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Linear Regression Modeling to Energy Estimation of Nodes in EC-AODV or AODV Protocols in MANETs

D. V. S. S. Subrahmanyam [1], Dr. T. Ch. Malleswara Rao [2]
1 Research scholar, Dept. of CSE, Rayalaseema University, A.P
2 NRSC, ISRO, Govt. Of INDIA (Retd.,)

Abstract: ***Required energy levels of participating mobile nodes in MANETs by using EC-AODV and AODV protocols are obtained by using simulations, for practical approaches. It is possible to obtain the same results approximately by using linear regression approach of Regression Analysis, which has now been widely using among industry and academia.***
Key words: MANETs, EC-AODV, AODV, linear regression, regression analysis

I. INTRODUCTION

Energy consumption plays a prominent role to improve the life span of any mobile ad hoc network as they are purely wireless networks[4][5]. Their battery resources are very limited so nodes have to be very conducive on their part in using the available battery energy more wisely, to achieve this nodes have to adopt new techniques to save the battery energy[1][5]. In order to fulfill the demands, a new protocol called Energy consumed Ad hoc On-Demand Vector routing protocol is introduced[4][5]. It is a more sophisticated extension to the existing Ad hoc On-Demand Vector routing protocol. EC-AODV protocol showed its efficiency in conserving energy at every participating node to transmit data packets to their next level nodes[2][3]. Many simulators like GlomoSim 2.0 or NS2 are used to obtain the energy levels utilized by intermediate nodes in transmitting their data packets. From simulation results the difference between energy consumptions of intermediate nodes by using EC-AODV and AODV protocols are obtained[4]. The aim of this paper is to prove that it is possible to predict the energy level needed by an intermediate node to forward the data packet to its next node either by using EC-AODV protocol or AODV protocol when one of the protocol results are obtained and it can be done without using any simulations.

II. LINEAR REGRESSION MODELLING

Regression Analysis a powerful and very useful mathematical tool to forecast the future values on the basis of the previous available results. It has many techniques to implement but here the main focus is only on Linear Regression technique[6][7]. This technique requires a dependent variable, an independent variable, and two regression constants to calculate future estimations[7]. Two data sets of energy consumed levels of various nodes in different protocols are taken into consideration. These two sets are obtained from two different protocols in the transmission of data to their next level of nodes. Regression Analysis helps to forecast future values on the basis of available existing data[6][7]. The calculated results that this model provides are approximately equal to the practical results which are obtained by simulations. Even though it is a statistical work, but is highly reliable technique for future prediction without considering any simulation processes and very helpful in comparing differences between predicted values and practically obtained values[6][7]. This is the reason why this technique has been taken into consideration for forecasting the energy levels required to transmit data packets to their next intermediate nodes in order to enhance the longevity of the network to avoid link failures at the maximum extent in the network. The regression of AODV curve can obtained on the regression line of EC-AODV protocol by using the relation of

$$Y = c + d X \qquad (1.1)$$

Where Y indicates regression of AODV and X indicates regression line of EC-AODV and c and d are known as regression constants and these constants can be calculated by

$$d = \frac{n \sum XY - \sum X \sum Y}{n \sum X^2 - (\sum X)^2} \quad \text{and} \quad c = \frac{\sum Y - q \sum X}{n} \qquad (1.2)$$

where n is the size of the sample set considered

III. SIMULATION RESULTS

A small MANET, for explanation purpose, with 20 intermediate nodes can be considered. A battery with energy of 90 joules is made available to that MANET. This implies that every node is supposed to get only 4.5 joules on an average. This network is examined in both EC-AODV and AODV protocol environments by using NS2 simulator. The following results are showing in the Table 1.1 the energy levels consumed by various participated intermediate nodes.

Table 1.1 simulation results of EC-AODV and AODV protocols

Node numbers	EC-AODV (in joules)	AODV (in joules)
0	3.92	4.48
1	3.88	4.52
2	4.08	4.57
3	4.27	4.61
4	4.15	4.72
5	4.28	4.58
6	3.91	4.69
7	4.34	4.68
8	4.16	4.82
9	4.38	4.65
10	3.84	4.71
11	4.25	4.67
12	4.36	4.70
13	4.18	4.69
14	3.95	4.73
15	4.27	4.55
16	4.15	4.76
17	3.94	4.77
18	4.11	4.69
19	4.24	4.72
Total energy in joules	82.66 j	93.31 j

Table 1.2: calculated values of $\sum X$, $\sum Y$, $\sum XY$ and $\sum X^2$

EC-AODV (X)	AODV (Y)	X * Y	$X*X=X^2$
3.92	4.48	17.5616	15.3664
3.88	4.52	17.5376	15.0544
4.08	4.57	18.6456	16.6464
4.27	4.61	19.6847	18.2329
4.15	4.72	19.5880	17.2225
4.28	4.58	19.6024	18.3184
3.91	4.69	18.3379	15.2881
4.34	4.68	20.3112	18.8356
4.16	4.82	20.0512	17.3056
4.38	4.65	20.3670	19.1844
3.84	4.71	18.0864	14.7456
4.25	4.67	19.8475	18.0625
4.36	4.70	20.4920	19.0096
4.18	4.69	19.6042	17.4724
3.95	4.73	18.6835	15.6025
4.27	4.55	19.4285	18.2329
4.15	4.76	19.7540	17.2225
3.94	4.77	18.7938	15.5236
4.11	4.69	19.2759	16.8921
4.24	4.72	20.0128	17.9776
$\sum X = 82.66$	$\sum Y = 93.31$	$\sum XY =$ 385.6658	$\sum X^2 =$ 344.960

