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# STUDYING AND ANALYZING ALGORITHM BEHAVIOR AND MECHANISM FOR WIRELESS AD HOC ROUTING PROTOCOLS

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**ABSTRACT**

The first phase of any research is to find out problem statement. The current study highlights inadequacies and weaknesses of previous studies in the field of ad hoc routing protocols. The main goal of any routing protocol is to discover the appropriate path between two nodes to be identified in a timely manner. The primary objective of this research is to address the weaknesses and evaluate the performance of routing protocols using computer simulations and theoretical analysis. The study carried out an analytical analysis of the techniques and distinguished among the routing protocols to address the problems in each protocol due to the strategies working behind the protocols. The results obtained in this study provided evidence of the weakness in the technique or mechanism of some routing protocols.

**Keywords:** Ad hoc routing protocol; algorithm.

## 1. INTRODUCTION

The term “routing” refers to the process in which a path (or route) is selected between a source node and a destination node along which the data istransmitted. The overall efficiency and effectiveness of packet switching mainly depend on the routing protocol being selected. A routing protocol is able to determine the best routing path between a given source node and its destination based on specified selection criteria and performance metrics. The first phase of this research is to analysis these ad hoc routing protocols:AODV, DSDV, OLSR, and DSR: in order to find out their weakness as already explained in the literature review of previous studies [1-4]. Yet, previous studies have not adequately captured these weaknesses. For instance, a previous study did not adequately identify all the weakness of WANET[5] protocols especially when being applied in real environments as this requires studying their behavior deeply. In order to understand the routing protocol, it is necessary to understand the routing algorithm which is illustrated in the flowcharts. Performance evaluation of ad hoc routing protocols was carried out using scenario based mobility models [6, 7]. Most studies in the field of ad hoc routing protocols have only focused on evaluation or comparison via experiments [7]. Yet, researchers have not dealt with studying and analyzing the behavior and mechanism of algorithms based on both theories as well as experiments in much details. Therefore, the present study provides a detailed explanation of the behavior of routing protocols based on the theoretical analysis and comparison of every part of the routing protocols while at the same time measure the performance of routing protocols in different scenarios by a couple of metrics. In addition, in investigating and analyzing the behaviors of routing protocols, the study included the flowcharts to show the weakness in each features or techniques. Thus, identification of the problems was not only based previous studies, but also based on testing and examining them using a simulator as illustrated later.

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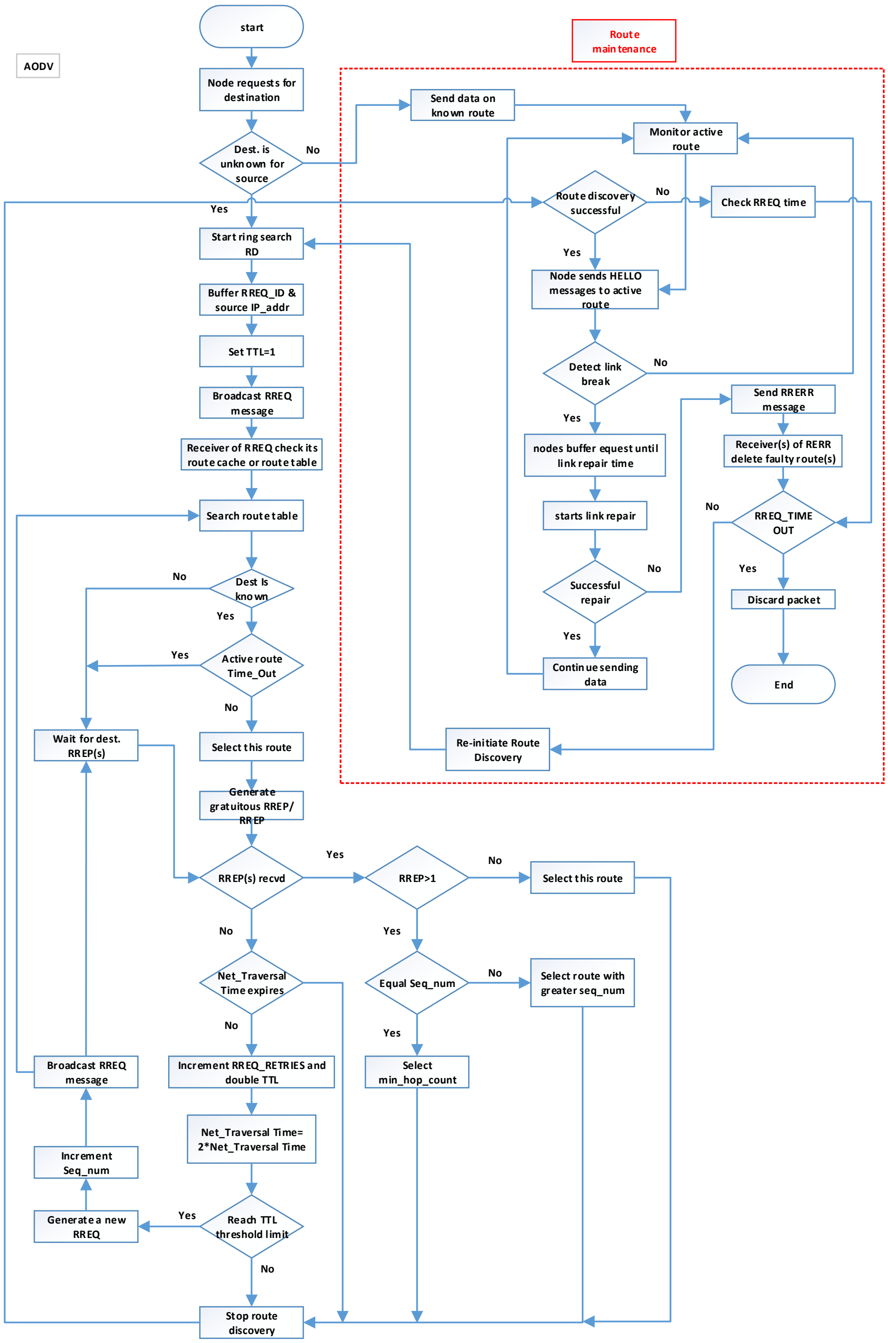


