The Performance and Simulative analysis of MANET Routing Protocols with Different Mobility Models

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Abstract— A Mobile Ad-hoc Network (MANET) consists of a number of mobile nodes. These mobile nodes can communicate without any centralized control mechanism. MANETs are self-organizing and self-configuring multi node wireless networks without any infrastructure. In MANET the structure of the network changes dynamically. The fundamental characteristic of MANETs which differentiate it from other wireless or wired networks is its mobility feature. The mobile nodes can receive and relay packets as a router. Routing is an important issue for an efficient routing protocol makes the MANET reliable. The node in the wireless or wired network not only acts as hosts but also act like a routers that route data to/from other nodes in network. Each device in a MANET is free to move independently in any direction and will therefore change its links to other devices frequently. Routing in Ad-HOC networks has been a challenging task before the wireless networks came into existence. There are two types of features of MANET - absence of fixed infrastructure. & absence of central control administration. MANET routing protocols are designed to adapt easily dynamic changes in topology while maximizing average throughput and packet delivery fraction, and minimizing end to end delay, network routing load and energy consumption. Important design issue for efficient and effective routing protocols for MANETs is to achieve the optimum values of performance parameters under network scenarios where nodes are subjected to different types of mobility model that dynamically change the network topology. In this we discuss about simulation & comparison of the performance between types of routing protocols, Table Driven (Proactive), On-Demand (Reactive) in different mobility models like Gauss Markov model, Manhattan Grid model and Random Walk model. The present approach shows simulation study and comparison of the performance between categories of routing protocols, table-driven (Proactive), on-demand (Reactive) routing protocol in three different mobility models. These three categories were illustrated by using four different examples of routing protocols. First example is AODV (Ad Hoc On-Demand Distance Vector) from the Proactive family, DSDV (Distance Vector Routing Protocol) from the Reactive family and DSR(Demand Source Routing) and AOMDV(Adhoc on Multipath Demand Distance Vector) .They are simulate in these three models Gauss Markov model, Manhattan Grid model and Random Walk model.

Keywords— Aodv, Dsdv, Dsr, Aomdv, Mobility Model, Protocol Selection.

I.   INTRODUCTION

A mobile adhoc network (MANET) is an autonomous, self-configuring, self-healing and infrastructure less system of mobile nodes connected by the wireless links. The nodes are free to move randomly in a network and they will come in or leave the network at their own will. Due to the randomness of element, the network topology of a system becomes unpredictable and may change very rapidly. A major issue in the design of MANETs is the development of dynamic routing protocols that can find the routes between two communicating nodes. The unpredictable making or failure of the links is caused by node mobility, the routing protocols need to quickly adapt the changes and find new paths automatically to avoid the failed links. Routing protocols is challenging in adaptation due to constraints like low wireless bandwidth and limited battery power of the nodes. Moreover, the overhead can have a significant impact on the performance of the MANET. The movement of mobile nodes is characterized by mobility models and each and every routing protocols exhibits specific characteristics for these models. In order to find the most adaptive and efficient routing protocol for dynamic MANET topologies, the nature of routing protocols needs to be analyzed at changing node speeds, network size, number of traffic nodes as well as node density . The node movement differs for different scenarios like military adhoc networks have both random and group movement of soldier nodes of low speed, and vehicle nodes (e.g. tanks, APVs etc.) of quite high speeds. This discussion leads us to believe that it is important to understand and evaluate the performance of routing protocols in different mobility scenarios before selecting a protocol for a particular scenario. The previous analysis on routing protocols to select the Random Waypoint mobility model for simulations. However, surveys on mobility models and impact on routing performance verify that the analysis of protocol performance using just Random Waypoint model is not enough; a given routing protocol may not deliver optimum performance under other mobility models. Mobility models are developed on the basis network traces. Mobility models have also been developed for simulating specific scenarios to evaluate the network performance. Therefore, in this paper, we aim to simulate and analyze the performance of MANET routing protocol under various mobility models with different parameters. The paper is organized as follows. In second part, we provide a brief overview of MANET routing protocols. In third part we describe the different mobility models for MANETs. In forth part we gives the details of our performance simulations for protocol evaluation along with their results and analysis. Papers last part is an outlook to future work.

