Performance Analysis Of Dynamic Source Routing Using Expanding Ring Search For Ad-hoc Networks

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Abstract:

This paper presents a protocol for routing in ad hoc networks that uses dynamic source routing (DSR). DSR uses a route discovery mechanism to dynamically discover routes when needed. This is done by broadcasting a Route Discovery packet with a hop limit of one and if no reply is received for this packet then broadcast a packet with a hop limit of a predefined maximum value. This ends up in disturbing almost all nodes in the network with a considerable number of routing overhead packets. Expanding Ring Search for DSR gradually increases the hop limit in the route discovery packet resulting in a gradual search for the destination thereby reducing this routing overhead. The protocol was implemented using the ns-2 network simulator. In this paper we have provided a summary of our simulation results, comparing the routing overhead generated by the basic DSR route discovery mechanism and DSR with Expanding Ring Search mechanism.

Index Terms: Ad-hoc Network, Expanding Ring search

1.Introduction

Mobile users will want to communicate in situations in which no fixed infrastructure is available. Ex: Disaster recovery (flood, earthquake). In such situations a collection of mobile hosts with wireless network interfaces may form a temporary network without the aid of any established infrastructure or centralized administration. Currently there are two types of mobile wireless networks-

a.Infrastructured Networks.

b. Infrastructureless Networks.

This is commonly known as ad hoc network. An ad hoc network is a dynamically changing network of mobile nodes that communicate without the support of a fixed infrastructure. In such a network, each mobile node operates, as a host as well as a router. A key protocol in ad hoc networks is routing. Routing protocols used for ad hoc networks must deal with the typical limitations of these networks, which include- limited wireless transmission range, packet losses due to transmission errors, mobility induced route changes, mobility induced packet losses, battery constraints, potentially frequent network partitions, ease of snooping on wireless transmissions, low bandwidth.

Routing Protocols for Ad Hoc Networks:

Routing protocols for ad hoc networks are generally categorized as-

a. Table Driven Routing:

These protocols require each node to maintain one or more tables to store routing information and nodes propagate routing updates throughout the network in response to changes in the network topology.

Disadvantages: Frequent broadcasts of the routing table will degrade the throughput of channel access and increase the overhead as the population of mobile hosts increases.

b. Source-Initiated On-Demand Routing:

The source node initiates a route discovery process within the network only when it needs a route. Once a route has been established, it is maintained by a route maintenance procedure.

2.Dynamic Source Routing Protocol

The Dynamic Source Routing protocol (DSR) [1]-[3] is a simple and efficient routing protocol designed specifically for use in multi-hop wireless adhoc networks of mobile nodes. Using DSR, the network is completely self-organizing and self-configuring, requiring no existing network infrastructure or administration. The use of source routing allows

- Nodes forwarding or overhearing packets to cache the routing information in them for their own future use.
- Packet routing to be trivially loop free.
- Avoids the need for up-to-date routing information in the intermediate nodes through which packets are forwarded.

Network nodes cooperate to forward packets for each other to allow communication over multiple "hops" between nodes not directly within wireless transmission range of one another. As nodes in the network move about or join or leave the network, and as wireless transmission conditions such as sources of interference change, all routing is automatically determined and maintained by the DSR routing protocol. Since the number or sequence of intermediate hops needed to reach any destination may change at any time, the resulting network topology may be rapidly changing. The DSR protocol allows nodes to dynamically discover a source across multiple network hops to any destination in the ad hoc network. Each data packet sent then carries in its header the complete ordered list of nodes through which the packet must pass, allowing packet routing to be loop free and avoiding the need for up-to-date routing information in the intermediate nodes through which the packet is forwarded. By including this source route in the header of each data packet, other nodes forwarding or overhearing any of these packets may also easily cache this routing information for future use.

The following assumptions [2] are made regarding the way computers are situated with respect to each other in an ad hoc network -

- All nodes wishing to communicate with other nodes within the ad hoc network are willing to participate fully in the protocols of the network.
- The diameter of the ad hoc network is assumed to be often small.
- Nodes within the ad hoc network may move at any time without notice, and may even move continuously, but we assume that the speed with which nodes move is moderate.
- Wireless communication ability between any pair of nodes may at times not work equally well in both directions

DSR Protocol Description:

The DSR protocol is composed of two mechanisms that work together to allow the discovery and maintenance of source routes in the ad hoc network:

a. DSR Route Discovery:

Route Discovery allows any host in the ad hoc network to dynamically discover a route to any other host in the ad hoc network, whether directly reachable within wireless transmission range or reachable through one or more intermediate network hops through other hosts. A host initiating a route discovery broadcasts a route discovery packet, which will be received by those hosts within wireless transmission range of it. The route request packet contains-

- The address of the original initiator and target node of the route request.
- A route record, in which is accumulated a record of the sequence of hops taken by the route request packet as it is propagated through the ad -hoc network during its route discovery.
- Each route request packet also contains a unique request id.