**Figure-1.** The AODV route discovery and route maintenance.

## 2. STUDYING AND ANALYZING THE PROTOCOLS: AODV, DSDV, OLSR, AND DSR

It is important for a routing protocol to be able to determine the optimal path as quickly as possible. When connections between nodes are created and destroyed, and whenit takes a long time to update each node, the network may become unstable in the sense that it causes routing loops and unreachable destinations. Therefore, connectivity information must be accurately and timely distributed amongst the nodes with a minimum delay.

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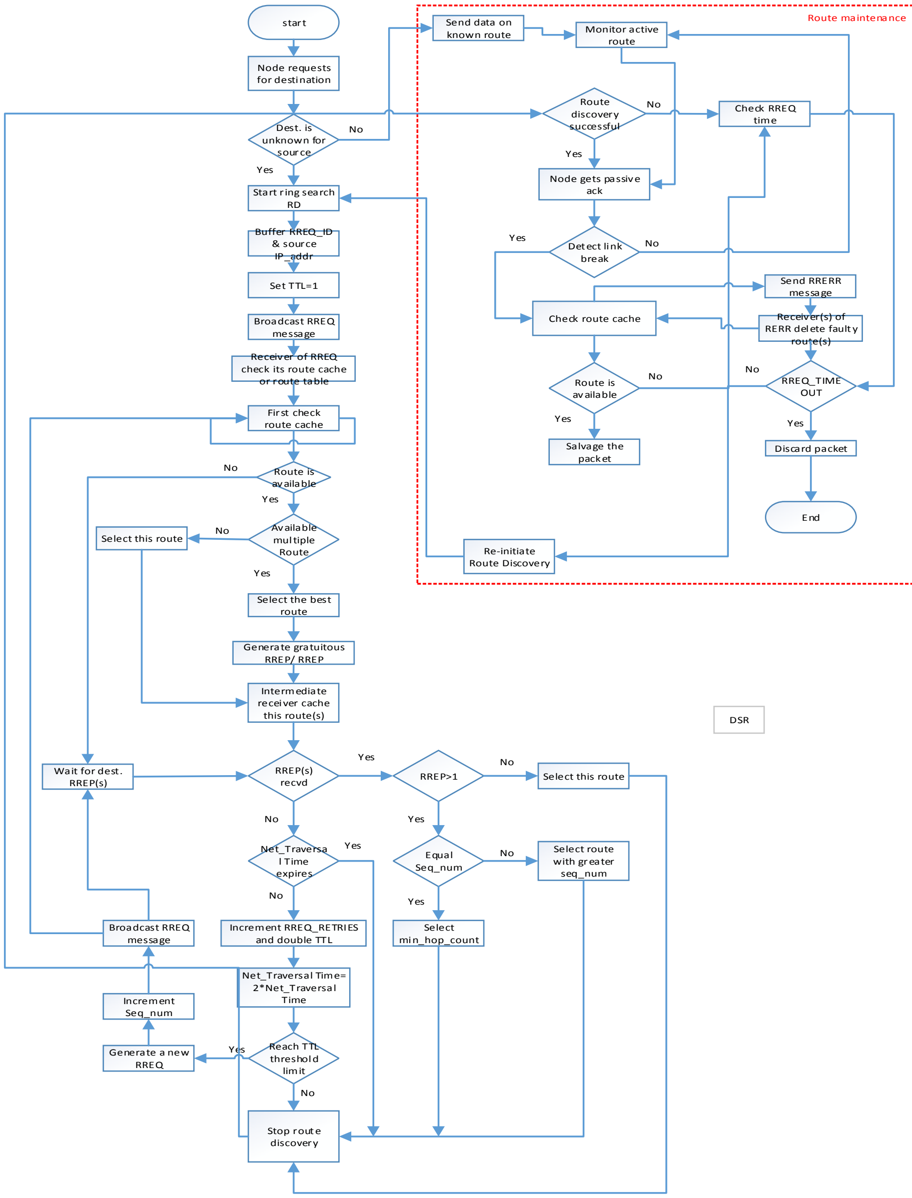


