

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

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**Abstract** – It is claimed that MANET transmission helps to save energy in ubicomp [55]. This strategy may be complemented by applying location-aware transmission in MANET, resulting in a situation of automatic cooperation between all nodes present in the topography. In situations of cooperation, a desirable transparent information remains Fairness of load distribution, taking into consideration all underlying features like hardware peculiarities, battery availability and especially of concern here, ratio of energy being required by the MANET node compared with the sender node itself, together with known 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. A first set of answers to this issue was provided in another paper [19].

In this paper, a second set of answers is provided with a metric Max\_R with its corresponding model of trend over varying node densities. This paper adds up to the area of modelling in ubicomp for designers to better provision for resources and architecture needs for ubicomp. This paper is a follow-up of previous research [1-19].

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

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## 1. Introduction

Many factors affect energy consumption in MAUC [2]. MANET transmission remains a considerable factor whereby the workload of transmission is distributed along MANET routes to achieve cooperative and complete transmission to receiver. This workload distribution is heavily affected by node densities. It is legitimate for cooperating nodes to know how much assistance they are required to give compared to sender node itself. Such a study is provided [18] whereby a metric ECR was tacked. The question which builds over this previous study [18] is “how much Fairness is

being reached as concerns energy distribution among cooperating nodes?”

It remains definitely important to devise more methods/metrics for analysing resulting situations evolving in MANETs as concerns Fairness among cooperating nodes. Following identification and analysis of a derived metric Min\_R [19] derived from ECR [18], the logical next metric to be derived and analysed is, Max\_R, which is also heavily affected by changes in MANET routes [18].

The key contributions of this paper is firstly, the development of a second derived metric Max\_R, which is derived from ECR [18], including its definition and rationale, and secondly, the model of trend put forward for the metric Max\_R with results for varying node densities from 7 until 56. The model suggested in this paper is the exponential model just like for Min\_R [19] but of different parameter and for node number 26 onwards, a linear model support was necessary. The rest of this paper is organised as follows: section 2- New Derived Metric- Maximum Ratio, section 3- Max\_R Trend Assessment over Varying Node Numbers, 4- Conclusion and References.

## 2. New Derived Metric: Maximum\_Ratio.

Max\_R is defined as “the largest ECR value that has been discovered during the whole of a CBR transmission”. Max\_R values will also be positive values just as ECR values [18]. A Max\_R value less than 1 is not obtainable since the sender itself will be reaching ECR value 1. Hence Max\_R value can be split into 2 categories:

- i. Max\_R values equal to 1: it depicts that each of the nodes involved in MANET routes have spent less or just equal amount of energy as the sender and hence a situation of “complete fairness” reached.
- ii. Max\_R values greater than 1: it implies that at least one MANET node has spent more energy than the sender node and is hence open for further probing.

Situations of complete Fairness, including Max\_R values, if appropriately gauged or even predicted, may serve for policy decision formulation including:

- i. Sender may decide to send more CBRs (or same CBR in multi-thread fashion) and forward all (or most) information in buffers for Ferry Transport Protocols [56], since an “economic sending situation” is reached.
- ii. Readjust transmission/processing modes from OS perspectives to take advantage of the “economic sending situation”.
- iii. MANET nodes may use this information to increase trust levels in the sender and reduce their constraints enforced.
- iv. History tracking can continue and Max\_R, just like Min\_R [19], may further help in enhancements of policy-based decision making.

### 3. Max\_R Trend Assessment over Varying Node Numbers.

#### 3.0 Major Observations.

The trends for Max\_R achieved for node numbers 7 until 25 have followed the exponential model of form:

$$G(x) = a * \exp (b*(x - 1.0 )) + c$$

Here, the leftmost point in each plot was at Max\_R 1.0 and for initial node numbers up to 25, it gives the highest % CBR value (i.e. the leftmost plot is also the peak value). The rightmost plot was far outlying along an asymptotic part of a decreasing curve. The x-range was hence taken from 1.0 until a value to ensure coverage of at least 99% of CBRs involved.

Since the graph starts at x-coordinate 1.0, a translation of 1 unit to the right was necessary (i.e. perform x-1.0).

As from node number 26, the peak value was observed at x-coordinate 2.0 and not 1.0. Previous to this peak value, there is only 1 plot at x-coordinate 1.0. Hence, the tendency is assumed to be linear with form:

$$F(x) = d * x + f$$

For node numbers 26 onwards, as from the peak value, the curve remains decreasing exponential with the amended form as follows:

$$G(x) = a * \exp (b*(x - 2.0 )) + c$$

#### 3.1 Tabular Summary of Results.

##### 3.1.1 Node Number 7 until 25

Below is a tabular summary for results of equations of curves (G(x)) concerning node numbers 7 until 25. 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	43.872 1	-0.690 178	0.394 347	0.348 352	1
8	36.704 5	-0.659 388	0.343 655	0.343 655	2

9	34.751 8	-0.609 12	0.272 657	0.122 988	3
10	27.042 8	-0.449 374	0.282 816	0.166 385	4
11	25.444 5	-0.408 284	0.239 183	0.124 213	5
12	24.654 5	-0.391 417	0.229 108	0.061 818 1	6
13	23.445 6	-0.357 104	0.199 69	0.107 902	7
14	22.294 2	-0.334 954	0.183 034	0.066 337 9	8
15	20.812 6	-0.306 607	0.172 254	0.035 530 3	9
16	20.066 4	-0.290 651	0.192 152	0.170 172	10
17	19.181 4	-0.278 449	0.169 169	0.136 764	11
18	18.948 2	-0.271 336	0.148 048	0.141 73	12
19	18.262 9	-0.259 395	0.155 409	0.182 095	13
20	17.722 5	-0.248 423	0.134 388	0.138 445	14
21	17.416 4	-0.240 864	0.123 774	0.092 533 4	15
22	16.569 3	-0.234 726	0.197 43	0.110 837	16
23	15.867 9	-0.219 38	0.153 062	0.172 184	17
24	15.622 8	-0.212 444	0.100 982	0.047 519 6	18
25	15.185 5	-0.202 871	0.099 181 4	0.090 040 8	19

Table 1: summary of results for Max\_R equations of curves node numbers 7-25

##### 3.1.2 Node Number 26 until 56.

Below is a tabular summary (split into 2 tables)for results of equations of curves (F(x) and G(x)) for node numbers 26 until 56, 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 for G(x), F→ value of parameter d, G→ value of parameter f, H→ sum of squares of residuals in plot, I→ corresponding figure number.

