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Implementation and Comparison of Reactive and Proactive Routing Protocols for Mobile Ad-Hoc Network

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Abstract

Mobile Ad-Hoc network also known as MANET, is a collection of mobile nodes forming a network without an actually fixed topology. In MANET network topology, each node acts as both the router and the client simultaneously, and can freely move out or join in the network. Each node or mobile device changes its location freely and automatically configures itself back to the network or joins another network. The highly dynamic nature of MANET network topology, results in difficult and complex routing mechanism. In this paper implementation, comparative analysis and behavioral study are carried out on various MANET routing protocols using Network Simulation (NS) version 2 and their performances are analyzed based on the effect of changing network parameters on different network performance metric such as network throughput, average end-to-end delay and the packet delivery ratio. The performance evaluation result have been analyzed and recommended based on the results obtained. The simulation result shows that the AODV out performs DSDV in both PDR and network throughput under different network parameters. Similarly both protocols are almost similar in good performance in packet delivery ratio under different topology, paused time and number of nodes. We believed that the research carried out in this paper will help researchers in finding appropriate routing protocol for Mobile Adhoc Network environment.

Keywords: *MANET, Routing, Protocols, DSDV, AODV, NS-2*

Background to the Study

With the rapidly increasing popularity of wireless network devices, Mobile Ad-Hoc Networks (MANETs) are getting larger and attracting significant interest due to their flexibility, performance and cost. The availability of a Global Positioning System (GPS) or similar systems enable MANET nodes to access each node within its geographical boundary (Patterson and Davie, 2011). In the last few years, many wireless standards for wireless communication and technologies have emerged. These technologies enable a wide range connection of computing and telecommunication devices easily and simply, without the need of buying, carrying or physical connection of network devices. These technologies deliver opportunities for rapid ad hoc connections and the possibility of automatic, unconscious connections between devices. They will virtually eliminate the need to purchase additional or proprietary cabling to connect individual devices, thus creating the possibility of using mobile data in a variety of applications. Wired local area networks (LANs) have been very successful in the last few years, and now with the help of these wireless connectivity technologies, wireless LANs (WLANs) have started emerging as much more powerful and flexible alternatives to the wired LANs(Sarkar, Basavaraju and Puttamadappa, 2007).

Mobile Ad-Hoc Networks are also known as MANETs. It is an infrastructure-less network where each device acts as both the router and the client. In MANET network topology, each and every mobile node/device is free to join or leave a network. Unlike other network topology, MANET network topology does not have a dedicated device that manages and control the network activities. The flexibility of nodes within MANET network environment has made designing, configuring and managing a reliable and efficient routing protocol a challenging task due to network mobility, multi-hop, network size combined with devices heterogeneity, network bandwidth and power constrain(Sarkar et al 2007). The aim and objective of this paper is to implement and carry out a comparative analysis and behavioral study on various MANET routing protocols such as Destination-Sequence Distance-Vector (DSDV), and Ad-Hoc On-demand Distance Vector (AODV) for different performance metric such as network throughput, average end-to-end delay and the packet delivery ratio.

Computer Networks

A computer network is a collection of autonomous networking devices interconnected through a communication medium or as a group of two or more computers linked together to share network resources and to communicate with one another freely. Computer network simply means a physical (wired) or wireless connection of two or more networking devices to share information. The network connection can be between two or more computers or computer to other networking devices such as printers, scannersand so on (Patterson and Davie, 2011), (Dhenakaran and Parvathavarthini, 2013).

Wireless Networks

Wireless communication or wireless network is known as Wireless Local Area Network (WLAN) or Wireless Fidelity (Wi-Fi) network. It is a type of network topology that does not require physical connection between two or more networking devices such as physical network cable to share network resources. Unlike wired network, wireless network environment uses wireless radio frequency wave to communicate with other devices on the same network (Hoebeke, Moerman, Dhoedt and Demeester, 2004), (Dhenakaran and Parvathavarthini, 2013).

