International Journal of Computer Science and Network (IJCSN)
Volume 1, Issue 3, June 2012 www.ijcsn.org ISSN 2277-5420

Minimizing the overhead in the terminode routing protocol in mobile adhoc networks.

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Abstract

In this paper we present an approach of using Optimized Link State Routing Protocol (OLSR) in the terminode routing method. Terminode routing uses the combination of location based routing i.e. Terminode Remote Routing (TRR), used when the destination is far and Link state routing i.e. Terminode Local Routing (TLR), used when the destination is close. Our proposed concept uses the OLSR instead of Link state routing when the location accuracy is low in MANET's. The key concept used in OLSR is that of Multi Point Relays (MPRs).Multi Point Relays are selected nodes which forward broadcast messages during the flooding process. This technique substantially reduces the message overhead. OLSR minimizes the number of control messages flooded in the network. Generally in terminode routing when a packet has arrived up to two hops away from the destination, a Link state routing protocol is used, but whenever the location accuracy is low and packet has arrived up to six hops or more than six hops away from the destination OLSR will be used instead of Link state routing without causing much overhead. So that we can improve the performance of the terminode routing when the location accuracy is low.

Keywords: *Optimized Link State Routing Protocol (OLSR), Terminode Remote Routing, MANETS, Multipoint Relays.*

1. Introduction

Location-based routing protocols uses location information to achieve scalability in large Mobile Ad Hoc Networks (MANETs).Terminode routing method which aims at keeping the scalability benefits of location based routing, while addressing the two issues of irregular topology and node mobility. Terminode routing uses the following ingredients. First, it combines a location-based routing method TRR, with a link state routing TLR. It uses a combination of location-based routing, when the destination is far, and Linkstate routing, used when the destination is close. Second, it uses a special form of restricted search mode, called Restricted Local Flooding (RLF). It sends four to six packet duplicates in the region where the destination is expected to be, thus increasing the probability of reaching the destination. Third, it introduces the concept of anchors, which are geographical points(not nodes) imagined by the sources for routing to specific destination. Anchored paths are discovered and managed by sources, using one of two low overhead protocols: Friend Assisted Path Discovery (FAPD) and Geographical Map-based Path Discovery (GMPD). Friend Assisted Path Discovery (FAPD) assumes that some nodes (FAPD responders) are able to provide assistance to others, typically because they have a stable view of the network density. FAPD responders help to find anchors, but are not used in the data path. Geographical Map-based Path Discovery (GMPD) assumes that network density maps are available to a source node.

In mobile ad hoc networks, systems may move arbitrarily. Examples where mobile ad hoc networks may be employed are the establishment of connectivity among handheld devices or between vehicles. Since mobile ad hoc networks change their topology frequently and without prior notice, routing in such networks is a challenging task. Topology-based routing protocols use the information about the links that exist in the network to perform packet forwarding.

We use a combination of two routing protocols: Terminode Local Routing (TLR) and Terminode Remote Routing (TRR). TLR is a mechanism that allows to reach destinations in the vicinity of a terminode and does not use location information for making packet forwarding decisions. In contrast, TRR is used to send data to remote destinations and uses geographic information; it is the key element for achieving scalability and reduced dependence on intermediate systems.
TRR consists of the following elements:

- **Anchored Geodesic Packet Forwarding (AGPF)** is a method that allows for data to be sent to remote terminodes. AGPF is solely based on locations. AGPF sends data along the anchored path. An anchored path defines a rough shape of the path from the source to the destination and is given with a list of anchors. Anchors are points described by geographical coordinates and do not, in general, correspond to any terminode location. A good anchored path should avoid obstacles and terminode "deserts" from the source to the destination. Between anchors geodesic packet forwarding is performed; this is a greedy method that follows successively closer geographic hops to an anchor or the final destination.
- **Friend Assisted Path Discovery (FAPD)** is the path discovery method used to obtain anchored paths. A terminode keeps a list of other terminodes, that it calls friends, to which it maintains one or several good path(s). In FAPD, a terminode may contact its friends in order to an anchored path to the destination of interest. FAPD is based on the concept of small world graphs [2].
- **Path Maintenance** is a method that allows a terminode to improve acquired paths, and delete obsolete or mal-functioning paths.
- In Multipath Routing a terminode normally attempts to maintain several anchored paths to any single destination of interest. In a highly mobile environment, anchored paths can be broken or become congested. A path that worked well suddenly can deteriorate. As a response to such uncertainty in the network, TRR uses multipath routing.

