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Analysing Collective Effect of Metrics on MANET Routing Protocols

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Abstract— Analysis of Protocol is of prime importance in order to optimize its performance. Performance metrics are useful parameters for analyzing the performance of any routing protocol in Mobile Ad hoc Networks (MANETs). It is generally observed during the simulation of protocols in MANETs that one protocol may performs better with respect to one performance metric as compared to another protocol but its performance may weaken with respect to another performance metric when compared with same protocol. Hence there is a need to evaluate a protocol using a cumulative performance value. This cumulative value for a protocol can be calculated by providing due weightage to different factors based on its performance in various metrics. In this paper a cumulative metric has been proposed. Based on the value of this metric, the overall performance of a protocol can be analyzed and can also be compared to the other protocols.

Keywords— Protocol, MANET, Metric, Uni-path, Multipath, Simulation.

I. INTRODUCTION

In MANETs [1] routing of packets from a source to destination node may require various mobile nodes for onward transmission. Based on the kind of requirements, various protocols exist in MANETs. There are on demand protocols [2] like Ad-Hoc On demand Distance Vector Routing protocol (AODV) [3] and proactive routing protocols like Destination Sequenced Distance Vector (DSDV) [4]. There also exist protocols which support multipath routing, for example Ad-Hoc On demand Multi-path Distance Vector Routing protocol (AOMDV) [5] [6]. All of these protocols have some special significance. In order to analyze the performance of any protocol, various metrics are also available. The examples of such metrics include Energy Consumed, End to End Delay, Packet Delivery Ratio, Throughput etc. A protocol according to the requirements may perform well in one metric but may not perform as well with another metric. In order to judge the overall performance of a protocol a cumulative metric is needed, which may analyze a protocol considering its different aspects. Sometimes certain tradeoffs are also involved amongst the metrics, and to deal with these tradeoff we need a metric which may provide due weightage to the protocol which is best suited to the requirements. This paper presents a cumulative metric that can be used for analyzing and comparing different protocols. The paper is divided into five sections. Section II presents the analysis of few works related to the performance comparison of different protocols. Section III provides various existing metrics along with the comparison of protocols namely DSDV, AODV and AOMDV. NS2 simulator has been used for the purpose. This section also illustrates the limitation of existing system of metrics. Section IV provides the designed cumulative metric along with its significance. Last section concludes the findings of work presented in the paper.

II. RELATED WORK

Based on the kind of routing strategy, MANETs protocols can be broadly divided into two categories i.e. proactive and reactive routing Protocols. Further we may also use uni-path or multipath routing. The DSDV and AODV are example of Proactive and Reactive routing protocols respectively. Both DSDV and AODV are Uni-Path Routing Protocol. The AOMDV represents the Multipath Routing protocol [6] i.e. it allows the selection of disjoint paths.

A lot of works have been done in the past, where performances of different routing protocols have been compared. As an example, C. Perkin at al. [7] compared the two on demand protocols namely Dynamic source routing (DSR) [8] and AODV. The results for delay and throughput show that DSR performs better than AODV in low load conditions. But, in high load conditions AODV outperforms DSR. However the DSR generates less routing load as compared to AODV.

In another work [9], AODV has been compared with DSDV. The observations show that packet delivery ratio and throughput in case of AODV are higher as compared to DSDV. However End to end delay of DSDV is less than AODV.

The DSDV, DSR and AODV protocols are uni-path routing protocols. An alternate available to the uni-path routing is multipath routing. AOMDV is an example of Multipath routing protocol. AOMDV can generate disjoint routes between source and destination. H.D. Trung et al. in their paper [6] compared four routing protocols namely AODV, AOMDV, LAR (location aided routing) and LAMR (location aided multipath routing). The observations of experiment prove the effectiveness of AOMDV in terms of average end-to-end delay. It can be observed that the performance values of AOMDV in term of packet delivery and average end to end delay consistently support multipath Routing over the uni-path routing. However, the primary limitations of using multipath over uni-path routing protocols are complexity and overhead associated with them.

The above works prove, if we want to compare a uni-path protocol to a uni-path protocol or a Multipath protocol to another multipath protocol or multipath protocol to a uni-path protocol than the results of a protocol may not be better than other protocol in all the performance metrics. But it also does not mean that while trying to have better results in one performance metric we can completely avoid another performance metric. So a cumulative metric is required which may measure the overall performance of protocol based on various performance metrics. One such metric NET has been proposed in this paper. In order to apply the NET metric in different categories of Protocols, we have selected three protocols namely DSDV, AODV and AOMDV. As the devised metric should be equally good in comparing the different categories of protocols so one protocol each have been selected from Proactive, Reactive and Multipath routing protocols.