II. MANET ROUTING PROTOCOLS: A BRIEF OVERVIEW

In reactive routing protocols, a route discovery process start when it was only needed. In this source node start route discovery process by broadcasting route query or request messages into the mobile network. Routing table is used for maintaining the discovered routes .In Routing table only valid routes are kept and all other routes are Deleted after an active route timeout; by this it improves network routing efficiency. In this there is one major problem is that link failures occur due to high node mobility and at the same time there is an establishment of new new links between previously distant nodes. By this there is a increases in the network broadcast traffic due to the link breakage or make up. This why the on demand driven routing protocols are subjected to an increase in network control overhead.

Adhoc on Demand Distance Vector (AODV): AODV is an on-demand routing algorithm that discovers routes only when they are desired. It uses the unique code of numbers called sequence numbers to ensure the freshness of routes. To find a path to a destination node, a node initiate using AODV broadcasts a route reques*t* (RREQ) packet. The RREQ(route request) contains the node's IP address, current sequence number, broadcast ID and most recent sequence number for the destination node to the source node. The destination node having a receipt of RREQ and unicasts a route reply (RREP) packets with the reverse path establishment of the intermediate nodes during the route discovery process. Whenever link failure arise then route error (RERR) packet is sent to the source node and destination nodes. By the help of the sequence numbers, the source nodes always find the new valid routes.

Dynamic Source Routing (DSR): Like AODV, DSR establishes a route discovery process to the destination node when a source node requests one. DSR uses the source routing strategy. By this strategy , the source node find the complete sequence of nodes from source to destination through which the data packets will be sent. In DSR, the source node initiates route discovery and broadcasts a route request packet. If the discovery process is successful then the initiator receives a response packet which lists the sequence of nodes by which the destination node can be reached. The route request packet thus contains the field of a record is called a record field, which compile the sequence of nodes visited during proliferation of the query in the network.

Destination-Sequenced Distance-Vector (DSDV): DSDV is a node-by-node vector routing protocol requiring each node to periodically broadcast routing updates. One key advantage of DSDV having key advantage over traditional vector protocols is that it guarantees loop-freeness. Each DSDV protocol node maintains a routing table for the "next node" to reach a destination node. DSDV combine each route with a sequence number and take a route *R* more favorable than *R'* if *R* has a greater sequence number than, or if the two routes *R* and *R'* have equal sequence numbers but *R* has a lower metric (such as transmission cost). Each node in the network advertises a monotonically increasing even sequence number for itself. When a node *B* decides that its route to a destination *D* has broken, it communicates the route to *D* with an infinite metric and a sequence number one greater than its sequence number for the route that has broken (making an odd sequence number). By this any node *A* routing packets through *B* to combine the infinite-metric route into its routing table just before node *A* hears a route to *D* with a larger sequence number.

Ad-hoc On-demand Multipath Distance Vector Routing(AOMDV): AOMDV is based on the demand single path protocol known as ad hoc on-demand distance vector (AODV). It is the modified version of the AODV protocol to discover multiple paths between the source node and the destination node in every route discovery process. In this Multiple paths are computed for *loop-freeness* and *disjoinnesst*. AOMDV has three protocol aspects compared to other on-demand multipath protocols. First, it does not have high inter-nodal coordination overheads like some other protocols (e.g., TORA , ROAM). Second, it guarantees the disjointness of alternate routes via dispersed computation without the use of source routing. Finally, AOMDV computes another paths with minimal additional overhead over AODV.

III. MOBILITY MODELS

In MANET, the movement pattern of mobile nodes is described by the rate of change of speed and direction. Mobility pattern helps in describing the performance of routing protocols. So when evaluating protocols, it is necessary to choose the proper mobility model for it. For example, in Random Waypoint model nodes behave quite differently as compared to nodes moving in groups. Therefore, there is a very important need for developing a understanding of mobility models and their impact on protocol performance. To describe the performance of protocols and use of mobility model so we show the performance of the routing protocols in three mobility models.