Types of Wireless Networks
Wireless networks can be in the form of infrastructure or infrastructure-lessnetwork such as Ad-Hoc network.

Infrastructure Networks
It is a type of fixed topology wireless network that is managed and controlled by a dedicated network device. In infrastructure wireless network, a dedicated device known as Access Point (AP) or based station controls the activities, transmission and access to the network resources. AP controls how, when and who transfers or receives messages in the network. AP is connected to the main network or other networks through the backbone connection as shown in Figure 1.

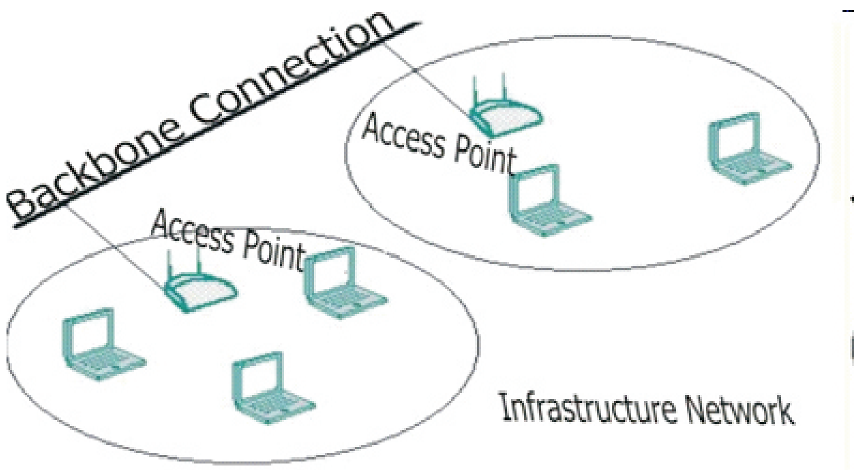


Figure : Infrastructure networktopology (Dhenakaran and Parvathavarthini, 2013)

Ad-Hoc Networks
Ad-Hoc networks are also known as infrastructure-less network. In Ad-Hoc networks, all devices act like a client and/or router. The Ad-Hoc networks do not have a fixed network topology. Figure 2 is a typical example of an Ad-Hoc network topology. The network comprises of four different nodes, each comprises of a particular network topology usually in the form of a cycle, or a hexagonal cell area used in most network model (Dhenakaran and Parvathavarthini, 2013).

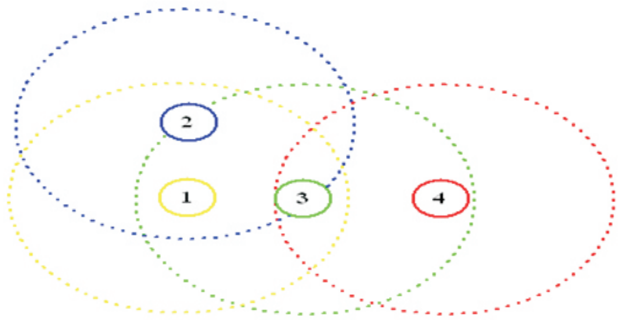


Figure : Ad-Hoc network topology(Dhenakaran and Parvathavarthini, 2013)

MANET Routing Protocols

The nature of MANET network topology have made designing and configuring a reliable, efficient routing protocol a challenging task in MANET configuration. In MANET topology each node acts as both the router and the client simultaneously, and can freely move out or join in the network. Each node or mobile device changes its location freely and automatically configures itself back to the network or joins another network. Unlike in wired network, routing protocol which can either be link state or distance vector routing protocol with a frequent or periodically exchange of routing update using flooding network strategy. In MANET routing protocols, frequently or periodic routing updates increase network bandwidth consumption, require a significant power supply (battery life) and high channel contention. To overcome the major MANET routing protocols issues and challenges, three different routing protocols has been proposed based on how mobile nodes acquire and maintain routing update as shown in Figure 3(Sarkar et al 2007),(Dhenakaran and Parvathavarthini, 2013).

