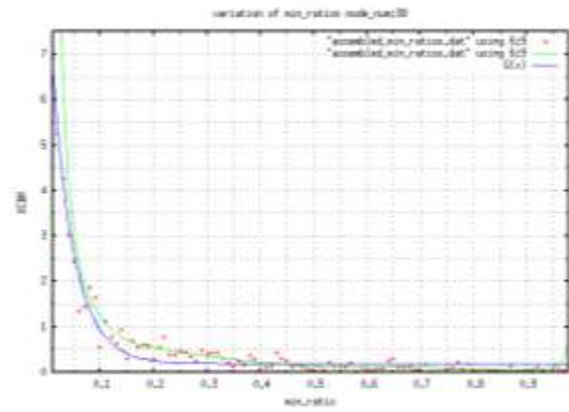


Figure 32: % cbr for Min_R node_number 38

33. Node Number 39

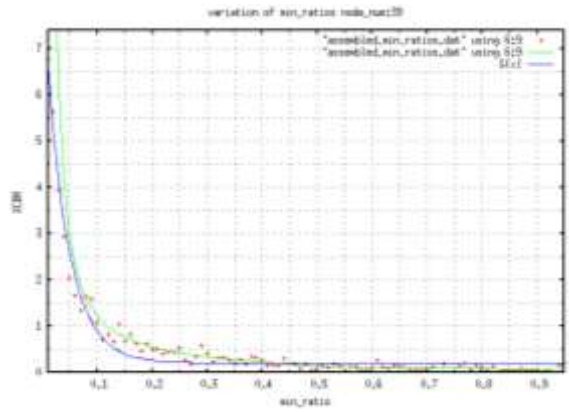


Figure 33: % cbr for Min_R node_number 39

34. Node Number 40

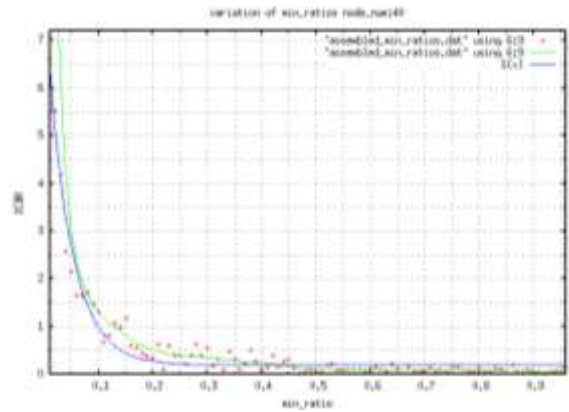


Figure 34: % cbr for Min_R node_number 40

35. Node Number 41

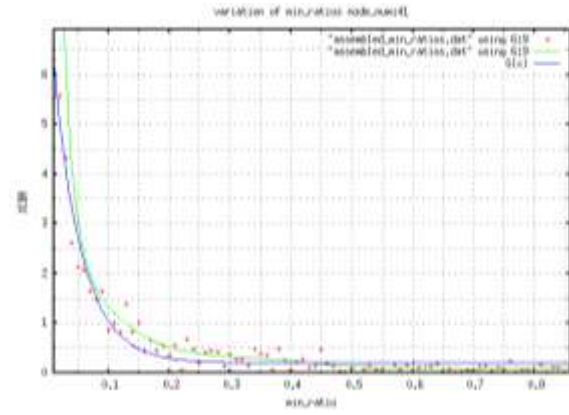


Figure 35: % cbr for Min_R node_number 41

36. Node Number 42

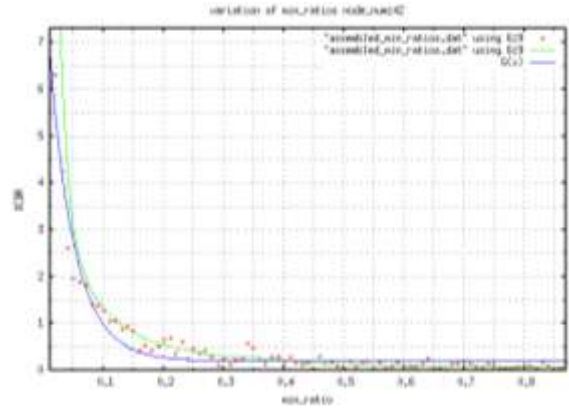


Figure 36: % cbr for Min_R node_number 42

37. Node Number 43

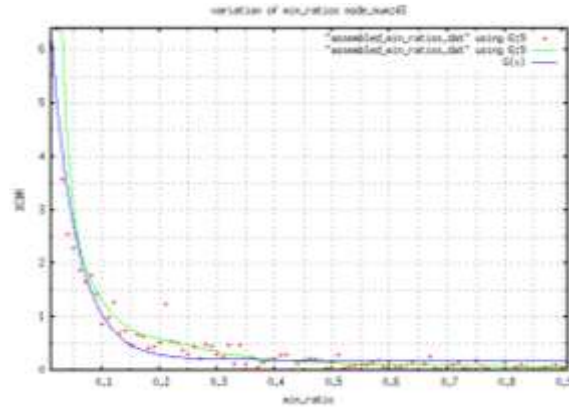


Figure 37: % cbr for Min_R node_number 43

38. Node Number 44

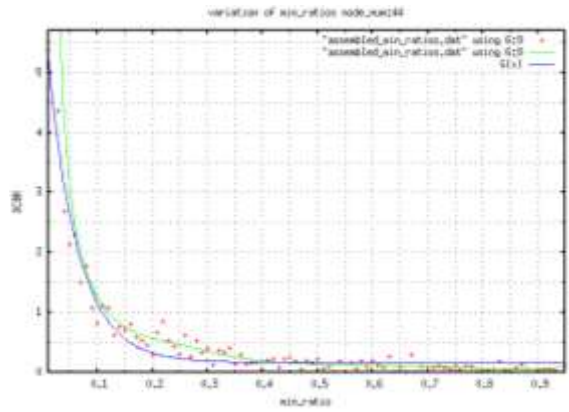


Figure 38: % cbr for Min_R node_number 44

39. Node Number 45

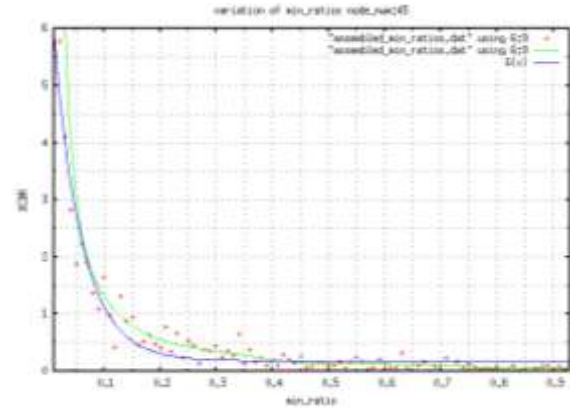


Figure 39: % cbr for Min_R node_number 45

