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Impact of Variation in Pause Time and Network Load in AODV and AOMDV Protocols

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***Abstract*—A MANET is a collection of mobile nodes by wireless links forming a dynamic topology without any network infrastructure such as routers, servers, access points/cables or centralized administration. The communication within the network is facilitated through a protocol which discovers routes between nodes. The two major classifications of routing protocols are unipath and multipath. In this paper, the performance comparison of widely used on-demand unipath and multipath routing protocols such as AODV and AOMDV is carried out in terms of variation in pause time and network load under RWM in CBR Traffic. These protocols have been selected for simulation due to their edges over other protocols in various aspects.**

***Index Terms*—MANET, pause time, network load, AODV, AOMDV.**

1. Introduction

Mobile Ad hoc NETwork (MANET) is a collection of mobile nodes by wireless links forming a dynamic topology without any network infrastructure such as routers, servers, access points/cables or centralized administration. Each mobile node functions as router as well as node. The most important characteristics of MANET are i) Dynamic topologies ii) Bandwidth-constrained links iii) Energy constrained operation and iv) limited physical security [1,2].

Routing protocols play a vital role in MANET to find routes for packet delivery and make sure that the packets are delivered to the correct destinations. These protocols are classified as: (i) proactive, (ii) reactive, and (iii) hybrid. Among these protocols, the reactive category is widely used because they find routes whenever needed (i.e.,on-demand). We present a simulation-based performance study of the two types of widely used reactive protocols such as AODV and AOMDV. Moreover, the performance comparison of both AODV and AOMDV is carried out with varying network load and pause time.

The rest of this paper is organized as follows: In Section 2, the major classifications of MANET routing protocols based on multiple routes are discussed; in section 3 the traffic and mobility are described; in section 4 the simulation model is discussed; in section 5 the performance metrics are described; in section 6 the experimental results are discussed and finally in section 7 the conclusion is given.

2. Routing Protocols

The communication within the network is facilitated through a protocol which establishes correct and efficient route between a pair of nodes so that messages may be delivered in a timely manner. The route construction should be done with a minimum of overhead and bandwidth consumption. The two major classifications of MANET routing protocols are unipath and multipath routing protocols.

2.1 Unipath Routing Protocols

The unipath routing protocols [2] find only a single route between a pair of source and destination. In response to every route break, a new route discovery is required which leads high overhead and latency. The two components of unipath routing protocols are *i) Route Discovery:* finding a route between a source and destination. *ii) Route Maintenance:* repairing a broken route or finding a new route in the presence of a route failure. The most commonly used unipath routing protocols are *Ad Hoc On-demand Distance Vector*

(AODV) [3], *Destination Sequenced Distance Vector* (DSDV) [3] and *Dynamic Source Routing* (DSR) [3,4].

2.1.1 The AODV Protocol

The AODV [3] protocol is a simple and widely used on-demand unipath routing protocol that starts a route discovery process through a route request (RREQ) to the destination throughout the network when needed for MANE. Once a non-duplicate RREQ is received, the intermediate node records the previous hop and checks for a valid and fresh route entry to the destination. The node sends a route reply (RREP) along with a unique sequence number to the source. On updating the route information, it propagates the route reply and gets additional RREPs if a RREP has either a larger destination sequence number (fresher) or a shorter route found.

2.2. Multipath Routing Protocols

The multipath routing protocols [2] find multiple routes between a pair of source and destination in order to have load balancing to satisfy Quality of Service (QoS) requirements. The three main components of multipath routing protocols are *i) Route Discovery:* finding multiple nodes disjoint, links disjoint, or non-disjoint routes between a source and destination. *ii) Traffic Allocation:* Once the route discovery is over, the source node has selected a set of paths to the destination and then begins sending data to the destination along the paths. *iii) Path Maintenance:* regenerating paths after initial path discovery in order to avoid link/node failures that happened over time and node mobility.

The most recently used multipath algorithms are *Temporarily-Ordered Routing Algorithm* (TORA) [5], Split Multipath Routing (SMR) [5], *Multipath Dynamic Source Routing* (MP-DSR) [2,5], *Ad hoc On-demand Distance Vector-Backup Routing* (AODV-BR)[5] and *Ad Hoc On-Demand Multipath Distance Vector Routing (*AOMDV) [5].

