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Model of Maximum Fairness Proportion Achievable in MANET Using Location-Aware Transmission for Ubicomp.

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***Abstract* – MANET transmission may help in energy containment in ubicomp [59]. This can be enhanced by location-aware transmission strategies and therefore management of energy consumption in ubicomp remains a serious topic of research. In MANETs for ubicomp, nodes present will transmit in an automated collective fashion, thereby sharing the workload. Hence, the ubicomp nodes will themselves be the infrastructure. The situation whereby every node must be providing equitable assistance will be rarely reached. However, the research area remains open : "By how much Fairness reached in a ubicomp deviates from the latter situation reached?". Such questions remain consequent in situations of cooperative functionality.**

A previous study in this direction was made [22], whereby a metric BFEA was devised to define "the theoretical equitable energy amount for Fairness" and first metric, ECFP, for Fairness analysis was put forward. In another paper [23], a second metric Min_FP, derived from ECFP, is defined and its corresponding trends over varying node densities are presented.

This paper builds further the area of modelling for energy management in ubicomp for designers to assess Fairness characteristics and subsequently better shape future ubicomp components. This paper is a follow-up of previous research [1-23].

Key terms: Ubicomp- Ubiquitous Computing, MAUC- Mobile and Ubiquitous Computing, MANET- Mobile Adhoc Network, BFEA- Basic Fairness Energy Amount, ECFP- Energy Consumption Fairness Proportion, Min_FP- Minimum Fairness Proportion, Max_FP- Maximum Fairness Proportion, CBR- Constant Bit Rate.

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1. Introduction

Among factors affecting energy consumption in MAUC [21], MANET transmission remains very considerable. Here, transmission load is distributed among those nodes which have been part of MANET route for a corresponding CBR. The situation being cooperation here, a direction of research crops up with the assumption that the workload of transmission is equitably distributed among all topographic nodes present, described by the metric BFEA [22]. Such a situation will be seldom reached. However, for long duration transmissions over highly dynamic MANET topologies, circumstances close to this situation may be reached. Hence, devising appropriate metrics for this study and knowledge about corresponding trends remain desirable.

The work presented here remains empirical and is built over previous work [22]. As mentioned previously, ECFP [23] remain a wide scope metric from which other sub-component metrics may be extracted for further study. Each such extracted metric may have been specific features that brings additional value for study of reliability in ubicomp.

The key contributions of this paper is firstly, the development of a third metric Max_FP extracted from a first metric ECFP [22]. The definition and rationale of metric Max_FP is put forward. Secondly, the model of trend is put forward for the metric Max_FP with results for varying node densities from 7 until 56 in a topography of 300 x 300 m^2. The model proposed is the decreasing exponential model. The rest of this paper is organised as follows: section 2- New Derived Metric – Maximum Fairness Proportion, section 3- Max_FP Trend Assessment over Varying Node Numbers, 4- Conclusion and References.

2. New Derived Metric – Maximum Fairness Proportion.

Following definition of ECFP given in previous paper [22], and Min_FP given in another paper [23], Max_FP will simply be the maximum value of ECFP recorded for a CBR.

Usually, Max_FP values will not be below 1. If Max_FP values themselves are overly high, then it can depict certain specific possible situations:

i. The topography has high proportions of misbehaving nodes refusing to forward data.
ii. A particular node having the Max_FP value for a CBR may be closely following movement patterns of sender nodes. This can be confirmed over successive CBRs.
iii. The node with very high FP may be of very high power compared to other nodes and

found accepting transmission over long ranges.

iv. Max_FP occurring at same node repetitively over many CBRs may depict that the node is located in a sparsely populated sub-region of the topography where infrastructure support may be desirable.

In general, Max_FP must be above 1. The smaller the value of Max_FP above 1, the healthier is the MANET conditions, i.e. distribution of workload is quite uniform across all nodes present in the topography.

Again, this metric, if appropriately gauged or even predicted, may also serve purposes elaborated in previous paper [21].

3. Max_FP - Trend Assessment over Varying Node Numbers.

3.0 Major Observations.

In all the plots obtained, the minimum value of Max_FP obtained has been at about 1.3 and the maximum value of Max_FP corresponds to the node number in the experiment set.

In all the plots obtained, a peak value is observed. Previous to the maximum point, the tendency is convincingly linear with equation of form:

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F(x) = d * x + f
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As from the peak value onwards, the trend is convincingly exponentially decreasing with equation of the form:

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G(x) = a * exp (b * (x – k)) + c
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3.1 Tabular Summary of Results.

A tabular summary for results of equations of curves (F(x) and G(x)) is shown below. Column headings are: A→node number, B→Value of parameter d, C→Value of parameter f, D→ reduced chi-square of plot F(x), E→ Value of parameter a, F→ value of parameter b, G→ value of parameter c, H→ value of parameter k, I→ reduced chi-square value of plot G(x), F→ Corresponding figure number.

A	B	C	D	E
7	16.485 3	-21.459 6	0.572 592	8.540 55
8	12.160 6	-18.045 9	0.208 668	7.190 7
9	10.436 5	-14.881	0.095 855 4	6.871 2
10	8.690 48	-11.738 1	0.522 411	6.922 3
11	9.835 6	-13.840 7	0.084 54	6.457 4
12	8.256 49	-11.422 4	0.211 726	6.185 85
13	7.272 49	-9.984 66	0.387 431	5.902 06
14	10.426 3	-15.539 7	0.202 304	5.888 86
15	5.873 02	-7.962 96	0.436 958	5.620 717
16	5.150 07	-6.950 94	0.439 69	5.198 781
17	4.725 83	-6.353 29	0.699 006	4.846 015
18	4.808 08	-6.485 14	0.517 87	4.849 359
19	7.794 78	-11.942 2	0.114 445	5.230 108
20	4.683 98	-6.644 44	0.541 261	4.672 610
21	4.593 74	-6.537 54	0.270 406	4.672 171
22	5.585 38	-8.539 11	0.226 921	4.927 599
23	4.410 03	-6.604 06	0.097 008 8	4.713 002
24	3.501 7	-5.012 74	0.337 087	4.121 874
25	3.991 01	-5.968 24	0.143 411	4.623 918
26	3.254 2	-4.515 41	0.384 569	3.666 526
27	6.061 98	-10.046 1	0.138 762	4.953 723
28	5.620 97	-9.210 29	0.155 694	4.542 462
29	4.203 73	-6.635 27	0.602 912	4.012 337
30	4.603 17	-7.544 01	0.240 256	4.437 02
31	2.665 97	-3.637 77	0.542 89	3.354 2
32	5.965 61	-10.338 6	0.184 16	4.550 06
33	3.275 07	-5.134 07	0.233 356	4.040 67
34	4.002 89	-6.653 39	0.213 692	4.325 7
35	3.104 81	-4.930 23	0.085 433 6	5.087 39
36	3.563 58	-5.960 75	0.145 952	4.503 33
37	2.703 51	-4.250 21	0.366 63	3.691 01
38	2.443 28	-3.709 24	0.410 116	3.691 43
39	4.200 1	-7.449 25	0.152 208	3.968 98
40	3.287 41	-5.690 85	0.247 695	3.600 23
41	3.244 37	-5.613 12	0.261 384	3.979 82
42	3.452 1	-6.055 59	0.154 613	4.189 3
43	2.054 54	-2.980 25	0.455 469	2.846 52
44	3.329 17	-5.830 21	0.078 911 9	4.126 92
45	3.180 71	-5.602 97	0.184 901	4.226 29
46	2.954 48	-5.090 66	0.148 285	3.678 29
47	3.524 81	-6.286 64	0.138 897	3.934 71
48	3.562 77	-6.471 57	0.237 202	4.106 34
49	3.094 77	-5.615 92	0.108 227	3.666 41
50	2.071 95	-3.446 53	0.257 593	3.284 88
51	2.771 68	-5.164 69	0.162 159	3.761 91
52	2.560 74	-4.736 36	0.205 337	3.239 99
53	2.877 68	-5.527 23	0.203 792	3.926 91
54	2.929 84	-5.636 1	0.353 716	3.823 47
55	2.532 2	-4.719 34	0.145 649	3.458 61
56	2.209 21	-4.071 37	0.116 112	3.128 58

