Comparative Analysis of AODV, DSDV and GPSR Routing Protocols in MANET Scenarios of Real Urban Area

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ABSTRACT

The widespread deployment of MANET networks that employ IEEE 802.11 as the underlying technology has attracted a great deal of research attention in both academia and industry. This has led to many new protocols specifically designed for MANET. Ad-hoc routing protocols are given most of the attention as they are the responsible of creating and maintaining the links between nodes in this network. These protocols might differ depending on the application and network architecture. Moreover, different protocols provide different performance depending on their ability to face network challenging, such as density of nodes, mobility speeds and number of connections. The main aim of this paper is to study the performance of different routing protocols in MANET with different network parameters. For this purpose, a thorough literature study is performed to identify the issues affecting the routing protocols performance and present a classification for the various approaches pursued. Then, a comparative analysis study has been conducted by simulating different routing protocols, taking into consideration different challenges and network parameters. On the basis of achieved results from the comparative study, recommendations are made for better selection of protocol regarding to application nature in the presence of considered challenges. As corroborated by intensive simulation experiments, reducing the overhead caused by sending routing messages is vital for good performance.

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INTRODUCTION

Wireless ad-hoc networks and portable computing platforms have experienced a widespread deployment in the last few years. This basically is due to their vast applications, cost efficiency, ease of installation, convenience and ease of integration with other networks. Moreover, the emergence of IEEE 802.11 Crow et al. (1997) techniques has facilitated the deployment of wireless ad-hoc networks for commercial purposes. This wide spread deployment generates substantial interest for research in both academia and industry. Within several research issues, studying routing protocols over multi-hop wireless networks that employ IEEE 802.11 as the underlying technology has acquired a great deal of attention among the wireless networks community and becomes one of the most prominent issues. Such great interest is basically motivated by some observations on the performance of the current routing protocols over wireless ad-hoc networks. Thus, providing performance quality and reliability of data delivery comparable to wired networks is a major challenge in wireless ad-hoc environment. Ad-hoc network is a complex distributed system that comprises of static or mobile nodes which can communicate with each other using wireless links Basagni et al. (2013). Due to the limited radio transmission range, many pairs of nodes in these networks may not be able to communicate directly. Hence, they may need other intermediate nodes to forward their packets. In this way, ad-hoc network paths can be established between any pair of nodes without relying on a pre-existing network infrastructure, centralized control or dedicated network devices (access points, routers, switches or servers). Compared to the traditional infrastructure wireless networks, MANET have many features such as a dynamic self-organization, self-configuration, free movement, high scalability, low deployment cost, robustness and ease maintenance. These features give MANET the ability to play an important role in civilian and military settings where the access to wired backbone is either ineffective or impossible.
Typically, MANET can operate in isolation or they can have one or more gateways that connect them to the Internet or other networks. In MANET, a source node transmits a packet to a neighboring node with which it can communicate directly. The neighboring node, in turn, transmits the packet to one of its neighbors and so on until the packet is transmitted to its ultimate destination. Each link a packet goes through is referred to as a hop.

The set of links that a packet travels over from the source to the destination is called a route or path. Routes are discovered by running a distributed routing protocol on the network. These routing protocols try to minimize retransmitting packets and average of packet delay Variation. The most common routing protocols in MANET networks that employ IEEE 802.11 as the underlying network technology.

Routing protocols in MANET can be grouped according to the routing structure into flat, hierarchical, and hybrid. From the structure perspective, they also can be grouped to flat and hierarchical routing protocols. Some routing protocols lie under the geographical casting classification. Many other improvised sets of protocols are developed to meet a specific requirement and suit particular scenarios. This article first provide a taxonomy of the most common routing protocols by assigning them to their important categories. Then, it studies and evaluates the performance of three routing protocols, AODV, DSDV and GPSR in MANET with different scenarios of urban area. Note that AODV is reactive based routing protocol while DSDV and GPSR are proactive and hybrid routing protocols, respectively. The evaluation has been conducted over three different scenarios of MANET. In the first scenario, we compare the considered protocols over different number of nodes in real urban area. For the second scenario, the comparison has been conducted by applying various number of connections ranging from low to high loads. In the last scenario, we vary the speed of mobile nodes and evaluate the performance as a function of different mobility speed.