Classification of MANET Routing Protocols

There are different types of MANET routing protocol under the family tree of three main types namely Reactive, Proactive and hybrid routing protocols as shown below.

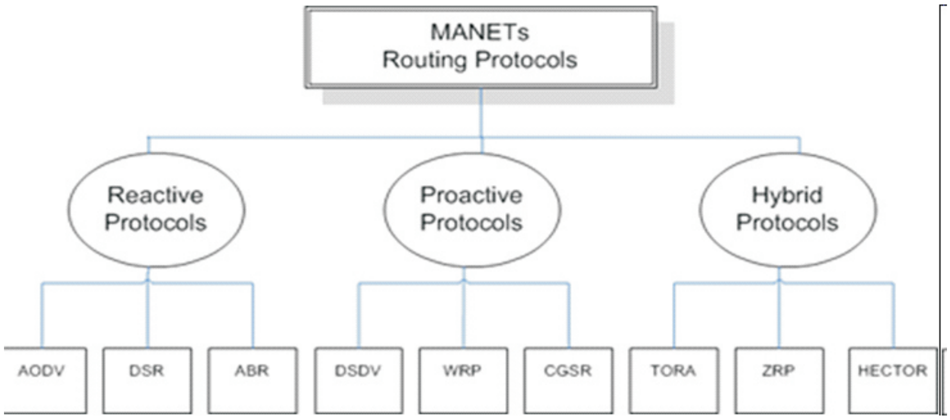


Figure 3: Types of Ad-Hoc routing protocols (Sarkar et al 2007)

Proactive Routing Protocol

A proactive routing protocol is also known as "table driven" because each mobile nodes maintains and manages full routing table information to maintain network consistency and up-to-date route to all network. To achieve this, each node propagates a periodic routing update throughout the network using either link state or distance vector routing algorithm used in wired network to determine the shortest path. Unlike wired network algorithm, proactive routing protocol calculates and maintains routing information weather network traffic exists or not. As such proactive is considered as a solution to major wired routing protocol drawback solution in wireless routing protocol (Dhenakaran and Parvathavarthini, 2013).

Destination-Sequence Distance-Vector (DSDV)

DSDV is a type of proactive routing protocol for mobile networks that uses a distance vector algorithm known as Bellman-Ford algorithm to determine the best route. Each node in DSDV network contains full information about the network topology. Unlike other reactive routing protocols, DSDV configured node sends a periodic routing update with a sequence number and the receiving nodes use the sequence number to distinguish between stale and new routing update information to avoid route loops formation. Whenever a node receives a routing update from its immediate neighbor, it compares the received sequence number with a stored sequence number to determine routing information stale(Hoebeke, et al, 2004).

Reactive Routing Protocol

A reactive routing protocol is also known as "on-driven" or "source initiated routing protocol" because each mobile node searches and maintains or manages routing table information only when required or needed to reduce routing network overhead. To achieve this, the required node invokes route discovery operation by examining all available route permutation, the operation terminates when route is discovered or no route is available. As such, reactive is considered as a solution to major proactive routing protocol drawbacks in MANET routing protocols (Sarkar et al 2007).

Ad-Hoc On-demand Distance Vector (AODV)

