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# Model of Distance Travelled by packets in MANETs using Location-Aware Transmission for Ubicomp.

M. Kaleem GALAMALI, Assoc. Prof Nawaz MOHAMUDALLY

***Abstract*** **– MANET transmission is one solution towards achieving routing in a ubicomp environment. If the corresponding protocols are well designed, it can assist in energy issues in ubicomp [61]. Applying location-aware transmission strategies may enhance energy management and hence remain a serious topic of research. Some of the enhancements being expected [1] involves application of land-based GPS systems, improved location refresh rates and location accuracy along with developments of better protocols optimised for transmission according to distance criteria. To assist in the latter protocol developments, one research result that would be required is the trends of distance coverages by packets in a ubicomp topography for varying node densities. Such knowledge will definitely be useful for refining transmission protocols so that best MANET performance is achieved.**

**In this paper, a metric PPD is put forward to assess the trend of distance coverages by packets in a ubicomp topography with varying node densities. This paper adds a result set to the area of modelling for Packets Per Distance management in ubicomp. Designers may use these results towards formulation of better transmission protocols for ubicomp. This paper is a follow-up of previous work [1-25].**

**Key terms: Ubicomp- Ubiquitous Computing, MAUC-Mobile and Ubiquitous Computing, MANET- Mobile Adhoc Network, PPD- Packets_Per_Distance, CBR-Constant Bit Rate, QoS- Quality of Service.**

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

Assoc. Prof Nawaz Mohamudally
University of Technology Mauritius,
Mauritius

## 1. Introduction

Distance coverage is a predominant factor affecting energy consumption in MAUC, which varies proportional to the square of distance [15]. When using MANETs, it is not only the sender node which is transmitting packets for a CBR but each node starting from the sender along the MANET route are forwarding packets, over a certain distance, before reaching the final destination node. This does have an impact over total number of packets circulating within the MANET topography and this may increase with increasing node density. This does not guarantee that distances the packets have to travel will be all reduced. The research questions put forward are: "What is the % Number of packets travelling each integer meter distance in the topography? What is the trend observable and how does it vary over varying node densities?"

The work presented here, also is empirical and is built over same experiment set as for previous work [14-25]. The results presented here, may serve towards development and refinement of MANET transmission protocols for ubicomp, and also towards setting the standards for location refresh rates that would be required for optimal MANET performance.

The key contributions of this paper is firstly, the development of a metric PPD for Packet Per Distance analysis. The definition and rationale of metric PPD is put forward. Secondly, the model of trend is put forward for the metric PPD with results for varying node densities from 7 until 56 in a topography of 300 x 300 $m^2$. The model proposed is mostly the decreasing exponential model with some linear model support. The rest of this paper is organised as follows: section 2- New Metric – Packets Per Distance, section 3- PPD Trend Assessment over Varying Node Numbers, 4- Conclusion and References.

## 2. New Metric – Packets Per Distance.

Following elaborations in the first paragraph of "Introduction" in this paper, the metric "Packets_Per_Distance" will thus be defined as the % number of packets that is covering each distance (rounded to nearest meter) from 0 m until the longest distance possible (in this case, the diagonal distance of the topography, at 424 m).

It is expected to have a certain % packets at 0 m distance. This would simply imply that the distance is less than 50 cm and is rounded to 0 m.

The results of this study may serve towards:

i. Better protocol developments for MANET packet transmission in an optimised energy saving fashion while combining sufficient QoS characteristics, including Ferry-Protocol approaches.

ii. Better Predicting the distance coverage expected and preparing resources required accordingly.
iii. Following part (ii) above, MANET relay nodes may better decide the probabilities of successful assistance in the MANET following their battery level availability.
iv. Providing base information for further developments in MANET self-healing approaches.
v. Providing base information for tuning security methods according to distance coverage needs

# 3. PPD - Trend Assessment over Varying Node Numbers.

*3.0 Major Observations.*

In all the plots obtained, the leftmost point has been found at x-value 0.0, and has been outside observable tendencies (i.e. quite outlying). The general tendency of the graph is increasing until a peak value and smoothly decreasing beyond the peak value.

For most of the plots, the smallest y-coordinate before peak value is at x-coordinate 1.0. Generally, the peak value tends to decrease with increasing node number.

Previous and up to the peak value, the trend, with good number of plots (though decreasing with increasing node numbers), assumes a linear trend of the form:

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

As from the peak value onwards, the trend is convincingly observed to be exponentially decreasing towards asymptotic towards the x-axis, with equation of the form:

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

*3.1 Tabular Summary of Results.*

A tabular summary for results of equations of curves (F(x) and G(x)) is shown below. Column headings are: A→node number, B→Value of parameter d, C→Value of parameter f, D→ reduced chi-square of plot F(x), E→ smallest value before peak value, F→ value of parameter a, G→ value of parameter b, H→ value of parameter c, I→ reduced chi-square value of plot G(x), F→ Corresponding figure number.

