

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

M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY

**Abstract** – The fields of location-tracking, ubicomp functionalities and MANET transmission strategies remain serious topics of research and development [1-54]. Presently, the merging of these fields has a lot to undergo, especially as concerns correct protocol design approaches which is determinant for such successful merging. Nevertheless, such approaches are considered as heuristic and poorly adapted for implementation [92]. Upgrades in middleware services and ubicomp network architecture is also desired [93, 94].

A judiciously defined objective in such vision for ubicomp advancement is accomplishing “realism” in design and evaluation of wireless routing protocols [95]. Such studies will yield components better suited for further studies of predictability in ubicomp. Such components are non-negligible since “realism” will propagate into every feature related to ubicomp, one of which was pondered over previously [23] to assess the trend of Minimum Fairness Proportion (Min\_FP) observable for CBRs under different sets of node densities in ubicomp environments. This study was supplemented by the study of Min\_FP parameter of equations [39].

To assimilate “realism” in knowledge of these trends, in this paper, the next study needed is: “What are observable critical values in Min\_FP trends over varying node densities and trends of such critical values?” Such refinements will engender the design of more realistic ubicomp scenarios which are more convenient for better sustained testing of experimental middleware components and communication protocols. This study follows-up from previous investigations [1-54].

**Key terms:** Ubicomp- Ubiquitous Computing, MAUC- Mobile and Ubiquitous Computing, Min\_FP- Minimum Fairness Proportion, CBR- Constant Bit Rate, MANET- Mobile Adhoc Network, CV- Critical Value.

M. Kaleem GALAMALI,  
University of Technology Mauritius (student)  
Mauritius

Assoc. Prof Nawaz Mohamudally  
University of Technology Mauritius,  
Mauritius

## 1. Introduction

It is anticipated that future ubicomp environments may suffer from poorly equipped networking devices and hence MANETs remain a hopeful solution. The task of

transmission is repartitioned among a hopeful solution. The task of transmission is repartitioned among cooperating nodes in ubicomp leading to energy consumption also being repartitioned. In such circumstances, the notion of Fairness must be well devised. This can also be viewed from various related metrics. One such metric, the Min\_FP, was studied before [23] for node densities varying between 7 until 56. The trend was observed to be the decreasing exponential equation of form:

$$G(x) = a * \exp(b * (x - 0.1)) + c$$

A follow-up study [39] was conducted to mathematically model the three parameters observed above. Results obtained are utilisable for better understanding of the evolution and predictability of ubicomp environments. These progresses, though slowly but surely getting constructed will enable designers to prepare more realistic simulation scenarios using which testing procedures can be exerted over freshly developed components for middleware and communication protocols.

The probing now required for metric Min\_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. Ten such CVs were observed.

The key contribution of this paper is the setting up of the trends of variations for each of the ten CVs observed for metric Min\_FP illustrated before [23, 39] over node numbers ranging from 7 until 56. Such kinds of information should imperatively be produced in the right way to more fluidly assist ubicomp designers to understand the evolution and predictability of ubicomp behaviour and be appropriately 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- Min\_FP Critical Values, section 3- Critical Values Trend Analyses- Metric Min\_FP, section 4- Conclusion and References.

## 2. Min\_FP Critical Values.

### 2.0 Critical Values Identified.

Ten CVs were identified as follows: Column headings are: C1→Min\_FP CV, C2→Meaning of Min\_FP CV, C3→Corresponding figure number for the Min\_FP CV.

C1	C2	C3
1	Minimum value of Min_FP	1
2	% CBR at modal value of Min_FP	2
3	Second modal value of Min_FP	3
4	% CBR at second modal value of Min_FP	4
5	Highest value of Min_FP	5
6	% CBR at highest value of Min_FP	6
7	Value of Min_FP previous to rightmost outlier.	7
8	% CBR at second highest value of Min_FP.	8
9	% CBR within range (excluding outlier)	9
10	% CBR with Min_FP value ≤ 1	10

**Table 1: Min\_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	CV4
7	0.0	88.809523810	0.1	3.492063492
8	0.0	88.538681948	0.1	2.992677491
9	0.0	89.079365079	0.1	3.126984127
10	0.0	85.873015873	0.1	6.126984127
11	0.0	85.904761905	0.1	6.603174603
12	0.0	86.406995231	0.1	6.502384738
13	0.0	86.253968254	0.1	7.031746032
14	0.0	86.158730159	0.1	7.253968254
15	0.0	86.269841270	0.1	7.158730159
16	0.0	85.698412698	0.1	7.793650794
17	0.0	83.730158730	0.1	9.396825397
18	0.0	83.746031746	0.1	9.587301587
19	0.0	83.126984127	0.1	9.825396825
20	0.0	83.158730159	0.1	9.920634921
21	0.0	82.238095238	0.1	11.746031746
22	0.0	81.777777778	0.1	12.000000000
23	0.0	81.507936508	0.1	12.126984127
24	0.0	81.698412698	0.1	11.904761905
25	0.0	82.174603175	0.1	11.984126984
26	0.0	81.079365079	0.1	12.825396825
27	0.0	81.079365079	0.1	13.000000000
28	0.0	81.095238095	0.1	12.634920635
29	0.0	80.873015873	0.1	12.841269841
30	0.0	81.063492063	0.1	12.873015873
31	0.0	81.317460317	0.1	12.063492063
32	0.0	81.126984127	0.1	12.000000000
33	0.0	81.587301587	0.1	11.873015873
34	0.0	81.095238095	0.1	12.682539683
35	0.0	81.047619048	0.1	12.793650794
36	0.0	80.857142857	0.1	13.047619048
37	0.0	79.377678997	0.1	14.414986506
38	0.0	79.412698413	0.1	14.206349206
39	0.0	79.031746032	0.1	14.936507937
40	0.0	79.777777778	0.1	14.349206349
41	0.0	79.698412698	0.1	14.650793651

