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PERFORMANCE EVALUATION OF DSDV IN HYBRID WIRELESS MESH NETWORK

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Abstract

Wireless Mesh Network (WMN) is a new wireless technology and it has the features of large area network coverage, Internet broadband access, self-healing, self-configuring and self-organizing. Routing is an important research issue in WMN. Many routing protocols are available in WMN. These protocols are divided into two categories proactive (Table Driven) and reactive (On-demand) protocols. This paper discusses the performance of proactive routing protocol Destination Sequenced Distance Vector (DSDV) in WMN by considering the various performance metrics (packet delivery ratio, routing overhead and dropped packets) by varying transmission rate and mesh client speed.

Keywords:

WMN, DSDV, Hybrid WMN, Mesh Router, Mesh Client

1. INTRODUCTION

Wireless Mesh Network is a new emerging technology in the wireless network world. It has the sophisticated features such as low deployment cost, easy network maintenance, robustness, resilent, wide area coverage, self-healing, self-configuring and self-organizing. Because of these features WMN is primarily appropriate for impenetrable areas, difficult to create wired network buildings or areas, disaster recovery etc. The various applications of WMN are Home Automation, Industrial Plant Monitoring (IPM), Automated Meter Reading, Defense and National Security, Healthcare, Industries and Office Management etc [1].

Wireless Mesh Network is a communication network made up of radio nodes arranged in mesh topology. In mesh topology all nodes are connected to more than one node in the network. Wireless Mesh Networks often consists of mesh clients, mesh routers and gateways. The mesh clients are often laptops, cell phones and other wireless devices. The mesh routers forward traffic to and from the gateways. The gateways may or may not connect to the Internet. The topology in the mesh network is changed frequently because the mobile nodes are dynamically connected with one another. The coverage area of the radio nodes working as a single network is sometimes called a mesh cloud. Access to this mesh cloud is dependent on the radio nodes working in harmony with each other to create a radio network.

Depending upon the deployment configuration, WMNs can be categorized into the following three types [2], [6]: Infrastructure, Client and Hybrid WMNs.

In Infrastructure WMNs, the Mesh Routers (MR) provides an end-to-end connectivity to Mesh Clients (MC) and also forms a high bandwidth wireless multi-hop backbone. Infrastructure WMN consists of static Mesh Routers. In this type of architecture, Mesh Clients can communicate with each other via the Mesh Routers, though, they never have to perform the routing or forwarding functions. This essentially requires Mesh Clients to have a single-hop path to at least one Mesh Router at all times.

Client WMN is simply another name for a mobile ad-hoc network [9]. An important characteristic of this type of WMN is that the network consists entirely of mobile client devices without a wireless backbone. The Mesh Clients in a client WMN assume the responsibility of Mesh Routers to route and forward packets from one client to another and expand the overall range of the network beyond the physical single-hop range of individual nodes.

Hybrid WMN [3] is an attractive version of WMN. As the name implies it is a combination of Infrastructure and Client WMN. Mesh Routers form a Mesh backbone infrastructure while Mesh Clients involve in the routing and forwarding of packets. Different type of communications can be established in Hybrid WMN. Mesh Clients within a network communicate directly. The mesh clients in one client mesh can communicate with mesh clients in another network through Mesh Routers. Mesh Clients communicate with Mesh Routers by discovering the appropriate mesh router to gain access to infrastructure part of the network. Mesh Router to Wired Network communication is through traditional or ad-hoc routing protocols.

Various protocols are available in the ad-hoc network and these are broadly categorized into two categories [6] proactive (table-driven) and reactive (on-demand) protocols. In proactive protocols, each node maintains a routing table, which contains routes to all other nodes in the network. The routes are computed and stored, even when they are not needed. It leads to the considerable overhead and bandwidth consumption due to the number of messages that have to be exchanged to keep up-to-date routing information. Destination Sequenced Distance Vector (DSDV) routing protocol is an example for proactive routing protocol [7].

