A Novel Architecture of Enhanced AODV Routing Protocol for Effective Data Transmission in Mobile Ad hoc Networks

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Abstract*— A mobile ad hoc network is a collection of wireless mobile nodes that dynamically form a network connection temporarily without any support of static infrastructure. Affected by mobility of nodes, routing protocols are taking a vital role in wireless transmission. There are mainly three types of routing protocols in ad hoc networks which are proactive, reactive and hybrid. The protocol presents the mechanism which reduces route loops and confirms trustworthy message exchange. The Ad hoc On Demand Distance Vector (AODV) routing algorithm is a reactive routing protocol designed for ad hoc mobile nodes. Since the network is compatible with the conventional, modify the routing protocol with allowed parameters. Hop count, total interference, node link delay, residual energy of a node and the node transmission power are the cost parameters assigned for link and path of the ad hoc networks. These parameters are combined in different optimization function with respect to AODV for selecting the optimal path. This paper addresses the regular AODV and Multicost Parameters Based AODV (MPB-AODV) Routing Protocol to acquire dynamic network performance metrics like Packet Delivery Ratio and Throughput of mobile ad hoc networks.

***Keywords*—Ad hoc Networks, Routing Protocols; Multicost Parameters; Packet delivery ratio, Throughput**

I. INTRODUCTION

Mobile ad hoc networks are paradigms for mobile communication in which mobile nodes are with dynamism and randomly located in such a manner that communication between nodes does not depend on any underlying static network infrastructure. The communication medium is broadcast and the nodes in a mobile ad hoc network are typically portable mobile devices with inhibited resources, Such as power, computation aptitude and storage capacity. Since no fixed infrastructure or centralized administration is Available, these networks are self-organized and end-to-end communication may require routing information [3] via several intermediate nodes.

The routing protocols are vital role and it has to adapt quickly to the repeated changes in the ad-hoc network topology. Ad-hoc routing protocols are categorized into following three types. Proactive or Table driven routing protocols: This kind of routing protocols are retains the network topology information in routing tables contains a updated list of destinations and their routes by time to time swapping their routing information with nearby nodes. Routing information is usually flooded in the entire network. At any time a node wants a route to the destination it runs a suitable path finding algorithm on the topology information it retains. E.g. DSDV, CGSR, WRP.

Reactive or on demand routing protocols: These kinds of protocols are not maintaining topology information of the network, with the help of connection establishment process nodes can obtain necessary route when it is required. And therefore this type of protocols is not exchanging the routing information time to time. E.g. DSR, AODV, TORA.

Hybrid routing protocols: In this protocols both proactive and reactive routing advantages are combined. The routing is in the beginning established with certain proactively prospected routes then it serves the demand from additionally activated nodes through reactive flooding. E.g. HRPLS, ZRP, HWMP. From the above DSDV, AODV, DSR and ZRP which have been proposed for providing communication among all the nodes in the network. Due to the lack of infrastructure and the limited transmission range of a node in a mobile ad hoc network [11] a node has to rely on neighbor nodes to route a packet to the destination node. In specific, all network functions are based on the node cooperation.

Currently, routing protocols for mobile ad hoc network, such as the Dynamic Source Routing (DSR) and the Ad hoc On Demand Distance Vector Routing Protocol (AODV) [1], [15] are based on the assumption that all nodes will cooperate. And without node cooperation, in a wireless ad hoc network, no route can be established; no packet can be forwarded, let alone any network applications. However, cooperative behavior, such as forwarding other node's messages, cannot be taken for decided.

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This paper focuses and analyzes through network simulation (NS2) which compares the quality of service metrics like Throughput, Delay and Packet Delivery ratio of both regular AODV and Multicost Parameters Based AODV (MPB-AODV).Hop count (h), total interference

(I), node link delay (d), residual energy of a node (R) and the node transmission power (T) are the cost parameters [5],[6],[7],[16] assigned for link and path of the ad hoc networks.
These parameters are combined in different optimization function [12]with respect to various routing algorithm for selecting the optimal path. The similar research have already done in modified AODV [8] and implemented earlier. The simulation result shows that the Multicost Parameters Based AODV performs well in significant metrics of wireless network performance.