40. Node Number 46

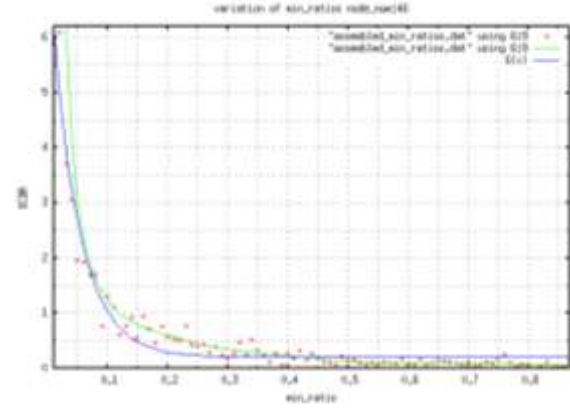


Figure 40: % cbr for Min_R node_number 46

41. Node Number 47

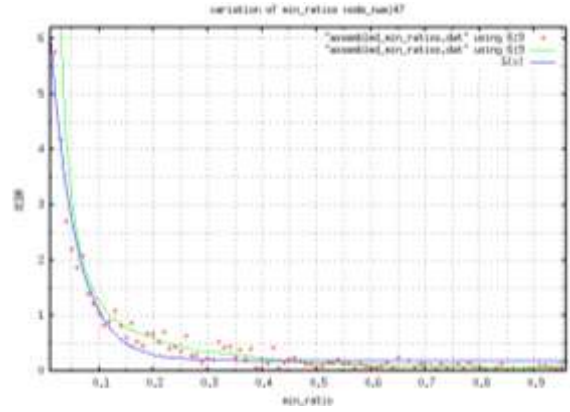


Figure 41: % cbr for Min_R node_number 47

42. Node Number 48

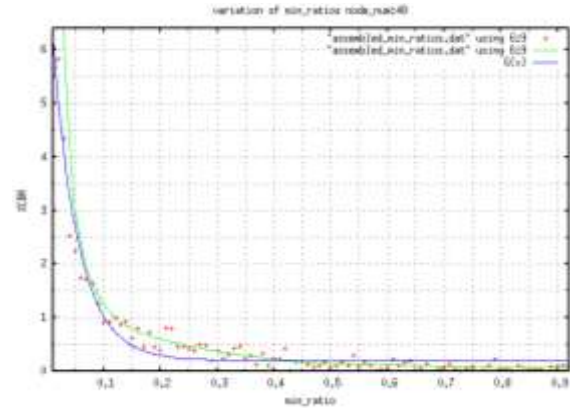


Figure 42: % cbr for Min_R node_number 48

43. Node Number 49

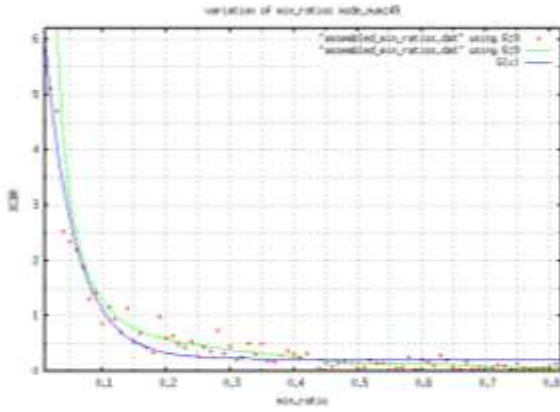


Figure 43: % cbr for Min_R node_number 49

44. Node Number 50

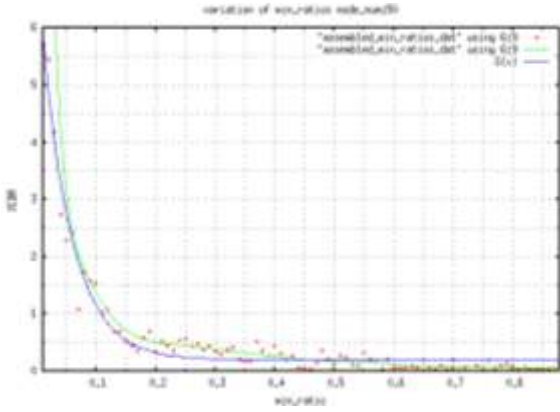


Figure 44: % cbr for Min_R node_number 50

45. Node Number 51

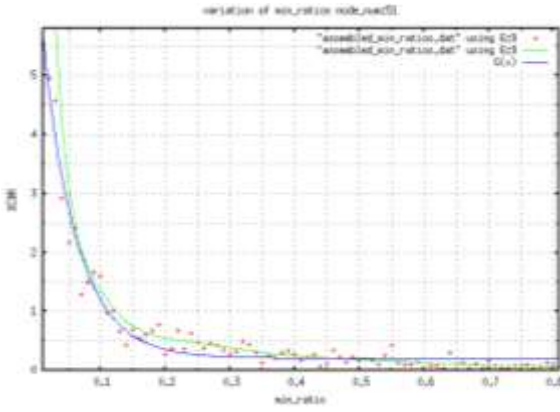


Figure 45: % cbr for Min_R node_number 51

46. Node Number 52

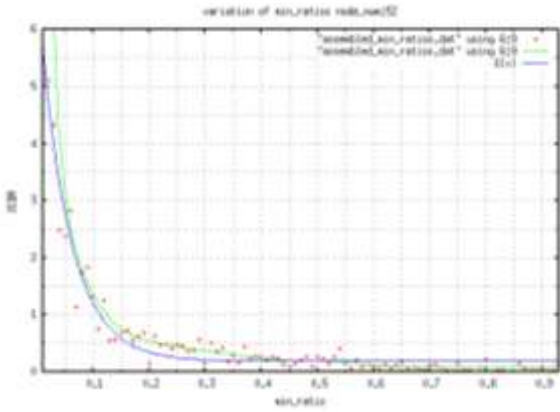


Figure 46: % cbr for Min_R node_number 52

47. Node Number 53

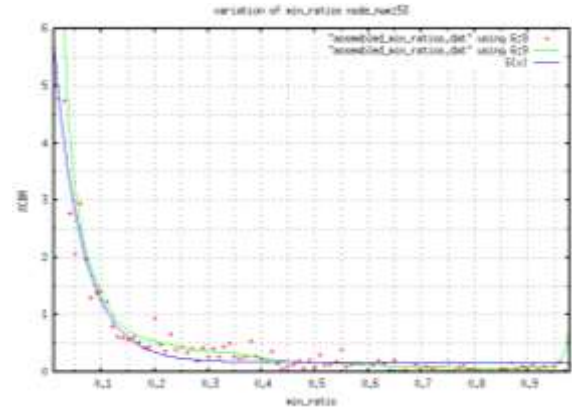


Figure 47: % cbr for Min_R node_number 53