2.2.1. The AOMDV Protocol

To eliminate the occurrence of frequent link failures and route breaks in highly dynamic ad hoc networks, AOMDV has been developed from a unipath path on-demand routing protocol AODV.
The AOMDV [2,5,6] protocol finds multiple paths and this involves two stages which are as follows: i) A route update rule establishes and maintains multiple loop-free paths at each node, and ii) A distributed protocol finds link-disjoint paths.

The AOMDV protocol finds node-disjoint or link-disjoint routes between source and destination. Link failures may occur because of node mobility, node failures, congestion in traffic, packet collisions, and so on. For finding node-disjoint routes, each node does not immediately reject duplicate RREQs. A node-disjoint path is obtained by each RREQ, arriving from different neighbor of the source because nodes cannot broadcast duplicate RREQs. Any two RREQs arriving at an intermediate node through a different neighbor of the source could not have traversed the same node. To get multiple link-disjoint routes, the destination sends RREP to duplicate RREQs regardless of their first hop. For ensuring link-disjointness in the first hop of the RREP, the destination only replies to RREQs arriving through unique neighbors. The RREPs follow the reverse paths, which are node-disjoint and thus link-disjoint after the first hop. Each RREP intersects at an intermediate node and also takes a different reverse path to the source to ensure link-disjointness.

The protocols AODV and AOMDV have been selected due to their edges over other protocols in various aspects. The comparison of AODV and AOMDV protocol is carried out in terms of variation in pause time and network load under Random Way point Mobility (RWM) in CBR Traffic. To analyze these protocols, traffic patterns and mobility models are essential and are discussed in subsequent sections.

3. Traffic and Mobility

3.1 Traffic

Traffic Patterns describe how the data is transmitted from source to destination. The widely used traffic pattern in MANET is CBR.

3.1.1 Constant Bit Rate (CBR)

The qualities of Constant Bit Rate (CBR) traffic pattern [7,8] are *i) unreliable:* since it has no connection establishment phase, there is no guarantee that the data is transmitted to the destination, *ii) unidirectional:* there will be no acknowledgment from destination for confirming the data transmission and *iii) predictable:* fixed packet size, fixed interval between packets, and fixed stream duration.

3.2 Mobility

Mobility models describe the movement pattern of the mobile users, their location; velocity and acceleration [9,10]. They play a vital role in determining the performance of a protocol and also differentiated in terms of their spatial and temporal dependencies. i) *Spatial dependency* is a measure of how two nodes are dependent in their motion. When the two nodes are moving in the same direction, then they have high spatial dependency. ii) *Temporal dependency* is a measure of how current velocity (magnitude and direction) are related to previous velocity. The two nodes are having the same velocity and direction means that they have high temporal dependency. The commonly used mobility model in MANET is RWM.

3.2.1 Random Way point Mobility (RWM)

RWM [10] model is the commonly used mobility model in which every node randomly chooses a destination and moves towards it from a uniform distribution $(0, V_{max})$ at any moment of time, where V_{max} is the maximum allowable velocity for every node. Each node stops for a duration defined by the ***'pause time'*** parameter when it reaches the destination. After the pause time it again chooses a random destination and repeats the whole process until the end of the simulation.

4. Simulation Model

The comparison of AODV and AOMDV is carried out in terms of RWM and CBR traffic using NS 2 [11,12,13] and Bonn Motion [14]. The following Fig.1 illustrates the simulation model [15] and the simulation scenarios are described in Table 1 and Table 2.
The result of simulation is generated as trace files and the awk & perl scripts are used for report generation.

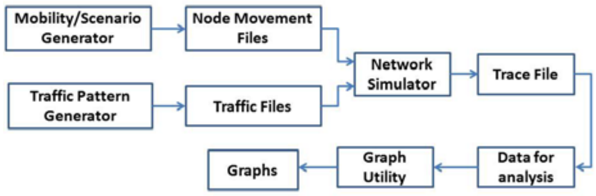

Fig 1: Overview of the simulation model.

