IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-7, Issue-1, Jan 2019 E-ISSN: 2347-2693

Identification of Important Performance Metrics of Different Routing Protocols in the context of Different Scenarios using ANOVA Test

Ch. Suresh Babu.[1*], K. Gangadhara Rao[2], B. Basaveswara Rao[3], K. Chandan[4]

[1]Department of Computer Science and Engineering, Acharya Nagarjuna University, Andhra Pradesh, India
[2]Computer Centre, Acharya Nagarjuna University, Andhra Pradesh, India
[3]Department of Statistics, Acharya Nagarjuna University, Andhra Pradesh, India

Corresponding Author: suresh.chandolu@gmail.com, Tel:+91-9949894050

Available online at: www.ijcseonline.org

Accepted: 26/Jan/2019, Published: 31/Jan/2019

Abstract- In this paper, the performance metrics of routing protocols by varying node density and transmission range are analyzed using the statistical tool called Two-way ANOVA. The performance of routing protocols namely AODV, DSR, DSDV and OLSR are evaluated in two different traffic classes using NS2 simulation study. The sample data is collected from this simulation study. The Quality of Service metrics such as PDR, NRO, E2ED, TP and Jitter are treated as dependent variables which are evaluated by varying independent factors namely Node Density and Transmission Range. The ANOVA test is intended to ratify the correctness of the results and to investigate the important metrics while using individual factors and interaction effect between factors. The results of the ANOVA test found to be inline with that of NS2 simulation.

Keywords: AODV, DSR, DSDV, OLSR, ANOVA, MANETs.

I. INTRODUCTION

Mobile Ad hoc Networks (MANETs) are made up of number of mobile devices which are connected with each other on ad hoc basis. Mobile node in the MANETs should act as a host to transmit data from one node to other node and also as a router in route establishment phase. Mobile nodes can arbitrarily join or leave the network because each node has the capability of self-configuring. These networks do not require any fixed infrastructure. Due to these characteristics, the network may change the node density and link failures occur in the topology erratically. In such networks transmission of data between nodes is most important issue. The number of routing protocols are available to transmit data from source node to destination node in mobile ad hoc networks. Hence selection of an efficient and an effective routing protocol is a major issue in MANETs besides finding important performance metrics affected by the routing protocols. In paper [1] the simulation study was performed to evaluate the performance of various routing protocols namely DSDV, OLSR, DSR and AODV under different scenarios using CBR and VBR traffic classes [8], [9], [10], [11]. The scenarios are Node Density Scenario (NDS) and Transmission Range Scenario (TRS). Each routing protocol's performance was evaluated by using Quality of Service metrics such as packet delivery ratio (PDR), throughput (TP), end-to-end delay (E2ED), normalized routing overhead (NRO) and jitter.

Many authors are using ANOVA statistical tool to prove the results statistically to validate the argument obtained from simulation. The performance of AODV, DSR and DSDV routing protocols analyzed by using NS2 the results so obtained are given as input to one-way ANOVA test varying node speed by the authors S.Goswami et.al. (2014) [2]. J.M.Dricot et.al. used ANOVA with multivariate statistics to unveil and characterize the four variables namely routing algorithm, propagation model, node density and mobility scheme [3]. B.A.S.Roopa Devi et.al. (2015) [4] used NS2 and two way ANOVA to investigate the impact of block hole attack on AODV routing protocol by varying number of nodes. The above findings never focused on transmission range and didn't identify which performance metric is more affected by the routing protocols in the context of node density and transmission range scenarios.

A factorial ANOVA is an Analysis of Variance test with more than one independent variable. It can also refer to more than one Level of Independent Variable. ANOVA test can be performed in two ways based on independent variable or factor. The first way is one-way ANOVA test which is performed when the sample data has one independent variable and the other is two-way ANOVA test which is performed when the sample data has two independent variables. According to the sample data collected from simulation study, two-way ANOVA has been selected to authorize the results statistically. In this paper a statistical analysis tool two-way ANOVA is used to find the significant difference among protocols factor, number of nodes factor and transmission range factor and also find the interaction effect between protocol verses number of nodes and protocol verses transmission ranges. The main objective of this paper is to find out whether there is significant difference among routing protocols and how the each factor affects the dependent variable i.e. performance metrics in both the scenarios such as node density and transmission range.

The rest of the paper is organized as follows. Section I contains introduction of importance of routing protocols and ANOVA statistical tool. Section II narrates a related work of ANOVA and routing protocols. Section III contains the metrics used for performance evaluation. The detailed consideration of ANOVA test in Section IV. Results are discussed in Section V and Section VI discusses conclusions and future scope of the work.

