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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

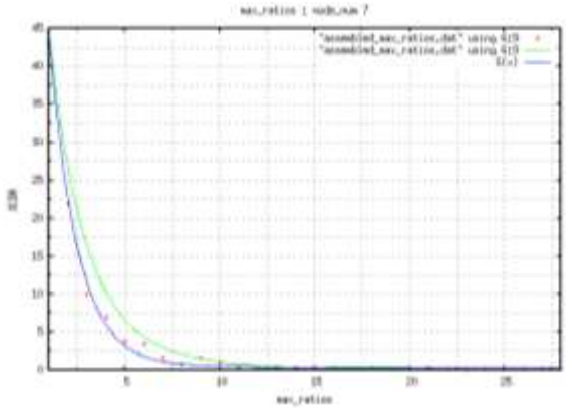

Figure 1: % cbr for Max_R node_number 7

2. Node Number 8

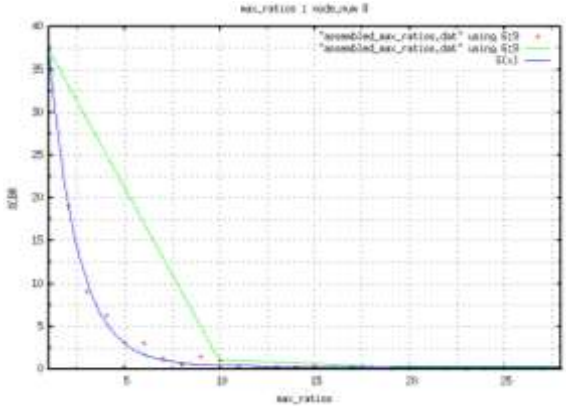

Figure 2: % cbr for Max_R node_number 8

3. Node Number 9

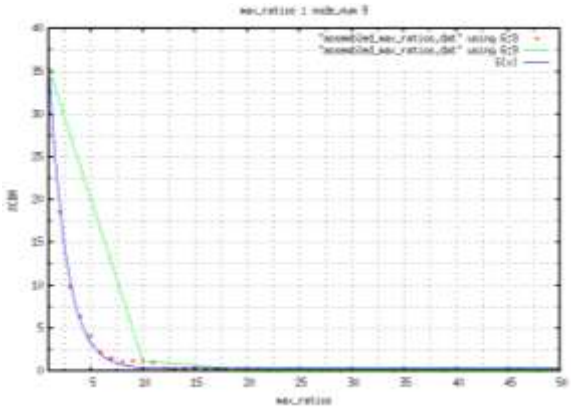

Figure 3: % cbr for Max_R node_number 9

4. Node Number 10

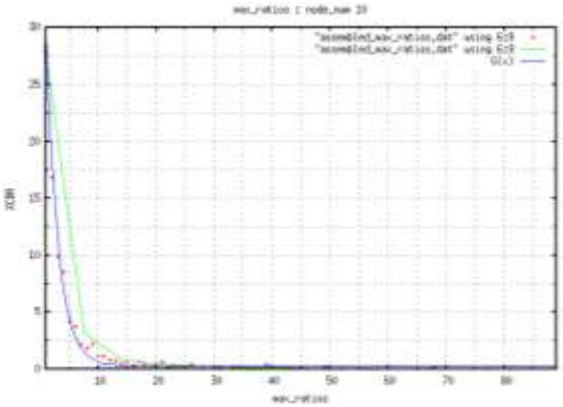

Figure 4: % cbr for Max_R node_number 10

5. Node Number 11

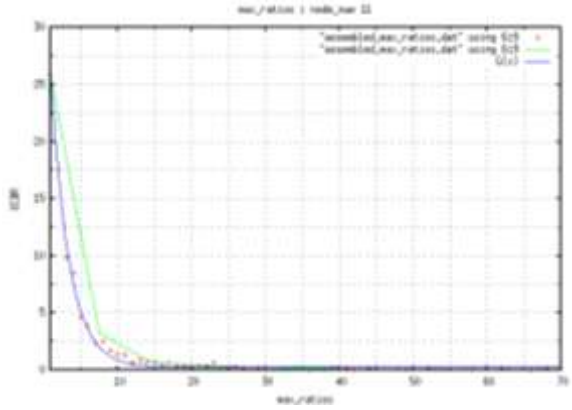

Figure 5: % cbr for Max_R node_number 11

6. Node Number 12

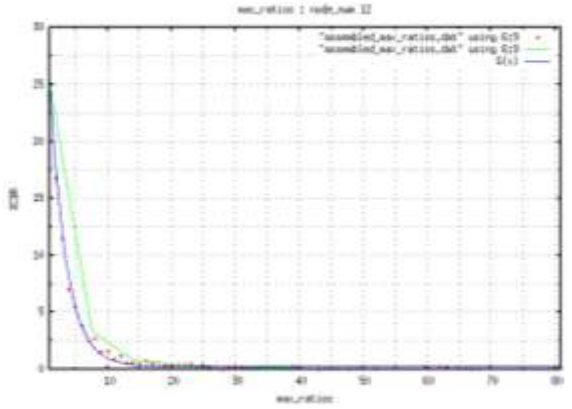

Figure 6: % cbr for Max_R node_number 12

7. Node Number 13

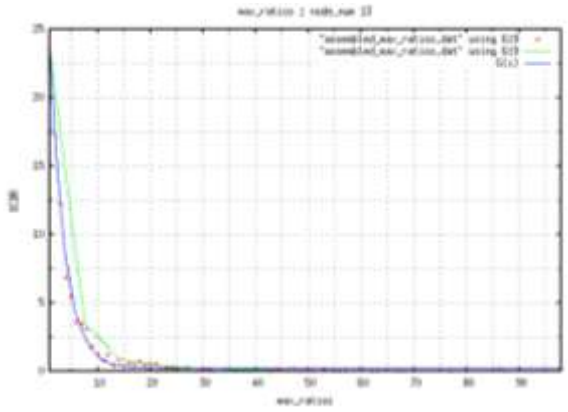

Figure 7: % cbr for Max_R node_number 13

8. Node Number 14

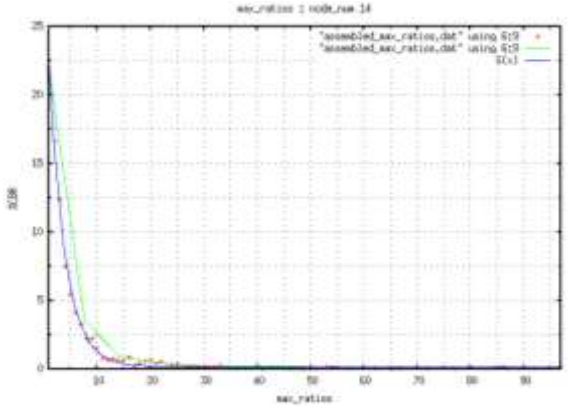

Figure 8: % cbr for Max_R node_number 14

9. Node Number 15

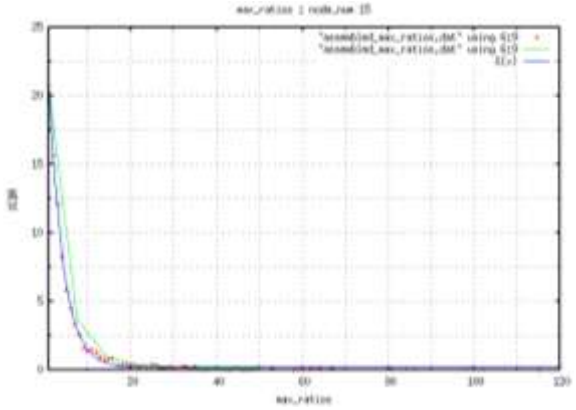