42	0.0	79.523809524	0.1	14.698412698
43	0.0	79.333333333	0.1	14.682539683
44	0.0	79.209021601	0.1	15.088945362
45	0.0	78.492063492	0.1	15.380952381
46	0.0	78.476190476	0.1	15.492063492
47	0.0	78.285714286	0.1	15.650793651
48	0.0	78.142857143	0.1	15.841269841
49	0.0	77.444444444	0.1	16.619047619
50	0.0	76.714285714	0.1	16.666666667
51	0.0	76.539682540	0.1	16.857142857
52	0.0	76.444444444	0.1	16.984126984
53	0.0	76.460317460	0.1	16.952380952
54	0.0	76.365079365	0.1	16.952380952
55	0.0	76.920634921	0.1	16.111111111
56	0.0	76.142857143	0.1	16.714285714

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

NN	CV5	CV6	CV7	CV8
7	7.0	1.714285714	3.2	0.015873016
8	8.0	1.703279210	3.6	0.095510984
9	9.0	1.634920635	4.1	0.015873016
10	10.0	0.634920635	5.0	0.079365079
11	11.0	0.634920635	5.5	0.079365079
12	12.0	0.556438792	6.0	0.079491256
13	13.0	0.476190476	5.9	0.079365079
14	14.0	0.396825397	6.4	0.079365079
15	15.0	0.396825397	6.8	0.079365079
16	16.0	0.396825397	7.3	0.079365079
17	17.0	0.158730159	6.5	0.079365079
18	18.0	0.158730159	6.9	0.079365079
19	19.0	0.158730159	7.2	0.079365079
20	20.0	0.158730159	7.6	0.079365079
21	21.0	0.238095238	6.9	0.158730159
22	22.0	0.238095238	7.2	0.158730159
23	23.0	0.238095238	7.5	0.158730159
24	24.0	0.238095238	7.9	0.079365079
25	25.0	0.238095238	8.2	0.158730159
26	26.0	0.238095238	10.9	0.079365079
27	27.0	0.238095238	11.3	0.079365079
28	28.0	0.238095238	11.7	0.079365079
29	29.0	0.238095238	12.1	0.079365079
30	30.0	0.238095238	12.6	0.079365079
31	31.0	0.158730159	9.6	0.079365079
32	32.0	0.158730159	9.9	0.079365079
33	33.0	0.158730159	10.2	0.079365079
34	34.0	0.158730159	10.5	0.079365079
35	35.0	0.158730159	10.9	0.079365079
36	36.0	0.158730159	11.2	0.079365079
37	37.0	0.238133037	6.7	0.079377679
38	38.0	0.238095238	6.9	0.079365079
39	39.0	0.238095238	7.0	0.079365079
40	40.0	0.238095238	7.2	0.079365079
41	41.0	0.238095238	7.4	0.079365079
42	42.0	0.238095238	7.6	0.079365079
43	43.0	0.238095238	11.0	0.079365079
44	44.0	0.238246506	11.3	0.079415502
45	45.0	0.238095238	11.5	0.079365079
46	46.0	0.238095238	11.8	0.079365079
47	47.0	0.238095238	12.0	0.079365079

48	48.0	0.238095238	12.3	0.079365079
49	49.0	0.238095238	12.5	0.079365079
50	50.0	0.238095238	7.9	0.079365079
51	51.0	0.238095238	8.0	0.079365079
52	52.0	0.238095238	8.2	0.079365079
53	53.0	0.238095238	8.3	0.079365079
54	54.0	0.238095238	8.5	0.079365079
55	55.0	0.238095238	8.6	0.079365079
56	56.0	0.238095238	8.8	0.079365079