II. RELATED WORK

S.Goswami et.al. (2014) evaluated the performance of AODV, DSR and DSDV protocols by changing speed of mobile nodes using NS2 simulation. Then the comparison analysis of these routing protocols proved using one-way ANOVA test. Finally the authors have concluded AODV routing protocol is the best one for MANETs. B.A.S.Roopa Devi et.al. (2015) investigated the impact of block hole attack on AODV routing protocol using NS2 simulator. This was measured using packet delivery ratio, throughput, end-to-end delay, jitter and packet dropped metrics. The impact of this attack on AODV is statistically proved using two way ANOVA test. J.M.Dricot et.al., proposed multivariate statistics to unveil and characterize the four variables namely routing algorithm, propagation model, node density and mobility scheme. The efficiency of routing algorithm is strongly correlated with the environment and the performance of routing protocols evaluated among cross-layer of protocol stack. C.F.Alvarez et.al.(2015) [6] proposed Link Disconnection Entropy Disorder (LDED) to analyze the relationship between channel traffic saturation and node speed when link breakages are more in the case of high speed of the nodes in the network and performed two-way ANOVA test on traffic and speed variables also. The authors concluded there is statistically significant change in traffic and speed. The study of different ANOVA tests used in various papers is presented in Table 1.

Table. 1. Details of ANOVA Test used in Mobile Ad Hoc Networks

Authors	Type of ANOVA	Protocols	Remarks
S.Goswami, S.Joardar, C.B.Das, S.Kar, D.K.Pal	One-Way ANOVA	AODV, DSR, DSDV	AODV exhibits better performance than other protocols.
J.M. Dricot, P.De Doncker, E.Zimanyi	Two-Way and Three-Way ANOVA	AODV, TORA, DSDV	Impact of routing algorithms, node density, mobility and propagation conditions on cross-layer approach.
B.A.S.Roopa, J.V.R.Murthy, G.Narasimha, S.P.Setty	Two-Way ANOVA	AODV	Impact of Block Hole attack on AODV before and after creating malicious nodes.
Ch.Chigan, L.Li, Y.Ye	Two-Way ANOVA	Resource-aware self-adaptive Security model	Analyze and compare the performance cost of security protocols.
C.F.Alvarez, L.E.Palafox, L.Aguilar	Two-Way ANOVA	Link Disconnection Entropy Disorder	Impact of speed and traffic while analyze the disorder in link entropy.

III. PERFORMANCE METRICS

The performance of the routing protocols should be evaluated using quantitative metrics such as PDR, NRO, E2ED, TP and jitter which are also considered to analyze the performance of DSDV, OLSR, DSR and AODV routing protocols. These metrics are considered from K.Gangadhara Rao et.al (2016).

A. Packet Delivery Ratio (PDR)

The ratio of the data packets carried successfully to destinations to the total data packets generated by the sources for destinations. The performance is better when PDR is high.

$$PDR = \frac{Sum\ of\ Received\ Packets}{Total\ generated\ packets} * 100$$

B. Normalized Routing Overhead (NRO)

The ratio of total number of control packets transmitted to the total number of data packets successfully received at destinations. The performance is better when NRO is low.

$$NRO = \frac{Sum\ of\ routing\ control\ packets}{sum\ of\ data\ packets\ delivered}$$

Here routing control packets are Route Request (RREQ), Route Reply (RREP) and Route Error (RERR) and data packets are CBR/VBR data packets.

C. End-to-End Delay (E2ED)

The average amount of time that is taken by a packet to reach the destination. It includes processing delay, queuing delay, transmission delay and propagation delay [7]. The performance is better when the packet end-to-end delay is low. Processing delay is the time from the arrival of packet until it is assigned to an output link for transmission. Queuing delay is the sum of waiting time at a source and intermediate nodes due to the route establishment and congestion. Transmission delay is the sum of time required to push all of the packet's bits into the link from a source to a destination. Propagation delay is the sum of time required to propagate a packet on each link from a source to a destination.

$$E2ED = \frac{\sum_{n=1}^{N}(RT_n - ST_n}{N}$$

Where N is Total number of packets received, RT_n is Time at which Packet n was received, ST_n is Time at which packet n was sent.

