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

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***Abstract* – MANET transmission is one solution towards achieving routing in a ubicomp environment and if well designed, it can help in energy containment in ubicomp [60]. Application of location-aware transmission strategies may enhance energy management and conservation and hence remain a serious topic of research. MANET nodes adopt an automated collective load sharing transmission strategy. Hence MANET nodes are themselves the infrastructure nodes. Situations of completely equitable transmission (Fairness) load sharing will be very rarely reached. However, one criteria which can serve for a sender to decide to start a transmission or not will be: "How much Fairness is being reached by other senders in the ubicomp?" This feature will require either recording of previous sender's Fairness Proportion or an empirical predictability model (or both). Such questions remain determining factors of success of transmission in cooperative functionality.**

Previous studies in this direction were made [22] whereby the metrics BFEA and ECFP were devised. Development of two derived metrics followed: Min_FP [23] and Max_FP [24]. In this paper, another metric S_FP, derived from ECFP, is defined and its corresponding trends over varying node densities are presented.

This paper consolidates further the area of modelling for energy management in ubicomp for designers to assess Fairness characteristics and subsequently better shape future ubicomp technology. This paper is a follow-up of previous research [1-24].

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, S_FP- Sender Fairness Proportion, CBR- Constant Bit Rate.

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1. Introduction

Among factors affecting energy consumption in MAUC [21], distance coverages and MANET transmission remain two predominant factors. As mentioned in previous paper [24] transmission is distributed cooperatively among MANET route nodes. In that same paper [24], mention is made that situation of completely equitable distribution will be rarely reached but studies benchmarked against this situation remain important. Hence, devising appropriate corresponding metrics and knowledge of their trends remain desirable.

The work presented here, also is empirical and is built over previous work [22]. It follows from the statement in previous paper [23] that ECFP remain 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.

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

2. New Derived Metric – Sender Fairness Proportion.

Following definition of ECFP given in previous paper [22], Min_FP [23] and Max_FP [24], S_FP will simply be the value of ECFP reached by the sender for a CBR.

Usually, S_FP values have to be positive. It could also be 0 in the following cases:

i. The sender is extremely close to the next neighbour node.
ii. The sender node has connected to an infrastructure support whereby the node is charging up and giving data (via cables) to the support part for further transmission.

Broadly, four ranges of values for S_FP are identified:

i. S_FP value of 1 or very close to 1: It can imply that from the perspective of the sender, there is fair chances of getting good cooperation from the other nodes.

ii. S_FP of positive value significantly below 1: it can imply that the topographic nodes cooperation is high; the smaller than 1 the value, the higher the cooperation of topographic nodes.

iii. S_FP value moderately higher than 1: can depict fair contribution from infrastructure nodes.

iv. S_FP value erroneously higher than 1: it can depict that MANET topography has not been to the favour of the sender node and policies for handling such situations must be formulated such as delaying sending of next CBR to allow for MANET topography change.

In general, S_FP value closer to 1 will depict high chances of healthy MANET conditions whereby distribution of workload is quite uniform across nodes present in the topography.

Again, this metric, if appropriately gauged or even predicted, may also serve purposes elaborated in previous paper [21]. One specific purpose here is the decision from sender to initiate transmission or not, based on range in which the predicted S_FP value falls.

3. S_FP - Trend Assessment over Varying Node Numbers.

3.0 Major Observations.

In all the plots obtained, the minimum value of S_FP obtained has been at 0.0. Of course, this is possible because it is a rounded value varying from 0.0 to just less than 0.05.

The maximum value of S_FP obtained corresponds to the node number in the experiment.

In this set of plots obtained, a peak value of S_FP is observed between 0.0 and 1.0. 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 - 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→ S_FP Value at Peak Value, F→ value of parameter a, G→ value of parameter b, H→ value of parameter c, I→ reduced chi-square value of plot G(x), F→ Corresponding figure number.

A	B	C	D	E	F
7	10.589 569	0.249 433	0.637 602	0.5	3.079 694
8	6.890 44	0.397 62	0.780 63	0.6	1.945 15
9	4.465 61	1.194	0.192 197	0.9	1.592 3
10	2.511 34	3.800 45	0.174 378	0.7	1.920 34
11	4.269 84	3.655 56	0.126 136	0.5	1.131 03
12	3.163 75	4.125 6	0.138 568	0.5	2.321 53
13	8.492 06	2.809 52	0.268 519	0.4	2.002 42
14	7.492 06	3.365 08	0.108 944	0.4	1.033 12
15	6.825 4	3.515 87	0.194 13	0.4	2.275 16
16	7.126 98	3.341 27	0.954 623	0.5	2.209 52
17	6.301 59	3.747 62	0.437 045	0.5	2.199 68
18	7.222 22	3.576 19	0.633 266	0.5	2.200 16
19	7.841 27	3.460 32	0.328 983	0.5	2.192 08
20	7.936 51	3.514 29	0.288 503	0.5	2.189 85
21	6.968 25	3.830 16	0.427 135	0.5	2.185 43
22	6.238 1	4.179 37	0.354 237	0.5	2.181 5
23	6.761 9	4.130 16	0.329 588	0.5	2.17891
24	7.285 71	4.093 65	0.301 092	0.5	2.173 21
25	8.158 73	3.876 19	0.082 103	0.5	2.172 73
26	11.063 5	2.750 79	0.744 629	0.4	2.191 12
27	10.603 2	2.974 6	0.491 005	0.5	2.190 18
28	10.587 3	3.173 02	1.375 42	0.5	2.186 9
29	8.634 92	3.542 86	2.533 94	0.4	2.189 04
30	10.095 2	3.231 75	3.271 15	0.4	2.185 88
31	12.777 8	2.338 1	3.156 82	0.4	2.194 21
32	12.936 5	2.385 71	1.442 87	0.4	2.187 29
33	12.968 3	2.487 3	2.028 21	0.4	2.181 79
34	12.873	2.541 27	2.154 96	0.4	2.182 55
35	13.904 8	2.2	1.522 94	0.4	2.187 2
36	11.730 2	2.712 7	1.701 95	0.4	2.190 81
37	11.319 3	2.954 44	3.538 46	0.4	2.175 69
38	11.428 6	2.965 08	2.928 93	0.4	2.175 74
39	11.698 4	2.846 03	3.136 67	0.4	2.176 46
40	11.761 9	2.753 97	3.365 64	0.4	2.174 91
41	14.111 1	2.185 71	2.087 6	0.4	2.172 04
42	13.063 5	2.446 03	1.865 89	0.4	2.173 4
43	13.936 5	2.136 51	1.392 42	0.4	2.177 08
44	13.516 5	2.250 64	1.561 39	0.4	2.175 59
45	12.158 7	2.622 22	3.266 52	0.4	2.173 49
46	11.238 1	2.8	2.038 33	0.4	2.178 19
47	13.968 3	2.161 9	1.345 33	0.4	2.172 02
48	13.031 7	2.512 7	2.709 76	0.4	2.166 95
49	14.047 6	2.242 86	2.782 42	0.4	2.164 11
50	13.523 8	2.726 98	1.101 6	0.4	2.159 99
51	13.396 8	2.765 08	0.765 063	0.5	2.160 19
52	14.317 5	2.631 75	0.500 109	0.5	2.158 81
53	12.523 8	3.001 59	0.554 691	0.5	2.163 08
54	12.285 7	3.092 06	0.523 591	0.4	2.159 45
55	12.079 4	3.185 71	0.759 881	0.4	2.157 07
56	11.920 6	3.207 94	0.573 873	0.5	2.161 59

