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A Study of Bellman-Ford, DSR and WRP Routing Protocols with Respect to Performance Parameters for Different Number of Nodes

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Abstract

A mobile ad-hoc network (MANET) is a self starting dynamic network comprising of mobile nodes that is connected through a wireless medium forming rapidly changing topologies. MANET is infrastructure less and can be set up anytime, anywhere. This work presents the study of protocol properties of MANET routing protocols and analyzed them with respect to different number of nodes. The routing protocols considered are Bellman-Ford, DSR and WRP. The study among these routing protocols are based on protocol property parameters such as End-to-End Delay, Packet delivery ratio, Drop Ratio and Normalized Routing Load (NRL) with respect to different number of nodes.

Keywords: Mobile ad-hoc network; DSR; WRP; Delay; PDR; NRL

1. INTRODUCTION

A mobile ad hoc network is a collection of wireless mobile nodes that dynamically establishes the network in the absence of fixed infrastructure. [3] One of the distinctive features of MANET is, each node must be able to act as a router to find out the optimal path to forward a packet. As nodes may be mobile, entering and leaving the network, the topology of the network will change continuously. MANET provides an emerging technology for civilian and military applications.

A fundamental problem in ad hoc networking is routing i.e. how to deliver data packets among

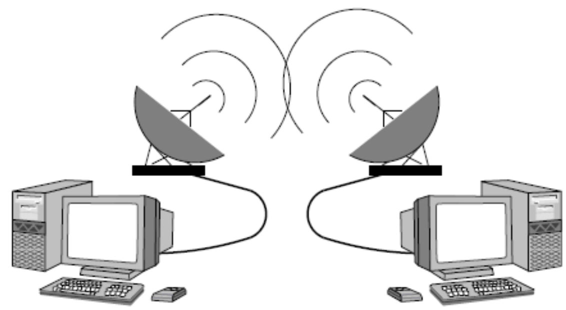

Fig 1: An example of a fixed wireless network

mobile nodes efficiently without predetermined topology or centralized control, which is the main objective of ad hoc routing protocols. Since mobile ad hoc networks change their topology frequently, routing in such networks is a challenging task. Moreover, bandwidth, energy and physical security are limited.

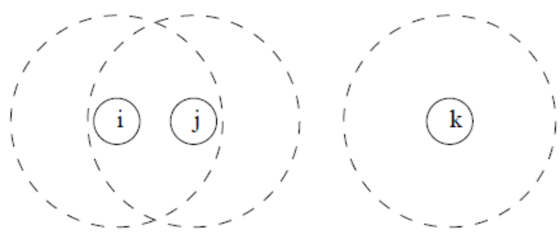

Fig 2: A simple network model for a mobile ad hoc network

To simplify the description of a MANET, the MANET model is usually illustrated as shown in Figure 2. Nodes *i*, *j*, and *k* are mobile nodes in the network. The dashed circles shown in the figure imply the radio coverage areas of nodes. In wireless

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networks, node *i* can hear node *j* if *i* is within the radio range of *j*. Node *i* is a neighbor of node *j* if node *j* can also hear node *i*. This is called a bi-directional connection. Two nodes are disconnected if one node is not in the radio range of the other. For example, nodes *j* and *k* are disconnected in the figure.

The Mobile ad-hoc network is characterized by energy constrained nodes [4], bandwidth constrained links and dynamic topology. One of the important research areas in MANET is establishing and maintaining the ad hoc network through the use of routing protocols. Though there are so many reactive routing protocols available, in this work we consider Bellman-Ford, DSR and WRP for performance comparisons due to its familiarity among all other protocols. These protocols are analyzed based on the important metrics such as End-to-End Delay, Packet delivery ratio, Drop Ratio and Normalized Routing Load with respect to different number of nodes and is presented with the simulation results obtained by Glomosim simulator.

2. MOBILE AD HOC NETWORK ROUTING PROTOCOLS

Routing protocols for Mobile ad hoc networks can be broadly classified into three main categories:

A. Proactive (table driven) Routing Protocols

Each node in the network has routing table for the broadcast of the data packets and want to establish connection to other nodes in the network. These nodes record for all the presented destinations, number of hops required to arrive at each destination in the routing table [4, 5]. The routing entry is tagged with a sequence number which is created by the destination node. To retain the stability, each station broadcasts and modifies its routing table from time to time.

The proactive protocols are appropriate for less number of nodes in networks, as they need to update node entries for each and every node in the routing table of every node. It results more Routing overhead problem. There is consumption of more bandwidth in routing table.