2. Related Work:
One of the common implementation of source routing is Ad hoc On Demand Distance Vector. AODV is completely on demand and need not require constant information updates so as to construct and keep up the routes. There are two major services like route discovery and route maintenance is only appealed when a mobile node requests them. The AODV protocol have a both the features of reactive routing like DSR and proactive routing like DSDV techniques are used. It is similar to DSDV with usage of hop by hop routing, sequence numbers for route refresh ness and periodic beacons also similar to DSR in route discovery and maintenance. AODV can compact with any type of mobility rates and in different form of data traffic.
A numerous of research and many authors wanted to analyze the performance and behavior with regard to performance metrics of AODV and stated that to modify the AODV protocol [8] from that to improve the performance metrics like Throughput, Delay, Route latency and Packet Delivery ratio. And found that AODV protocol reveals much better QoS than DSDV and DSR.

AD HOC ON DEMAND DISTANCE VECTOR:
AODV implements an exclusive technique to keep routing information in wireless ad hoc networks. AODV is on-demand routing protocol and basic essential for connectivity is to discover the routes to a mobile node through flooding of request messages.

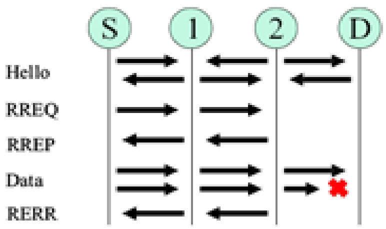

Figure 1: AODV Routing Message

Usually reactive protocols are never maintaining the routing information at the mobile nodes if no connectivity in the network. AODV uses old-style routing tables like one entry per destination node. Whereas DSR is maintains several routes cache entries for every destination node. AODV finds route when node needs to communicate from source to destination and moreover assurance the loop-free routing. Every node is transmitting with other node through various wireless links and the nodes function as a router to route the data packets from one node to another node. The AODV protocol mechanism as to send a message (Fig.1.), the data source starts a path-discovery process so as to discover the route. AODV routines sequence numbers retained at each destination to discover freshness of routing data and to avoid routing loops. The route request packet (RREQ) is flooded to the network and the transitional nodes record the neighbor from which they get the route request packet (RREQ) first, so as to establish inverse paths back to the source. When the RREQ reaches at the destination, it then directs back to a route reply (RREP) to the source node in reverse paths. AODV wants symmetric links; else the RREP may possibly not to reach the source and AODV might fail. And also, all the routing packets are bringing these sequence numbers. A main feature of AODV is maintaining each node with timer-based states for deployment of individual routing table entries. If fail to use recent entry, the recent entry get expired in the routing table. A pair of predecessor nodes is maintained individually for the routing table entry, stating that the pair of neighboring nodes to transmit the data packets.
In distinction with DSR, The Route Error Message (RERR) data packets in AODV [9] are projected to inform all sources using a link when a failure happens. Single-source shortest path Dijkstra's algorithm, computes of the shortest path from the source to every left behind vertices in the graph and find shortest path through Dijkstra's algorithm in AODV routing protocol.

MULTICOST PARAMETERS BASED AODV ROUTING PROTOCOL
A.AODV with Multicost Parameters:
This section presents the improvement of the AODV protocol in order to strengthen the Packet Delivery Ratio, Average End-To-End Delay and Throughput in wireless ad hoc networks. Since the network is compatible with the conventional, modify the routing protocol with allowed parameters. The AODV routing protocol with other parameters are used to establish a route between the mobile nodes in the network as usual with performance metrics.
The experiment simulation shows that the network performance with respect to packet delivery ratio and throughput of the wireless ad hoc networks. The Multicost Parameters Based AODV (MPB-AODV) routing protocol with multicost parameters [10],[13],[14] used to when the origin node wishes to route a packet or a session to a given destination, a scalar cost optimization function 'f' is functional to the cost vectors of the non-dominated paths [2] leading to that destination, and the path that gives the minimum cost is chosen. The optimization function f used depends on the QoS requirements of the session and may be different for different sessions. Since the optimization function does not need to be applied to each potential path for a given source-destination pair, but only to the set of non-dominated paths; this was proven in [7].
Let, V (P) = (V_1l,V_2l,…,Vkl) the link cost vector of Link
The cost vector V (P) = (V1,V2,………VK) of a path P containing of links l = 1, 2… L is obtained from the cost vectors of the links that comprise a monotonic