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

A	G	H	I	J
7	-0.746 475 5	1.501 816 0	0.165 231	1
8	-0.698 893	1.967 6	0.124 321	2
9	-0.889 544	2.151 02	0.126 68	3
10	-0.986 083	1.757 75	0.060 821 3	4
11	-0.939 24	2.299 78	0.074 541 7	5
12	-0.921 462	1.525 92	0.086 310 9	6
13	-0.942 288	1.685 07	0.103 038	7
14	-0.943 906	2.368 41	0.124 363	8
15	-1.028 32	1.502	0.089 695 2	9
16	-1.103 93	1.520 87	0.070 194 4	10
17	-1.148 55	1.498 5	0.071 771	11
18	-1.122 86	1.499 92	0.038 775 4	12
19	-1.179 06	1.480 97	0.052 865 8	13
20	-1.190 45	1.475 75	0.039 335 7	14
21	-1.280 81	1.462 96	0.066 702 7	15
22	-1.278	1.454 87	0.040 988 2	16
23	-1.30242	1.448 71	0.080 096 2	17

24	-1.334 34	1.434 64	0.054 011 2	18
25	-1.310 4	1.434 66	0.065 133 7	19
26	-1.197 57	1.478 72	0.063 402 5	20
27	-1.220 96	1.476 05	0.096 735 8	21
28	-1.220 7	1.468 88	0.093 890 4	22
29	-1.187	1.474 46	0.060 983 7	23
30	-1.209 22	1.466 89	0.048 024 5	24
31	-1.150 14	1.486 48	0.078 356 4	25
32	-1.236 12	1.469 13	0.070 430 8	26
33	-1.263 44	1.456 01	0.072 883 3	27
34	-1.258 69	1.458 04	0.078 455 8	28
35	-1.245 12	1.468 76	0.072 076 7	29
36	-1.211 18	1.477 83	0.100 338	30
37	-1.347 8	1.440 6	0.077 813 2	31
38	-1.349 21	1.440 94	0.050 534 3	32
39	-1.348 77	1.442 92	0.072 857 6	33
40	-1.379 39	1.438 11	0.101 955	34
41	-1.421 74	1.430 33	0.052 731 4	35
42	-1.399 81	1.435 03	0.046 057 1	36
43	-1.376 79	1.443 88	0.050 762 8	37
44	-1.400 85	1.439 24	0.049 385 8	38
45	-1.409 66	1.433 8	0.132 47	39
46	-1.369 74	1.446 32	0.085 354 9	40
47	-1.432 43	1.429 62	0.049 126 6	41
48	-1.459 51	1.416 64	0.074 021 1	42
49	-1.487 06	1.408 14	0.118 775	43
50	-1.447 57	1.401 92	0.083 946 7	44
51	-1.446 44	1.402 55	0.121 602	45
52	-1.454 22	1.399 05	0.135 121	46
53	-1.416 83	1.410 58	0.124 408	47
54	-1.455 8	1.400 99	0.141 265	48
55	-1.460 46	1.395 37	0.147 395	49
56	-1.416 23	1.407 66	0.109 439	50

Table 1(b): summary of results for S_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

