

Trend Analyses of Critical Values Obtained for Sender Fairness Proportion Achievable in Ubicomp MANETs Using Location-Aware Transmission Strategies.

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Abstract – Consequential research is currently being invested on as concerns location-tracking, ubicomp functionalities and MANET transmission strategies [1-56]. Attempts for their merging are still at early stages and are not yielding commendable results. One crucial factor for this successful merging remains correct protocol design approaches, which is currently regarded as heuristic and inadequately suited for implementation [94]. Advancements in middleware services and ubicomp network architecture are also desirable [95, 96].

A well-structured objective that manifests along such development path in ubicomp is reaching out for “realism” in design and evaluation of wireless routing protocols [97]. Such studies will entail serious technical constituents useful for further studies of predictability in ubicomp. Their importance is high since “realism” will propagate into each ubicomp feature. One such feature was studied previously [25] to assess the trend of Sender Fairness Proportion (S_FP) observable for CBRs under different sets of node densities in ubicomp environments. This study was augmented with the study of S_FP parameter of equations [41].

To enfold “realism” in knowledge of these trends, in this paper, the successive study required is put forward as: “What are the observable critical values in S_FP trends over varying node densities and trends of such critical values?” Following such developments, the design of more realistic ubicomp schemes will succeed. These are entrusted to be more eligible for sustained testing of experimental middleware and communication protocols. This study dwells as a follow-up of prior ones [1-56].

Key terms: Ubicomp- Ubiquitous Computing, MAUC- Mobile and Ubiquitous Computing, S_FP- Sender Fairness Proportion, CBR- Constant Bit Rate, MANET- Mobile Adhoc Network, CV- Critical Value.

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1. Introduction

It is projected that many of the future ubicomp environments may be significantly under equipped with networking support and hence the welcome solution is

expected to be MANETs. Here, the task of transmission is repartitioned among cooperating nodes leading to energy consumption being repartitioned. In such resulting situations, the notions of Fairness must be fully well circumscribed. One such notion is from the angle of metrics, one of which is S_FP, studied in a prior paper [25] for node densities varying between 7 until 56. The trend observed was split into two with respect to a peak value.

- Previous to the maximum point, the linear tendency is visible of form:

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

- As from the peak value onwards, the exponentially decreasing trend is visible of form:

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

A follow-up study [41] was effectuated to model mathematically the five parameters observed above. Results obtained will definitely be useful towards better understanding the evolution and predictability of ubicomp environments. These advancements are slowly being delivered and will facilitate designers for preparing better realistic simulation scenarios based on which testing exercises can be undertaken over experimental components for middleware and communication protocols.

The probing now needed for metric S_FP is the identification of observable critical values obtained during experiments execution and formulation of corresponding theoretical trend of such CVs over varying node densities. Six such CVs were observed.

The key contribution of this paper is the mathematical formulation of the trends of variations for each of the six CVs observed for metric S_FP expounded previously [25, 41] over node numbers ranging from 7 until 56. Such variety of information should compulsorily be presented in an appropriate format to conveniently aid designers to understand the evolution and predictability of ubicomp behaviour and be sufficiently equipped to carry credulous simulation scenarios over which new communication features could be tested. The rest of this paper is organised as follows: section 2- S_FP Critical Values, section 3- Critical Values Trend Analyses- Metric S_FP, section 4- Conclusion and References.

2. S_FP Critical Values.

2.0 Critical Values Identified.

Six CVs were identified as follows: Column headings are: C1→S_FP CV, C2→Meaning of S_FP CV, C3→Corresponding figure number for S_FP CV.

C1	C2	C3
1	% CBR at smallest value of S_FP	1
2	Highest value of S_FP	2
3	% CBR at highest value of S_FP	3
4	% CBR with S_FP value < modal S_FP value	4
5	% CBR with S_FP value > modal S_FP value	5
6	S_FP value up to which 97.5 % CBR lie	6

Table 1: S_FP 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
7	0.158730159	7.0	1.984126984
8	13.482967208	8.0	1.957975167
9	13.555555556	9.0	1.888888889
10	10.777777778	10.0	0.714285714
11	10.619047619	11.0	0.714285714
12	10.763116057	12.0	0.635930048
13	10.666666667	13.0	0.555555556
14	10.666666667	14.0	0.476190476
15	10.666666667	15.0	0.476190476
16	10.746031746	16.0	0.476190476
17	10.666666667	17.0	0.238095238
18	10.888888889	18.0	0.238095238
19	10.746031746	19.0	0.222222222
20	10.666666667	20.0	0.222222222
21	10.095238095	21.0	0.301587302
22	10.174603175	22.0	0.301587302
23	10.174603175	23.0	0.301587302
24	10.174603175	24.0	0.301587302
25	10.269841270	25.0	0.238095238
26	10.619047619	26.0	0.238095238
27	10.539682540	27.0	0.238095238
28	10.460317460	28.0	0.238095238
29	10.539682540	29.0	0.238095238
30	10.682539683	30.0	0.238095238
31	10.730158730	31.0	0.158730159
32	10.714285714	32.0	0.158730159
33	10.682539683	33.0	0.158730159
34	10.650793651	34.0	0.158730159
35	10.571428571	35.0	0.158730159
36	10.571428571	36.0	0.158730159
37	9.953960946	37.0	0.238133037
38	9.952380952	38.0	0.238095238
39	10.031746032	39.0	0.238095238
40	10.031746032	40.0	0.238095238
41	10.031746032	41.0	0.238095238
42	10.031746032	42.0	0.238095238