Substituting the values of $\sum X$, $\sum Y$, $\sum XY$ and $\sum X^2$ in equation (1.2)
and here the size of the sample set is n = 20
The values of regression constants are obtained as
d = ((20 * 385.6658)–82.66 * 93.31)) / ((20 * 344.96) – (82.66)(82.66)
= (7713.316 – 7713.0046) / (6899.2 – 6832.6756)
⇨ d = 0.3114 / 66.5244 = 0.004681
c = (93.31 – 0.004681 * 82.66) / 20 = (93.31 – 0.386931) / 20
⇨ c = 4.6461545
Now putting the values of c and d in the equation (1.2). The Regression line of AODV protocol on the regression line of EC-AODV protocol is given by

$$Y = 4.6461545 + 0.004681 * X \quad (1.3)$$

which forecasts the required energy levels of AODV protocol. The regression of EC-AODV protocol can be obtained on the regression line of AODV protocol. As the size of the data set increases the quantity and impact of small numeric errors will come to normalcy.

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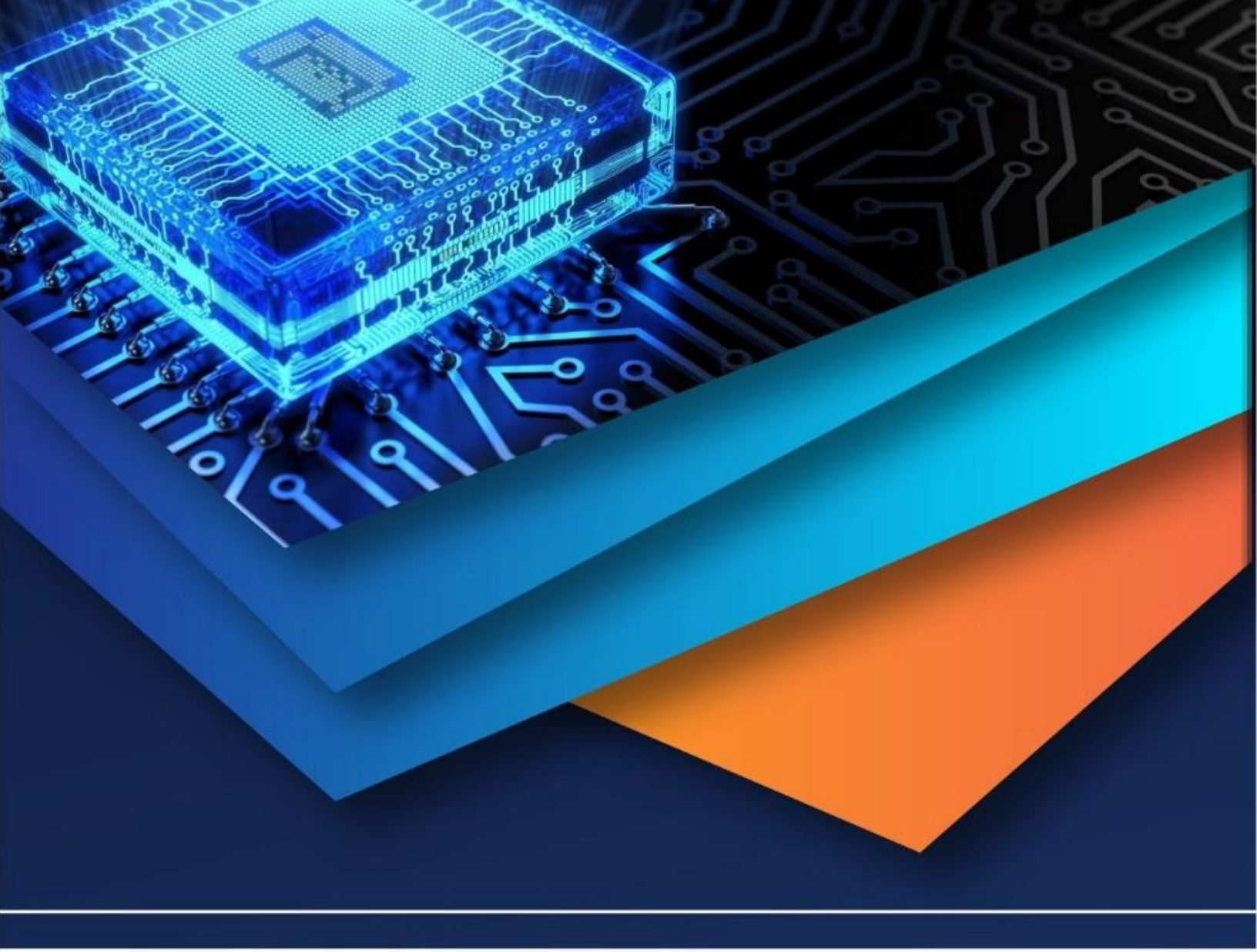

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