Figure 9: % cbr for Max_R node_number 15

10. Node Number 16

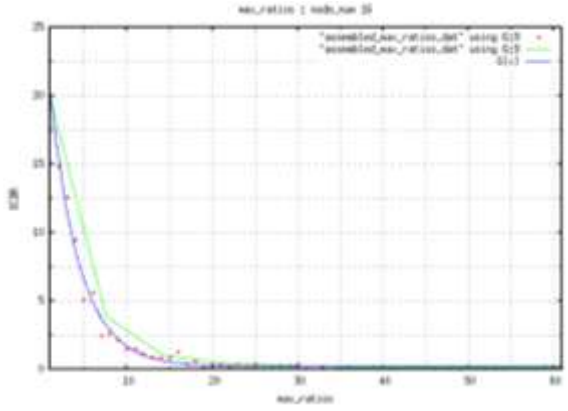

Figure 10: % cbr for Max_R node_number 16

11. Node Number 17

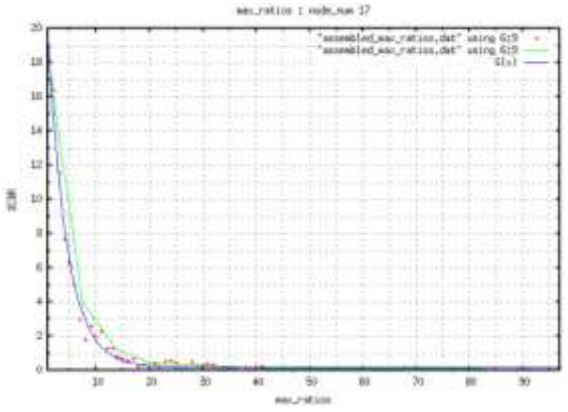

Figure 11: % cbr for Max_R node_number 17

12. Node Number 18

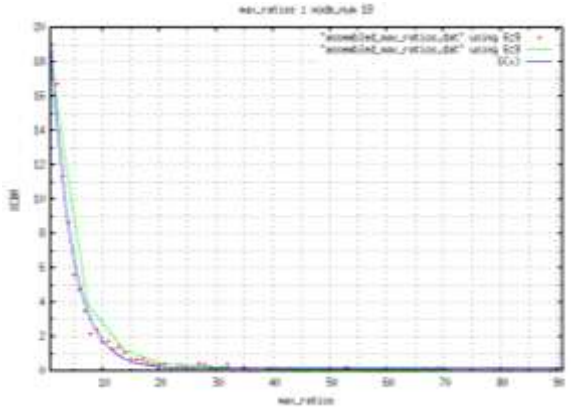

Figure 12: % cbr for Max_R node_number 18

13. Node Number 19

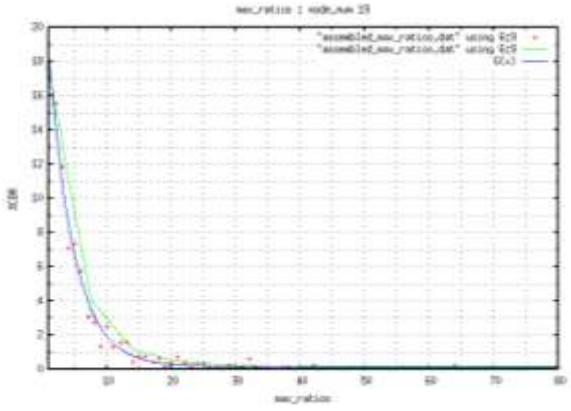

Figure 13: % cbr for Max_R node_number 19

14. Node Number 20

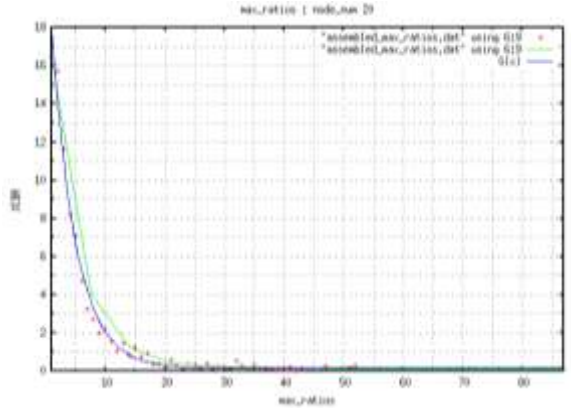

Figure 14: % cbr for Max_R node_number 20

15. Node Number 21

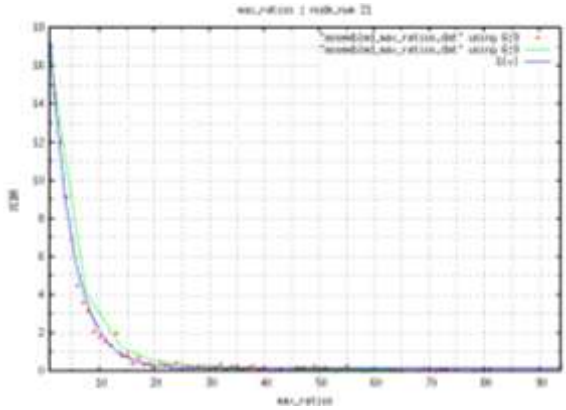

Figure 15: % cbr for Max_R node_number 21

16. Node Number 22

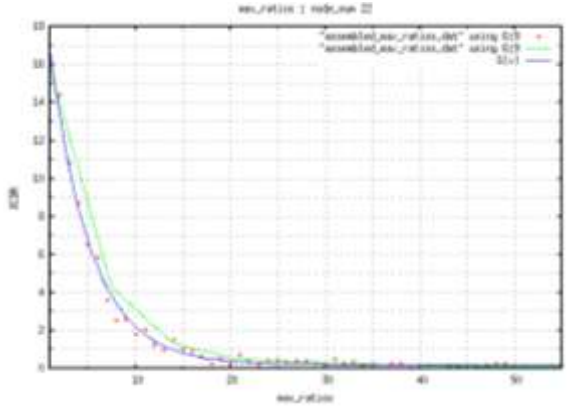

Figure 16: % cbr for Max_R node_number 22

17. Node Number 23

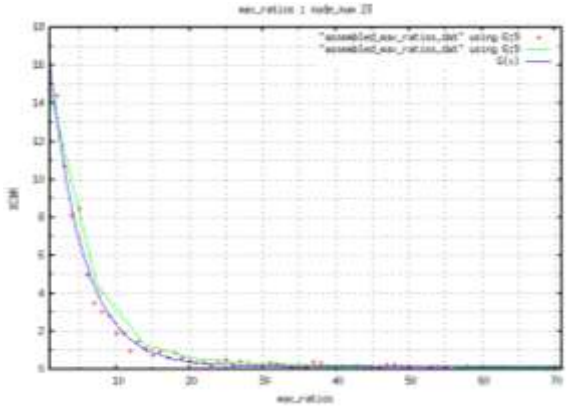

Figure 17: % cbr for Max_R node_number 23

18. Node Number 24

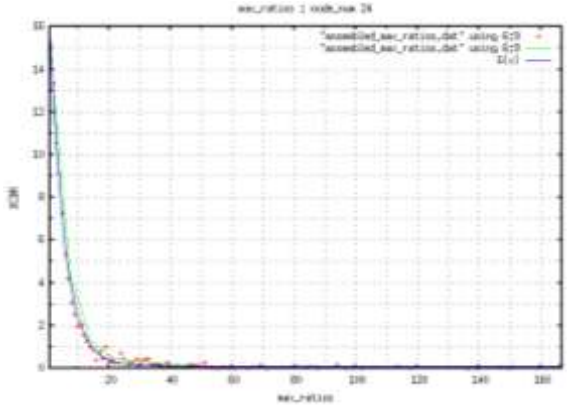