Table 1(a): summary of results for Max_Fp equations of curves node numbers 7-56

A	F	G	H	I	J
7	-1.191 3	0.156 901	1.8	0.161 713	1
8	-1.053 64	0.148 35	2.1	0.169 617	2
9	-1.013 43	0.120 66	2.1	0.116 361	3
10	-0.882 1	0.072 7	2.0	0.207 567	4
11	-0.800 8	0.029 25	2.0	0.129 461	5
12	-0.952 98	0.100 0	2.2	0.054 180 1	6
13	-0.839 698	0.058 128	2.2	0.056 810 5	7
14	-0.681 455	0.000 982	2.6	0.111 678	8
15	-0.941 008	0.111 317	2.4	0.053 377 2	9
16	-0.886 079	0.091 369	2.5	0.053 545 2	10
17	-0.903 871	0.120 465	2.6	0.079 376 8	11
18	-0.770 282	0.078 90	2.5	0.061 791 9	12
19	-0.649 748	0.032 115	2.2	0.058 413 3	13
20	0.776 678	0.085 178	2.6	0.056 859	14
21	-0.774 949	0.088 877	2.6	0.042 230 6	15
22	-0.677 560	0.085 584	2.4	0.066 821 8	16
23	-0.723 377	0.086 796	2.6	0.049 148 2	17
24	-0.774 693	0.103 242	2.9	0.039 543 2	18
25	-0.739 451	0.088 066	2.7	0.048 669 2	19
26	-0.763 883	0.100 083	3.0	0.050 763 7	20
27	-0.642 526	0.061 119	2.4	0.058 866 5	21
28	-0.630 656	0.075 397	2.5	0.057 295 9	22
29	-0.664 114	0.078 968	2.8	0.057 594	23
30	-0.682 124	0.088 704	2.7	0.063 913 8	24
31	-0.724 507	0.100 206	3.2	0.047 844 5	25
32	-0.541 927	0.039 073	2.4	0.070 846 5	26
33	-0.740 318	0.112 973	3.0	0.034 922 6	27
34	-0.599 747	0.066 251	2.7	0.063 116 3	28
35	-0.700 614	0.092 417	3.1	0.024 302 6	29
36	-0.606 631	0.070 276	2.8	0.045 227 3	30
37	-0.702 577	0.111 786	3.2	0.047 760 5	31
38	-0.685 994	0.105 84	3.2	0.028 838 2	32
39	-0.479 067	0.038 734	2.6	0.058 918 8	33

40	-0.599 225	0.082 362	3.1	0.055 340 9	34
41	-0.631 428	0.092 856	3.0	0.044 892 9	35
42	-0.566 503	0.064 967	2.8	0.052 041 6	36
43	-0.718 916	0.119 627	3.6	0.042 518 8	37
44	-0.671 185	0.109 157	3.0	0.040 435 6	38
45	-0.621 514	0.095 053	2.9	0.035 72	39
46	-0.666 681	0.106 644	3.2	0.043 886	40
47	-0.532 356	0.065 754	2.8	0.044 114 3	41
48	-0.511 424	0.056 299	2.7	0.046 489 3	42
49	-0.614 979	0.098 221	3.2	0.052 020 6	43
50	-0.630 873	0.113 392	3.5	0.041 455 4	44
51	-0.578 119	0.086 508	3.2	0.043 208 9	45
52	-0.614 731	0.103 061	3.5	0.049 520 3	46
53	-0.580 836	0.099 842	3.1	0.057 447 4	47
54	-0.594 225	0.098 948	3.2	0.040 500 1	48
55	-0.603 57	0.108 326	3.4	0.032 714 8	49
56	-0.663 662	0.124 225	3.7	0.047 291 1	50

Table 1(b): summary of results for Max_Fp equations of curves node numbers 7-56

3.2 Graphical Plots for Results Obtained.

This analysis is performed in gnuplot in Linux.

