

# Trend Analyses of Critical Values Obtained for Overall Fairness Ratio Achievable in Ubicomp MANETs Using Location-Aware Transmission Strategies.

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**Abstract** – The fields of location-tracking, ubicomp functionalities and MANET transmission strategies are prone to quite a lot of productive research [1-52]. It remains undeniable that the merging of these fields has a long way before fruitfully materialising. An essential factor determining the success of such merging is correct protocol design approaches, which is currently agreed as heuristic in nature and hence unsuitable for implementation [90]. Refinement in middleware and rework in network architecture is also needed [91, 92].

A sharpened objective in this direction of technological progress is achievement of “realism” in design and evaluation of wireless routing protocols [93]. Such studies may yield more suitable components for studies in predictability in ubicomp. “Realism” is a tardy process since it drags along each and every feature related to ubicomp. One such feature was explored in a prior paper [21] to assess the trend of Overall Fairness Ratio (OFR) readable for CBRs under different sets of node densities in ubicomp environments. This study was corroborated by the related study of trends for each OFR parameter of equations [37].

To embrace “realism” in knowledge of these trends, in this paper, the next investigation required is stated as: “What are observable critical values in OFR trends over varying node densities and trends of such critical values?”

Such knowledge will eventually lead to the design of more realistic ubicomp scenarios which are better suited for more sustained testing of freshly designed middleware components and communication protocols. The work presented here is a follow-up of previous ones[1-52].

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

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## 1. Introduction

MANETS remain a fulfilling solution to scant resource availability in ubicomp, in which the load of energy

requirements is distributed among cooperating nodes in the topography. This load is radically influenced by varying node densities. An anterior study [21] was designed for finding the trends observable for metric OFR for node densities varying between 7 until 56. The model suggested in that paper [21] combined the exponential and linear models of form:

$$F(x) = a * \exp(b*x) + (c*x) + d$$

Following this study, a successive study [37] was conducted to model mathematically the trends of the four parameters observed above. Results obtained are expected to serve towards better understanding of the evolution and predictability of ubicomp environments. With such gently occurring progresses, designers will produce more authentic simulation scenarios over which testing exercises can be conducted for newly built middleware and communication components.

The quest now required for metric OFR is the identification of observable critical values obtained during experimentations and formulation of corresponding theoretical trend of such critical values over varying node densities. Five such critical values were observed.

The key contribution of this paper is the setting up of the trends of variations for each of the five critical values observed for metric OFR expounded previously [21, 37] englobing node numbers 7 until 56. Such information should compulsorily be presented in an orderly fashion to more fluidly assist ubicomp designers to understand the evolution and predictability of ubicomp behaviour and be better equipped to carry credulous simulation scenarios over which new communication protocol features could be tested. The rest of this paper is organised as follows: section 2- OFR Critical Values, section 3- Critical Values Trend Analyses- Metric OFR, section 4- Conclusion and References.

## 2. OFR Critical Values.

### 2.0 Critical Values Identified.

Five critical values have been identified as follows: Column headings are: C1→OFR CV, C2→ Meaning of

OFR CV, C3 → Corresponding figure number for the OFR CV.

C1	C2	C3
1	%CBR at minimum value of OFR	1
2	Maximum OFR value reached.	2
3	Modal value of OFR as from 10 nodes	3
4	% CBR at modal value of OFR	4
5	% CBR in OFR range 0 until <1	5

**Table 1: OFR Critical Values**

2.1 Experimental Critical Values Obtained.

The values obtained during experiments have been summarised below. Values have been rounded to a maximum of 9 decimal places. Column heading NN → Node Number.