The Gauss-Markov model ("GaussMarkov"): The Gauss-Markov Mobility Model was developed by Liang and Haas.This modeled as the Gauss – Markov stochastic process because the velocity of node is assumed to be correlated over time. The Gauss-Markov stochastic process can be represented in a two-dimensional simulation field, by the following equations

$$V_t = \alpha o V_{t-1} + (1-\alpha) o v + \sigma o \sqrt{1-\alpha^2} o W_{t-1}$$

Where $V_t = [v_t^x - v_t^y]^t$ and $V_{t-1} = [v_t^x - v_t^y]^t$ are the velocity vector time t and time t-1

Respectively $W_{t-1} = [w_{t-1}^x - w_{t-1}^y]^t$ is the uncorrelated random Gaussian process with mean 0 and variance σ^2, $\alpha = [\alpha^x, \alpha^y]^T, v = [v^x, v^y]^T$ and $\sigma = [\sigma^x, \sigma^y]^T$ are the vectors that represent the Memory level, asymptotic mean and asymptotic standard deviation. When the node is going to travel across the boundary of the simulation field, the direction of movement of the node is forced to flip 180 degree. By this way, the nodes remain away from the boundary of simulation field. In Gauss-Markov model the main commonalties are that for each mobile node, two separate values are maintained instead of one speed vector: The mobile's speed and its direction of movement. Nodes

may continue to walk beyond the area boundary of the simulation field , It causes the next movement vector update which are not to be based on the prior angle, but on the angle which come back in the simulation field. Therefore, the field size is automatically adapted to the node movements after scenario generation.

Random Walk Model ("Random Walk"): The Random Walk model was proposed for evaluating the movement of the particles in physics. It is also known as the Brownian motion. Because the nodes are move in an unexpected manner, Random Walk mobility model is proposed to mimic their movement behavior. The Random Walk models have many similarities with the Random Way point model because the movement of node is strong randomness in both models. The Random Walk model as the specific Random Way point model with having a pause time is Zero. It is a simple mobility model based on random directions and speeds of the nodes. In this mobility model, a mobile nodes moves from its current location to a new location by randomly selecting a direction and speed in which to travel. The new changing speed and direction of the mobile nodes are chosen from predefined ranges, [minspeed; maxspeed] and [0; 2π] respectively. In similar way the new speed v (t) follows like a Gaussian distribution from [0, V]. So during time interval t, velocity vector of the nodes are (v(t)cosθ, v(t)sinθ). If the movement of node underlying the above rules and reaches the boundary of simulation field, the leaving node is bounce off to the field with the angle of tθ .This effect is called border effect.

Manhattan Grid model ("Manhattan Grid"): The Manhattan Grid model is developed in [ETSI 1998]. In Manhattan Grid model, nodes are moving only in predefined paths. The arguments -u and -v are used for setting the number of blocks between the paths. As an example, "-u 3 -v 2" places the following paths on the simulation area:

```
+ - + - + - +
|   |   |   |
+ - + - + - +
|   |   |   |
+ - + - + - +
```

Implementation contains some modifications of the Manhattan Grid Model:

1) Some parameter is introduced to minimize the speed of a mobile node. It

helpful because the speed of a mobile node can be close to 0 and so this model defines

the speed of the distance intervals which is updated, so if this parameter is not used then slow node movement occurs .

2) There is two additional parameters are used to pause:

The pause probability (the speed of node does not change then it will pause with that probability) and the maximum pause time.

In this model all nodes are start at the same position (0, 0).

IV.   PERFORMANCE EVALUATION

Simulations have been performed in network simulator, ns-2, to determine the impact of mobility on performance of routing protocols. We evaluate four MANET protocols (AODV, DSR, DSDV, AOMDV) against three mobility models (RANDOM WALK, GAUSS MARKOV, MANHATTAN GRID). We select four different terrain sizes, i.e. 500 × 500*m*2, 700 × 700*m*2, 1000 × 1000*m*2 and 1200 × 1200*m*2, and vary the number of nodes as 25, 50,75 and 100. The performance is analysed for three types of networks; (1) small networks of 25 to 50 nodes with area 500×500*m*2 and 700×700*m*2, (2) medium size network of 75 nodes with area 1000 × 1000*m*2, and (3)large network of 100 nodes with area 1200×1200*m*2

The comparison is done on the basis of following performance parameters:

1 Packet Delivery Ratio (PDR)
2 Average Delays (Davg*)*
3 Normalized Routing Load (NRL)

• ***Packet Delivery Ratio (PDR)***
It is defined as the fraction of packets delivered successfully from source node to destination nodes and the total number of packets generated for those destinations. PDR characterizes the packet loss rate, pdr limited the throughput of the manet. Pdr is high means the performance of the routing protocol is high. Those protocols have higher pdr means they are better in performance.
 PDR is determined as:
PDR = (Precv/Psen) × 100
where Precv is the total packets received and Psen is the total packets sent.