1. Node Number 7

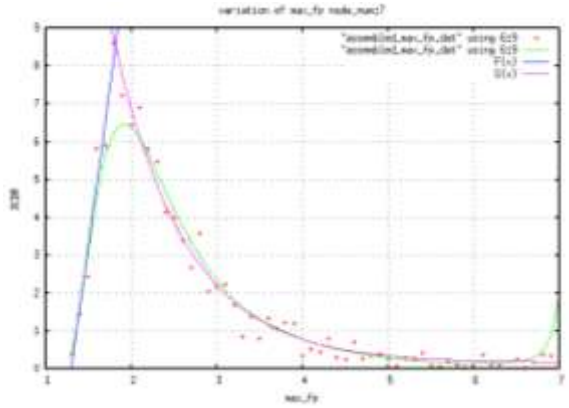

Figure 1: % CBR for Max_FP node_number 7

2. Node Number 8

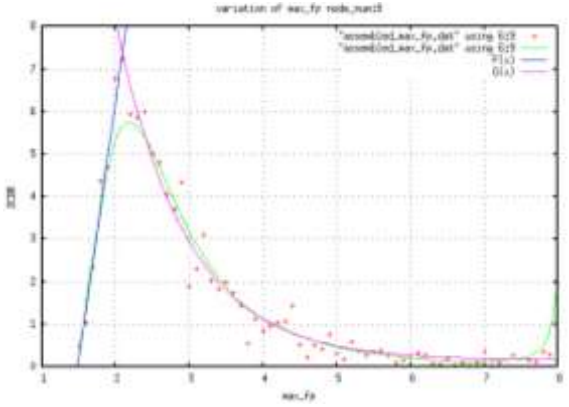

Figure 2: % CBR for Max_FP node_number 8

3. Node Number 9

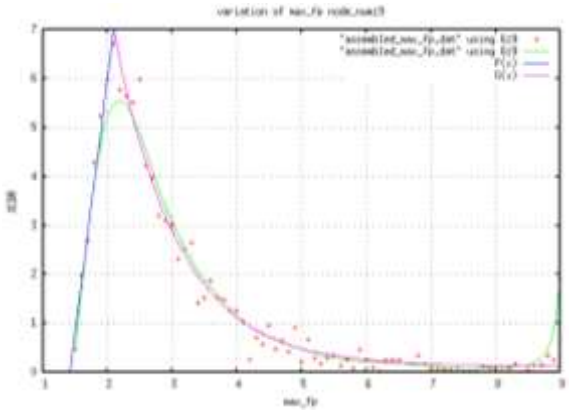

Figure 3: % CBR for Max_FP node_number 9

4. Node Number 10

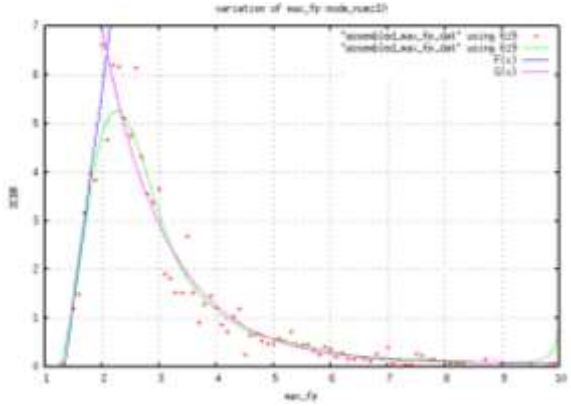

Figure 4: % CBR for Max_FP node_number 10

5. Node Number 11

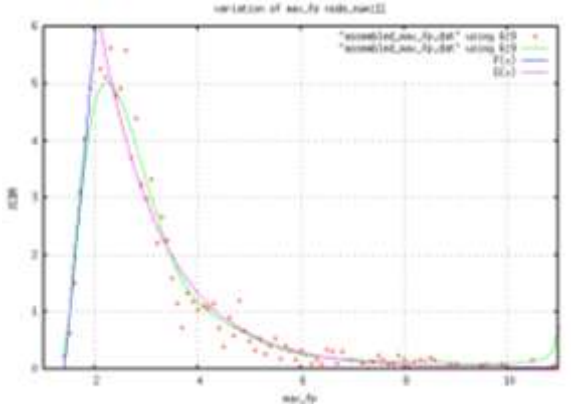

Figure 5: % CBR for Max_FP node_number 11

6. Node Number 12

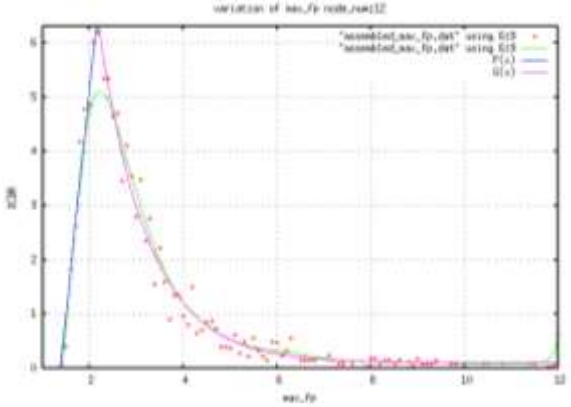

Figure 6: % CBR for Max_FP node_number 12

7. Node Number 13

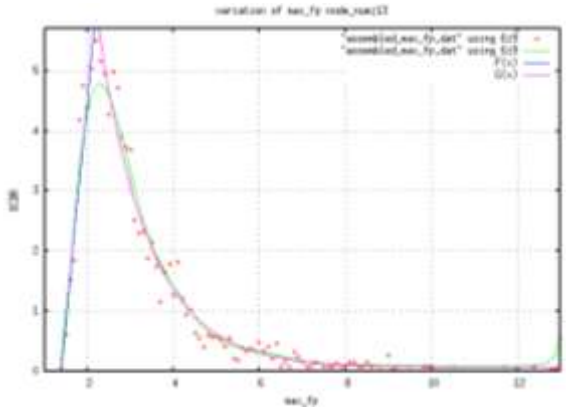

Figure 7: % CBR for Max_FP node_number 13

8. Node Number 14

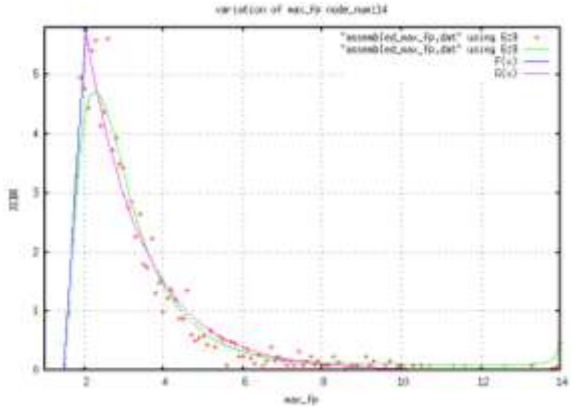

Figure 8: % CBR for Max_FP node_number 14

9. Node Number 15

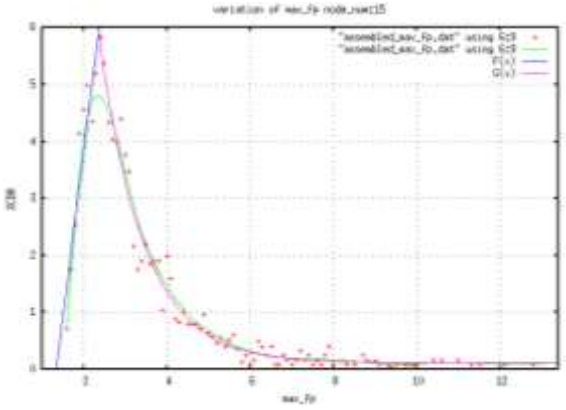

Figure 9: % CBR for Max_FP node_number 15

10. Node Number 16

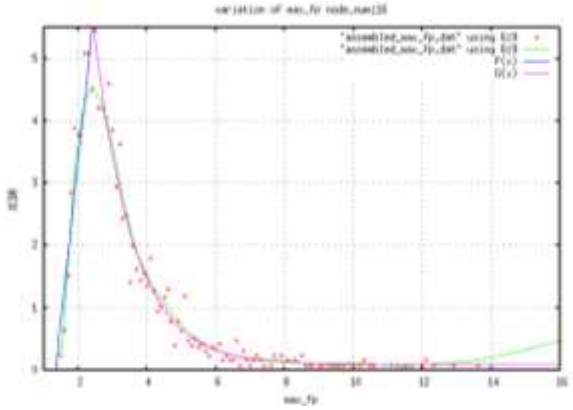

Figure 10: % CBR for Max_FP node_number 16