NN	CV1	CV2	CV3	CV4	CV5
7	4.301587302	7.0	7.00	20.253968254	37.857142857
8	7.640878701	7.0	7.00	15.934415791	47.723654887
9	6.920634921	8.0	8.00	14.190476190	51.142857143
10	7.095238095	10.0	0.11	14.952380952	55.523809524
11	6.714285714	10.0	0.10	15.174603175	58.539682540
12	6.470588235	12.0	0.09	15.421303657	56.979332273
13	6.333333333	12.0	0.08	13.666666667	59.984126984
14	6.206349206	13.0	0.08	15.682539683	58.285714286
15	6.238095238	14.0	0.07	14.269841270	60.460317460
16	6.285714286	15.0	0.07	15.888888889	58.095238095
17	5.746031746	17.0	0.06	15.349206349	59.380952381
18	5.714285714	18.0	0.06	16.253968254	58.238095238
19	5.793650794	19.0	0.06	15.968253968	59.238095238
20	5.698412698	20.0	0.05	14.968253968	57.317460317
21	5.238095238	20.0	0.05	15.603174603	59.222222222
22	5.142857143	21.0	0.05	16.126984127	58.222222222
23	5.190476190	22.0	0.05	15.968253968	59.126984127
24	5.349206349	23.0	0.04	14.587301587	58.000000000
25	5.206349206	24.0	0.04	16.095238095	59.555555556
26	5.492063492	25.0	0.04	14.111111111	57.873015873
27	5.460317460	26.0	0.04	14.333333333	59.428571429
28	5.460317460	27.0	0.04	14.111111111	58.158730159
29	5.301587302	28.0	0.04	14.079365079	58.619047619
30	5.396825397	29.0	0.03	13.444444444	58.126984127
31	5.126984127	30.0	0.03	13.777777778	58.634920635
32	5.206349206	31.0	0.03	13.904761905	58.174603175
33	5.047619048	32.0	0.03	14.142857143	58.873015873
34	4.888888889	33.0	0.03	14.158730159	58.000000000
35	4.952380952	34.0	0.03	14.412698413	58.333333333
36	5.158730159	35.0	0.03	14.619047619	58.126984127
37	4.540403239	36.0	0.03	13.811716145	57.977456739
38	4.587301587	37.0	0.03	13.809523810	58.650793651
39	4.666666667	38.0	0.03	13.555555556	59.222222222
40	4.571428571	39.0	0.03	13.396825397	58.888888889
41	4.523809524	40.0	0.03	13.619047619	60.634920635
42	4.603174603	41.0	0.02	13.126984127	59.428571429
43	4.634920635	42.0	0.02	13.396825397	59.714285714
44	4.653748412	43.0	0.02	13.881829733	59.386912325
45	4.698412698	44.0	0.02	14.158730159	59.317460317
46	4.904761905	45.0	0.02	14.063492063	59.460317460

47	4.746031746	46.0	0.02	14.301587302	59.428571429
48	4.730158730	47.0	0.02	14.444444444	58.380952381
49	4.555555556	48.0	0.02	14.539682540	58.587301587
50	5.539682540	49.0	0.02	14.206349206	59.174603175
51	5.650793651	50.0	0.02	14.238095238	59.714285714
52	5.492063492	51.0	0.02	14.460317460	59.174603175
53	5.539682540	52.0	0.02	14.825396825	59.317460317
54	5.825396825	53.0	0.02	14.317460317	59.063492063
55	5.682539683	54.0	0.02	14.444444444	59.777777778
56	5.666666667	55.0	0.02	13.936507937	59.539682540

**Table 2: Experimental Critical Values Obtained**

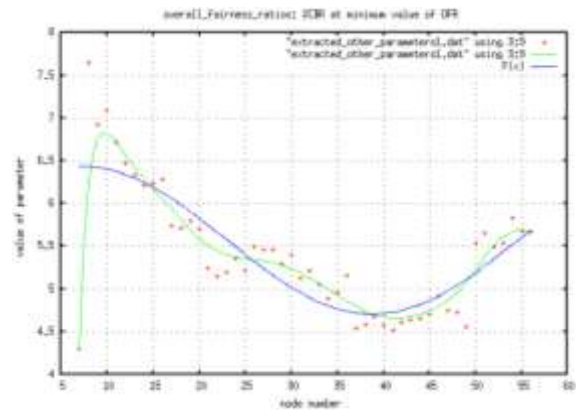
### 3. Critical Values Trend Analyses- Metric OFR.

3.0 General Procedure Adopted.

Firstly, the tabulated data for each OFR CV is plotted on gnuplot. Secondly, graphical analyses are carried out and general observations are detailed. Thirdly, various equations of fit are tried. Choice of best fit was made depending on value of reduced chi-square and projected best extendability produced at higher node numbers. Fourthly, parameters values for each OFR CV is noted.

3.1 Trend Analysis – OFR CV1.

Generally, the curve obtained depicts a decreasing tendency until a minimum point and then shows an increasing tendency. The plots appear appears to be about half of an oscillation.



**Figure 1: OFR Critical Value 1**

$$F(x) = a * \sin (( b* x ) - c) + d$$

$$\text{Ch\_sq} = 0.209\ 599 \quad F(80) = 6.064\ 192\ 019$$

$$F(100) = 4.720\ 639\ 314 \quad F(120) = 5.767\ 278\ 285$$

The parameters for best fit are: a = -0.863 871 , b = 0.099 586 5 , c = -3.989 1 , d=5.569 06

3.2 Trend Analysis – OFR CV2.

Here, a very strong linear relationship is observed.