43	10.333333333	43.0	0.238095238
44	10.419313850	44.0	0.238246506
45	10.333333333	45.0	0.238095238
46	10.333333333	46.0	0.238095238
47	10.333333333	47.0	0.238095238
48	10.333333333	48.0	0.238095238
49	10.412698413	49.0	0.238095238
50	10.174603175	50.0	0.238095238
51	10.158730159	51.0	0.238095238
52	10.158730159	52.0	0.238095238
53	10.158730159	53.0	0.238095238
54	10.079365079	54.0	0.238095238
55	10.158730159	55.0	0.238095238
56	10.126984127	56.0	0.238095238

Table 2(a): Experimental Critical Values Obtained(1)

NN	CV4	CV5	CV6
7	11.301587302	82.619047619	6.3
8	24.864692773	69.659344158	7.2
9	39.412698413	55.603174603	8.1
10	38.746031746	55.587301587	5.3
11	29.317460317	64.698412698	5.5
12	30.461049285	63.863275040	5.0
13	23.793650794	69.603174603	5.0
14	25.126984127	68.380952381	5.0
15	25.015873016	68.444444444	5.3
16	31.063492063	61.857142857	5.0
17	32.111111111	61.142857143	5.4
18	32.603174603	60.396825397	5.3
19	32.761904762	60.190476190	5.3
20	32.857142857	59.857142857	5.4
21	31.888888889	60.301587302	5.3
22	32.857142857	59.571428571	5.4
23	33.015873016	59.031746032	5.3
24	33.285714286	58.428571429	5.6
25	34.111111111	58.111111111	5.6
26	25.936507937	66.507936508	5.0
27	33.698412698	58.682539683	4.6
28	34.428571429	57.793650794	4.9
29	27.015873016	65.301587302	4.7
30	27.047619048	64.555555556	4.6
31	25.158730159	65.269841270	4.8
32	25.825396825	65.682539683	4.5
33	26.047619048	64.904761905	4.6
34	26.126984127	65.047619048	4.6
35	25.857142857	65.793650794	4.2
36	26.269841270	65.730158730	4.7
37	25.591363709	64.883314812	4.9
38	25.761904762	64.904761905	4.6
39	25.603174603	64.968253968	4.8
40	25.095238095	65.222222222	4.7
41	24.666666667	65.714285714	4.7
42	25.079365079	65.634920635	4.9
43	25.095238095	65.904761905	4.5
44	24.904701398	65.803684879	4.4
45	25.095238095	65.095238095	4.0
46	25.285714286	65.682539683	4.0
47	24.587301587	66.047619048	4.1
48	24.888888889	65.095238095	4.2

49	24.746031746	65.031746032	4.0
50	26.444444444	64.650793651	4.2
51	35.285714286	55.920634921	4.2
52	35.349206349	55.206349206	4.2
53	35.285714286	56.047619048	4.3
54	26.619047619	64.507936508	4.3
55	26.841269841	64.142857143	4.3
56	35.555555556	55.952380952	4.4

Table 2(b): Experimental Critical Values Obtained(2)

3. Critical Values Trend Analyses- Metric S_FP.

3.0 General Procedure Adopted.

The initial step is to plot the tabulated data for each S_FP CV on gnuplot. The following step is to perform graphical analyses and describing the general observations reachable. In the third step, the applicability of certain selected equations of fit is explored. Choice of best fit is based on values of least reduced chi-square and best extendability produced at node numbers 80, 100 and 120 for five CVs and for one CV, it takes the exact value of x (i.e. the node number). The last step consist of recording the values of parameters for each S_FP CV equation.

3.1 Trend Analysis – S_FP CV1.

Here, the plots depict a mild oscillation along a mildly decreasing straight line. One plot is largely outlying and 2 plots are quite outlying.

