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Analysis of Prominent Reactive Routing Protocols using Self Created Network Scenario

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Abstract — **Mobile Adhoc Network is characterized by multi-hop wireless connectivity and dynamic topology. The mobile nodes in this network communicate with each other without established infrastructure. Since the wireless links are highly error prone and can go down frequently due to mobility of nodes, therefore, routing in MANET is a critical task due to highly dynamic environment. In this research paper, pattern analysis of two on-demand routing protocols has been done by presenting their functionality. A simulation model with TCP and UDP connections has been developed to study inter-layer interactions and their performance implications. The performance differential parameters have been analyzed using metrics like PDR with varying speed and pause time. Based on the simulation results, recommendations have been made about the significance of either protocol in various situations. The study reveals that DSR protocol outperforms AODV protocol under low as well as high mobility situation in case of UDP as well as TCP connections. AODV protocol also starts performing well under high mobility situation. DSR protocol outperforms AODV protocol when the connections are through UDP and this analysis is independent of pause time. AODV protocol outperforms the DSR protocol when the connections are through TCP and the pause time is increased up to a large extent.**

Key Words—**MANET, DSR, AODV, Routing, Mobility Patterns**

I. Introduction

The wireless networks are classified as Infrastructured or Infrastructure less. In Infrastructured wireless networks, the mobile node can move while communicating, the base stations are fixed and as the node goes out of the range of a base station, it gets into the range of another base station. In Infrastructureless or Ad Hoc wireless network, the mobile node can move while communicating, there are no fixed base stations and all the nodes in the network act as routers. The mobile nodes in the Ad Hoc network dynamically establish routing among themselves to form their own network 'on the fly'. A Mobile Ad Hoc Network is a collection of wireless mobile nodes forming a temporary network without any fixed infrastructure where all nodes are free to move about arbitrarily and where all the nodes configure themselves. In this network, each node acts both as a router and as a host & even the topology of network may also change rapidly. Some of the key challenges in the area of MANET include stable unicast/multicast routing, dynamic network topology, network overhead, scalability, security and power aware routing. In this research paper, intend is to study the mobility patterns of two prominent MANET routing protocols i.e. DSR and AODV using simulation modeling over varying number of UDP/TCP connections.

II. Description of Routing Protocols

A routing protocol is needed whenever a packet needs to be transmitted to a destination via number of nodes and numerous routing protocols have been proposed for such kind of ad hoc networks. These protocols find a route for packet delivery and deliver the packet to the correct destination. The studies on various aspects of routing protocols [1, 2] have been an active area of research for many years. Many protocols have been suggested keeping applications and type of network in view. Basically, routing protocols can be broadly classified into two types as: Table Driven Protocols or Proactive Protocols and On-Demand Protocols or Reactive Protocols. In Table Driven routing protocols each node maintains one or more tables containing routing information to every other node in the network. All nodes keep on updating these tables to maintain latest view of the network. Some of the existing table driven protocols are DSDV [4], GSR [8], WRP [7] and ZRP [10]. In on-demand routing protocols, routes are created as and when required. When a transmission occurs from source to destination, it invokes the route discovery procedure. The route remains valid till destination is achieved or until the route is no longer needed. Some of the existing on demand routing protocols are: DSR [5], AODV [3] and TORA [9]. The emphasis in this research paper is concentrated on the study of mobility pattern and performance analysis of two prominent on-demand routing Protocols i.e. DSR and AODV. Surveys of routing protocols for ad hoc networks have been discussed in [11, 12, 13]. A brief review of DSR and AODV is presented here as these have been compared for their performance.

