SIMULATION AND PERFORMANCE ANALYSIS OF DSDV, OLSR, DSR AND ZRP ROUTING PROTOCOLS IN MANETs

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Abstract

Mobile ad hoc network (MANET) is an autonomous system of mobile nodes connected by wireless links. Each node operates not only as an end system, but also as a router to forward packets. The nodes are free to move about and organize themselves into a network. These nodes change position frequently. The main classes of routing protocols are Proactive, Reactive and Hybrid. Ad hoc wireless networks are characterized by multihop wireless connectivity, infrastructure less environment and frequently changing topology. In this thesis the problem of routing is considered. In this thesis we investigated the effect of routing protocol on performance within MANETs. In this work attempt has been made to compare the performance of three types of MANETs: Proactive (DSDV, OLSR), Reactive (DSR), and Hybrid (ZRP) .As per our findings the differences in the protocol mechanics lead to significant performance differentials of these protocols. The performance differentials are analyzed using varying simulation time. These simulations are carried out using the ns-2 network simulator. The results presented in this work illustrate the importance in carefully evaluating and implementing routing protocols in an ad hoc environment.

Keywords: - Routing Protocol, MANETs, and Performance.

I. Introduction

Wireless cellular systems have been in use since 1980s. We have seen their evolutions to first, second and third generation's wireless systems. These systems work with the support of a centralized supporting structure such as an access point. The wireless users can be connected with the wireless system by the help of these access points, when they roam from one place to the other. A wireless network is a growing new technology that will allow users to Access services and information electronically, irrespective of their geographic position. Wireless Networks can be classified in two types: - infrastructure network and infrastructure less (ad hoc) Networks. Infrastructure network consists of a network with fixed and wired gateways. A mobile host interacts with a bridge in the network (called base station) within its communication radius. The mobile unit can move geographically while it is communicating. When it goes out of range of one base station, it connects with new base station and starts communicating through it. This is called handoff. In this approach the base stations are fixed.

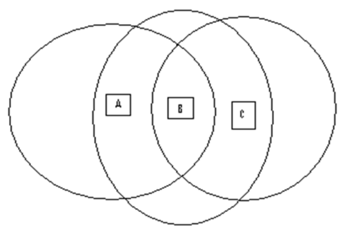

Figure1: Example of a simple ad-hoc network with three participating node

Mobile ad hoc network is a collection of independent mobile nodes that can communicate to each other via radio waves. The mobile nodes can directly communicate to those nodes that are in radio range of each other, whereas others nodes need the help of intermediate nodes to route their packets. These networks are fully distributed, and can work at any place without the aid of any infrastructure. This property makes these networks highly robust. In Figure 1: nodes A and C must discover the route through B in order to communicate. [1]

II. Routing

Routing is the act of moving information from a source to a destination in an internetwork. At least one intermediate node within the internetwork is encountered during the transfer of information. Basically two activities are involved in this concept: determining optimal routing paths and transferring the packets through an internetwork. Routing protocols use several metrics as a standard measurement to calculate the best path for routing the packets to its destination that could be number of hops, which are used by the routing algorithm to determine the optimal path for the packet to its destination. The process of path determination is that, routing algorithms find out and maintain routing tables, which contain the total route information for the packet. The information of route varies from one routing algorithm to another. The routing tables are filled with entries in the routing table are ip-address prefix and the next hop. Routing is mainly classified into static routing and dynamic routing. Static routing refers to the routing strategy being stated manually or statically, in the router. Static routing maintains a routing table usually written by a networks administrator. The routing table doesn‘t depend on the state of the network status, i.e., whether the destination is active or not [3].

III. Routing in Mobile Ad hoc Networks

Mobile Ad-hoc networks are self-organizing and self-configuring multihop wireless networks, where the structure of the network changes dynamically. This is mainly due to the mobility of the nodes [3]. Nodes in these networks utilize the same random access wireless channel, cooperating in an intimate manner to engaging themselves in multichip forwarding. The node in the network not only acts as hosts but also as routers that route data to/from other nodes in network [5]. In mobile ad-hoc networks there is no infrastructure support as is the case with wireless networks, and since a destination node might be out of range of a source node transferring packets; so there is need of a routing procedure. This is always ready to find a path so as to forward the packets appropriately between the source and the destination. Within a cell, a base station can reach all mobile Nodes without routing via broadcast in common wireless networks. In the case of ad-hoc networks, each node must be able to forward data for other nodes. This creates additional problems along with the problems of dynamic topology which is unpredictable connectivity changes [6].