Figure 18: % cbr for Max_R node_number 24

19. Node Number 25

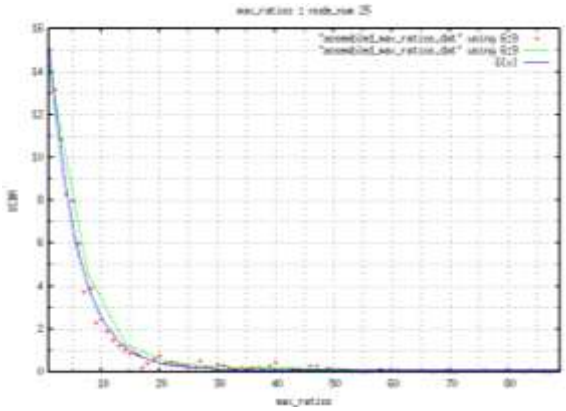

Figure 19: % cbr for Max_R node_number 25

20. Node Number 26

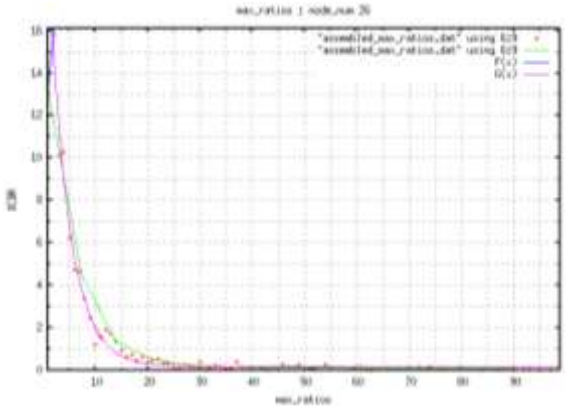

Figure 20: % cbr for Max_R node_number 26

21. Node Number 27

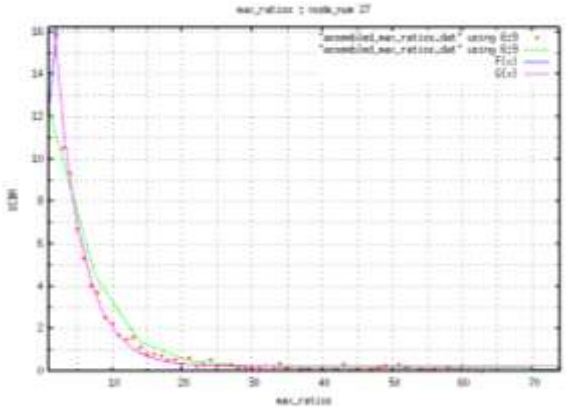

Figure 21: % cbr for Max_R node_number 27

22. Node Number 28

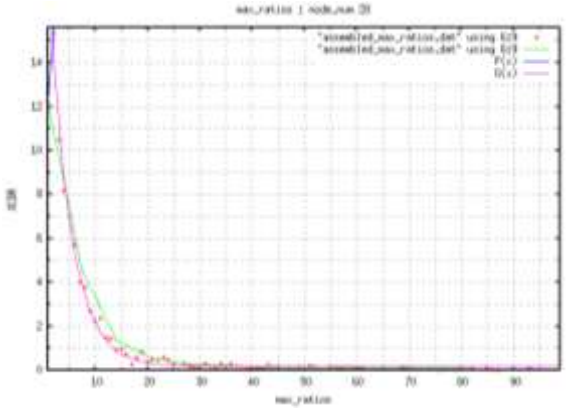

Figure 22: % cbr for Max_R node_number 28

23. Node Number 29

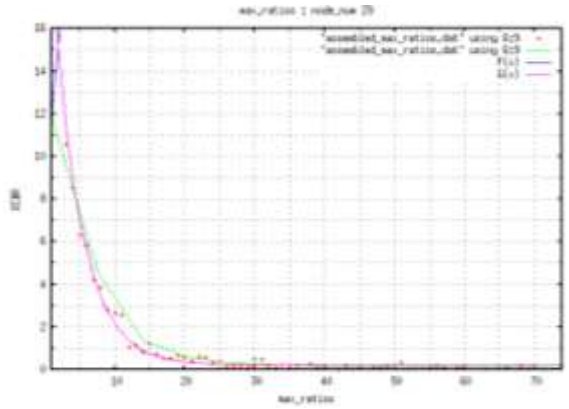

Figure 23: % cbr for Max_R node_number 29

24. Node Number 30

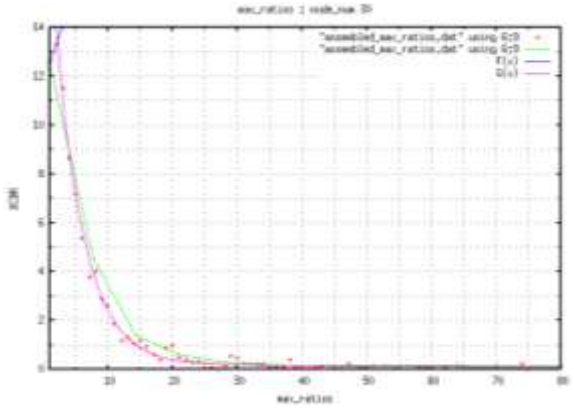

Figure 24: % cbr for Max_R node_number 30

25. Node Number 31

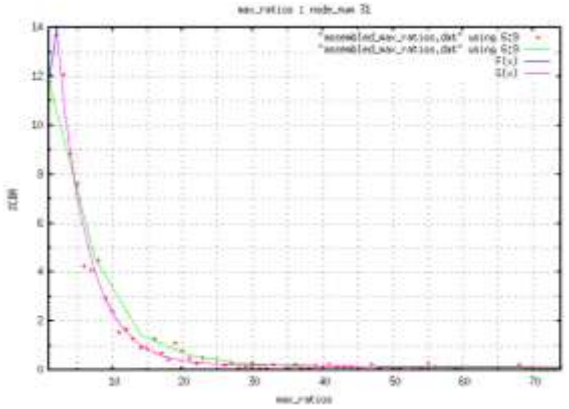

Figure 25: % cbr for Max_R node_number 31

26. Node Number 32

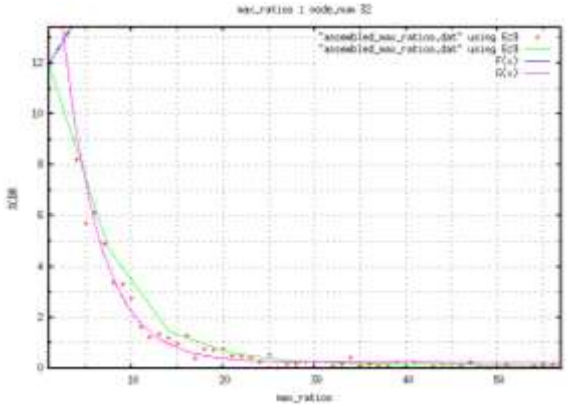

Figure 26: % cbr for Max_R node_number 32

27. Node Number 33

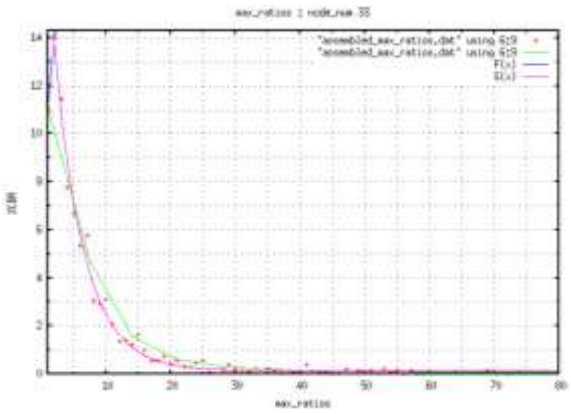