associative operator to each cost vector parameter (Eq.1)

$$V_m = \odot_{l=1}^{L} V_{ml} \qquad (1)$$

where $V_m = m^{th}$ Parameter of the cost vector.

SUM/MIN Energy-Half-Interference-Half Hop Multicost algorithm

The optimization function is used as maximum representative of cost metrics in Various Energy-Half-Interference-Half Hop multicost algorithm:
SUM/MIN Energy-Interference algorithm: The standard optimized through (Eq.2):

$$\min_P \frac{T_1(P) \, . \, I_1(P)}{R(P).d(P)}, \qquad (2)$$

It is likely to select paths that root slight total interference, use slight total transmission power, and permit through by nodes that have enormous residual energies.

SUM/MIN Energy-Half-Interference algorithm: This cost function optimized is resembling with one used in the SUM/MIN Energy-Interference algorithm, but has a minor dependency with the interference metric (Eq.3):

$$\min_P \frac{T_\infty(P) \, . \, \sqrt{I_\infty(P)}}{R(P).d(P)} \qquad (3)$$

SUM/MIN Energy-Interference-Half Hop algorithm: The optimization cost function is equivalent to the SUM/MIN Energy-Interference function, multiplied by so as to depress, to a assured extent, the usage of long paths(Eq.4):

$$\min_P \frac{\sqrt{h(P)}. \, T_1(P) \, . \, I_1(P)}{R(P).d(P)} \qquad (4)$$

SUM/MIN Energy-Half-Interference-Half Hop algorithm: The optimization function used is equivalent to that in the SUM/MIN Energy-Half-Interference algorithm (Eq.5), multiplied by $\sqrt{h(P)}$:

$$\min_P \frac{\sqrt{h(P)}.T_\infty(P) \, . \, \sqrt{I_\infty(P)}}{R(P).d(P)}. \qquad (5)$$

If the cost vector comprises two or more additive metrics (other than the hop count) then the algorithm is exponential. The complication considerations make some (polynomial) algorithms interesting even though they underperform some other (exponential) algorithms. As a result the SUM/MIN (Energy-Interference and Mixed) algorithm (Eq.5) is exponential and perform better than MAX/MIN Energy-Interference and Mixed) algorithm. MAX Interference algorithm: The cost function optimized is the maximum of the interferences of the links on the path (Eq.6):

$$\min_P I_1(P). \qquad (6)$$

MAX/MIN Energy-Half-Interference algorithm: The optimization function is close to that in the SUM/MIN Energy-Half-Interference algorithm, excluding that the transmission power and the interference are used as maximum representative instead of additive cost metrics (Eq.7):

$$\min_P \frac{T_\infty(P) \, . \, \sqrt{I_\infty(P)}}{R(P).d(P)} \qquad (7)$$

MAX/MIN Energy-Half-Interference-Half Hop algorithm: The optimization function is also close to that in the SUM/MIN Energy-Half-Interference-Half Hop algorithm, excluding that the transmission power and the interference are used as maximum representative instead of additive cost metrics (Eq.8):

$$\min_P \frac{\sqrt{h(P)}.T_\infty(P) \, . \, \sqrt{I_\infty(P)}}{R(P).d(P)} \qquad (8)$$

Where, $h(P)$ = hop count of the path. $T_\infty(P)$ = maximum transmission power of the nodes on the path. I_∞ = maximum interference of the path. $R(P)$ = residual energy of the path. $d(P)$ = delay link of the path.
Generally, the number of different non-dominated paths depends on the number of parameters in the cost vector, and on the type of operators used for calculating a path's cost vector from the establishes links' cost vectors. The cost parameters, h, d, are additive metrics, while R, T_∞ and $I_\infty$are concave (restrictive or maximum representative). Based on [13], if the cost vector comprises at most one additive metric (other than the hop count), then the algorithm is polynomial, individually of the number of the restrictive (that use the minimization operator) and maximum representative (that use the maximization operator) metrics.