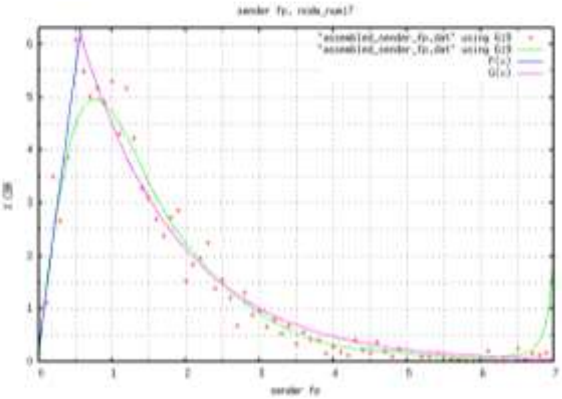

Figure 1: % CBR for S_FP node_number 7

2. Node Number 8

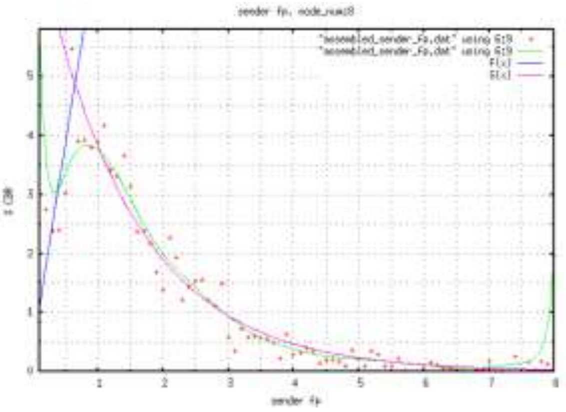

Figure 2: % CBR for S_FP node_number 8

3. Node Number 9

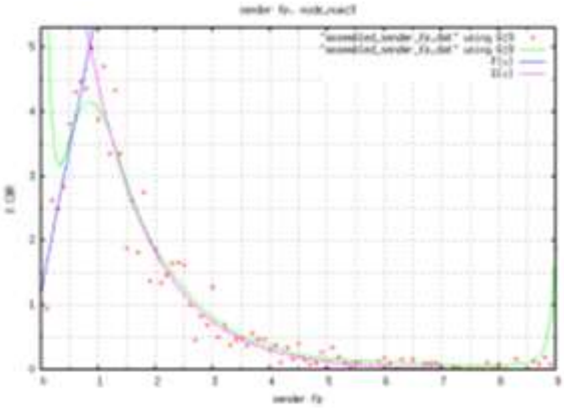

Figure 3: % CBR for S_FP node_number 9

4. Node Number 10

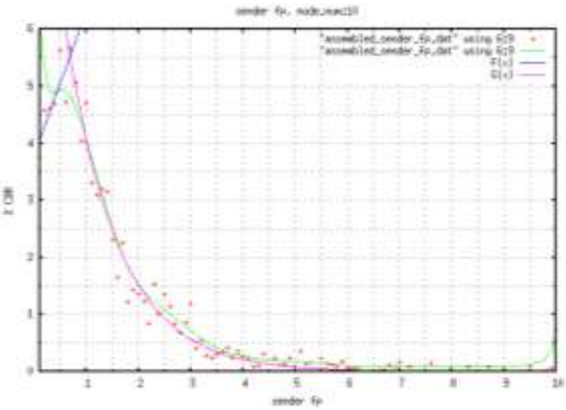

Figure 4: % CBR for S_FP node_number 10

5. Node Number 11

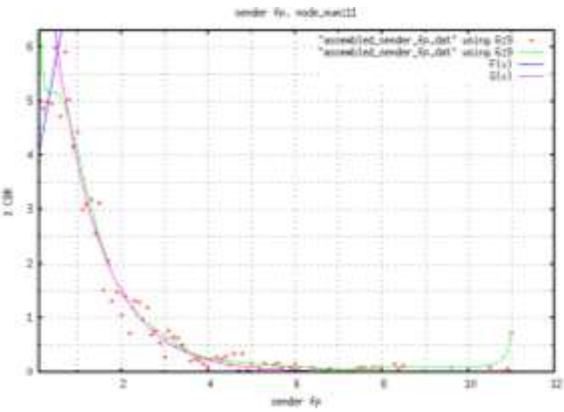

Figure 5: % CBR for S_FP node_number 11

6. Node Number 12

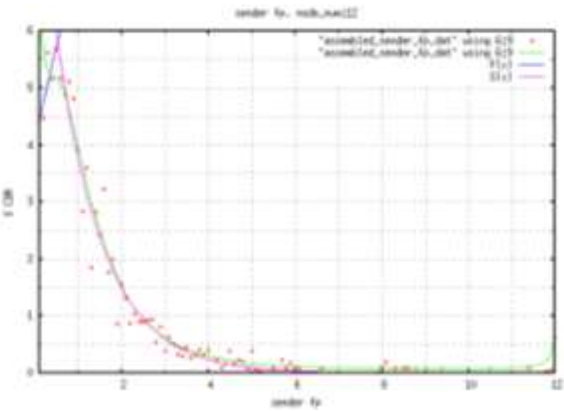

Figure 6: % CBR for S_FP node_number 12

7. Node Number 13

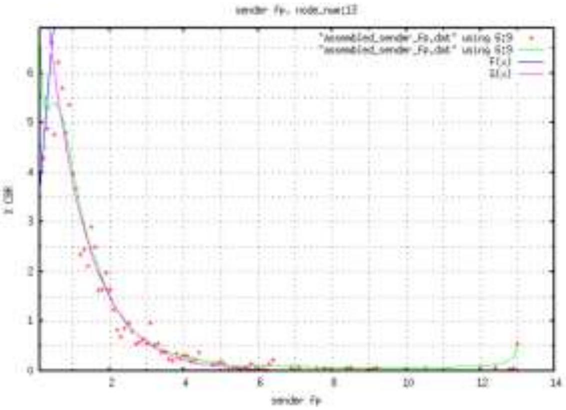

Figure 7: % CBR for S_FP node_number 13

8. Node Number 14

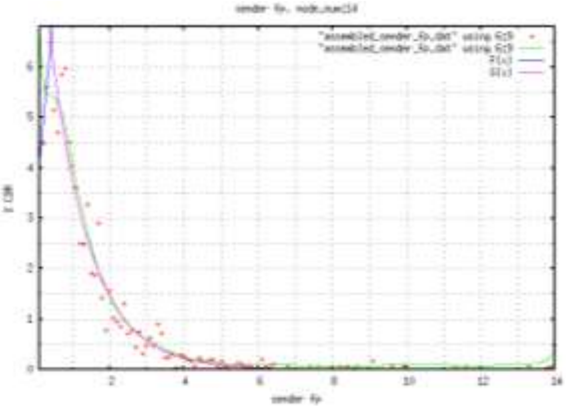

Figure 8: % CBR for S_FP node_number 14

9. Node Number 15

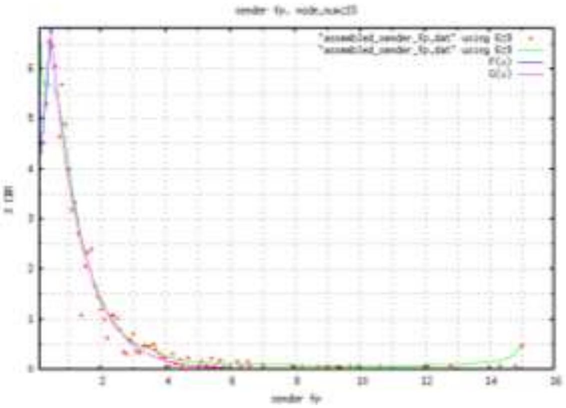

Figure 9: % CBR for S_FP node_number 15

10. Node Number 16