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

NN	CV9	CV10
7	9.476190476	97.333333333
8	9.758038841	97.246099968
9	9.285714286	97.634920635
10	13.492063492	97.698412698
11	13.460317460	97.539682540
12	13.036565978	97.297297297
13	13.269841270	98.317460317
14	13.444444444	98.317460317
15	13.333333333	98.317460317
16	13.904761905	98.142857143
17	16.111111111	99.285714286
18	16.095238095	99.206349206
19	16.714285714	99.126984127
20	16.682539683	99.126984127
21	17.523809524	98.968253968
22	17.984126984	98.968253968
23	18.253968254	98.888888889
24	18.063492063	98.968253968
25	17.587301587	98.968253968
26	18.682539683	99.047619048
27	18.682539683	98.968253968
28	18.666666667	98.968253968
29	18.888888889	98.888888889
30	18.698412698	98.968253968
31	18.523809524	99.047619048
32	18.714285714	99.047619048
33	18.253968254	99.047619048
34	18.746031746	99.047619048
35	18.793650794	99.047619048
36	18.984126984	99.047619048
37	20.384187966	99.126845531
38	20.349206349	99.126984127
39	20.730158730	99.126984127
40	19.984126984	99.126984127
41	20.063492063	99.126984127
42	20.238095238	99.126984127
43	20.428571429	99.206349206
44	20.552731893	99.205844981
45	21.269841270	99.126984127
46	21.285714286	99.126984127
47	21.476190476	99.126984127
48	21.619047619	99.126984127
49	22.317460317	99.206349206
50	23.047619048	99.206349206
51	23.222222222	99.206349206
52	23.317460317	99.206349206
53	23.301587302	99.206349206

54	23.396825397	99.206349206
55	22.841269841	99.206349206
56	23.619047619	99.206349206

Table 2(c): Experimental Critical Values Obtained(3)

### 3. Critical Values Trend Analyses- Metric Min\_FP.

#### 3.0 General Procedure Adopted.

The first step is to plot the tabulated data for each Min\_FP CV on gnuplot. The second step is to accomplish graphical analyses and report general observations. The third step is to explore the applicability of some selected equations of fit. Choice of best fit is made considering values of least reduced chi-square and best extendability at node numbers 80, 100 and 120 for 6 CVs; on flat values for 3 Cvs and a combination of least reduced chi-square and flat values for 1 CV. The fourth step is to record the values of parameters for each Min\_FP CV equation.

#### 3.1 Trend Analysis – Min\_FP CV1.

This value stays constant at 0 only.

$$F(x) = 0$$

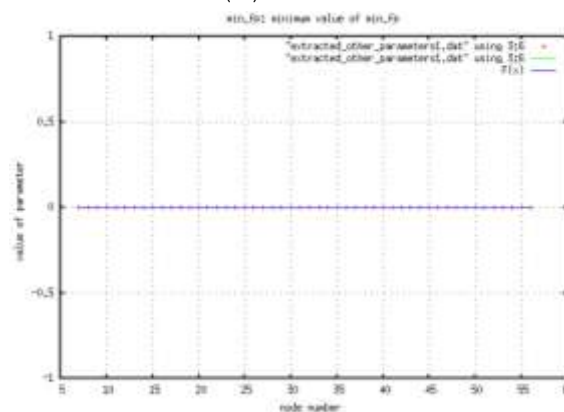


Figure 1: Min\_FP Critical Value 1

For node numbers above 56, the projected Critical value will be at 0 only.

#### 3.2 Trend Analysis – Min\_FP CV2.

The curve depicts a general decreasing tendency.

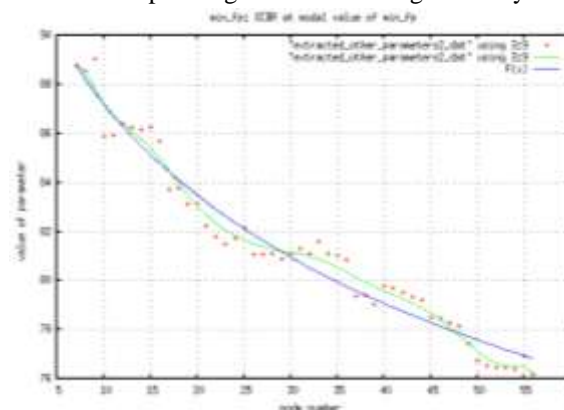


Figure 2: Min\_FP Critical Value 2

The potentially applicable equations are:

1.  $F(x) = d * x + f$   
 $Ch\_sq = 0.907\ 673$        $F(80) = 70.207\ 833\ 041$   
 $F(100) = 65.624\ 116\ 370$     $F(120) = 61.040\ 399\ 699$
2.  $F(x) = \exp (( a * x ) + b ) + c )$   
 $Ch\_sq = 0.605\ 867$        $F(80) = 74.955\ 570\ 000$   
 $F(100) = 74.126\ 269\ 581$     $F(120) = 73.657\ 701\ 907$
3.  $F(x) = a / (\log ((b * x) + c) + d)$   
 $Ch\_sq = 0.567\ 51$        $F(80) = 74.441\ 385\ 356$   
 $F(100) = 72.967\ 807\ 165$     $F(120) = 71.780\ 704\ 171$
4.  $F(x) = a / (\log ((b*x)+c) + (d/x))$   
 $Ch\_sq = 0.578\ 11$        $F(80) = 74.652\ 117\ 136$   
 $F(100) = 73.285\ 867\ 281$     $F(120) = 72.193\ 128\ 348$

