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Analysis of dynamic source routing protocol for wireless mobile ad-hoc networks

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Abstract

The need for ad hoc networking; has been tremendously brought to limelight by the various global communication demands ranging from disaster relief, military and academic usage to several commercial applications. The preference of Dynamic Source Routing protocol (DSR) over other ad hoc routing protocols has to do with its on-demand and non-periodic activity, hence can guarantee a reasonable extent of reliable and optimal routing. However, some conflicting ad hoc routing issues such as dynamic topology, limited transmission range, routing overheads among other factors hinder effective ad hoc communication thereby introducing inefficient path deviations, delays and packet losses. The DSR protocol thus is analyzed using animations and an ad hoc DSR-enabled network designed with the Matlab Interactive tool QualNet Simulator respectively. A triangular mesh theory is implied to create a model for comparative analysis with the conventional DSR protocol. The failure probabilities obtained from the model are graphically analyzed using Matlab to bring into view some evaluated improvements.

Key Words: Ad hoc, nodes, Mobile Ad hoc Network (MANET), Internet Engineering Task Force (IETF), Dynamic Source Routing (DSR), Route cache

Introduction

The ability for nodes to form ad hoc networks in the absence of communication infrastructure is a critical area of current research. In a mobile ad hoc network MANET, mobile nodes come together for a period of time to exchange information. The nodes are probable to continue its mobile movement while exchanging information hence the network must be prepared to adapt continually. The basic routing problem is that of finding an ordered series of intermediate nodes that can transport a packet across a network from its source to its destination by forwarding the packet along this series of intermediate nodes. The goal of the routing protocol is to ensure that the overall data structure contains a consistent and correct view of the actual network topology [1,2]. If the route caches at some nodes were to become inconsistent, then packets can loop in the network and would be eventually dropped after the expiration of Time To Live or Round Trip Times [3].

The problem of maintaining a consistent view of the network becomes harder when there is an increase in the number of nodes whose information must be correct and the rate of change in the actual topology increasing still [4]. Therefore, the challenge in creating a robust routing protocol for ad hoc networks is to design a single ad hoc protocol that can adapt to the wide variety of conditions that can be present in any ad hoc network over time. The routing protocol must perform efficiently in environments in which nodes are stationary and bandwidth is not a limiting factor; yet the same protocol must still functions efficiently when the bandwidth available between nodes is low and the level of mobility and topology change is high. Since it is often impossible to know abinitio what environment the protocol will thrive in and because the environment can change unpredictably, the routing protocol must be able to adapt automatically.

2 MANET PROTOCOLS

In general, MANET routing protocols are mainly divided into two techniques; Table-driven and Source-initiated routing [1,2,5]. Table-driven routing protocol requirements are periodic advertisement of the change in the network and its global dissemination of connectivity because of which it is unsuitable for large-sized networks. Protocols based on table-driven techniques include Destination Sequence Distance Vector protocol (DSDV) [1], Cluster Based Routing (CBR) [6] among others.

Source-initiated routing only requires that the sender learns the complete, ordered sequence of network hops

necessary to reach the destination and at a conceptual level, each packet to be routed carries this list of hops in its header. Protocols based on source-initiated technique include Ad hoc On-demand distance Vector (AODV) [1], Temporary Ordered Routing Algorithm (TORA), Zone Routing Protocol (ZRP) [5] and others.
A comparison of four routing protocols in MANET can be analyzed in a tabular form as shown in Table 1.
Efficient routing in an ad hoc network requires that the routing protocol operate in an on-demand fashion and requires that the routing protocol limit the number of nodes that must be informed of topology changes. In this dissertation, , it can be fundamentally asserted that there are two keys to designing a routing protocol that operates successfully given the challenges of ad hoc network [7]. First, the protocol must be fundamentally on- demand meaning that it reacts to changes in the environment only when necessary. Second, the protocol must limit the number of nodes that are required to share consistent state information since it is extremely expensive or impossible to maintain a distributed data structure in a consistent state across all the nodes in a rapidly changing ad hoc network.