**Related Work:**

Routing protocols in MANETs can be classified according to the routing process into three sets: proactive, reactive and hybrid. In the proactive routing protocols, the routing information are maintained periodically regardless of the need to have fresh information. Destination-Sequence Distance-Vector (DSDV) Mahdipour et al. (2009) and Optimized Link State Routing (OLSR) Zhiyuan and Jinhong (2010) are common examples of proactive routing protocols. The Reactive routing protocols send the information on demand and they are activated only when they are needed. Dynamic Source Routing (DSR) Broch et al. (1998), Temporally Ordered Routing Algorithm (TORA) Park and Corson (2001) and Ad-hoc Demand Distance Vector (AODV) Das et al. (2003) are the most popular routing protocols in reactive routing category. Hybrid routing protocols combines the two routing processes and reacting both as proactive and reactive. Zone Routing Protocol (ZRP) Haas et al. (1999) and Greedy Perimeter Stateless Routing (GPSR) are examples of Hybrid routing protocols.

Routing protocols can be also classified based on the routing structure into flat and hierarchical. Flat structure means that there are no groups or clusters of nodes. All nodes are spread and treated in one zone, AODV, DSR and OLSR are classified under flat routing protocols. Hierarchical structure networks are partitioned into levels and communications are done only among few nodes and only paths between clusters are saved rather than paths between every two communicated nodes and that will help to reduce the routing information and, as a consequence, will increase the scalability of the routing algorithm. Inside each cluster there is one node that responsible of coordinating the activities of the cluster, called (cluster-head). Rather than cluster-head there are number of normal nodes that only access to their gateways and cluster-head directly. As an example of hierarchical routing protocols is the cluster based routing protocol (CBRP) Jiang (1999).

Many surveys and evaluations studies has been done to assess the role of each different protocol with different mobility models in respect to some particular scenarios to compute the required performance parameters. In Chaba et al. (2009) the authors focus on evaluating three reactive protocols AODV, DSR and CBRP. While AODV and DSR were both flat structured, CBRP was hierarchical structured protocol. However the evaluation showed that DSR and CBRP achieved low routing overhead than AODV, the end-to-end delay and packet delivery ratio are less in AODV. In Gupta et al. (2010), a performance evaluation has been done to cover three common reactive routing protocols used in mobile ad-hoc networks, DSR, TORA and AODV. These protocols have been evaluated in terms of overhead, dropped packets, end-to-end delay and packet delivery ratio performance metrics.

In Bobade and Mhala (2010), AODV has been evaluated in term of average end-to-end delay, normalized routing load and throughput performance metrics with UDP and CBR traffic type as a function of different number of nodes. The authors in Torres et al. (2012) choose to evaluate AODV as reactive routing protocol with CBRP as clustered based routing protocol along with Backup cluster head protocol (BCHP) as two hierarchical routing protocols in respect to end-to-end Delay, Rate of sent packets and average of packet delay Variation. The behaviour of AODV and DSR as proactive routing protocols and DSDV as proactive routing protocol is
presented in Khandakar(2012). The compression has been conducted with different number of nodes, speeds and pause time to compute the packet delivery fraction, end-to-end delay and routing load performance metrics using CBR traffic with UDP. The authors in Jadeja and Patel(2013) have compared the same three protocols using CBR traffic with TCP in term of packet delivery ratio, end-to-end delay and throughput performance metrics as a function of different number of nodes and speeds. In Quispe and Galan(2014), three different types of protocols have been evaluated in an emergency scenario, they selected AODV as a reactive routing protocol, DSDV as a proactive routing protocol and CBRP to represent the hierarchal routing protocol. The evaluation has been done for an emergency and rescue scenario with different number of nodes in term of average jitter, average end-to-end delay, dropped packets and send packet rate. As we can observe and spot, there are only few researches have been done to evaluate different types of routing protocols in correspondence to different routing protocols categories for routing process or routing structure or even a set of geographical casting protocols. Moreover, the effect of different network parameters such as mobility speeds and traffic connections are not studied well.

