International Journal of Advance in Computer Science & its application – IJCSIA 2018
Copyright © Institute of Research Engineers and Doctors , SEEK Digital Library
Volume 7 : Issue 2 [ISSN : 2250-3765] - Publication Date: 25 June , 2018

Trend Analyses of Critical Values Obtained for Energy Consumption 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 are yielding commendable output and justify the research effort input in them [1-53]. With present research status, the merging of these fields still has a lot to undergo. Correct protocol design approaches is a crucial factor for successful merging of these fields. However, it is currently agreed that such approaches are heuristic in nature and hence unsuitable for implementation [91]. Improvements in middleware services and ubicomp network architecture is also needed [92, 93].**

A well-shaped objective in this direction of ubicomp advancement is achievement of "realism" in design and evaluation of wireless routing protocols [94]. Such investigations may generate components better adapted for studies of predictability in ubicomp. These may be required since "realism" will dripple into every feature related to ubicomp, one of which was studied previously [22] to assess the trend of Energy Consumption Fairness Proportion (ECFP) observable for CBRs under different sets of node densities in a ubicomp environment. This study was reinforced by the related study of trends for each ECFP parameter of equations [38].

To accommodate "realism" in knowledge of these trends, in this paper, the next study required is: "What are observable critical values in ECFP trends over varying node densities and trends of such critical values?" Such knowledge will entail the design of more realistic ubicomp scenarios which are better conducive for more sustained testing of experimental middleware components and communication protocols. This study abides as a follow-up of prior ones [1-53].

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

M. Kaleem GALAMALI,
University of Technology Mauritius (student)
Mauritius
mkaleemg@gmail.com

Assoc. Prof Nawaz Mohamudally
University of Technology Mauritius,
Mauritius
alimohamudally@umail.utm.ac.mu

1. Introduction

Present ubicomp environments may be subject to scant resource equipment. A laudable solution to it is use of MANETS whereby the load of energy requirements is distributed among cooperating nodes in the topography. This feature is markedly influenced by varying node densities. A previous study [22] was conducted for finding the trends observable for metric ECFP for node densities varying between 7 until 56. The observations were split into two, with respect to a peak value found.

i. Previous to the peak value, trend is linear of form:
   `F(x) = d * x + f`
ii. From the peak onwards, the trend is exponential:
   `G(x) = a * exp (b * ( x – c ))`

A consecutive study [38] was carried out to mathematically model the five parameters observed above. Results obtained are trusted to serve towards better understanding of the evolution and predictability of ubicomp environments. These progresses, though happening slowly, will enable designers to produce more realistic simulation scenarios over which testing procedures can be applied for new middleware and communication components.

The investigation now required for metric ECFP is the identification of observable CVs 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 development of the trends of variations for each of the ten critical values observed for metric ECFP explained previously [22, 38] over node numbers ranging from 7 until 56. Such information should effectively be presented in the right way to more fluidly assist ubicomp designers to understand the evolution and predictability of ubicomp behaviour and be appropriately prepared 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- ECFP Critical Values, section 3- Critical Values Trend Analyses- Metric ECFP, section 4- Conclusion and References.

2. ECFP Critical Values.

2.0 Critical Values Identified.

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

C1	C2	C3
1	Effective total number of communicating nodes.	1
2	Smallest value of FP.	2
3	% communicating nodes at smallest FP value.	3
4	Largest FP value	4
5	% communicating nodes at largest FP value.	5
6	Smallest FP value of 1st five records	6
7	% communicating nodes at smallest FP value of 1st five records.	7
8	% communicating nodes with FP < modal value of FP.	8
9	% communicating nodes with FP > modal value of FP.	9
10	Value of FP below or equal to which 98% of communicating nodes lie.	10