11. Node Number 17

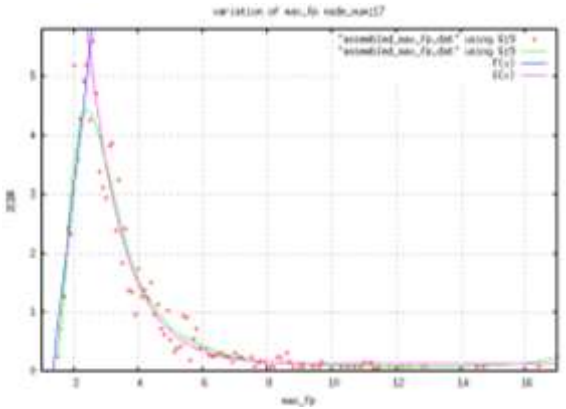

Figure 11: % CBR for Max_FP node_number 17

12. Node Number 18

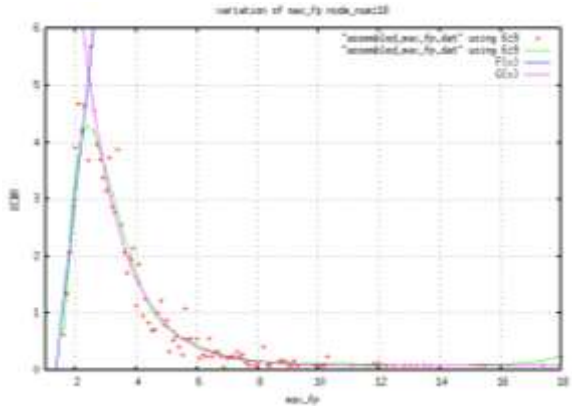

Figure 12: % CBR for Max_FP node_number 18

13. Node Number 19

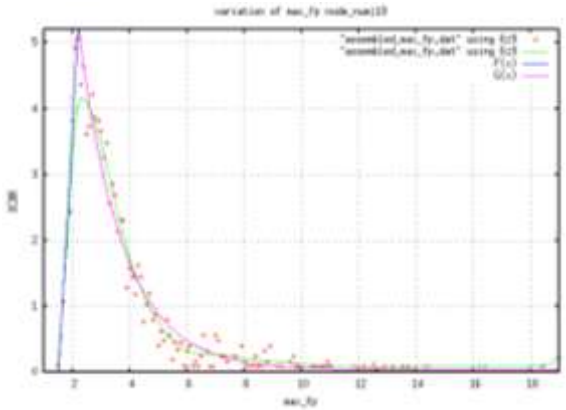

Figure 13: % CBR for Max_FP node_number 19

14. Node Number 20

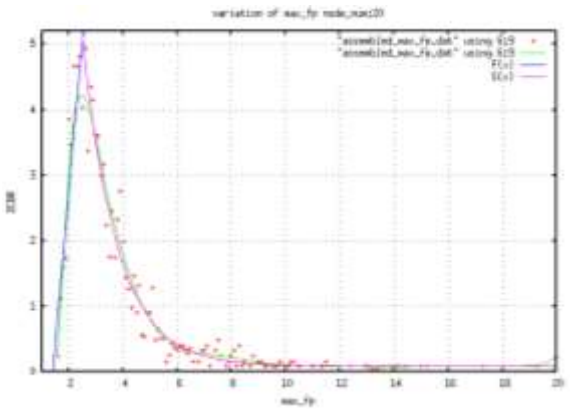

Figure 14: % CBR for Max_FP node_number 20

15. Node Number 21

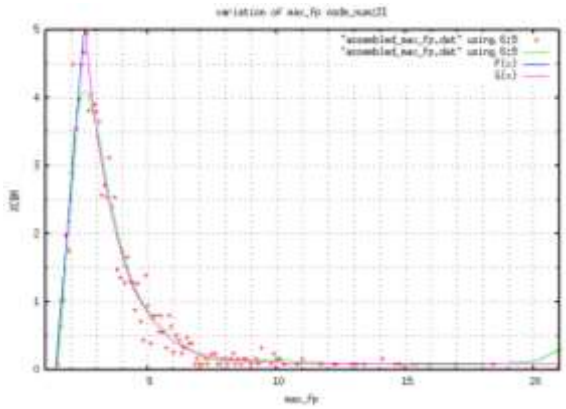

Figure 15: % CBR for Max_FP node_number 21

16. Node Number 22

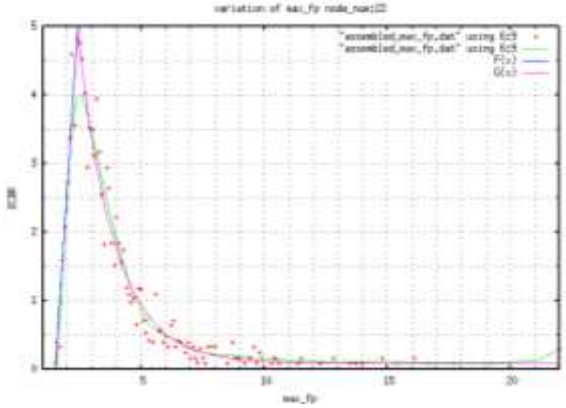

Figure 16: % CBR for Max_FP node_number 22

17. Node Number 23

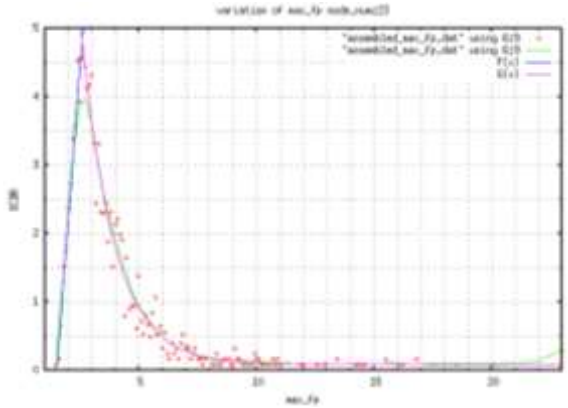

Figure 17: % CBR for Max_FP node_number 23

18. Node Number 24

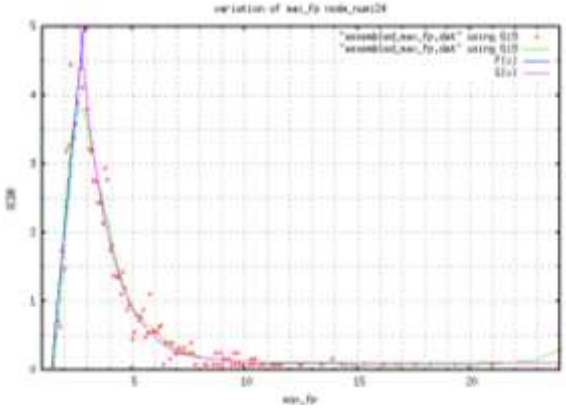

Figure 18: % CBR for Max_FP node_number 24

19. Node Number 25

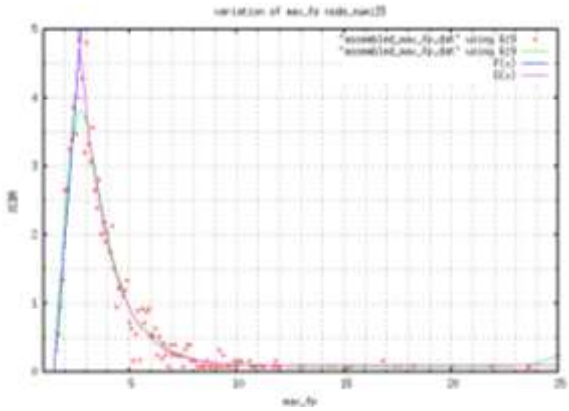

Figure 19: % CBR for Max_FP node_number 25

20. Node Number 26

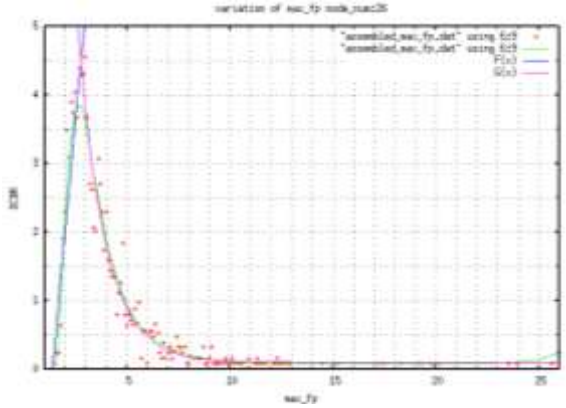