Unlike previous works, this paper present a comparative analysis of different routing protocols classification as proactive, reactive, hybrid, at structure, hierarchal structure and geographical routing protocols. The evaluation have been conducted for different MANET scenarios of different number of nodes, different connection load and different mobility speeds. Moreover, different performance metrics have been chosen for fair comparison, packet delivery ratio, delay average and normalized routing load.

**Ad-hoc Routing Protocols**

**Ad hoc on-demand distance vector (AODV):**

It is a routing protocol designed for ad-hoc mobile networks Das et al.,2003; Das, Shukla 2012. It is an on demand routing algorithm, capable of both unicast and multicast routing. By on demand, it thus builds routes between nodes only when desired by source nodes. The route is maintained for as long as needed by the source node. AODV forms trees connecting multicast group members. The trees are composed of the group members and the nodes needed to connect the individuals in the group. To ensure route is active, AODV marks the routes with sequence of numbers. The protocol employs route request (RREQ), where the messages flooded via the network so as to discover the paths needed by a source node. An intermediate node that receives the RREQ replies using a route reply message only if either it has a route to the destination whose corresponding destination sequence number is greater or equal to the one contained in the RREQ or it is the required destination. In the latter case it unicasts a RREP back to the source, while for the former it rebroadcasts the RREQ. The RREQ also contains the most recent sequence number for the destination of which the source node is aware. Nodes keep track of the RREQ's source IP address and the corresponding broadcast ID. If a RREQ that have already been processed are received, they discard it.

Discard the RREQ without it been forwarded. The nodes continue to set up forward pointers to the destination while the RREP propagates back to the source. The source node proceeds with forwarding packets to the destination once it receives the RREP. If later it either receives a RREP containing a greater sequence number or the one with same sequence number as a smaller hop count, it update its routing information accordingly and switch to the better route. The route is maintained so long as it remains active.

![Fig. 1: Reverse Path Formation Perkins and Royer(1999).](image-url)
link breaks while a route is active, the node upstream of the break generate and propagates a route error (RERR) message to the source node informing it that the destination(s) is now unreachable.

Whenever node wishes to transmit a packet to destination, it do Route Discovery by employing control messages route request(RREQ) and route reply(RREP). To control network wide broadcasts of RREQs, the source node utilize an expanding ring search algorithm. The forward path sets up in intermediate nodes in its route table with a lifetime association using RREP. When either destination or intermediate node seized to exist, a route error (RERR) is transmitted to the affected source nodes. On receiving the (RERR)

By the source node, it has to perform new route discovery necessary. Information from the neighborhood are gathered by broadcasting a special beacon packet Misra and Mandal(2005).

As illustrated in Figure 1, The RREQ automatically sets up reverse path from all nodes back to the source while travels from a source to various destinations. Figure 2, in the other hand, depict the forward path setup as the RREP travels from the destination D to the source node S. AODV is adaptable to highly dynamic networks. Node may however experience large delays due to the process of route construction; the link failure adds up to the delay as it may initiates new route discovery. As such more bandwidth is consumed proportionate to the size of the network. Figure 3 is illustrating AODV route discovery (a) is the propagation of the RREQ and (b) is for path of the RREP to the source.