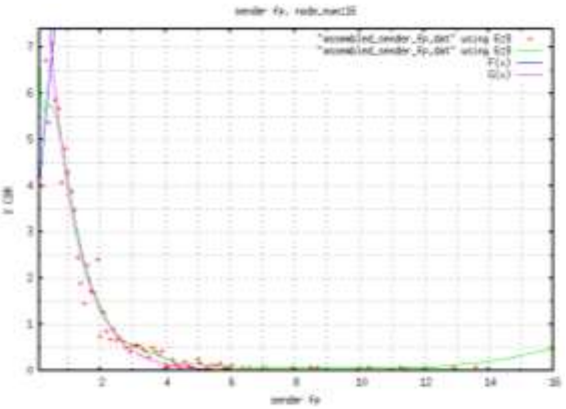

Figure 10: % CBR for S_FP node_number 16

11. Node Number 17

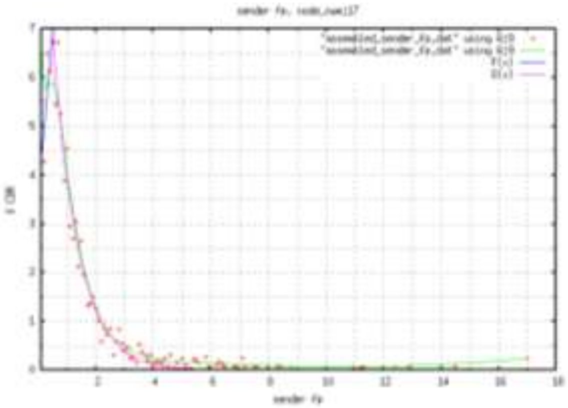

Figure 11: % CBR for S_FP node_number 17

12. Node Number 18

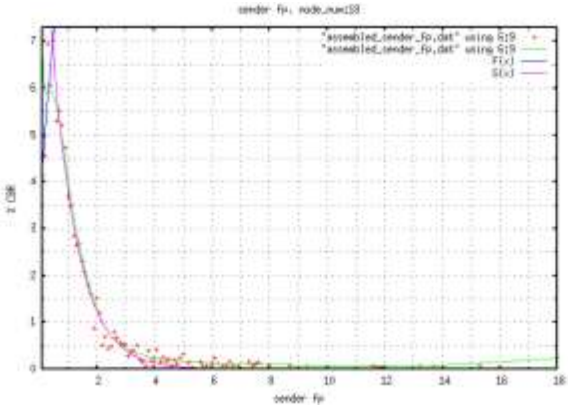

Figure 12: % CBR for S_FP node_number 18

13. Node Number 19

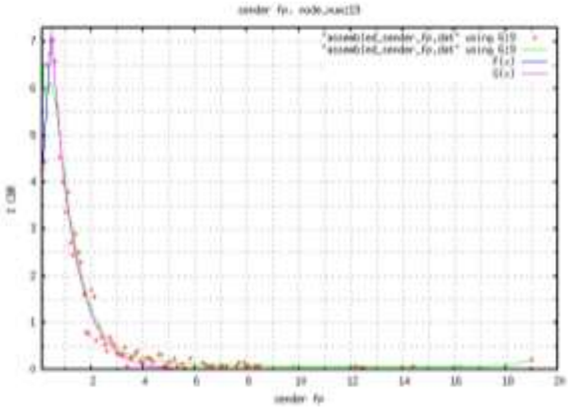

Figure 13: % CBR for S_FP node_number 19

14. Node Number 20

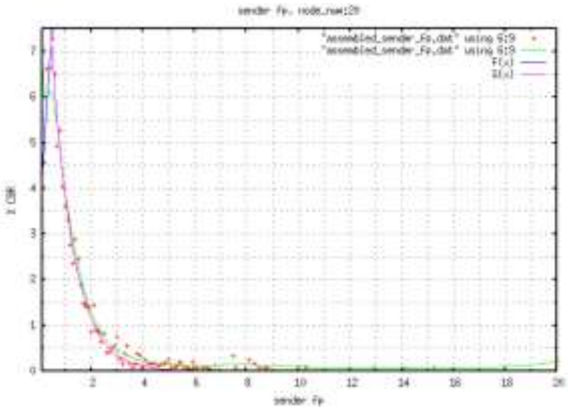

Figure 14: % CBR for S_FP node_number 20

15. Node Number 21

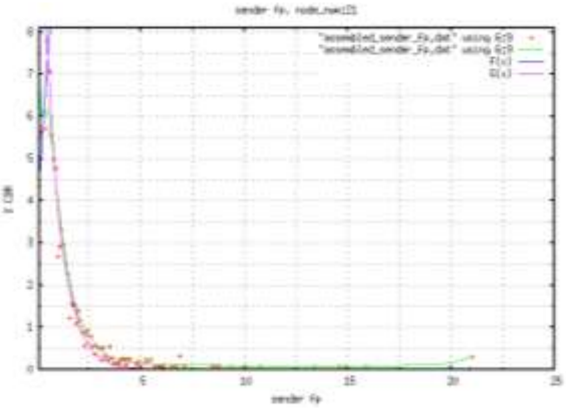

Figure 15: % CBR for S_FP node_number 21

16. Node Number 22

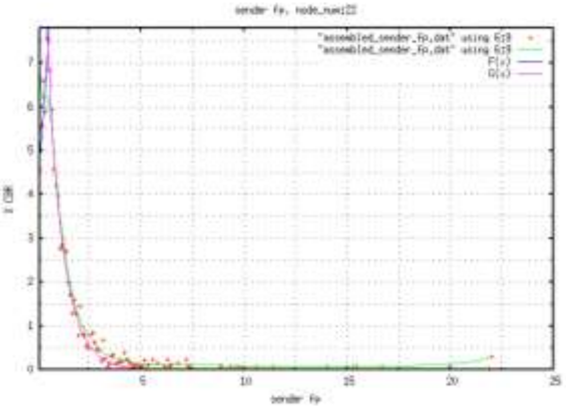

Figure 16: % CBR for S_FP node_number 22

17. Node Number 23

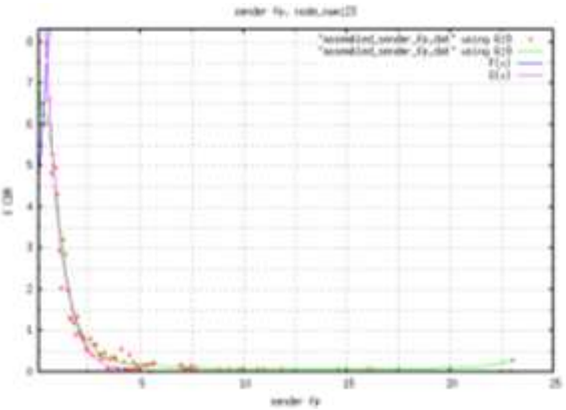

Figure 17: % CBR for S_FP node_number 23

18. Node Number 24

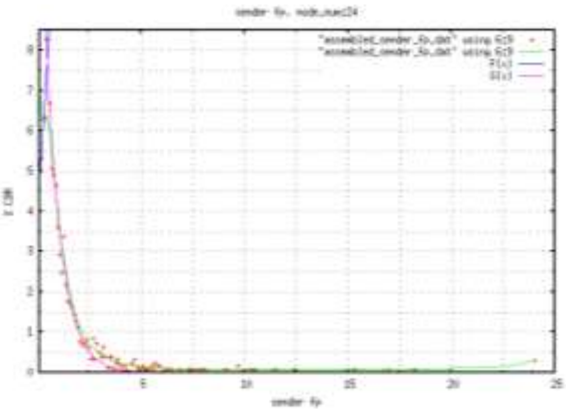

Figure 18: % CBR for S_FP node_number 24

19. Node Number 25

