GPS-Based Shortest-Path Routing Scheme in Mobile Ad Hoc Network

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Abstract

A Mobile Ad Hoc NETwork (MANET) is a collection of wireless mobile nodes that forms a temporary network without the need for any existing network infrastructure or centralized administration. Therefore, such a network is designed to operate in a highly dynamic environment due to node mobility. In mobile ad hoc network, frequent topological changes cause routing a challenging problem and without the complete view of the network topology, establishing the shortest path from the source node to the destination node is difficult. In this paper, we suggest a routing approach which utilizes *location information* to setup the shortest possible path between the source node and the destination node. Location information is obtained through Global Positioning System (GPS) and this geographical coordinate information of the destination node is used by the source node and intermediate nodes receiving route request messages to determine the shortest path to the destination from current node.

1. Introduction

Widespread availability of wireless communication and handheld devices has stimulated researches on self-organizing networks in which any established infrastructure or centralized administration is absent. These Mobile Ad hoc NETworks or so called, MANETs consist of autonomous mobile nodes that cooperate with each other in order to transport information to a destined node. In this kind of network, every node acts as a router and as an end system at the same time.

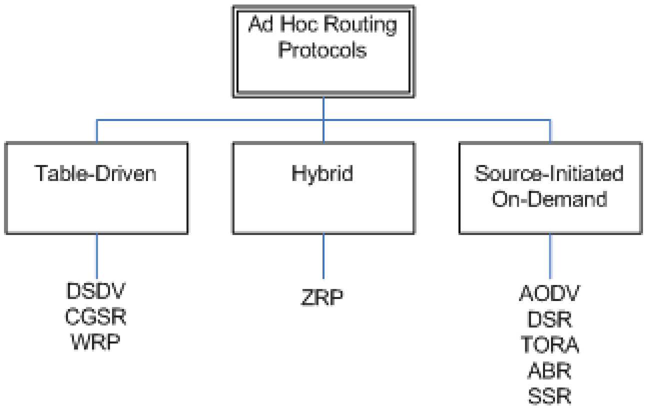
One of the distinguishing nature of MANET is that the topology of the network is highly dynamic since every node participating in the network has different degree of mobility which compounds the difficulty in predicting the full view of the network. Therefore, discovering and maintaining the routes in MANET is a challenging task and many efficient routing protocols and algorithms have been proposed.

In this paper, we suggest a scheme to discover the shortest path that can be achieved using location information obtained via Global Positioning System (GPS). The GPS provides the necessary location information when requested by the sending node to set up a path which guarantees is to be the shortest path. Limitation in broadcasting route request packets can substantially reduce network overhead and directing packets towards the destination node can also decrease route discovery time.

2. Related Works

In MANETs, all of the nodes can receive messages sent by another node when they are within sender's transmission range. However, if a node happens to be outside the sender's transmission range, the messages have to be forwarded by neighboring nodes, acting as a router, towards the intended receiver. However due to node mobility, it is not possible to establish a fixed path throughout the transmission period. Accordingly, numerous routing protocols have been developed for MANET to deal with typical limitations of these networks. These protocols may generally be categorized as *Table-Driven (aka. Proactive)* and

Source-Initiated On-Demand-Driven (aka. Reactive) protocols depending on their characteristics. There are also some *Hybrid* protocols which, as the name implies, is a mixture of both table-driven and source-initiated on-demand protocols. [Figure 1] is a general categorization of ad hoc routing protocols [1, 2, 3, 4, 5, 6, 7].



[Figure 1] Categorization of ad hoc routing protocols

Most of the proactive routing protocols are based on shortest path algorithms adapted to the mobile environment which attempt to maintain consistent up-to-date routing information from each node to every other node in the network. These protocols require each node to maintain one or more routing tables and periodically propagate routing information throughout the network to constantly update network view at all times. This implies update overhead with each exchange and, since these routing tables are possibly large, a majority of network capacity and node energy is spent in their transmission. Also even in times when the route setup process is not required, these protocols need to exchange update information to maintain network topology which wastes network resources undesirably.

Compared to proactive routing protocols, reactive routing protocols search for a route in an "on-demand" fashion. That is, a route is created only when it is desired by the source node. When a node requires a route to a destination, it initiates a route discovery process within the network. This process is completed once a route is found or every permutation has been examined. After establishing a route, it is maintained by a route maintenance process until either the destination node becomes inaccessible or the route is no longer needed.

3. Proposed Scheme

Routing protocols discussed above are considered as topology-based routing protocols which do not take into account the physical location of the destination node. However in this paper, we propose a scheme which is a position-based approach that uses location information.

The main objectives of the proposed scheme can be summarized as follows.

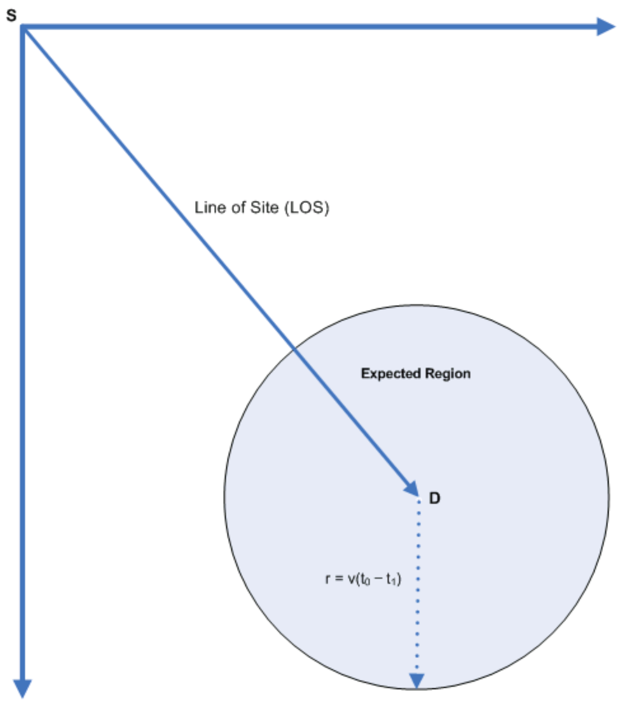
First, it multicasts route request packets instead of broadcasting in the route discovery process. Since, forwarding packets in MANET is a costly transaction, in terms of consuming network bandwidth and generating network traffic, a preferable approach is to minimize the number of packets submitted into the network as much as possible. Dynamic Source Routing (DSR) [3, 4, 7] and Ad hoc On-demand Distance Vector (AODV) [2, 7], being one of the renown on-demand routing protocols, use broadcasting in discovering a route. This can substantially increase meaningless network overhead.