**Fig. 2:** Forward Path ELIZABETH M. ROYER(1999).

**Fig. 3:** AODV Route Discovery Formation Perkins and Royer(1999).

*Destination sequenced distance vector routing (DSDV):*

The DSDV algorithm Perkins and Bhagwat(1994) is a modified version of DBF Bellman and Kalaba (1957) Ford and Fulkerson(1962). DSDV is modified to suit ad-hoc networks from the conventional Routing Information Protocol (RIP). Each entry in the route table of the traditional RIP gets an added new attribute and sequence number.
Mobile nodes use the recently added sequence number to recognize outdated routes from the new thus prohibiting the formation of routing loops. In DSDV, there is a routing table in every mobile node, which contains all obtainable destinations, each destination’s metric, next hop and the sequence number created by the destination node. The packets are transferred between nodes of ad-hoc network by using such routing tables. The routing table of each node is updated periodically with frequent announcements or when new important information is available, this helps keep the consistency of the routing table with the changing topology of the network. Every mobile node announces routing information by broadcasting a routing table update packet periodically or when a network topology change is detected. At first the update packet starts one hop to frontal connected nodes. This means that the distance to every receiving node is one metric (hop) from the sending node. Therefore it is different from that of traditional routing algorithms. When a node receives the update packet, it updates its routing table and increments the metric by one and transferring the update packet to its neighbors. The process will continue until all nodes receive a copy of the update packet. The update data has to wait for the best route for every destination in every node before updating its routing table and retransferring the update packet. If multiple update packets are received from the same destination, then the routes chosen are the ones chosen as the basis for packet forwarding decisions are the ones with the more recent sequence number.

However the routing information may not be announced immediately, if only the sequence numbers have changed. In the case of the update packet having a similar sequence number with the same node, then the update packet that has the smallest metric will be used and the current route will be discarded or saved as a not preferable route. In such case, the update packet will be broadcasted with the sequence number to all the nodes of the ad-hoc network. The announcement of the routes that are going to change might be delayed pending the finding of the best route. Delaying the announcement of possibly unstable route can inhibit the changes of the routing table and decrease the amount of rebroadcasts of routes that can possibly arrive with the same sequence number. With the dynamically changing topology of the ad-hoc network the routing table of each node has to change dynamically to uphold consistency. To achieve this consistency, the announcement of routing information has to be frequent or fast to make sure that each node has the ability to locate all other mobile nodes in the dynamic ad-hoc network. Depending on the updated routing information, data packets are relayed between nodes depending on the dynamically created ad-hoc network.

The prime goal of DSDV is to make the distance vector routing more appropriate for ad-hoc networks and handle the problem of looping of the conventional distance vector protocol. On the other hand, DSDV increases route changes due to its criteria of route updates. Also, DSDV doesn’t fix the widespread problem of all distance vector routing protocols, the unidirectional links problem. Inhibiting Changes, Unidirectional Links and It is hard to define the maximum setting time. DSDV doesn't uphold multi-path routing. The destination focal synchronization experiences latency problem. Periodic and triggered updates cause too much communication overhead. Every node must have a complete routing table. Figure 4 is an example of Ad-hoc network where is Table 1 is representing the routing table for node 6 He(2002). Greedy Perimeter Stateless Routing (GPSR): GPSR is a datagram wireless network routing protocol. In GPSR packet forwarding decisions are made by using the positions of each router and packet’s destinations. GPSR using greedy forwarding to decide the path making use of information of router’s direct neighbors within the same network topology.

![Fig. 4: Example of Ad-hoc Network He (2002).](image)

Perimeter of the region algorithm is working whenever a packet arrives to a region where greedy forwarding is not possible. GPSR behavior is much better in per- router state than ad-hoc routing protocols and shortest-path when network destination number is increased. Local topology information can be used to find the correct new path rapidly once any mobility change happen to the network topology Karp and Kung(2000). In GPSR, each packet is identified by the location of destination assigned by its sender. Consequently a node can forward the packet with choosing the best greedy next hop. Specially, if the position for its neighbor is known. The neighbor which is geographically closest to the destinations is considered as the best choice for the next hop. The forwarding process is continue sequentially choosing the nearer geographic hops towards destination. Figure 5 illustrates an example of selecting a greedy next hop, where node x get a packet with D node as a destination. The dotted circle around x is representing the radio range for node x, where dashed arc
about D node is showing the equality of arc radius to the distance between node D and node y. Since the distance between node D and node y is less than any other distance between node D and other x's neighbors, the packet is forwarded from x to y. This process for greedy forwarding is repeated, until the forwarded packet arrives the destination node D.