A	B	C	D	E
26	14.882 2	-0.262	0.178 51	0.135 206
27	14.877 2	-0.260 54	0.211 139	0.064 993 9
28	14.269 4	-0.245	0.171 264	0.057 115 9
29	14.485 8	-0.250	0.198 673	0.084 907 6
30	13.484 9	-0.225	0.153 436	0.044 2
31	13.941 5	-0.231	0.165 228	0.099 764 7
32	11.636 8	-0.251	0.232 562	0.167 181
33	13.494 7	-0.219	0.131 746	0.072 063 1
34	13.538 9	-0.223	0.185 985	0.056 328 8
35	10.793 3	-0.219	0.210 341	0.089 184 7
36	11.790 2	-0.249	0.248 893	0.154 159
37	14.453 5	-0.198 26	0.197 6	0.116 138
38	11.246 1	-0.224	0.234 452	0.095 132 3
39	12.312 1	-0.191	0.161 51	0.161 51
40	12.506 8	-0.193 76	0.168 154	0.077 695 5
41	12.180 6	-0.183	0.135 907	0.075 522 7
42	12.171 4	-0.183	0.129 689	0.098 997 6
43	12.104 5	-0.183	0.136 525	0.151 647
44	12.150 7	-0.182	0.126 581	0.107 798
45	11.822 8	-0.176	0.129 805	0.147 152
46	11.974 7	-0.177	0.115 258	0.103 613
47	11.643 4	-0.171	0.108 676	0.133 367
48	11.825 6	-0.177	0.139 459	0.142 924
49	10.803 1	-0.199	0.189 526	0.104 447
50	11.417 5	-0.175	0.176 47	0.151 806
51	11.153 8	-0.168	0.167 699	0.067 235
52	10.306 6	-0.155	0.117 704	0.042 832 5
53	10.102 5	-0.150	0.109 885	0.055 408 4
54	9.784 42	-0.170	0.157 366	0.078 328 3
55	9.630 22	-0.168	0.149 995	0.045 202 1
56	9.628 21	-0.165	0.142 044	0.050 588

Table 2(a): summary of results for Max\_R equations of curves node numbers 26-56.

A	F	G	H	I
26	2.619 05	10.603 2	0	20
27	3.507 94	8.873 02	0	21
28	3.111 11	9.126 98	0	22
29	3.793 65	8.095 24	0	23
30	0.841 27	11.682 5	0	24
31	1.888 89	9.936 51	0	25

32	0.595 238	11.381	0.000 377 929	26
33	2.793 65	8.396 83	0	27
34	2.920 63	7.952 38	0	28
35	3.063 49	7.190 48	0	29
36	1.444 44	8.846 56	1.213 57	30
37	1.936 82	8.175 9	0	31
38	1.134 92	8.740 74	0.445 494	32
39	2.190 48	7.253 97	0	33
40	3.222 22	5.746 03	0	34
41	2.793 65	6.126 98	0	35
42	2.396 83	6.539 68	0	36
43	1.984 13	7.380 95	0	37
44	2.811 31	5.749 68	0	38
45	2.253 97	6.253 97	0	39
46	2.968 25	5.079 37	0	40
47	1.825 4	6.682 54	0	41
48	2.619 05	5.619 05	0	42
49	1.595 24	6.513 23	1.088 48	43
50	2.968 25	5.079 37	0	44
51	3.365 08	3.952 38	0	45
52	3.365 08	3.952 38	0	46
53	2.714 29	4.460 32	0	47
54	1.841 27	5.444 44	1.452 76	48
55	1.658 73	5.862 43	1.730 45	49
56	1.753 97	5.497 35	1.531 91	50

Table 2(b): summary of results for Max\_R equations of curves node numbers 26-56.

### 3.2 Graphical Plots for Results Obtained.

This analysis is performed in gnuplot in Linux.