Table 1: Simulation Scenario 1

Parameter	Value
Simulator	NS 2.34
MAC Type	802.11
Simulation Time	100 seconds
Channel Type	Wireless Channel
Routing Protocol	AODV,AOMDV
Antenna Model	Omni
Simulation Area	1520 m x 1520 m
Traffic Type	CBR
Data Payload	512 bytes/packet
Network Loads	4 packets/sec
Radio Propagation Model	TwoRayGround
Interface Queue Length	50
Interface Queue Type	DropTail/PriQueue
Number of nodes	25
Pause Time	0,10,20,40,60,80,100 sec
Mobility Model	Random Way point Mobility

Table 2: Simulation Scenario 2

Parameter	Value
Simulator	NS 2.34
MAC Type	802.11
Simulation Time	100 seconds
Channel Type	Wireless Channel
Routing Protocol	AODV,AOMDV
Antenna Model	Omni
Simulation Area	1520 m x 1520 m
Traffic Type	CBR
Data Payload	512 bytes/packet
Network Loads	1,2,3,4,5 packets/sec
Radio Propagation Model	TwoRayGround
Interface Queue Length	50
Interface Queue Type	DropTail/PriQueue
Number of nodes	25
Pause Time	20 sec
Mobility Model	Random Way point Mobility

5. Performance Metrics

Performance Metrics [16] are quantitative measures that can be used to evaluate any MANET routing protocol. The following six metrics are considered in order to compare the performance of unipath and multipath on-demand routing protocols AODV and AOMDV respectively in terms of variation in Pause Time (PT) and Network Load (NL) under RWM in CBR Traffic. The number of bits transferred per second through the traffic medium is called **`network load`** and the time taken by a node to choose the destination for packet delivery is called **`pause time`**

5.1 Packet Delivery Fraction (PDF)

PDF is the ratio of data packets delivered to the destination to those generated by the sources and is calculated as follows:

$$Packet\ Delivery\ Fraction = \frac{Number\ of\ Packets\ Received}{Number\ of\ Packets\ Sent}\ x\ 100.$$

5.2 Average Throughput (TP)

Average Throughput [17] is the number of bytes received successfully and is calculated by

$$Average\ Throughput = \frac{Number\ of\ bytes\ received\ x\ 8}{Simulation\ time\ x\ 1000}\ kbps.$$

5.3 Routing Overhead (ROH)

Routing overhead is the total number of control packets or routing packets generated by routing protocol during simulation and is obtained by

$$Routing\ Overhead = Number\ of\ RTR\ packets.$$

5.4 Normalized Routing Overhead (NROH)

Normalized Routing Overhead is the number of routing packets transmitted per data packet towards destination and calculated as follows:

$$Normalized\ Routing\ Overhead = \frac{Number\ of\ Routing\ Packets}{Number\ of\ Packets\ Received}.$$

5.5 Average End-to-End Delay (e2e delay)

Average End-to-End [18] delay is the average time of the data packet to be successfully transmitted across a MANET from source to destination. It includes all possible delays such as buffering during the route discovery latency, queuing at the interface queue, retransmission delay at the MAC (Medium Access Control), the propagation and the transfer time. The average e2e delay is computed by,

$$D = \frac{\sum_{i=1}^{n}(R_i - S_i)}{n}\ m\sec,$$

Where D is the average end-to-end delay, n is the number of data packets successfully transmitted over the MANET, $'i'$ is the unique packet identifier, R_i is the time at which a packet with unique identifier $'i'$ is received and S_i is the time at which a packet with unique identifier $'i'$ is sent. The Average End-to-End Delay should be less for high performance.

5.6 Packet Loss (PL)

Packet Loss is the difference between the number of data packets sent and the number of data packets received. It is calculated as follows:

$$\text{Packet Loss} = \text{Number of data packets sent} - \text{Number of data packets received.}$$

6. Results and Discussion

The performance of AODV and AOMDV protocols are evaluated in terms of variation in pause time and network load in CBR traffic under RWM. Table 3(a) and Table 3(b) shows the observed values of AODV and AOMDV protocols with respect to varying network load based on simulation. Table 4(a) and Table 4(b) shows the observed values of AODV and AOMDV protocols with respect to varying pause time based on simulation.

