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PERFORMANCE EVALUATION OF DSR AND AODV OVER UDP AND TCP CONNECTIONS

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ABSTRACT

Ad hoc networks are characterized by multi-hop wireless connectivity, frequently changing network topology and the need for efficient dynamic routing protocols. The wireless mobile nodes in this network communicate with each other without centralized control or 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 recent years, several routing protocols have been proposed for mobile ad hoc networks and prominent among them are DSR (Dynamic Source Routing) and AODV (Ad hoc On Demand Distance Vector). In this research paper, a comparison of the performance of these two on-demand routing protocols has been done by presenting their functionality. An extensive simulation model having scenario of 20 nodes and 6 TCP/UDP connections has been used to study inter-layer interactions and their performance implications. A demonstration has been made 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 and pause time. Based on the observations, recommendations can be made about the performance of either protocol.

Keywords: Ad hoc Networks, DSR, AODV, Routing, Performance evaluation

1. INTRODUCTION

The wireless network can be classified into two types: 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/short-lived 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 challenges in this network include:

a. Unicast/Multicast routing
b. Dynamic network topology
c. Network overhead
d. Scalability
e. QoS
f. Stable routing
g. Secure routing
h. Power aware routing

The key challenges faced at different layers of Mobile Networks in fig. 1. It represents layered structure and approach to ad hoc networks.

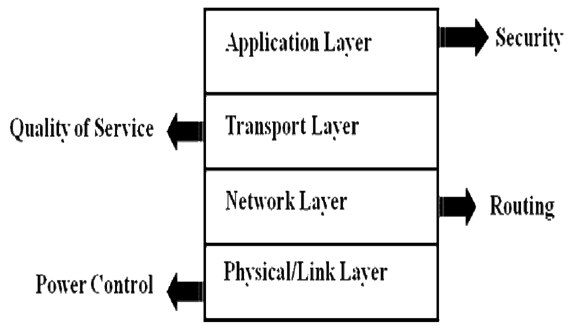


Fig. 1: MANET Challenges

In this research paper, intend is to focus on routing issue over network layer. The performance evaluation of two prominent routing protocols i.e. DSR and AODV is done using a simulated model over UDP and TCP connections.

2. 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 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 [5, 10], DBF [6], GSR [12], WRP [11] and ZRP [15, 9]. 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 [7, 8], AODV [3, 4] and TORA [13, 14]. The emphasis in this research paper is concentrated on the performance analysis of two prominent on-demand routing Protocols i.e. DSR and AODV.

DYNAMIC STATE ROUTING (DSR) [7, 8]

DSR is an Ad Hoc routing protocol which is based on the theory of source-based routing rather than table-based. This protocol is source-initiated rather than hop-by-hop. 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.

2.1.1 Benefits and Limitations:

The benefits of DSR protocol are:

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. 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.

c. 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.

d. The routes are maintained only between nodes that need to communicate. This reduces overhead of route maintenance.

e. 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

f. The DSR protocol guarantees loop-free routing and very rapid recovery when routes in the network change.

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 limitations of this protocol can be summarized as:

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 Route Maintenance protocol does not locally repair a broken link. The broken link is only communicated to the initiator.
d. Packet header size grows with route length due to source routing.
e. 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.
a. 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.
b. 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.

AD HOC ON DEMAND DISTANCE VECTOR ROUTING (ADOV) [3, 4]

AODV 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.

2.2.1 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.

2.2.2 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.

2.2.3 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.

2.2.4 Benefits and Limitations:

The benefits of AODV protocol are as under:

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 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.
c. It also responds very quickly to the topological changes that affects the active routes.
d. It does not put any additional overheads on data packets as it does not make use of source routing.

The limitations of AODV protocol are summarized below:

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 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.
c. 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.
d. The various performance metrics begin decreasing as the network size grows.
e. 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.

3. PERFORMANCE METRICS

There are number of qualitative and quantitative metrics that can be used to compare reactive routing protocols. Most of the existing routing protocols ensure the qualitative metrics. Therefore, we have used the packet delivery ratio as quantitative metrics for analyzing the performance of aforementioned routing protocols. The packet delivery ratio is defined as fraction of successfully received packets, which survive while finding their destination. This performance metric determines the completeness and correctness of the routing protocol.

4. SIMULATION MODEL

An extensive simulation model having scenario of 20 mobile nodes and 6 UDP/TCP connections is used to study inter-layer interactions and their performance implications. The other parameters used in this model are as under:

Software for simulation: Network simulator 2.34

Channel: wireless

Simulation runs time: 500 seconds.

