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Correlation Techniques to Measure the Degree of Association Between Nodes of Different Protocols in MANETs, In Terms of Their Energy Consumption in Data Transmission

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ABSTRACT

Several protocols have been using in networks, especially in MANETs, to increase efficiency in energy consumption of intermediate nodes while transmitting data packets to the destination node. Several protocols like energy efficient and energy consumption protocols are introduced in MANETs to increase the overall life time of MANETs. MANETs can't survive for longer times without the property of energy consumption, as the available battery resources are very limited. Different protocols are implemented and tested, by simulation like NS2, on the basis of their energy consumption levels. To know the fairness and reliability of data obtained from different protocols, several statistical analysis methods are suggested. Finding the coefficient of correlation and rank correlation methods are very popular among them. These methods help to know the actual existing relation between the considered energy consumption data sets of intermediate nodes of two different protocols. This information will be very helpful to MANETs in estimating the required future energy consumption levels of its intermediate nodes and the degree of fairness between them.

Keywords : MANETs, protocols, energy consumption levels, intermediate nodes, coefficient of correlation, rank correlation, relation, association, degree of fairness, data packets, transmission, and simulation.

I. INTRODUCTION

No one can deny the role of MANETs in real life as well as practical applications. Since the availability of energy resources are very limited, MANETs have to look after the energy requirements of their intermediate nodes from time to time. So they can be termed as self-manageable wireless networks. Even though, Media Access Control protocol assists in coordinating the available energy resources of wireless networks the role and applications of MANETs in inevitable. So many protocols have been introducing from time to time to save energy consumptions in wireless networks, Ad-hoc On-Demand Distance Vector Routing protocol (AODV) played an important role in energy savings of nodes in wireless networks like MANETs. But its contribution is not sufficient in energy management, so in order to take the future needs and requirements into considerations, protocols like energy efficient and energy consumed protocols are introduced[3][4][5]. In order to increase the energy management behaviour of MANETs, so many number of techniques by the name of protocols were incorporated into it. By using simulations for various protocols, the energy management details of MANETs for their intermediate nodes can be obtained. Even though, a little amount of energy is allocated to MANETs, they try their best to utilize the available battery resources for longer times for all of its participating nodes in order to increase the life time of the network. It has been practically proved that there is a lot of difference in energy consumption between wired networks and wireless networks like MANETs[1][2][4]. Now-a-days, much number of principles of wireless networks, wherever possible, have been introducing in wired networks like desktops etc., In MANETs itself, many energy savings schemes are being introduced from time to time[1][2][4][5]. The focus of this paper is on Mathematical modelling techniques of MANETs in order to find the difference of energy consumption levels by using normal energy savings protocols and specific energy savings protocols like energy efficient protocol, which will help in estimating the future energy requirements of MANETs, on an overall basis, to provide the sufficient and minimum energy to its intermediate nodes to make their data transmissions to the next level nodes.

A simple MANET with 15 nodes is assumed with a battery supply of 75 joules. On an average, every node is supposed to use 5 joules only. Two protocols, one normal energy savings protocol and specific protocol like Energy Efficient protocol are used in collecting data of energy consumptions by intermediate nodes by using NS2 simulation, which is shown in the following Table I.

TABLE I

ENERGY CONSUMPTIONS OF NODES IN NORMAL ENERGY PROTOCOL AND ENERGY EFFICIENT PROTOCOL BY USING NS2 SIMULATION

Normal Energy Savings Protocol (in joules)	Energy Efficient Protocol (in joules)
5.01	4.75
5.02	4.76
4.98	4.70
4.85	4.80
5.04	4.73
4.95	4.71
4.85	4.72
5.03	4.81
4.94	4.72
4.84	4.75
5.04	4.83
4.96	4.77
5.05	4.84
5.00	4.85
4.8	4.78
4.90	4.82

On the basis of the data collected from the Table I, it is clear that the energy consumed by nodes of specific energy efficient protocol is much less than that of the energy consumed by nodes of normal protocols. Now it is possible to forecast the future energy requirements of nodes but it is allowed only when the relation between data sets of these protocols is fair and uncorrelated. Here, it is possible to find the relation between the data sets of the above protocols without using any simulations or specific software. Many statistical approaches are available to find the genuinely between relations of the available data sets, Correlation Techniques are one among them[6][7]. This paper attempts to find the actual association between the data sets of various protocols, which are used for simulation results, purely on the basis of statistical methods of Correlation Analysis.

II. RANK CORRELATION COEFFICIENT TECHNIQUE

Coefficient of Correlation and Rank Correlation techniques are among them which have been more popularly used among Industry and Academia[6][7]. Rank correlation also known as Spearman's Rank Correlation Coefficient (r). These two techniques can be used in this paper, but importance is given to Rank Correlation Coefficient technique to know the fairness of data between data sets of the two protocols, without using any simulations or other Mathematical software. The following Table shows the calculation part of coefficient of correlation.

Rank correlation coefficient takes values from -1 to +1. The range of r is $-1 \le r \le +1$. In this procedure, r = 1 => a perfect and very strong association exists between the two data sets and dependency of data can be encountered. r = -1 => a perfect negative association exists between the two data sets and these two sets neutral each other. If r=0, this implies that no relation exists between the data sets. i.e., neither positive association nor negative association exists and data sets are purely independent. If r moves towards +1 implies that the data set is building a strong association with another data set. Similarly, if r moves towards -1 implies that the data set is building a negative association with another data set. Neither Karl Pearson Correlation Coefficient nor Rank correlation Coefficient examines what relation is existing between them, but they always focuses on "if relation exists, how strong it is"[6][7].

