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# Performance Evaluation of Extended Aodv Using Different Scenarios

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**Abstract** — *The mobile Ad Hoc networks have become a major component of the future network development due to their ease of deployment, self configurability; flexibility and independence on any existing network infrastructure Mobile ad-hoc network have the attributes such as wireless connection, continuously changing topology, distributed operation and ease of deployment. Routing protocol election in MANET (Mobile Ad Hoc Network) is a great challenge, because of its frequent topology changes and routing overhead. In mobile ad hoc network research, simulation plays an important role in determining the network characteristics and measuring performance. For this reason, constructing simulation models closer to the real circumstances is very significant. For widening the coverage area of the MANET there is a growing need to integrate these ad hoc networks to the Internet. For this purpose we need gateways which act as bridges between these two different protocol architectures. The gateway discovery in hybrid network is considered as a critical and challenging task. In this paper the AODV reactive routing protocol is extended to support the communication between the MANET and the Internet. We have carried out a systematic simulation based performance evaluation of the different gateway discovery approaches using NS2 under different network scenarios. The performance differentials are analyzed on the basis of three metrics – packet delivery fraction, average end-to-end delay and normalized routing load.*

**Keywords-** *Mobile ad hoc network, MIPMANET, Internet, gateway discovery approaches, mobility models, performance study, CBR, packet delivery fraction, average end-to-end delay, normalized routing load*

## I. INTRODUCTION

MANET is a collection of wireless mobile nodes that communicate with each other using multi-hop wireless links without any existing network infrastructure or centralized administration [1]. Each node in the network behaves as a router and forwards packets for other nodes. In some cases, it turns out to be impossible or too costly to deploy permanent infrastructures (i.e. wireless routers, satellite links, GSM [2] networks) for a wireless network. For several military and civil applications, networking the mobile or

Static nodes with wireless links in an ad hoc manner can be necessary and/or effective [3].

Within the IETF, several solutions have been proposed to deal with the interconnection of MANETs to the Internet. One of the first proposals by Broch et al. [4] is based on an integration of Mobile IP and MANETs employing a source routing protocol. MIPMANET [5] followed a similar approach based on AODV, but it only works with Mobile IPv4 because it requires foreign agents (FA).

To achieve this network interconnection, gateways that understand not only the IP suite, but also the MANET protocol stack, are needed. Thus, a gateway acts as a bridge between a MANET and the Internet and all communication between the two networks must pass through any of the gateways.

This paper evaluates three approaches for gateway discovery. An interesting question is whether the configuration phase with the gateway should be initiated by the gateway (proactive method), by the mobile node (reactive method) or by mixing these two approaches. When using proactive routing protocols, also called “table driven” protocols, mobile nodes continuously evaluate routes to all reachable nodes and attempt to maintain consistent and up-to-date routing information, regardless of whether data traffic exists or not. The advantages of this type of protocols are discovery of the shortest path through network and availability of routes at the time of need, which reduces delays. The lack of proactive routing protocols is providing a resistance to network topology changes. On the other hand, when mobile nodes use reactive routing protocols, also called “on-demand” protocols, route discovery operation is performed only when a routing path is needed, and it is terminated when a route or no route has been found. A very important operation in reactive routing is route maintenance. The advantages of this type of protocols are efficiency, reliability and less control overhead. However, a major lack is a long delay caused by a route discovery operation in order to transmit data packets. These protocols perform variously depending on type of traffic, number of nodes, rate of mobility, etc...

There are various mobility models such as Random Way Point, Reference Point Group Mobility Model (RPGM), Manhattan Mobility Model, Freeway Mobility Model, Gauss Markov Mobility Model etc that have been proposed for evaluation [6],[7].

In this paper we have described the design and implementation of various gateway discovery approaches and studied the performance differentials of these approaches under different scenarios using ns2 based simulation.

The rest of the paper is organized as follows. Section 2 gives an overview of the related work so far. Section 3 describes the AODV Protocol. Section 4 describes the integration of the MANET and the Internet. The issues involved in MANET-Internet connectivity are discussed in Section 4. The simulation setup is described in Section 5. The simulation results are presented and analyzed in section 6. Finally section 7 concludes the paper.