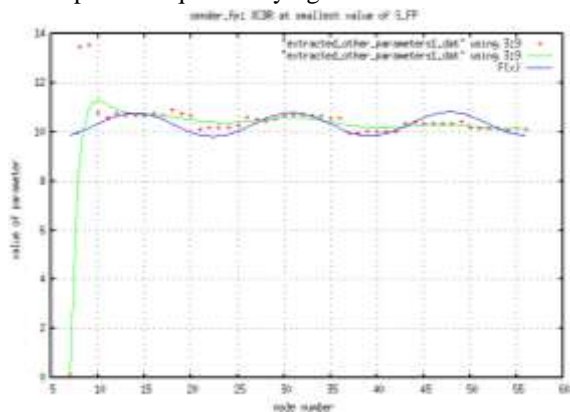


Figure 1: S_FP Critical Value 1

$F(x) = a * \sin((b*x)+c) + d*x + f$
 $Ch_sq = 2.59148$ $F(80) = 10.793286344$
 $F(100) = 10.800324853$ $F(120) = 10.334834442$
 The parameters of fit are:
 $a = -0.481109$, $b = 0.372298$, $c = -0.481889$, $d = 0.001360353397$, $f = 10.2725849077456$

3.2 Trend Analysis – S_FP CV2.

Here, the y-axis value varies exactly as x-axis value, i.e. node number.

$$F(x) = x$$

Sum of squares of residuals = 0

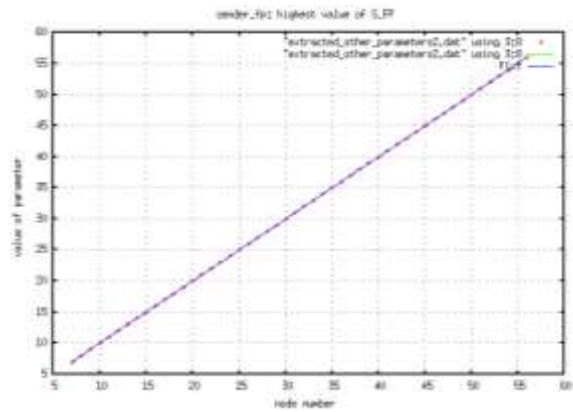


Figure 2: S_FP Critical Value 2

3.3 Trend Analysis – S_FP CV3.

In the beginning third of the plot, the curve depicts a decreasing trend at a decreasing rate. Then the curve tends to stabilise at a value between 0 and 0.5

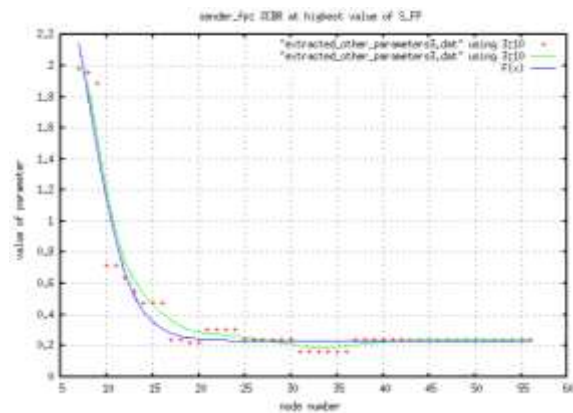


Figure 3: S_FP Critical Value 3

The potentially applicable equations are:

- $F(x) = a * \exp((b*x) + c) + d$
 $Ch_sq = 0.0136908$ $F(80) = 0.220743550$
 $F(100) = 0.220743548$ $F(120) = 0.220743548$
- $F(x) = a * x * \exp((b*x)+c) + d$
 $Ch_sq = 0.012982$ $F(80) = 0.224615737$
 $F(100) = 0.224615737$ $F(120) = 0.224615737$
- $F(x) = a * x^2 * \exp((b*x)+c) + d$
 $Ch_sq = 0.0124427$ $F(80) = 0.227882183$
 $F(100) = 0.227882183$ $F(120) = 0.227882183$
- $F(x) = a * x^3 * \exp((b*x)+c) + d$
 $Ch_sq = 0.0120302$ $F(80) = 0.230707572$
 $F(100) = 0.230707572$ $F(120) = 0.230707572$
- $F(x) = a * x^4 * \exp((b*x)+c) + d$
 $Ch_sq = 0.011715$ $F(80) = 0.233222547$
 $F(100) = 0.233222547$ $F(120) = 0.233222547$

Choice of best fit for S_FP Critical value 3

The equation in part 5 above has been selected because of least ch_sq and good extendability. The parameters for best fit are: $a = 0.0474586$, $b = -0.725878$, $c = 0.993435$, $d = 0.233223$

3.4 Trend Analysis – S_FP CV4.

The plot here appears to be taking oscillating tendency.