Table 1: ECFP 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	39726	0.0	24.316568494	6.9
8	39598	0.0	22.147583211	7.9
9	45729	0.0	19.414375998	8.9
10	52462	0.0	13.951050284	9.0
11	58297	0.0	12.667890286	10.5
12	64293	0.0	11.646680043	11.5
13	70845	0.0	10.443926883	11.7
14	76746	0.0	9.608318349	12.6
15	82882	0.0	8.939214787	11.5
16	89052	0.0	8.336702152	12.3
17	95628	0.0	7.670347597	16.4
18	101666	0.0	7.208899730	17.4
19	107775	0.0	6.853166319	18.4
20	113850	0.0	6.529644269	19.3
21	120413	0.0	6.059976913	18.4
22	126393	0.0	5.722627044	19.2
23	132559	0.0	5.430789309	20.1
24	138628	0.0	5.222610151	21.0
25	144722	0.0	5.023424220	21.9
26	151847	0.0	4.717906840	23.5
27	157821	0.0	4.535518087	24.4
28	164089	0.0	4.414067975	25.3
29	170191	0.0	4.252868836	26.2
30	176428	0.0	4.121227923	27.1
31	182026	0.0	4.035687210	24.3
32	188211	0.0	3.909973381	25.1
33	194318	0.0	3.822085448	25.9
34	200385	0.0	3.701873893	26.7
35	206622	0.0	3.553348627	27.5
36	212735	0.0	3.463463934	28.3
37	219868	0.0	3.327905834	29.6
38	226002	0.0	3.260590614	30.4
39	232193	0.0	3.202508258	31.2
40	238523	0.0	3.148962574	32.0
41	244729	0.0	3.066657405	32.8
42	250725	0.0	2.973377206	32.0
43	257048	0.0	2.835657154	32.8
44	263097	0.0	2.798967681	33.5
45	269502	0.0	2.727994597	34.3
46	275426	0.0	2.699091589	35.1
47	281453	0.0	2.611448448	35.8
48	287436	0.0	2.558134680	36.6
49	293877	0.0	2.484712992	37.3
50	299163	0.0	2.424765095	40.1
51	305322	0.0	2.344082641	40.9
52	311348	0.0	2.282333595	41.7
53	318046	0.0	2.255648554	42.5
54	324300	0.0	2.221399938	43.3
55	330262	0.0	2.216119323	44.1
56	336488	0.0	2.189974085	44.9

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

NN	CV5	CV6	CV7	CV8
7	0.025172431	0.2	1.676483915	48.192619443
8	0.025253801	0.3	1.431890500	46.118490833
9	0.021867961	0.2	1.504515734	50.838636314
10	0.009530708	0.2	2.296900614	40.383515688
11	0.008576771	0.2	2.139046606	39.964320634
12	0.007776896	0.2	2.359510367	33.468651331
13	0.007057661	0.2	2.295151387	33.721504693
14	0.006514998	0.2	2.198160165	33.248638366
15	0.006032673	0.2	2.236915132	40.802586810
16	0.005614697	0.2	2.259354085	33.058213179
17	0.005228594	0.1	2.255615510	33.589534446
18	0.004918065	0.1	2.253457400	33.460547282
19	0.004639295	0.1	2.206448620	33.415912781
20	0.004391744	0.2	2.081686430	33.393061045
21	0.004152376	0.2	2.070374461	33.157549434
22	0.003955915	0.1	2.145688448	33.289818265
23	0.003771905	0.1	2.139424709	33.674062116
24	0.003606775	0.1	2.083273220	33.781054332
25	0.003454900	0.1	2.018352427	33.647268556
26	0.003292788	0.1	2.218680646	33.461313032
27	0.003168146	0.2	2.155606668	33.670424088
28	0.003047127	0.1	2.079968797	34.076019721
29	0.002937876	0.1	2.048874500	24.081766956
30	0.002834017	0.1	1.944135851	34.222459020
31	0.002746860	0.1	1.857426961	33.651236637
32	0.002656593	0.1	1.887243572	34.050082089
33	0.002573102	0.1	1.831533877	33.969061024
34	0.002495197	0.1	1.839958081	33.961623874
35	0.002419878	0.1	1.788289727	33.856510923
36	0.002350342	0.1	1.806002773	34.024960632
37	0.002274092	0.1	1.862026307	23.795641021
38	0.002212370	0.1	1.808833550	23.825010398
39	0.002153381	0.1	1.826067108	23.969284173
40	0.002096234	0.1	1.864809683	23.959115054
41	0.002043076	0.1	1.788508922	34.631367758
42	0.001994217	0.1	1.779240203	23.514607638
43	0.001945162	0.1	1.706296100	23.541906570
44	0.001900440	0.1	1.695192267	34.551515221
45	0.001855274	0.1	1.719838814	23.340086530
46	0.001815370	0.1	1.666146261	23.035588507
47	0.001776496	0.1	1.582857529	22.986431127
48	0.001739518	0.1	1.511988756	23.128974798
49	0.001701392	0.1	1.566301548	23.077682160
50	0.001671330	0.1	1.548654078	23.595832372
51	0.001637615	0.1	1.518069448	23.370408945
52	0.001605920	0.1	1.510849596	23.433906754
53	0.001572100	0.1	1.520534765	23.465473548
54	0.001541782	0.1	1.535306815	23.388837496
55	0.001513950	0.1	1.494873767	23.568863508