Figure 27: % cbr for Max_R node_number 33

28. Node Number 34

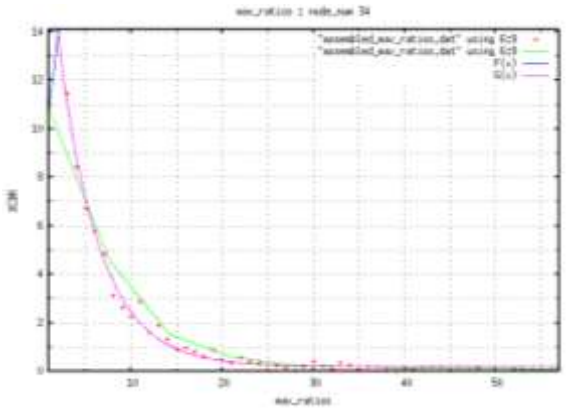

Figure 28: % cbr for Max_R node_number 34

29. Node Number 35

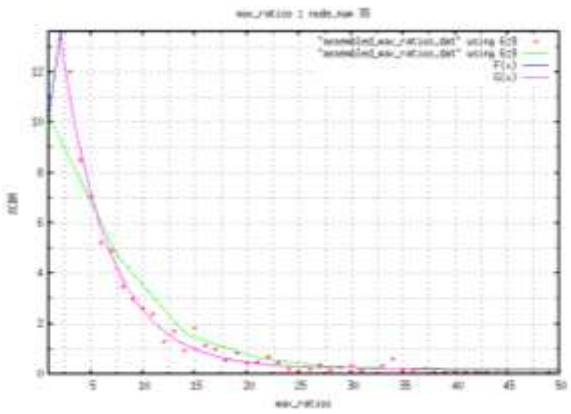

Figure 29: % cbr for Max_R node_number 35

30. Node Number 36

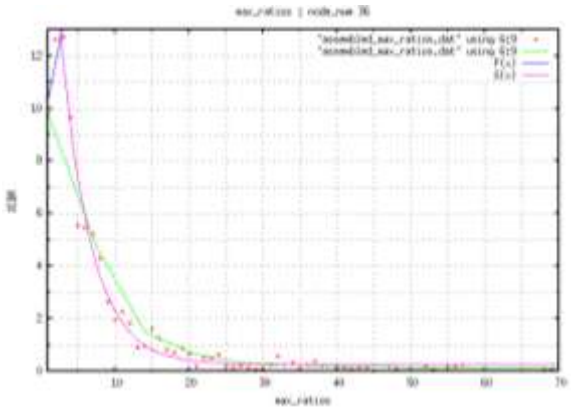

Figure 30: % cbr for Max_R node_number 36

31. Node Number 37

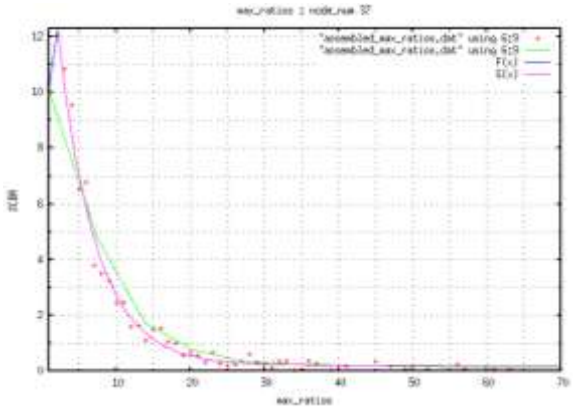

Figure 31: % cbr for Max_R node_number 37

32. Node Number 38

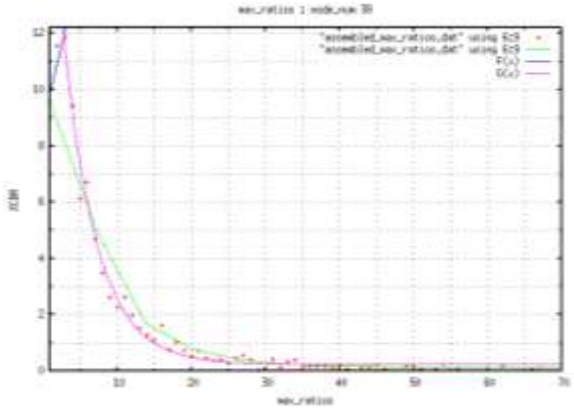

Figure 32: % cbr for Max_R node_number 38

33. Node Number 39

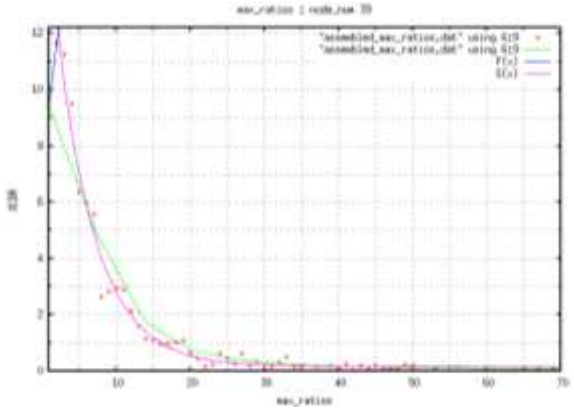

Figure 33: % cbr for Max_R node_number 39

34. Node Number 40

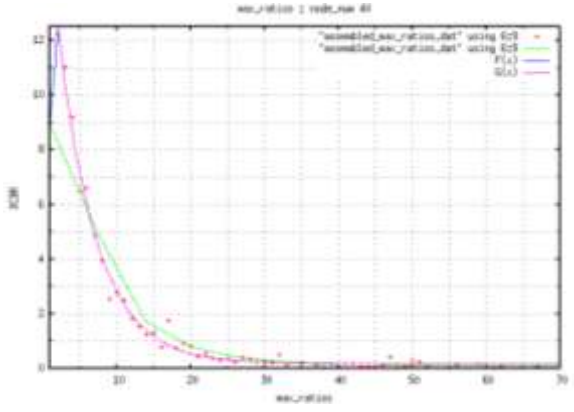

Figure 34: % cbr for Max_R node_number 40

35. Node Number 41

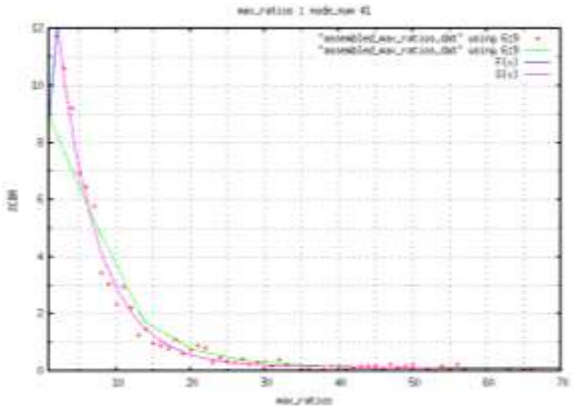

Figure 35: % cbr for Max_R node_number 41

36. Node Number 42

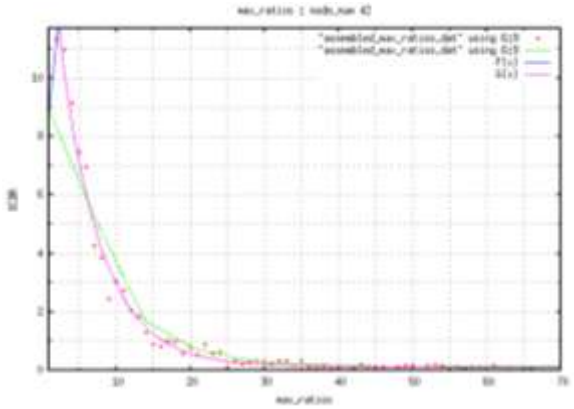