AODV is a type of MANET routing protocol that uses an on-driven or source initiated routing protocol technique of reactive routing protocol for finding route only when it is required. An AODV node works independently and does not carry routing information of its adjacent node when sending routing update. It employs the techniques of using destination sequence number to differentiate between new and stale routing update information used in DSDV. Unlike other reactive routing protocol, AODV sends routing update to it neighbor using Route Request (RREQ), Route Reply (RREP) and Route Error (RERR) control mechanisms as shown in the Figure 4 and 5 respectively. An RREQ request message is initiated by Node 1 requesting routing information update to Node 8, through other connected nodes. Every RREQ message sent between AODV nodes carries a Time To Live (TTL) which contains information about the number of node count from sender (Node 1) to destination (Node 8) as shown in Figure 4. A unicast routing information RREP message is sent back to the initiating or sending node from the receiver, Node 8 to 1 using a best route as shown in Figure 5. AODV uses RERR control message mechanism to monitor link status of every active route. When a link failure is detected, RERR message is used to inform all connected nodes about the link status update(Basu, D. Shivahare, Charu Wahi and Shalini Shivhare, 2012).

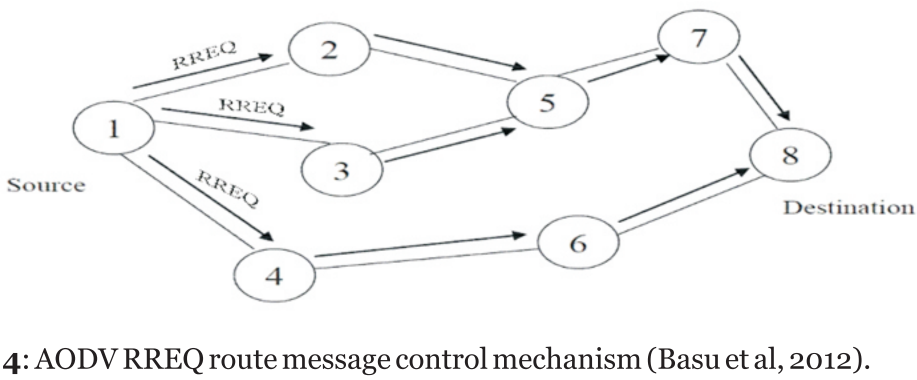


Figure 4: AODV RREQ route message control mechanism (Basu et al, 2012).

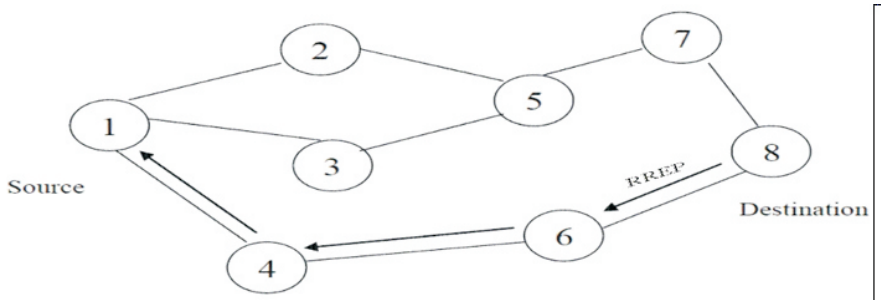


Figure 5: AODV RREP route message control mechanism (Basu et al,2012).

Comparison of Routing Protocols

Table 1 presents a comparative analysis of proactive (DSDV) and reactive (AODV) routing protocols for MANET under different networkparameters/criteria

Criteria	Proactive (DSDV)	Reactive (AODV)
Routing mechanism	Table driven	On-demand
Routing update	Periodically	On-demand
Network maintenance	Route table and data position	Route table and cache
Routing metrics	Shortest path	Shortest & fastest path
Route discovery	Periodically	On-demand
Routing information	Full	Partial
Routing overhead	High	Less
Network delay	Low	High
Network scalability	Low	High
Network load balance	No	Yes
Loop free support	Yes	Yes
Multicast support	No	Yes

Table : Comparative analysis of proactive and reactive routing protocols (Basu et al, 2012).

Methodology

There are different types of network simulators used to design and configure network environment, each of which have different design architecture, method and performance management such as OPNET, Netsim and Network Simulator. For the purpose of this paper, NS version 2 is used to design and implement reactive and proactive routing protocols under different network topologies.

