Comparison of OLSR and TORA Routing Protocols Using OPNET Modeler

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Abstract

Ad hoc networks are infrastructure less self organizing networks. These networks are referred to as infrastructure less because there is no physical connection between the entities of ad-hoc networks. All the entities in ad-hoc networks communicate with other entities which lie in its radio frequency range. All the mobile nodes in the network dynamically set up paths among themselves to transmit packets temporarily. A MANET is an autonomous system of mobile nodes. Nodes act as a router, client and server as well and its topology is dynamic as nodes join the network whenever there is need to transmit data and leave the network when transmission gets over. These networks do not have a Central Authority for the management of the network. In recent past, several routing protocols for MANET are being proposed. Some of the prominent and promising among them are AODV, DSR, TORA, OLSR, DSDV. In this report, reactive routing protocols and Pro-reactive routing Protocols such as Optimized Linked State Routing (OLSR) and Temporally Ordered Routing Algorithm (TORA), are compared on the basis of their few parameters.

1. Introduction

Mobile Ad hoc Network (MANET) is a collection of mobile nodes in which the wireless links are frequently broken down due to mobility and dynamic infrastructure. Routing is a significant issue and challenge in ad hoc networks. Many routing protocols have been proposed like OLSR, AODV, DSR, ZRP, and TORA so far to improve the routing performance and reliability. In MANET the set of wireless mobile nodes connected together to form temporary network in which the nodes are communicating with each other without centralized control. The nodes are free to move randomly and organize themselves arbitrarily. Hence the network's topology may change rapidly and unpredictably. The nodes that are within each other's radio range can communicate directly, while remote nodes rely on their neighboring nodes to forward packets as a router. Routing is a core problem in networks for sending data from one node to another. Routing protocols works well in wired networks does not show the same performance in mobile ad hoc networks due to the rapid change of topology. A MANET includes many challenges and issues such as Dynamic topologies, Frequency of updates or network overhead, energy, speed, routing and security. The routing protocol is required whenever the source needs to transmit and delivers the packets to the destination. Many routing protocols have been proposed for the mobile ad hoc network and classified as: Proactive or Table Driven routing Protocol, Reactive or On Demand Routing Protocol [1].

A. Proactive or table-driven routing protocols:

In proactive protocols, each node maintains individual routing table containing routing information for every node in the network. Each node maintains consistent and current up-to-date routing information by sending control messages periodically between the nodes which update their routing tables. The proactive routing protocols use link-state routing algorithms which frequently flood the link information about its neighbors. The drawback of proactive routing protocol is that all the nodes in the network always maintain an updated table. Some of the existing proactive routing protocols are DSDV and OLSR [1].

B. Reactive or On Demand Routing Protocol:

In Reactive routing protocols, when a source wants to send packets to a destination, it invokes the route discovery mechanisms to find the route to the destination. The route remains valid till the destination is reachable or until the route is no longer needed. Unlike table driven protocols, all nodes need not maintain up-to-date routing information. Some of the most used on demand routing protocols are DSR, TORA and AODV [1].

2. Overview of Protocols

A. OPTIMIZED LINK STATE PROTOCOL :

The information in this section concerning the Optimized Link State Protocol is taken from its RFC 3561 [2]. Optimized Link State Protocol (OLSR) is a proactive routing protocol, so the routes are always immediately available when needed. OLSR is an optimization version of a pure link state protocol. So the topological changes cause the flooding of the topological information to all available hosts in the network. To reduce the possible overhead in the network protocol uses Multipoint Relays (MPR). The idea of MPR is to reduce flooding of broadcasts by reducing the same broadcast in some regions in the network, more details about MPR can be found later in this chapter. Another reduce is to provide the shortest path. The reducing the time interval for the control messages transmission can bring more reactivity to the topological changes.

OLSR uses two kinds of the control messages: Hello and Topology Control (TC). Hello messages are used for finding the information about the link status and the host's neighbours. With the Hello message the Multipoint Relay (MPR) Selector set is constructed which describes which neighbours has chosen this host to act as MPR and from this information the host can calculate its own set of the MPRs. the Hello messages are sent only one hop away but the TC messages are broadcasted throughout the entire network. TC messages are used for broadcasting information about own advertised neighbours which includes at least the MPR Selector list. The TC messages are broadcasted periodically and only the MPR hosts can forward the TC messages.