Figure 36: % cbr for Max_R node_number 42

37. Node Number 43

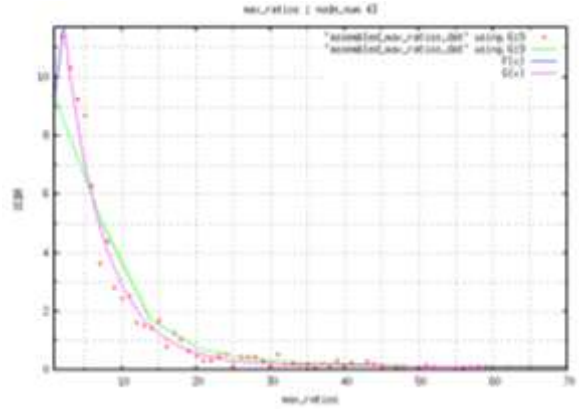

Figure 37: % cbr for Max_R node_number 43

38. Node Number 44

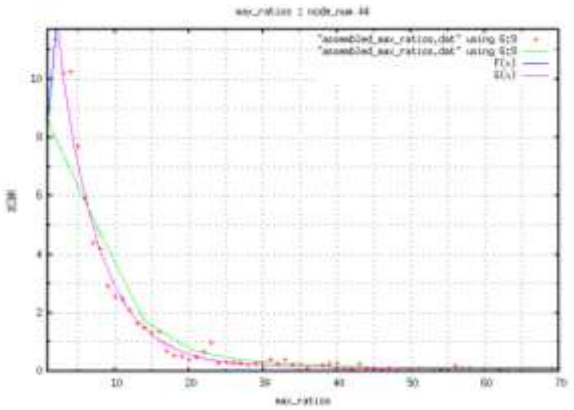

Figure 38: % cbr for Max_R node_number 44

39. Node Number 45

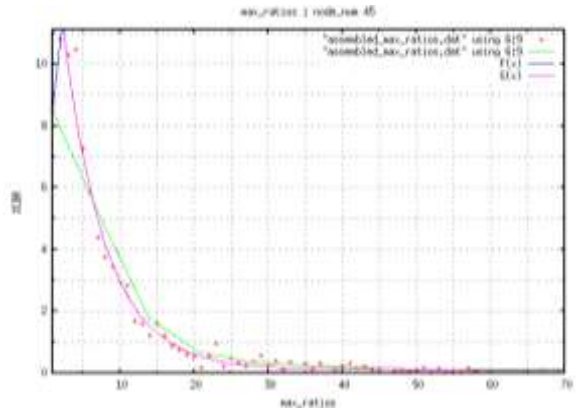

Figure 39: % cbr for Max_R node_number 45

40. Node Number 46

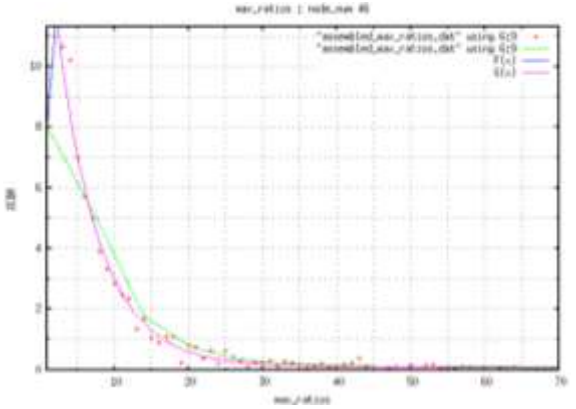

Figure 40: % cbr for Max_R node_number 46

41. Node Number 47

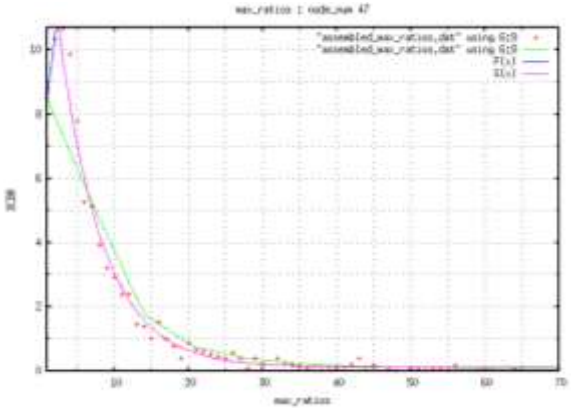

Figure 41: % cbr for Max_R node_number 47

42. Node Number 48

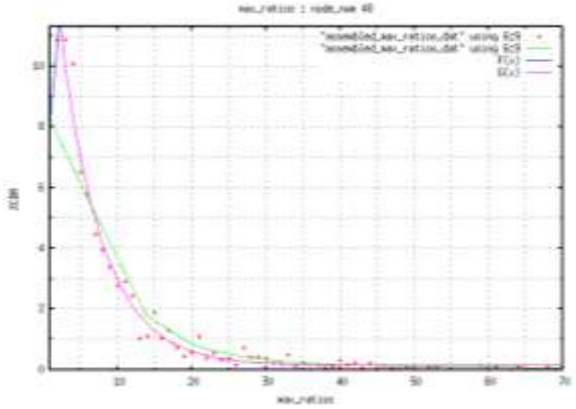

Figure 42: % cbr for Max_R node_number 48

43. Node Number 49

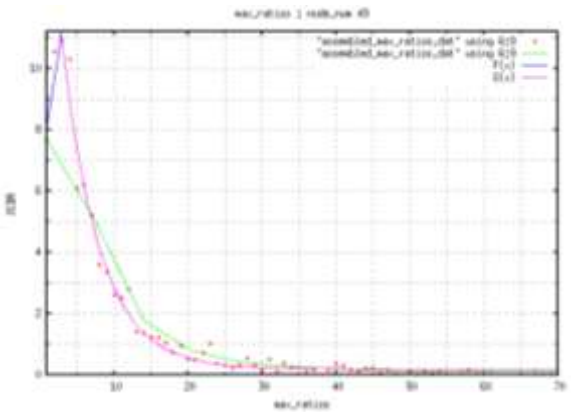

Figure 43: % cbr for Max_R node_number 49

44. Node Number 50

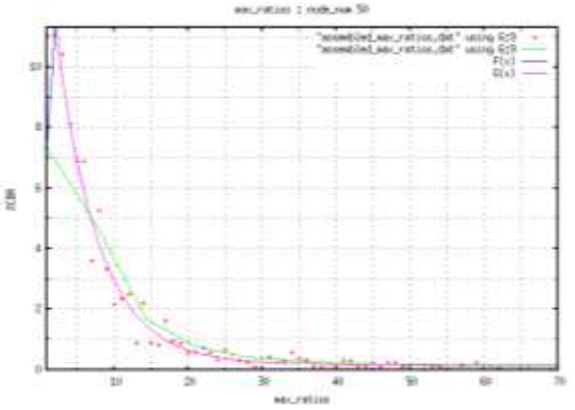

Figure 44: % cbr for Max_R node_number 50

45. Node Number 51

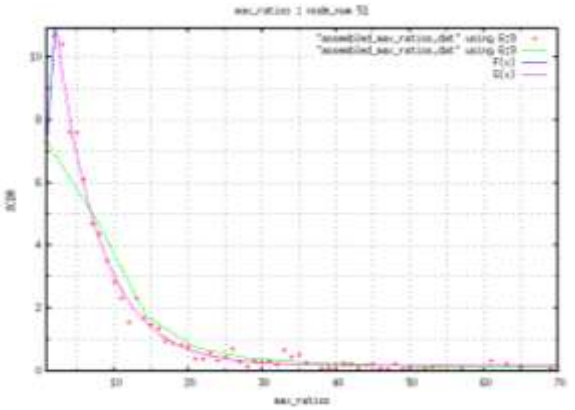