The only drawback with greedy forwarding comes with some special topologies, where a packet need to travel farther than its destination D when it's the only route available to that destination Finn(1987), Karp(1998). Figure 6 illustrating an example of such topology where x node is closer to distinction D node from its neighbors y and W. The same here the dashed arc about D node is showing the equality of arc radius to the distance between node D and node y. Two paths from x to D are available (X-Y-Z-D) and (X-W-V-D) both with greedy forwarding which is not suitable here, so x should use other mechanism to forward the packet to destination D node.

Table 1: The Routing Table for Node H6 at One Instant Perkins and Bhagwat(1994).

<table>
<thead>
<tr>
<th>Destination</th>
<th>Next Hop</th>
<th>Metric</th>
<th>Sequence Number</th>
<th>Install</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>H4</td>
<td>3</td>
<td>S406_H1</td>
<td>T001_H6</td>
</tr>
<tr>
<td>H2</td>
<td>H4</td>
<td>2</td>
<td>S128_H2</td>
<td>T001_H6</td>
</tr>
<tr>
<td>H3</td>
<td>H4</td>
<td>3</td>
<td>S564_H3</td>
<td>T001_H6</td>
</tr>
<tr>
<td>H4</td>
<td>H4</td>
<td>1</td>
<td>S710_H4</td>
<td>T002_H6</td>
</tr>
<tr>
<td>H5</td>
<td>H7</td>
<td>3</td>
<td>S392_H5</td>
<td>T001_H6</td>
</tr>
<tr>
<td>H6</td>
<td>H6</td>
<td>0</td>
<td>S076_H6</td>
<td>T001_H6</td>
</tr>
<tr>
<td>H7</td>
<td>H7</td>
<td>1</td>
<td>S128_H7</td>
<td>T002_H6</td>
</tr>
<tr>
<td>H8</td>
<td>H7</td>
<td>2</td>
<td>S050_H8</td>
<td>T002_H6</td>
</tr>
</tbody>
</table>

Fig. 5: Greedy Forwarding Example x is Closest to D Than w and y Karp and Kung(2000).

Fig. 6: Greedy Forwarding Failure. y is x's Closest Neighbor to D Karp and Kung(2000).

MATERIALS AND METHOD

4.1 Methodology for Comparative Analysis:

To make a comparative analysis of routing protocols, this paper establish and consummate a logical sequence of steps, presented in Figure 7. Following this methodological process, the results will be adequate and valid. The development of this analysis can be roughly divided into five main stages: preparation, implementation, data collection, analysis of results and conclusions. Because of the generality of these stages, they can be decomposed in different subtasks, such as the connections generation or the scenario generation.

4.2 Proposed Scenario:

This paper considered the Emergency and rescue scenario (ERS) presented in Quispe and Galan(2014) for the center of Loja city, Figure 8. In order to set the scene for the ERS, an area of 1000m x 500m was used. The participants urban parishes of the city are: Valle, San Sebastian, Sagrario and Sucre. Random Waypoint Mobility Model have been used to simulate the movement in this area. For example, if we consider that we are
using the DSDV routing protocol in the simulated sector, a node must find the quickest way out of the disaster area and constantly update the information in its routing table. But if many nodes are connected, updating their tables, and occupying a given bandwidth, other nodes may not communicate. Also due to constant updating process, the delay may increase and therefore not allow a quickly departure from the affected area.