**II. RELATED WORK**

In this section we explore the most significant features of the main MANET interconnection mechanisms namely those from Wakikawa *et al*[8]., Jelger *et al.*[9], Singh *et al*[10]. and Ros *et al.*

Table I summarizes the main features provided by each one.

TABLE I.

SUMMARY OF FEATURES OF WELL-KNOWN EXISTING PROPOSALS.  
 P = PROACTIVE, R = REACTIVE, H = HYBRID, A = ADAPTIVE, RH = ROUTING HEADER, DR = DEFAULT ROUTING, OPT = OPTIONAL

	Wakikawa	Jelger	Singh	Ros
GW Discovery	P/R	P	H	A
Multiple Prefix	Yes	Yes	No	Yes
Stateless/ful	less	less	n/a	less
DAD	Yes	No	n/a	Opt
Header/Default	RH	DR	Both	n/a
Limited Flooding	No	Yes	No	Yes
Load Balancing	No	No	Yes	No
Complete Spec.	Yes	Yes	No	Yes

“Wakikawa”[8] defines two mechanisms, a reactive and a proactive one. In the reactive version, when a node requires global connectivity it issues a request message which is flooded throughout the MANET. When this request is received by a gateway, then it sends a message which creates reverse routes to the gateway on its way back to the originator. The proactive approach of “Wakikawa” is based on the periodic flooding of gateway advertisement messages, allowing mobile nodes to create routes to the Internet in an unsolicited manner.

Ratanchandani et al. [11] introduced a hybrid gateway discovery approach which combines the advantages of both the proactive and reactive approaches. This scheme uses AODV and two Mobile IP foreign agents for interconnecting the MANET with the Internet. The excessive flooding of the proactive approach is reduced by carefully controlling the TTL value of the foreign agent advertisement. This reduces the total number of hops that the advertisement can traverse. Thus only the mobile nodes close to the foreign agent receive the advertisement proactively. The nodes which are further away find the gateway following the reactive approach.

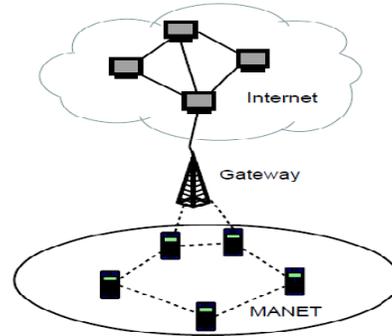


Figure 1. Hybrid Network

**III.AODV(Ad Hoc On-demand Distance Vector)**

The AODV [12] routing protocol is an “on demand” routing protocol, which means that routes are established when they are required. AODV is a reactive protocol based upon the distance vector algorithm This routing protocol is based on transmitting Route Reply (RREP) packets back to the source node and routing data packets to their destination. Used algorithm consists of two steps: route discovery and route maintenance.

Route discovery process begins when one of the nodes wants to send packets. That node sends Route Request (RREQ) packets to its neighbours. Neighbours return RREP packets if they have a corresponding route to destination. However, if they don’t have a corresponding route, they forward RREQ packets to their neighbours, except the origin node. Also, they use these packets to build reverse paths to the source node. This process occurs until a route has been found. The algorithm uses hello messages (a special RREP) that are broadcasted periodically to the immediate neighbours. These hello messages are local advertisements for the continued presence of the node, and neighbours using routes through the broadcasting node will continue to mark the routes as valid. If hello messages stop coming from a particular node, the neighbour can assume that the node has moved away and mark that link to the node as broken and notify the affected set of nodes by sending a link failure notification (a special RREP) to that set of nodes.