Area in which nodes move: 670 X 670

Packet size: 512bytes

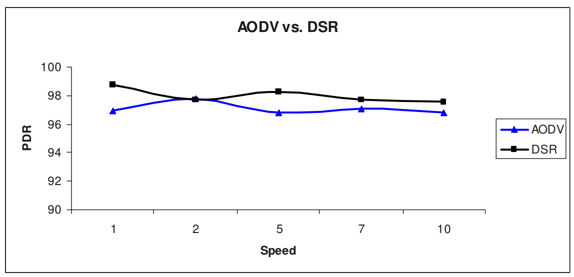
Speed: 1m/s to 10 m/s

Pause time: 100s to 500s

Bandwidth for transmitting data: 5Mb

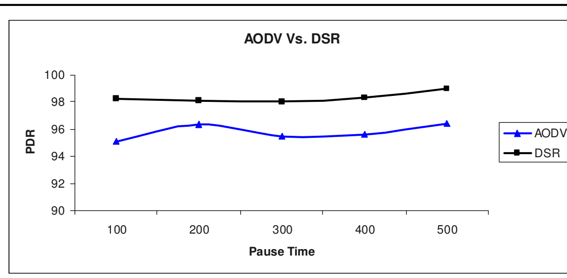
It has been shown that even though DSR and AODV share a similar on-demand behavior, the differences in the protocol mechanics can lead to significant performance differentials. The performance differentials are analyzed using packet delivery ratio with respect to varying mobility (1m/s to 10m/s) and pause time (100s to 500s).

Graph 1 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.



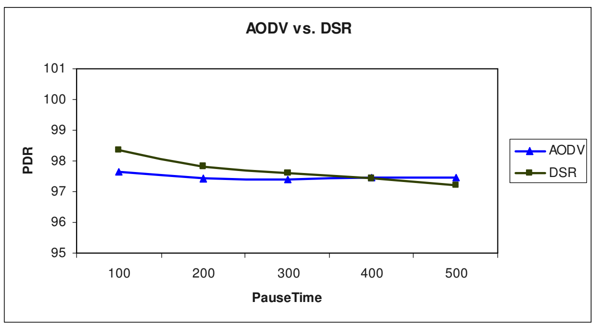
Graph 1: Movement of 20 nodes with 6 UDP connections (PDR w.r.t. Speed)

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 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.

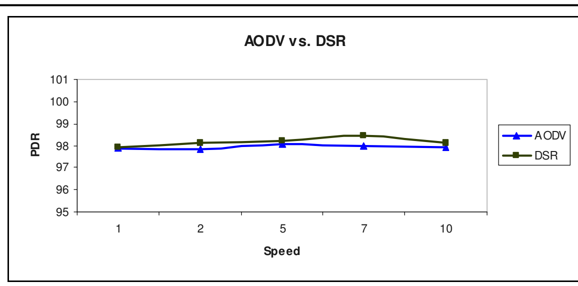


Graph 2: Movement of 20 nodes with 6 UDP connections (PDR w.r.t. Pause Time)

Graph 3 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 4: Movement of 20 nodes with 6 TCP connections (PDR w.r.t. Pause Time)



Graph 3: Movement of 20 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 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.

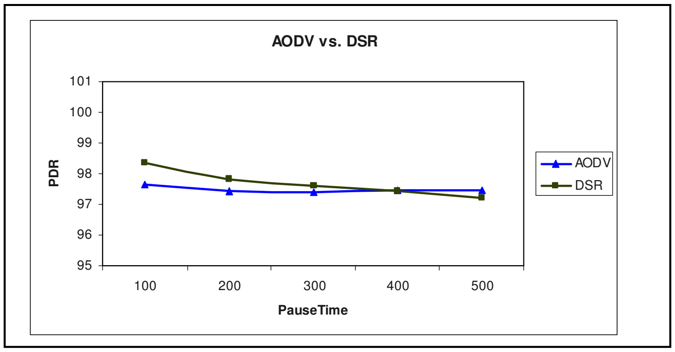


Table 1: PDR with respect to low mobility for UDP & TCP connections

PROTOCOL	Packet Delivery Ratio	
	UDP CONNECTIONS	TCP CONNECTIONS
DSR	High	High
AODV	Low	Average

Table 2: PDR with respect to high mobility for UDP & TCP connections

PROTOCOL	Packet Delivery Ratio	
	UDP CONNECTIONS	TCP CONNECTIONS
DSR	Average	High
AODV	Low	Average

Table 3: PDR with respect to low pause time for UDP & TCP connections

PROTOCOL	Packet Delivery Ratio	
	UDP CONNECTIONS	TCP CONNECTIONS
DSR	High	Average
AODV	Low	Average

Table 4: PDR with respect to high pause time for UDP & TCP connections

PROTOCOL	Packet Delivery Ratio	
	UDP CONNECTIONS	TCP CONNECTIONS
DSR	High	Average
AODV	Low	High

5. CONCLUSION

In this research 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. The results after analysis have been reflected in tables numbering from table 1 to table 4.