International Journal of Advance in Computer Science & its application – IJCSIA 2018
Copyright © Institute of Research Engineers and Doctors , SEEK Digital Library
Volume 7 : Issue 2 [ISSN : 2250-3765] - Publication Date: 25 June , 2018

56	0.001485937	0.1	1.509117710	23.524167281

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

NN	CV9	CV10
7	45.927100639	3.0
8	48.487297338	3.5
9	43.510682499	3.5
10	53.410087301	3.6
11	53.246307700	3.6
12	59.850994665	3.5
13	59.345049051	3.6
14	59.261720481	3.6
15	51.692768032	3.6
16	59.103669766	3.6
17	58.014389091	3.5
18	58.121692601	3.6
19	57.708188355	3.6
20	57.423803250	3.6
21	57.734629982	3.6
22	57.337827253	3.6
23	56.942191779	3.6
24	56.635023228	3.7
25	56.645845138	3.6
26	56.732105343	3.6
27	56.114205334	3.6
28	55.974501642	3.6
29	65.890675770	3.6
30	55.685605459	3.6
31	55.845318801	3.6
32	55.479754106	3.7
33	55.522905752	3.6
34	55.546572847	3.6
35	55.498930414	3.7
36	55.296025572	3.7
37	65.630742082	3.6
38	65.569773719	3.6
39	65.273285586	3.7
40	65.223898744	3.6
41	54.476175688	3.6
42	65.504835976	3.6
43	65.403737823	3.6
44	54.432775744	3.6
45	65.408048920	3.6
46	65.535570353	3.6
47	65.500101260	3.6
48	65.383250532	3.6
49	65.320865532	3.6
50	64.899068401	3.8
51	64.976320082	3.7
52	64.923815152	3.7
53	64.826157223	3.7
54	64.654640765	3.7
55	64.532704338	3.7
56	64.604384109	3.7

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

3. Critical Values Trend Analyses- Metric ECFP.

3.0 General Procedure Adopted.

To begin with, the tabulated data for each ECFP CV is plotted on gnuplot. Graphical analyses are then performed and general observations reported. As next step, quite some equations of fit are examined. For two CVs, best fit is based on flat values; for another two CVs, it is based only on values of reduced chi-square and for 3 CVs, it is based on reduced chi-square values and best extendability produced at node numbers 80, 100 and 120. As the last step, the values of parameters for each ECFP CV equation is noted.

3.1 Trend Analysis – ECFP CV1.

This section is identical to figure 1 in prior paper [50] where the tendency was clearly linear increasing.

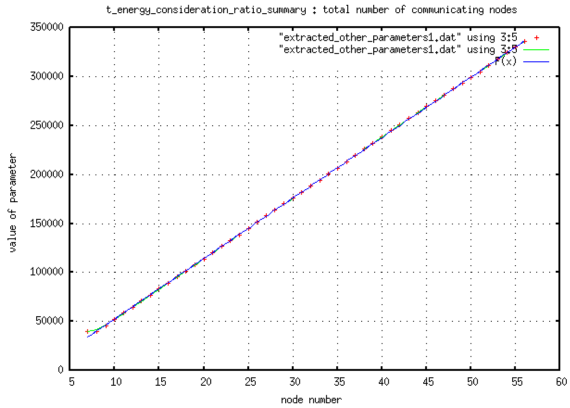

Figure 1: ECFP Critical Value 1

F(x) = d* x + f

Ch_sq = 870 696 F(80) = 484 951.386 746 697

F(100)=608 471.587 466 984 F(120)=731 991.788 187 272

The parameters obtained for best fit are:

d = 6 176.01 , f = -9 129.42

3.2 Trend Analysis – ECFP CV2.

Here, the value has remained at 0.0 for all node numbers, and will apply for node numbers above 56.