B. Reactive (on-demand) Routing Protocols

In this protocol, a node initiates a route discovery process throughout the network, only when it wants to send packets to its destination. This process is completed once a route is determined or all possible permutations have been examined [6, 7, 8]. Once a route has been established, it is maintained by a route maintenance process until either the destination becomes inaccessible along every path from the source or the route is no longer desired. A route search is needed for every unknown destination. Therefore, theoretically the communication overhead is reduced at expense of delay due to route search.

C. Hybrid routing protocols

This protocol incorporates the merits of proactive as well as reactive routing protocols. Nodes are grouped into zones based on their geographical locations or distances from each other. Inside a single zone, routing is done using table-driven mechanisms while an on-demand routing is applied for routing beyond the zone boundaries [9, 10]. The routing table size and update packet size are reduced by including in them only art of the network (instead of the whole); thus, control overhead is reduced.

The following routing protocols are used in this study-

2.1 Bellman Ford

Bellman-Ford Routing Algorithm, also known as Ford-Fulkerson Algorithm, is used as a distance vector routing protocol. Routers that use this algorithm have to maintain the distance tables, which tell the distances and shortest path to sending packets to each node in the network. The information in the distance table is always updated by exchanging information with the neighboring nodes. Bellman Ford is a table-driven routing scheme for ad hoc mobile networks based on the Bellman-Ford algorithm. It was developed by C. Perkins and P. Bhagwat in 1994. The main contribution of the algorithm was to solve the routing loop problem. Each entry in the routing table contains a sequence number. If a link presents the sequence numbers are even generally, otherwise an odd number is used. The number is generated by the

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destination, and the emitter needs to send out the next update with this number. Routing information is distributed between nodes by sending *full dumps* infrequently and smaller incremental updates more frequently.

Selection of Route: If a router receives new information, then it uses the latest sequence number. If the sequence number is the same as the one already in the table, the route with the better metric is used. Stale entries are those entries that have not been updated for a while. Such entries as well as the routes using those nodes as next hops are deleted. Then new destination comes. This is how it works.

Influence: Since no formal specification of this algorithm is present, there is no commercial implementation of this algorithm. But some other protocols have used similar techniques. The best-known sequenced distance vector protocol is AODV, which, by virtue of being a reactive protocol, can use simpler sequencing heuristics. Besides, Babel is a distance-vector routing protocol for IPv4 and IPv6 with fast convergence properties. It was designed to make Bellman Ford more robust, more efficient and more widely applicable for both wireless mesh networks and classical wired networks while staying within the framework of proactive protocols.

Advantages: Bellman Ford was one of the early algorithms available. It is quite suitable for creating ad hoc networks with small number of nodes.

Disadvantages: Bellman Ford requires a regular update of its routing tables, which uses up battery power and a small amount of bandwidth even when the network is idle. Also, whenever the topology of the network changes, a new sequence number is necessary before the network re-converges; thus, Bellman Ford is not suitable for highly dynamic networks.

2.2 Dynamic Source Routing (DSR)

The Dynamic Source Routing (DSR) [4] protocol is a distance-vector routing protocol for MANETs. When a node generates a packet to a certain destination and it does not have a known route to that destination, this node starts a route discovery procedure. Therefore, DSR is a reactive protocol. One advantage of DSR is that no periodic routing packets are required. DSR also has the capability to handle unidirectional links. Since DSR discovers routes on-demand, it may have poor performance in terms of control overhead in networks with high mobility and heavy traffic loads. Scalability is said to be another disadvantage of DSR [2], because DSR relies on blind broadcasts to discover routes.

There are two main operations in DSR, route discovery and route maintenance. Figure 3 shows a simple example for DSR. Routers *A*, *B*, and *C* form a MANET. Routers *A* and *C* are disconnected, while both of them connect to router *B*. Assume that at the beginning, the route caches that memorize previous routes in the routers are empty. When Router *A* wants to send a packet to Router *C*, it broadcasts a route request to start the corresponding route discovery procedure. Router *B* receives the request since it is within the radio range of *A*. Router *C* is the destination in the request and *B* does not have a route entry to *C* in its cache at this time. Hence, Router *B* appends its own ID to the list of intermediate router IDs in the request and rebroadcasts it. When *C* receives the broadcast route request message originated by *B*, it determines that the destination ID matches its own ID. Thus, the route from *A* to *C* is found. To help the initiator and all intermediate routers construct proper routing entries, Router *C* sends a reply back to *A* using source routing if links are bi-directional. This procedure is feasible because all intermediate routers are in the ID list of the corresponding route request. Intermediate routers construct proper routing tables when they receive the reply originated from *C*. Thus, a route from *A* to *C* is built.

During the route discovery procedure, routers maintain ID lists of the recently seen requests to avoid repeatedly processing the same route request. Requests are discarded if they were processed recently since they are assumed to be duplicates. If a router receives a request and detects that the request contains its own ID in the list of intermediate routers, this router discards the request to avoid loops.