**IV. MANET AND INTERNET**

Figure 2 shows the protocol architecture needed for interconnection between the MANET and the Internet. The Internet nodes use the TCP/IP suite and the MANET nodes use the MANET protocol stack. Whenever a mobile node wants to send a data packet to the Internet, it has to forward it to the gateway. The gateway then transmits the packet to the corresponding node in the Internet. Thus the gateway functions as a bridge between the MANET and the Internet. It has to translate between these two different protocols and must

understand both. Therefore, it needs to implement both the

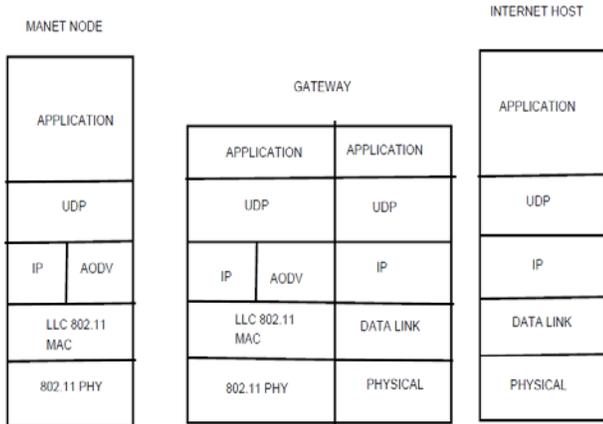


Figure 2: Protocol Architecture for Interconnection between MANET and Internet

V. SIMULATION SETUP

We have used Network Simulator (NS)-2 in our evaluation. The NS-2 is a discrete event driven simulator [13] developed at UC Berkeley. We have used Red Hat Linux environment with version NS-2.34 of network simulator. NS-2 is suitable for designing new protocols, comparing different protocols and traffic evaluations. It is an object oriented simulation written in C++, with an OTcl interpreter as a frontend.

As buffering is needed for the data packets which are destined for a particular target node and for which the route discovery process is currently going on, the protocols have a send buffer of 64 packets. In order to prevent indefinite waiting for these data packets, the packets are dropped from the buffers when the waiting time exceeds 30 seconds. The interface queue has the capacity to hold 50 packets and it is maintained as a priority queue. The interface queue holds both the data and control traffic sent by the routing layer until they are transmitted by the MAC layer. The control packets get higher priority than the data packets.

1. Traffic Models

There are three types of traffic models; namely CBR, Pareto and Exponential [14,15,16]. These are generated using the tool *cbrgen.tcl* [17], with the following parameters:

**CBR:** Constant Bit Rate traffic model. This is generated at a deterministic rate with some randomizing dither enabled on the interpacket departure interval.

**Exponential:** The exponential traffic model is an ON/OFF model with an exponential distribution. During ON period, the traffic is generated at 2 kb/s.

**Pareto:** The Pareto model is also composed of ON/OFF periods. However, these periods follow a Pareto distribution, where traffic is generated at 2 kb/s during ON periods.

MANET protocol stack and the TCP/IP suite.

2. Mobility Models

There exists different classification criteria proposed by several studies [18,19,20,21] for mobility models in the literature. Table 1 shows a summary of these criteria.

Table1 Different criteria proposed for mobility model classifications

Classification Criteria	Classifications
Generation of Mobility	Traces Synthetic Models
Social Behavior of Mobile Nodes	Group Models Entity Models
Degree of Randomness	Total pseudo-random movement process (Statistical Models) Bounded pseudo-random process (Constrained Topology based Models) Trace-based movement Model
General	Integrated Mobility Models

We bring these together to form a hybrid classification as depicted in Fig. 2.

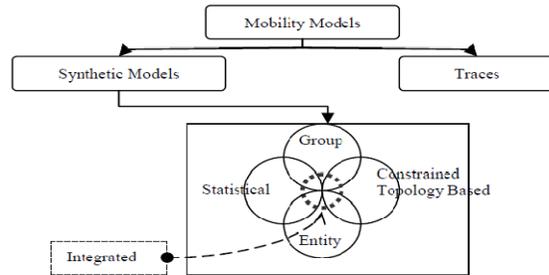


Figure 2 HYBRID CLASSIFICATION STRUCTURE

2.1 Traces

Traces are pre-determined mobility patterns that are observed in real life. For ad hoc networks, tracing the actual behavior of mobile nodes is a hard process and researchers mostly use synthetic models [22]. Traces hardly let researchers to change simulation parameters, which can be a disadvantage for performance analysis of ad hoc networks.