**Figure-2.** The DSR route discovery and route maintenance.

The analysis of these are routing protocol was performed based on two aspects. The first aspect is represented by previous studies which explained the routing protocols in details including their standard/Request For Comments (RFC) documents such as RFC 3626 OLSR [8], RFC 4728 DSR [9], RFC 6126 DSDV [10] and RFC 3561 AODV [11]. Such previous research is valuable for studying the behaviors of routing protocols in different scenarios [12]. The second aspect was applying a simulator to study and analyze the real behaviors of routing protocols as well as studying theirnetwork performance.

Most previous studies measured the performance of routing protocols in different scenarios using acouple of metrics[13-15]. Other related studies focused on the theoretical analysis and comparison. Only a fewstudiesshowedthe routing protocol behaviors. Thus, this study explains the behaviors of routing protocols based on the theoretical analysis and comparison of each part of routing protocols, taking into account measuring the performance of routing protocols in different scenarios by a couple of metrics. This includes generating the flow chart (algorithm) for every protocol as shown in Figures (1-4). After generating the flow chart for every protocol, the route discover and route maintenance which are the most important parts in routing protocols are illustrated.

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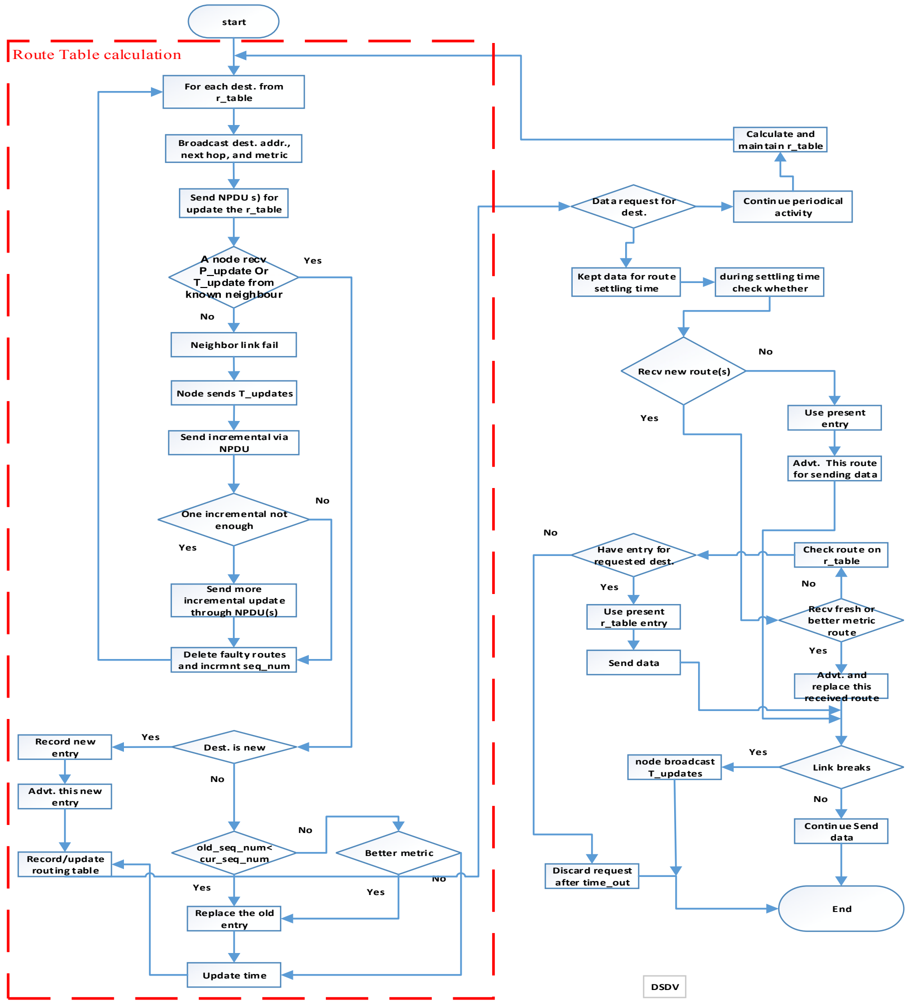


**Figure-3.** The DSDV route discovery and route maintenance.

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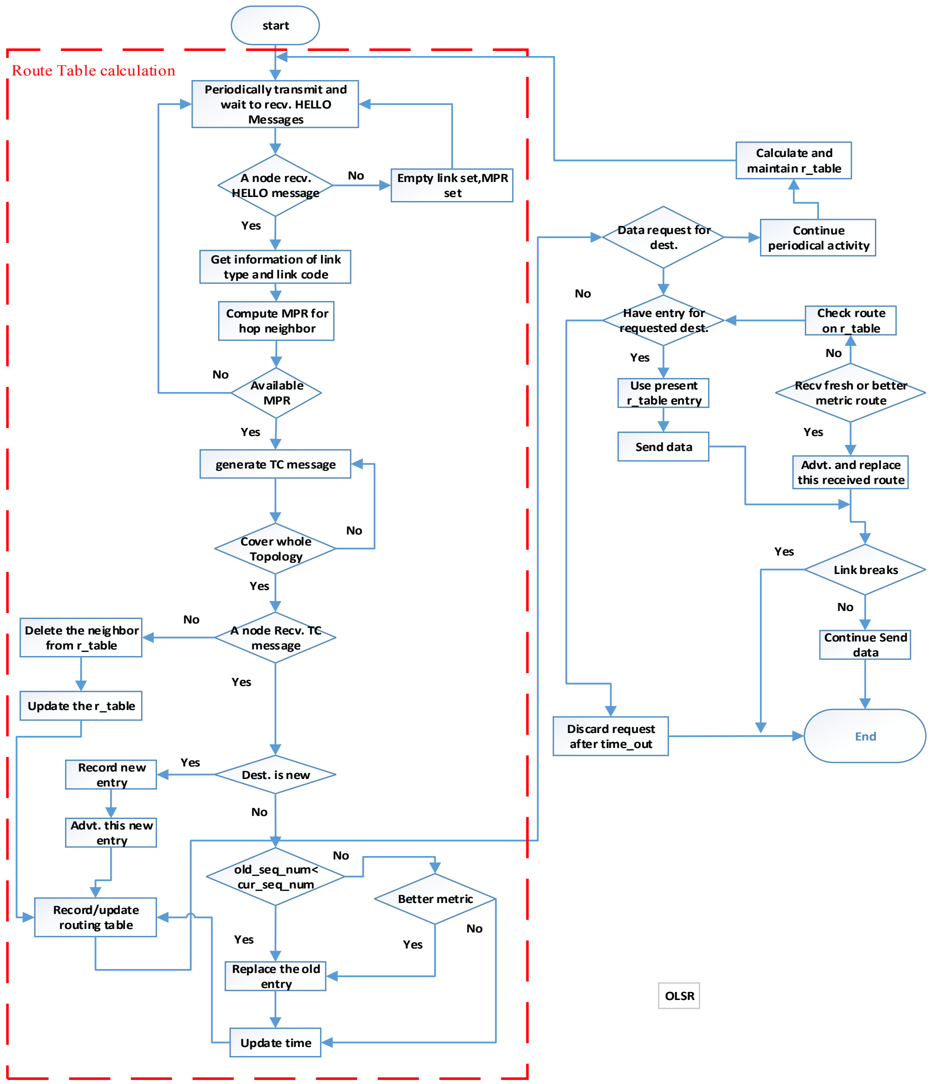