TABLE II

CALCULATIONS OF RANK COEFFICIENT OF CORRELATION (r)

Normal Energy Savings Protocol (X)	Energy Efficient Protocol (Y)	Rank of X = X i	Rank of Y = Yi	Di = Xi - Yi	Di^2
5.01	4.75	6	10.5	-4.5	20.25
5.02	4.76	5	9	-4	16
4.98	4.70	8	16	-8	64
4.85	4.80	13.5	6	7.5	56.25
5.04	4.73	2.5	12	-9.5	90.25
4.95	4.71	10	15	-5	25
4.85	4.72	13.5	13.5	0	00
5.03	4.81	4	5	-1	01
4.94	4.72	11	13.5	-2.5	6.25
4.84	4.75	15	10.5	4.5	20.25
5.04	4.83	2.5	3	-0.5	0.25
4.96	4.77	9	8	1	01
5.05	4.84	1	2	-1	01
5.00	4.85	7	1	6	36
4.8	4.78	16	7	9	81
4.90	4.82	12	4	8	64
				$\sum Di = 0$	$\sum Di^2 = 482.50$

III. CALCULATIONS OF r

$$r = 1 - \{6 \sum Di^2\} / \{N (N^2 - 1)\} \qquad (1)$$

From the equation (1)[6][7], N = the number of data values considered, in the above Table it is 16 i.e., N =16.

Di = Xi – Yi , where

Xi = ranks of data values of X

Yi = ranks of data values of Y

Di = the difference between ranks of data sets of Xi and Yi respectively.

The equation (1) represents for the data items which have no repeated values

If data items have repeated values then there is a modification to the above formula (1).

$$r = 1 - \frac{6 \{ \sum Di^2 + m_j (m_j^2 - 1) / 12 \}}{N (N^2 - 1)} \qquad (2)$$

In the equation (2), m_j is the number of times the ranks repeated in each of the data sets X and Y. The procedure to be followed in case of repeated ranks is :

In the data set of Y, 4.85 has the highest value, so its rank is 1. Next highest value in Y is 4.84 so its rank is 2. Another value 4.75 in Y is repeated for 2 times, their actual ranks are 10 and 11 respectively since it is repeated for 2 times, the average value of 10 and 11 is 10.5, then 10.5 is the common rank of 4.75. Similarly, 4.72 in Y is repeated for 2 times and their actual ranks are13 and 14 respectively, since it is repeated for 2 times, here average of 13 and 14 is 13.5. Considering X, 5.05 has the highest value so its rank is 1. Next highest value in X is 5.04, which is repeated for two times , their actual ranks are 2 and 3 respectively, so the average of 2 and 3 is 2.5 so their common rank is 2.5. Another value 4.85 in X is repeated for 2 times. Its actual ranks are 13 and 14 respectively. Since it is repeated for 2 times the average of these two values is 13.5, so 13.5 is the common rank of the value 4.85.

In the above equation (2), m_j stands for the value, that is to added to $\sum Di^2$, the number of data values are repeated. Calculating the values of m_j :

From the data set X :

5.04 is repeated for 2 times, so $m_{5.04} = 2(2^2 -1)/12$

Thus $m_{5.04} = ½$ and 4.85 is also repeated for 2 times i.e., $m_{4.85} = 1/2$

Total affect of repeated ranks in X is ½ +1/2 = 1 (3)

Similarly calculating the total affect of repeated ranks in Y is ($m_{4.75}$ = ½) + ($m_{4.72}$ = 1/2)

=> Total affect of repetitions in Y is 1 (4)

From equations (3) and (4), the sum that is added to $\sum Di^2$ in equation (2) is 1 + 1 = 2 (5)

Now substituting the values of (5) and $\sum Di^2$ from Table II in (2), then

$$r = 1 - 6\{482.50 + 2\} / \{16 * 255\} =$$

$$1 – (2907 / 4080) = 1- 0.7125 = 0.2875$$

⇨ Rank Correlation Coefficient = 0.2875 (6)

From equation (6), it is clear that, a positive relation is existing between these two data set values. There is a possibility of modelling their relation. Once modelling is done, then it will be used to predict the future requirements of energy nodes. The advantage of using Rank correlation over Correlation coefficient is that i) it never gives importance to quantity of data rather it gives importance to ranks. ii) due to float values, calculations will be tedious and complex in correlation coefficient procedure and any change in the value will have high impact on the output. Iii) to avoid the disadvantages of Coefficient of Correlation procedure, Rank correlation method is introduced.

IV.RESULTS AND DISCUSSION

From the above exercise, it is clear that a relation or an association can be detected by using Correlation Coefficient methods. These methods can be applied anywhere irrespective of their domains. The results which are obtained from statistical methods have already proven their track that these results are on par with that of simulations results[8][9]. These methods have been widely used in industries including software industry too. Here, only a small sample of data is considered but this can be applicable to big data sets too. These methods always provide a reliable and efficient decisions to predict future data values as well[8][9].

V. CONCLUSION

The main focus of this paper is that powerful statistical methods can be used to forecast future energy needs and requirements intermediate nodes of a network, without much dependence on simulations or other software[8][9]. More sophisticated methods are also there to use polished data in the experiments, it will be presented in another paper.

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