A. Dynamic State Routing (DSR)

DSR [5] is an Ad Hoc routing protocol which is source-initiated rather than hop-by-hop and is based on the theory of source-based routing rather than table-based. This is particularly designed for use in multi hop wireless ad hoc networks of mobile nodes. Basically, DSR protocol does not need any existing network infrastructure or administration and this allows the Network to be completely self-organizing and self-configuring. This Protocol is composed of two essential parts of route discovery and route maintenance. Every node maintains a cache to store recently discovered paths. When a node desires to send a packet to some node, it first checks its entry in the cache. If it is there, then it uses that path to transmit the packet and also attach its source address on the packet. If it is not there in the cache or the entry in cache is expired (because of long time idle), the sender broadcasts a route request packet to all of its neighbors asking for a path to the destination. The sender will be waiting till the route is discovered. During waiting time, the sender can perform other tasks such as sending/forwarding other packets. As the route request packet arrives to any of the nodes, they check from their neighbor or from their caches whether the destination asked is known or unknown. If route information is known, they send back a route reply packet to the destination otherwise they broadcast the same route request packet. When the route is discovered, the required packets will be transmitted by the sender on the discovered route. Also an entry in the cache will be inserted for the future use. The node will also maintain the age information of the entry so as to know whether the cache is fresh or not. When a data packet is received by any intermediate node, it first checks whether the packet is meant for itself or not. If it is meant for itself (i.e. the intermediate node is the destination), the packet is received otherwise the same will be forwarded using the path attached on the data packet. Since in Ad hoc network, any link might fail anytime. Therefore, route maintenance process will constantly monitors and will also notify the nodes if there is any failure in the path. Consequently, the nodes will change the entries of their route cache.

B. Ad hoc On Demand Distance Vector Routing (ADOV)

AODV [3] is a variation of Destination-Sequenced Distance-Vector (DSDV) routing protocol which is collectively based on DSDV and DSR. It aims to minimize the requirement of system-wide broadcasts to its extreme. It does not maintain routes from every node to every other node in the network rather they are discovered as and when needed & are maintained only as long as they are required. The key steps of algorithm used by AODV for establishment of unicast routes are explained below.

Route Discovery:

When a node wants to send a data packet to a destination node, the entries in route table are checked to ensure whether there is a current route to that destination node or not. If it is there, the data packet is forwarded to the appropriate next hop toward the destination. If it is not there, the route discovery process is initiated. AODV initiates a route discovery process using Route Request (RREQ) and Route Reply (RREP). The source node will create a RREQ packet containing its IP address, its current sequence number, the destination's IP address, the destination's last sequence number and broadcast ID. The broadcast ID is incremented each time the source node initiates RREQ. Basically, the sequence numbers are used to determine the timeliness of each data packet and the broadcast ID & the IP address together form a unique identifier for RREQ so as to uniquely identify each request. The requests are sent using RREQ message and the information in connection with creation of a route is sent back in RREP message. The source node broadcasts the RREQ packet to its neighbours and then sets a timer to wait for a reply. To process the RREQ, the node sets up a reverse route entry for the source node in its route table. This helps to know how to forward a RREP to the source. Basically a lifetime is associated with the reverse route entry and if this entry is not used within this lifetime, the route information is deleted. If the RREQ is lost during transmission, the source node is allowed to broadcast again using route discovery mechanism.

Setting up of Forward Path:

When the destination node or an intermediate node with a route to the destination receives the RREQ, it creates the RREP and unicast the same towards the source node using the node from which it received the RREQ as the next hop. When RREP is routed back along the reverse path and received by an intermediate node, it sets up a forward path entry to the destination in its routing table. When the RREP reaches the source node, it means a route from source to the destination has been established and the source node can begin the data transmission.

Route Maintenance:

A route discovered between a source node and destination node is maintained as long as needed by the source node. Since there is movement of nodes in mobile ad hoc network and if the source node moves during an active session, it can reinitiate route discovery mechanism to establish a new route to destination. Conversely, if the destination node or some intermediate node moves, the node upstream of the break initiates Route Error (RERR) message to the affected active upstream neighbors/nodes. Consequently, these nodes propagate the RERR to their predecessor nodes. This process continues until the source node is reached. When RERR is received by the source node, it can either stop sending the data or reinitiate the route discovery mechanism by sending a new RREQ message if the route is still required.