**Figure-4.** The OLSR route discovery and route maintenance.

Then, three simulation models were created. They are mobility, network load and scalability scenarios as shown in Table-1. The current study includ ananalysis of the scalability and traffic handling properties for routing protocols to find performance leaks in each protocol due to the strategies working behind the protocols. Every column in Table-1 represents the different scenarios whereas column 2 represents the mobilityscenario where nodes have different speeds. Column 3 represent the network load scenario by including different rates of data speed. Column 4 represent the scalability scenario by increasing the number of the nodes.

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**Table-1.** Mobility, network load, and scalability parameters.

| Metrics | Mobility | Network load | Scalability |
|---|---|---|---|
| continuous Bit Rate CBR packet size/time | packet size 512B/s | packet size 64B/2,4,8,16,32s | packet size 512B/s |
| source=>destination nodes | 20 nodes | 20 nodes | 20 nodes |
| mobility model random | table (2) | 20m/s | 20m/s |
| place | 1000m*1000m | 1000m*1000m | 1000m*1000m |
| total number of nodes | 50 nodes | 50 nodes | 10,20,30,40,50,60,70, 80,90,100 nodes |
| transmission range | 250m | 250m | 250m |
| bandwidth link | 2Mbps | 2Mbps | 2Mbps |
| simulation time | 900s | 900s | 900s |

**Table.2.** Mobility speed.

| Name of model | Speed in meter/second | Speed in km/hour |
|---|---|---|
| Fast Car Model (FCM) | 30m/s | 108km/h |
| Slow Car Model (SCM) | 15m/s | 45km/h |
| Human Running Model (HRM) | 8m/s | 28.8km/h |
| Human Walking Model (HWM) | 2 m/s | 7.2km/h |

## 3. DISCUSSIONS

Routing protocol is the essential part in the wireless ad hoc network WANET. And the most important parts are the route discovery and route maintenance. As shown in Figures (1- 4), the route discovery had impact on the overall of network performance in large networks unlike in small networks. In addition, the route maintenance resulted into degrading the performance due tothe add overhead packets. The AODV protocol was adapted as “it can handle low, moderate, and relatively high mobility rates, as well as a variety of data traffic levels”. For the DSRprotocol, “it adapts quickly to the topological changes when movement of nodes is frequent. It requires little or no routing overhead during the periods in which the nodes move less frequently or remain at rest”. The first scenario in which the simulator was applied was themobility scenario (column 2 in Table-1). In such scenario, all the nodes move in different speeds based on the real environments as shown in Table-2. The speeds of the nodes in the stimulator are represented by Fast Car Model (FCM), Slow Car Model (SCM), Human Running Model (HRM), and Human Walking Model (HWM). The throughput, overhead, and End to End Delay E2ED for each speed were also measured in this study. The results showed that the average throughput in the scenario mobility model is as follows: DSR, AODV, DSDV, and OLSR ordinal, respectively.

What is the novelty of the current study added to previous research is that theDSRprotocol produces the highest throughput because it does not generate more routing packets as in the case of the AODV protocol.The all results experimental shown in Figures 5 to 7. The routing packet refers to the number of updating a message to update the routing protocols database. Figures (3, 4) show the Route Table (RT) calculation phase that took place first and then the phase of response to the data request is given in proactive protocols [16]. This leads to degrading the performance due to the re-calculated route while the link breaks because of the mobility. Thus, based on these results, the DSRprotocolwas found to be better than the AODV protocol except in high speed mobility. The AODVprotocol alters the basic distance vector algorithm by adding a sequence number. Therefore, in high mobility, the Fast Car Model (FCM) AODV produces more throughput. The DSRprotocol is a source routing algorithm. It inherits some features from the AODVprotocol. It monitors (active routes) by link layer per hop acknowledgments or through passive acknowledgments. The DSRprotocol possess maximum throughput except in FCM at no or less pause times.