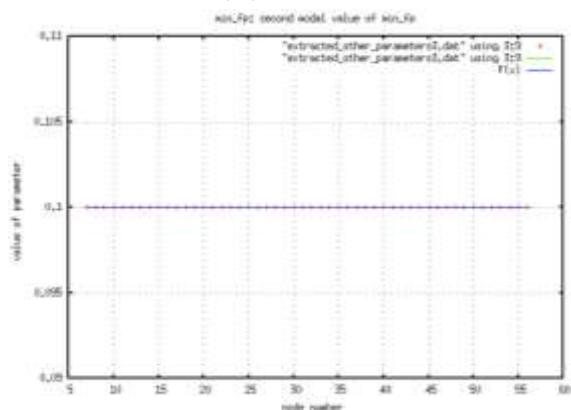
**Choice of best fit for Min\_FP Critical Value 2**

The equation in part 3 above has been selected because of smallest ch\_sq and good extendability. The parameters obtained for best fit are:  
 $a = 724.06$  ,  $b = 3.298$  ,  $c = 40.057\ 4$  ,  $d = 4.009\ 89$

3.3 Trend Analysis – Min\_FP CV3.

Here, the value stays constant at 0.1 only.

$$F(x) = 0.1$$

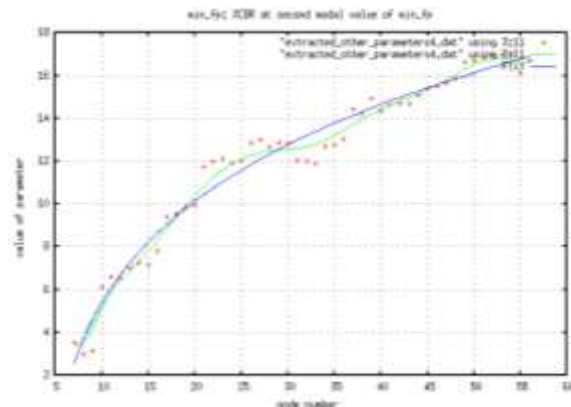


**Figure 3: Min\_FP Critical Value 3**

Projected value of this critical value for any node number above 56 will remain at 0.1.

3.4 Trend Analysis – Min\_FP CV4.

An increasing tendency at a decreasing rate is found with a mild non-uniform oscillation.



**Figure 4: Min\_FP Critical Value 4**

The potentially applicable equations are:

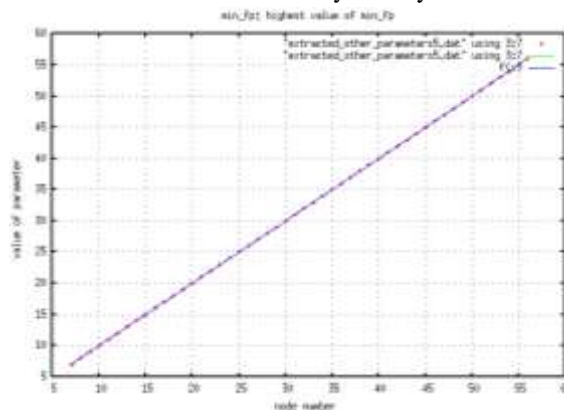
1.  $F(x) = (a * \log ((b*x) + c)) + d$   
 $Ch\_sq = 0.513\ 715$        $F(80) = 19.078\ 729\ 979$   
 $F(100) = 20.483\ 734\ 068$     $F(120) = 21.628\ 064\ 600$
2.  $F(x) = (a*x^{0.25} * \log ((b*x)+c)) + d$   
 $Ch\_sq = 0.565\ 973$        $F(80) = 20.244\ 029\ 298$   
 $F(100) = 22.361\ 599\ 449$     $F(120) = 24.217\ 989\ 334$
3.  $F(x) = (a*x^{-0.25}*\log ((b*x)+c)) + d$   
 $Ch\_sq = 0.513\ 982$        $F(80) = 18.968\ 882\ 557$   
 $F(100) = 20.295\ 386\ 338$     $F(120) = 21.353\ 238\ 967$
4.  $F(x) = (a*x^{-0.3}*\log ((b*x) + c)) + d$   
 $Ch\_sq = 0.515\ 656$        $F(80) = 18.905\ 267\ 914$   
 $F(100) = 20.186\ 959\ 540$     $F(120) = 21.198\ 861\ 646$
5.  $F(x) = (a*\log ((b*x)+c)) + (d*x)$   
 $Ch\_sq = 0.512\ 262$        $F(80) = 19.359\ 035\ 472$   
 $F(100) = 20.989\ 928\ 239$     $F(120) = 22.386\ 915\ 141$

**Choice of best fit for Min\_FP Critical Value 4**

The equation in part 5 above has been selected because of smallest ch\_sq and good extendability. The parameters obtained for best fit are:  
 $a = 5.449\ 91$  ,  $b = 0.340\ 066$  ,  $c = -0.823\ 998$  ,  $d = 0.019\ 042\ 1$