There is also Multiple Interface Declaration (MID) messages which are used for informing other host that the announcing host can have multiple OLSR interface addresses. The MID message is broadcasted throughout the entire network only by MPRs. There is also a "Host and Network Association" (HNA) message which provides the external routing information by giving the possibility for routing to the external addresses. The HNA message provides information about the network- and the net mask addresses, so that OLSR host can consider that the announcing host can act as a gateway to the announcing set of addresses. The HNA is considered as a generalized version of the TC message with only difference that the TC message can inform about route cancelling while HNA message information is removed only after expiration time. The MID and HNA messages are not explained in more details in this chapter, the further information concerning these messages can be found in [1,2].

i. Routing Neighbour Sensing

The link in the ad hoc network can be either unidirectional or bidirectional so the host must know this information about the neighbours. The Hello messages are broadcasted periodically for the neighbour sensing. The Hello messages are only broadcasted one hop away so that they are not forwarded further. When the first host receives the Hello message from the second host, it sets the second host status to asymmetric in the routing table. When the first host sends a Hello message and includes that, it has the link to the second host as asymmetric, the second host set first host status to symmetric in own routing table. Finally, when second host send again Hello message, where the status of the link for the first host is indicated as symmetric, then first host changes the status from asymmetric to symmetric. In the end both hosts knows that their neighbour is alive and the corresponding link is bidirectional. [1,2].

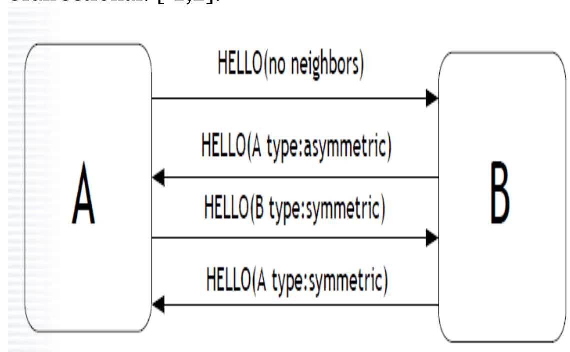

Fig. 1 Hello Message Flow

The Hello messages are used for getting the information about local links and neighbours. The Hello messages periodic broadcasting is used for link sensing, neighbour's detection and MPR selection process. Hello message contains: information how often the host sends Hello messages, willingness of host to act as a Multipoint Relay, and information about its neighbour. Information about the neighbours contains: interface address, link type and neighbour type. The link type indicates that the link is symmetric, asymmetric or simply lost. The neighbour type is just symmetric, MPR or not a neighbour. The MPR type indicates that the link to the neighbour is symmetric and that this host has chosen it as Multipoint Relay. [1,2]

ii. Multipoint Relays

The Multipoint Relays (MPR) is the key idea behind the OLSR protocol to reduce the information exchange overhead. Instead of pure flooding the OLSR uses MPR to reduce the number of the host which broadcasts the information throughout the network. The MPR is a host's one hop neighbour which may forward its messages. The MPR set of host is kept small in order for the protocol to be efficient. In OLSR only the MPRs can forward the data throughout the network. [1,2] Each host must have the information about the symmetric one hop and two hop neighbours in order to calculate the optimal MPR set. The Fig. 1 is taken from [10] to illustrate these concepts. Information about the neighbours is taken from the Hello messages. The two hop neighbours are found from the Hello message because each Hello message contains all the hosts' neighbours. Selecting the minimum number of the one hop neighbours which covers all the two hop neighbours is the goal of the MPR selection algorithm. Also each host has the Multipoint Relay Selector set, which indicates which hosts has selected the current host to act as a MPR. [1, 2]

When the host gets a new broadcast message, which is need to be spread throughout the network and the message's sender interface address is in the MPR Selector set, then the host must forward the message. Due to the possible changes in the ad hoc network, the MPR Selectors sets are updated continuously using Hello messages. [10]

iii. Multipoint Relays Selection

In this section the proposed algorithm for the selection of Multipoint Relay set is described. This algorithm is found from [ ]. The algorithm constructs the MPR set which includes minimum number of the one hop symmetric neighbours from which it is possible to reach all the symmetrical strict two hop neighbours. The host must have the information about one and two hop symmetric neighbours in order to start the needed calculation for the MPR set. All the exchange of information are broadcasted using Hello messages. The neighbours which have status of willingness different than WILL_NEVER in the Hello message can be chosen to act as MPR. The neighbour must be symmetric in order to become an MPR.