When any host receives a route request packet, it processes the request according to the following steps:

1. If this packet id is found in this host's list of recently seen requests, then discard the route request packet and do not process it further.
2. Otherwise, if this host's address is already listed in the route record in the request, then discard the route request packet and do not process it further.
3. Otherwise, if the target of the request matches this host's own address, then the route record in the packet contains the route by which the request reached this host from the initiator of the route request. Return a copy of this route in a route reply packet to the initiator.
4. Otherwise, append this host's own address to the route record in the route request packet, and re-broadcast the request.

The route request thus propagates through the ad hoc network until it reaches the target host, which then replies to the initiator. Only those hosts within wireless transmission range of the initiating host receive the original route request packet, and each of these hosts propagates the request if it is not the target and if the request does not appear to this host to be redundant. Discarding the request because the host's address is already listed in the route record guarantees that no single copy of the request can propagate around a loop. Also discarding the request when the host has recently seen one with the same id removes later copies of the request that arrive at this host by a different route.

In order to return a route reply packet to the initiator of the route discovery, the target host must have a route to the initiator. If the target has an entry for this destination in its route cache, then it may send the route reply packet using this route in the same way as is used to send any other packet. Otherwise, the target may reverse the route in the route record from the route request packet, and use this route to send the route reply packet. This however requires the wireless network communication between each of these pair of hosts to work equally well in both directions, which may not be true in some environments or with some MAC-level protocols. An alternative approach is to piggyback the route reply packet on a route request targeted at the initiator of the route discovery to which it is replying.

All source routes learned by a node are kept in a route cache, which is used to further reduce the cost of route discovery. A node may learn of routes from virtually any packet the node forwards or overhears. When a node wishes to send a packet, it examines its own route cache and performs route discovery only if no suitable source route is found.

b. Route Maintenance:

This is the mechanism by which a source node is able to detect, while using a source route to a destination, if the network topology has changed such that it can no longer use this route. Route Maintenance is used only when a node is actually sending packets to a destination.

3. *Problem Formulation*

Existing Route Discovery Operation:

The initiator of the route request packet has the ability to specify in the route request packet, a "hop limit". This ability is used during route discovery as follows:

1.**Nonpropagating Route Request:** This route request packet has a hop limit of one and is the initial route discovery packet.

2. **Propagating Route Request:** If no route reply is received from the previous route request within a small timeout period, a new request is sent with a hop limit set to a predefined "maximum" value.

This procedure uses the hop limit on the route request packet to inexpensively check if the target is currently within wireless transmitter range of the initiator or if another host within range has a route cache entry for this target. Since the initial request is limited to one network hop, the timeout period before sending the propagating request can be quite small.

Disadvantages: Potentially every node in the network will be disturbed whenever a request packet is created.

4.Solution

Route Discovery Using Expanding Ring Search:

An expanding ring search can be implemented for the route discovery, in which the hop limit is gradually increased in subsequent retransmissions of the route request for this target.

Implementation:

1. A non-propagating route request (hop limit = 1) is broadcast first and the initiator waits until the timeout interval to receive a reply.

2. If no reply is received within the timeout interval the node initiates another route request with a hop limit of five.

3. For each route request initiated, if no route reply is received for it, the node increases the hop limit used on the previous attempt by five. This is done until the predefined maximum value of hop limit is reached. In actual use, it is expected that hosts communicate mostly with a small common subset of the available hosts (such as servers), which would reduce the number of route discoveries required.

The hop limit is implemented using the *Time-to-Live (TTL)* field in the IP header of the packet carrying the route request.

Table I show the constants used in the simulation of the ad hoc network using the DSR protocol with Expanding Ring Search.

Table I: Constants used in the Simulation

Parameter	Value
Non-propagating route request time out	100msec
Maximum route request period	10sec
Time to hold packets awaiting routes	30sec
Route request time out	500msec
Packet forwarding jitter	1-2msec

5. Performance Analysis and Results

Parameter for Analysis:

The main goal of this project was to measure the routing overhead of the DSR protocol using the Expanding Ring Search in comparison to the basic DSR route discovery mechanism that does not use an expanding ring search to discover routes.

Routing overhead:

It is the total number of routing packets transmitted during the simulation. For packets sent over multiple hops, each transmission (each hop) of the packet counts as one transmission. Routing overhead measures the scalability of the protocol, the degree to which it will function in congested or low-bandwidth environments. Protocols that send large number of routing packets: Consumes more battery power, Consumes bandwidth and may delay data packets in network interface transmission queues.

Simulation results:

Fig.1 shows the routing overhead (packets) generated by DSR without Expanding Ring Search and the routing overhead generated by DSR with Expanding Ring Search that was measured for 10 and 20 sources for pause time values ranging from 0 to 500 seconds using the ns-2 simulator [4], [5].

