Performance Evaluation of Wireless Routing Protocols for MANET

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Abstract— Mobile ad hoc network (MANET) is a wireless local area network (WLA) that has all mobile nodes connected together directly without the need to central points. MANET has several practical applications such as rescuing somebody lost in fire forest, in the battle field where soldiers in front need to communicate and share important information, and in any rescue operations. Nodes (mobile phone, PDA, laptop, etc…) needs to communicate to each other where the transmitting range is limited due to limited energy source, and so nodes need nodes in the middle (neighbor nodes) to act as mediator to relay the coming message to their neighbor nodes in turn.

Several routes from sender node (source) to the receiving node (destination) can be found, the source targets to find the minimum cost path to destination; several protocols have been designed to find such route, some of those protocols consume more energy than the others while other protocols cause network overhead but achieves the required task. This project aims to study wireless routing protocols (AODV, DSR, OLSR, and TORA) for MANET showing their advantages, disadvantages and characteristics, several scenarios will be designed using network simulator (OPNET) which will be used to study some metrics such as throughput, delay and network overhead.

Keywords—MANET, Routing protocol.

I. Introduction

WIRELESS Local Area Networks (WLANs) provide wireless access to different types of mobile hosts such as personal digital assistants (PDA), laptops and cellular phones. These nodes are equipped with short range transmitters and receivers, and antennas which may be omnidirectional (broadcast), highly-directional (point-to-point), or some combination of the two [1].

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In a WLAN environment, routing protocols then enable nodes to relay data packets if they are within transmission range, or if they can communicate directly. If they are away from each other, intermediate nodes are required to establish a multihop route between the sender and receiver. The wireless routing protocols that provide this key functionality, in general, are classified as either topological based or position based.

A) Topological based routing protocols use the existing information about links in network to flood (or forward) packets. There are two main routing strategies classified as topological based; proactive [2] that maintains routing information for each node in the network and stores this information in routing tables. The second type is reactive routing protocols which maintain a route on demand.

1) *Proactive Routing Protocols*

Proactive (or table driven) protocols [5] maintain routing information for each node in the network and store information in routing tables. This information is then updated whenever the topology changes and so one or more routing tables are required by each node to store routing information. Most proactive strategies share the same features, but they differ in the number of routing tables and frequency of topological update. Examples of proactive routing protocols are Destination-Sequenced Distance Vector (DSDV) [3], Cluster-head Gateway Switch Routing (CGSR) [3], Wireless Routing Protocol (WRP) [4], and Optimized Link State Routing Protocol (OLSR) [5].

2) Reactive Routing Protocols

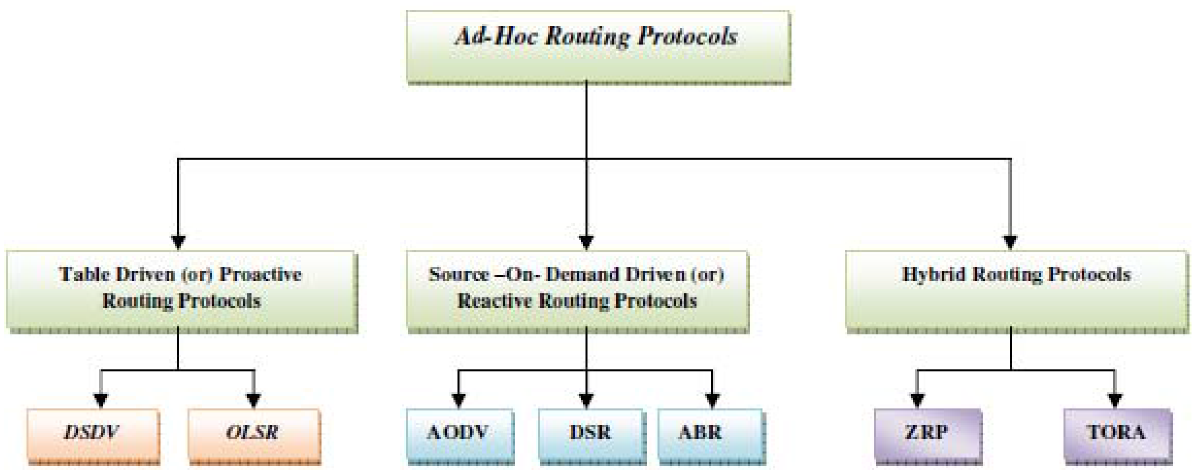
Reactive routing protocols maintain route information on demand, i.e. when source node wants to send message to destination, it initiates route request (RREQ) to find route to destination. When a route fails, a route maintenance process is launched to repair the failed route.