• ***Average Delay (Davg)***
It indicate*s* the time taken for one packet to travel from the source node to the destination node. The average delay is computed as:
Davg = (trecv − tsen) / Precv
where tsen is the packet send time and trecv is the packet receive time for the same packet at destination.

• ***Normalized Routing Load (NRL)***
It is the fraction of control packets over data packets in the manet. It gives a measure of the protocol routing overhead in the network; i.e. how many control packets were required to successfully transport data packets to their destinations. It characterizes the protocol routing performance under congestion.
NRL is determined as:
NRL = Pcp/Pdp
Where Pcp is the total control packets sent and Pdp is the total data packets sent.

Packet Delivery Ratio:
The simulation results for packet delivery ratio measured for the routing protocols under three mobility models are shown in Figs. 2(a), 2(b) and 2(c). We first compare the group mobility models (Gauss Markov, Manhattan Grid, Random Walk) . In small networks, the delivery ratio is more than 90% for all routing protocols in above mobility model. However, when network size along with the number of nodes is increased, we observed decrease in pdr, which is quite significant for AODV in these three mobility model. DSR, AOMDV, DSDV achieve good PDR in large networks for Markov and Random model but in case of

Grid model pdr is degraded. The simulation results for packet delivery ratio measured for the routing protocols fewer than three mobility models are shown in Figs. 2(a), 2(b) and 2(c). We compare the group mobility models (markov, grid random) in grid model pdr is good for small network as well as medium network but it can bad for large networks.

In markov as well as random aodv is not well for any network size but other protocols are god in all type of network size.

Average Delay:
We relate the packet delay with PDR and we conclude that high PDR would generally imply lower delay values. Our simulated results, shown in Figs. 3(a), 3(b) and 3(c), indicate that on the average packet delay is increased for all compared protocols when network size (area & number of nodes) is increased under the selected mobility models. With regard to performance under group mobility models, we find that AODV, DSDV and DSR have comparatively lower delays. We observed in our analysis AOMDV has higher delay.
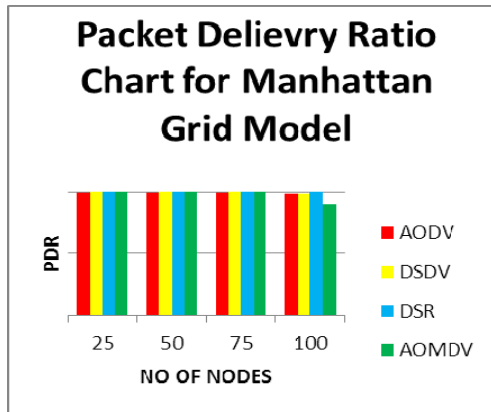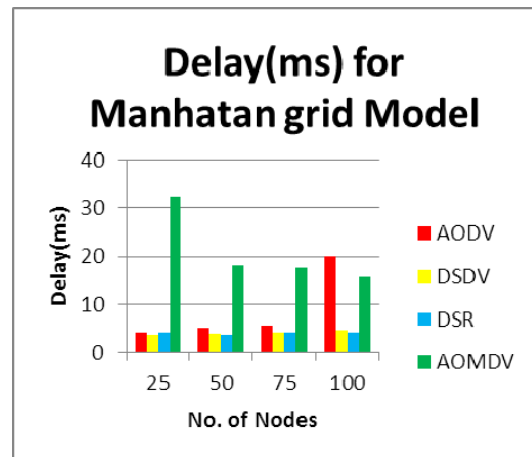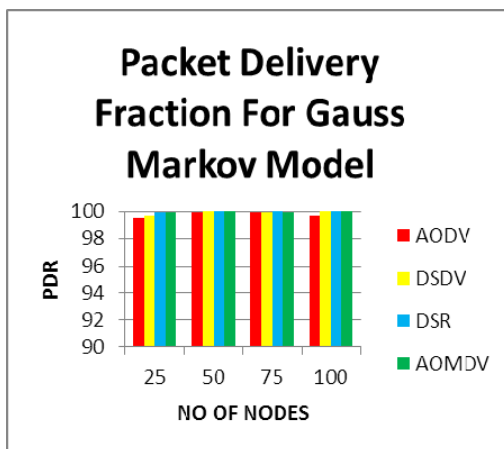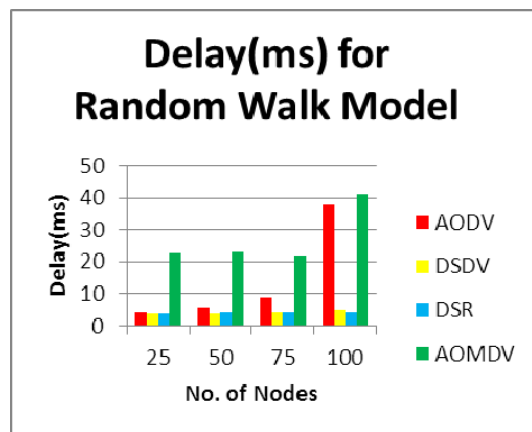