Figure 20: % CBR for Max_FP node_number 26

21. Node Number 27

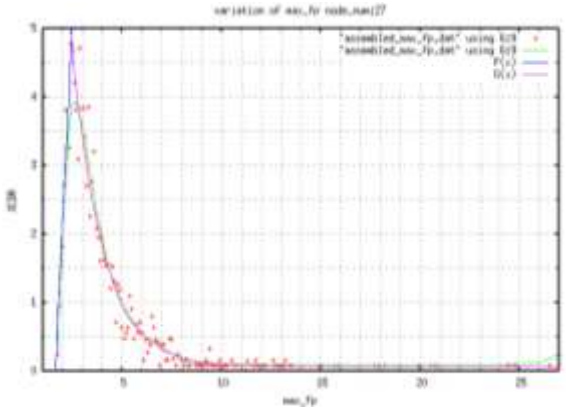

Figure 21: % CBR for Max_FP node_number 27

22. Node Number 28

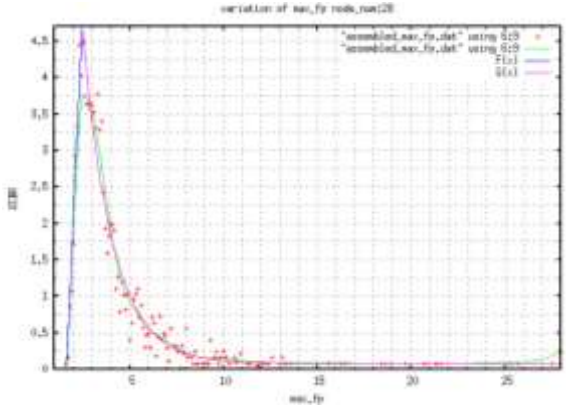

Figure 22: % CBR for Max_FP node_number 28

23. Node Number 29

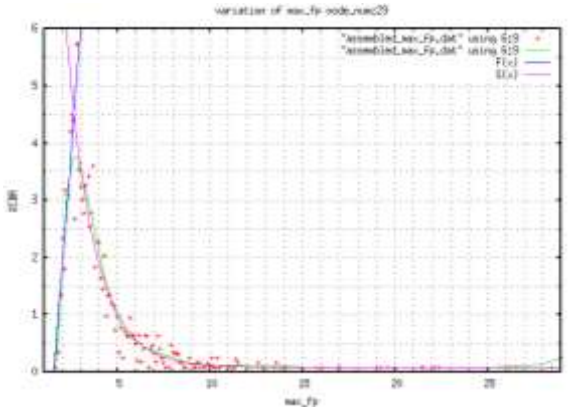

Figure 23: % CBR for Max_FP node_number 29

24. Node Number 30

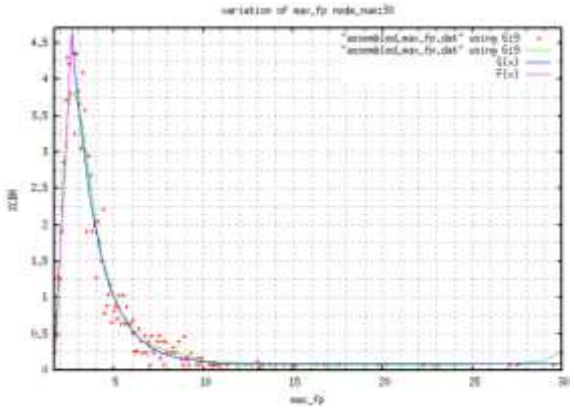

Figure 24: % CBR for Max_FP node_number 30

25. Node Number 31

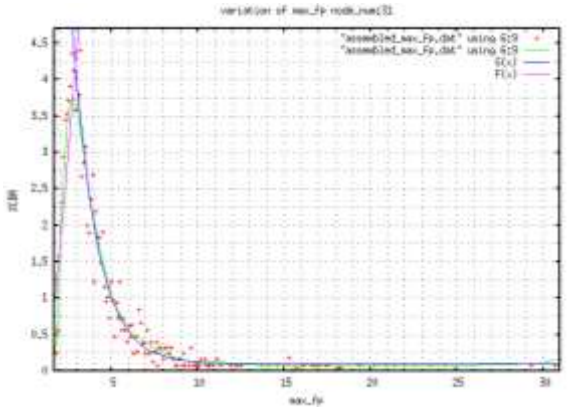

Figure 25: % CBR for Max_FP node_number 31

26. Node Number 32

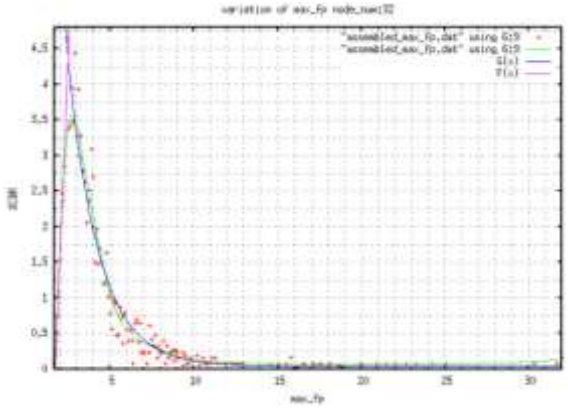

Figure 26: % CBR for Max_FP node_number 32

27. Node Number 33

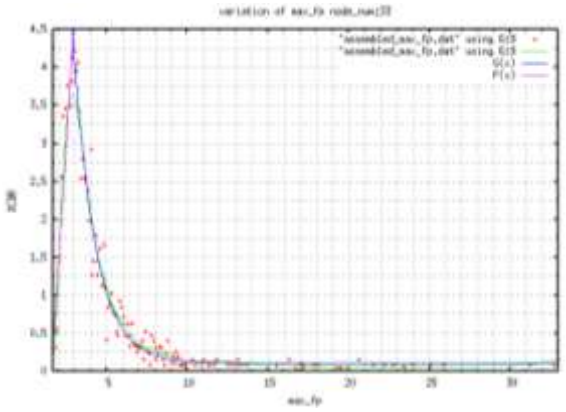

Figure 27: % CBR for Max_FP node_number 33

28. Node Number 34

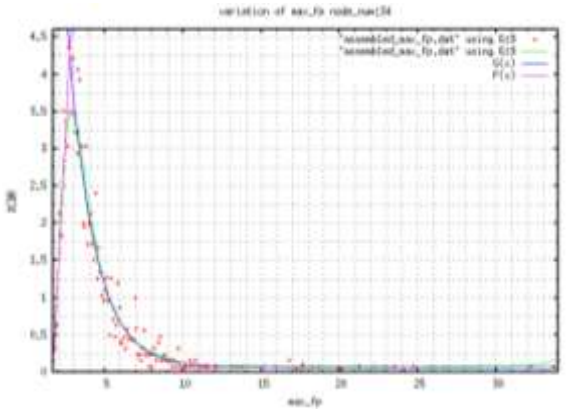

Figure 28: % CBR for Max_FP node_number 34

29. Node Number 35

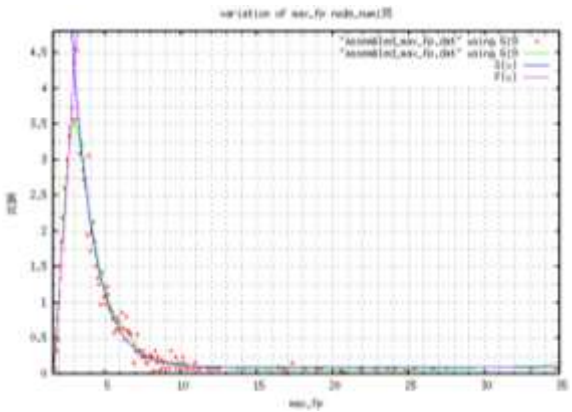

Figure 29: % CBR for Max_FP node_number 35