A. Properties of Ad-Hoc Routing protocols

- Distributed operation
- Loop free
- Demand based operation
- Unidirectional link support
- Security
- Multiple routes
- Quality of Service Support

B. Problems in routing with Mobile Ad hoc Networks

- Asymmetric links
- Routing Overhead
- Interference
- Dynamic Topology

IV. Classification of Routing Protocols

Classification of routing protocols in mobile ad hoc network can be done in many ways, but most of these are done depending on routing strategy and network structure [2] [3] [7]. Routing protocol in MANET are classified into three different categories according to their functionality

A. Proactive
B. Reactive
C. Hybrid

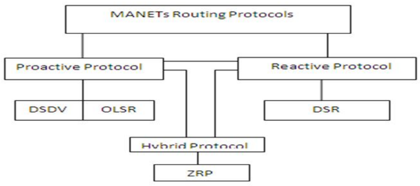

Figure 2: Classification of Routing Protocols in Mobile Ad-hoc Networks [3]

A. Pro-Active Protocols

Proactive MANET protocols are also called as table-driven protocols and will actively determine the layout of the network. Through a regular exchange of network topology packets between the nodes of the network, at every single node an absolute picture of the network is maintained. There is hence minimal delay in determining the route to be taken. This is especially important for time-critical traffic [3].

1. DSDV

This protocol is based on classical Bellman-Ford routing algorithm designed for MANETS. Each node maintains a list of all destinations and number of hops to each destination. Each entry is marked with a sequence number. It uses full dump or incremental update to reduce network traffic generated by rout updates. The broadcast of route updates is delayed by settling time. The only improvement made here is avoidance of routing loops in a mobile network of routers. With this improvement, routing information can always be readily available, regardless of whether the source code requires the information or not. DSDV solve the problem of routing loops and count to infinity by associating each route entry with a sequence number indicating its freshness. In DSDV, a sequence number is linked to a destination node, and usually is originated by that node (the owner). The only case that a non-owner node updates a sequence number of a route is when it detects a link break on that route. An owner node always uses even-numbers as sequence numbers, and a non-owner node always uses odd-numbers. With the addition of sequence numbers, routes for the same destination are selected based on the following rules: 1) a route with a newer sequence number is preferred; 2) in the case that two routes have a same sequence number, the one with a better cost metric is preferred. [11]

2. OLSR

The information in this section concerning the Optimized Link State Protocol is taken from its RFC 3561 [13]. 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. [14, 15, 16, 17, 18, 19, 20]

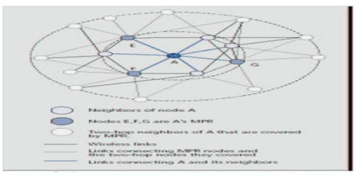

Figure 3: The basic concept of multipoint Relay in OLSR

- **Routing in OLSR**
  - Neighbor Sensing
  - Multipoint Relays

B. Reactive (On Demand) protocol

Portable nodes- Notebooks, palmtops or even mobile phones usually compose wireless ad-hoc networks. This portability also brings a significant issue of mobility. This is a key issue in ad-hoc networks. The Mobility of the nodes causes the topology of the network to change constantly. Keeping track of this topology is not an easy task, and too many resources may be consumed in signaling. Reactive routing protocols were intended for these types of environments. These are based on the design that there is no point on trying to have an image of the entire network topology, since it will be constantly changing. Instead, whenever a node needs a route to a given target, it initiates a route discovery process on the fly, for discovering out a pathway [6].Reactive protocols start to set up routes on-demand. The routing protocol will try to establish such a route, whenever any node wants to initiate communication with another node to which it has no route. This kind of protocols is usually based on flooding the network with Route Request (RREQ) and Route reply (RERP) messages .By the help of Route request message the route is discovered from source to target node; and as the target node gets a RREQ message it send RERP message for the confirmation that the route has been established. This kind of protocol is usually very effective on single-rate networks. It usually minimizes the number of hops of the selected path. However, on multi-rate networks, the number of hops is not as important as the throughput that can be obtained on a given path [8].

1. Dynamic Source Routing (DSR)

Dynamic Source Routing (DSR) is a routing protocol for wireless mesh networks. It is similar to AODV in that it establishes a route on-demand when a transmitting mobile node requests one. However, it uses source routing instead of relying on the routing table at each intermediate device [4]. Dynamic source routing protocol (DSR) is an on-demand, source routing protocol [9], whereby all the routing information is maintained (continually updated) at mobile nodes. DSR allows the network to be completely self-organizing and self-configuring, without the need for any existing network infrastructure or administration. The protocol is composed of the two main mechanisms of "Route Discovery" and "Route Maintenance", which work together to allow nodes to discover and maintain routes to arbitrary destinations in the ad hoc network [1].

C. Hybrid Routing Protocols

Since proactive and reactive protocols each work best in oppositely different scenarios, hybrid method uses both. It is used to find a balance between both protocols. Proactive operations are restricted to small domain, whereas, reactive protocols are used for locating nodes outside those domains [6].