B. Simulation Model

Actually, most of the presently available devices afford a limited set of possible power levels of transmission power control. Assume that the transmission power can take sequence values are mainly made for the simulations, and is not essential by the algorithms themselves. To calculate the minimum transmission power for communicate among two nodes with some distance d can use the following equation mentioned below in Eq. 9.

$$P_r(d) = \frac{P_t \, . \, G_t \, . \, G_r \, . \, \lambda^2}{(4\pi)^2 \, . \, d^a \, . \, L} \qquad (9)$$

where, P_r is the received power signal, P_t is the transmitted power signal G_t is the gain the senders antenna, G_r is the gains of receivers antenna, $L \geq 1$ the system loss and λ the wavelength used. In the calculations , assume L = 1 and G_t = 1, G_r = 1.The parameter 'a' is the path loss constant and is usually in between 2 and 4 subject to the wireless channel as well as assume a = 2, corresponding to the Free Space transmission model.

2. PERFORMANCE COMPARISON

A. Simulation

Simulations play a dynamic role in the development and testing of ad hoc networking protocols. However, the simulation of large networks is still a tedious task that consumes a lot of computing power, memory, and time.

Table. 1. Simulation Parameters for node mobility

PARAMETER	VALUE
Routing Protocol	AODV, Modified AODV
MAC Layer	802.11
Terrain Size	600m x 600m
No.of Nodes	50
Pause Time	10 seconds
Mobility Model	Random Mobility Model
Packet Size	1500B
Bandwidth	11MB
Frequency	2.472GHz
Speed	1-20 m/s
Simulation Time	100 s
Application Layer	FTP

The changes were made to the implementation of AODV written for NS2. A 50 nodes network in a field size of 600m x 600m was used. The mobility model used was random waypoint in a square/rectangular field. In random waypoint, each node starts its journey from its current location to a random location within the field. The speed is randomly chosen to be between 1-20 M/sec. The pause time is set to 10 seconds and to set the simulation time is 600 seconds.

Once the destination is reached, another random destination is embattled after a specified pause. Used here 10-second pause time, which results in unbroken node mobility in our simulations. The simulation parameters used for the experimental set are shown in Table 1. However, in practice, found that the running times of the non-polynomial algorithms were also acceptable, at least for the network sizes used in the simulations. In all cases, the algorithms first find cost parameters (h, T, I, d, R), and then use the corresponding optimization function f (h, T, I, d, R) to select the optimal path with respect to AODV. In other words the computation of algorithm and the AODV routing path is done at the end in a way proposed. The function to be optimized at the last step may depend on the QoS requirements of the user.

B.Proposed Improvements

The following performance metrics are conferred with AODV and Multicost Parameters Based AODV(MPB-AODV).Packet Delivery Ratio/ Packet Delivery: Throughput and Packet delivery ratio is calculated by dividing the number of packets received by the destination through the number of packets originated. It specifies the packet loss rate, which limits the maximum throughput of the network. The better the delivery ratio, the more complete and correct is the routing protocol.