Table 3 (a): Performance data of AODV protocol with respect to NL

NL	PDF (%)	TP (kbps)	ROH (pkts)	NROH (%)	e2e delay (ms)	PL (pkts)
1	53.5587	12.34	213	0.707641	92.0065	261
2	52.6316	24.18	444	0.752542	262.762	531
3	53.1288	36.21	660	0.747452	245.207	779
4	52.1333	48.05	934	0.796249	235.886	1077
5	52.4133	60.08	1183	0.806958	235.734	1331

Table 3(b): Performance data of AOMDV protocol with respect to NL

NL	PDF (%)	TP (kbps)	ROH (pkts)	NROH (%)	e2e delay (ms)	PL (pkts)
1	51.6814	11.96	262	0.89726	9.89801	273
2	51.4286	23.61	516	0.895833	12.9667	544
3	51.8429	35.16	761	0.886946	15.8564	797
4	52.0161	47.57	1022	0.880276	14.2446	1071
5	51.5335	59.2	1295	0.896194	15.4594	1359

Table 4 (a): Performance data of AODV protocol with respect to PT

PT	PDF (%)	TP (kbps)	ROH (pkts)	NROH (%)	e2e delay (ms)	PL (pkts)
0	0	0	1848	0	0	2245
10	7.8877	7.27	1734	9.79661	0	2067
20	52.1333	48.05	934	0.796249	235.886	1077
40	12.5113	11.4	1544	5.55396	0.059603	1944
60	14.7387	19.16	1523	4.61515	1.54794	1909
80	31.2811	28.3	1310	1.8958	2.37255	1518
100	11.3677	10.49	1724	6.73438	0	1996

Table 4 (b): Performance data of AOMDV protocol with respect to PT

PT	PDF (%)	TP (kbps)	ROH (pkts)	NROH (%)	e2e delay (ms)	PL (pkts)
0	0	0	2114	0	0	2229
10	7.77827	7.14	1973	11.3391	0	2063
20	52.0161	47.57	1022	0.880276	14.2446	1071
40	12.5278	11.55	1858	6.58865	0.23325	1969
60	14.1368	18.18	1771	5.67628	1.44004	1895
80	30.8072	28.15	1485	2.16157	2.39711	1543
100	11.1061	10.14	1895	7.67206	0	1977

The comparison results of AODV and AOMDV protocols are described in terms of six performance metrics by graphs and are discussed below.

6.1 Packet Delivery Fraction

Fig. 2(a) and Fig. 2(b) shows the delivery rate of the data packets of AODV and AOMDV in terms of variation in pause time and network load under RWM in CBR Traffic respectively. The Packet Delivery rate needs to be high for effective performance of routing. Variation in pause time gives same impact in both AODV and AOMDV protocols where as variation in network load gives a significant impact for AODV protocol.

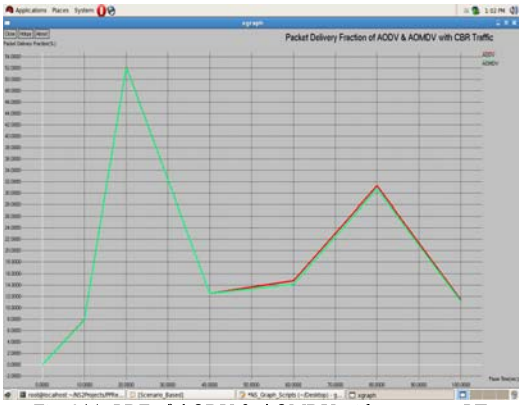

Fig. 2(a): PDF of AODV & AOMDV with respect to PT

Fig. 2 (b): PDF of AODV & AOMDV with respect to NL

6.2. Average End to End Delay

The End to End Delay is a significant parameter for evaluating a protocol which must be low for good performance. From Fig. 3(a) and Fig. 3(b), the variation in pause time and network load gives significant impact in AOMDV protocol. In other words, the AOMDV is performing well than AODV when the pause time and network load varies.