3.5 Trend Analysis – Min\_FP CV5.

The trend observed here is very cleanly linear



**Figure 5: Min\_FP Critical Value 5**

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

- Sum       $F(80) = 80.0$
- $F(100) = 100.0$        $F(120) = 120.0$

The parameters obtained for best fit are:  $d = 1$  ,  $f = 0$  ;  
 Effectively:  $F(x) = x$

3.6 Trend Analysis – Min\_FP CV6.

In this plot, an initial descending tendency is observed in the initial range of node number 7-16. Then, mostly curve is at a constant value between 0.158 and 0.238 .

$$F(x) = \begin{cases} d*x + f & 7 \leq x \leq 16 \\ 0.218\ 259 & x \geq 17 \end{cases}$$

For node number 7-16 :  $ch\_sq = 0.086\ 550\ 5$  ,  $d = -0.168\ 166$  ,  $f = 2.788\ 46$

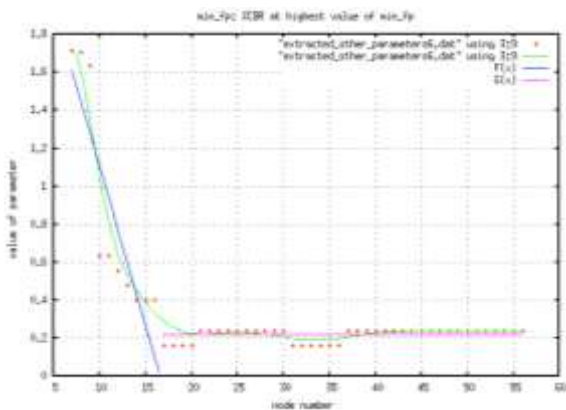


Figure 6: Min\_FP Critical Value 6

3.7 Trend Analysis – Min\_FP CV7.

Here, although the plots are very scattered and different subsets of linear trend are observed, the overall tendency is increasing at a decreasing rate.

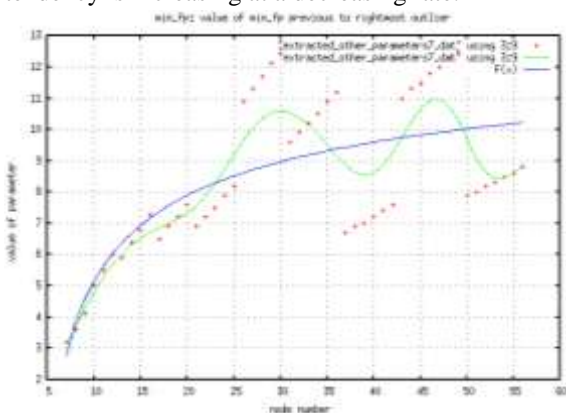


Figure 7: Min\_FP Critical Value 7

The potentially applicable equations are:

1.  $F(x) = (a * \log (b*x) + c)) + d$   
 $Ch\_sq = 3.22013$        $F(80) = 10.793359600$   
 $F(100) = 11.171015629$        $F(120) = 11.473783081$
2.  $F(x) = (a * \log (b*(x+c))) + (d*x)$   
 $Ch\_sq = 3.22227$        $F(80) = 11.051227153$   
 $F(100) = 11.509201070$        $F(120) = 11.878384403$
3.  $F(x) = (a * \log (b*(x+c))) + (d*x^{0.5})$   
 $Ch\_sq = 2.84027$        $F(80) = 7.606624831$   
 $F(100) = 5.886834$        $F(120) = 4.011106$
4.  $F(x) = (a * \log (b*(x+c))) + (d*x^{0.25})$   
 $Ch\_sq = 2.93768$        $F(80) = 8.963463943$   
 $F(100) = 8.307987025$        $F(120) = 7.589317303$
5.  $F(x) = (a * \log (b*(x+c))) + (d*x^{-0.25})$   
 $Ch\_sq = 3.2206$        $F(80) = 11.050872083$   
 $F(100) = 11.511246811$        $F(120) = 11.883076196$
6.  $F(x) = (a * \log (b*(x+c))) + (d*x^{-1})$   
 $Ch\_sq = 3.13317$        $F(80) = 10.813872894$   
 $F(100) = 11.147156695$        $F(120) = 11.405226776$

**Choice of best fit for ECFP Critical Value 7**

The equation in part 6 above has been selected because of good extendability even if ch\_sq is not smallest. The parameters obtained for best fit are:

$a = 1.0778, b = 436.979, c = -5.10916, d = -31.2691$

3.8 Trend Analysis – Min\_FP CV8.

Here, most plots are at y-value of 0.0793. As from node number 24 onwards, all plots are at 0.0793.