| A | B | C | D | E | F |
|---|---|---|---|---|---|
| 7 | 0.041 814 6 | 0.151 757 | 0.005 796 1 | 1 | 3.107 5 |
| 8 | 0.036 180 8 | 0.131 461 | 0.004 337 22 | 1 | 2.687 37 |
| 9 | 0.039 510 7 | 0.162 265 | 0.006 463 29 | 1 | 3.047 52 |
| 10 | 0.033 118 8 | 0.421 301 | 0.007 101 31 | 3 | 3.556 54 |
| 11 | 0.035 910 8 | 0.452 874 | 0.011 205 7 | 3 | 3.900 99 |
| 12 | 0.043 106 8 | 0.430 277 | 0.010 412 2 | 2 | 3.917 36 |
| 13 | 0.059 126 1 | 0.347 814 | 0.004 639 8 | 3 | 3.613 38 |
| 14 | 0.063 751 | 0.356 361 | 0.006 781 47 | 2 | 3.886 04 |
| 15 | 0.067 958 2 | 0.371 025 | 0.009 887 02 | 1 | 4.156 57 |
| 16 | 0.071 575 | 0.389 221 | 0.012 991 3 | 1 | 4.429 86 |
| 17 | 0.083 050 5 | 0.342 888 | 0.008 338 83 | 1 | 4.440 98 |
| 18 | 0.086 803 5 | 0.363 886 | 0.010 215 8 | 1 | 4.709 56 |
| 19 | 0.090 416 1 | 0.385 649 | 0.013 030 4 | 1 | 4.978 64 |
| 20 | 0.093 550 8 | 0.411 969 | 0.016 631 3 | 1 | 5.237 94 |
| 21 | 0.101 741 | 0.408 41 | 0.015 882 3 | 1 | 5.306 29 |
| 22 | 0.109 382 | 0.399 803 | 0.014 452 2 | 1 | 5.331 36 |
| 23 | 0.112 558 | 0.418 337 | 0.016 635 7 | 1 | 5.615 16 |
| 24 | 0.115 605 | 0.440 916 | 0.020 051 9 | 1 | 5.838 04 |
| 25 | 0.118 392 | 0.459 009 | 0.023 045 6 | 1 | 6.050 81 |
| 26 | 0.121 997 | 0.485 385 | 0.028 319 7 | 1 | 6.402 37 |
| 27 | 0.123 994 | 0.509 121 | 0.031 991 6 | 1 | 6.556 87 |
| 28 | 0.126 296 | 0.529 045 | 0.036 562 2 | 1 | 6.762 63 |
| 29 | 0.136 3 | 0.500 024 | 0.032 499 2 | 1 | 6.674 32 |
| 30 | 0.138 782 | 0.519 241 | 0.036 253 4 | 1 | 6.851 75 |
| 31 | 0.159 258 | 0.434 331 | 0.022 819 2 | 1 | 6.532 64 |
| 32 | 0.161 421 | 0.455 065 | 0.025 864 | 1 | 6.681 04 |
| 33 | 0.165 542 | 0.467 195 | 0.028 303 8 | 1 | 6.873 29 |
| 34 | 0.168 361 | 0.484 658 | 0.032 057 4 | 1 | 7.038 7 |
| 35 | 0.171 125 | 0.506 312 | 0.036 826 6 | 1 | 7.279 84 |
| 36 | 0.173 869 | 0.527 533 | 0.040 522 | 1 | 7.448 94 |
| 37 | 0.176 717 | 0.549 73 | 0.046 968 5 | 1 | 7.574 49 |
| 38 | 0.179 059 | 0.575 131 | 0.052 484 2 | 1 | 7.743 3 |
| 39 | 0.181 124 | 0.602 512 | 0.058 776 8 | 1 | 7.882 4 |
| 40 | 0.183 458 | 0.630 092 | 0.065 634 7 | 1 | 8.030 22 |
| 41 | 0.185 349 | 0.652 753 | 0.072 069 8 | 1 | 8.179 16 |
| 42 | 0.187 134 | 0.673 473 | 0.077 160 6 | 1 | 8.306 3 |
| 43 | 0.189 085 | 0.705 722 | 0.086 619 | 1 | 8.486 51 |
| 44 | 0.191 161 | 0.724 779 | 0.091 226 7 | 1 | 8.627 36 |
| 45 | 0.192 935 | 0.742 125 | 0.096 543 7 | 1 | 8.780 95 |
| 46 | 0.227 683 | 0.583 148 | 0.059 521 6 | 1 | 8.160 36 |
| 47 | 0.230 447 | 0.604 124 | 0.065 186 9 | 1 | 8.313 03 |
| 48 | 0.233 01 | 0.620 475 | 0.069 387 7 | 1 | 8.459 32 |
| 49 | 0.234 477 | 0.643 032 | 0.074 638 7 | 1 | 8.599 72 |
| 50 | 0.238 294 | 0.663 671 | 0.079 867 4 | 1 | 8.835 35 |
| 51 | 0.240 582 | 0.679 651 | 0.085 056 8 | 1 | 8.957 86 |
| 52 | 0.263 068 | 0.595 498 | 0.063 839 8 | 1 | 8.797 82 |
| 53 | 0.265 912 | 0.613 716 | 0.068 168 2 | 1 | 8.913 87 |
| 54 | 0.268 08 | 0.630 511 | 0.072 594 2 | 1 | 8.861 7 |
| 55 | 0.270 16 | 0.649 142 | 0.077 225 3 | 1 | 8.978 36 |
| 56 | 0.272 716 | 0.668 424 | 0.082 313 3 | 1 | 9.101 53 |

**Table 1(a): summary of results for PPD equations of curves node numbers 7-56**

| A | G | H | I | J |
|---|---|---|---|---|
| 7 | -0.020 987 | 0.140 704 | 0.002 282 99 | 1 |
| 8 | -0.020 975 5 | 0.133 007 | 0.001 704 72 | 2 |
| 9 | -0.022 962 7 | 0.150 943 | 0.001 527 66 | 3 |
| 10 | -0.026 133 9 | 0.100 865 | 0.000 925 196 | 4 |
| 11 | -0.028 036 8 | 0.323 363 | 0.000 699 643 | 5 |
| 12 | -0.028 551 2 | 0.308 108 | 0.001 025 75 | 6 |
| 13 | -0.027 736 | 0.185 031 | 0.002 717 72 | 7 |
| 14 | -0.029 288 9 | 0.207 186 | 0.002 418 61 | 8 |
| 15 | -0.030 821 1 | 0.232 761 | 0.002 102 01 | 9 |
| 16 | -0.032 329 5 | 0.260 929 | 0.001 916 35 | 10 |
| 17 | -0.032 766 6 | 0.260 183 | 0.002 413 18 | 11 |
| 18 | -0.034 291 8 | 0.291 22 | 0.002 171 83 | 12 |
| 19 | -0.035 830 7 | 0.358 205 | 0.001 849 51 | 13 |
| 20 | -0.037 279 8 | 0.386 254 | 0.001 694 57 | 14 |
| 21 | -0.038 013 2 | 0.422 376 | 0.001 897 94 | 15 |
| 22 | -0.038 545 1 | 0.513 33 | 0.002 166 19 | 16 |
| 23 | -0.039 757 2 | 0.228 519 | 0.001 843 56 | 17 |
| 24 | -0.041 114 8 | 0.356 071 | 0.001 737 47 | 18 |
| 25 | -0.042 268 8 | 0.402 756 | 0.001 617 48 | 19 |
| 26 | -0.043 825 | 0.247 751 | 0.001 687 46 | 20 |
| 27 | -0.044 896 8 | 0.433 097 | 0.001 597 89 | 21 |
| 28 | -0.046 022 1 | 0.479 298 | 0.001 474 04 | 22 |
| 29 | -0.045 996 7 | 0.466 016 | 0.001 779 4 | 23 |
| 30 | -0.047 015 2 | 0.497 997 | 0.001 612 21 | 24 |
| 31 | -0.046 086 2 | 0.443 49 | 0.002 623 53 | 25 |
| 32 | -0.046 952 5 | 0.469 083 | 0.002 538 71 | 26 |
| 33 | -0.048 066 9 | 0.501 63 | 0.002 369 25 | 27 |
| 34 | -0.049 045 2 | 0.542 029 | 0.002 187 05 | 28 |
| 35 | -0.050 129 6 | 0.424 388 | 0.002 107 04 | 29 |
| 36 | -0.051 347 6 | 0.592 972 | 0.001 940 08 | 30 |
| 37 | -0.052 250 5 | 0.685 841 | 0.001 890 03 | 31 |
| 38 | -0.053 304 9 | 0.743 471 | 0.001 773 33 | 32 |
| 39 | -0.054 273 | 0.810 243 | 0.001 652 45 | 33 |

| | | | | |
|---|---|---|---|---|
| 40 | -0.055 294 4 | 0.873 528 | 0.001 513 4 | 34 |
| 41 | -0.056 24 | 0.926 521 | 0.001 436 91 | 35 |
| 42 | -0.057 103 3 | 0.992 374 | 0.001 318 94 | 36 |
| 43 | -0.058 256 8 | 1.049 46 | 0.001 234 85 | 37 |
| 44 | -0.059 206 9 | 1.121 18 | 0.001 120 74 | 38 |
| 45 | -0.060 058 7 | 1.138 93 | 0.001 088 62 | 39 |
| 46 | -0.057 362 3 | 0.814 377 | 0.002 553 8 | 40 |
| 47 | -0.058 395 9 | 0.882 712 | 0.002 432 18 | 41 |
| 48 | -0.059 362 5 | 0.942 979 | 0.002 326 47 | 42 |
| 49 | -0.060 158 3 | 0.943 153 | 0.002 272 82 | 43 |
| 50 | -0.061 338 6 | 0.875 775 | 0.002 104 64 | 44 |
| 51 | -0.062 169 2 | 0.931 344 | 0.001 978 16 | 45 |
| 52 | -0.060 800 3 | 0.458 739 | 0.002 937 48 | 46 |
| 53 | -0.061 667 1 | 0.528 566 | 0.002 761 22 | 47 |
| 54 | -0.062 441 6 | 0.875 728 | 0.002 628 66 | 48 |
| 55 | -0.063 205 5 | 0.904 436 | 0.002 538 89 | 49 |
| 56 | -0.064 058 7 | 0.942 226 | 0.002 392 99 | 50 |

**Table 1(b): summary of results for PPD equations of curves node numbers 7-56**

### *3.2 Graphical Plots for Results Obtained.*

This analysis is performed in gnuplot in Linux. x-axis distance is in meters.