#### 1. Node Number 7

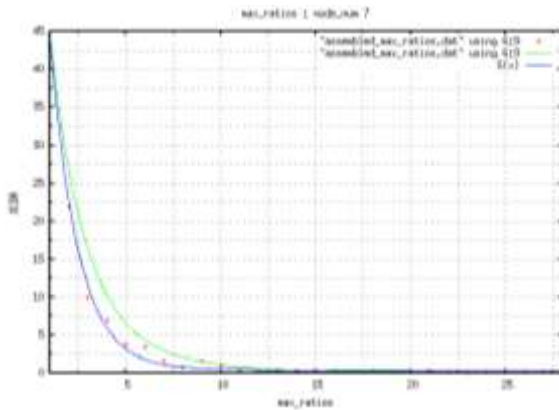


Figure 1: % cbr for Max\_R node\_number 7

#### 2. Node Number 8

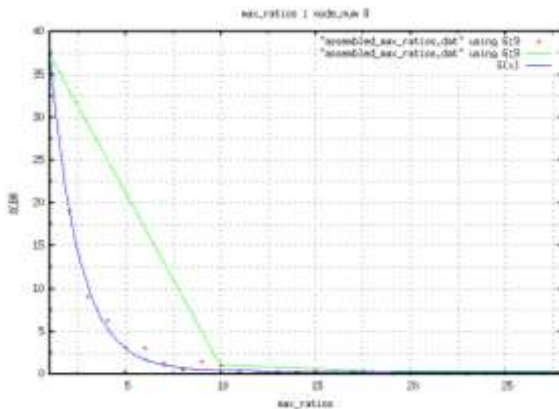


Figure 2: % cbr for Max\_R node\_number 8

#### 3. Node Number 9

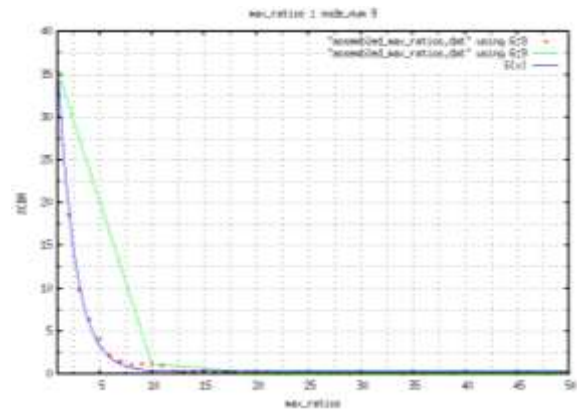


Figure 3: % cbr for Max\_R node\_number 9

#### 4. Node Number 10

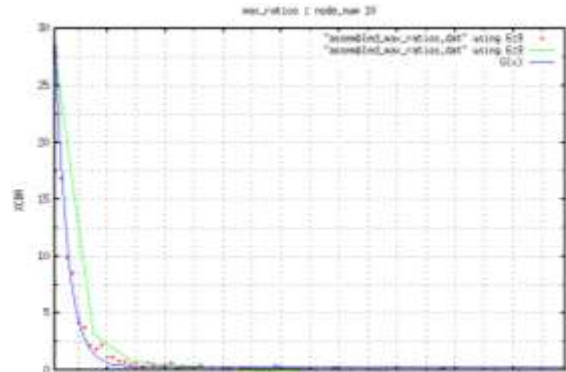


Figure 4: % cbr for Max\_R node\_number 10

#### 5. Node Number 11

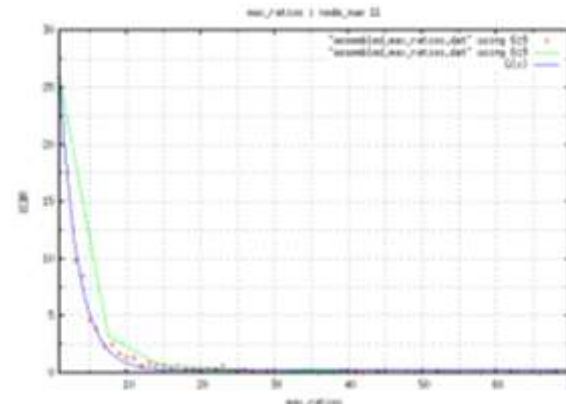


Figure 5: % cbr for Max\_R node\_number 11

#### 6. Node Number 12

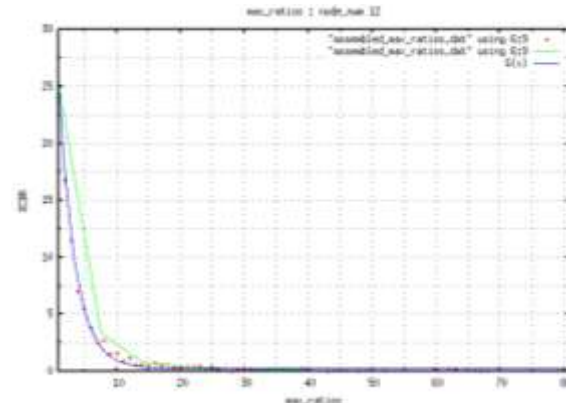
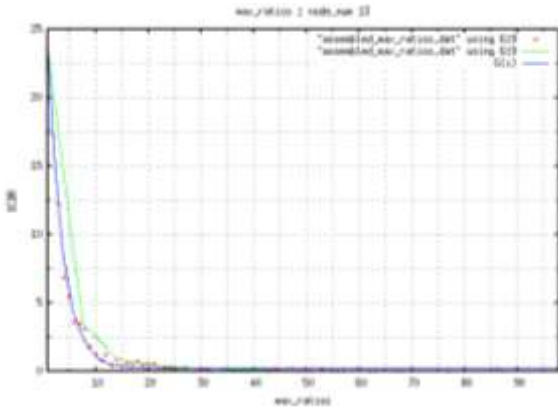


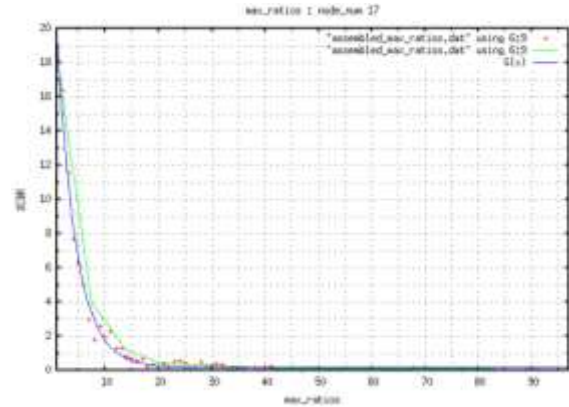
Figure 6: % cbr for Max\_R node\_number 12

#### 7. Node Number 13

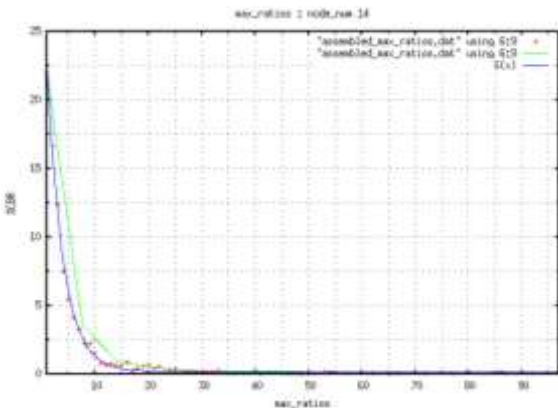




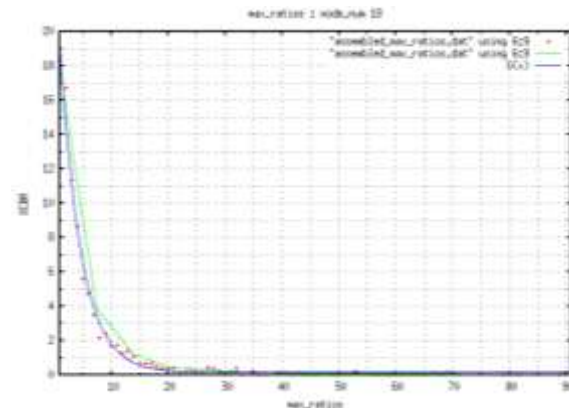
**Figure 7: % cbr for Max\_R node\_number 13**  
8. Node Number 14



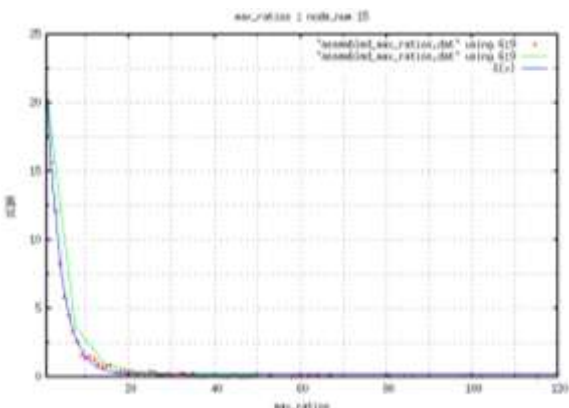
**Figure 11: % cbr for Max\_R node\_number 17**  
12. Node Number 18



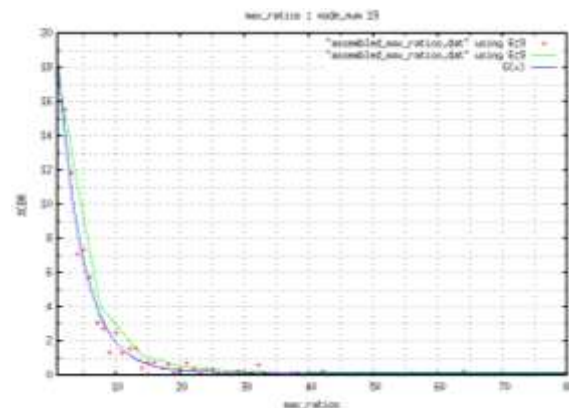
**Figure 8: % cbr for Max\_R node\_number 14**  
9. Node Number 15