III. Critique of DSR and AODV

These two prominent on-demand routing protocols share certain salient characteristics. Specifically, they both discover routes only in the presence of data packets in the need for a route to a destination. Route discovery in either protocol is based on query and reply cycles and route information is stored in all intermediate nodes on the route in the form of route table entries (AODV) or in route caches (DSR). However, there are several important differences in the dynamics of these two protocols, which may give rise to significant performance differentials. The important differences are given below in the form of advantages and drawbacks of these protocols. These differences help in studying the mobility pattern and performance analysis of either protocol.

A. Advantages and Drawbacks of DSR

The advantages of DSR protocol are as under:

a. DSR uses no periodic routing messages (e.g. no router advertisements and no link-level neighbor status messages), thereby reducing network bandwidth overhead, conserving battery power, and avoiding the propagation of potentially large routing updates throughout the ad hoc network.
b. There is no need to keep routing table so as to route a given data packet as the entire route is contained in the packet header.
c. The routes are maintained only between nodes that need to communicate. This reduces overhead of route maintenance.
d. Route caching can further reduce route discovery overhead. A single route discovery may yield many routes to the destination, due to intermediate nodes replying from local caches
e. The DSR protocol guarantees loop-free routing and very rapid recovery when routes in the network change.
f. It is able to adapt quickly to changes such as host movement, yet requires no routing protocol overhead during periods in which no such changes occur.
g. In addition, DSR has been designed to compute correct routes in the presence of asymmetric (uni-directional) links. In wireless networks, links may at times operate asymmetrically due to sources of interference, differing radio or antenna capabilities, or the intentional use of asymmetric communication technology such as satellites. Due to the existence of asymmetric links, traditional link-state or distance vector protocols may compute routes that do not work. DSR, however, will find a correct route even in the presence of asymmetric links.

The drawbacks of this protocol are given as below:

a. The DSR protocol is mainly efficient for mobile ad hoc networks with less than two hundred nodes. This is not scalable to large networks.
b. DSR requires significantly more processing resources than most other protocols. In order to obtain the routing information, each node must spend lot of time to process any control data it receives, even if it is not the intended recipient.
c. The contention is increased if too many route replies come back due to nodes replying using their local cache. The Route Reply Storm problem is there.
d. An intermediate node may send Route Reply using a stale cached route, thus polluting other caches. This problem can be eased if some mechanism to purge (potentially) invalid cached routes is incorporated.
e. The Route Maintenance protocol does not locally repair a broken link. The broken link is only communicated to the initiator.
f. Packet header size grows with route length due to source routing.
g. Flood of route requests may potentially reach all nodes in the network. Care must be taken to avoid collisions between route requests propagated by neighboring nodes.

B. Advantages and Drawbacks of AODV

The advantages of AODV protocol are summarized below:

a. The routes are established on demand and destination sequence numbers are used to find the latest route to the destination. The connection setup delay is lower.
b. It also responds very quickly to the topological changes that affects the active routes.
c. It does not put any additional overheads on data packets as it does not make use of source routing.
d. It favors the least congested route instead of the shortest route and it also supports both unicast and multicast packet transmissions even for nodes in constant movement.

The drawbacks of AODV protocol are mentioned as under:

a. The intermediate nodes can lead to inconsistent routes if the source sequence number is very old and the intermediate nodes have a higher but not the latest destination sequence number, thereby having stale entries.
b. The various performance metrics begin decreasing as the network size grows.
c. It is vulnerable to various kinds of attacks as it based on the assumption that all nodes must cooperate and without their cooperation no route can be established.
d. The multiple Route Reply packets in response to a single Route Request packet can lead to heavy control overhead. The periodic beaconing leads to unnecessary bandwidth consumption.
e. It expects/requires that the nodes in the broadcast medium can detect each others' broadcasts. It is also possible that a valid route is expired and the determination of a reasonable expiry time is difficult. The reason behind this is that the nodes are mobile and their sending rates may differ widely and can change dynamically from node to node.