Reactive routing protocols [6] only compute routes when they are needed. The process of finding a suitable route requires the transmission of route requests and the wait for route replies with a path to the destination. Due to this delay for finding a route, this approach is not suitable for operations that require immediate route availability. Ad-hoc On Demand Distance Vector (AODV) [8] routing protocol is an example for reactive routing protocol.

Many researchers have analyzed various routing protocols in MANET, Ad-hoc and Hybrid WMN. In 2001, Charles et al [13] compared the performance of DSR and AODV for ad-hoc networks. The application-oriented metrics such as delay and throughput were considered for analysis. DSR outperforms AODV in smaller number of nodes and lower load and/or mobility. AODV outperforms DSR in more stressful situations with widening performance gaps with an increasing load and higher mobility. It has been found that DSR always produced less routing load than AODV. In 2006, Asad et al [3] performed a comparison of AOMDV and DSR-MP, a multipath variant of AODV and DSR. The metrics such as packet loss, Latency and path optimality had been analyzed. The Comparison indicated that the MESH-ROUTERS helped the routing protocols to reduce packet loss, improve packet delivery ratio and lower latency of the network. In the same year, Peizhao et al [4] analyzed the AODV protocol in Hybrid WMN and evaluated the performance by varying speed and traffic load. In this paper, a packet delivery rate of 90% and above with a latency of almost 10ms and the packet injection rate 1 Mbps had been achieved in Hybrid WMN. In 2007, Saad Khan et al [16] studied and compared the four variants of the AODV protocol, which can be used to establish a hybrid wireless mesh network. All the four protocols have their own merits and demerits. However, a common problem in most of the protocols is their inability to use the wide frequency spectrum presented by the Mesh Routers. This generally results in irregular operation of the channels, which causes higher contention for the wireless medium, thereby, causing severe packet losses and increased latency. According to the author, in addition to effective channel diversity, improved routing metrics the path length, link capacity, packet loss ratio and interference in the network are to be considered. In 2009, Abdul et al [10] measured the performance of the AODV, DSDV and I-DSDV routing protocols with metrics Packet Delivery Fraction, End to End Delay and Routing Overhead in the following scenarios: pause time, number of nodes and node speed. The results indicated that the performance of I-DSDV is superior to regular DSDV. It has been observed that I-DSDV is better than AODV protocol in Packet Delivery Fraction but in End to End Delay and Routing Overhead it is not so. In 2010, Anuj et al [5] evaluated the performance of ad-hoc routing protocols DSR, AODV and TORA in MANET. It has been observed that the AODV had the best performance than DSR and TORA. In the same year, S.S. Tyagi et al [11] compared AODV, DSR and DSDV using NS2. DSDV is selected as representative of proactive routing protocol while AODV and DSR as the representative of reactive routing protocols. It has been proved that AODV and DSR are better than DSDV. In 2011, Vijay et al [14] evaluated the performance of AODV and DSR routing protocols in MANET. The simulated experiment has shown that AODV has the overall best performance. In the same year, Priti et al [15] analyzed both DSR and TORA routing protocols on various mobility, packet size and time interval metrics. The performance metrics considered are routing load, average delay, packet delivery ratio and throughput. The results indicated that the performance of TORA protocol at mobility variation of nodes has better throughput, packet delivery ratio and routing load than DSR protocol. But average delay of DSR is less as compared to TORA.

The rest of the paper is organized as follows. Section II deals with the architecture of WMN, Section III deals with an overview of DSDV protocol. Section IV deals with Simulation Environment and Section V deals with simulation results. Section VI concludes the paper.

2. ARCHITECTURE OF WIRELESS MESH NETWORK

Wireless Mesh Network consists of Mesh clients and Mesh Routers and Gateway. Mesh clients are mobile devices such as cell phones, laptops, PDA etc which usually run on batteries, and mesh routers and gateways are static nodes. Static mesh routers form the wireless backbone. Mesh clients access the network through mesh routers as well as directly connecting with each other. The gateway is also a mesh router with a high bandwidth wired connection to the Internet. Fig.1 shows the architecture of Hybrid Wireless Mesh Network.