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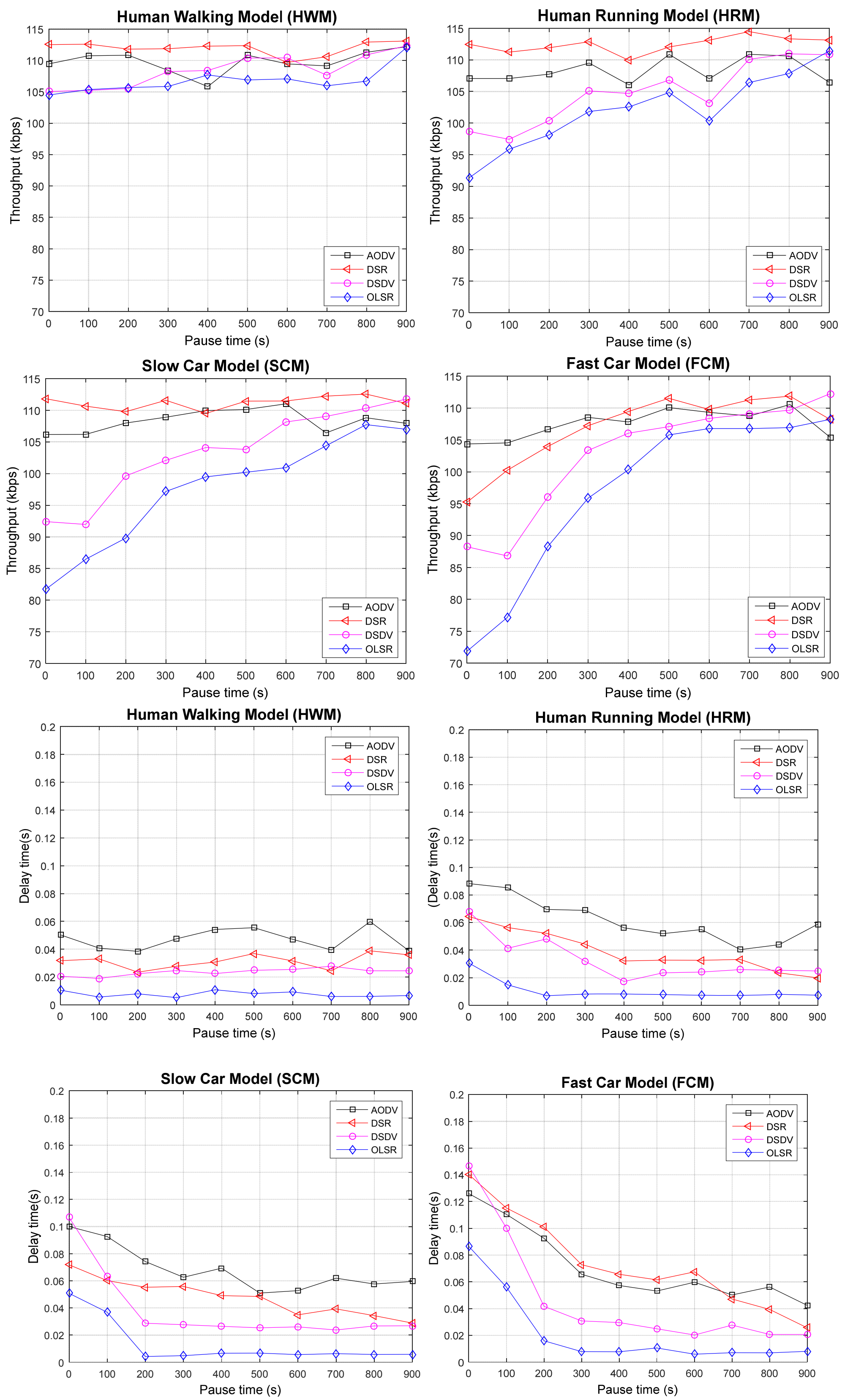