IV. MOBILITY METRICS

There are number of qualitative and quantitative mobility metrics that can be used to study the mobility pattern of reactive routing protocols viz. packet delivery ratio, average end to end delay, protocol control overhead etc.

Packet Delivery Ratio: This is the ratio of number of packets received at the destination to the number of packets sent from the source. In other words, fraction of successfully received packets, which survive while finding their destination, is called as packet delivery ratio.

Average end-to-end delay: This is the average time delay for data packets from the source node to the destination node.

Protocol Control Overhead:

This is the ratio of the number of protocol control packets transmitted to the number of data packets received.

Most of the existing routing protocols ensure the qualitative metrics. Therefore, we have used the packet delivery ratio as quantitative metrics for analyzing the mobility pattern and performance of aforementioned routing protocols. This performance metric determines the completeness and correctness of the routing protocol.

V. SIMULATION AND RESULTS

An extensive simulation model having scenario of 10 and 20 mobile nodes & 6 UDP/TCP connections is used to study inter-layer interactions and their performance implications. The Simulator used is NS 2.34. Area considered is 670 × 670 for 10 nodes and 750 × 750 for 20 nodes. Simulation run time is 500 seconds and speed has been varied from 1m/s to 10 m/s. Pause time varies 100 to 500s. Packet size is 512 bytes and transferring rate is 5mbps. It has been shown that even though DSR and AODV share a similar on-demand behavior, the differences in the protocol mechanics can lead to significant performance differentials. The performance differentials are analyzed using packet delivery ratio with respect to varying mobility (1m/s to 10m/s) and pause time (100s to 500s). All simulation parameters have been summarized in table I and the simulation results achieved for DSR & AODV have been shown in tables II to V.

Table I: Simulation Parameters

Simulation Software	NS-2.34	
Channel	Wireless	
Mobility Model	Random Waypoint	
Data Rate	5 mbps	
Protocols	DSR & AODV	
Packet size	512 byte	
Transmission Range	200 meter	
Traffic Agents	UDP & TCP	
Number of Nodes	10	20
Simulation Time (seconds)	500	500
Area	670 × 670	750 × 750
Speed (meter/second)	1 to 10	1 to 10
Pause time (seconds)	100 to 500	100 to 500

Table II: Simulation results for 10 nodes using UDP traffic agents

Speed	**AODV PDR**	**DSR PDR**
1	99.66384462	99.51142907
2	99.54763172	99.71293482
5	99.47630604	99.58622973
7	99.36062953	99.65168353
10	99.29368555	99.33289945
Pause Time		
100	99.62461456	99.63284379
200	99.39363315	99.31845289
300	99.59155888	99.545534
400	99.47368421	99.64009358
500	99.94922139	99.88954345

Table III: Simulation results for 10 nodes using TCP traffic agents

Speed	**AODV PDR**	**DSR PDR**
1	98.01840108	98.12675881
2	97.93248365	97.9997542
5	97.6920632	97.63234916
7	97.71369527	97.92583952
10	97.86011127	97.61684509
Pause Time		
100	97.8364253	97.74565509
200	97.80237588	97.75802491
300	97.84248958	97.96954691
400	97.73268402	98.00208903
500	97.74031744	97.96540297

Table IV: Simulation results for 20 nodes using UDP traffic agents

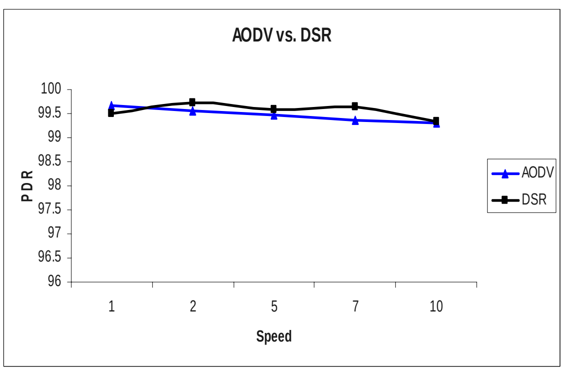
Speed	**AODV PDR**	**DSR PDR**
1	96.92606133	98.73966662
2	97.78203009	97.67538976
5	96.81619804	98.29201935
7	97.05522411	97.72044772
10	96.83212579	97.57567457
Pause Time		
100	95.09536785	98.23247454
200	96.33355504	98.07166717
300	95.49640047	98.0450679
400	95.63781211	98.30821286
500	96.39348501	98.94440535