D. Throughput (TP)

The total number of successfully received packets by the destination per unit time. The performance is better when throughput is high.

$$throughput = \frac{successfully\ received\ packets}{unit\ time}$$

E. Jitter

Jitter is the packet latency between each received data packets. The variation in the packet arrival time should be minimum to have better performance. This is an important metric in multimedia applications.

$$jitter = (R_{i+1} - S_{i+1}) - (R_i - S_i)$$

Where R_i is receiving time of packet i and S_i is sending time of packet i.

IV. ANOVA

The Analysis of Variance is generally known as ANOVA. This test applies when there are more than two independent groups. The fundamental approach of ANOVA is to systematically examine the mean differences with in the groups and among the groups. The Two-way ANOVA test has two categories based on groups of independent variables, one is Two-Way ANOVA without replication and the other is Two-Way ANOVA with replication [4], [5]. Two-Way ANOVA without replication is used when there is one group that takes two tests on the same group. Two-Way ANOVA with replication is used when there are two groups that are taking more than one test. The F Ratio is the ratio of the variance between groups and the variance within groups. A standardized distribution table can be used to find $F_{critical}$ value for any system. This value will depend on alpha that is treated as measure of the confidence level. Basically the alpha value is 0.05 which is equivalent to the 95% confidence level. This is represented as critical value of F at p=0.05 level of significance also. If the observed value of F is greater than the critical value of F then conclude with 0.05 level of significance that the null hypothesis is rejected.

In this paper two-way ANOVA is proposed based on independent variables. In the sample number of nodes, transmission range, routing protocol and content type are independent variables. The performance metrics namely PDR, NRO, E2ED, TP and Jitter are used as dependent variables. Each independent variable has multiple groups. The number of nodes has five groups (nodes20, nodes40, nodes60, nodes80 and nodes100), transmission range has six groups (range100, range200, range300, range400, range500 and range600), routing protocol has four groups (AODV, DSR, DSDV and OLSR) and content type has two groups (CBR and VBR). Protocols, Number of Nodes and Transmission Range factor's outcome is considered separately is called Main Effect. (Protocol * Number of Nodes) and (Protocol * Range) are called Interaction Effect. The interaction effect is the effect that one factor has on the other factor [5], [6]. The following hypothesis is considered to test the system.

- Null Hypothesis (H_0): All the protocol groups have equal impact on metrics.
- Alternate Hypothesis (H_a): All the protocol groups have not equal impact on metrics

The outcome of the Two-Way ANOVA is F-ratio and P value for each independent input variable and each 2-way interaction between the variables. Based on these values the test tells the input variable has a significant impact on the system.

The Two-Way ANOVA test is performed using following steps.

1. Samples are obtained from Mobile Ad Hoc Networks.
2. The routing protocols group is considered as first factor and Number of Nodes or Transmission Range group is considered as second factor.
3. Draw the mean table and find the marginal mean.
4. Calculate Sum of Squares Total by adding sum of squares of first factor, sum of squares of second factor, sum of squares within and sum of squares of both factors.
5. Compute Degree of Freedom
    a. Degree of Freedom for first factor= Number of rows -1
    b. Degree of Freedom for second factor= Number of columns-1
    c. Degree of Freedom for both factors= a * b
6. Evaluate Mean Square value by using Sum of Squares over Degree of Freedom.

7. Calculate F Ratio= Mean Square / Sum of Square Error.

A. ANOVA test using R

The following steps are used while conducting Two-Way ANOVA test in R Programming.

Step 1: Collect the sample and save it as .csv file. Read this file into R Studio by using read.csv() command.

Step 2: Tell about this data to the R using attach(filename) method.

Step 3: Perform Two Way ANOVA test using this command Data name for anova = aov(y variable ~ x1 variable*x2 variable)

Here aov() is the function to perform analysis of variance, y variable is dependent variable, x1, x2 variables are independent variables.

Step 4: P_r (>F) value is called as P value. This P value is greater than 0.05 level of significant. If the P value is less than 0.05 then the results are considered as statistically significant.

V RESULTS

The Quality of Service metrics namely Packet Delivery Ratio, Normalized Routing Overhead, End-to-End Delay, Throughput and Jitter are analyzed with Two-Way ANOVA test using R tool in two different scenarios. The first one is Node Density Scenario and other is Transmission Range Scenario.

A. Node Density Scenario

In this scenario, the p-value is less than 0.05 significance level i.e. confidence of up to 95%. According to the F-Distribution, the $F_{critical}$ value is 3.10. Each table represents the Degree of Freedom, Sum of Squares, Mean Square Values, F Ratio and P values giving to the factor protocol, factor NN and both the factors (protocol * NN).

