Performance Evaluation of Reactive, Proactive and Hybrid Routing Protocols in MANET

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***Abstract*—This Mobile Ad hoc Networks (MANET) is a set of wireless mobile nodes dynamically form spontaneous network which works without centralized administration. Due to this characteristic, there are some challenges that protocol designers and network developers are faced with. These challenges include routing, service and frequently topology changes. Therefore routing discovery and maintenance are critical issues in these networks. There are also limited battery power and low bandwidth available in each node. In this paper, we evaluate the performance of four MANET routing protocols using simulations: AODV, OLSR, DSR and GRP. Our evaluation metrics are End-to-End delay, network load, throughput and media access delay. Most of the papers consider the first three parameters, but here we also consider MAC delay.**

Keywords- MANET; Routing Protocols; OPNET; AODV; OLSR; DSR; GRP

I. INTRODUCTION

MANET is a dynamic distributed system [1], in which wireless devices with limited energy can move arbitrary. In this network, nodes communicate without any fixed infrastructure. MANET is a self-configurable network and nodes are free to move randomly, so topology may change and this event is unpredictable [6]. According to these characteristics, routing is a critical issue and we should choose an efficient routing protocol to makes the MANET reliable [10].

The most popular routing protocols [1] in MANET are AODV (reactive), DSR (reactive), OLSR (proactive) and GRP (hybrid). Reactive protocols find the routes when they are needed. Proactive protocols are table driven protocols and find routes before they need it. And finally hybrid routing protocols offer an efficient framework that can simultaneously draw on the strengths of proactive and reactive routing protocols.

In this paper, we focus on four MANET routing protocols, AODV, OLSR, DSR and GRP. We consider four parameters to evaluate the performance of these routing protocols: End-to-end delay, network load, throughput and media access delay**.** The organization of the paper is as follows. We explain routing protocols in section 2, related works are discussed in section 3, section 4 explains the experiment and performance analysis, our simulation result presented in section 4 and finally section 5 concludes the paper.

II. ROUTING PROTOCOLS IN MANETS

Four routing protocols are considered in this paper, namely; DSR, AODV, GRP and OLSR. Below is a brief description of each protocol:

A. DSR – Dynamic Source Routing (DSR)

DSR is a reactive routing protocol that discovers and maintains routes between nodes. In the route discovery, DSR floods Route Request Packet to the network. Each node that receives this packet, first add its address to it and then forwards the packet to the next node. When the targeted node or a node that has route to the destination receives the Route Request, it returns a Route Reply to the sender and a route is established. Each time a packet follows an established route, each node has to ensure that the link is reliable between itself and the next node. In the Route maintenance, DSR provides three successive steps: link layer acknowledgment, passive acknowledgment and network layer acknowledgment. When a route is broken and one node detects the failure, it sends a Route Error packet to the original sender [1, 5].

B. Optimized Link State Routing (OLSR)

OLSR is a table driven protocol. It usually stores and updates its routes so when a route is needed, it present the route immediately without any initial delay. In OLSR, some candidate nodes called multipoint relays (MPRs) are selected and responsible to forward broadcast packets during the flooding process. This technique reduces the overhead of packet transmission compared to flooding mechanism [1]. OLSR performs hop-by-hop routing, where each node uses its most recent routing information to route packets. MPR's is made in a way that it covers all nodes that are two hops away (i.e. neighbors of the neighbors). A node senses and selects its MPR's with control messages called HELLO messages. Hello messages are used to ensure a bidirectional link with the neighbor. HELLO messages are sent at a certain interval. Nodes broadcast "TC" or Topology control messages to determine it's MPRs [11].

C. Ad Hoc on-Demand Distance Vector Routing (AODV)

AODV provides on-demand route discovery in MANET. Whenever the nodes need to send data to the destination, if the source node doesn't have routing information in its table, route discovery process begins to find the routes from source to destination. Route discovery begins with broadcasting a route request (RREQ) packet by the source node to its neighbors. RREQ packet comprises broadcast ID, two sequence numbers, the addresses of source and destination and hop count. The intermediary nodes which receive the RREQ packet could do two steps: If it isn't the destination node then it'll rebroadcast the RREQ packet to its neighbors. Otherwise it'll be the destination node and then it will send a unicast replay message, route replay (RREP), directly to the source from which it was received the RREQ packet. A copied RREQ will be ignored.

Each node has a sequence number. When a node wants to initiate route discovery process, it includes its sequence number and the most fresh sequence number it has for destination. The intermediate node that receive the RREQ packet, replay to the RREQ packet only when the sequence number of its path is larger than or identical to the sequence number comprised in the RREQ packet. A reverse path from the intermediate node to the source forms with storing the node's address from which initial copy of RREQ.