2.2 Synthetic Mobility Models

a. *Random Walk Mobility Model* This mobility model is called as Brownian Motion Mobility Model [24] or Brownian Walk [23]. In this mobility model, entities (mobile nodes) move randomly choosing a speed and direction from pre-defined ranges ( $[minspeed, maxspeed]$  and  $[0, 2\pi]$ , respectively) in constant time intervals ( $\Delta t$ ). Due to its simplicity of implementation, Random Walk is a widely used mobility model in simulations. On the other hand, because of its memoryless behavior (i.e. decision of the next state doesn't

depend on previous states) it creates unrealistic mobility patterns with sharp turns and sudden stops.

selects a random position  $(x, y)$  in the simulation area as a destination point and a velocity  $(v)$  from a uniformly distributed range  $[speedmin, speedmax]$ . Then node starts to travel to the chosen destination point with the constant selected speed,  $v$ . When the node arrives to the destination point, it pauses for a specific time (*pause\_time*) defined as a simulation parameter. After this time, node selects a new destination and speed and repeats the process [26]. Random Waypoint Mobility Model is placed into the intersection of Entity and Statistical models in our classification.

Here in our work we have used the Random Waypoint model. This model is a simple and common mobility model and is widely used for the performance evaluation of MANET protocols in simulated environment. The mobile nodes are initially distributed over the entire simulation area. In order to ensure randomness in the initial distribution, data gathering has to start after a certain simulation time. A mobile node starts simulation by waiting at one location for a specified pause time. After this time is over, it randomly selects the next destination in the simulation area. It also chooses a random speed uniformly distributed between a maximum and minimum speed and travels with a speed  $v$  whose value is uniformly chosen in the interval  $(0, v_{max})$ . Then the mobile node moves towards its selected destination at the selected speed. After reaching its destination, the mobile node again waits for the specified pause time before choosing a new way point and speed.

### 3. Movement Model

In the simulation environment the mobile nodes move according to our selected random waypoint mobility model. We have generated the movement scenario files using the *setdest* program which comes with the NS-2 distribution. These scenario files are characterized by pause time. The total duration of our each simulation run is 900 seconds. We have varied our simulation with movement patterns for ten different pause times: 0, 100, 200, 300, 400, 500, 600, 700, 800, 900 seconds. These varying pause times affect the relative speed of the mobile nodes. A pause time of 900 seconds corresponds to the motionless state of the nodes in the simulation environment as the total duration of the simulation run is 900 seconds. On the contrary when we choose the pause time of 0 second, it indicates continuous motion of the nodes. We have performed our experiment with two different numbers of source nodes: 10 source nodes and 20 source nodes. We have generated scenario files with 100 different movement patterns, 10 for each value of pause time. In order to compare the performance based on the identical scenario, each of the gateway discovery approaches was run with these 100 different movement patterns.

*b. Random Waypoint Mobility Model:* Random Waypoint Mobility is the most widely used model in simulations by the research community [25]. In this model, a mobile node

### 4. Communication Model

In our simulation environment the MANET nodes use constant bit rate (CBR) traffic sources when they send data to the Internet domain. We have used the *cbrgen* traffic-scenario generator tool available in NS2 to generate the CBR traffic connections between the nodes. Data packets transmitted are of 512 bytes. We have used two different communication patterns corresponding to 10 and 20 sources. Data packets are sent by each source at the rate of 5 packets/second. The complete list of simulation parameters are shown in Table 2.