Performance Metrics

For the purpose of thispaper, three different performance metrics are considered and measured quantitatively, such as the network throughput, average end-to-end delay and PDR.

Network Throughput

Throughput involves the use of computer resources or network device to accomplish routing function. It is determined by the routing protocol and the environment operated. The network throughput is simply the total number of successful data packets transmitted over a communication network in a given period of time usually express in a second as given in formula(Khandakar, 2012).

$$\text{Throughput} = \frac{\text{Total number of packets sent} \times 8 \times 512}{\text{Simulation time}} \quad (1)$$

Here the packet size is assumed as 512 bytes and 8 in (1) is used to covert from bits to bytes.

Average End-to-End Delay

Also known as network latency is defined as the total time expressed in seconds (s) taken for the packets to be transmitted across a network from source to destination divided by the total number of connections [Ghosh, 2013].

$$\text{Average end-to-end delay} = \frac{\text{(Arrive time-sent time)}}{\text{Total number of connections}} \quad (2)$$

σ

Packet Delivery Ratio

PDR is the total number of received packets divided by the total number of sent packets as

$$\text{PDR}=\frac{\text{Total number of packets received}}{\text{Total number of packets sent}} \quad (3)$$

Simulation Result and Analysis

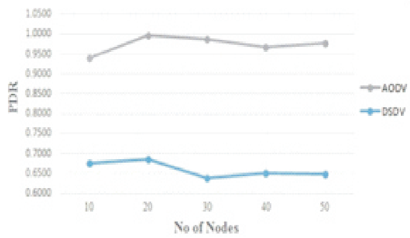
In this paper work a performance analysis is carried out in an ad hoc network by varying three parameters i.e. number of nodes, paused time and network area while keeping other network parameters constant as shown in table 2. Two MANET routing protocols are considered under different performance/simulation parameters such as network load, network mobility and network size analyses as shown below.

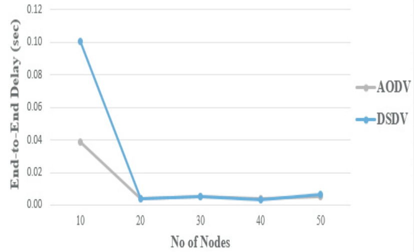
Simulation Parameters	**Value**
Network Type	Mobile Network
Connection Pattern	Random Waypoint Mobility
Packet Size	512 bytes
Simulation Time	150 s
Connection Type	CBR/UDP
Maximum Speed	10 m/s
Number of Nodes	10, 20, 30, 40, 50
Pause Time	0 s, 30 s, 90 s, 120 s, 150 s
Simulation Area (Sqm)	200×200, 400×400, 600×600, 800×800, 1000×1000
Network Protocols	AODV, DSDV

Table 2: The Simulation parameters (Ghosh, 2013)

Performance Analysis by Varying Network Load

The number of nodes are varies between 10, 20, 30, 40 and 50 to compute the effect of varying network load on the network parameters whereas the pause time and network area are fixed as 30s. It can beobservedfrom Figure 6, AODV has PDR from 0.93 (93%) to almost 0.99 (99%) while DSDV has PDR from 0.63 (63%) to 0.68 (68%) based on network load. This is an evident of having better performance with AODV protocol in both small and crowded networks due to reactive nature of AODV.





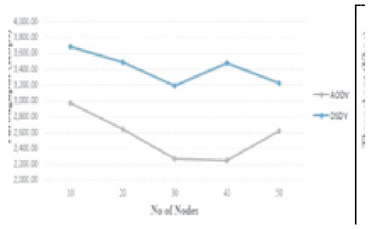
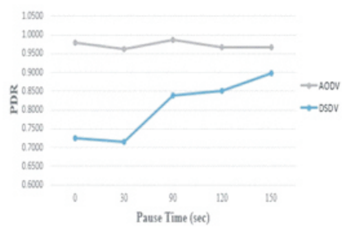
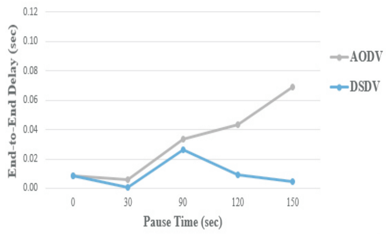