The simulation results (Fig.1) shows that the DSR using Expanding Ring Search mechanism for route discovery performs better than the basic DSR route discovery mechanism. The Fig.1 clearly shows a decrease in the number of routing overhead packets, by a margin of 1000 packets. This is because, the basic DSR route discovery mechanism results in the route discovery packet being propagated throughout the network when the nonpropagating route request is not replied, whereas the Expanding Ring Search limits the propagation of the route discovery packet by including a hop limit, which results in a gradual search for the destination node. The Expanding Ring Search performs extremely well at higher values of pause times, when node mobility is minimal and routes once discovered can be used for a longer time.

6. Conclusion

The previous works on DSR has shown that it delivers over 95% of data packets regardless of mobility rate and has the least overhead compared to other routing protocols used for ad hoc networks. In this paper we have provided the results of implementing the same DSR protocol, but using an Expanding Ring Search of route discovery that has further reduced the routing overhead.

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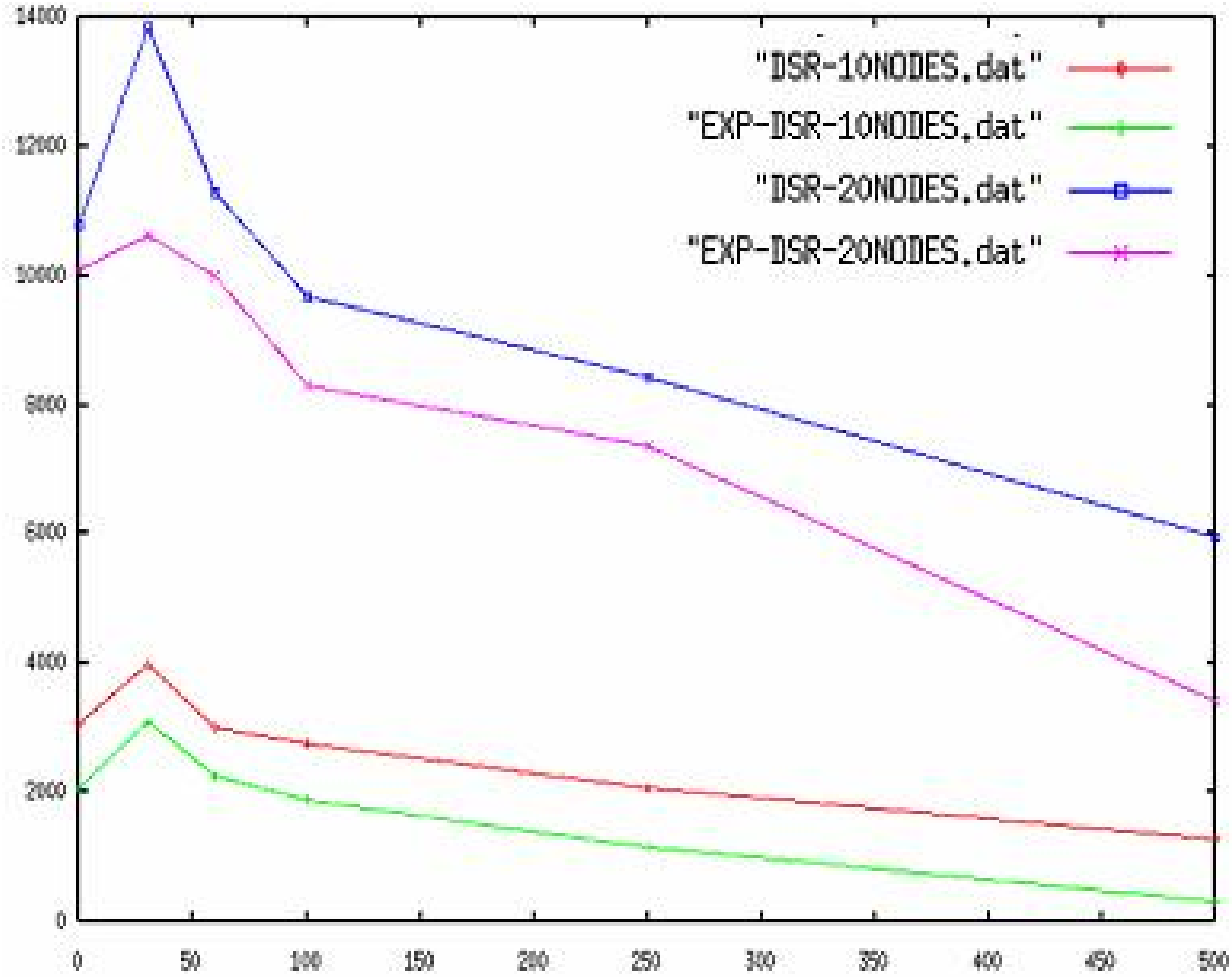

Fig.1 Routing overhead Vs Pause Time (10 and 20 nodes)