The Mobile Ad-Hoc Networks

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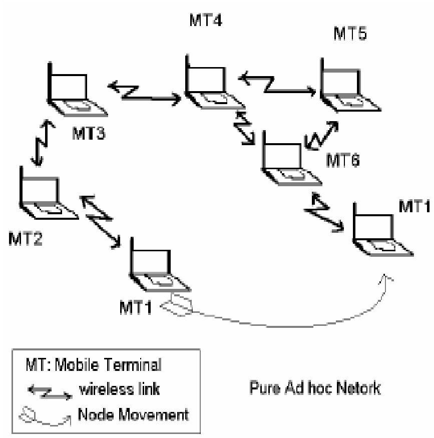
Abstract: In recent times, the wide leap advancement has taken place in the field of communication. Now, communication with mobility has become an utmost necessity. Mobile Ad-Hoc Networks (MANETS) is one such powerful and efficient way of highly mobile and flexible communication. In this paper, I present the standards which are used to implement MANETs along with the routing protocols. Apart from this, the current area of wide research is the cost metrics that define the efficiency and performance of an ad-hoc network. Another key area of research is the ways to reduce the power consumption in ad-hoc networks. Here, I propose a different approach for reduction in power consumption of MANETs that will help in a longer life and maintenance of the mobile ad-hoc networks.

A mobile ad hoc network (MANET) is an autonomous system of mobile nodes, a kind of a wireless network where the mobile nodes dynamically form a network to exchange information without utilizing any pre-existing fixed network infrastructure For a MANET to be constructed, all needed is a node willing to send data to a node willing to accept data. Each mobile node of an ad-hoc network operates as a host as well as a router, forwarding packets for other mobile nodes in the network that may not be within the transmission range of the source mobile node. Each node participates in an ad-hoc routing protocol that allows it to discover multi-hop paths through the network to any other node.



MANET is the infrastructureless approach to WLANs and WLLs etc. It is a self-configuring network of nodes and routers connected by wireless links, which in synchronization form a dynamic topology. These networks operate in standalone manner where routers and nodes are free to move and organize themselves randomly, causing a rapidly changing topology. This is why, these networks are very flexible and suitable for several types of applications, as they allow the establishment of temporary communication without any pre installed infrastructure.

The transmission range of a mobile node in the network is limited to a circular region around the node, whose radius depends on the transmitted power, receiver sensitivity and propagation loss model. If the destination node is not in the transmission range of the source node, then the mobile ad hoc network works like a multi hop network with one or more node acting as routing node. Due to the limited wireless transmission range of each node, data packets then may be forwarded along multi-hops. The three types of traffic in MANETS are

1) Peer –to Peer: Communication between two nodes with one hop
2) Remote to Remote: Communication beyond one hop but existence of stable route
3) Dynamic Traffic: Nodes are dynamic and routes are reconstructed frequently.

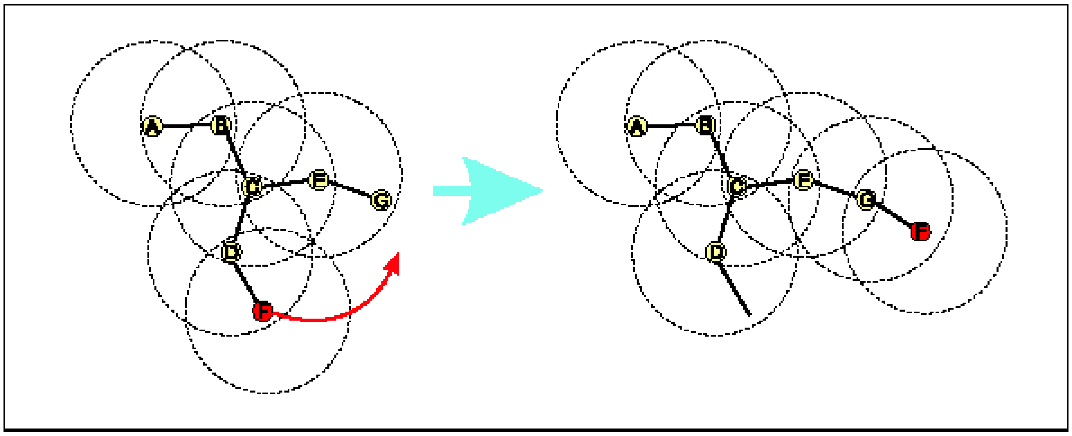


Figure 1: A mobile multi-hop ad-hoc network. Node F moves into the general vicinity of node G

Salient features of MANET

1) **Dynamic topologies:** Nodes are free to move arbitrarily; thus network topology—which is typically multihop—may change randomly and rapidly at unpredictable times. Adjustment of transmission and reception parameters such as power may also impact the topology.
2) **Bandwidth-constrained, variable capacity links:** Wireless links will continue to have significantly lower capacity than their hard-wired counterparts. One effect of this relatively low to moderate link capacities is that congestion is typically the norm rather than the exception; *i.e.* aggregate application demand is likely to exceed network capacity frequently.
3) **Power-constrained operations:** Some or all the nodes in a MANET rely on batteries for their energy. Thus, for these nodes, the most important design criteria may be that of power conservation.
4) **Limited physical security:** Mobile wireless networks are generally more prone to physical security threats than fixed, hard-wired networks. Existing link security techniques are often applied within wireless networks to reduce security threats.