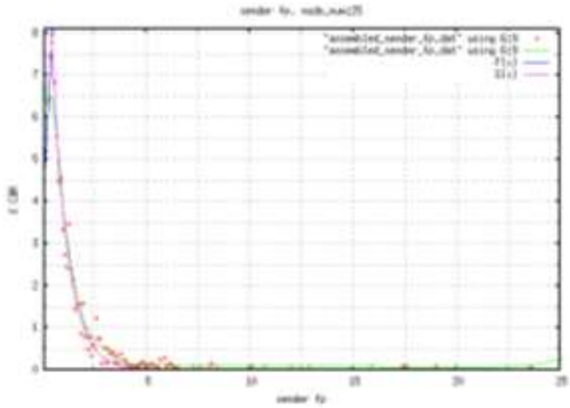

Figure 19: % CBR for S_FP node_number 25

20. Node Number 26

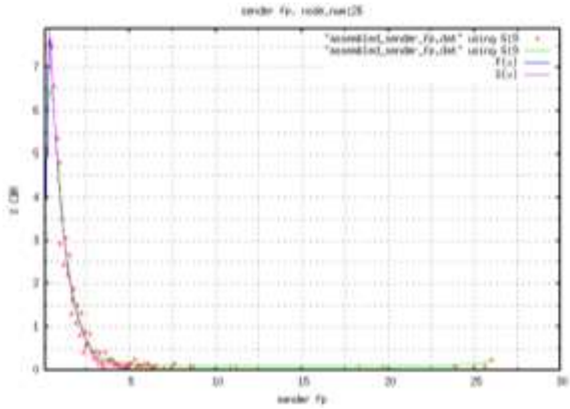

Figure 20: % CBR for S_FP node_number 26

21. Node Number 27

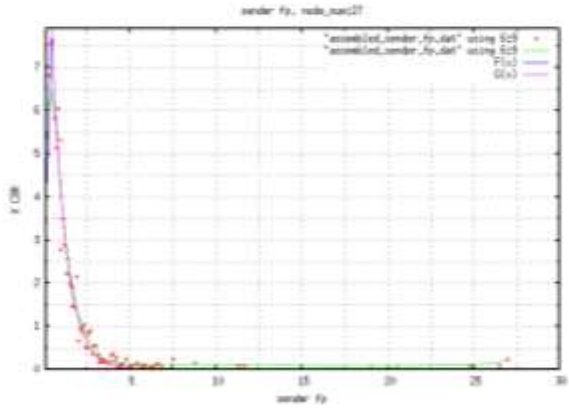

Figure 21: % CBR for S_FP node_number 27

22. Node Number 28

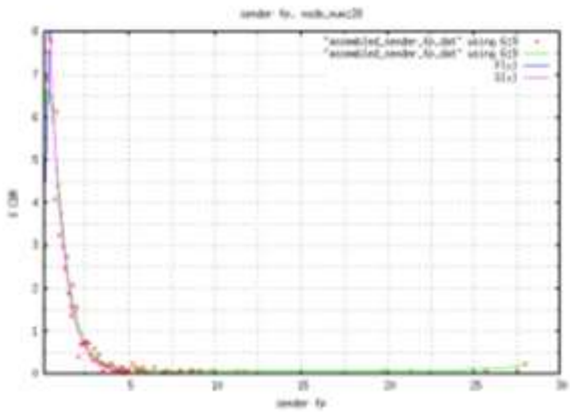

Figure 22: % CBR for S_FP node_number 28

23. Node Number 29

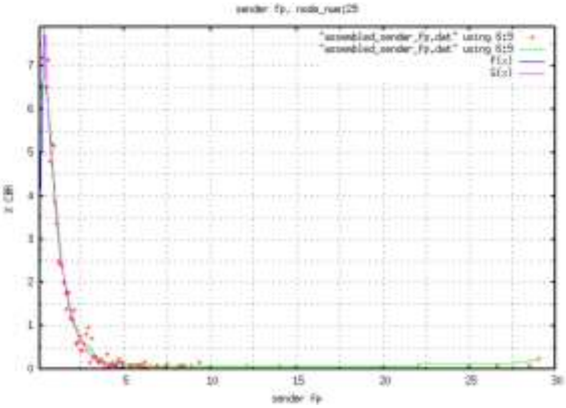

Figure 23: % CBR for S_FP node_number 29

24. Node Number 30

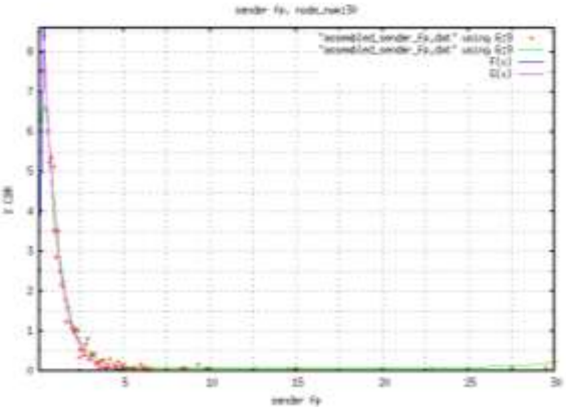

Figure 24: % CBR for S_FP node_number 30

25. Node Number 31

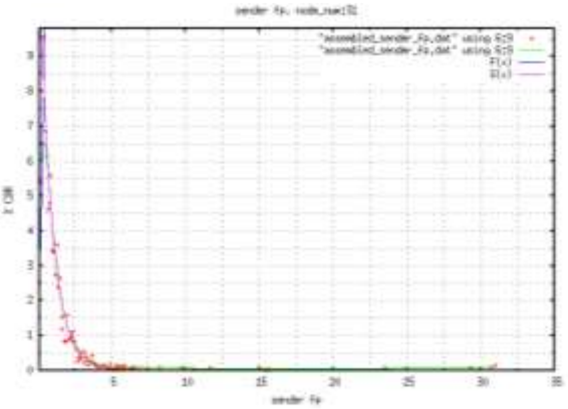

Figure 25: % CBR for S_FP node_number 31

26. Node Number 32

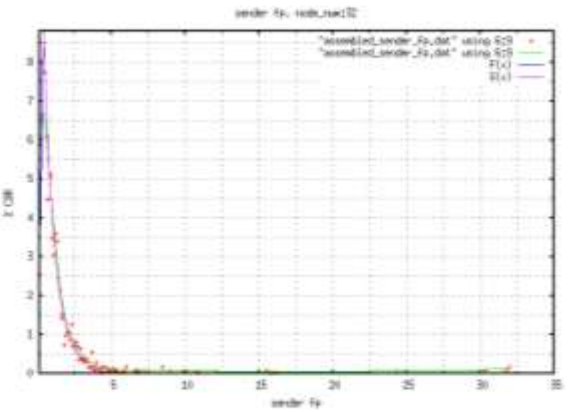

Figure 26: % CBR for S_FP node_number 32

27. Node Number 33

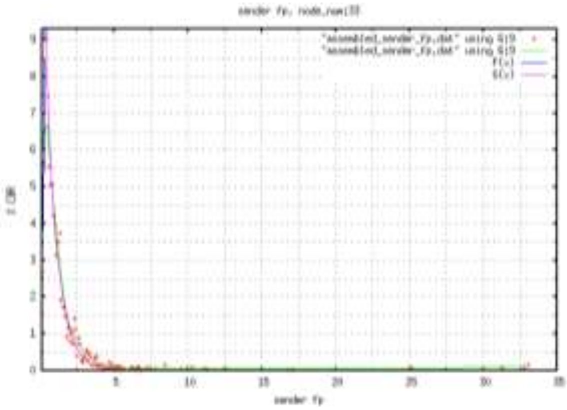

Figure 27: % CBR for S_FP node_number 33

28. Node Number 34