Figure: 6 **Figure: 7** **Figure: 8**

Figure 7shows the analysis of overall network packet delay in terms of route discovery, queuing, time of transmission and network propagation delay with respect to different number of nodes. With The change in number of nodes, both AODV and DSDV have almost the same average delay.Figure 8 shows the analysis of overall network throughput with respect to different number of nodes. The result shows that DSDV overall network throughput is relatively high with a peak throughput of 2.97Mbps due to the proactive nature of DSDV where the network performance relies on the network density.

Performance Analysis by Varying Pause Time





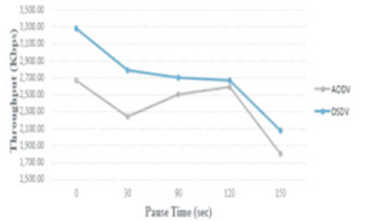
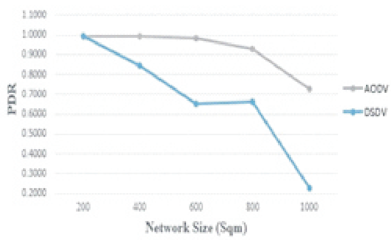
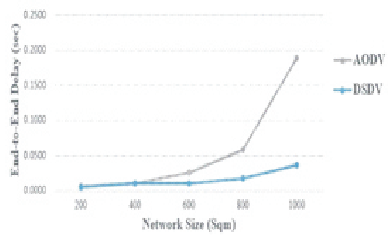


Figure: 11 **Figure: 9** **Figure: 10**

Results in Figure9 shows that AODV has higher PDR when the pause time varies. On the other hand, the average end-to-end delays of both protocols in Figure 10 are closely related but with the change at 120s and 150s. The result in Figure 11 shows that DSDV has the highest throughput compared to AODV due to high demand and used of network resources.

Performance Analysis by Network Area





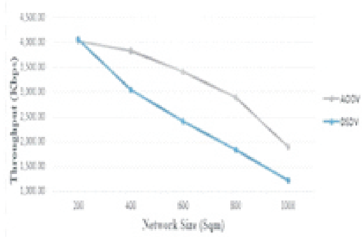


Figure: 12 **Figure: 13** **Figure: 14**

It is been observed from the results presented in Figure 12 that PDR decreases with the change in topology for both AODV and DSDV. The results presented in Figure 13 shows that the average end-to-end delays of both protocols increase as the network area increases. AODV and DSDV network delays in 200×200 and 400×400 $m^2$are almost the same but AODV has a higher delay at larger network area. The results presented in Figure 14 shows that the throughput is almost the same for AODV and DSDV at the area of 200×200 m^2 and decreases as the network area increases having a higher throughput for AODV.

Conclusion and Recommendations

In this paper, the performance evaluation is carried out on two routing protocols, DSDV and AODV with respect to PDR, End to End delay and network throughput with different network parameters. From the result analysis, it has been observed that AODV is the best in terms of average PDR. For high mobility conditions of nodes AODV gives a better packet delivery ratio than DSDV making it a suitable choice in highly random mobile networks for paused time, network size and different network mobility rate. Similarly for network size analysis it is observed that the AODV protocol outper form DSDV, if the network size is less than 600x600sqm.From this analysis we consider 600X600 SQM size networks to evaluate the network load analysis and mobility analysis.

We recommend that in future, designing such a MANET routing protocol that can utilize these performances to provide suitable data integrity as well as data delivery in highly random mobility network. And also focus on analyzing the energy metrics as the cost function for better quality of service applications.

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