Ad hoc On-Demand Distance Vector (AODV) [6], Dynamic Source Routing (DSR) [7], Temporally Ordered Routing Algorithm (TORA) [4], and Associativity-Based Routing (ABR) [3] are examples of reactive strategy.

B) Position based routing protocols exploit positional information to direct flooding towards the destination in order to reduce overheads and power consumption, Location Aided Routing Protocol (LAR) [8], GRID [9], Compass [10], and Greedy Perimeter Stateless Routing (GPSR) [11] are examples of position based routing protocols.

This research aims to study the performance of AODV, TORA, OLSR, and DSR routing protocols focusing on the best performance of any of them in terms of throughput, delay and network overhead using the OPNET [12] simulator, in addition to analyzing the advantages of OPNET over other most common network simulators such as ns-2 [13] and OMNET [14].

The rest of paper is organized as follows: section 2 summarizes related work and motivation, section 3 presents simulation results, and the summary in section 4.



II. Related Work and Motivation

This section describes the four protocols (AODV, DSR, TORA, and OLSR) in addition to summarizing the advantages and disadvantages of them.

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

AODV is an up to date routing protocol that adopts a purely reactive approach and capable of both unicast and multicast routing: it sets up a route on-demand at the start of a communication session, and uses it till it breaks, after which a new route setup is initiate AODV uses destination sequence number to ensure the loop freedom and freshness of route [14].

AODV is capable of both unicast and multicast routing. The source node of AODV sends a route request message to its neighbors. If all those neighbor nodes have any information about the destination node then they will continue sending the message to its neighbors and so on until the destination node is found.

The node which has information of the destination node sends a route reply message to the initiator of the route request message. The path is recorded in the intermediate nodes in the routing table and this path identifies the route. When the initiator receives the route reply message the route is ready and the initiator can start sending the packets. The route error RRER is reported when the link with the next hop breaks [15].

Route error propagation in AODV can be visualized conceptually as a tree whose root is the node at the point of failure and all sources using the failed link [16].

Advantages of AODV:

- Routes are established on demand and destination sequence numbers are used to find the latest route to the destination.
- It supports both unicast and multicast packet transmissions even for nodes in constant movement.
- It supports lower delay for connection setup.
- The Hello messages, which are responsible for the route maintenance, are limited so that they do not create unnecessary overhead in the network.

Disadvantage:

- AODV doesn't allow handling unidirectional links.
- As the size of network grows, various performance metrics begin decreasing.
- Multiple Route Reply packets in response to a single Route Request packet can lead to heavy control overhead.
- A route discovered with AODV may no longer be the optimal route further along in time.

B) Dynamic Source Routing (DSR):

DSR is a reactive routing protocol which uses the concept of source routing. In source routing the sender knows complete hop-by-hop route to the destination. All the routes are stored in the route cache. When a node attempts to send a data packet to a destination for which it does not know the route [17]. In DSR each node maintains a route cache with route entries which are continuously updated as and when route learns new routes [18].

Advantage:

- It guaranteed loop-free routing as the sender can avoid duplicate hops in the selected routes [19].
- Nodes can store multiple paths to destination.
- It has the capability to handle unidirectional links [20].
- It requires no periodic packets of any kind at any layer within the network. The sender of the packets selects and controls the route used for its own packets.

Disadvantage:

- In the implementation of the DSR, source will transmit the RREQ messages to all the neighbouring nodes to find the route to destination. If few nodes in the network, it will easily find a route and it can receive a RREP message from the desired destination. But if in case the network size is high and participating nodes are numerous, then it is possible to have many routes to the destination.
- It may result in the reply storms this may cause collision of packets and it may increase the congestion at the nodes while sending reply [19].
- It is not scalable for the WMN, it is not suitable for the large networks, When the traffic load is high congestion will occur and it has poor mechanisms for controlling congestion.
- When network size increases then delay rate increases more compared to other protocols.