2. Proposed approach

OLSR is a proactive link-state routing protocol, employing periodic message exchange for updating topological information in each node in the network. i.e. topological information is flooded to all nodes in the network.

Generally in terminode routing when a packet arrives up to two hops away from the destination, a Link state routing protocol (Terminode local routing) is used. But whenever the location accuracy is low and a packet arrives up to six or more than six hops away from the destination OLSR will be used instead of LSR without causing much overhead. We can use this approach to improve the performance of the terminode routing when the location accuracy is low.

Conceptually, OLSR contains three elements: Mechanisms for neighbor sensing based on periodic exchange of HELLO messages within a node's neighborhood. Generic mechanisms for efficient flooding of control traffic into the network employing the concept of multipoint relays (MPRs) [5] for a significant reduction of duplicate retransmissions during the flooding process. And a specification of a set of control-messages providing each node with sufficient topological information to be able to compute an optimal route to each destination in the network using any shortest-path algorithm.

3. Overview of Terminode routing

Each terminode has a permanent End-system Unique Identifier (EUI), and a temporary, location-dependent address (LDA). The LDA is simply a triplet of geographic coordinates (longitude, latitude, altitude) obtained, for example, by means of the Global Positioning System (GPS) or the GPS-free positioning method

3.1 Combination of Location based routing method and Link state routing

It uses a combination of location-based routing (Terminode Remote Routing, TRR), used when the destination is far, and link state routing (Terminode Local Routing, TLR), used when the destination is close. TLR uses location independent addresses only. TRR uses a combination of direct paths, perimeter mode, and anchors described in the rest of this section.

3.2 Anchored paths in Location based routing (TRR)

An anchored path is a list of fixed geographic points, called anchors. In traditional paths made of lists of nodes, if nodes move far from where they were at the time when the path was computed,

the path cannot be used to reach the destination. Given that geographic points do not move, the advantage of anchored paths is that an anchored path is always ”valid”. In order to forward packets along an anchored path, TRR uses the method called *Anchored Geodesic Packet Forwarding (AGPF)*

AGPF is a loose source routing method designed to be robust for mobile networks. A source terminode adds to the packet a route vector made of a list of anchors, which is used as loose source routing information. Between anchors, geodesic packet forwarding is employed. When laying terminode are receives a packet with a route vector, it checks whether it is close to the first anchor in the list. If so, it removes the first anchor and sends the packet towards the next anchor or the final destination using geodesic packet forwarding. If the anchors are correctly set, then the packet will arrive at the destination with a high probability.

3.3 Computing Fixed Geographical points

Anchored paths, however, come at the price of computing good anchors. We propose two methods. They are always implemented at sources:

- Friend Assisted Path Discovery:

FAPD is a default protocol for obtaining anchored paths. It is based on the concept of small-world graphs (SWG). SWG are very large graphs that tend to be sparse, clustered, and have a small diameter. It assumes that some nodes (FAPD responders) are able to provide assistance to others, typically because they have a stable view of the network density. FAPD responders help find anchors, but are not used in the data path

- Geographical Map-based Path Discovery.

We believe that a good model of a large mobile network does not assume that nodes are uniformly distributed in the network. In order to model a terminode network, we identify the areas with a higher node density, which we call towns. Two towns are interconnected by all the nodes in between them (we call it a highway). If two towns are interconnected with a highway, there is a high probability that there are terminodes to ensure connectivity from one town to another. Assumes that network density maps are available to a source node. This is for an ad hoc network where all nodes are individually mobile, but the node density can still be predicted a common assumption for car networks. We find that GMPD performs better, but requires the overhead of map distribution.