*1. Node Number 7*

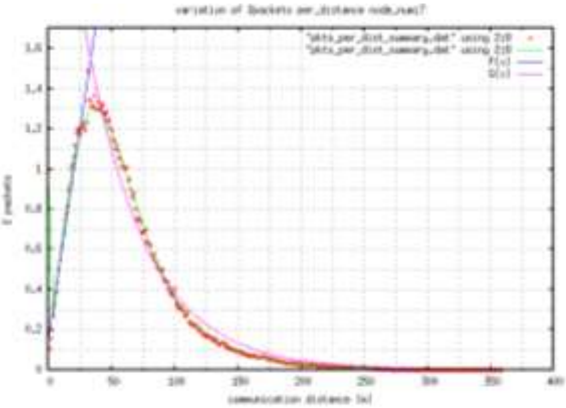

**Figure 1: % PPD node_number 7**

*2. Node Number 8*

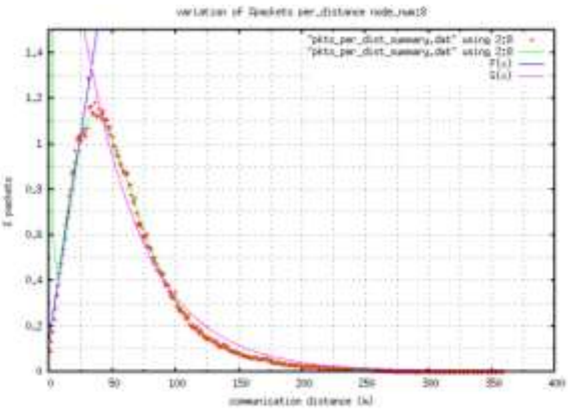

**Figure 2: % PPD node_number 8**

*3. Node Number 9*

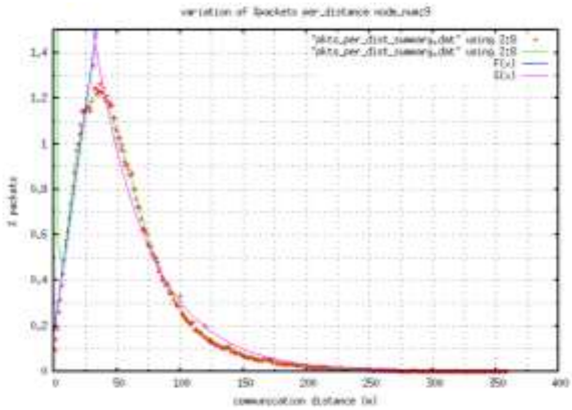

**Figure 3: % PPD node_number 9**

*4. Node Number 10*

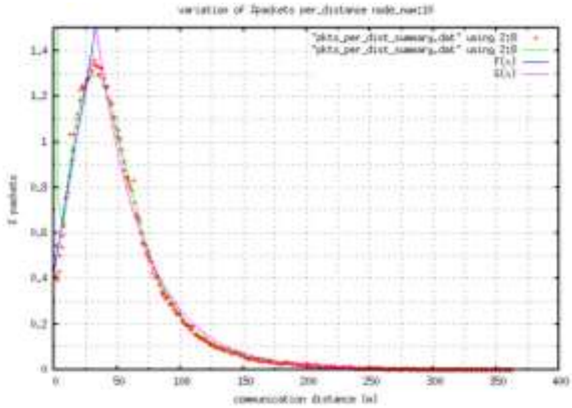

**Figure 4: % PPD node_number 10**

*5. Node Number 11*

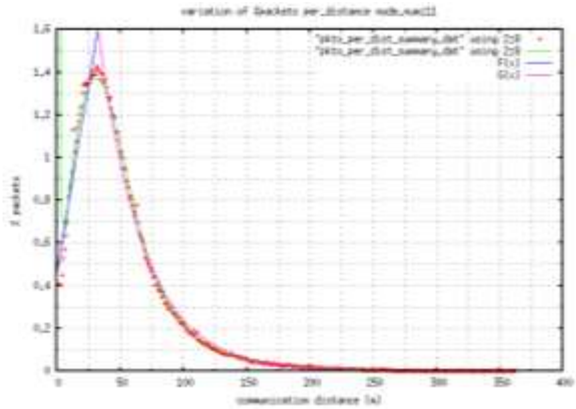

**Figure 5: % PPD node_number 11**

*6. Node Number 12*

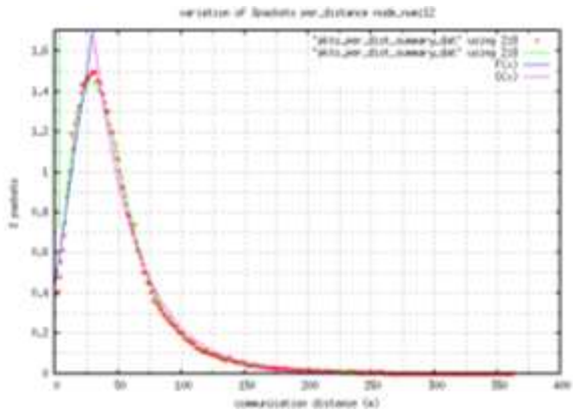

**Figure 6: % PPD node_number 12**

*7. Node Number 13*

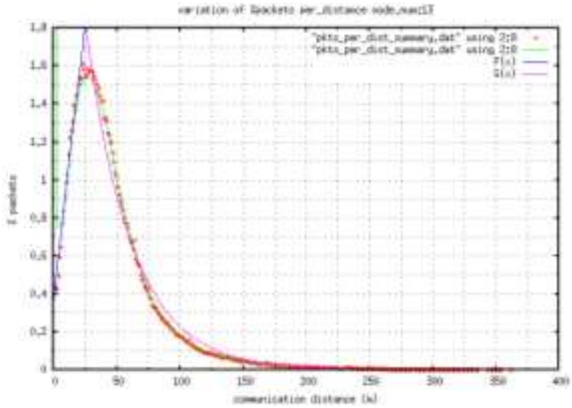

**Figure 7: % PPD node_number 13**

*8. Node Number 14*

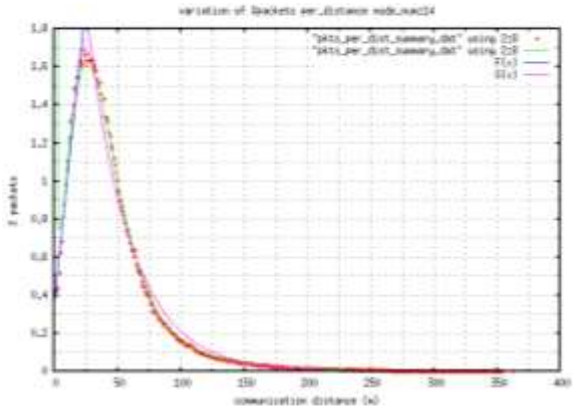

**Figure 8: % PPD node_number 14**

*9. Node Number 15*

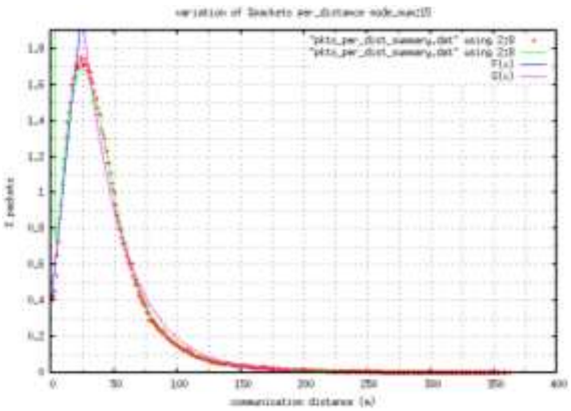

**Figure 9: % PPD node_number 15**

*10. Node Number 16*

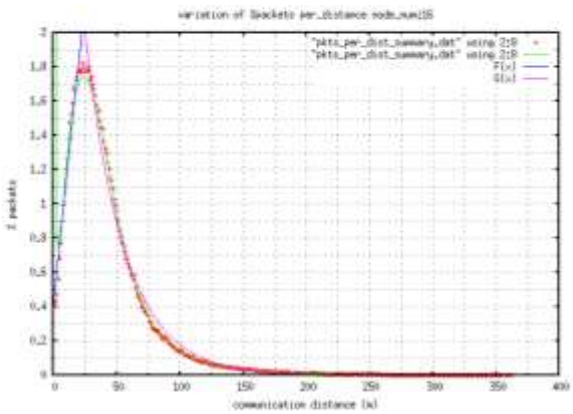

**Figure 10: % PPD node_number 16**

*11. Node Number 17*

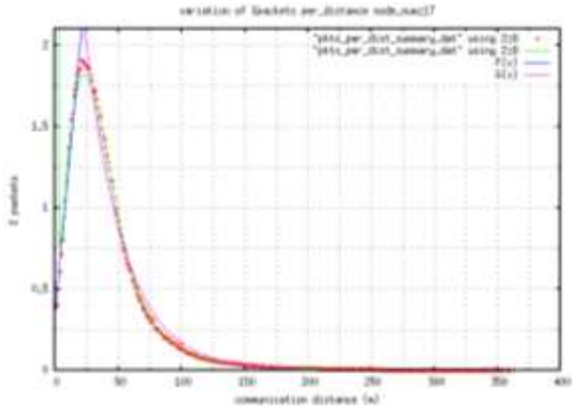