C) Optimized Link State Routing (OLSR)

OLSR is a proactive routing protocol for mobile ad hoc networks [21], in which all routes have route table for maintaining information to every node in the network.

The protocol inherits the stability of the link state algorithm and has the advantage of having routes immediately available when needed due to its proactive nature.

It limits the number of mobile nodes that can forward network wide traffic and for this purpose it use multi point relays (MPRs), which are responsible for forwarding routing messages and optimization for flooding operation.

The routes are immediately available whenever needed due to the route tables. OLSR is an optimized version of link state protocol.

The episodic nature of OLSR creates a large amount of overhead in the network caused by flooding of control traffic. In order to reduce the overhead, the concept of MPR is used.

MPRs are chosen by a node, such that, it may reach each two hop neighbor via at least one MPR, then it can forward packets, if control traffic received from a previous hop has selected the current node as a MPR.

OLSR uses two types of control messages: Hello and Topology Control (TC). Hello message are used to find the link state and neighboring nodes. TC message is used to for broadcasting information for own advertised neighbors which includes at least the MPR selector list [22].

The protocol is very efficient for traffic patterns where a large subset of nodes is communicating with another large subset of nodes, and where the [source, destination] pairs changeover time.

The larger and more dense a network, the more optimization can be achieved as compared to the classic link state algorithm. OLSR uses hop-by-hop routing, i.e., each node uses its local information to route packets [23].

Advantages:

- OLSR does not need central administrative system to handle its routing process because it is a flat routing protocol.
- The link is reliable for the control messages, since the messages are sent periodically and the delivery does not have to be sequential.
- OLSR is suitable for high density networks.
- It does not allow long delays in the transmission of packets.

Disadvantages:

- OLSR protocol periodically sends the updated topology information throughout the entire network.
- It allows and increase protocol bandwidth usage.

D) Temporary Ordered Routing Algorithm(TORA)

TORA is an adaptive on demand routing protocol for multi hop networks which is based on link reversal algorithms. It is source initiated specially proposed routing protocol for highly dynamic mobile, multi-hop wireless networks [26]. It establishes the routes quickly and minimizes the communication overhead by localizing algorithm reaction to topological changes when possible [24]. TORA algorithm maintains the “direction of the next destination” to forward the packets instead of using the concept of shortest path for computing routes which take huge amount of bandwidth. The source node of TORA maintains one or two “downstream paths” to the destination node through multiple intermediate neighboring nodes. It has three main steps: route creation, route maintenance, and route erasure.

It uses the concept of “directed acyclic graphs” to establish downstream paths to destination and such DAG is known as “Destination Oriented DAG” [25].

Advantages of TORA:

- It does not require a periodic update, so communication overhead and bandwidth utilization is minimized.
- It provides the supports of link status sensing and neighbor delivery, in-order control packet delivery, reliable, and security authentication.
- It supports multiple routes between source and destination. Failure or removal of any of the nodes quickly resolved without source intervention by switching to an alternate route to improve congestion.

Disadvantages of TORA:

- It depends on synchronized clocks among nodes in the ad hoc network.
- The dependence of this protocol on intermediate lower layers for certain functionality presumes that the link status sensing, neighbor discovery, in order packet delivery and address resolution are all readily available. This solution is to run the Internet MANET Encapsulation Protocol at the layer immediately below TORA.
- This will make the overhead for this protocol difficult to separate from that imposed by the lower layer.

Table 1 summarizes the most important characteristics of the four tested routing protocol.

Parameter	AODV	DSR	OLSR	TORA
Category	Reactive	Reactive	Proactive	Hybrid
Multicast capability	Yes	No	Yes	No
Routes maintained in	Route table	Route cache	Route table	Route table
Multi route	No	Yes	No	Yes
Loop free	Yes	Yes	Yes	Yes
Routing philosophy	Flat	Flat	Flat	Flat
Multicast	Yes	No	yes	no
Route reconfiguration methodology	Erase route, notify source	Erase route, notify source	Control messages sent in advance to increase reactivity	Link reversal, route repair
Time complexity	O(2n)	O(2n)	O(2n)	O(2n)

Table 1. Protocols Comparisons.