There is an associated lifetime value for every entry in the routing table. Suppose that some routes are not applied within their lifetime period, so these routes are expired and should be dropped from the table. But if routes are used, the lifetime period is updated so those routes are not expired. When a source node wants to send data to some destination, first it searches the routing table; if it can find it, it will use it. Otherwise, it must start a route discovery to find a route [1]. It is also Route Error (RERR) message that used to notify the other nodes about some failures in other nodes or links [9].

D. Gathering-based routing protocol (GRP)

This schema collects network information at a source node with a small amount of control overheads. According to the collected information, source node can finds routes and continuously transmit data even if the current route is disconnected. The result of this approach is achieving fast transfer with less overhead of control massages [15]. This approach is widely known as hybrid routing protocol, because it can simultaneously use the strengths of reactive routing and proactive routing protocols. A packet that named DQ is used continuously to forward to each node's neighbors until the destination is reached. When it reaches the destination, the destination node broadcasts a network information gathering (NIG) packet to its neighbors. The source node computes the best route according to collected information and then immediately starts to transmit data packets.

III. RELATED WORKS

In [1], OPNET 14.5 was used for simulation. The simulation study for MANET network under five routing protocols AODV, DSR, OLSR, TORA and GRP were deployed using FTP traffic analyzing. These protocols were tested with three QOS parameters. From their analysis, the OLSR outperforms others in both delay and throughput.

khan et al. [2] conclude that when the MANET setup for a small amount of time, then AODV is better because of low initial packet loss. DSR is not prefers because of its packet loss. On the other hand if we have to use the MANET for a longer duration so we can use both protocols, because after sometimes both have the same behavior. AODV have very good packet receiving ratio in comparison to DSR. At the end, they concluded that the combined performance of both AODV and DSR routing protocol could be the best solution for routing in MANET.

In [3], Bindra et al. evaluate the performance of AODV and DSR routing protocol for a scenario of Group Mobility Model such as military battlefield. They used Reference Point Group Mobility (RPGM) Model for their scenario. They concluded that in Group mobility model with CBR traffic sources, AODV is better than DSR but when TCP traffic used, DSR perform better in stressful situation like high load or high mobility. DSR routing load is always less than AODV in all type of traffic. Average end-to-end delay of AODV is less than DSR in both type of traffic. Over all the performance of AODV is better than DSR in CBR traffic and real time delivery of data. But DSR perform better in TCP traffic under limitation of bandwidth.

In [4], Barakovic et al. compared performances of three routing protocols: DSDV, AODV and DSR. They analyzed these routings with different load and mobility scenarios with Network Simulator version 2 (NS-2). They concluded that in low mobility and low load scenarios, all three protocols react in a similar way, but when mobility or load is increasing, DSR outperforms AODV and DSDV.

In [5], Sathish et al. do a performance comparison of DSR, AODV, FSR and ZRP routing protocols for mobile Ad-hoc networks. Performance of these routing protocols is evaluated with some metrics such as average end to end delay, packet delivery ratio, throughput and average jitter. Simulation results show that DSR has best performance than AODV, in terms of packet delivery ratio and throughput as a function of pause time.

In [6], Kaushik et al. compared three routing protocols DSDV, AODV and DSR. They concluded that AODV performs predictably because it delivers the data at node with low mobility virtually, and it has problem when node mobility increases. But DSR was very good in situation that node has mobility and DSDV performs almost as well as DSR, but it needs many routing overhead packets. As far as packet delay and dropped packets ratio are concerned, DSR/AODV performs better than DSDV with large number of nodes. So for real time traffic AODV is preferred over DSR and DSDV. For less number of nodes and less mobility, DSDV's performance is better.

In [7], performance of AODV, OLSR and DSR was analyzed using NS2. The protocols were tested using the same parameters with high CBR traffic flow and random mobility. Performance of protocols with respect to scalability has also analyzed. Results showed that, AODV and OLSR experienced higher packet delay and network load compared to DSR. But, both OLSR and AODV performed very reliably when segment delay is considered. DSR has high end-to-end delay due to formation of temporary loops within the network. Throughput was considered as the main factor in evaluation. According to this factor DSR is performed worst. However, AODV showed better efficiency compared to OLSR and DSR.

In [8], Shah et al. compared the performance of DSDV, AODV and DSR routing protocols under different network load, mobility, and network size. According to simulation results from ns -2 network simulator, they concluded that both AODV and DSR perform better than DSDV, under high mobility.