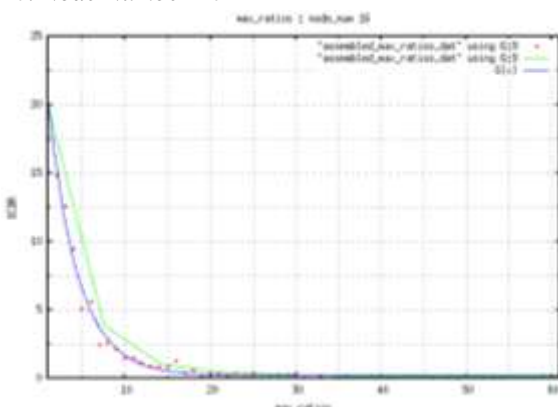
**Figure 12: % cbr for Max\_R node\_number 18**  
13. Node Number 19



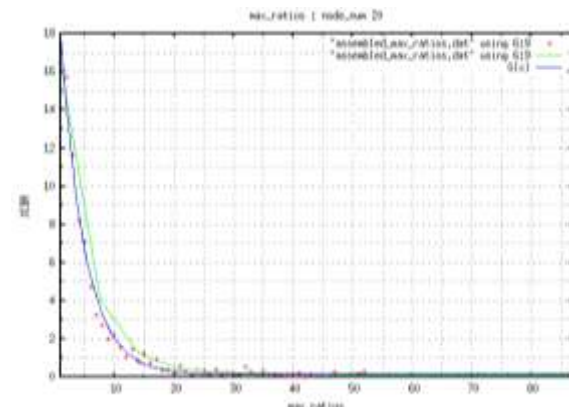
**Figure 9: % cbr for Max\_R node\_number 15**  
10. Node Number 16



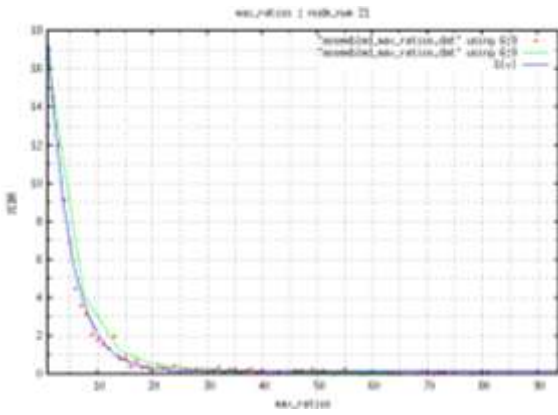
**Figure 13: % cbr for Max\_R node\_number 19**  
14. Node Number 20



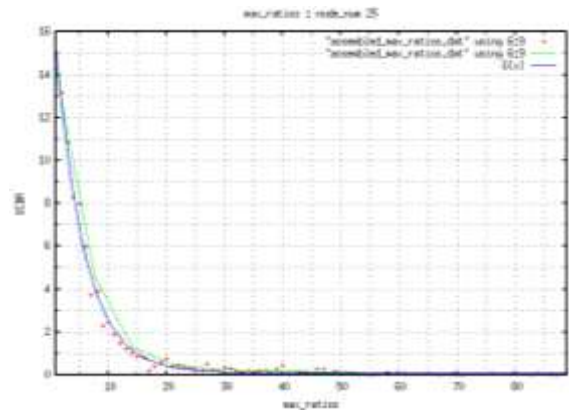
**Figure 10: % cbr for Max\_R node\_number 16**  
11. Node Number 17



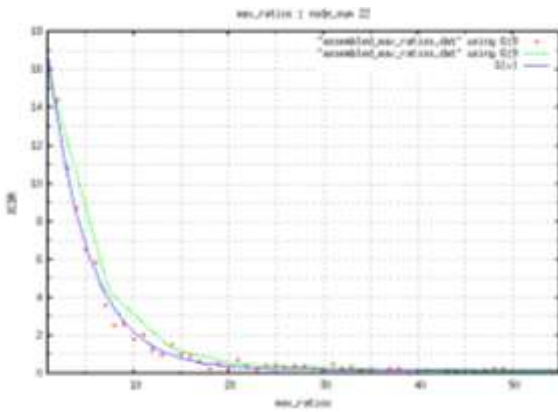
**Figure 14: % cbr for Max\_R node\_number 20**  
15. Node Number 21



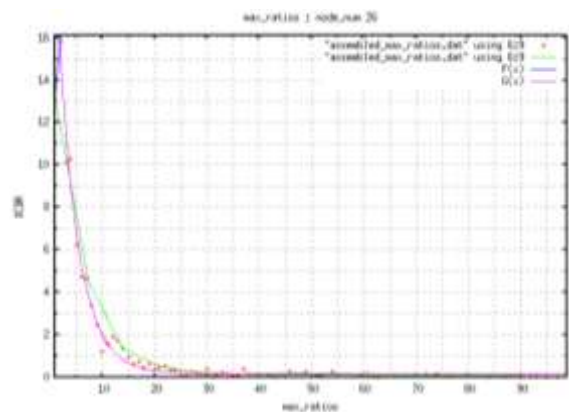
**Figure 15: % cbr for Max\_R node\_number 21**  
 16. Node Number 22



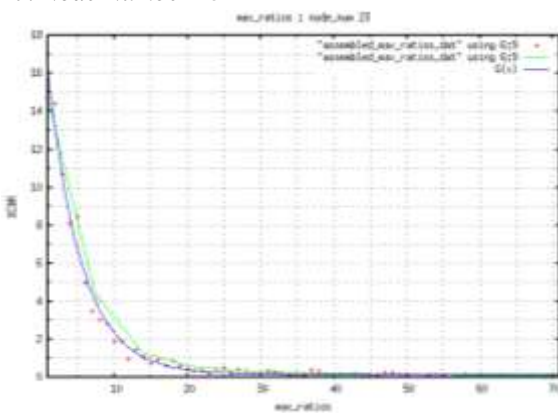
**Figure 19: % cbr for Max\_R node\_number 25**  
 20. Node Number 26



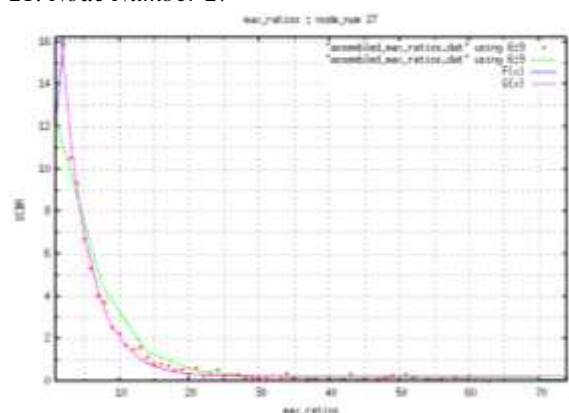
**Figure 16: % cbr for Max\_R node\_number 22**  
 17. Node Number 23