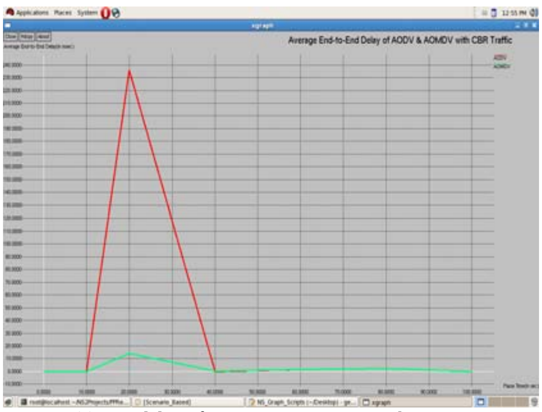

Fig. 3 (a): e2e delay of AODV & AOMDV with respect to PT

Fig. 3 (b): e2e delay of AODV & AOMDV with respect to NL

6.3 Average Throughput

From Fig. 4(a) and Fig. 4(b), the variation in pause time and network load gives more or less the same throughput in both AODV and AOMDV protocol. Since the AOMDV's throughput is somewhat higher than the AODV due to its multiple routes capability which is an added advantage to AOMDV protocol.

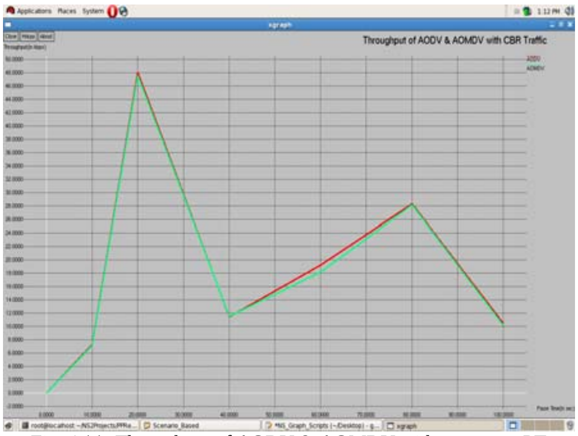

Fig. 4 (a): Throughput of AODV & AOMDV with respect to PT

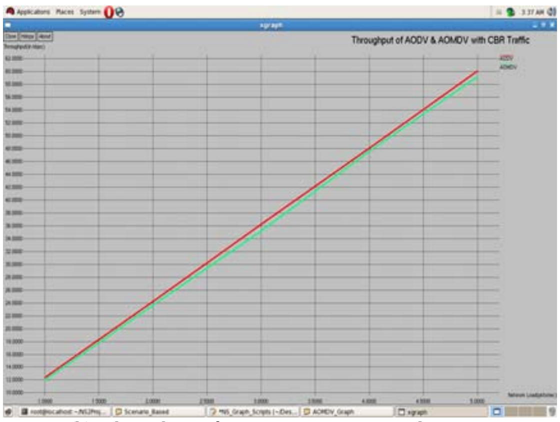

Fig. 4 (b): Throughput of AODV & AOMDV with respect to NL

6.4 Routing Overhead (ROH)

From Fig. 5(a) and Fig. 5(b), the variation in pause time and network load gives considerable reduction of ROH in AOMDV protocol. From Fig.5 (a) the AOMDV's ROH is somewhat higher than the AODV due to its multiple paths. From Fig.5 (b), the ROH of AOMDV protocol is higher than the AODV when the variation in network loads.