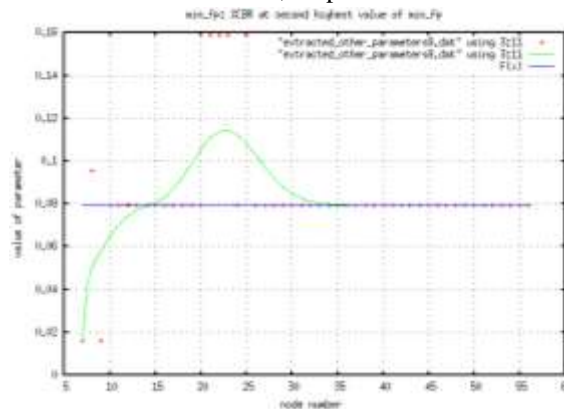


Figure 8: Min\_FP Critical Value 8

$F(x) = 0.0793$

The outliers can be considered as exceptional cases.

3.9 Trend Analysis – Min\_FP CV9.

Here an increasing tendency at a decreasing rate is generally observed. A slight oscillation is also noticed but it is not uniform nor significant in amplitude.

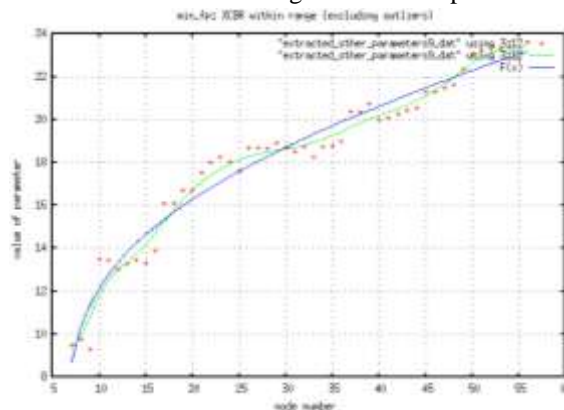


Figure 9: Min\_FP Critical Value 9

The potentially applicable equations are:

1.  $F(x) = (a * \log (b*(x+c))) + d$   
 $Ch\_sq = 0.637183$        $F(80) = 25.035721990$   
 $F(100) = 26.410928031$        $F(120) = 27.532038531$
2.  $F(x) = (a * x^{0.5} * \log (b*(x+c))) + d$   
 $Ch\_sq = 0.701858$        $F(80) = 27.453978602$   
 $F(100) = 30.434331510$        $F(120) = 33.223077891$
3.  $F(x) = (a * x^{0.25} * \log (b*(x+c))) + d$   
 $Ch\_sq = 0.601039$        $F(80) = 26.395042027$   
 $F(100) = 28.699007084$        $F(120) = 30.776363984$

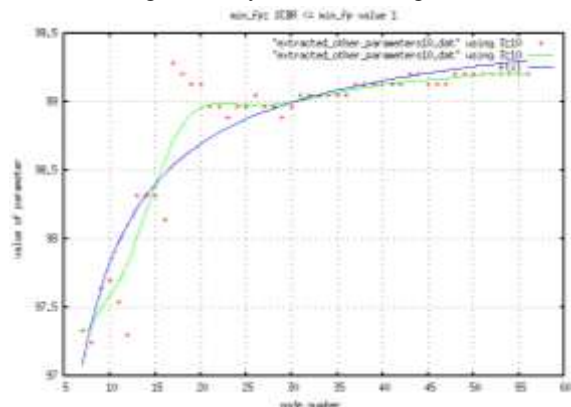
**Choice of best fit for Min\_FP Critical Value 9**

The equation in part 3 above has been selected because of smallest ch\_sq and good extendability. The parameters obtained for best fit are:

$a = 3.90016, b = 0.00538038, c = -4.83555, d = 36.9549$

### 3.10 Trend Analysis – Min\_FP CV10.

An increasing tendency at a decreasing rate is observed.



**Figure 10: Min\_FP Critical Value 10**

The potentially applicable equations are:

1.  $F(x) = (a \cdot \log(b \cdot (x+c))) + d$   
 $Ch_{sq} = 0.0644511$        $F(80) = 99.524934496$   
 $F(100) = 99.637181615$        $F(120) = 99.727181413$
2.  $F(x) = (a \cdot \log(b \cdot (x+c))) + (d/x)$   
 $Ch_{sq} = 0.0577967$        $F(80) = 99.434565965$   
 $F(100) = 99.509094438$        $F(120) = 99.569172124$
3.  $F(x) = (a \cdot \log(b \cdot (x+c))) + (d/x^2)$   
 $Ch_{sq} = 0.062555$        $F(80) = 99.468089627$   
 $F(100) = 99.617559111$        $F(120) = 99.761739749$

#### Choice of best fit for ECFP Critical Value 10

The equation in part 2 above has been selected because of smallest  $ch_{sq}$  and good extendability. The parameters obtained for best fit are:  
 $a = 6.52416$ ,  $b = 1044.74$ ,  $c = 4034.78$ ,  $d = -17.1578$

## 4. Conclusion.

The major aim of this study has been to identify some CVs observable for metric Min\_FP and study their corresponding trends over varying node densities in a MANET topography of 300 x 300 m<sup>2</sup>. The models described in this paper, do constitute of quite complex mathematical equations. The output illustrated here will reinforce our existing tools for better studies of MANETs for ubicomp environments as viewed from software engineering. These output can systematically be implemented in computational algorithms to produce more precise simulation schemes which may, in turn, serve for adopting better testing procedures over communication and middleware components.

