# Routing in Mobile Ad-Hoc Networks

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***Abstract*—An ad-hoc network is a collection of wireless mobile hosts forming a temporary network without any centralized administration or established infrastructure. In this paper, we study Routing in Mobile Ad-hoc networks(MANETs). Routing in these networks is significantly different and face a whole new set of problems from routing in traditional networks. We survey existing and previous routing protocols for MANETs and discuss current trends in MANETs research.**

## I. Introduction

Mobile Ad-Hoc Networks (MANETs) have become very popular in recent years owing to their ease and speed of deployment and their decreased dependence on infrastructure. Routing is one major challenge in these networks because of the dynamic nature of the network, and a route from a source to destination will contain potentially multiple hops. A few challenges[1] in routing in MANETs are as follows:

- **Asymmetric Links:** Unlike wired networks which rely on symmetric links, links in MANETs are mostly unsymmetric as nodes are mobile and are constantly changing. For example, if a node $A$ sends a signal to a node $B$, it does not tell anything about the quality of the connection in the reverse direction.
- **Routing Overhead:** Since nodes constantly change their location in these networks, *stale* routes are generated in the routing table which leads to unnecessary routing overhead.
- **Interference:** As links are dynamic, there is a possibility that one transmission might interfere with another one and node might overhear transmissions of other nodes and can corrupt the total transmission. Another related problem is the *Hidden Terminal Problem*[2]. For example in Figure I, if nodes $A$ and $C$ cannot hear each other, then transmission by nodes $A$ and $C$ can collide at node $B$. In such a case, we say nodes $A$ and $C$ are *hidden* from each other.

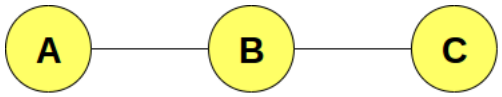


Fig. 1. The Hidden Terminal Problem

As is evident from the above discussion, Routing Algorithms in these networks should be adaptive and routing table updations should happen every 30sec or so, which is difficult in these networks. Most proposed algorithms address only a sub-space of the problem domain because of the large number of factors in consideration.

The remaining paper is organized as follows. Section II is a literature survey on Routing in MANETs. A very detailed survey of all Routing Algorithms in MANETs till date is out of scope of this paper, so we mention the most significant advances in a logical order. A disclaimer is that for almost all of these algorithms, many different optimizations were proposed later which we do not cover here. Section III presents conclusions and future work.

## II. Literature Survey

Routing Protocols in Ad-Hoc networks have been classified in many ways[3], based on routing strategy and network structure. According to routing strategy, the routing protocols can be categorized as table-driven and source initiated, while depending on the network structure these are classified as flat routing, hierarchial routing and geographic position assisted routing. Both table-driven and source initiated protocols come under flat routing. See Figure II.

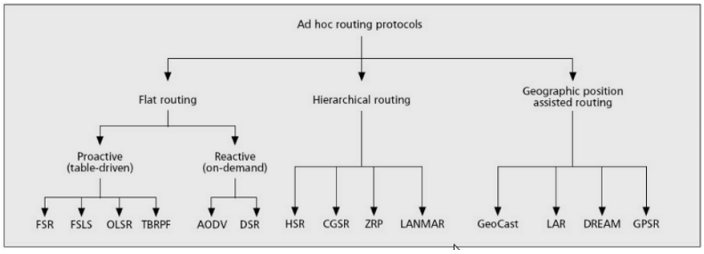


Fig. 2. Classification of Routing Protocols in MANETS[cite]

It should be mentioned at this point that owing to the dynamic link topology, there are both unipath and multipath routing protocols. Most multipath routing protocols are built upon unipath routing protocols, hence we restrict our discussion to mostly unipath routing protocols.

A lot of the routing protocols mainly make use of the *flooding* technique for route discovery which we briefly mention as follows: A sender $S$ broadcasts data packet $P$ to all its neighbours, and each node receiving $P$ forwards $P$ to its neighbours - In this way, packet $P$ reaches the destination $D$ provided a path from $S$ to $D$ exists. Node $D$ does not forward the packet. We describe two routing protocols that make use

of this technique, namely Dynamic Source Routing (DSR)[4] and Ad-hoc On-Demand Distance Vector Routing (AODV)[5].

DSR uses *source routing* instead of relying on the routing table at each intermediate device. DSR uses a combination of Route Request(**RREQ**), Route Reply(**RREP**) and Route Error(**RERR**) messages to establish a route from source to destination. In addition DSR also uses *route caching* to speed up route discovery. The main advantage of DSR is that a route to a destination is established only when it is required to, and a single route discovery often discovers routes to other destinations in the process. However, the main drawbacks of DSR are increased size of packet header with the length of the route, *stale caches*, etc.

AODV is a reactive(on-demand) protocol which borrows the advantageous concepts from DSR and DSDV (Destination Sequenced Distance Vector Routing)(We mention this later) like on-demand route discovery and route maintainence, and the usage of node sequence numbers from DDSV. The actual working of AODV is beyond our scope. See [5] for a good description. AODV is one of the most successful routing protocols in MANETs mainly because of its desirable features like *Minimal Space Complexity* and *Maximum Bandwidth Utilization*.

We now look at another widely deployed protocol called Destination Sequenced Distance Vector Routing Protocol (DSDV)[6]. DSDV is a proactive (means routes are independent of traffic pattern) protocol which is a modification of the conventional *Bellman-Ford* algorithm. The important feature of DSDV is the use of sequence numbers for the routing table entries. These sequence numbers are generated by the destination stations and routing tables at each node are synchronised by each node advertising its routing table information to its neighbours frequently. Forwarding decisions are made based on the sequence numbers. The main advantages of DSDV is that it guarantees loop-free paths and always maintains the *best* path to destination rather than multiple paths. However, routing table updates are costly, and there is no support for multi-path routing.

More recently, because of the rapid advances in Global Positioning Systems(GPS), Geographic Routing Protocols are becoming popular. One such protocol is the Geographic Distance Routing (GEDIR)[7]. In GEDIR, location of the destination node is assumed to be known, and each node knows the locations of its neighbours and forwards a packet to the neighbour closest to the destination. Many interesting advances have been made in Geographic Routing like Routing based on Virtual Co-ordinates [9], Routing without Location Information [8], etc.

In addition to Reactive and Proactive routing protocols, we also have Hybrid schemes like the Zone Routing Protocol (ZRP) [10] which proactively maintain state information for links within a short distance, say $d$, from any given node (*Intra-Zone Routing*) and uses a route discovery protocol for determining routes to a nodes at a distance greater than $d$ (*Inter-Zone Routing*).

Most protocols we have seen so far use some kind of flooding. There are few protocols like the *Link Reversal Algorithm* and Temporally-Ordered Routing Algorithm (TORA) which try to avoid/reduce flooding behaviour. See [11] and [12] respectively for discussions.

Routing Protocols which define the optimization criteria as a function of the energy consumption are called *Power-Aware Routing Protocols*[13]. The idea is to assign each link a weight which is a function of energy consumed when transmitting a packet on that link. The goal is to route through paths with minimum weight. Such protocols are usually built on top of existing protocols like DSR.

## III. Conclusion

Routing in MANETs is a very active area of research because no one solution fits all criteria of an ideal protocol. One interesting direction of research is Routing with Local Information. Very promising advancements have been made towards routing without knowledge of the global topology[8] - this means that there may be a day when we can route successully without maintaining routing tables.

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