In [10], Kumar Sharma et al. had a Behavioral Study of MANET Routing Protocols by using NS-2. After their analysis in different situations of network, they concluded that AODV perform better than DSDV and DSR in terms of throughput and average delay, while DSR is the best in case of Packet delivery ratio. Finally by considering all the aspect, AODV was better.

In [11], Maashri et al. analyzed the performance of DSR, AODV and OLSR routing protocols. They used NS-2. They concluded that DSR has superior performance in terms of data packet delivery ratio, throughput and end-to-end delay at the speeds of less than 10 m/s compared to AODV and OLSR. But, OLSR performed weak in the presence of a statistically self-similar traffic at high mobility especially in terms of data packet delivery ratio, overhead and delay. Also in AODV, low end-to-end delay was observed.

In [12], Usop et al. decided to choose the best routing protocol when implementing the routing protocols in the target mobile grid application. They compared DSDV, DSR and AODV with ns-2 simulator. Results show that DSR have a dramatic decrease in performance when mobility is high. However the AODV and DSDV perform well when mobility is high.

In [13] Kumari et al. concluded that in Freeway Mobility Model with CBR traffic sources, AODV performs better than OLSR and DSDV. Routing overhead of DSDV is always less than AODV and OLSR. DSDV gives better throughput with CBR traffic. With TCP traffic sources, OLSR gives better result than AODV and DSDV, but with higher routing overhead and end-end delay. Throughput of OLSR is also better with TCP traffic.

In [14] Performance of AODV, TORA and DSDV protocols is evaluated under both CBR and TCP traffic pattern. Extensive Simulation is done using NS-2. Simulation results show that Reactive protocols perform better in terms of packet delivery ratio and average end-to-end delay.

IV. DESIGN THE EXPERIMENT AND PERFORMANCE ANALYSIS

In this paper, we have four different scenarios in OPNET modeler 14.0. In each scenario, we apply a various routing protocol. Comparisons have been made between AODV, DSR, OLSR and GRP protocols. Fig. 1 shows the simulation environment of scenarios containing 20 mobile nodes with 7 meter/s speed. One of them is WLAN server and other are wlan_wkstn_adv node model. The "Application Config" node is used to specify UDP (VOICE: PCM Quality speech) and TCP (FTP: High Load) applications. Each scenario was run for 60 minutes. We considered five parameters for the evaluation; delay, network load, throughput, media access delay and load. In each figure from Fig. 2 to Fig. 6, the horizontal axis shows the simulation time in hour and minute format, and the vertical axis represent one of the five parameters (delay, network load, throughput, media access delay and load).

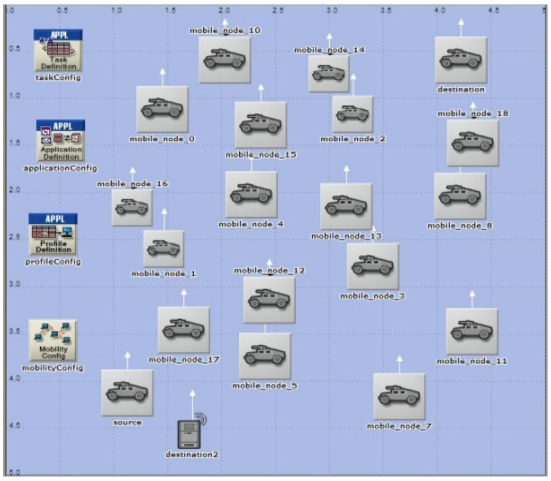

Figure 1. Simulation Environment

In all of the following figures red, dark blue, blue and green colors used to represent DSR, AODV, OLSR and GRP routing protocols respectively.

V. SIMULATION RESULTS

A. *Throughput:*

Fig. 2 show that throughput in AODV is the highest, in GRP is higher than OLSR and in DSR, we have the minimum throughput.

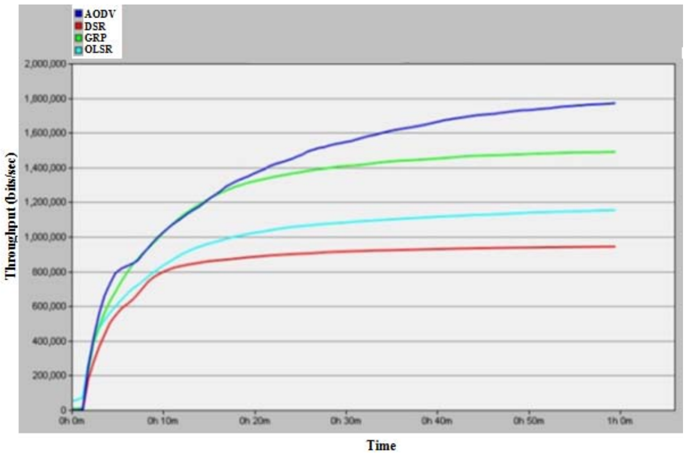

Figure 2. Throughput comparison in four routing protocols

B. *Network Load:*

According to simulation result in Fig. 3, we can see that GRP network load increases until the end of simulation and has the maximum Network Load. We can order the network load respectively: GRP > OLSR > AODV > DSR.