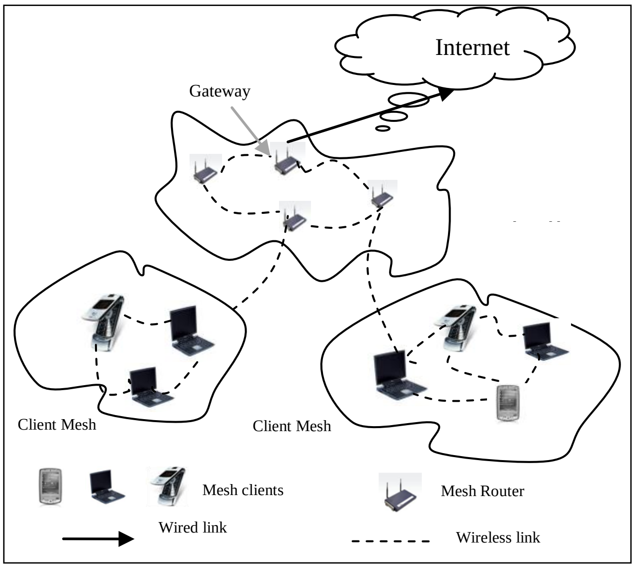

Fig.1. Hybrid Wireless Mesh network

The mesh backbone connected to Internet through Gateway is a wired connection whereas the other connections such as Mesh Client to Mesh Routers in the network are wireless connections. The Mesh Routers are connected to each other to share its information. The Internet connection is an optional one. The Mesh Client and Mesh Routers are connected in a multihop fashion. Each Mesh Router and Mesh Client are connected to more than one Mesh Router and Mesh Client, so that if a mesh router or mesh client in the network fails, it automatically finds an alternate path for sending data to the destination.

3. OVERVIEW of DSDV PROTOCOL

3.1 DESTINATION SEQUENCED DISTANCE VECTOR (DSDV)

DSDV [7], [12] is a table-driven or proactive routing scheme for ad-hoc mobile networks based on the Bellman-Ford algorithm. The main purpose of the algorithm was to solve the routing loop problem. Every node in this protocol maintains a routing table which contains next hop entry and number of hops needed for all reachable destinations from that node. Each route table entry is attached with a sequence number. If a link is present then the sequence numbers are even number otherwise it is an odd number. The number is generated by the destination. The emitter needs to send out the next update with this number. The updates are done periodically to maintain the consistency in the dynamic environment. The list entries may be changed frequently. The advertisement must be made at regular intervals to each of its current neighbour nodes.

Routing information is distributed between nodes by sending full dumps occasionally and smaller incremental updates more regularly.

When a mobile node receives new routing information, either ‘Full Dump’ or ‘incremental’, that information is compared with the information already available from previous routing information packets. The route with the recent sequence number is considered for next transmission of packets and routes with older sequence number is discarded. If more than one route having the same sequence number then the route with the best metric is considered for the next transmission of packets. Each update entry contains the destination node IP address, destination node sequence number and hop count. After the update is performed, each update is broadcasted in the network. In response to the topology changes, mobile nodes may cause broken links and these broken links may be detected by layer-2 protocol.

DSDV was one of the early algorithms available. It is quite suitable for creating ad-hoc networks with small number of nodes. DSDV [10] guarantees for loop free path. DSDV requires a regular update of its routing tables, which uses up battery power and a small amount of bandwidth even when the network is idle.