**Figure 11: % PPD node_number 17**

*12. Node Number 18*

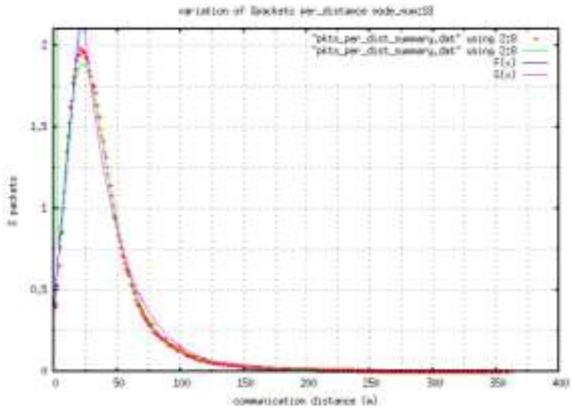

**Figure 12: % PPD node_number 18**

*13. Node Number 19*

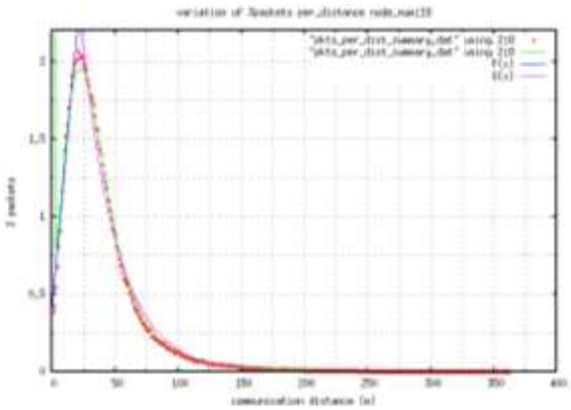

**Figure 13: % PPD node_number 19**

*14. Node Number 20*

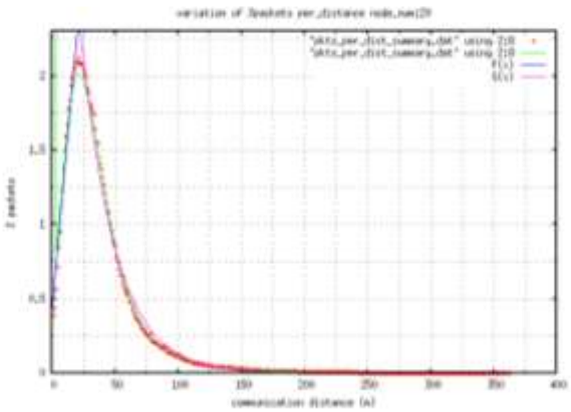

**Figure 14: % PPD node_number 20**

*15. Node Number 21*

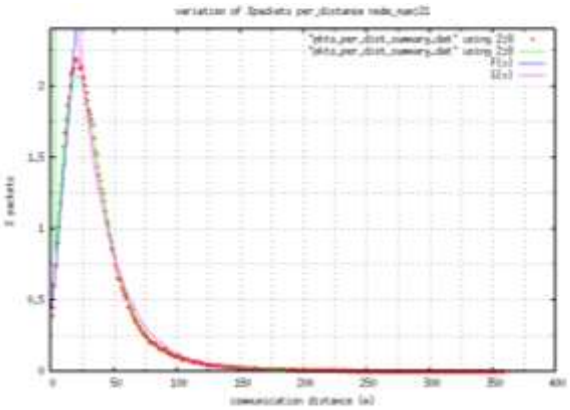

**Figure 15: % PPD node_number 21**

*16. Node Number 22*

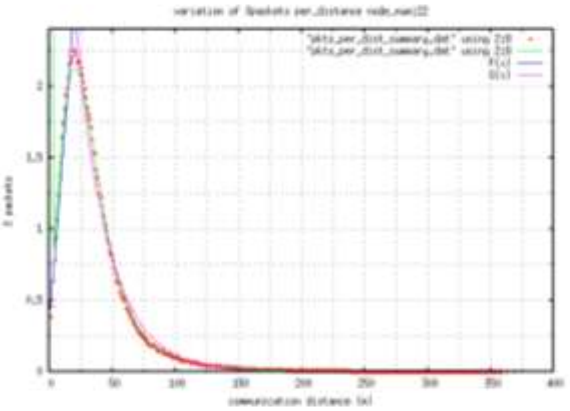

**Figure 16: % PPD node_number 22**

*17. Node Number 23*

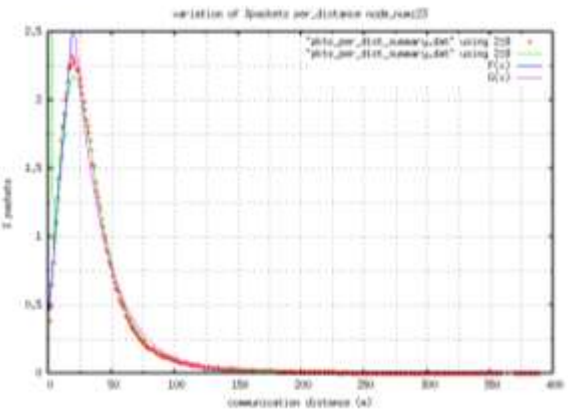

**Figure 17: % PPD node_number 23**

*18. Node Number 24*

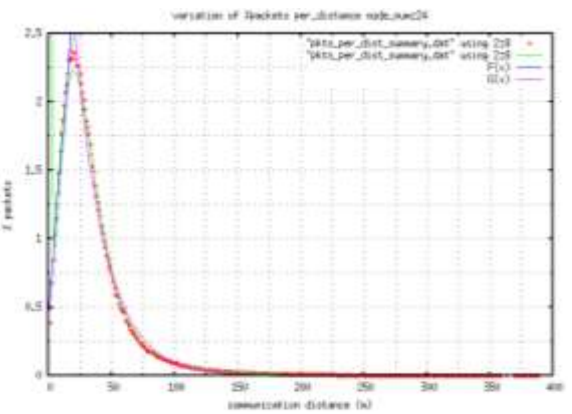

**Figure 18: % PPD node_number 24**

*19. Node Number 25*

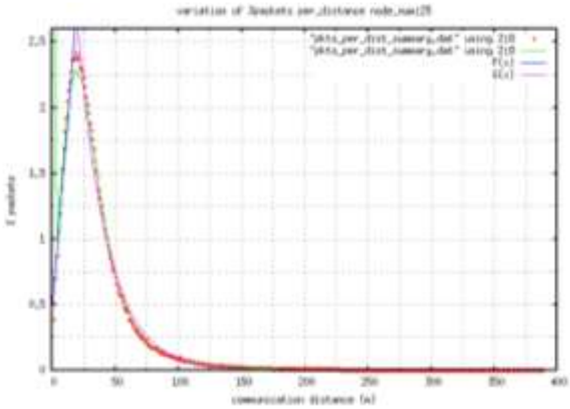

**Figure 19: % PPD node_number 25**

*20. Node Number 26*

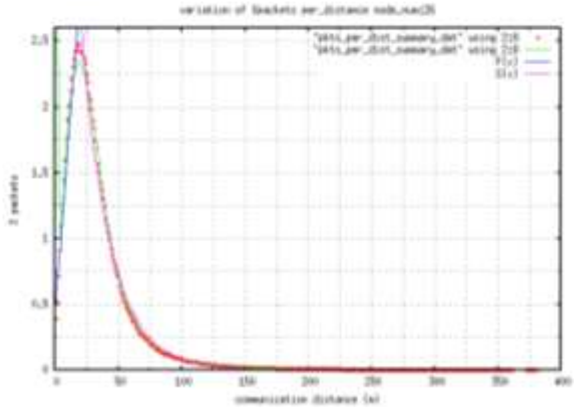

**Figure 20: % PPD node_number 26**

*21. Node Number 27*

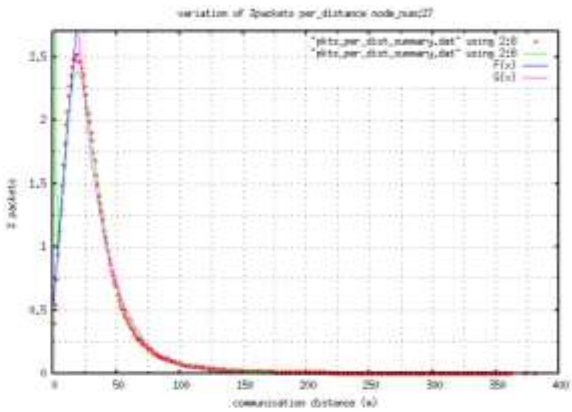

**Figure 21: % PPD node_number 27**

*22. Node Number 28*

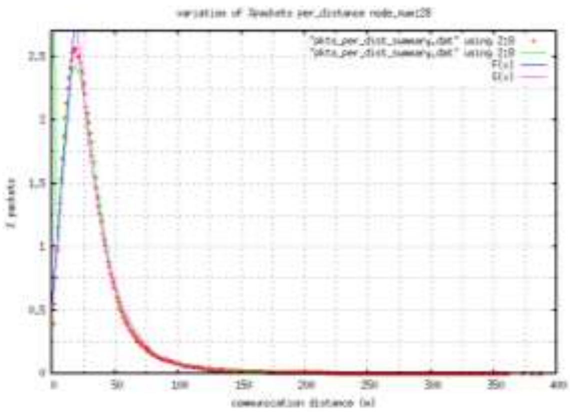