3.4 Restricted Local Flooding

Restricted Local Flooding (RLF), sends four to six packet duplicates in the region where the destination is expected to be, thus increasing the probability of reaching the destination. RLF recovers from location inaccuracies when the destination is within several transmission ranges from the node that starts RLF. In large networks, sending duplicates always has considerably less overhead than flooding. RLF is used for two types of discoveries: 1) search a limited area for a given node or for a node type (FAPD responder, Section 5.1.2) and 2) establish long distance relations.

4. Overview of OLSR

The protocol is an optimization of the classical link state algorithm tailored to the requirements of a mobile wireless LAN. The key concept used in the protocol is that of multipoint relays (MPRs). MPRs are selected nodes which forward broadcast messages during the flooding process. This technique substantially reduces the message overhead as compared to a classical flooding mechanism, where every node retransmits each message when it receives the first copy of the message. In OLSR, link state information is generated only by nodes elected as MPRs. Thus, a second optimization is achieved by minimizing the number of control messages flooded in the network. As a third optimization, an MPR node may chose to report only links between itself and its MPR selectors. Hence, as contrary to the classic link state algorithm, partial link state information is distributed in the network. This information is then used for route calculation. OLSR provides optimal routes (in terms of number of hops).The protocol is particularly suitable for large and dense networks as the technique of MPRs works well in this context.

4.1 Multi Point Relays

Each node selects a set of its neighbor nodes as "multipoint relays" (MPR). In OLSR, only nodes, selected as such MPRs, are responsible for forwarding control traffic, intended for diffusion into the entire network. MPRs provide an efficient mechanism for flooding control traffic by reducing the number of transmissions required. Nodes, selected as MPRs, also have a special responsibility when declaring link state information in the network. Indeed, the only requirement for OLSR to provide shortest path routes to all destinations is that MPR nodes declare link-state information for their MPR selectors. Additional available link-state information may be utilized, e.g., for redundancy.

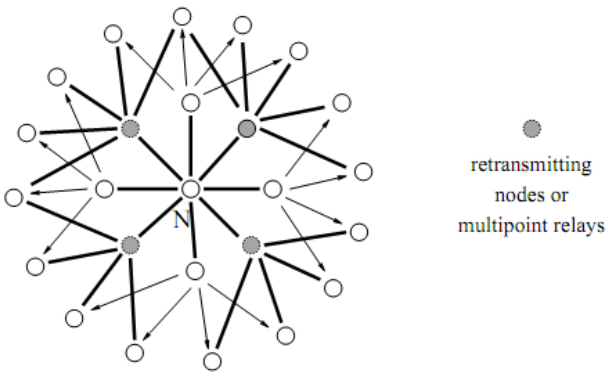

Fig: 1 Multi Point Relays

Fig 1 shows multi point selection around node N. Nodes which have been selected as multipoint relays by some neighbor node(s) announce this information periodically in their control messages. Thereby a node announces to the network, that it has reachability to the nodes which have selected it as an MPR. In route calculation, the MPRs are used to form the route from a given node to any destination in the network. Furthermore, the protocol uses the MPRs to facilitate efficient flooding of control messages in the network A node selects MPRs from among its one hop neighbors with "symmetric", i.e., bi-directional, linkages. Therefore, selecting the route through MPRs automatically avoids the problems associated with data packet transfer over uni-directional links (such as the problem of not getting link-layer acknowledgments for data packets at each hop, for link-layers employing this technique for unicast traffic).

4.2 Applicability

OLSR is a proactive routing protocol for mobile ad-hoc networks (MANETs). It is well suited to large and dense mobile networks, as the optimization achieved using the MPRs works well in this context. The larger and more dense a network, the more optimization can be achieved as compared to the classic link state algorithm. OLSR uses hop-by-hop routing, i.e., each node uses its local information to route packets.