1. *Zone Routing Protocol (ZRP)*

As explained above, both a purely proactive and purely reactive approach to implement a routing protocol for a MANET has their disadvantages. The Zone Routing Protocol, or ZRP, as described in this document combines the advantages of both into a hybrid scheme, taking advantage of pro-active discovery within a node’s local neighborhood, and using a reactive protocol for communication between these neighborhoods. In a MANET, it can safely be assumed that the most communication takes place between nodes close to each other. Changes in the topology are most important in the vicinity of a node – the addition or the removal of a node on the other side of the network has only limited impact on the local neighborhoods.

As mentioned earlier, the ZRP is not so much a distinct protocol as it provides a framework for other protocols. The separation of a nodes local neighborhood from the global topology of the entire network allows for applying different approaches – and thus taking advantage of each technique's features for a given situation. These local neighborhoods are called zones (hence the name); each node may be within multiple overlapping zones, and each zone may be of a different size. The "size" of a zone is not determined by geographical mesas mentioned earlier; the ZRP is not so much a distinct protocol as it provides a framework for other protocols. The global topology of the entire network allows for applying different approaches – and thus taking advantage of each technique's features for a given situation. These local neighborhoods are called zones (hence the name); each node may be within multiple overlapping zones, and each zone may be of a different size. The "size" of a zone is not determined by geographical measurement, as one might expect, but is given by a radius of length p, where p is the number of hops to the perimeter of the zone. By dividing the network into overlapping, variable size zones, ZRP avoids a hierarchical map of the network and the overhead involved in maintaining this map. Instead, the network may be regarded as flat, and route optimization is possible if overlapping zones are detected. While the idea of zones often seems to imply similarities with cellular phone services, it is important to point out that each node has its own zone, and does not rely on fixed nodes (which would be impossible in MANETs). Figure 4 shows an example routing zone with p=2.

Note that in this example node A has multiple routes to node F, including one that has a hop count of c > p. Since it also has a route with c ≤ p, F still belongs to A's zone. Node G is out of A's zone, the nodes on the perimeter of the zone (i.e. with a hop count hc = p) are referred to as peripheral nodes (marked gray), nodes with hc < p) are interior nodes. Obviously a node needs to first know about its neighbors before it can construct a routing zone and determine its peripheral nodes. In order to learn about its direct neighbors, a node may use the media access control (MAC) protocols directly. Alternatively, it may require a Neighbor Discovery Protocol (NDP). Again, we see that ZRP, as a framework, does not strictly specify the protocol used but allows for local independent implementations. Such a Neighbor Discovery Protocol typically relies on the transmission of "hello" beacons by each node. If a node receives a response to such a message, it may note that it has a direct point-to-point connection with this neighbor. The NDP is free to select nodes on various criteria, such as signal strength or frequency/delay of beacons etc. Once the local routing information has been collected, the node periodically broadcasts discovery messages in order to keep its map of neighbors up to date. In doing so, it is assumed that these "link layer (neighbor) uncast are delivered reliably and in-sequence."[12]

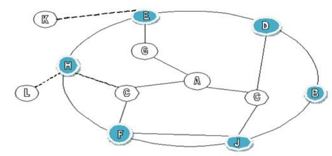

Figure 4: ZRP protocol

V. Simulation & Analysis

We simulate DSDV, DSR and ZRP on Network Simulator-2 and then compare and analyze their performance. A flat grid topology is used which tracks on the mobile nodes boundary. In this boundary 10 nodes are arranged in grid faction. Simulations were performed on the NS-2 simulator with wireless component which were developed by the Monarch research group in CMU.

Nine important performance metrics are measured and their output graphs are shown in following Figures.

A. *Send packets*

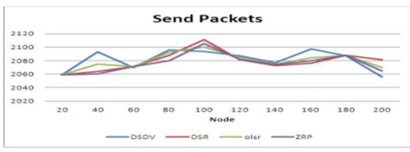

Figure 5: Send Packets graph for DSDV, OLSR, DSR and ZRP Protocol

We can show in this following figure that DSR send sends Maximum packets to route at different nodes and OLSR give optimal solution but DSDV give low result.