The route maintenance procedure is used when routes become invalid due to the unpredictable movement of routers. Each router monitors the links that it uses to forward packets. Once a link is down, a route error packet is immediately sent to the initiator of the associated route. Therefore, the invalid route is quickly discarded [2].

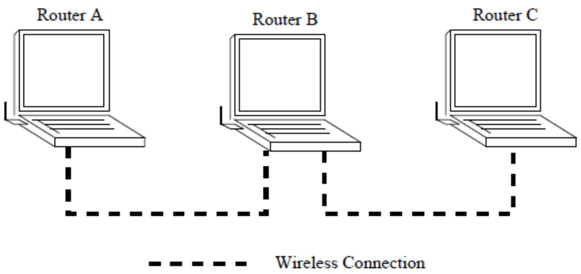

Fig 3: Example of DSR Routing Protocols

To handle unreliable transmissions of control messages, DSR either relies on the underlying MAC protocol to provide guaranteed delivery or it retransmits control messages for a certain number of times. Since DSR is a reactive protocol, it cannot tell whether a destination is unreachable or the route request is lost. Therefore, it suffers more overhead if the underlying MAC layer does not support guaranteed delivery. This is a common problem for reactive routing protocols because when no reply message is heard, routers with a reactive routing protocol cannot tell the difference between the case of a transmission error and the case of unreachable nodes. Reactive routing protocols try to use extra acknowledgements or a small number of retransmissions to solve this problem and, thus, introduce more overhead. Proactive routing protocols periodically broadcast control messages and remove local routing entries if they time out. Hence, they do not have this problem. But, of course, the periodically broadcast control messages contribute to overhead.

2.3 Wireless Routing Protocol (WRP)

The Wireless Routing Protocol (WRP) is proactive unicast routing protocol for mobile adhoc networks (MANETs). It is a table-based protocol similar to DSDV that inherits the properties of Bellman Ford Algorithm. The main goal is maintaining among all nodes in the network regarding the shortest distance to every destination. WRP is another loop-free proactive protocol.WRP is path-finding algorithm with the exception of avoiding the count-to infinity problem by forcing each node to perform consistency checks of predecessor information reported by all its neighbors. Each node in the network uses a set of four tables to maintain more accurate information: Distance table, Routing table, Link-cost table, Message retransmission list table. In case of link failure between two nodes, the nodes send update messages to their neighbors. This eliminates looping situations and enables faster route convergence when a link failure occurs. Loop avoidance is based on providing for the shortest path to each destination both the distance and the second-to-last hop (predecessor) information. Despite the variance in the number of routing tables used, and the difference in routing information maintained in these tables, proactive routing protocols like WRP are distance vector shortest-path based, and have the same degree of complexity during link failures and additions.

3. PERFORMANCE PARAMETERS

We will take four performance parameters for study of Bellman-Ford, DSR and WRP which are End-to End delay, Packet Delivery Ratio, Drop Ratio and Normalized Routing Load which are described as below:

A. End-to-End Delay

The average end-to-end delay of data packets is the interval between the data packet generation time and the time when the last bit arrives at the destination. A low end-to-end delay is desired in any network. [1]

B. Packet Delivery Ratio

Packet Delivery Ratio (PDR) is the ratio between the number of packets transmitted by a traffic source and the number of packets received by a traffic sink. [1] It measures the loss rate as seen by transport protocols and as such, it characterizes both the correctness and efficiency of ad hoc routing protocols. A high packet delivery ratio is desired in any network.

C. Drop Ratio

Packet Drop rate is one of the indicators for network congestion. In wireless environment, due to the physical media and bandwidth limitations, the chance for packet dropping is increased. Therefore we choose it as one metric.

D. Normalized Routing Load (NRL)

Normalized Routing Load (NRL) [1] is the ratio of control packets to data packets in the network. It gives a measure of the protocol routing overhead; i.e. how many control packets were required (for route discovery/maintenance) to successfully transport data packets to their destinations. It characterizes the protocol routing performance under congestion. NRL is determined as:

$$NRL = Pc / Pd$$

Where Pc is the total control packets sent and Pd is the total data packets sent.

4. SUMMARY

In this paper we have studied the routing protocols Bellman-Ford, DSR and WRP over various numbers of nodes. Here we study four performance metrics like End-to-End Delay, Packet Delivery Ratio, Drop Ratio and Normalized Routing Load (NRL). And the studies shows that the behavior of routing protocols varies as the no. of nodes, speed of nodes and number of source nodes are changed. The performance of routing protocols varies with the above models. We can implement these protocols on Glomosim Simulator [11].

For future work we can implement other routing protocols with the above mobility models and different models (scenario). And we can use different performance metrics.

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