**Figure 22: % PPD node_number 28**

*23. Node Number 29*

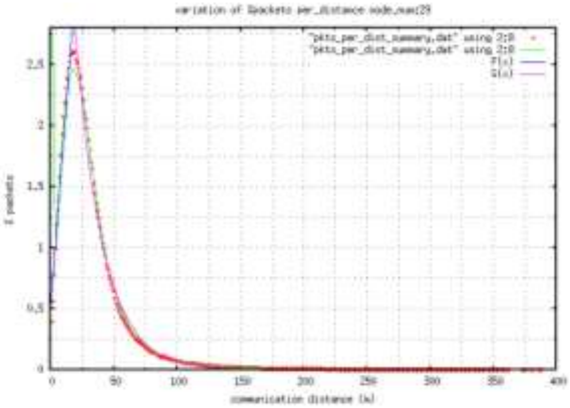

**Figure 23: % PPD node_number 29**

*24. Node Number 30*

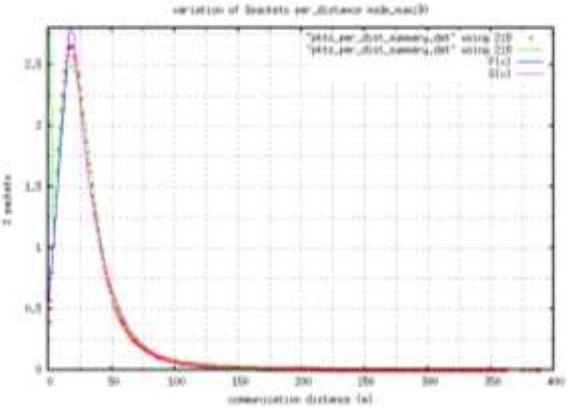

**Figure 24: % PPD node_number 30**

*25. Node Number 31*

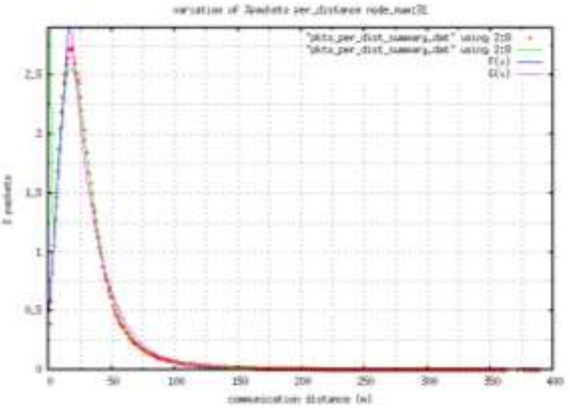

**Figure 25: % PPD node_number 31**

*26. Node Number 32*

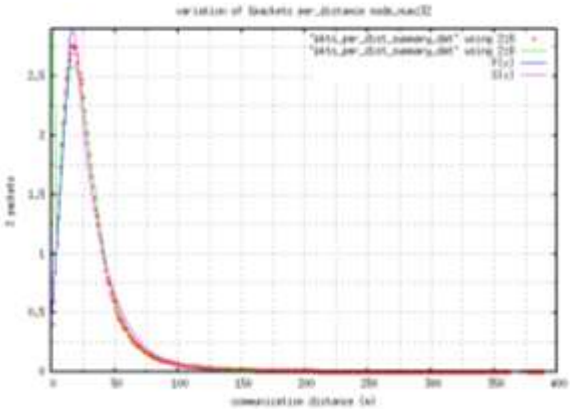

**Figure 26: % PPD node_number 32**

*27. Node Number 33*

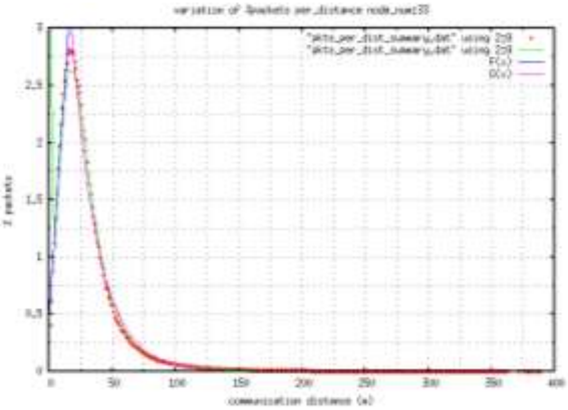

**Figure 27: % PPD node_number 33**

*28. Node Number 34*

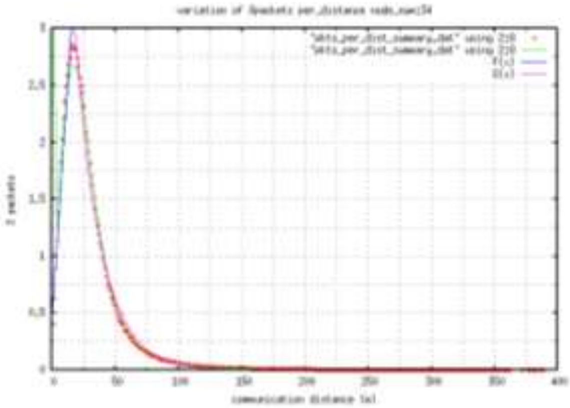

**Figure 28: % PPD node_number 34**

*29. Node Number 35*

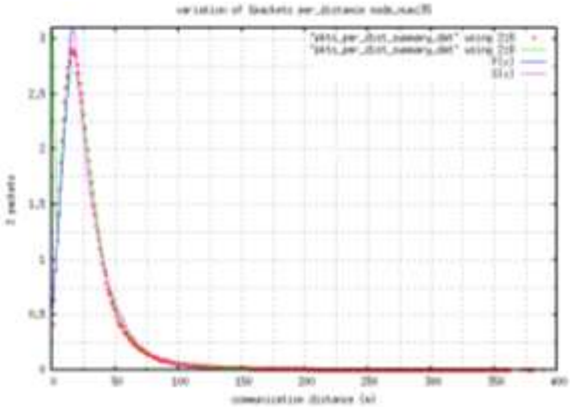

**Figure 29: % PPD node_number 35**

*30. Node Number 36*

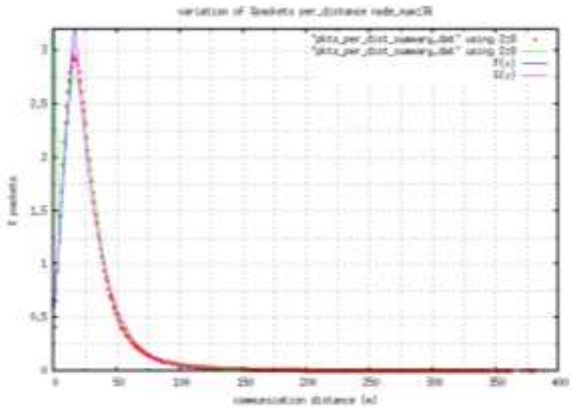

**Figure 30: % PPD node_number 36**

*31. Node Number 37*

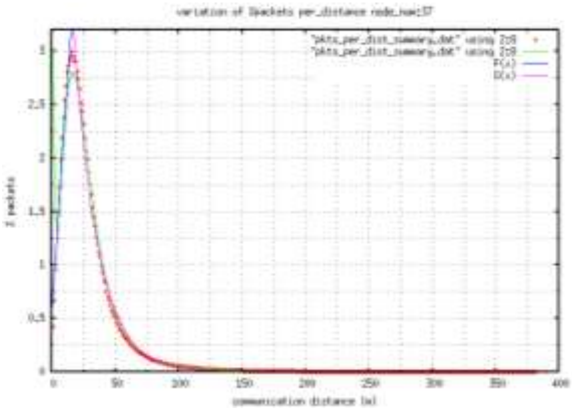

**Figure 31: % PPD node_number 37**

*32. Node Number 38*

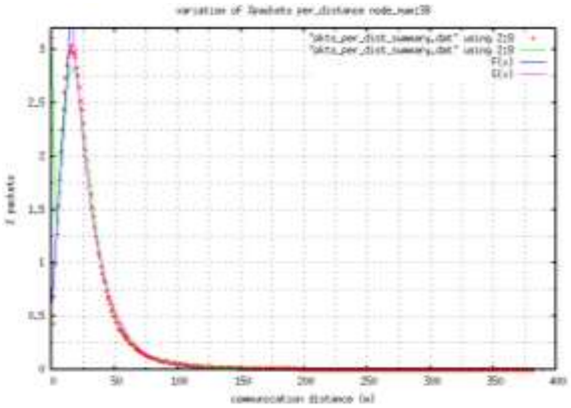

**Figure 32: % PPD node_number 38**

*33. Node Number 39*