1) Packet Delivery Ratio (PDR)

The PDR is evaluated by using number of packets sent by the source and number of packets received by the destination. The PDR is not significant because the F value of protocol factor (0.246), NN factor (0.086) and interaction effect (Protocol * NN) (0.021) is less than 3.10. The results are significant if the available F values are greater than F critical value. Hence accept the null hypothesis. There is no significant difference among the protocols group and also number of nodes group. This can also be shown by using P-value. Here P-values are greater than 0.05 that is shown in Table 2.

Table 2. Summary of PDR

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Protocol	3	1264	421.4	0.246	0.863
NN	4	586	146.6	0.086	0.986
Protocol:NN	12	426	35.5	0.021	1.000
Residuals	20	34256	1712.8		

2) Normalized Routing Overhead (NRO)

The NRO shows significant difference among the number of nodes factor and there is no significant difference among protocol factor and also interaction effect (protocol * number of nodes).

Table 3. Summary of NRO

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Protocol	3	100.3	33.43	2.983	0.05575 .
NN	4	264.0	66.00	5.890	0.00267 **
Protocol:NN	12	138.4	11.53	1.029	0.46081
Residuals	20	224.1	11.21		

Signif. Codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

According to the table 3, F=2.983 < 3.10 i.e. accept the null hypothesis in the case of factor 1 means protocol group. When increasing number of nodes, each node generates control packets to establish the route from source to destination that causes overhead. In this case F value of NN factor is 5.890 which is greater than 3.10 that is reject the null hypothesis that means the NRO is significant at number of nodes factor. The P-value is also less than 0.05. So, there is significant difference among different number of nodes.

3) End-to-End Delay (E2ED)

The most important performance metric is End-to-End Delay which causes the drop the performance of whole network. Here the F value of protocol factor is 12.143 which is greater than 3.10 that is not accepting the null hypothesis. Hence there is significant difference among different routing protocols. The F value of NN factor is 1.374 which is less than F critical value that means accepting the null hypothesis that is shown in table 4.

Table 4. Summary of E2ED

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Protocol	3	44.82	14.940	12.143	9.53e-05 ***
NN	4	6.76	1.690	1.374	0.278
Protocol:NN	12	8.65	0.721	0.586	0.828
Residuals	20	24.61	1.230		

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

4) Throughput (TP)

The Throughput is related to Packet Delivery Ratio metric. The protocols factor and number of nodes factor have less impact on throughput. The P-value is greater than 0.05 in all the three cases i.e. the protocols, the number of nodes and both the factors. The F values of all factors less than F critical value hence the null hypothesis is acceptable that is there is no difference among the routing protocols group, number of nodes groups and the interaction effect (protocol * NN). It is represented in the table 5.

Table 5. Summary of Throughput

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Protocol	3	28014	9338	1.206	0.333
NN	4	12862	3215	0.415	0.796
Protocol:NN	12	7877	656	0.085	1.000
Residuals	20	154912	7746		

5) Jitter

The packet jitter is expressed as the delay between arrival packets. The F value of the factor Protocol 4.889 is greater than critical value hence the null hypothesis is rejected that is shown in table 6. That means, there is significant difference among various protocols in terms of jitter performance. The P value 0.0104 of the protocol is less than 0.05. The F value of NN factor is 2.247 which is less than F critical value hence the null hypothesis is accepted that is there is no significant difference even when there is increase the number of nodes.

Table 6. Summary of Jitter

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Protocol	3	0.0014540	0.0004847	4.889	0.0104 *
NN	4	0.0008912	0.0002228	2.247	0.1002
Protocol:NN	12	0.0012362	0.0001030	1.039	0.4535
Residuals	20	0.0019826	0.0000991		

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

B. Transmission Range Scenario

In this scenario, the p-value is less than 0.05 significance level i.e. confidence of up to 95%. According to the F-Distribution, the $F_{critical}$ value is 3.01. Each table represents the Degree of Freedom, Sum of Squares, Mean Square Values, F Ratio and P values giving to the factor protocol, factor range and both the factors (protocol *range).

1) Packet Delivery Ratio (PDR)

The F- value of protocol factor (0.180), Range factor (1.463) and both the factors (0.034) is less than 3.01 F critical value. The results are significant at 95% confidence level hence accept the null hypothesis. This can also be shown by using P-value. Here P-values are greater than 0.05. There is no difference among the protocol group and transmission range group. So, the protocols shows less impact on the PDR when increasing transmission range that is shown in Table 7.