**Figure-5.** Mobility scenario.

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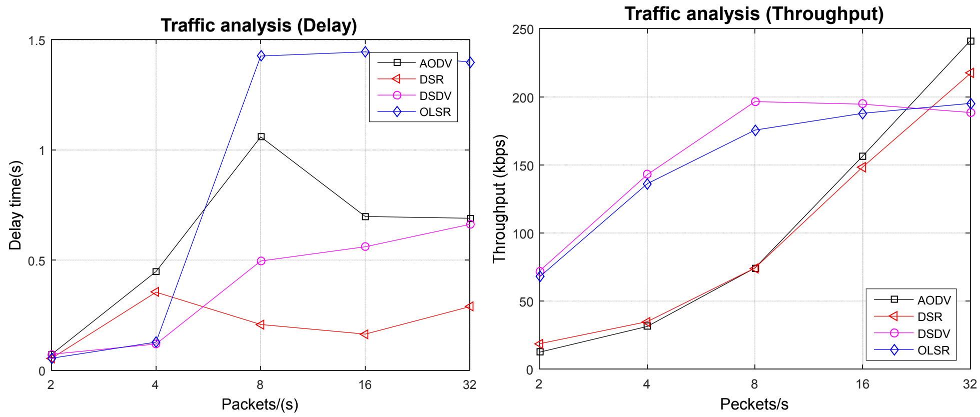


**Figure-6.** Network load scenario.

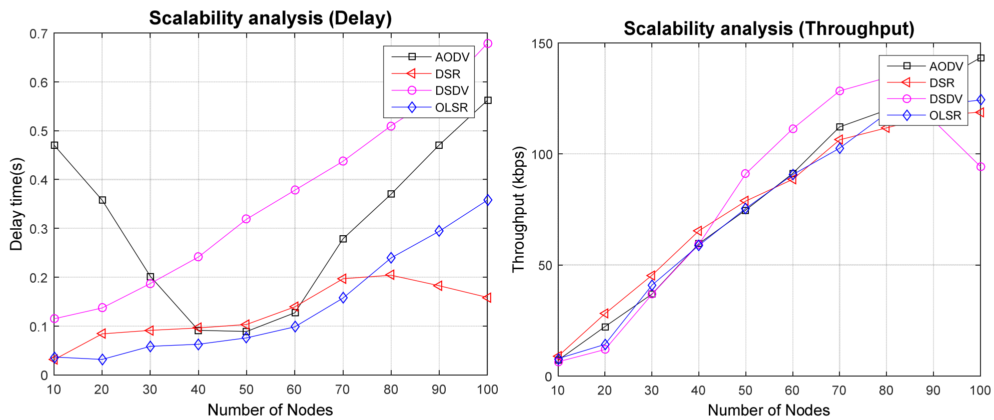


**Figure-7.** Scalability scenario.

The DSDV routing information is advertised by broadcasting the packets periodically. To reduce the amount of routing information carried by routing packets, the DSDV protocol uses full and incremental update. When the first data packet arrives, it is kept until the best route is found for a particular destination. The DSDVprotocol keeps higher E2ED because the DSDV keeps thedata packet until it receives a good route, thus making the delay longer. The DSRprotocol does not implement LLR, so its AE2ED is less than the AODVprotocol, but during high mobility at high speed, the Route Cache (RC) search fails frequently, thus resulting into increasing the delay. The OLSRprotocol outperforms the rest of the routing protocols in E2ED. The OLSR protocol is a proactive link-state-based protocol that exchanges a topological connectivity of information among its neighboring nodes periodically. It uses a technique called hop-by-hop routing, and such packets do not carry a source-route within their packet headers. Instead, each intermediate relay node uses its local routing table to guide and forward a packet towards the destination node. The OLSRprotocol makes a use of two techniques to acquire topological information in order to build a routing table at each node, and these are discussed hereafter.

Proactive protocols have low throughput in high mobility because, unlike the reactive protocols, proactive protocols perform route calculation before data transmission. Therefore, reactive protocols attain more throughputs. Moreover, reactive protocols cause more delay as compared to proactiveprotocols, and therefore, the less delay time order can be as follows: OLSR, DSDV, DSR, and then AODV. Some real time application needs less delay so we prefer the OLSR protocol. The results of the current study showed that the average overhead in the scenario mobility model is as follows: OLSR, AODV, DSDV, and DSR ordinal. In the overhead, it was found that the DSRprotocol outperforms the rest of the routing protocols. The DSRprotocol is better and less overhead in reactive protocols. However, the DSDVprotocol is better and less overhead in proactive protocols.