III. ANALYSIS OF PERFORMANCE METRICS USED IN MOBILE ADHOC NETWORKS

A. Performance metrics

The performances of routing protocols in MANETs can be evaluated on the basis of the following metrics [2] [9]:

a. Packet Delivery Ratio: (PDR) is the ratio of the number of packets received by the destination to the number of packets originated from the source.

b. Throughput: is the amount of data moved successfully from source to a destination in a given time.

c. End to End delay: computes the amount of time taken by packets constituting the message to successfully move through a network from source node to destination node.

d. Energy Consumption: is the energy consumed by various processes taking place in the node.

B. MANET protocols for NS2 simulation

The Network simulator (NS2) is an important tool to analyze various MANET protocols. Here three protocols have been compared namely AODV, DSDV and AOMDV. A brief about these protocols is as follows:

a. AODV

AODV [3] [7] [9] is an on demand protocol. It uses hop by hop routing by using the routing tables at intermediate nodes. The routing process involves two phases namely route discovery and route maintenance. The route request and reply packets are responsible for carrying out route discovery process. The route maintenance phase uses route error packets to deal with broken links.

b. DSDV

DSDV [4] is a proactive routing protocol. Each node is responsible for maintaining a routing table. The entries of routing table include next hop required to reach a destination, number of hops to destination and the sequence number. Each node periodically sends updates to the neighbor nodes. There are two ways of sending updates: a “full dump” and “incremental” update.

c. AOMDV

AOMDV [6] [10] is a multipath variant of AODV protocol. Advertised hop count is used to achieve multiples loop free paths. Each duplicate route advertisement received by a node leads to multiple paths to the destination.

C. Limitation Observed

The DSDV and AODV are the best examples of proactive and reactive routing protocols respectively. Further the results of these two protocols have also been compared with a multipath routing protocol AOMDV. On the basis of above metrics, the three protocols have been tested for different number of nodes.

Table 1. SIMULATION PARAMETERS

Routing Protocol	AODV, AOMDV, DSDV
Network topology	1000 * 1000
MAC Type	802.11
Traffic Type	TCP
Max. Packet in IFQ	50
Radio propagation model	Two ray ground
Number of Nodes	20,40,60,80,100
Packet size	1500 byte
Max. Simulation time	50 s
Initial Energy	100 joule

The table 1 shows the simulation parameters for the simulation of DSDV, AODV and AOMDV. The results so obtained corresponding to various metrics have been shown in the table 2. The important thing to observe among these results is that if some protocol is performing better corresponding to certain metric than it can be the case that its performance is not so good corresponding to another metric. For e.g. AOMDV has throughput 72.17 as compared to 47.69 and 51.62 of DSDV and AODV respectively for 20 nodes. But in case of End to End delay, AOMDV performance is lower than DSDV and AODV for same number of nodes with AOMDV, DSDV, AODV having delays of 175.12, 166.09 and170.58 respectively. In terms of PDR, the DSDV is consistently giving better results as compared to PDR of AODV and AOMDV for e.g. the PDR of DSDV is 94.98 percent as compared to 90.58 and 90.38 percent of AODV and AOMDV for 20 nodes. The simulation results also show that for any number of nodes the energy consumption is more in AOMDV as compared to AODV or DSDV i.e. for 100 nodes it is 49.99 in AOMDV as compared to 49.08 of AODV and 49.98 of DSDV but its throughput is also very high as compared to the other two protocols for same number of nodes i.e it is 419.96 for AOMDV as compared to 372.7 and 142.84 of AODV and DSDV. This is an important observation as for number of node equal to 100 we may observe that AOMDV is taking approximately .91 units more energy than the AODV but its throughput is far better than the AODV. So there is a need to analyze, how much value any factor is contributing toward the positive or negative aspects of the performance in a protocol. So there is a need for a cumulative metric which may consider all factors. Based on the value of this metric the performance of a protocol can be judged.

Table 1. Comparison table of Various Protocols based on NS2 Simulation

Nodes	ENERGY	END TO END DELAY (ms)	PDR	Throughput
AODV				
20	48.25	170.58	90.58	51.62
40	49.22	175.64	95.97	73.73
60	49.28	249.44	90.64	97.97
80	49.27	290.97	84.66	206.3
100	49.08	313.02	81.54	372.7
AOMDV				
20	49.98	175.12	90.38	72.17
40	49.94	277.63	81.33	110.11
60	49.99	255.94	92.08	161.84
80	49.98	343.64	87.06	276.63
100	49.99	309.62	87.64	419.96
DSDV				
20	49.88	166.09	94.98	47.69
40	49.61	255.25	94.95	58.71
60	49.8	244.7	95.56	78.27
80	49.92	305.14	92.55	104.54
100	49.98	284.71	96.42	142.84