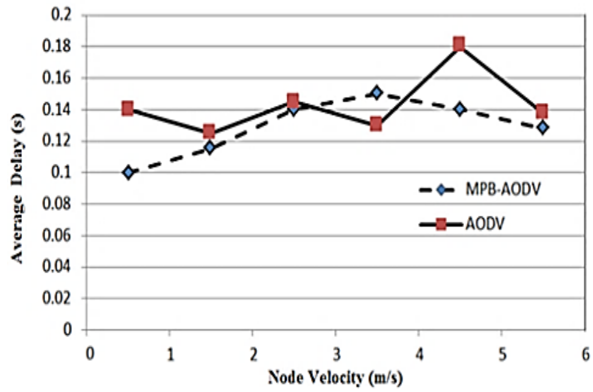

Fig. 2 Average delay when node velocity increases

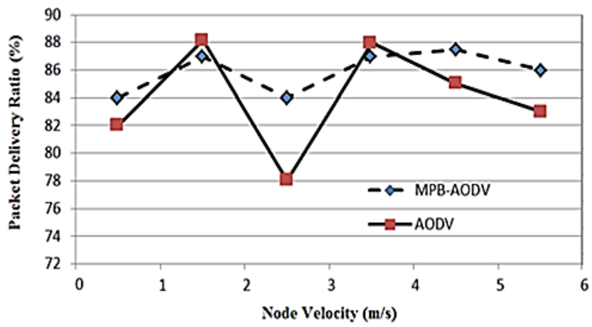

Fig. 3 Packet delivery ratio when node velocity various

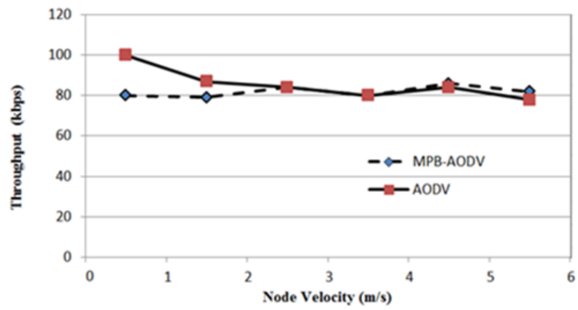

Fig. 4 Throughput when node velocity various

Average End-To-End Delay: Average End-to-End delay (seconds) is the average time it takes a data packet to reach the destination. This metric is calculated by subtracting "time at which first packet was transmitted by source" from "time at which first data packet arrived to destination". This includes all possible delays affected by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC [4], propagation and transfer times.

Throughput:

The throughput is defined as the total amount of data a receiver receives from the sender divided by the time it takes for the receiver to get the last packet. The throughput is measured in bits per second (bit/s or bps). Throughput is the ratio of the total amount of data that reaches a receiver from a sender to the time it takes or the receiver to get the last packet. Packet Delivery Ratio/ Packet Delivery and Throughput are major importance of the performance of the network. The projected improvements in this paper to construct the enhancements in routing protocol of AODV with multicost parameters. The Multicost Parameters Based AODV (MPB-AODV), Where the cost parameters of multicost algorithm h, d, R, T_∞ and I_∞ are carefully examined with AODV protocol and are combined in various optimization functions only at the end to improve the Packet Delivery Ratio and Throughput in wireless ad hoc networks. In AODV, when a host wants a route to another host, the route request packet (RREQ) is flooded to the network and the transitional nodes record the neighbor from which they get the route request packet (RREQ) first, so as to establish inverse paths back to the source. Simulation graph plotted on the different scales to best show the effects of varying packet delivery ratio, average delay and throughput in AODV and Multicost Parameters Based AODV. Based on the simulation results, Multicost Parameters Based AODV has uniformly good of average end to end delay(Fig.2). a worthy packet delivery ratio (Fig.3) and the dynamic throughput (Fig.4,) Hence, Multicost Parameters Based AODV shows better performance with respect to throughput among basic AODV protocol in mobile ad hoc network in limited load density.

3. CONCLUSION

In this paper, the performance of the wireless routing protocols such as AODV and Multicost Parameters Based AODV (MPB-AODV) was analyzed using NS-2 Simulator. Deliberated complete simulation results of throughput, average delay and packet delivery ratio over the routing protocols AODV and Modified AODV by varying node velocity and simulation time. Data packet exchange will increase each time network topology changes since AODV protocol maintaining each node with timer-based states regarding deployment of individual routing table entries. Though Comparing Modified AODV protocol (MPB-AODV) with basic AODV, it performs better in case of packet delivery ratio but it performs slowly down in terms of throughput when increases node velocity in the network. Overall, Multicost Parameters Based AODV protocol outperforms is better because it has high packet delivery ratio and throughput when nodes have high mobility and considering with the Energy-Interference multicost algorithm.

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