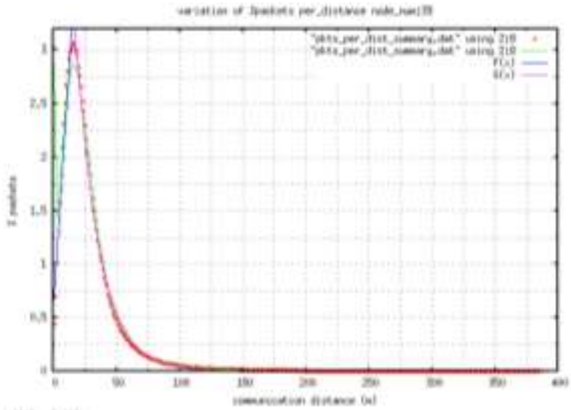

**Figure 33: % PPD node_number 39**

*34. Node Number 40*

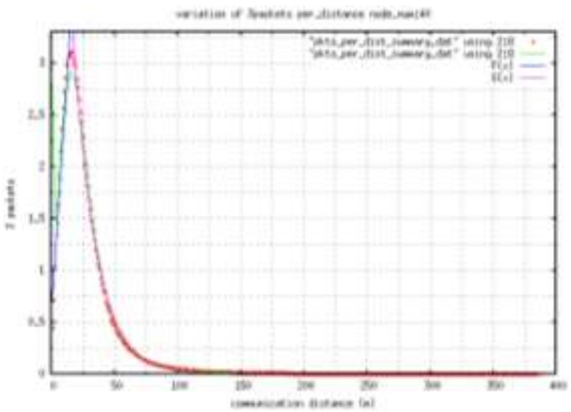

**Figure 34: % PPD node_number 40**

*35. Node Number 41*

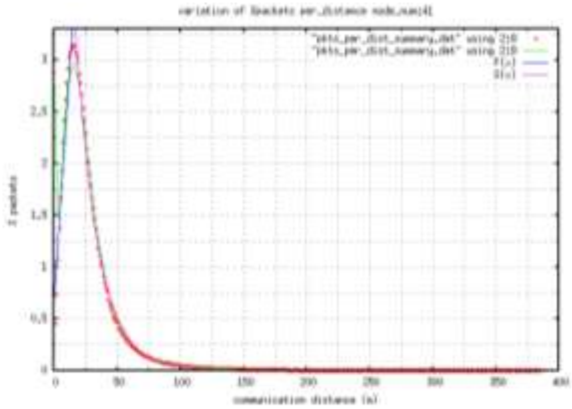

**Figure 35: % PPD node_number 41**

*36. Node Number 42*

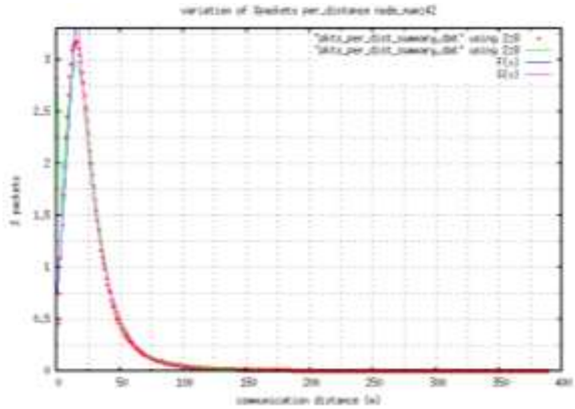

**Figure 36: % PPD node_number 42**

*37. Node Number 43*

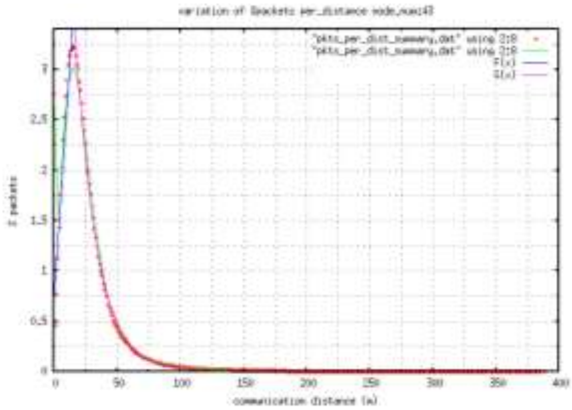

**Figure 37: % PPD node_number 43**

*38. Node Number 44*

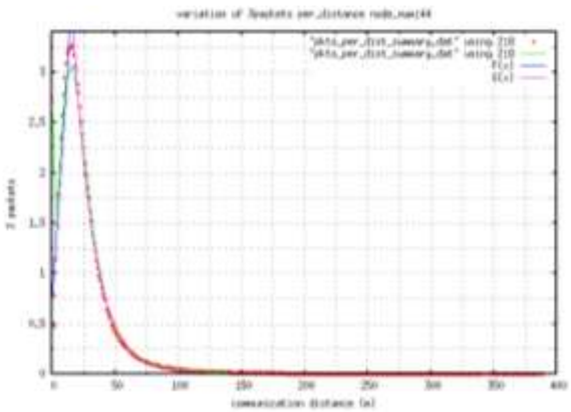

**Figure 38: % PPD node_number 44**

*39. Node Number 45*

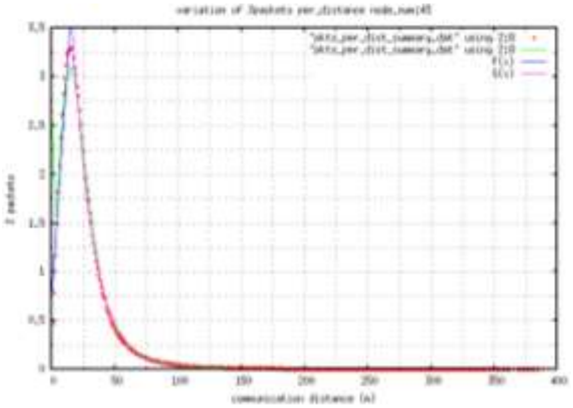

**Figure 39: % PPD node_number 45**

*40. Node Number 46*

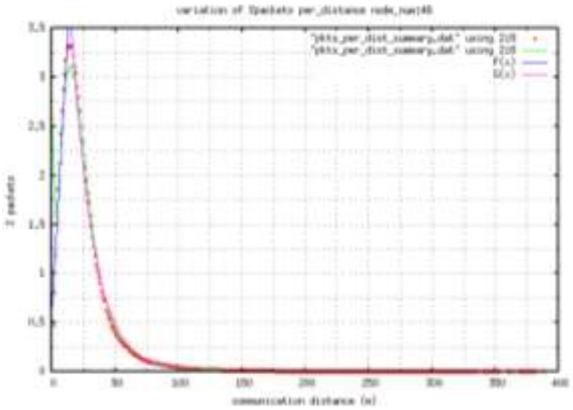

**Figure 40: % PPD node_number 46**

*41. Node Number 47*

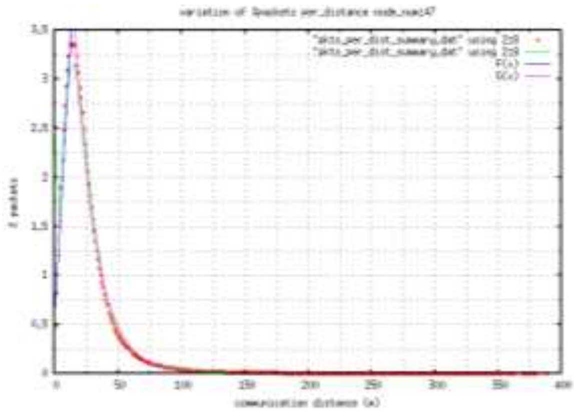

**Figure 41: % PPD node_number 47**

*42. Node Number 48*

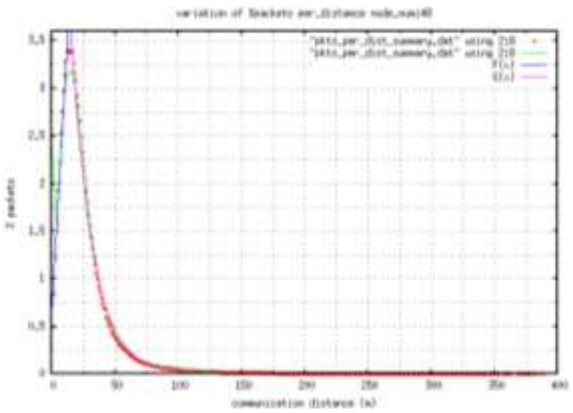

**Figure 42: % PPD node_number 48**

*43. Node Number 49*

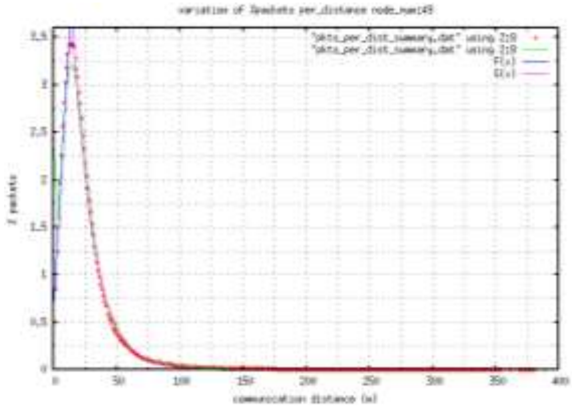