Table 2. Comparison table of AODV, AOMDV and DSDV

Nodes	ENERGY	END TO END DELAY (ms)	PDR	Throughput	ENERGY FACTOR	DELAY FACTOR	PDR FACTOR	THROUGHPUT FACTOR	NET
AODV									
20	48.25	170.58	90.58	51.62	0.04	0.00	-0.05	-0.35	-0.36
40	49.22	175.64	95.97	73.73	0.01	0.70	0.18	-0.36	0.54
60	49.28	249.44	90.64	97.97	0.01	0.01	-0.05	-0.56	-0.60
80	49.27	290.97	84.66	206.3	0.01	0.22	-0.09	0.30	0.44
100	49.08	313.02	81.54	372.7	0.02	-0.10	-0.18	1.28	1.01
AOMDV									
20	49.98	175.12	90.38	72.17	-0.04	-0.05	-0.05	0.51	0.37
40	49.94	277.63	81.33	110.11	-0.01	-0.11	-0.18	0.88	0.57
60	49.99	255.94	92.08	161.84	-0.01	-0.05	-0.02	1.07	0.98
80	49.98	343.64	87.06	276.63	-0.01	-0.13	-0.04	1.65	1.47
100	49.99	309.62	87.64	419.96	-0.02	-0.08	-0.03	1.94	1.81
DSDV									
20	49.88	166.09	94.98	47.69	-0.03	0.05	0.05	-0.51	-0.44
40	49.61	255.25	94.95	58.71	0.00	0.07	0.15	-0.88	-0.66
60	49.8	244.7	95.56	78.27	-0.01	0.05	0.05	-1.07	-0.97
80	49.92	305.14	92.55	104.54	-0.01	0.13	0.09	-1.65	-1.44
100	49.98	284.71	96.42	142.84	-0.02	0.10	0.18	-1.94	-1.68

IV. CUMULATIVE METRIC FOR PERFORMANCE ANALYSIS

In order to design a cumulative metric there is a need to study various aspects such as:

1. The factors contributing in a positive way toward the performance.
2. The factors contributing in a negative way toward the performance.
3. Proportionate increase or decrease in the metric.

Taking care of above factors a cumulative metric, NET has been designed as follows.

$$NETi = Ei + Pi + Ti + Di \quad (1)$$

$$Ei = -[((Ec-Emin) - (Emax - Ec))/Emin] \quad (2)$$

$$Pi = [((Pc-Pmin) - (Pmax - Pc))/Pmin] \quad (3)$$

$$T\,i = [((Tc-Tmin) - (Tmax - Tc))/Tmin] \quad (4)$$

$$Di = -[((Dc-Dmin) - (Dmax - Dc))/Dmin] \quad (5)$$

(Ei= Energy factor, Pi = PDR factor, Ti = Throughput factor, Di = Delay factor) for I number of nodes for a particular protocol.

(Ec= Energy, Pc =PDR, Tc= Throughput, Dc = Delay) for I number of nodes for a particular protocol.

(Emin= Minimum Energy, Pmin= Minimum PDR, Tmin= Minimum Throughput, Dmin= Minimum Delay) for I number of nodes among all protocols.

(Emax= Maximum Energy, Pmax= Maximum PDR, Tmax= Maximum Throughput, Dmax= Maximum Delay for I number of nodes among all protocols.

This NET metric can be used to evaluate the performance of a particular protocol. The results obtained from the simulation of the above mentioned protocols have been evaluated on the basis of NET metric in the table 3. The NET metric shows that AOMDV out performs both the protocols i.e. For 20 nodes the value of NET metric of AOMDV is 0.37 as compared to -0.36 and -0.44 of AODV and DSDV respectively. With increase in the number of nodes also AOMDV is outperforming the other two protocols i.e. for

100 nodes the value of NET metric of AOMDV is 1.81 as compared to 1.01 and -1.68 of AODV and DSDV respectively. Now it can be easily established that although AOMDV is taking slightly more energy as compared to other protocols but the throughput it is providing is much higher than the other two protocols i.e. the increase in Throughput factor with value 1.94 is too high as compared to deficit in Energy factor with value -0.02. The important thing to analyze here is that the energy factor of the AOMDV is showing some negative results and thus rightly proves the scope of improvement.

The analysis of the above table shows the importance of multipath routing protocol. Although the NET metric shows that the AOMDV out performs the other protocols but the negative values of Energy factor also shows and prove the scope of work in this area. Therefore Energy is the factor which can be exploited to get better results.

V. CONCLUSION

The Performance metrics are valuable parameters for measuring the performance of any protocol. But there also exist various kinds of tradeoffs among these metrics in the simulation environment. The current work presented the simulation of three protocols namely AODV, DSDV and AOMDV. The simulation rightly proved that a single protocol cannot provide better results in every metric. Moreover, the decision of choosing the protocol cannot be done on the basis of one metric leaving behind the other metric. So there has to be a way to deal effectively with all these tradeoffs. This paper presented a cumulative metric NET to deal with all these tradeoffs. The complete value for NET metric is evaluated on the basis of four factors namely Energy factor, PDR factor, Throughput factor and Delay factor. These factors help in deciding the overall value of NET metric and thus lead to a complete and effective analysis of any protocol. Further this metric also helps in deciding the factor which can be exploited to increase the performance of a protocol.

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