Some standards on which MANETs operate:

In 1997, the IEEE adopted the first wireless local area network standard, named IEEE 802.11, with data rates up to 2 Mbps. The IEEE 802.11 standard defines two operational modes for WLANs: infrastructure-based and infrastructure-less or ad hoc networks. Infrastructure mode resembles cellular infrastructure-based networks. It is the mode commonly used to construct the so-called Wi-Fi hotspots, i.e., to provide wireless access to the Internet. In the ad hoc mode, any station that is within the transmission range of any other, after a synchronization phase, can start communicating. No Access Permission is required, but if one of the stations operating in the ad hoc mode has a connection also to a wired network, stations forming the ad hoc network gain wireless access to the Internet.

Table 1
Transmission ranges at different data rates

	11 Mbps	5.5 Mbps	2 Mbps	1 Mbps
TX_range	30 m	70 m	90–100 m	110–130 m

802.11b

1 **Uses**: Unregulated radio frequency of 2.4GHz

2 **Pros of 802.11b** - lowest cost; signal range is good and not easily obstructed

3 **Cons of 802.11b** - slowest maximum speed; home appliances may interfere on the unregulated frequency band

802.11a

- **Uses**: Bandwidth of 54Mbps, Regulated frequency spectrum around 5 GHz.
- **Pros of 802.11a** - fast maximum speed; regulated frequencies prevent signal interference from other devices
- **Cons of 802.11a** - highest cost; shorter range signal that is more easily obstructed

802.11g

1 **Uses**: Bandwidth of 54Mbps, Regulated frequency spectrum around 2.4 GHz

2 **Pros of 802.11g** - fast maximum speed; signal range is good and not easily obstructed

3 **Cons of 802.11g** - costs more than 802.11b; appliances may interfere on the unregulated signal frequency

802.11n

The newest IEEE standard in the Wi-Fi category is *802.11n*.

1 **Uses**: Bandwidth of 100Mbps, Regulated frequency spectrum around 2.4 GHz

2 **Pros of 802.11n** - fastest maximum speed and best signal range; more resistant to signal interference from outside sources

3 **Cons of 802.11n** - standard is not yet finalized; costs more than 802.11g; the use of multiple signals may greatly interfere with nearby 802.11b/g based networks.

Routing Protocols

Network Management is the key issue in the implementation of MANETs keeping in mind the various constraints due to the lack of infrastructure and high flexibility of nodes. Again, owing to the limited transmission range of the mobile nodes, it is indispensable that each node executes a routing algorithm to establish and maintain routes to other nodes in the network.

A preliminary classification of the routing protocols can be done via the type of cast property, i.e., whether they use a Unicast, Multicast, or Broadcast forwarding. **Unicast** forwarding means a one-to-one communication, i.e., one source transmits data packets to a single destination. This is the largest class of routing protocols found in ad hoc networks. **Multicast** routing protocols come into play when a node needs to send the same message, or stream of data, to multiple destinations. **Broadcast** is the basic mode of operation over a wireless channel; each message transmitted on a wireless channel is generally received by all neighbors located within one-hop from the sender. The simplest implementation of the broadcast operation to all network nodes is by naive flooding, but this may cause the broadcast storm problem due to redundant re-broadcast.

Another major concern of routing protocols is whether the nodes in the ad-hoc network should keep track of routes to all possible destinations, or instead, keep track of only those destinations of immediate interest. A node in an ad hoc network does not need a route to a destination until that destination is to be the recipient of packets sent by the node, either as the actual source of the packet or as an intermediate node along a path from the source to the destination.

Protocols that keep track of routes for all destinations in the ad hoc network are called **Proactive protocols** or Table-driven Protocols, as the routes can be assumed to exist in the form of tables. Proactive protocols have the **advantage** that communications with arbitrary destinations experience minimal initial delay from the point of view of the application. When the application starts, a route can be immediately selected from the route table. But, the **disadvantage** is that, additional control traffic is needed to continually update stale route entries. Unlike the Internet, an ad-hoc network contains numerous mobile nodes and therefore links are continuously broken and re-established. If the broken route has to be repaired, even though no applications are using it, the repair effort can be considered wasted. This wasted effort can cause scarce bandwidth resources to be wasted and can cause further congestion at intermediate network points as the control packets occupy valuable queue space. Since control packets are often put at the head of the queue, the likely result will be data loss at congested network points. Data loss often translates to retransmission, delays, and further congestion.

In contrast, there exist **Reactive protocols** that acquire routing information only when it is actually needed. These protocols often use far less bandwidth for maintaining the route tables at each node, but the latency for many applications will drastically increase. Most applications are likely to suffer a long delay when they start because a route to the destination will have to be acquired before the communications can begin. Due to the high uncertainty in the position of the nodes, however, the reactive protocols are much suited and perform better for ad-hoc networks.