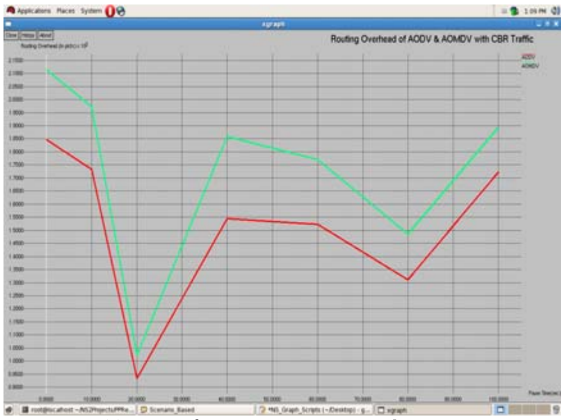

Fig. 5 (a): ROH of AODV & AOMDV with respect to PT

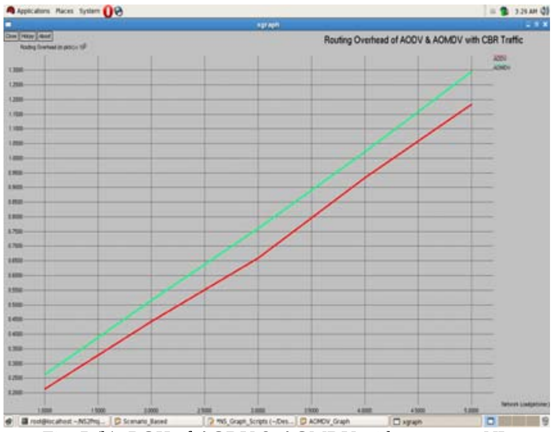

Fig. 5 (b): ROH of AODV & AOMDV with respect to NL

6.5 Normalized Routing Overhead (NROH)

From Fig. 6(a) and Fig. 6(b), the variation in pause time and network load gives considerable reduction of NROH in AOMDV protocol. Thus the AOMDV's NROH is somewhat higher than the AODV due to its multiple routes capability.

Fig. 6 (a): NROH of AODV & AOMDV with respect to PT

Fig. 6 (b): NROH of AODV & AOMDV with respect to NL

6.6 Packet Loss

From Fig. 7(a) and Fig. 7(b), the variation in pause time gives zigzag packet loss in AOMDV protocol where as the incremental variation in network load shows an increase in packet loss in both AODV and AOMDV protocols.

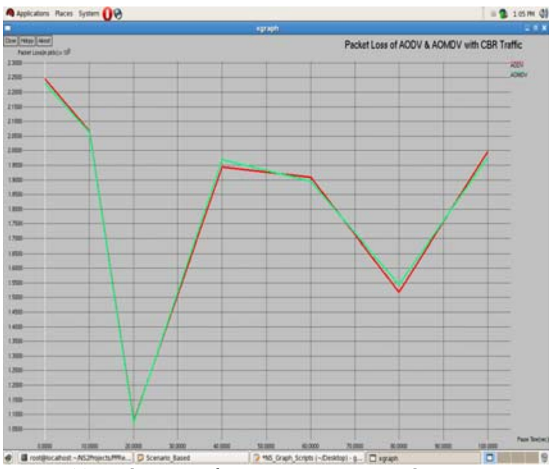

Fig. 7 (a): Packet Loss of AODV & AOMDV with respect to PT

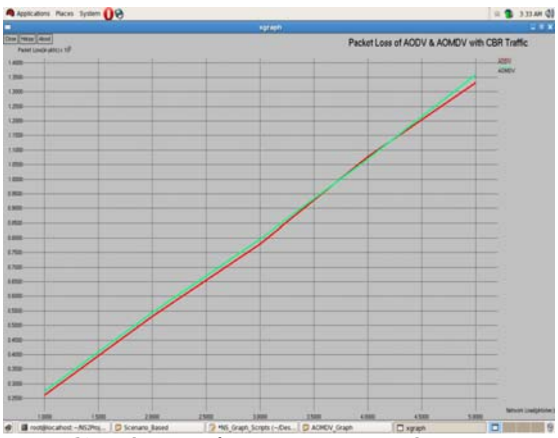

Fig. 7 (b): Packet Loss of AODV & AOMDV with respect to NL

7. Conclusions and Future Work

The AODV and AOMDV protocols are compared in terms of the variation in pause time and network load in CBR traffic under RWM. Due to randomness in mobility, the RWM and CBR are selected as scenario parameters. The AOMDV protocol is giving better performance than the AODV protocol for most of the performance parametric measures.

The ROH and NROH parameters are comparatively high for AOMDV protocol which can be reduced by the reduction of control packets. The future work of the research will focus on the reduction of the usage of control packets in routing.

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