![Methodology for Comparative Analysis of Routing Protocols](image)

Fig. 7: Methodology for Comparative Analysis of Routing Protocols.

It is also important to mention that in this type of routing, each node has an information table where you have to update the list of routes, the number of hops to the destination, and the order number assigned by this destination. On the other side, if we use AODV routing protocol in the simulated area, a node should wait to receive a signal from the target point and then start looking for new communication in the affected location. Internally, a node can also initiate communication to other nodes. Evacuation routes are only given when there is a request. This type of routing in emergency and rescue scenarios may be suitable as long as there are no obstacles in the path. Although each node has two routing tables: an optimized list of routes and the destination sequence number, the obstacles can be a problem. If there is no updated information, communication may be directed to places where there are obstacles and the evacuation time could be higher. Of course, compared to Proactive routing, reactive routing is still the best in performance metrics. In contrast, if we use the hierarchical routing protocol, the big picture gets better. Here when a node wants to leave the disaster area, it joins a group and the group designate a leader, which has the ability to get them out faster to the target point. Also while the group leader is fulfilling this task, another node acts as a communicator with nearby groups in order to inform the best point of evacuation. It is important to also note that for this type of routing, each node has a table with information about their neighbors or nodes that are more close to him. This gives it the advantage of being able to rely on them to get out faster from the disaster area. For performance measures, this routing type has shown the best results, as we will see later.
4.3 Performance Metrics

4.3.1 Packet Delivery Ratio (PDR):
Packet delivery ratio is the rate of the successful received packets that the communication link can forward from a sender to a receiver. It can be measured as the ratio of the number of packet received at a TCP receiver $R$ to the total number of packet sent from the sender $S$.

$$PDR = \frac{\sum_{i=1}^{m} R(k)}{\sum_{i=1}^{m} S(i)} \times 100$$

where $m$ is the total number of senders or receivers.

4.3.2 Delay Average:
Delay is a critical metric in multimedia services such as video streaming, real-time audio, and interactive gaming. It can be defined as the time experienced by a successfully transmitted packet while travelling from its source to the destination. Delay is classified into processing, queuing, transmission, and propagation delay. A packet may suffer from all of these delays in its journey from the sender to the receiver. The measurement unit of the delay used throughout this paper is second.

In this paper, the delay measurement is started from the time the packet is sent by TCP sender ($t_s$) to the time when it is received by the TCP receiver ($t_r$) and thus called end-to-end delay. All the processing, queuing, transmission, and propagation delays are accounted for. The average delay is calculated accordingly as the ratio of the total delay to the total number ($n$) of the correctly TCP data packets received. The delay $D$ and average $D_{avg}$ delay are expressed as in Equations (3) and (4), respectively.

$$D = t_r - t_s$$

$$D_{avg} = \frac{\sum_{i=1}^{n} t_r(i) - t_s(i)}{n}$$

4.3.3 Normalized Routing Load (NRL):
The normalized routing load is defined as the fraction of all routing control packets sent by all nodes over the number of received data packets at the destination nodes. In other words, it is the ratio between the total numbers of routing packets sent over the network to the total number of data packets received.

$$NRL = \frac{\sum_{i=1}^{m} C(i)}{\sum_{j=1}^{n} D(j)}$$

where $C(i)$ is the total routing packets sent in the $i^{th}$ node, $n$ is the total number of nodes, $D(i)$ is the total data packets received in the $j^{th}$ node and $m$ is the total number of receivers.

Performance evaluation:
Routing protocols mainly concentrate on achieving high performance by dynamically computing the routes to and from each node. Simulation experiments have been carried out to investigate and evaluate AODV, DSDV
and GPSR routing protocols in different scenarios of MANET. Packet delivery ratio, end-to-end transmission delay and normalized routing load performance metrics have been evaluated in different scenarios and network conditions, such as varying number of nodes, number of connections, and movement speeds.