48. Node Number 54

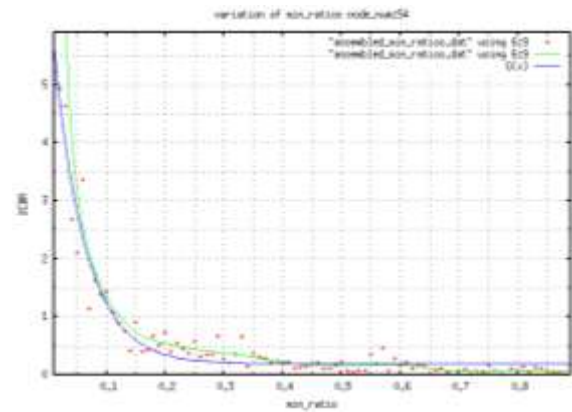


Figure 48: % cbr for Min_R node_number 54

49. Node Number 55

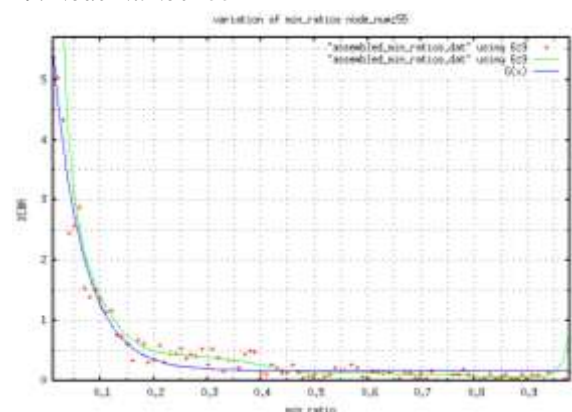


Figure 49: % cbr for Min_R node_number 55

50. Node Number 56

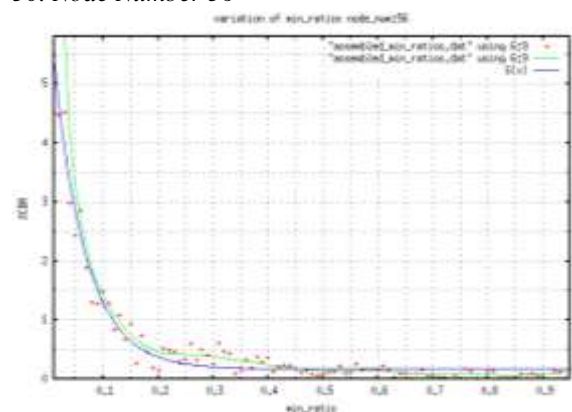


Figure 50: % cbr for Min_R node_number 56

4. Conclusion.

This piece of research was aimed at developing one method towards studying Fairness reachable in energy consumption by nodes participating in a MANET transmission, in a topography of 300 x 300 m². For this purpose, one metric, Min_R, was derived from another previously explained metric, ECR [18]. The trend for metric Min_R has also been put forward. This research remains empirical based and was implemented over same experiment as explained in another paper [15]. The model put forward is the exponential model. Here, again, several components are assumed as available even if they remain subjects of research, e.g. lightweight algorithms for location-aware transmission in mobile environments, lightweight MAUC OS support for efficient and very rapid binding/unbindings of MANET nodes and appropriate multi-threading/parallel communication in modules of MANET nodes.

The further works identified may include: trend analyses of parameters of equation for the model, formulating method of predictability for metric Min_R and its trend and reporting observations of certain critical values identified. Other research avenues remain development of other metrics for assessing fairness in energy expenditure of participating nodes in MANET transmission, together with the trend analyses.

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