30. Node Number 36

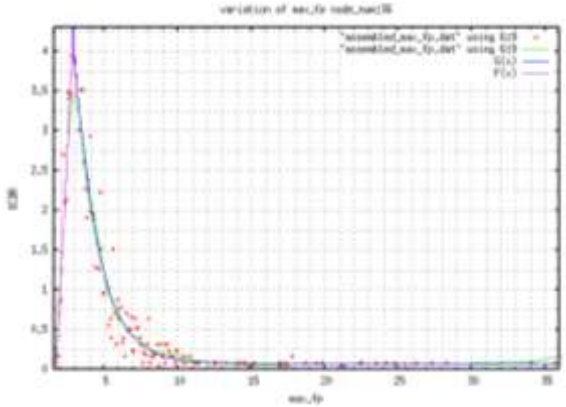

Figure 30: % CBR for Max_FP node_number 36

31. Node Number 37

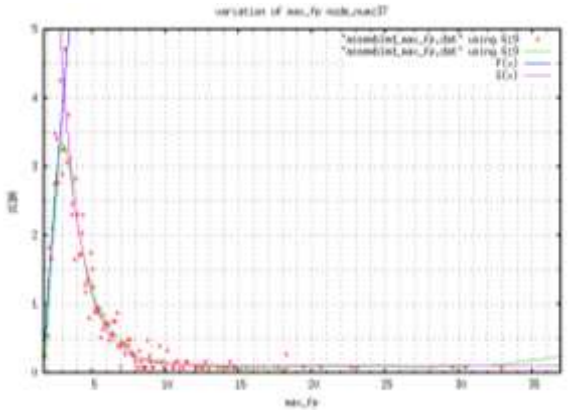

Figure 31: % CBR for Max_FP node_number 37

32. Node Number 38

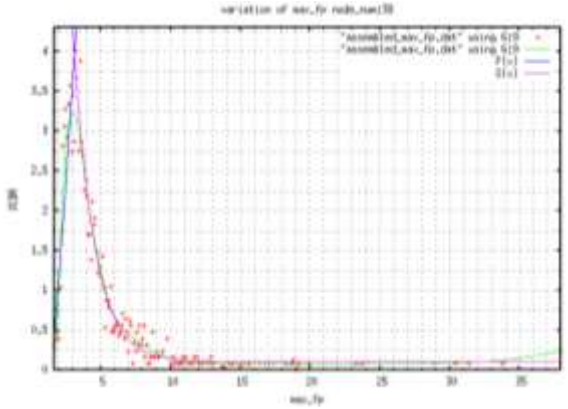

Figure 32: % CBR for Max_FP node_number 38

33. Node Number 39

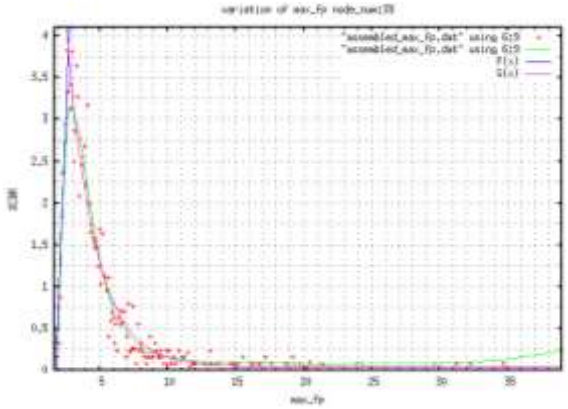

Figure 33: % CBR for Max_FP node_number 39

34. Node Number 40

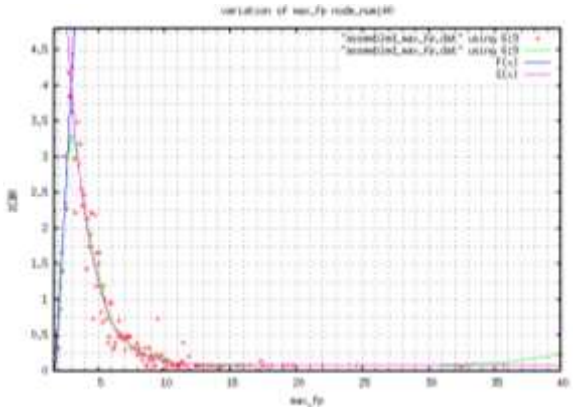

Figure 34: % CBR for Max_FP node_number 40

35. Node Number 41

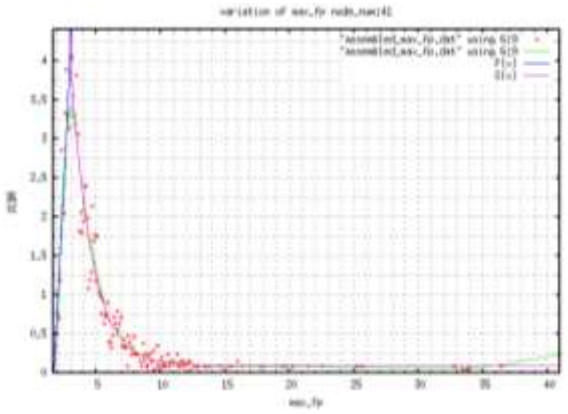

Figure 35: % CBR for Max_FP node_number 41

36. Node Number 42

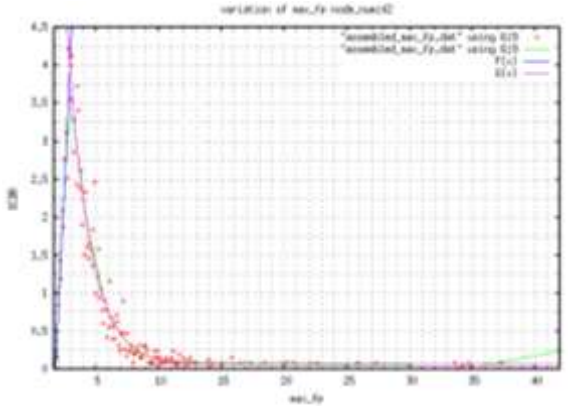

Figure 36: % CBR for Max_FP node_number 42

37. Node Number 43

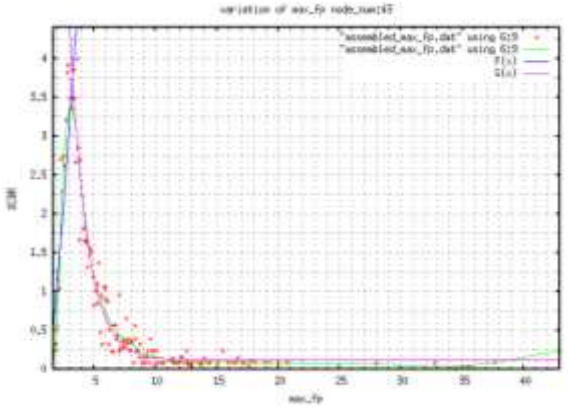

Figure 37: % CBR for Max_FP node_number 43

38. Node Number 44

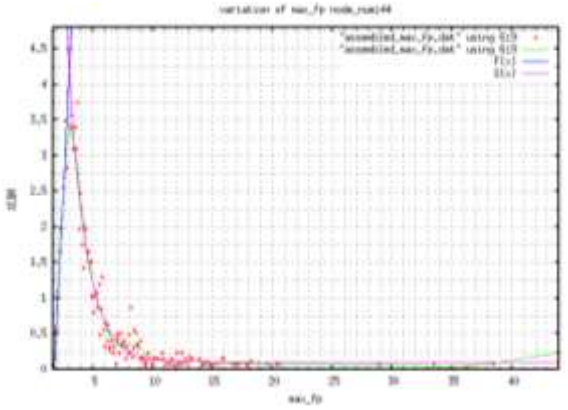

Figure 38: % CBR for Max_FP node_number 44

39. Node Number 45

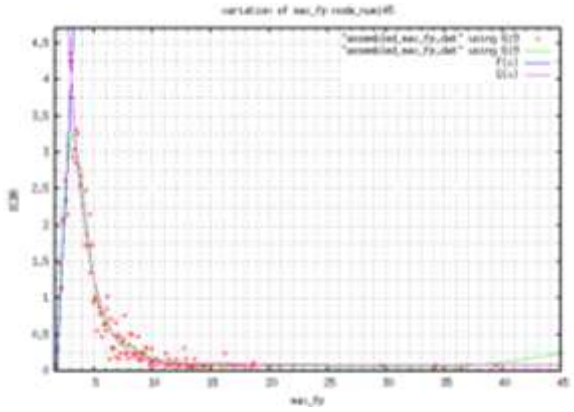