Figure 45: % cbr for Max_R node_number 51

46. Node Number 52

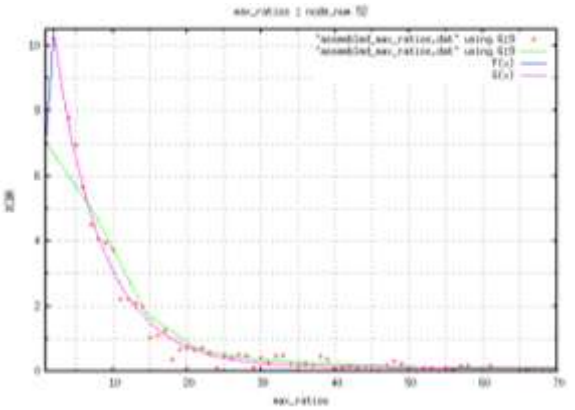

Figure 46: % cbr for Max_R node_number 52

47. Node Number 53

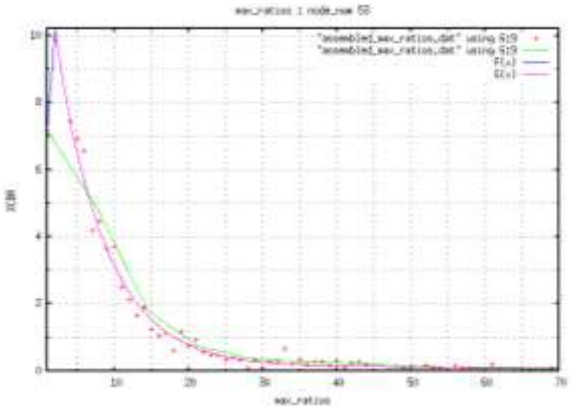

Figure 47: % cbr for Max_R node_number 53

48. Node Number 54

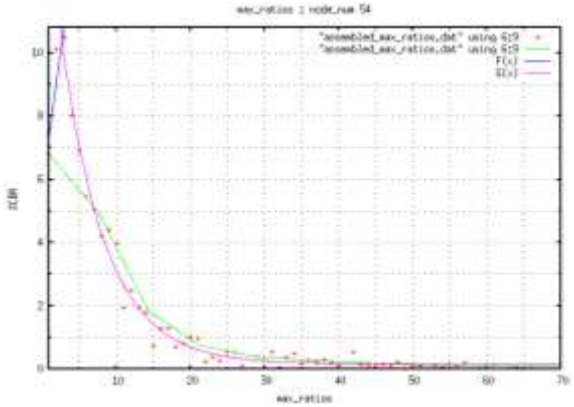

Figure 48: % cbr for Max_R node_number 54

49. Node Number 55

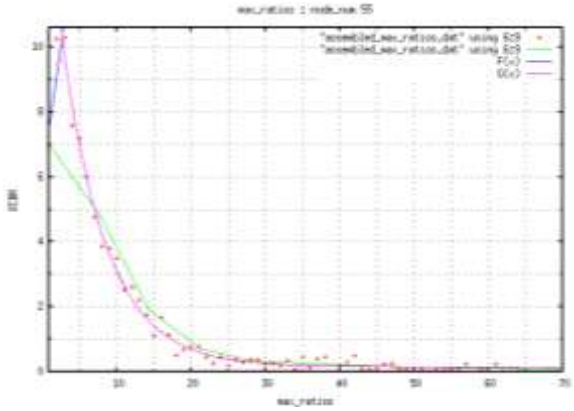

Figure 49: % cbr for Max_R node_number 55

50. Node Number 56

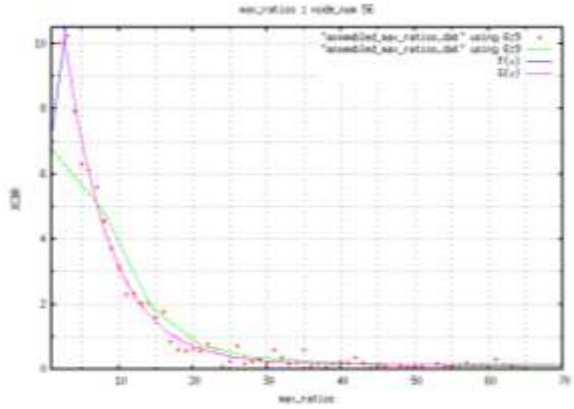

Figure 50: % cbr for Max_R node_number 56

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^2, 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.

References

[1] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Towards Dependable Pervasive Systems-A Position and Vision Paper, CEET 2014

[2] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Energy Savings achievable with Location-aware Node-to-Node Transmission in UbiComp , CEET 2014

[3] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Energy Savings achievable with Location-aware Node-to-Node Transmission in UbiComp Using Location Refresh Intervals, CEET 2014

[4] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Energy Savings achievable with Location-aware Transmission in UbiComp Using Relays, CEET 2014

[5] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Mathematical modeling of need of exact number of relays to ensure seamless mobility in mobile computing, CEET 2014

[6] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Modelling of need for multiple relays for ensuring seamless mobility, CEET 2014

[7] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Investigation of prominence of placements of relays in a ubicomp topography,

[8] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of energy savings achievable with location-aware transmission in ubicomp using optimised number of relays.