III. Simulation Results

OPNET simulator is a tool to simulate the behavior and performance of any type of network. The main difference with other simulators lies in its power and versatility. This simulator makes possible working with OSI model, from layer 7 to the modification of the most essential physical parameters.

OPNET provides high fidelity modeling and scalable simulation and a detailed analysis of a broad range of wired and wireless networks, which helps developers to Develop proprietary wireless protocols and technologies, plus it evaluates enhancements to standards-based protocols and it tests. And it demonstrates technology designs in realistic scenarios before production. The selection of OPNET is due to the disadvantages of other simulators which are summarized below:

A) ns-2 disadvantages:

- People who want to use this simulator need to familiar with writing scripting language and modeling technique, the Tool Command Language is somewhat difficult to understand and write.
- Sometimes using ns-2 is more complex and time-consuming than other simulators to model a desired job.
- ns-2 provides a poor graphical support, no Graphical User Interface (GUI); the users have to directly face to text commands of the electronic devices. Fourthly, due to the continuing changing the code base, the result may not be consistent, or contains bugs.

B) OMNET disadvantages:

- The number of available protocols is not larger enough.
- The compatible problem will rise since individual researching groups developed the models separately, this makes the combination of models difficult and programs may have high probability report bugs

Identical scenario is designed for all protocols, the scenario is designed in a campus at 1 kilometer long, and it includes 12 nodes, those nodes are designed to test the protocols (AODV, DSR, OLSR, and TORA). One node is considered as the source and another one as destination, TCP protocol is used for data transmission, fixed number data bits (100 kb) are sent from source to destination, and the simulation time is 15 minutes. Nodes are distributed randomly following the normal distribution over the area of campus.

Three metrics are measured during testing the protocols, network overhead, delay and throughput. The following results are obtained by the simulator:

Figure 1 shows the throughput for the four protocols, as it is shown, the AODV achieves the best throughput, around (84,000 bits/sec) then comes the OLSR which is between the 60s and 70s thousand bits/sec, while DSR is the worst one (6,000 bits/sec).

Figure 2 shows the retransmission attempts. When a node sends packets to another node and the receiver fails to receive it so the sender node tries to resend it again. The figure express the network overhead, it shows that TORA has the highest retransmission attempts which means it has the highest overhead, while DSR has the best performance in terms of overhead which almost near zero value.

Figure 3 shows the delay for the previous mentioned protocols, the figure shows that the TORA has the highest delay while OLSR has the best one which means OLSR can find the destination faster than the other protocols.