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

$$\text{Ch\_sq} = 0.097\ 793\ 1 \quad F(80) = 78.592\ 701\ 080$$

$$F(100) = 98.367\ 010\ 804 \quad F(120) = 118.141\ 320\ 528$$

Values of F(x) obtained may simply be rounded off to nearest unit. The parameters for best fit are:  
 $d = 0.988\ 715$ ,  $f = -0.504\ 538$

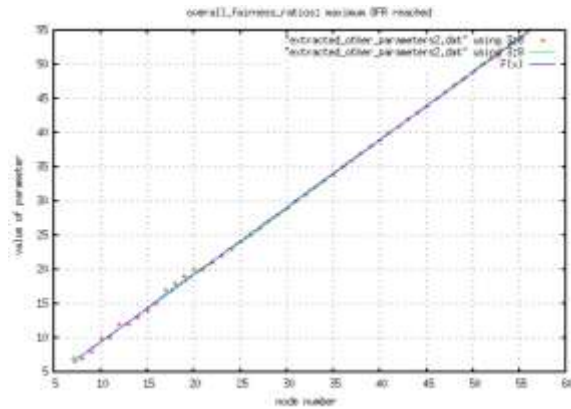


Figure 2: OFR Critical Value 2

**3.3 Trend Analysis – OFR CV3.**

Generally, the curve shows a decreasing tendency at a decreasing rate. Some staircase feature is observed possibly due to rounding off to 2 d.p.

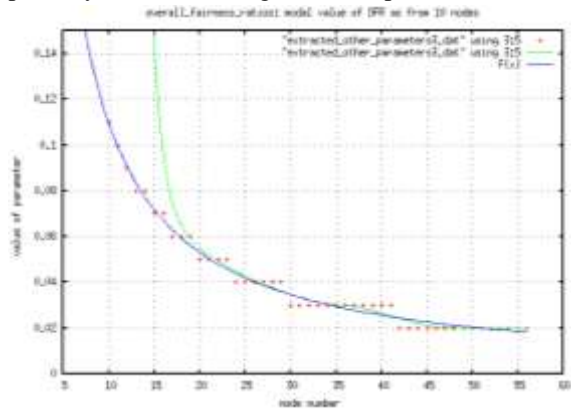


Figure 3: OFR Critical Value 3

The potentially applicable equations are:

1.  $F(x) = a * \exp((b * x) + c) + d$   
 $Ch\_sq = 9.415\ 64(e^{-06})$      $F(80) = 0.018\ 979\ 903$   
 $F(100) = 0.018\ 839\ 344$      $F(120) = 0.018\ 815\ 667$
2.  $F(x) = a * x^{0.25} * \exp((b * x) + c) + d$   
 $Ch\_sq = 1.050\ 82(e^{-05})$      $F(80) = 0.019\ 827\ 133$   
 $F(100) = 0.019\ 754\ 780$      $F(120) = 0.019\ 745\ 649$
3.  $F(x) = a * x^{-0.25} * \exp((b * x) + c) + d$   
 $Ch\_sq = 8.528\ 05(e^{-06})$      $F(80) = 0.017\ 959\ 684$   
 $F(100) = 0.017\ 686\ 937$      $F(120) = 0.017\ 625\ 395$
4.  $F(x) = a * x^{-0.5} * \exp((b * x) + c) + d$   
 $Ch\_sq = 7.871\ 24(e^{-06})$      $F(80) = 0.016\ 703\ 630$   
 $F(100) = 0.016\ 172\ 176$      $F(120) = 0.016\ 010\ 324$
5.  $F(x) = a * x^{-1.0} * \exp((b * x) + c) + d$   
 $Ch\_sq = 7.355\ 65(e^{-06})$      $F(80) = 0.013\ 002\ 501$   
 $F(100) = 0.010\ 817\ 854$      $F(120) = 0.009\ 505\ 016$
6.  $F(x) = a * x^{1.1} * \exp((b * x) + c) + d$   
 $Ch\_sq = 7.449(e^{-06})$      $F(80) = 0.013\ 101\ 126$   
 $F(100) = 0.010\ 702\ 134$      $F(120) = 0.009\ 139\ 649$

**Choice of best fit for OFR Critical Value 3**

The equation in part 5 above has been selected because of smallest reduced chi-square value obtained and good extendability. The parameters obtained for best fit are:  
 $a = 0.857\ 52$ ,  $b = -0.010\ 246\ 3$ ,  $c = 0.284\ 021$ ,  $d = 0.006\ 729$

**3.4 Trend Analysis – OFR CV4.**

Here, the plots are quite scattered with an oscillation along a decreasing axis line.