Proposed algorithm for selecting Multipoint Relay set:

1. Take all the symmetric one hop neighbours which are willing to act as an MPR.
2. Calculate for every neighbour host a degree, which is a number of the symmetric neighbours, that are two hops way from the calculating source and does not include the source or its one hop neighbours.
3. Add the neighbour symmetric host to the MPR set. If it is the only neighbour from which is possible to get to the specific two hop neighbour, then remove the chosen host neighbours from the two hop neighbour set.
4. If there are still some hosts in the two hop neighbour set, then calculate the reach ability of the each one hop neighbour, meaning the number of the two hop neighbours, that are yet uncovered by MPR set. Choose the node with highest willing value, if the values are the same then takes the node with greater number of reach ability. If the reach ability is the same, then take the one with greater degree counted in the second step. After choosing the neighbour for MPR set remove the reachable two hop neighbour from the two hop neighbour set.
5. Repeat previous step until the two hop neighbours set is empty.
6. For the optimization, set the hosts in the MPR set in the increasing order basing on the willingness. If one host is taken away and all the two hop neighbours, covered by at least one host and the willingness of the host is smaller than WILL_ALWAYS, then the host may be removed.

The possible improvements of this algorithm are needed, for example, when there are multiple possible interface addresses for one host [1,2]. The finding the optimum MPR set for the two hop neighbour coverage is considered to be an NP problem based on.

iv. Topology Information

In order to exchange the topological information and build the topology information base the host that were selected as MPR need to sent the topology control (TC) message. The TC messages are broadcasted throughout the network and only MPR are allowed to forward TC messages. The TC messages are generated and broadcasted periodically in the network.

The TC message is sent by a host in order to advertise own links in the network. The host must send at least the links of its MPR selector set. The TC message includes the own set of advertised links and the sequence number of each message. The sequence number is used to avoid loops of the messages and for indicating the freshness of the message, so if the host gets a message with the smaller sequence number it must discard the message without any updates. The host must increment the sequence number when the links are removed from the TC message and also it should increment the sequence number when the links are added to the message. The sequence numbers are wrapped around. When the hosts advertised links set becomes empty, it should still send empty TC messages for specified amount of time, in order to invalidate previous TC messages. This should stop sending the TC messages until it has again some information to send. [11]. The size of the TC message can be quite big, so the TC message can be sent in parts, but then the receiver must combine all parts during some specified amount of time. Host can increase its transmission rate to become more sensible to the possible link failures. When the change in the MPR Selector set is noticed, it indicates that the link failure has happened and the host must transmit the new TC message as soon as possible.

v. Control traffic

All OLSR control traffic is to be transmitted over UDP on port 698. This port is assigned to OLSR by the Internet Assigned Numbers Authority (IANA). The RFC states that this traffic is to be broadcasted when using IPv4, but no broadcast address is specified. When using IPv6 broadcast addresses does not exist, so even though it is not specified in the RFC, it is implicit understood that one must use a multicast address in this case.

vi. Routing Table Calculations

The host maintains the routing table, the routing table entries have following information: destination address, next address, number of hops to the destination and local interface address. Next address indicates the next hop host. The information is got from the topological set (from the TC messages) and from the local link information base (from the Hello messages). So if any changes occur in these sets, then the routing table is recalculated. Because this is proactive protocol then the routing table must have routes for all available hosts in the network. The information about broken links or partially known links is not stored in the routing table.

The routing table is changed if the changes occur in the following cases: neighbour link appear or disappear, two hops neighbour is created or removed, topological link is appeared or lost or when the multiple interface association information changes. But the update of this information does not lead to the sending of the messages into the network. For finding the routes for the routing table entry the shortest path algorithm is used [11].

ADVANTAGES

OLSR is also a flat routing protocol it does not need central administrative system to handle its routing process. The proactive characteristic of the protocol provides that the protocol has all the routing information to all participated hosts in the network. The flooding is minimized by the MPRs, which are only allowed to forward the topological messages. The reactiveness to the topological changes can be adjusted by changing the time interval for broadcasting the Hello messages.

DISADVANTAGES

Pro-reactive schemes are not suitable for reconfigurable wireless networks, as they use more time to keep the network routing information current. If the movement of the node is very fast, then every time it needs to calculate the new route which may never be used. This leads to the waste of network capacity. However, as a drawback OLSR protocol needs that each host periodic sends the updated topology information throughout the entire network, this increase the protocols bandwidth usage.