[9] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Investigation of Prominence of Placements of Optimised Number of Relays in a Ubicomp Topography using Location-Aware Transmission, CEET 2015.
[10] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Extending Node Battery Availability in Ubicomp with Location-Aware Transmission, CEET 2015.
[11] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Extending Node Battery Availability in Ubicomp with Location-Aware Transmission using Location Refresh Intervals, CEET 2015.
[12] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Extending Node Battery Availability in Ubicomp with Location-Aware Transmission using Uniformly Placed Relays, CEET 2015.
[13] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Extending Node Battery Availability in Ubicomp with Location-Aware Transmission Using Optimally Placed Relays, CEET 2015.
[14] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Sender Node Energy Savings Achievable with Location-Aware MANET Transmission in Ubicomp, ACCN 2016
[15] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Overall Node Energy Savings Achievable with Location-Aware MANET Transmission in Ubicomp, ACCN 2016
[16] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Sender Node Extra Energy Savings Achievable in MANET Against Direct Node-to-Node Transmission Using Location-Aware Transmission in Ubicomp, ACCN 2016
[17] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Overall Node Extra Energy Savings Achievable in MANET against Direct Node-to-Node Transmission Using Location-Aware Transmission in Ubicomp, ACCN 2016
[18] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Energy Consumption Ratio Achievable in MANET Using Location-Aware Transmission in Ubicomp, ACCN 2016
[19] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY Model of Minimum Energy Consumption Ratio Achievable in MANET Using Location-Aware Transmission in Ubicomp, ACCN 2016
[20] Markus Bylund and Zary Segall, Towards seamless mobility with personal servers, 2004.
[21] Masugi Inoue, Mikio Hasegawa, Nobuo Ryoki and Hiroyuki Morikawa, Context-Based Seamless Network and Application Control, 2004
[22] Xiang Song, Umakishore Ramachandran, MobiGo: A Middleware for Seamless Mobility, College of Computing Georgia Institute of Technology, Atlanta, GA, USA, August 2007
[23] Budzisz, Ferrús, R., Brunstrom A., Grinnemo, K, Fracchia, R., Galante, G., and Casadevall, F. Towards transport-layer mobility: Evolution of SCTP multihoming, March 2008
[24] Paul Dourish & Genevieve Bell, Divining a digital future, 2011.
[25] Xiang Song, Seamless Mobility In Ubiquitous Computing Environments, PhD Thesis, Georgia Institute of Technology, August 2008
[26] Kevin O Mahony, Jian Liang, Kieran Delaney, User-Centric Personalization and Autonomous Reconfiguration Across Ubiquitous Computing Environments, NIMBUS Centre Cork Institute of Technology, Cork, Ireland, UBICOMM 2012
[27] Pablo Vidales, Seamless mobility in 4G systems, *Technical Report, University of Cambridge*, Computer Laboratory, Number 656, November 2005
[28] João Pedro Sousa and David Garlan, Aura: An Architectural Framework for User Mobility in Ubiquitous Computing Environments, School of Computer Science, Carnegie Mellon University, USA, *August 2002*
[29] Dennis Lupiana, Ciaran O'Driscoll, Fredrick Mtenzi, Defining Smart Space in the Context of Ubiquitous Computing, Dublin Institute of Technology, Ireland, Special Issue on ICIT 2009 Conference - Web and Agent Systems, 2009
[30] N.S.V.Shet1, Prof.K.Chandrasekaran2 and Prof. K.C.Shet3, *WAP Based Seamless Roaming In Urban Environment with Wise Handoff Technique*, International Journal of UbiComp (IJU), Vol.1, No.4, October 2010
[31] Yipeng Yu Dan He Weidong Hua Shijian Li Yu Qi Yueming Wang Gang Pan, FlyingBuddy2: A Brain-controlledAssistant for the Handicapped, Zhejiang University, *UbiComp'12,* September 5-8, 2012.
[32] Jing Su, James Scott, Pan Hui, Jon Crowcroft, Eyal de Lara Christophe Diot, Ashvin Goel, Meng How Lim, and Eben Upton, Haggle: Seamless Networking for Mobile Applications, 2007
[33] Rui Han, Moustafa M. Ghanem, Li Guo, Yike Guo∗, Michelle Osmond, Enabling cost-aware and adaptive elasticity of multi-tier cloud applications, Future Generation Computer Systems, 2012
[34] Byrav Ramamurthy, K. K. Ramakrishnan , Rakesh K. Sinha, Cost and Reliability Considerations in Designing the Next-Generation IP over WDM Backbone Networks, 2012.
[35] Bhavish Aggarwal, Aditya Akella, Ashok Anand, Athula Balachandran, Pushkar Chitnis, Chitra Muthukrishnan, Ram Ramjee and George Varghese, EndRE: An End-System Redundancy Elimination Service for Enterprises, NSDI 2010, San Jose, CA
[36] Ashok Anand, Vyas Sekar and Aditya Akella, SmartRE: An Architecture for Coordinated Network-wide Redundancy Elimination, SIGCOMM 2009, Barcelona, Spain
[37] John Breeden II, "Smart-phone battery life could double – without better batteries", Nov 14, 2012
[38] Andy Boxall, "When will your phone battery last as long as your kindle", December 5, 2012.
[39] Imielinski, T. and Navas, J.C. (1999). GPS-based geographic addressing, routing, and resource discovery. *Comms. ACM*, Vol. 42, No. 4, pp. 86-92.
[40] Hightower, J. and Borriello, G. (2001). Location Systems for Ubiquitous Computing. *IEEE Computer*, Vol. 34, No. 8, August, pp. 57-66.
[41] Harter, A., Hopper, A., Steggles, P., Ward, A. and Webster, P. (2002). The Anatomy of a Context-Aware Application. Wireless Networks, Vol. 8, No. 2-3, Mar-May, pp. 187-197.
[42] Hightower, J., Brumitt, B. and Borriello, G. (2002). The Location Stack: A Layered Model for Location in Ubiquitous Computing. *Proceedings of the 4th IEEE Workshop on Mobile Computing Systems & Applications (WMCSA 2002)*, Callicoon, NY, USA, June, pp. 22-28.
[43] Graumann, D., Lara, W., Hightower, J. and Borriello, G. (2003). Real-world implementation of the Location Stack: The Universal Location Framework. *Proceedings of the 5th IEEE Workshop on Mobile Computing Systems & Applications (WMCSA 2003)*, Monterey, CA, USA, October, pp. 122-128.
[44] Ko, Y., & Vaidya, N. H. (2000). Location-aided routing (LAR) in mobile ad hoc networks. *Wireless Networks*, *6*(4), 307-321.
[45] Liao, W.-H., Tseng, Y.-C., & Sheu, J.-P. (2001). GRID: a fully location-aware routing protocol for mobile ad hoc networks. *Telecommunication Systems*, *18*(1), 37-60.
[46] Kuhn, F., Wattenhofer, R., Zhang, Y., & Zollinger, A. (2003). Geometric ad-hoc routing: of theory and practice. In *Proceedings of the ACM (PODC'03)* (pp. 63-72).
[47] Jiang, X., & Camp, T. (2002). Review of geocasting protocols for a mobile ad hoc network. In Proceedings of the *Grace Hopper Celebration (GHC)*.
[48] Ko, Y. & Vaidya, N. H. (1999). Geocasting in mobile ad hoc networks: location-based multicast algorithms. In *Proceedings of the IEEE (WMCSA'99)* (pp. 101).
[49] Mauve, M., Fuler, H., Widmer, J., & Lang, T. (2003). *Position-based multicast routing for mobile ad-hoc networks* (Technical Report TR-03-004). Department of Computer Science, University of Mannheim.

[50] Xu, Y., Heidemann, J., & Estrin, D. (2001). Geography-informed energy conservation for adhoc routing. In *Proceedings of the ACM/IEEE (MOBICOM'01)* (pp. 70-84).

[51] Hu, Y.-C., Perrig, A., & Johnson, D. (2003). Packet leashes: a defense against wormhole attacks in wireless ad hoc networks. In *Proceedings of the INFOCOM' 03* (pp. 1976-1986).

[52] Patwari, N., Hero III, A. O., Perkins, M., Correal, N. S., & O'Dea, R. J. (2003). Relative location estimation in wireless sensor networks. *IEEE Transactions on Signal Processing*, *51*(8), 2137-2148.

[53] Baldauf, M., Dustdar, S., & Rosenberg, F. (2007). A Survey on Context Aware Systems. *International Journal of Ad Hoc and Ubiquitous Computing*, Inderscience Publishers. forthcoming. Pre-print from: http://www.vitalab.tuwien.ac.at/~florian/ papers/ijahuc2007.pdf

[54] Hong, D., Chiu, D.K.W., & Shen, V.Y. (2005). Requirements elicitation for the design of context-aware applications in a ubiquitous environment. In *Proceedings of ICEC'05* (pp. 590-596).

[55] Neeraj Tantubay, Dinesh Ratan Gautam and Mukesh Kumar Dhariwal, A Review of Power Conservation in Wireless Mobile Ad hoc Network (MANET)", International Journal of computer Science Issues, Vol 8, Issue 4, No 1, July 2011.

[56] Wenrui Zhao, Mostafa Ammar and Ellen Zegura, "A Message Ferrying Approach for Data Delivery in Sparse Mobile Ad Hoc Networks", *MobiHoc'04,* May 24–26, 2004, Roppongi, Japan.

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