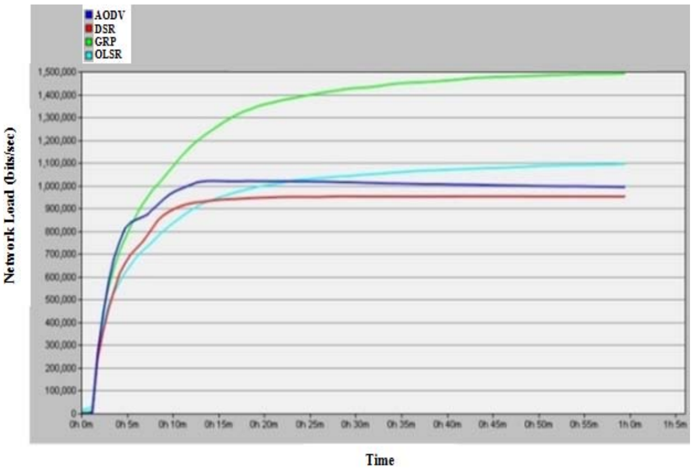

Figure 3. Network load comparison in four routing protocols

C. Media Access Delay:

In Fig. 4, we see that DSR has initial media access delay at first of simulation. We can conclude that media access delay in DSR is the highest, in AODV is higher than OLSR and in GRP we have the minimum Media Access Delay.

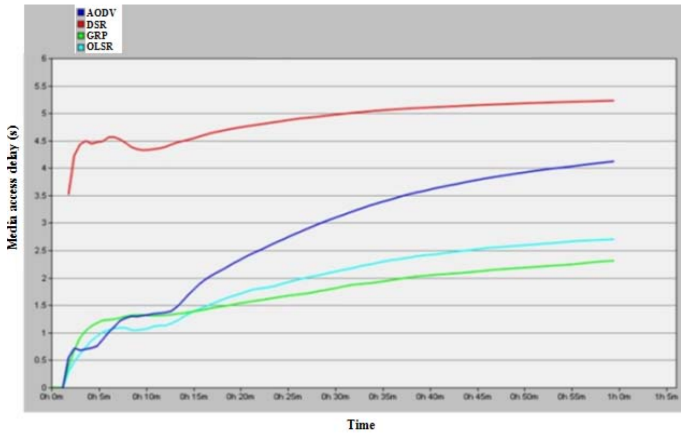

Figure 4. Media access delay comparison in four routing protocols

D. Load:

According to simulation, as we can see in Fig. 5, load in DSR is higher than GRP and load in GRP is higher than AODV and finally the minimum value of load belongs to OLSR.

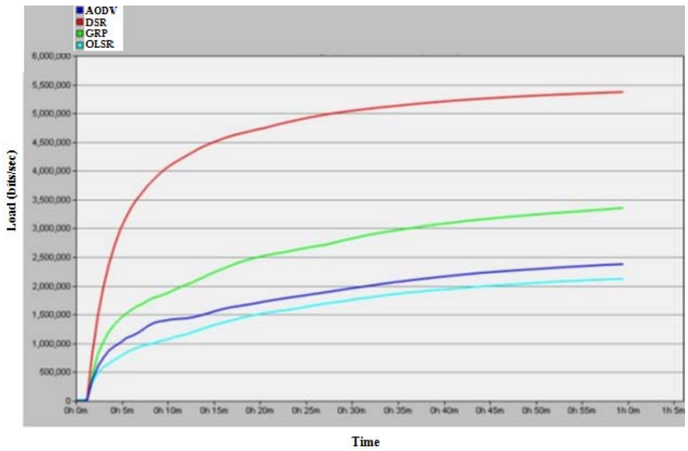

Figure 5. Load (bits/sec) comparison in four routing protocols

E. Delay:

According to Fig. 6, DSR has initial Delay compared to others. Simulation results show that delay in DSR is the highest and in GRP is the lowest. Delay in AODV is higher than OLSR.