Table V: Simulation results for 20 nodes using TCP traffic agents

Speed	**AODV PDR**	**DSR PDR**
1	97.87038953	97.9209172
2	97.81623725	98.11152594
5	98.07724403	98.20177856
7	97.97607728	98.47331203
10	97.9366073	98.09939394
Pause Time		
100	97.64535029	98.34741336
200	97.44134538	97.83622122
300	97.37866771	97.62207226
400	97.46199836	97.41166291
500	97.47999878	97.23100278

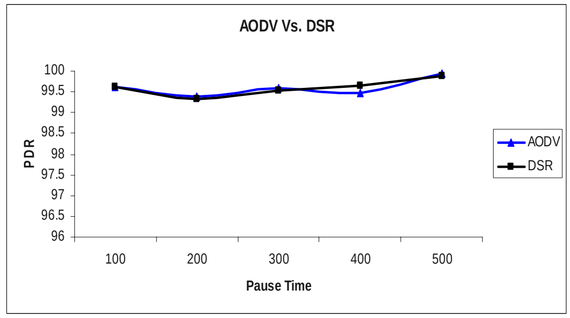
A. Mobility pattern for 10 nodes using UDP

Graph 1 shows the packet delivery ratio using speed as a parameter. This performance metric has been evaluated for DSR and AODV using 10 nodes and 6 UDP connections. Speed has been varied from 1m/s to 10 m/s. The PDR values, computed using received and dropped packets, range from 99.29% to 99.71%. The results show that only at one point of time, DSR and AODV gives same PDR value (approx.), otherwise, DSR protocol outperforms AODV in "low mobility" situation.



Graph 1: Movement of 10 nodes with 6 UDP connections (PDR w.r.t. Speed)

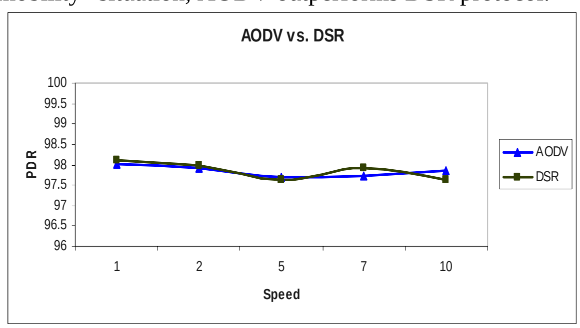
In graph 2, the packet delivery ratio has been evaluated for DSR and AODV protocols using pause time as parameter with same number of nodes and UDP connections. Pause time has been varied from 100 to 500. Pause time of 0 means very fast moving nodes and 500 shows minimum movement. The PDR values, computed using received and dropped packets, range from 99.31% to 99.94%. In this scenario, the observation is that the DSR and AODV protocol gives approximately same PDR values when pause time ranges from 100 to 300, DSR outperforms AODV when pause time is between 300 and 500 & AODV outperforms DSR when pause time is more than 500.