Table 1: Comparison of MANET Routing Protocols

	DSDV	AODV	TORA	DSR
Update routing table periodically	Yes	Send Hello	No	No
Support one-way link	No	No	No	Yes
The Mechanism of routing	Next Hop	Next Hop	Next Hop	Source Routing
The Metrics of routing	Shortest Path	Shortest Path	Shortest Path	Shortest Path
Need other protocol support	NO	NO	IMEP	NO

3.0 DSR OVERVIEW

In multi-hop ad hoc networks, two nodes desiring to communicate but are not neighbors deploy the services of intermediate hosts between them to relay their messages. In the simplest scenarios, nodes may be able to communicate directly with each other, for example, when they are within wireless transmission range of each other. However, ad hoc networks must also support communication between nodes that are only indirectly connected by a series of wireless hops through other nodes. For example, in Figure 1, nodes **A** and **C** must enlist the aid of node **B** to relay packets between them in order to communicate [8]. In general, an ad hoc network is a network in which every node is potentially a router, and every node is potentially mobile.

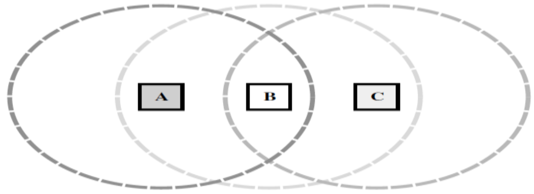

Figure 1: An ad hoc network of three nodes, where nodes **A** and **C** must discover the route through **B** in order to communicate. The circles indicate the nominal range of each node's radio transceiver. Nodes **A** and **C** are not in direct transmission range of each other, since **A**'s circle does not cover **C**.

3.1 DSR ASSUMPTIONS

It is assumed that all nodes wishing to communicate with each other within the ad hoc network are willing to participate fully in the protocols of the network. In particular, each node participating in the network should also be willing to forward packets for other nodes in the network [9]. Nodes within the ad hoc network may move at anytime without notice and may even move continuously, but it is assumed that the speed with which nodes move is moderate with respect to the packet transmission latency and wireless transmission range of the particular underlying network hardware in use. It is also assumed that nodes do not continuously move so rapidly (above 50m/s or 180km/hr) as to make the flooding of every individual data packet the only possible routing means. It is further assumed that nodes may be able to enable promiscuous receive mode on their wireless network interface hardware causing the hardware to deliver every received packet to the network driver software without filtering based on link layer destination address.

3.2 BASIC OPERATION OF THE DSR PROTOCOL

The DSR protocol consists of two basic mechanisms: Route Discovery and Route Maintenance [6, 7].
Route Discovery is the mechanism by which a node **S** wishing to send a packet to a destination **D** obtains a source route to **D**. Route Discovery works by flooding a request through the network in a controlled manner, seeking a route to some target destination. In its simplest form as shown in figure 2, a source node **A** attempting to discover a route to a destination node **D** broadcasts a Route Request packet that is re-broadcast by intermediate nodes until it reaches **D**, which then answers by returning a Route Reply packet to **A**. To reduce the cost of Route Discovery, each node maintains a Route Cache of source routes it has learned or overheard [10].

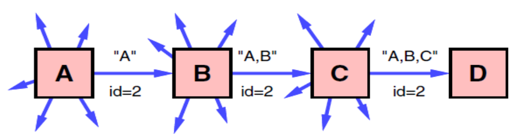

Figure 2: Basic Operation of Route Discovery

Route Maintenance is the mechanism by which a packet's originator **S** detects if the network topology has changed such that it can no longer use its route to the destination **D** because some of the nodes listed on the route have moved out of range of each other [11,12]. Each node along the route, when transmitting the packet to the next hop, is responsible for detecting if its link to the next hop has broken. Figure 3 shows the basic operation of the DSR protocol.