B. Temporally Ordered Routing Algorithm (TORA):

TORA is adaptive and scalable routing algorithm based on the concept of link reversal. It finds multiple routes from source to destination in a highly dynamic mobile networking environment. An important design concept of TORA is that control messages are localized to a small set of nodes nearby a topological change. Nodes maintain routing information about their immediate one-hop neighbors. The protocol has three basic functions: route creation, route maintenance, and route erasure . Nodes use a “height” metric to establish a directed cyclic graph (DAG) rooted at the destination during the route creation and route maintenance phases. The link can be either an upstream or downstream based on the relative height metric of the adjacent nodes. TORA’s metric contains five elements: the unique node ID, logical time of a link failure, the unique ID of a node that defined the new reference level, a reflection indicator bit, and a propagation ordering parameter. Establishment of DAG resembles the query/reply process discussed in Lightweight Mobile Routing (LMR). Route maintenance is necessary when any of the links in DAG is broken. Figure 2. Denotes the control flow for the route maintenance in TORA [12]. The main strength of the protocol is the way it handles the link failures. TORA’s reaction to link failures is optimistic that it will reverse the links to re-position the DAG for searching an alternate path. Effectively, each link reversal sequence searches for alternative routes to the destination. This search mechanism generally requires a single-pass of the distributed algorithm since the routing tables are modified simultaneously during the outward phase of the search mechanism.

Other routing algorithms such as LMR use two-pass whereas both DSR and AODV use three pass procedure. TORA achieves its single-pass procedure with the assumption that all the nodes have synchronized clocks (via GPS) to create a temporal order of topological change of events. The “height” metric is dependent on the logical time of a link failure [2, 3,8].

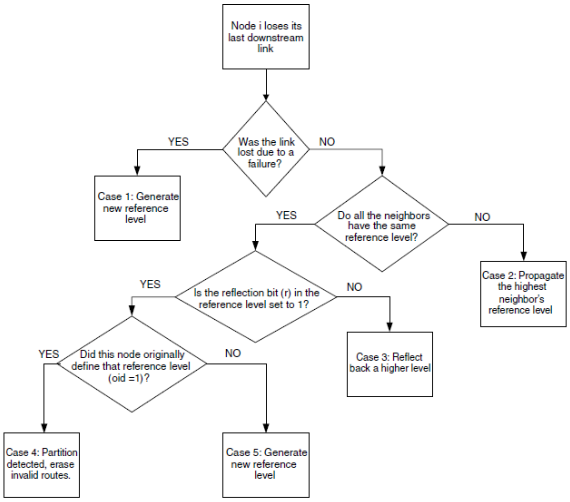

Fig 2. FLOW DIAGRAM OF ROUTE MAINTENANCE IN TORA

Advantages and Limitations

The advantage of TORA is that the multiple routes are supported by this protocol between the source and destination node. Therefore, failure or removal of any of the nodes is quickly resolved without source intervention by switching to an alternate route to improve congestion. It does not require a periodic update, consequently communication overhead and bandwidth utilization is minimized. It provides the support of link status sensing and neighbor delivery, reliable in-order control packet delivery and security authentication.

Also TORA consist some of the limitations like which 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. The 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.

3. Simulation Parameter

Table 1. Parameter values for simulation

Maximum Simulation Time	**420 Seconds**
Physical terrain Dimensions	**4000*4000**
Number of nodes	**70**
Mobility	**Mobility Random way Point**
Routing Protocol	**OLSR, TORA**
MAC Layer Protocol	**IEEE 802.11**
Node Placement	**Uniform**

Simulation Model:

OPNET Modeler is commercial network simulation environment for network modeling and simulation. It allows the users to design and study communication networks, devices, protocols, and applications with flexibility and scalability. It simulates the network graphically and gives the graphical structure of actual networks and network components. The users can design the network model visually. The modeler uses object-oriented modeling approach. The nodes and protocols are modeled as classes with inheritance and specialization. The development language is C. It provides a variety of toolboxes to design, simulate and analyze a network topology, routing protocols on the basis of various network parameters. MANET toolbox has been used in this work to simulate the network. Components used for designing of the network are MANET_Station (mobile), application configuration which decides the type of application running in the network, profile configuration for configuring the type of profile on the network. Mobility configuration will decide the mobility model of every node which is selected as random waypoint for this simulation. Attributes of workstation will set the routing protocol used for the simulation [9].