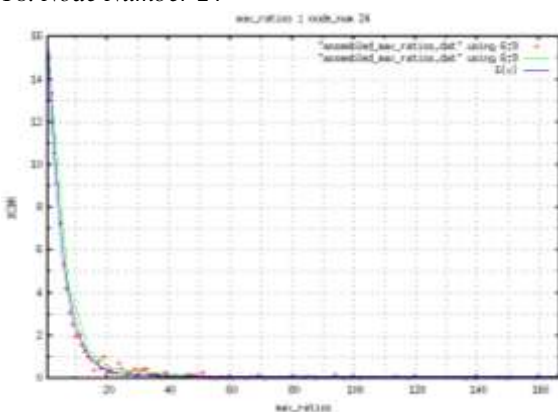
**Figure 20: % cbr for Max\_R node\_number 26**  
 21. Node Number 27



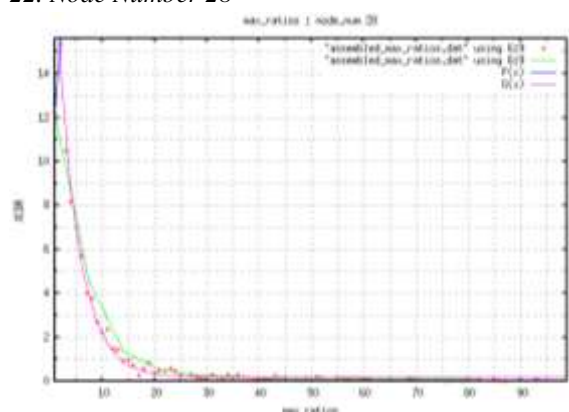
**Figure 17: % cbr for Max\_R node\_number 23**  
 18. Node Number 24



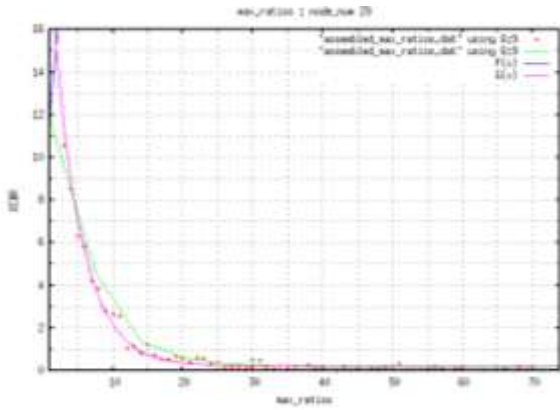
**Figure 21: % cbr for Max\_R node\_number 27**  
 22. Node Number 28



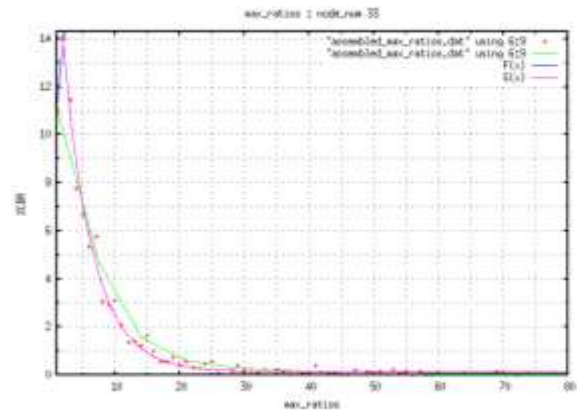
**Figure 18: % cbr for Max\_R node\_number 24**  
 19. Node Number 25



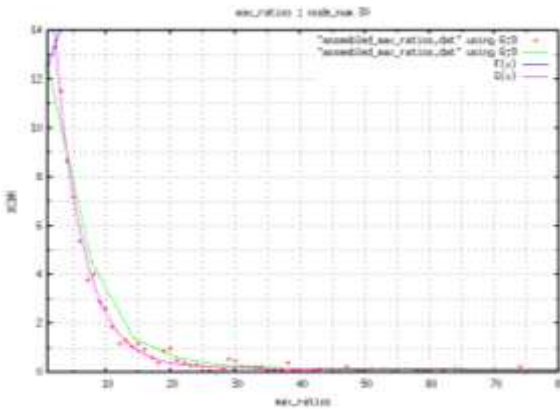
**Figure 22: % cbr for Max\_R node\_number 28**  
 23. Node Number 29



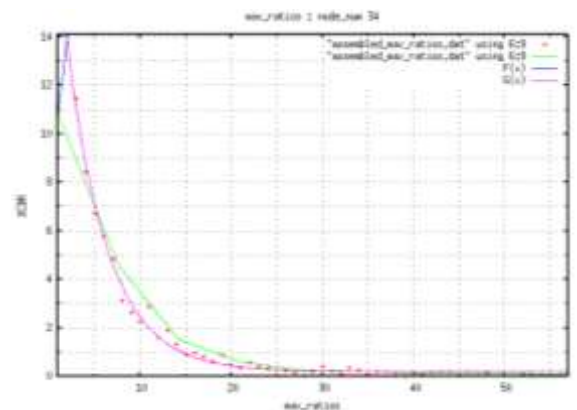
**Figure 23: % cbr for Max\_R node\_number 29**  
 24. Node Number 30



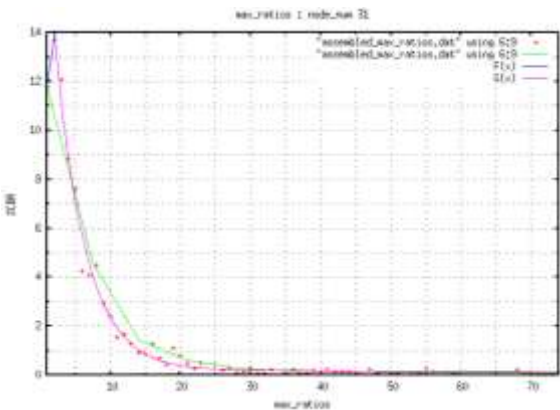
**Figure 27: % cbr for Max\_R node\_number 33**  
 28. Node Number 34



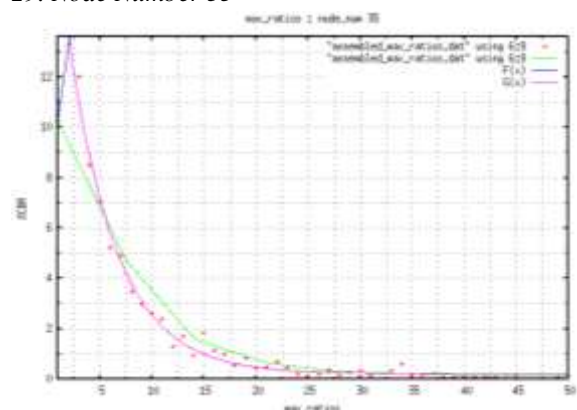
**Figure 24: % cbr for Max\_R node\_number 30**  
 25. Node Number 31