F(x) = 0

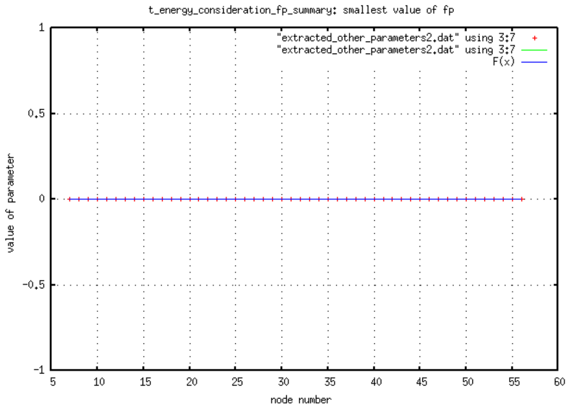

Figure 2: ECFP Critical Value 2

3.3 Trend Analysis – ECFP CV3.

The curve obtained here depicts a decreasing tendency at a decreasing rate.

The potentially applicable equations are:

1. F(x) = a * exp ((b * x) +c) + d

International Journal of Advance in Computer Science & its application – IJCSIA 2018
Copyright © Institute of Research Engineers and Doctors , SEEK Digital Library
Volume 7 : Issue 2 [ISSN : 2250-3765] - Publication Date: 25 June , 2018

Ch_sq = 0.502 058 F(80) = 2.946 302 622
F(100) = 2.945 975 793 F(120) = 2.945 959 776

2. $F(x) = a * exp((b*x)+c) + d*x^{-1}$

Ch_sq = 0.164 476 F(80) = 1.546 051 057
F(100)= 1.236 840 845 F(120)= 1.030 700 704

3. $F(x) = a*x^{0.25} * exp((b*x)+c) + d$

Ch_sq = 0.583 446 F(80) = 3.033 522 167
F(100) = 3.033 423 807 F(120)=3.033 420 706

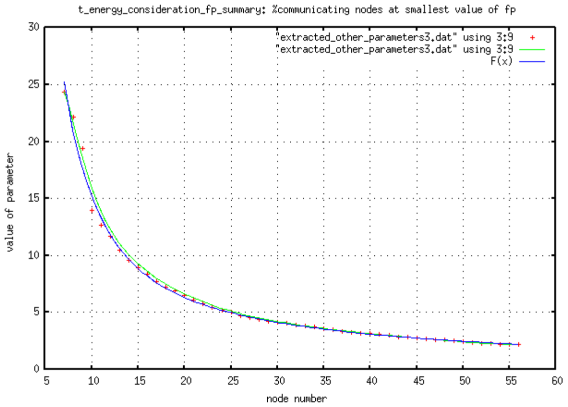

Figure 3: ECFP Critical Value 3

Choice of best fit for ECFP Critical Value 3

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 = 6.955 85 , b = -0.314 54 , c = 2.286 52 , d = 123.684

3.4 Trend Analysis – ECFP CV4.

Generally the CV increases linearly with node number.

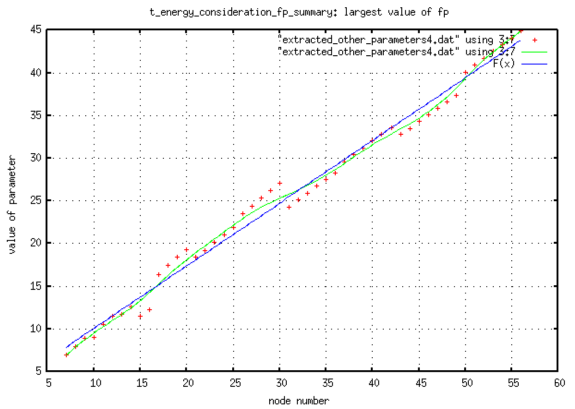

Figure 4: ECFP Critical Value 4

The potentially applicable equations are:

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

Ch_sq = 1.492 8 F(80) = 61.459 899 519
F(100)= 76.150 992 128 F(120)= 90.842 084 737

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

Ch_sq = 1.613 89 F(80) = 63.143 949 589
F(100)= 79.743 025 786 F(120)= 97.054 671 879

3. $F(x) = a * log((b * x) +c) + d$

Ch_sq = 1.543 51 F(80)= 59.409 404 554
F(100)= 84.040 589 333 F(120)= 84.040 589 333

Choice of best fit for ECFP Critical Value 4

The equation in part 1 above has been selected because of smallest ch_sq and good extendability. parameters obtained for best fit are: d = 0.734 555 , f = 2.695 53

3.5 Trend Analysis – ECFP CV5.

The first 3 plots appear as outliers. As from the fourth plot, the curve is more clearly decreasing at a decreasing rate.

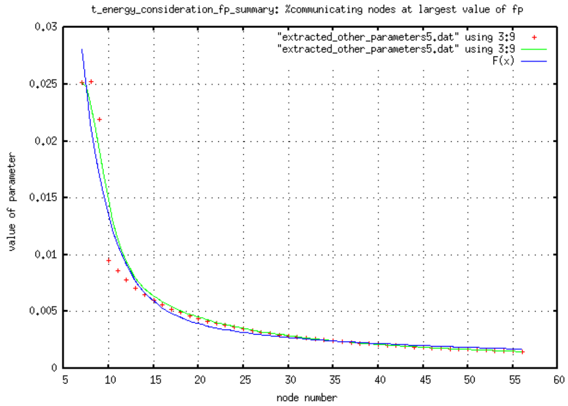

Figure 5: ECFP Critical Value 5

The potentially applicable equations are:

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

   Ch_sq = 1.887 14(e^{-06}) F(80) = 0.002 342 089
   F(100) = 0.002 342 089 F(120) = 0.002 342 089

2. $F(x) = a * exp((b * x) +c) + d * x^{-0.5}$

   Ch_sq = 1.623 86(e^{-06}) F(80) = 0.001 633 196
   F(100) = 0.001 460 774 F(120) = 0.001 333 499

3. $F(x) = a * exp((b * x) +c) + d * x^{-0.75}$

   Ch_sq = 1.571 12(e^{-06}) F(80) = 0.001 304 417
   F(100) = 0.001 103 402 F(120)= 0.000 962 383

4. $F(x) = a * exp((b * x) +c) + d * x^{-1}$

   Ch_sq = 1.605 58(e^{-06}) F(80) = 0.001 001 730
   F(100) = 0.000 801 384 F(120)= 0.000 667 820

Choice of best fit for ECFP Critical Value 5

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 = 0.210 46 , b = -0.377 736 , c = 0.109 637 , d = 0.080 138 5

3.6 Trend Analysis – ECFP CV6.

Here, mostly 2 ranges are observed. Within each range, the critical value is constant.

$$F(x) = \begin{cases} 0.2 & 7 \le x \le 16 \\ 0.1 & x \ge 17 \end{cases}$$

For x values above 56, CV is projected to stay at 0.1.

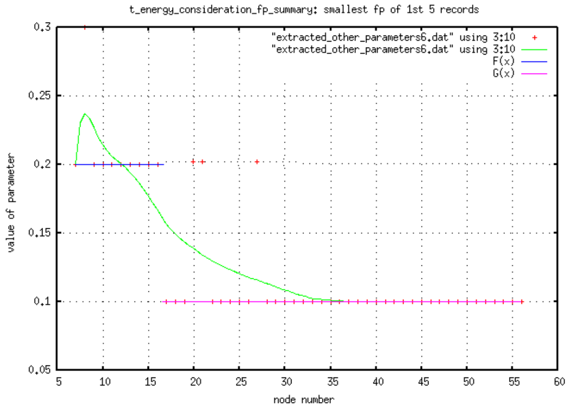

Figure 6: ECFP Critical Value 6

3.7 Trend Analysis – ECFP CV7.

The curve obtained here, depicts a sudden rise in the beginning until a maximum point and then follows a smoother fall.