OLSR is well suited for networks, where the traffic is random and sporadic between a larger set of nodes rather than being almost exclusively between a small specific set of nodes. As a proactive protocol, OLSR is also suitable for scenarios where the communicating pairs change over time: no additional control traffic is generated in this situation since routes are maintained for all known destinations at all times.

5. OLSR in terminode routing and its Performance.

Generally in terminode routing a packet has arrived up to two hops away from the destination, a link state routing protocol is used, which does not use location. In Fig2(a), some intermediate node on the direct path finds that D is one or two hops away, using its TLR reachability information (which is based on permanent addresses, not location).The combination of TLR and TRR is able to keep the scalability benefits of location-based routing, while avoiding problems due to mobility.

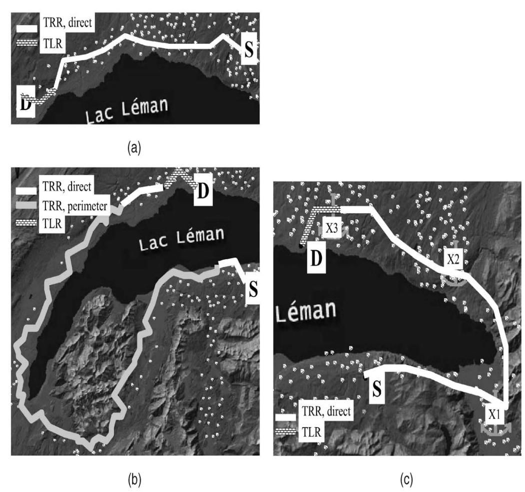

Fig 2:a)Terminode routing with direct path mode.
b)Terminode routing with perimeter mode.
c)Terminode routing with Anchored path mode.

However, combining TLR and TRR in one protocol poses a number of design challenges (in particular, avoiding loops). Perimeter Mode: Fig. (b) shows a case where the direct path does not work well: The packet may be “stuck” at a node that does not have a neighbor closer to the destination than self. Here, TRR uses perimeter mode to circumvent the topology hole. Perimeter mode consists of turning around the obstacle. This is achieved by planar graph traversal. This goes on until a node is found that reduces the distance to the destination, from where on the packet is forwarded using a direct path, as in the previous case. Perimeter mode may give very long suboptimal paths.

Furthermore, it can cause frequent routing loops in mobile ad hoc networks. Thus, we restrict the use of perimeter mode to discovery phases, when a better mode is not available to the source.

In order to avoid perimeter mode, we introduce the concept of anchors, which are imaginary locations used to assist in routing. In Fig2.(c), source S uses three anchors to route the packet to D. The anchors are geographical locations, not nodes. The list of anchors is written by the source into the packet header, similar to IP loose source routing information. The packet is sent by intermediate nodes in the direction of the next anchor in the list until it reaches a node close to an anchor, at which point the next anchor becomes the following in the list. The location of the final destination takes the role of the last anchor. Link state routing is used when the packet comes close to the final destination, as previously shown. When location accuracy is low we will use OLSR instead of Link state routing .Because in Link state routing protocol a lot of control messages unnecessary duplicated. In OLSR only MPR retransmit control messages. By this we can Reduce size of control message, minimize the flooding and cost overhead. The cost overhead is reduced by the OLSR comparing to Pure Link state algorithm given in the table

Table 1: Comparison of overhead in Link state routing and OLSR

Protocol	Transmission range	Cost	
		Over head	MPR count
Standard OLSR	300 M	12	65
	200 M	24	68
	100 M	05	42
Pure Link State routing	300 M	1245	100
	200 M	979	100
	100 M	28	100

5. Conclusion

Link state routing used in Terminode routing whenever the packet arrived up to two hops away from the destination. If the accuracy of the location information is low then packet may not reach as more close as up to two hops away from the destination. In this situation, if Link state routing is used then the overhead will be increased because it unnecessary duplicates a lot of control messages. To overcome this problem OLSR is used instead of Link state routing which improves the performance of terminode routing by reducing the cost overhead.

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