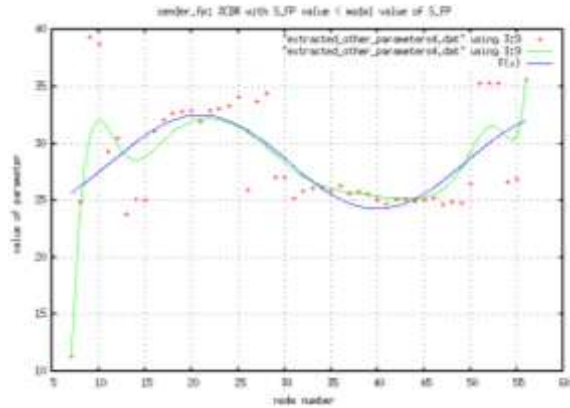


Figure 4: S_FP Critical Value 4

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

$$\begin{aligned} \text{Ch_sq} &= 18.447\ 5 & F(80) &= 24.450\ 323\ 674 \\ F(100) &= 32.044\ 691\ 978 & F(120) &= 25.026\ 294\ 954 \end{aligned}$$

The parameters of fit are: a = 4.123 57 , b = 0.164 81 , c = -1.873 12 , d = 28.369 6

3.5 Trend Analysis – S_FP CV5.

Again, plot appears to be taking oscillating tendency.

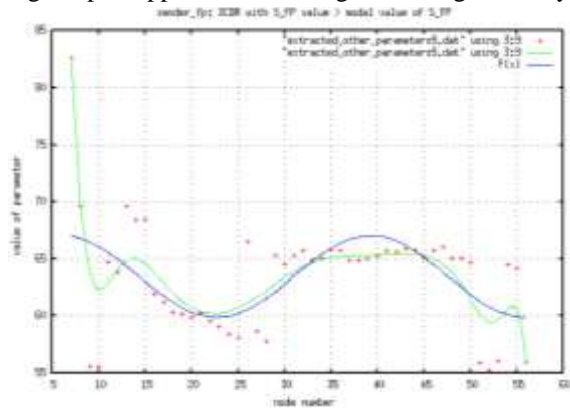


Figure 5: S_FP Critical Value 5

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

$$\begin{aligned} \text{Ch_sq} &= 17.798\ 4 & F(80) &= 64.024\ 288\ 280 \\ F(100) &= 65.102\ 308\ 717 & F(120) &= 60.245\ 185\ 203 \end{aligned}$$

The parameters of fit are: a = 3.575 12 , b = -0.188 958 , c = 2.710 07 , d = 63.456 8

3.6 Trend Analysis – S_FP CV6.

Here also, the plot here appears to be taking oscillating tendency along a decreasing axis.

The potentially applicable equations are:

1. $F(x) = a * \sin ((b*x) + c) + (d*x) + f$
 $\text{Ch_sq} = 0.162\ 726$ $F(80) = 2.576\ 600\ 529$
 $F(100) = 2.286\ 203\ 567$ $F(120) = 1.712\ 114\ 622$
2. $F(x) = a * \sin ((b*x) + c) + (d / \log (x)) + f$
 $\text{Ch_sq} = 0.138\ 654$ $F(80) = 3.935\ 650\ 458$
 $F(100) = 3.643\ 763\ 449$ $F(120) = 3.685\ 477\ 317$

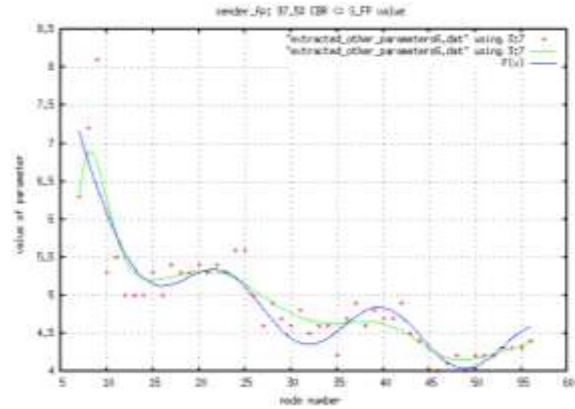


Figure 6: S_FP Critical Value 6

4. Conclusion.

The aim of this study was to determine the relevant CVs observable for metric S_FP and scrutinise their corresponding trends over varying node densities in a MANET topography of 300 x 300 m². The models illustrated in this paper, are composed of mathematical equations of varying complexity. The output detailed here will add to the set of existing tools for more expert studies of MANETs for ubicomp environments viewed from software engineering. These output can meticulously be implemented into computational algorithms to generate better simulation scenarios which may serve for enabling better testing procedures over communication and middleware components.

This experiment was performed in NS-2 over Linux. Plottings and “Fit” attempts were done with gnuplot software. Selection of best fit was mostly made using least reduced chi-square values and best extendability produced at higher node numbers. Assumptions put forward in prior papers [25, 41].

This study aligns as a continuation to previous studies [1-56]. Improvements to these results remain possible in the future. A possible future work is the formulation of predictability for metric S_FP and its trend.

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