This experiment was conducted in NS-2 over Linux. Plottings and “Fit” attempts were done using gnuplot. Best fit was chosen using a combination of flat values, least reduced chi-square values, and best extendability produced at higher node numbers. Assumptions illustrated previously [23, 39] are upheld here also.

This study follows up from previous studies [1-54]. Upgrades to output presented here are possible in the future. A possible future work remain the formulation of predictability for metric Min\_FP and its trend.

## 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] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Maximum Energy Consumption Ratio Achievable in MANET Using Location-Aware Transmission in Ubicomp. ACCN 2016
- [21] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Overall Energy Consumption Fairness Ratio Achievable in MANET Using Location-Aware Transmission in Ubicomp. ACCN 2016
- [22] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Overall Energy Consumption Fairness Proportion Achievable in MANET Using Location-Aware Transmission for Ubicomp, CEET 2016
- [23] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Minimum Fairness Proportion Achievable in MANET Using Location-Aware Transmission for Ubicomp, CEET 2016
- [24] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Maximum Fairness Proportion Achievable in MANET Using Location-Aware Transmission for Ubicomp, CEET 2016
- [25] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Sender Fairness Proportion Achievable in MANET Using Location-Aware Transmission for Ubicomp, CEET 2016
- [26] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Distance Travelled by packets in MANETs using Location-Aware Transmission for Ubicomp, CEET 2016
- [27] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Maximum CBR Distance Travelled by packets in MANETs using Location-Aware Transmission for Ubicomp, CEET 2016
- [28] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Minimum CBR Distance Travelled by packets in MANETs using Location-Aware Transmission for Ubicomp, CEET 2016
- [29] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Model of Range CBR Distance Experienced by Transmissions in MANETs using Location-Aware Transmission for Ubicomp, CEET 2016
- [30] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Parameters of Equations for Sender Node Energy Savings Achievable in ubicomp MANETs using Location-Aware Transmission, ACCN 2017.
- [31] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Parameters of Equations for Overall Node Energy Savings Achievable in ubicomp MANETs using Location-Aware Transmission, ACCN 2017.
- [32] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Parameters of Equations for Sender Node Extra Energy Savings Achievable in MANET against Direct Node-to-Node Location-Aware Transmission, ACCN 2017.
- [33] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Parameters of Equations for Overall Nodes Extra Energy Savings Achievable in MANET against Direct Node-to-Node Location-Aware Transmission, ACCN 2017.
- [34] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Parameters of Equations for Energy Consumption Ratio Achievable in Ubicomp MANET Using Location-Aware Transmission, ACCN 2017.
- [35] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Parameters of Equations for Minimum Energy Consumption Ratio Achievable in Ubicomp MANETs Using Location-Aware Transmission, ACCN 2017.
- [36] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Parameters of Equations for Maximum Energy Consumption Ratio Achievable in Ubicomp MANETs Using Location-Aware Transmission, ACCN 2017.
- [37] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Parameters of Equations for Overall Fairness Ratio Achievable in Ubicomp MANETs Using Location-Aware Transmission, ACCN 2017.
- [38] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Parameters of Equations for Energy Consumption Fairness Proportion Achievable in Ubicomp MANETs Using Location-Aware Transmission, CEET 2017
- [39] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Parameters of Equations for Minimum Fairness Proportion Achievable in Ubicomp MANETs Using Location-Aware Transmission, CEET 2017
- [40] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Parameters of Equations for Maximum Fairness Proportion Achievable in Ubicomp MANETs Using Location-Aware Transmission, CEET 2017
- [41] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Parameters of Equations for Sender Fairness Proportion Achievable in Ubicomp MANETs Using Location-Aware Transmission, CEET 2017
- [42] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Parameters of Equations for Packets Per Distance Achievable in Ubicomp MANETs Using Location-Aware Transmission, CEET 2017
- [43] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Parameters of Equations for Maximum CBR Distance Achievable in Ubicomp MANETs Using Location-Aware Transmission, CEET 2017
- [44] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Parameters of Equations for Minimum CBR Distance Achievable in Ubicomp MANETs Using Location-Aware Transmission, CEET 2017
- [45] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Parameters of Equations for Range CBR Distance Achievable in Ubicomp MANETs Using Location-Aware Transmission, CEET 2017
- [46] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Critical Values Obtained for Sender Node Energy Savings Achievable in Ubicomp MANETs Using Location-Aware Transmission, CEET 2017
- [47] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Critical Values Obtained for Overall Node Energy Savings Achievable in Ubicomp MANETs Using Location-Aware Transmission, CEET 2017
- [48] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Critical Values Obtained for Sender Node Extra Energy Savings Achievable in Ubicomp MANET Against Direct Node-to-Node Location-Aware Transmission, CEET 2017
- [49] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Critical Values Obtained for Overall Nodes Extra Energy Savings Achievable in Ubicomp MANET Against Direct Node-to-Node Location-Aware Transmission, CEET 2017
- [50] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Critical Values Obtained for Energy Consumption Ratio Achievable in Ubicomp MANETs Using Location-Aware Transmission Strategies, CEET 2017
- [51] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Critical Values Obtained for Minimum Energy Consumption Ratio Achievable in Ubicomp MANETs Using Location-Aware Transmission Strategies, CEET 2017
- [52] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Critical Values Obtained for Maximum Energy Consumption Ratio Achievable in Ubicomp MANETs Using Location-Aware Transmission Strategies, CEET 2017
- [53] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Critical Values Obtained for Overall Fairness Ratio Achievable in Ubicomp

