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PERFORMANCE ANALYSIS OF AODV, DSR AND DSDV ROUTING PROTOCOLS IN MOBILE AD-HOC NETWORK (MANET)

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Abstract- A Mobile Ad-hoc Network (MANET) is a collection of wireless nodes that can dynamically form a network to exchange information without using any pre-existing fixed network infrastructure. MANET is a self organized and self configurable network where the mobile nodes move arbitrarily. The mobile nodes can receive and forward packets as a router. Each node operates not only as an end system, but also as a router to forward packets. The nodes are free to move about and organize themselves into a network. These nodes change position frequently. For relatively small networks flat routing protocols may be sufficient. However, in larger networks either hierarchical or geographic routing protocols are needed. The protocols have to be chosen according to network characteristics, such as density, size and the mobility of the nodes. MANET does not require any fixed infrastructure, such as a base station; therefore, it is an attractive option for connecting devices quickly and spontaneously. In this three routing protocols AODV (Ad- Hoc On-Demand Distance Vector), DSDV (Destination Sequenced Distance-Vector) and DSR (Dynamic Source Routing Protocol) are compared. Most of the previous research on MANET routing protocols have focused on simulation study by varying various parameters, such as network size, pause times etc. The performance of these routing protocols is analyzed in terms of their Packet Delivery Fraction, Average End-to-End Delay and their results are shown in graphical forms. The comparison analysis will be carrying out about these protocols and in the last the conclusion will be presented, that which routing protocol is the best one for mobile ad -hoc networks.
Keywords- Mobile Ad-hoc Network, Performance Analysis, Routing Protocols, AODV, DSR, DSDV, Simulation

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Introduction

Wireless cellular systems have been in use since 1980s. These systems work with the support of a centralized supporting structure such as an access point. The wireless users can be connected with the wireless system by the help of these access points, when they roam from one place to the other. Recent advancements such as Bluetooth introduced a fresh type of wireless systems which is frequently known as mobile ad-hoc networks. Mobile ad-hoc networks or "short live" networks control in the nonexistence of permanent infrastructure. Ad-hoc is a Latin word, which means "for this or for this only."[1] Mobile ad-hoc network is an autonomous system of mobile nodes connected by wireless links; each node operates as an end system and a router for all other nodes in the network. A wireless network is a growing new technology that will allow users to access services and information electronically, irrespective of their geographic position. Wireless networks can be classified in two types: - infrastructured network and infrastructure less (ad-hoc) networks. Infrastructured network consists of a network with fixed and wired gateways. In this work, an attempt has been made to compare the performance of two prominent on demand reactive routing protocols and one proactive routing protocol for MANETs AODV, DSR and DSDV protocols. DSR and AODV is a reactive gateway discovery algorithm where a mobile device of MANET connects by gateway only when it is needed. As per our findings the differences in the protocol mechanism lead to significant performance variation for both of these protocols. Further, AODV performed better in terms of average delay. We demonstrate that even though DSR and AODV share similar on-demand behavior as compared to DSDV, the differences in the protocol mechanisms also contribute to performance differences.

This paper is organized as follows. Section II gives a brief description of the related work. Section III discusses types of routing protocols in ad-hoc network. Section IV gives the overview of AODV, DSR and DSDV protocols. Simulation environment and performance metrics are described in Section V. Results of our simulation experiments are presented and discussed in Section VI. Finally, our conclusions from this study is planned future work are listed in Section VII.