Figs. 2(a)
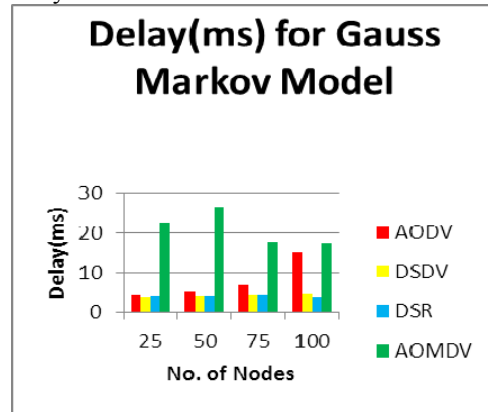

Figs. 3(a)
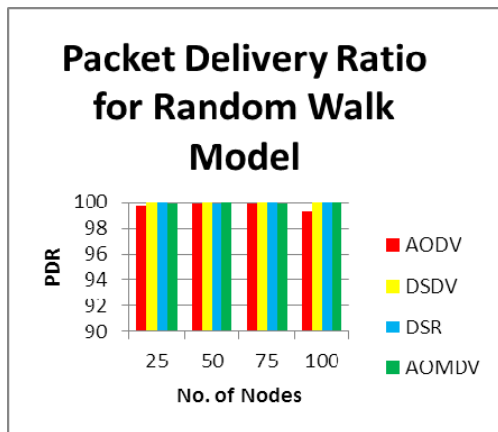
Figs. 2(b)

Figs. 3(b)

Figs. 2(c)

Figs. 3(c)

Normalized Routing Load:

MANET routing protocols need to have a low routing load for the better performance in different mobility model. When NRL is low of routing protocol then it will produce high delivery ratio and less packet delay. The simulated experimental results for NRL of all protocols are shown in Figs.4 (a), 4(b) and 4(c). We can see that all protocols have low NRL values for small networks except AOMDV. When network size increases then increase in NRL is observed. This indicates that in order to route data packets in large networks with node mobility, the routing protocols need to generate large number of control packets to discover/maintain the routes. DSDV has significantly better NRL performance in medium and large networks when compared with other protocols for Random, Grid and Markov models. DSDV gives the best performance.
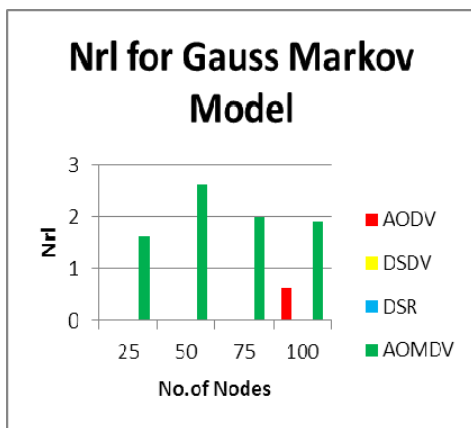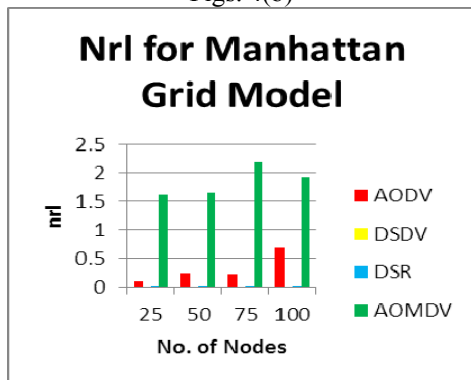