Figure 39: % CBR for Max_FP node_number 45

40. Node Number 46

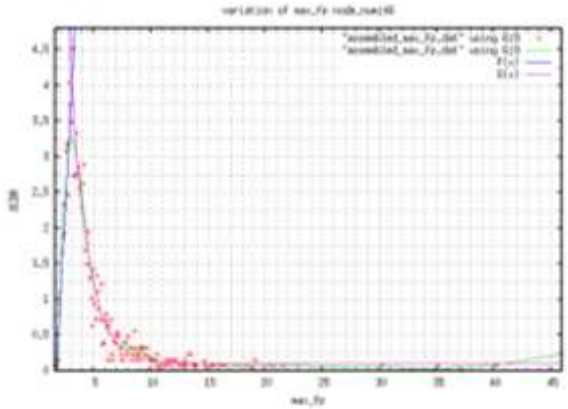

Figure 40: % CBR for Max_FP node_number 46

41. Node Number 47

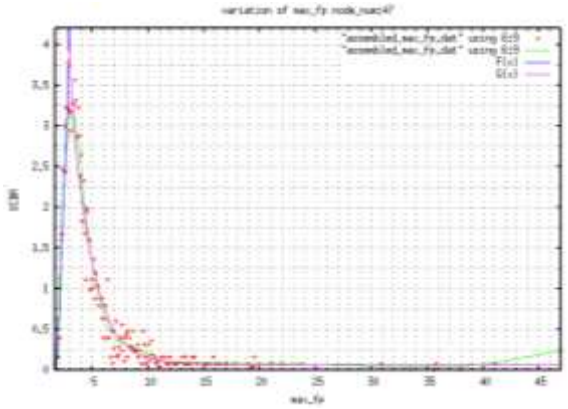

Figure 41: % CBR for Max_FP node_number 47

42. Node Number 48

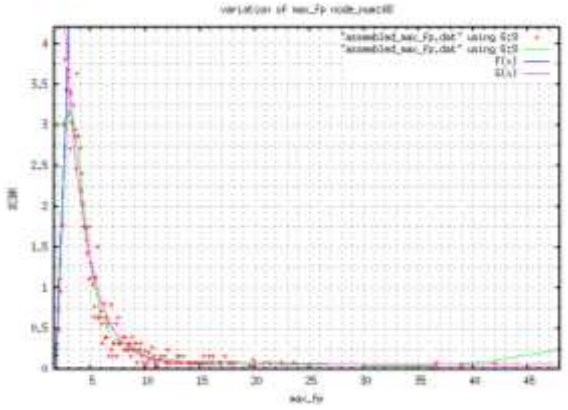

Figure 42: % CBR for Max_FP node_number 48

43. Node Number 49

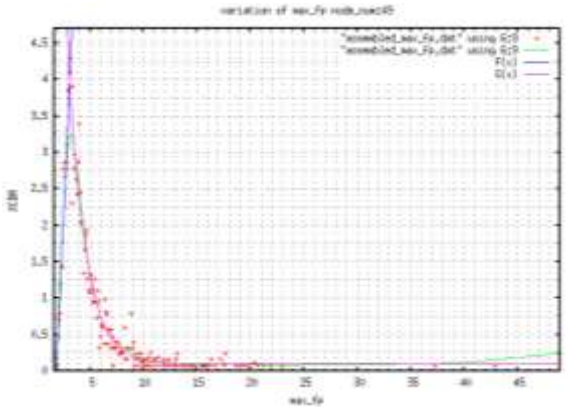

Figure 43: % CBR for Max_FP node_number 49

44. Node Number 50

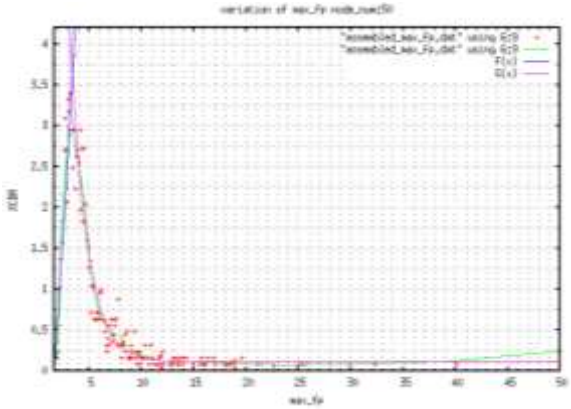

Figure 44: % CBR for Max_FP node_number 50

45. Node Number 51

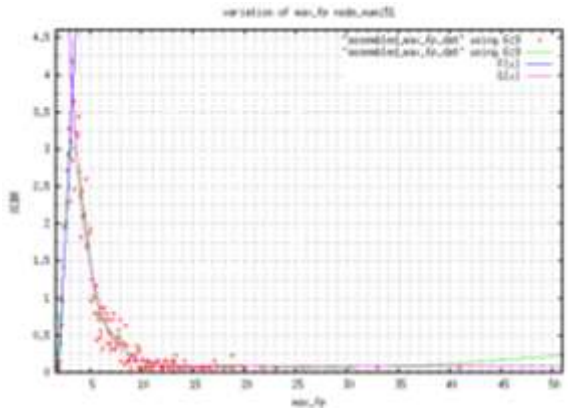

Figure 45: % CBR for Max_FP node_number 51

46. Node Number 52

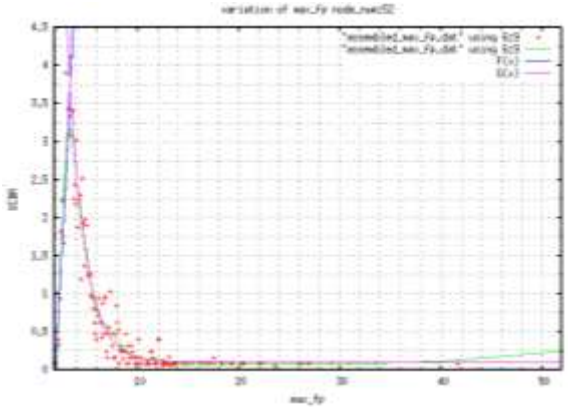

Figure 46: % CBR for Max_FP node_number 52

47. Node Number 53

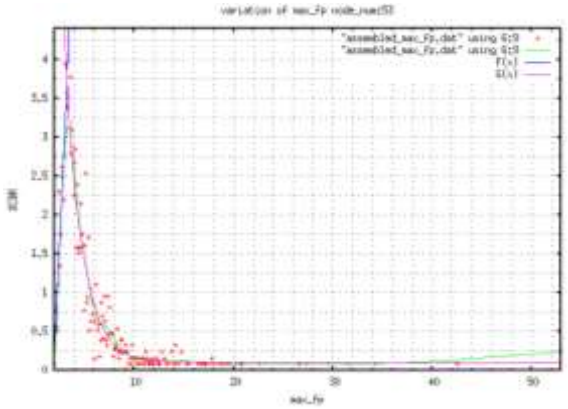

Figure 47: % CBR for Max_FP node_number 53

48. Node Number 54

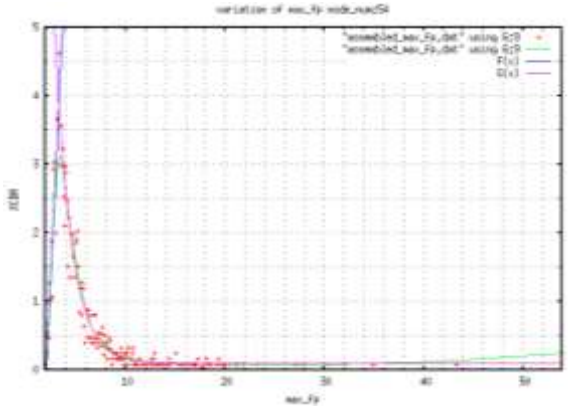

Figure 48: % CBR for Max_FP node_number 54

49. Node Number 55