Graph 2: Movement of 10 nodes with 6 UDP connections (PDR w.r.t. Pause Time)

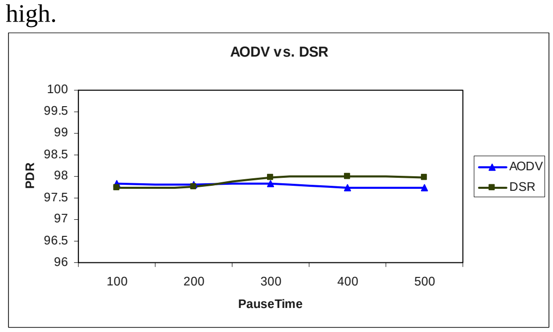
B. Mobility pattern for 10 nodes using TCP

Graph 3 depicts the packet delivery ratio using speed as a parameter for DSR and AODV protocols. The results are on the basis of 10 mobile nodes and 6 TCP connections. Speed variation is from 1m/s to 10 m/s. The PDR values, computed using received and dropped packets, range from 97.61% to 98.12%. The results show that in "low mobility" situation, AODV protocol gives approximately same PDR value as that of DSR protocol but in "high mobility" situation, AODV outperforms DSR protocol.



Graph 3: Movement of 10 nodes with 6 TCP connections (PDR w.r.t. Speed)

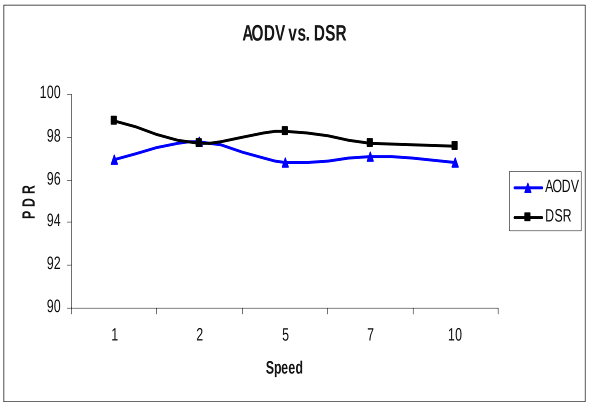
In graph 4, the packet delivery ratio has been evaluated using pause time as a parameter on 10 mobile nodes having 6 TCP connections. Pause time varies 0 to 500. The PDR values, computed using received and dropped packets, range from 97.74% to 98%. The observation is that the AODV protocol outperforms DSR when pause time is less but DSR outperforms AODV when pause time is high.



Graph 4: Movement of 20 nodes with 6 TCP connections (PDR w.r.t. Pause Time)

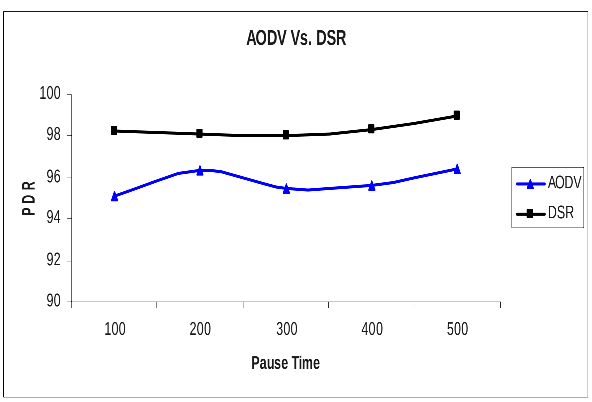
C. Mobility pattern for 20 nodes using UDP

Graph 5 shows the packet delivery ratio using speed as a parameter. This performance metric has been evaluated for DSR and AODV using 20 nodes and 6 UDP connections. Speed has been varied from 1m/s to 10 m/s. The PDR values, computed using received and dropped packets, range from 96.92% to 98.74%. The results show that only at one point of time, DSR and AODV gives same PDR value (approx.), otherwise, DSR protocol outperforms AODV in "low mobility" situation.



Graph 5: Movement of 20 nodes with 6 UDP connections (PDR w.r.t. Speed)