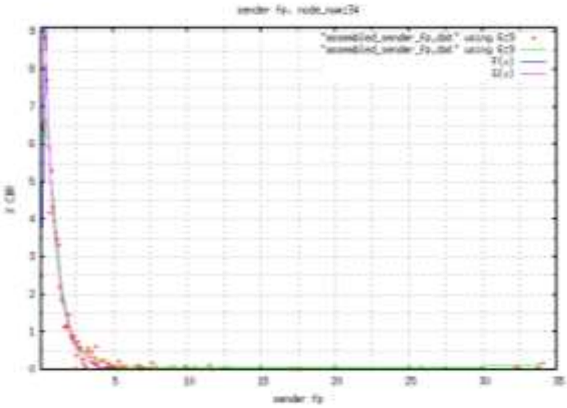

Figure 28: % CBR for S_FP node_number 34

29. Node Number 35

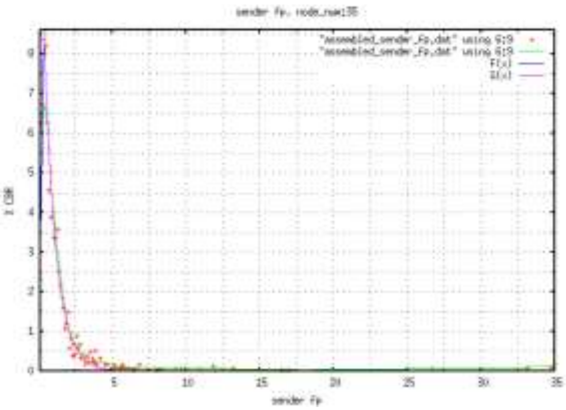

Figure 29: % CBR for S_FP node_number 35

30. Node Number 36

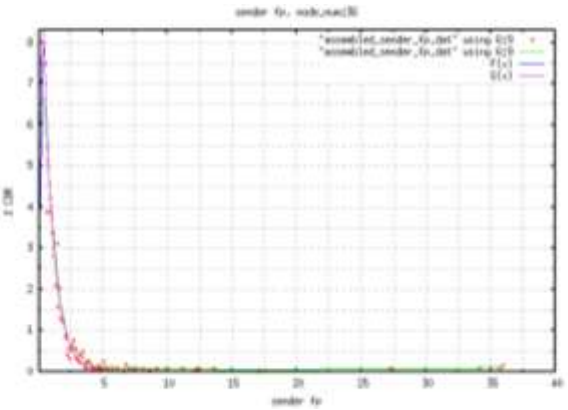

Figure 30: % CBR for S_FP node_number 36

31. Node Number 37

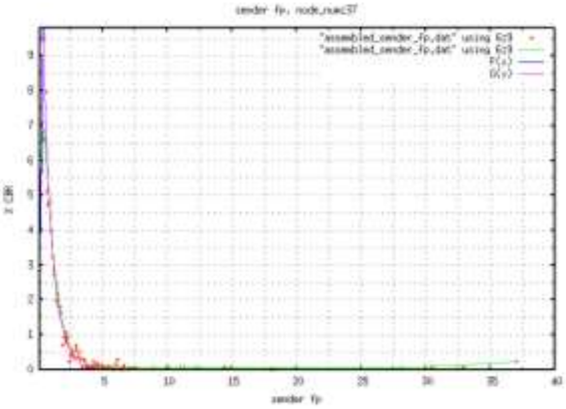

Figure 31: % CBR for S_FP node_number 37

32. Node Number 38

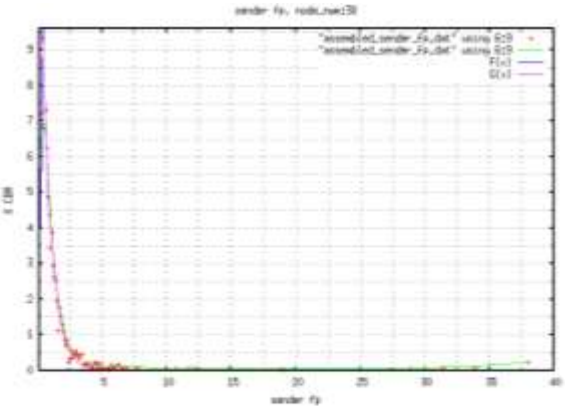

Figure 32: % CBR for S_FP node_number 38

33. Node Number 39

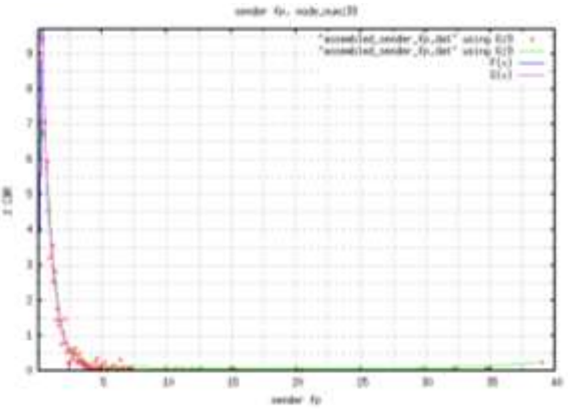

Figure 33: % CBR for S_FP node_number 39

34. Node Number 40

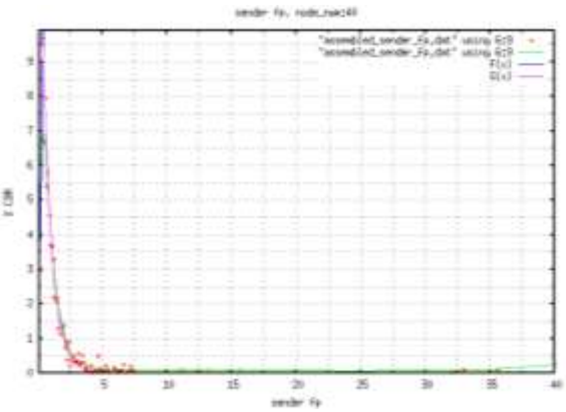

Figure 34: % CBR for S_FP node_number 40

35. Node Number 41

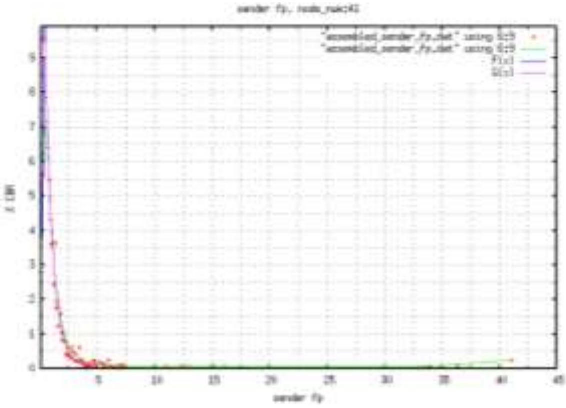

Figure 35: % CBR for S_FP node_number 41

36. Node Number 42

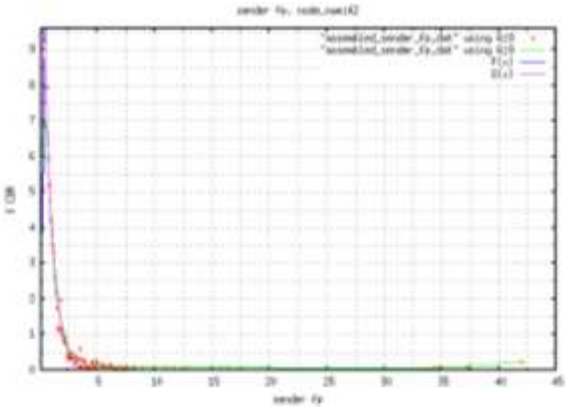

Figure 36: % CBR for S_FP node_number 42

37. Node Number 43