4. SIMULATION

The Simulations are performed using Network Simulator 2 (NS-2) [17]. For the purpose of the performance evaluation of DSDV protocol in hybrid WMN, a network with 3 Mesh Clients and 4 Mesh Routers have been created. The layout is shown in Fig.2. The mesh clients and mesh routers are placed in an area of 1000 x 800 meters. Mesh routers are placed statically so that it helps the mesh clients in establishing reliable connections to the network. The dotted lines show the wireless connections between the mesh clients and mesh routers. Initially the three mesh clients MN1, MN2 and MN3 are placed at fixed position and connected to MR1, MR2 and MR3 respectively. During simulation, the mesh clients moves and connects it to different mesh routers automatically. Two CBR connections that are established from MN1 to MR3 and MR4 to MR2 are demonstrated below.

For the first CBR connection, the packets are transferred from MN1 → MR1 → MR3 and then MN1 is moved to the area of MR2. After movement, the path is changed to MN1→MR2→MR3. For the second CBR connection, the packets are transferred from MR4→MR3→MN1→ MN2, and then MN2 is moved to the area of MR3. After movement, the path is changed to MR4→MR3→MN2.

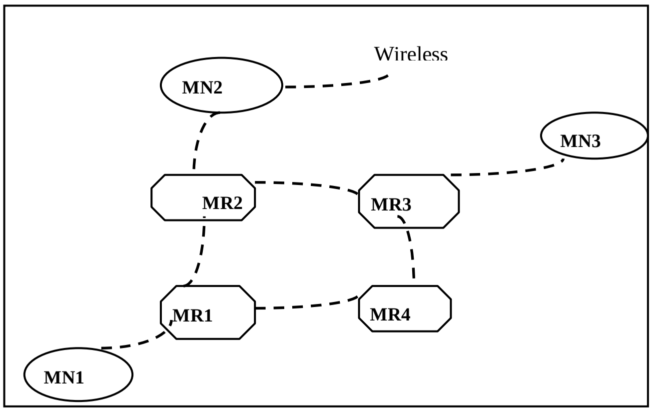

Fig.2. Simulation Layout

The Simulation Layout shown in Fig.2 serves as a basis for evaluating the performance of the DSDV protocol. The following simulation parameters are used for evaluating the performance of DSDV protocol in Hybrid WMN.

The various performance metrics such as packet delivery ratio, average end to end delay, routing overhead, dropped packets, average latency, average throughput, bandwidth, energy consumption etc are used for analyzing the performance of DSDV protocol in hybrid WMN. From the above metrics, this paper considers the packet delivery ratio, routing overhead and dropped packets by varying the mesh client speed and transmission rate for evaluation.

Table.1. Simulation Parameters

Parameter	Value
Simulation	NS-2
Simulation area	1000 x 800m
Simulation time	300 sec
Transmission range	250 m
Mesh client speed	5, 10 ,15, 20, 25 ms
Packet Size	512 bytes
Transmission rate	.016, .032, .064, .128, .256, .512, 1.0 Mbps
Traffic Type	CBR(UDP)

4.1 PERFORMANCE METRICS

4.1.1 Packet Delivery Ratio:

The ratio between the numbers of packets successfully received at the destinations and the total number of packets sent by the sources.

*PDR = received packets/sent packets * 100*

4.1.2 Routing Overhead:

This is the ratio of total numbers of control packets generated to the total number of data packets received during the simulation time.

Routing overhead = data packets received/ control packets generated

4.1.3 Dropped Packets:

This is the number of packets that dropped due to unavailable or incorrect routes.

Dropped packets = sent packets – received packets

5. SIMULATION RESULTS

The performance analysis was conducted in the simulation layout to evaluate the performance of DSDV protocol in Hybrid WMN by varying client speed and transmission rate (traffic load). The simulation results are shown in the form of line graphs. The transmission rates are varied from .016 Mbps to 1.0 Mbps for each client speed such as 5ms, 10ms, 15ms, 20ms and 25ms. Fig.3.1 to 3.3 shows the graph for the metrics packet delivery ratio, routing overhead and dropped packets. The simulation values for the considered performance metrics are given in Appendix A.