Related Work

Vijaya et. al [1] compares the performance of two prominent on-demand reactive protocols for mobile ad-hoc networks: DSR and AODV with traditional proactive DSDV protocol. The network performance such as throughput delivery ratio and end-to-end delay carried out using NS2 simulator. Anuj K. Gupta et. al. [2] is subjected to the on-demand routing protocols with identical loads and environment conditions and evaluates their relative performance with respect to the two performance metrics: average End-to-End delay and packet delivery ratio and investigates various simulation scenarios with varying pause times. Using the latest simulation environment NS 2, it evaluates the performance of three widely used ad-hoc network routing protocols using packet-level simulation. Singh Annapurna et. al. [4] compares the performance of three on-demand routing protocol i.e. DSR, DSDV and TORA for MANET by varying the size of the networks. The performance metrics used are Total traffic received, Traffic Load, Throughput, Number of Hops per route and Route Discovery time. The simulator used is OPNET simulator. Mohd. Izuan Mohd Saad et. al.[5] studied the effect of the different mobile node movement pattern in random-based mobility model group (Random Waypoint Mobility Model, Random Walk Mobility Model and Random Direction Mobility Model)on the performance of Ad-hoc On-demand Distance Vector (AODV). To evaluate the performance, a detail simulation was conducted using the discrete-event simulator OMNeT++. Azizol Abdullah et. al. [6] compares three ad-hoc routing protocols named DSDV, DSR and AODV using NS2 simulator. Simulation results show that when number of nodes participating in the network is increased, packet delivery fraction of data packet delivered by all the protocols will become lesser. M.Sulleman Memon et. al. [8] contributes an effort towards anthology of one of the major segment of routing protocols i.e. unicast, their categories and the main type of unicast routing protocols such as DSDV from proactive plus DSR from reactive. Muazzam Ali Khan Khattak et. al. [11] analyze different performance parameters of three well known Ad-hoc network routing protocols (AODV, DSDV, DSR) with varying node density and velocity, under reliable TCP and unreliable UDP transport layer protocols. From simulation results it is observed that each protocol perform in different way with different node density and velocity. Comparing result for both UDP and TCP, it concludes that all the protocols perform well under TCP as far as packets received are concerned.

Routing Protocols In Ad-Hoc Network

There are many ways to classify the MANET routing protocols. Depends on how the protocols handle the packet to deliver from source to destination, most of the protocol classifications are made as [7].

A. Flat Routing Protocol

Flat routing protocols are divided into two classes; Proactive routing (table driven) protocols and Reactive (on-demand) routing protocols. Common for both protocol classes is that all nodes participating in routing play an equal role. They have further been classified after their design principles; proactive routing is mostly based on LS (link-state) while on-demand routing is based on DV (distance-vector).

B. Pro-Active / Table Driven routing Protocols

Proactive MANET protocols are table-driven and will actively determine the layout of the network. This is especially important for time-critical traffic. However, a drawback to a proactive MANET of protocol is that the life span of a link is significantly short. This phenomenon is brought about by the increased mobility of the nodes, which will render the routing information in the table invalid quickly. Proactive MANET protocols work best in networks that have low node mobility or where the nodes transmit data frequently. Examples of Proactive are DSDV (Destination Sequenced Distance Vector), OLSR (Optimized Link State Routing).

Reactive / On Demand Routing Protocols: On-demand routing is a popular routing category for wireless ad-hoc routing. The design follows the idea that each node tries to reduce routing overhead by only sending routing packets when communication is requested. Common for most on-demand routing protocols are the route discovery phase where packets are flooded into the network in search of an optimal path to the destination node in the network. Examples of Reactive are DSR (Dynamic Source Routing), AODV (Ad-hoc On-Demand Distance Vector).

C. Hierarchical Routing protocol

As the size of the wireless network increases, the flat routing protocols may produce too much overhead for the MANET. In this case a hierarchical solution may be preferable. CGSR (Clusterhead Gateway Switch Routing), HSR (Hierarchical State Routing) and ZRP (Zone Routing Protocol) are three hierarchical routing protocols that have different solutions to the organization of the routing of nodes in a MANET.

D. Geographical Routing protocol

There are two approaches to geographic mobile Ad-hoc networks: Actual geographic coordinates (as obtained through GPS - the Global Positioning System) and Reference points in some fixed coordinate system. An advantage of geographic routing protocols is that they prevent network-wide searches for destinations. A disadvantage, however, is that all nodes must have access to their geographical coordinates all the time to make the geographical routing protocols useful. The routing update must be done faster than the network mobility rate to make the location-based routing effective. This is because the nodes locations may change quickly in a MANET. Examples are GeoCast (Geographic Addressing and Routing), DREAM (Distance Routing Effect Algorithm for Mobility), GPSR (Greedy Perimeter Stateless Routing).

Overview of Aodv, Dsr and Dsdv

Every routing protocol has its own merits and demerits, none of them can be claimed as absolutely better than others. We have selected the three routing protocols - AODV, DSR and DSDV for evaluation.