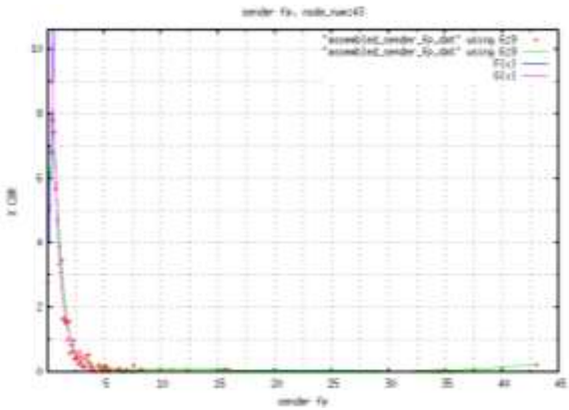

Figure 37: % CBR for S_FP node_number 43

38. Node Number 44

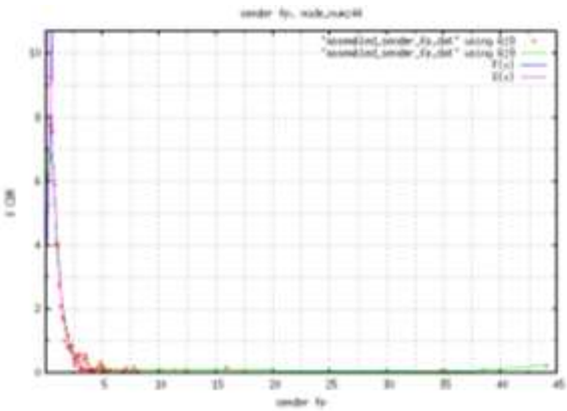

Figure 38: % CBR for S_FP node_number 44

39. Node Number 45

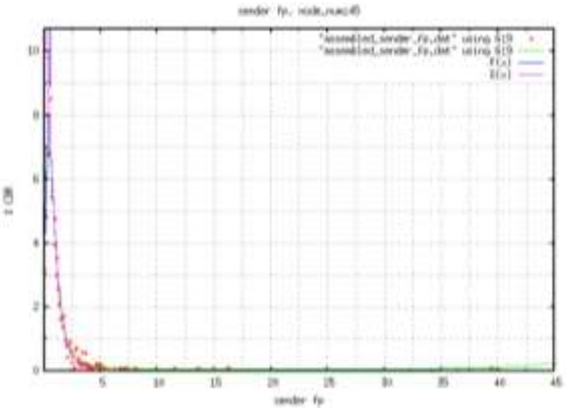

Figure 39: % CBR for S_FP node_number 45

40. Node Number 46

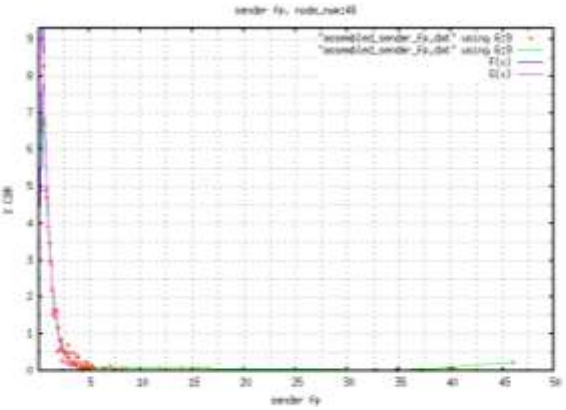

Figure 40: % CBR for S_FP node_number 46

41. Node Number 47

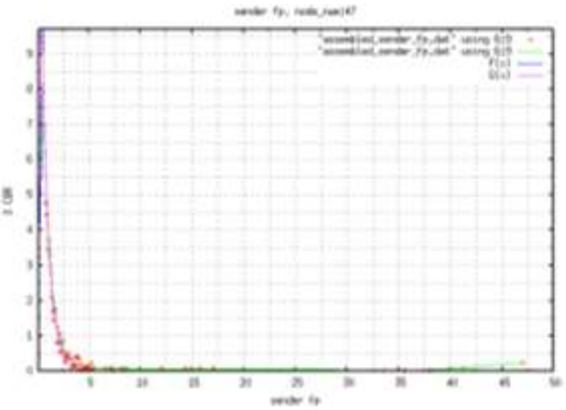

Figure 41: % CBR for S_FP node_number 47

42. Node Number 48

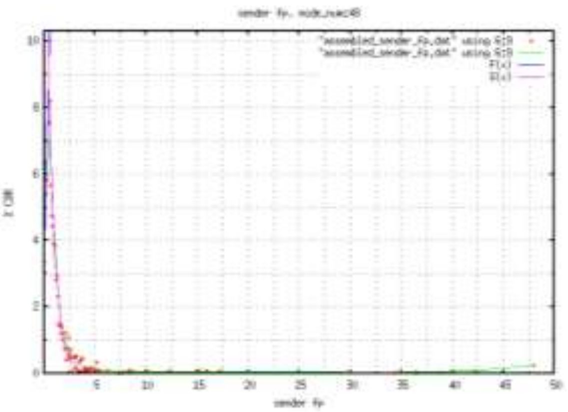

Figure 42: % CBR for S_FP node_number 48

43. Node Number 49

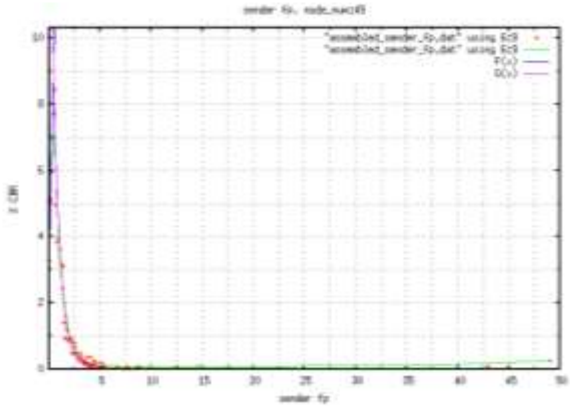

Figure 43: % CBR for S_FP node_number 49

44. Node Number 50

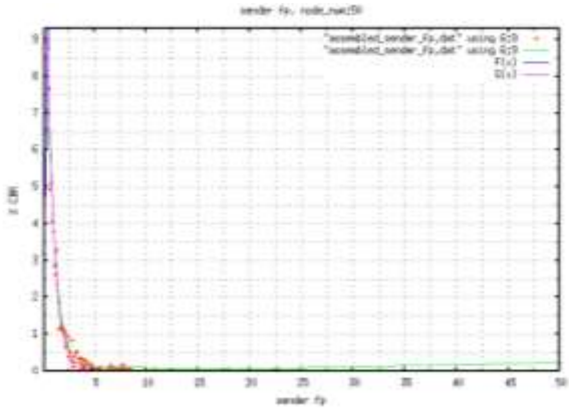

Figure 44: % CBR for S_FP node_number 50

45. Node Number 51

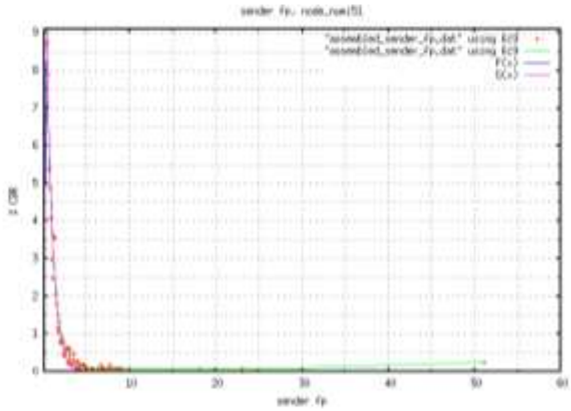

Figure 45: % CBR for S_FP node_number 51

46. Node Number 52