Figs. 4(a)
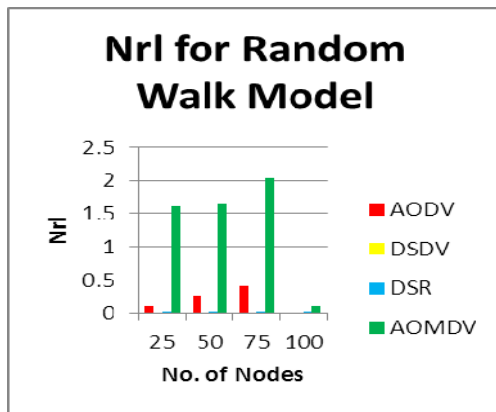
Figs. 4(b)

Fig. 4(c)

V. PROTOCOL SELECTION

The performance evaluation of routing protocols under various mobility models provides a basis for selection of MANET protocols to meet specific network scenarios. Table 1 presents the matrix of guidelines as a result of our investigation. We define some selection criteria for selection of protocol. Firstly, we choose a routing protocol if it performs in a right way in any of the two performance parameters for a given mobility model; e.g. Delay/NRL or NRL/PDR, etc. Such protocols are used to be selected for the particular MANET scenario. The results presented in Table 1 indicate that AODV/DSDV has a higher performance under GAUSS MARKOV model for small networks. Consequently, we may choose AODV/DSDV for small networks with GAUSS MARKOV as the mobility model. Similarly, large DSDV networks with MANHATTAN GRID as mobility model perform better. Now we have to select a particular protocol according to our selection of the network performance parameters. After that we select a routing

protocol if it outperforms in any two mobility models for a single performance parameter, e.g. Delay in RW/MG or NRL in GM/MG, etc. These protocols are our second best candidates. Lastly, we search for the protocols that give the best performance for different parameters under the different mobility models. These types of the protocols are the third best candidates for selection as a routing agent in a MANET. So Lastly DSDV gives best Performance.

VI. CONCLUSION

In this paper, we have analysed the behaviour of MANET routing protocols under three mobility models (Random walk, Manhattan grid, Gauss Markov). We observe that in our scenario the increase in the network size and number of mobile nodes has similar impact on all protocols under various mobility models, i.e. a decrease of the network performance in some models or some give excellent performance. However, the degree of degradation varies for different combinations of protocols and mobility models. From our experimental results, we propose key lines for the selection of routing protocols to meet MANET needs when nodes are subjected in different types of mobility models. MANET protocols generally provide optimum performance for small networks of around 50 nodes in an area of 700 × 700m2. The performance of Random Walk model provides initial view to judge the quality of routing protocols when there is no group movement mobility model. In this research our aim is to develop an understanding of the effects of mobility patterns on routing performance. In future, we study mobility models to determine the MANET protocols which best suited to secure military mobile adhoc networks.

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TABLE I

MOBIITY MODEL	25			50			75			100		
	NRL	AD	PDR	NRL	AD	PDR	NRL	AD	PDR	NRL	AD	PDR
G/M	AODV/DSDV	AODV/DSDV	DSR/AOMDV	AODV/DSDV	DSDV	AODV/DSDV/DSR/AOMDV	AODV/DSDV	DSDV	AODV/DSDV/DSR/AOMDV	DSDV	DSR	DSDV/DSR/AOMDV
MG	DSDV	DSDV/DSR	AODV/DSR/DSDV/AOMDV	DSDV	DSDV	AODV/DSDV/DSR/AOMDV	DSDV	DSDV	AODV/DSDV/DSR/AOMDV	DSDV	DSDV	DSR
RW	DSDV	DSDV/DSR DSDV	DSDV/DSR/AOMDV DSDV	DSDV	DSDV	AODV/DSDV/DSR/AOMDV	DSDV	DSR	AODV/DSDV/DSR/AOMDV	AODV/DSDV	DSDV/DSR	DSDV/DSR/AOMDV