The second and third scenarios shown in Table 1, column 3, and 4 applied thesimulator as network load and scalability. All the nodes move randomly with 20m/s speed. The Metrecs throughput, overhead, and E2ED for different number of nodes and data traffic were also measured. The results revealed the average throughput in the scenario mobility model is as follows: DSR, AODV, DSDV, and OLSR ordinal, respectively.

The AODV protocol performs better inreactive protocols for high network flows and traffic rates for few or a high number of nodes (thousand nodes). The DSRprotocol guarantees outstanding performance for up to 200 nodes/ packet salvaging (PS) technique, and it is more suitable for small populations due to the PS. For the DSRprotocol, RC in the medium or high traffic load degraded the performance. The OLSRprotocol is scalable but a less converged protocol for high traffic rates, and it suits large and dense mobile networks. Moreover, when the traffic load increases, there is no mechanism of multi-path routing, so this protocol cannot perform well in higher data flows. In E2ED, the DSRprotocolshows less delay in high traffic and scalability. The DSDVprotocol has also less delay in high traffic but,the OLSRprotocol is better in high scalability, and it has less delay.

This study provides a summary of the weaknesses as identified and distinguished among routing protocols in Table-3. These weaknesses as distinguished in different scenarios are provided above (Table 1-2). Studying the behaviors of routing protocols is a critical topic. Due to the complexity of study, it is important to first study and understand routing protocols themselves (as standard)and then understand the code in details. The second step is applying the scenarios with trace every functionality and techniques. The third step is catching or identifying the weaknesses and distinguishing them by analysis and comparison.

**Table-3.** Weakness and distinguished in routing protocols.

| | AODV | DSDV | DSR | OLSR |
|---|---|---|---|---|
| **Distinguished** | **local link repair (LLR) mechanism** | **periodic /T-updates; P-updates** | **packet salvaging (PS) technique/route cache RC** | **Multi-point Relay (MPRs)** |
| notes | (LLR) mechanism produce high delay | full and incremental update | RT calculation phase take place first and then response to data request phase is given produce maximum throughput. but at high speed mobility RC search fails frequently and results in increased delay | MPR when traffic load increases there is no mechanism of multi-path routing, so, this protocol cannot perform well in higher data flows |
| Path calculation | Flooding-based route discovery | Distributed Bellman Ford (DBF) algorithm | Flooding-based route discovery | Dijkstra's algorithm |
| Packet forwarding | hop-to-hop | hop-to-hop | Source Routing | hop-to-hop |
| Flooding control mechanism | Ring search algorithm | Exchange topology information with neighbor only | Ring search algorithm | Broadcast by MPR |
| notes | | when the first data packet arrives, it is kept until the best route is found for a particular destination | | |
| Overhead | back-off algorithm & RREP | Incremental update | back-off algorithm and packet salvaging | MPRs |
| Notes | | | DSR produces the highest throughput because it does not generate more routing packets, like AODV | |
| Routing technique | Distance vector | Distance vector | source routing algorithm | like state |
| In high speed mobility | more throughput | More throughput | maximum throughput except in FCM | low throughput |
| Delay E2ED | attains the highest delay, Because LLR for link breaks in routes sometimes result in increased path lengths. | DSDV higher E2ED from OLSR, Because DSDV keeps a data packet until it receives a good route which gives more delay | | outperforms rest of the routing protocols in E2ED |

## 4. CONCLUSIONS

This paper addressed the weaknesses and evaluated the performance of routing protocol using computer simulations and theoretical analysis as summarized in Table-3. This outcome addresses some problems as to help researchers. We studied and compared wireless ad hoc routing protocols in terms of algorithm behavior and mechanism.Based on the results of the current study, it can be concluded that the AODV protocol is suitable tomassive networks and it has a high mobility, but it produces a high delay because of the LLR mechanism. The DSRprotocolis suitable tosmall networks, and it has an average mobility which produces a maximum throughput. But at high speed mobility, the RC search fails frequently and results into an increased delay. The OLSR protocol suits small or large networks with an average mobility. It is suitable for real time applications because it producesless E2ED. However, ithas less throughput because of the periodical update. The study showed that the DSDV protocol is suitable for average networks because the Distributed Bellman Ford DBF algorithm is not scalable, and it produces a delay in the calculation stage.

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