A. Ad-hoc On-Demand Distance Vector Routing (AODV)

AODV adopts a very different mechanism to maintain routing information. It uses traditional routing tables, one entry per destination. This is in contrast to DSR, which can maintain multiple route cache entries for each destination. AODV uses sequence numbers maintained at each destination to determine freshness of routing information and to prevent routing loops. All routing packets carry these sequence numbers. An important feature of AODV is the maintenance of timer-based states in each node, regarding utilization of individual routing table entries. A routing table entry is expired if not used recently. A set of predecessor nodes is maintained for each routing table entry, indicating the set of neighboring nodes which use that entry to route data packets. These nodes are notified with RERR packets when the next-hop link breaks. In contrast to DSR, RERR packets in AODV are intended to inform all sources using a link when a failure occurs.

B. Dynamic Source Routing (DSR)

The key distinguishing feature of DSR is the use of source routing. That is, the sender knows the complete hop-by-hop route to the destination. These routes are stored in a route cache. The data packets carry the source route in the packet header. When a node in the ad hoc network attempts to send a data packet to a destination for which it does not already know the route, it uses a route discovery process to dynamically determine such a route [4]. Route discovery works by flooding the network with route request (RREQ) packets. Each node receiving an RREQ rebroadcasts it unless it is the destination or it has a route to the destination in its route cache. Such a node replies to the RREQ with a route reply (RREP) packet that is routed back to the original source. RREQ and RREP packets are also source routed. The RREQ builds up the path traversed across the network. The RREP routes itself back to the source by traversing this path backward. The route carried back by the RREP packet is cached at the source for future use. If any link on a source route is broken, the source node is notified using a route error (RERR) packet. The source removes any route using this link from its cache. A new route discovery process must be initiated by the source if this route is still needed. DSR makes very aggressive use of source routing and route caching.

C. Destination Sequenced Distance Vector (DSDV)

Destination Sequenced Distance Vector [9] is a loop free routing protocol in which the shortest-path calculation is based on the Bellman-Ford algorithm. Data packets are transmitted between the nodes using routing tables stored at each node. Each routing table contains all the possible destinations from a node to any other node in the network and also the number of hops to each destination. The protocol has three main attributes: to avoid loops, to resolve the "count to infinity" problem, and to reduce high routing overhead. Each node issues a sequence number that is attached to every new routing-table update message and uses two different types of routing-table updates, named "full" and "incremental dumps", respectively, to minimize the number of control messages disseminated in the network. Each node keeps statistical data concerning the average setting time of a message that the node receives from any neighboring node. The data is used to reduce the number of rebroadcasts of possible routing entries that may arrive at a node from different paths but with the same sequence number. DSDV takes into account only bidirectional links between nodes. In all table driven protocols each node maintains a table that contains the next hop to reach all destinations. To keep the tables up to date they are exchanged between neighboring nodes at regular intervals or when a significant topology changes are observed.

Research methodology

The simulations were performed using mat lab, particularly popular in the ad-hoc networking community. The traffic sources are CBR (continuous bit-rate). The source-destination pairs are spread randomly over the network. The mobility model uses 'random waypoint model' in a rectangular filed of 600m x 600m with 50 nodes. During the simulation, each node starts its journey from a random spot to a random chosen destination. Once the destination is reached, the node takes a rest period of time in second and another random destination is chosen after that pause time. This process repeats throughout the simulation, causing continuous changes in the topology of the underlying network. The model parameters that have been used in the following experiments are summarized in Table 1.

Table 1- Simulation Parameters

Parameter Name	Value
Routing Protocols	AODV,DSR,DSDV
Mobility Model	Random Waypoint
Simulation time	500 second
Number of nodes	10/20/50 nodes
Simulation area	600 x 600
Transmission range	250 m
Traffic Type	CBR
Packet Size	512 bytes
Bandwidth	2Mbps
Simulator	MATLAB

Performance Metrics

There are different kinds of parameters for the performance evaluation of the routing protocols. These have different behavior of the overall network performance. This comparative study uses the following performance metrics [1]:

Packet Delivery Fraction (PDF): This is the ratio of total number of packets successfully received by the destination nodes to the number of packets sent by the source nodes throughout the simulation.

$$PDF = \frac{\text{Number of received packets}}{\text{Number of sent packets}}$$

This estimate gives us an idea of how successful the protocol is in delivering packets. A high value of Packet Delivery Fraction indicates that most of the packets are being delivered to the higher layers and is a good indicator of the protocol performance.