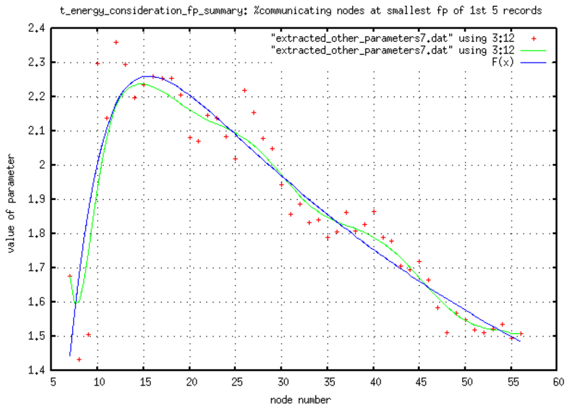

Figure 7: ECFP Critical Value 7

The potentially applicable equations are:

1. F(x) = ((a*x^f)+g)/(exp((b*x)+c)+d)

   Ch_sq = 0.012 447 1 F(80) = 1.181 784 208

   F(100)= 1.008 891 552 F(120) = 0.876 609 819

2. F(x)=((a*x^f)+g)/(exp((b*x)+c)+(d*x^-2))

   Ch_sq = 0.012 817 8 F(80) = 1.114 417 731

   F(100)= 0.904 674 932 F(120)= 0.740 009 716

3. F(x)=((a*x^f)+g)/(exp((b*x)+c)+(d*x^-3))

   Ch_sq = 0.011 844 1 F(80) = 1.184 092 755

   F(100) = 0.997 061 545 F(120) = 0.847 382 940

4. F(x)=((a*x^f)+g)/(exp((b*x)+c)+(d*x^-4))

   Ch_sq = 0.012 409 6 F(80) = 1.108 158 295

   F(100) = 0.877 205 830 F(120) = 0.693 908 985

5. F(x)=((a*x^f)+g)/(exp((b*x)+c)+(d*x^-2.75))

   Ch_sq = 0.011 837 5 F(80) = 1.186 691 099

   F(100) = 0.999 575 571 F(120) = 0.845 949 821

6. F(x)=((a*x^f)+g)/(exp((b*x)+c)+(d*x^-2.8))

   Ch_sq = 0.011 828 3 F(80) = 1.190 830 014

   F(100)= 1.005 642 105 F(120)= 0.853 755 707

Choice of best fit for ECFP Critical Value 7

The equation in part 6 above has been selected because of smallest ch_sq and good extendability. The parameters obtained for best fit are:

a = 1.628 4 , b = -0.000 140 682 , c = -4.802 82 , d = 2.366 08 , f = -0.004 300 99 , g = -1.588 32

3.8 Trend Analysis – ECFP CV8.

Here, mostly 2 sets of observations for trends are made:

i. For node numbers 12 until 36, a mostly linear trend with small positive gradient is observed with values between 33 and 35.

ii. For node numbers 37 until 56, a mostly linear trend with small negative gradient is observed with values between 22 and 24.

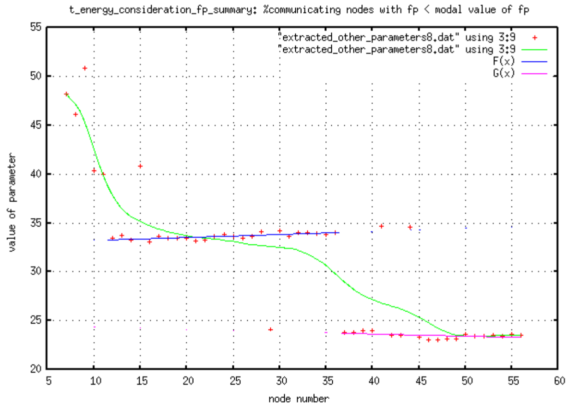

Figure 8: ECFP Critical Value 8

For node numbers 7 until 11, no observable trend is found, only that values are between 40 and 51.

$$F(x) = \begin{cases} 40 \le F(x) \le 51 & 7 \le x \le 11 \\ d * x + f & 12 \le x \le 36 \\ g * x + h & 37 \le x \le 56 \end{cases}$$

For node numbers 12-36 : ch_sq = 0.049 865 1 , d = 0.030 901 7 , f = 32.898 6

For node numbers 37-56 : ch_sq = 0.072 195 5 , g = -0.022 924 4 , h = 24.549 6

Suggestion: Equation “F(x)=g * x + h” may serve for prediction over larger node numbers.