4. Simulation Results

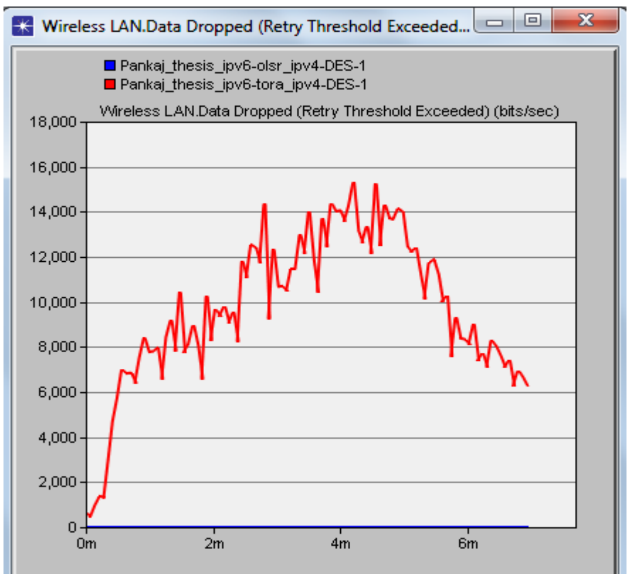

Fig. 3 Data Dropped

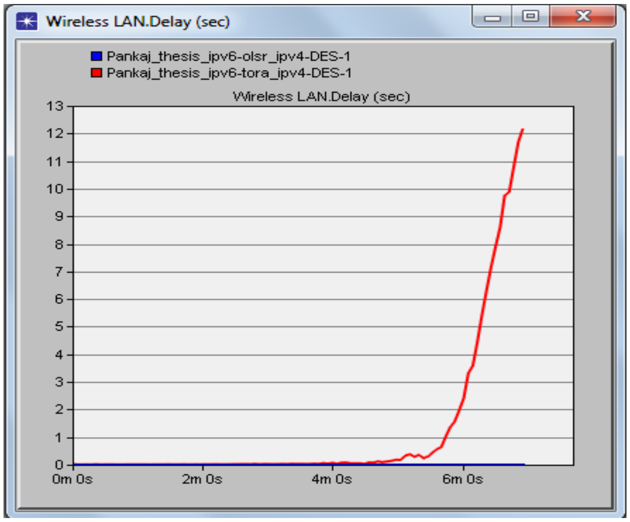

Fig 4. Delay

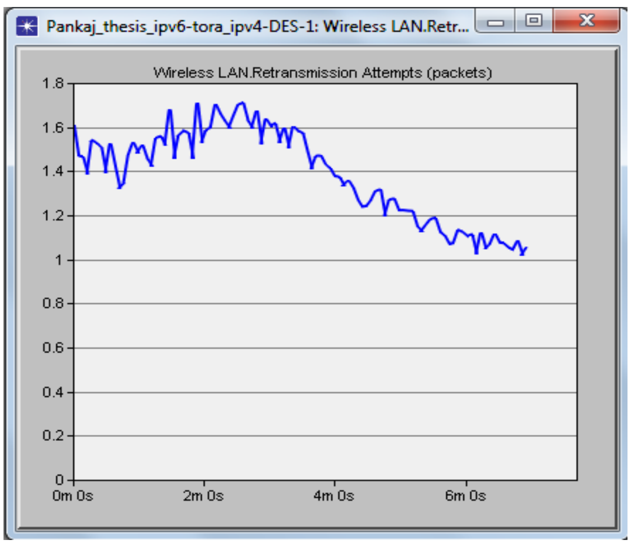

Fig 5. Retransmission Attempts

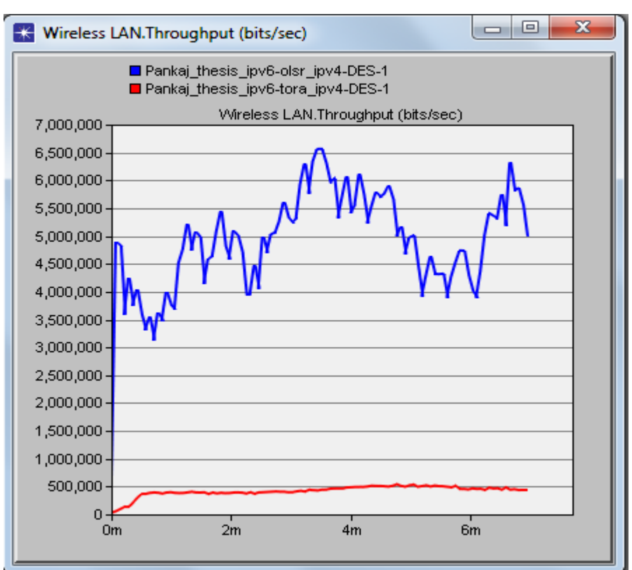

Fig 6. Throughput

5. Simulation Analysis

From the simulation results we conclude that OLSR is better than TORA for the given scenario from fig 3. data dropped shows that data dropped is too much where as there is no data dropped in OLSR, from fig 4. delay is also large in TORA as comparative to OLSR, from fig 5. It is clear that there is no retransmission attempts in OLSR where as there is retransmission attempts in TORA, fig 6. shows that the throughput is far better in OLSR than TORA. From the results it is clear that the OLSR is better in all ways.

6. Conclusion

The conclusion of this paper on the basis of the results is that the OLSR is better in those scenario where bandwidth is large as OLSR always updated their nodes so large bandwidth is used than TORA on same conditions.

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