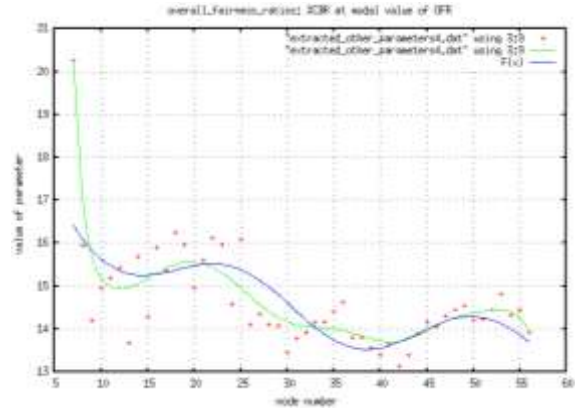


Figure 4: OFR Critical Value 4

The potentially applicable equations are:

1.  $F(x) = d * x + f + a * \sin((b * x) + c)$   
 $Ch\_sq = 0.805\ 444$      $F(80) = 12.823\ 375\ 174$   
 $F(100) = 11.684\ 310\ 044$      $F(120) = 9.801\ 559\ 629$
2.  $F(x) = d * \log(x) + f + a * \sin((b * x) + c)$   
 $Ch\_sq = 0.751\ 422$      $F(80) = 13.432\ 240\ 255$   
 $F(100) = 12.991\ 114\ 255$      $F(120) = 11.865\ 002\ 951$

**Choice of best fit for OFR Critical Value 4**

The equation in part 2 above has been selected because of smallest reduced chi-square value obtained and good extendability. The parameters obtained for best fit are:  
 $a = -0.603\ 058$ ,  $b = 0.236\ 804$ ,  $c = -0.999\ 732$ ,  $d = -1.570\ 82$ ,  $f = 19.841\ 4$

**3.5 Trend Analysis – OFR CV5.**

The curve here depicts an initial increase and then drops the rate of increase very suddenly.

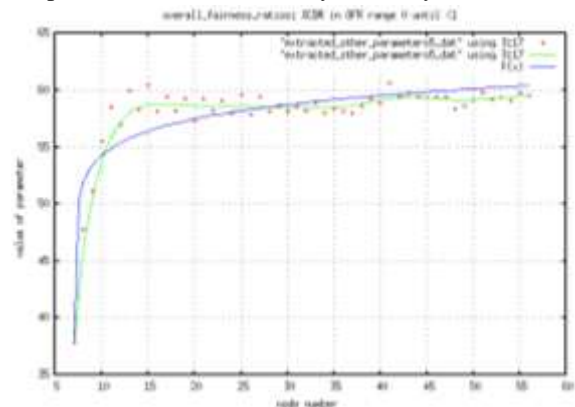


Figure 5: OFR Critical Value 5

$$F(x) = a * \log((b*x)+c) + (d*x^g) + f$$

Ch\_sq = 2.698 3      F(80) = 61.297 344 867

F(100) = 61.833 907 747      F(120) = 62.265 544 944

The parameters for best fit are:

$$a = 2.215 97, b = 5.329 29, c = -37.295 1, d = 0.005 646 79, f = 48.082, g = -5.013 71$$

## 4. Conclusion.

This piece of investigation was meant to identify some critical values applicable to metric OFR and study their corresponding trends over varying node densities in a MANET topography of 300 x 300 m<sup>2</sup>. The models formulated here consist of quite complex mathematical equations. The outputs detailed here will enrich our existing tools for more propitious studies of MANETs for ubiomp environment from the context of computational algorithms to produce better pragmatic simulation schemes. These will in turn be utilised for more precocious testing of communication protocols and middleware components.

This experiment was executed in NS-2 over Linux. Gnuplot was used to carry out the plottings and “fit” attempts. Best fit was selected based on values of least reduced chi-square and best extendability of equations observed at higher node numbers. Assumptions adopted in previous papers [21, 37] are carried forward in this paper also.

This study remains a follow-up of earlier studies [1-13, 21, 37] and prevails as a subject for future upgrades. One such task identified is the formulation of predictability for metric OFR and its trend.

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