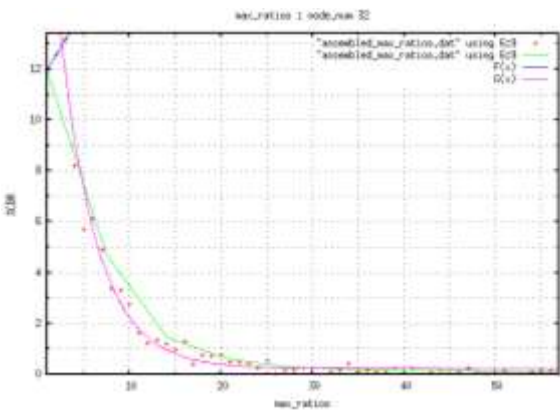
**Figure 28: % cbr for Max\_R node\_number 34**  
 29. Node Number 35



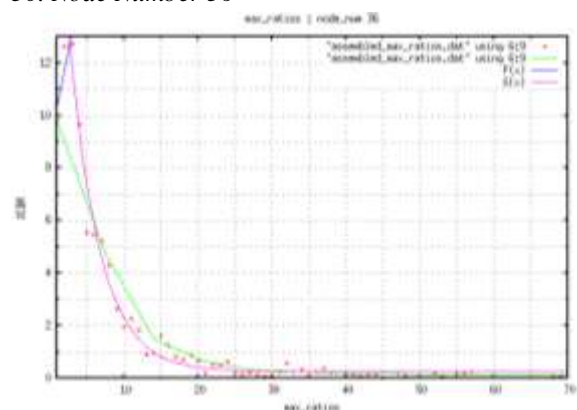
**Figure 25: % cbr for Max\_R node\_number 31**  
 26. Node Number 32



**Figure 29: % cbr for Max\_R node\_number 35**  
 30. Node Number 36

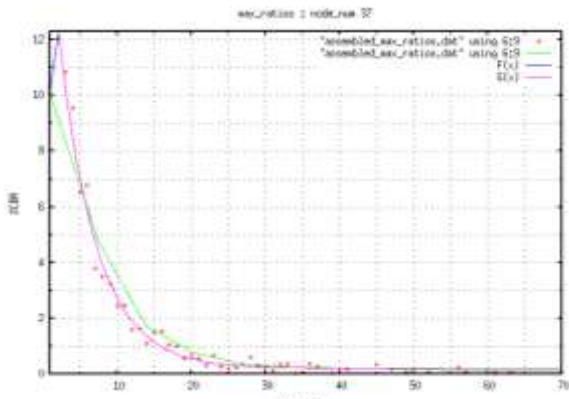


**Figure 26: % cbr for Max\_R node\_number 32**  
 27. Node Number 33

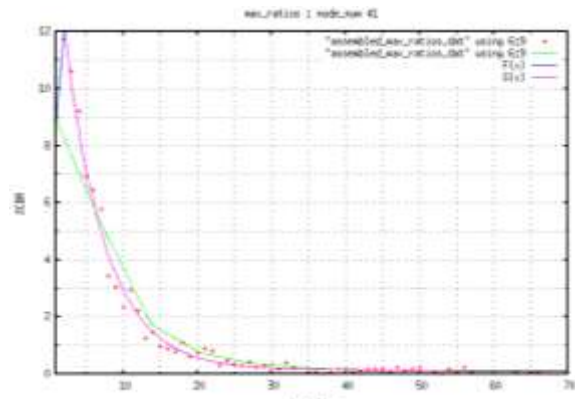


**Figure 30: % cbr for Max\_R node\_number 36**  
 31. Node Number 37

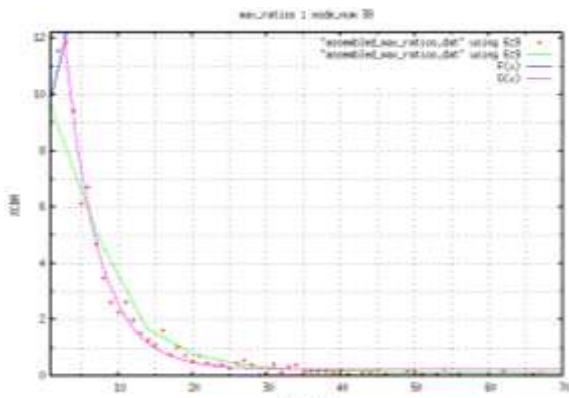




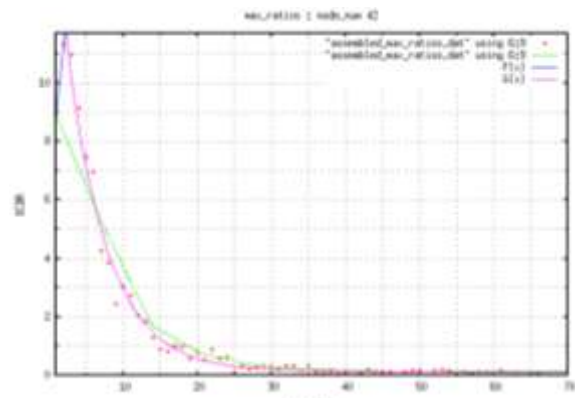
**Figure 31: % cbr for Max\_R node\_number 37**  
 32. Node Number 38



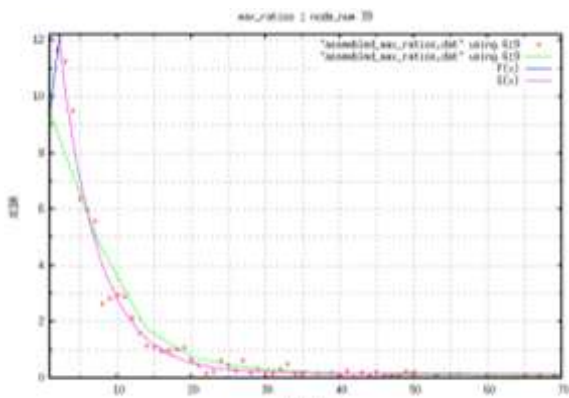
**Figure 35: % cbr for Max\_R node\_number 41**  
 36. Node Number 42



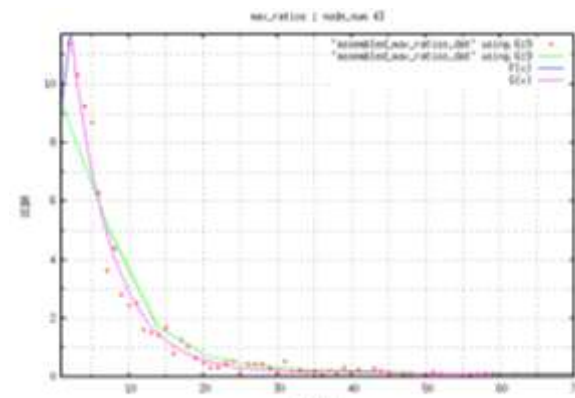
**Figure 32: % cbr for Max\_R node\_number 38**  
 33. Node Number 39