5.1 PACKET DELIVERY RATIO (PDR)

Fig.3 shows the performance of DSDV protocol on the basis of packet delivery ratio by varying the transmission rate and client speed. The Packet delivery ratio is 70% to 90% at transmission rates of 0.016 Mbps to 0.256 Mbps for the client speeds varying from 5ms to 25ms. PDR is high at transmission rate of 0.032 Mbps with the client speed of 25ms. From the transmission rate of 0.256 Mbps the PDR deteriorates. The ideal range for transferring data for Hybrid WMN is at the client speed of 5ms to 25ms with the transmission rate not greater than 0.256Mbps.

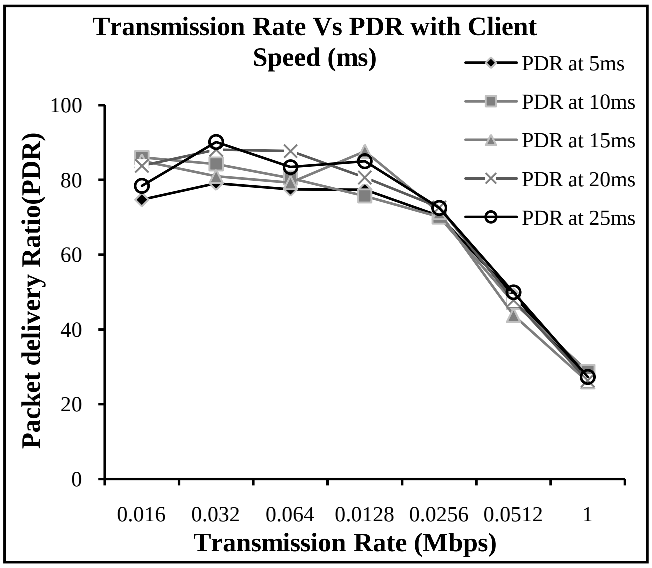

Fig.3. Transmission Rate Vs PDR with Client Speed (ms)

5.2 ROUTING OVERHEAD

Fig.4 shows the performance of DSDV protocol on the basis of routing overhead by varying the transmission rate and client speed. The best result was on routing overhead is at the transmission rate of 0.032 Mbps with the client speed of 15ms. The evaluation does not generate expected results for routing overhead after the transmission rate of 0.256Mbps for the client speeds varying from 5ms to 25ms. At 5ms client speed the routing overhead is high for all transmission rates when compared to other client speed. The ideal range for routing overhead is from the client speed of 10ms to 25ms within the transmission rate of 0.256Mbps.

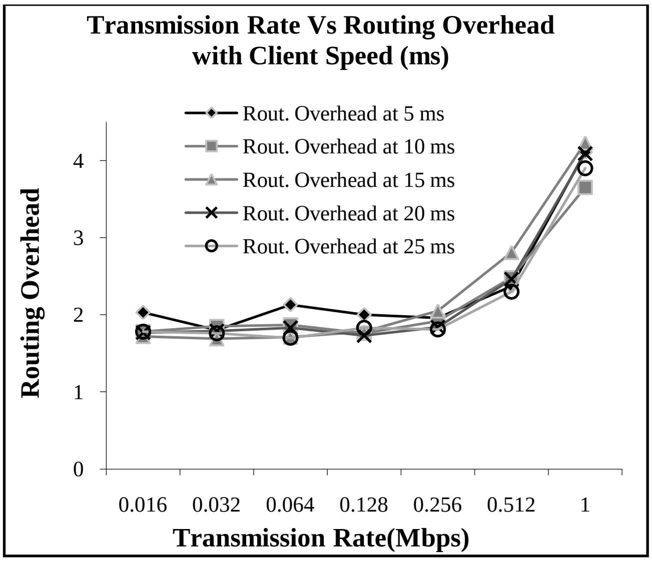

Fig.4. Transmission Rate Vs Routing Overhead with Client Speed (ms)