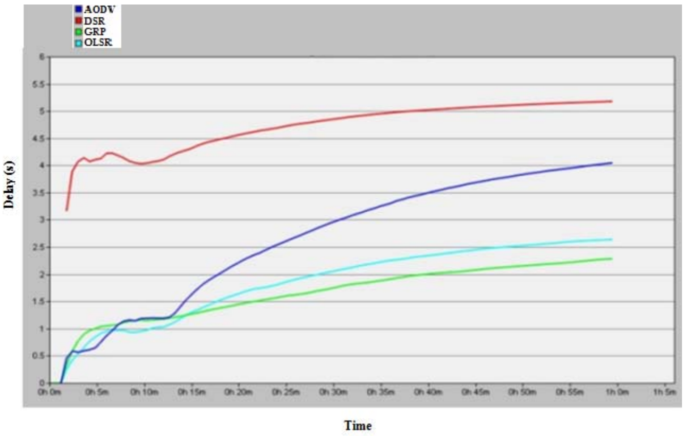

Figure 6. Delay (s) comparison in four routing protocols

F. Overall performance evaluation

We can also present performance metrics with KIVIAT diagram. This diagram helps us in quick identification of performance evaluation. We consider the obtained value of three metrics; Network Load, Delay and Throughput. According to Fig. 7, we can conclude that AODV and OLSR perform better than the others, because of their non-zero values in this diagram. GRP is better than DSR in both throughput and delay, and not in the Network Load, so we can say that DSR is the worst choice here.

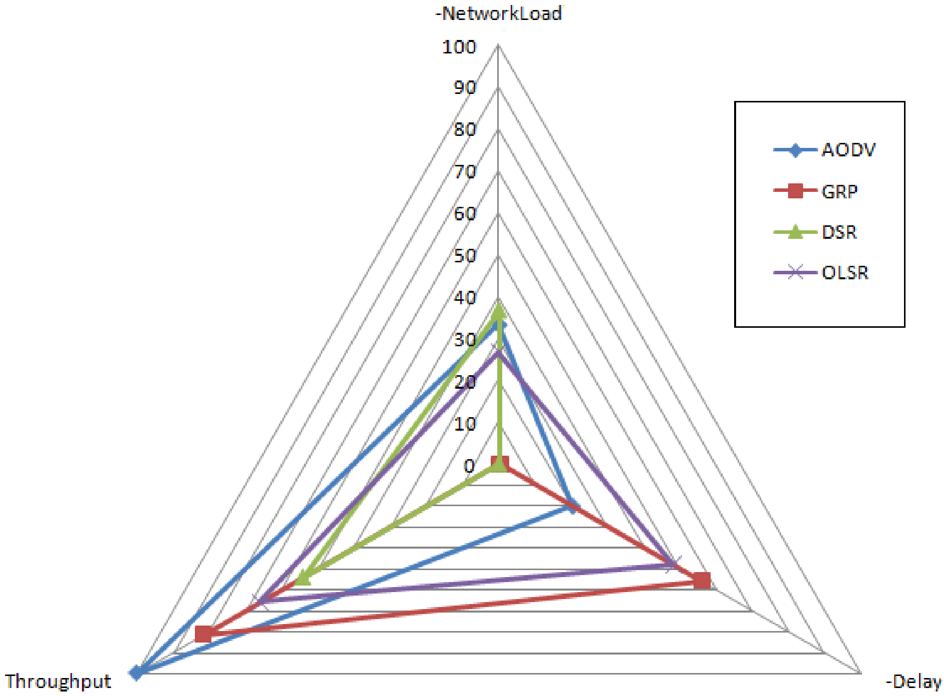

Figure 7. KIVIAT diagram with “throughput”, “Delay” and “Network Load” metrics for routing protocols comparison

VI. CONCLUSION

In this paper, performance of AODV, OLSR, GRP and DSR were evaluated, using OPNET modeler 14.0. We summarized the results in table 1. Numbers used in this table show the best to worst choice in selecting routing protocols. Number “1” represents the best protocol, and number “4” shows the worst one.

TABLE I. COMPARISION BETWEEN MANET ROUTING PROTOCOLS

Routing protocol	***Reactive/ proactive/ hybrid***	***Media Access Delay***	***Delay***	***throughput***	***Load***	***Network load***
AODV	reactive	3	3	1	2	2
OLSR	proactive	2	2	3	1	3
DSR	reactive	4	4	4	4	1
GRP	hybrid	1	1	2	3	4

From the above table, we can see that, DSR is the worst choice when we consider four metrics; Media Access Delay, Delay, Throughput and load. Balanced and non worst values belong to AODV and OLSR. In summary, we can say that AODV and OLSR perform better than the others and DSR is the worst routing protocol here.

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