Second, on-demand routing protocols are preferred over table-driven routing protocols since they only create route when it is desired. On the other hand, they tend to have relatively high delay in establishing a route compared to table-driven routing protocols. However in our scheme, although the routes are requested when desired which is similar to on-demand routing protocols, it tries to minimize the delay in establishing a route. This can be achieved by the help of GPS. With the location information given by the GPS, the sender and intermediate nodes forward packets "in the direction of" the destination node.

3.1 Location Information

The proposed scheme makes use of location information to reduce routing overhead. Location information is provided by the GPS [8, 9, 10, 11] and with it, it is possible for a mobile host to know its physical location when requested. Current GPS provides accurate three-dimensional position, i.e., latitude, longitude, and altitude, velocity, and precise time traceable to Coordinated Universal Time (UTC) [12]. In reality, it is possible for the position information provided by the GPS to include some error which is the difference between GPS-calculated coordinates and the real coordinates. However, the proposed scheme can be applied even if the position information is known approximately.

3.2 Line of Site (LOS) and Deviation Angle



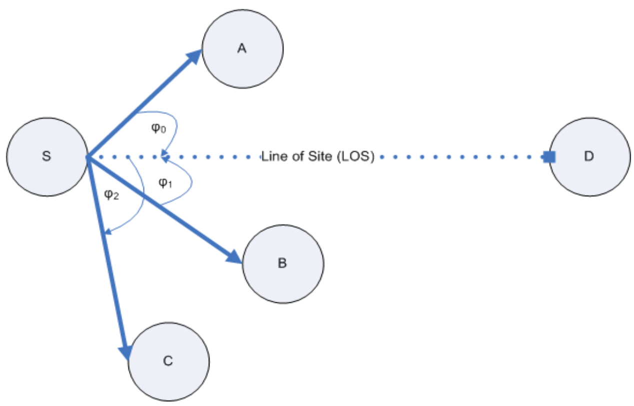
[Figure 2] Line of Site (LOS)

In [Figure 2], the source node S wants to establish a route with the destination node D in which the packets from S will be forwarded "in the direction of" D with the help of GPS. As seen from GPS point of view ignoring any geographical limitations, the shortest possible path from S to D is a straight line drawn that connects each other. We call this the *Line of Site (LOS)*.

Apparently, if there exists a route along the LOS, then it is surely the shortest path obtainable. However in reality, this is a very ideal situation. Most of the time, intermediate nodes will not be aligned along the LOS to form a route instead they would be scattered around the LOS.

An *Expected Region* is an approximated area where the destination node would be since all the nodes have their own degree of mobility. The radius (r) of the expected region is calculated as $r = v(t_0 - t_1)$, where v is the velocity of the destination node and $(t_0 - t_1)$ being the time difference when it was first observed by the GPS and when the information was delivered to the requesting node. Because of the existence of the expected region, the LOS must be adjusted accordingly. However in this paper, we will assume that the degree of mobility of the destination node is quite negligible resulting in a smaller expected region.

In our scheme, every time a node requests GPS for location information of the destination, the node is required to calculate a *"deviation angle"* of every neighboring nodes.



[Figure 3] Deviation Angle

To establish a route, the source node initiates route discovery process by propagating route request packets to its neighboring nodes as shown in [Figure 3]. It will calculate a deviation angle from the LOS of each neighboring nodes. Node A has a deviation angle of θ_0, and node B of θ_1. Node S will then compare both deviation angles and forward packets to the node with smaller deviation angle. Assume θ_1 has a smaller deviation angle, then Node B will receive packets from Node S. In the following route discovery process, identical procedure will be taken, that is, LOS is setup between Node B and Node D and calculation of deviation angles are executed again, until the packets are arrived at Node D.

The matter of how many deviation angles are to be compared are not discussed in this paper. This subject will be discussed on later researches which will determine the optimal parameters for this scheme. In [Figure 3], actually three deviation angles (θ_0, θ_1, and θ_2) were compared.

4. Conclusion

In this paper, we proposed an on-demand routing scheme that makes use of location information provided by the GPS. It attempts to reduce the number of route request packets in route discovery process and also by directing packets "in the direction of" the intended destination node, the delay of route discovery process can be shortened. When a node wants to send a packet, be it the source node or an intermediate node, it first consults GPS and sets up an imaginary line called, the Line of Site (LOS). Calculating deviation angles of all or some of neighboring nodes, it will forward the packet to the node with the smallest deviation angle until it reaches the destination node.

In the future, we will conduct substantial amount of simulations to support our proposed scheme and some experiments in determining how many deviation angles should be compared for optimal performance will be covered. Also, when the mobility of the destination node is taken into consideration with higher importance, the adjustment of LOS is required.

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