Average End-to-End Delay (AED**):** This is defined as the average time taken by the data packets to reach the intended destinations.

$$AED = \frac{\Sigma \text{ (time received} - \text{time sent)}}{\text{Total data packets received}}$$

This include delay occurred due to different reasons like queuing delay, propagation delay, processing delay etc. It is very important for application where data is processed online.

Performance analysis and results

The simulation results are shown in the following section in the form of line graphs. Graphs show comparison between the three protocols by varying different numbers of sources on the basis of the above-mentioned metrics as a function of pause time.

A. Packet Delivery Fraction (PDF) Vs Pause Time

Figure 1. (a)-(c), shows comparison between the routing protocols on the basis of Packet Delivery Fraction as a function of pause time and using different number of traffic sources. The brown line shows graph for DSDV, the pink line shows the graph for DSR protocol and the blue line shows graph for AODV. From these graphs it is clear that throughput decrease with increase in mobility. As the packet drop at such a high load traffic is much high. DSDV performs better at high mobility but as the number of sources increases it shows lower throughput. The reason is that in DSDV routing table update mechanism is not fast enough to update the routing tables when topology changes occur. DSR and AODV drop a considerable number of packets during the route discovery phase. Buffering of data packets while route discovery in progress, has a great potential of improving DSR, AODV and DSDV performances. AODV has a slightly lower packet delivery performance than DSR because of higher drop rates. AODV uses route expiry, dropping some packets when a route expires and a new route must be found.

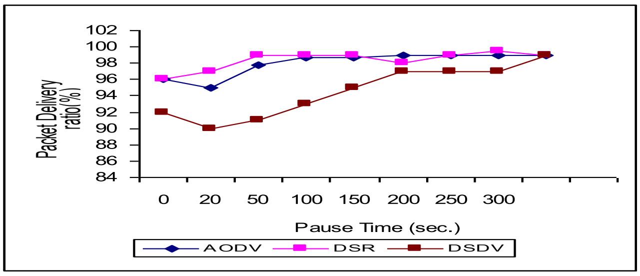

Fig. 1(a)- Packet delivery Fraction vs. Pause time for 10 sources

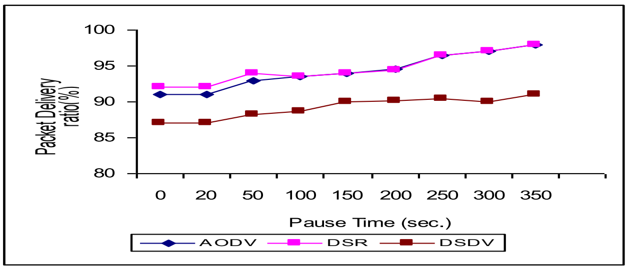

Fig.1(b)- Packet delivery Fraction vs. Pause time for 20 sources

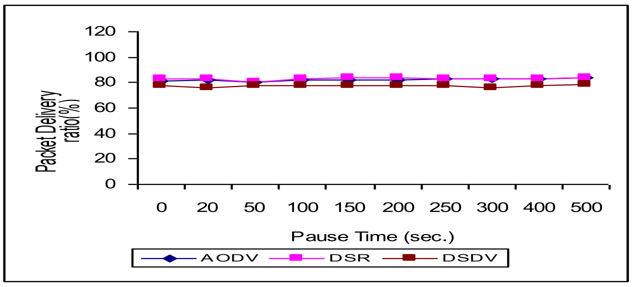

Fig. 1(c)- Packet delivery Fraction vs. Pause time for 50 sources

B. Average End - to- End Delay Vs Pause time

Figure 2. (a) - (c), shows graph for end to end delay Vs pause time. The brown line shows graph for DSDV, the pink line shows the graph for DSR protocol and the blue line shows graph for AODV. These graphs shows that the average packet delay increases for increase in number of nodes waiting in the interface queue while routing protocols try to find valid route to the destination. In general, high mobility and high traffic load increases the delay; when congestion starts to become a problem the delay at low mobility is higher than at medium mobility. The delay time is also affected by route discovery, which is the first step to begin a communication session. In DSDV route construction may not occur quickly. This lead to lengthy delays waiting or new routes to be determined. In DSR route discovery is fast, therefore shows a better delay performance. But in case of congestion (high traffic) DSR control messages get loss thus eliminating its advantage of fast establishing new route. Under such situations DSR has relatively high delay than AODV, but it decreases with increase in pause time.