3.9 Trend Analysis – ECFP CV9.

Here also, two sets of observations for trends are made:

i. For node numbers 12 until 36, a mostly decreasing trend at a decreasing rate with values between 55 and 60.

ii. For node numbers 37 until 56, a mostly decreasing trend at a decreasing rate with values between 64 and 66.

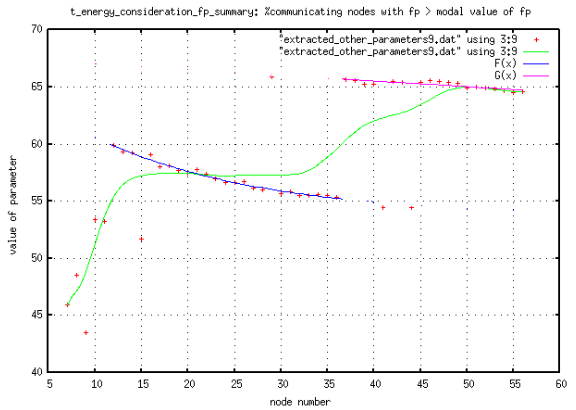

Figure 9: ECFP Critical Value 9

For node number 7 until 11, no observable trend is found, only that the values are between 43 and 54.

$$F(x) = \begin{cases} 43 \le F(x) \le 54 & 7 \le x \le 11 \\ a * \exp((b*x) + c) + d & 12 \le x \le 36 \\ f * x + g & 37 \le x \le 56 \end{cases}$$

For node numbers 12-36 :

ch_sq = 0.046 078 9 , a = 2.270 67 , b = -0.057 110 9 , c = 1.690 28 , d = 53.671 9

For node numbers 37-56, two possibilities were tried:

1. F(x) = f * exp((g * x) + h) + i)
   Ch_sq = 0.048 543
   f = 2.100 14 g = -0.004 952 07
   h = 1.780 31 i = 55.298 7
2. F(x) = f * x + g
   Ch_sq = 0.041 330
   f = -0.049 630 8 g = 67.506 1

Here, the equation in part 2 above has been selected because of least ch_sq. This same equation may be used for prediction over larger node numbers.

3.10 Trend Analysis – ECFP CV10.

Here values are rounded to 1 d.p. Else, from smooth bezier, the trend is noted increasing at a decreasing rate.

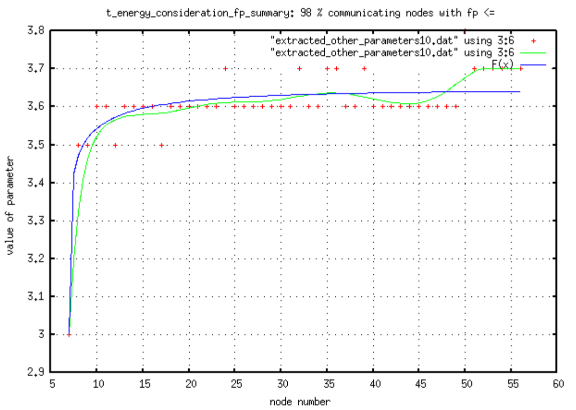

Figure 10: ECFP Critical Value 10

The potentially applicable equations are:

```
1. F(x) = a * log ((b*x)+c)+d
```

Ch_sq = 0.003 190 57 F(80) = 3.682 200 599
F(100)= 3.694 010 743 F(120)= 3.703 511 286

```
2. F(x) = a*x^-0.1 * log ((b*x)+c) + d
```

Ch_sq = 0.002 620 17 F(80) = 3.676 575 717
F(100)= 3.685 203 834 F(120)= 3.691 749 283

```
3. F(x) = a*x^-0.25 * log ((b*x)+c) + d
```

Ch_sq = 0.002 593 89 F(80) = 3.642 705 471
F(100)= 3.642 823 581 F(120)= 3.642 446 376