- MANETs Using Location-Aware Transmission Strategies, CEET 2017
- [54] M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY, Trend Analyses of Critical Values Obtained for Energy Consumption Fairness Proportion Achievable in UbiComp MANETs Using Location-Aware Transmission Strategies, ACCN 2017.
- [55] Markus Bylund and Zary Segall, Towards seamless mobility with personal servers, 2004.
- [56] Masugi Inoue, Mikio Hasegawa, Nobuo Ryoki and Hiroyuki Morikawa, Context-Based Seamless Network and Application Control, 2004
- [57] Xiang Song, Umakishore Ramachandran, MobiGo: A Middleware for Seamless Mobility, College of Computing Georgia Institute of Technology, Atlanta, GA, USA, August 2007
- [58] Budzisz, Ferrús, R., Brunstrom A., Grinnemo, K, Fracchia, R., Galante, G., and Casadevall, F. Towards transport-layer mobility: Evolution of SCTP multihoming, March 2008
- [59] Paul Dourish & Genevieve Bell, Divining a digital future, 2011.
- [60] Xiang Song, Seamless Mobility In Ubiquitous Computing Environments, PhD Thesis, Georgia Institute of Technology, August 2008
- [61] 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, UBI COMM 2012
- [62] Pablo Vidales, Seamless mobility in 4G systems, *Technical Report, University of Cambridge*, Computer Laboratory, Number 656, November 2005
- [63] 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
- [64] 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
- [65] 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
- [66] Yipeng Yu Dan He Weidong Hua Shijian Li Yu Qi Yueming Wang Gang Pan, FlyingBuddy2: A Brain-controlled Assistant for the Handicapped, Zhejiang University, *UbiComp '12*, September 5-8, 2012.
- [67] Jing Su, James Scott, Pan Hui, Jon Crowcroft, Eyal de Lara Christophe Diot, Ashvin Goel, Meng How Lim, and Eben Upton, Hagggle: Seamless Networking for Mobile Applications, 2007
- [68] 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
- [69] Byrav Ramamurthy, K. K. Ramakrishnan , Rakesh K. Sinha, Cost and Reliability Considerations in Designing the Next-Generation IP over WDM Backbone Networks, 2012.
- [70] 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
- [71] Ashok Anand, Vyas Sekar and Aditya Akella, SmartRE: An Architecture for Coordinated Network-wide Redundancy Elimination, SIGCOMM 2009, Barcelona, Spain
- [72] John Breeden II, "Smart-phone battery life could double – without better batteries", Nov 14, 2012
- [73] Andy Boxall, "When will your phone battery last as long as your kindle", December 5, 2012.
- [74] Imielinski, T. and Navas, J.C. (1999). GPS-based geographic addressing, routing, and resource discovery. *Comms. ACM*, Vol. 42, No. 4, pp. 86-92.
- [75] Hightower, J. and Borriello, G. (2001). Location Systems for Ubiquitous Computing. *IEEE Computer*, Vol. 34, No. 8, August, pp. 57-66.
- [76] Harter, A., Hopper, A., Steggle, 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.
- [77] 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.
- [78] 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.
- [79] Ko, Y., & Vaidya, N. H. (2000). Location-aided routing (LAR) in mobile ad hoc networks. *Wireless Networks*, 6(4), 307-321.
- [80] 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.
- [81] 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).
- [82] Jiang, X., & Camp, T. (2002). Review of geocasting protocols for a mobile ad hoc network. In *Proceedings of the Grace Hopper Celebration (GHC)*.
- [83] 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).
- [84] 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.
- [85] 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).
- [86] 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).
- [87] 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.
- [88] 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>
- [89] 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).
- [90] 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.
- [91] 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.
- [92] Sgroi et al., "Designing Wireless Protocols: Methodology and Applications, February 2000.
- [93] Gyula et al., "Simulation-based optimization of communication protocols for large-scale wireless sensor networks", 10 October 2002
- [94] Rao and Sharma, "Cross Layer Protocols For Multimedia Transmission in Wireless Networks", June 2012
- [95] Herms et al, "Realism in Design and Evaluation of Wireless Routing Protocols", 2007.

About Author (s):

Associate Professor Nawaz Mohamudally works at University of Technology, Mauritius (UTM) and has undertaken supervision of MPhil/PhD Students for many years.



M. Kaleem Galamali is a part-time student (achieved M Phil Transfer on 28.10.2014, currently PhD student) at UTM under supervision of A.P. Nawaz Mohamudally.