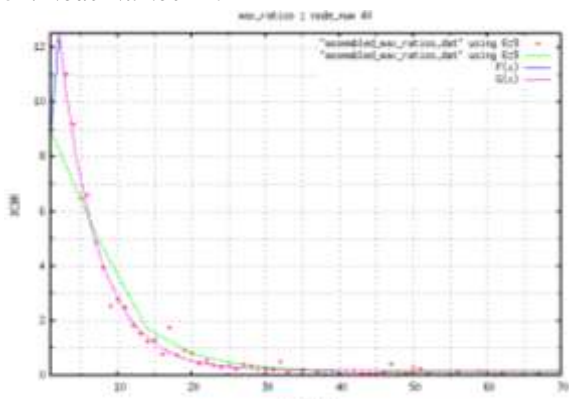
**Figure 36: % cbr for Max\_R node\_number 42**  
 37. Node Number 43



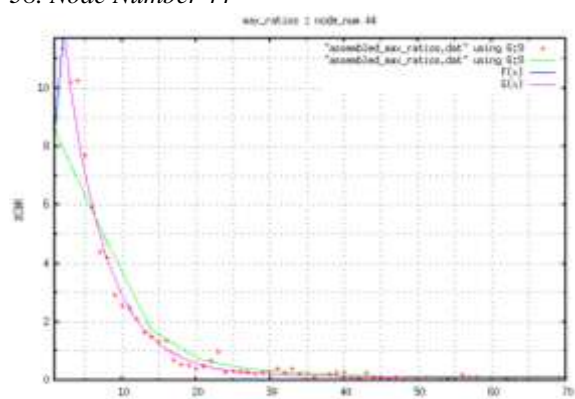
**Figure 33: % cbr for Max\_R node\_number 39**  
 34. Node Number 40



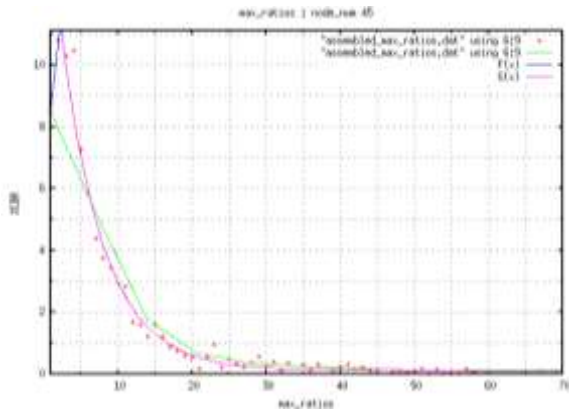
**Figure 37: % cbr for Max\_R node\_number 43**  
 38. Node Number 44



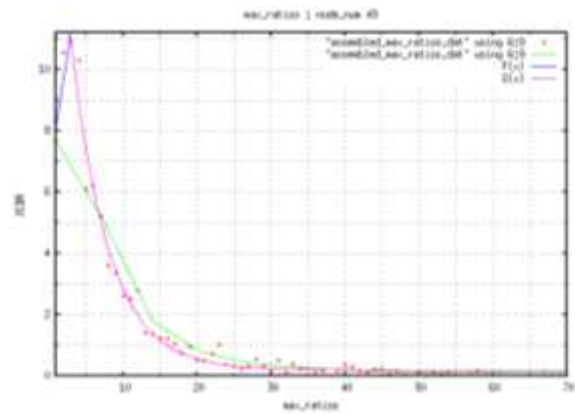
**Figure 34: % cbr for Max\_R node\_number 40**  
 35. Node Number 41



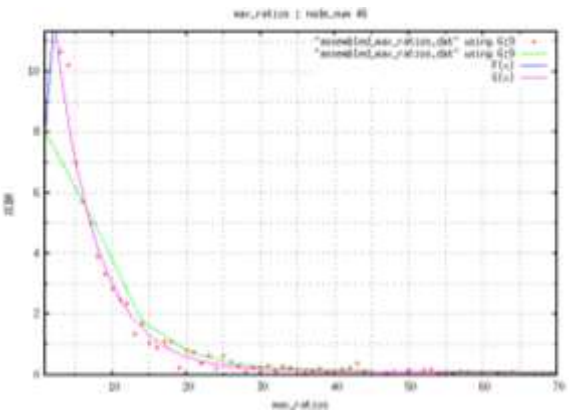
**Figure 38: % cbr for Max\_R node\_number 44**  
 39. Node Number 45



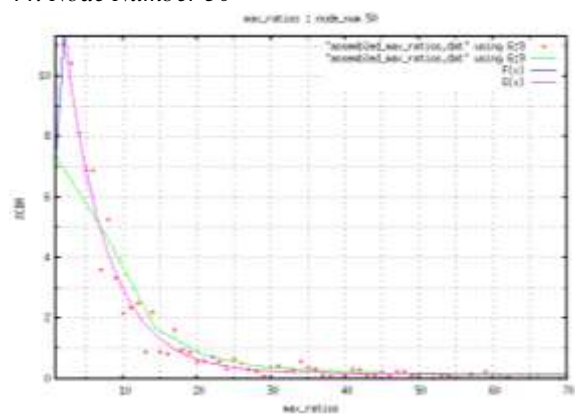
**Figure 39: % cbr for Max\_R node\_number 45**  
40. Node Number 46



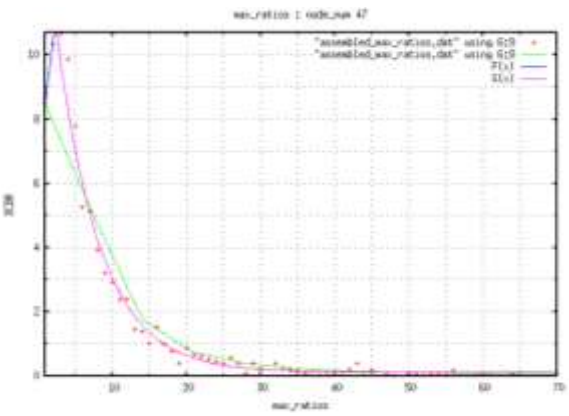
**Figure 43: % cbr for Max\_R node\_number 49**  
44. Node Number 50