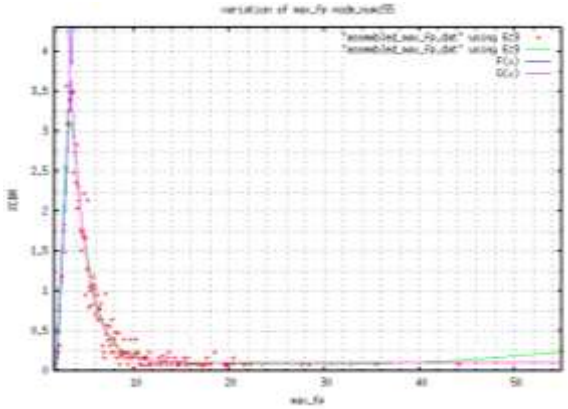

Figure 49: % CBR for Max_FP node_number 55

50. Node Number 56

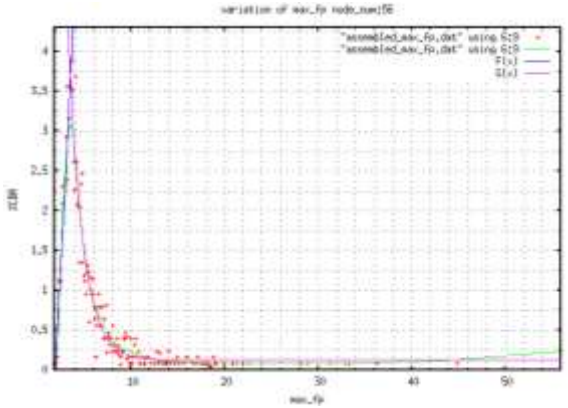

Figure 50: % CBR for Max_FP node_number 56

4. Conclusion.

This piece of research was aimed at studying trends of Fairness reached in ubicomp as concerns energy load distribution. This research extends from previous work [22, 23], in the sense that here, a second sub component of previously defined metric, ECFP [22], is studied. This second metric Max_FP, is also built over the BFEA and the experimental results presented here remain empirical based. The model put forward combines mostly the decreasing exponential model and partially the linear model. Again, previously stated assumptions [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_FP and its trend and reporting observations of certain critical values identified. Development of further metrics for studying Fairness in ubicomp remain desirable.

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