**Table 2 SIMULATION PARAMETERS**

Parameter	Value
Number of Mobile nodes	50
Number of sources	10,20
Number of gateways	2
Number of hosts	2
Transmission range	250 m
Simulation time	900 s
Topology size	1200 m X 800 m
Source type	Constant bit rate
Packet rate	5 packets/sec
Packet size	512 bytes
Pause time	0,100,200,300,400,500,600,700,800,900 seconds
Maximum speed	20 m/sec
Mobility model	Random way point
Gateway discovery approaches	Proactive, reactive and hybrid

### 5. Hybrid Scenario

We have used a rectangular simulation area of 1200 m x 800 m. The choice of rectangular area instead of square area was made in order to ensure longer routes between nodes. The simulation was performed with the first scenario of 50 mobile nodes among which 10 are sources, 2 gateways, 2 routers and 2 hosts and the second scenario of 50 mobile nodes among which 20 are sources, 2 gateways, 2 routers and 2 hosts. Each host is connected to the gateway through a router. For our hybrid network environment we have two gateways located at each side of the simulation area and running both extended AODV and fixed IP routing protocols. Their x, y-coordinates in meters are (200, 400) and (1000, 400). Every communication between the wired and wireless part goes through the gateway. In our two simulation scenarios 10 and 20 mobile nodes respectively act as constant bit rate traffic

sources. They are initially distributed randomly within the MANET.

These sources start sending data packets after the first 10 seconds of simulation in order to ensure that the data packets are not dropped due to the lack of routes not yet established.

**VI. RESULTS AND DISCUSSION**

We have primarily selected the following three parameters in order to study the performance comparison of the three gateway discovery approaches.

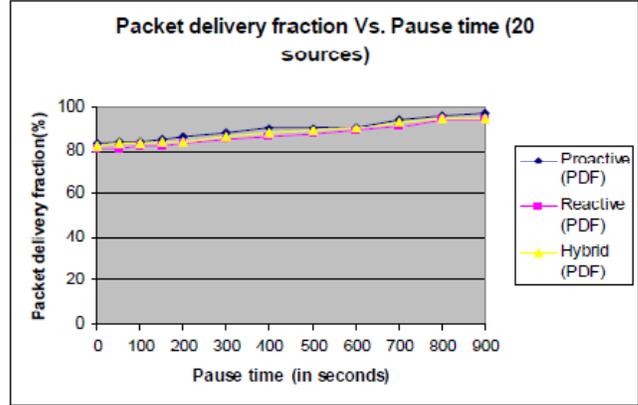
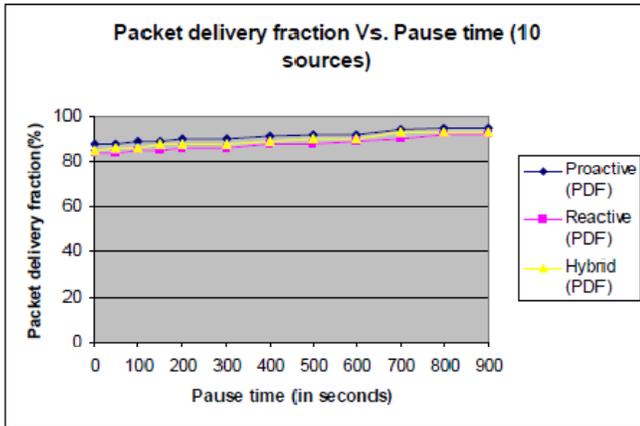
**Packet delivery fraction:** This is defined as the ratio between the number of delivered packets and those generated by the constant bit rate (CBR) traffic sources.

**Average end-to-end delay:** This is basically defined as the ratio between the summation of the time difference between the packet received time and the packet sent time and the summation of data packets received by all nodes.