The parameters high average and low depict the PDR values (approx.) as under:

High: >98%

Average: 97% to 98%

Low: <97%

The study reveals that the DSR protocol outperforms the AODV protocol under low as well as high mobility situation. Moreover, the AODV protocol also starts performing well under high mobility situation. The mobility factor taken here is from 1m/s to 10m/s. On the other side, DSR protocol outperforms AODV protocol when the pause time is less and AODV protocol outperforms the DSR protocol when the pause time is increased up to a large extent.

6. FUTURE SCOPE

In this study, the effect of increasing number of nodes on the network performance is under consideration. Efforts are to test the 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 as well in the coming time. Apart from this, analysis of other routing protocols such as TORA, ZRP and CBRP and measurements/estimation of power consumption and processing costs will be done in future work.

REFERENCES

[1] A.Kush, R.Chauhan, "Optimization of routing techniques", CSI India Journal, Vol. 35, No. 2, pp 68-74, June 2005.

[2] A.Kush, R.Chauhan,C.Hwang and P.Gupta, "Stable and Energy Efficient Routing for Mobile Adhoc Networks", Proceedings of the Fifth International Conference on Information Technology: New Generations, ISBN:978-0-7695-3099-4 available at ACM Digital Portal, pp. 1028-1033, 2008.

[3] C. Perkins, E. B. Royer, S. Das, "Ad hoc On-Demand Distance Vector (AODV) Routing - Internet Draft", RFC 3561, IETF Network Working Group, July 2003.

[4] C. E. Perkins and E. M. Royer, "Ad-Hoc On Demand Distance Vector Routing", Proceedings of the 2nd IEEE Workshop on Mobile Computing Systems and Applications (WMCSA), New Orleans, LA, pp. 90-100, 1999.

[5] C. E. Perkins and P. Bhagwat, "Highly dynamic destination-sequenced distance vector routing (DSDV) for mobile computers", Proceedings of ACM SIGCOMM 94, pp. 34–244, 1994.

[6] D. Bertsekas and R. Gallager, "Data Networks" Prentice Hall Publ., New Jersey, 2002.

[7] D. B. Johnson, D. A. Maltz, Y.C. Hu, "The Dynamic Source Routing Protocol for Mobile Ad Hoc Networks (DSR)", IETF Draft, http://www.ietf.org/internet-drafts/draft-ietf-manet-dsr-09.txt, April 2003.

[8] D. B. Johnson and D. A. Maltz, "Dynamic Source Routing in Ad Hoc Networks", Mobile Computing, T. Imielinski and H. Korth, Eds., Kulwer Publ., pp. 152-81, 1996.

[9] Farhat Anwar, Md. Saiful Azad, Md. Arafatur Rahman, Mohammad Moshee Uddin, "Performance Analysis of Ad hoc Routing Protocols in Mobile WiMAX Environment", IAENG International Journal of Computer Science, 35:3, IJCS_35_3_13.

[10] P. Chenna Reddy, Dr. P. Chandrasekhar Reddy, "Performance Analysis of Adhoc Network Routing Protocols", Academic Open Internet Journal, Volume 17, 2006.

[11] S. Murthy and J. J. Garcia-Luna-Aceves, "An Efficient Routing Protocol for Wireless Networks", ACM Mobile Networks and App. Journal, Special Issue on Routing in Mobile Communication Networks, pp. 183-97, 1996.

[12] Tsu-Wei Chen and M. Gerla, "Global State Routing: A New Routing Scheme for Ad-hoc Wireless Networks", Proceedings of International Computing Conference IEEE ICC 1998.

[13] V. Park and S. Corson, Temporally Ordered Routing Algorithm (TORA) Version 1, Functional specification IETF Internet draft, http://www.ietf.org/internet-drafts/draft-ietf-manet-tora-spec-01.txt, 1998.

[14] V. D. Park and M. S. Corson, “A Highly Adaptive Distributed Routing Algorithm for Mobile Wireless Networks”, Proceedings of the IEEE International Conference on Computer Communications (INFOCOM), Kobe, Japan, pp. 1405-1413, 1997.

[15] Z. J. Hass and M. R. Pearlman, “Zone Routing Protocol (ZRP)”, Internet draft available at www.ietf.org.