5.1 Simulation Setup:
To show the efficiency of each routing protocol, this work mainly focuses on comparing them against each other. In this evaluation, the considered routing protocols are examined over different topologies with varying number of nodes, traffic loads, and mobility speeds. The simulation experiments were performed using NS2 simulator Fall and Varadhan(2009) with the default settings unless mentioned otherwise. The File Transfer Protocol (FTP) Postel and Reynolds(1985) has been chosen as a traffic generator, while TCP is the transmission protocol. The packet size is set to 512 bytes and the channel bandwidth is 2Mbps. The simulation time is set to 150 s. All data points are obtained by taking the average of 30 simulation runs with different random seeds. Table 2 presents the parameters settings of the scenarios used in this paper.

Table 2: Parameters Setting.

<table>
<thead>
<tr>
<th>Simulation Parameters</th>
<th>Scenario1 Different number of node</th>
<th>Scenario2 Different number of Connections</th>
<th>Scenario3 Different mobility Speeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation time (Sec)</td>
<td>150 seconds</td>
<td>150 seconds</td>
<td>150 seconds</td>
</tr>
<tr>
<td>Terrain Dimensions</td>
<td>500 M, 1000 M</td>
<td>500 M, 1000 M</td>
<td>500 M, 1000 M</td>
</tr>
<tr>
<td>Number of Nodes</td>
<td>97,100,120,160</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Minimum speed</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Maximum speed</td>
<td>6</td>
<td>6</td>
<td>4,8,12,16,20</td>
</tr>
<tr>
<td>Traffic Connections</td>
<td>20</td>
<td>10,20,30,40,50</td>
<td>20</td>
</tr>
<tr>
<td>Traffic Model</td>
<td>FTP</td>
<td>FTP</td>
<td>FTP</td>
</tr>
<tr>
<td>Transport layer protocols</td>
<td>TCP</td>
<td>TCP</td>
<td>TCP</td>
</tr>
<tr>
<td>Mobility Model</td>
<td>Random way Point</td>
<td>Random way Point</td>
<td>Random way Point</td>
</tr>
<tr>
<td>Propagation model</td>
<td>TwoRayGround</td>
<td>TwoRayGround</td>
<td>TwoRayGround</td>
</tr>
<tr>
<td>MAC-Protocol</td>
<td>802.11</td>
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<td>802.11</td>
</tr>
<tr>
<td>Routing Protocols</td>
<td>AODV, DSDV, GPSR</td>
<td>AODV, DSDV, GPSR</td>
<td>AODV, DSDV, GPSR</td>
</tr>
<tr>
<td>Pause Time (Sec)</td>
<td>2 second</td>
<td>2 second</td>
<td>2 second</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION

Simulation experiments are conducted in order to evaluate the performance of AODV, DSDV and GPSR under different number of nodes, traffic loads, and mobility speeds.

5.2.1 Performance of Routing Protocols for Varying Number of Nodes:
To conduct the experiments for varying number of nodes, we have adopted the topology and setting in Quispe and Galan(2014). In this topology, the nodes are randomly distributed, so that nodes which are 4 hops away can transmit simultaneously without interference since the interference range is two times the transmission range.

Figure 9 shows the PDR of the considered routing protocols as a function of various number of nodes. In this figure, it can be observed that for all the nodes DSDV performs best among the other protocols by showing the highest delivery of packets.