5.3 DROPPED PACKETS

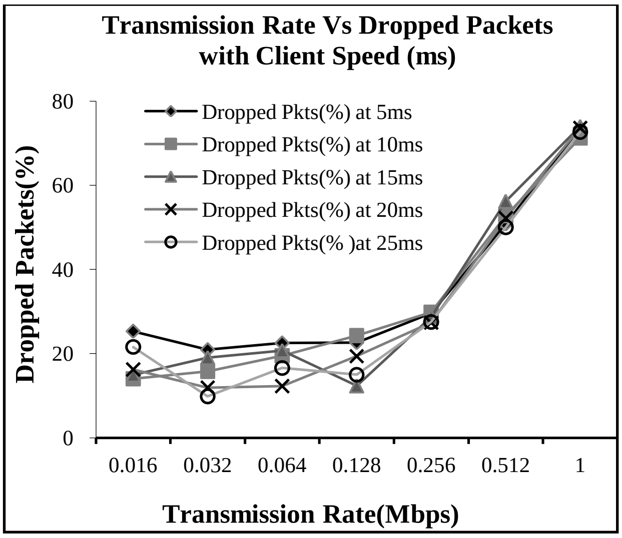

Fig.5. Transmission Rate Vs Dropped Packets with Client Speed (ms)

Of the dropped packets of varying client speed the minimum value is considered for each transmission rate and is represented in the form of graph in Fig.5. From the observed results, acceptable value of 15% packet is dropped, above which the values are unacceptable. The ideal range for reducing the dropped packets is from the transmission rate of 0.016Mbps to 0.256Mbps for the client speeds varying from 5ms to 25ms.

6. CONCLUSION

Hybrid Wireless Mesh Network is a combination of both mobile ad-hoc network and infrastructure mesh network. Hybrid WMNs supports a large amount of communication nodes and routes can be established using mesh routers or mesh clients or both. The DSDV protocol is now being used in mobile ad-hoc networks. In this paper, the performance of DSDV protocol in Hybrid Wireless Mesh Network by considering the performance metrics of packet delivery ratio, routing overhead and dropped packets in varying transmission rate with client speed has been evaluated. The results has been observed and evaluated from the graph indicates that the DSDV protocol provides an average of 80% packet delivery ratio with the minimum routing overhead of 1.79 and with 12% of dropped packets within the transmission range less than 0.128Mbps under the considered ideal performance metrics. In similar line, the performance evaluation of AODV, DSR and other such WMN suitable protocols can be evaluated for various performance metrics.

APPENDIX -A

Performance Metrics Values

Client speed(ms)	5 ms	10 ms	15 ms	20 ms	25 ms	5 ms	10 ms	15 ms	20 ms	25 ms	5 ms	10 ms	15 ms	20 ms	25 ms
Transmission Rate (Mbps)	**PDR (%)**					**Routing Overhead**					**Dropped Packets(%)**				
0.016 Mbps	74.69	85.98	85.09	83.75	78.42	2.03	1.78	1.72	1.77	1.78	25.31	14.02	14.91	16.24	21.58
0.032 Mbps	79.08	84.25	80.97	88.06	90.12	1.8	1.85	1.69	1.79	1.76	20.92	15.74	19.03	11.93	9.87
0.064 Mbps	77.47	80.49	79.28	87.7	83.41	2.13	1.87	1.71	1.83	1.7	22.51	19.50	20.71	12.30	16.58
0.128 Mbps	77.38	75.7	87.68	80.6	85	2	1.76	1.78	1.73	1.83	22.61	24.29	12.32	19.39	14.99
0.256 Mbps	70.36	70.12	71.27	72.63	72.47	1.96	1.92	2.05	1.84	1.81	29.63	29.87	28.72	27.37	27.53
0.512 Mbps	49.18	47.24	43.81	47.81	49.93	2.37	2.48	2.81	2.46	2.3	50.81	52.75	56.18	52.19	50.06
1.0 Mbps	26.36	28.75	26.03	26.35	27.3	4.11	3.65	4.23	4.09	3.9	73.63	71.24	73.97	73.65	72.69

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