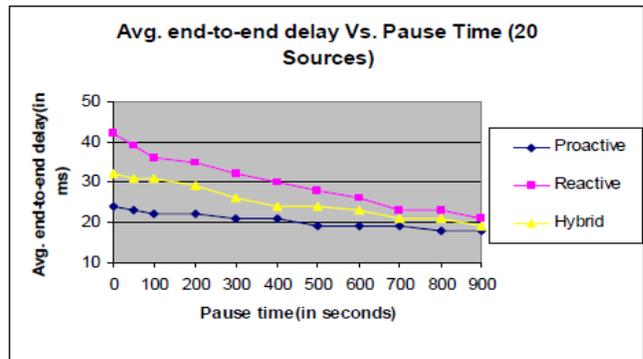
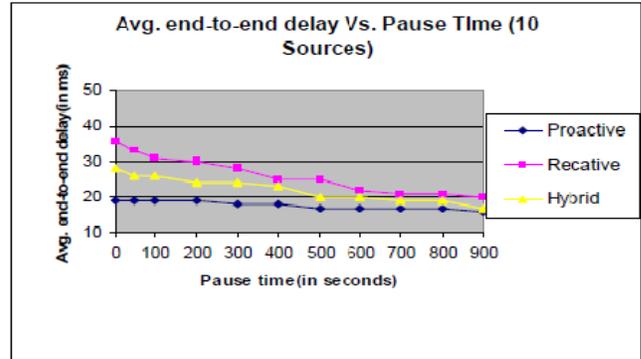
**Normalized routing load:** This is defined as the number of routing packets transmitted per data packet delivered at the destination. Each hop-wise transmission of a routing packet is counted as one transmission.

They stop sending data packets 5 seconds before the end of the simulation so that the data packets sent late get enough time to reach their destinations.

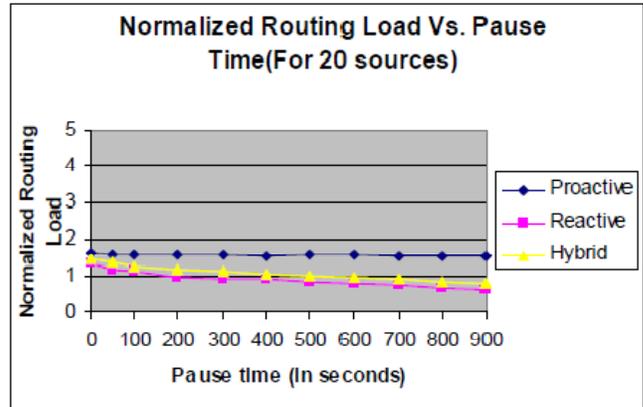
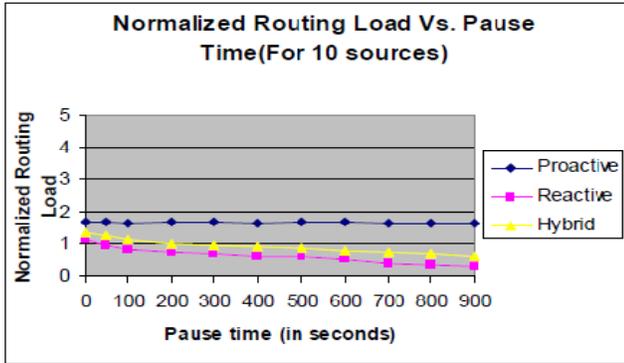
Packet Delivery Fraction (PDF) Comparison



Average End-to-End Delay Comparison



C. Normalized Routing Load Comparison



VII. CONCLUSION

This paper resembles an effort to re-examine three popular routing protocols and carried out a detailed ns2 based simulation to study and analyse the performance differentials of these approaches under different scenarios. From the simulation results we see that the proactive approach shows better packet delivery performance than the reactive approach mainly due to the instant availability of fresher and newer routes to the gateway all the time. With greater number of sources, although initially the packet delivery performance becomes better but later when the number of sources is increased more, due to congestion the packet delivery ratio drops. In terms of the average end-to-end delay, the proactive and hybrid gateway discovery approaches outperform the reactive gateway discovery. As we decrease the pause time and increase the number of sources, all the approaches suffer from greater average end-to-end delay. As far as normalized routing overhead is concerned, the reactive approach performs better than the proactive and hybrid approaches. In case of the proactive approach the normalized routing load remains almost constant for a particular advertisement interval irrespective of the pause time. With more number of sources, the number of received data packets increases for the proactive approach which accounts for its reduced normalized routing load. Whereas for the reactive approach, with decreasing pause time and increasing number of sources, the number of gateway discoveries and as a result the amount of control traffic also increases, which ultimately results in higher normalized routing load.

The hybrid approach being a combination of proactive and reactive approaches, its normalized routing load lies between them.

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