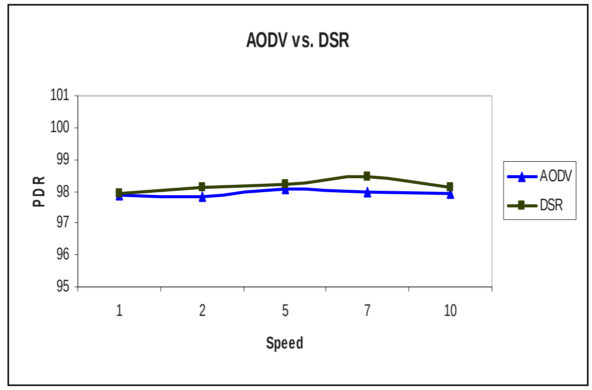
In graph 6, the packet delivery ratio has been evaluated for DSR and AODV protocols using pause time as parameter with same number of nodes and UDP connections. Pause time has been varied from 0 to 500. Pause time of 0 means very fast moving nodes and 500 shows minimum movement. The PDR values, computed using received and dropped packets, range from 95.09% to 98.94%. In this scenario, the observation is that the DSR protocol outperforms AODV in all the situations.



Graph 6: Movement of 20 nodes with 6 UDP connections (PDR w.r.t. Pause Time)

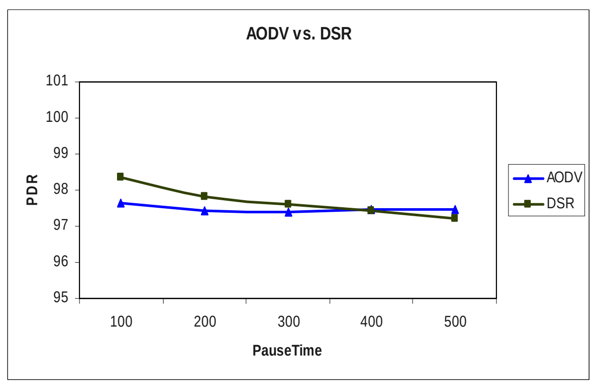
D. Mobility pattern for 20 nodes using TCP

Graph 7 depicts the packet delivery ratio using speed as a parameter for DSR and AODV protocols. The results are on the basis of 20 mobile nodes and 6 TCP connections. Speed variation is from 1m/s to 10 m/s. The PDR values, computed using received and dropped packets, range from 97.81% to 98.47%. The results show that in "low mobility" situation, AODV protocol gives same PDR value (approx.) as that of DSR protocol in the beginning, intermediate and end stage only otherwise, DSR protocol outperforms AODV. On the other hand, AODV outperforms DSR protocol in "high mobility" situation.



Graph 7: Movement of 20 nodes with 6 TCP connections (PDR w.r.t. Speed)

In graph 8, the packet delivery ratio has been evaluated using pause time as a parameter on 20 mobile nodes having 6 TCP connections. Pause time varies 0 to 500. The PDR values, computed using received and dropped packets, range from 97.23% to 98.34%. The observation is that the DSR protocol outperforms AODV when pause time is less but AODV outperforms DSR when pause time is high.



Graph 8: Movement of 20 nodes with 6 TCP connections (PDR w.r.t. Pause Time)

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VI. CONCLUSION

In this paper, an effort has been made to concentrate on the comparative study and performance analysis of two prominent on demand routing protocols i.e. DSR and AODV on the basis of packet delivery ratio for 10 and 20 mobile nodes having varying number of UDP and TCP connections. The earlier work by researchers has been taken into consideration. An effort has been made to perform analysis on a new random way point self created network scenario. The results after analysis have been reflected in graphs. The mobility factor taken here is from 1m/s to 10m/s. The study reveals that DSR protocol outperforms AODV protocol under low as well as high mobility situation in case of UDP as well as TCP connections. AODV protocol also starts performing well under high mobility situation. DSR protocol outperforms AODV protocol when the connections are through UDP and this analysis is independent of pause time. AODV protocol outperforms the DSR protocol when the connections are through TCP and the pause time is increased up to a large extent.

VII. FUTURE SCOPE

The effect of increasing number of nodes on the network performance is under consideration with varying number of connections. Efforts are to test more performance metrics with denser mediums and using more TCP/UDP connections. Also the network performance for real time traffic has not been checked. Therefore, intend is to focus on this issue. Apart from this, performance analysis of other routing protocols such as TORA and ZRP & measurement of energy consumption and processing costs will be done in future work.

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