Choice of best fit for ECFP Critical Value 10

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= 0.116 43, b = 0.881 716, c = -6.170 78, d = 3.480 57

4. Conclusion.

This study had as objective to identify some CVs applicable to metric ECFP and study their corresponding trends over varying node densities in a MANET topography of 300 x 300 m^2. The models formulated in this paper comprise of quite complex mathematical equations. The results illustrated here will reinforce our existing tools for better studies of MANETs for ubicomp environment from the angle of software engineering. These output can methodically be implemented in computational algorithms to produce more realistic simulation schemes which may in turn serve for conducting better testing procedure of communication protocols and middleware components.

This experiment was carried out in NS-2 over Linux. Plottings and "Fit" attempts were done in gnuplot. selection of best fit was made based on a combination of flat values, least reduced chi-square values and best extendability produced at higher node numbers. Assumptions illustrated in previous studies [22, 38] are maintained here also.

This study stands as a follow-up of previous studies [1-53] and remains open for future upgrades. A future task remains the formulation of predictability for metric ECFP 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] Markus Bylund and Zary Segall, Towards seamless mobility with personal servers, 2004.

[55] Masugi Inoue, Mikio Hasegawa, Nobuo Ryoki and Hiroyuki Morikawa, Context-Based Seamless Network and Application Control, 2004

[56] Xiang Song, Umakishore Ramachandran, MobiGo: A Middleware for Seamless Mobility, College of Computing Georgia Institute of Technology, Atlanta, GA, USA, August 2007

[57] Budzisz, Ferrús, R., Brunstrom A., Grinnemo, K, Fracchia, R., Galante, G., and Casadevall, F. Towards transport-layer mobility: Evolution of SCTP multihoming, March 2008

[58] Paul Dourish & Genevieve Bell, Divining a digital future, 2011.

[59] Xiang Song, Seamless Mobility In Ubiquitous Computing Environments, PhD Thesis, Georgia Institute of Technology, August 2008

[60] 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

[61] Pablo Vidales, Seamless mobility in 4G systems, *Technical Report, University of Cambridge,* Computer Laboratory, Number 656, November 2005

[62] 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*

[63] 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

[64] 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

[65] 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.

[66] 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

[67] 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

[68] Byrav Ramamurthy, K. K. Ramakrishnan , Rakesh K. Sinha, Cost and Reliability Considerations in Designing the Next-Generation IP over WDM Backbone Networks, 2012.

[69] 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

[70] Ashok Anand, Vyas Sekar and Aditya Akella, SmartRE: An Architecture for Coordinated Network-wide Redundancy Elimination, SIGCOMM 2009, Barcelona, Spain

[71] John Breeden II, "Smart-phone battery life could double – without better batteries", Nov 14, 2012

[72] Andy Boxall, "When will your phone battery last as long as your kindle", December 5, 2012.

[73] Imielinski, T. and Navas, J.C. (1999). GPS-based geographic addressing, routing, and resource discovery. *Comms. ACM*, Vol. 42, No. 4, pp. 86-92.

[74] Hightower, J. and Borriello, G. (2001). Location Systems for Ubiquitous Computing. *IEEE Computer*, Vol. 34, No. 8, August, pp. 57-66.

[75] 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.

[76] 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.

[77] 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.

[78] Ko, Y., & Vaidya, N. H. (2000). Location-aided routing (LAR) in mobile ad hoc networks. *Wireless Networks*, *6*(4), 307-321.

[79] 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.

[80] 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).

[81] Jiang, X., & Camp, T. (2002). Review of geocasting protocols for a mobile ad hoc network. In Proceedings of the *Grace Hopper Celebration (GHC)*.

[82] 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).

[83] 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.

[84] 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).

[85] 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).

[86] 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.

[87] 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

[88] 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).

[89] 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.

[90] 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.

[91] Sgroi et al., "Designing Wireless Protocols: Methodology and Applications, February 2000.

[92] Gyula et al., "Simulation-based optimization of communication protocols for large-scale wireless sensor networks", 10 October 2002

[93] Rao and Sharma, "Cross Layer Protocols For Multimedia Transmission in Wireless Networks", June 2012

[94] 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.