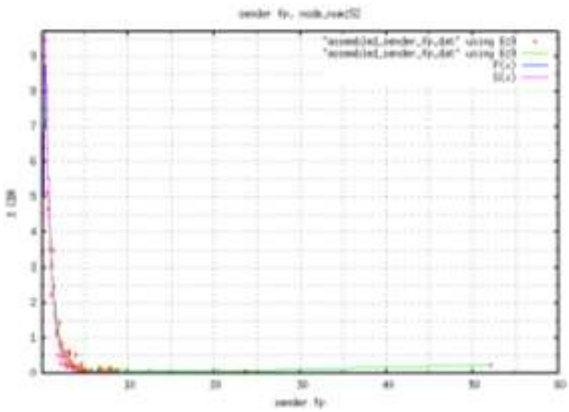

Figure 46: % CBR for S_FP node_number 52

47. Node Number 53

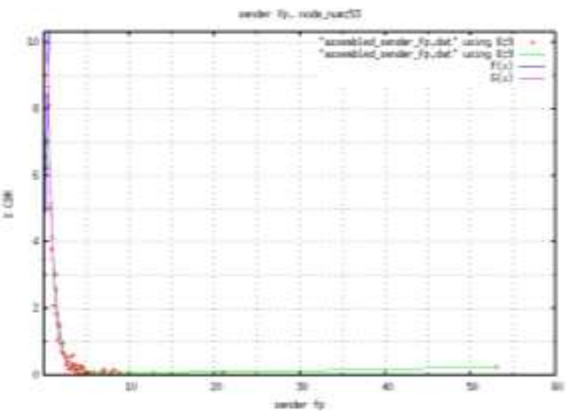

Figure 47: % CBR for S_FP node_number 53

48. Node Number 54

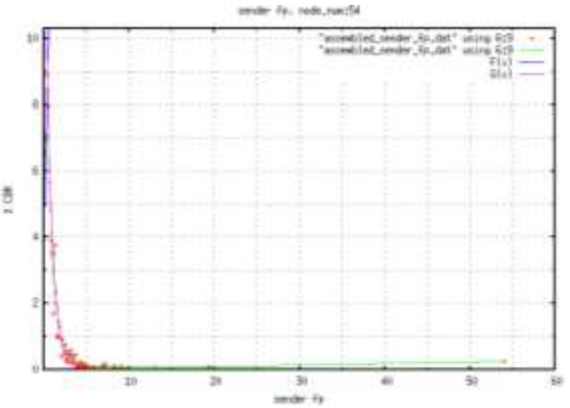

Figure 48: % CBR for S_FP node_number 54

49. Node Number 55

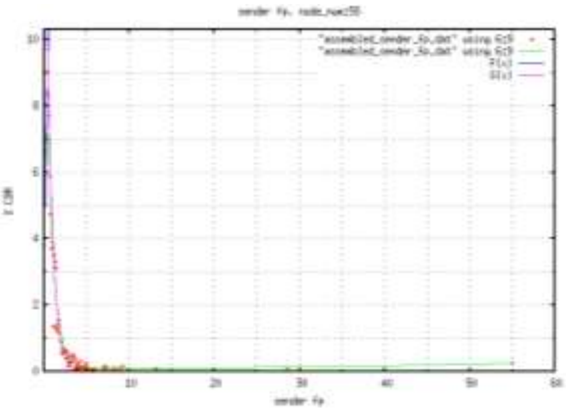

Figure 49: % CBR for S_FP node_number 55

50. Node Number 56

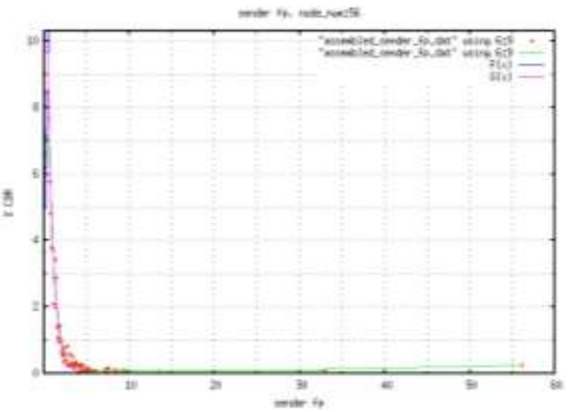

Figure 50: % CBR for S_FP node_number 56

4. Conclusion.

This piece of research was aimed at studying trends of Fairness reached by sender node in ubicomp as concerns energy load distribution. This work extends from previous work [22-24]. More precisely here, a third sub-component of a previously defined metric, S_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 S_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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