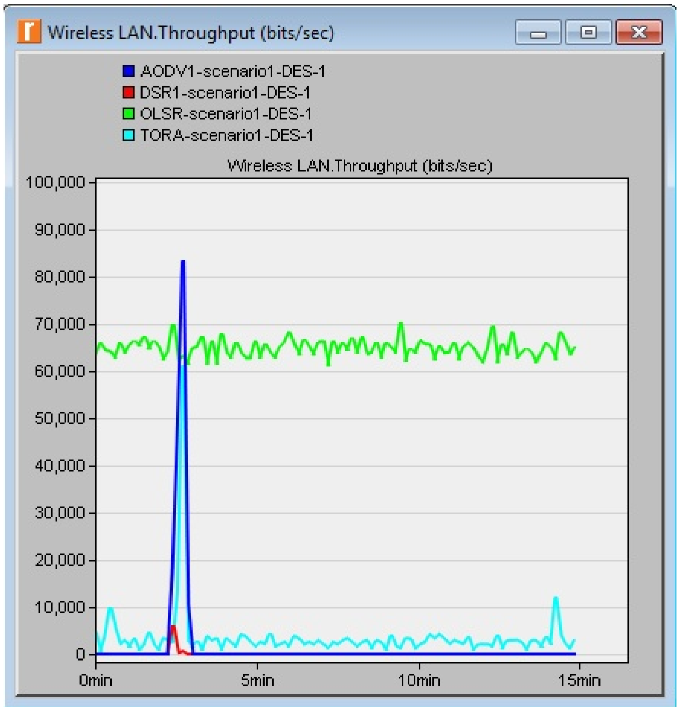


Fig.1. Throughput

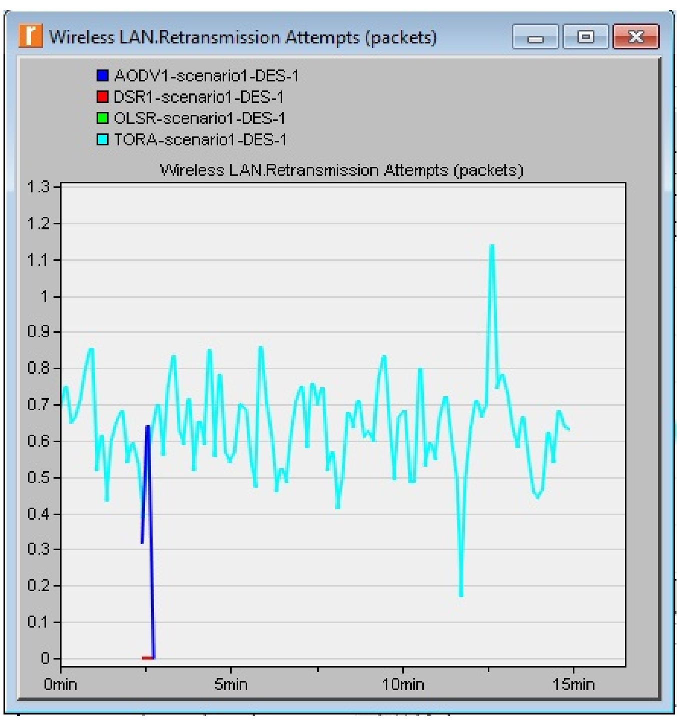


Fig.2. Network overhead

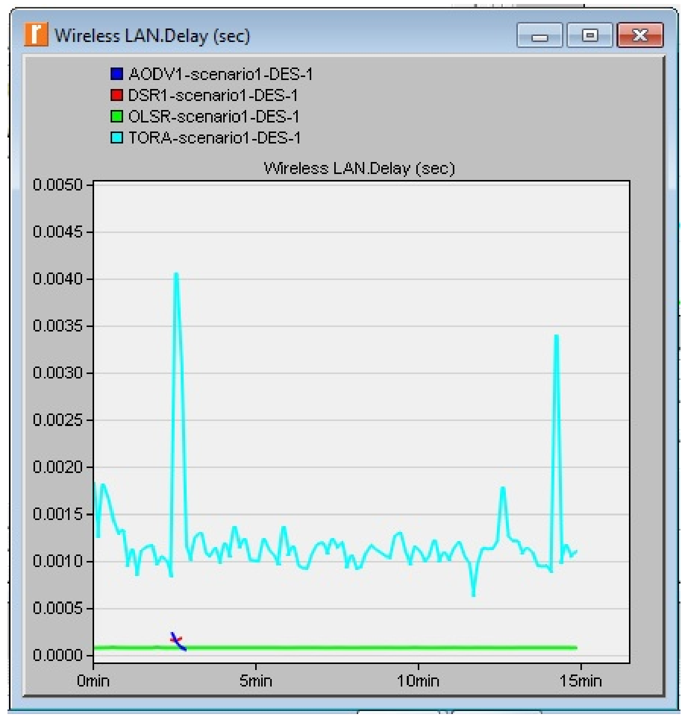


Fig.3. Delay

IV. CONCLUSION

In this paper, comparisons between four wireless routing protocols for MANT (AODV, OLSR, TORA, and DSR) were performed using OPNET simulator in addition to comparison between some common simulators in use. The comparison were performed on protocols in terms of delay, throughput and network overhead, simulation results shows that DSR is the best protocols among the four tested ones in term of delay while TORA has the highest delay, the same results are recorded for network overhead, AODV has the best throughput and DSR ahs the least throughput.

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