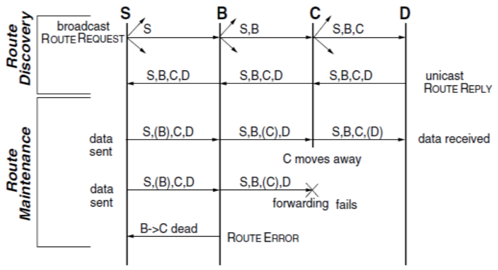

Figure 3: Basic Operation of the DSR Protocol

3.3 ROUTE CACHE

All the routing information needed by a node participating in an ad hoc network using DSR is stored in a Route Cache. Each node in the network maintains its own Route Cache, to which it adds information as it learns of new links between nodes in the ad hoc network, for example through packets carrying either a Route Reply or a source route. Likewise, the node removes information from the cache as it learns previously existing links in the ad hoc network have broken, for example through packets carrying a Route Error or through the link-layer retransmission mechanism reporting a failure in forwarding a packet to its next-hop destination. The Route Cache is indexed logically by destination node address and can be optimized in several ways [5,13].

4 MANET IMPLEMENTATION AND ANIMATION USING MATLAB

The Matlab software can be used to generate a simulated MANET. The simulated area is specified while the participating nodes (source, intermediate and destination nodes) are distinguished from one another and are animated as mobile nodes.

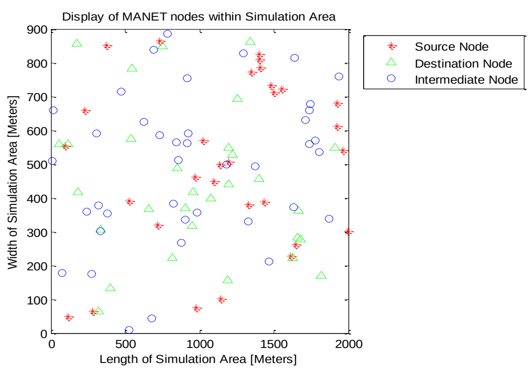

Figure 4: Simulation of a typical movement scenario observed in random waypoint model with 100 nodes (30 Source, 40 Intermediate, 30 Destination nodes) simulated in Matlab

From figure 4 , Matlab codes are written and used to set up animated mobile nodes to represent the source, intermediate and destination nodes within the simulation area of the Mobile Ad hoc Network [10]. There are 30 source and destination nodes while there are 40 intermediate nodes within the 1.8 square km area (2000m by 900m)

In figure 5, the simulation area contains source and destination nodes which using the Random Waypoint mobility model intercommunicate. The random movement is simulated above and the distance coverage between the source and target. This figure represents a MANET topology under which DSR protocol exists.

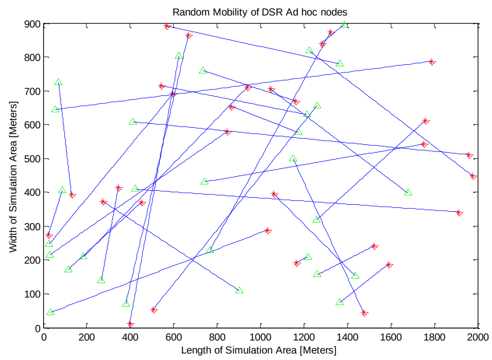

Figure 5: Random Mobility Generation of Ad hoc Nodes in Matlab

5. IMPLEMENTATION OF DSR PROTOCOL USING QUALNET SIMULATOR

QualNet is a network modeling software that predicts performance of networking protocols and networks through simulation and emulation. Using simulation allows the researcher to reproduce the unfavorable conditions of networks in a controllable and repeatable lab setting [10, 13].. The QualNet version used for this simulation is version 4.5.1 released in July, 2008 by Los Angeles Scalable Networks Inc.