B. *Received Packets*

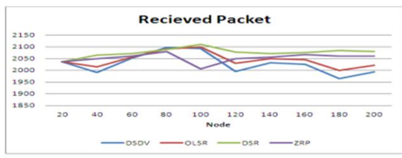

Figure 6: Received Packets graph for DSDV, OLSR, DSR and ZRP Protocol

As we can see that DSR receives maximum packets as compare to DSDV but ZRP receives maximum packets as compare to DSR and OLSR give middle level result

C. Routing Packets

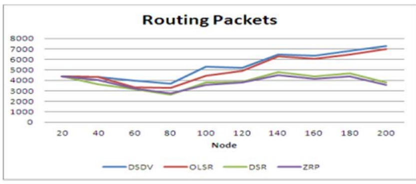

Figure 7: Routing Packets graph for DSVD, OLSR, DSR and ZRP protocol

Routing packets are overhead for the network. By the simulation we found that ZRP have minimum routing packets among DSDV and DSR, OLSR. So it is better with respect to routing packets.

D. Packet Delivery Friction

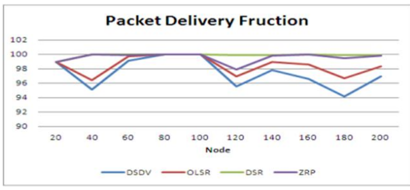

Figure 8: Packet Delivery Friction graph for DSDV, OLSR, DSR and ZRP Protocol

As we can see in following Figure 8 that the packet delivery friction of DSR is maximum as compare to DSDV, ZRP. But DSR is also maximum .so both are better.

E. Normalized Routing Load

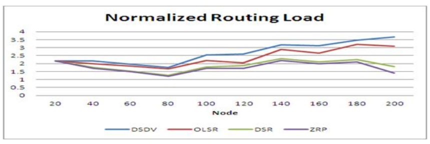

Figure 9: Normalized Routing Load graph for DSDV, OLSR, DSR and ZRP protocol

We can see that the load in routing is minimum at ZRP and DSR.

F. Route Discovery Delay

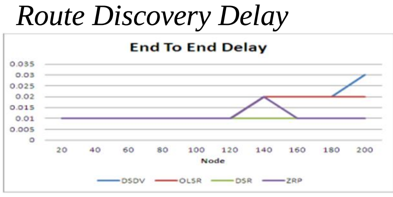

Figure 10: Route Discovery Delay graph for DSDV, OLSR, DSR, and ZRP protocol

End to end delay is one of the important parameters in analyzing performance of Mantes. It is the time interval between the instant a node initiates a route query and the instant it receives the first reply. In this graph DSR is giving best output as compare to DSDV and OLSR but ZRP is also giving good output to DSDV.

G. Dropped Packets

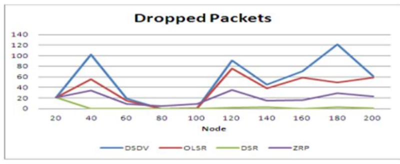

Figure 11: Dropped Packets graph for DSDV, OLSR, DSR, ZRP protocol

We can see that DSDV is giving poor output and DSR is giving best result at the time of dropped packets but ZRP is giving good output at the time of dropping packets and OLSR give optimal solution.

H. Dropped Bytes

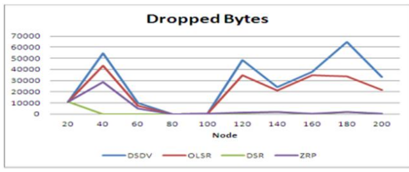

Figure 12: Dropped Bytes graph for DSDV, OLSR, DSR and ZRP protocol

DSR and ZRP are giving less no. of dropped bytes at the time of routing.

I. Packet Delivery Ratio

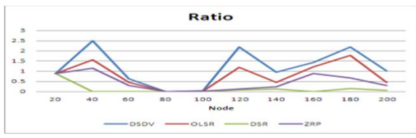

Figure 13: Packet Delivery Ratio graph for DSDV, OLSR, DSR and ZRP protocol

As we can see in following Figure 13, the packet delivery ratio has a downtrend with the zone radius increase in ZRP Protocol. And the downtrend is not same in three senses. A different speed of nodes in the network and a different radius for ZRP protocol will cause great difference of Packet Delivery Ratio And DSR give best output.

VI. Conclusions and Future Prospects:

Results are compared between the routing protocols DSDV, OLSR, DSR and ZRP with nine parameters. Those are shown in Section.5.In the simulations the protocol of routing were subjects to the same variations of setting. Comparisons between DSDV, OLSR, DSR and ZRP are done for 20,40,60,80,100,120,140,160,180 and 200 nodes shows the better performance for DSR and ZRP but sometimes OLSR give also good result or optimal solution nearby DSR with these parameters and ZRP gives some time good result when it react like reactive protocol and sometime react like proactive protocol. AWK script is used to analyze the Trace Files, which are generated during simulations.

Future prospects of these algorithms such as Proactive, Reactive, and Hybrid have some limitations. To remove these limitations, we can combine the above mentioned algorithms to produce a higher level algorithm or we can secure the algorithms separately or by combining them together and also control congestion control and also evaluate the performance at the time of link failures of these algorithms.

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