Table 7. Summary of PDR

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Protocol	3	801	267.1	0.180	0.909
Range	5	10837	2167.4	1.463	0.239
Protocol:Range	15	756	50.4	0.034	1.000
Residuals	24	35561	1481.7		

2) Normalized Routing Overhead (NRO)

According to the table 8, the available F value of protocol factor is 1.431 which is less than F critical value 3.01 i.e. accept the null hypothesis in the case of main effect i.e. protocol group. When increasing transmission range, more number of nodes cover under transmission range that causes to generate more congestion in the network. In case of transmission range factor the F value is 3.621 which is greater than F critical value 3.01 that is reject the null hypothesis that means there is significant difference among different transmission ranges. The F value of interaction effect (Protocol * Range) is greater than F critical value that means one factor interacts with other factor. The NRO is significant at main effect range and interaction effect (protocol * range).

Table 8. Summary of NRO

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Protocol	3	12.56	4.187	1.431	0.258257
Range	5	100.35	20.071	6.862	0.000419 ***
Protocol:Range	15	158.88	10.592	3.621	0.002488 **
Residuals	24	70.20	2.925		

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

3) End-to-End Delay (E2ED)

When the number of intermediate nodes are high between source and destination, it requires more number of hops to reach the destination, which causes more end-to-end delay. Here the F value of the protocol factor is 15.302 which is greater than 3.01 that is not accepting the null hypothesis. Hence there is significant difference among different routing protocols. The F value of other factor range is 1.110 which is less than 3.01 so there is no significant difference among different ranges. The protocol group has more impact on end-to-end delay that is depicted in table 9.

Table 9. Summary of E2ED

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Protocol	3	31.588	10.529	15.302	8.93e-06 ***
Range	5	3.817	0.763	1.110	0.382
Protocol:Range	15	6.259	0.417	0.606	0.841
Residuals	24	16.514	0.688		

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

4) Throughput (TP)

The range factor also carry out much impact on throughput. The F-value of the range factor is 10.837 which is greater than the critical value 3.01 that is null hypothesis is rejected. Hence there is significant difference among different ranges. The F value of the remaining factors is less than the critical value hence the null hypothesis is acceptable that is there is no difference among different routing protocols. It is represented in the table 10.

Table 10. Summary of Throughput

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Protocol	3	87978	29326	2.750	0.0649 .
Range	5	577912	115582	10.837	1.54e-05 ***
Protocol:Range	15	40221	2681	0.251	0.9961
Residuals	24	255964	10665		

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

5) Jitter

The packet jitter is expressed as the delay between arrival packets. The F value of the factor range is 6.421 which is greater than critical value hence the null hypothesis is rejected that is shown in table 11. That means, there is significant difference among various ranges in terms of jitter performance. The range factor affects more on Jitter. The P value 0.000642 of the protocol is far less than 0.05.

Table 11. Summary of Jitter

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Protocol	3	0.00160	0.000532	0.186	0.905043
Range	5	0.09200	0.018400	6.421	0.000642 ***
Protocol:Range	15	0.01310	0.000873	0.305	0.989831
Residuals	24	0.06878	0.002866		

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

VI. CONCLUSION

In this paper the sample data is obtained from authors K.Gangadhara Rao et.al. (2016) by conducting NS2 simulation on AODV, DSR, DSDV and OLSR routing protocols by varying node density and transmission range. The performance metrics such as PDR, NRO, E2ED, TP and Jitter were considered as Quality of Service metrics to evaluate the difference among routing protocols using Two-way ANOVA test. In the case of Node Density Scenario, F values of dependent variables vis-a-vis E2ED and Jitter are 12.143 and 4.889 with respect to the Protocols factor. These values show there is a significant difference between protocols that means these protocols carry out more impact on E2ED and Jitter. In the second case i.e. Transmission Range Scenario, F value of performance metric E2ED is 15.302 which is greater than F critical value 3.01 hence reject the null hypothesis that means there is a significant difference among protocols factor. The F values of dependent variables NRO, TP and Jitter are 6.862, 10.837 and 6.421 respectively for the factor Range. It shows there is a significant difference among different ranges. Finally the ANOVA test statistically proved that the metric E2ED is influenced by the protocols factor in both the scenarios. Hence the End-to-End delay is considered as one of the important metrics. In future the End-to-End Delay is evaluated using queuing model in the above said two scenarios.