In setting up an ad hoc network scenario using DSR protocol, a twenty node ad hoc network model is set up using QualNet. The nodes make use of lookup packets to trace their next target through the intermediate nodes.Figure 6 shows the 20-node network.

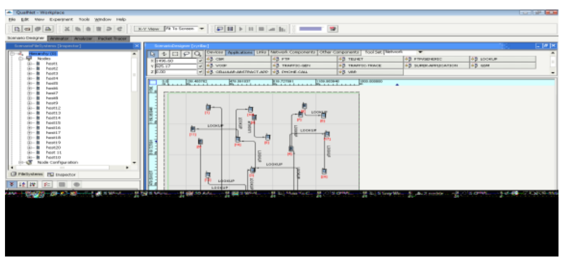

Figure 6: A 20-node ad hoc network setup using DSR protocol for performance Analysis.

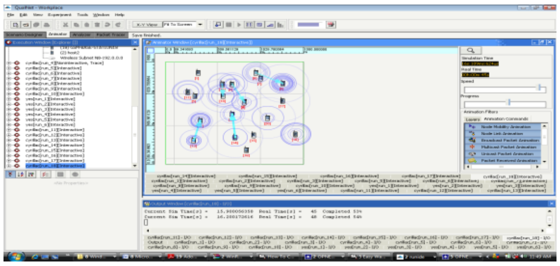

Figure 7: Discrete Simulation of a 20-Node DSR-Enabled Mobile Ad hoc Network.

Modeled parameters set for the simulation include Radio type, Mobility Model, MAC Propagation delay, Network protocol, Promiscuous mode enablement, number of simulated packets, fading model, weather conditions among other wireless network parameters.Figure 7 shows a captured simulation of the above modeled network illustrating the propagation of packets through wireless transmission to other nodes.

Some generated graphs after the simulation are shown in figures 8 and 9.
From the charts, figure 8 indicates an average of about 10 Resource Request (RREQ) packets forwarded within 100 packets. In figure 9, the DSR simulation shows that about 10 RERR packets per node make up the 100 packet simulation run. These performances of the conventional DSR would be compared with the efforts of the enhanced DSR protocol generated using Matlab.

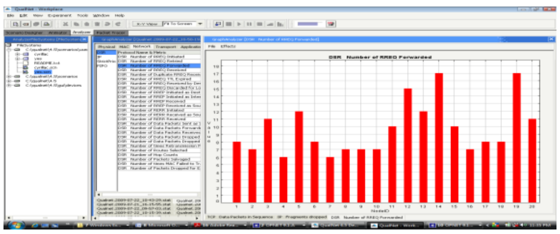

Figure 8: Simulation Result on DSR Number of RREQ (Route Requests) Forwarded over every 100 packets

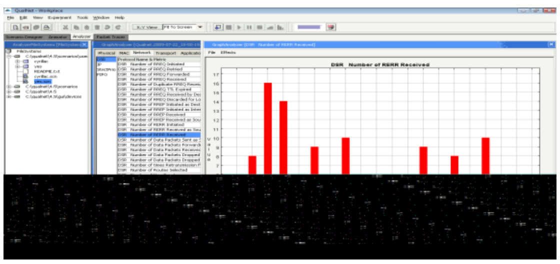

Figure 9: DSR Number of RERR (Route Errors) Received

6. CONCLUSION: This paper reveals that DSR performs efficiently in less random movement scenarios and likewise in smaller network size. However, it's optimal performance is reduced when the situation gets stressed which is still highly obtainable in the QualNet simulation, i.e. increase in link failure probability and number of participating nodes. This is due to the aggressive usage of source routing cache especially as the network topology spans over large areas.

Finally, the results of the analysis and simulations have brought more clarity that the wake of conferring DSR protocol as a global standard by the IETF is not far-fetched. Thus the end to all the different means of implementing this protocol lies with its high performance optimality in advanced ad hoc network test bed.

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