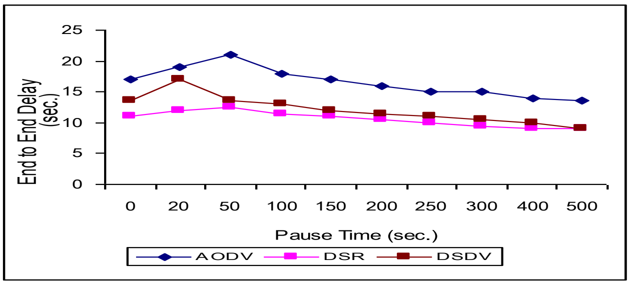

Fig. 2(a)- Average End -to - End Delay vs. Pause time for 10 sources

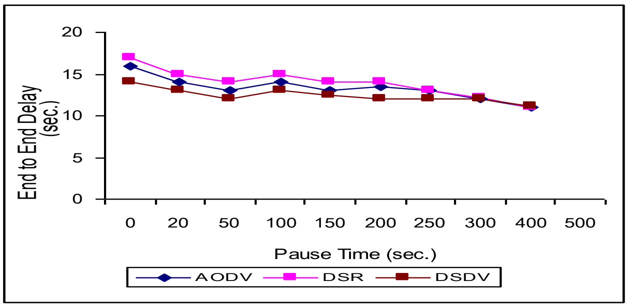

Fig. 2(b)- Average End -to - End Delay vs. Pause time for 20 sources

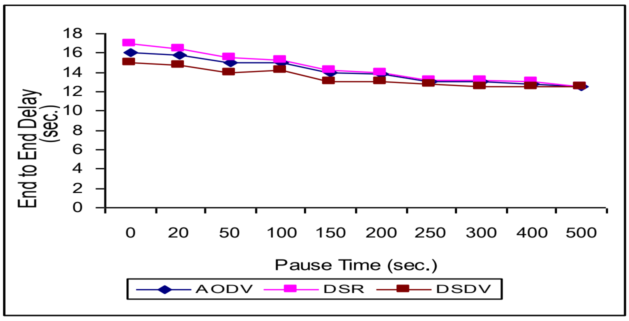

Fig. 2(c)- Average End -to - End Delay vs. Pause time for 50 sources

Conclusion and Future Scope

This work mainly consists of two studies, one is analytical study and other is simulation study. From analytical study it is concluded that routing protocols in new modern arena of telecommunications, internet systems and in seamless communication play prominent role to develop better communication between end users. The selection of suitable protocol according to the network definitely increases the reliability of that network.

The simulation study consisted of three routing protocols AODV, DSR and DSDV, analyzing their behavior with respect to two parameters, Packet delivery fraction and Average end-to-end delay. The motive was to check the performance of these three routing protocols in MANET in the above mentioned parameters. The conclusions of entire study from my experimental results are as follows:

1. Increase in the density of nodes yields to an increase in the mean End-to-End delay.
2. Increase in the pause time leads to a decrease in the mean End-to-End delay.
3. AODV has the best all round performance. It has an improvement of DSR and DSDV.
4. DSR is suitable for networks with moderate mobility rate. It has low overhead that makes it suitable for low bandwidth and low power network.
5. DSDV is suitable for operation in large mobile networks having dense population of nodes. The major benefit is its excellent support for multiple routes and multicasting.

The next step for the future work would be to implement the protocol in a real time environment which consists of nodes running different routing protocols and check the performance of the protocol under different scenarios and can be extended to various other protocols like TORA and also analyze performance of such protocols on the performance parameter like path optimality, delay overload and energy consumption, etc.

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