Figure 10 presents the results of the end-to-end transmission delay in terms of nodes. The results show that GPSR provides much lower latency than DSDV and AODV. In the figure, for large number of nodes DSDV and AODV behave closely. However, DSDV performs much better than AODV in most cases. We admit this because AODV has reactive routing process. Using large number of nodes means less hops between the sender and destination and consequently less queue time for the data packets. However, GPSR has to send more messages to the networks by increasing number of nodes. Moreover, it can be observed that there is a drastic fall in the delay of AODV and DSDV protocols with increasing number of nodes. The reason is quite intuitive since multiple nodes increase the availability of routes. However, the delay increases in the case of GPSR by increasing number of nodes. The primary reason for this trend is due to the characteristics of GPSR. In particular, this mostly happens due to the high contention caused by generation more routing messages to inform other nodes about the current position. The consequence demonstrates that adopting GPSR to satisfy the requirement from time-sensitive applications is quite comparable.
In Figure 11, it can be observed that normalized routing load is the highest in GPSR due to the generation of multiple routing messages. It can be noticed that the whole behavior of normalized routing load is increasing with the increasing number of nodes.

**Fig. 9: Packet Delivery Ratio vs. Number of Nodes.**

**Fig. 10: Transmission Delay vs. Number of Nodes.**

**Fig. 11: Normalized Routing Load vs. Number of Nodes.**

### 5.2.2 Performance of Routing Protocols for Varying Number of Connections:

Figure 12 shows the PDR of the considered routing protocols as a function of various number of nodes. It is clear that all the protocols provides the same delivery ratio and they are not affected by the changing in number of connections.

In Figure 13, it's clear that average delay is the minimum with GPSR since it achieves less average delay than proactive routing protocol. It can be noticed that the average delay is an increasing function of number of connections.

**Fig. 12: Packet Delivery Ratio vs. Number of Connections.**
In Figure 14, it can be observed that normalized routing load is the highest in hybrid GPSR protocol as it sends diversity of routing messages in order to create stable routes. Furthermore, it can be noticed that the whole behavior of normalized routing load is fluctuated and not affected by the increasing number of connections.

5.2.3 Performance of Routing Protocols for Varying Mobility Speeds:

Figure 15 shows the PDR of the considered routing protocols as a function of various mobility speeds. It is clear that all the protocols provides the same delivery ratio and they are not affected by the changing of mobility speeds.

In Figure 16, it can be observed that average delay is quite high in the reactive routing protocol AODV and this is due to the mechanism of these routing protocols where paths are not automatically available, they are on demand routing protocols that provides the route once it needed by the source. It's clear that average delay is less with proactive routing protocol DSDV. This is quite intuitive due to the process of continuous updating for the routing table and availability of fresh routes. We can also observe that hybrid routing protocol GPSR still achieves less average delay than proactive routing protocols. It can be noticed that the average delay of GPSR is an increasing function of speeds, while AODV and DSDV try to maintain their delay with the speed increment.

Fig. 13: Average Delay vs. Number of Connections.

Fig.14: Normalized Routing Load vs. Number of Connections.

Fig. 15: Packet Delivery Ratio vs. Number of Connections.
In Figure 17, it can be observed that normalized routing load is the highest in GPSR due to the nature of this protocol as it sends many routing messages to maintain its routes.

**Conclusion:**

It has been proven in the literature that routing protocols face several problems and challenges when applied over MANET networks. One of the crucial sources of routing protocols performance degradation lies in the generation of redundant routing messages, which compete for the same path with data packets and increase the overhead and delay in the network. Accordingly, new approaches were introduced in order to reduce these overheads and improve the performance. To clearly understand the behavior of routing protocols when applied over wireless networks and in order to identify the relation between these protocols and the factors that play major role on their performance, this paper presented a comparative analysis of AODV, DSDV, and GPSR routing protocols in different scenarios of MANET with various number of nodes, number of connections and mobility speeds. The analysis studied the Packet delivery ratio, average delay and normalized routing load as key performance metrics in this field. The analysis has been conducted using the well know network simulator (NS2). The experimental results shows that each protocol has its behavior against each performance metrics with respect to different scenarios of speeds, load and Nodes. Hence, choosing the best routing protocol should be according to the requirements of a particular scenario in MANET. As corroborated by intensive simulation experiments, reducing the overhead caused by sending routing messages is vital for good performance.

**REFERENCES**