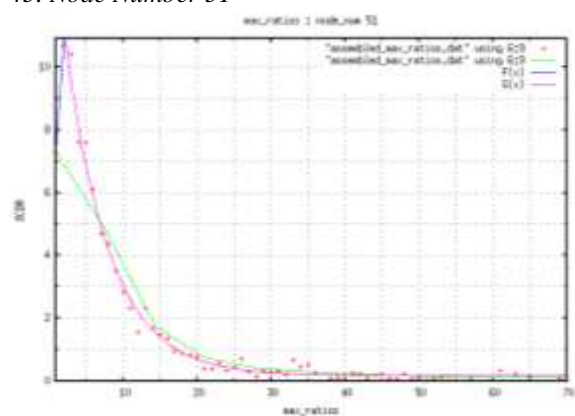
**Figure 40: % cbr for Max\_R node\_number 46**  
41. Node Number 47



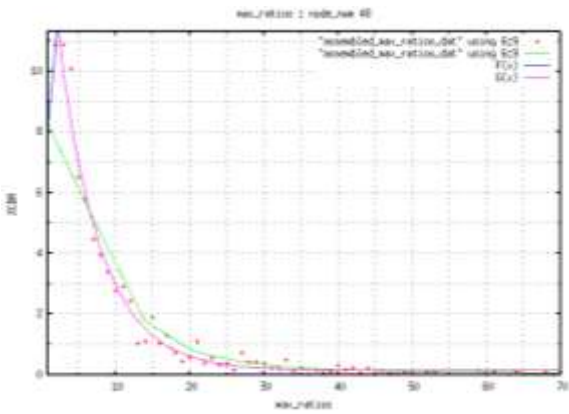
**Figure 44: % cbr for Max\_R node\_number 50**  
45. Node Number 51



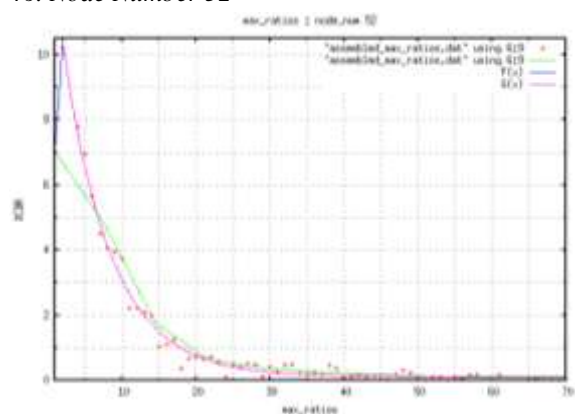
**Figure 41: % cbr for Max\_R node\_number 47**  
42. Node Number 48



**Figure 45: % cbr for Max\_R node\_number 51**  
46. Node Number 52

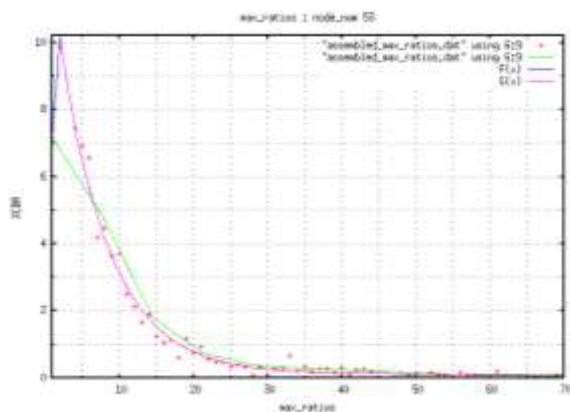


**Figure 42: % cbr for Max\_R node\_number 48**  
43. Node Number 49

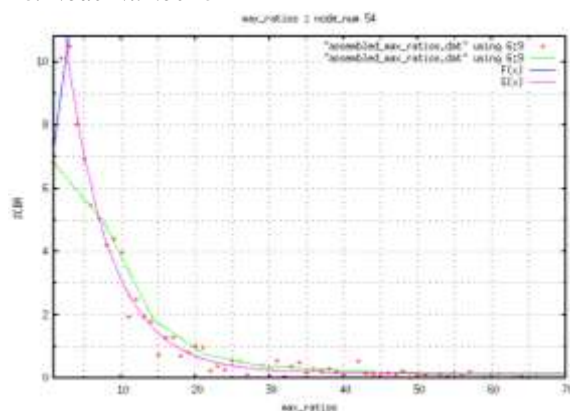


**Figure 46: % cbr for Max\_R node\_number 52**  
47. Node Number 53

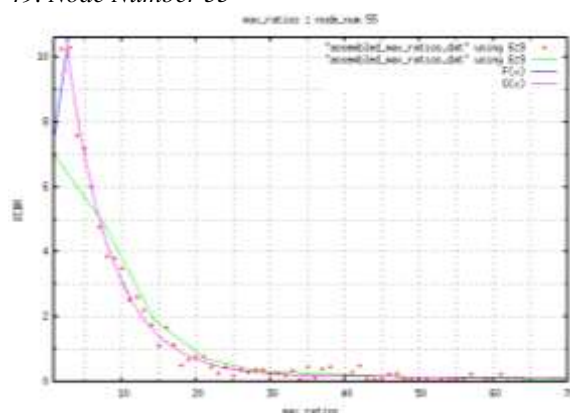




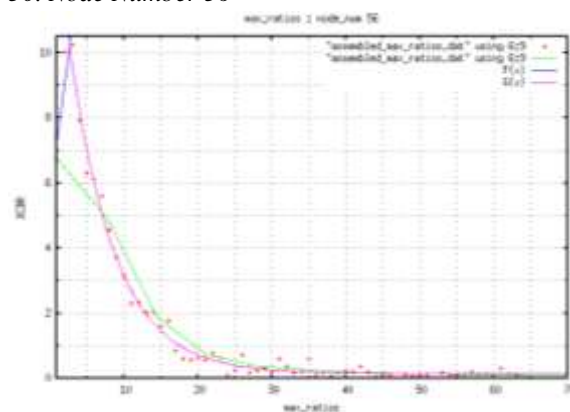
**Figure 47: % cbr for Max\_R node\_number 53**  
 48. Node Number 54



**Figure 48: % cbr for Max\_R node\_number 54**  
 49. Node Number 55



**Figure 49: % cbr for Max\_R node\_number 55**  
 50. Node Number 56



**Figure 50: % cbr for Max\_R node\_number 56**

## 4. Conclusion.

This piece of research was aimed at developing a second method towards studying Fairness reachable in energy consumption by nodes participating in a MANET transmission, in a topography of 300 x 300 m<sup>2</sup>, following a previous method put forward [19]. For this purpose, another metric, Max\_R, has been derived from another previously explained metric, ECR [18]. The trends for metric Max\_R have 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 mostly the exponential model with some support from linear model. Here also, several components are assumed as available even if they are still subjects of research, e.g. lightweight algorithms for location-aware transmission in mobile environments, lightweight MAUC OS support for efficient binding/unbinding 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 Max\_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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