REFERENCES

[1] K.Gangadhara Rao, Ch.Suresh Babu, B.Basaveswara Rao, D.Venkatesulu, “Simulation Based Performance Evaluation of Various Routing Protocols in MANETs”, IOSR journal of Mobile Computing & Application, Vol 3, Issue 4, pp 23-39, 2016.

[2] Subhrananda Goswami, “Performance comparison of routing protocols of MANET using NS2”, LAP LAMBERT Academic Publishing, pp 1-140, 2014.

[3] Jean-Michel D, P.D.Doncker, E.Zimanyi, “Multivariate Analysis of the Cross-Layer Interaction in Wireless Networks Simulations”, In the Proceedings of International Workshop on Wireless Ad-hoc Networks, IWWAN, pp 121-125, 2005.

[4] B.A.S.Roopa Devi, J.V.R.Murty, G.Narasimha, S.Pallam Setty, “Investigating the Impact of Black Hole Attack on AODV with Statistical Tool-ANOVA”, International Journal of Current Engineering and Technology”, Vol 5, No. 1, pp 97-103, 2015.

[5] C.Chigan, L.Li, Y.Ye, “Resource-aware Self-Adaptive Security Provisioning in Mobile Ad Hoc Networks”, Journal of IET Information Security. May, 2014.

[6] C.F.Alvarez, L.E.Palafox, L.Aguilar, “Link Disconnection Entropy Disorder in Mobile Adhoc Networks”, International Journal of Recent Research in Electrical and Electronics Engineering, Vol 2, Issue 3, pp 119-125, 2015.

[7] Yongda Lin, Fengjie Li, “An Integrated Testbed for Routing Performance of MANET”. In the proceedings of 2017 IEEE 2nd Information Technology, Networking, Electronic and Automation Control Conference (ITNEC), China, pp 33-38 2017.

[8] Fahad Taha AL-Dhief , Naseer Sabri , M.S. Salim , S. Fouad , S. A. Aljunid, “MANET Routing Protocols Evaluation: AODV, DSR and DSDV Perspective”, In the proceedings of MATEC Web of Conferences 150, No 06024, pp 1-6, 2018.

[9] Umar Draz, Tariq Ali, Sana Yasin, Ahmad Shaf, “Evaluation Based Analysis of Packet Delivery Ratio for AODV and DSR under UDP and TCP Environment”, In the proceedings of 2018 International Conference on Computing mathematics and Engineering Technologies, Pakistan, 2018.

[10] Lubdha M. Bendale, Roshani. L. Jain, Gayatri D. Patil, “Study of Various Routing Protocols in Mobile Ad-Hoc Networks”, International Journal of Scientific Research in Network Security and Communication, Vol 6, Issue 1, pp 1-5, 2018.

[11] R. Kumari, P. Nand, “Performance Analysis for MANETs using certain realistic mobility models: NS-2”, International Journal of Scientific Research in Computer Science and Engineering, Vol 6, Issue 1, pp 70-77, 2018.

Authors Profile

Suresh babu Chandolu is pursuing his Doctoral programme at Acharya Nagarjuna University under RGNF (a country level fellowship eligibility test conducted by UGC). He did his M.Tech from JNTU Kakinada and MCA from Acharya Nagarjuna University. His research interests includes areas like Computer Networks specifically MANETs, Cloud Computing.

K. Gangadhara Rao received his Doctoral degree in Computer Science under faculty of Engineering in the year 2011 from Acharya Nagarjuna University. He did his M.Tech from Andhra University, Vishakhapatnam and B.Tech from Acharya Nagarjuna University. Currently he is working as Associate Professor in Department of Computer Science and Engineering, Acharya Nagarjuna University. His areas of interest includes Data Mining, Cloud Computing, Computer Networks and Software Engineering. He has published 36 papers in national and international journals.

B. Basaveswara Rao received his Doctoral degree in Computer Science under faculty of Engineering in the year 2010 from Acharya Nagarjuna University. He did his MCA from Madurai Kamaraj University. Currently he is working as programmer in the university Computer Centre, Acharya Nagarjuna University. His areas of interest includes Data Mining, Cloud Computing, Computer Networks and Software Engineering. He has published 40 papers in national and international journals.

K. Chandan received his Doctoral degree in Statistics from IIT Kharagpur in the year 1986, he did his masters in Statistics from Osmania University in the year 1980. Currently he is working as Professor in Department of Statistics. His areas of interest includes Operation Research (Queuing Theory), Game Theory, Investment Analysis. Besides this he is also interested in collaborative research in computer science where Queuing Theory, Game Theory plays a vital role.