Again, since the medium in ad-hoc networks is common, simultaneous communication will collide. A suitable MAC layer protocol avoids the collision. The transmission of unicast packet is preceded by a Request-to-Send/Clear-to-Send (RTS/CTS) exchange that reserves the channel for transmission of the data packets. Routing protocols are used to set up and maintain the route between the source and destination by means of Route-Request/Route-reply (RREQ/RREP) packet exchange. Route-Error (RERR) packet is used to detect link/route failure.

Some of the proactive protocols are
1) DSDV
2) Wireless Routing Protocol
3) Global state routing
4) Fisheye state Routing
5) Hierarchical State routing
6) Zone-based Hierarchical Link State Routing Protocol
7) Cluster head Gateway Switch Routing Protocol

Some of the reactive protocols are
1) DSR
2) Ad-Hoc On-Demand Distance Vector Routing (AODV)
3) Cluster based

4) Temporally Ordered Routing Algorithm
5) Associativity Based Routing
6) Signal Stability Routing

Cost Metrics

The primary motivation of Mobile ad-hoc networks is increased flexibility and high mobility. But, MANET has its own limitations in terms of coverage area, bandwidth, scarce battery power, scalability and security. Random node mobility along with various other factors such as network size and traffic intensity may be very dynamic, resulting in unpredictable variations in the overall network performance. The major problem a MANET faces is its requirement of large number of nodes in a given area for a scalable network.

Thus while evaluating the performance of an ad-hoc network with high rate of transitions, the effect of basic five factors should be taken into consideration:

1) Node speed,
2) Pause-time,
3) Network size,
4) Number of traffic sources, and
5) Type of routing (source versus distributed),

Apart from these factors, other metric that can be considered are

1) Hop-count,
2) Path-congestion, and
3) Energy-usage.

While selecting a routing algorithm or using a hybrid of the routing algorithms, considering the above mentioned metrics results in a system performance with greater packet delivery ratio, lower end-to-end delay, lower overhead, and lower per-node energy usage.

Different routing protocols use one or more of a small set of metrics to determine the optimal path:

· The most common metric used is shortest hop routing, as in the case of **Dynamic Source Routing** (DSR), **Destination-Sequenced Distance Vector** (DSDV), **Temporally-Ordered Routing Algorithm** (TORA) and the **Wireless Routing Protocol** (WRP). These protocols can also use shortest delay as the metric, as the shortest distance leads to the shortest amount of time.

· Link quality is a metric that is used by **Signal Stability based Adaptive Routing** (SSA) and by the **DARPA** protocol. Since link quality information is used to select one among many different routes, sometimes a shortest hop route may not be used. In addition to link quality, SSA also uses location stability to bias route selections towards routes with relatively stationary nodes (which will require fewer updates).

· The **Spine Routing Algorithm** (SRA) attempts to minimize the message and time overhead of computing routes. In this protocol, nodes are assigned to clusters (one or two hops in diameter) and clusters are joined together by a virtual backbone, so that packets destined for other clusters get routed by this backbone.

· In **Associativity Based Routing** (ABR), each mobile node periodically transmits beacons to identify itself and constantly updates its associativity ticks in accordance with the mobile hosts sighted (i.e. hearing others' beacons) in the neighborhood.

· Power-aware routing is the most recent cost metric and the most popular algorithms in this field include **Power-Aware Multi-Access Protocol with Signaling** (PAMAS), **Minimum Energy Mobile Wireless Networks** and **Routing for Maximum System Lifetime** (MSL). While the Minimum Energy Protocol aims at designing a network that consumes the minimum overall energy, MSL uses a maximum residual energy path routing algorithm to maximize the time until any node fails.

Reduction in Power Consumption in MANETS

A mobile device in a network mainly exists in either of the following modes: **Standby, Active, Sniff, Hold and Park**. Mobile devices rely on batteries for energy. Battery power is finite, and represents one of the greatest constraints in designing algorithms for mobile devices. Limitation on battery life, and the additional energy requirements for supporting network operations (e.g., routing) inside each node, make the power conservation one of the main concern in ad hoc networking. The importance of this problem has produced a great deal of research on energy saving in wireless networks in general, and ad hoc networks in particular.

Strategies for power saving have been investigated at several levels of a mobile device including the physical-layer transmissions, the operating system, and the applications Power-saving policies at the operating system level include strategies for CPU scheduling, and for the hard-disk management. At the application-level, policies that exploit the application semantic or profit of tasks remote execution have been proposed.

However, in small mobile devices, networking activities have a major impact on energy consumption. Experimental results show that power consumption related to networking activities is approximately 10% of the overall power consumption of a laptop computer, but it raises up to 50% in handheld devices. The key point in energy-aware networking is the fact that a wireless interface consumes nearly the same amount of energy in the receive, transmit, and idle state; while in the standby state, an interface cannot transmit or receive, and its power consumption is highly reduced.

Power consumption of the mobile nodes in a network can be broadly divided as those at the **hardware level** and those at the **software level**. At the software level, the basic idea is to estimate when a device will transmit data and suspend it for the time it will not be used. Hence, for power consumption, it is necessary to define protocols that maximize the time the interface spends in the power saving mode.