**Figure 43: % PPD node_number 49**

*44. Node Number 50*

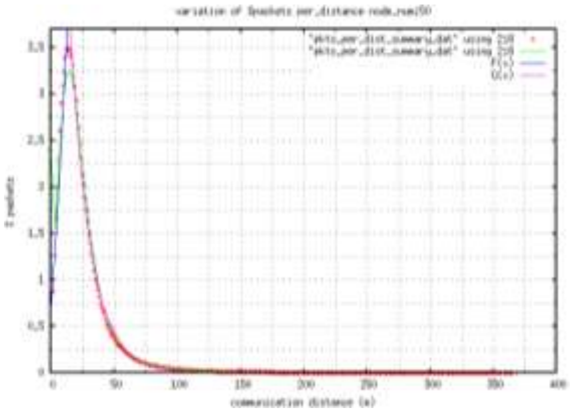

**Figure 44: % PPD node_number 50**

*45. Node Number 51*

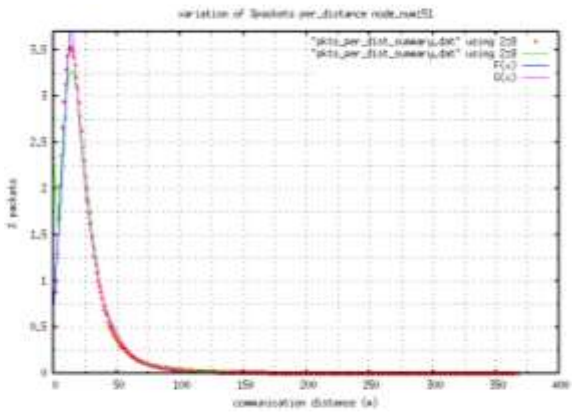

**Figure 45: % PPD node_number 51**

*46. Node Number 52*

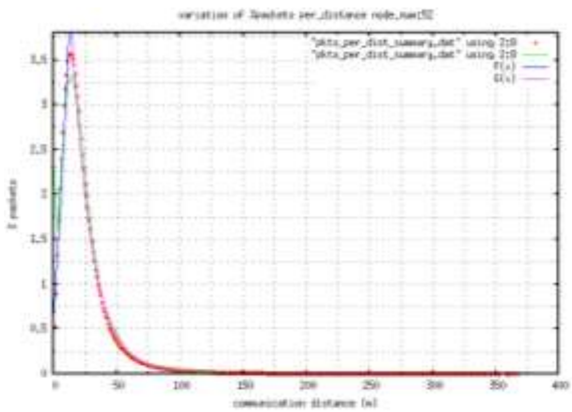

**Figure 46: % PPD node_number 52**

*47. Node Number 53*

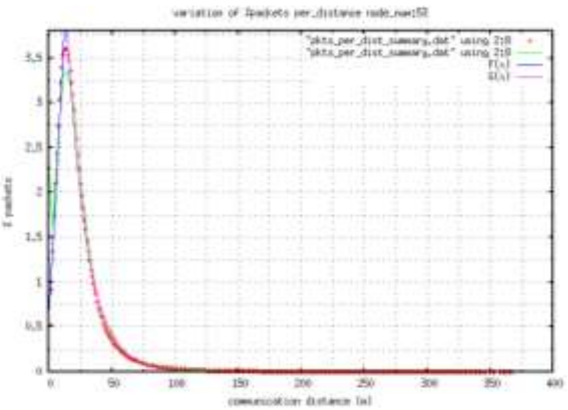

**Figure 47: % PPD node_number 53**

*48. Node Number 54*

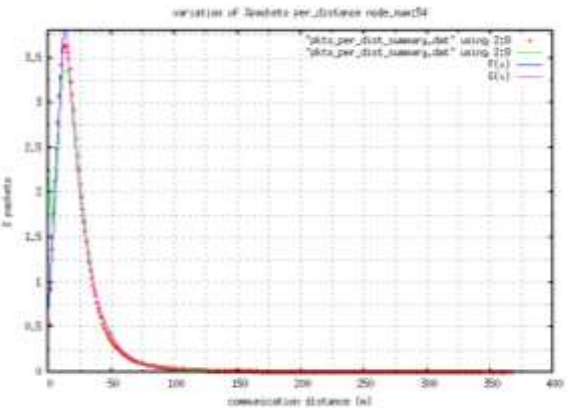

**Figure 48: % PPD node_number 54**

*49. Node Number 55*

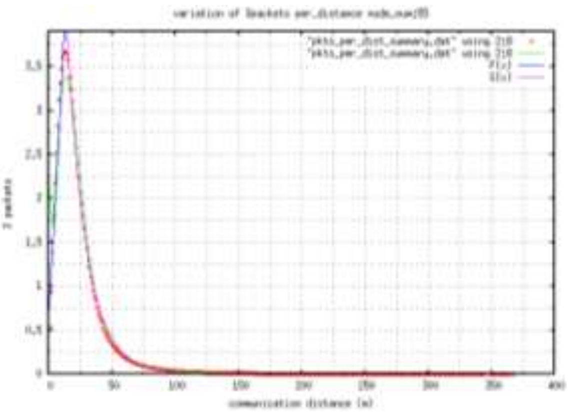

**Figure 49: % PPD node_number 55**

*50. Node Number 56*

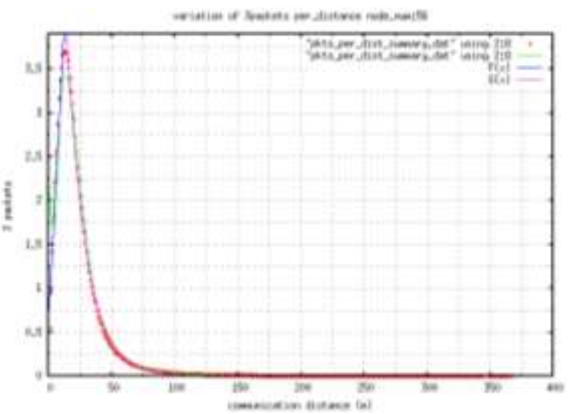

**Figure 50: % PPD node_number 56**

# 4. Conclusion.

This piece of research was aimed at studying distance coverages, rounded to nearest meter, by packets in ubicomp in situation of MANET transmission over varying Node densities. The experiment was built over same simulation programs as for studying energy load distributions [14-25].

More precisely here, a metric PPD, to assess the trend of distance coverages by packets in a ubicomp topography with varying node densities, is developed. The experimental results presented here remain empirical based. The model put forward combines mostly the decreasing exponential model and partially the linear model.

The assumptions stated in previous paper [21] hold, e.g availability of lightweight algorithms for location-aware transmission in mobile environments, lightweight MAUC OS supports for efficient binding/unbinding of MANET nodes and appropriate multi-threading/parallel communication in modules of MANET nodes.

The further work identified may include: trend analyses of parameters of equations for the model, formulating methods of predictability for metric PPD and its trend and reporting observations of certain critical values identified. It is also put forward that the metric PPD is a quite wide scope metric from which sub-component metrics may be developed.

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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.